FINAL

SWMU B-3 BIOREACTOR

OPERATION AND MAINTENANCE MANUAL

Prepared For:

Camp Stanley Storage Activity

Boerne, Texas

July 2010

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ACRONYMS AND ABBREVIATIONS

btoc	below top of casing
BTS	Bioreactor Trench Sump
CC	Cow Creek Formation
CSSA	Camp Stanley Storage Activity
DO	Dissolved oxygen
DOC	Dissolved organic carbon
ft	Feet
GAC	Granular activated carbon
gpm	Gallons per minute
HDPE	High density polyethylene
HOA	Hand off automatic
Hp	Horsepower
HSP	Health and Safety Plan
MPMW	Multi port monitoring well
MSL	Mean sea level
MW	Monitoring well
NTP	Notice to proceed
O&M	Operation and Maintenance
ORP	Oxidation reduction potential
Parsons	Parsons Infrastructure and Technology
PCE	Perchloroethene
PLC	Programmable Logic Controller
psi	Pounds per square inch
PVC	Polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
RTU	Remote Telemetry Unit
SCADA	Supervisory Control and Data Acquisition
SWMU	Solid Waste Management Unit
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TOC	Total organic carbon
toc	top of casing
TCE	Trichlorethene
VOC	Volatile organic compound
VC	Vinyl Chloride

SECTION 1
INTRODUCTION

This Operations and Maintenance (O&M) Plan documents the necessary activities to be performed during operation and maintenance of the Solid Waste Management (SWMU) B-3 bioreactor and injection system installed at Camp Stanley Storage Activity (CSSA) in Boerne, Texas.

The purpose of this O&M Plan is to describe the procedures to be followed during normal operation of the system. The Plan provides a detailed description of the injection system, including specifications of system components, data to be collected during normal system operations, system maintenance procedures, and general site maintenance to facilitate effective system operations. The Plan furthermore provides CSSA with a set of procedures for monitoring the equipment used for operating the SWMU B-3 bioreactor as well as monitoring the effectiveness of the bioreactor at reducing the concentrations of VOCs in the aquifer underlying SWMU B-3.

Section 2 provides a description of the pilot study remedial (bioreactor) system in operation at the Site, including a detailed description of the system components. Section 3 describes the system operation and monitoring requirements, Section 4 presents the system maintenance activities to be performed, and Section 5 discusses reporting requirements. The Texas Commission on Environmental Quality (TCEQ) Authorization Letter(s) for the underground injection of VOC impacted groundwater is included in Appendix A. Product manuals and literature of system components are included in Appendix B through J. Field data forms to be used during O&M activities are included in Appendix K.

1.1 HEALTH AND SAFETY

CSSA and Parsons Infrastructure and Technology (Parsons) are committed to performing the O&M activities at the B-3 site in a safe manner. A Health and Safety Plan (HSP) has been prepared that addresses worker safety during performance of the O&M activities at the site. The HSP identifies potential safety hazards associated with the O&M work activities and describes safety procedures that must be implemented to ensure that the work can be completed without incident. A copy of the HSP is maintained at CSSA.

All personnel performing O&M activities at the site must read the HSP to become familiar with the potential work hazards and the safety procedures to be followed. After familiarizing themselves with the HSP, all employees must sign the HSP Acknowledgement Form maintained at CSSA. The procedures presented in the HSP must be followed by Parsons Employees and subcontractors at all times while on CSSA. The HSP will be updated as needed to address new site work hazards or incorporate work tasks as they are identified.

1.2 SITE DESCRIPTION

CSSA is located in northwestern Bexar County about 19 miles northwest of San Antonio, Texas. The installation consists of 4,004 acres immediately east of State Highway 3351 and approximately one-half mile from Interstate Highway 10. Additional background information regarding CSSA is located in CSSA's Environmental Encyclopedia (**Volume 1-1, Background Information Report**).

SWMU B-3 was a landfill area thought to have been used primarily for garbage disposal and trash burning from the 1950's through the 1980s. The trench areas were reportedly closed in 1990-1991. In 1991, chlorinated hydrocarbons were detected in groundwater from Well CS-16, approximately 500 feet north-northwest of SWMU B-3. The VOC concentrations, which were above drinking water standards, prompted several investigations aimed at identifying possible source areas that could be contributing to the contamination. SWMU B-3, along with nearby SWMU O-1 (oxidation pond), was identified as potential sources of groundwater contamination within the inner cantonment.

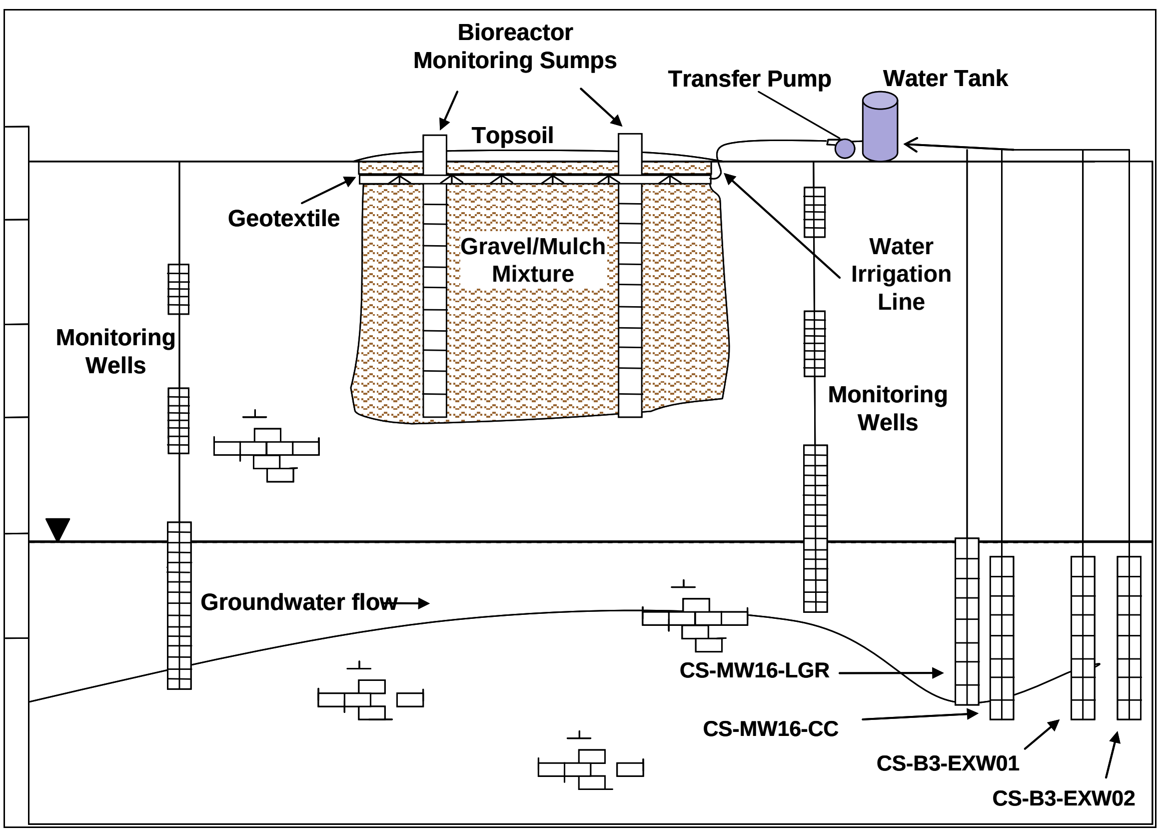
As part of the Resource Conservation and Recovery Act (RCRA) Administrative Consent Order, a pilot study using a bioreactor was conceptualized, designed, and constructed at SWMU B-3. The bioreactor is designed to remediate the affected groundwater and unsaturated zone underlying SWMU B-3. The design included excavation, removal, and offsite disposal of affected soil, debris, and waste contained within six trenches. The waste is believed to be a likely source of contaminants impacting the underlying fractured limestone (bedrock) and groundwater.

Based on the general design of the bioreactor, a request for a Class V Aquifer Remediation Injection Well was submitted to the Industrial and Hazardous Waste Permits Section of the Waste Permits Division at the Texas Commission on Environmental Quality (TCEQ) in May 2006. The permit application was approved July 20, 2006 and TCEQ Authorization Number 5X2600431; WWC 12002216; CN602728206/RN104431655 was assigned to the SWMU B-3 injection system. An amendment to CSSA's Class V Aquifer Remediation Injection permit was submitted November 26, 2006 to authorize the use of a sixth trench that was encountered during removal actions at SWMU B-3. A copy of the Class V Aquifer Remediation Injection Well permit authorization letter and correspondence related to amendments are presented in Appendix A.

SECTION 2
SYSTEM DESCRIPTION

The general concept (see Figure 2.1) is to pump extracted groundwater from recovery wells CS-MW16-LGR, CS-MW16-CC, and CS-B3-EXW01 to a 5,000-gallon storage tank. Level switches within the storage tank are set to communicate directly with the extraction wells to maintain an available water supply in the tank for subsequent injection into bioreactor trenches. A transfer pump pumps water from the storage tank to the network of pipes buried approximately 1.5 ft below a gravel surface which overlies the SWMU B-3 gravel/mulch filled trenches. Water from the storage tank is sprayed into the gravel/bark mulch mixture in each trench through downward-pointing discharge nozzles located at 10-foot centers along 1.5-inch flexible high density polyethylene (HDPE) pipe. The use of these nozzles allows a more even distribution of injected water along the trench.

Figure 2.1 General Components of the Bioreactor



To prevent the bioreactor from overfilling, a level switch is installed in monitoring sump 1-1 (Trench 1 - sump 1) which will shut down the transfer pump in the event that the water level in trench 1 reaches the high-level shut-off. The level switch high-level shut-off is set at approximately one foot below trench 1 capacity. Sump 1-1 is located in the deepest portion of the bioreactor, west and downslope of the other trenches. Additional transducers may be added to a sump in the remaining trenches to provide simultaneous monitoring locations to assess subsurface flows within the bioreactor.

Water is pumped into selected trenches to saturate a portion of the gravel/tree mulch mixture backfill. The bioreactor capability to reduce contaminants associated with extracted groundwater from CS-MW16-LGR, CS-MW16-CC, CS-B3-EXW01, and CS-B3-XW02 as well as contaminants in the subsurface beneath the bioreactor is assessed through periodic sampling of groundwater monitoring wells, trench sumps, piezometers and multi-port monitoring wells (MPMWs) located in and around SWMU B-3.

2.1 BIOREACTOR CONSTRUCTION

The details associated the construction of the bioreactor are provided in *"B-3 Bioreactor Construction Report"* (Parsons, February 2007).

2.2 MAJOR EQUIPMENT

Equipment was installed to provide control of water flow from the two CS-MW-16 wells, CS-B3-EXW01, and CS-B3-EXW02. The process diagram depicting the equipment and the controls regulating the flow of water through the system is shown in Figure 2.2.

2.2.1 Recovery Well Pumps

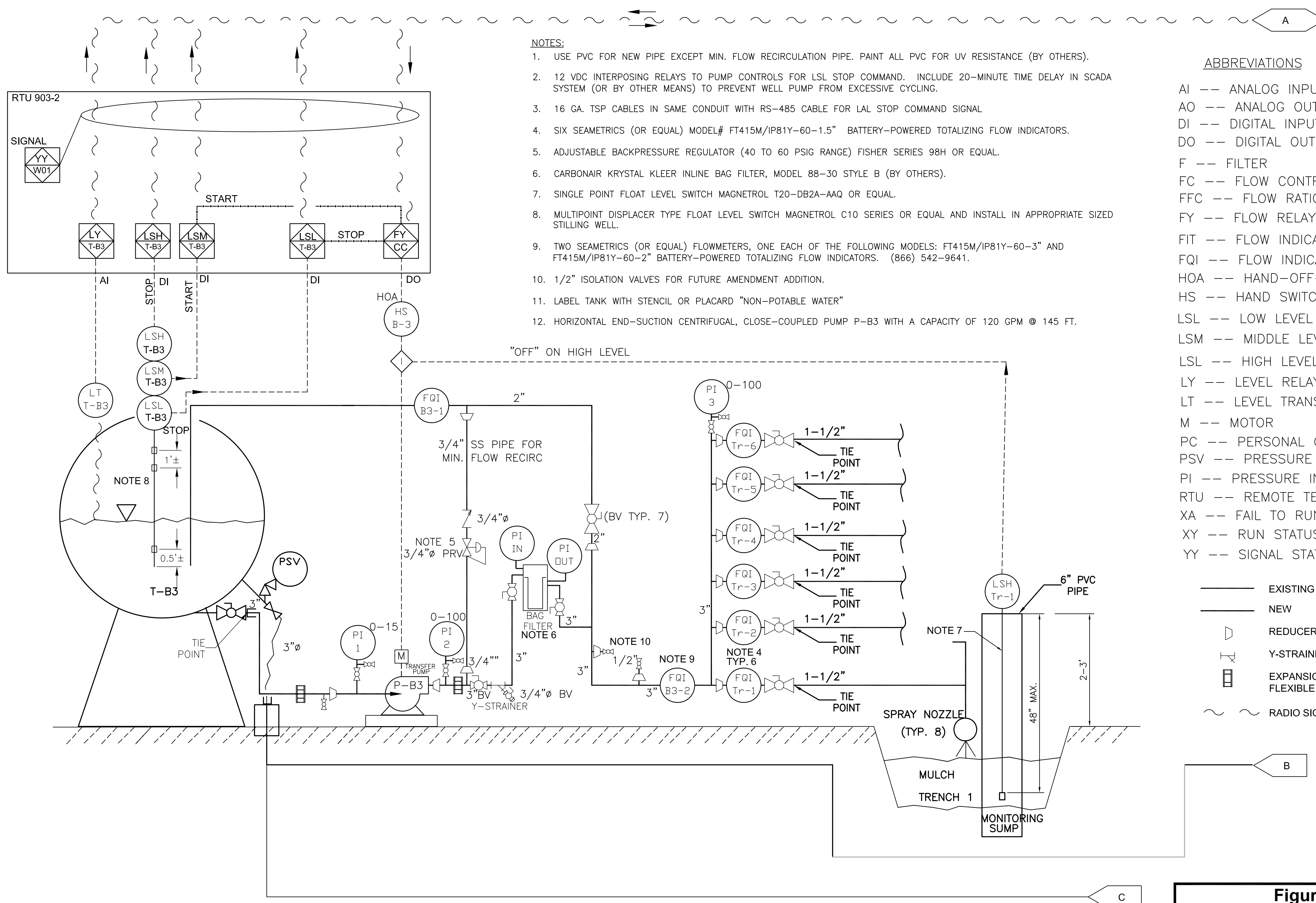
Extraction wells CS-MW16-LGR and CS-MW16-CC utilize submersible pumps installed in 2002. A 1-inch diameter flex-pipe line was installed in CS-MW-16LGR to facilitate water level probe access and access to a QED low-flow pump used for sampling purposes. A 5-horsepowser (hp) pump was installed in CS-B3-EXW01 in 2009. A fourth extraction well is planned to provide additional water to the bioreactor. This new extraction well due to be completed in the fall of 2010 will include a 5-hp pump to extract and transmit groundwater to the storage tank. These pumps supply recovered groundwater to the 5,000 gallon storage tank, which is ultimately injected into the bioreactor trenches. Transducers are installed in both CS-MW-16 wells, as well as CS-B3-EXW01. This fourth well, CS-B3-XW02 is located near the former oxidation pond O-1 located 700 feet south of the trenches.

Both CS-B3-EXW01 and CS-B3-EXW02 are equipped with SymCom PumpSaver 235P motor protection devices. The sensing devices monitor the amperage being used by the pump motor. After an initial calibration by the Operator, if the PumpSaver detects and undercurrent condition (user settable between 10 and 30 percent) or an overcurrent condition of more than 25 percent, the well pump is disabled for a specified time period. This protects the motor from running dry (undercurrent) or pumping too hard (overcurrent). The use of these devices requires that they be calibrated by the Operator using the methods outlined in the product brochure included in Appendix B.

Pump details, including operations and maintenance instructions and parts listing are also provided in Appendix B.

2.2.2 System Transfer Pump

An end suction centrifugal pump manufactured by Price® Pump Co. is installed to transfer water from the storage tank through the bioreactor injection manifold and ultimately into the trenches. The transfer pump cycles on/off automatically depending on the water level detected in the bioreactor and the water level in the storage tank. The pump is connected to the storage tank with a 2-inch suction hose and schedule 80 polyvinyl chloride (PVC) line and is bolted to the concrete pad constructed adjacent to the storage tank. A 1.5-inch line installed from the pump to the bag filter and then from the bag filter to the 3-inch header connects the pump to the distribution system. Since portions of the line between the storage tank and the distribution line are above ground, precautions are taken to prevent line damage during freezing weather conditions. Additional information about the pump is provided in Appendix C.



NOTES:

1. USE PVC FOR NEW PIPE EXCEPT MIN. FLOW RECIRCULATION PIPE. PAINT ALL PVC FOR UV RESISTANCE (BY OTHERS).
2. 12 VDC INTERPOSING RELAYS TO PUMP CONTROLS FOR LSL STOP COMMAND. INCLUDE 20-MINUTE TIME DELAY IN SCADA SYSTEM (OR BY OTHER MEANS) TO PREVENT WELL PUMP FROM EXCESSIVE CYCLING.
3. 16 GA. TSP CABLES IN SAME CONDUIT WITH RS-485 CABLE FOR LAL STOP COMMAND SIGNAL
4. SIX SEAMETRICS (OR EQUAL) MODEL# FT415M/IP81Y-60-1.5" BATTERY-POWERED TOTALIZING FLOW INDICATORS.
5. ADJUSTABLE BACKPRESSURE REGULATOR (40 TO 60 PSIG RANGE) FISHER SERIES 98H OR EQUAL.
6. CARBONAIR KRYSTAL KLEER INLINE BAG FILTER, MODEL 88-30 STYLE B (BY OTHERS).
7. SINGLE POINT FLOAT LEVEL SWITCH MAGNETROL T20-DB2A-AAQ OR EQUAL.
8. MULTIPOINT DISPLACER TYPE FLOAT LEVEL SWITCH MAGNETROL C10 SERIES OR EQUAL AND INSTALL IN APPROPRIATE SIZED STILLING WELL.
9. TWO SEAMETRICS (OR EQUAL) FLOWMETERS, ONE EACH OF THE FOLLOWING MODELS: FT415M/IP81Y-60-3" AND FT415M/IP81Y-60-2" BATTERY-POWERED TOTALIZING FLOW INDICATORS. (866) 542-9641.
10. 1/2" ISOLATION VALVES FOR FUTURE AMENDMENT ADDITION.
11. LABEL TANK WITH STENCIL OR PLACARD "NON-POTABLE WATER"
12. HORIZONTAL END-SUCTION CENTRIFUGAL, CLOSE-COUPLED PUMP P-B3 WITH A CAPACITY OF 120 GPM @ 145 FT.

ABBREVIATIONS

AI -- ANALOG INPUT
AO -- ANALOG OUTPUT
DI -- DIGITAL INPUT
DO -- DIGITAL OUTPUT
F -- FILTER
FC -- FLOW CONTROLLER
FFC -- FLOW RATIO CONTROLLER
FY -- FLOW RELAY
FIT -- FLOW INDICATING TRANSMITTER
FQI -- FLOW INDICATING RECORDER
HOA -- HAND-OFF-AUTO
HS -- HAND SWITCH
LSL -- LOW LEVEL SWITCH
LSM -- MIDDLE LEVEL SWITCH
LSL -- HIGH LEVEL SWITCH
LY -- LEVEL RELAY
LT -- LEVEL TRANSMITTTER
M -- MOTOR
PC -- PERSONAL COMPUTER
PSV -- PRESSURE SAFETY VALVE
PI -- PRESSURE INDICATOR (GAGE)
RTU -- REMOTE TERMINAL UNIT
XA -- FAIL TO RUN ALARM
XY -- RUN STATUS RELAY
YY -- SIGNAL STATUS RELAY

Figure 2.2 (Page 1 of 2)

Bioreactor Pumping System
Process Diagram

CSSA SWMU B3

PARSONS

747145.07 B3 P-10M-03-31-10.DWG

2.2.3 Storage Tank

A 5000-gallon former transport tanker was placed on the north side of the bioreactor and secured. The former transport tank serves as temporary storage of ground water from the extraction wells and is the on demand water supply to the bioreactor. Monthly inspections are conducted to examine the condition of the tank and any deficiencies are noted in the field logbook.

2.2.4 Bag Filter System

The water sprayer discharge openings in the bioreactor trenches are small (0.063-inch orifice for 1.7 gallons per minute (gpm) spray nozzles and a 0.094-inch orifice for 2.5 gpm spray nozzles); therefore, it is necessary to remove as much sediment from the injection water as possible to reduce the potential for clogging the spray heads. As shown in Figure 2.2, the bag filter equipment is installed downstream of the transfer pump before the distribution manifold. The bag filter equipment, manufactured by Krystil Klear Filtration® consists of a single chamber with a coarse mesh basket and a bag filter fitted inside the mesh basket. Bag filter replacement should follow the schedule recommended by the manufacturer, or more frequently as determined by use in the field. Additional information about the bag filter equipment is provided in Appendix D.

2.2.5 Eductor for Incorporation of Additive

An eductor system may be included down stream of the bag filter for future use if it is deemed necessary to inject additional additive into the bioreactor. A container of oil or similar microbial enhancement amendment can be placed near the eductor and an intake pipe will be placed in the container to inject the specified dosage. The additive is drawn into the flow system via the eductor as water passes through the piping which then uniformly distributes the additive with injected groundwater.

2.3 TRENCH AND INJECTION PIPING LAYOUT

The details associated with excavation trenches are provided in *"B-3 Bioreactor Construction Report"* (Parsons, February 2007). There are six trenches within SWMU B-3 potentially utilized for injection of extracted groundwater. The injection piping from the transfer piping is constructed of 1.5-inch HDPE piping with pressure type fittings. Brass injection nozzles are located in each trench with orifice openings of 0.063-inch for 1.7 gpm spray nozzles, and a 0.094-inch orifice for 2.5 gpm spray nozzles. Nozzle specifications are provided in Appendix E.

2.4 INSTRUMENTS AND CONTROL

The Bioreactor has been automated to operate with minimal supervision since it was first installed. In March 2010, the Bioreactor automation system was upgraded to provide additional controls and provide connectivity to the CSSA Supervisory Control and Data Acquisition (SCADA) system. The system uses four Remote Telemetry Units (RTU) to control the operation of the Bioreactor System. The RTUs are located at the GAC Shack, the Bioreactor Tank, and extraction wells CS-B3-EXW01 and CS-B3-

EXW02. The RTUs use wireless radios (900 MHz) to communicate commands, status, and data between the Bioreactor components. Ultimately, the data is wireless transferred (VHF radio) back to the SCADA system for viewing at the SCADA workstations located in Buildings 1, 36, 38, and 606. The Bioreactor can be operated from either the control screen located in the GAC Shack or SCADA workstation by an operator with the proper credentials.

The main RTU (903-1) is located inside the GAC Shack, and serves as the hub for the Bioreactor controls. It communicates directly with the slave RTUs at the Bioreactor Tank (RTU 903-2), CS-B3-EXW01 (RTU 903-3), and CS-B3-EXW02 (RTU 903-4) to control the operation of Bioreactor. In addition, the GAC Shack RTU communicates directly with SCADA system to transmit data and receive commands. The 903-1 RTU features touch screen controls to operate the Bioreactor system. The 903-1 RTU also controls the MW16 wells, the weather station and the GAC Shack treatment system.

Slave RTU 903-2 communicates directly with Master RTU 903-1, and controls the functions at the Storage Tank and Transfer Pump. The storage tank is equipped with high, medium, and low level switches which dictate when the wells are activated to fill the tank. The level switches in the tank also control the operation of the transfer pump to convey water from the tank to the trenches. The tank is also equipped with an ultrasonic level meter to monitor the level of water in the tank. The purpose of the ultrasonic meter is to provide an accurate reading of the water level in the tank and to serve as a redundant control in the event if the mechanical switches fail. RTU 903-2 also monitors the high level switch located in Trench 1 (Monitoring Sump 1-1). When the switch indicates that Trench 1 is full to capacity, the production and transfer of water to the trenches ceases until the water level recedes as indicated by the switch.

Slave RTU 903-3 communicates directly with Master RTU 903-1, and controls the operation of extraction well CS-B3-EXW01. This location is equipped with pump controls, pressure transducer, and a water flowmeter. Based on commands given by the Master RTU 903-1, this RTU operates the well pump and communicates the groundwater level and flowrate back to the Master RTU 903-1.

Slave RTU 903-4 communicates directly with Master RTU 903-1, and controls the operation of extraction well CS-B3-EXW02. This location is equipped with pump controls, pressure transducer, and a water flowmeter. Based on commands given by the Master RTU 903-1, this RTU operates the well pump and communicates the groundwater level and flowrate back to the Master RTU 903-1.

Each major component in the system is equipped with a motor control panel that feature **"HAND-OFF-AUTO"** (HOA) switches. For the system to be automated, it is necessary the individual motor control panels at wells CS-MW16-LGR, CS-MW16-CC, CS-B3-EXW01, CS-B3-EXW02, and the Transfer Pump are switched to **"AUTO"**. The control equipment for each of these pumps are located at their respective locations.

Product information for controllers and instruments are provided in Appendix F.

2.4.1 Pressure Gauges and Flow Meters

As required by TCEQ, the monitoring and reporting of flow volumes discharged into the subsurface is and must be reported in scheduled (semi-annual) UIC authorization reports. Instruments to monitor line pressures and volume of injection water are provided for the B-3 bioreactor System. Pressure gauges are located at various locations between the storage tank and the main header as shown in the design drawings in *"B-3 Bioreactor Construction Report"* (Parsons, February 2007.). In addition, flow meters are installed to provide injection volumes in each of the six trenches, as well as extraction volumes from the extraction wells. A K factor of 98.0 is used for flow meters installed on 1.5" lines, and a K factor of 25.4 is used for flow meters installed on 3" lines. The injection manifold containing the six trench injection lines are equipped with FT415 SeaMetrics flow meters to obtain discrete volumes injected into each trench.

Extraction wells CS-B3-EXW01 and CS-B3-EXW02 are equipped with an Endress+Hauser Prowirl 72F flowmeter with SCADA connectivity. Wells CS-MW16-LGR and CS-MS16–CC are equipped with GPI TM150 flowmeters that do not offer SCADA connectivity, and therefore require manual readings.

Product information for the various flow meters is provided in Appendix G**.**

2.4.2 Liquid Level Switches and Meters

Multiple sets of water level indicators are required for the automation system to operate effectively. One set is installed within the storage tank and is comprised of three Magnetrol, model C10, liquid level switches. These switches indicate high, medium, and low levels within the storage tank. Another liquid level meter (Endress+Hauser FMU40) is also installed to provide instantaneous level measurements from within the tank.

One model T20, Magnetrol liquid level switch is installed in Sump 1-1, to communicate the water level within the trench to the control system which, in turn, controls the transfer pump.

Each well is equipped with a pressure transducer to monitor the groundwater level in the borehole. Wells CS-MS16-LGR and CS-MS16–CC are both equipped with In-Situ LevelTroll 500 devices. Extraction wells CS-B3-EXW01 and CS-B3-EXW02 are equipped with an Endress+Hauser WaterPilot FMX167.

Product information for the liquid level switches and level transducers are provided in Appendix H.

2.4.3 SCADA Controls

The SCADA controls are made up of a myriad of components from various manufacturers. The individual components are consolidated into single enclosures to comprise an RTU. In general, the RTUs feature General Electric VersaMax Programmable Logic Controllers (PLC), Weidmuller 900 MHz radios, and Red Lion protocol converters.

Product information for the SCADA controls is provided in Appendix I.

SECTION 3
SYSTEM OPERATION AND MONITORING

3.1 SITE ACCESS

Camp Stanley is an active military installation. Security regulations mandate that the base be informed about any operation that are to take place inside the installation borders. Visitors and subcontractors need to contact the base 48 hours in advance with personal information to obtain entrance permit. Entry to the base occurs through the main gate situated in the south-west corner of the base, on FM 3351. Access related issues are coordinated through the CSSA Environmental Office.

3.2 NORMAL OPERATION PROCEDURES

During normal operation, the system will be pumping groundwater from four wells, CS-MW16-LGR, CS-MW16-CC, CS-B3-EXW01, and CS-B3-EXW02. The extracted groundwater is pumped into the storage tank which is then pumped through a bag filter to remove suspended solids that could cause fouling of the spray nozzles and ultimately into trenches filled with deciduous tree mulch/gravel mixture. The following sections outline the steps in the operation of the bioreactor. The intent of operating and controlling the groundwater recovery system (CS-MW16 and CS-B3-EXW wells) and the bioreactor transfer pumping system (5,000 gallon storage tank) is to maximize the throughput of water to the bioreactor.

3.2.1 Pumping water from Extraction Wells to Storage Tank

Submersible pumps in Wells CS-MW16-CC, CS-MW16-LGR, CS-B3-EXW01, and CS-B3-EXW02 are expected to pump water at a combined, sustainable flow rate ranging between 50 gpm and 200 gpm to the 5,000-gallon storage tank. The estimated ranges of flowrates are highly variable and are dependent upon the condition of the aquifer. A 70 gpm rate is an estimated average rate that may fluctuate depending on which wells are currently operational and aquifer groundwater availability. To ensure the pump will not run dry, each well is equipped with a pressure transducer that is set to signal deactivation of the pump if the water level gets too low during the drawdown phase. The pressure transducers also signal the pump when the water level is high enough for pumping to resume after the recovery phase. The different scenarios controlling the operation of the well pumps (water levels in recovery well and 5,000 gallon storage tank) are identified in Table 3.1.

In addition to the RTU controllers for the extraction wells, there is a separate RTU controller connected to level switches located in the 5,000-gallon storage tank. There is an HOA switch at each pump that should be kept in the automatic mode where both the well transducer and the storage tank level switches control the activation of the pump.

Table 3.1 Scenarios Dictating Activation of the Submersible Pumps at Groundwater Supply Wells

Water Level in Well	Water Level in 5000-gallon Storage Tank	Activation of All or One Extraction Well Based on Water Levels in Well and Storage Tank
1. During drawdown phase and above the low level turn-off depth.	Below the high level turn-off.	**<u>On</u>**
2. During drawdown phase and above the low level turn-off depth.	At the high level turn-off.	Off
3. During recovery phase and above the low level turn-off depth, but also below the high level restart.	Below the high level turn-off.	Off
4. During recovery phase and above the low level turnoff depth.	At the high level turn-off.	Off
5. High level is attained (*i.e.*, completion of recovery phase)	Below the high level turn-off.	**<u>On</u>**
6. High level is attained (*i.e.*, completion of recovery phase)	At the high level turn-off.	Off

Note: Controllers are switches that start or stop operations under certain conditions.

Generally, the controllers associated with the recovery wells will allow recovery well pumps to operate when there is sufficient water in the wells and sufficient volume capacity in the 5,000 gallon storage tank.

3.2.2 Pumping Water from Storage Tank to the Bioreactor

Extracted water stored in the storage tank is pumped to the bioreactor with an end-suction centrifugal transfer pump located between the storage tank and the bioreactor trench manifold. The operation of the transfer pump is controlled by level switches in the storage tank as well as a level switches in bioreactor trench sump 1-1 in Trench 1. This sump is located in the deepest bioreactor trench and should provide a representative water level elevation of the saturated conditions across the base of the bioreactor in Trenches 1 through 6. There is an HOA switch at the transfer pump that should be kept in the automatic mode so that both the sump water level switch and the storage tank level switches control the activation of the transfer pump. The different scenarios controlling the operation of the transfer pump are identified in Table 3.2.

Table 3.2 Scenarios Dictating Activation/Deactivation of the Transfer Pump

Water Level in Bioreactor Sump	**Water Level in 5000-Gallon Storage Tank**	**Response of Transfer Pump Based on Signal from a Sump or a Tank Level Switch**
1. Below the high level turn-off switch and water level rising in Trench 1 with transfer pump operating.	Above the low level turn-off.	Continues operating
2. Below the high level turn-off switch and water level rising in Trench 1 with transfer pump operating.	Water level reaches the low level turn-off.	Turns off
3. Below the high level turn-off switch and water level dropping in Trench 1 with transfer pump off.	Water level rising in tank and reaches the medium-level turn-on (switch set just below the high level switch).	Turns on
4. Pump has been off and water level recedes below the sump level switch.	Water level at high-level switch.	Turns on
5. Pump has been on and water rises to the sump level switch.	Water level above low-level turn-off switch.	Turns off

Generally, the controllers at the 5,000 gallon storage tank will operate the transfer pump when there is sufficient volume of water in the 5,000 gallon storage tank and sufficient volume capacity within trench 1.

3.3 SCADA OPERATION PROCEDURES

3.3.1 General Operating Principle

As of March 2010, the Bioreactor components have been incorporated into the SCADA system. Simply stated, the process logic to operate the supply/extraction wells and transfer pump are automated to deliver groundwater to the Bioreactor infiltration trenches. Safeguards have also been included to prevent the extraction wells and transfer pump from running dry, or preventing the Bioreactor Storage Tank and infiltration trenches from overflowing. All systems include “manual override” operation by setting the **“HAND-OFF-AUTO”** (HOA) switches at each motor control panel to **“HAND”**. For the system to operate under automatic control, the HOA switches at the following locations all need to be switched to the **“AUTO”** position:

- CS-MW16-LGR;
- CS-MW16-CC;

- CS-B3-EXW01;
- CS-B3-EXW02; and
- Bioreactor Transfer Pump.

Several criteria must be met for the wells to operate and provide water to the Bioreactor tank:

1. The water level in Trench 1 must be below the mechanical float trigger point installed in Sump 1-1. If the mechanical float in this well is active, the trenches are filled to capacity and therefore no more groundwater will be introduced until the trench water levels recede below the Sump 1-1 mechanical float setpoint.
2. The operation of the transfer pump and supply wells are interlocked with the capacity of the storage tank. The storage tank is equipped with a triple-point (**HIGH-MEDIUM-LOW**) mechanical float with redundant level measurement from an ultrasonic level meter.
    a. The **HIGH** float setpoint is used to turn off the supply wells (Table 3.1). If the water level in the tank is below the **HIGH** float setpoint and the trenches are not full (see item 1) the supply wells will run, assuming the groundwater level has recovered to its' minimum start depth.
    b. The **LOW** float setpoint is used to turn off the transfer pump. This setpoint prevents the transfer pump from running dry (Table 3.2).
    c. The **MEDIUM** float setpoint is used to turn on the transfer pump once the tank has been re-filled by the supply wells to above two-thirds capacity (Table 3.2). The transfer pump will continue to run until the water level decreases to the **LOW** float switch. The **MEDIUM** float setpoint is also used to re-start the wells once the tank level drops below two-thirds capacity.
3. Each well is equipped with a pressure transducer to monitor the water level within the borehole and prevents the well pump from running dry, and also dictates the amount of water level recovery that must occur before the well can be re-started. The **START** and **STOP** setpoints for each well is definable by the Operator via the SCADA interface. Even if the Bioreactor tank controls (**HIGH** float) are calling for the well operation, the well will not actuate if the recovery phase is not complete.

Bioreactor automation process is all controlled locally at the site from the GAC Shack RTU. As previously described, the GAC Shack RTU communicates wireless between the groundwater wells and the Bioreactor tank. Because the automation logic is housed locally at the site, the Bioreactor system does not depend upon interface between the SCADA Master PLC, Server, or Operator Workstations.

Assuming that the motor control HOA switches are in the **"AUTO"** position, the Bioreactor system can manipulated either locally at the GAC Shack, or remotely from any of the SCADA workstations (B1, B36, B38, or B606). The following are descriptions on how to interface with the Bioreactor SCADA Controls.

3.3.2 Local SCADA Control from GAC Shack

The operational programming functions reside in the local PLC located at the GAC Shack RTU. Most functions are internal and have been programmed by the SCADA integrator, Systems Control & Instrumentation (SCI, 210-661-9901). However, limited operational functionality resides with the Bioreactor Operator and includes:

- ***OFF/AUTO Pump Status*** (CS-MW16-LGR, CS-MW16-CC, CS-B3-EXW01, CS-B3-EXW02, and Transfer Pump);
- ***Water Level Operational Setpoints*** (CS-MW16-LGR, CS-MW16-CC, CS-B3-EXW01, and CS-B3-EXW02).

The GAC Shack RTU includes a touchscreen user interface to review the status of the Bioreactor system, and allow the Operator to make changes. Current Operators authorized to manipulate the RTU view screen are:

- ***SCI:*** Richard Fincke;
- ***Parsons:*** Julie Bouch, Samantha Elliott, Scott Pearson, Eric Tennyson.

To add additional users to the system, the user will need to contact Richard Fincke (210-661-9901) for technical support.

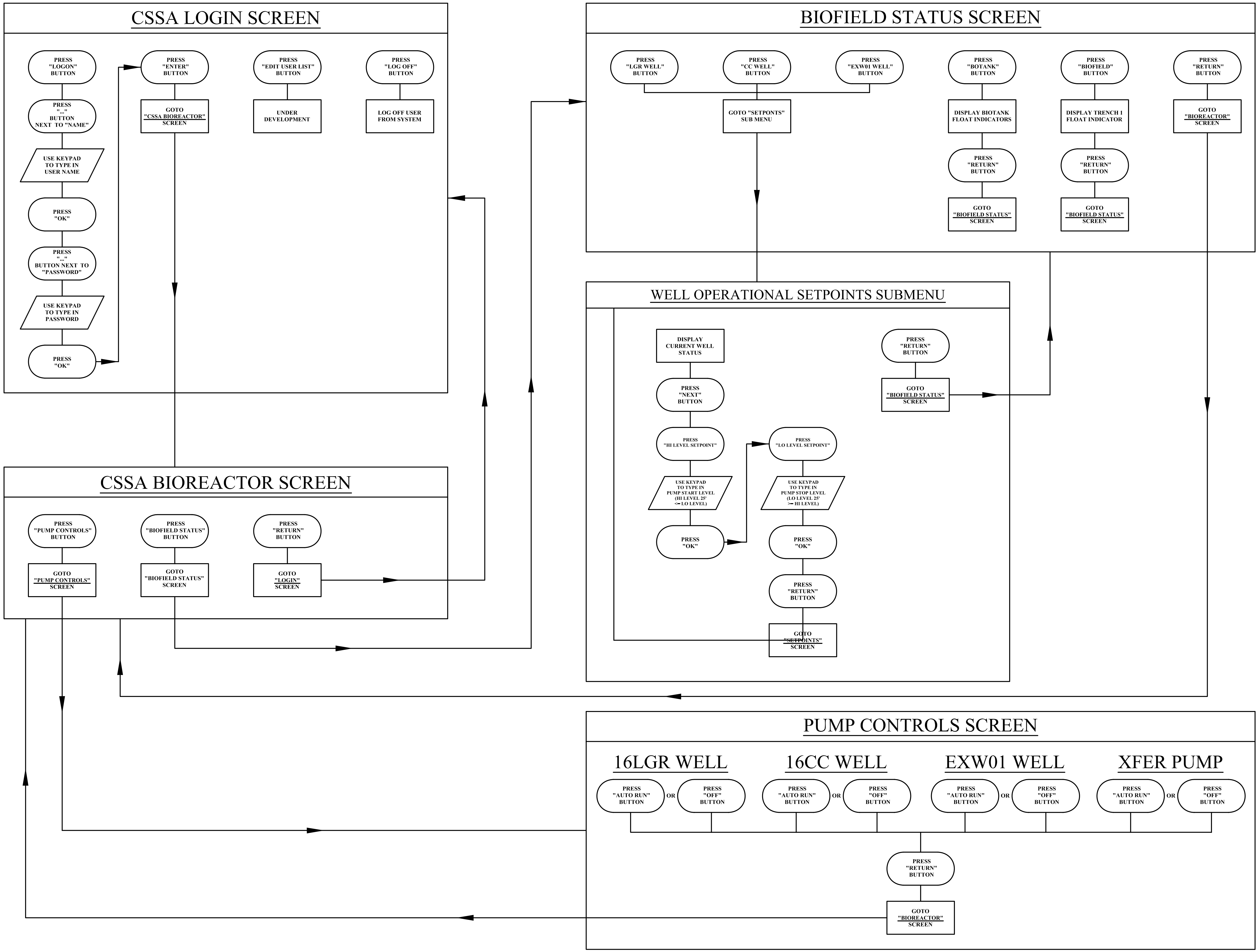
To operate the Bioreactor system in **"Automatic"** mode, the Operator will need to ensure that the HOA switches at the selected motor control panels (four groundwater supply wells and transfer pump) are set to **"AUTO"**. It is important to note that not all wells are required to operate Bioreactor in **"Automatic"** mode. As few as one groundwater extraction well could be run and allowed to gravity feed into the trenches if so desired. However, for this discussion all wells and transfer pump will be assumed to be needed for operation.

The GAC Shack RTU viewscreen provides a series of five menus to observe and control the function of the Bioreactor. Figure 3.1 depicts the process logic used to navigate through the menus. The menus are described below. Text within a box indicate that button can pressed on the viewscreen.

3.3.2.1 CSSA LOGIN SCREEN

The Login Screen allows the user gain access to the operational submenus. The initial login user name is typically their First Name with a password that is the last four digits of their cell phone number. The SCI system integrator will be responsible for setting up new users on the system.

Once a user has correctly submitted their user name and password, they have the option to continue to the ***CSSA BIOREACTOR SCREEN*** or ***LOG OFF***.


CSSA LOGIN SCREEN
PRESS "LOGON" BUTTON
PRESS "..." BUTTON NEXT TO "NAME"
USE KEYPAD TO TYPE IN USER NAME
PRESS "OK"
PRESS "..." BUTTON NEXT TO "PASSWORD"
USE KEYPAD TO TYPE IN PASSWORD
PRESS "OK"
PRESS "ENTER" BUTTON
GOTO "CSSA BIOREACTOR" SCREEN
PRESS "EDIT USER LIST" BUTTON
UNDER DEVELOPMENT
PRESS "LOG OFF" BUTTON
LOG OFF USER FROM SYSTEM
BIOFIELD STATUS SCREEN
PRESS "LGR WELL" BUTTON
PRESS "CC WELL" BUTTON
PRESS "EXW01 WELL" BUTTON
GOTO "SETPONTS" SUB MENU
PRESS "BOTANK" BUTTON
DISPLAY BIOTANK FLOAT INDICATORS
PRESS "RETURN" BUTTON
GOTO "BIOFIELD STATUS" SCREEN
PRESS "BIOFIELD" BUTTON
DISPLAY TRENCH 1 FLOAT INDICATOR
PRESS "RETURN" BUTTON
GOTO "BIOFIELD STATUS" SCREEN
PRESS "RETURN" BUTTON
GOTO "BIOREACTOR" SCREEN
WELL OPERATIONAL SETPOINTS SUBMENU
DISPLAY CURRENT WELL STATUS
PRESS "NEXT" BUTTON
PRESS "HI LEVEL SETPOINT"
USE KEYPAD TO TYPE IN PUMP START LEVEL (HI LEVEL 25' <= LO LEVEL)
PRESS "OK"
PRESS "LO LEVEL SETPOINT"
USE KEYPAD TO TYPE IN PUMP STOP LEVEL (LO LEVEL 25' >= HI LEVEL)
PRESS "OK"
PRESS "RETURN" BUTTON
GOTO "SETPOINTS" SCREEN
PRESS "RETURN" BUTTON
GOTO "BIOFIELD STATUS" SCREEN
CSSA BIOREACTOR SCREEN
PRESS "PUMP CONTROLS" BUTTON
GOTO "PUMP CONTROLS" SCREEN
PRESS "BIOFIELD STATUS" BUTTON
GOTO "BIOFIELD STATUS" SCREEN
PRESS "RETURN" BUTTON
GOTO "LOGIN" SCREEN
PUMP CONTROLS SCREEN
16LGR WELL
PRESS "AUTO RUN" BUTTON
OR
PRESS "OFF" BUTTON
16CC WELL
PRESS "AUTO RUN" BUTTON
OR
PRESS "OFF" BUTTON
EXW01 WELL
PRESS "AUTO RUN" BUTTON
OR
PRESS "OFF" BUTTON
XFER PUMP
PRESS "AUTO RUN" BUTTON
OR
PRESS "OFF" BUTTON
PRESS "RETURN" BUTTON
GOTO "BIOREACTOR" SCREEN

3.3.2.2 CSSA BIOREACTOR SCREEN

This is the top level menu on the viewscreen controls. This allows the user to either navigate to the ***PUMP CONTROLS SCREEN***, ***BIOFIELD STATUS SCREEN***, or press ***RETURN*** to redirect to the ***LOGIN SCREEN***.

3.3.2.3 PUMP CONTROLS SCREEN

This screen allows the user to toggle the status of each pump associated with the Bioreactor. Each pump may be selected to either be in the ***AUTO RUN*** position or ***OFF*** position. Pressing the toggle for each pump will result in a change of color on the viewscreen toggle switch. For each pump, the toggle position displayed in the color "**RED**" indicates the current setting for that pump. For the setting to have any effect, it is imperative that the **HOA** switch for that pump is in the "**AUTO"** position. The pumps will actuate when all the level setpoint criteria are met as outlined in Section 3.3.1.

Once the pump controls are in their desired state, press the ***RETURN*** button to redirect back to the ***CSSA BIOREACTOR SCREEN***.

3.3.2.4 BIOFIELD STATUS SCREEN

This viewscreen displays the status for each component of the Bioreactor system. From this screen the user can access the ***WELL OPERATIONAL SETPOINTS SUBMENU*** (described below), or view the status of ***BIOTANK*** or ***BIOFIELD*** (Sump 1-1) Float switches (HIGH or LOW level indicators). Press the ***RETURN*** button to redirect back to the ***CSSA BIOREACTOR SCREEN***.

3.3.2.5 WELL OPERATIONAL SETPOINTS SUBMENU

This submenu is accessed from the ***BIOFIELD STATUS SCREEN*** and is used to display the current status of each groundwater supply well. For each given well, the current water level and water temperature (if available) is displayed. If the well has attained its low level setpoint and is in the recovery phase, the "Low Level" indicator will illuminate in the color "**RED**". Pressing the ***NEXT*** button will give the user access to change the ***START*** and ***STOP*** point for a given well. These user inputs are important because they can affect the operation of the pump. The numbers inputted here represent a specific groundwater level in that well as measured from Below Top of Casing (BTOC).

- ***STOP***: The corresponding water level in the well at which the well pump will be turned off. It is imperative that the ***STOP*** water level be at a depth above the well pump to prevent it from running dry. These depths need to be less than the following:
    - CS-MW16-LGR ***STOP*** < 290 feet BTOC;
    - CS-MW16-CC ***STOP*** < 390 feet BTOC;
    - CS-B3-EXW01 ***STOP*** < 330 feet BTOC;
    - CS-B3-EXW02 ***STOP*** < TBD feet BTOC;

- ***START*** : The corresponding water level in the well at which the well pump will turn on. It is imperative that the ***START*** water level be at a depth at least 25 feet less than the ***STOP*** position and at no time should the ***START*** depth be greater than the ***STOP*** depth. The Operator should have working knowledge of the current static water level of the aquifers. If a ***START*** level is set at a depth less than the static water level, the pump will never run. In general, these depths need to follow the general guidelines:
  - ***START*** must be greater than STATIC Water Level (measured by Operator)
  - ***START*** must be at least 25 feet less than the ***STOP*** value;
  - STATIC < ***START*** < (***STOP***-25);
  - CS-MW16-LGR Example:
    - Measured Static Water Level = 235 feet BTOC
    - ***START*** = 265 feet BTOC
    - ***STOP*** = 290 feet BTOC

Once the operational setpoints are established for each well, the Operator can press the Return button to redirect back to the ***CSSA BIOFIELD STATUS SCREEN***.

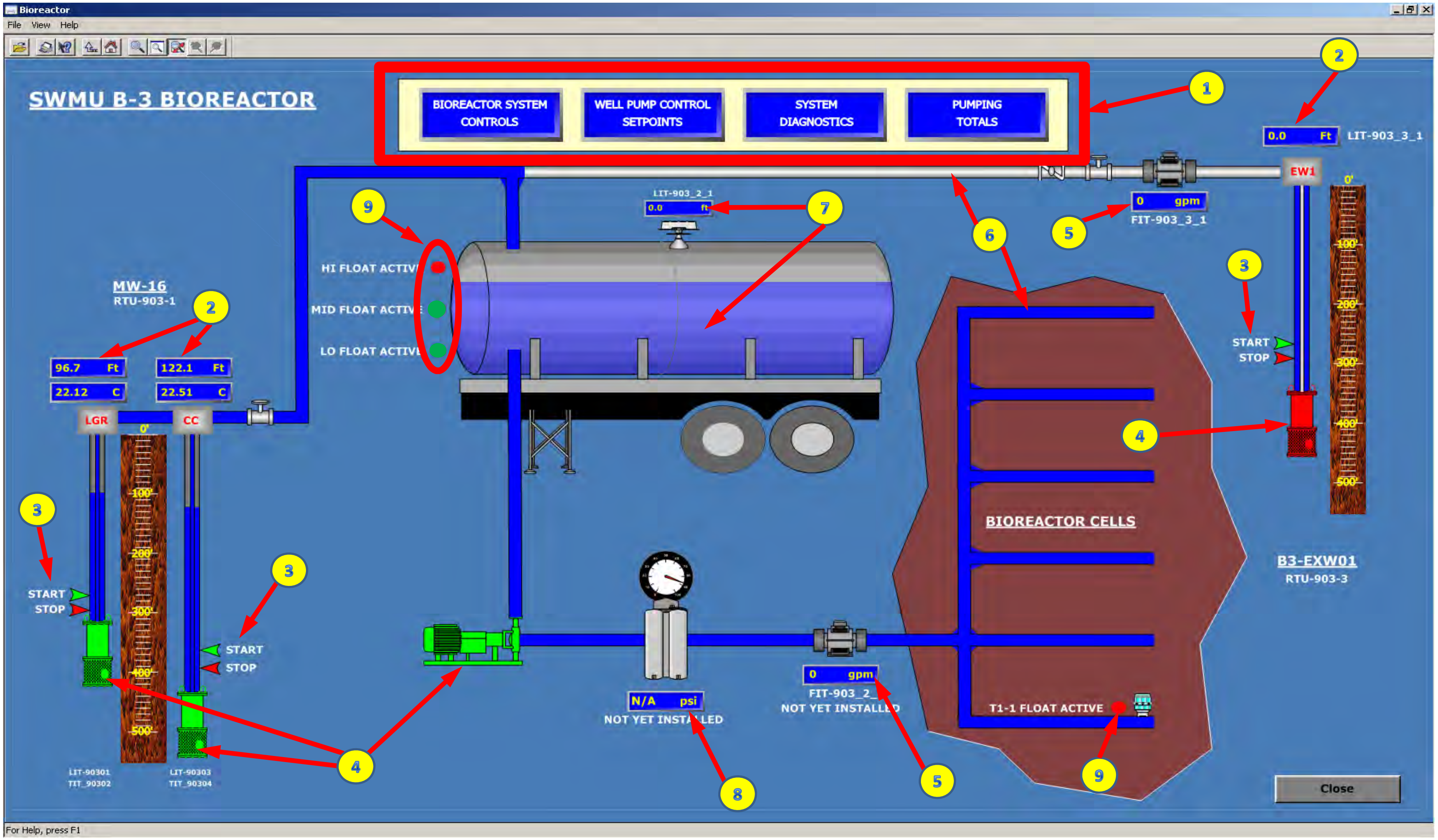
3.3.3 Remote SCADA Control from Workstations

The Operator can also display the Bioreactor status and access controls from any of the SCADA workstations at CSSA (B1, B36, B38, and B606). The Operator must have login and password credentials already established by the SCADA integrator (SCI). The BIOREACTOR screen is accessed from the left column of the ***MAIN MENU***. Real-time data from the Bioreactor is updated on the workstation approximately every three minutes due to the polling cycle of the VHF radio communications. Feedback on commands issued to the Bioreactor from a workstation may take as long as five minutes to indicate on the workstation screen because of the established VHF radio polling cycle.

3.3.3.1 MAIN BIOREACTOR SCREEN

Figure 3.2 is a screen capture from the SCADA workstation. The ***BIOREACTOR*** screen displays the physical layout of the current wellfield, storage tank, transfer pump, and infiltration trenches. The ***BIOREACTOR*** screen provides access to control menus as well as graphically displaying information about the system. Key features of the ***BIOREACTOR*** screen are enumerated on Figure 3.2 as listed below:

Figure 3.2
Bioreactor Monitoring Screen on CSSA SCADA



1. Links to related Bioreactor Screens
2. Moniitoring Well Water Level and/or Water Temperature
3. Well Pump Start/Stop Level Indicators
4. Pump Status (Green = Running, Red = Stop)
5. Water Flow Rate Indicator
6. Water Transmission Through Pipe (Blue = Water Flowing, White = No Water Flow)
7. Storage Tank Status (Measured Water Column Height and Visual Indicator)
8. Bag Filter Differential Pressure Meter (Optional Item not yet Installed)
9. Float Switch Status (Green = Water Level >Switch Depth, Red = Water Level < Swtich Depth)

1 ***Submenu Bar:*** Each button navigates to one of four Submenus.

2 ***Well Transducer***: Provides water level and/or water temperature from each Bioreactor supply well. The current water level of the well is graphically shown in the wellbore.

3 ***START/STOP Indicators***: Displays the current ***START*** and ***STOP*** setpoints for each well. The water level in the borehole is graphically approximate to the currently established ***START/STOP*** setpoints.

4 ***Pump Status Indicator***: When a pump is running it is displayed in the color "**GREEN**". When a pump is off it is displayed in the color "**RED**".

5 ***Water Flowmeter***: The current flowrate is displayed from CS-B3-EXW01. In the future, other wells and the Transfer Pump will have a similar functionality.

6 ***Water Flow Indication***: When water is being transmitted through pipe segments in the system, empty pipes turn the color "**BLUE**" to indicate water flow.

7 ***Storage Tank***: The status is of water storage tank is displayed. The height of the water in the tank as measured by the ultrasonic level meter is displayed at the top of the tank. Additionally, the tank is graphically filled in the color "**BLUE**" to a level proportional to the current level of the tanks capacity.

8 ***Differential Pressure***: In the future, the differential pressure across the Bag Filtration Unit will be displayed.

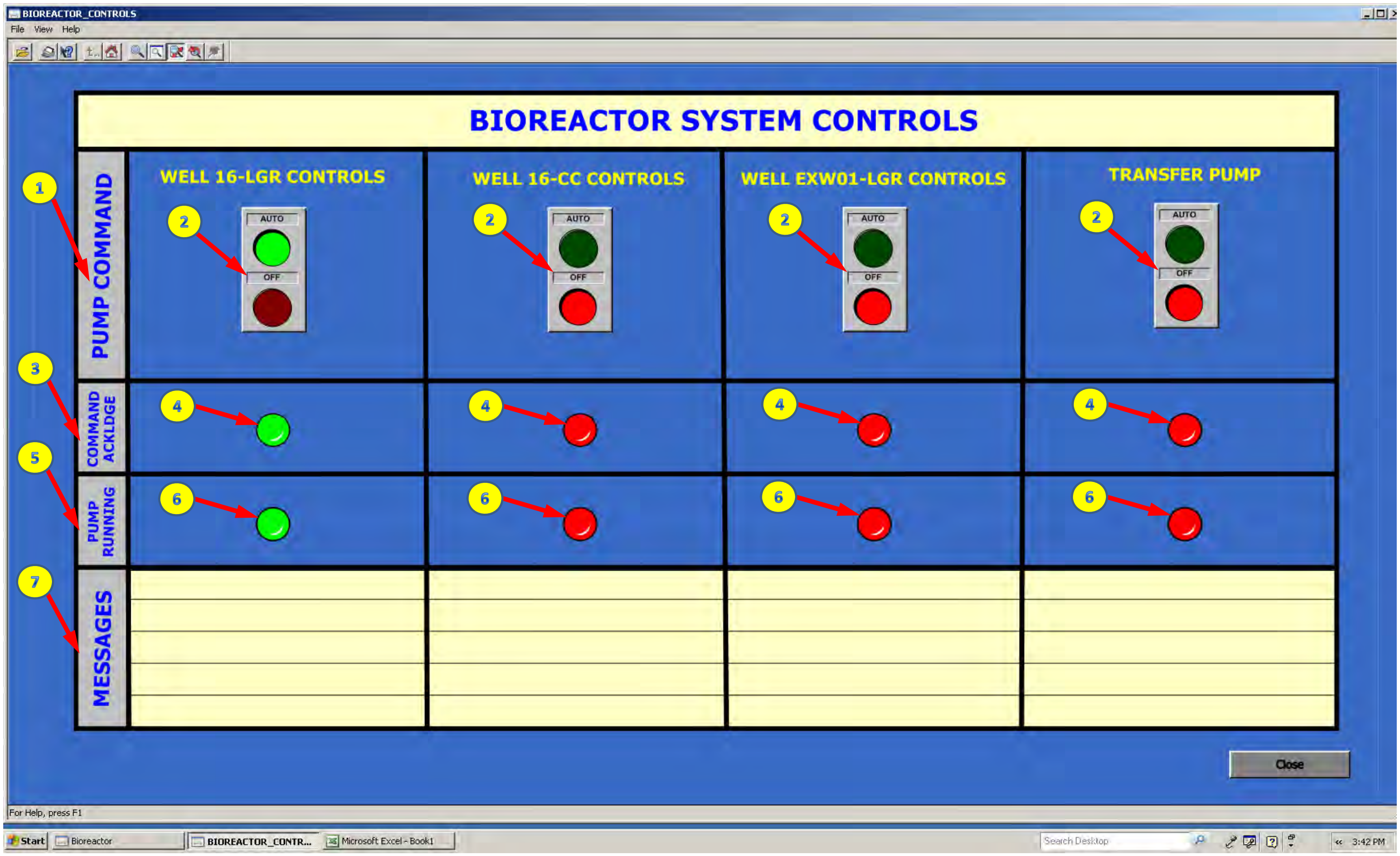
9 ***Float Switch Indicators***: The status of the mechanical float meters in the storage tank and Sump 1-1 are graphically displayed. If a switch is activated by the current level of the water, it is displayed in the color "**GREEN**". If the switch is not activated by the water level, the color is "**RED**".

Pressing the CLOSE button will return you to the Bioreactor Main Screen.

3.3.3.2 BIOREACTOR SYSTEM CONTROLS SCREEN

This interactive screen is accessed from the Submenu bar, and allows the Operator to control the operation of the water supply pumps and transfer pump (Figure 3.3). The functionality of this screen is very similar to the ***PUMP CONTROLS SCREEN*** (Section 3.3.2.3) at the GAC Shack RTU viewscreen. For each well, the control, status, and available messages are presented on this screen. Once again, for these functions to take effect, it is imperative that the **HOA** switch at each motor control panel is set to **"AUTO"**. Key features of the ***BIOREACTOR SYSTEM CONTROLS*** screen are enumerated on Figure 3.3 as listed below:

Figure 3.3
Bioreactor System Controls Screen on CSSA SCADA



1 Pump Control (Auto or Off)

2 Pump Control Toggles (Green = Auto, Red = Off)

3 Command Acknowledge Indicators (Green = RTU under Run Command, Red = RTU under Stop Con

4 Command Acknowledge Indicators (Green = RTU under Run Command, Red = RTU under Stop Con

5 Pump Status

6 Pump Running Indicator (Green = Runnning, Red = Stop)

7 System Messages and Alarms

1 ***Pump Command***: This row displays the current pump command status for each well or transfer pump.

2 ***AUTO/OFF Toggle Switch***: This screen allows the user to toggle the status of each pump associated with the Bioreactor. Each pump may be selected to either be in the **"AUTO"** position (indicated in the color "**GREEN**" or "**OFF**" position (indicated in the color "**RED**"). Using the mouse to the toggle the switch for each pump will result in a change of color. For the setting to have any effect, it is imperative that the **HOA** switch for that pump is in the "**AUTO"** position. The pumps will actuate when all the level setpoint criteria are met as outlined in Section 3.3.1.

3 ***Command Acknowledge***: This row confirms that the Pump Command has been received by the GAC Shack RTU. If a pump is toggled to **"AUTO"**, a receipt of this command result in a change of color from "**RED**" to "**GREEN**", indicating that system is ready to pump if the float switch criteria given in section 3.3.1 is met.

4 ***Command Acknowledge Indicators***: These indicators will illuminate "**GREEN**" when a pump is switched to "**AUTO**". The indicators remain "**RED**" if the GAC Shack RTU has not received a command to switch the pumps to "**AUTO**". If a pump is switched to "**AUTO**" and the indicator does not turn "**GREEN**" within six minutes, this indicates that there is a problem at the GAC Shack RTU.

5 ***Pump Running***: This row of indicators display whether a pump is currently running.

6 ***Pump Running Indicators***: If the indicator is the color "**RED**", the pump is not running. If the indicator is the color "**GREEN**" the pump is the color "**GREEN**". If the Pump Running Indicator is "**RED**" and pump is set to **"AUTO"** and Command Acknowledged Indicator is "**GREEN**", this means that either the well has achieved at ***STOP*** water level, or the Bioreactor Tank is full.

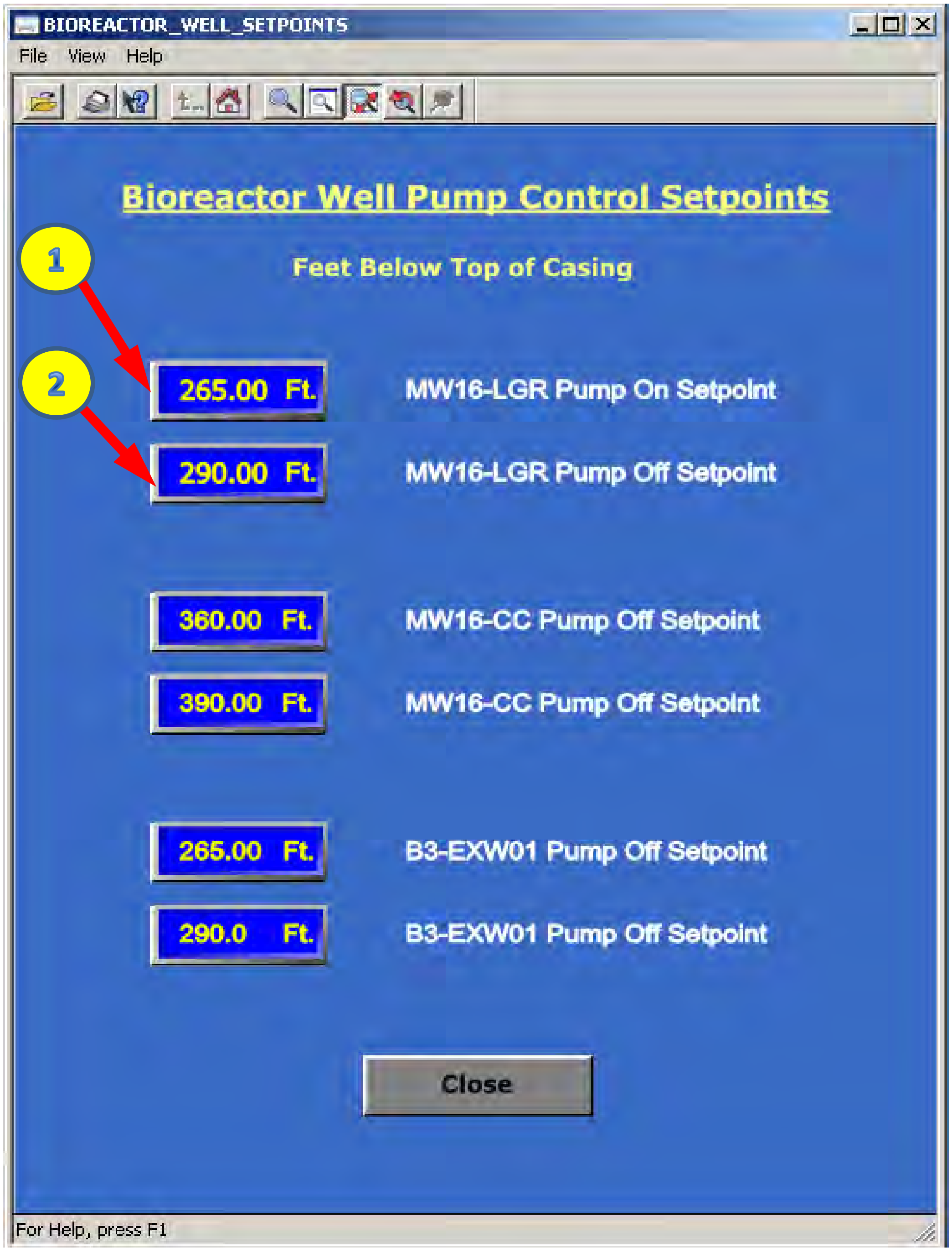
7 ***Messages***: Status messages for each pump will display in this section. Messages may include "Low Level", "Loss of Power", or Pump Fail".

Pressing the CLOSE button will return you to the Bioreactor Main Screen.

3.3.3.3 WELL PUMP CONTROL SETPOINTS SCREEN

This interactive screen is accessed from the Submenu bar, and allows the Operator to transmit operational well setpoints for the water supply wells (Figure 3.9). The functionality of this screen is very similar to the ***WELL OPERATIONAL SETPOINTS SUBMENU*** at the GAC Shack RTU viewscreen. From this screen the Operator can program the ***START/STOP*** water levels for each water supply well:

Figure 3.4
Well Pump Control Setpoints Screen on CSSA SCADA



1 Required Water Level in Well to Start Pump (Feet Below Top of Casing)

2 Low Water Level Cut-off to Stop Pump (Feet Below Top of Casing)

1 $\boxed{\textit{\textbf{START}}}$: The corresponding water level in the well at which the well pump will turn on. It is imperative that the ***START*** water level be at a depth at least 25 less than the ***STOP*** position, and at no time should the ***START*** depth be greater than the ***STOP*** depth. The Operator should have working knowledge of the current static water level of the aquifers. If a ***START*** level is set at a depth less than the static water level, the pump will never run. In general, these depths need to follow the general guidelines:

a. ***START*** must be greater than STATIC Water Level (measured by Operator)

b. ***START*** must be at least 25 less than the ***STOP*** value;

c. STATIC < ***START*** < (***STOP***-25);

d. CS-MW16-LGR Example:

i. Measured Static Water Level = 235 feet BTOC

ii. ***START*** = 265 feet BTOC

iii. ***STOP*** = 290 feet BTOC

2 ***STOP***: The corresponding water level in the well at which the well pump will be turned off. It is imperative that the ***STOP*** water level be at a depth above the well pump to prevent it from running dry. These depths need to be less than the following:

a. CS-MW16-LGR ***STOP*** < 290 feet BTOC;

b. CS-MW16-CC ***STOP*** < 390 feet BTOC;

c. CS-B3-EXW01 ***STOP*** < 330 feet BTOC;

d. CS- B3-EXW02 ***STOP*** < TBD feet BTOC;

Pressing the $\boxed{\text{CLOSE}}$ button will return you to the Bioreactor Main Screen.

3.3.3.4 SYSTEM DIAGNOSITCS SCREEN

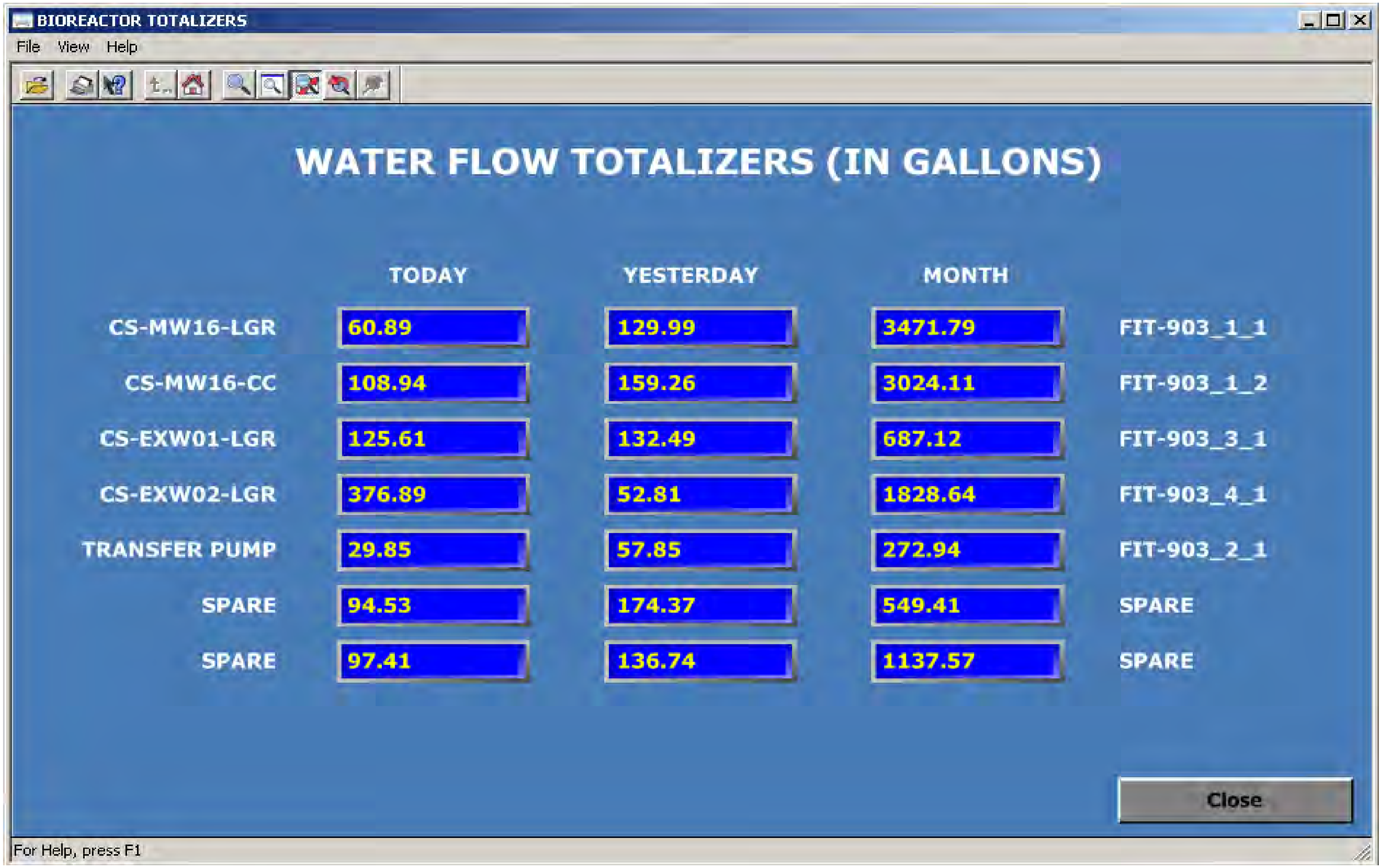
This screen is currently under development. Information useful for the SCADA integrator will be displayed here.

3.3.3.5 PUMPING TOTALS SCREEN

This static screen is accessed from the Submenu bar, and allows the Operator to view statistics about the volume of water pumped at the Bioreactor system (Figure 3.5). The screen displays the current (TODAY), YESTERDAY, and MONTH totals pumped at the Bioreactor. The screen is configured to display multiple flowmeter statistics planned for future expansions. However, currently pumping volumes from CS-B3-EXW01 is currently available.

Pressing the $\boxed{\text{CLOSE}}$ button will return you to the Bioreactor Main Screen.

Figure 3.5
Bioreactor Flowmeter Totals on CSSA SCADA



3.4 LOCKOUT/TAGOUT

When the system is being shut down to perform any electrical or piping service it is necessary to follow the lockout/tagout procedure to prevent potential injuries, prevent exposure to contaminated materials, and reduce the potential for spillage of contaminated groundwater. Maintenance and repair activities requiring lockout/tagout procedures include work on the RTUs, submersible pumps, pressure transducers, storage tank, and bag filter system. Each time a lockout/tagout becomes necessary, the authorized person shall log the activity to be performed, the name of the person carrying out the activity, the date, and the time in the Logout/Tagout Log form included in Appendix J; after completing the maintenance activity the authorized person shall proceed to file the filled out tag used during the activities in the Lockout/Tagout folder, to be preserved as a safety record.

Phase I – Locking, Blocking or Releasing Energy:

- The authorized person notifies all affected people on site that a lockout/tagout procedure is ready to begin.
- The authorized person will turn off the power to the system and lockout the power switch.
- The authorized person releases or restrains all stored energy (*i.e.* venting residual pressure in the filter, or closing the valve upstream of the section of piping affected to isolate it before performing the necessary work)
- All locks and tags are checked for defects. If any are found, the lock or tag is discarded and replaced.
- The authorized person places a personalized lock or tag on the energy isolating device.
- The authorized person tries to start the system to ensure that it has been isolated from its energy source. The system is then de-energized again after this test. If the work to be performed is of an electrical nature, it will be necessary to test the affected components with a volt-meter to ensure that they are not energized.
- The system is now ready for service or maintenance.

Phase II – Returning the System to Normal Operation:

- The authorized person checks the system to be certain no tools have been left behind.
- All safety guards are checked to be certain that they have been replaced properly, if applicable.
- All affected people on site are notified that the system is about to go back into normal operation.
- The authorized person performs a secondary check of the area to ensure that no one is exposed to danger.

- ♦ The authorized person removes the lock and/or tag from the energy isolating device and restores energy to the system.

3.5 SYSTEM MONITORING

System operation monitoring will be performed to measure the effectiveness of the groundwater recovery and treatment processes and to assess performance and maintenance requirements for the system components. Periodic monitoring and sampling will also be implemented to assess the effectiveness of the bioreactor to treat the contaminants in the groundwater being pumped to the trench, and treat the contaminants present in the materials surrounding and underlying the excavation trenches.

Data to be collected for compliance with UIC requirements of the groundwater recovery and bioreactor operations include:

- water elevation measurements;
- contaminant concentrations which include:
  - ✓ Volatile Organic Compounds (VOCs-PCE, TCE, *cis*-1,2-DCE, *trans*-1-2 DCE, VC, and ethene),
  - ✓ Total Dissolve Solids (TDS),
  - ✓ and pH;
- injection volumes; and
- system pressure readings.

Performance monitoring measurements include:

- Dissolved Organic Carbon (DOC),
- Methane, Ethane, Ethene,
- Dissolved Hydrogen,
- Temp, Specific Conductivity,
- Oxidation Reduction Potential (ORP),
- Dissolved Oxygen (DO),
- Dehalococcides populations, including vcrA reductase, TCE reductase, BAV1,
- Total Organic Carbon (TOC),
- Carbon Dioxide,
- Alkalinity,
- Methane, Ethane and Ethene,
- Sulfate, Chloride, Ferrous Iron, Manganese,
- Total Metals, and
- rainfall totals.

The methods for collecting the data listed above and the end use of the data are described in the following sections.

3.5.1 Monitoring of Treatment within the Bioreactor

To evaluate the contaminant concentrations of bioreactor injection water (the water in the storage tank), a water sample is collected from a sampling port located prior to the injection nozzles at the trench injection line manifold. In addition, water samples are collected from the bioreactor sumps monthly in accordance with this O&M plan's monitoring schedule. Water levels and water quality measurements will be recorded weekly for all sufficiently saturated (greater than 1 foot saturated thickness) bioreactor sumps. Transducers may be installed in at least one sump per trench to measure simultaneous fluctuating water levels in the bioreactor. A summary of the monitoring (both performance and regulatory monitoring) and sample collection schedule is presented in Table 3.3. Additional details such as proper sample collection methods are provided in the CSSA Sampling and Analysis Plan and associated amendments (Parsons, December 2005) which include additional details associated with the test methods such as container type(s) and preservative(s).

3.5.2 Monitoring the Treatment of Zones Underlying the Bioreactor

Four Multi-Port Monitoring Wells (MPMW) or Westbay® wells were installed around B-3 to monitor the groundwater infiltrating through the underlying formations at SWMU B-3. The multi-port wells allow discrete samples from distinct hydrostratigraphic zones be collected from a single location. A representative sample can be collected from up to nine, discrete monitoring zones. These zones are sealed at the top and bottom with permanent well packers to evaluate migration patterns of treated groundwater moving away from the bioreactor to the underlying aquifer. Locations of the four MPMW wells are shown in Figure 3.6. A summary of the discrete intervals and the sample port depths relative to the top of casing (TOC) is provided in Table 3.4. A cross section (Figure 3.7) depicts the location of each sample port relative to elevation and within the subsurface. Water levels are determined in each zone by lowering a pressure probe that locks into the selected zone sample port. The probe is connected to a data logger at the surface which records zone pressures. Pressures are converted to water levels via the following formula:

$$Water\ Level = \frac{D-(P-A)}{0.4335}$$

Where D = depth of sample port below reference point
P = pressure of zone
A = Atm pressure at well head

A summary of the monitoring and samples to be collected is presented in Table 3.6. Appendix J provides a copy of the Westbay® monitoring well operations and repair manual.

3.5.3 Monitoring of Surrounding Monitor Wells

In addition to monitoring water levels and collecting samples from the MPMWs, samples are collected from four monitoring wells and all intervals of the four MPMWs that surround the site on a quarterly basis. The locations of these four wells and the MPMW's are shown in Figure 3.8. Additional piezometers set in the Upper Glen Rose formation will be installed for monitoring bioreactor influence in the shallow portions of the vadose zone. One piezometer, CS-MW27 is installed, and another eight piezometers are scheduled for installation in May, 2010. Water levels will be collected on a weekly basis. Figure 3.9 shows a topographical survey of the bioreactor and the trench sump locations. The list of monitoring wells is identified in Table 3.5.

3.5.4 Monitoring the Upper Glen Rose

Nine shallow (less than 45 foot) piezometers installed in the Upper Glen Rose (UGR) formation around the bioreactor provide sample locations to monitor the lateral influence from bioreactor activities. Water samples from these piezometers will be collected monthly for the first six months following installation. Sample frequency will be reevaluated after the initial six month period. Field parameter information will be collected during the monthly sampling events to determine if the reaction zone created by the bioreactor is expanding, contracting, or remaining stable. The piezometers are labeled B3-MW-26-UGR through B3-MW-34-UGR.

Table 3.3
Class V Aquifer Remediation Injection Well Permit #5X2600431
Sampling and Monitoring Schedule for the B3 Bioreactor Pilot Study
CSSA – Boerne, Texas

	Sampling or Monitoring Location	Parameter(s)	Sampling Frequency	Reporting Frequency
Original Regulatory Req.	Flow meters (6) for each trench on downstream side of the header and one flow meter on the upstream side of the header	Injection volume	Twice per month (record)	Monthly
	Pressure gages (4) on both sides of the transfer pump, at the bag filter and on the header	Pressure on the transfer pump	Twice per month (record)	Monthly
	Sampling port (1) on the upstream side of the distribution header	- pH (field) and TDS (lab) - VOCs (b)	Twice per month	Monthly
	Trench sumps (5) (b)	- pH (field) and TDS (lab) - VOCs (b)	Monthly	Quarterly
	MPMWs (4) (b)	- TDS (lab) - VOCs (b)	Quarterly	Quarterly
Current Regulatory Req.	Flow meters (6) for each trench on downstream side of the header and one flow meter on the upstream side of the header	Injection volume	Monthly (record)	Semi-Annual
	Pressure gages (4) on both sides of the transfer pump, at the bag filter and on the header	Pressure on the transfer pump	Monthly (record)	Semi-Annual
	Sampling port (1) on the upstream side of the distribution header	- pH (field) and TDS (lab) - VOCs (a)	Monthly	Semi-Annual
	Trench sumps (5) (b)	- pH (field) and TDS (lab) - VOCs (a)	Quarterly	Semi-Annual
	MPMWs (4) (b)	- pH (field) and TDS (lab) - VOCs (a)	Quarterly	Semi-Annual

Notes:

(a) Standard list of VOCs tested at CSSA
(b) Bioreactor trench sumps (BTS) include: Trench 1 – 1-1, 1-2 and 1-3; Trench 2 – 2-1 and 2-2; Trench 3 – 3-1 and 3-2; Trench 4 – 4-1; Trench 5 – 5-1 and 5-2; Trench 6 – 6-1 and 6-2. Samples are collected from all trench sumps which includes the injection of CS-MW16 groundwater.
Multi-port monitoring wells (MPMW) include: CS-WB05 (9 sampling ports), CS-WB06 (6 sampling ports), CS-WB07 (6 sampling ports) and CS-WB08 (6 sampling ports).
MPMW will be sampled quarterly and include only Zone LGR-03B for each MPMW.
Surrounding monitor wells includes: CS-MW1-LGR, CS-B3-MW01-LGR, CS-D-LGR, CS-MW16-LGR and CS-MW16-CC.

Table 3.4
List of Multi-Port Monitoring Wells

Well	Elevation (a) (Top of Casing)	Zone	Interval (Ft. BTOC)	Elevation (Ft MSL)		Sampling Port (b) (Ft BTOC)	
				Top of Interval	Base of Interval	Primary	Secondary
CS-WB05	1242.93	LGR-01	32 - 109	1210.93	1133.93	99	
		LGR-02	114 - 192	1128.93	1050.93	182	
		LGR-03	197 - 272	1045.93	970.93	216	262
		LGR-04A	277 - 286	965.93	956.93	277	
		LGR-04B	291 - 342	951.93	900.93	329	
		BS-01	347 - 390	895.93	852.93	362	
		CC-01	395 - 444	847.93	798.93	432	
		CC-02	449 - 482	793.93	760.93	460	
CS-WB06	1235.20	UGR-01	12 - 30	1223.20	1205.20	20	
		LGR-01	35 - 103	1200.20	1132.20	93	
		LGR-02	108 - 184	1127.20	1051.20	174	
		LGR-03	189 - 270	1046.20	965.20	207	260
		LGR-04	275 - 335.5	960.20	899.70	320	
CS-WB07	1235.13	UGR-01	9 - 24	1226.13	1211.13	14	
		LGR-01	29 - 100	1206.13	1135.13	90	
		LGR-02	105 -185	1130.13	1050.13	175	
		LGR-03	190 - 267	1045.13	968.13	208	257
		LGR-04	272 - 336.75	963.13	898.38	318	
CS-WB08	1253.26	UGR-01	12 - 48	1241.26	1205.26	38	
		LGR-01	53 - 125	1200.26	1128.26	115	
		LGR-02	130 - 203	1123.26	1050.26	193	
		LGR-03	208 - 283	1045.26	970.26	228	273
		LGR-04	288 - 357.5	965.26	895.76	341	

Notes:
BTOC - Below Top of Casing
(a) Top of Casing (TOC) elevations surveyed by Baker and Associates located in San Antonio, Texas.
(b) For each well there is one zone where both the upper (primary) and lower (secondary) portions are monitored.

Table 3.5
List of Surrounding Monitoring Wells

Well ID	TOC Elev. (Ft MSL)	Screen Interval Depth below TOC (Ft bgs)	Pump Depth (Ft bgs)	Pump Elevation (Ft MSL)	Depth to LGR/BS Contact (Ft bgs)	Planned Performance Monitoring Frequency
CS-MW1-LGR	1220.73	288 – 313	300	920.73	319	Baseline + Quarterly
CS-MW2-LGR	1237.08	318 – 343	330	907.08	347	Baseline + Quarterly
CS-MW-D-LGR	1257.27	296 – 321	283	974.27		Baseline + Quarterly
CS-B3-MW01	1242.84	277 - 287	284	958.84		Baseline + Quarterly

bgs = below ground surface
MSL = mean sea level

Table 3.6
B-3 O&M Monitoring Schedule

	Recurrence Interval	Activity
Performance Requirement	Weekly	Trench Sumps and MPMWs Water Level Measurements
	Monthly	Trench Sumps, Uppermost Interval (LGR 03B) of WB-05 thru WB-08 Performance Sampling (metals only)
	Quarterly	Trench Sumps, MPMWs, and Surrounding Wells Performance Sampling
Regulatory Requirement	Monthly	Headers and Flow Meter Measurements
	Monthly	Transfer Pump and Filter Pressure Readings
	Monthly	Sampling Port Monitoring (pH, TDS, VOCs)
	Monthly	Trench Sumps Sampling (ph, TDS, VOCs)
	Monthly	Uppermost Saturated Interval (LGR 03B) MPMWs Sampling (TDS, VOCs)

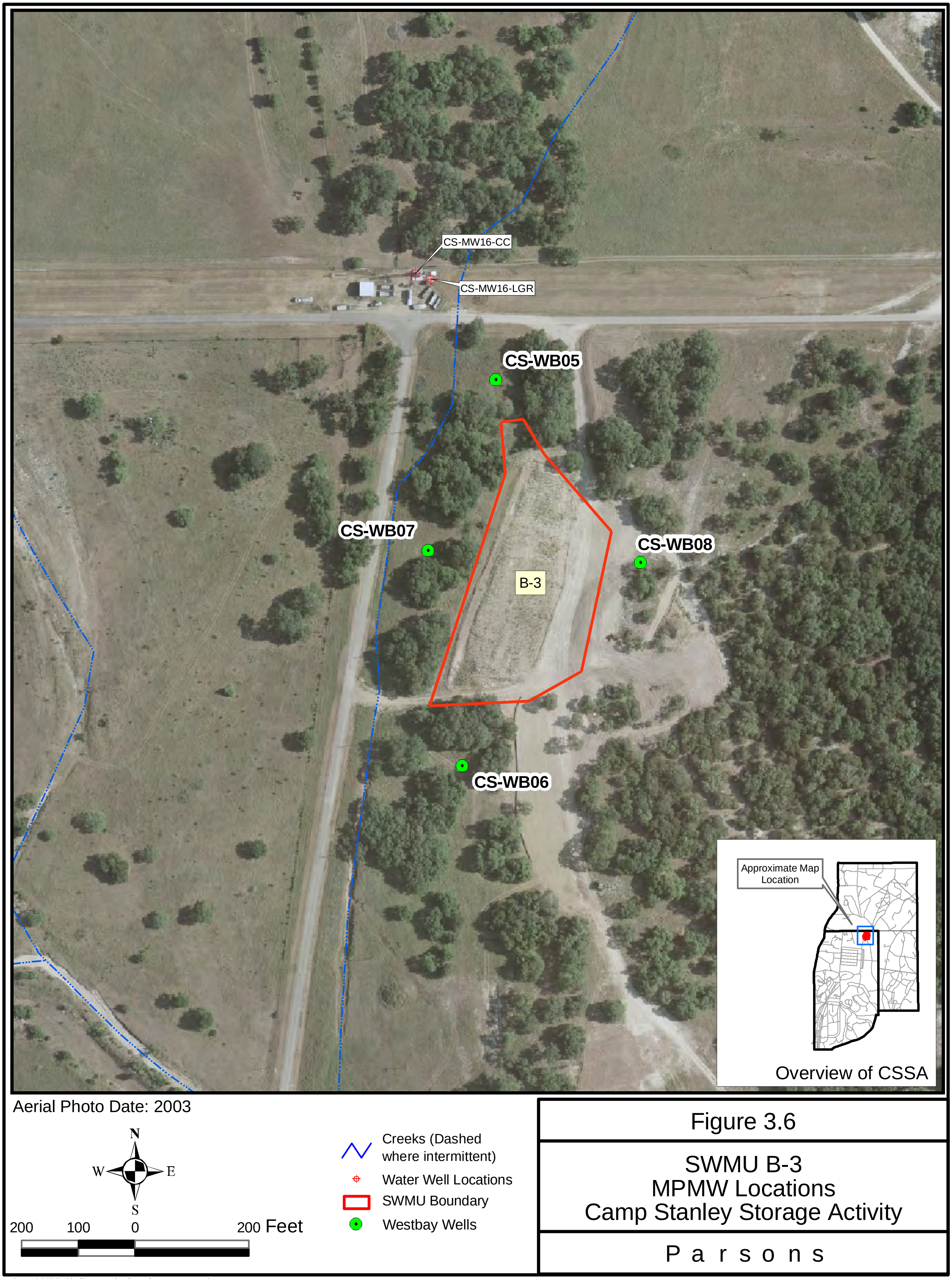


Figure 3.6

SWMU B-3
MPMW Locations
Camp Stanley Storage Activity

P a r s o n s

J:\744223\GIS\pilot_study_location_map.mxd

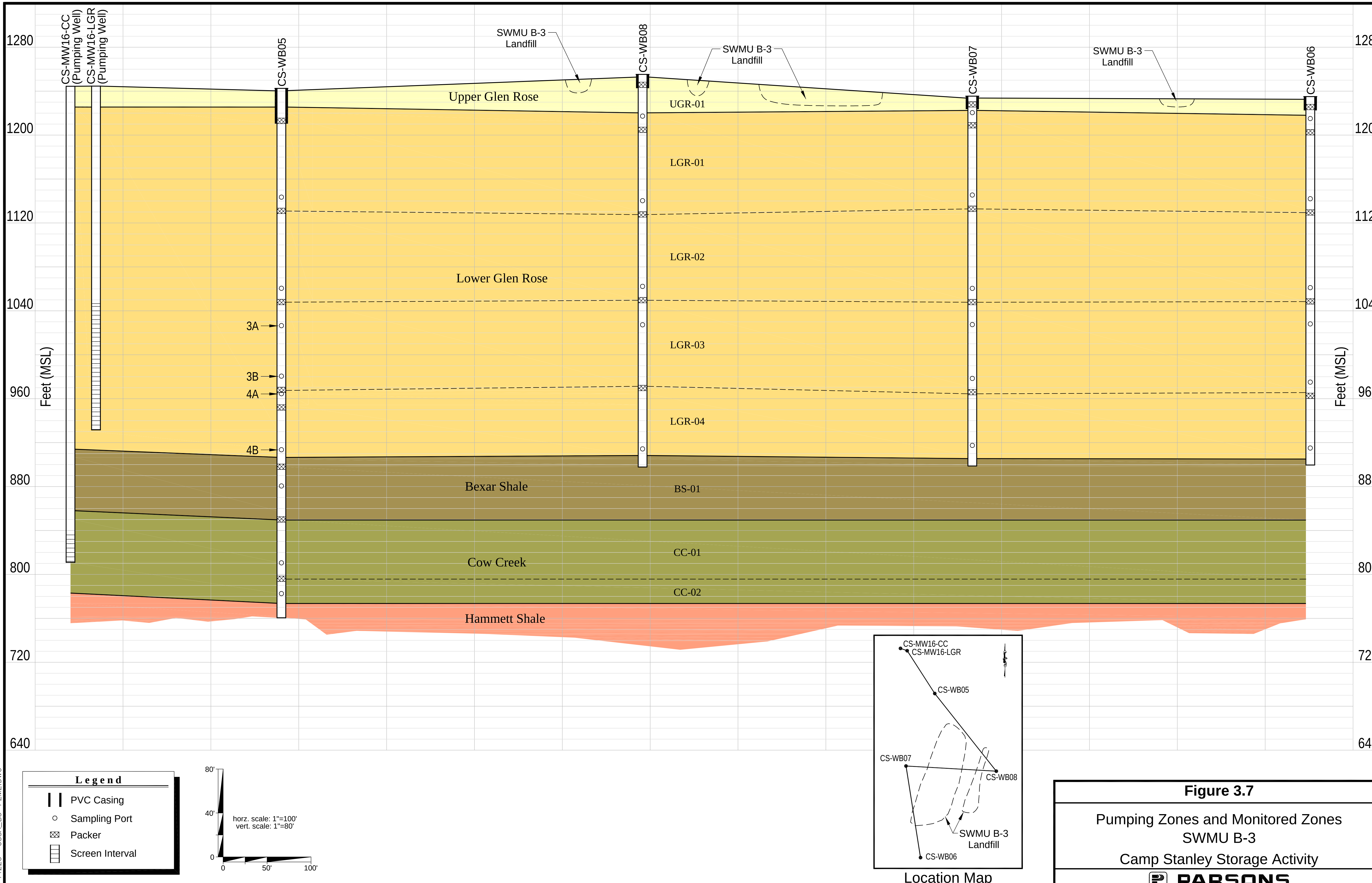


Figure 3.7

Pumping Zones and Monitored Zones
SWMU B-3
Camp Stanley Storage Activity

PARSONS

Aerial Photo Date: 2008

N
W E
S

170 85 0 170 Feet

- Proposed UGR Monitoring Well Location
- Proposed Groundwater Extraction Well Location
- Existing Westbay Multi-port Well
- Existing Supply/Monitoring Well
- SWMU Boundary
- Proposed HDPE Water Delivery
- Proposed Power Extension

Figure 3.8

SWMU B-3
Monitoring Locations
Camp Stanley Storage Activity

PARSONS

J:\747\747144_747145\GIS\mxd\b3_new_wells_proposal.mxd - 1/6/2010 @ 3:19:05 PM

N
W E
S

80 40 0 80 Feet

Irrigation Nozzles
Bioreactor Trench Sumps
Westbay Wells
B3 Boundary
Elevation Contours (1' interval)
Berm Location
Tank
Former Trench Locations

Figure 3.9

B-3 Site Survey Map
Camp Stanley Storage Activity

PARSONS

SECTION 4
SYSTEM MAINTENANCE

4.1 BIOREACTOR INSPECTION

The bioreactor will be inspected weekly to determine if the components are operating properly. Future plans call for the possible installation of equipment to monitor the equipment remotely. Items to include in the inspection include the following:

- Condition of all visible piping;
- Condition of berms identifying any erosional features that may be indicative of surface drainage not being collected in the bioreactor;
- Readings will be collected from pressure gages, flow meters and water levels in the bioreactor sumps weekly;
- Conditions of the storage tank;
- Replacement of bag filter, as necessary.

A System Operation and Monitoring logbook will be maintained documenting all maintenance activities associated with bioreactor system operations, as well as, documenting monthly system inspections.

4.2 MAINTENANCE

To reduce the potential for unexpected equipment shutdown, a maintenance schedule will be incorporated based on the required maintenance specified by the equipment manufacturers.

4.2.1 Bag Filter Replacement

The filters in the bag filtration system must be replaced when they become plugged with particulates. The filters will be replaced when the pressure drop across the filter increases and negatively impacts the capacity of the transfer pump due to high head loss within the treatment system. To prevent the pressure drop across the filter from exceeding safe levels, the filters will be changed if the pressure drop is determined to be 12 pounds per square inch (psi) or greater during a weekly site visit. Spare filters will be stored in the GAC building at CSSA Outfall 002. The procedure for replacing the filter follows:

1. Turn off the system and initiate lockout/tagout procedures in Subsection 3.2.3.
2. Close the ball valve before and after the filter system to isolate the filter from further flow.
3. Carefully bleed off residual pressure inside the filter vessel by slowly opening the vent on the top of the vessel. Think Safety!
4. Loosen the retaining lugs and remove the lid from the top of the vessel.
5. Replace used filters with new ones and place used filters in 55-gal container.

6. Realign the vessel lid and tighten the retaining lugs.
7. Open the ball valves before and after the filter system.
8. Turn the recovery system back on.
9. Check the filter vessel for leaks.

Replacement of the bag filters will be documented on the System Operation and Maintenance Form (Appendix K) to reflect the replacement date of the filters, new filter sizes, and condition of the old filters.

4.2.2 Recovery Pump Maintenance

Pump maintenance will be performed to maintain optimum pump operation, maximize pump life, and to repair pump problems. During the pump maintenance events, each pump will be removed from its well, inspected for wear and damage, and any necessary/recommended repairs made to ensure optimal performance. Pump maintenance may be performed when determined necessary based on pump performance, such as diminishing groundwater yield. Additionally, any time a recovery well will be idled for periods greater than 1 month, the pump in that well will either be operated for at least two hours each month or removed from the well. This is done to prevent accumulation of calcium or iron precipitation on the idle pump components which may foul the pump and/or shorten the pump life.

During the pump maintenance, worn or malfunctioning components will be repaired or replaced. Two spare groundwater pumps are stored in the treatment compound to minimize system down time during such maintenance events. In the event that a pump malfunctions, it will be pulled for service and repaired, as necessary, and a spare pump will be installed in its place. The faulty pump will become a spare after it is repaired.

In the event that a pump must be removed from a well, the following procedures requiring a two-man crew will be followed:

1. Turn off power and initiate lockout/tagout procedures per Subsection 3.3.
2. Disconnect the pipe coupling in the discharge pipe within the well box.
3. Loosen the bolts in the well seal on top of the recovery well so the discharge pipe easily moves through the opening in the seal.
4. Lift the pump from the well by hand until the first flush-thread pipe connection is observed in the discharge pipe.
5. One crew member will secure the discharge pipe below the pipe joint using a pipe wrench while the other crew member loosens and removes the top section of pipe.
6. Care must be taken to secure and manage the electrical cables and steel support cables that attach to the pressure transducer and the pump. These wires/cables should be secured to the discharge pipe by plastic cable ties which must be cut and removed to manage the wiring and cable. CAUTION: The transducer cable includes an internal vented tube. Careful handling of this cable is necessary to prevent pinching or kinking of the cable which may damage and obstruct the vent tube.

7. Continue to remove sections of the pipe while managing the wires and cables, until the last section of pipe is brought to the surface. Carefully lay the pump and pipe next to the well without allowing dirt to plug the pump head.
8. Make necessary repairs to pump or transducer.
9. Carefully reinsert the pump in the well.
10. Reinstall the pump assembly in the well by reversing the removal instructions. New cable ties should be used to re-secure the transducer and pump lead wires to the discharge pipe as it reinserted into the well. CAUTION: Carefully insert the pump and piping assembly into the well without pinching or kinking the transducer cable which could block the internal vent tube.
11. Turn the system back on.

4.3 SPILL PREVENTION AND CONTAINMENT PLAN

To reduce the potential for offsite drainage from the site, the following guidelines will be incorporated:

1. Construction of a berm along the western side of the site to help retain water in the bioreactor;
2. Maintain a stand of vegetation along the west side of Trench 1 to reduce the potential for the development of erosional features along the west side of the site;
3. Precautions, such as storm water diversion berms, will be taken to prevent overfilling of the bioreactor with stormwater runoff; and
4. Level controller located in trench 1 monitoring sump 1 which will cease injection of water upon reaching high level.

4.4 SITE MAINTENANCE

During each visit, the following activities will take place:

- The site will be inspected to ensure no obstructions are present that could impact normal operation.
- The area around the treatment area and bioreactor will be inspected. Ensure that access to the compound is clear of tree branches and debris.
- Buried water and electrical lines will be inspected to ensure that the lines are still properly covered, and that no apparent leaks are present.

See the System Operation and Monitoring Form in Appendix K for a list of necessary activities to perform during each site visit.

SECTION 5
REPORTING REQUIREMENTS

Since the bioreactor design called for the discharge of affected water from all extraction wells into the subsurface via a buried water distribution system, it was necessary to apply for a Class V Aquifer Remediation Injection Well Permit through the Industrial and Hazardous Waste Permits Section of the Waste Permits Division at the TCEQ. The permit application was accepted on July 20, 2006 and the following TCEQ Authorization Number was assigned to the SWMU B-3 injection system: No. 5X2600431; WWC 12002216; CN602728206/RN104431655. A copy of the authorization letter and subsequent revisions of the authorization letter indicating modifications to the injection permit are presented in Appendix A.

As stated in the letter, there are four requirements that must be met as set by the Remediation Division and the UIC rules provided by 30 Texas Administrative Code (TAC) Chapter 331.

Requirement 1. All injection wells are to be constructed to meet the standards provided in 30 TAC 331.132 and completed well logs or construction diagrams submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 upon completion. Since a subsurface water distribution system instead of an injection well was proposed and accepted in the permit application, this requirement is not applicable to the B3 bioreactor.

Requirement 2. Operational and status changes shall be reported to and approved by the UIC Permits Team. Any changes to the operation of the B3 bioreactor not presented in a monitoring report can be provided to the UIC Permits Team via a letter.

Requirement 3. Closure (plugging) of injection wells, points and/or trenches shall comply with the standards provided in 30 TAC 331.133. Closure reports including plugging reports and injection well monitoring data (injection volumes, pressures and results) shall be submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 within 60 days of completion of injection or plugging activities. If closure activities do proceed in the future for SWMU B-3, then the most suitable option for closure of the trenches, and the recommended option will be presented to the UIC Permits Team. The volume of water (cumulative) as well as the chemical data results will be presented in each monitoring report submitted to the UIC Permits Team. Additional discussion on the chemical data monitoring is presented in Requirement 4.

Requirement 4. Injection volumes, pressures, and concentrations of contaminants (including selected VOCs, pH and total dissolved solids) in the injected groundwater shall be sampled bimonthly at the point of re-injection (prior to fluids being released into the trenches) and submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 on a monthly basis. The concentration of contaminants in the trench bioreactor monitoring sumps and the surrounding monitoring wells shall be sampled monthly and submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 on a quarterly basis. The twice monthly and monthly monitoring and sampling program is presented in Section 4. The sampling and monitoring program will adhere to Requirement 4.

Table 5.1 outlines the monitoring and reporting activities scheduled during months 31 through 43 of the O&M period.

Table 5.1
B-3 O&M Activities Outline Months 31 – 43

	Month	Monday	Tuesday	Wednesday	Thursday	Friday	Week	Reporting
Quarter 11	November, 2009 Month 31	2	3	4	5	6	132	
		9	10	11	12	13	133	
		16	17	18	19	20	134	
		23	24	25	26	27	135	
		30					136	Quarter 10 Performance Report
	December, 2009 Month 32		1	2	3	4		
		7	8	9	10	11	137	
		14	15	16	17	18	138	
		21	22	23	24	25	139	
		28	29	30	31		140	
	January, 2010 Month 33					1		
		4	5	6	7	8	141	
		11	12	13	14	15	142	
		18	19	20	21	22	143	
		25	26	27	28	29	144	
Quarter 12	February, 2010 Month 34	1	2	3	4	5	145	
		8	9	10	11	12	146	
		15	16	17	18	19	147	
		22	23	24	25	26	148	
	March, 2010 Month 35	1	2	3	4	5	149	
		8	9	10	11	12	**150**	Quarter 11 Performance Report
		15	16	17	18	19	151	
		22	23	24	25	26	152	
		29	30	31			153	
	April, 2010 Month 36				1	2		
		5	6	7	8	9	154	
		12	13	14	15	16	155	
		19	20	21	22	23	156	
		27	28	29	30		157	
Quarter 13	May, 2008 Month 37	3	4	5	6	7	158	
		10	11	12	13	14	159	
		17	18	19	20	21	160	
		24	25	26	27	28	161	
		31					**162**	B3 UIC Bi-Annual Report
	June, 2010 Month 38		1	2	3	4		
		7	8	9	10	11	**163**	Quarter 12 Performance Report
		14	15	16	17	18	164	
		21	22	23	24	25	165	
		28	29	30			166	
	July, 2010 Month 39				1	2		
		5	6	7	8	9	167	
		12	13	14	15	16	168	
		19	20	21	22	23	169	
		26	27	28	29	30	170	
Quarter 14	August, 2010 Month 40	2	3	4	5	6	171	
		9	10	11	12	13	172	
		16	17	18	19	20	173	
		23	24	25	26	27	174	
		30	31				175	
	September, 2010 Month 41			1	2	3		
		6	7	8	9	10	**176**	Quarter 13 Performance Report
		13	14	15	16	17	177	
		20	21	22	23	24	178	
		27	28	29	30		179	
	October, 2010 Month 42					1		
		4	5	6	7	8	180	
		11	12	13	14	15	181	
		18	19	20	21	22	182	
		25	26	27	28	29	183	
Quarter 15 (partial)	November, 2010 Month 43	1	2	3	4	5	184	
		8	9	10	11	12	185	
		22	23	24	25	26	186	
		29	30				**187**	B3 UIC Bi-Annual Report
	December 2010			1	2	3		
		6	7	8	9	10	188	

Monthly Sampling and UIC Sampling
Quarterly Sampling
Semi-Annual UIC Report submittal
Quarterly Performance Report

APPENDIX A

TCEQ Authorization Letters

July 20, 2006

June 25, 2007

April 25, 2008

July 20, 2006 Transmittal

Kathleen Hartnett White, *Chairman*
Larry R. Soward, *Commissioner*
Glenn Shankle, *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

July 20, 2006

Mr. Jason Shirley
Installation Manager
U.S. Army, Camp Stanley Storage Activity
25800 Ralph Fair Road
Boerne, TX 78015

Re: Authorization and Registration of Class V Aquifer Remediation Injection Wells
TCEQ Authorization No. 5X2600431; WWC 12002216; CN602728206/RN104431655
Camp Stanley Storage Activity
25800 Ralph Fair Road
Boerne, TX 78015

Dear Mr. Shirley:

The Underground Injection Control (UIC) staff has completed review of the inventory/authorization form dated May 30, 2006 from Parsons requesting approval for the injection of groundwater into five infiltration galleries filled with gravel, wood chips and vegetable oil as part of the remediation process at the above site. Our consideration for this proposed project for injection has included coordination with the commission's Remediation Division. Based on our review, approval is hereby given for construction and operation of the injection wells according to the submitted plans and specifications.

In order to maintain authorization by rule for the injection operations, the project must meet all requirements set by the Remediation Division and the UIC rules provided by 30 TAC Chapter 331. Requirements for the injection include:

1. All injection wells are to be constructed to meet the standards provided in 30 TAC §331.132 and completed well logs or construction diagrams submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 upon completion;

2. Operational and status changes shall be reported to and approved by the UIC Permits Team;

3. Closure (plugging) of injection wells, points and/or trenches shall comply with standards provided in 30 TAC §331.133. Closure reports including plugging reports and injection well monitoring data (injection volumes, pressures, and results) shall be submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 within 60 days of completion of injection or plugging activities; and

4. Injection volumes, pressures, and concentrations of contaminants (including pH and total dissolved solids) in the injected groundwater shall be sampled bimonthly at the point of reinjection (prior to fluids being released into the trenches) and submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 on a monthly basis. The concentration of contaminates in the trench bioreactor monitoring sumps and the surrounding monitoring wells shall be sampled monthly and submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 on a quarterly basis. The concentrations of the contaminants shall not exceed those limits listed in 40 CFR §261.24 Toxicity characteristic table 1 that would deem them hazardous by concentration.

If you have any questions regarding this matter, please contact me at (512) 239-6075. If you will be corresponding by mail, please use mail code MC-130.

Sincerely,

Bryan S. Smith

Bryan Smith, P.G., Engineering Specialist
Industrial and Hazardous Waste Permits Section
Waste Permits Division
Texas Commission on Environmental Quality

BSS/ff

cc: Mr. Brian Vanderglas, Parsons, Austin

June 25, 2007 Transmittal

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

June 25, 2007

Mr. Jason Shirley
Installation Manager
U.S. Army, Camp Stanley Storage Activity
25800 Ralph Fair Road
Boerne, TX 78015

Re: Amendment to Authorization of Class V Aquifer Remediation Injection Wells
TCEQ Authorization No. 5X2600431; WWC12033366; CN602728206/RN104431655
Camp Stanley Storage Activity
25800 Ralph Fair Road
Boerne, TX 78015

Dear Mr. Shirley:

The Underground Injection Control (UIC) staff has completed review of the modification request dated November 29, 2006 requesting approval for the addition of one infiltration galleries filled with gravel, wood chips and vegetable oil as part of the remediation process at the above site. Our consideration for this proposed project for injection has included coordination with the commission's Remediation Division. Based on our review, approval is hereby given for construction and operation of the injection wells according to the submitted plans and specifications.

In order to maintain authorization by rule for the injection operations, the project must meet all requirements set by the Remediation Division and the UIC rules provided by 30 Texas Administrative Code (TAC) Chapter 331. Requirements for the injection include:

1. All injection wells are to be constructed to meet the standards provided in 30 TAC Section (§)331.132 and completed well logs or construction diagrams submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 upon completion;

2. Operational and status changes shall be reported to and approved by the UIC Permits Team;

3. Closure (plugging) of injection wells, points and/or trenches shall comply with standards provided in 30 TAC §331.133. Closure reports including plugging reports and injection well monitoring data (injection volumes, pressures, and results) shall be submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 within 60 days of completion of injection or plugging activities; and

4. Injection volumes, pressures, and concentrations of contaminants (including pH and total dissolved solids) in the injected groundwater shall be sampled bimonthly at the point of reinjection (prior to fluids being released into the trenches) and submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 on a monthly basis. The concentration of contaminates in the trench bioreactor monitoring sumps and the surrounding monitoring wells shall be sampled monthly and submitted to the UIC Permits Team, Industrial and Hazardous Waste Permits Section, at mail code MC-130 on a quarterly basis. The concentrations of the contaminants shall not exceed those limits listed in 40 CFR §261.24 Toxicity characteristic table 1 that would deem them hazardous by concentration.

If you have any questions regarding this matter, please contact me at (512) 239-6075. If you will be corresponding by mail, please use mail code MC-130.

Sincerely,

Bryan Smith

Bryan Smith, P.G., Engineering Specialist
Industrial and Hazardous Waste Permits Section
Waste Permits Division
Texas Commission on Environmental Quality

BSS/ff

cc: Mr. Brian Vanderglas, Parsons, Austin

April 25, 2008 Transmittal

DEPARTMENT OF THE ARMY
CAMP STANLEY STORAGE ACTIVITY, MCAPP
25800 RALPH FAIR ROAD, BOERNE, TX 78015-4800

April 25, 2008

U-###-08

Mr. Bryan Smith
Texas Commission on Environmental Quality
Industrial and Hazardous Waste Permits Section
P.O. Box 13087 (MC-130)
Austin, TX 78711-3087

Subject: Request for Reduction of Data Collection and Reporting Requirements for the Pilot Study Class V Aquifer Remediation Injection Wells at Camp Stanley Storage Activity, Boerne, Texas, TCEQ Authorization No. 5X2600431; WWC12002216; CN602728206/RN104431655

Dear Mr. Smith:

The Camp Stanley Storage Activity (CSSA), McAlester Army Ammunition Plant, U.S. Army Field Support Command, Army Materiel Command, U.S. Army, is submitting this request to seek authorization to reduce the data collection requirements for the subject Class V Aquifer Remediation Injection Wells as discussed during your recent visit in December 2007. The injection activities are performed at the on-post Solid Waste Management Unit (SWMU) B-3 site as pilot study activities which include the injection of recovered groundwater into mulch/gravel-filled bioreactor trenches.

CSSA's current data collection and reporting requirements as specified by the subject Texas Commission on Environmental Quality (TCEQ) Underground Injection Control (UIC) permit for the SWMU B-3 Bioreactor Pilot Study includes:

- **Bimonthly** - Injection volumes, pressures, and concentrations of contaminants (including pH and total dissolved solids) in the injected groundwater sampled bimonthly at the point of re-injection (prior to fluids being released into the trenches) and submitted to the TCEQ on a monthly basis.

- **Monthly** - The concentrations of contaminants in the trench bioreactor monitoring sumps and the surrounding monitoring wells sampled monthly and submitted to the TCEQ on a quarterly basis.

CSSA is requesting authorization for the reduction of data collection and reporting for the subject UIC permit based on the results of the data collected through ten months of operations at SWMU B-3 bioreactor pilot study. These data indicate that concentrations of contaminants in the injected groundwater continue to be well below the limits specified in 40 CFR §261.24 Toxicity Characteristics Table 1. Therefore, CSSA proposes that bimonthly sampling requirements move to monthly sampling and the monthly sampling requirements move to quarterly. Additionally, CSSA requests all monthly and quarterly collected data be reported semi-annually to the TCEQ (see attached table

1 for a summary of current and proposed monitoring and reporting schedule). As you are aware, this UIC well is near the middle of the 4,000-acre installation, approximately a mile from the nearest off-post boundaries.

If you have any questions regarding the information contained in this letter, please feel free to contact Glare Sanchez, CSSA Environmental Program Manager, at (210) 698-5208 or Ken Rice, Parsons, at (512) 719-6050.

Sincerely,

Jason D. Shirley
Installation Manager

Attachments

cc: Glare Sanchez, CSSA Environmental Program Manager
Greg Lyssy, USEPA Region 6
Robert Bowersock, USACE
Julie Burdey, Parsons
Ken Rice, Parsons
Brian Vanderglas, Parsons
File: 745493.03000

Table 1

Class V Aquifer Remediation Injection Well Permit #5X2600431
Sampling and Monitoring Schedule for the B3 Bioreactor Pilot Study
CSSA – Boerne, Texas

Table 1
Class V Aquifer Remediation Injection Well Permit #5X2600431
Sampling and Monitoring Schedule for the B3 Bioreactor Pilot Study
CSSA – Boerne, Texas

	Sampling or Monitoring Location	Parameter(s)	Sampling Frequency	Reporting Frequency
Current Regulatory Req.	Flow meters (6) for each trench on downstream side of the header and one flow meter on the upstream side of the header	Injection volume	Twice per month (record)	Monthly
	Pressure gages (4) on both sides of the transfer pump, at the bag filter and on the header	Pressure on the transfer pump	Twice per month (record)	Monthly
	Sampling port (1) on the upstream side of the distribution header	- pH (field) and TDS (lab) - VOCs (b)	Twice per month	Monthly
	Trench sumps (5) (b)	- pH (field) and TDS (lab) - VOCs (b)	Monthly	Quarterly
	MPMWs (4) (c)	- pH (field) and TDS (lab) - VOCs (b)	Quarterly	Quarterly
Proposed Regulatory Req.	Flow meters (6) for each trench on downstream side of the header and one flow meter on the upstream side of the header	Injection volume	Monthly (record)	Semi-Annual
	Pressure gages (4) on both sides of the transfer pump, at the bag filter and on the header	Pressure on the transfer pump	Monthly (record)	Semi-Annual
	Sampling port (1) on the upstream side of the distribution header	- pH (field) and TDS (lab) - VOCs (a)	Monthly	Semi-Annual
	Trench sumps (5) (b)	- pH (field) and TDS (lab) - VOCs (a)	Quarterly	Semi-Annual
	MPMWs (4) (c)	- pH (field) and TDS (lab) - VOCs (a)	Quarterly	Semi-Annual

Notes:
(a) Standard list of VOCs tested at CSSA
(b) Bioreactor trench sumps (BTS) include: Trench 1 – 1-1, 1-2 and 1-3; Trench 2 – 2-1 and 2-2; Trench 3 – 3-1 and 3-2; Trench 4 – 4-1; Trench 5 – 5-1 and 5-2; Trench 6 – 6-1 and 6-2. Samples are collected from all trench sumps which includes the injection of CS-MW16 groundwater.
(c) Multi-port monitoring wells (MPMW) include: CS-WB05 (9 sampling ports), CS-WB06 (6 sampling ports), CS-WB07 (6 sampling ports) and CS-WB08 (6 sampling ports). MPMW will be sampled quarterly and include only Zone LGR-03B for each MPMW. Surrounding monitor wells includes: CS-MW1-LGR, CS-B3-MW01-LGR, CS-D-LGR, CS-MW16-LGR and CS-MW16-CC.

APPENDIX B

Product Information:

Recovery Well Pumps and SymCom PumpSaver

CS-MW16-LGR

CS-MW16-CC

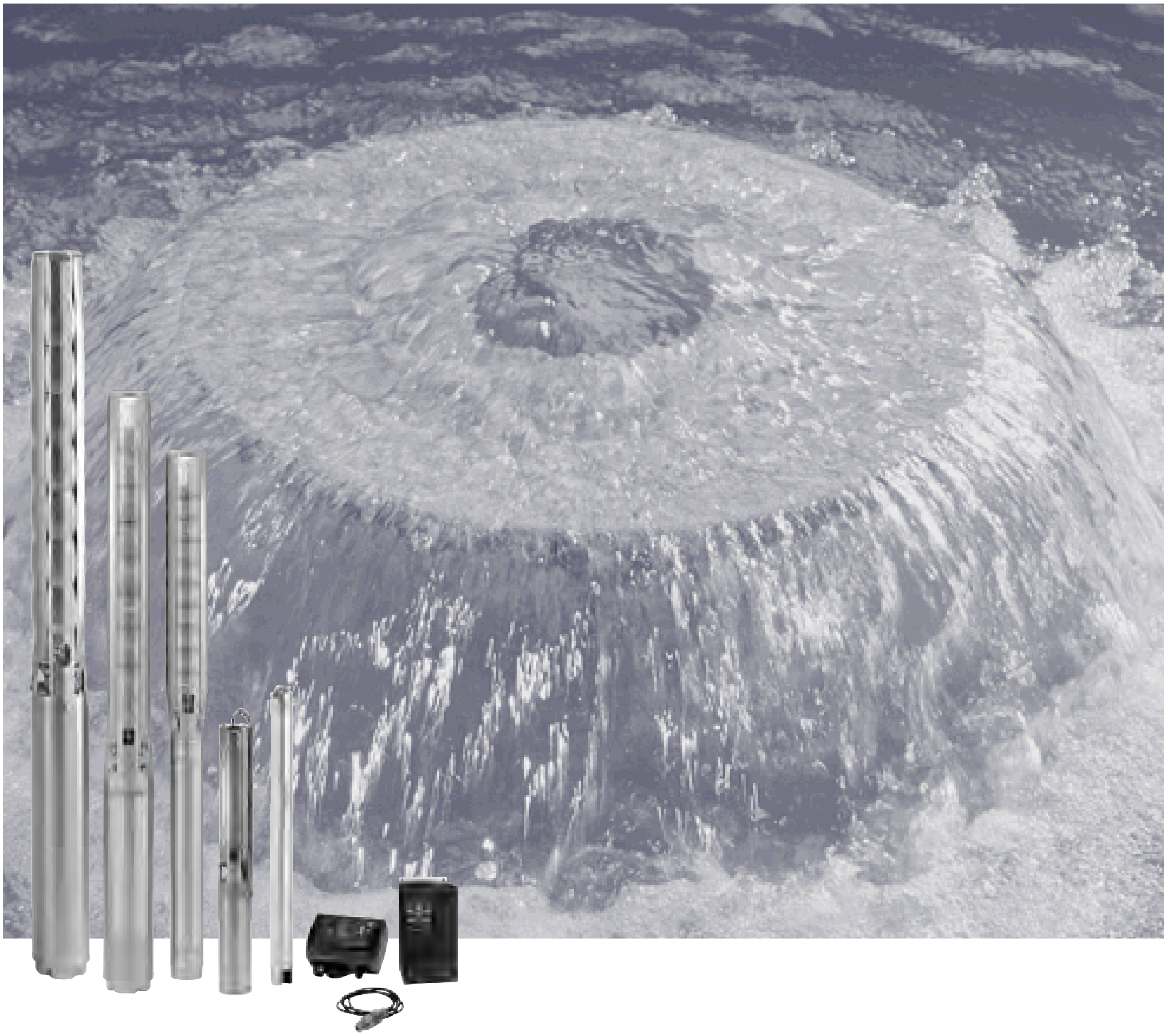
CS-EXW01-LGR

CS-EXW02-LGR

CS-MW16-LGR PUMP SPECIFICATIONS

SQ, SQE, SP

Stainless steel submersible pumps and accessories
60 Hz



Mission

- to successfully develop, produce, and sell high quality pumps and pumping systems worldwide, contributing to a better quality of life and healthier environment

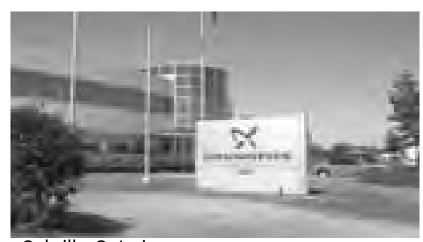
Bjerringbro, Denmark

Fresno, California

Olathe, Kansas

Monterrey, Mexico

Allentown, Pennsylvania



Oakville, Ontario

- One of the 3 largest pump companies in the world with over 11,000 employees worldwide
- World headquarters in Denmark
- North American headquarters in Kansas City - Manufacturing in Fresno, California
- 60 companies in 40 countries
- More than 10 million pumps produced annually worldwide
- North American companies operating in USA, Canada and Mexico
- Continuous reinvestment in growth and development enables the company to **BE** responsible, **THINK** ahead, and **INNOVATE**

Submittal Data Sheet

Company name: ______________________
Prepared by: ______________________
Phone number: (   )   -
Fax number: (   )   -
Date: __________ Page 1 of: __________
Quote number: ______________________

Client Information

Project title: ______________ Client name: ______________
Reference number: ______________ Client number: ______________
Client contact: Client phone no: (   )   -

Location Information

For: ______________ Unit: ______________
Site: ______________ Service: ______________
Address: City: State: Zip Code:

Technical Data

Flow (GPM) ______________
Head (Ft) ______________
Motor ______________
Max Fluid Temp ______________
Min Fluid Temp ______________
Max Working Pressure ______________
Min Required Inlet Pressure ______________
Connection Type and Size ______________

Motor Information

HP: ______________
Phase: ______________
Voltage: ______________
Enclosure: ______________

Pump Information

Model Information from Type Key and Codes: ______________
Quantity Required: ______________ Example: SP 150S
Minimum required flow: ______________ NPSH required at duty point: ______________

Product Guide additional information pages

Materials page number: ______________ Performance curve page number: ______________
Technical data page number: Motor data page number:

Custom-built pump information (optional): ______________

Additional Information ______________

TABLE OF CONTENTS

STAINLESS STEEL CONSTRUCTION

Grundfos submersibles feature rugged and durable stainless steel construction for all vital pump components. Impellers, diffusers, shafts, vanes, cable guards, couplings...even the nuts and bolts are stainless steel. Grundfos' 4-inch pump systems include the stainless steel pump, motor, and control box and are delivered ready to install.

Computer-aided design and manufacturing techniques ensure that each *pump* is built to exacting tolerance and performs to industry-leading standards. Grundfos state-of-the-art production equipment includes extensive use of robotics and advanced quality assurance procedures. You can rely on quality Grundfos' groundwater products for outstanding pump performance and best value.

SUBMERSIBLES

4-INCH and LARGER WELLS
The 4-inch submersibles line covers all flow requirements from 1.2 to 95 gpm and heads to 2000 feet. This broad range ensures proper pump selection for all domestic groundwater system applications.

6, 8, & 10-INCH and LARGER WELLS
For high flow requirements, this submersible line includes 6, 8, and 10-inch models for flows up to 1,400 gpm and heads to 2100 feet.

Grundfos offers 18 models of submersible pumps designed for domestic and industrial applications with flow rates from five to 1,400 gpm. Horsepower range extends from 1/3 hp to 250 hp. These pumps are marketed through more than 300 distributors and nearly 2,000 dealers nationwide.

THE STAINLESS STEEL ADVANTAGE

TOP PUMP PERFORMANCE
Grundfos pumps are built to work hard with every component designed for maximum hydraulic efficiency. With the inherently smooth surfaces of fabricated stainless steel, peak performance is maintained over many years of service.

RELIABLE OPERATION
Highly advanced design and manufacturing techniques minimize the number of moving parts. This, plus Grundfos' use of rugged stainless steel construction, make GRUNDFOS groundwater pumps the toughest, most reliable pumps on the market. With Grundfos you can rely on getting the water you need, when you need it.

LONG PUMP LIFE
Stainless steel is the best available material to resist wear and corrosion in water system applications. Compare Grundfos' stainless steel construction to the best the other manufactures have to offer. Grundfos stainless steel pumps are designed to operate efficiently and effectively for a long, long time.

SQ/SQE SUBMERSIBLE PUMPS

3-Inch SQ/SQE Submersible Well Pumps
3-Inch and Larger Wells

SQ/SQE pumps are suitable for both continuous and intermittent operation for a variety of applications:

- Domestic water supply
- Small waterworks
- Irrigation
- Tank applications

SQ, SQE pumps offer the following features:

- Dry-Run protection
- High efficiency pump and motor
- Protection against up-thrust
- Soft-start
- Over-voltage and under-voltage protection
- Overload protection
- Over-temperature protection
- High starting torque

Additionally, the SQE pumps offer:

- Constant pressure control
- Variable speed
- Electronic control and communication

The SQ and SQE pump models incorporate an innovative motor design. With the use of permanent-magnet technology within the motor, the SQ/SQE pumps deliver unmatched performance. By combining permanent-magnet motors and Grundfos's own micro frequency converter, we are now able to control and communicate with the pump in ways never before possible. A few of the features that come out of this combination are Constant Pressure Control, Soft-Start, and integrated Dry-Run protection. These are just a few of the many features that the SQ/SQE pumps can offer.

The SQ pump models operate at a constant speed much like today's conventional pumps. The difference between it and traditional pumps is you get all the benefits of an electronically controlled permanent-magnet motor that cannot be accomplished with a conventional induction motor. The SQ pumps are available for single phase power. They use a simple 2-wire design making installation easy.

The SQE uses the Grundfos "Smart Motor". Like the SQ model, we still use the high efficiency permanent magnet motor, but we give this motor the ability to communicate. The "Smart Motor" communicates via the CU301 status box through the power leads. It is not necessary to run any additional wires down the well. By being able to communicate with the pump you can have Constant Pressure Control and the ability to change the pump performance while the pump is installed in the well. Like the SQ motor, this is also a 2-wire motor designed for single-phase operation.

TYPE KEYS

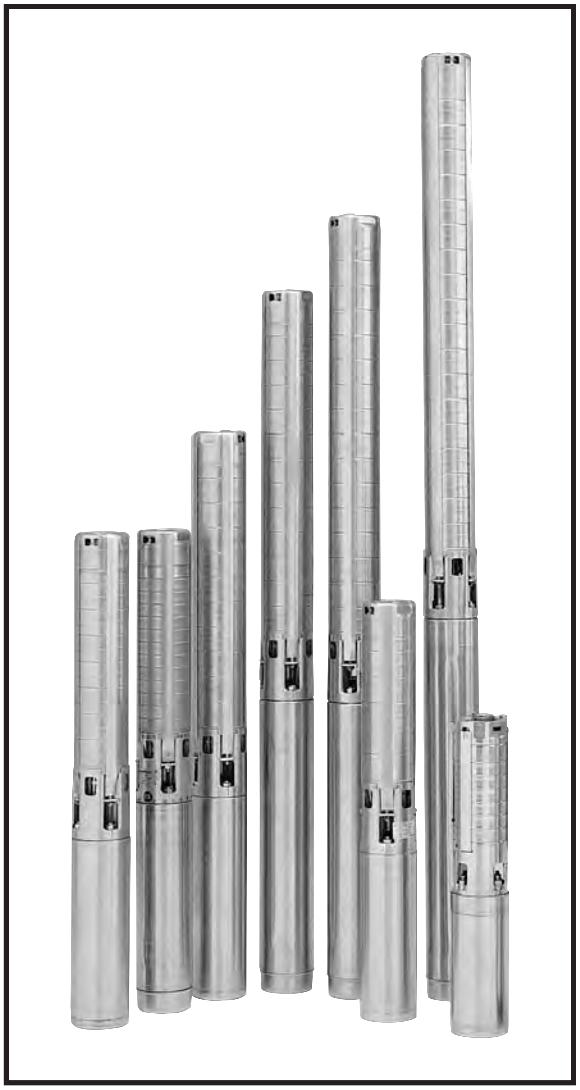
SP Example 10 S 05 - 9

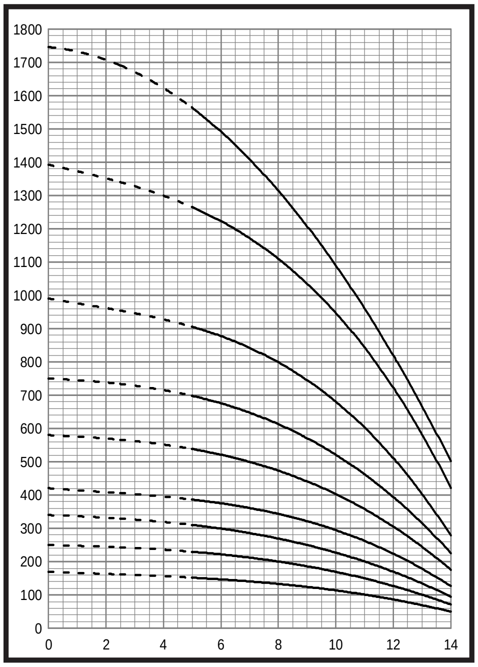
- 10 — Rated gallons per minute
- S — Material of construction
- 05 — Horsepower
- 9 — Number of pump stages

SQ/SQE Example 10 SQ E 05 - 160

- 10 — Rated gallons per minute
- SQ — Basic version (without communication)
- E — Electronic communication
- 05 — Horsepower
- 160 — Total Dynamic Head in (ft) at rated flow

Easy Selection Chart
Performance Curves and Technical Data
4-Inch Submersible Pumps





Performance Curves

Materials of Construction

Grundfos Stainless Steel Submersible Pumps

4" Submersible Easy Selection Charts.

5 GPM

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE

(1.2 TO 7 GPM)

PUMP OUTLET
1 " NPT

			DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET																								
PUMP MODEL	**HP**	**PSI**	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**	**340**	**400**	**460**	**520**	**600**	**700**	**800**	**900**	**1000**	**1100**
5S03-9	**1/3**	0				7.1	6.7	6.2	5.8	5.3	4.8	4.3	3.2	2.1													
		20		7.0	6.6	6.1	5.7	5.2	4.6	4.0	2.8	1.6															
		30		6.5	6.0	5.6	5.1	4.6	3.8	2.9	1.5																
		40	6.7	6.0	5.5	5.1	4.4	3.8	2.4																		
		50	6.2	5.5	4.9	4.4	3.4	2.5	1.3																		
		60	5.6	4.9	4.2	3.5	1.9																				
SHUT-OFF PSI:			102	94	85	76	68	59	50	42	33	24	16	7													
5S05-13	**1/2**	0						7.1	6.8	6.4	6.1	5.8	5.5	5.2	4.8	4.5	3.9	2.3									
		20			7.3	7.0	6.7	6.3	6.0	5.7	5.4	5.1	4.7	4.3	3.7	3.1	2.0										
		30		7.2	6.9	6.6	6.3	6.0	5.7	5.4	5.0	4.7	4.2	3.7	2.8	2.0											
		40	7.2	6.9	6.6	6.3	5.9	5.6	5.3	5.0	4.6	4.2	3.5	2.8	1.6												
		50	6.8	6.5	6.2	5.9	5.6	5.3	4.9	4.6	4.0	3.5	2.6	1.6													
		60	6.5	6.2	5.8	5.5	5.2	4.9	4.5	4.0	3.3	2.6	1.3														
SHUT-OFF PSI:			152	143	134	126	117	108	100	91	82	74	65	56	48	39	30	13									
5S07-18	**3/4**	0								7.1	6.9	6.7	6.4	6.2	6.0	5.8	5.6	5.1	4.2	2.7							
		20						7.1	6.8	6.6	6.4	6.2	5.9	5.7	5.5	5.3	5.0	4.5	3.2								
		30					7.0	6.8	6.6	6.3	6.1	5.9	5.7	5.5	5.2	5.0	4.7	4.0	2.5								
		40			7.2	7.0	6.8	6.5	6.3	6.1	5.9	5.6	5.4	5.2	4.9	4.7	4.4	3.5	1.5								
		50		7.2	7.0	6.7	6.5	6.3	6.1	5.8	5.6	5.4	5.1	4.9	4.6	4.3	3.9	2.9									
		60	7.1	6.9	6.7	6.5	6.2	6.0	5.8	5.6	5.3	5.1	4.9	4.6	4.3	3.9	3.4	2.1									
SHUT-OFF PSI:			213	204	195	187	178	169	161	152	143	135	126	117	109	100	91	74	48	22							
5S10-22	**1**	0										7.1	6.9	6.7	6.6	6.4	6.2	5.8	5.3	4.7	3.8	1.7					
		20								7.1	6.9	6.7	6.5	6.3	6.1	6.0	5.8	5.4	4.8	4.0	2.8						
		30							7.0	6.8	6.7	6.5	6.3	6.1	5.9	5.7	5.6	5.2	4.6	3.6	2.1						
		40						7.0	6.8	6.6	6.5	6.3	6.1	5.9	5.7	5.5	5.4	5.0	4.3	3.1	1.3						
		50				7.2	7.0	6.8	6.6	6.4	6.2	6.1	5.9	5.7	5.5	5.3	5.1	4.7	3.9	2.5							
		60			7.1	6.9	6.8	6.6	6.4	6.2	6.0	6.0	5.7	5.5	5.3	5.1	4.9	4.4	3.5	1.7							
SHUT-OFF PSI:					245	237	228	219	211	202	194	185	176	168	159	150	142	124	98	72	46	12					
5S15-26	**1 1/2**	0												7.1	7.0	6.8	6.7	6.4	5.9	5.4	4.9	4.1	2.1				
		20										7.1	6.9	6.8	6.6	6.5	6.3	6.0	5.5	5.1	4.5	3.4					
		30									7.1	6.9	6.7	6.6	6.4	6.3	6.1	5.8	5.4	4.8	4.2	2.9					
		40								7.0	6.9	6.7	6.6	6.4	6.3	6.1	6.0	5.6	5.2	4.6	5.6	2.4					
		50							7.0	6.9	6.7	6.5	6.4	6.2	6.1	5.9	5.8	5.5	5.0	4.4	3.6	1.7					
		60						7.0	6.8	6.7	6.5	6.4	6.2	6.1	5.9	5.8	5.6	5.3	4.8	4.1	3.1						
SHUT-OFF PSI:								269	260	252	243	234	226	217	208	200	191	174	148	122	96	61	18				
5S15-31	**1 1/2**	0														7.1	7.0	6.7	6.3	5.9	5.5	6.7	4.1	2.6			
		20												7.1	6.9	6.8	6.7	6.4	6.0	5.6	5.2	4.6	3.5	1.6			
		30											7.0	6.9	6.8	6.6	6.5	6.2	5.9	5.5	5.1	4.4	3.2	0.9			
		40										7.0	6.9	6.8	6.6	6.5	6.4	6.1	5.7	5.3	4.9	4.2	2.8				
		50								7.1	7.0	6.9	6.7	6.6	6.5	6.3	6.2	6.0	5.6	5.2	4.7	4.0	2.3				
		60							7.1	7.0	6.8	6.7	6.6	6.5	6.3	6.2	6.1	5.8	5.4	5.0	4.5	3.7	1.7				
SHUT-OFF PSI:									320	311	303	294	285	277	268	259	251	233	207	181	155	121	77	34			

See 5S performance curves for higher head models.
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

7S EASY SELECTION CHART

7 GPM

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE

(3 TO 10 GPM)

PUMP OUTLET
1 " NPT

PUMP MODEL	HP	PSI	DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET																								
			20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
7S03-8	1/3	20	10.0	9.5	8.7	8.0	7.2	6.4	5.0	3.7	1.8																
		30	9.3	8.7	7.9	7.1	6.1	5.1	2.6																		
		40	8.5	7.8	7.0	6.1	4.5	2.9	1.5																		
		50	7.6	6.9	5.8	4.7	2.3																				
		60	6.7	5.8	3.9	2.0																					
SHUT-OFF PSI:			86	77	69	60	52	43	34	26	17	8															
7S05-11	1/2	0					9.9	9.5	8.9	8.4	7.8	7.3	6.7	6.0	5.0	4.0											
		20			9.8	9.3	8.8	8.2	7.7	7.1	6.5	5.8	4.7	3.5	1.8												
		30	10.1	9.7	9.2	8.7	8.1	7.6	7.0	6.4	5.6	4.7	2.9														
		40	9.6	9.2	8.6	8.1	7.5	6.9	6.2	5.6	4.3	3.0	1.5														
		50	9.1	8.5	8.0	7.4	6.8	6.2	5.3	4.3	2.2																
		60	8.4	7.9	7.3	6.8	6.0	5.3	3.8	2.3																	
SHUT-OFF PSI:			122	113	105	96	87	79	70	61	53	44	35	27	18	10											
7S07-15	3/4	0						10.2	9.9	9.5	9.2	8.8	8.4	8.0	7.6	7.1	6.7	5.6	2.9								
		20				10.1	9.8	9.4	9.0	8.6	8.2	7.8	7.4	7.0	6.5	6.1	5.4	3.6									
		30			10.0	9.7	9.4	9.0	8.6	8.2	7.8	7.4	6.9	6.5	5.9	5.4	4.5	1.8									
		40		10.0	9.7	9.3	8.9	8.5	8.1	7.7	7.3	6.9	6.4	5.9	5.2	4.5	3.2	1.0									
		50	9.9	9.6	9.2	8.9	8.5	8.1	7.6	7.2	6.8	6.4	5.8	5.2	4.2	3.2	1.6										
		60	9.5	9.2	8.8	8.4	8.0	7.6	7.2	6.7	6.2	5.7	4.9	4.2	2.8	1.4											
SHUT-OFF PSI:			170	101	153	144	135	127	118	110	101	92	84	75	66	58	49	32	6								
7S10-19	1	0								10.1	9.8	9.6	9.3	9.0	8.7	8.4	8.0	7.4	6.4	4.8							
		20						10.0	9.8	9.5	9.2	8.9	8.6	8.3	7.9	7.6	7.3	6.6	5.3	2.8							
		30					10.0	9.7	9.5	9.2	8.9	8.5	8.2	7.9	7.6	7.3	6.9	6.2	4.6	1.4							
		40				10.0	9.7	9.4	9.1	8.8	8.5	8.2	7.8	7.5	7.2	6.9	6.5	5.6	3.7								
		50		10.2	9.9	9.7	9.4	9.1	8.8	8.4	8.1	7.8	7.5	7.2	6.8	6.5	6.0	5.0	2.4								
		60	10.1	9.9	9.6	9.3	9.0	8.7	8.4	8.1	7.8	7.4	7.1	6.8	6.4	6.0	5.5	4.2									
SHUT-OFF PSI:			218	209	200	192	183	174	166	157	148	140	131	123	114	105	97	79	53	27							
7S15-26	1 1/2	0											10.1	9.9	9.7	9.5	9.3	8.8	8.1	7.4	6.7	5.5					
		20									10.0	9.8	9.6	9.4	9.2	9.0	8.8	8.3	7.6	6.9	6.1	4.4					
		30								10.0	9.8	9.6	9.4	9.2	9.0	8.7	8.5	8.0	7.3	6.6	5.7	3.7					
		40						10.1	10.0	9.8	9.6	9.4	9.1	8.9	8.7	8.5	8.2	7.8	7.1	6.3	5.2	2.9					
		50					10.1	9.9	9.7	9.6	9.3	9.1	8.9	8.7	8.4	8.2	8.0	7.5	6.8	5.9	4.7	1.9					
		60				10.1	9.9	9.7	9.5	9.3	9.1	8.9	8.6	8.4	8.2	7.9	7.7	7.2	6.5	5.5	4.1						
SHUT-OFF PSI:						274	265	257	248	239	231	222	213	205	196	187	179	161	135	110	84	49					
7S20-32	2	0	0										10.6	10.5	10.4	10.4	10.3	10.1	9.6	9.1	8.4	7.3	5.7				
		20	46.2								10.5	10.5	10.4	10.3	10.3	10.2	10.0	9.8	9.2	8.6	7.8	6.6	4.8				
		30	69.3							10.5	10.5	10.4	10.3	10.2	10.1	10.0	9.9	9.6	9.0	8.3	7.5	6.2	4.3				
		40	92.4						10.5	10.5	10.4	10.3	10.2	10.1	10.0	9.9	9.7	9.4	8.8	8.0	7.2	5.8	3.9				
		50	116						10.5	10.4	10.3	10.2	10.1	10.0	9.8	9.7	9.5	9.1	8.5	7.7	6.8	5.4	3.3				
		60	139					10.5	10.4	10.3	10.2	10.1	10.0	9.8	9.7	9.5	9.3	8.9	8.2	7.4	6.4	5.0					
SHUT-OFF PSI:							343	334	326	317	308	300	291	282	274	265	256	239	213	187	161	126	83				

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

10 GPM

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE

(5 TO 14 GPM)

PUMP OUTLET
1 1/4" NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET																											
PUMP MODEL	**HP**	**PSI**	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**	**340**	**400**	**460**	**520**	**600**	**700**	**800**	**900**	**1000**	**1100**
10S03-6	**1/3**	20	14.0	13.2	12.4	10.6	8.9	5.3																			
		30	13.2	11.8	10.4	8.4																					
		40	11.9	10.1	8.3																						
		50	9.8	7.5																							
		60	7.7	3.9																							
SHUT-OFF PSI:			64	55	47	38	29	21	12	3																	
10S05-9	**1/2**	0				14.1	13.4	12.4	11.4	10.4	9.5	8.3	6.6	3.5													
		20		13.9	13.1	12.1	11.1	10.1	9.2	7.9	5.8	2.0															
		30	13.8	13.0	12.0	11.0	10.0	9.0	7.6	5.3	1.2																
		40	12.8	11.8	10.8	9.8	8.8	7.3	4.8																		
		50	11.7	10.7	9.7	8.6	7.0	4.3																			
		60	10.5	9.5	8.4	6.7	3.7																				
SHUT-OFF PSI:			100	92	83	74	66	57	48	40	31	23	14	5													
10S07-12	**3/4**	0					14.3	13.8	13.2	12.5	11.7	11.0	10.2	9.5	8.7	7.6	6.0										
		20			14.2	13.6	12.9	12.2	11.5	10.7	10.0	9.3	8.4	7.2	5.4	2.6											
		30		14.1	13.5	12.9	12.1	11.4	10.6	9.9	9.2	8.2	7.0	5.0	2.0												
		40	14.0	13.4	12.8	12.0	11.3	10.5	9.8	9.0	8.1	6.7	4.7	1.4													
		50	13.3	12.6	11.9	11.1	10.4	9.7	8.9	7.9	6.5	4.2															
		60	12.5	11.8	11.0	10.3	9.6	8.8	7.7	6.2	3.8																
SHUT-OFF PSI:			137	129	120	111	103	94	85	77	68	59	51	42	33	25	16										
10S10-15	**1**	0							14.1	13.6	13.1	12.5	11.9	11.3	10.7	10.1	9.6	8.2	3.8								
		20					13.9	13.5	12.9	12.3	11.7	11.1	10.5	10.0	9.4	8.7	7.9	5.2									
		30				13.9	13.4	12.8	12.2	11.6	11.0	10.5	9.9	9.3	8.6	7.7	6.6	2.6									
		40		14.2	13.8	13.3	12.7	12.1	11.5	10.9	10.4	9.8	9.2	8.5	7.6	6.3	4.6										
		50	14.1	13.7	13.2	12.6	12.1	11.4	10.9	10.3	9.7	9.1	8.3	7.4	6.1	4.3	1.7										
		60	13.6	13.1	12.6	12.0	11.4	10.8	10.2	9.6	9.0	8.2	7.2	5.9	3.9												
SHUT-OFF PSI:			174	165	157	148	139	131	122	113	105	96	87	79	70	61	53	35	10								
10S15-21	**1 1/2**	0									14.2	13.9	13.6	13.3	12.9	12.5	12.0	11.2	9.9	8.5	6.3						
		20							14.1	13.9	13.5	13.1	12.7	12.3	11.9	11.5	11.0	10.2	8.9	6.9	2.9						
		30						14.1	13.8	13.5	13.1	12.7	12.3	11.8	11.4	11.0	10.5	9.7	8.3	5.7							
		40					14.1	13.8	13.4	13.0	12.6	12.2	11.8	11.3	10.9	10.5	10.1	9.2	7.5	4.1							
		50				14.0	13.7	13.3	13.0	12.5	12.1	11.7	11.3	10.8	10.4	10.0	9.6	8.7	6.5	2.0							
		60		14.2	14.0	13.6	13.3	12.9	12.5	12.1	11.6	11.2	10.8	10.4	9.9	9.5	9.1	8.0	5.1								
SHUT-OFF PSI:				237	229	220	211	203	194	185	177	168	159	151	142	133	125	107	81	55	29						
10S20-27	**2**	0												14.1	13.9	13.7	13.4	12.8	11.8	10.8	9.8	8.3	4.7				
		20										14.1	13.8	13.6	13.3	13.0	12.7	12.0	11.0	10.0	9.0	7.1	1.5				
		30									14.0	13.8	13.5	13.3	12.9	12.6	12.3	11.6	10.6	9.7	8.6	6.2					
		40							14.2	14.0	13.8	13.5	13.2	12.9	12.6	12.2	11.9	11.2	10.3	9.3	8.1	5.2					
		50						14.2	14.0	13.7	13.5	13.2	12.8	12.5	12.2	11.9	11.5	10.9	9.9	8.9	7.4	3.8					
		60					14.1	13.9	13.7	13.4	13.1	12.8	12.5	12.1	11.8	11.5	11.1	10.5	9.5	8.4	6.6	2.1					
SHUT-OFF PSI:							285	276	268	259	250	242	233	224	216	207	198	181	155	129	103	68	25				
10S30-34	**3**	0																13.8	13.2	12.5	11.9	10.9	9.6	7.9	4.8		
		20														13.9	13.7	13.3	12.7	12.0	11.3	10.3	8.9	6.7	2.7		
		30													13.9	13.7	13.5	13.1	12.4	11.7	11.0	10.0	8.5	6.0	1.3		
		40											14.0	13.8	13.7	13.5	13.3	12.8	12.2	11.5	10.8	9.7	8.0	5.1			
		50										14.0	13.8	13.6	13.4	13.2	13.0	12.6	11.9	11.2	10.5	9.4	7.5	4.2			
		60										13.8	13.6	13.4	13.2	13.0	12.8	12.3	11.6	10.9	10.2	9.0	6.9	3.1			
SHUT-OFF PSI:												332	324	315	306	298	289	272	246	220	194	159	116	73	29		

See 10S performance curves for higher head models.
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

16S EASY SELECTION CHART

16 GPM

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE
(10 TO 20 GPM)

PUMP OUTLET
1 1/4 " NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

PUMP MODEL	HP	PSI	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
		20	20.3	18.2	14.1	10.0	5.0																				
16S05-5	1/2	30	17.3	14.4	8.0	1.6																					
		40	12.7	8.0	4.0																						
		50	6.5																								
		60	2.9																								
SHUT-OFF PSI:			58	49	40	32	23	14																			
		0					20.5	19.2	17.5	15.8	12.8	9.8	5.2														
		20			20.1	18.8	16.9	15.2	11.8	8.5	4.3																
16S07-8	3/4	30	21.2	19.9	18.4	16.9	14.3	11.8	7.5	3.2	1.6																
		40	19.7	18.3	16.3	14.3	10.8	7.2	3.6																		
		50	17.9	16.3	13.5	10.7	6.2	1.7																			
		60	15.7	13.5	9.6	5.8	2.9																				
SHUT-OFF PSI:			97	88	80	71	62	54	45	36	28	19	10														
		0						20.8	19.8	18.8	17.3	15.9	13.7	11.4	8.0	4.7											
		20				20.5	19.4	18.3	16.8	15.3	12.9	10.5	7.0	3.5	1.8												
16S10-10	1	30			20.3	19.3	18.1	16.8	14.8	12.8	9.8	6.7	3.3														
		40		20.2	19.1	18.0	16.4	14.8	12.2	9.6	5.9	2.3															
		50	20.0	19.0	17.7	16.3	14.2	12.0	8.8	5.6	2.8																
		60	18.8	17.6	15.8	14.1	11.3	8.6	4.8																		
SHUT-OFF PSI:			123	115	106	97	89	80	71	63	54	45	37	28	19	11											
		0								21.0	20.3	19.6	18.8	18.0	16.9	15.8	14.3	10.7	3.3								
		20							20.1	19.3	18.5	17.7	16.6	15.4	13.8	12.2	10.0	5.1									
16S15-14	1 1/2	30					20.7	20.0	19.2	18.4	17.4	16.5	15.1	13.7	11.8	9.8	7.3	2.4									
		40				20.6	19.8	19.1	18.3	17.4	16.0	15.0	13.3	11.6	9.3	7.0	4.3										
		50			20.4	19.8	18.9	18.2	17.2	16.1	14.7	13.2	11.2	9.1	6.5	3.9	2.0										
		60		20.3	19.6	18.8	18.0	17.1	15.8	14.5	12.8	11.0	8.6	6.3	3.4												
SHUT-OFF PSI:				167	158	149	141	132	123	115	106	97	89	80	71	63	54	37	28								
		0										21.2	20.6	20.0	19.5	18.9	18.2	16.7	13.5	8.8	2.7						
		20									20.4	19.8	19.3	18.7	18.0	17.3	16.4	14.3	10.0	4.2							
16S20-18	2	30								20.3	19.8	19.2	18.6	17.9	17.2	16.3	15.3	12.8	7.9	1.9							
		40							20.3	19.7	19.1	18.5	17.8	17.1	16.1	15.2	13.9	11.1	5.7								
		50						20.2	19.6	19.0	18.3	17.7	16.8	16.0	14.9	13.8	12.3	9.2	3.2								
		60					20.1	19.5	18.9	18.3	17.5	16.8	15.8	14.8	13.5	12.3	10.6	7.0									
SHUT-OFF PSI:							194	186	177	168	160	151	142	134	125	116	108	90	65	39	13						
		0																19.6	18.3	16.5	14.2	9.8	2.1				
		20													20.3	19.9	19.5	18.6	17.0	14.8	11.8	6.5					
16S30-24	3	30												20.3	19.8	19.4	19.0	18.0	16.3	13.7	10.4	4.7					
		40											20.2	19.8	19.3	18.9	18.4	17.3	15.3	12.5	8.9	2.8					
		50										20.2	19.8	19.3	18.8	18.3	17.8	16.7	14.3	11.3	7.3						
		60									20.1	19.7	19.2	18.8	18.3	17.8	17.2	15.8	13.3	9.8	5.5						
SHUT-OFF PSI:											239	230	221	213	204	195	187	169	143	117	91	57	13				
		0																			21.5	20.4	18.7	16.5	13.4	8.9	2.1
		20																			20.9	19.6	17.7	15.2	11.5	6.1	
16S50-38	5	30																		21.4	20.5	19.2	17.2	14.5	10.5	4.5	
		40																		21.1	20.2	18.8	16.7	13.7	9.3	2.7	
		50																	21.6	20.7	19.8	18.4	16.1	12.8	8.0	0.8	
		60																	21.3	20.4	19.4	17.9	15.4	11.9	6.6		
SHUT-OFF PSI:																			314	288	262	227	184	141	98	54	11

See 16S performance curves for higher head models.
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

25 GPM

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE

(18 TO 32 GPM)

PUMP OUTLET

1 1/2" NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

PUMP MODEL	HP	PSI	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
25S05-3	1/2	20	18.6	6.5	3.3																						
		30	10.5																								
		40																									
		50																									
		60																									
SHUT-OFF PSI:			31	22	13	5																					
25S07-5	3/4	0			34.5	29.8	23.9	18.1																			
		20	32.9	28.6	21.8	15.1	7.5																				
		30	27.1	22.5	12.3	2.0																					
		40	19.5	11.8	5.8																						
		50	10.1																								
		60	4.1																								
SHUT-OFF PSI:			57	48	39	31	22	13																			
25S10-7	1	0					31.3	28.5	24.3	20.2	12.7	5.1															
		20		33.2	30.3	27.6	22.9	18.3	10.4	2.5	1.3																
		30	33.0	29.9	26.5	23.1	13.0	9.6	4.8																		
		40	29.4	26.6	21.3	16.2	8.2																				
		50	25.3	21.5	14.3	7.0	3.5																				
		60	19.7	13.9	7.0																						
SHUT-OFF PSI:			83	74	65	57	48	39	31	22	13	5															
25S15-9	1 1/2	0						32.2	30.0	27.9	24.8	21.6	16.3	10.8													
		20				31.5	29.3	27.2	23.7	20.3	14.5	8.8	4.4														
		30			31.3	29.1	26.4	23.7	18.9	14.2	7.8	1.5															
		40		30.8	28.6	26.3	22.6	18.8	12.8	6.8	3.4																
		50	30.6	28.4	25.5	22.5	17.4	12.3	6.2																		
		60	27.8	25.5	21.3	17.2	11.0	4.8	2.4																		
SHUT-OFF PSI:			109	100	91	83	74	65	57	48	39	31	22	13													
25S20-11	2	0						33.1	31.1	29.3	27.6	25.1	22.5	18.5	14.5	9.3											
		20					32.5	30.6	28.8	27.0	24.3	21.5	17.3	13.0	7.8	2.5											
		30				32.0	30.3	28.7	26.4	24.2	20.6	16.9	12.0	7.0	3.5												
		40			31.8	30.1	28.2	26.3	23.3	20.4	15.9	11.4	6.3														
		50		31.5	29.8	28.1	25.7	23.3	19.4	15.6	10.4	5.3	2.7														
		60	31.3	29.6	27.6	25.6	22.4	19.3	14.5	9.8	4.9																
SHUT-OFF PSI:			135	126	118	109	100	92	83	74	66	57	48	40	31	23											
25S30-15	3	0										32.3	31.0	29.8	28.4	27.1	25.2	20.7									
		20								31.8	30.6	29.3	28.0	26.6	24.6	22.7	19.8	13.5									
		30						33.0	31.7	30.4	29.2	27.8	26.2	24.5	22.1	19.7	16.4	9.3									
		40					32.8	31.5	30.3	29.0	27.5	26.0	24.0	21.9	19.0	16.1	12.4	4.9									
		50				32.6	31.3	30.0	28.7	27.4	25.7	23.8	21.3	18.8	15.3	12.0	8.2	2.2									
		60			32.4	31.1	29.8	28.6	27.0	25.5	23.3	21.2	18.1	15.0	11.3	7.6	3.8										
SHUT-OFF PSI:					170	161	152	144	135	126	118	109	100	92	83	74	66	48									
25S50-26	5	0																32.5	30.3	28.0	25.3	19.9	10.2				
		20															32.3	30.8	28.6	25.9	22.5	15.8	5.0				
		30														32.1	31.3	29.9	27.7	24.7	20.8	13.5	2.5				
		40													32.0	31.3	30.5	29.1	26.7	23.3	18.9	11.0					
		50											32.7	31.8	31.2	30.4	29.7	28.2	25.5	21.8	16.8	8.5					
		60										32.5	31.8	31.0	30.3	29.6	28.8	27.3	24.3	20.0	14.6	5.8					
SHUT-OFF PSI:												253	245	236	227	219	210	193	167	141	115	80	37				

See 25S performance curves for higher head models.
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

40S EASY SELECTION CHART

40 GPM

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE

(24 TO 55 GPM)

PUMP OUTLET
2 " NPT

				DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET																								
PUMP MODEL	**HP**	**PSI**		**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**	**340**	**400**	**460**	**520**	**600**	**700**	**800**	**900**	**1000**	**1100**
40S10-3	**1**	20	46.2	33.0																								
		30	69.3																									
		40	92.4																									
		50	116																									
		60	139																									
SHUT-OFF PSI:			0	28	19	11	2																					
40S15-5	**1 1/2**	0	0				52.0	41.0	24.0																			
		20	46.2	57.0	50.0	37.0	18.0																					
		30	69.3	48.0	34.0	15.0																						
		40	92.4	31.0	11.0																							
		50	116	7.0																								
		60	139																									
SHUT-OFF PSI:			0	52	44	35	26	18	9																			
40S20-7	**2**	0	0					54.0	49.0	40.0	29.0	15.0																
		20	46.2			53.0	46.0	37.0	25.0	10.0																		
		30	69.3		52.0	45.0	35.0	23.0	8.0																			
		40	92.4	51.0	44.0	33.0	21.0	5.0																				
		50	116	42.0	32.0	18.0	2.0																					
		60	139	30.0	16.0																							
SHUT-OFF PSI:			0	77	68	59	51	42	33	25	16	7																
40S30-9	**3**	0	0							53.0	47.0	41.0	32.0	22.0														
		20	46.2					51.0	45.0	38.0	29.0	19.0																
		30	69.3				50.0	44.0	37.0	28.0	17.0																	
		40	92.4		54.0	50.0	43.0	35.0	26.0	15.0																		
		50	116	54.0	49.0	42.0	34.0	24.0	13.0																			
		60	139	48.0	41.0	33.0	23.0	11.0																				
SHUT-OFF PSI:			0	102	94	85	76	68	59	50	42	33	24	16	7													
40S50-12	**5**	0	0									53.0	49.0	44.0	39.0	32.0	25.0	16.0										
		20	46.2							52.0	48.0	43.0	37.0	30.0	22.0	13.0												
		30	69.3						51.0	47.0	42.0	36.0	29.0	21.0	12.0													
		40	92.4					51.0	46.0	41.0	35.0	28.0	20.0	11.0														
		50	116			54.0	50.0	45.0	40.0	34.0	26.0	18.0	9.0															
		60	139		53.0	49.0	45.0	39.0	33.0	25.0	17.0	8.0																
SHUT-OFF PSI:			0		130	122	113	104	96	87	78	70	61	52	44	35	26	18										
40S50-15	**5**	0	0											52.0	49.0	46.0	42.0	37.0	26.0									
		20	46.2									51.0	48.0	45.0	40.0	35.0	30.0	24.0										
		30	69.3								51.0	48.0	44.0	40.0	35.0	29.0	23.0	16.0										
		40	92.4							51.0	47.0	43.0	39.0	34.0	28.0	21.0	14.0											
		50	116						50.0	47.0	43.0	38.0	33.0	27.0	20.0	13.0												
		60	139					50.0	46.0	42.0	37.0	32.0	26.0	19.0	12.0													
SHUT-OFF PSI:			0					141	132	124	115	107	98	89	81	72	63	55	37	11								
40S75-21	**7 1/2**	0	0																49.0	41.0	29.0	15.0						
		20	46.2													53.0	51.0	48.0	43.0	32.0	19.0							
		30	69.3												52.0	50.0	48.0	45.0	39.0	27.0	13.0							
		40	92.4											52.0	50.0	48.0	45.0	42.0	35.0	22.0	6.0							
		50	116										52.0	50.0	47.0	44.0	41.0	38.0	30.0	16.0								
		60	139									51.0	49.0	47.0	44.0	41.0	38.0	34.0	25.0	10.0								
SHUT-OFF PSI:			0									181	172	163	155	146	137	129	111	85	59	33						
40S75-25	**7 1/2**	0	0																	51.0	45.0	37.0	23.0					
		20	46.2																52.0	47.0	39.0	29.0	14.0					
		30	69.3															54.0	50.0	44.0	35.0	25.0						
		40	92.4														54.0	52.0	48.0	41.0	32.0	21.0						
		50	116													53.0	52.0	50.0	45.0	38.0	28.0							
		60	139												53.0	51.0	49.0	47.0	43.0	34.0	24.0							
SHUT-OFF PSI:			0												203	194	186	177	160	134	108	82	47					
***40S100-30** **40S100-30**	**10**	0	0																		53.0	49.0	41.0	27.0				
		20	46.2																	54.0	50.0	44.0	35.0	20.0				
		30	69.3																	52.0	48.0	42.0	32.0	16.0				
		40	92.4																	51.0	46.0	39.0	28.0	12.0				
		50	116																	49.0	43.0	36.0	25.0	8.0				
		60	139																52.0	47.0	41.0	33.0	21.0					
SHUT-OFF PSI:																			222	196	170	144	110	66	23			

*** 6" Motor**

See 40S performance curves for higher head models.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

60 GPM

SELECTION CHARTS FLOW RANGE PUMP OUTLET

(Ratings are in GALLONS PER MINUTE-GPM) (40 TO 75 GPM) 2 " NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

PUMP MODEL	HP	PSI	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
60S20-4	2	20	72.3	64.5	38.6	12.7	6.3																				
		30	58.6	44.9	22.4																						
		40	30.4																								
		50	17.9																								
		60																									
SHUT-OFF PSI:			46	37	29	20	11	3																			
60S30-5	3	0				74.8	66.8	58.8	34.3																		
		20	77.8	72.9	63.8	54.8	27.4																				
		30	76.0	64.3	47.3	30.0	15.0																				
		40	60.4	49.9	25.0																						
		50	40.4	19.4	9.8																						
		60	22.0																								
SHUT-OFF PSI:			60	51	42	34	25	16	8																		
60S50-7	5	0					77.5	73.8	68.4	63.1	52.2	41.3															
		20			76.3	72.4	66.6	61.1	48.3	35.8	17.9																
		30		76.0	71.3	66.5	57.8	49.2	24.6																		
		40	75.1	71.0	64.6	58.2	43.8	29.4	14.8																		
		50	69.7	64.6	54.8	44.9	22.5																				
		60	62.3	55.3	38.7	22.0	11.0																				
SHUT-OFF PSI:			88	80	71	62	54	45	36	28	19	10															
60S50-9	5	0							74.8	71.7	67.3	63.0	55.6	48.2	32.8	17.3											
		20					73.8	70.5	65.9	61.3	53.0	44.8	27.5	10.2	5.1												
		30			76.5	73.5	69.6	65.7	59.4	53.2	40.7	28.1	14.0														
		40		76.2	72.8	69.3	64.3	59.4	50.3	41.0	20.5																
		50	75.5	72.5	68.3	64.2	57.3	50.4	36.3	22.2	11.1																
		60	71.7	68.1	62.7	57.3	47.1	36.8	18.4																		
SHUT-OFF PSI:			115	106	98	89	81	72	63	55	46	37	29	20	11	3											
*60S75-13	7 1/2	0									77.3	75.4	73.1	70.7	67.8	64.8	60.7	50.0	21.5								
		20							76.8	74.8	72.3	69.9	66.8	63.8	59.3	55.0	47.9	28.9									
		30						76.6	74.3	72.1	69.3	66.6	62.8	59.2	53.3	47.7	38.2	14.3									
		40					76.2	74.1	71.6	69.1	65.8	62.7	57.9	53.3	45.6	37.9	25.0	6.0									
		50				75.9	73.6	71.3	68.4	65.6	61.7	57.7	51.6	45.4	35.0	24.7	12.3										
		60			75.5	73.3	70.8	68.2	64.8	61.4	56.3	51.3	43.1	34.8	20.8	6.8											
SHUT-OFF PSI:					152	143	134	126	117	108	100	91	82	74	65	56	48	30	4								
*60S100-18	10	0													76.5	75.0	73.3	69.8	63.1	52.6	35.8						
		20											76.1	74.6	72.8	71.2	69.2	64.7	55.8	40.0	14.2						
		30										75.9	74.3	72.7	70.8	68.9	66.7	61.6	50.9	31.5							
		40									75.7	74.1	72.3	70.6	68.5	66.5	63.9	58.0	45.0	20.7							
		50								75.4	73.8	72.1	70.2	68.3	66.0	63.7	60.7	53.6	37.5	10.0							
		60							75.2	73.6	71.8	70.0	67.8	65.8	63.1	60.5	56.8	48.2	28.3								
SHUT-OFF PSI:									186	177	169	160	152	143	134	126	117	100	74	46	22						

*** 6" Motor**

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

75S EASY SELECTION CHART

75 GPM

SELECTION CHARTS
(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE
(45 TO 95 GPM)

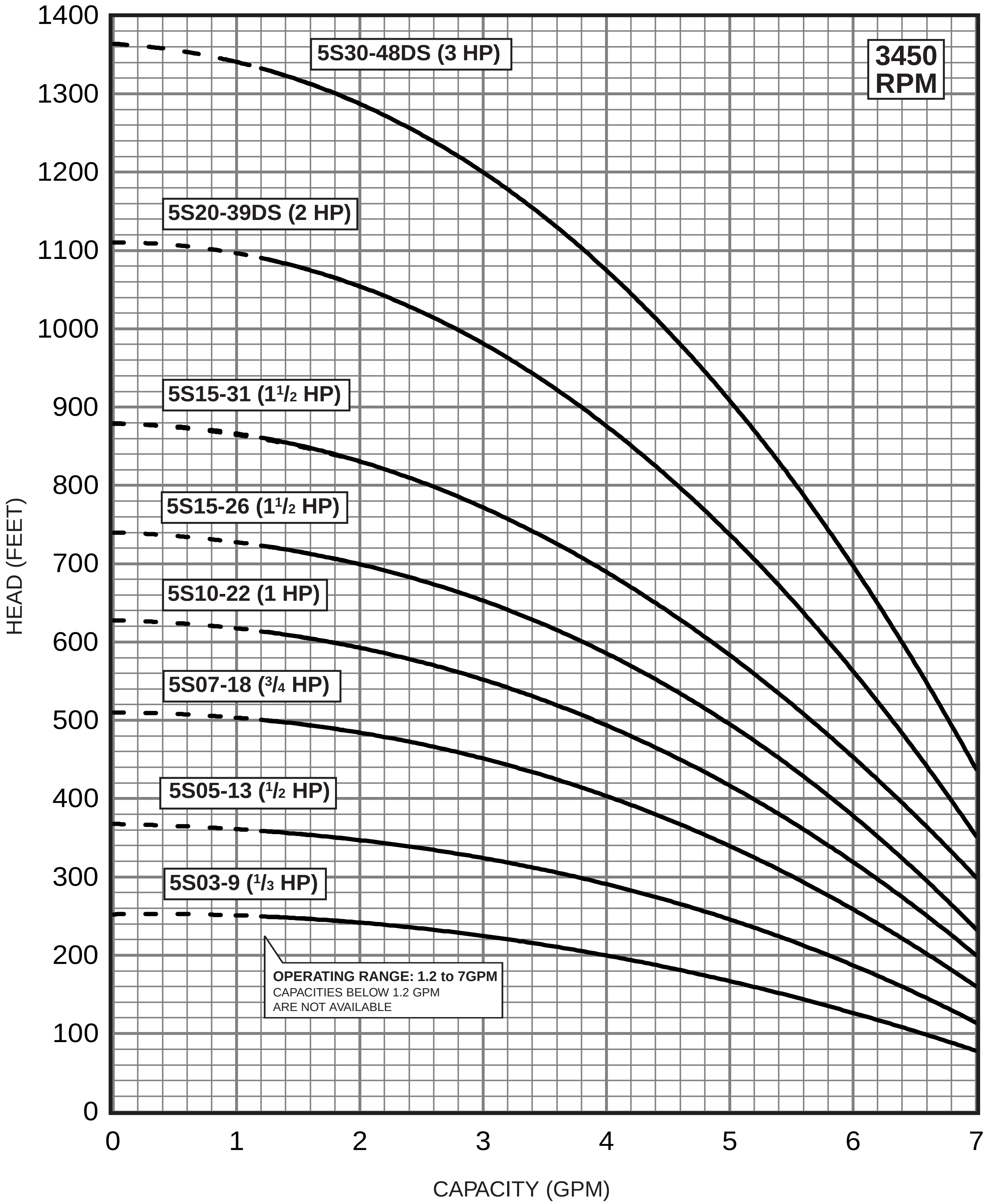
PUMP OUTLET
2" NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

PUMP MODEL	HP	PSI	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
75S20-3	**2**	20	69.6	45.8	22.9																						
		30	36.2																								
		40	12.4																								
		50																									
		60																									
SHUT-OFF PSI:			32	23	14	6																					
75S30-5	**3**	0			89.8	90.2	78.8	67.6																			
		20	96.3	86.8	74.8	62.9	31.5																				
		30	85.8	74.2	51.8	29.5	14.8																				
		40	70.2	57.1	28.6																						
		50	35.3																								
		60	24.2																								
SHUT-OFF PSI:			58	49	41	32	23	15																			
75S50-8	**5**	0						93.3	86.5	79.6	72.0	64.5	46.9	29.4													
		20			97.4	91.3	84.7	77.5	69.4	61.3	40.3	19.4	9.8														
		30		96.9	90.1	83.3	76.3	69.3	56.3	43.1	21.6																
		40	95.5	89.1	82.3	75.4	66.5	57.5	28.8																		
		50	88.0	81.2	73.9	66.7	51.2	35.8	17.9																		
		60	80.2	73.3	63.2	53.0	26.5																				
SHUT-OFF PSI:			98	90	81	72	64	55	46	38	29	20	12	3													
***75S75-11**	**7 1/2**	0								97.8	93.3	88.8	84.3	79.8	75.1	70.4	63.7	43.4									
		20						96.5	92.0	87.4	82.9	78.3	73.5	68.8	61.4	54.0	38.8	11.8									
		30					95.7	91.3	86.8	82.2	77.6	73.1	67.3	61.4	50.3	39.3	19.7										
		40				95.2	90.6	86.0	81.5	77.0	72.0	67.0	58.9	50.8	33.5	16.3	8.2										
		50			94.3	89.9	85.3	80.8	76.2	71.6	65.3	59.0	46.6	34.2	17.1												
		60	97.9	93.8	89.2	84.6	80.1	75.6	70.3	65.2	56.1	47.0	23.5														
SHUT-OFF PSI:			151	142	133	125	116	107	99	90	81	73	64	55	47	38	29	12									
***75S100-15**	**10**	0											96.7	93.4	90.0	86.5	83.2	76.3	64.7	40.9							
		20									95.7	92.4	88.9	85.5	82.1	78.7	75.2	67.4	49.3	12.5							
		30								95.3	91.8	88.4	85.0	81.5	78.2	74.8	70.9	61.6	37.1								
		40						98.0	94.7	91.3	87.8	84.4	81.0	77.7	74.1	70.6	66.0	54.0	19.9								
		50					97.3	94.3	90.8	87.3	83.9	80.5	77.1	73.7	69.7	65.8	59.8	43.5									
		60				97.0	93.7	90.3	86.8	83.3	80.0	76.6	73.0	69.3	64.5	59.6	51.5	21.7									
SHUT-OFF PSI:						178	170	161	152	144	135	126	118	109	100	92	83	66	40	14							

*** 6" Motor** Performance is the same at Best Efficiency Point only, consult factory for actual performance.
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

FLOW RANGE: 1.2 - 7 GPM **OUTLET SIZE: 1" NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 3450 RPM.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 2 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES					APPROX. SHIP WT.
					A	B	C	D	E	
5S03-9	A	1/3	4"	1" NPT	22.3	8.8	13.5	3.8	3.9	27
5S05-13	A	1/2	4"	1" NPT	26.4	9.5	16.9	3.8	3.9	31
5S07-18	A	3/4	4"	1" NPT	31.7	10.7	21.0	3.8	3.9	34
5S10-22	A	1	4"	1" NPT	36.1	11.8	24.3	3.8	3.9	42
5S15-26	A	1 1/2	4"	1" NPT	41.2	13.6	27.6	3.8	3.9	46
5S15-31	A	1 1/2	4"	1" NPT	47.1	13.6	33.5	3.8	3.9	58
5S20-39DS	A	2	4"	1" NPT	55.2	15.1	40.1	3.8	3.9	65
5S30-48DS	A	3	4"	1" NPT	70.0	20.6	45.8	3.8	3.9	90

NOTES: All models suitable for use in 4" wells.
Weights include pump end with motor in lbs.

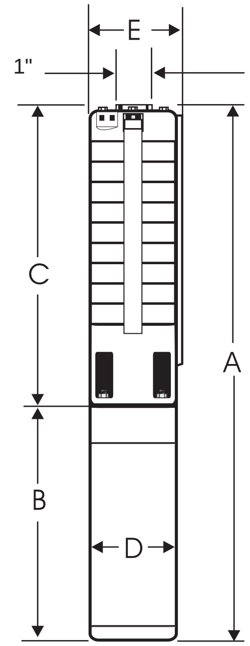


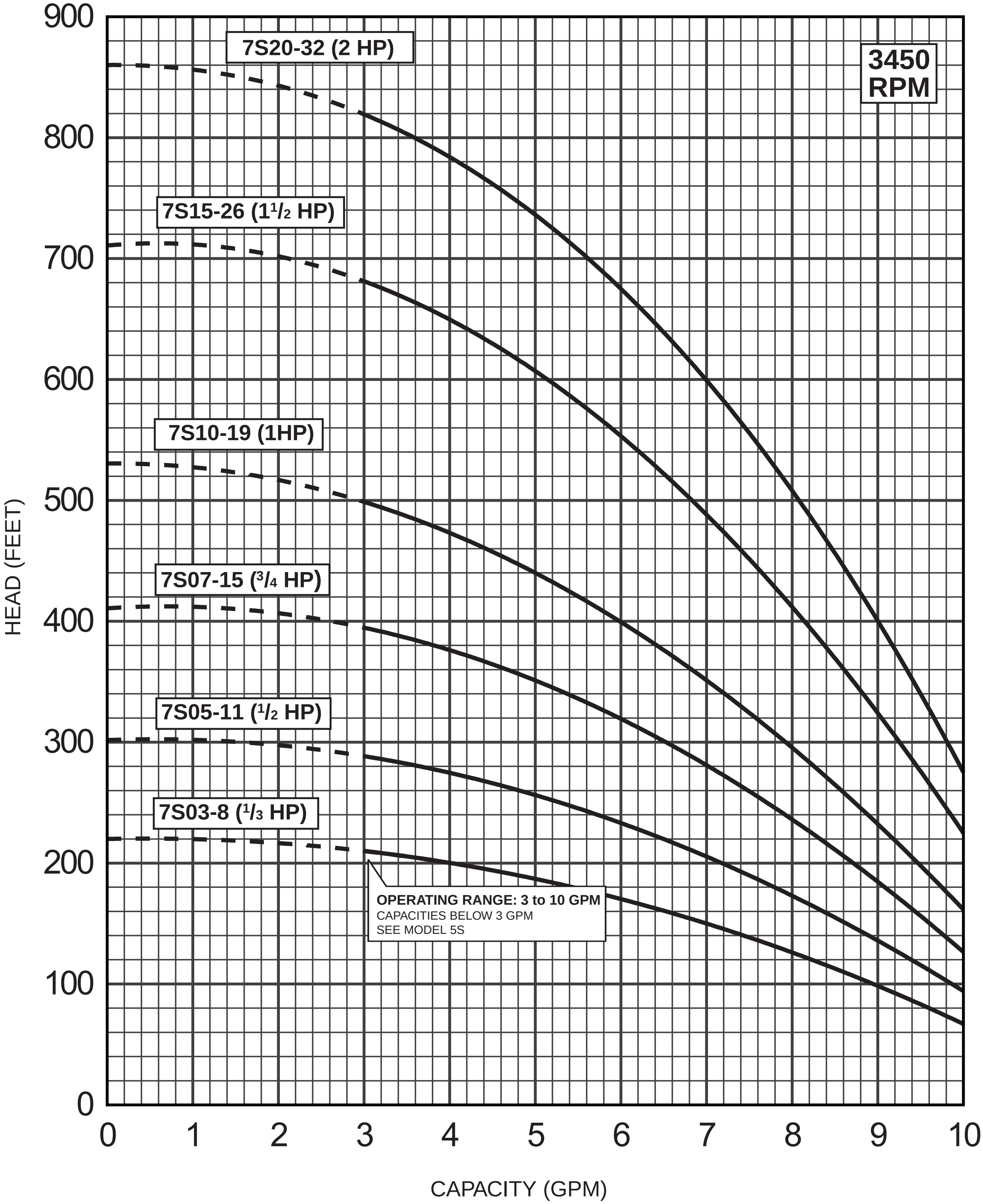
Fig. A

MATERIALS OF CONSTRUCTION

COMPONENT	SPLINED SHAFT (9-26 Stgs.)	CYLINDRICAL SHAFT (31-48 Stgs.)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel
Pump Shaft	304 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	316 Stainless Steel
Coupling	329/420/431 Stainless Steel	329/420/431 Stainless Steel
Check Valve Seat	NBR/304 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR/304 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/PBT (Valox®)	NBR/PPS (Ryton®)
Intermediate Bearings	NBR	304 Stainless Steel
Shaft Washer	Not Required	LCP (Vectra®)
Split Cone	Not Required	304 Stainless Steel
Split Cone Nut	Not Required	316 Stainless Steel

NOTES: Specifications subject to change without notice.
Valox® is a registered trademark of General Electric Co.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
Ryton® is a registered trademark of Phillips 66.

FLOW RANGE: 3 -10 GPM **OUTLET SIZE: 1" NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 3450 RPM.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 2 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
7S03-8	A	1/3	4"	1" NPT	21.5	8.8	12.7	3.8	3.9	27
7S05-11	A	1/2	4"	1" NPT	24.7	9.5	15.2	3.8	3.9	30
7S07-15	A	3/4	4"	1" NPT	29.2	10.7	18.5	3.8	3.9	33
7S10-19	A	1	4"	1" NPT	33.6	11.8	21.8	3.8	3.9	36
7S15-26	A	1 1/2	4"	1" NPT	41.2	13.6	27.6	3.8	3.9	46
7S20-32	A	2	4"	1" NPT	48.5	14.0	34.5	3.8	3.9	59

NOTES: All models suitable for use in 4" wells.
Weights include pump end with motor in lbs.

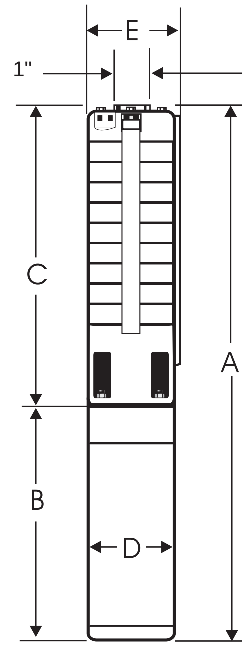


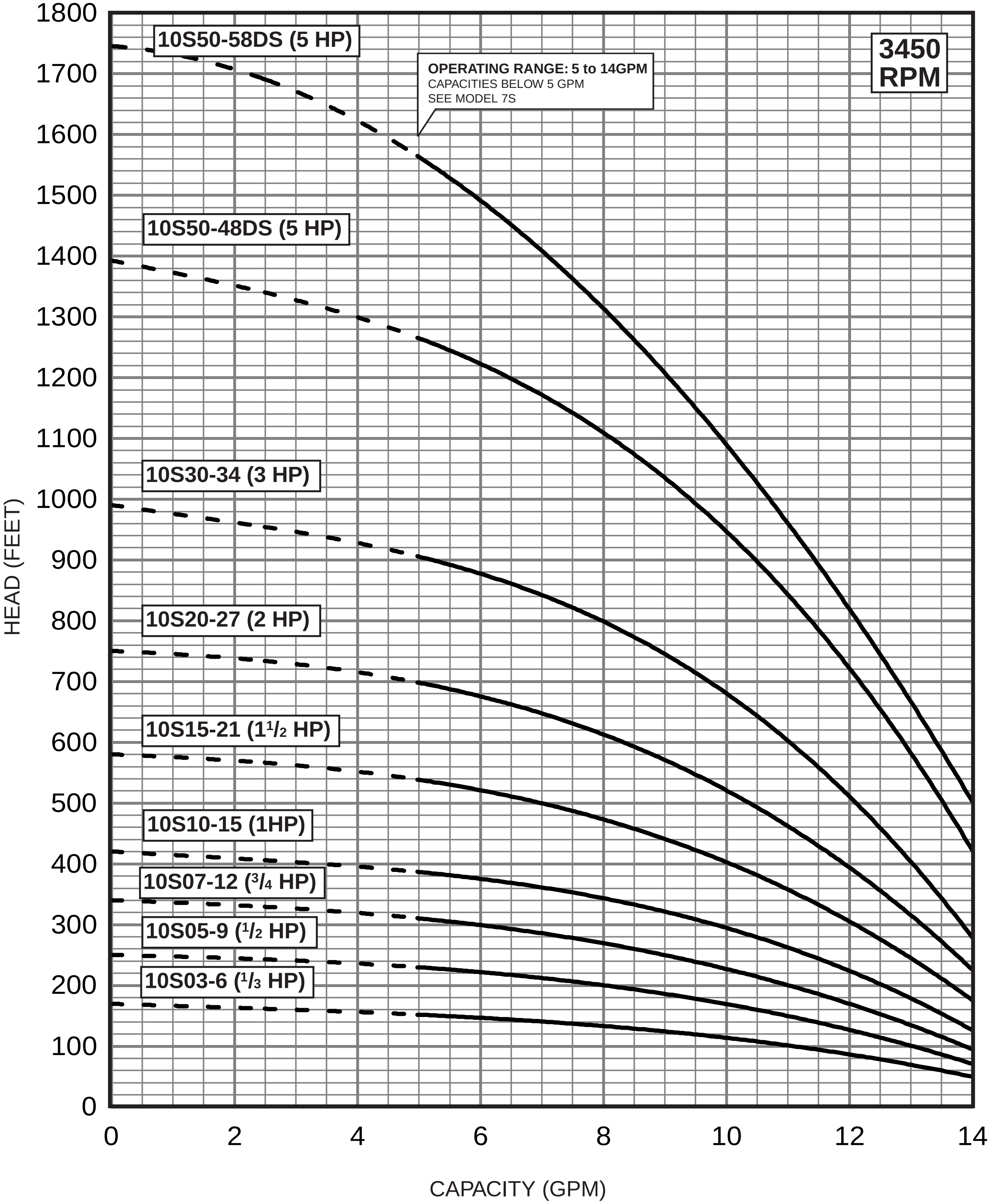
Fig. A

MATERIALS OF CONSTRUCTION

COMPONENT	SPLINE SHAFT
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel
Impeller	304 Stainless Steel
Suction Interconnector	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Pump Shaft	304 Stainless Steel
Straps	304 Stainless Steel
Cable Guard	304 Stainless Steel
Priming Inducer	304 Stainless Steel
Coupling	316/431 Stainless Steel
Check Valve Seat	NBR/304 Stainless Steel
Top Bearing	NBR
Impeller Seal Ring	NBR/PBT (Valox ®)
Intermediate Bearings	NBR

NOTES: Specifications subject to change without notice.
Valox® is a registered trademark of General Electric Co.

FLOW RANGE: 5 -14 GPM **OUTLET SIZE: 1¼ " NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 3450 RPM.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 2 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
10S03-6	A	1/3	4"	1 1/4" NPT	19.9	8.8	11.1	3.8	3.9	26
10S05-9	A	1/2	4"	1 1/4" NPT	23.0	9.5	13.5	3.8	3.9	29
10S07-12	A	3/4	4"	1 1/4" NPT	26.7	10.7	16.0	3.8	3.9	32
10S10-15	A	1	4"	1 1/4" NPT	30.3	11.8	18.5	3.8	3.9	34
10S15-21	A	1 1/2	4"	1 1/4" NPT	37.1	13.6	23.5	3.8	3.9	44
10S20-27	A	2	4"	1 1/4" NPT	43.5	15.1	28.4	3.8	3.9	49
10S30-34	A	3	4"	1 1/4" NPT	54.7	20.6	34.1	3.8	3.9	83
10S50-48DS	A	5	4"	1 1/4" NPT	71.3	23.6	47.7	3.8	3.9	115
10S50-58DS*	B	5	4"	1 1/4" MPT	88.2	23.6	64.5	3.8	4.3	142

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs.
* Built into sleeve 1¹/₄" MPT discharge, 5" min. well dia.

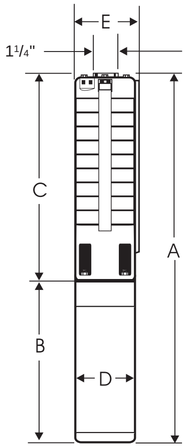


Fig. A

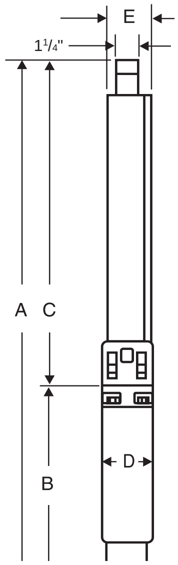


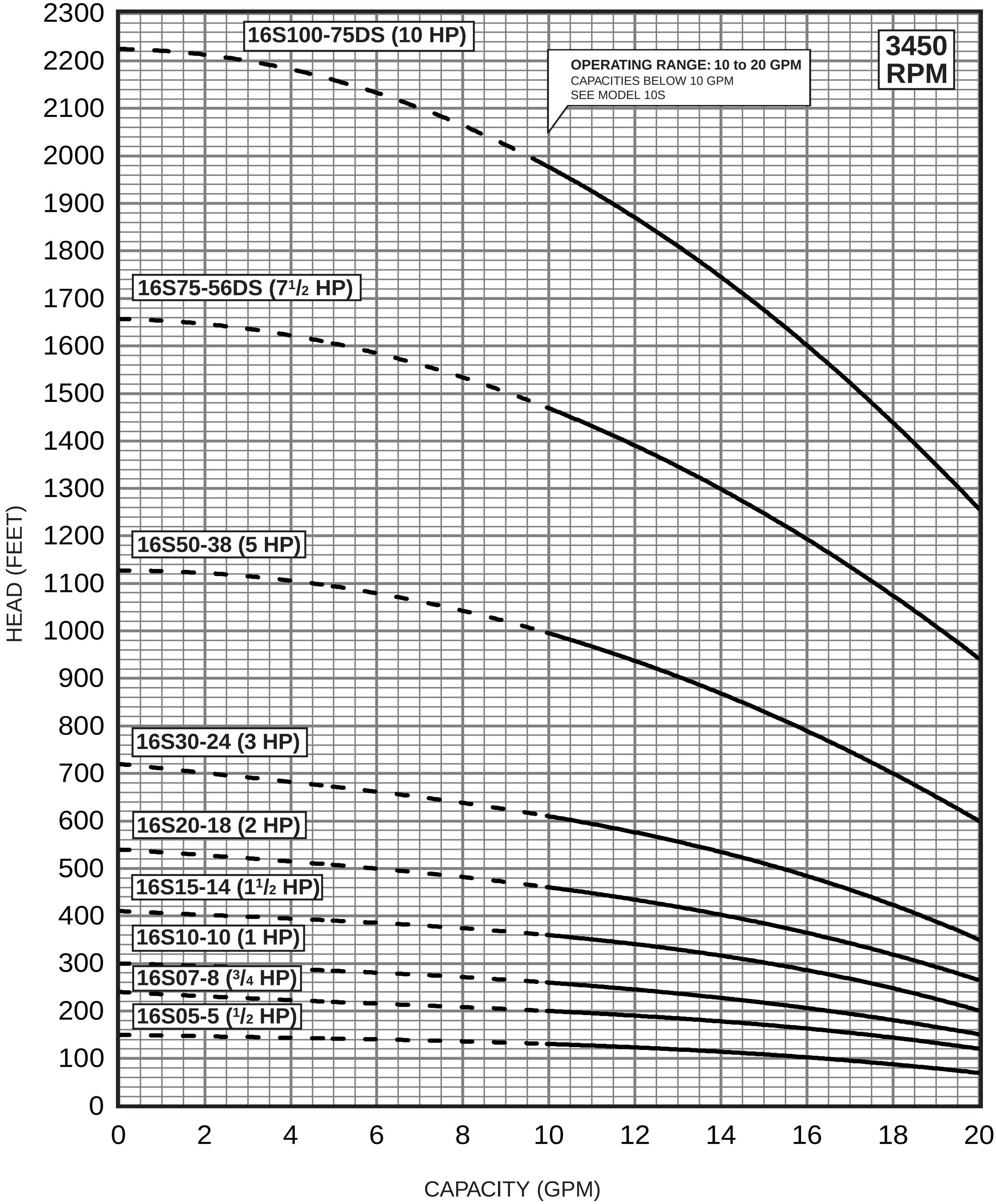
Fig. B

MATERIALS OF CONSTRUCTION

COMPONENT	SPLINED SHAFT (6-27 Stgs.)	CYLINDRICAL SHAFT (34-48 Stgs.)	DEEP SET (58 Stgs.)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Pump Shaft	304 Stainless Steel	431 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Coupling	316/431 Stainless Steel	316/431 Stainless Steel	316/431 Stainless Steel
Check Valve Seat	NBR/304 Stainless Steel	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/PBT (Valox®)	NBR/PPS (Ryton®)	NBR/PPS (Ryton®)
Intermediate Bearings	NBR	304 Stainless Steel	NBR/316 Stainless Steel
Shaft Washer	Not Required	LCP (Vectra®)	LCP (Vectra®)
Split Cone	Not Required	304 Stainless Steel	304 Stainless Steel
Split Cone Nut	Not Required	316 Stainless Steel	304 Stainless Steel
Sleeve	Not Required	Not Required	316 Stainless Steel
Sleeve Flange	Not Required	Not Required	Zincless Bronze*

NOTES: Specifications subject to change without notice.
Valox® is a registered trademark of General Electric Co.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
Ryton® is a registered trademark of Phillips 66.
*** Stainless Steel option available.**

FLOW RANGE: 10 -20 GPM **OUTLET SIZE: 1$^{1}/_{4}$ " NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, .5 -5 HP/3450 RPM.
6" MOTOR STANDARD,7.5 -10HP/3450 RPM.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 2 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
16S05-5	A	1/2	4"	1 1/4" NPT	19.7	9.5	10.2	3.8	3.9	27
16S07-8	A	3/4	4"	1 1/4" NPT	23.4	10.7	12.7	3.8	3.9	29
16S10-10	A	1	4"	1 1/4" NPT	26.2	11.8	14.4	3.8	3.9	32
16S15-14	A	1 1/2	4"	1 1/4" NPT	32.8	15.1	17.7	3.8	3.9	36
16S20-18	A	2	4"	1 1/4" NPT	36.0	15.1	20.9	3.8	3.9	40
16S30-24	A	3	4"	1 1/4" NPT	46.5	20.6	25.9	3.8	3.9	64
16S50-38	A	5	4"	1 1/4" NPT	61.1	23.6	37.5	3.8	3.9	94
16S75-56DS*	B	7 1/2	6"	1 1/4" MPT	93.0	24.2	68.8	5.4	4.6	220
16S100-75DS*	B	10	6"	1 1/4" MPT	109.9	25.4	84.5	5.4	4.6	245

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs..
* Built into sleeve 1¼" MPT discharge, 6" min. well dia.

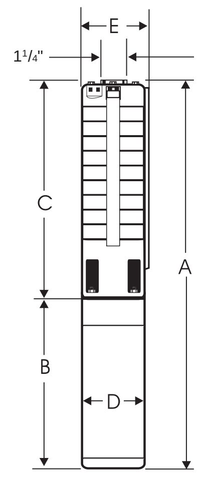


Fig. A

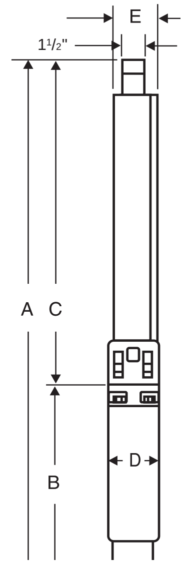


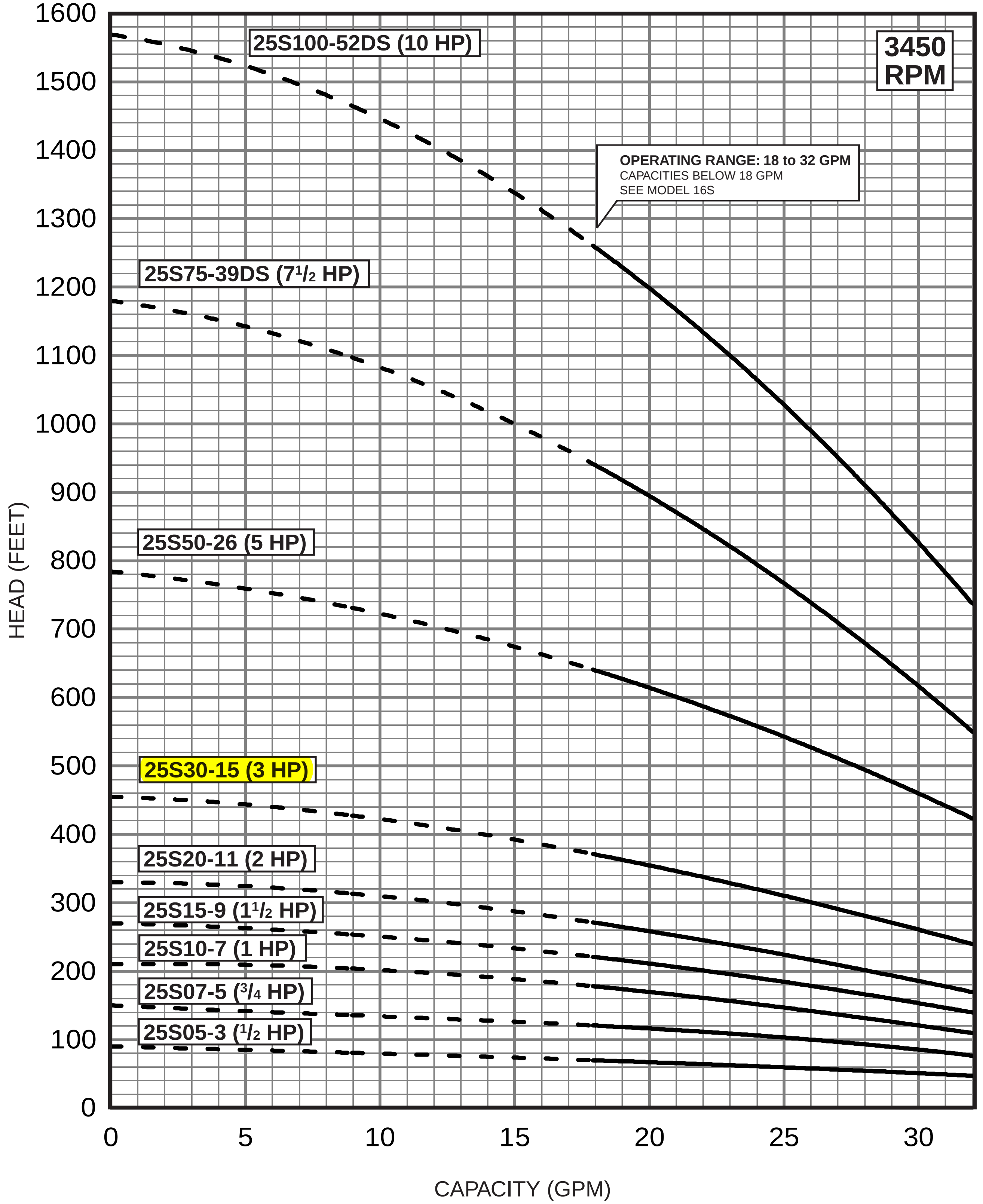
Fig. B

MATERIALS OF CONSTRUCTION

COMPONENT	SPLINED SHAFT (5-24 Stgs.)	CYLINDRICAL SHAFT (38 Stgs.)	DEEP SET (56-75 Stgs)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Pump Shaft	304 Stainless Steel	431 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Coupling	316/431 Stainless Steel	316/431 Stainless Steel	329/416 Stainless Steel**
Check Valve Seat	NBR/304 Stainless Steel	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/PBT (Valox®)	NBR/PPS (Ryton®)	NBR/PPS (Ryton®)
Intermediate Bearings	NBR	304 Stainless Steel	NBR/316 Stainless Steel
Shaft Washer	Not Required	LCP (Vectra®)	LCP (Vectra®)
Split Cone	Not Required	304 Stainless Steel	304 Stainless Steel
Split Cone Nut	Not Required	316 Stainless Steel	304 Stainless Steel
Sleeve	Not Required	Not Required	316 Stainless Steel
Sleeve Flange	Not Required	Not Required	304 Stainless Steel
Coupling Key	Not Required	Not Required	302/304 Stainless Steel**

NOTES: Specifications are subject to change without notice.
Valox® is a registered trademark of General Electric Co.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
Ryton® is a registered trademark of Phillips 66.
***Stainless Steel option available.**
** If using 4" non-standard motors, refer to 329/420/431 Stainless Steel for coupling.
A coupling key is not required.

FLOW RANGE: 18 -32 GPM **OUTLET SIZE: 1½ " NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, .5 -5 HP/3450 RPM.
6" MOTOR STANDARD,7.5 -10HP/3450 RPM.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 2 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
25S05-3	A	1/2	4"	1 1/2" NPT	18.1	9.5	8.6	3.8	3.9	26
25S07-5	A	3/4	4"	1 1/2" NPT	20.9	10.7	10.2	3.8	3.9	28
25S10-7	A	1	4"	1 1/2" NPT	23.7	11.8	11.9	3.8	3.9	29
25S15-9	A	1 1/2	4"	1 1/2" NPT	27.1	13.6	13.5	3.8	3.9	34
25S20-11	A	2	4"	1 1/2" NPT	30.3	15.1	15.2	3.8	3.9	37
25S30-15	A	3	4"	1 1/2" NPT	39.1	20.6	18.5	3.8	3.9	59
25S50-26	A	5	4"	1 1/2" NPT	51.2	23.6	27.6	3.8	3.9	76
25S75-39DS	A	7 1/2	6"	1 1/2" NPT	66.8	24.2	42.6	5.4	4.6	168
25S100-52DS*	B	10	6"	1 1/2" MPT	90.9	25.4	65.5	5.4	5.4	226

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs.
* Built into sleeve 1 1/2" MPT discharge, 6" min. well dia.

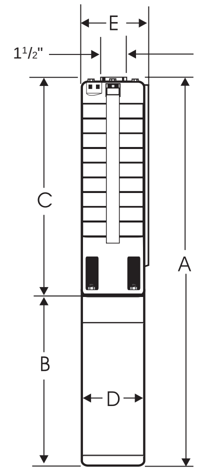


Fig. A

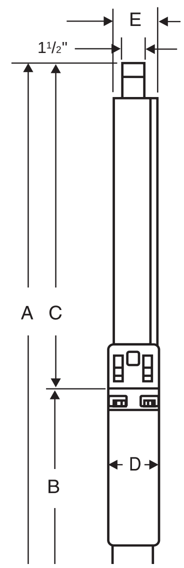


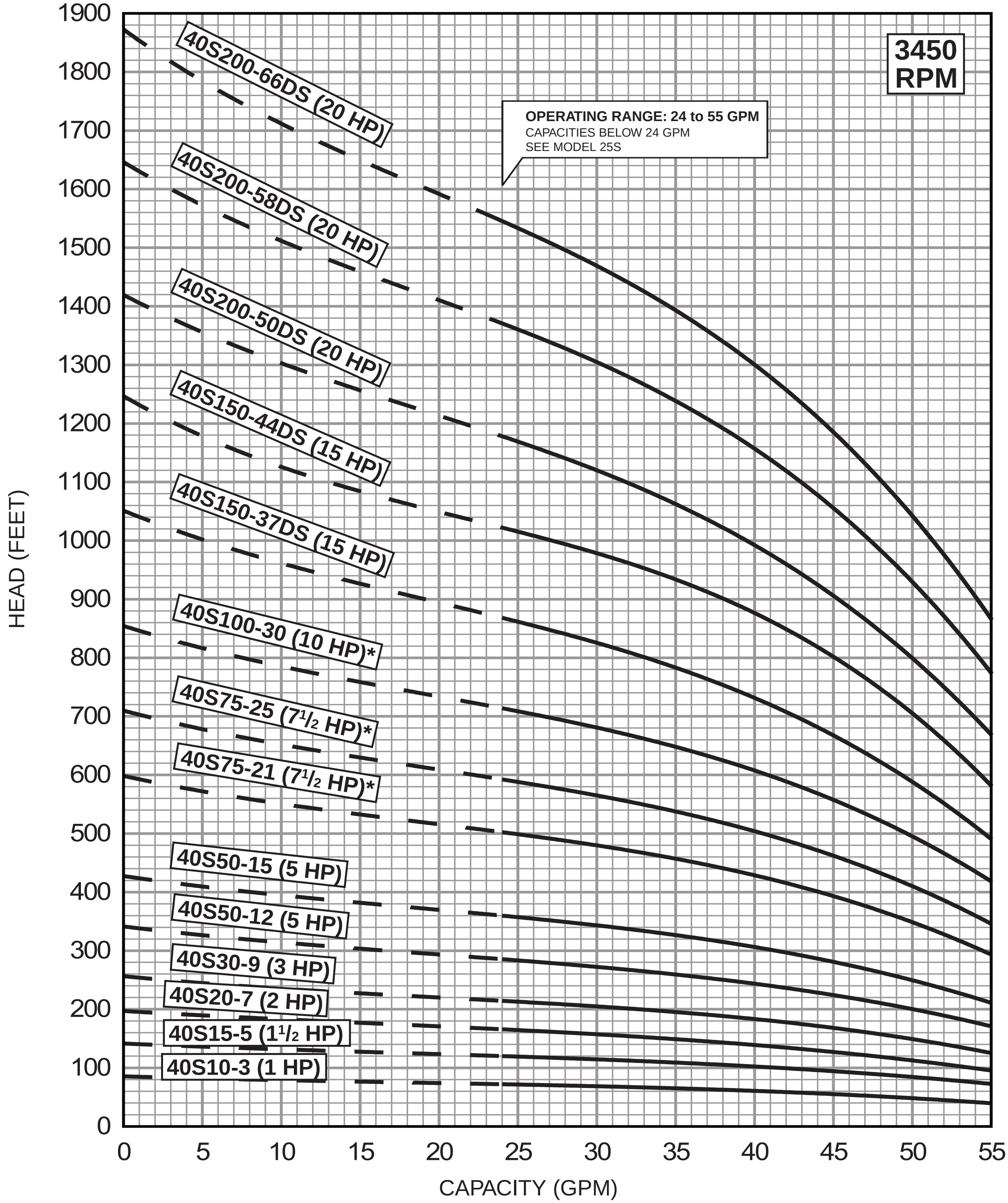
Fig. B

MATERIALS OF CONSTRUCTION

COMPONENT	SPLINED SHAFT (3-26 Stgs.)	CYLINDRICAL SHAFT (39 Stgs.)	DEEP SET (52 Stgs)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Pump Shaft	304 Stainless Steel	431 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Coupling	316/431 Stainless Steel	316/431 Stainless Steel	329/416 Stainless Steel**
Check Valve Seat	NBR/304 Stainless Steel	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/PBT (Valox®)	NBR/PPS (Ryton®)	NBR/PPS (Ryton®)
Intermediate Bearings	NBR	304 Stainless Steel	NBR/316 Stainless Steel
Shaft Washer	Not Required	LCP (Vectra®)	LCP (Vectra®)
Split Cone	Not Required	304 Stainless Steel	304 Stainless Steel
Split Cone Nut	Not Required	316 Stainless Steel	304 Stainless Steel
Sleeve	Not Required	Not Required	316 Stainless Steel
Sleeve Flange	Not Required	Not Required	304 Stainless Steel
Coupling Key	Not Required	Not Required	302/304 Stainless Steel**

NOTES: Specifications are subject to change without notice.
Valox® is a registered trademark of General Electric Co.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
Ryton® is a registered trademark of Phillips 66.
***Stainless Steel option available.**
** If using 4" non-standard motors, refer to 329/420/431 Stainless Steel for coupling.
A coupling key is not required.

FLOW RANGE: 24 - 55 GPM **OUTLET SIZE: 2 " NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 1-10 HP/3450 RPM.
6" MOTOR STANDARD,15-20 HP/3450 RPM.
* Also available with 6" motor.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 5 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
40S10-3	A	1	4"	2" NPT	24.6	11.8	12.8	3.8	3.9	32
40S15-5	A	1 1/2	4"	2" NPT	29.7	13.6	16.1	3.8	3.9	37
40S20-7	A	2	4"	2" NPT	34.5	15.1	19.4	3.8	3.9	41
40S30-9	A	3	4"	2" NPT	43.3	20.6	22.7	3.8	3.9	65
40S50-12	A	5	4"	2" NPT	51.3	23.6	27.7	3.8	3.9	78
40S50-15	A	5	4"	2" NPT	56.2	23.6	32.6	3.8	3.9	84
40S75-21*	A	7 1/2	4"	2" NPT	74.6	29.6	45.0	3.8	3.9	120
40S75-25*	A	7 1/2	4"	2" NPT	81.2	29.6	51.6	3.8	3.9	124
40S100-30*	A	10	4"	2" NPT	103.7	43.9	59.8	3.8	3.9	181
40S150-37DS	A	15	6"	2" NPT	99.5	28.0	71.5	5.4	5.4	244
40S150-44DS	A	15	6"	2" NPT	111.0	28.0	83.0	5.4	5.4	340
40S200-50DS**	B	20	6"	2" MPT	136.0	30.6	105.4	5.4	5.5	319
40S200-58DS**	B	20	6"	2" MPT	149.2	30.6	118.6	5.4	5.5	334
40S200-66DS**	B	20	6"	2" MPT	162.4	30.6	131.8	5.4	5.5	394

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs.
* Also available with 6" motor.
** Built into sleeve 2" MPT discharge, 6" min. well dia.

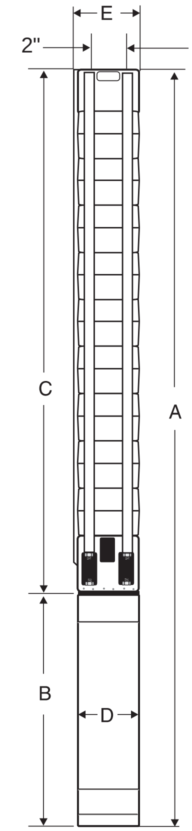


Fig. A

MATERIALS OF CONSTRUCTION

COMPONENT	CYLINDRICAL SHAFT (3-44 Stgs.)	DEEP SET (50-66 Stgs.)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel
Pump Shaft	431 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	304 Stainless Steel
Coupling	316/431 Stainless Steel **	329/ 416 Stainless Steel
Check Valve Seat	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Intermediate Bearings	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Shaft Washer	LCP (Vectra®)	LCP (Vectra®)
Split Cone	304 Stainless Steel	304 Stainless Steel
Split Cone Nut	304 Stainless Steel	304 Stainless Steel
Sleeve	Not Required	316 Stainless Steel
Sleeve Flange	Not Required	304 Stainless Steel

NOTES: Specifications are subject to change without notice.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
***Stainless Steel option available.**

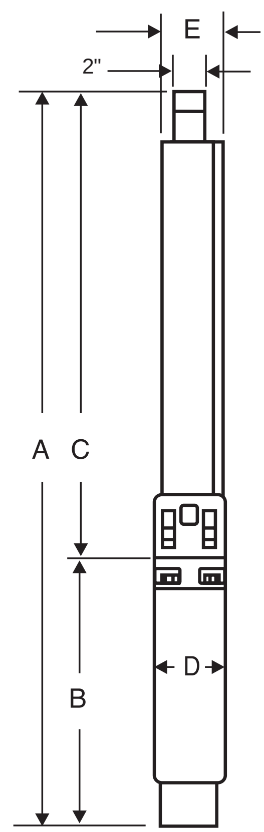
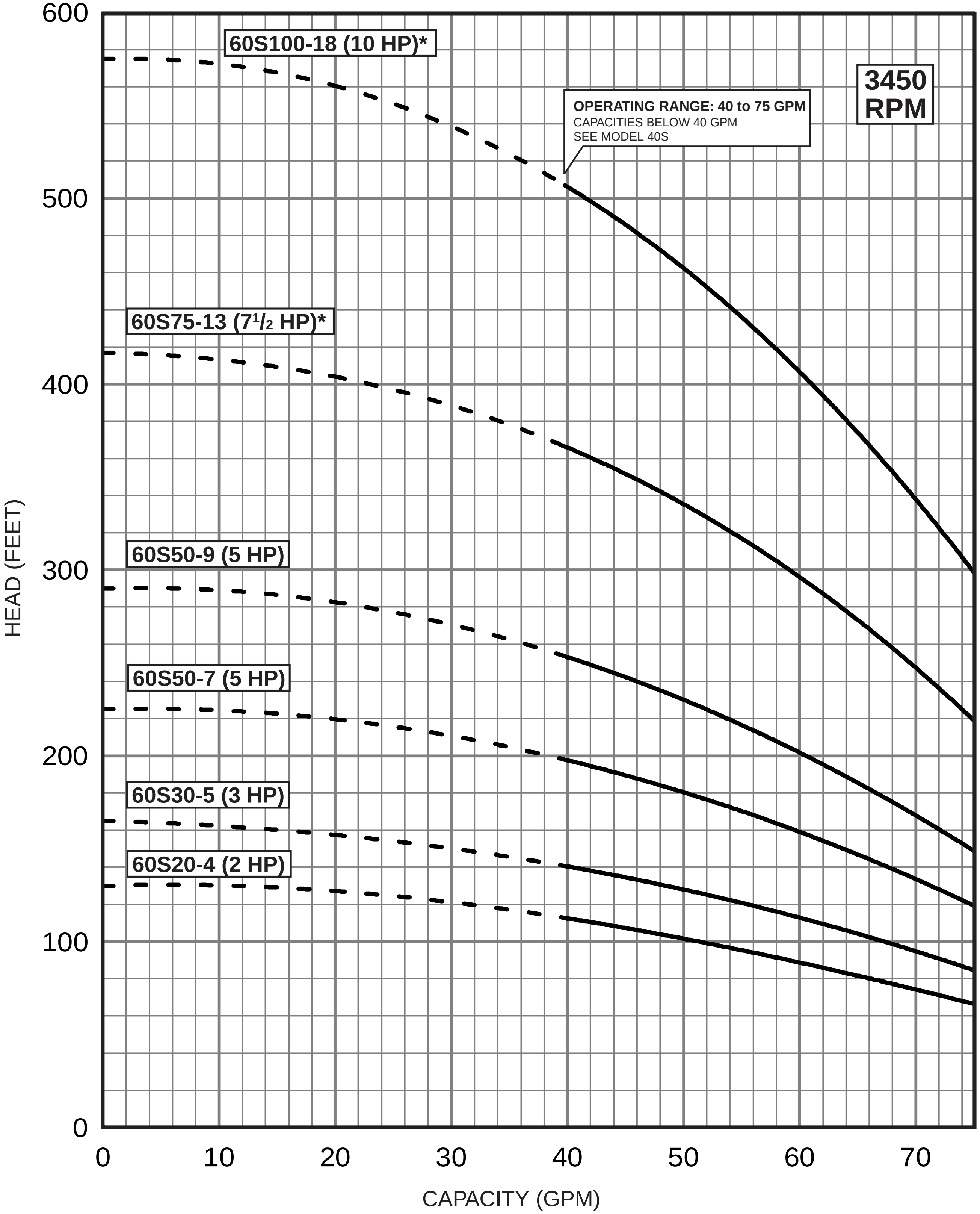


Fig. B

FLOW RANGE: 40 -75 GPM **OUTLET SIZE: 2 " NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 3450 RPM.
* Also available with 6" motor.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 5 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
60S20-4	A	2	4"	2" NPT	32.6	15.1	17.5	3.8	3.9	39
60S30-5	A	3	4"	2" NPT	40.7	20.6	20.1	3.8	3.9	64
60S50-7	A	5	4"	2" NPT	48.8	23.6	25.2	3.8	3.9	75
60S50-9	A	5	4"	2" NPT	53.9	23.6	30.3	3.8	3.9	80
60S75-13*	A	7 1/2	4"	2" NPT	70.1	29.6	40.5	3.8	3.9	105
60S100-18*	A	10	4"	2" NPT	97.3	43.9	53.4	3.8	3.9	160

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs..
* Also available with 6" motor.

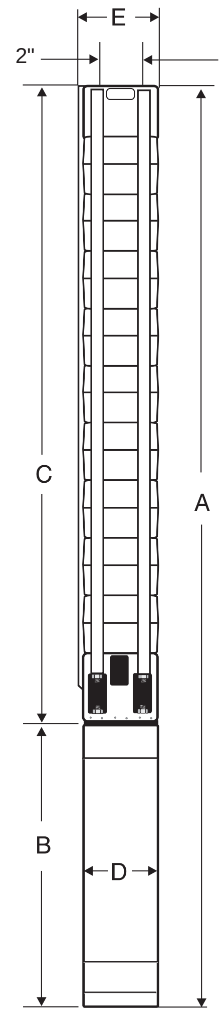


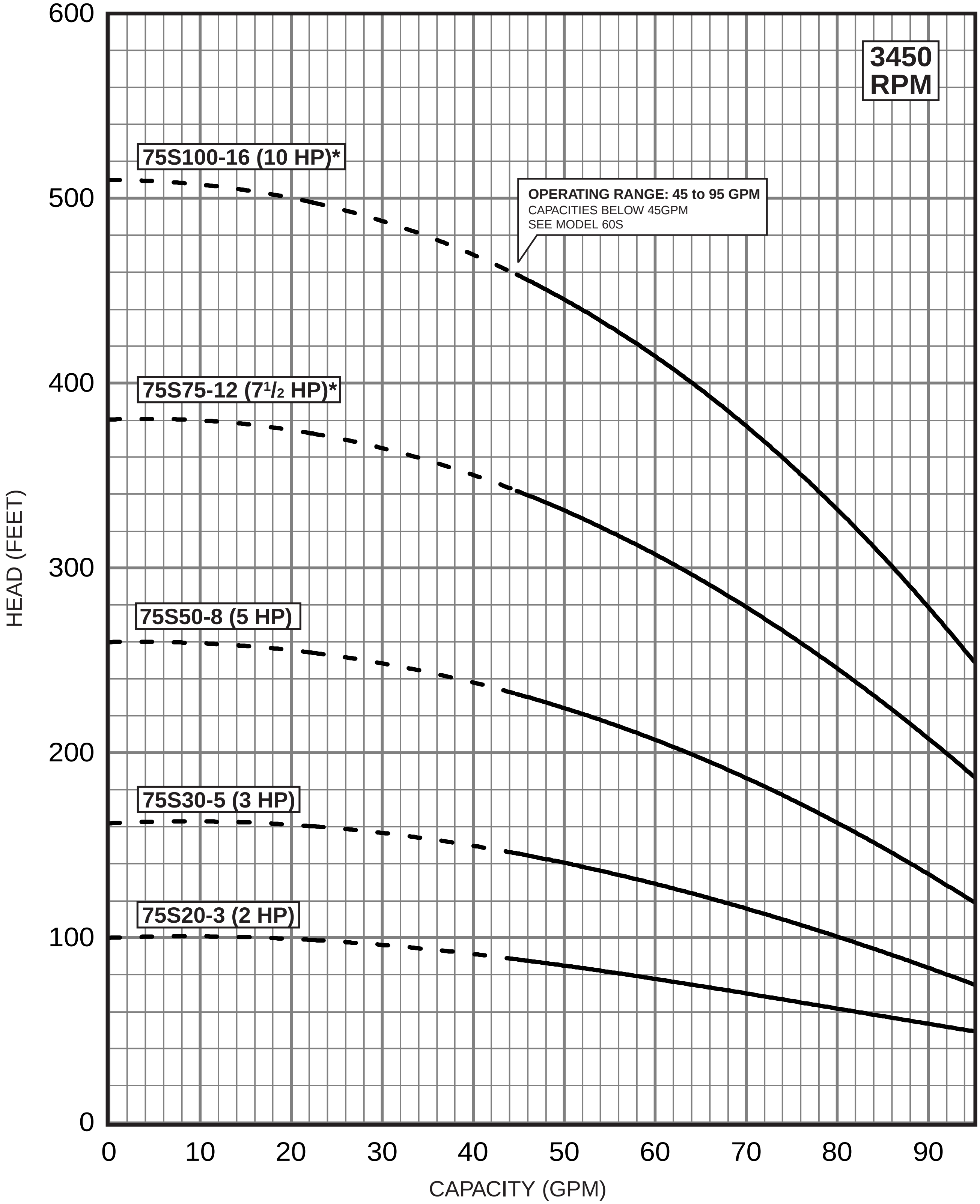
Fig. A

MATERIALS OF CONSTRUCTION

COMPONENT	CYLINDRICAL SHAFT (4-18 Stgs.)
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel
Impeller	304 Stainless Steel
Suction Interconnector	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Pump Shaft	431 Stainless Steel
Straps	304 Stainless Steel
Cable Guard	304 Stainless Steel
Priming Inducer	304 Stainless Steel
Coupling	316/431 Stainless Steel**
Check Valve Seat	NBR/316 Stainless Steel
Top Bearing	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/316 Stainless Steel
Intermediate Bearings	NBR/316 Stainless Steel
Shaft Washer	LCP (Vectra®)
Split Cone	304 Stainless Steel
Split Cone Nut	304 Stainless Steel

NOTES: Specifications are subject to change without notice.
Vectra® is a registered trademark of Hoechast Calanese Corporation.

FLOW RANGE: 45 - 95 GPM **OUTLET SIZE: 2" NPT** **NOMINAL DIA.: 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD,2-10 Hp 3450 RPM.
* Also available with 6" motor, performance is the same only at Best Effeciency point. Consult factory for actual performance.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 5 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
75S20-3	A	2	4"	2" NPT	30.0	15.1	14.9	3.8	3.9	38
75S30-5	A	3	4"	2" NPT	40.7	20.6	20.1	3.8	3.9	64
75S50-8	A	5	4"	2" NPT	51.4	23.6	27.8	3.8	3.9	78
75S75-12*	A	7 1/2	4"	2" NPT	67.5	29.6	37.9	3.8	3.9	100
75S100-16*	A	10	4"	2" NPT	92.1	43.9	48.2	3.8	3.9	155

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs.
* Also available with 6" motor, performance is the same only at Best Efficiency point. Consult factory for actual performance.

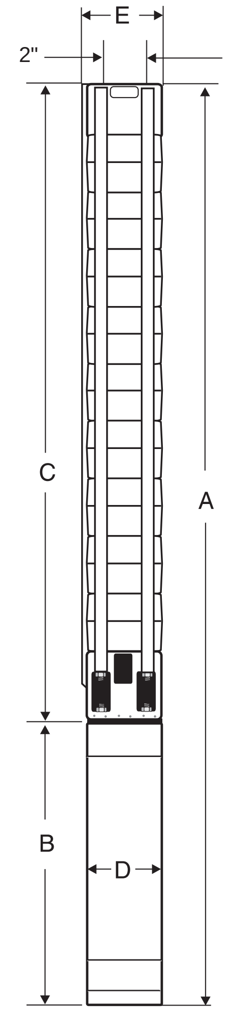


Fig. A

MATERIALS OF CONSTRUCTION

COMPONENT	CYLINDRICAL SHAFT (3-16 Stgs.)
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel
Impeller	304 Stainless Steel
Suction Interconnector	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Pump Shaft	431 Stainless Steel
Straps	304 Stainless Steel
Cable Guard	304 Stainless Steel
Priming Inducer	304 Stainless Steel
Coupling	316/431 Stainless Steel**
Check Valve Seat	NBR/316 Stainless Steel
Top Bearing	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/316 Stainless Steel
Intermediate Bearings	NBR/316 Stainless Steel
Shaft Washer	LCP (Vectra®)
Split Cone	304 Stainless Steel
Split Cone Nut	304 Stainless Steel

NOTES: Specifications are subject to change without notice.
Vectra® is a registered trademark of Hoechast Calanese Corporation.

Part 1 – INTRODUCTION

Part 2 – CABLE SELECTION

Part 3 – MISC. TECHNICAL DATA, FORMULAS, AND CONVERSIONS

PART 1: INTRODUCTION

General

This section will provide the technical information needed to properly select GRUNDFOS groundwater products. The information applies primarily to domestic groundwater systems using 4-inch wells with submersible or jet pumps, pressure tanks, and accessories. It is important to be familiar with typical system components and their basic hydraulic principles to ensure a better understanding of the more technical information found later in this section.

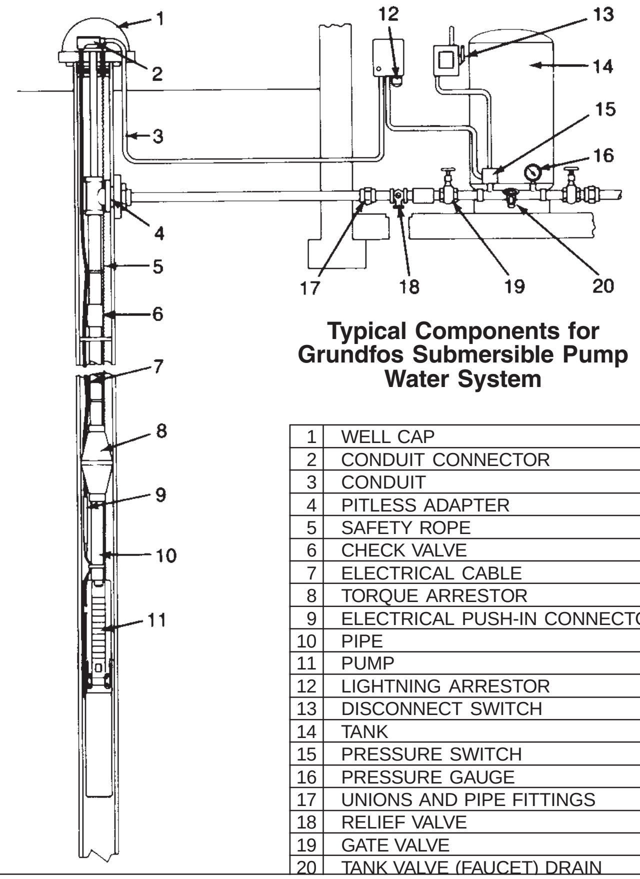
Prior to selecting the pump, the basic system requirements must be determined. System capacity and system pressure must be calculated and friction losses determined to ensure proper system performance. These calculations are covered in detail in **Part 1.** In **Part 2**, information is provided on proper cable selection. Also provided in **Part 3** are miscellaneous technical data and formulas commonly used in the selection of domestic groundwater systems.

Typical System Components

Domestic groundwater systems are made up of a pump, storage tank, and accessories to operate the system automatically. Pumps are generally of the submersible or jet variety and include the pump and motor as a unit. Refer to Figure 8-A for the components found in a typical automatic groundwater pumping system.

In a ***closed, automatic water system*** a pressure tank is used to store water and maintain system pressure between specified limits (such as 30 to 50 psi). As the water level in the tank rises, tank air is compressed in the upper part of the tank until the upper pressure limit is reached (i.e., 50 psi). At this "cut-out" point a pressure switch opens the electrical circuit to the motor and the pump stops.

The compressed air in the tank acts like a spring pushing down on the water to create system pressure. When a valve is opened in the water system, the air pressure in the upper part of the tank forces the water to flow out of the tank and into the system. As the water is drawn from the tank, the air occupies a larger space and the pressure drops until the lower limit is reached (i.e., 30 psi). At this "cut-in" point the pressure switch closes the electrical circuit to the motor and the pump starts. A cycle is thereby completed.



Typical Components for Grundfos Submersible Pump Water System

1	WELL CAP
2	CONDUIT CONNECTOR
3	CONDUIT
4	PITLESS ADAPTER
5	SAFETY ROPE
6	CHECK VALVE
7	ELECTRICAL CABLE
8	TORQUE ARRESTOR
9	ELECTRICAL PUSH-IN CONNECTOR
10	PIPE
11	PUMP
12	LIGHTNING ARRESTOR
13	DISCONNECT SWITCH
14	TANK
15	PRESSURE SWITCH
16	PRESSURE GAUGE
17	UNIONS AND PIPE FITTINGS
18	RELIEF VALVE
19	GATE VALVE
20	TANK VALVE (FAUCET) DRAIN

FIGURE 8-A
Components found in a typical automatic groundwater pumping system including a submersible pump, pressure tank, and pressure control accessories.

In an ***open, automatic water system*** the pump is used to fill a large, elevated storage tank which utilizes gravity to maintain system pressure. Tank level controls are used to cycle the pump to maintain water levels within prescribed limits.

Refer to the following illustrations for schematic layouts of typical domestic groundwater systems and components: Figure 8-B (Submersible Pump - Closed System), Figure 8-C (Submersible Pump - Open System), Figure 8-D (Shallow Well Jet Pump), and Figure 8-E (Deep Well Jet Pump).

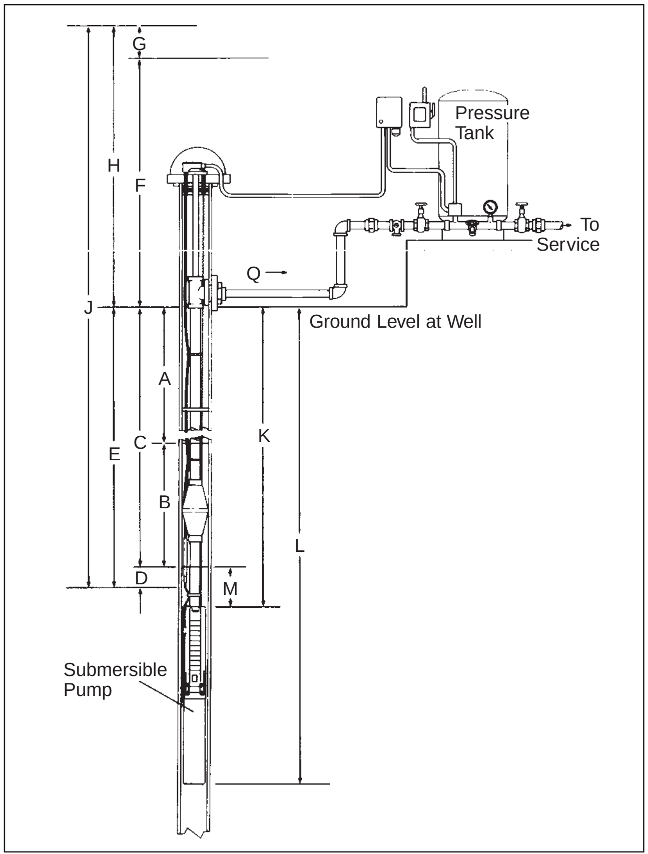


FIGURE 8-B
Figure 8-B illustrates a schematic layout of a CLOSED goundwater pumping system using a submersible pump and pressure tank set for automatic operation. A pressure switch controls the cycling of the pump.

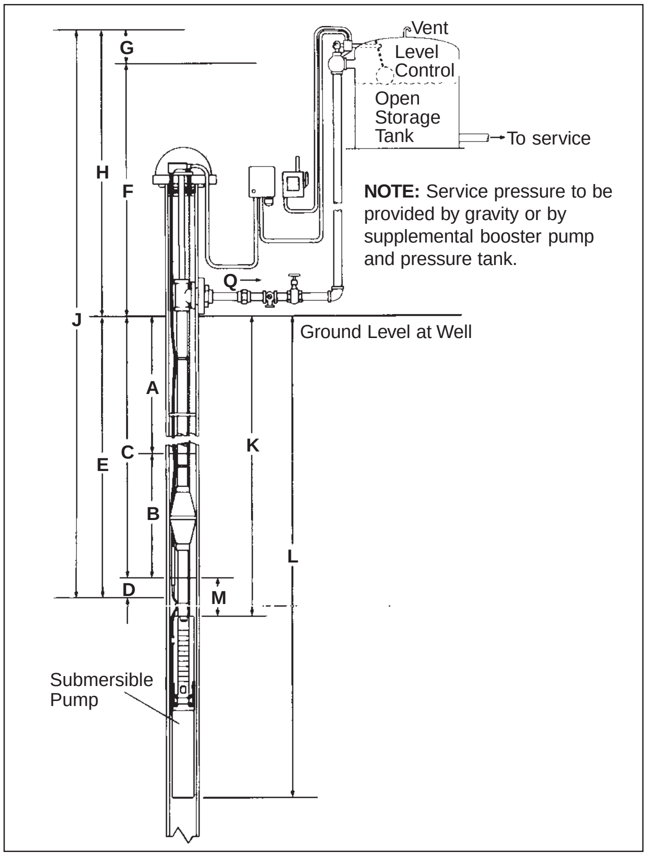


FIGURE 8-C
Figure 8-C illustrates a schematic layout of an OPEN groundwater pumping system using a submersible pump and an elevated storage tank set for automatic operation. A level control on the storage tank controls the cycling of the pump.

Closed Groundwater System with Submersible Pump

A. STATIC WATER LEVEL (in feet): vertical distance from the top of the well to the standing water level or water table.

B. DRAWDOWN (in feet): reduction in the water level during pumping (varies with well yield and pump capacity).

C. PUMPING WATER LEVEL or LIFT (in feet): C = A + B.

D. FRICTION LOSSES in the WELL (in feet): friction losses caused by the drop pipe and fittings between the pump and the top of the well.

E. TOTAL LIFT in the WELL (in feet): E = A + B + D.

F. STATIC DISCHARGE HEAD (in feet): for PRESSURE TANK SYSTEMS it is the elevation rise in feet of the pressure tank, discharge nozzles, etc., above the top of the well plus the pressure (in feet) required at that level.

G. FRICTION LOSSES in the DISCHARGE SYSTEM (in feet): friction losses caused by piping, valves, and fittings between the top of the well and the point of discharge.

H. TOTAL DISCHARGE HEAD (in feet): H = F + G.

J. TOTAL PUMPING HEAD (in feet): J = E + H.

K. SETTING OF PUMP (in feet): vertical distance from the top of the well to the top of the pump.

L. OVERALL LENGTH (in feet): vertical distance from the top of the well to the bottom of the pump.

M. SUBMERGENCE (in feet): M = K - C.

Q. CAPACITY (in gpm or gph): rate of pumping.

Open Groundwater System with Submersible Pump

A. STATIC WATER LEVEL (in feet): vertical distance from the top of the well to the standing water level or water table.

B. DRAWDOWN (in feet): reduction in the water level during pumping (varies with well yield and pump capacity).

C. PUMPING WATER LEVEL or LIFT (in feet): C = A + B.

D. FRICTION LOSSES in the WELL (in feet): friction losses caused by the drop pipe and fittings between the pump and the top of the well.

E. TOTAL LIFT in the WELL (in feet): E = A + B + D.

F. STATIC DISCHARGE HEAD (in feet): for OPEN DISCHARGE SYSTEMS it is the elevation of the highest water level above the top of the well.

G. FRICTION LOSSES in the DISCHARGE SYSTEM (in feet): friction losses caused by piping, valves, and fittings between the top of the well and the point of discharge.

H. TOTAL DISCHARGE HEAD (in feet): H = F + G.

J. TOTAL PUMPING HEAD (in feet): J = E + H.

K. SETTING OF PUMP (in feet): vertical distance from the top of the well to the top of the pump.

L. OVERALL LENGTH (in feet): vertical distance from the top of the well to the bottom of the pump.

M. SUBMERGENCE (in feet): M = K - C.

Q. CAPACITY (in gpm or gph): rate of pumping.

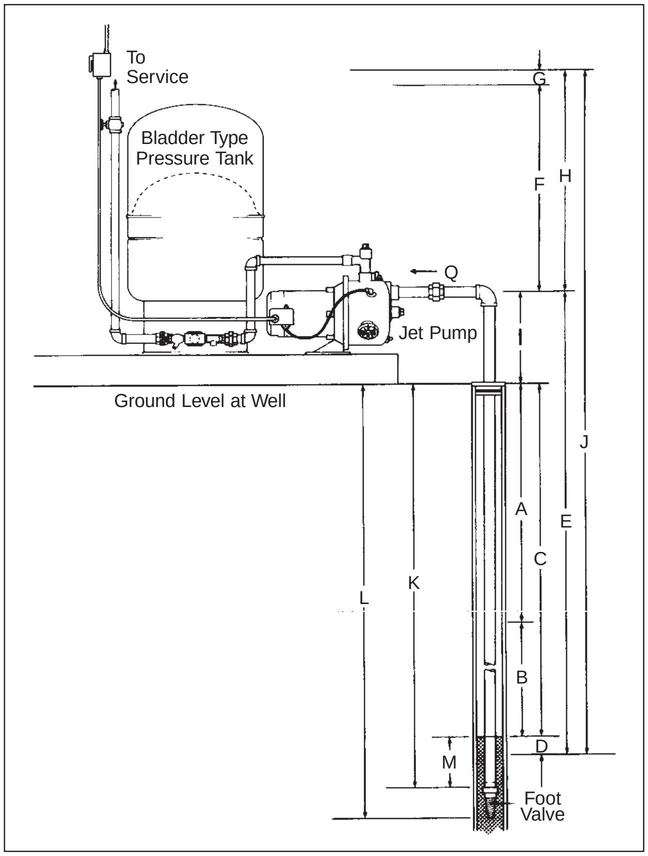


FIGURE 8-D
Figure 8-D illustrates a schematic layout of a SHALLOW WELL groundwater pumping system using a shallow well JET PUMP designed for setting to 25 feet. The pressure tank is set for automatic operation with a pressure switch controlling the cycling of the pump.

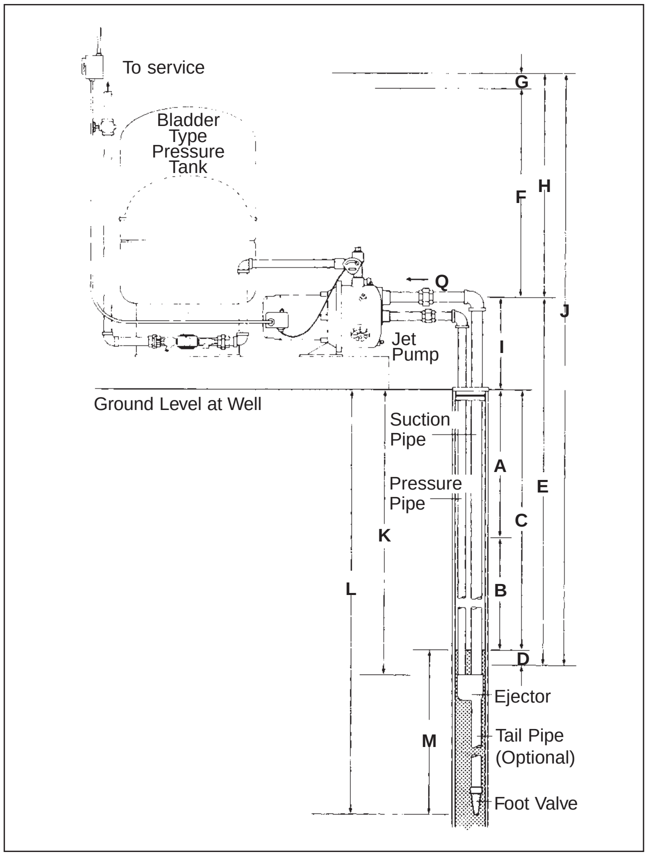


FIGURE 8-E
Figure 8-E illustrates a schematic layout of an DEEP WELL groundwater pumping system using a deep well JET PUMP designed for settings to 100 feet. The pressure tank is set for automatic operation with a pressure switch controlling the cycling of the pump.

CLOSED GROUNDWATER SYSTEM WITH SHALLOW WELL JET PUMP

A. Statics Water Level (in feet): vertical distance from the top of the well to the standing water level or water table.

B. Drawdown (in feet): reduction in the water level during pumping (varies with well yield and pump capacity).

C. Pumping Water Level or Lift (in feet): C = A + B.

D. Friction Losses in the Suction System (in feet): friction losses caused by suction piping between the pump and foot valve.

E. Total Suction Lift (in feet): E = A + B + D + I.

F. Static Discharge Head (in feet): for *Pressure Tanks Systems* it is the elevation rise in feet of the pressure tank, discharge nozzles, etc., above the pump plus the pressure (in feet) discharge nozzles, etc., above the pump plus the pressure (in feet) required at that level. For *Open Discharge Systems* it is the elevation in feet of the highest water level above the pump.

G. Friction Losses in the Discharge System (in feet): friction losses caused by piping, valves, and fittings between the top of the well and the point of discharge.

H. Total Discharge Head (in feet): H = F + G.

I. Elevation of the Pump above the Top of the Well (in feet).

J. Total Pumping Head (in feet): J = E + H.

K. Setting of the Foot Valve or Strainer (in feet): vertical distance from the top of the well to the top of the foot valve or strainer.

L. Overall Length (in feet): vertical distance from the top of the well to the bottom of the foot valve or strainer.

M. Submergence (in feet): M = K - C.

Q. Capacity (in gpm or gph): rate of pumping.

CLOSED GROUNDWATER SYSTEM WITH SHALLOW WELL JET PUMP

A. Static Water Level (in feet): vertical distance from the top of the well to the standing water level or water table.

B. Drawdown (in feet): reduction in the water level during pumping (varies with well yield and pump capacity).

C. Pumping Water Level or Lift (in feet): C = A + B.

D. Friction Losses in the Suction System (in feet): friction losses caused by suction piping between the pump and foot valve.

E. Total Suction Lift (in feet): E = A + B + D + I.

F. Static Discharge Head (in feet): for PRESSURE TANK SYSTEMS it is the elevation rise in feet of the pressure tank, discharge nozzles, etc., above the pump plus the pressure (in feet) discharge nozzles, etc., above the pump plus the pressure (in feet) required at that level. For OPEN DISCHARGE SYSTEMS it is the elevation in feet of the highest water level above the pump.

G. Friction Losses in the Discharge System (in feet): friction losses caused by piping, valves, and fittings between the top of the well and the point of discharge.

H. Total Discharge Head (in feet): H = F + G.

I. Elevation of the Pump above the Top of the Well (in feet).

J. Total Pumping Head (in feet): J = E + H.

K. Setting of the Foot Valve or Strainer (in feet): vertical distance from the top of the well to the top of the foot valve or strainer.

L. Overall Length (in feet): vertical distance from the top of the well to the bottom of the foot valve or strainer.

M. Submergence (in feet): M=K–C. The ejector should be set as close to the bottom of its maximum depth rating as the well will permit.

Q. Capacity (in gpm or gph): rate of pumping.

Head and Pressure

Head and pressure are related in a very simple and direct manner. Since water has known weight, we know that a 231 foot long, one-inch square pipe holds 100 pounds of water. At the bottom of the one-inch square pipe we refer to the pressure as 100 pounds per square inch (psi). For any diameter pipe 231 feet high, the pressure will always be 100 psi at the bottom. Refer to Figure 8-F**.**

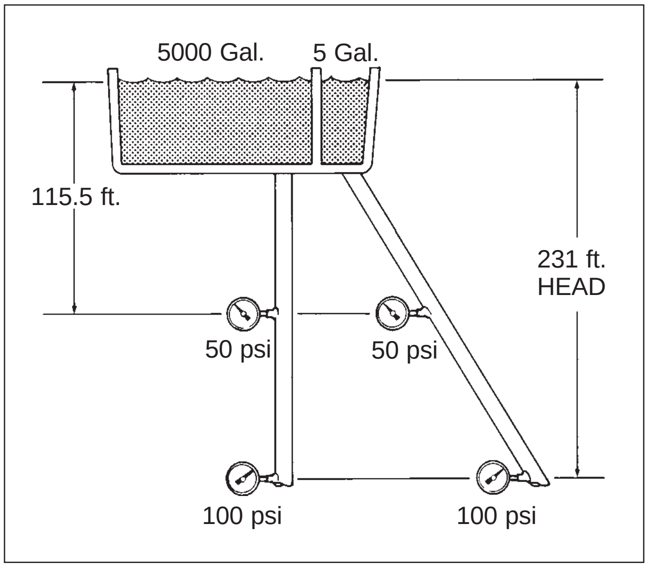


FIGURE 8-F

Figure 8-F illustrates the relationship between head and pressure.

Head is usually expressed in feet and refers to the height, or elevation, of the column of water. In Figure 8-F we see that a column of water 231 feet high creates a pressure reading of 100 psi. That same column of water is referred to as having 231 feet of **head**. Thus, for water, 231 feet of head is equivalent to 100 psi. Or, 2.31 feet of head equals 1 psi.

It should be noted that head and pressure readings for non-flowing water depend on the elevation of the water and not on the volume of water nor the size or length of piping.

Flow and Friction Loss

Flow is measured as the volume of water moved over a given length of time. This is generally referred to as gallons per minute (gpm) for larger flows and gallons per hour (gph) for smaller flows. When water moves through a pipe, it must overcome resistance to flow caused by friction as it moves along the walls of the pipe as well as resistance caused by its own turbulence. Added together, these losses are referred to as **friction losses** and may significantly reduce system pressure.

Figure 8-G illustrates the relationship of flow and friction loss. For any flow through a level pipe the gauge pressure at the pipe inlet will be greater than the gauge pressure at the pipe outlet. The difference is attributed to friction losses caused by the pipe itself and by fittings.

In general, friction losses occur or are increased under the following conditions:

1. Friction losses result from flow through any size or length of pipe (Figure 8-G).
2. Friction losses increase as the flow rate increases or as the pipe size decreases (if the flow rate doubles for a given pipe size, friction losses quadruple, Figure 8-G).
3. Friction losses increase with the addition of valves and fittings to the system (Figure 8-G).

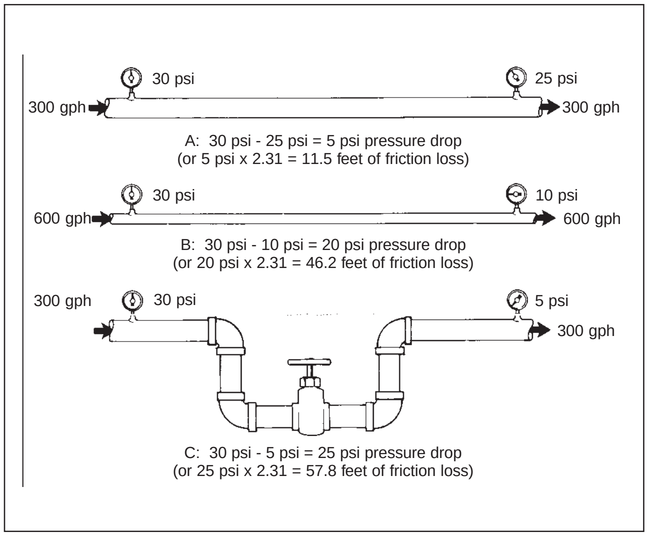


FIGURE 8-G

As shown in these illustrations friction losses increase with additional flow

Power is required to push water to a higher elevation, to increase outlet pressure, to increase flow rates, and to overcome friction losses. Good system design and common sense indicate that friction losses should be minimized whenever possible. The costs of larger pumps, bigger motors, and increased power consumption to overcome friction losses must be balanced against the increased cost of larger, but more efficient, system piping. In either case, unnecessary valves and fittings should be eliminated wherever possible.

Submersible Pumps vs. Jet Pumps

Submersible and jet pumps are both used in domestic groundwater systems. When high flow rates and pressure settings are required at high operating efficiencies, submersible pumps are generally preferred. Submersible pumps have the advantage of performing well both in shallow well applications as well as at depths to 2,000 feet. An extensive range of submersible pump models is also available allowing a precise match to exact system requirements.

Convertible jet pumps are sometimes an economical alternative to submersibles, especially in shallow well installations of 25 feet or less. The pumps are less expensive, installation is simplified, and they are easily converted for deep well installations down to 100 feet (Figure 8-H).

In "weak" well applications where the pump lowers the water level in the well faster than the well can replenish itself, a deep well jet pump with a tail pipe is particularly effective when flow requirements are relatively small. By adding 35 feet of tail pipe below the jet assembly with the foot valve attached to the bottom, it will not be possible to pull the well down and allow air to enter the system. Pump delivery remains at 100% of the rated capacity down to the level of the jet assembly. If the water level falls below that point, flow decreases in proportion to the drawdown as shown in Figure 8-I. When pump delivery equals well inflow, the water level remains constant until the pump shuts off. At 33.9 feet of drawdown the pump will no longer deliver water but the foot valve will remain fully submerged.

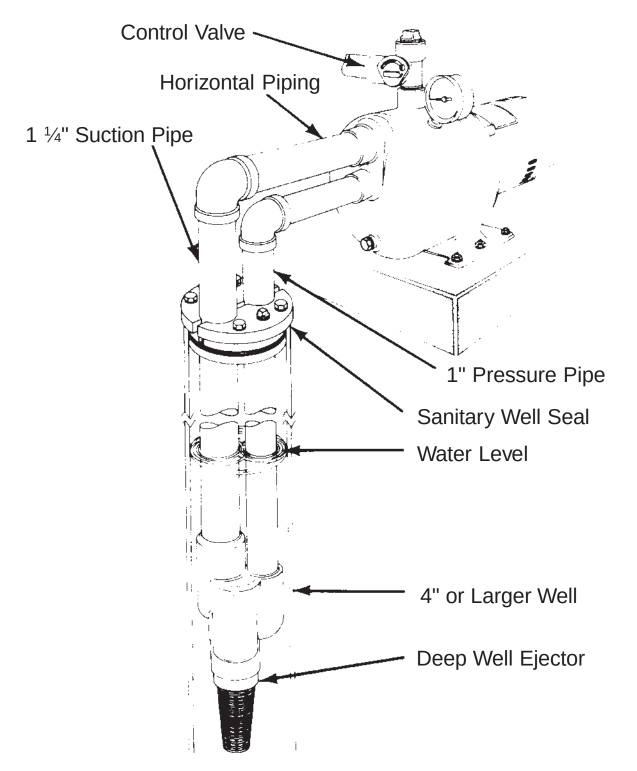


FIGURE 8-H
Figure 8-H illustrates a convertible jet pump set for deep well use (to 100 feet).

Final Pump Selection

Final pump selection will depend upon specific application requirements and cost considerations. Regardless of the pump type, system flow and head requirements (discussed in detail in Part 2) must be determined prior to actual pump selection.

Flow requirement will be determined by the size of the house or farm (including the number of bathrooms, outlets and appliances), the size of family, and the number of farm animals, if applicable.

Total Pumping Head must be calculated to ensure that the pump selected will meet all head or discharge pressure requirements. Total pumping head is the combination of the total suction lift (or lift in well), plus the pump discharge head (consisting of the elevation from the pumping water level to pressure tank plus pressure tank discharge pressure), plus all system friction losses.

Total Dynamic Head is equivalent to total pumping head plus velocity head. In most residential systems, velocity head is negligible. Because of this, the velocity head term has been left out of future examples and formulas. From the information gathered on flow and head requirements, a specific submersible or jet pump may be selected and an appropriately sized pressure tank ordered.

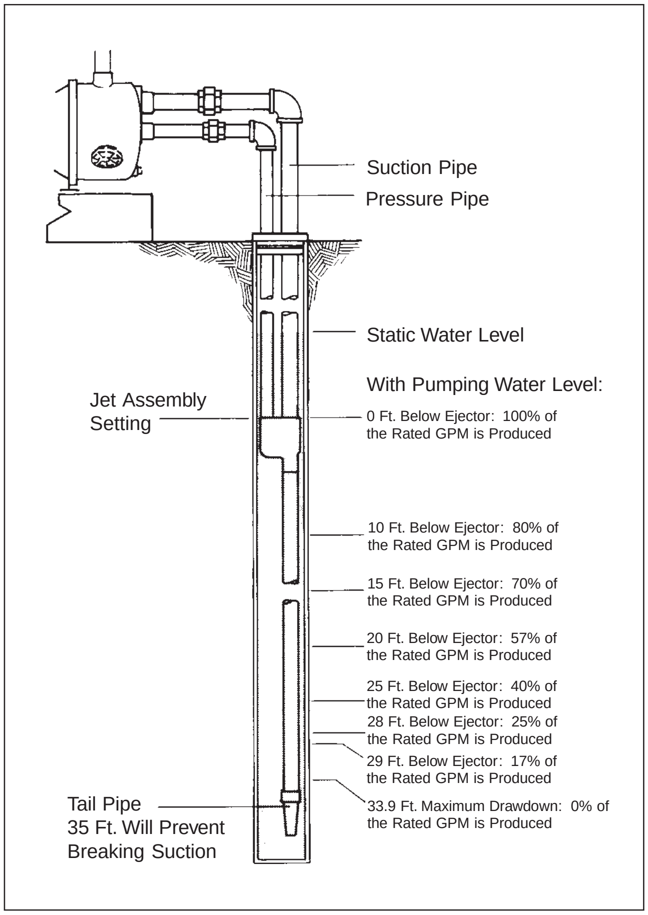


FIGURE 8-I
Figure 8-I illustrates the use of a tail pipe on a deep well convertible jet pump to compensate for weak well conditions.

PART 2: CABLE SELECTION

Submersible Pump Cable Selection Charts (60 Hz)

CABLE LENGTH SELECTION TABLES

The following table (Table 8-Q(2)) lists the recommended copper cable sizes and various cable lengths for submersible pump motors. Proper wire size will ensure that adequate voltage will be supplied to the motor.

This table complies with the 1978 edition of the National Electric Table 310-16, Column 2 for 75°C wire. The ampacities (current carrying properties of a conductor) have been divided by 1.25 per the N.E.C., Article 430-22, for motor branch circuits based on motor amps at rated horsepower.

To assure adequate starting torque, the maximum cable lengths are calculated to maintain 95% of the service entrance voltage at the motor when the motor is running at maximum nameplate amps. Cable sizes larger than specified may always be used and will reduce power usage.

The use of cables smaller than the recommended sizes will void the warranty. Smaller cable sizes will cause reduced starting torque and poor motor operation.

CALCULATING MIXED CABLE SIZES

In a submersible pump installation any combination of cable sizes may be used as long as the total percentage length of the individual cables does not exceed 100%. Mixed cable sizes are most often encountered when a pump is being replaced with a larger horsepower model and part of the old cable will be left in place.

In the following example, a 2 HP, 230 volt, 1 phase pump is being installed to replace a smaller model. The 115 feet of buried #12 cable located between the service entrance and the well head will be used in the replacement installation. The well driller must be able to calculate the required size of cable in the well to connect the new motor at a setting of 270 feet.

Cable Size Calculation:
Step 1–Check Table 8-Q(2) to see if the 115 feet of existing #12 cable is large enough to provide current to the larger 2 HP replacement pump. The table tells us that #12 cable is adequate for a maximum length of 250 feet.

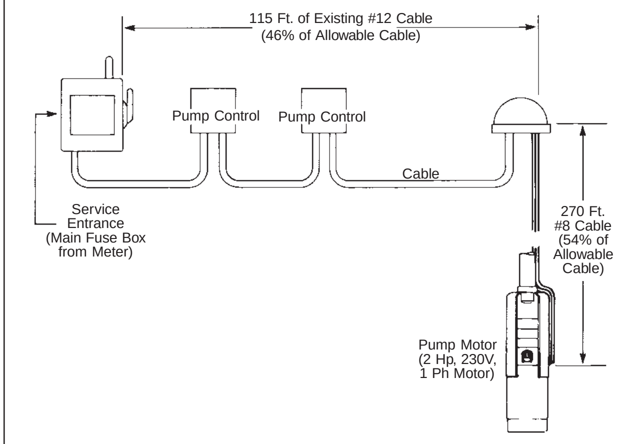


FIGURE 8-Q(1)
Example of Mixed Cable Installation

Step 2–Since 250 feet is the maximum allowable cable length for the #12 cable, calculate the percent used by the 115-foot run. (115 ft. ÷ 250 ft. = 46%)

Step 3–With 46% of the total allowable cable used between the service entrance and the well head, 54% remains for use in the well (100% - 46% = 54%). Therefore, the 270 feet of cable required in the well can utilize only 54% of the total feet allowed in the table.

Step 4–From Table 8-Q(2) determine the proper size cable required for the 2 HP pump set at 270 feet. (Remember, you are limited to 54% of the length listed in the table.) A check of #10 cable at 2 HP indicates that only 210 feet of this cable could be used (390 ft. x 54% = 210 ft.). Since this is less than the 270 required, the next larger size should be tried. For #8 cable, 54% of 620 feet = 335 feet. ***The #8 cable is suitable for use in the well at a pump setting of 270 feet.***

See Chart 8-Q(2) next page.

MAXIMUM MOTOR CABLE LENGTH

(Motor Service to Entrance)

TABLE 8-Q(2)
Single Phase 60Hz

Motor Rating		Copper Wire Size												
Volts	**HP**	**14**	**12**	**10**	**8**	**6**	**4**	**2**	**0**	**00**	**000**	**0000**	**250**	**300**
115	1/3	130	210	340	540	840	1300	1960	2910					
	1/2	100	160	250	390	620	960	1460	2160					
230	1/3	550	880	1390	2190	3400	5250	7960						
	1/2	400	650	1020	1610	2510	3880	5880						
	3/4	300	480	760	1200	1870	2890	4370	6470					
	1	250	400	630	990	1540	2380	3610	5360	6520				
	1½	190	310	480	770	1200	1870	2850	4280	5240				
	2	150	250	390	620	970	1530	2360	3620	4480				
	3	120	190	300	470	750	1190	1850	2890	3610				
	5			180	280	450	710	1110	1740	2170				
	7½				200	310	490	750	1140	1410				
	10					250	390	600	930	1160				

Three Phase 60Hz

Volts	**HP**	**14**	**12**	**10**	**8**	**6**	**4**	**2**	**0**	**00**	**000**	**0000**	**250**	**300**
208	1½	310	500	790	1260									
	2	240	390	610	970	1520								
	3	180	290	470	740	1160	1810							
	5		170	280	440	690	1080	1660						
	7½			200	310	490	770	1180	1770					
	10				230	370	570	880	1330	1640				
	15					250	390	600	910	1110	1340			
	20						300	460	700	860	1050	1270		
	25							370	570	700	840	1030	1170	
	30							310	470	580	700	850	970	1110
230	1½	360	580	920	1450									
	2	280	450	700	1110	1740								
	3	210	340	540	860	1340	2080							
	5		200	320	510	800	1240	1900						
	7½			230	360	570	890	1350	2030					
	10				270	420	660	1010	1520	1870				
	15					290	450	690	1040	1280	1540			
	20						350	530	810	990	1200	1450		
	25						280	430	650	800	970	1170	1340	
	30							350	540	660	800	970	1110	1270
460	1½	1700												
	2	1300	2070											
	3	1000	1600	2520										
	5	590	950	1500	2360									
	7½	420	680	1070	1690	2640								
	10	310	500	790	1250	1960	3050							
	15			540	850	1340	2090	3200						
	20			410	650	1030	1610	2470	3730					
	25				530	830	1300	1990	3010	3700				
	30				430	680	1070	1640	2490	3060	3700			
	40						790	1210	1830	2250	2710	3290		
	50						640	980	1480	1810	2190	2650	3010	
	60							830	1250	1540	1850	2240	2540	2890
	75								1030	1260	1520	1850	2100	2400
	100									940	1130	1380	1560	1790
	125											1080	1220	1390
	150												1050	1190
	200												1080	1300
	250													1080
575	1½	2620												
	2	2030												
	3	1580	2530											
	5	920	1480	2330										
	7½	660	1060	1680	2650									
	10	490	780	1240	1950									
	15		530	850	1340	2090								
	20			650	1030	1610	2520							
	25			520	830	1300	2030	3110						
	30				680	1070	1670	2560	3880					
	40					790	1240	1900	2860	3510				
	50						1000	1540	2310	2840	3420			
	60						850	1300	1960	2400	2890	3500		
	75							1060	1600	1970	2380	2890	3290	

CAUTION: Use of wire size smaller than listed will void warranty.

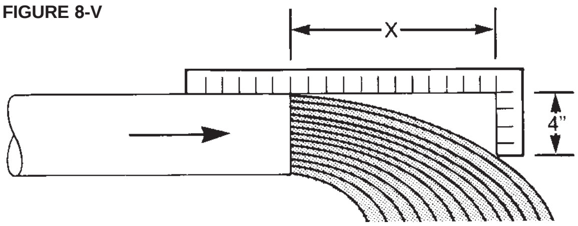
Notes:
1. If aluminum conductor is used, multiply lengths by 0.5 Maximum allowable length of aluminum is considerably shorter than copper wire of same size.
2. The portion of the total cable which is between the service entrance and a 3ø motor starter should not exceed 25% of the total maximum length to assure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.
3. Cables #14 to #0000 are AWG sizes, and 250 to 300 are MCM sizes.

Calculating Discharge Rate by Using The Horizontal Open Discharge Method

The most reliable method of measuring flow is to use a flow meter. When a flow meter is not available, however, it is possible to estimate the discharge capacity by constructing an “L” shaped measuring stick similar to that shown in Figure 8-V. With the water flowing from the pipe, place the long end of the “L” on top of the pipe. Position the “L” so that the end of the short 4-inch side just touches the stream of water as the stream slants downward. Note the horizontal distance “X” from this point to the open end of the discharge pipe. With the value “X” and and the nominal inside diameter of the pipe, use Table 8-X to find the discharge rate in gallons per minute.

EXAMPLE: Horizontal distance ”X” is measured to be 12 inches. The size of the pipe Is known to be 1½" (nominal diameter). Find 12 inches in the left hand column of the chart and move across to the 1½" pipe size column. Table 8-X indicates that the discharge rate is 40.0 gallons per minute.

FIGURE 8-V



Calculating Low Capacity Outlets: A simple procedure for measuring low capacity outlets such as small pump outlets, hose spigots, and faucets is to record the amount of time it takes to fill a container of known size.

EXAMPLE: Select a container of known size such as a 5-gallon paint bucket. With a watch, measure, in seconds, the amount of time it takes to fill the bucket. If it takes 30 seconds to fill a 5-gallon bucket, Table 8-W indicates that the flow is 10.0 gallons per minute. To obtain gallons per hour (gph) multiply 10.0 x 60 to obtain 600 gph.

TABLE 8-W

Discharge Rate in Gallons Per Minute (GPM) for Low Capacity Systems

Capacity of Container (Gallons)	Time (in seconds) to Fill Container							
	10	15	20	30	45	60	90	120
	Discharge Rate in Gallons Per Minute (GPM)							
1	6.0	4.0	3.0	2.0	1.3	1.0	.7	.5
3	18.0	12.0	9.0	6.0	4.0	3.0	2.0	1.5
5	30.0	20.0	15.0	10.0	6.7	5.0	3.3	2.5
10	60.0	40.0	30.0	20.0	13.3	10.0	6.7	5.0

NOTE: Multiply gallons per minute (GPM) by 60 to obtain gallons per hour (GPH).

Calculating Distance to Water Level

Install ⅛" or ¼" pipe or tubing into the well so that the end of the tubing extends 10 to 20 feet below the lowest possible pumping water level. Be sure that all joints in the tubing are airtight. As the tubing is lowered into the well measure its length. Record the measurement.

TABLE 8-X

Discharge Rate in Gallons Per Minute (GPM) for Large Capacity Systems

Horiz. Dist. (X) Inches	Nominal Pipe Size (in Inches)									
	1	1 ¼"	1 ½"	2"	2 ½"	3"	4"	5"	6"	8"
	Discharge Rate in Gallons Per Minute (GPM)									
4	5.7	9.8	13.3	22.0	31	48	83			
5	7.1	12.2	16.6	27.5	39	61	104	163		
6	8.5	14.7	20.0	33.0	47	73	125	195	285	
7	10.0	17.1	23.2	38.5	55	85	146	228	334	380
8	11.3	19.6	26.5	44.0	62	97	166	260	380	665
9	12.8	22.0	29.8	49.5	70	110	187	293	430	750
10	14.2	24.5	33.2	55.5	78	122	208	326	476	830
11	15.6	27.0	36.5	60.5	86	134	229	360	525	915
12	17.0	29.0	40.0	66.0	94	146	250	390	570	1000
13	18.5	31.5	43.0	71.5	102	158	270	425	620	1080
14	20.0	34.0	46.5	77.0	109	170	292	456	670	1160
15	21.3	36.3	50.0	82.5	117	183	312	490	710	1250
16	22.7	39.0	53.0	88.0	125	196	334	520	760	1330
17		41.5	56.5	93.0	133	207	355	550	810	1410
18			60.0	99.0	144	220	375	590	860	1500
19				100.0	148	232	395	620	910	1580
20					156	244	415	650	950	1660
21						256	435	685	1000	1750

Once the tubing is fixed in a stationary position at the top of the well, connect an air line and pressure gauge. With a tire pump or other air supply, pump air into the line until the pressure gauge reaches a point where it doesn't read any higher. Record the pressure gauge reading at this point.

Figure 8-Y illustrates a typical method for measuring distance to water level:

X = Distance to water level (in feet). This figure to be determined.

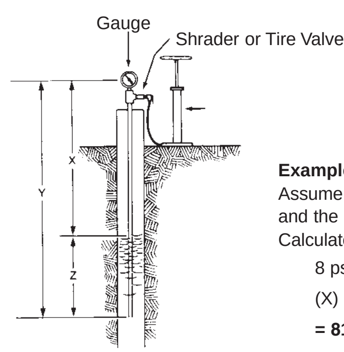
Y = Total length of air line (in feet).

Z = Length of submerged air line. This value is obtained from the pressure gauge reading which reads in pounds per square inch (psi). Multiply the pressure gauge reading by 2.31 to obtain the length of the submerged air line in feet.

Distance to water level (X) = (Y) - (Z)
= The total length of the air line (Y) minus the length of the submerged portion of the air line (Z).

Figure 8-Y

Calculating the distance to water level.



Example:
Assume that the air line is 100 feet long and the pressure gauge reads 8 psi. Calculate the distance to water level (X).

8 psi x 2.31 = 18.5 feet

(X) = 100 feet (Y) - 18.5 feet (Z)

= 81.5 feet = distance to water level

FORMULAS

TEMPERATURE CONVERSIONS:

Degrees **C** = $\frac{5}{9}$ x (Degrees F - 32)

Degrees **F** = ($\frac{9}{5}$ x Degrees C) + 32

Area of a Circle:

Area = πr^2

Circumference of a Circle:

Circumference = $2 \pi r$

r = radius

π = 3.14

Volume of a Tank or Cistern:

3.14 x (radius of tank)^2 x (ht. of tank) x 7.48 = Gallons
Radius and height of tank measured in feet
7.48 = number of gallons per cubic foot of water

WORK, POWER, AND EFFICIENCY:

The amount of work required to lift 1 pound to a height of 1 foot is defined as 1 ft.-lb. To lift 100 pounds to a height of 60 feet is 100 pounds x 60 feet = 6,000 ft-lbs. This amount of energy remains the same whether it takes one minute or one hour to lift the weight. The rate of working, however, is referred to as **power** and was 6,000 ft-lbs. per minute in the first case and 100 foot pounds per minute in the second case.

Power can be represented either mechanically or electrically. **Mechanical power** is measured in horsepower (HP). One HP is the theoretical power required to raise 33,000 pounds to a height of one foot in one minute, or:

1 HP = 33,000 ft.-lb./minute
= 550 ft.-lb./second

Electrical power is measured in watts(w) or kilowatts(kw), and:

1,000 w = 1 kw = 1.34 hp, or
1 HP = 745 w = 0.746 kw

WATER HORSEPOWER (WHP):

Water horsepower is the power required to raise water at a specified rate against a specified head, assuming 100% efficiency.

$$\text{WHP} = \frac{\text{GPM x Total Pumping Head}}{3{,}960}$$

BRAKE HORSEPOWER (BHP):

Brake horsepower is based on test data and can be either the horsepower developed at the motor shaft (motor output) or that absorbed at the pump shaft (pump input).

$$\text{Pump BHP} = \frac{\text{WHP x 100}}{\text{Pump Efficiency (\%)}}$$

$$= \frac{\text{GPM x Total Pumping Head x 100}}{\text{3,960 x Pump Efficiency (\%)}}$$

$$\text{Motor BHP} = \frac{\text{Power input x Motor Efficiency (\%)}}{100}$$

$$= \frac{\text{1.34 x kw input x Motor Efficiency (\%)}}{100}$$

PUMP EFFICIENCY:

Pumps and motors, like all machines, are not 100% efficient. Not all of the energy supplied to them is converted into useful work. Pump efficiency is the ratio of power output to power input, or:

$$\text{Efficiency (\%)} = \frac{\text{Power Output x 100}}{\text{Power Input}}$$

$$\text{Pump Eff. (\%)} = \frac{\text{WHP x 100}}{\text{Pump BHP (Input)}}$$

$$= \frac{\text{GPM x Total Pumping Head x 100}}{\text{3960 x Pump BHP (Input)}}$$

$$\text{Motor Eff. (\%)} = \frac{\text{Motor BHP (Output) x 100}}{\text{1.34 x kw input}}$$

$$\text{Plant Eff. (\%)} = \frac{\text{GPM x Total Pumping Head x 100}}{\text{5,300 x kw Input}}$$

ELECTRIC POWER (AC):

E = Electrical pressure (volts). Similar to hydraulic head.

I = Electrical current (amps). Similar to rate of flow.

W = Electrical power (watts) = E x I x PF

kw = Kilowatt (1,000 watts)

kw-hr. = Kilowatt-hour = 1,000 watts for one hour

Apparent Power = E x I = volt-amperes

PF = Power Factor = Useful Power ÷ Apparent Power

Power Calculations for Single-Phase Power
W (Watts) = E x I x PF
NOTE: When measuring single-phase power use a single-phase wattmeter.

Input HP to motor = W ÷ 746 = 1.34 x kw

Power Calculations for Three-Phase Power
W (Watts) = 1.73 x E x I x PF
Where: E = effective (RMS) voltage between phases
I = average current in each phase
NOTE: When measuring three-phase power use either (1) three-phase wattmeter, (2) single-phase wattmeters, or the power company's revolving disc wattmeter.

When calculating power with a revolving disc wattmeter use the following formulas:

$$\text{kw input} = \frac{\text{K x R x 3.60}}{\text{t}}$$

$$\text{Input HP (to motor)} = \frac{\text{K x R x 3,600}}{\text{746 x t}}$$

$$= \frac{\text{K x R x 4.83}}{\text{t}}$$

FORMULAS

Motor BHP (output) = $\dfrac{\text{Input HP x Motor Eff.(\%)}}{100}$

Where K = Meter constant = watts per revolution of revolving disc (value of K is marked on the meter nameplate or on the revolving disc). Where current transformers are used, multiply meter constant by current transformer ratio.

R = Number of disc revolutions counted.

t = Time in seconds for R revolutions.

CALCULATING OPERATING COSTS OF PUMPS:
Costs in Cents per 1,000 Gallons:

Cost (¢) = $\dfrac{\text{kw Input x r x 1,000}}{\text{GPH}}$

Cost in Cents per Acre-Inch

Cost (¢) = $\dfrac{\text{kw Input x r x 452.6}}{\text{GPM}}$

Where: r = cost of power in cents per kw-hr.

FRICTION LOSS TABLES

Friction Loss Table – SCH 40 STEEL PIPE

(Friction Loss in Feet of Head Per 100 Feet of Pipe)

GPM	GPH	1/2" ID 0.622"	3/4" ID 0.824"	1" ID 1.049"	1 1/4" ID 1.380"	1 1/2" ID 1.610"	2" ID 2.067"	2 1/2" ID 2.469"	3" ID 3.068"	4" ID 4.026"
2	120	4.8								
3	180	10	2.5							
4	240	17.1	4.2							
5	300	25.8	6.3	1.9						
6	360	36.5	8.9	2.7						
7	420	48.7	11.8	3.6						
8	480	62.7	15	4.5						
9	540	78.3	18.8	5.7						
10	600	95.9	23	6.9	1.8					
12	720		32.6	9.6	2.5	1.2				
14	840		43.5	12.8	3.3	1.5				
16	960		56.3	16.5	4.2	2				
20	1,200		86.1	25.1	6.3	2.9				
25	1,500			38.7	9.6	4.5	1.3			
30	1,800			54.6	13.6	6.3	1.8			
35	2,100			73.3	18.2	8.4	2.4			
40	2,400			95	23.5	10.8	3.1	1.3		
45	2,700				29.4	13.5	3.9	1.6		
50	3,000				36	16.4	4.7	1.9		
60	3,600				51	23.2	6.6	2.7		
70	4,200				68.8	31.3	8.9	3.6	1.2	
80	4,800				89.2	40.5	11.4	4.6	1.6	
90	5,400					51	14.2	5.8	2	
100	6,000					62.2	17.4	7.1	2.4	
120	7,200						24.7	10.1	3.4	
140	8,400						33.2	13.5	4.5	1.2
160	9,600						43	17.5	5.8	1.5
200	12,000						66.3	27	8.9	2.3
260	15,600							45	14.8	3.7
300	18,000							59.6	19.5	4.9

Friction Loss Table – SCH 40 PVC

(Friction Loss in Feet of Head Per 100 Feet of Pipe)

GPM	GPH	1/2" ID 0.622"	3/4" ID 0.824"	1" ID 1.049"	1 1/4" ID 1.380"	1 1/2" ID 1.610"	2" ID 2.067"	2 1/2" ID 2.469"	3" ID 3.068"	4" ID 4.026"
2	120	4.1								
3	180	8.7	2.2							
4	240	14.8	3.7							
5	300	22.2	5.7	1.8						
6	360	31.2	8	2.5						
7	420	41.5	10.6	3.3						
8	480	53	13.5	4.2						
9	540	66	16.8	5.2						
10	600	80.5	20.4	6.3	1.7					
12	720		28.6	8.9	2.3	1.1				
14	840		38	11.8	3.1	1.4				
16	960		48.6	15.1	4	1.9				
20	1,200		60.5	22.8	6	2.8				
25	1,500			38.7	9.1	4.3	1.3			
30	1,800				12.7	6	1.8			
35	2,100				16.9	8	2.4			
40	2,400				21.6	10.2	3	1.1		
45	2,700				28	12.5	3.8	1.4		
50	3,000					15.4	4.6	1.7		
60	3,600					21.6	6.4	2.3		
70	4,200					28.7	8.5	3	1.2	
80	4,800					36.8	10.9	3.8	1.4	
90	5,400					45.7	13.6	4.8	1.8	
100	6,000					56.6	16.5	5.7	2.2	
120	7,200						23.1	8	3	
140	8,400						30.6	10.5	4	1.1
160	9,600						39.3	13.4	5	1.4
200	12,000						66.3	20.1	7.6	2.1
260	15,600							32.4	12.2	3.4
300	18,000							42.1	15.8	4.4

Friction Loss Table – VALVES and FITTINGS

(Friction Loss in Equivalent Number of Feet of Straight Pipe)

TYPE OF FITTING AND APPLICATION	PIPE AND FITTING	NOMINAL SIZE OF FITTING AND PIPE						
		1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"
		EQUIVALENT LENGTH OF PIPE(IN FEET)						
Insert Coupling	Plastic	3	3	3	3	3	3	3
Threaded Adapter (Plastic to Thread)	Plastic	3	3	3	3	3	3	3
90° Standard Elbow	Steel	2	2	3	4	4	5	6
	Plastic	2	2	3	4	4	5	6
Standard Tee (Flow Through Run)	Steel	1	2	2	3	3	4	4
	Plastic	1	2	2	3	3	4	4
Standard Tee (Flow Through Side)	Steel	4	5	6	7	8	11	13
	Plastic	4	5	6	7	8	11	13
Gate Valve[1]	Steel	1	1	1	1	2	2	2
Swing Check Valve[1]	Steel	5	7	9	12	13	17	21

NOTES:

Based on schedule 40 steel and plastic fittings.

Figures given are friction losses in terms of Equivalent Lenghts of straight pipe.

① Friction loss figures are for screwed valves and are based on equivalent lengths of steel pipe.

CONVERSION TABLES

UNITS OF FLOW

CONVERT TO ▶ / CONVERT FROM ▼	U.S. GALLONS PER MINUTE	MILLION U.S. GALLONS PER DAY	CUBIC FEET PER SECOND	CUBIC METERS PER HOUR	LITERS PER SECOND
	MULTIPLY BY:				
(1) U.S. GALLON PER MINUTE	1	0.001440	0.00223	0.2271	0.0631
(1) MILLION U.S. GALLONS PER DAY	694.5	1	1.547	157.7	43.8
(1) CUBIC FOOT PER SECOND	448.83	0.646	1	101.9	28.32
(1) CUBIC METER PER HOUR	4.403	0.00634	0.00982	1	0.2778
(1) LITER PER SECOND	15.85	0.0228	0.0353	3.60	1

UNITS OF PRESSURE AND HEAD

CONVERT TO ▶ / CONVERT FROM ▼	LBS. PER SQUARE INCH	FEET OF WATER ①	METERS OF WATER ①	INCHES OF MERCURY ②	ATMOSPHERES	KILOGRAMS PER SQUARE CM
	MULTIPLY BY:					
(1) LB. PER SQUARE INCH	1	2.31	0.704	2.04	0.0680	0.0703
(1) FOOT OF WATER ①	0.433	1	0.305	0.881	0.02945	0.0304
(1) METER OF WATER ①	1.42	3.28	1	2.89	0.0966	.1
(1) INCH OF MERCURY ②	0.491	1.135	0.346	1	0.0334	0.0345
(1) ATMOSPHERE (at Sea Level)	14.70	33.96	10.35	29.92	1	1.033
(1) KILOGRAM PER SQUARE CM	14.22	32.9	10	28.96	0.968	1

NOTES: ① Equivalent units are based on density of fresh water at 68°F.
② Equivalent units are based on density of mercury at 32°F.
Each 1,000 feet of ascent decreases pressure about ½ pound per square inch.

UNITS OF VOLUME AND WEIGHT

CONVERT TO ▶ / CONVERT FROM ▼	U.S. GALLONS	IMPERIAL GALLONS	CUBIC INCHES	CUBIC FEET	ACRE FEET	POUNDS ③	CUBIC METERS	LITERS
(1) U.S. GALLON	1	0.833	231	0.1337	$3.07x10^{-6}$	8.34	0.003785	3.785
(1) IMPERIAL GALLON	1.201	1	277.4	0.1605	$3.69x10^{-6}$	10.01	0.004546	4.546
(1) CUBIC INCH	0.00433	0.00360	1	0.000579	—	0.0361	$1.64x10^{-5}$	0.0164
(1) CUBIC FOOT	7.48	6.23	1728	1	$2.30x10^{-5}$	62.4	0.02832	28.32
(1) ACRE FOOT	325,850	271,335	—	43,560	1	$2.7x10^{6}$	1233.5	$1.23x10^{6}$
(1) POUND ③	0.120	0.0998	27.7	0.0160	$3.68x10^{-7}$	1	$4.54x10^{-4}$	0.454
(1) CUBIC METER	264.2	220	61,024	35.315	$8.11x10^{-4}$	2202	1	1000
(1) LITER	0.2642	0.220	61.024	0.0353	$8.11x10^{-7}$	2.202	0.001	1

NOTES: ③ Weight equivalent basis water at 60°F.

UNITS OF LENGTH

(1) Inch = 0.0833 Ft. = 0.0278 Yd. = 25.4 mm = 2.54 cm
(1) Ft. = 12 Inches = 0.333 Yd. = 30.48 cm = 0.3048 Meter
(1) Yard = 36 Inches = 3 Ft. = 91.44 cm = 0.9144 Meters

(1) Mile = 5280 Ft. = 1760 Yds. = 1.61 km = 1609 Meters
(1) Meter = 3.281 Ft. = 39.37 In. = 0.000621 Miles = 0.001 km
(1) Kilometer = 1000 m = 1093.61 Yds. = 0.62137 Miles = 3281 Ft.

BE > THINK > INNOVATE >

Being responsible is our foundation
Thinking ahead makes it possible
Innovation is the essence

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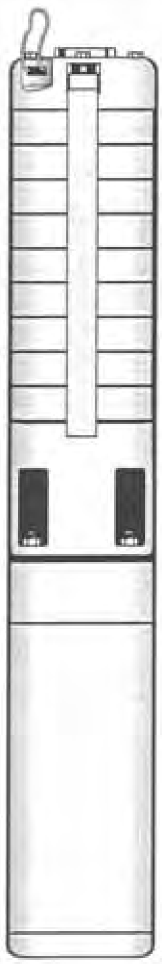


Kits List

4" Submersibles

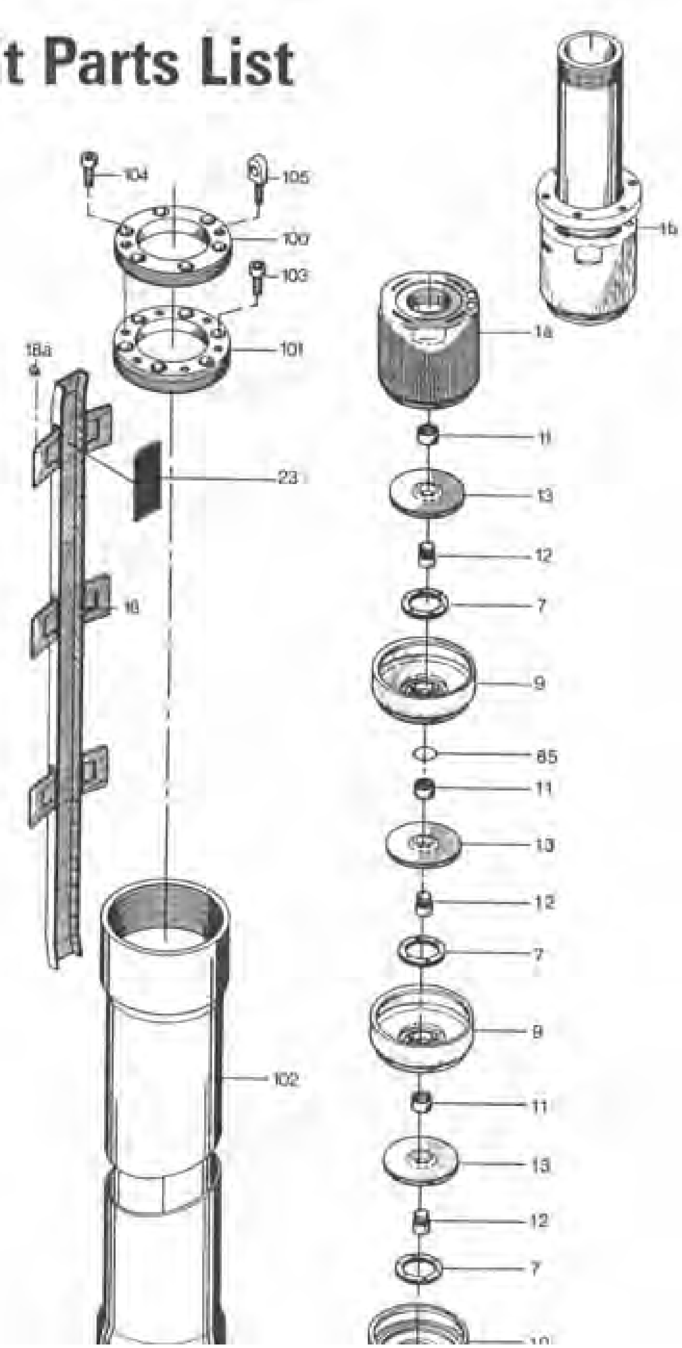
Contents

25S

Smooth Shaft

LSP-KL-0055 (Rev. 5/95)

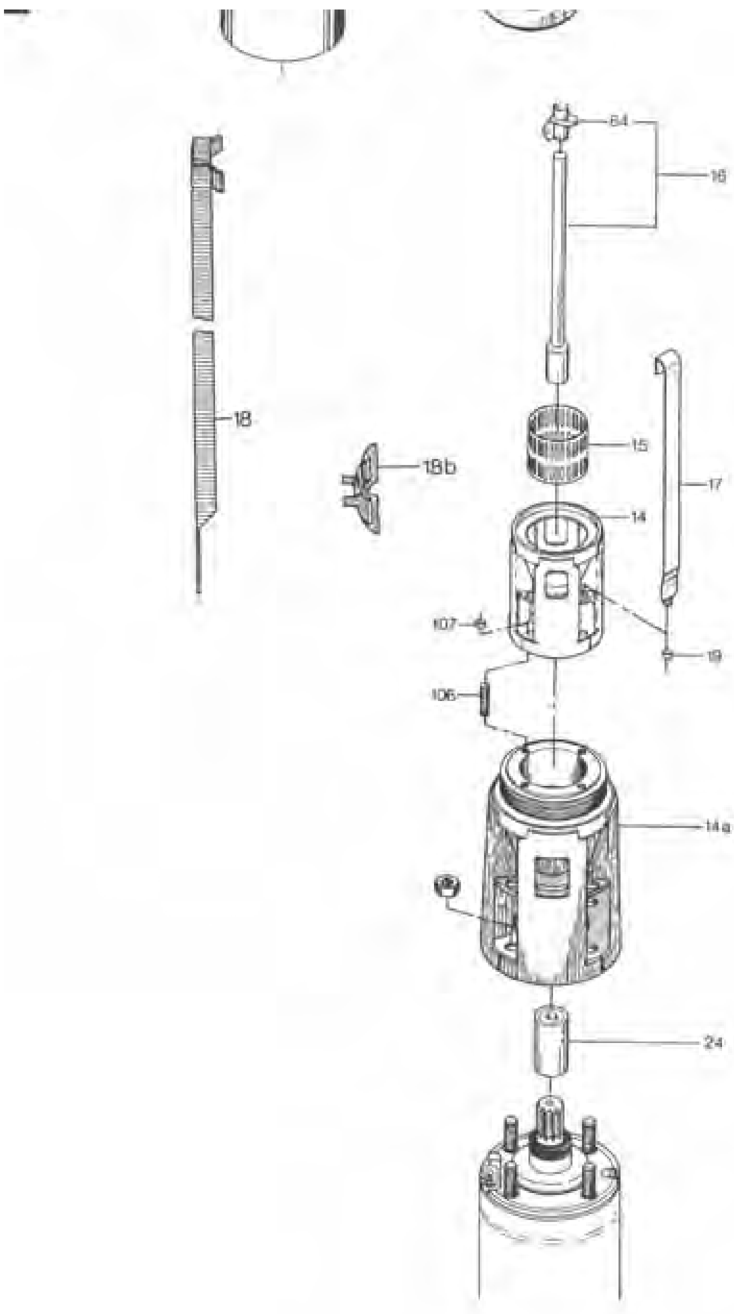
Kit Parts List



25S SMOOTH SHAFT

GRUNDFOS
"Leaders in Pump Technology"

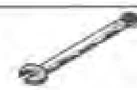
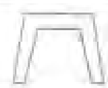
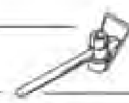
POS.	DESCRIPTION	QTY	PART #	KIT
	INLET/DISCHARGE KIT			
1a	H/P TOP PIECE W/CHECK VALVE	1	105015	*INLET/DISCHARGE KIT* Part No. 05003Z
14	4"X6" INLET	1	115038	
10	CHAMBER LOWER INT	1	095004	
15	STRAINER	1	090017	
	INLET/DISCHARGE SLEEVE KIT			
1b	DISCHARGE W /PIPE	1	105020	*INLET/DISCHARGE KIT* 52 STAGES 6" Pn. 05004Z
10	CHAMBER LOWER INT.	1	095004	
14a	INLET W/ CONN. PIECE 6"	1	115031	
14	INLET 4"	1	115023	
15	STRAINER	1	090017	
	BEARING KIT			
85	UPTHRUST WASHER	3	100090	*BEARING KIT* 39 STAGES Pn. 08006Z 52 STAGES Pn. 08008Z
7	SEAL RINGS (NBR)	SEE KIT	095006	
	IMPELLER KIT			
13	IMPELLER	SEE KIT	055002	*IMPELLER KIT* 39 STAGES Pn. 05008Z 52 STAGES Pn. 05009Z
19	NUT FOR STRAP	4	ID7187	
12	SPLIT CONE	SEE KIT	090012	
11	SPLIT CONE NUT	SEE KIT	095515	
	NUT KIT 6"	1	UB9001	
	CHAMBER KIT			
9	INT. CHAMBERS	SEE KIT	055005	*CHAMBER KIT* 39 STAGES Pn. 05013Z 52 STAGES Pn. 05014Z
19	NUT FOR STRAP	4	ID7187	
10	CHAMBER LOWER INT	1	095004	
	NUT KIT 6"	1	UB9001	
	25S75-39DS STRAP KIT			
17	STRAP	4	099039	*STRAP KIT* Part No. 08072Z
19	NUT FOR STRAP	4	ID7187	
18	CABLE GUARD	1	109339	
18b	CABLE GUARD CLIP	1	080509	
	25S100-52DS STRAP KIT			
17	STRAP	4	119026	*STRAP KIT* Part No.08075Z
19	NUT FOR STRAP	4	ID7187	
102	SLEEVE	1	108752	
100	TIGHT FLANGE COUNTER	1	110080	
101	TIGHT FLANGE	1	110081	
105	EYE BOLT	1	ID7389	
103/104	ALLEN SCREW	12	ID1368	
18a	CHEESE HD SCREW	6	ID1393	
18	CABLE GUARD	1	109052	



	SHAFT KIT			SHAFT KIT
16	25S75-39 SHAFT	1	106439	Part No. 08044Z
16	25S100-52DS SHAFT	1	106052	Part No. 08046Z
*	NUT KIT	1	UB9011	
24	COUPLING	1	795939	

Special Tool Kits

(Tools not generally available from normal sources)

Part Number	Description	
96022539	**Tool Kit: 5S-75S Model Pumps**	
ID1204	Tool Kit Includes: ALLEN WRENCH 6mm	
SV0006/ SV0007 SV0008 SV0009 SV0011	SHAFT SPACER 39.3mm SHAFT SPACER 38mm SHAFT SPACER 39mm SHAFT SPACER 41mm SHAFT SPACER 77mm	
SV0231 SV00211 SV00261	SHAFT SPACER 76mm SHAFT SPACER 77.5mm SHAFT SPACER 42.5mm	
SV0049	MOUNTING PLATE 4" & 6" MOTORS	
SV0054 SV0055	BOX/OPEN END WRENCH 19mm BOX/OPEN END WRENCH 13mm	
SV0074 SV0183	BOLT FOR SHAFT M8X65mm BOLT FOR SHAFT M8X110mm	
SV0114 SV0115	SHAFT HEIGHT GAUGE 4" MOTOR SHAFT HEIGHT GAUGE 6" MOTOR	
SV0182	SPLIT CONE NUT WRENCH 5S-25S	
SV0187 SV0217	SPLIT CONE NUT WRENCH 40S SPLIT CONE NUT WRENCH 60S-75S	
SV0226	SHAFT SPACER 43mm (SPLINE SHAFT MODELS)	
SV0280	SHAFT BEARING DRIVER KIT	
SV0288	SPECIAL KEY FOR SLEEVE MODELS	
SV0853	STRAP WRENCH	

* All tools may be purchased separately

96022537	TORQUE WRENCH KIT: 5S - 225S MODEL PUMPS (Kit includes three torque wrenches with fittings, range: 4Nm-200Nm)	

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Motors
4-6-8-10"

CONTENTS

4 Inch (Two Wire) Motors - *Control Box Not Required*

SINGLE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load*	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff. %	Power Factor	Line-to-Line Resistance Black-Yellow	Line-to-Line Resistance Red-Yellow	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
1/3	.25	230	1.75	2.6	4.6	25.7	59	0.77	6.8-8.2		S	900	79952101	96465614
1/2	.37	115	1.60	7.5	12	55	62	0.76	1.1-1.3		R	900	79922102	96465574
		230	1.60	3.8	6	34.5	62	0.76	5.2-6.3		R	900	79952102	96465616
3/4	.55	230	1.50	5.6	8.4	40.5	62	0.75	3.2-3.8		N	900	79952103	96465618
1	.75	230	1.40	7.0	9.8	48.4	63	0.82	2.5-3.1		M	900	79952104	96465620
1 1/2	1.1	230	1.30	10.1	13.1	62	64	0.85	1.9-2.3		L	900	79952105	96465622

4 Inch (Three Wire) Motors

SINGLE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load*	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff. %	Power Factor	Line-to-Line Resistance Black-Yellow	Line-to-Line Resistance Red-Yellow	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
1/3	.25	115	1.75	5.1	9	29	59	0.77	1.55-1.9	2.4-3	M	900	79423101	96465571
		230	1.75	2.6	4.6	14	59	0.77	6.8-8.3	17.3-21.1	L	900	79453101	96465603
1/2	.37	115	1.60	7.5	12	42.5	61	0.76	.9-1.1	1.9-2.35	L	900	79423102	96023039
		230	1.60	3.8	6	21.5	62	0.76	4.7-5.7	15.8-19.6	L	900	79453102	96465606
3/4	.55	230	1.50	5.6	8.4	31.4	62	0.75	3.2-3.9	14-17.2	L	900	79453103	96465608
1	.75	230	1.40	7.0	9.8	37	63	0.82	2.6-3.1	10.3-12.5	K	900	79453104	96465610
1 1/2	1.1	230	1.30	8.9	11.6	45.9	69	0.89	1.9-2.3	7.8-9.6	H	900	79453105	96465612
2	1.5	230	1.25	10.6	13.2	57	72	0.86	1.5-1.8	3.4-4.1	G	1500	79454506	96449947
3	2.2	230	1.15	14.8	17	77	74	0.93	1.2-1.4	2.45-3	F	1500	79454507	96449948
5	3.7	230	1.15	23.9	27.5	110	77	0.92	.65-.85	2.1-2.6	F	1500	79454509	96449949

4 Inch Motors

THREE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load*	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff. %	Power Factor	Line-to-Line Resistance Black-Yellow	Line-to-Line Resistance Red-Yellow	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
1/2	.37	208	1.60	2.2	3.5	24.5	70	0.87	2.24		N	900	79322002	96465633
		230	1.60	2.0	3.15	15.7	69	0.72	8.1		N	900	79302002	96465624
		460	1.60	1.0	1.6	7.85	69	0.72	6.92		N	900	79362002	96465638
3/4	.55	208	1.50	3.4	5.1	24.5	69	0.7	4.6		N	900	79322003	96465634
		230	1.50	3.1	4.6	22.3	69	0.7	5.7		N	900	79302003	96465626
		460	1.50	1.5	2.3	11.2	69	0.7	23.2		N	900	79362003	96465639
1	.75	208	1.40	4.3	6	30	71	0.73	3.72		M	900	79322004	96465635
		230	1.40	3.9	5.4	27	71	0.73	4.7		M	900	79302004	96465627
		460	1.40	1.9	2.7	13.5	71	0.73	19		M	900	79362004	96465650
1 1/2	1.1	208	1.30	6.2	8.1	44.6	75	0.72	2.68		M	900	79322005	96465636
		230	1.30	5.6	7.3	40.3	75	0.72	3.12		M	900	79302005	96465629
		460	1.30	2.8	3.7	20.1	75	0.72	15.9		K	900	79362005	96465651
		575	1.30	2.2	2.9	16.1	75	0.72	25.2		K	900	79392005	–
2	1.5	208	1.25	7.7	9.6	53	77	0.75	1.9		L	900	79322006	96465637
		230	1.25	7.0	8.7	48	76	0.75	3		J	900	79302006	96465630
		460	1.25	3.5	4.4	24	76	0.75	12.1		J	900	79362006	96465652
		575	1.25	2.8	3.5	19.2	76	0.75	18.8		J	900	79392006	–
3	2.2	208	1.00	10.8	10.8	–	89	0.84	2.12		–	1500	79324507	96405806
		208/230	1.15	10.6	12.2	56	77	0.75	2.2		H	1500	79304507	96405801
		460	1.15	5.3	6.1	28	77	0.75	9		H	1500	79354507	96405810
		575	1.15	4.2	4.8	22	77	0.75	13		H	1500	79395507	–
5	3.7	208	1.15	18.1	20.8	–	80	0.82	1.2		–	1500	79324509	96405807
		208/230	1.15	17.2	19.8	108	80	0.82	1.2		H	1500	79304509	96405802
		440/460	1.15	8.6	9.9	54	80	0.82	5		H	1500	79354509	96405811
		575	1.15	6.9	7.9	54	80	0.82	7.3		H	1500	79394509	–
7 1/2	5.5	208/230	1.15	21.7	25	130	81	0.82	0.84		H	1500	79305511	96405805
		440/460	1.15	11.1	12.8	67	81	0.82	3.24		J	1500	79355511	96405814
		575	1.15	9.2	10.6	53	81	0.82	5.2		J	1500	79395511	–
10	7.5	440/460	1.15	15.7	18	90	81	0.80	1.16		H	1500	79355512	96440318
		575	1.15	12.5	14.4	72	81	0.80	1.84		H	1500	79395512	–

*This is a calculated value.

HP	Kw	Voltage	FUSE(5)		Circuit Breaker	NEMA Starter Size	IEC Starter Size	OVERLOADS			
			Fast Acting	Time Delay				Cutler Hammer (1)	Allen Bradley (2)	General Electric (3)	Siemens (4)

4 Inch (Two Wire) Motors - *Control Box Not Required*

SINGLE PHASE

1/3	.25	230	8	5	10	–	–	–	–	–	–
1/2	.37	115	25	15	20	–	–	–	–	–	–
		230	15	7	10	–	–	–	–	–	–
3/4	.55	230	20	10	15	–	–	–	–	–	–
1	.75	230	25	12	20	–	–	–	–	–	–
1 1/2	1.1	230	30	20	25	–	–	–	–	–	–

4 Inch (Three Wire) Motors

SINGLE PHASE

1/3	.25	115	15	9	15	–	–	–	–	–	–
		230	8	5	10	–	–	–	–	–	–
1/2	.37	115	25	15	20	–	–	–	–	–	–
		230	15	7	10	–	–	–	–	–	–
3/4	.55	230	20	10	15	–	–	–	–	–	–
1	.75	230	25	12	20	–	–	–	–	–	–
1 1/2	1.1	230	30	20	25	–	–	–	–	–	–
2	1.5	230	35	20	30	–	–	–	–	–	–
3	2.2	230	45	30	40	–	–	–	–	–	–
5	3.7	230	70	45	60	–	–	–	–	–	–

4 Inch Motors

THREE PHASE

1/2	.37	208	7	4	10	00	A	H2106B-3	J12	255A	K26
		230	6	3	10	00	A	H2106B-3	J11	232A	K24
		460	3	2	10	00	A	104	J4	193A	K21
3/4	.55	208	10	6	10	00	A	108	J17	420A	K32
		230	9	5	10	00	A	107	J16	380A	K29
		460	5	3	10	00	A	105	J8	174A	K21
1	.75	208	15	8	15	00	A	108	J19	510A	K34
		230	15	7	10	00	A	108	J18	463A	K33
		460	6	3	10	00	A	105	J10	232A	K23
1 1/2	1.1	208	20	15	20	00	A	109	J23	750A	K41
		230	20	10	15	00	A	109	J22	680A	K39
		460	9	5	10	00	A	107	J15	343A	K28
		575	7	4	10	00	A	106	J12	255A	K26
2	1.5	208	25	15	20	0	B	110	J25	910A	K43
		230	20	15	20	0	B	109	J24	825A	K43
		460	10	6	10	00	A	108	J17	420A	K32
		575	8	5	10	00	A	107	J15	343A	K28
3	2.2	208	40	25	35	0	C	111	J30	147B	K56
		208/230	35	20	30	0	C	110	J28	122B	K53
		460	20	9	15	0	A	109	J21	618A	K37
		575	15	7	10	0	A	108	J19	510A	K34
5	3.7	208	60	35	45	1	D	112	J34	220B	K61
		208/230	50	30	45	1	D	112	J33	199B	K60
		440/460	30	15	25	0	B	110	J26	100B	K50
		575	25	15	20	0	A	109	J24	825A	K43
7 1/2	5.5	208/230	65	40	60	1	E	112	J36	265B	K64
		440/460	35	20	30	1	C	111	J29	135B	K54
		575	30	20	25	1	B	110	J27	111B	K50
10	7.5	440/460	50	30	40	1	D	112	J32	181B	K60
		575	40	25	35	1	C	111	J30	147B	K56

Notes:

(1) These overloads are for both NEMA and IEC Freedom series starters by EATON Cutler-Hammer. The complete part number is H2_B-3. This information was collected from EATON Cutler-Hammer catalog number CA08102001E.

(2) These overload heater coils are for the Allen Bradley Bulletin 509 Starter. This information was collected from the Allen Bradley catalog number A115-CA001A-EN-P.

(3) These overloads are designed for use with GE NEMA starters. Complete part numbers are CR123L____. For use with GE CR124 single element overloads. This information was collected from page 1-107 of the Control Catalog, Rev. 07/03.

(4) These overloads are designed for Siemens NEMA Overload Relays. This information was collected from page 8/151 of the 2006 Siemens Industrial Control Catalog.

(5) The Fuses and Circuit Breakers were calculated from the NEC table 430.52.

Starters and overloads should always be sized by a licensed electrician that is familiar with local codes and standards. The overloads for submersible motors should be Class 10 Quick trip ambient compensated.

6 Inch (Three Wire) Motors

THREE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Calculated Full Load	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff %	Power Factor	Line-to-Line Resistance Black-Yellow	Line-to-Line Resistance Red-Yellow	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
7 1/2	5.5	208/230	1.15	23.9/23.9	27.5/27.5	118.3/132	80.5	0.76	0.56		H	1500	78305511	96405781
		440/460	1.15	11.5	13.2/13.2	56.8/59.4	80.5	0.76	2.4		G	1500	78355511	96405794
		575	1.15	9.2	10.6	48	80.5	0.76	4.07		H	1500	78395511	–
10	7.5	208/230	1.15	31.7/30.9	36.5/35.5	153.3/170.4	82.5	0.79	0.41		H	1500	78305512	96405782
		440/460	1.15	15.1/14.8	17.4/17	74.8/78.2	82	0.79	1.8		G	1500	78355512	96405795
		575	1.15	11.8	13.6	63	82	0.79	3.1		G	1500	78395512	–
15	11	208/230	1.15	47/43.9	54/50.5	232.2/252.5	82.5	0.82	0.25		H	7000	78305514	96405783
		440/460	1.15	22.2/21.3	25.5/24.5	109.7/115.2	82.5	0.82	1.16		G	7000	78355514	96405796
		575	1.15	17.0	19.6	92	82.5	0.82	1.9		G	7000	78395514	–
20	15	208/230	1.15	60.9/58.7	70/67.5	329/364.5	84	0.81	0.2		J	7000	78305516	96405784
		440/460	1.15	29.1/28.7	33.5/33	164.2/171.6	84	0.82	0.8		H	7000	78355516	96405797
		575	1.15	23.0	26.4	137	84	0.82	1.32		H	7000	78395516	–
25	18.5	208/230	1.15	76.5/74.3	88/85.5	431.2/470.3	84.5	0.80	0.156		J	7000	78305517	96405785
		440/460	1.15	36.5/35.7	42/41	210/217.3	84.5	0.80	0.62		H	7000	78355517	96405798
		575	1.15	28.7	33	175	84.5	0.80	1.04		H	7000	78395517	–
30	22	208/230	1.15	87.8/84.3	101/97	464.6/514.1	85	0.83	0.13		H	7000	78305518	96405786
		440/460	1.15	41.7/40.4	48/46.5	225.6/237.2	85	0.83	0.55		G	7000	78355518	96405799
		575	1.15	32.2	37	189	84.5	0.83	0.92		G	7000	78395518	–
40	30	440/460	1.15	57.8/55.7	66.5/64	305.9/320	64	0.82	0.39		H	7000	78355520	96405800

*This is a calculated value.

6 Inch (Three Wire) Motors

THREE PHASE

HP	Kw	Voltage	FUSE(5) Fast Acting	FUSE(5) Time Delay	Circuit Breaker	NEMA Starter Size	IEC Starter Size	OVERLOADS Cutler Hammer (1)	OVERLOADS Allen Bradley (2)	OVERLOADS General Electric (3)	OVERLOADS Siemens (4)
7 1/2	5.5	208/230	70	45	60	1	E	113	J36	293B	K64
		440/460	35	20	30	1	C	111	J29	135B	K55
		575	30	18	30	1	B	110	J27	111B	K50
10	7.5	208/230	90	60	80	2	F	114	J39	352B	K70
		440/460	45	30	40	1	D	112	J32	181B	K58
		575	35	20	30	1	C	111	J29	147B	K55
15	11	208/230	150	90	125	2	H	116	J42	593B	K75
		440/460	70	40	60	2	E	113	J35	265B	K63
		575	50	30	50	2	D	112	J33	199B	K60
20	15	208/230	200	110	150	3	J	117	J44	710B	K77
		440/460	90	50	80	2	F	114	J38	352B	K69
		575	70	40	60	2	E	113	J36	265B	K64
25	18.5	208/230	225	150	200	3	K	–	J70	950B	K85
		440/460	110	65	100	2	G	115	J39	464B	K72
		575	90	50	80	2	F	114	J38	352B	K69
30	22	208/230	300	150	225	3	L	–	J71	107C	K87
		440/460	125	75	110	3	H	–	J42	464B	K72
		575	100	55	80	3	G	–	J39	352B	K70
40	30	440/460	175	100	150	3	J	–	J44	710B	K77

Notes:

(1) These overloads are for both NEMA and IEC Freedom series starters by EATON Cutler-Hammer. The complete part number is H2_B-3. This information was collected from EATON Cutler-Hammer catalog number CA08102001E.

(2) These overload heater coils are for the Allen Bradley Bulletin 509 Starter. This information was collected from the Allen Bradley catalog number A115-CA001A-EN-P.

(3) These overloads ae designed for use with GE NEMA starters. Complete part numbers are CR123L____. For use with GE CR124 single element overloads. This information was collected from page 1-107 of the Control Catalog, Rev. 07/03.

(4) These overloads are designed for Siemens NEMA Overload Relays. This information was collected from page 8/151 of the 2006 Siemens Industrial Control Catalog.

(5) The Fuses and Circuit Breakers were calculated from the NEC table 430.52.

Starters and Overloads should always be sized by a licensed electrician that is familiar with local codes and standards. The Overloads for submersible motors should be Class 10 Quick trip ambient compensated.

4 Inch Industrial Motors

THREE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load*	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff %	Power Factor	Line-to-Line Resistance	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
3	2.2	230	1.15	9.9	11.4	–	78	0.81	2.08	J	1500	79305807	96415732
		460	1.15	5.0	5.7	–	78	0.81	8.00	J	1500	79355807	96415734
		575	1.15	4.0	4.55	–	78	0.81	12.00	J	1500	79395807	96415736
5	3.7	230	1.15	15.7	18	–	80.5	0.82	1.12	K	1500	79305809	96415733
		460	1.15	7.9	9.05	–	80.5	0.83	4.20	K	1500	79355809	96415735
		575	1.15	6.5	7.5	–	80.5	0.83	6.40	K	1500	79395809	96415737

6 Inch (Three Wire) Industrial Motors

THREE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load*	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff %	Power Factor	Line-to-Line Resistance	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
7 1/2	5.5	230	1.15	23.9	27.5	457.25	77.5	0.82	0.477	K	4400	78305311	96415738
		460	1.15	12.0	13.8	81.42	78	0.82	1.833	K	4400	78195811	96415744
10	7.5	230	1.15	30.4	35	206.5	81.5	0.86	0.393	J	4400	78305312	96415739
		460	1.15	15.3	17.6	103.84	81.5	0.86	1.493	K	4400	78195812	96415745
15	11	230	1.15	44.3	51	244.8	82.5	0.86	0.27	G	4400	78305314	96415740
		460	1.15	22.2	25.5	122.4	82	0.86	1.067	H	4400	78195814	96415746
20	15	230	1.15	60.4	69.5	403.1	84	0.86	0.17	J	4400	78305316	96415741
		460	1.15	30.0	34.5	200.1	83.5	0.86	0.657	K	4400	96415747	96415747
25	18.5	230	1.15	72.2	83	473.1	84.5	0.86	0.143	J	4400	78305317	96415742
		460	1.15	36.1	41.5	236.55	84.5	0.86	0.553	J	4400	78195817	96415748
30	22	230	1.15	86.5	99.5	557.2	84	0.86	0.116	H	4400	78305318	96415743
		460	1.15	43.5	50	280	84	0.86	0.483	J	4400	78195818	96415749

*This is a calculated value.

4 Inch Motors Industrial Motors

THREE PHASE

HP	Kw	Voltage	FUSE(5) Fast Acting	FUSE(5) Time Delay	Circuit Breaker	NEMA Starter Size	IEC Starter Size	OVERLOADS Cutler Hammer Overload (1)	OVERLOADS Allen Bradley (2)	OVERLOADS General Electric (3)	OVERLOADS Siemens (4)
3	2.2	230	30	17	25	0	C	110	J28	122B	K52
		460	15	9	15	0	C	109	J21	618A	K37
		575	12	7	10	0	A	108	J18	463A	K33
5	3.7	230	50	30	40	1	D	112	J32	181B	K60
		460	25	15	20	1	D	110	J25	910A	K49
		575	20	11	20	0	B	109	J23	750A	K42

6 Inch (Three Wire) Industrial Motors

THREE PHASE

HP	Kw	Voltage	FUSE(5) Fast Acting	FUSE(5) Time Delay	Circuit Breaker	NEMA Starter Size	IEC Starter Size	OVERLOADS Cutler Hammer Overload (1)	OVERLOADS Allen Bradley (2)	OVERLOADS General Electric (3)	OVERLOADS Siemens (4)
7 1/2	5.5	230	75	45	60	1	E	114	J36	293B	K64
		460	40	25	30	1	C	111	J30	147B	K55
10	7.5	230	100	60	80	2	F	114	J38	352B	K70
		460	50	30	40	1	D	112	J32	181B	K60
15	11	230	140	80	125	2	H	116	J42	520B	K76
		460	65	40	60	2	E	113	J35	265B	K64
20	15	230	200	110	150	3	J	117	J44	710B	K77
		460	90	60	80	2	F	114	J38	352B	K69
25	18.5	230	225	150	200	3	K	117	J46	866B	K83
		460	110	70	90	2	G	115	J40	464B	K72
30	22	230	275	150	225	3	L	-	J71	107C	K87
		460	130	80	125	3	H	-	J41	520B	K75

Notes:

(1) These overloads are for both NEMA and IEC Freedom series starters by EATON Cutler-Hammer. The complete part number is H2_B-3. This information was collected from EATON Cutler-Hammer catalog number CA08102001E.

(2) These overload heater coils are for the Allen Bradley Bulletin 509 Starter. This information was collected from the Allen Bradley catalog number A115-CA001A-EN-P.

(3) These overloads ae designed for use with GE NEMA starters. Complete part numbers are CR123L____. For use with GE CR124 single element overloads. This information was collected from page 1-107 of the Control Catalog, Rev. 07/03.

(4) These overloads are designed for Siemens NEMA Overload Relays. This information was collected from page 8/151 of the 2006 Siemens Industrial Control Catalog.

(5) The Fuses and Circuit Breakers were calculated from the NEC table 430.52.

Starters and Overloads should always be sized by a licensed electrician that is familiar with local codes and standards. The Overloads for submersible motors should be Class 10 Quick trip ambient compensated.

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff %	Power Factor	Line-to-Line Resistance	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.

6 Inch (460V) Motors

THREE PHASE

50	37	460	1.15	68.7	79	470	84	0.83	0.378	G	13000	96476890	96023200

8 Inch (460V) Motors

THREE PHASE

40	30	460	1.15	55.7	64	380	83	0.85	0.35	K	13000	96530180	96023204
50	37	460	1.15	67.8	78	550	84	0.85	0.25	J	13000	96530182	96023205
60	45	460	1.15	80.4	92.5	640	86	0.85	0.18	K	13000	96476891	96023206
75	55	460	1.15	97.4	112	580	86	0.86	0.15	J	13000	96476892	96023207
100	75	460	1.15	130.4	150	570	87	0.86	0.13	J	13000	96476893	96023208
125	92	460	1.15	160.0	184	600	87	0.87	0.09	J	13000	96476894	96023209
150	110	460	1.15	191.3	220	580	86	0.87	0.08	J	13000	96511375	96023210

10 Inch (460V) Motors

THREE PHASE

100	75	460	1.15	133.9	154	570	87	0.84	0.092	J	13000	–	96023211
125	92	460	1.15	165.2	190	550	87	0.83	0.7	J	13000	96540300	96023212
150	110	460	1.15	194.8	224	580	88	0.84	0.055	J	13000	96540301	96023213
175	132	460	1.15	230.4	265	570	88	0.85	0.045	J	13000	96521619	96023214
200	147	460	1.15	265.2	305	620	87	0.82	0.04	K	13000	96540302	96023215
250	190	460	1.15	352.2	405	610	87	0.79	0.033	K	13000	96463669	96023217

*This is a calculated value.

HP	Kw	Voltage	FUSE Standard	FUSE Time Delay	Circuit Breaker	NEMA Size	IEC Size	OVERLOADS Cutler Hammer (1)	OVERLOADS Allen Bradley (2)	OVERLOADS General Electric (3)	OVERLOADS Siemens (4)

6 Inch (460V) Motors

THREE PHASE

50	37	460	225	125	175	3	N	117	J46	866B	K83

8 Inch (460V) Motors

THREE PHASE

40	30	460	175	100	150	3	N	117	J43	710B	K76
50	37	460	225	125	175	3	–	117	J46	866B	K83
60	45	460	250	150	200	4	–	105	J70	950B	K86
75	55	460	300	175	250	4	–	105	J72	107C	K88
100	75	460	400	225	350	4	–	106	J75	155C	K92
125	92	460	500	300	400	5	–	107	J14	100B	K94
150	110	460	600	350	500	5	–	107	J16	111B	K96

10 Inch (460V) Motors

THREE PHASE

100	75	460	400	250	350	4	–	106	J75	155C	K92
125	92	460	500	300	400	5	–	107	J15	100B	K96
150	110	460	600	350	500	5	–	107	J17	122B	–
175	132	460	700	400	600	5	–	108	J18	135B	–
200	147	460	800	500	700	5	–	108	J20	165B	–
250	190	460	1100	600	1000	6	–	107	J14	–	–

Notes:

(1) These overloads are for both NEMA and IEC Freedom series starters by EATON Cutler-Hammer. The complete part number is H2___B-3. This information was collected from EATON Cutler-Hammer catalog number CA08102001E.

(2) These overload heater coils are for the Allen Bradley Bullitin 509 Starter. This information was collected from the Allen Bradley catalog number A115-CA001A-EN-P.

(3) These overloads are designed for use with GE NEMA starters. Complete part numbers are CR123L_ _ _ _. For use with GE CR124 single element overloads. This information was collected from page 1-107 of the Control Catalog Rev. 07/03.

(4) These overloads are designed for Siemens NEMA Overload Relays. This information was collected form page 8/151 of the 2006 Siemens Industrial Control Catalog.

(5) The Fuses and Circuit Breakers were calculated from the NEC table 430.52.

Starters and Overloads should always be sized by a licensed electrician that is familiar with local codes and standards.
The Overloads for submersible motors should be Class 10 Quick trip Ambient compensated.

Generator Sizing

HP	Kw	KVA
1/3	1.5	1.9
1/2	2	2.5
3/4	3	3.8
1	4	4.8
1 1/2	5.9	7
2	7	9
3	10	12
5	15	18.75
7 1/2	25	33
10	35	31.5
15	49	60
20	66	81
25	82	102
30	96	116
40	125	153
50	138	162
60	163	192
75	200	233
100	269	320
125	382	461
150	456	543
175	546	642
200	606	740
250	776	982

Notes:
These values were calculated by using the following formulas:

Single Phase: (3 X FLA)V X PF/1000

Three phase through 100 HP:
(3 X FLA) V X PF X1.73/1000

Three phase 125 and above:
(3.5 X FLA) V X PF X1.73/1000

This is a guide. The generator manufacturer should be asked to assist in sizing all generators.

Transformer Capacity

Required for Three-Phase Motors

Submersible Three- Phase Motor HP Rating	Total Effective KVA Required *	Smallest KVA Rating — Each Transformer	
		Open WYE or DELTA 2 Transformers	WYE or DELTA 3 Transformers
1.5	3 **	2	1
2	4 **	2	1.5
3	5 **	3	2
5	7.5 **	5	3
7.5	10 **	7.5	5
10	15 **	10	5
15	20 **	15	7.5
20	25	15	10
25	30	20	10
30	40	25	15
40	50	30	20
50	60	35	20
60	75	40	25
75	90	50	30
100	120	65	40
125	150	85	50
150	175	100	60
175	200	115	70
200	230	130	75

* Pump motor KVA requirements only -- does not include allowances for other loads
** This is also the KVA required for single phase motors

Motor Cooling

(refer to page 12 of the Troubleshooting section of this Service Manual)

Total Resistance of Drop Cable

(refer to page 16 of the Troubleshooting section of this Service Manual)

Motor Service to Entrance

SINGLE PHASE 60 HZ

Motor Rating		Copper Wire Size												
VOLTS	HP	14	12	10	8	6	4	2	0	00	000	0000	250	300
115	1/3	130	210	340	540	840	1300	1960	2910					
	1/2	100	160	250	390	620	960	1460	2160					
230	1/3	550	880	1390	2190	3400	5250	7960						
	1/2	400	650	1020	1610	2510	3880	5880						
	3/4	300	480	760	1200	1870	2890	4370	6470					
	1	250	400	630	990	1540	2380	3610	5360	6520				
	1 1/2	190	310	480	770	1200	1870	2850	4280	5240				
	2	150	250	390	620	970	1530	2360	3620	4480				
	3	120	190	300	470	750	1190	1850	2890	3610				
	5			180	280	450	710	1110	1740	2170				
	7 1/2				200	310	490	750	1140	1410				
	10					250	390	600	930	1160				

THREE PHASE 60 HZ

VOLTS	HP	14	12	10	8	6	4	2	0	00	000	0000	250	300
208	1 1/2	310	500	790	1260									
	2	240	390	610	970	1520								
	3	180	290	470	740	1160	1810							
	5		170	280	440	690	1080	1660						
	7 1/2			200	310	490	770	1180	1770					
	10				230	370	570	880	1330	1640				
	15					250	390	600	910	1110	1340			
	20						300	460	700	860	1050	1270		
	25							370	570	700	840	1030	1170	
	30							310	470	580	700	850	970	1110
230	1 1/2	360	580	920	1450									
	2	280	450	700	1110	1740								
	3	210	340	540	860	1340	2080							
	5		200	320	510	800	1240	1900						
	7 1/2			230	360	570	890	1350	2030					
	10				270	420	660	1010	1520	1870				
	15					290	450	690	1040	1280	1540			
	20						350	530	810	990	1200	1450		
	25						280	430	650	800	970	1170	1340	
	30							350	540	660	800	970	1110	1270
460	1 1/2	1700												
	2	1300	2070											
	3	1000	1600	2520										
	5	590	950	1500	2360									
	7 1/2	420	680	1070	1690	2640								
	10	310	500	790	1250	1960	3050							
	15			540	850	1340	2090	3200						
	20			410	650	1030	1610	2470	3730					
	25				530	830	1300	1990	3010	3700				
	30				430	680	1070	1640	2490	3060	3700			
	40						790	1210	1830	2250	2710	3290		
	50						640	980	1480	1810	2190	2650	3010	
	60							830	1250	1540	1850	2240	2540	2890
	75								1030	1260	1520	1850	2100	2400
	100									940	1130	1380	1560	1790
	125											1080	1220	1390
	150												1050	1190
	200												1080	1300
	250													1080
575	1 1/2	2620												
	2	2030												
	3	1580	2530											
	5	920	1480	2330										
	7 1/2	660	1060	1680	2650									
	10	490	780	1240	1950									
	15		530	850	1340	2090								
	20			650	1030	1610	2520							
	25			520	830	1300	2030	3110						
	30				680	1070	1670	2560	3880					
	40					790	1240	1900	2860	3510				
	50						1000	1540	2310	2840	3420			
	60						850	1300	1960	2400	2890	3500		
	75							1060	1600	1970	2380	2890	3290	
	100								1190	1460	1770	2150	2440	2790

FOOTNOTES:

1. If aluminum conductor is used, multiply lengths by 0.5. Maximum allowable length of aluminum is considerably shorter than copper wire of same size.
2. The portion of the total cable which is between the service entrance and a 3Ø motor starter should not exceed 25% of the total maximum length to assure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.
3. Cables #14 to #0000 are AWG sizes, and 250 to 300 are MCM sizes.

Please Note:

For Franklin motor specifications, refer to Franklin's Submersible Motor Application • Installation • Maintenance • Manual

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GRUNDFOS®

SP4"

4-Inch Stainless Steel Submersible Pumps

(US) Installation and operating instructions

CLASSIFIED

WATER QUALITY
DRINKING WATER
SYSTEM COMPONENTS
ANSI/NSF 61
65 GM
30°C/86°F
PUMP END ONLY

Please leave these instructions with the pump for future reference.

SAFETY WARNING

WARNING: Reduced risk of electric shock during operation of this pump requires the provision of acceptable grounding. If the means of connection to the supply connected box is other than grounded metal conduit, ground the pump back to the service by connecting a copper conductor (at least the size of the circuit supplying the pump) to the grounding screw provided within the wiring compartment.

NOTICE: This product is designes for pumping water only. Third party agency evalustions are based on pumping water only.

Pre-Installation Checklist

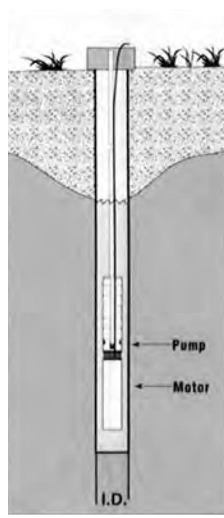
1. Well Preparation

If the pump is to be installed in a new well then the well should be fully developed and bailed or blown free of cuttings and sand. The stainless steel construction of the GRUNDFOS submersibles make it resistant to abrasion; however, no pump made of any material can forever withstand the destructive wear that occurs when constantly pumping sandy water.

If this pump is used to replace an oil-filled submersible or oil-lubricated line-shaft turbine in an existing well, the well must be blown or bailed clear of oil.

2. Make Sure You Have The Right Pump

Determine the maximum depth of the well, and the draw-down level at the pump's maximum capacity. Pump selection and setting depth should be based on this data.



3. Pumped Fluid Requirements

CAUTION: Submersible well pumps are designed for pumping clear, cold water; free of air or gases. Decreased pump performance and life expectancy can occur if the water is not cold, clear or contains air or gasses. Water temperature should not exceed 102°F.

A check should be made to ensure that the installation depth of the pump will always be at least three feet below the maximum drawdown level of the well. The bottom of the motor should never be installed lower than the top of the screen or within five feet of the well bottom.

Ensure that the requirement for minimum flow past the motor is met, as shown in the table below:

Minimum Water Flow Requirements for Submersible Pump Motors

MINIMUM DIAMETER	CASING OR SLEEVE I.D. IN INCHES	MIN. GPM FLOW PASSING THE MOTOR
4-Inch	4	1.2
	5	7
	6	13
	7	21
	8	30

NOTES: For proper motor cooling, a flow inducer or sleeve must be used if the water enters the well above the motor or if there is insufficient water flow past the motor. The minimum water velocity past 4" motors is 0.25 feet per second.

PRE-INSTALLATION CHECKLIST

4. Splicing the Motor Cable

If the splice is carefully made, it will be as efficient as any other portion of the cable, and will be completely watertight. There are a number of cable splicing kits available today – epoxy filled, rubber-sealed and so on. Many perform well if the manufacturer's directions are followed carefully. If one of these kits is not used, we recommend the following method for splicing the motor cable.

Examine the motor cable and drop cable carefully for damage. Cut the motor leads off in a staggered manner. Cut the ends of the drop cable so that the ends match up with the motor leads. Be sure to match the colors. Strip back and trim off one-half inch of insulation from each lead, making sure to scrape the wire bare to obtain a good connection. Be careful not to damage the copper conductor when stripping off the insulation. Insert a properly sized Sta-kon-type connector on each pair of leads, again making sure that colors are matched. Using Sta-kon crimping pliers, indent the lugs. Be sure to squeeze down hard on the pliers, particularly when using large cable. Form a piece of electrical insulation putty tightly around each Sta-Kon. The putty should overlap on the insulation of the wire. Use a good quality tape such as ***#33 Scotch Waterproof*** or ***Plymouth Rubber Company Slipknot Grey***. Wrap each wire and joint tightly for a distance of about 2-1/2 inches on each side of the joint. Make a minimum of four passes over each joint and overlap each pass approximately one inch to assure a completely watertight seal.

INSTALLATION PROCEDURES

1. Attach the Pump to the Motor

When attaching the pump to the motor we recommend the pump be bolted down in a cross pattern around the four bolts. Starting from the back (opposite the cable opening) and using a cross pattern, tighten the motor bolts to 13.5 ft-lbs, using progressive tightening until torque is met. (See figure 1 for example).

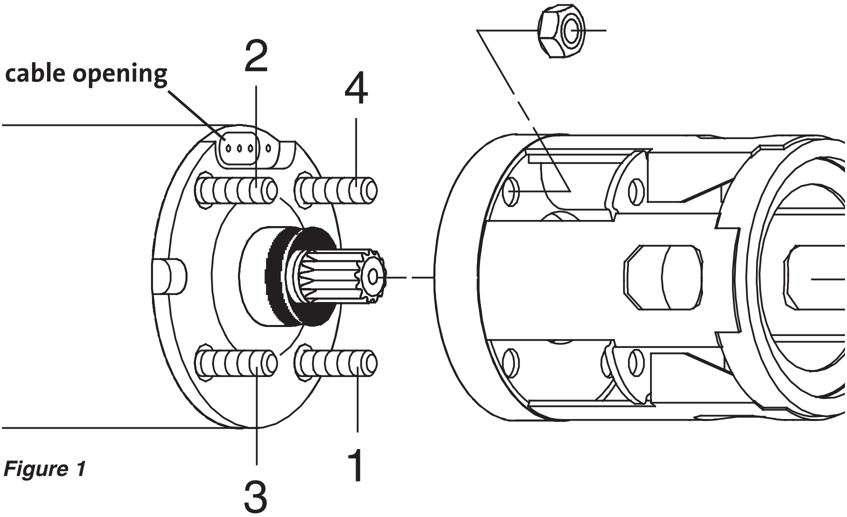


Figure 1

INSTALLATION PROCEDURES

2. Attach the Pump to the Pipe

A back-up wrench should be used when riser pipe is attached to the pump. The pump should only be gripped by the flats on the top of the discharge chamber. Under no circumstances grip the body of the pump, cable guard or motor. When tightened down, the threaded end of the first section of the riser pipe or the nipple must not come in contact with the check valve retainer in the discharge chamber of the pump. After the first section of the riser pipe has been attached to the pump, the lifting cable or elevator should be clamped to the pipe. Do not clamp the pump. When raising the pump and riser section, be careful not to place bending stress on the pump by picking it up by the pump-end only. It is recommended that plastic-type riser pipe be used only with the smaller domestic submersibles. The manufacturer or representative should be contacted to ensure the pipe type and physical characteristics are suitable for this use. Use the correct joint compound recommended by the specific pipe manufacturer. Besides making sure that points are fastened, we recommend the use of a torque arrestor when using plastic pipe.

3. Lower the Pump Into the Well

Make sure the electrical cables are not cut or damaged in any way when the pump is being lowered in the well. Do not use the power cables to support the weight of the pump.

To protect against surface water entering the well and contaminating the water source, the well should be finished off above grade utilizing a locally approved well seal or pitless adaptor unit. We recommend that steel riser pipes always be used with the larger submersibles. A pipe thread compound should be used on all joints. Make sure that the joints are adequately tightened in order to resist the tendency of the motor to loosen the joints when stopping and starting.

The drop cable should be secured to the riser pipe at approximately every 10 ft/3 m to prevent sagging, looping and possible cable damage. Nylon cable clips or waterproof tape may be used. The cable splice should be protected by securing it with clips or tape just above each joint.

Figure 2

Figure 3

IMPORTANT: *Plastic pipe tends to stretch under load. This stretching must be taken into account when securing the cable to the riser pipe. Leave three to four inches of slack between clips or taped points. This tendency for plastic pipe to stretch will also affect the calculation of the pump setting depth. As a general rule, you can estimate that plastic pipe will stretch to approximately 2% of its length. When plastic riser pipe is used, it is recommended that a safety cable be attached to the pump to lower and raise it. The discharge chamber of GRUNDFOS 4-inch submersibles is designed to accommodate this cable. (See Figures 2 & 3.)*

Check Valves: A check valve should always be installed at the surface of the well and one at a maximum of 25 feet above static water level. In addition, for installations deeper than 200 feet, check valves should be installed at no more than 200 foot intervals.

4. Electrical Connections

WARNING: Reduced risk of electric shock during operation of this pump requires the provision of acceptable grounding. If the means of connection to the supply connected box is other than grounded metal conduit, ground the pump back to the service by connecting a copper conductor (at least the size of the circuit supplying the pump) to the grounding screw provided within the wiring compartment.

Verification of the electrical supply should be made to ensure the voltage, phase and frequency match that of the motor. Motor electrical data can be found on page 6. If voltage variations are larger than ± 10%, do not operate the pump. Single-phase motor control boxes should be connected as shown on the wiring diagram mounted on the inside cover of the control box supplied with the motor. The type of wire used between the pump control boxes should be approved for submersible pump application. The conductor insulation should be type RW, RUW, TW or equivalent.

A high-voltage surge arrestor should be used to protect the motor against lightning and switching surges. Lightning voltage surges in power lines are caused when lightning strikes somewhere in the area. Switching surges are caused by the opening and closing of switches on the main high-voltage distribution power lines.

The correct voltage-rated surge arrestor should be installed on the supply (line) side of the control box or starter (See Figure 4a & 4b). The arrestor must be grounded in accordance with the National Electric Code and local governing regulations.

PUMPS SHOULD NEVER BE STARTED UNLESS THE PUMP IS TOTALLY SUBMERGED. SEVERE DAMAGE MAY BE CAUSED TO THE PUMP AND MOTOR IF THEY ARE RUN DRY.

The control box shall be permanently grounded in accordance with the National Electric Code and local governing codes or regulations. The ground wire should be a bare stranded copper conductor at least the same size as the drop cable wire size. Ground wire should be as short a distance as possible and securely fastened to a true grounding point. True grounding points are considered to be: a grounding rod driven into the water strata; steel well casing submerged into the water lower than the pump setting level; and steel discharge pipes without insulating couplings. If plastic discharge pipe and well casing are used, a properly sized bare copper wire should be connected to a stud on the motor and run to the control panel. Do not ground to a gas supply line. Connect the grounding wire to the ground point first, then to the terminal in the control box.

Single Phase Hookup

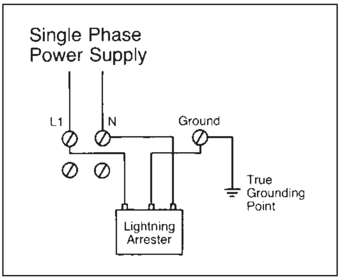


Figure 4a

Three Phase Hookup

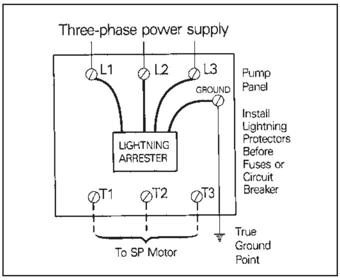
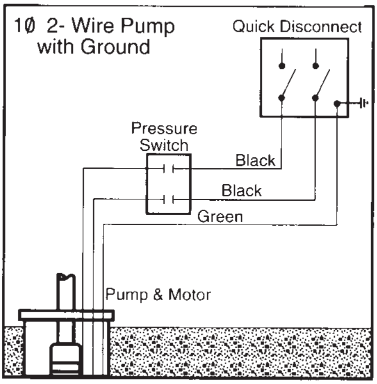


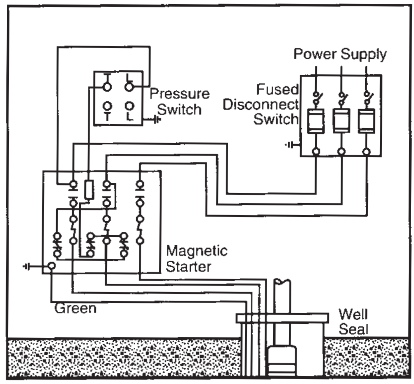
Figure 4b

INSTALLATION PROCEDURES

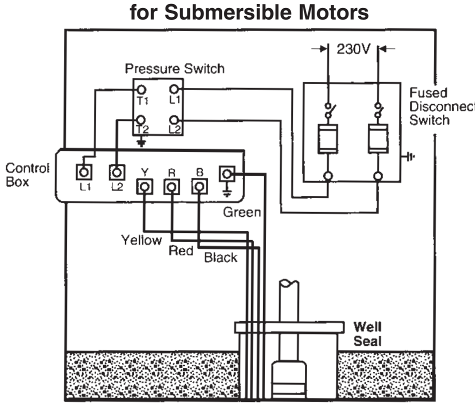
Single-Phase 2-Wire Wiring Diagram for Submersible Motors



Three-Phase Wiring Diagram for Submersible Motors



Single-Phase 3-Wire Control Box for Submersible Motors



4. Starting the Pump for the First Time

A. Attach a temporary horizontal length of pipe to the riser pipe.
B. Install a gate valve and another short length of pipe to the temporary pipe.
C. Adjust the gate valve one-third of the way open.
D. Verify that the electrical connections are in accordance with the wiring diagram.
E. After proper rotation has been checked, start the pump and let it operate until the water runs clear of sand, silt and other impurities.
F. Slowly open the valve in small increments as the water clears until the valve is all the way open. The pump should not be stopped until the water runs clear.
G. If the water is clean and clear when the pump is first started, the valve should still be opened until it is all the way open.

MOTOR INFORMATION

Grundfos motors specifications

1- Phase motors

HP	Ph	Volt	Service factor	Amperage		Full load		Max. thrust (lbs)	Line-to-Line resistance ( )		KVA code	Nameplate no.
				SF	Start	Eff. (%)	Pwr fact.		Blk-Yel	Red-Yel		
4-inch, single phase, 2-wire motors (control box not required)												
1/3	1	230	1.75	4.6	25.7	59	77	900	6.8-8.2		S	79952101
1/2	1	115	1.60	12.0	55	62	76	900	1.1-1.3		R	79922102
1/2	1	230	1.60	6.0	34.5	62	76	900	5.2-6.3		R	79952102
3/4	1	230	1.50	8.4	40.5	62	75	900	3.2-3.8		N	79952103
1	1	230	1.40	9.8	48.4	63	82	900	2.5-3.1		M	79952104
1 1/2	1	230	1.30	13.1	62	64	85	900	1.9-2.3		L	79952105
4-inch, single phase, 3-wire motors												
1/3	1	115	1.75	9.0	29	59	77	900	1.55-1.9	2.4-3	M	79423101
1/3	1	230	1.75	4.6	14	59	77	900	6.8-8.3	17.3-21.1	L	79453101
1/2	1	115	1.60	12.0	42.5	61	76	900	0.9-1.1	1.9-2.35	L	79423102
1/2	1	230	1.60	6.0	21.5	62	76	900	4.7-5.7	15.8-19.6	L	79453102
3/4	1	230	1.50	8.4	31.4	62	75	900	3.2-3.9	14-17.2	L	79453103
1	1	230	1.40	9.8	37	63	82	900	2.6-3.1	10.3-12.5	K	79453104
1.5	1	230	1.30	11.6	45.9	69	89	900	1.9-2.3	7.8-9.6	H	79453105
2	1	230	1.25	13.2	57	72	86	1500	1.5-1.8	3.4-4.1	G	79454506
3	1	230	1.15	17.0	77	74	93	1500	1.2-1.4	2.45-3	F	79454507
5	1	230	1.15	27.5	110	77	92	1500	0.65-0.85	2.1-2.6	F	79454509

3-Phase motors

HP	Ph	Volt	Service factor	Amperage		Full load		Max. thrust (lbs)	Line-to-Line resistance ( )		KVA code	Nameplate no.
				SF	Start.	Eff. (%)	Pwr fact.		Blk-Yel	Red-Yel		
4-inch, three phase, 3-wire motors												
1 1/2	3	230	1.30	7.3	40.3	75	72	900	3.9		K	79302005
		460	1.30	3.7	20.1	75	72	900	15.9		K	79362005
		575	1.30	2.9	16.1	75	72	900	25.2		K	79392005
3	3	230	1.25	8.7	48	76	75	900	3.0		J	79302006
		460	1.25	4.4	24	76	75	900	12.1		J	79362006
		575	1.25	3.5	19.2	76	75	900	18.8		J	79392006
3	3	230	1.15	12.2	56	77	75	900	2.2		H	79302006
		460	1.15	6.1	28	77	75	900	9.0		H	79362007
		575	1.15	4.8	22	77	75	900	13.0		H	79395507
5	3	208/230	1.15	18.6/17.4	108	80	82	1500	1.2		H	79304509
		440/460	1.15	8.65/8.65	54	80	82	1500	5.0		H	79354509
		575	1.15	7.9	54	80	82	1500	7.3		H	79394509
7 1/2	3	208/230	1.15	27.0/25.0	130	81	82	1500	0.84		H	79305511
		440/460	1.15	12.8/12.6	67	81	82	1500	3.24		J	79355511
		575	1.15	10.6	53	81	82	1500	5.2		J	79395511
10	3	440/460	1.15	18.0/18.6	90	81	80	1500	1.16		H	79355512
		575	1.15	14.4	72	81	80	1500	1.84		H	79395512

*All Grundfos 4" motors have a ground (green wire)

GRUNDFOS Control Box SA-SPM5

RATING		GRUNDFOS MOTOR MODEL	GRUNDFOS CONTROL BOX	GRUNDFOS STANDARD #'s	GRUNDFOS RUN CAP/DELUXE #'s
HP	VOLT				
1/3	115	MS402B	SA-SPM5	91126150	–
1/3	230	MS402B	SA-SPM5	91126151	–
1/2	115	MS402B	SA-SPM5	91126152	–
1/2	230	MS402B	SA-SPM5	91126153	–
3/4	230	MS402B	SA-SPM5	91126154	–
1	230	MS402B	SA-SPM5	91126155	91126211
1.5	230	MS402B	SA-SPM5	91126212	91126213
2	230	MS4000	SA-SPM5	91126214	91126215
3	230	MS4000	SA-SPM5	91126216	91126217
5	230	MS4000	SA-SPM5	91126218	91126219

MOTOR INFORMATION

The key to long submersible motor life is good cooling. Most submersible pumps rely on moving heat away from the motor by forced convection. The ambient/produced fluid is typically drawn by the motor in the course of pumping to accomplish this task. Submersible motors used in the water supply industry are typically designed to operate at full load in water up to 30°C (86°F), provided the flow velocity can be maintained at a minimum of 0.5 feet per second (fps).

Required Cooling Flow and Velocity

AWWA specifications state the maximum motor diameter and the minimum inside diameter of the well shall be in such relationship that under any operating condition the water velocity past the motor shall not exceed 12 fps (3.7 m/s) nor be less than 0.5 fps (0.15 m/s). The AWWA specification are principally applicable to motors 6-inch and larger, as most 4-inch motor designs are based on a minimum cooling flow velocity of 0.25 fps (0.08 m/s) at rated ambient temperature. Table 8 relates flow, casing and motor size requirements to accomplish minimum cooling velocity.

Table 8: Minimum Submersible Cooling Flow Requirements

Casing/Sleeve I.D. (inches)	4" Motor (0.25 fps)	6" Motor (0.5 fps)
	(gpm)	
4	1.2	–
5	7.0	–
6	13	9
7	20	25
8	30	45
10	50	90
12	80	140
14	110	200
16	150	280
18	–	380

Notes:
1. Minor irregularities associated with motor shape and diameter variations between manufactures are not accounted for in the table.
2. At the velocity specified in the table the temperature differential between the motor surface and ambient water will range from 5° - 15°C (10-30°F).

Some submersible motor manufactures require no cooling fluid flow past the motor, when the produced fluid temperature is 20°C (68°F) or less. Cooling by free convection in such cases, is only permitted in the vertical position and is contingent on no adverse operating conditions present such as; poor power, high stop/start frequency, presence of incrustating deposits on the motor surface, etc. Detramental operating conditions are difficult to identify or predict, and for this reason, the minimum cooling flow should be provided whenever possible - regardless of the ambient fluid temperature.

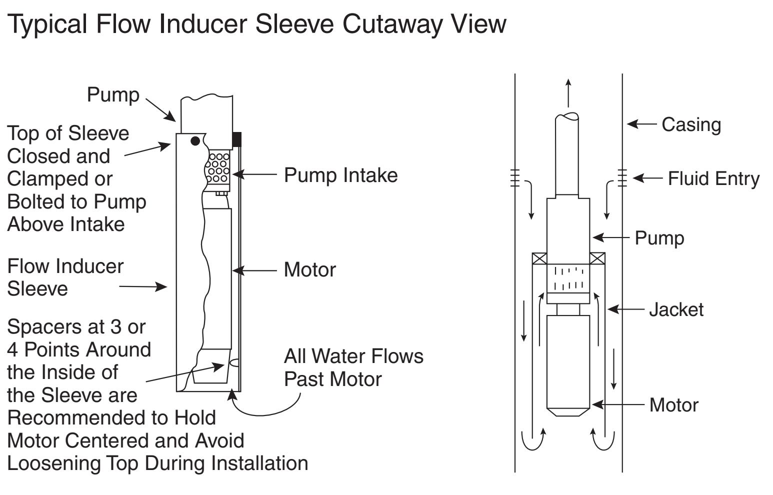
Typical Motor Jacket/Shroud Configurations.

The motor shroud is generally of the next nominal diameter of standard pipe larger than the motor or the pump, depending on the shroud configuration used. The tubular/pipe material can be plastic or thin walled steel (corrosion resistant materials preferred). The cap/top must accommodate power cable without damage and provide a snug fit, so that only a very small amount of fluid can be pulled through the top of the shroud. The fit should not be completely water tight as ventilation is often required to allow escape of the air or gas that might accumulate. The shroud body should be stabilized to prevent rotation and maintain the motor centered within the shroud. The shroud length should extend to a length of 1-2 times the shroud diameter beyond the bottom of the motor when possible. Shrouds are typically attached immediately above the pump intake or at the pump/column correction.

A typical motor sleeve/shroud selection example is sited below and illustrated in Figure 8:

If a well feeds water from above the pump, has a casing/chamber too small to allow a motor jacket/sleeve on the pump, and does not have adequate level and flow to allow raising the pump above the inflow, it is difficult to properly cool the motor. When possible, the casing depth should be increased to allow flow to come from below the motor. If this is not practical, adequate flow past the motor can usually be attained by employing a motor jacket with a stringer pipe or by using a jet tube.

Figure 8: Typical Motor Jacket Installation Scenarios



MOTOR INFORMATION

Single-Phase 60 Hz

MOTOR RATING		COPPER WIRE SIZE (AWG)								
VOLTS	**HP**	**14**	**12**	**10**	**8**	**6**	**4**	**2**	**0**	**00**
115	1/3	130	210	340	540	840	1300	1960	2910	
	1/2	100	160	250	390	620	960	1460	2160	
230	1/3	550	880	1390	2190	3400	5250	7960		
	1/2	400	650	1020	1610	2510	3880	5880		
	3/4	300	480	760	1200	1870	2890	4370	6470	
	1	250	400	630	990	1540	2380	3610	5360	6520
	1-1/2	190	310	480	770	1200	1870	2850	4280	5240
	2	150	250	390	620	970	1530	2360	3620	4480
	3	120	190	300	470	750	1190	1850	2890	3610
	5	180	280	450	710	1110	1740	2170		

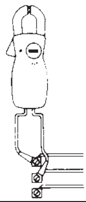
Three-Phase 60 Hz

MOTOR RATIN		COPPER WIRE SIZE (AWG)						
VOLTS	**HP**	**14**	**12**	**10**	**8**	**6**	**4**	**2**
208	1-1/2	310	500	790	1260			
	2	240	390	610	970	1520		
	3	180	290	470	740	1160	1810	
		5170	280	4690	1080			1660
230	1-1/2	360	580	920	1450			
	2	280	450	700	1110	1740		
	3	210	340	540	860	1340	2080	
	5		200	320	510	800	1240	1900
460	1-1/2	1700						
	2	1300	2070					
	3	1000	1600	2520				
	5	590	950	1500	2360			
575	1-1/2	2620						
	2	2030						
	3	1580	2530					
	5	920	1480	2330				

FOOTNOTES:

1. If aluminum conductor is used, multiply lengths by 0.5. Maximum allowable length of aluminum is considerably shorter than copper wire of same size.
2. The portion of the total cable which is between the service entrance and a 3Ø motor starter should not exceed 25% of the total maximum length to ensure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.
3. Cables #14 to #0000 are AWG sizes, and 250 to 300 are MCM sizes.

SUPPLY VOLTAGE



How to Measure

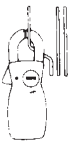
By means of a voltmeter, which has been set to the proper scale, measure the voltage at the control box or starter. On single-phase units, measure between line and neutral.

What it Means

When the motor is under load, the voltage should be within ± 10% of the nameplate voltage. Larger voltage variation may cause winding damage. Large variations in the voltage indicate a poor electrical supply and the pump should not be operated until these variations have been corrected.

If the voltage constantly remains high or low, the motor should be changed to the correct supply voltage.

CURRENT MEASUREMENT



How to Measure

By use of an ammeter, set on the proper scale, measure the current on each power lead at the control box. See page 6, for motor amp draw information.

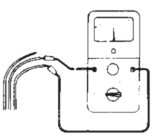
Current should be measured when the pump is operating at a constant discharge pressure with the motor fully loaded.

What it Means

If the amp draw exceeds the listed service factor amps (SFA), check for the following:

1. Loose terminals in control box or possible cable defect. Check winding and insulation resistances.
2. Too high or low supply voltage.
3. Motor windings are shorted.
4. Pump is damaged causing a motor overload.

WINDING RESISTANCE



How to Measure

Turn off power and disconnect the drop cable leads in the control box. Using an ohmmeter, set the scale selectors to Rx1 for values under 10 ohms and Rx10 for values over 10 ohms.

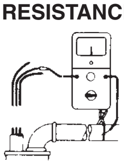
Zero-adjust the meter and measure the resistance between leads. Record the values. Motor resistance values can be found on page 6.

What it Means

If all the ohm values are normal, and the cable colors correct, the windings are not damaged. If any one ohm value is less than normal, the motor may be shorted. If any one ohm value is greater than normal, there is a poor cable connection or joint. The windings or cable may also be open.

If some of the ohm values are greater than normal and some less, the drop cable leads are mixed. To verify lead colors, see resistance values on page 6.

INSULATION RESISTANCE



How to Measure

Turn off power and disconnect the drop cable leads in the control box. Using an ohm or mega ohmmeter, set the scale selector to Rx 100K and zero-adjust the meter. Measure the resistance between the lead and ground (discharge pipe or well casing, if steel).

What it Means

For ohm values, refer to table below. Motors of all Hp, voltage, phase and cycle duties have the same value of insulation resistance.

OHM VALUE	MEGAOHM VALUE	CONDITION OF MOTOR AND LEADS
		Motor not yet installed:
2,000,000 (or more)	2.0	New Motor.
1,000,000 (or more)	1.0	Used motor which can be reinstalled in the well.
		Motor in well (Ohm readings are for drop cable plus motor):
500,000 - 1,000,000	0.5 - 1.0	A motor in reasonably good condition.
20,000 - 500,000	0.02 - 0.5	A motor which may have been damaged by lightning or with damaged leads. Do not pull the pump for this reason.
10,000 - 20,000	0.01 - 0.02	A motor which definitely has been damaged or with damaged cable. The pump should be pulled and repairs made to the cable or the motor replaced. The motor will still operate, but probably not for long.
less than 10,000	0 - 0.01	A motor which has failed or with completely destroyed cable insulation. The pump must be pulled and the cable repaired or the motor replaced. The motor will not run in this condition.

TROUBLESHOOTING

Pump Won't Start

POSSIBLE CAUSE	CHECK THIS BY...	CORRECT THIS BY...
No power at the motor	Check for voltage at the control box or panel.	If there is no voltage at the control panel, check the feeder panel for tripped circuits and reset those circuits.
Fuses are blown or the circuit breakers have tripped	Turn off the power and remove the fuses. Check for continuity with an ohmmeter.	Replace the blown fuses or reset the circuit breaker. If the new fuses blow or the circuit breaker trips, the electrical installation, motor, and wires must be check for defects.
(3-phase motors only) **Motor starter overloads are burned or have tripped**	Check for voltage on the line and load side of the starter. Check the amp draw and make sure the heater is sized correctly.	Replace any burned heaters or reset. Inspect the starter for other damage. If the heater trips again, check the supply voltage. Ensure that heaters are sized correctly and the trip setting is appropriately adjusted.
(3-phase motors only) **Starter does not energize**	Energize the control circuit and check for voltage at the holding coil.	If there is no voltage, check the control circuit fuses. If there is voltage, check the holding coil for weak connections. Ensure that the holding coil is designed to operate with the available control voltage. Replace the coil if defects are found.
Defective controls	Check all safety and pressure switches for defects. Inspect the contacts in control devices.	Replace worn or defective parts or controls.
Motor or cable is defective	Turn off the power and disconnect the motor leads from the control box. Measure the lead-to-lead resistance with an ohmmeter (set to R x 1). Measure the lead-to-ground values with an ohmmeter (set to R x 100K).	If an open or grounded winding is found, remove the motor from the well and recheck the measurements with the lead separated from the motor. Repair or replace the motor or cable.
(1-phase motors only) **Defective capacitor**	Turn off the power and discharge the capacitor by shorting the leads together. Check it with an analog ohmmeter (set to R x 100k).	When the meter is connected to the capacitor, the needle should jump toward 0 (zero) ohms and slowly drift back to infinity (Ą). Replace capacitor if it is defective.
Defective pressure switch or the tubing to it is plugged	Watch the pressure gauges as the pressure switch operates. Remove the tubing and blow through it.	Replace as necessary.
The pump is mechanically bound or stuck	Turn off the power and manually rotate the pump shaft. Also check the motor shaft rotation, the shaft height, and the motor's amp draw (to see if it indicates a locked rotor).	If the pump shaft doesn't rotate, remove the pump and examine it. If necessary, dismantle it and check the impellers and seal for obstruction. Check for motor corrosion.

Pump Does Not Produce Enough Flow (GPM)

POSSIBLE CAUSE	CHECK THIS BY...	CORRECT THIS BY...
(3-phase motors only) **Shaft is turning in the wrong direction**	Check to make sure the electrical connections in the control panel are correct.	Correct the wiring. For single phase motors, check the wiring diagram on the motor. For three phase motors, simply switch any two power leads.
Pump is operating at the wrong speed (too slow)	Check for low voltage and phase imbalance.	Replace defective parts or contact power company, as applicable.
Check valve is stuck (or installed backwards)	Remove the check valve.	Re-install or replace.
Parts or fittings in the pump are worn **– or –** **Impellers or Inlet Strainer is clogged**	Install a pressure gauge near the discharge port, start the pump, and gradually close the discharge valve. Read the pressure at shutoff. (Do not allow the pump to operate for an extended period at shutoff.)	Convert the PSI you read on the gauge to Feet of Head by: **PSI x 2.31 ft/PSI = ______ ft.** **Specific Gravity** Add to this number the number of feet (vertically) from the gauge down to the water's pumping level. Refer to the pump curve for the model you are working with to determine the shutoff head you should expect for that model. If that head is close to the figure you came up with (above), the pump is probably OK. If not, remove the pump and inspect impellers, chambers, etc.
The water level in the well may be too low to supply the flow desired **– or –** **Collapsed well**	Check the drawdown in the well while the pump is operating.	If the pumping water level (including drawdown) is not **AT LEAST 3 FEET** above the pump's inlet strainer, either: 1. Lower the pump further down the well. 2. Throttle back the discharge valve to decrease the flow, thereby reuding drawdown.
Broken shaft or coupling	Pull pump and inspect.	Replace as necessary.
There are leaks in the fittings or piping	Pull the pump out of the well.	The suction pipe, valves, and fittings must be made tight. Repair any leaks and retighten all loose fittings.

TROUBLESHOOTING

Fuses Blow or Heaters Trip

POSSIBLE CAUSE	CHECK THIS BY...	CORRECT THIS BY...
Improper voltage	Check the voltage at the control box or panel.	If the voltage varies by more than 10% (+ or -), contact the power company.
	If the incoming voltage is OK, check the wire size and the distance between the pump motor and the pump control panel.	Rewire with correct gauge. Undersized wire and a great distance between the control panel and the pump motor increases resistance and decreases the voltage by the time it reaches the pump motor.
The starter overloads are set too low	Cycle the pump and measure the amperage.	Increase the heater size or adjust the trip setting. Do not, however, exceed the recommended rating.
(3-phase motors only) **The three-phase current is imbalanced**	Check the current draw on each lead to the motor.	The current draw on each lead must be within 5% of each other (+ or -). If they are not, check the wiring.
The wiring or connections are faulty	Check to make sure the wiring is correct and there are no loose terminals.	Tighten any loose terminals and replace any damaged wire.
(1-phase motors only) **Capacitor is defective**	Turn off the power and discharge the capacitor. Check the capacitor with an ohmmeter (set at R x 100k). See page 15 for instructions.	When the meter is connected to the capacitor, the needle should jump toward 0 (zero) ohms and then slowly drift back to infinity (¥). Replace capacitor if it is defective.
Fuse, heater, or starter are the wrong size	Check the fuses and heaters against the motor manufacturer's specification charts.	Replace as necessary.
The control box location is too hot	Touch the box with your bare hand during the hottest part of the day – you should be able to keep your hand on it without burning.	Shade, ventilate, or move the control box so its environment does not exceed 120°F.
(1-phase motors only) **Wrong control box**	Check requirements for the motor against the control box specifications.	Replace as necessary.
Defective pressure switch	Watch gauges as pressure switch operates.	Replace as necessary.
The motor is shorted or grounded.	Turn off the power and disconnect the wiring. Measure the lead-to-lead resistance with an ohmmeter (set to R x 1). Measure the lead-to-ground values with an ohmmeter (set to R x 100K) or a megaohmmeter. Compare these measurements to the rated values for your motor.	If you find an open or grounded winding, remove the motor and recheck the leads. If OK, check the leads for continuity and for bad splice.
Poor motor cooling	Find the internal diameter of the well casing (or sleeve, if used). For proper cooling, the flow of water **must not be less than the GPM shown across the bottom scale on page __.**	Throttle up the pump flow (GPM) so proper cooling is possible. – or – Pull the pump out of the well and add a sleeve with a smaller internal diameter.

Pump Cycles Too Often

POSSIBLE CAUSE	CHECK THIS BY...	CORRECT THIS BY...
The pressure switch is defective or is not properly adjusted	Check the pressure setting on the switch. Check the voltage across closed contacts.	Readjust the pressure switch or replace it if defective.
The tank is too small	Check the tank size and amount of air in the tank. The tank volume should be approximately 10 gallons for each Gallon-Per-Minute of pump capacity. At the pump cut-in pressure, the tank should be about 2/3 filled with air.	Replace the tank with one that is the correct size.
There is insufficient air charging of the tank or piping is leaking	Pump air into the tank or diaphragm chamber. Check the diaphragm for leaks. Check the tank and piping for leaks with soapy water. Check the air-to-water ratio in the tank.	Repair as necessary.
Plugged snifter valve or bleed orifice (causing pressure tank to be waterlogged)	Examine them for dirt or erosion.	Repair or replace as necessary.
Leak in the pressure tank or piping	Apply soapy water to pipes and tank, then watch for bubbles, indicating leaks.	Repair or replace as necessary.
The level control is defective or is not properly set	Check the setting and operation of the level control.	Readjust the level control setting (according to the manufacturer's instructions) or replace it if defective.
Pump is oversized for the application. It is outpumping the yield of the well and pumping itself dry.	Check the yield of the well (determined by the well-test) against the pump's performance curve.	Reduce the flow by throttling back the valve. – or – Change the pump.

LIMITED WARRANTY

Products manufactured by GRUNDFOS are warranted to the original user only to be free of defects in material and workmanship for a period of 24 months from date of installation, but not more than 30 months from date of manufacture. GRUNDFOS' liability under this warranty shall be limited to repairing or replacing at GRUNDFOS' option, without charge, F.O.B. GRUNDFOS' factory or authorized service station, any product of GRUNDFOS' manufacture. GRUNDFOS will not be liable for any costs of removal, installation, transportation, or any other charges which may arise in connection with a warranty claim. Products which are sold but not manufactured by GRUNDFOS are subject to the warranty provided by the manufacturer of said products and not by GRUNDFOS' warranty. GRUNDFOS will not be liable for damage or wear to products caused by abnormal operating conditions, accident, abuse, misuse, unauthorized alteration or repair, or if the product was not installed in accordance with GRUNDFOS printed installation and operating instructions.

To obtain service under this warranty, the defective product must be returned to the distributor or dealer of GRUNDFOS products from which it was purchased together with proof of purchase and installation date, failure date, and supporting installation data. Unless otherwise provided, the distributor or dealer will contact GRUNDFOS or an authorized service station for instructions. Any defective product to be returned to GRUNDFOS or a service station must be sent freight prepaid; documentation supporting the warranty claim and/or a Return Material Authorization must be included if so instructed.

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BE > THINK > INNOVATE >

Being responsible is our foundation
Thinking ahead makes it possible
Innovation is the essence

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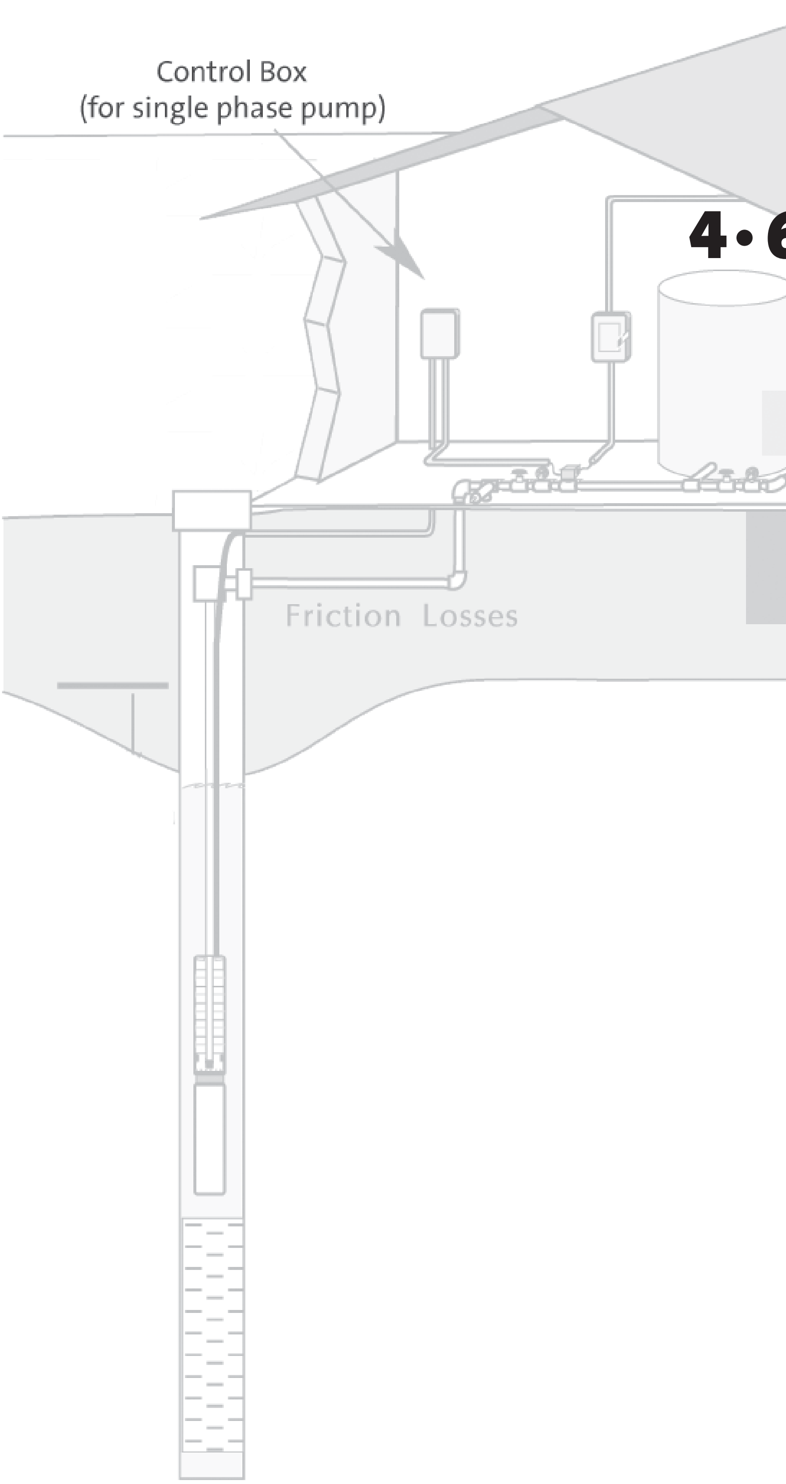


4•6•8•10" Submersibles
Troubleshooting

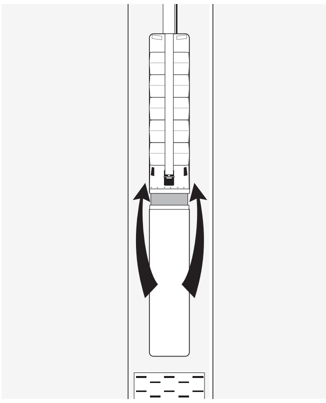
CONTENTS

Poor Motor Cooling*

A submersible pump motor is cooled by the flow of water past its outer housing as the pump is pumping. The water must flow past the motor at a certain velocity for proper cooling to take place, and the minimum velocity needed is different for each diameter motor.

MINIMUM VELOCITY OF WATER PAST MOTOR*

4" diameter motor .... .25 feet per second
6" diameter motor .... .5 feet per second
8" diameter motor .... .5 feet per second
10" diameter motor .... .5 feet per second

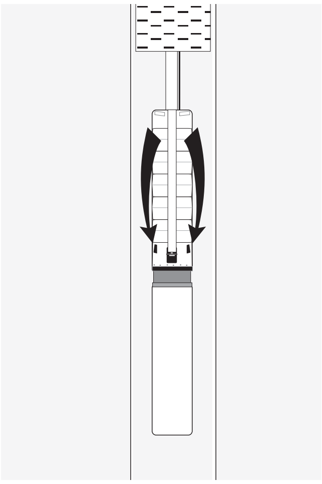


Correct screen position for proper cooling

To determine whether water is flowing past the motor at a high enough velocity, note where the motor diameter and outside sleeve or casing diameter intersect on the following chart. The Gallons Per Minute scale indicates the **minimum flow required** to keep the motor properly cooled.

MINIMUM FLOW REQUIREMENTS FOR SUBMERSIBLE MOTORS*

WELL CASING OR FLOW INDUCER SLEEVE (internal diameter in inches)	4" motor	6" motor	8" motor	10" motor	MOTOR DIAMETER
4 inches	1.2 GPM	--	--	--	MINIMUM FLOW (GPM) (to ensure proper motor cooling)
5	7	--	--	--	
6	13	10	--	--	
7	21	28	--	--	
8	30	45	10	--	
10	--	85	55	30	
12	--	140	110	85	
14	--	198	180	145	
16	--	275	255	220	
18	--	--	--	305	



Cascading water from screen does not flow past motor

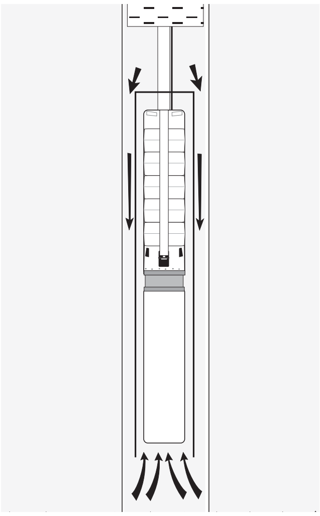
Insufficient cooling can sometimes result when:

(1) The screen is located above or at the pump, so that the water cascades down into the pump's suction intake without first flowing past the motor.

(2) The casing diameter is so large that the water is drawn into the pump's suction intake from the side without first flowing past the motor.

These problems can be solved by fitting the pump and motor into a **Flow Inducer Sleeve.** This sleeve attaches to the pump and forces water to pass around it and enter the pump's suction intake from below the motor.

If the diameter of the well's casing is too small for a sleeve inducer, a rigid tube (usually 1/4" inside diameter) can be tapped into the discharge piping above the pump (but below any check valves) with the other end positioned below the motor and pointing upwards.



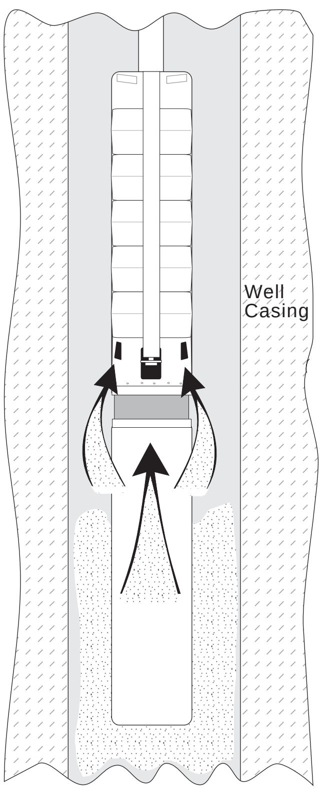
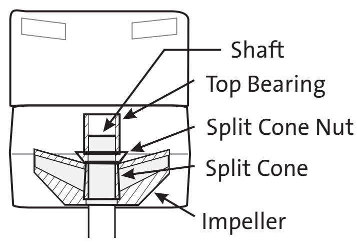
Flow Inducer Sleeve forces water past motor

***Grundfos motors have a more effective internal cooling design; therefore, a cooling sleeve is not required in water up to 30° C (86° F). However, all motors will have a longer life with a cooling sleeve installed.**

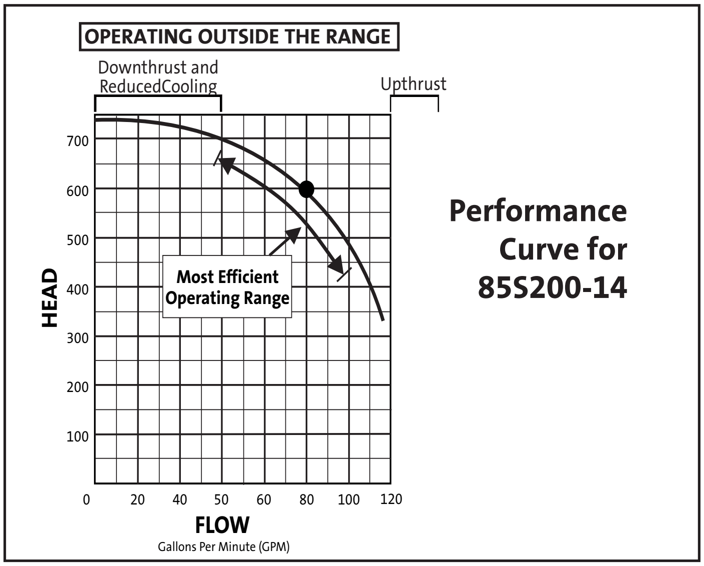
Pumping Sand

All submersible water pumps are designed with the idea they will be used to pump clean, clear water. Some design changes can be made to enable them to better handle situations that don't meet this ideal, but only to a limited degree.

No situation shortens the life of submersible pump more than pumping silt or **SAND**.

Effect On Pump	Will Be First Noticed By...	Design Changes To Deal With The Problem
SAND works its way into all moving parts of the pump, grinding bearings, impellers, and all other components as they spin against each other. 	Reduced flow (GPM) and head, since the perfect fit of the impellers and other components will be slowly worn away and the pump will become less and less efficient.  At some point, the pump's performance will become so poor it becomes quite apparent that something is seriously wrong. If the pump is pulled out of the well and the impellers and other moving components are examined, **uniform** wear (not random pitting, which might indicate that pump may have been cavitating) can be seen on virtually every moving part.	There is no way to eliminate all pump damage due to pumping sand. The effects can only be minimized. Since sand tends to be carried along with flow rates greater than 5-8 feet per second (water velocity), an enlarged drop pipe can reduce the water velocity and thereby reduce the chance sand can enter the pump. Of course, if the water velocity drops below the chart on the previous page, motor cooling may become a problem.

Upthrust Condition

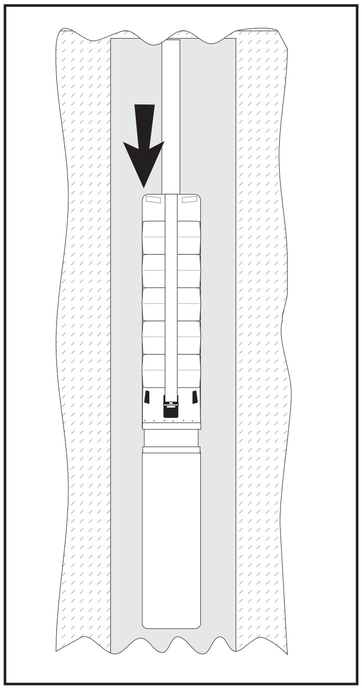


Pumps are designed with the expectation that the correct size pump will be used in the right situation. An 80 gallon per minute pump which can produce about 600 feet of head (at the same time it delivers 80 GPM) is designed so that if it is used in this situation, the pump will operate at its best efficiency **and** all its components will have a long life. The perfomance curve to the right shows the most efficient operating range for this type of pump.

If the pump is not operated within this range, problems can occur.

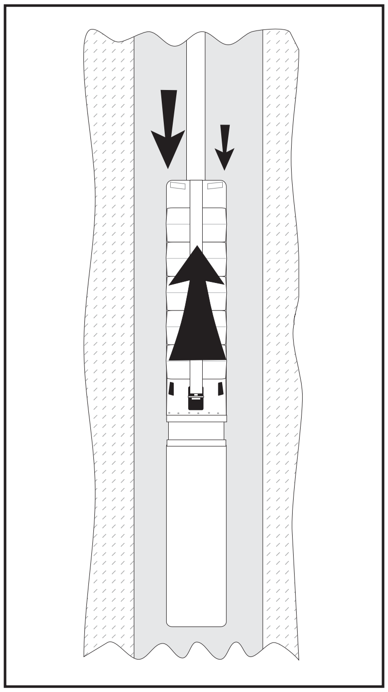
One such problem can occur when a pump is installed and run in a situation in which it will produce far GREATER flow (GPM) than it was designed for. **In other words, the pump is oversized for what is really needed.** When such a pump is started, the initial thrust (upward water surge) generated by the spinning impellers is so much GREATER than the downward thrust it is expecting to overcome (such as the force of the different water pressure, the weight of the impellers and shaft, etc.), that the entire stack of impellers within the pump is lifted upwards **(UPTHRUST).** Pumps are manufactured with bearings designed to handle intermittent upward water surges up to a certain degree. If the actual flow is much greater than this, an upthrust condition exists. The force of this **UPTHRUST** will first put pressure on the motor's thrust bearing. If and when this bearing wears out, the pump's components will begin to absorb the upthrust as they grind against each other. Upthrust is especially damaging when the pump is started and the drop pipe is empty -- causing a great upthrust of water since no head is present. Check valves in the drop pipe will prevent this from occuring.

BEFORE
pump starts pumping



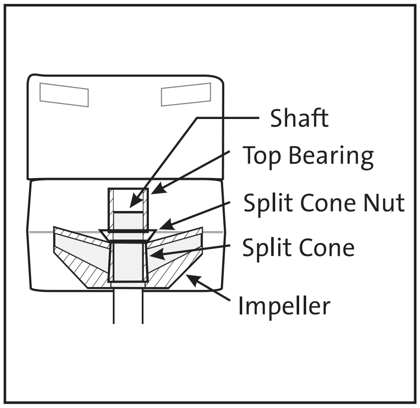
Weight of water and impellers pushes down

AFTER
pump starts pumping



Initial surge of water thrusts impellers upwards

DAMAGE CAUSED



Once the motor's thrust bearing is worn, the pump components begin wearing

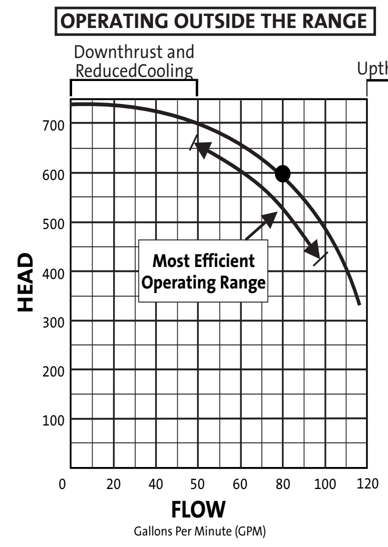
Usually, the **UPTHRUST** condition lasts for only a few seconds until the water pressure above the impellers acts as a counterforce to press the impeller stack down onto the motor shaft. Sometimes, however, if the pump is producing far more flow than for which it was designed, the upthrust condition can continue until the pump is stopped.

Downthrust Condition

Pumps are designed with the expectation that the correct size pump will be used in the right situation. An 80 gallon per minute pump which can produce about 600 feet of head (at the same time it delivers 80 GPM) is designed so that if it is used in this situation, the pump will operate at its best efficiency **and** all its components will have a long life. The perfomance curve at right shows the most efficient operating range for this type of pump.

If the pump is not operated in this range, problems can occur.

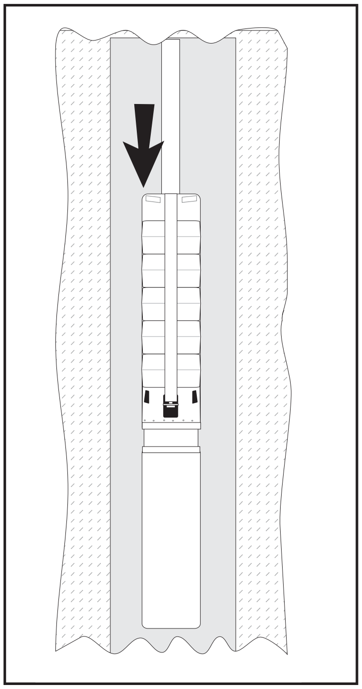
One such problem can occur when a pump is installed and run in a situation in which it will produce HEAD in the range of shut-off pressure (left part of the curve, as shown above). Although the pump is designed to operate over the full curve, if it does not produce enough flow the weight of the shaft and the pressure of the water in the drop pipe is not counterbalanced, causing possible wear to the bearings in the pump and motor. **This can occur if a valve has been closed down so far that the flow is greatly restricted or when the pump is pumping water faster than the well can refill itself.**



Performance Curve for 85S200-14

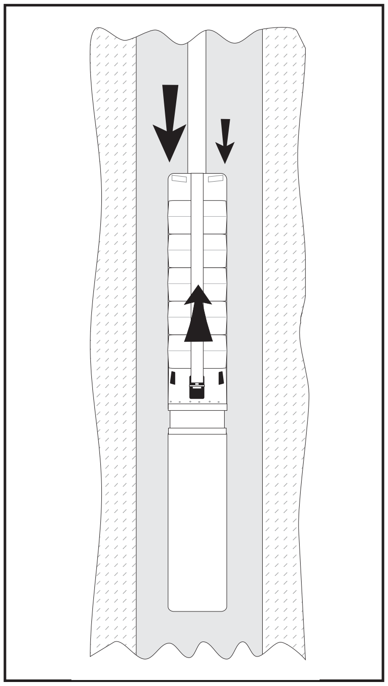
In addition to causing possible bearing damage, operating the pump in a downthrust condition is an inefficient use of energy and may not allow for proper motor cooling (see page 2).

BEFORE
pump starts pumping



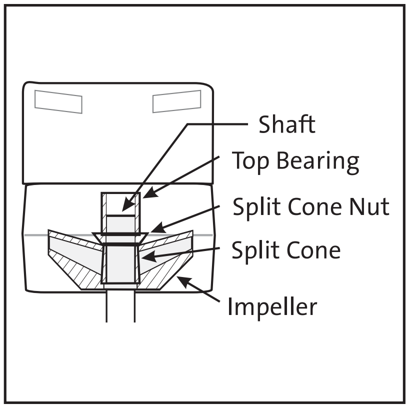
Weight of water and impellers pushes down

AFTER
pump starts pumping



Impellers can produce so much pressure they can grind down against each other

DAMAGE CAUSED



After motor's thrust bearing has worn out, pump components begin to show equal wear from grinding

The best way to check for motor bearing damage is with a shaft height gauge. Refer to the Dismantling & Reassembly section of this manual for complete instructions.

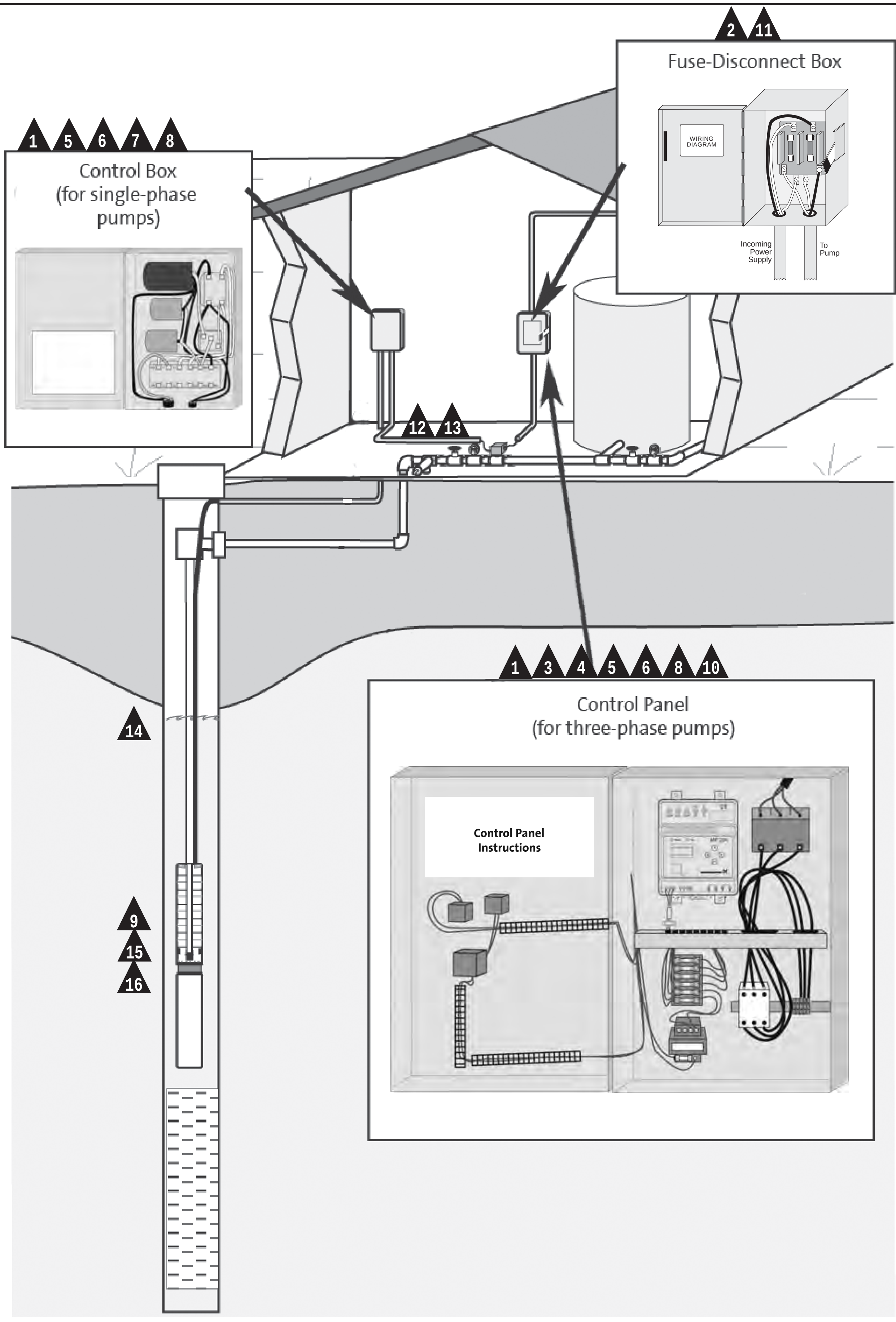
When Something Goes Wrong. . .

Pump Won't Start

Possible Cause	Check This By . . .	Correct This By . . .	
Low or no power at the motor	Check for voltage at the control box or panel. See page 11 for instructions.	If there is no voltage at the control panel, check the feeder panel for tripped circuits and reset those circuits.	1
Fuses are blown or the circuit breakers have tripped.	Turn off the power and remove the fuses. Check for continuity with an ohmmeter as shown on page 13.	Replace the blown fuses or reset the circuit breaker. If the new fuses blow or the circuit breaker trips, the electrical installation, motor, and wires must be checked for defects.	2
(3-phase motors only) **Motor starter overloads are burned or have tripped**	Check for voltage on the line and load side of the starter. Check the amp draw and make sure the heater is sized correctly.	Replace any burned heaters or reset. Inspect the starter for other damage. If the breaker trips again, check the supply voltage. Ensure that heaters are sized correctly and the trip setting is appropriately adjusted.	3
(3-phase motors only) **Starter does not energize**	Energize the control circuit and check for voltage at the holding coil.	If there is no voltage, check the control circuit fuses. If there is voltage, check the holding coil for weak connections. Ensure that the holding coil is designed to operate with the available control voltage. Replace the coil if defects are found.	4
Defective controls	Check all safety and pressure switches for defects. Inspect the contacts in control devices.	Replace worn or defective parts or controls.	5
Motor or cable is defective	Turn off the power and disconnect the motor leads from the control box. Measure the lead-to-lead resistance of the drop cable with an ohmmeter (set to R x 1). Measure the lead-to-ground values with a megohmmeter (set to R x 100K). See pages 12 and 13. Compare these measurements to the rated values for your motor.	If an open or grounded winding is found, pull the pump from the well and recheck the measurements with the lead separated from the motor. Repair or replace the motor or cable.	6
(1-phase motors only) **Defective capacitor**	Turn off the power and discharge the capacitor by shorting the leads together. Check it with an analog ohmmeter (set to R x 100K). See page 11 or use an audible capacitor tester.	When the meter is connected to the capacitor, the needle should jump toward 0 (zero) ohms and slowly drift back to infinity (∞). Replace the capacitor if it is defective.	7
Defective pressure switch or the tubing to it is plugged.	Watch the pressure gauges as the pressure switch operates. Remove the tubing and blow through it.	Replace as neccessary.	8
The pump is mechanically bound or stuck	Turn off the power, pull the pump, and manually rotate the pump shaft. Also check the motor shaft rotation, the shaft height, and the motor's amp draw (to see if it indicates a locked rotor).	If the pump shaft doesn't rotate, remove the pump and examine it. If necessary, dismantle it and check the impellers for obstruction. Check for motor corrosion.	9

Pump Does Not Produce Enough Flow (GPM)

Possible Cause	Check This By . . .	Correct This By . . .	
Shaft is turning in the wrong direction.	Check to make sure the electrical connections in the control panel are correct.	Turn off the power. Correct the wiring. For single phase motors, check the wiring diagram on the motor. For three phase motors, simply switch any two power leads.	10
Pump is operating at the wrong speed (too slow)	Check for low voltage (as shown on page 11) and phase imbalance (as shown on page 10)	Replace defective parts or contact power company, as applicable.	11
Check valve is stuck (or installed backwards)	Pull the pump and reove the check valve.	Re-install or replace.	12
Parts in the pump are worn **or** **Impellers, Inlet Strainer, or Well Screen is clogged**	Install a pressure gauge, start the pump, and gradually close the discharge valve. Read the pressure at shutoff. (Do not allow the pump to operate for an extended period at shutoff).	Convert the PSI you read on the gauge to Feet of Head by: **PSI x 2.31 ft** Add to this number the number of feet (vertically) from the gauge down to the water's pumping level. Refer to the pump curve for the model you are working with to determine the shutoff head expected for that model. If those figures and yours do not match, remove the pump and inspect impellers, chambers, etc., for clogging.	13
The water level in the well may be too low to supply the flow desired **or** **Collapsed well**	Using a depth gauge, check the drawdown in the well while the pump is operating.	If the pumping water level (including drawdown) is not **AT LEAST 3 FEET** above the pump's inlet strainer, either: 1. Lower the pump further down the well. 2. Throttle back the discharge valve to decrease the flow, thereby reducing drawdown.	14
Broken shaft or coupling	Pull pump and inspect	Replace as necessary.	15
There are leaks in the fittings or piping	Pull the pump out of the well.	The suction pipe, valves, and fittings must be made tight. Repair any leaks and retighten all loose fittings.	16



2
11
Fuse-Disconnect Box
WIRING DIAGRAM
Incoming Power Supply
To Pump
1
5
6
7
8
Control Box
(for single-phase pumps)
12
13
14
1
3
4
5
6
8
10
Control Panel
(for three-phase pumps)
Control Panel Instructions
9
15
16

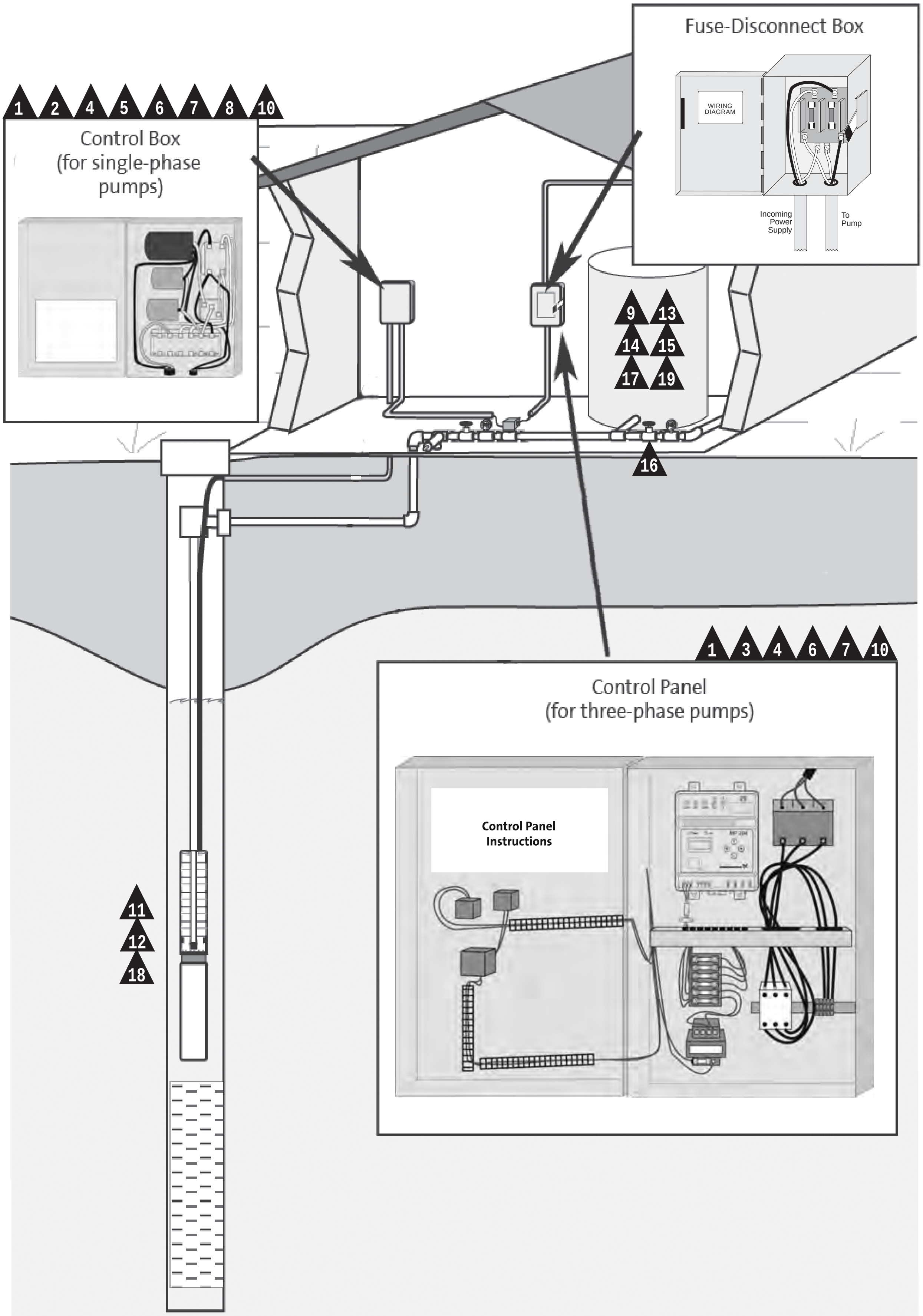
When Something Goes Wrong. . .

Fuses Blow or Heaters Trip

Possible Cause	Check This By . . .	Correct This By . . .	
Improper voltage	Check the voltage at the control box or panel. See page 11 for instructions. If the incoming voltage is + or -10%, check the wire size and then measure the distance between the pump motor and the pump control panel.	If voltage varies by more than 10% (+ or -), contact the power company. Rewire with correct gauge. Undersized wire and a great distance between the control panel and the pump motor increases resistance and decreases the voltage by the time it reaches the pump motor.	1
The starter overload is set too low.	Cycle the pump and measure the amperage. See page 10 for instructions.	Increase the heater size (use a slo-bio) or adjust the trip setting. Do not, however, exceed the recommended rating.	2
(3-phase motors only) **Current is imbalanced.**	Check the current draw on each lead to the motor. See page 11 for instructions.	The current imbalance must be within 5% of each other. If they are not, check the wiring and the power supply.	3
The wiring or connections are faulty.	Check to make sure the wiring is correct and there are no loose terminals.	Tighten any loose terminals and replace any damaged wire.	4
(1-phase motors only) **Capacitor is defective**	Turn off the power and discharge the capacitor. Check start and run capacitors with an ohmmeter (set at R x 100K). See page 11 for instructions.	When the meter is connected to the capacitor, the needle should jump towards 0 (zero) ohms and then slowly drift back to infinity (∞). Replace the capacitor if it is defective.	5
Fuse, heater, or starter are the wrong size	Check the fuses and heaters against the motor manufacturer's specification charts.	Replace as necessary.	6
The control box location is too hot	Touch the box with your bare hand during the hottest part of the day -- you should be able to keep your hand on it without burning.	Shade, ventilate, or move the control box so its environment does not exceed 120°F.	7
(1-phase motors only) **Wrong control box**	Check requirements for the motor against the control box specifications.	Replace as necessary.	8
Defective pressure switch	Watch gauges as pressure switch operates.	Replace as necessary.	9
The motor is shorted or grounded.	Turn off the power and disconnect the wiring. Measure the lead-to-lead resistance with an ohmmeter (set to R x1). Measure the lead-to-ground resistance (set to R x100K). Compare these measurements to the rated values for your motor.	If you find an open or grounded winding, remove the motor and recheck the leads. If OK, check the leads for continuity and for bad splice.	10
Poor motor cooling	Find the internal diameter of the well casing (or sleeve, if used) on the chart on page 2 and check for proper cooling.	Increase the pump flow (GPM) so proper cooling is possible (see chart on page 2) or pull the pump out of the well and add a sleeve with a smaller internal diameter *(see chart on page 2).*	11
Bad motor thrust bearing	Measure for high amps as explained on page 10.	If amps are too high, pull the pump and replace the motor.	

Pump Cycles Too Often

Possible Cause	Check This By . . .	Correct This By . . .	
The pressure switch is defective or is not properly adjusted.	Check the pressure setting on the switch. Check the voltage across closed contacts.	Adjust the pressure switch with a screwdriver or replace it if defective.	13
The tank is too small	Check the tank size and amount of air in the tank. The tank size should be about 10 gallons for each GPM needed (16 GPM = 160 gal.). At the pump cut-in pressure, the tank should be about 2/3 filled with air.	Replace the tank with one that is the correct size.	14
There is insufficient air charging of the tank or piping is leaking.	Pump air into the tank or diaphragm chamber. Check the diaphragm for leaks. Check the tank and piping for leaks with soapy water. Check the air-to-water ratio in the tank.	Repair as necessary.	15
Plugged snifter valve or bleed orifice (causing pressure tank to be water-logged)	Examine them for dirt or erosion.	Repair or replace as necessary.	16
Leak in the pressure tank or piping.	Check the setting and operation of the level control.	Readjust the level control setting (according to the manufacturer's instructions) or replace it if defective.	17
The level control is defective or is not properly set.	Check the yield of the well (determined by the well-test) against the pump's performance curve.	Reduce the flow by throttling back the valve. or Change the pump.	18
Pump is oversized for the application. It is outpumping the yield of the well and pumping itself dry.	Refer to the tank's operating and installation instructions and make sure it is installed correctly.	Repair or replace as needed.	19



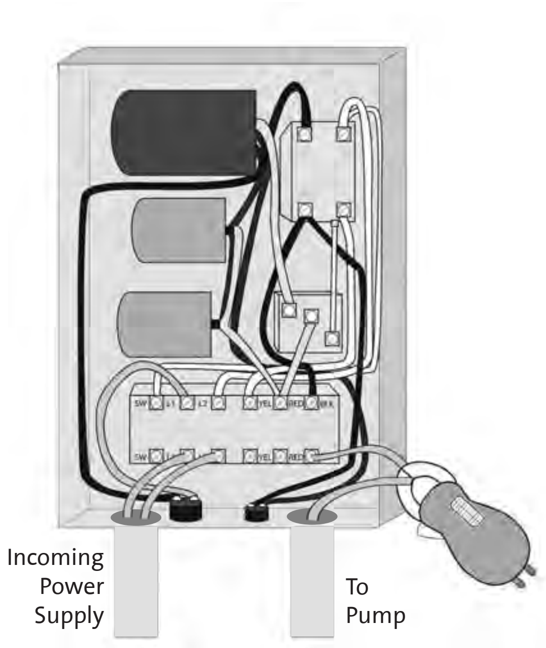
1 2 4 5 6 7 8 10
Control Box
(for single-phase pumps)
Fuse-Disconnect Box
WIRING DIAGRAM
Incoming Power Supply
To Pump
9 13
14 15
17 19
16
1 3 4 6 7 10
Control Panel
(for three-phase pumps)
Control Panel Instructions
11
12
18

Amperage Check

To check the electrical current (measured in amperes, or "amps") use an ammeter.

Instructions

1. Make sure the pump is running
2. Set the rotary scale on the front of the ammeter to the highest scale.
3. Open the control box and place the jaws of the ammeter around the wire to be measured.
4. Slowly rotate the scale on the ammeter back towards 0 (zero) until an exact reading is shown.
5. Record the measurement
6. Repeat for the other wires.



Evaluation

If the amp draw exceeds the service factor amps for the pump (as listed in the Motors section of the Service Manual), then:

- The motor starter may have burned contacts
- The terminals in the starter or terminal box may be loose
- There may be a winding defect. Check the winding and insulation resistance (see pages 12 and 13)
- The motor windings may be shorted or grounded
- The pump may be damaged in some way and may be causing a motor overload.
- A voltage supply or current imbalance (3-phase only) may exist. Follow the steps below to determine if this is true.
- The insulation on the drop cable may be torn, exposing the cable.

Current Imbalance On Three-Phase Motors

If the motor is connected to three-phase power, the balance of those three phases can be checked in the following way:

1. Measure the amperage of each wire as instructed above and record these figures.
2. Add together the total amperage measured by the three wires.
3. Divide this number by three to get the **average** amperage reading for the three wires.
4. Check over your numbers and determine which wire has the greatest difference from the average.
5. Take that number and subtract it from the average to determine the amount of **difference**.
6. Divide the **difference** by the **average**.
7. Multiply this number by 100 to obtain the percent of current imbalance for that particular hookup.
8. Turn **POWER OFF**
9. Repeat these steps for the other two possible hookup installations so that each motor lead is connected to a different power lead than it was before.

	Hookup 1	Hookup 2	Hookup 3
Incoming power leads	L1 L2 L3	L1 L2 L3	L1 L2 L3
Motor leads	A B C	C A B	B C A

(where A, B, and C represent each motor lead or each set of leads joined together to make a single motor lead)

Example:

A	=	51 amps	C	=	50 amps	B	=	50 amps
B	=	46 amps	A	=	49 amps	C	=	48 amps
C	=	53 amps	B	=	51 amps	A	=	52 amps
Total	=	150	Total	=	150	Total	=	150
150/3	=	50	150/3	=	50	150/3	=	50
- 46	=	4	- 49	=	1	- 48	=	2
4/50	=	.08 or 8 %	1/50	=	.02 or 2 %	2/50	=	.04 or 4 %

Evaluation

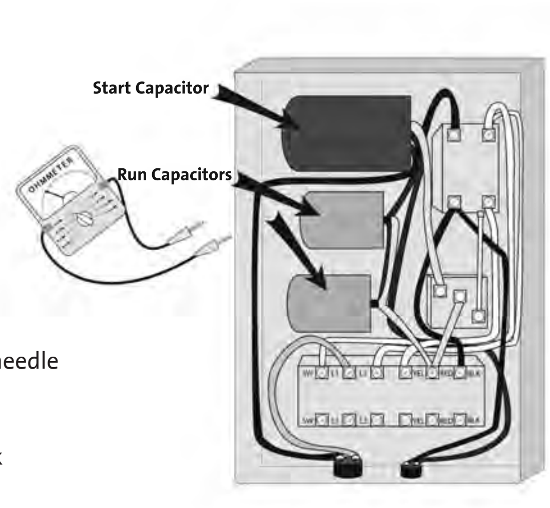
If the the current imbalance is greater than 5% on all three hookups, then:

- If the largest difference in amps is consistently drawn from the same power lead (L1, L2, or L3 above), contact the power company. Your voltage should be balanced to within + or - 5%.
- If the largest difference in amps is consistently drawn from the same motor lead (A, B, or C above), there is likely a problem with the motor. Check the items listed under "Evaluation" near the top of this page.

If the current imbalance exceeds 5% one or two of the legs, use the hookup that has the least difference and check the motor for some of the other problems listed under "Evaluation" near the top of this page.

Capacitor Check

To check the condition of any capacitor on single phase motors, use an ohmmeter.



Instructions:

1. Turn the **POWER OFF**.
2. Disconnect the capacitor from the power source.
3. Discharge the capacitor by touching its leads together.
4. Set the scale selector on the ohmmeter to R x 100K.
5. Connect the leads of the ohmmeter to the black and orange wires of the capacitor.
6. Watch the ohmmeter scale.
7. Disconnect one lead from the capacitor for approximately 30 seconds. The needle should return to the last reading taken.

Evaluation

If the capacitor is OK, the needle should swing towards zero and then float back towards infinity (∞). If the needle drops and remains at zero, the capacitor is probably shorted. If the needle remains at a high value, there is an open circuit.
CAUTION: This test may indicate a good capacitor even though it may have lost some capacitance, making the motors run noisy or draw high amps. To safeguard against this, the capacitor can be checked with a capacitor meter.

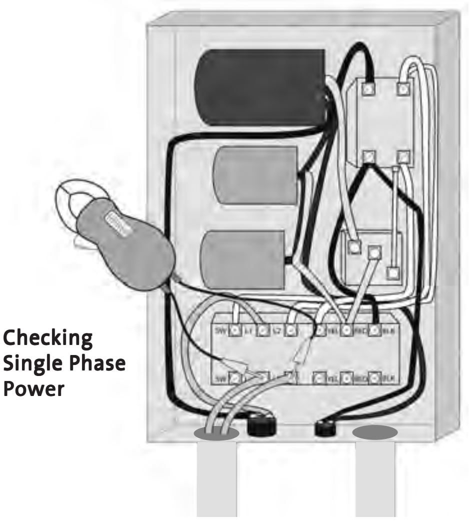
Supply Voltage Check

To check the supply voltage, use a voltmeter (or amprobe) with the power on.

Instructions

1. Set the voltmeter to the highest scale
2. Remove the cover of the control box...BE CAREFUL -- POWER IS STILL BEING SUPPLIED TO THE CIRCUIT. Do not touch the voltmeter leads together while they are in contact with the power lines.
3. Touch the ends of the voltmeter leads as follows:

<u>Single Phase Motors</u>
Touch one voltmeter lead to each of the lines supplying power to the control (L_1 and L_2 , or L_1 and N for 115V circuits). →



Checking Single Phase Power

<u>Three Phase Motors</u>
Touch a voltmeter lead to the following:

- Power leads L_1 and L_2
- Power leads L_2 and L_3
- Power leads L_3 and L_1
- Two fuses
- Two contact points
- Two heaters

These tests should give a reading of full line voltage. (applies to the three power lead pairs)

Evaluation

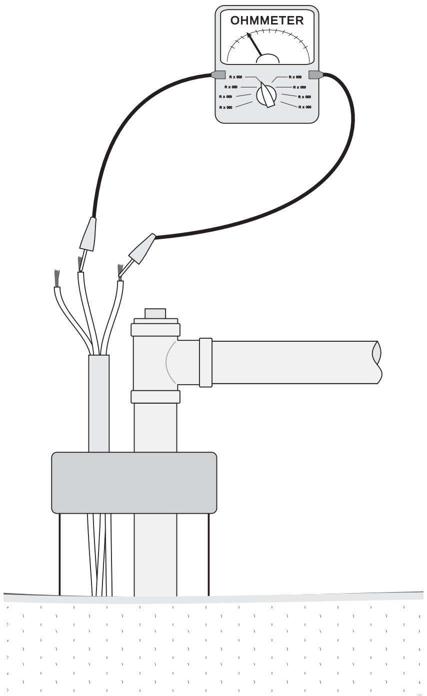
When the motor is under load, the voltage should be -10% and +6% of the nameplate voltage. Any variation larger than this can cause damage to the motor windings and should be noticeable as a high amp problem.

If The Motor Nameplate Reads . . .		Then the minimum and maximum voltage should be . . . Minimum	Maximum
115V	(single phase)	105 volts	121 volts
208V	(single or three phase)	188 "	220 "
230V	" "	210 "	243 "
460V	(three phase)	414 "	487 "
575V	" "	518 "	609 "

Any variations larger than these may indicate a poor electrical supply. The motor should not be operated under these conditions. Contact your power supplier to correct the problem or change the motor to one requiring the voltage you are receiving.

Motor Winding Resistance (lead-to-lead)

To check the electrical condition of the drop cable, splice, and motor windings, a resistance check with an ohmmeter is required.



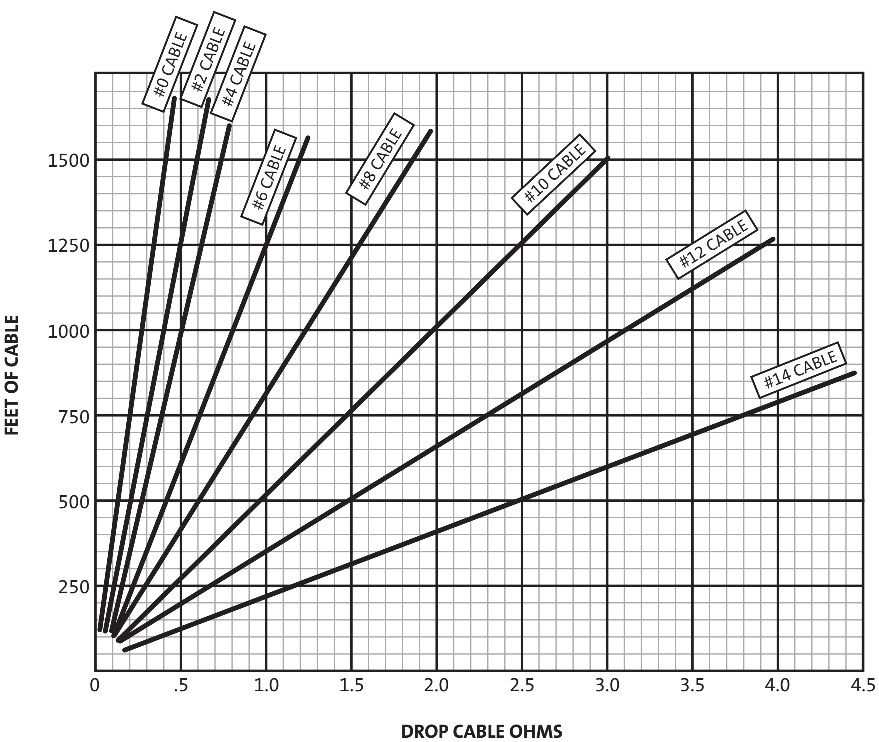
Instructions:

1. Turn the **POWER OFF**.
2. Disconnect all electrical leads to the drop cable.
3. Set the scale selector on the ohmmeter to R x 1 (if you expect ohm values under 10) or R x 10 (for ohm values over 10).
4. Touch the leads of the ohmmeter to two motor leads:
   Single Phase Motors
   Touching the leads of the ohmmeter to the black and yellow leads will measure the main winding's resistance for Franklin and Grundfos 402 motors. The red and yellow leads will be the start winding's resistance.
   Three Phase Motors
   Touching the leads of the ohmmeter to any two black leads will measure that winding's resistance. Repeat for all three possible lead combinations.
5. Watch the ohmmeter scale and record this figure. Subtract the ohm resistance for the drop cable (chart below) from the number. Compare the remaining figure with the one shown in the Motors section of this manual.

If:	Then:
Ohm values are normal	Motor windings are okay
One ohm value is less than normal	That motor winding may be starting to short
One ohm value is greater than normal	That winding may be starting to open
Some ohm values are greater than normal (>25%) and some are less than normal (± 25%)	The leads may be connected incorrectly, or have a break in the insulating jacket

If ohm readings are not normal and you want to verify the problem is not with the splice or drop cable, remove the lead from the motor and check the resistances from pin to pin directly at the motor. If the motor checks out okay, the fault is in the lead or splice (see page 14).

Total Resistance of Drop Cable *(from control box to motor and back)*

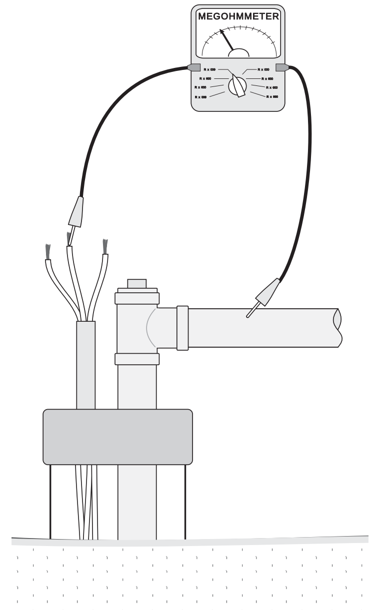


The values shown are for copper conductors. If aluminum conductor drop cable is used, the resistance will be higher for each foot of cable of the same size.

Copper ÷ .61 = Aluminum

Insulation Resistance (lead-to-ground)

To check the insulation resistance of the drop cable, splice, and motor leads, a megohmmeter is required.



Instructions:

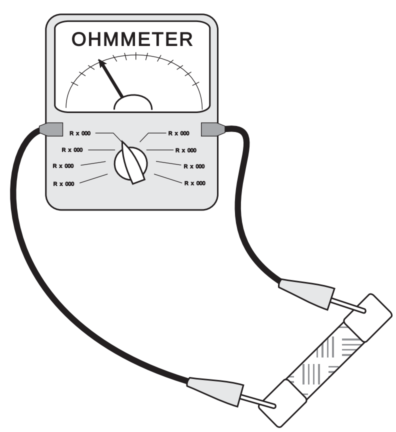
1. Turn the **POWER OFF**.
2. Disconnect all electrical leads to the drop cable.
3. Set the scale selector on the megohmmeter to R x 100, touch its leads together, and adjust the indicator to zero.
4. Touch the leads of the megohmmeter to each of the motor leads and to ground (i.e. L_1 to ground; L_2 to ground, etc.). The well casing, if made of steel, makes an excellent ground.
5. Watch the megohmmeter scale and compare this figure with the chart below.

Evaluation: In general, any ohm value above 1,000,000 ohms indicates everything is OK. The following table gives more specifics.

OHM VALUE	**MEGA**ohm **VALUE**	THIS INDICATES THAT ...
		If The Motor HAS NOT Yet Been Installed:
2,000,000 (or more)	2.0	It is a new motor
1,000,000 (or more)	1.0	It is a used motor than can be used again (insulation OK)
		If The Motor HAS Been Installed: *(means that ohm readings will be for the drop cable plus the motor)*
500,000 - 1,000,000	0.5 - 1.0	The motor is in reasonably good condition
20,000 - 500,000	.02 - 0.5	The motor may have been damaged by lightning or has damaged leads.
10,000 - 20,000	.01 - .02	The motor has certainly been damaged or has damaged leads. The pump should be pulled and repairs made to the motor leads or replace the motor completely. The motor may still operate, but probably not for long.
less than 10,000	0 - .01	The motor has failed or the motor lead insulation has been completely destroyed. The pump must be pulled and the motor lead (drop cable) repaired or the entire motor replaced. **The motor will not run in this condition.**

Fuses

To check the condition of electrical fuses, an ohmmeter is required.



Instructions:

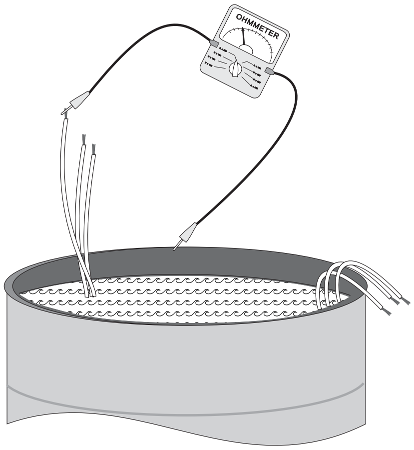
1. Turn the **POWER OFF** at the main disconnect or power source.
2. Remove the fuse.
3. Set the scale selector on the ohmmeter to R x 1.
4. Touch each lead of the ohmmeter to one end of the fuse.

Evaluation:

A good fuse should have zero (0) ohm reading. If the ohm value is near or past infinity, the fuse must be replaced.

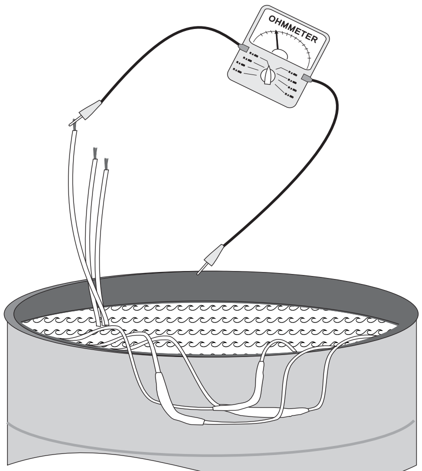
Cable and Splice Condition

To check the electrical condition of the cable and splice insulation, a megohmmeter is required.



Instructions:

1. Turn the **POWER OFF.**
2. Remove the cable from the motor and electrical supply.
3. Submerge the cable in a steel barrel of water. Make sure both ends stay out of the water. Salt may be added to increase the conductance of the water.
4. Set the megohmmeter to R x 100K. Zero-adjust the ohmmeter by touching its two leads together.
5. Touch one megohmmeter lead to the steel barrel and other to a bare cable lead.
6. If the megohmmeter drifts towards zero (0), either that lead or the splice for that lead has a leak (fault). To find out if it is the splice:



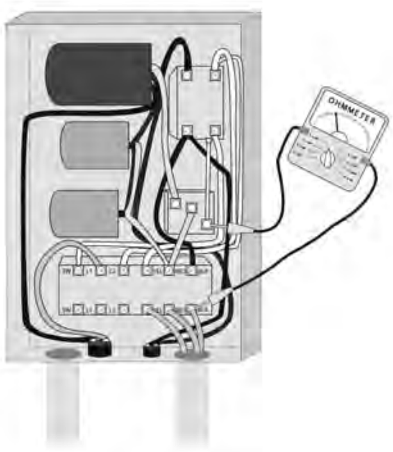
   a. Raise the splice for that lead out of the water.
   b. Repeat step 5.
   c. If the megohmmeter drifts towards infinity, the fault is in the splice.
   d. If the megohmmeter drifts towards zero (0), the fault is somewhere else in that lead. Gradually pull the rest of that cable lead out of the water until the megohmmeter drifts towards infinity. When it does, the leak is at that point in the cable lead.
7. Repeat for each of the motor leads.

Evaluation:
Any faulty leads should be replaced using waterproof electrical tape.

Checking the Relay

(SINGLE-PHASE CONTROL BOXES ONLY)
To check the electrical condition of the relays on single phase control boxes, an ohmmeter is required.

Specific instructions for checking the relay differ from control box to control box. Refer to the inside cover of your control box.



Overload Protection

To check the electrical condition of the thermal overloads, an ohmmeter is required.

Instructions:

1. Turn the **POWER OFF**.
2. Set the scale selector on the ohmmeter to R x 1.
3. Touch one of the ohmmeter leads to an overload protector and one to terminal 1, then terminal 3. Repeat for each overload protector.

Evaluation:
If the ohm values are 0.5 ohms or less, the overload protectors should still be functional. If not, they should be replaced.

Definitions

NET POSITIVE SUCTION HEAD (two types)

Before a centrifugal water pump can operate, the water must enter the pump under a certain minimum amount of pressure. For submersible pumps, this minimum is easily reached, since the pump is submerged in water and both the atmospheric pressure (14.7 psi) and the pressure of the water in the well are present. The amount of pressure (expressed in feet of head) required for a given pump to operate is known as its Net Positive Suction Head **Required**.

This number is determined by extensive testing of the pump by the manufacturer. These requirements are normally shown in graphical form (an **NPSH curve**) for a pump at every flow (GPM) within the flow range for which the pump is designed**.** As a pump's flow (GPM) increases, the NPSHR needed to continue that flow (without cavitating) also increases.

The amount of pressure (expressed in feet of head) that is actually available to a pump is known as its Net Positive Suction Head **Available**. Since the NPSH **Available** to the pump is almost always greater than the NPSH **Required** (for submersible pumps, that is), they are usually not a cause for any concern when sizing a pump or troubleshooting.

For submersible pumps, NPSH Required should not be confused with Total Dynamic Head, which is the amount of head the pump must produce to deliver water at the desired flow rate (GPM) in a given situation. ***Total Dynamic Head*** *(or TDH, as it is sometimes called) is explained below.*

TOTAL DYNAMIC HEAD

When selecting (or "sizing") a pump, two questions must be answered:

1. How much flow is needed ?
   (expressed in Gallons Per Minute)

2. How much head must the pump produce ?
   (known as ***Total Dynamic Head****)*

To determine the Total Dynamic Head the pump must produce, 5 pieces of information are needed:

A **STATIC WATER LEVEL**

+

B **DRAWDOWN**
(as the pump is pumping)

+

C **TANK ELEVATION**

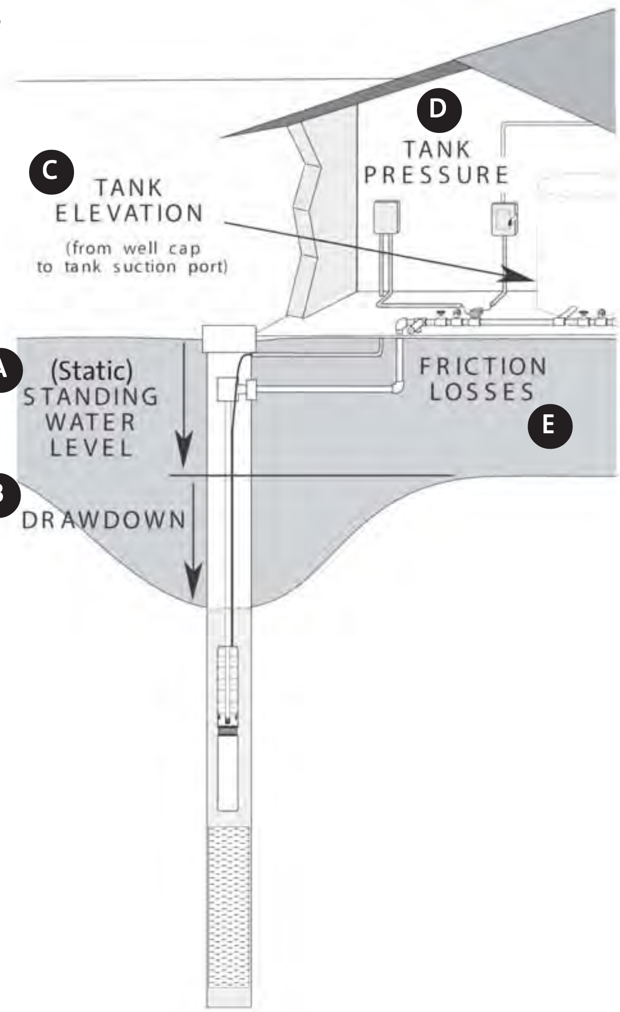
+

D **TANK PRESSURE**
(multiply by 2.31 to
convert psi to feet of head)

+

E **FRICTION LOSSES**

THE TOTAL
OF THESE 5 NUMBERS IS
THE AMOUNT OF HEAD
THE PUMP MUST PRODUCE



AFFINITY LAWS

The mathematical relationships which permit the head, capacity, brake horsepower (BHP), and NPSH of centrifugal pumps to be predicted based on small changes in impeller diameter size or shaft speed (RPM) changes. These relationships are:

For diameter changes at a constant RPM:

$$\frac{D_1}{D_2} = \frac{GPM_1}{GPM_2}$$

Flow changes in direct proportion to the ratio of the diameter change.

$$\left(\frac{D_1}{D_2}\right)^2 = \frac{H_1}{H_2}$$

Head changes to the square ratio of the ratio of the diameter change.

$$\left(\frac{D_1}{D_2}\right)^3 = \frac{BHP_1}{BHP_2}$$

BHP changes to the cube of the ratio of the diameter change

For RPM changes:

$$\frac{RPM_1}{RPM_2} = \frac{GPM_1}{GPM_2}$$

$$\left(\frac{RPM_1}{RPM_2}\right)^2 = \frac{NPSH_1}{NPSH_2}$$

$$\left.\begin{aligned}\left(\frac{RPM_1}{RPM_2}\right)^2 &= \frac{H_1}{H_2}\\ \left(\frac{RPM_1}{RPM_2}\right)^3 &= \frac{BHP_1}{BHP_2}\end{aligned}\right\}$$

Head is affected by the square of the ratio of RPM change
and
BHP is affected by the cube of the ratio of the RPM change

Conversion Formulas

HEAD
(in feet)

$$= \frac{\text{Pressure (PSI)} \times 2.31}{\text{Specific Gravity (for water, 1.0 at ambient temperatures)}}$$

PRESSURE
(PSI)

$$= \frac{\text{HEAD (in ft)} \times \text{Specific Gravity (for water, 1.0 at ambient temperatures)}}{2.31}$$

ATMOSPHERIC PRESSURE
Pressure of the Atmosphere Pushing Down (at sea level)

= 14.7 PSI = 34 feet of HEAD

BRAKE HORSEPOWER
Horsepower Delivered to the Pump Shaft

$$= \frac{\text{GPM} \times \text{HEAD} \times \text{Specific Gravity (for water, 1.0 at ambient temps)}}{3960 \times \text{Efficiency Of Pump}}$$

PUMP EFFICIENCY
Of The Pump

$$= \frac{\text{GPM} \times \text{HEAD} \times \text{Specific Gravity}}{3960 \times \text{Brake Horsepower}}$$

FOOT POUNDS = Newton Meters (or Nm) x .7376

DEGREES FARENHEIT = (Degrees Celsius x 9/5) + 32

Water Vapor Pressure and Specific Gravity

°F	°C	Specific Gravity (1 at 60°F)	Weight (Lbs per cubic foot)	Vapor Pressure (PSIA)	Vapor Pressure (in feet)
32	0	1.002	62.42	0.0885	0.204
40	4.4	1.001	62.42	0.1217	0.281
45	7.2	1.001	62.40	0.1475	0.340
50	10.0	1.001	62.38	0.1781	0.411
55	12.8	1.000	62.34	0.2563	0.591
60	15.6	1.000	62.34	0.2563	0.591
65	18.3	.999	62.31	0.3056	0.839
70	21.1	.999	62.27	0.3631	0.839
75	23.9	.998	62.24	0.4298	0.994
80	26.7	.998	62.19	0.5069	1.172
85	29.4	.997	62.16	0.5959	1.379
90	32.2	.996	62.11	0.6982	1.617
95	35.0	.995	62.06	0.8153	1.890
100	37.8	.994	62.00	0.9492	2.203
110	43.3	.992	61.84	1.275	2.965
120	48.9	.990	61.73	1.692	3.943
130	54.4	.987	61.54	2.223	5.196
140	60.0	.985	61.39	2.889	6.766
150	65.6	.982	61.20	3.718	8.735
160	71.1	.979	61.01	4.741	11.172
170	76.7	.975	60.79	5.992	14.178
180	82.2	.972	60.57	7.510	17.825
190	87.8	.968	60.35	9.339	22.257
200	93.3	.964	60.13	11.526	27.584
212 (boiling point)	100.0	.959	59.81	14.696	35.353
220	104.4	.956	59.63	17.186	41.343
240	115.6	.948	59.10	24.97	60.77
260	126.7	.939	58.51	35.43	87.05
280	137.8	.929	58.00	49.20	122.18
300	148.9	.919	57.31	67.01	168.22
320	160.0	.909	56.66	89.66	227.55
340	171.1	.898	55.96	89.66	227.55
360	182.2	.886	55.22	153.04	398.49
380	193.3	.874	54.47	195.77	516.75
400	204.4	.860	53.65	247.31	663.42
420	215.6	.847	52.80	308.83	841.17
440	226.7	.833	51.92	381.59	1056.8
460	237.8	.818	51.02	466.9	1317.8
480	248.9	.802	50.00	566.1	1628.4
500	260.0	.786	49.02	680.8	1998.2

Water Properties at Different Altitudes

ALTITUDE		BAROMETER READING		ATMOS. PRESSURE		Boiling Point Of Water F°
Feet	Meters	IN. HG.	MM. HG	PSIA	Feet of Water	
-1000	-304.8	31.0	788	15.2	35.2	213.8
-500	-152.4	30.5	775	15.0	34.6	212.9
0	**0.0**	**29.9**	**760**	**14.7**	**33.9**	**212.0**
+500	+152.4	29.4	747	14.4	33.3	211.1
+1000	304.8	28.9	734	14.2	32.8	210.2
1500	457.2	28.3	719	13.9	32.1	209.3
2000	609.6	27.8	706	13.7	31.5	208.4
2500	762.0	27.3	694	13.4	31.0	207.4
3000	914.4	26.8	681	13.2	30.4	206.5
3500	1066.8	26.3	668	12.9	29.8	205.6
4000	1219.2	25.8	655	12.7	29.2	204.7
4500	1371.6	25.4	645	12.4	28.8	203.8
5000	1524.0	24.9	633	12.2	28.2	202.9
5500	1676.4	24.4	620	12.0	27.6	201.9
6000	1828.8	24.0	610	11.8	27.2	201.0
6500	1981.2	23.5	597	11.5	26.7	200.1
7000	2133.6	23.1	587	11.3	26.2	199.2
7500	2286.0	22.7	577	11.1	25.7	198.3
8000	2438.4	22.2	564	10.9	25.2	197.4
8500	2590.8	21.8	554	10.7	24.7	196.5
9000	2743.2	21.4	544	10.5	24.3	195.5
9500	2895.6	21.0	533	10.3	23.8	194.6
10000	3048.0	20.6	523	10.1	23.4	193.7
15000	4572.0	16.9	429	8.3	19.2	184.0

LSP-TL-015 | Rev. 08/06
PRINTED IN USA

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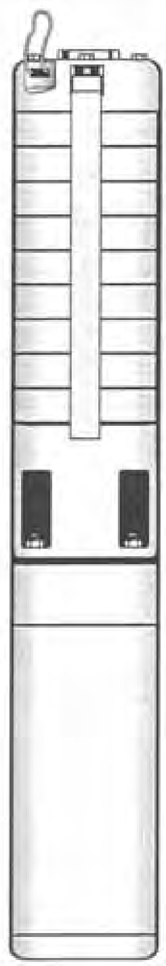
CS-MW16-CC PUMP SPECIFICATIONS

GRUNDFOS



Kits List

4" Submersibles

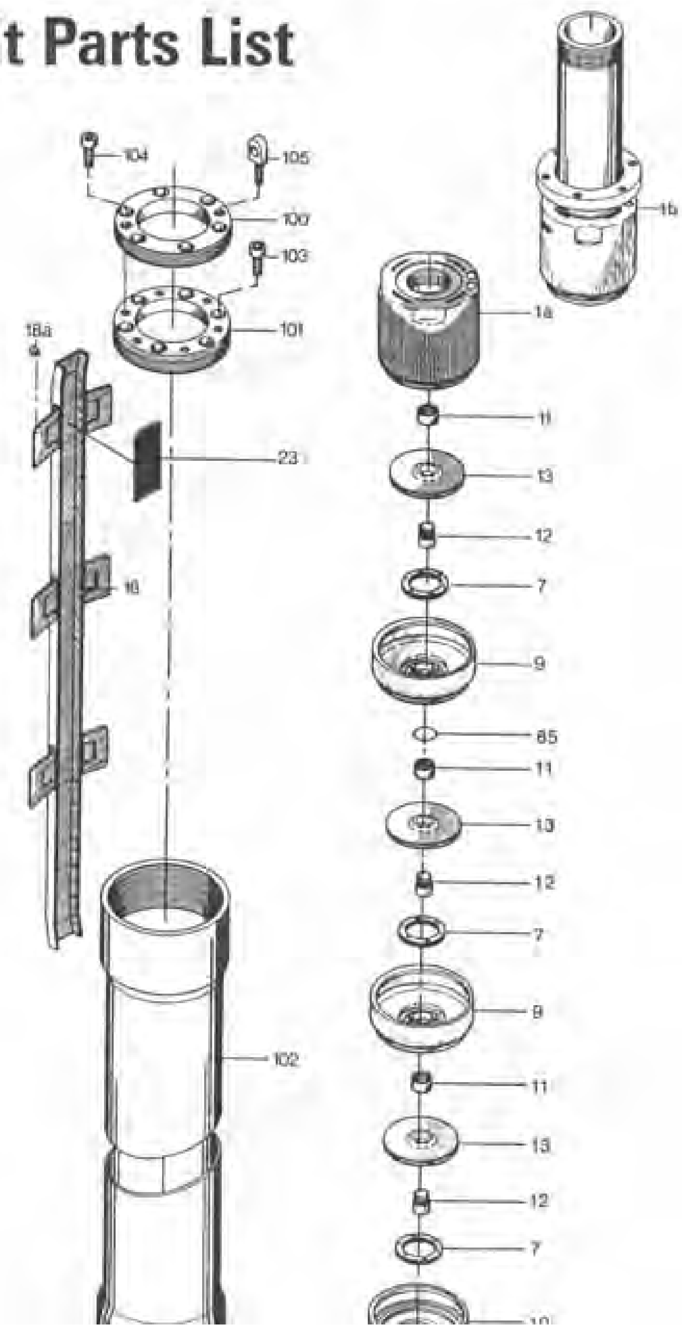
Contents

25S

Smooth Shaft

LSP-KL-0055 (Rev. 5/95)

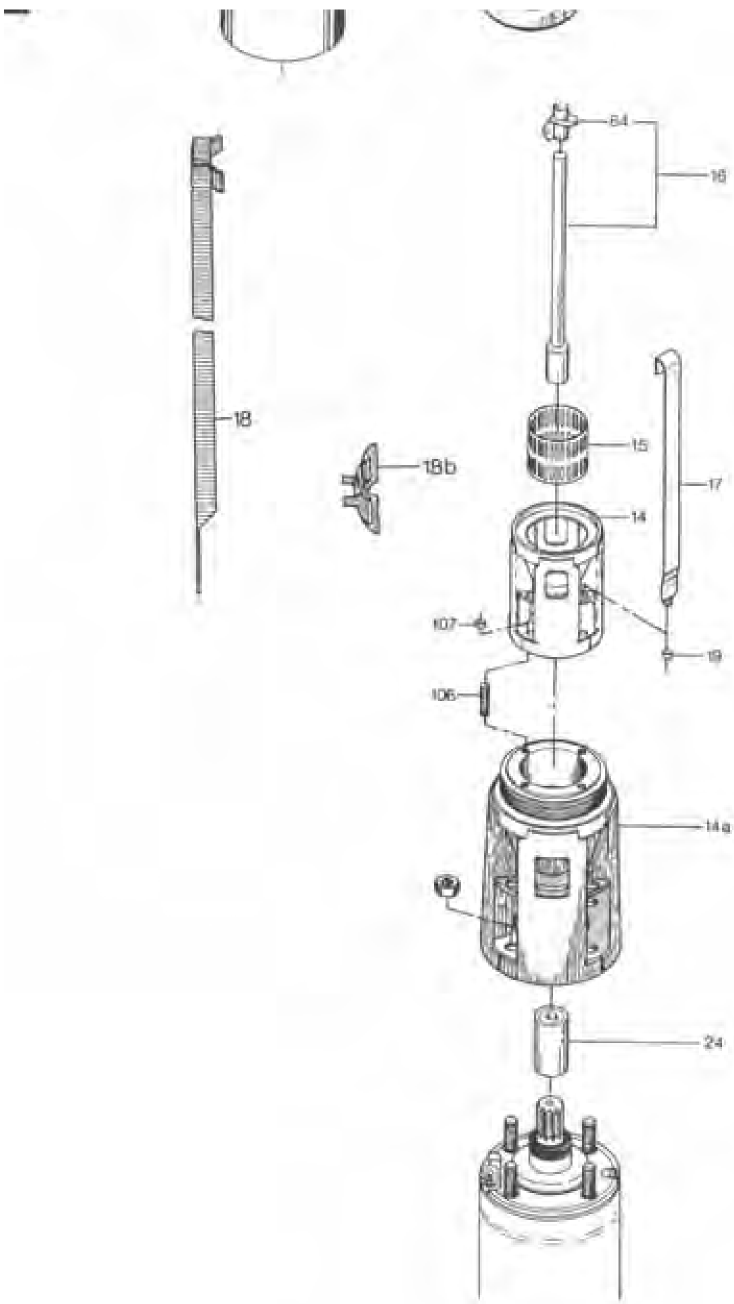
Kit Parts List



25S SMOOTH SHAFT

GRUNDFOS
"Leaders in Pump Technology"

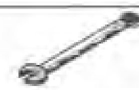
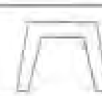
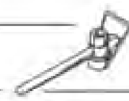
POS.	DESCRIPTION	QTY	PART #	KIT
	INLET/DISCHARGE KIT			
1a	H/P TOP PIECE W/CHECK VALVE	1	105015	*INLET/DISCHARGE KIT* Part No. 05003Z
14	4"X6" INLET	1	115038	
10	CHAMBER LOWER INT	1	095004	
15	STRAINER	1	090017	
	INLET/DISCHARGE SLEEVE KIT			
1b	DISCHARGE W /PIPE	1	105020	*INLET/DISCHARGE KIT* 52 STAGES 6" Pn. 05004Z
10	CHAMBER LOWER INT.	1	095004	
14a	INLET W/ CONN. PIECE 6"	1	115031	
14	INLET 4"	1	115023	
15	STRAINER	1	090017	
	BEARING KIT			
85	UPTHRUST WASHER	3	100090	*BEARING KIT* 39 STAGES Pn. 08006Z 52 STAGES Pn. 08008Z
7	SEAL RINGS (NBR)	SEE KIT	095006	
	IMPELLER KIT			
13	IMPELLER	SEE KIT	055002	*IMPELLER KIT* 39 STAGES Pn. 05008Z 52 STAGES Pn. 05009Z
19	NUT FOR STRAP	4	ID7187	
12	SPLIT CONE	SEE KIT	090012	
11	SPLIT CONE NUT	SEE KIT	095515	
	NUT KIT 6"	1	UB9001	
	CHAMBER KIT			
9	INT. CHAMBERS	SEE KIT	055005	*CHAMBER KIT* 39 STAGES Pn. 05013Z 52 STAGES Pn. 05014Z
19	NUT FOR STRAP	4	ID7187	
10	CHAMBER LOWER INT	1	095004	
	NUT KIT 6"	1	UB9001	
	25S75-39DS STRAP KIT			
17	STRAP	4	099039	*STRAP KIT* Part No. 08072Z
19	NUT FOR STRAP	4	ID7187	
18	CABLE GUARD	1	109339	
18b	CABLE GUARD CLIP	1	080509	
	25S100-52DS STRAP KIT			
17	STRAP	4	119026	*STRAP KIT* Part No.08075Z
19	NUT FOR STRAP	4	ID7187	
102	SLEEVE	1	108752	
100	TIGHT FLANGE COUNTER	1	110080	
101	TIGHT FLANGE	1	110081	
105	EYE BOLT	1	ID7389	
103/104	ALLEN SCREW	12	ID1368	
18a	CHEESE HD SCREW	6	ID1393	
18	CABLE GUARD	1	109052	



	SHAFT KIT			*SHAFT KIT*
16	25S75-39 SHAFT	1	106439	*Part No. 08044Z*
16	25S100-52DS SHAFT	1	106052	*Part No. 08046Z*
*	NUT KIT	1	UB9011	
24	COUPLING	1	795939	

Special Tool Kits

(Tools not generally available from normal sources)

Part Number	Description	
96022539	**Tool Kit: 5S-75S Model Pumps**	
ID1204	Tool Kit Includes: ALLEN WRENCH 6mm	
SV0006/ SV0007 SV0008 SV0009 SV0011	SHAFT SPACER 39.3mm SHAFT SPACER 38mm SHAFT SPACER 39mm SHAFT SPACER 41mm SHAFT SPACER 77mm	
SV0231 SV00211 SV00261	SHAFT SPACER 76mm SHAFT SPACER 77.5mm SHAFT SPACER 42.5mm	
SV0049	MOUNTING PLATE 4" & 6" MOTORS	
SV0054 SV0055	BOX/OPEN END WRENCH 19mm BOX/OPEN END WRENCH 13mm	
SV0074 SV0183	BOLT FOR SHAFT M8X65mm BOLT FOR SHAFT M8X110mm	
SV0114 SV0115	SHAFT HEIGHT GAUGE 4" MOTOR SHAFT HEIGHT GAUGE 6" MOTOR	
SV0182	SPLIT CONE NUT WRENCH 5S-25S	
SV0187 SV0217	SPLIT CONE NUT WRENCH 40S SPLIT CONE NUT WRENCH 60S-75S	
SV0226	SHAFT SPACER 43mm (SPLINE SHAFT MODELS)	
SV0280	SHAFT BEARING DRIVER KIT	
SV0288	SPECIAL KEY FOR SLEEVE MODELS	
SV0853	STRAP WRENCH	

* All tools may be purchased separately

96022537	TORQUE WRENCH KIT: 5S - 225S MODEL PUMPS (Kit includes three torque wrenches with fittings, range: 4Nm-200Nm)	

GRUNDFOS®

"Leaders in Pump Technology"

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Motors
4-6-8-10"

CONTENTS

4 Inch (Two Wire) Motors - *Control Box Not Required*

SINGLE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load*	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff. %	Power Factor	Line-to-Line Resistance Black-Yellow	Line-to-Line Resistance Red-Yellow	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
1/3	.25	230	1.75	2.6	4.6	25.7	59	0.77	6.8-8.2		S	900	79952101	96465614
1/2	.37	115	1.60	7.5	12	55	62	0.76	1.1-1.3		R	900	79922102	96465574
		230	1.60	3.8	6	34.5	62	0.76	5.2-6.3		R	900	79952102	96465616
3/4	.55	230	1.50	5.6	8.4	40.5	62	0.75	3.2-3.8		N	900	79952103	96465618
1	.75	230	1.40	7.0	9.8	48.4	63	0.82	2.5-3.1		M	900	79952104	96465620
1 1/2	1.1	230	1.30	10.1	13.1	62	64	0.85	1.9-2.3		L	900	79952105	96465622

4 Inch (Three Wire) Motors

SINGLE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load*	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff. %	Power Factor	Line-to-Line Resistance Black-Yellow	Line-to-Line Resistance Red-Yellow	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
1/3	.25	115	1.75	5.1	9	29	59	0.77	1.55-1.9	2.4-3	M	900	79423101	96465571
		230	1.75	2.6	4.6	14	59	0.77	6.8-8.3	17.3-21.1	L	900	79453101	96465603
1/2	.37	115	1.60	7.5	12	42.5	61	0.76	.9-1.1	1.9-2.35	L	900	79423102	96023039
		230	1.60	3.8	6	21.5	62	0.76	4.7-5.7	15.8-19.6	L	900	79453102	96465606
3/4	.55	230	1.50	5.6	8.4	31.4	62	0.75	3.2-3.9	14-17.2	L	900	79453103	96465608
1	.75	230	1.40	7.0	9.8	37	63	0.82	2.6-3.1	10.3-12.5	K	900	79453104	96465610
1 1/2	1.1	230	1.30	8.9	11.6	45.9	69	0.89	1.9-2.3	7.8-9.6	H	900	79453105	96465612
2	1.5	230	1.25	10.6	13.2	57	72	0.86	1.5-1.8	3.4-4.1	G	1500	79454506	96449947
3	2.2	230	1.15	14.8	17	77	74	0.93	1.2-1.4	2.45-3	F	1500	79454507	96449948
5	3.7	230	1.15	23.9	27.5	110	77	0.92	.65-.85	2.1-2.6	F	1500	79454509	96449949

4 Inch Motors

THREE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load*	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff. %	Power Factor	Line-to-Line Resistance Black-Yellow	Line-to-Line Resistance Red-Yellow	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
1/2	.37	208	1.60	2.2	3.5	24.5	70	0.87	2.24		N	900	79322002	96465633
		230	1.60	2.0	3.15	15.7	69	0.72	8.1		N	900	79302002	96465624
		460	1.60	1.0	1.6	7.85	69	0.72	6.92		N	900	79362002	96465638
3/4	.55	208	1.50	3.4	5.1	24.5	69	0.7	4.6		N	900	79322003	96465634
		230	1.50	3.1	4.6	22.3	69	0.7	5.7		N	900	79302003	96465626
		460	1.50	1.5	2.3	11.2	69	0.7	23.2		N	900	79362003	96465639
1	.75	208	1.40	4.3	6	30	71	0.73	3.72		M	900	79322004	96465635
		230	1.40	3.9	5.4	27	71	0.73	4.7		M	900	79302004	96465627
		460	1.40	1.9	2.7	13.5	71	0.73	19		M	900	79362004	96465650
1 1/2	1.1	208	1.30	6.2	8.1	44.6	75	0.72	2.68		M	900	79322005	96465636
		230	1.30	5.6	7.3	40.3	75	0.72	3.12		M	900	79302005	96465629
		460	1.30	2.8	3.7	20.1	75	0.72	15.9		K	900	79362005	96465651
		575	1.30	2.2	2.9	16.1	75	0.72	25.2		K	900	79392005	–
2	1.5	208	1.25	7.7	9.6	53	77	0.75	1.9		L	900	79322006	96465637
		230	1.25	7.0	8.7	48	76	0.75	3		J	900	79302006	96465630
		460	1.25	3.5	4.4	24	76	0.75	12.1		J	900	79362006	96465652
		575	1.25	2.8	3.5	19.2	76	0.75	18.8		J	900	79392006	–
3	2.2	208	1.00	10.8	10.8	–	89	0.84	2.12		–	1500	79324507	96405806
		208/230	1.15	10.6	12.2	56	77	0.75	2.2		H	1500	79304507	96405801
		460	1.15	5.3	6.1	28	77	0.75	9		H	1500	79354507	96405810
		575	1.15	4.2	4.8	22	77	0.75	13		H	1500	79395507	–
5	3.7	208	1.15	18.1	20.8	–	80	0.82	1.2		–	1500	79324509	96405807
		208/230	1.15	17.2	19.8	108	80	0.82	1.2		H	1500	79304509	96405802
		440/460	1.15	8.6	9.9	54	80	0.82	5		H	1500	79354509	96405811
		575	1.15	6.9	7.9	54	80	0.82	7.3		H	1500	79394509	–
7 1/2	5.5	208/230	1.15	21.7	25	130	81	0.82	0.84		H	1500	79305511	96405805
		440/460	1.15	11.1	12.8	67	81	0.82	3.24		J	1500	79355511	96405814
		575	1.15	9.2	10.6	53	81	0.82	5.2		J	1500	79395511	–
10	7.5	440/460	1.15	15.7	18	90	81	0.80	1.16		H	1500	79355512	96440318
		575	1.15	12.5	14.4	72	81	0.80	1.84		H	1500	79395512	–

*This is a calculated value.

HP	Kw	Voltage	FUSE(5)		Circuit Breaker	NEMA Starter Size	IEC Starter Size	OVERLOADS			
			Fast Acting	Time Delay				Cutler Hammer (1)	Allen Bradley (2)	General Electric (3)	Siemens (4)

4 Inch (Two Wire) Motors - *Control Box Not Required*

SINGLE PHASE

1/3	.25	230	8	5	10	–	–	–	–	–	–
1/2	.37	115	25	15	20	–	–	–	–	–	–
		230	15	7	10	–	–	–	–	–	–
3/4	.55	230	20	10	15	–	–	–	–	–	–
1	.75	230	25	12	20	–	–	–	–	–	–
1 1/2	1.1	230	30	20	25	–	–	–	–	–	–

4 Inch (Three Wire) Motors

SINGLE PHASE

1/3	.25	115	15	9	15	–	–	–	–	–	–
		230	8	5	10	–	–	–	–	–	–
1/2	.37	115	25	15	20	–	–	–	–	–	–
		230	15	7	10	–	–	–	–	–	–
3/4	.55	230	20	10	15	–	–	–	–	–	–
1	.75	230	25	12	20	–	–	–	–	–	–
1 1/2	1.1	230	30	20	25	–	–	–	–	–	–
2	1.5	230	35	20	30	–	–	–	–	–	–
3	2.2	230	45	30	40	–	–	–	–	–	–
5	3.7	230	70	45	60	–	–	–	–	–	–

4 Inch Motors

THREE PHASE

1/2	.37	208	7	4	10	00	A	H2106B-3	J12	255A	K26
		230	6	3	10	00	A	H2106B-3	J11	232A	K24
		460	3	2	10	00	A	104	J4	193A	K21
3/4	.55	208	10	6	10	00	A	108	J17	420A	K32
		230	9	5	10	00	A	107	J16	380A	K29
		460	5	3	10	00	A	105	J8	174A	K21
1	.75	208	15	8	15	00	A	108	J19	510A	K34
		230	15	7	10	00	A	108	J18	463A	K33
		460	6	3	10	00	A	105	J10	232A	K23
1 1/2	1.1	208	20	15	20	00	A	109	J23	750A	K41
		230	20	10	15	00	A	109	J22	680A	K39
		460	9	5	10	00	A	107	J15	343A	K28
		575	7	4	10	00	A	106	J12	255A	K26
2	1.5	208	25	15	20	0	B	110	J25	910A	K43
		230	20	15	20	0	B	109	J24	825A	K43
		460	10	6	10	00	A	108	J17	420A	K32
		575	8	5	10	00	A	107	J15	343A	K28
3	2.2	208	40	25	35	0	C	111	J30	147B	K56
		208/230	35	20	30	0	C	110	J28	122B	K53
		460	20	9	15	0	A	109	J21	618A	K37
		575	15	7	10	0	A	108	J19	510A	K34
5	3.7	208	60	35	45	1	D	112	J34	220B	K61
		208/230	50	30	45	1	D	112	J33	199B	K60
		440/460	30	15	25	0	B	110	J26	100B	K50
		575	25	15	20	0	A	109	J24	825A	K43
7 1/2	5.5	208/230	65	40	60	1	E	112	J36	265B	K64
		440/460	35	20	30	1	C	111	J29	135B	K54
		575	30	20	25	1	B	110	J27	111B	K50
10	7.5	440/460	50	30	40	1	D	112	J32	181B	K60
		575	40	25	35	1	C	111	J30	147B	K56

Notes:

(1) These overloads are for both NEMA and IEC Freedom series starters by EATON Cutler-Hammer. The complete part number is H2_B-3. This information was collected from EATON Cutler-Hammer catalog number CA08102001E.

(2) These overload heater coils are for the Allen Bradley Bulletin 509 Starter. This information was collected from the Allen Bradley catalog number A115-CA001A-EN-P.

(3) These overloads are designed for use with GE NEMA starters. Complete part numbers are CR123L____. For use with GE CR124 single element overloads. This information was collected from page 1-107 of the Control Catalog, Rev. 07/03.

(4) These overloads are designed for Siemens NEMA Overload Relays. This information was collected from page 8/151 of the 2006 Siemens Industrial Control Catalog.

(5) The Fuses and Circuit Breakers were calculated from the NEC table 430.52.

Starters and overloads should always be sized by a licensed electrician that is familiar with local codes and standards. The overloads for submersible motors should be Class 10 Quick trip ambient compensated.

6 Inch (Three Wire) Motors

THREE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE			Eff %	Power Factor	Line-to-Line Resistance		KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
				Calculated Full Load	Service Factor	Locked Rotor			Black-Yellow	Red-Yellow				
7 1/2	5.5	208/230	1.15	23.9/23.9	27.5/27.5	118.3/132	80.5	0.76	0.56		H	1500	78305511	96405781
		440/460	1.15	11.5	13.2/13.2	56.8/59.4	80.5	0.76	2.4		G	1500	78355511	96405794
		575	1.15	9.2	10.6	48	80.5	0.76	4.07		H	1500	78395511	–
10	7.5	208/230	1.15	31.7/30.9	36.5/35.5	153.3/170.4	82.5	0.79	0.41		H	1500	78305512	96405782
		440/460	1.15	15.1/14.8	17.4/17	74.8/78.2	82	0.79	1.8		G	1500	78355512	96405795
		575	1.15	11.8	13.6	63	82	0.79	3.1		G	1500	78395512	–
15	11	208/230	1.15	47/43.9	54/50.5	232.2/252.5	82.5	0.82	0.25		H	7000	78305514	96405783
		440/460	1.15	22.2/21.3	25.5/24.5	109.7/115.2	82.5	0.82	1.16		G	7000	78355514	96405796
		575	1.15	17.0	19.6	92	82.5	0.82	1.9		G	7000	78395514	–
20	15	208/230	1.15	60.9/58.7	70/67.5	329/364.5	84	0.81	0.2		J	7000	78305516	96405784
		440/460	1.15	29.1/28.7	33.5/33	164.2/171.6	84	0.82	0.8		H	7000	78355516	96405797
		575	1.15	23.0	26.4	137	84	0.82	1.32		H	7000	78395516	–
25	18.5	208/230	1.15	76.5/74.3	88/85.5	431.2/470.3	84.5	0.80	0.156		J	7000	78305517	96405785
		440/460	1.15	36.5/35.7	42/41	210/217.3	84.5	0.80	0.62		H	7000	78355517	96405798
		575	1.15	28.7	33	175	84.5	0.80	1.04		H	7000	78395517	–
30	22	208/230	1.15	87.8/84.3	101/97	464.6/514.1	85	0.83	0.13		H	7000	78305518	96405786
		440/460	1.15	41.7/40.4	48/46.5	225.6/237.2	85	0.83	0.55		G	7000	78355518	96405799
		575	1.15	32.2	37	189	84.5	0.83	0.92		G	7000	78395518	–
40	30	440/460	1.15	57.8/55.7	66.5/64	305.9/320	64	0.82	0.39		H	7000	78355520	96405800

*This is a calculated value.

HP	Kw	Voltage	FUSE(5) Fast Acting	FUSE(5) Time Delay	Circuit Breaker	NEMA Starter Size	IEC Starter Size	OVERLOADS Cutler Hammer (1)	OVERLOADS Allen Bradley (2)	OVERLOADS General Electric (3)	OVERLOADS Siemens (4)

6 Inch (Three Wire) Motors

THREE PHASE

7 1/2	5.5	208/230	70	45	60	1	E	113	J36	293B	K64
		440/460	35	20	30	1	C	111	J29	135B	K55
		575	30	18	30	1	B	110	J27	111B	K50
10	7.5	208/230	90	60	80	2	F	114	J39	352B	K70
		440/460	45	30	40	1	D	112	J32	181B	K58
		575	35	20	30	1	C	111	J29	147B	K55
15	11	208/230	150	90	125	2	H	116	J42	593B	K75
		440/460	70	40	60	2	E	113	J35	265B	K63
		575	50	30	50	2	D	112	J33	199B	K60
20	15	208/230	200	110	150	3	J	117	J44	710B	K77
		440/460	90	50	80	2	F	114	J38	352B	K69
		575	70	40	60	2	E	113	J36	265B	K64
25	18.5	208/230	225	150	200	3	K	–	J70	950B	K85
		440/460	110	65	100	2	G	115	J39	464B	K72
		575	90	50	80	2	F	114	J38	352B	K69
30	22	208/230	300	150	225	3	L	–	J71	107C	K87
		440/460	125	75	110	3	H	–	J42	464B	K72
		575	100	55	80	3	G	–	J39	352B	K70
40	30	440/460	175	100	150	3	J	–	J44	710B	K77

Notes:

(1) These overloads are for both NEMA and IEC Freedom series starters by EATON Cutler-Hammer. The complete part number is H2_B-3. This information was collected from EATON Cutler-Hammer catalog number CA08102001E.

(2) These overload heater coils are for the Allen Bradley Bulletin 509 Starter. This information was collected from the Allen Bradley catalog number A115-CA001A-EN-P.

(3) These overloads ae designed for use with GE NEMA starters. Complete part numbers are CR123L____. For use with GE CR124 single element overloads. This information was collected from page 1-107 of the Control Catalog, Rev. 07/03.

(4) These overloads are designed for Siemens NEMA Overload Relays. This information was collected from page 8/151 of the 2006 Siemens Industrial Control Catalog.

(5) The Fuses and Circuit Breakers were calculated from the NEC table 430.52.

Starters and Overloads should always be sized by a licensed electrician that is familiar with local codes and standards. The Overloads for submersible motors should be Class 10 Quick trip ambient compensated.

4 Inch Industrial Motors

THREE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load*	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff %	Power Factor	Line-to-Line Resistance	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
3	2.2	230	1.15	9.9	11.4	–	78	0.81	2.08	J	1500	79305807	96415732
		460	1.15	5.0	5.7	–	78	0.81	8.00	J	1500	79355807	96415734
		575	1.15	4.0	4.55	–	78	0.81	12.00	J	1500	79395807	96415736
5	3.7	230	1.15	15.7	18	–	80.5	0.82	1.12	K	1500	79305809	96415733
		460	1.15	7.9	9.05	–	80.5	0.83	4.20	K	1500	79355809	96415735
		575	1.15	6.5	7.5	–	80.5	0.83	6.40	K	1500	79395809	96415737

6 Inch (Three Wire) Industrial Motors

THREE PHASE

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load*	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff %	Power Factor	Line-to-Line Resistance	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.
7 1/2	5.5	230	1.15	23.9	27.5	457.25	77.5	0.82	0.477	K	4400	78305311	96415738
		460	1.15	12.0	13.8	81.42	78	0.82	1.833	K	4400	78195811	96415744
10	7.5	230	1.15	30.4	35	206.5	81.5	0.86	0.393	J	4400	78305312	96415739
		460	1.15	15.3	17.6	103.84	81.5	0.86	1.493	K	4400	78195812	96415745
15	11	230	1.15	44.3	51	244.8	82.5	0.86	0.27	G	4400	78305314	96415740
		460	1.15	22.2	25.5	122.4	82	0.86	1.067	H	4400	78195814	96415746
20	15	230	1.15	60.4	69.5	403.1	84	0.86	0.17	J	4400	78305316	96415741
		460	1.15	30.0	34.5	200.1	83.5	0.86	0.657	K	4400	96415747	96415747
25	18.5	230	1.15	72.2	83	473.1	84.5	0.86	0.143	J	4400	78305317	96415742
		460	1.15	36.1	41.5	236.55	84.5	0.86	0.553	J	4400	78195817	96415748
30	22	230	1.15	86.5	99.5	557.2	84	0.86	0.116	H	4400	78305318	96415743
		460	1.15	43.5	50	280	84	0.86	0.483	J	4400	78195818	96415749

*This is a calculated value.

			FUSE(5)					OVERLOADS			
HP	Kw	Voltage	Fast Acting	Time Delay	Circuit Breaker	NEMA Starter Size	IEC Starter Size	Cutler Hammer Overload (1)	Allen Bradley (2)	General Electric (3)	Siemens (4)

4 Inch Motors Industrial Motors

THREE PHASE

3	2.2	230	30	17	25	0	C	110	J28	122B	K52
		460	15	9	15	0	C	109	J21	618A	K37
		575	12	7	10	0	A	108	J18	463A	K33
5	3.7	230	50	30	40	1	D	112	J32	181B	K60
		460	25	15	20	1	D	110	J25	910A	K49
		575	20	11	20	0	B	109	J23	750A	K42

6 Inch (Three Wire) Industrial Motors

THREE PHASE

7 1/2	5.5	230	75	45	60	1	E	114	J36	293B	K64
		460	40	25	30	1	C	111	J30	147B	K55
10	7.5	230	100	60	80	2	F	114	J38	352B	K70
		460	50	30	40	1	D	112	J32	181B	K60
15	11	230	140	80	125	2	H	116	J42	520B	K76
		460	65	40	60	2	E	113	J35	265B	K64
20	15	230	200	110	150	3	J	117	J44	710B	K77
		460	90	60	80	2	F	114	J38	352B	K69
25	18.5	230	225	150	200	3	K	117	J46	866B	K83
		460	110	70	90	2	G	115	J40	464B	K72
30	22	230	275	150	225	3	L	-	J71	107C	K87
		460	130	80	125	3	H	-	J41	520B	K75

Notes:

(1) These overloads are for both NEMA and IEC Freedom series starters by EATON Cutler-Hammer. The complete part number is H2_B-3. This information was collected from EATON Cutler-Hammer catalog number CA08102001E.

(2) These overload heater coils are for the Allen Bradley Bulletin 509 Starter. This information was collected from the Allen Bradley catalog number A115-CA001A-EN-P.

(3) These overloads ae designed for use with GE NEMA starters. Complete part numbers are CR123L____. For use with GE CR124 single element overloads. This information was collected from page 1-107 of the Control Catalog, Rev. 07/03.

(4) These overloads are designed for Siemens NEMA Overload Relays. This information was collected from page 8/151 of the 2006 Siemens Industrial Control Catalog.

(5) The Fuses and Circuit Breakers were calculated from the NEC table 430.52.

Starters and Overloads should always be sized by a licensed electrician that is familiar with local codes and standards. The Overloads for submersible motors should be Class 10 Quick trip ambient compensated.

HP	Kw	Voltage	Service Factor	AMPERAGE Full Load	AMPERAGE Service Factor	AMPERAGE Locked Rotor	Eff %	Power Factor	Line-to-Line Resistance	KVA Code	Max. Thrust	Nameplate Number	GRUNDFOS MATERIAL NO.

6 Inch (460V) Motors

THREE PHASE

50	37	460	1.15	68.7	79	470	84	0.83	0.378	G	13000	96476890	96023200

8 Inch (460V) Motors

THREE PHASE

40	30	460	1.15	55.7	64	380	83	0.85	0.35	K	13000	96530180	96023204
50	37	460	1.15	67.8	78	550	84	0.85	0.25	J	13000	96530182	96023205
60	45	460	1.15	80.4	92.5	640	86	0.85	0.18	K	13000	96476891	96023206
75	55	460	1.15	97.4	112	580	86	0.86	0.15	J	13000	96476892	96023207
100	75	460	1.15	130.4	150	570	87	0.86	0.13	J	13000	96476893	96023208
125	92	460	1.15	160.0	184	600	87	0.87	0.09	J	13000	96476894	96023209
150	110	460	1.15	191.3	220	580	86	0.87	0.08	J	13000	96511375	96023210

10 Inch (460V) Motors

THREE PHASE

100	75	460	1.15	133.9	154	570	87	0.84	0.092	J	13000	–	96023211
125	92	460	1.15	165.2	190	550	87	0.83	0.7	J	13000	96540300	96023212
150	110	460	1.15	194.8	224	580	88	0.84	0.055	J	13000	96540301	96023213
175	132	460	1.15	230.4	265	570	88	0.85	0.045	J	13000	96521619	96023214
200	147	460	1.15	265.2	305	620	87	0.82	0.04	K	13000	96540302	96023215
250	190	460	1.15	352.2	405	610	87	0.79	0.033	K	13000	96463669	96023217

*This is a calculated value.

			FUSE					OVERLOADS			
HP	Kw	Voltage	Standard	Time Delay	Circuit Breaker	NEMA Size	IEC Size	Cutler Hammer (1)	Allen Bradley (2)	General Electric (3)	Siemens (4)

6 Inch (460V) Motors

THREE PHASE

50	37	460	225	125	175	3	N	117	J46	866B	K83

8 Inch (460V) Motors

THREE PHASE

40	30	460	175	100	150	3	N	117	J43	710B	K76
50	37	460	225	125	175	3	–	117	J46	866B	K83
60	45	460	250	150	200	4	–	105	J70	950B	K86
75	55	460	300	175	250	4	–	105	J72	107C	K88
100	75	460	400	225	350	4	–	106	J75	155C	K92
125	92	460	500	300	400	5	–	107	J14	100B	K94
150	110	460	600	350	500	5	–	107	J16	111B	K96

10 Inch (460V) Motors

THREE PHASE

100	75	460	400	250	350	4	–	106	J75	155C	K92
125	92	460	500	300	400	5	–	107	J15	100B	K96
150	110	460	600	350	500	5	–	107	J17	122B	–
175	132	460	700	400	600	5	–	108	J18	135B	–
200	147	460	800	500	700	5	–	108	J20	165B	–
250	190	460	1100	600	1000	6	–	107	J14	–	–

Notes:

(1) These overloads are for both NEMA and IEC Freedom series starters by EATON Cutler-Hammer. The complete part number is H2___B-3. This information was collected from EATON Cutler-Hammer catalog number CA08102001E.

(2) These overload heater coils are for the Allen Bradley Bullitin 509 Starter. This information was collected from the Allen Bradley catalog number A115-CA001A-EN-P.

(3) These overloads are designed for use with GE NEMA starters. Complete part numbers are CR123L_ _ _ _. For use with GE CR124 single element overloads. This information was collected from page 1-107 of the Control Catalog Rev. 07/03.

(4) These overloads are designed for Siemens NEMA Overload Relays. This information was collected form page 8/151 of the 2006 Siemens Industrial Control Catalog.

(5) The Fuses and Circuit Breakers were calculated from the NEC table 430.52.

Starters and Overloads should always be sized by a licensed electrician that is familiar with local codes and standards.
The Overloads for submersible motors should be Class 10 Quick trip Ambient compensated.

Generator Sizing

HP	Kw	KVA
1/3	1.5	1.9
1/2	2	2.5
3/4	3	3.8
1	4	4.8
1 1/2	5.9	7
2	7	9
3	10	12
5	15	18.75
7 1/2	25	33
10	35	31.5
15	49	60
20	66	81
25	82	102
30	96	116
40	125	153
50	138	162
60	163	192
75	200	233
100	269	320
125	382	461
150	456	543
175	546	642
200	606	740
250	776	982

Notes:
These values were calculated by using the following formulas:

Single Phase: (3 X FLA)V X PF/1000

Three phase through 100 HP:
(3 X FLA) V X PF X1.73/1000

Three phase 125 and above:
(3.5 X FLA) V X PF X1.73/1000

This is a guide. The generator manufacturer should be asked to assist in sizing all generators.

Transformer Capacity

Required for Three-Phase Motors

Submersible Three- Phase Motor HP Rating	Total Effective KVA Required *	Smallest KVA Rating — Each Transformer: Open WYE or DELTA 2 Transformers	WYE or DELTA 3 Transformers
1.5	3 **	2	1
2	4 **	2	1.5
3	5 **	3	2
5	7.5 **	5	3
7.5	10 **	7.5	5
10	15 **	10	5
15	20 **	15	7.5
20	25	15	10
25	30	20	10
30	40	25	15
40	50	30	20
50	60	35	20
60	75	40	25
75	90	50	30
100	120	65	40
125	150	85	50
150	175	100	60
175	200	115	70
200	230	130	75

* Pump motor KVA requirements only -- does not include allowances for other loads
** This is also the KVA required for single phase motors

Motor Cooling

(refer to page 12 of the Troubleshooting section of this Service Manual)

Total Resistance of Drop Cable

(refer to page 16 of the Troubleshooting section of this Service Manual)

Motor Service to Entrance

SINGLE PHASE 60 HZ

Motor Rating		Copper Wire Size												
VOLTS	**HP**	**14**	**12**	**10**	**8**	**6**	**4**	**2**	**0**	**00**	**000**	**0000**	**250**	**300**
115	1/3	130	210	340	540	840	1300	1960	2910					
	1/2	100	160	250	390	620	960	1460	2160					
230	1/3	550	880	1390	2190	3400	5250	7960						
	1/2	400	650	1020	1610	2510	3880	5880						
	3/4	300	480	760	1200	1870	2890	4370	6470					
	1	250	400	630	990	1540	2380	3610	5360	6520				
	1 1/2	190	310	480	770	1200	1870	2850	4280	5240				
	2	150	250	390	620	970	1530	2360	3620	4480				
	3	120	190	300	470	750	1190	1850	2890	3610				
	5			180	280	450	710	1110	1740	2170				
	7 1/2				200	310	490	750	1140	1410				
	10					250	390	600	930	1160				

THREE PHASE 60 HZ

VOLTS	HP	14	12	10	8	6	4	2	0	00	000	0000	250	300
208	1 1/2	310	500	790	1260									
	2	240	390	610	970	1520								
	3	180	290	470	740	1160	1810							
	5		170	280	440	690	1080	1660						
	7 1/2			200	310	490	770	1180	1770					
	10				230	370	570	880	1330	1640				
	15					250	390	600	910	1110	1340			
	20						300	460	700	860	1050	1270		
	25							370	570	700	840	1030	1170	
	30							310	470	580	700	850	970	1110
230	1 1/2	360	580	920	1450									
	2	280	450	700	1110	1740								
	3	210	340	540	860	1340	2080							
	5		200	320	510	800	1240	1900						
	7 1/2			230	360	570	890	1350	2030					
	10				270	420	660	1010	1520	1870				
	15					290	450	690	1040	1280	1540			
	20						350	530	810	990	1200	1450		
	25						280	430	650	800	970	1170	1340	
	30							350	540	660	800	970	1110	1270
460	1 1/2	1700												
	2	1300	2070											
	3	1000	1600	2520										
	5	590	950	1500	2360									
	7 1/2	420	680	1070	1690	2640								
	10	310	500	790	1250	1960	3050							
	15			540	850	1340	2090	3200						
	20			410	650	1030	1610	2470	3730					
	25				530	830	1300	1990	3010	3700				
	30				430	680	1070	1640	2490	3060	3700			
	40						790	1210	1830	2250	2710	3290		
	50						640	980	1480	1810	2190	2650	3010	
	60							830	1250	1540	1850	2240	2540	2890
	75								1030	1260	1520	1850	2100	2400
	100									940	1130	1380	1560	1790
	125											1080	1220	1390
	150												1050	1190
	200												1080	1300
	250													1080
575	1 1/2	2620												
	2	2030												
	3	1580	2530											
	5	920	1480	2330										
	7 1/2	660	1060	1680	2650									
	10	490	780	1240	1950									
	15		530	850	1340	2090								
	20			650	1030	1610	2520							
	25			520	830	1300	2030	3110						
	30				680	1070	1670	2560	3880					
	40					790	1240	1900	2860	3510				
	50						1000	1540	2310	2840	3420			
	60						850	1300	1960	2400	2890	3500		
	75							1060	1600	1970	2380	2890	3290	
	100								1190	1460	1770	2150	2440	2790

FOOTNOTES:

1. If aluminum conductor is used, multiply lengths by 0.5. Maximum allowable length of aluminum is considerably shorter than copper wire of same size.
2. The portion of the total cable which is between the service entrance and a 3Ø motor starter should not exceed 25% of the total maximum length to assure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.
3. Cables #14 to #0000 are AWG sizes, and 250 to 300 are MCM sizes.

Please Note:

For Franklin motor specifications, refer to Franklin's Submersible Motor Application • Installation • Maintenance • Manual

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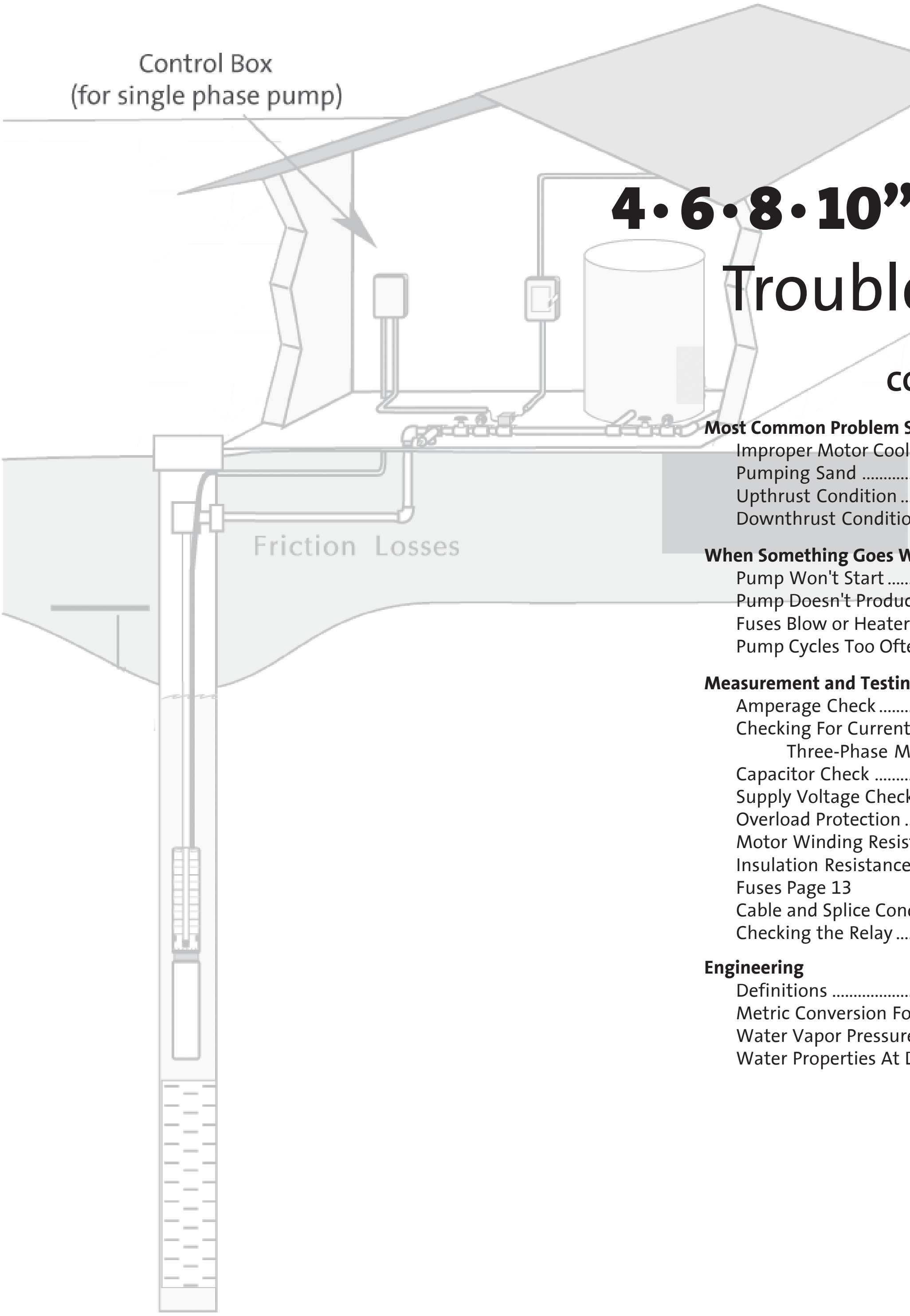


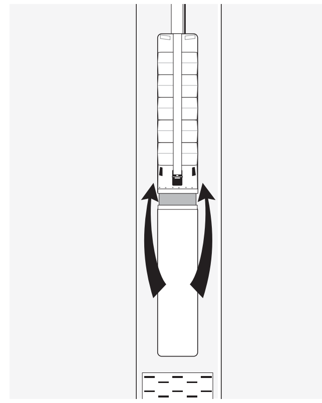
4·6·8·10" Submersibles
Troubleshooting

CONTENTS

Most Common Problem Situations

Poor Motor Cooling*

A submersible pump motor is cooled by the flow of water past its outer housing as the pump is pumping. The water must flow past the motor at a certain velocity for proper cooling to take place, and the minimum velocity needed is different for each diameter motor.



Correct screen position for proper cooling

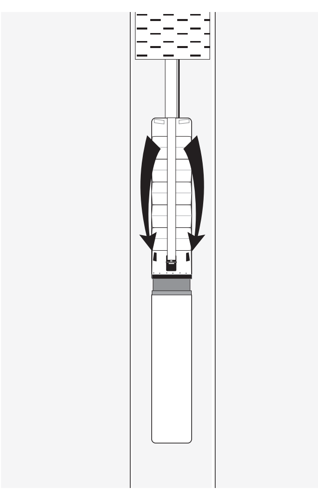
MINIMUM VELOCITY OF WATER PAST MOTOR*

4" diameter motor	.25 feet per second
6" diameter motor	.5 feet per second
8" diameter motor	.5 feet per second
10" diameter motor	.5 feet per second

To determine whether water is flowing past the motor at a high enough velocity, note where the motor diameter and outside sleeve or casing diameter intersect on the following chart. The Gallons Per Minute scale indicates the **minimum flow required** to keep the motor properly cooled.

MINIMUM FLOW REQUIREMENTS FOR SUBMERSIBLE MOTORS*

WELL CASING OR FLOW INDUCER SLEEVE (internal diameter in inches)	4" motor	6" motor	8" motor	10" motor	MOTOR DIAMETER
4 inches	1.2 GPM	--	--	--	**MINIMUM FLOW (GPM)** (to ensure proper motor cooling)
5	7	--	--	--	
6	13	10	--	--	
7	21	28	--	--	
8	30	45	10	--	
10	--	85	55	30	
12	--	140	110	85	
14	--	198	180	145	
16	--	275	255	220	
18	--	--	--	305	



Cascading water from screen does not flow past motor

Insufficient cooling can sometimes result when:

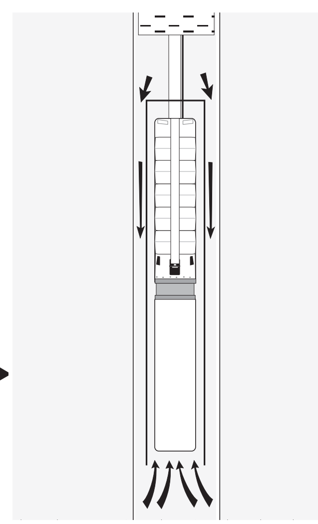
(1) The screen is located above or at the pump, so that the water cascades down into the pump's suction intake without first flowing past the motor.

(2) The casing diameter is so large that the water is drawn into the pump's suction intake from the side without first flowing past the motor.

These problems can be solved by fitting the pump and motor into a **Flow Inducer Sleeve.** This sleeve attaches to the pump and forces water to pass around it and enter the pump's suction intake from below the motor.

If the diameter of the well's casing is too small for a sleeve inducer, a rigid tube (usually 1/4" inside diameter) can be tapped into the discharge piping above the pump (but below any check valves) with the other end positioned below the motor and pointing upwards.

***Grundfos motors have a more effective internal cooling design; therefore, a cooling sleeve is not required in water up to 30° C (86° F). However, all motors will have a longer life with a cooling sleeve installed.**

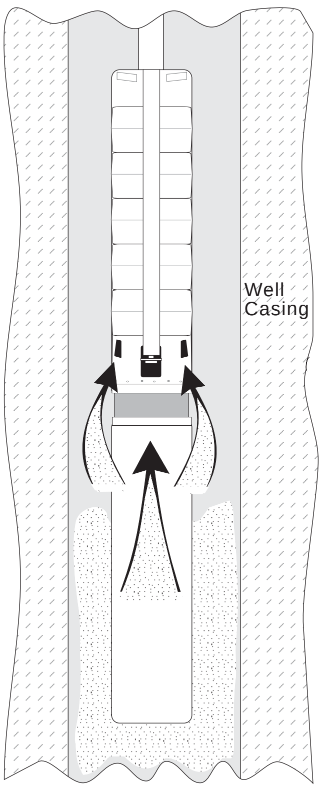
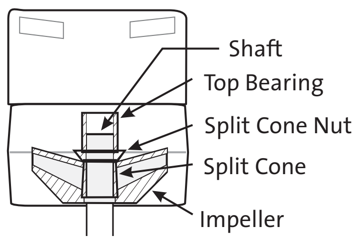


Flow Inducer Sleeve forces water past motor

Pumping Sand

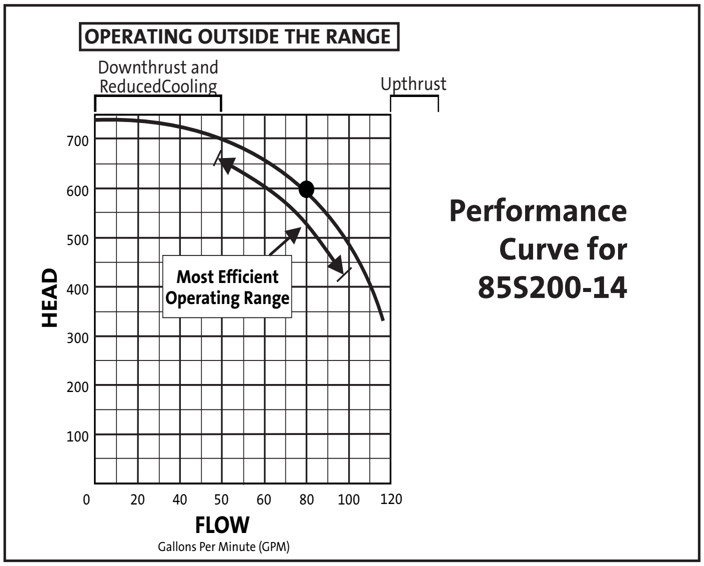
All submersible water pumps are designed with the idea they will be used to pump clean, clear water. Some design changes can be made to enable them to better handle situations that don't meet this ideal, but only to a limited degree.

No situation shortens the life of submersible pump more than pumping silt or **SAND**.

Effect On Pump	Will Be First Noticed By...	Design Changes To Deal With The Problem
SAND works its way into all moving parts of the pump, grinding bearings, impellers, and all other components as they spin against each other.  	Reduced flow (GPM) and head, since the perfect fit of the impellers and other components will be slowly worn away and the pump will become less and less efficient.  At some point, the pump's performance will become so poor it becomes quite apparent that something is seriously wrong. If the pump is pulled out of the well and the impellers and other moving components are examined, **uniform** wear (not random pitting, which might indicate that pump may have been cavitating) can be seen on virtually every moving part.	There is no way to eliminate all pump damage due to pumping sand. The effects can only be minimized. Since sand tends to be carried along with flow rates greater than 5-8 feet per second (water velocity), an enlarged drop pipe can reduce the water velocity and thereby reduce the chance sand can enter the pump. Of course, if the water velocity drops below the chart on the previous page, motor cooling may become a problem.

Upthrust Condition

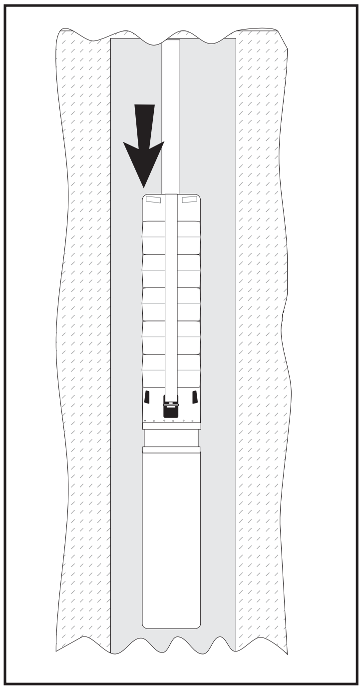
Pumps are designed with the expectation that the correct size pump will be used in the right situation. An 80 gallon per minute pump which can produce about 600 feet of head (at the same time it delivers 80 GPM) is designed so that if it is used in this situation, the pump will operate at its best efficiency **and** all its components will have a long life. The perfomance curve to the right shows the most efficient operating range for this type of pump.



If the pump is not operated within this range, problems can occur.

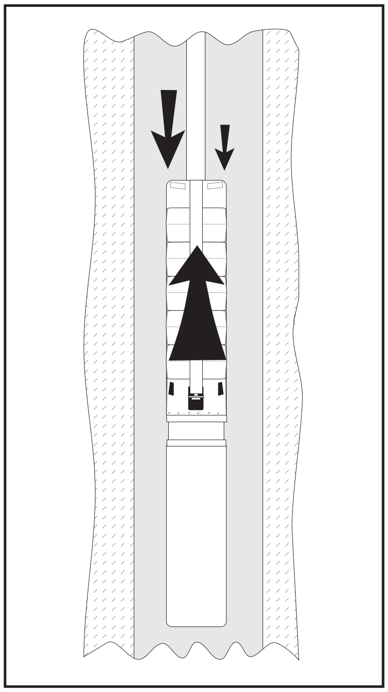
One such problem can occur when a pump is installed and run in a situation in which it will produce far GREATER flow (GPM) than it was designed for. **In other words, the pump is oversized for what is really needed.** When such a pump is started, the initial thrust (upward water surge) generated by the spinning impellers is so much GREATER than the downward thrust it is expecting to overcome (such as the force of the different water pressure, the weight of the impellers and shaft, etc.), that the entire stack of impellers within the pump is lifted upwards **(UPTHRUST).** Pumps are manufactured with bearings designed to handle intermittent upward water surges up to a certain degree. If the actual flow is much greater than this, an upthrust condition exists. The force of this **UPTHRUST** will first put pressure on the motor's thrust bearing. If and when this bearing wears out, the pump's components will begin to absorb the upthrust as they grind against each other. Upthrust is especially damaging when the pump is started and the drop pipe is empty -- causing a great upthrust of water since no head is present. Check valves in the drop pipe will prevent this from occuring.

BEFORE
pump starts pumping



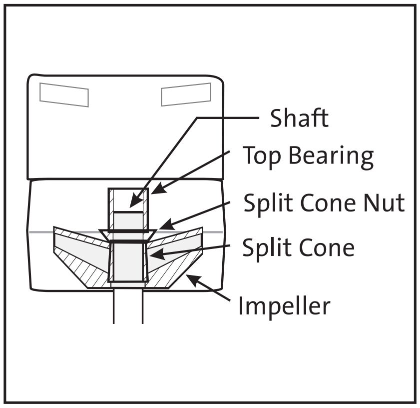
Weight of water and impellers pushes down

AFTER
pump starts pumping



Initial surge of water thrusts impellers upwards

DAMAGE CAUSED



Once the motor's thrust bearing is worn, the pump components begin wearing

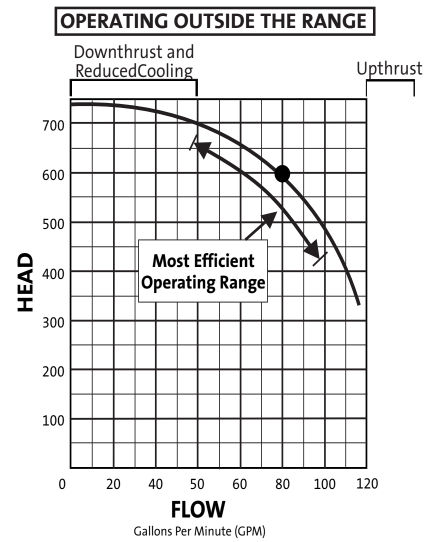
Usually, the **UPTHRUST** condition lasts for only a few seconds until the water pressure above the impellers acts as a counterforce to press the impeller stack down onto the motor shaft. Sometimes, however, if the pump is producing far more flow than for which it was designed, the upthrust condition can continue until the pump is stopped.

Downthrust Condition

Pumps are designed with the expectation that the correct size pump will be used in the right situation. An 80 gallon per minute pump which can produce about 600 feet of head (at the same time it delivers 80 GPM) is designed so that if it is used in this situation, the pump will operate at its best efficiency **and** all its components will have a long life. The perfomance curve at right shows the most efficient operating range for this type of pump.

If the pump is not operated in this range, problems can occur.

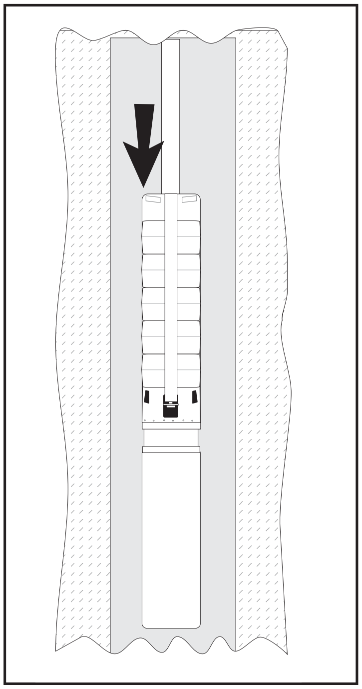
One such problem can occur when a pump is installed and run in a situation in which it will produce HEAD in the range of shut-off pressure (left part of the curve, as shown above). Although the pump is designed to operate over the full curve, if it does not produce enough flow the weight of the shaft and the pressure of the water in the drop pipe is not counterbalanced, causing possible wear to the bearings in the pump and motor. **This can occur if a valve has been closed down so far that the flow is greatly restricted or when the pump is pumping water faster than the well can refill itself.**



Performance Curve for 85S200-14

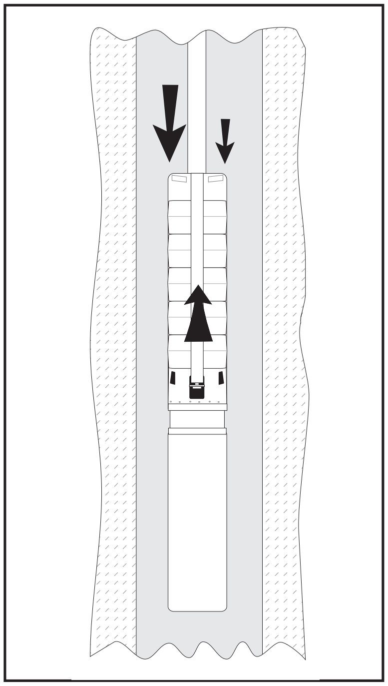
In addition to causing possible bearing damage, operating the pump in a downthrust condition is an inefficient use of energy and may not allow for proper motor cooling (see page 2).

BEFORE
pump starts pumping



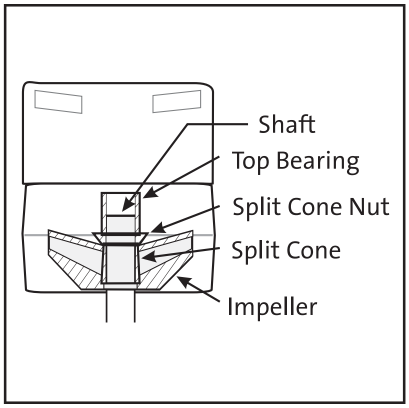
Weight of water and impellers pushes down

AFTER
pump starts pumping



Impellers can produce so much pressure they can grind down against each other

DAMAGE CAUSED



After motor's thrust bearing has worn out, pump components begin to show equal wear from grinding

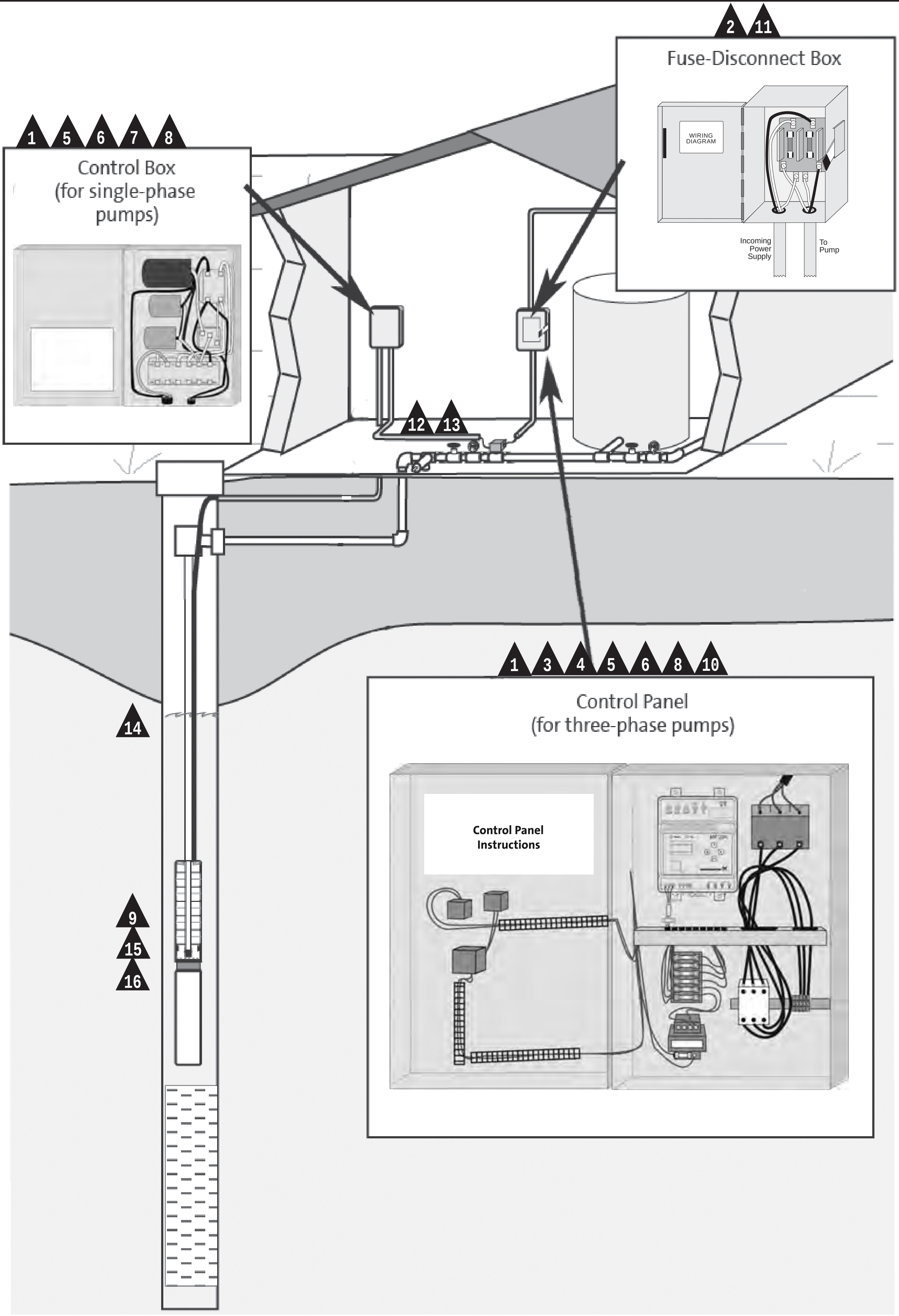
The best way to check for motor bearing damage is with a shaft height gauge. Refer to the Dismantling & Reassembly section of this manual for complete instructions.

Pump Won't Start

Possible Cause	Check This By . . .	Correct This By . . .	
Low or no power at the motor	Check for voltage at the control box or panel. See page 11 for instructions.	If there is no voltage at the control panel, check the feeder panel for tripped circuits and reset those circuits.	1
Fuses are blown or the circuit breakers have tripped.	Turn off the power and remove the fuses. Check for continuity with an ohmmeter as shown on page 13.	Replace the blown fuses or reset the circuit breaker. If the new fuses blow or the circuit breaker trips, the electrical installation, motor, and wires must be checked for defects.	2
(3-phase motors only) **Motor starter overloads are burned or have tripped**	Check for voltage on the line and load side of the starter. Check the amp draw and make sure the heater is sized correctly.	Replace any burned heaters or reset. Inspect the starter for other damage. If the breaker trips again, check the supply voltage. Ensure that heaters are sized correctly and the trip setting is appropriately adjusted.	3
(3-phase motors only) **Starter does not energize**	Energize the control circuit and check for voltage at the holding coil.	If there is no voltage, check the control circuit fuses. If there is voltage, check the holding coil for weak connections. Ensure that the holding coil is designed to operate with the available control voltage. Replace the coil if defects are found.	4
Defective controls	Check all safety and pressure switches for defects. Inspect the contacts in control devices.	Replace worn or defective parts or controls.	5
Motor or cable is defective	Turn off the power and disconnect the motor leads from the control box. Measure the lead-to-lead resistance of the drop cable with an ohmmeter (set to R x 1). Measure the lead-to-ground values with a megohmmeter (set to R x 100K). See pages 12 and 13. Compare these measurements to the rated values for your motor.	If an open or grounded winding is found, pull the pump from the well and recheck the measurements with the lead separated from the motor. Repair or replace the motor or cable.	6
(1-phase motors only) **Defective capacitor**	Turn off the power and discharge the capacitor by shorting the leads together. Check it with an analog ohmmeter (set to R x 100K). See page 11 or use an audible capacitor tester.	When the meter is connected to the capacitor, the needle should jump toward 0 (zero) ohms and slowly drift back to infinity (∞). Replace the capacitor if it is defective.	7
Defective pressure switch or the tubing to it is plugged.	Watch the pressure gauges as the pressure switch operates. Remove the tubing and blow through it.	Replace as neccessary.	8
The pump is mechanically bound or stuck	Turn off the power, pull the pump, and manually rotate the pump shaft. Also check the motor shaft rotation, the shaft height, and the motor's amp draw (to see if it indicates a locked rotor).	If the pump shaft doesn't rotate, remove the pump and examine it. If necessary, dismantle it and check the impellers for obstruction. Check for motor corrosion.	9

Pump Does Not Produce Enough Flow (GPM)

Possible Cause	Check This By . . .	Correct This By . . .	
Shaft is turning in the wrong direction.	Check to make sure the electrical connections in the control panel are correct.	Turn off the power. Correct the wiring. For single phase motors, check the wiring diagram on the motor. For three phase motors, simply switch any two power leads.	10
Pump is operating at the wrong speed (too slow)	Check for low voltage (as shown on page 11) and phase imbalance (as shown on page 10)	Replace defective parts or contact power company, as applicable.	11
Check valve is stuck (or installed backwards)	Pull the pump and reove the check valve.	Re-install or replace.	12
Parts in the pump are worn **or** **Impellers, Inlet Strainer, or Well Screen is clogged**	Install a pressure gauge, start the pump, and gradually close the discharge valve. Read the pressure at shutoff. (Do not allow the pump to operate for an extended period at shutoff).	Convert the PSI you read on the gauge to Feet of Head by: **PSI x 2.31 ft** Add to this number the number of feet (vertically) from the gauge down to the water's pumping level. Refer to the pump curve for the model you are working with to determine the shutoff head expected for that model. If those figures and yours do not match, remove the pump and inspect impellers, chambers, etc., for clogging.	13
The water level in the well may be too low to supply the flow desired **or** **Collapsed well**	Using a depth gauge, check the drawdown in the well while the pump is operating.	If the pumping water level (including drawdown) is not **AT LEAST 3 FEET** above the pump's inlet strainer, either: 1. Lower the pump further down the well. 2. Throttle back the discharge valve to decrease the flow, thereby reducing drawdown.	14
Broken shaft or coupling	Pull pump and inspect	Replace as necessary.	15
There are leaks in the fittings or piping	Pull the pump out of the well.	The suction pipe, valves, and fittings must be made tight. Repair any leaks and retighten all loose fittings.	16



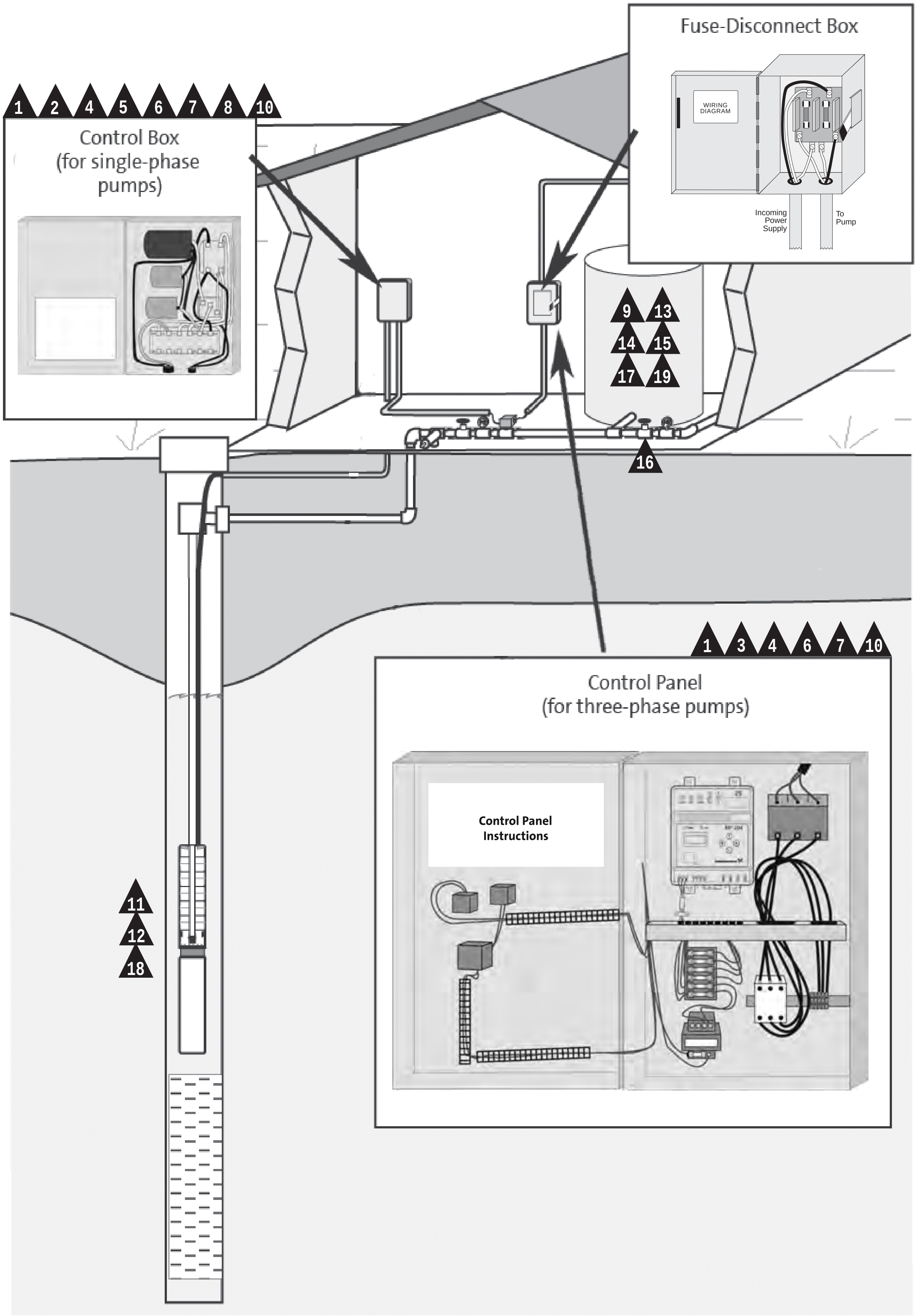
2
11
Fuse-Disconnect Box
WIRING DIAGRAM
Incoming Power Supply
To Pump
1
5
6
7
8
Control Box (for single-phase pumps)
12
13
14
1
3
4
5
6
8
10
Control Panel (for three-phase pumps)
Control Panel Instructions
9
15
16

Fuses Blow or Heaters Trip

Possible Cause	Check This By . . .	Correct This By . . .	
Improper voltage	Check the voltage at the control box or panel. See page 11 for instructions. If the incoming voltage is + or -10%, check the wire size and then measure the distance between the pump motor and the pump control panel.	If voltage varies by more than 10% (+ or -), contact the power company. Rewire with correct gauge. Undersized wire and a great distance between the control panel and the pump motor increases resistance and decreases the voltage by the time it reaches the pump motor.	1
The starter overload is set too low.	Cycle the pump and measure the amperage. See page 10 for instructions.	Increase the heater size (use a slo-bio) or adjust the trip setting. Do not, however, exceed the recommended rating.	2
(3-phase motors only) **Current is imbalanced.**	Check the current draw on each lead to the motor. See page 11 for instructions.	The current imbalance must be within 5% of each other. If they are not, check the wiring and the power supply.	3
The wiring or connections are faulty.	Check to make sure the wiring is correct and there are no loose terminals.	Tighten any loose terminals and replace any damaged wire.	4
(1-phase motors only) **Capacitor is defective**	Turn off the power and discharge the capacitor. Check start and run capacitors with an ohmmeter (set at R x 100K). See page 11 for instructions.	When the meter is connected to the capacitor, the needle should jump towards 0 (zero) ohms and then slowly drift back to infinity (∞). Replace the capacitor if it is defective.	5
Fuse, heater, or starter are the wrong size	Check the fuses and heaters against the motor manufacturer's specification charts.	Replace as necessary.	6
The control box location is too hot	Touch the box with your bare hand during the hottest part of the day -- you should be able to keep your hand on it without burning.	Shade, ventilate, or move the control box so its environment does not exceed 120°F.	7
(1-phase motors only) **Wrong control box**	Check requirements for the motor against the control box specifications.	Replace as necessary.	8
Defective pressure switch	Watch gauges as pressure switch operates.	Replace as necessary.	9
The motor is shorted or grounded.	Turn off the power and disconnect the wiring. Measure the lead-to-lead resistance with an ohmmeter (set to R x1). Measure the lead-to-ground resistance (set to R x100K). Compare these measurements to the rated values for your motor.	If you find an open or grounded winding, remove the motor and recheck the leads. If OK, check the leads for continuity and for bad splice.	10
Poor motor cooling	Find the internal diameter of the well casing (or sleeve, if used) on the chart on page 2 and check for proper cooling.	Increase the pump flow (GPM) so proper cooling is possible (see chart on page 2) or pull the pump out of the well and add a sleeve with a smaller internal diameter *(see chart on page 2).*	11
Bad motor thrust bearing	Measure for high amps as explained on page 10.	If amps are too high, pull the pump and replace the motor.	

Pump Cycles Too Often

Possible Cause	Check This By . . .	Correct This By . . .	
The pressure switch is defective or is not properly adjusted.	Check the pressure setting on the switch. Check the voltage across closed contacts.	Adjust the pressure switch with a screwdriver or replace it if defective.	13
The tank is too small	Check the tank size and amount of air in the tank. The tank size should be about 10 gallons for each GPM needed (16 GPM = 160 gal.). At the pump cut-in pressure, the tank should be about 2/3 filled with air.	Replace the tank with one that is the correct size.	14
There is insufficient air charging of the tank or piping is leaking.	Pump air into the tank or diaphragm chamber. Check the diaphragm for leaks. Check the tank and piping for leaks with soapy water. Check the air-to-water ratio in the tank.	Repair as necessary.	15
Plugged snifter valve or bleed orifice (causing pressure tank to be water-logged)	Examine them for dirt or erosion.	Repair or replace as necessary.	16
Leak in the pressure tank or piping.	Check the setting and operation of the level control.	Readjust the level control setting (according to the manufacturer's instructions) or replace it if defective.	17
The level control is defective or is not properly set.	Check the yield of the well (determined by the well-test) against the pump's performance curve.	Reduce the flow by throttling back the valve. or Change the pump.	18
Pump is oversized for the application. It is outpumping the yield of the well and pumping itself dry.	Refer to the tank's operating and installation instructions and make sure it is installed correctly.	Repair or replace as needed.	19

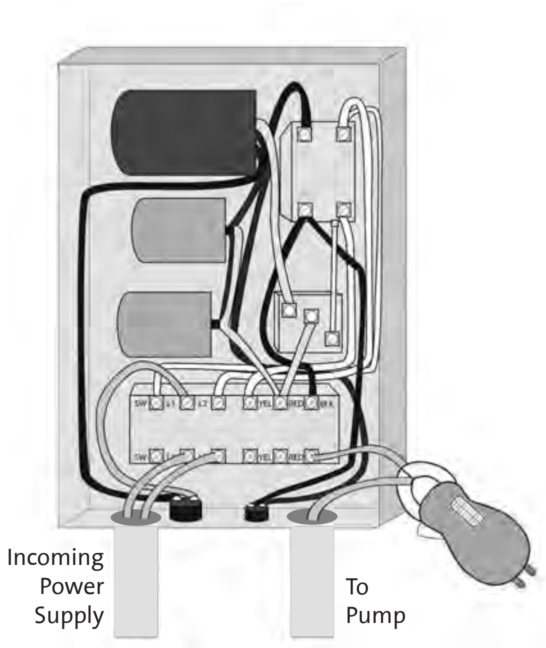

Fuse-Disconnect Box
WIRING DIAGRAM
Incoming Power Supply
To Pump
1 2 4 5 6 7 8 10
Control Box
(for single-phase pumps)
9 13
14 15
17 19
16
1 3 4 6 7 10
Control Panel
(for three-phase pumps)
Control Panel Instructions
11
12
18

Amperage Check

To check the electrical current (measured in amperes, or "amps") use an ammeter.

Instructions

1. Make sure the pump is running
2. Set the rotary scale on the front of the ammeter to the highest scale.
3. Open the control box and place the jaws of the ammeter around the wire to be measured.
4. Slowly rotate the scale on the ammeter back towards 0 (zero) until an exact reading is shown.
5. Record the measurement
6. Repeat for the other wires.



Evaluation

If the amp draw exceeds the service factor amps for the pump (as listed in the Motors section of the Service Manual), then:

- The motor starter may have burned contacts
- The terminals in the starter or terminal box may be loose
- There may be a winding defect. Check the winding and insulation resistance (see pages 12 and 13)
- The motor windings may be shorted or grounded
- The pump may be damaged in some way and may be causing a motor overload.
- A voltage supply or current imbalance (3-phase only) may exist. Follow the steps below to determine if this is true.
- The insulation on the drop cable may be torn, exposing the cable.

Current Imbalance On Three-Phase Motors

If the motor is connected to three-phase power, the balance of those three phases can be checked in the following way:

1. Measure the amperage of each wire as instructed above and record these figures.
2. Add together the total amperage measured by the three wires.
3. Divide this number by three to get the **average** amperage reading for the three wires.
4. Check over your numbers and determine which wire has the greatest difference from the average.
5. Take that number and subtract it from the average to determine the amount of **difference**.
6. Divide the **difference** by the **average**.
7. Multiply this number by 100 to obtain the percent of current imbalance for that particular hookup.
8. Turn **POWER OFF**
9. Repeat these steps for the other two possible hookup installations so that each motor lead is connected to a different power lead than it was before.

	Hookup 1	**Hookup 2**	**Hookup 3**
Incoming power leads	L1 L2 L3	L1 L2 L3	L1 L2 L3
Motor leads	A B C	C A B	B C A

(where A, B, and C represent each motor lead or each set of leads joined together to make a single motor lead)

Example:

A	=	51 amps	C	=	50 amps	B	=	50 amps
B	=	46 amps	A	=	49 amps	C	=	48 amps
C	=	53 amps	B	=	51 amps	A	=	52 amps
Total	=	150	Total	=	150	Total	=	150
150/3	=	50	150/3	=	50	150/3	=	50
- 46	=	4	- 49	=	1	- 48	=	2
4/50	=	.08 or 8 %	1/50	=	.02 or 2 %	2/50	=	.04 or 4 %

Evaluation

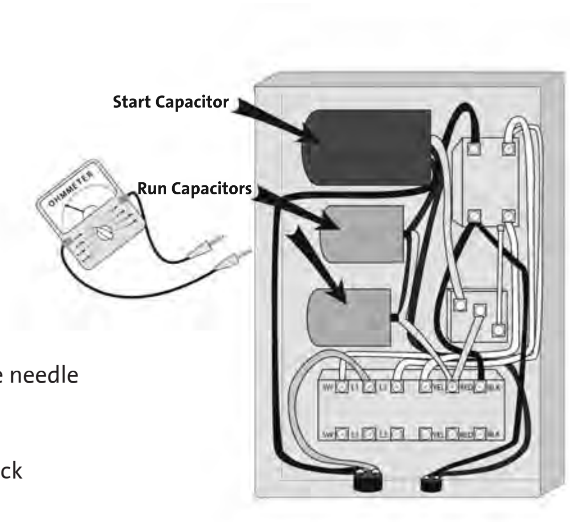
If the the current imbalance is greater than 5% on all three hookups, then:

- If the largest difference in amps is consistently drawn from the same power lead (L1, L2, or L3 above), contact the power company. Your voltage should be balanced to within + or - 5%.
- If the largest difference in amps is consistently drawn from the same motor lead (A, B, or C above), there is likely a problem with the motor. Check the items listed under "Evaluation" near the top of this page.

If the current imbalance exceeds 5% one or two of the legs, use the hookup that has the least difference and check the motor for some of the other problems listed under "Evaluation" near the top of this page.

Capacitor Check

To check the condition of any capacitor on single phase motors, use an ohmmeter.

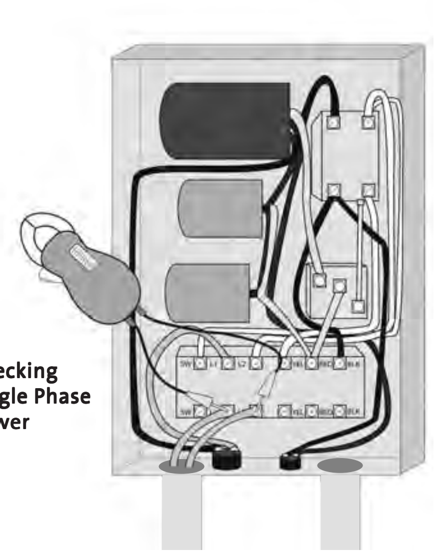


Instructions:
1. Turn the **POWER OFF**.
2. Disconnect the capacitor from the power source.
3. Discharge the capacitor by touching its leads together.
4. Set the scale selector on the ohmmeter to R x 100K.
5. Connect the leads of the ohmmeter to the black and orange wires of the capacitor.
6. Watch the ohmmeter scale.
7. Disconnect one lead from the capacitor for approximately 30 seconds. The needle should return to the last reading taken.

Evaluation
If the capacitor is OK, the needle should swing towards zero and then float back towards infinity (∞). If the needle drops and remains at zero, the capacitor is probably shorted. If the needle remains at a high value, there is an open circuit.
CAUTION: This test may indicate a good capacitor even though it may have lost some capacitance, making the motors run noisy or draw high amps. To safeguard against this, the capacitor can be checked with a capacitor meter.

Supply Voltage Check

To check the supply voltage, use a voltmeter (or amprobe) with the power on.



Checking Single Phase Power

Instructions
1. Set the voltmeter to the highest scale
2. Remove the cover of the control box...BE CAREFUL -- POWER IS STILL BEING SUPPLIED TO THE CIRCUIT. Do not touch the voltmeter leads together while they are in contact with the power lines.
3. Touch the ends of the voltmeter leads as follows:

<u>Single Phase Motors</u>
Touch one voltmeter lead to each of the lines supplying power to the control (L_1 and L_2 , or L_1 and N for 115V circuits). →

<u>Three Phase Motors</u>
Touch a voltmeter lead to the following:

- Power leads L_1 and L_2
- Power leads L_2 and L_3
- Power leads L_3 and L_1
- Two fuses
- Two contact points
- Two heaters

These tests should give a reading of full line voltage.

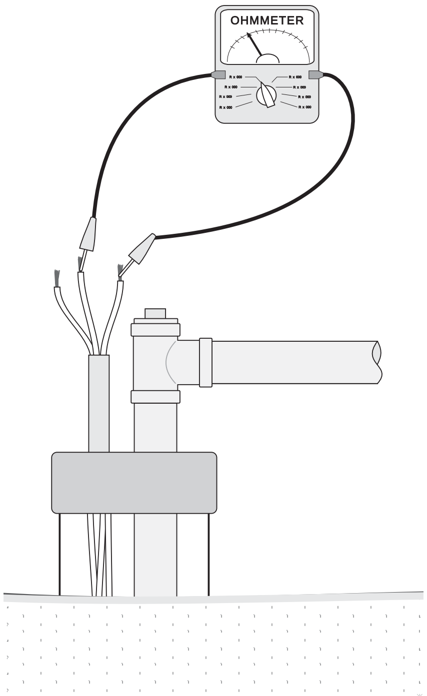
Evaluation
When the motor is under load, the voltage should be -10% and +6% of the nameplate voltage. Any variation larger than this can cause damage to the motor windings and should be noticeable as a high amp problem.

If The Motor Nameplate Reads . . .		Then the minimum and maximum voltage should be . . .	
		Minimum	**Maximum**
115V	(single phase)	105 volts	121 volts
208V	(single or three phase)	188 "	220 "
230V	" "	210 "	243 "
460V	(three phase)	414 "	487 "
575V	" "	518 "	609 "

Any variations larger than these may indicate a poor electrical supply. The motor should not be operated under these conditions. Contact your power supplier to correct the problem or change the motor to one requiring the voltage you are receiving.

Motor Winding Resistance (lead-to-lead)

To check the electrical condition of the drop cable, splice, and motor windings, a resistance check with an ohmmeter is required.



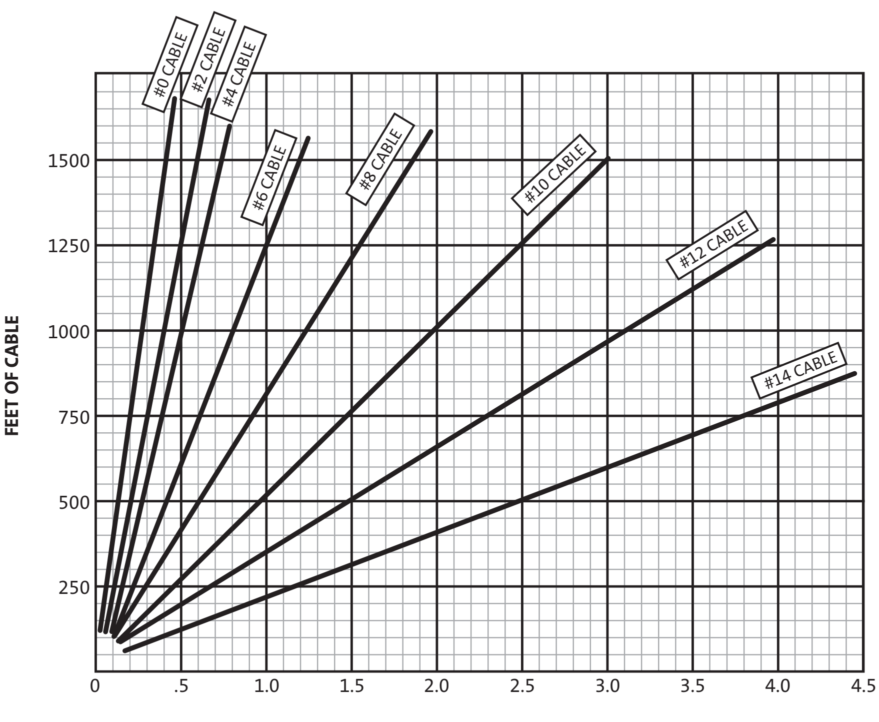
Instructions:

1. Turn the **POWER OFF**.
2. Disconnect all electrical leads to the drop cable.
3. Set the scale selector on the ohmmeter to R x 1 (if you expect ohm values under 10) or R x 10 (for ohm values over 10).
4. Touch the leads of the ohmmeter to two motor leads:
   Single Phase Motors
   Touching the leads of the ohmmeter to the black and yellow leads will measure the main winding's resistance for Franklin and Grundfos 402 motors. The red and yellow leads will be the start winding's resistance.
   Three Phase Motors
   Touching the leads of the ohmmeter to any two black leads will measure that winding's resistance. Repeat for all three possible lead combinations.
5. Watch the ohmmeter scale and record this figure. Subtract the ohm resistance for the drop cable (chart below) from the number. Compare the remaining figure with the one shown in the Motors section of this manual.

If:	Then:
Ohm values are normal	Motor windings are okay
One ohm value is less than normal	That motor winding may be starting to short
One ohm value is greater than normal	That winding may be starting to open
Some ohm values are greater than normal (>25%) and some are less than normal (± 25%)	The leads may be connected incorrectly, or have a break in the insulating jacket

If ohm readings are not normal and you want to verify the problem is not with the splice or drop cable, remove the lead from the motor and check the resistances from pin to pin directly at the motor. If the motor checks out okay, the fault is in the lead or splice (see page 14).

Total Resistance of Drop Cable *(from control box to motor and back)*

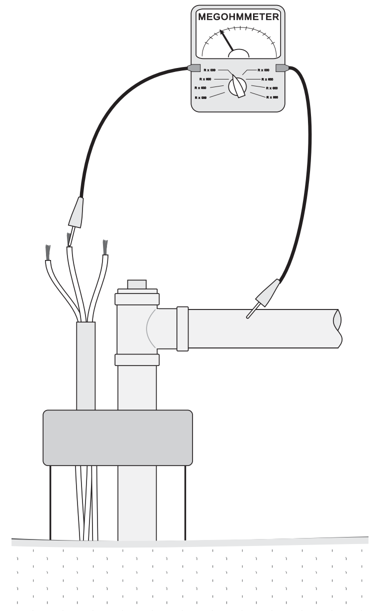


The values shown are for copper conductors. If aluminum conductor drop cable is used, the resistance will be higher for each foot of cable of the same size.

Copper ÷ .61 = Aluminum

Insulation Resistance (lead-to-ground)

To check the insulation resistance of the drop cable, splice, and motor leads, a megohmmeter is required.



Instructions:

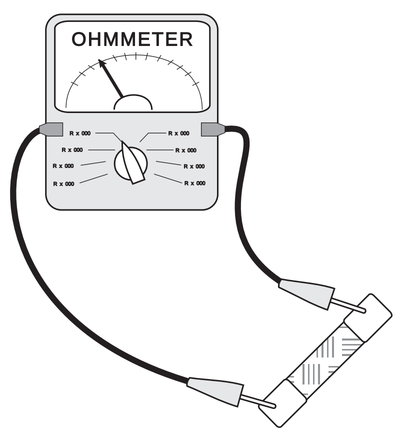
1. Turn the **POWER OFF**.
2. Disconnect all electrical leads to the drop cable.
3. Set the scale selector on the megohmmeter to R x 100, touch its leads together, and adjust the indicator to zero.
4. Touch the leads of the megohmmeter to each of the motor leads and to ground (i.e. L_1 to ground; L_2 to ground, etc.). The well casing, if made of steel, makes an excellent ground.
5. Watch the megohmmeter scale and compare this figure with the chart below.

Evaluation: In general, any ohm value above 1,000,000 ohms indicates everything is OK. The following table gives more specifics.

OHM VALUE	MEGAohm VALUE	THIS INDICATES THAT ...
		If The Motor HAS NOT Yet Been Installed:
2,000,000 (or more)	2.0	It is a new motor
1,000,000 (or more)	1.0	It is a used motor than can be used again (insulation OK)
		If The Motor HAS Been Installed: *(means that ohm readings will be for the drop cable plus the motor)*
500,000 - 1,000,000	0.5 - 1.0	The motor is in reasonably good condition
20,000 - 500,000	.02 - 0.5	The motor may have been damaged by lightning or has damaged leads.
10,000 - 20,000	.01 - .02	The motor has certainly been damaged or has damaged leads. The pump should be pulled and repairs made to the motor leads or replace the motor completely. The motor may still operate, but probably not for long.
less than 10,000	0 - .01	The motor has failed or the motor lead insulation has been completely destroyed. The pump must be pulled and the motor lead (drop cable) repaired or the entire motor replaced. **The motor will not run in this condition.**

Fuses

To check the condition of electrical fuses, an ohmmeter is required.



Instructions:

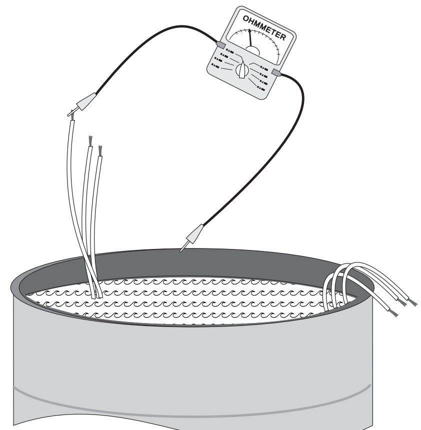
1. Turn the **POWER OFF** at the main disconnect or power source.
2. Remove the fuse.
3. Set the scale selector on the ohmmeter to R x 1.
4. Touch each lead of the ohmmeter to one end of the fuse.

Evaluation:

A good fuse should have zero (0) ohm reading. If the ohm value is near or past infinity, the fuse must be replaced.

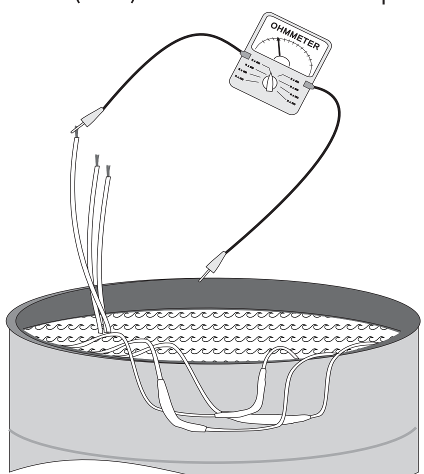
Cable and Splice Condition

To check the electrical condition of the cable and splice insulation, a megohmmeter is required.



Instructions:

1. Turn the **POWER OFF.**
2. Remove the cable from the motor and electrical supply.
3. Submerge the cable in a steel barrel of water. Make sure both ends stay out of the water. Salt may be added to increase the conductance of the water.
4. Set the megohmmeter to R x 100K. Zero-adjust the ohmmeter by touching its two leads together.
5. Touch one megohmmeter lead to the steel barrel and other to a bare cable lead.
6. If the megohmmeter drifts towards zero (0), either that lead or the splice for that lead has a leak (fault). To find out if it is the splice:



   a. Raise the splice for that lead out of the water.
   b. Repeat step 5.
   c. If the megohmmeter drifts towards infinity, the fault is in the splice.
   d. If the megohmmeter drifts towards zero (0), the fault is somewhere else in that lead. Gradually pull the rest of that cable lead out of the water until the megohmmeter drifts towards infinity. When it does, the leak is at that point in the cable lead.

7. Repeat for each of the motor leads.

Evaluation:

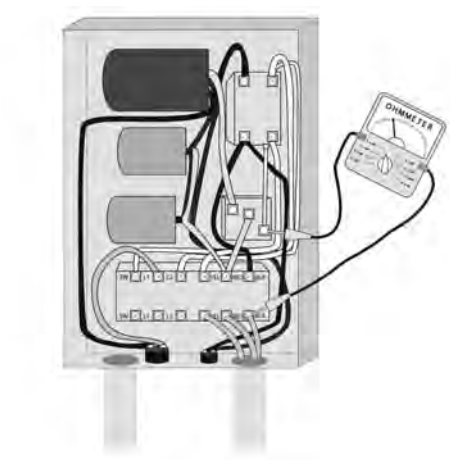
Any faulty leads should be replaced using waterproof electrical tape.

Checking the Relay

(SINGLE-PHASE CONTROL BOXES ONLY)

To check the electrical condition of the relays on single phase control boxes, an ohmmeter is required.

Specific instructions for checking the relay differ from control box to control box. Refer to the inside cover of your control box.



Overload Protection

To check the electrical condition of the thermal overloads, an ohmmeter is required.

Instructions:

1. Turn the **POWER OFF**.
2. Set the scale selector on the ohmmeter to R x 1.
3. Touch one of the ohmmeter leads to an overload protector and one to terminal 1, then terminal 3. Repeat for each overload protector.

Evaluation:

If the ohm values are 0.5 ohms or less, the overload protectors should still be functional. If not, they should be replaced.

Definitions

NET POSITIVE SUCTION HEAD (two types)

Before a centrifugal water pump can operate, the water must enter the pump under a certain minimum amount of pressure. For submersible pumps, this minimum is easily reached, since the pump is submerged in water and both the atmospheric pressure (14.7 psi) and the pressure of the water in the well are present. The amount of pressure (expressed in feet of head) required for a given pump to operate is known as its Net Positive Suction Head **Required**.

This number is determined by extensive testing of the pump by the manufacturer. These requirements are normally shown in graphical form (an **NPSH curve**) for a pump at every flow (GPM) within the flow range for which the pump is designed**.** As a pump's flow (GPM) increases, the NPSHR needed to continue that flow (without cavitating) also increases.

The amount of pressure (expressed in feet of head) that is actually available to a pump is known as its Net Positive Suction Head **Available**. Since the NPSH **Available** to the pump is almost always greater than the NPSH **Required** (for submersible pumps, that is), they are usually not a cause for any concern when sizing a pump or troubleshooting.

For submersible pumps, NPSH Required should not be confused with Total Dynamic Head, which is the amount of head the pump must produce to deliver water at the desired flow rate (GPM) in a given situation. ***Total Dynamic Head*** *(or TDH, as it is sometimes called) is explained below.*

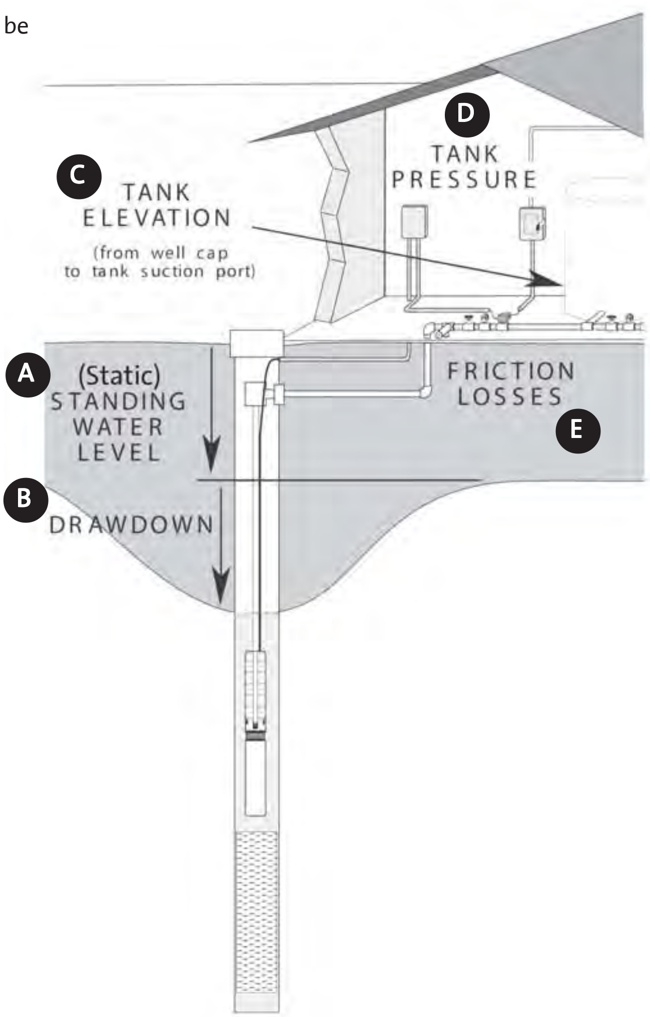
TOTAL DYNAMIC HEAD

When selecting (or "sizing") a pump, two questions must be answered:

1. How much flow is needed ?
   (expressed in Gallons Per Minute)

2. How much head must the pump produce ?
   (known as ***Total Dynamic Head****)*

To determine the Total Dynamic Head the pump must produce, 5 pieces of information are needed:



A **STATIC WATER LEVEL**

+

B **DRAWDOWN**
(as the pump is pumping)

+

C **TANK ELEVATION**

+

D **TANK PRESSURE**
(multiply by 2.31 to
convert psi to feet of head)

+

E **FRICTION LOSSES**

THE TOTAL
OF THESE 5 NUMBERS IS THE AMOUNT OF HEAD THE PUMP MUST PRODUCE

AFFINITY LAWS

The mathematical relationships which permit the head, capacity, brake horsepower (BHP), and NPSH of centrifugal pumps to be predicted based on small changes in impeller diameter size or shaft speed (RPM) changes. These relationships are:

For diameter changes at a constant RPM:

$$\frac{D_1}{D_2} = \frac{GPM_1}{GPM_2}$$

Flow changes in direct proportion to the ratio of the diameter change.

$$\left(\frac{D_1}{D_2}\right)^2 = \frac{H_1}{H_2}$$

Head changes to the square ratio of the ratio of the diameter change.

$$\left(\frac{D_1}{D_2}\right)^3 = \frac{BHP_1}{BHP_2}$$

BHP changes to the cube of the ratio of the diameter change

For RPM changes:

$$\frac{RPM_1}{RPM_2} = \frac{GPM_1}{GPM_2} \qquad \left(\frac{RPM_1}{RPM_2}\right)^2 = \frac{NPSH_1}{NPSH_2}$$

$$\left.\begin{aligned}\left(\frac{RPM_1}{RPM_2}\right)^2 &= \frac{H_1}{H_2}\\ \left(\frac{RPM_1}{RPM_2}\right)^3 &= \frac{BHP_1}{BHP_2}\end{aligned}\right\}$$

Head is affected by the square of the ratio of RPM change
and
BHP is affected by the cube of the ratio of the RPM change

Conversion Formulas

HEAD
(in feet)

$$= \frac{\text{Pressure (PSI)} \times 2.31}{\text{Specific Gravity (for water, 1.0 at ambient temperatures)}}$$

PRESSURE
(PSI)

$$= \frac{\text{HEAD (in ft)} \times \text{Specific Gravity (for water, 1.0 at ambient temperatures)}}{2.31}$$

ATMOSPHERIC PRESSURE
Pressure of the Atmosphere Pushing Down (at sea level)

= 14.7 PSI = 34 feet of HEAD

BRAKE HORSEPOWER
Horsepower Delivered to the Pump Shaft

$$= \frac{\text{GPM} \times \text{HEAD} \times \text{Specific Gravity (for water, 1.0 at ambient temps)}}{3960 \times \text{Efficiency Of Pump}}$$

PUMP EFFICIENCY
Of The Pump

$$= \frac{\text{GPM} \times \text{HEAD} \times \text{Specific Gravity}}{3960 \times \text{Brake Horsepower}}$$

FOOT POUNDS = Newton Meters (or Nm) x .7376

DEGREES FARENHEIT = (Degrees Celsius x 9/5) + 32

Water Vapor Pressure and Specific Gravity

°F	°C	Specific Gravity (1 at 60°F)	Weight (Lbs per cubic foot)	Vapor Pressure (PSIA)	Vapor Pressure (in feet)
32	0	1.002	62.42	0.0885	0.204
40	4.4	1.001	62.42	0.1217	0.281
45	7.2	1.001	62.40	0.1475	0.340
50	10.0	1.001	62.38	0.1781	0.411
55	12.8	1.000	62.34	0.2563	0.591
60	15.6	1.000	62.34	0.2563	0.591
65	18.3	.999	62.31	0.3056	0.839
70	21.1	.999	62.27	0.3631	0.839
75	23.9	.998	62.24	0.4298	0.994
80	26.7	.998	62.19	0.5069	1.172
85	29.4	.997	62.16	0.5959	1.379
90	32.2	.996	62.11	0.6982	1.617
95	35.0	.995	62.06	0.8153	1.890
100	37.8	.994	62.00	0.9492	2.203
110	43.3	.992	61.84	1.275	2.965
120	48.9	.990	61.73	1.692	3.943
130	54.4	.987	61.54	2.223	5.196
140	60.0	.985	61.39	2.889	6.766
150	65.6	.982	61.20	3.718	8.735
160	71.1	.979	61.01	4.741	11.172
170	76.7	.975	60.79	5.992	14.178
180	82.2	.972	60.57	7.510	17.825
190	87.8	.968	60.35	9.339	22.257
200	93.3	.964	60.13	11.526	27.584
212 (boiling point)	100.0	.959	59.81	14.696	35.353
220	104.4	.956	59.63	17.186	41.343
240	115.6	.948	59.10	24.97	60.77
260	126.7	.939	58.51	35.43	87.05
280	137.8	.929	58.00	49.20	122.18
300	148.9	.919	57.31	67.01	168.22
320	160.0	.909	56.66	89.66	227.55
340	171.1	.898	55.96	89.66	227.55
360	182.2	.886	55.22	153.04	398.49
380	193.3	.874	54.47	195.77	516.75
400	204.4	.860	53.65	247.31	663.42
420	215.6	.847	52.80	308.83	841.17
440	226.7	.833	51.92	381.59	1056.8
460	237.8	.818	51.02	466.9	1317.8
480	248.9	.802	50.00	566.1	1628.4
500	260.0	.786	49.02	680.8	1998.2

Water Properties at Different Altitudes

ALTITUDE		BAROMETER READING		ATMOS. PRESSURE		Boiling Point Of Water F°
Feet	Meters	IN. HG.	MM. HG	PSIA	Feet of Water	
-1000	-304.8	31.0	788	15.2	35.2	213.8
-500	-152.4	30.5	775	15.0	34.6	212.9
0	**0.0**	**29.9**	**760**	**14.7**	**33.9**	**212.0**
+500	+152.4	29.4	747	14.4	33.3	211.1
+1000	304.8	28.9	734	14.2	32.8	210.2
1500	457.2	28.3	719	13.9	32.1	209.3
2000	609.6	27.8	706	13.7	31.5	208.4
2500	762.0	27.3	694	13.4	31.0	207.4
3000	914.4	26.8	681	13.2	30.4	206.5
3500	1066.8	26.3	668	12.9	29.8	205.6
4000	1219.2	25.8	655	12.7	29.2	204.7
4500	1371.6	25.4	645	12.4	28.8	203.8
5000	1524.0	24.9	633	12.2	28.2	202.9
5500	1676.4	24.4	620	12.0	27.6	201.9
6000	1828.8	24.0	610	11.8	27.2	201.0
6500	1981.2	23.5	597	11.5	26.7	200.1
7000	2133.6	23.1	587	11.3	26.2	199.2
7500	2286.0	22.7	577	11.1	25.7	198.3
8000	2438.4	22.2	564	10.9	25.2	197.4
8500	2590.8	21.8	554	10.7	24.7	196.5
9000	2743.2	21.4	544	10.5	24.3	195.5
9500	2895.6	21.0	533	10.3	23.8	194.6
10000	3048.0	20.6	523	10.1	23.4	193.7
15000	4572.0	16.9	429	8.3	19.2	184.0

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PART 1: INTRODUCTION

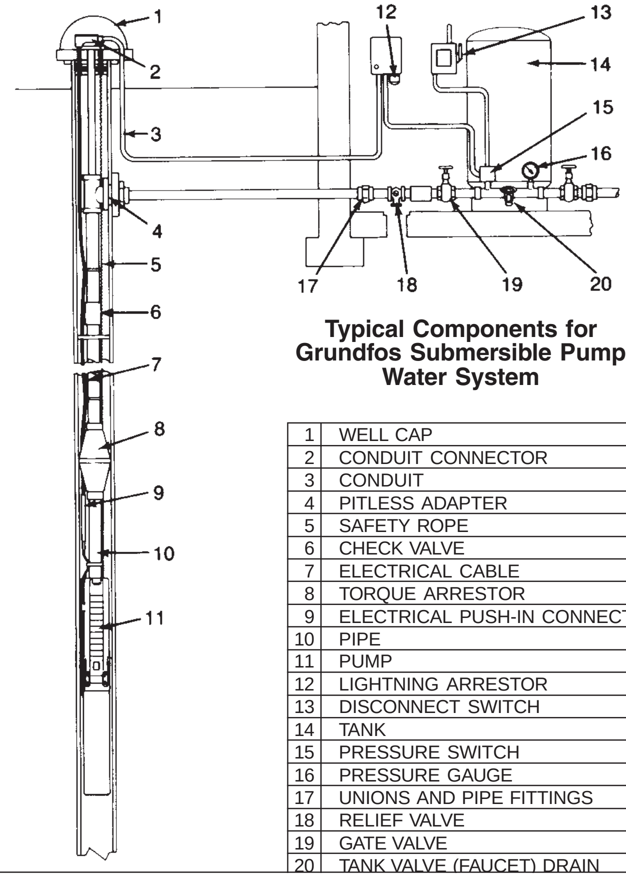
General

This section will provide the technical information needed to properly select GRUNDFOS groundwater products. The information applies primarily to domestic groundwater systems using 4-inch wells with submersible or jet pumps, pressure tanks, and accessories. It is important to be familiar with typical system components and their basic hydraulic principles to ensure a better understanding of the more technical information found later in this section.

Prior to selecting the pump, the basic system requirements must be determined. System capacity and system pressure must be calculated and friction losses determined to ensure proper system performance. These calculations are covered in detail in **Part 1.** In **Part 2**, information is provided on proper cable selection. Also provided in **Part 3** are miscellaneous technical data and formulas commonly used in the selection of domestic groundwater systems.

Typical System Components

Domestic groundwater systems are made up of a pump, storage tank, and accessories to operate the system automatically. Pumps are generally of the submersible or jet variety and include the pump and motor as a unit. Refer to Figure 8-A for the components found in a typical automatic groundwater pumping system.



Typical Components for Grundfos Submersible Pump Water System

1	WELL CAP
2	CONDUIT CONNECTOR
3	CONDUIT
4	PITLESS ADAPTER
5	SAFETY ROPE
6	CHECK VALVE
7	ELECTRICAL CABLE
8	TORQUE ARRESTOR
9	ELECTRICAL PUSH-IN CONNECTOR
10	PIPE
11	PUMP
12	LIGHTNING ARRESTOR
13	DISCONNECT SWITCH
14	TANK
15	PRESSURE SWITCH
16	PRESSURE GAUGE
17	UNIONS AND PIPE FITTINGS
18	RELIEF VALVE
19	GATE VALVE
20	TANK VALVE (FAUCET) DRAIN

FIGURE 8-A
Components found in a typical automatic groundwater pumping system including a submersible pump, pressure tank, and pressure control accessories.

In a ***closed, automatic water system*** a pressure tank is used to store water and maintain system pressure between specified limits (such as 30 to 50 psi). As the water level in the tank rises, tank air is compressed in the upper part of the tank until the upper pressure limit is reached (i.e., 50 psi). At this “cut-out” point a pressure switch opens the electrical circuit to the motor and the pump stops.

The compressed air in the tank acts like a spring pushing down on the water to create system pressure. When a valve is opened in the water system, the air pressure in the upper part of the tank forces the water to flow out of the tank and into the system. As the water is drawn from the tank, the air occupies a larger space and the pressure drops until the lower limit is reached (i.e., 30 psi). At this “cut-in” point the pressure switch closes the electrical circuit to the motor and the pump starts. A cycle is thereby completed.

In an ***open, automatic water system*** the pump is used to fill a large, elevated storage tank which utilizes gravity to maintain system pressure. Tank level controls are used to cycle the pump to maintain water levels within prescribed limits.

Refer to the following illustrations for schematic layouts of typical domestic groundwater systems and components: Figure 8-B (Submersible Pump - Closed System), Figure 8-C (Submersible Pump - Open System), Figure 8-D (Shallow Well Jet Pump), and Figure 8-E (Deep Well Jet Pump).

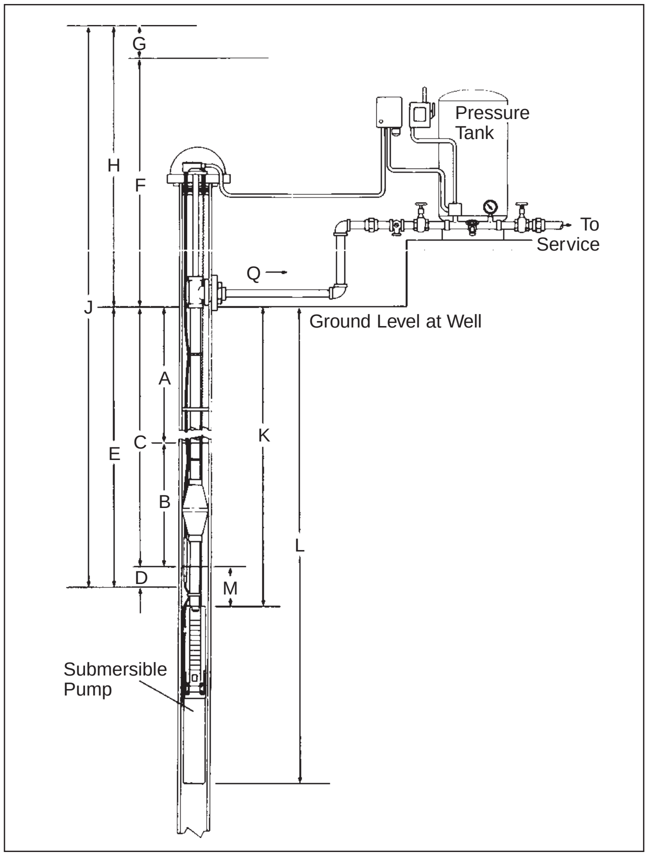


FIGURE 8-B
Figure 8-B illustrates a schematic layout of a CLOSED goundwater pumping system using a submersible pump and pressure tank set for automatic operation. A pressure switch controls the cycling of the pump.

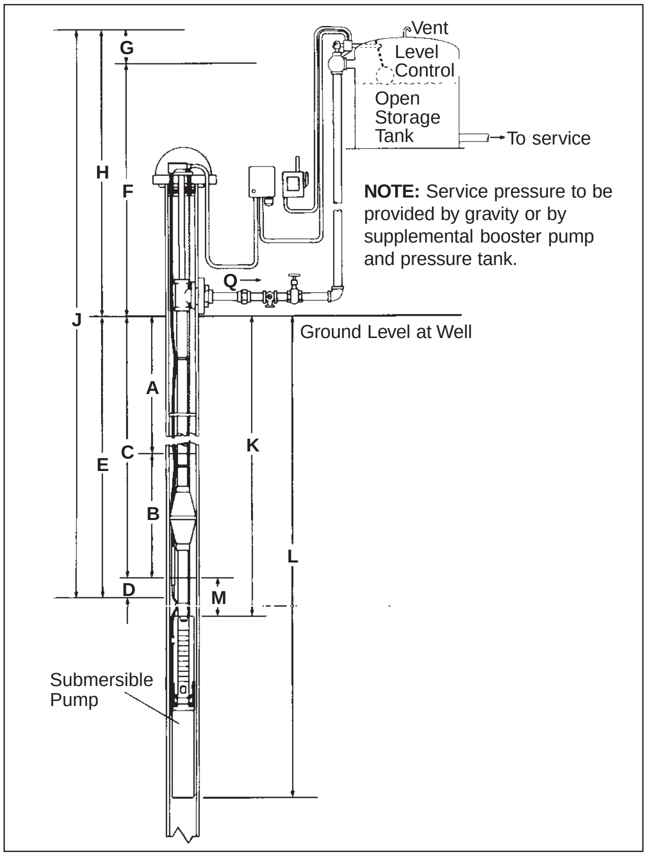


FIGURE 8-C
Figure 8-C illustrates a schematic layout of an OPEN groundwater pumping system using a submersible pump and an elevated storage tank set for automatic operation. A level control on the storage tank controls the cycling of the pump.

Closed Groundwater System with Submersible Pump

A. STATIC WATER LEVEL (in feet): vertical distance from the top of the well to the standing water level or water table.

B. DRAWDOWN (in feet): reduction in the water level during pumping (varies with well yield and pump capacity).

C. PUMPING WATER LEVEL or LIFT (in feet): C = A + B.

D. FRICTION LOSSES in the WELL (in feet): friction losses caused by the drop pipe and fittings between the pump and the top of the well.

E. TOTAL LIFT in the WELL (in feet): E = A + B + D.

F. STATIC DISCHARGE HEAD (in feet): for PRESSURE TANK SYSTEMS it is the elevation rise in feet of the pressure tank, discharge nozzles, etc., above the top of the well plus the pressure (in feet) required at that level.

G. FRICTION LOSSES in the DISCHARGE SYSTEM (in feet): friction losses caused by piping, valves, and fittings between the top of the well and the point of discharge.

H. TOTAL DISCHARGE HEAD (in feet): H = F + G.

J. TOTAL PUMPING HEAD (in feet): J = E + H.

K. SETTING OF PUMP (in feet): vertical distance from the top of the well to the top of the pump.

L. OVERALL LENGTH (in feet): vertical distance from the top of the well to the bottom of the pump.

M. SUBMERGENCE (in feet): M = K - C.

Q. CAPACITY (in gpm or gph): rate of pumping.

Open Groundwater System with Submersible Pump

A. STATIC WATER LEVEL (in feet): vertical distance from the top of the well to the standing water level or water table.

B. DRAWDOWN (in feet): reduction in the water level during pumping (varies with well yield and pump capacity).

C. PUMPING WATER LEVEL or LIFT (in feet): C = A + B.

D. FRICTION LOSSES in the WELL (in feet): friction losses caused by the drop pipe and fittings between the pump and the top of the well.

E. TOTAL LIFT in the WELL (in feet): E = A + B + D.

F. STATIC DISCHARGE HEAD (in feet): for OPEN DISCHARGE SYSTEMS it is the elevation of the highest water level above the top of the well.

G. FRICTION LOSSES in the DISCHARGE SYSTEM (in feet): friction losses caused by piping, valves, and fittings between the top of the well and the point of discharge.

H. TOTAL DISCHARGE HEAD (in feet): H = F + G.

J. TOTAL PUMPING HEAD (in feet): J = E + H.

K. SETTING OF PUMP (in feet): vertical distance from the top of the well to the top of the pump.

L. OVERALL LENGTH (in feet): vertical distance from the top of the well to the bottom of the pump.

M. SUBMERGENCE (in feet): M = K - C.

Q. CAPACITY (in gpm or gph): rate of pumping.

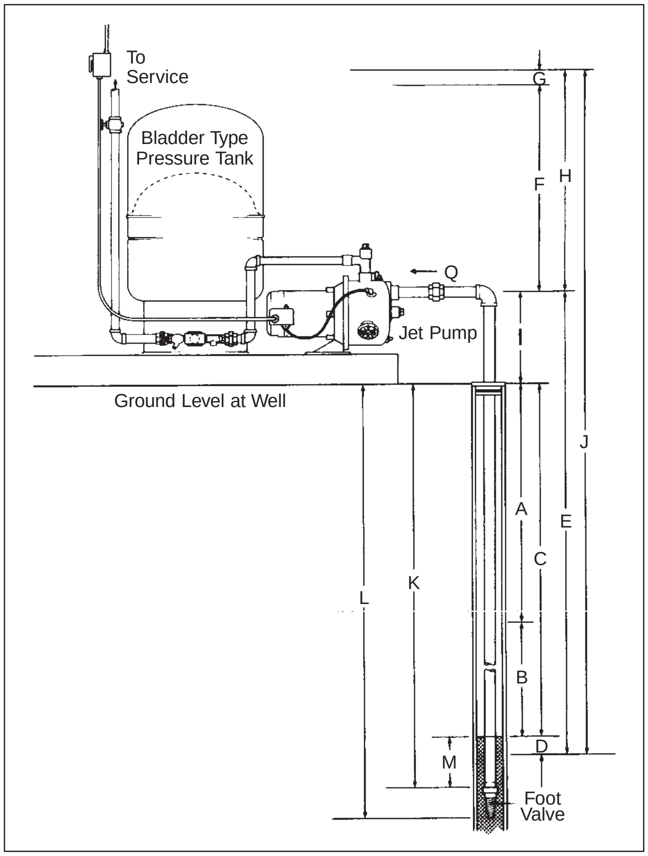


FIGURE 8-D
Figure 8-D illustrates a schematic layout of a SHALLOW WELL groundwater pumping system using a shallow well JET PUMP designed for setting to 25 feet. The pressure tank is set for automatic operation with a pressure switch controlling the cycling of the pump.

CLOSED GROUNDWATER SYSTEM WITH SHALLOW WELL JET PUMP

A. Statics Water Level (in feet): vertical distance from the top of the well to the standing water level or water table.

B. Drawdown (in feet): reduction in the water level during pumping (varies with well yield and pump capacity).

C. Pumping Water Level or Lift (in feet): C = A + B.

D. Friction Losses in the Suction System (in feet): friction losses caused by suction piping between the pump and foot valve.

E. Total Suction Lift (in feet): E = A + B + D + I.

F. Static Discharge Head (in feet): for *Pressure Tanks Systems* it is the elevation rise in feet of the pressure tank, discharge nozzles, etc., above the pump plus the pressure (in feet) discharge nozzles, etc., above the pump plus the pressure (in feet) required at that level. For *Open Discharge Systems* it is the elevation in feet of the highest water level above the pump.

G. Friction Losses in the Discharge System (in feet): friction losses caused by piping, valves, and fittings between the top of the well and the point of discharge.

H. Total Discharge Head (in feet): H = F + G.

I. Elevation of the Pump above the Top of the Well (in feet).

J. Total Pumping Head (in feet): J = E + H.

K. Setting of the Foot Valve or Strainer (in feet): vertical distance from the top of the well to the top of the foot valve or strainer.

L. Overall Length (in feet): vertical distance from the top of the well to the bottom of the foot valve or strainer.

M. Submergence (in feet): M = K - C.

Q. Capacity (in gpm or gph): rate of pumping.

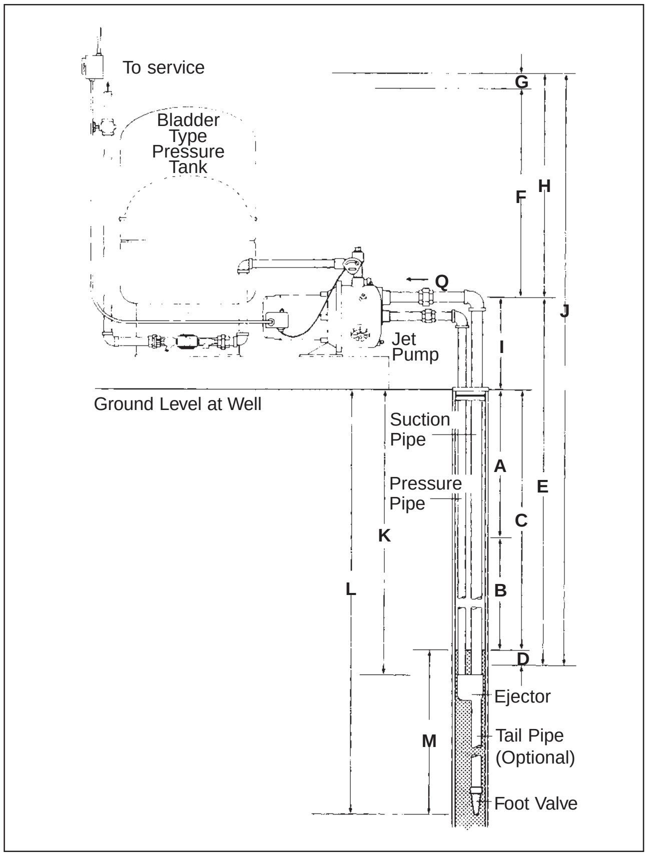


FIGURE 8-E
Figure 8-E illustrates a schematic layout of an DEEP WELL groundwater pumping system using a deep well JET PUMP designed for settings to 100 feet. The pressure tank is set for automatic operation with a pressure switch controlling the cycling of the pump.

CLOSED GROUNDWATER SYSTEM WITH SHALLOW WELL JET PUMP

A. Static Water Level (in feet): vertical distance from the top of the well to the standing water level or water table.

B. Drawdown (in feet): reduction in the water level during pumping (varies with well yield and pump capacity).

C. Pumping Water Level or Lift (in feet): C = A + B.

D. Friction Losses in the Suction System (in feet): friction losses caused by suction piping between the pump and foot valve.

E. Total Suction Lift (in feet): E = A + B + D + I.

F. Static Discharge Head (in feet): for PRESSURE TANK SYSTEMS it is the elevation rise in feet of the pressure tank, discharge nozzles, etc., above the pump plus the pressure (in feet) discharge nozzles, etc., above the pump plus the pressure (in feet) required at that level. For OPEN DISCHARGE SYSTEMS it is the elevation in feet of the highest water level above the pump.

G. Friction Losses in the Discharge System (in feet): friction losses caused by piping, valves, and fittings between the top of the well and the point of discharge.

H. Total Discharge Head (in feet): H = F + G.

I. Elevation of the Pump above the Top of the Well (in feet).

J. Total Pumping Head (in feet): J = E + H.

K. Setting of the Foot Valve or Strainer (in feet): vertical distance from the top of the well to the top of the foot valve or strainer.

L. Overall Length (in feet): vertical distance from the top of the well to the bottom of the foot valve or strainer.

M. Submergence (in feet): M=K–C. The ejector should be set as close to the bottom of its maximum depth rating as the well will permit.

Q. Capacity (in gpm or gph): rate of pumping.

Head and Pressure

Head and pressure are related in a very simple and direct manner. Since water has known weight, we know that a 231 foot long, one-inch square pipe holds 100 pounds of water. At the bottom of the one-inch square pipe we refer to the pressure as 100 pounds per square inch (psi). For any diameter pipe 231 feet high, the pressure will always be 100 psi at the bottom. Refer to Figure 8-F.

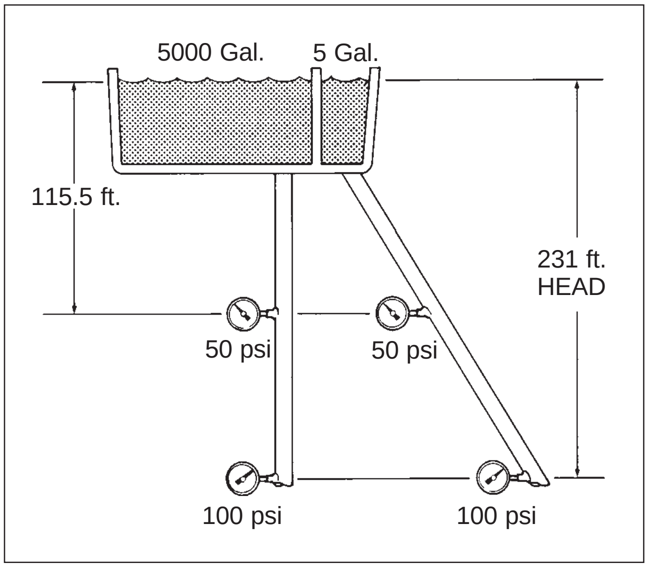


FIGURE 8-F
Figure 8-F illustrates the relationship between head and pressure.

Head is usually expressed in feet and refers to the height, or elevation, of the column of water. In Figure 8-F we see that a column of water 231 feet high creates a pressure reading of 100 psi. That same column of water is referred to as having 231 feet of **head**. Thus, for water, 231 feet of head is equivalent to 100 psi. Or, 2.31 feet of head equals 1 psi.

It should be noted that head and pressure readings for non-flowing water depend on the elevation of the water and not on the volume of water nor the size or length of piping.

Flow and Friction Loss

Flow is measured as the volume of water moved over a given length of time. This is generally referred to as gallons per minute (gpm) for larger flows and gallons per hour (gph) for smaller flows. When water moves through a pipe, it must overcome resistance to flow caused by friction as it moves along the walls of the pipe as well as resistance caused by its own turbulence. Added together, these losses are referred to as **friction losses** and may significantly reduce system pressure.

Figure 8-G illustrates the relationship of flow and friction loss. For any flow through a level pipe the gauge pressure at the pipe inlet will be greater than the gauge pressure at the pipe outlet. The difference is attributed to friction losses caused by the pipe itself and by fittings.

In general, friction losses occur or are increased under the following conditions:

1. Friction losses result from flow through any size or length of pipe (Figure 8-G).

2. Friction losses increase as the flow rate increases or as the pipe size decreases (if the flow rate doubles for a given pipe size, friction losses quadruple, Figure 8-G).

3. Friction losses increase with the addition of valves and fittings to the system (Figure 8-G).

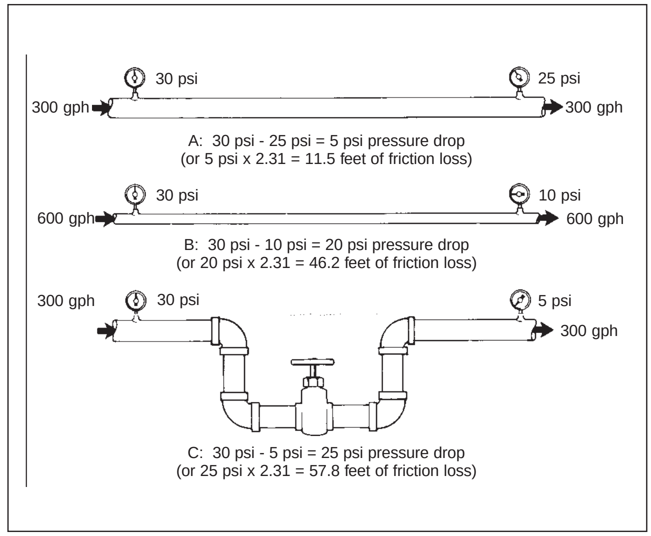


FIGURE 8-G
As shown in these illustrations friction losses increase with additional flow

Power is required to push water to a higher elevation, to increase outlet pressure, to increase flow rates, and to overcome friction losses. Good system design and common sense indicate that friction losses should be minimized whenever possible. The costs of larger pumps, bigger motors, and increased power consumption to overcome friction losses must be balanced against the increased cost of larger, but more efficient, system piping. In either case, unnecessary valves and fittings should be eliminated wherever possible.

Submersible Pumps vs. Jet Pumps

Submersible and jet pumps are both used in domestic groundwater systems. When high flow rates and pressure settings are required at high operating efficiencies, submersible pumps are generally preferred. Submersible pumps have the advantage of performing well both in shallow well applications as well as at depths to 2,000 feet. An extensive range of submersible pump models is also available allowing a precise match to exact system requirements.

Convertible jet pumps are sometimes an economical alternative to submersibles, especially in shallow well installations of 25 feet or less. The pumps are less expensive, installation is simplified, and they are easily converted for deep well installations down to 100 feet (Figure 8-H).

In "weak" well applications where the pump lowers the water level in the well faster than the well can replenish itself, a deep well jet pump with a tail pipe is particularly effective when flow requirements are relatively small. By adding 35 feet of tail pipe below the jet assembly with the foot valve attached to the bottom, it will not be possible to pull the well down and allow air to enter the system. Pump delivery remains at 100% of the rated capacity down to the level of the jet assembly. If the water level falls below that point, flow decreases in proportion to the drawdown as shown in Figure 8-I. When pump delivery equals well inflow, the water level remains constant until the pump shuts off. At 33.9 feet of drawdown the pump will no longer deliver water but the foot valve will remain fully submerged.

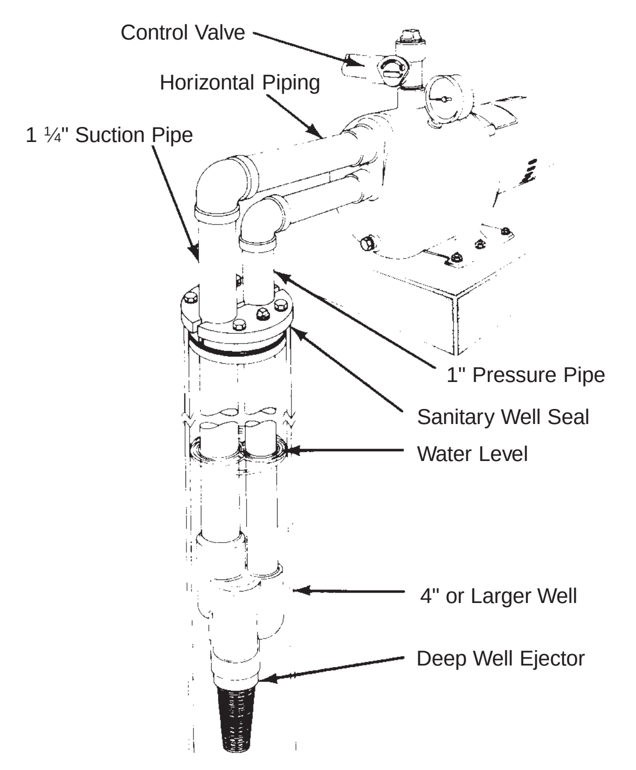


FIGURE 8-H
Figure 8-H illustrates a convertible jet pump set for deep well use (to 100 feet).

Final Pump Selection

Final pump selection will depend upon specific application requirements and cost considerations. Regardless of the pump type, system flow and head requirements (discussed in detail in Part 2) must be determined prior to actual pump selection.

Flow requirement will be determined by the size of the house or farm (including the number of bathrooms, outlets and appliances), the size of family, and the number of farm animals, if applicable.

Total Pumping Head must be calculated to ensure that the pump selected will meet all head or discharge pressure requirements. Total pumping head is the combination of the total suction lift (or lift in well), plus the pump discharge head (consisting of the elevation from the pumping water level to pressure tank plus pressure tank discharge pressure), plus all system friction losses.

Total Dynamic Head is equivalent to total pumping head plus velocity head. In most residential systems, velocity head is negligible. Because of this, the velocity head term has been left out of future examples and formulas. From the information gathered on flow and head requirements, a specific submersible or jet pump may be selected and an appropriately sized pressure tank ordered.

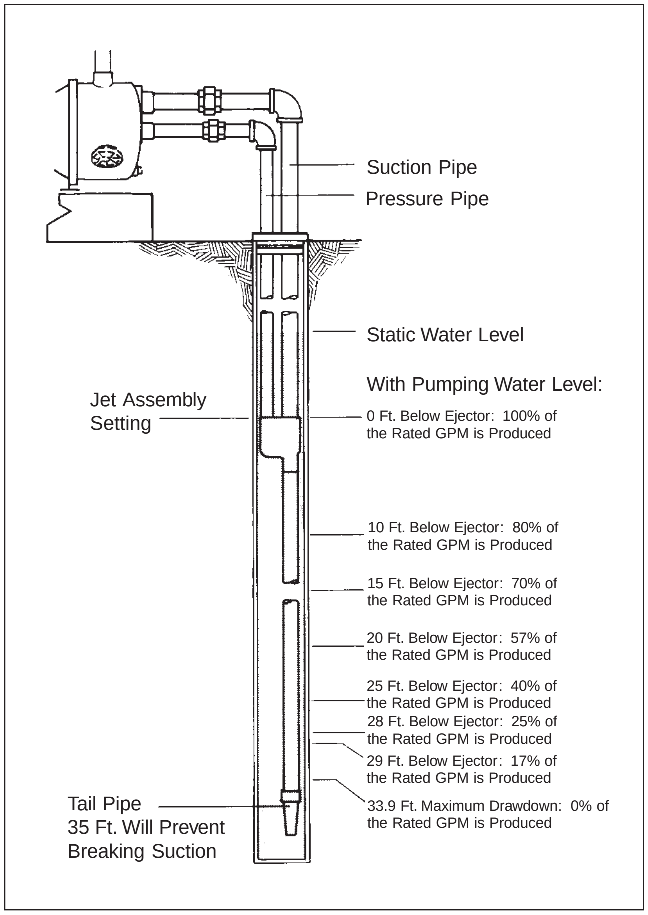


FIGURE 8-I
Figure 8-I illustrates the use of a tail pipe on a deep well convertible jet pump to compensate for weak well conditions.

PART 2: CABLE SELECTION

Submersible Pump Cable Selection Charts (60 Hz)

CABLE LENGTH SELECTION TABLES

The following table (Table 8-Q(2)) lists the recommended copper cable sizes and various cable lengths for submersible pump motors. Proper wire size will ensure that adequate voltage will be supplied to the motor.

This table complies with the 1978 edition of the National Electric Table 310-16, Column 2 for 75°C wire. The ampacities (current carrying properties of a conductor) have been divided by 1.25 per the N.E.C., Article 430-22, for motor branch circuits based on motor amps at rated horsepower.

To assure adequate starting torque, the maximum cable lengths are calculated to maintain 95% of the service entrance voltage at the motor when the motor is running at maximum nameplate amps. Cable sizes larger than specified may always be used and will reduce power usage.

The use of cables smaller than the recommended sizes will void the warranty. Smaller cable sizes will cause reduced starting torque and poor motor operation.

CALCULATING MIXED CABLE SIZES

In a submersible pump installation any combination of cable sizes may be used as long as the total percentage length of the individual cables does not exceed 100%. Mixed cable sizes are most often encountered when a pump is being replaced with a larger horsepower model and part of the old cable will be left in place.

In the following example, a 2 HP, 230 volt, 1 phase pump is being installed to replace a smaller model. The 115 feet of buried #12 cable located between the service entrance and the well head will be used in the replacement installation. The well driller must be able to calculate the required size of cable in the well to connect the new motor at a setting of 270 feet.

Cable Size Calculation:
Step 1–Check Table 8-Q(2) to see if the 115 feet of existing #12 cable is large enough to provide current to the larger 2 HP replacement pump. The table tells us that #12 cable is adequate for a maximum length of 250 feet.

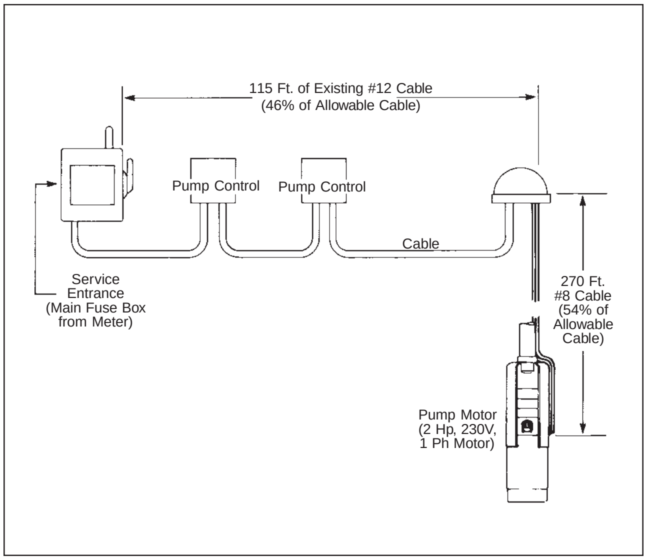


FIGURE 8-Q(1)
Example of Mixed Cable Installation

Step 2–Since 250 feet is the maximum allowable cable length for the #12 cable, calculate the percent used by the 115-foot run. (115 ft. ÷ 250 ft. = 46%)

Step 3–With 46% of the total allowable cable used between the service entrance and the well head, 54% remains for use in the well (100% - 46% = 54%). Therefore, the 270 feet of cable required in the well can utilize only 54% of the total feet allowed in the table.

Step 4–From Table 8-Q(2) determine the proper size cable required for the 2 HP pump set at 270 feet. (Remember, you are limited to 54% of the length listed in the table.) A check of #10 cable at 2 HP indicates that only 210 feet of this cable could be used (390 ft. x 54% = 210 ft.). Since this is less than the 270 required, the next larger size should be tried. For #8 cable, 54% of 620 feet = 335 feet. ***The #8 cable is suitable for use in the well at a pump setting of 270 feet.***

See Chart 8-Q(2) next page.

MAXIMUM MOTOR CABLE LENGTH

(Motor Service to Entrance)

TABLE 8-Q(2)
Single Phase 60Hz

Motor Rating		Copper Wire Size												
Volts	**HP**	**14**	**12**	**10**	**8**	**6**	**4**	**2**	**0**	**00**	**000**	**0000**	**250**	**300**
115	1/3	130	210	340	540	840	1300	1960	2910					
	1/2	100	160	250	390	620	960	1460	2160					
230	1/3	550	880	1390	2190	3400	5250	7960						
	1/2	400	650	1020	1610	2510	3880	5880						
	3/4	300	480	760	1200	1870	2890	4370	6470					
	1	250	400	630	990	1540	2380	3610	5360	6520				
	1½	190	310	480	770	1200	1870	2850	4280	5240				
	2	150	250	390	620	970	1530	2360	3620	4480				
	3	120	190	300	470	750	1190	1850	2890	3610				
	5			180	280	450	710	1110	1740	2170				
	7½				200	310	490	750	1140	1410				
	10					250	390	600	930	1160				

Three Phase 60Hz

Volts	HP	14	12	10	8	6	4	2	0	00	000	0000	250	300
208	1½	310	500	790	1260									
	2	240	390	610	970	1520								
	3	180	290	470	740	1160	1810							
	5		170	280	440	690	1080	1660						
	7½			200	310	490	770	1180	1770					
	10				230	370	570	880	1330	1640				
	15					250	390	600	910	1110	1340			
	20						300	460	700	860	1050	1270		
	25							370	570	700	840	1030	1170	
	30							310	470	580	700	850	970	1110
230	1½	360	580	920	1450									
	2	280	450	700	1110	1740								
	3	210	340	540	860	1340	2080							
	5		200	320	510	800	1240	1900						
	7½			230	360	570	890	1350	2030					
	10				270	420	660	1010	1520	1870				
	15					290	450	690	1040	1280	1540			
	20						350	530	810	990	1200	1450		
	25						280	430	650	800	970	1170	1340	
	30							350	540	660	800	970	1110	1270
460	1½	1700												
	2	1300	2070											
	3	1000	1600	2520										
	5	590	950	1500	2360									
	7½	420	680	1070	1690	2640								
	10	310	500	790	1250	1960	3050							
	15			540	850	1340	2090	3200						
	20			410	650	1030	1610	2470	3730					
	25				530	830	1300	1990	3010	3700				
	30				430	680	1070	1640	2490	3060	3700			
	40						790	1210	1830	2250	2710	3290		
	50						640	980	1480	1810	2190	2650	3010	
	60							830	1250	1540	1850	2240	2540	2890
	75								1030	1260	1520	1850	2100	2400
	100									940	1130	1380	1560	1790
	125											1080	1220	1390
	150												1050	1190
	200												1080	1300
	250													1080
575	1½	2620												
	2	2030												
	3	1580	2530											
	5	920	1480	2330										
	7½	660	1060	1680	2650									
	10	490	780	1240	1950									
	15		530	850	1340	2090								
	20			650	1030	1610	2520							
	25			520	830	1300	2030	3110						
	30				680	1070	1670	2560	3880					
	40					790	1240	1900	2860	3510				
	50						1000	1540	2310	2840	3420			
	60						850	1300	1960	2400	2890	3500		
	75							1060	1600	1970	2380	2890	3290	

CAUTION: Use of wire size smaller than listed will void warranty.

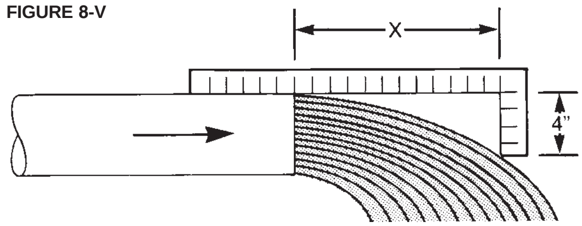
Notes:
1. If aluminum conductor is used, multiply lengths by 0.5 Maximum allowable length of aluminum is considerably shorter than copper wire of same size.
2. The portion of the total cable which is between the service entrance and a 3ø motor starter should not exceed 25% of the total maximum length to assure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.
3. Cables #14 to #0000 are AWG sizes, and 250 to 300 are MCM sizes.

Calculating Discharge Rate by Using The Horizontal Open Discharge Method

The most reliable method of measuring flow is to use a flow meter. When a flow meter is not available, however, it is possible to estimate the discharge capacity by constructing an "L" shaped measuring stick similar to that shown in Figure 8-V. With the water flowing from the pipe, place the long end of the "L" on top of the pipe. Position the "L" so that the end of the short 4-inch side just touches the stream of water as the stream slants downward. Note the horizontal distance "X" from this point to the open end of the discharge pipe. With the value "X" and and the nominal inside diameter of the pipe, use Table 8-X to find the discharge rate in gallons per minute.

EXAMPLE: Horizontal distance "X" is measured to be 12 inches. The size of the pipe Is known to be 1½" (nominal diameter). Find 12 inches in the left hand column of the chart and move across to the 1½" pipe size column. Table 8-X indicates that the discharge rate is 40.0 gallons per minute.

FIGURE 8-V



Calculating Low Capacity Outlets: A simple procedure for measuring low capacity outlets such as small pump outlets, hose spigots, and faucets is to record the amount of time it takes to fill a container of known size.

EXAMPLE: Select a container of known size such as a 5-gallon paint bucket. With a watch, measure, in seconds, the amount of time it takes to fill the bucket. If it takes 30 seconds to fill a 5-gallon bucket, Table 8-W indicates that the flow is 10.0 gallons per minute. To obtain gallons per hour (gph) multiply 10.0 x 60 to obtain 600 gph.

TABLE 8-W

Discharge Rate in Gallons Per Minute (GPM) for Low Capacity Systems

Capacity of Container (Gallons)	Time (in seconds) to Fill Container							
	10	15	20	30	45	60	90	120
	Discharge Rate in Gallons Per Minute (GPM)							
1	6.0	4.0	3.0	2.0	1.3	1.0	.7	.5
3	18.0	12.0	9.0	6.0	4.0	3.0	2.0	1.5
5	30.0	20.0	15.0	10.0	6.7	5.0	3.3	2.5
10	60.0	40.0	30.0	20.0	13.3	10.0	6.7	5.0

NOTE: Multiply gallons per minute (GPM) by 60 to obtain gallons per hour (GPH).

Calculating Distance to Water Level

Install ⅛" or ¼" pipe or tubing into the well so that the end of the tubing extends 10 to 20 feet below the lowest possible pumping water level. Be sure that all joints in the tubing are airtight. As the tubing is lowered into the well measure its length. Record the measurement.

TABLE 8-X

Discharge Rate in Gallons Per Minute (GPM) for Large Capacity Systems

Horiz. Dist. (X) Inches	Nominal Pipe Size (in Inches)									
	1	1 ¼"	1 ½"	2"	2 ½"	3"	4"	5"	6"	8"
	Discharge Rate in Gallons Per Minute (GPM)									
4	5.7	9.8	13.3	22.0	31	48	83			
5	7.1	12.2	16.6	27.5	39	61	104	163		
6	8.5	14.7	20.0	33.0	47	73	125	195	285	
7	10.0	17.1	23.2	38.5	55	85	146	228	334	380
8	11.3	19.6	26.5	44.0	62	97	166	260	380	665
9	12.8	22.0	29.8	49.5	70	110	187	293	430	750
10	14.2	24.5	33.2	55.5	78	122	208	326	476	830
11	15.6	27.0	36.5	60.5	86	134	229	360	525	915
12	17.0	29.0	40.0	66.0	94	146	250	390	570	1000
13	18.5	31.5	43.0	71.5	102	158	270	425	620	1080
14	20.0	34.0	46.5	77.0	109	170	292	456	670	1160
15	21.3	36.3	50.0	82.5	117	183	312	490	710	1250
16	22.7	39.0	53.0	88.0	125	196	334	520	760	1330
17		41.5	56.5	93.0	133	207	355	550	810	1410
18			60.0	99.0	144	220	375	590	860	1500
19				100.0	148	232	395	620	910	1580
20					156	244	415	650	950	1660
21						256	435	685	1000	1750

Once the tubing is fixed in a stationary position at the top of the well, connect an air line and pressure gauge. With a tire pump or other air supply, pump air into the line until the pressure gauge reaches a point where it doesn't read any higher. Record the pressure gauge reading at this point.

Figure 8-Y illustrates a typical method for measuring distance to water level:

X = Distance to water level (in feet). This figure to be determined.

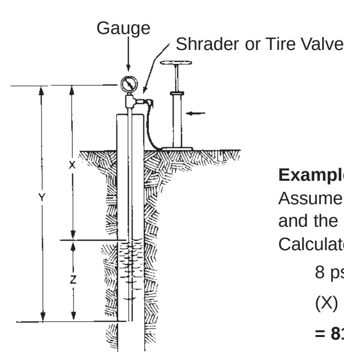
Y = Total length of air line (in feet).

Z = Length of submerged air line. This value is obtained from the pressure gauge reading which reads in pounds per square inch (psi). Multiply the pressure gauge reading by 2.31 to obtain the length of the submerged air line in feet.

Distance to water level (X) = (Y) - (Z)
= The total length of the air line (Y) minus the length of the submerged portion of the air line (Z).

Figure 8-Y

Calculating the distance to water level.



Example:
Assume that the air line is 100 feet long and the pressure gauge reads 8 psi. Calculate the distance to water level (X).

8 psi x 2.31 = 18.5 feet

(X) = 100 feet (Y) - 18.5 feet (Z)

= 81.5 feet = distance to water level

FORMULAS

TEMPERATURE CONVERSIONS:

Degrees **C** = $\frac{5}{9}$ x (Degrees F - 32)

Degrees **F** = ($\frac{9}{5}$ x Degrees C) + 32

Area of a Circle:

Area = πr^2

Circumference of a Circle:

Circumference = $2 \pi r$

r = radius

π = 3.14

Volume of a Tank or Cistern:

3.14 x (radius of tank)^2 x (ht. of tank) x 7.48 = Gallons
Radius and height of tank measured in feet
7.48 = number of gallons per cubic foot of water

WORK, POWER, AND EFFICIENCY:

The amount of work required to lift 1 pound to a height of 1 foot is defined as 1 ft.-lb. To lift 100 pounds to a height of 60 feet is 100 pounds x 60 feet = 6,000 ft-lbs. This amount of energy remains the same whether it takes one minute or one hour to lift the weight. The rate of working, however, is referred to as **power** and was 6,000 ft-lbs. per minute in the first case and 100 foot pounds per minute in the second case.

Power can be represented either mechanically or electrically. **Mechanical power** is measured in horsepower (HP). One HP is the theoretical power required to raise 33,000 pounds to a height of one foot in one minute, or:

1 HP = 33,000 ft.-lb./minute
= 550 ft.-lb./second

Electrical power is measured in watts(w) or kilowatts(kw), and:

1,000 w = 1 kw = 1.34 hp, or
1 HP = 745 w = 0.746 kw

WATER HORSEPOWER (WHP):

Water horsepower is the power required to raise water at a specified rate against a specified head, assuming 100% efficiency.

$$\text{WHP} = \frac{\text{GPM x Total Pumping Head}}{3{,}960}$$

BRAKE HORSEPOWER (BHP):

Brake horsepower is based on test data and can be either the horsepower developed at the motor shaft (motor output) or that absorbed at the pump shaft (pump input).

$$\text{Pump BHP} = \frac{\text{WHP x 100}}{\text{Pump Efficiency (\%)}}$$

$$= \frac{\text{GPM x Total Pumping Head x 100}}{\text{3,960 x Pump Efficiency (\%)}}$$

$$\text{Motor BHP} = \frac{\text{Power input x Motor Efficiency (\%)}}{100}$$

$$= \frac{\text{1.34 x kw input x Motor Efficiency (\%)}}{100}$$

PUMP EFFICIENCY:

Pumps and motors, like all machines, are not 100% efficient. Not all of the energy supplied to them is converted into useful work. Pump efficiency is the ratio of power output to power input, or:

$$\text{Efficiency (\%)} = \frac{\text{Power Output x 100}}{\text{Power Input}}$$

$$\text{Pump Eff. (\%)} = \frac{\text{WHP x 100}}{\text{Pump BHP (Input)}}$$

$$= \frac{\text{GPM x Total Pumping Head x 100}}{\text{3960 x Pump BHP (Input)}}$$

$$\text{Motor Eff. (\%)} = \frac{\text{Motor BHP (Output) x 100}}{\text{1.34 x kw input}}$$

$$\text{Plant Eff. (\%)} = \frac{\text{GPM x Total Pumping Head x 100}}{\text{5,300 x kw Input}}$$

ELECTRIC POWER (AC):

E = Electrical pressure (volts). Similar to hydraulic head.

I = Electrical current (amps). Similar to rate of flow.

W = Electrical power (watts) = E x I x PF

kw = Kilowatt (1,000 watts)

kw-hr. = Kilowatt-hour = 1,000 watts for one hour

Apparent Power = E x I = volt-amperes

PF = Power Factor = Useful Power ÷ Apparent Power

Power Calculations for Single-Phase Power
W (Watts) = E x I x PF
NOTE: When measuring single-phase power use a single-phase wattmeter.

Input HP to motor = W ÷ 746 = 1.34 x kw

Power Calculations for Three-Phase Power
W (Watts) = 1.73 x E x I x PF
Where: E = effective (RMS) voltage between phases
I = average current in each phase
NOTE: When measuring three-phase power use either (1) three-phase wattmeter, (2) single-phase wattmeters, or the power company's revolving disc wattmeter.

When calculating power with a revolving disc wattmeter use the following formulas:

$$\text{kw input} = \frac{\text{K x R x 3.60}}{t}$$

$$\text{Input HP (to motor)} = \frac{\text{K x R x 3,600}}{\text{746 x t}}$$

$$= \frac{\text{K x R x 4.83}}{t}$$

FORMULAS

$$\text{Motor BHP (output)} = \frac{\text{Input HP} \times \text{Motor Eff.(\%)}}{100}$$

Where K = Meter constant = watts per revolution of revolving disc (value of K is marked on the meter nameplate or on the revolving disc). Where current transformers are used, multiply meter constant by current transformer ratio.

R = Number of disc revolutions counted.

t = Time in seconds for R revolutions.

CALCULATING OPERATING COSTS OF PUMPS:
Costs in Cents per 1,000 Gallons:

$$\text{Cost (¢)} = \frac{\text{kw Input} \times r \times 1{,}000}{\text{GPH}}$$

Cost in Cents per Acre-Inch

$$\text{Cost (¢)} = \frac{\text{kw Input} \times r \times 452.6}{\text{GPM}}$$

Where: r = cost of power in cents per kw-hr.

FRICTION LOSS TABLES

Friction Loss Table – SCH 40 STEEL PIPE

(Friction Loss in Feet of Head Per 100 Feet of Pipe)

GPM	GPH	1/2" ID 0.622"	3/4" ID 0.824"	1" ID 1.049"	1 1/4" ID 1.380"	1 1/2" ID 1.610"	2" ID 2.067"	2 1/2" ID 2.469"	3" ID 3.068"	4" ID 4.026"
2	120	4.8								
3	180	10	2.5							
4	240	17.1	4.2							
5	300	25.8	6.3	1.9						
6	360	36.5	8.9	2.7						
7	420	48.7	11.8	3.6						
8	480	62.7	15	4.5						
9	540	78.3	18.8	5.7						
10	600	95.9	23	6.9	1.8					
12	720		32.6	9.6	2.5	1.2				
14	840		43.5	12.8	3.3	1.5				
16	960		56.3	16.5	4.2	2				
20	1,200		86.1	25.1	6.3	2.9				
25	1,500			38.7	9.6	4.5	1.3			
30	1,800			54.6	13.6	6.3	1.8			
35	2,100			73.3	18.2	8.4	2.4			
40	2,400			95	23.5	10.8	3.1	1.3		
45	2,700				29.4	13.5	3.9	1.6		
50	3,000				36	16.4	4.7	1.9		
60	3,600				51	23.2	6.6	2.7		
70	4,200				68.8	31.3	8.9	3.6	1.2	
80	4,800				89.2	40.5	11.4	4.6	1.6	
90	5,400					51	14.2	5.8	2	
100	6,000					62.2	17.4	7.1	2.4	
120	7,200						24.7	10.1	3.4	
140	8,400						33.2	13.5	4.5	1.2
160	9,600						43	17.5	5.8	1.5
200	12,000						66.3	27	8.9	2.3
260	15,600							45	14.8	3.7
300	18,000							59.6	19.5	4.9

Friction Loss Table – SCH 40 PVC

(Friction Loss in Feet of Head Per 100 Feet of Pipe)

GPM	GPH	1/2" ID 0.622"	3/4" ID 0.824"	1" ID 1.049"	1 1/4" ID 1.380"	1 1/2" ID 1.610"	2" ID 2.067"	2 1/2" ID 2.469"	3" ID 3.068"	4" ID 4.026"
2	120	4.1								
3	180	8.7	2.2							
4	240	14.8	3.7							
5	300	22.2	5.7	1.8						
6	360	31.2	8	2.5						
7	420	41.5	10.6	3.3						
8	480	53	13.5	4.2						
9	540	66	16.8	5.2						
10	600	80.5	20.4	6.3	1.7					
12	720		28.6	8.9	2.3	1.1				
14	840		38	11.8	3.1	1.4				
16	960		48.6	15.1	4	1.9				
20	1,200		60.5	22.8	6	2.8				
25	1,500			38.7	9.1	4.3	1.3			
30	1,800				12.7	6	1.8			
35	2,100				16.9	8	2.4			
40	2,400				21.6	10.2	3	1.1		
45	2,700				28	12.5	3.8	1.4		
50	3,000					15.4	4.6	1.7		
60	3,600					21.6	6.4	2.3		
70	4,200					28.7	8.5	3	1.2	
80	4,800					36.8	10.9	3.8	1.4	
90	5,400					45.7	13.6	4.8	1.8	
100	6,000					56.6	16.5	5.7	2.2	
120	7,200						23.1	8	3	
140	8,400						30.6	10.5	4	1.1
160	9,600						39.3	13.4	5	1.4
200	12,000						66.3	20.1	7.6	2.1
260	15,600							32.4	12.2	3.4
300	18,000							42.1	15.8	4.4

Friction Loss Table – VALVES and FITTINGS

(Friction Loss in Equivalent Number of Feet of Straight Pipe)

TYPE OF FITTING AND APPLICATION	PIPE AND FITTING	NOMINAL SIZE OF FITTING AND PIPE						
		1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"
		EQUIVALENT LENGTH OF PIPE(IN FEET)						
Insert Coupling	Plastic	3	3	3	3	3	3	3
Threaded Adapter (Plastic to Thread)	Plastic	3	3	3	3	3	3	3
90° Standard Elbow	Steel	2	2	3	4	4	5	6
	Plastic	2	2	3	4	4	5	6
Standard Tee (Flow Through Run)	Steel	1	2	2	3	3	4	4
	Plastic	1	2	2	3	3	4	4
Standard Tee (Flow Through Side)	Steel	4	5	6	7	8	11	13
	Plastic	4	5	6	7	8	11	13
Gate Valve[1]	Steel	1	1	1	1	2	2	2
Swing Check Valve[1]	Steel	5	7	9	12	13	17	21

NOTES:

Based on schedule 40 steel and plastic fittings.

Figures given are friction losses in terms of Equivalent Lenghts of straight pipe.

① Friction loss figures are for screwed valves and are based on equivalent lengths of steel pipe.

CONVERSION TABLES

UNITS OF FLOW

CONVERT TO ➧ / CONVERT FROM ⬇	U.S. GALLONS PER MINUTE	MILLION U.S. GALLONS PER DAY	CUBIC FEET PER SECOND	CUBIC METERS PER HOUR	LITERS PER SECOND
	MULTIPLY BY:				
(1) U.S. GALLON PER MINUTE	1	0.001440	0.00223	0.2271	0.0631
(1) MILLION U.S. GALLONS PER DAY	694.5	1	1.547	157.7	43.8
(1) CUBIC FOOT PER SECOND	448.83	0.646	1	101.9	28.32
(1) CUBIC METER PER HOUR	4.403	0.00634	0.00982	1	0.2778
(1) LITER PER SECOND	15.85	0.0228	0.0353	3.60	1

UNITS OF PRESSURE AND HEAD

CONVERT TO ➧ / CONVERT FROM ⬇	LBS. PER SQUARE INCH	FEET OF WATER ①	METERS OF WATER ①	INCHES OF MERCURY ②	ATMOSPHERES	KILOGRAMS PER SQUARE CM
	MULTIPLY BY:					
(1) LB. PER SQUARE INCH	1	2.31	0.704	2.04	0.0680	0.0703
(1) FOOT OF WATER ①	0.433	1	0.305	0.881	0.02945	0.0304
(1) METER OF WATER ①	1.42	3.28	1	2.89	0.0966	.1
(1) INCH OF MERCURY ②	0.491	1.135	0.346	1	0.0334	0.0345
(1) ATMOSPHERE (at Sea Level)	14.70	33.96	10.35	29.92	1	1.033
(1) KILOGRAM PER SQUARE CM	14.22	32.9	10	28.96	0.968	1

NOTES: ① Equivalent units are based on density of fresh water at 68°F.
② Equivalent units are based on density of mercury at 32°F.
Each 1,000 feet of ascent decreases pressure about ½ pound per square inch.

UNITS OF VOLUME AND WEIGHT

CONVERT TO ➧ / CONVERT FROM ⬇	U.S. GALLONS	IMPERIAL GALLONS	CUBIC INCHES	CUBIC FEET	ACRE FEET	POUNDS ③	CUBIC METERS	LITERS
(1) U.S. GALLON	1	0.833	231	0.1337	3.07×10^{-6}	8.34	0.003785	3.785
(1) IMPERIAL GALLON	1.201	1	277.4	0.1605	3.69×10^{-6}	10.01	0.004546	4.546
(1) CUBIC INCH	0.00433	0.00360	1	0.000579	—	0.0361	1.64×10^{-5}	0.0164
(1) CUBIC FOOT	7.48	6.23	1728	1	2.30×10^{-5}	62.4	0.02832	28.32
(1) ACRE FOOT	325,850	271,335	—	43,560	1	2.7×10^{6}	1233.5	1.23×10^{6}
(1) POUND ③	0.120	0.0998	27.7	0.0160	3.68×10^{-7}	1	4.54×10^{-4}	0.454
(1) CUBIC METER	264.2	220	61,024	35.315	8.11×10^{-4}	2202	1	1000
(1) LITER	0.2642	0.220	61.024	0.0353	8.11×10^{-7}	2.202	0.001	1

NOTES: ③ Weight equivalent basis water at 60°F.

UNITS OF LENGTH

(1) Inch = 0.0833 Ft. = 0.0278 Yd. = 25.4 mm = 2.54 cm
(1) Ft. = 12 Inches = 0.333 Yd. = 30.48 cm = 0.3048 Meter
(1) Yard = 36 Inches = 3 Ft. = 91.44 cm = 0.9144 Meters

(1) Mile = 5280 Ft. = 1760 Yds. = 1.61 km = 1609 Meters
(1) Meter = 3.281 Ft. = 39.37 In. = 0.000621 Miles = 0.001 km
(1) Kilometer = 1000 m = 1093.61 Yds. = 0.62137 Miles = 3281 Ft.

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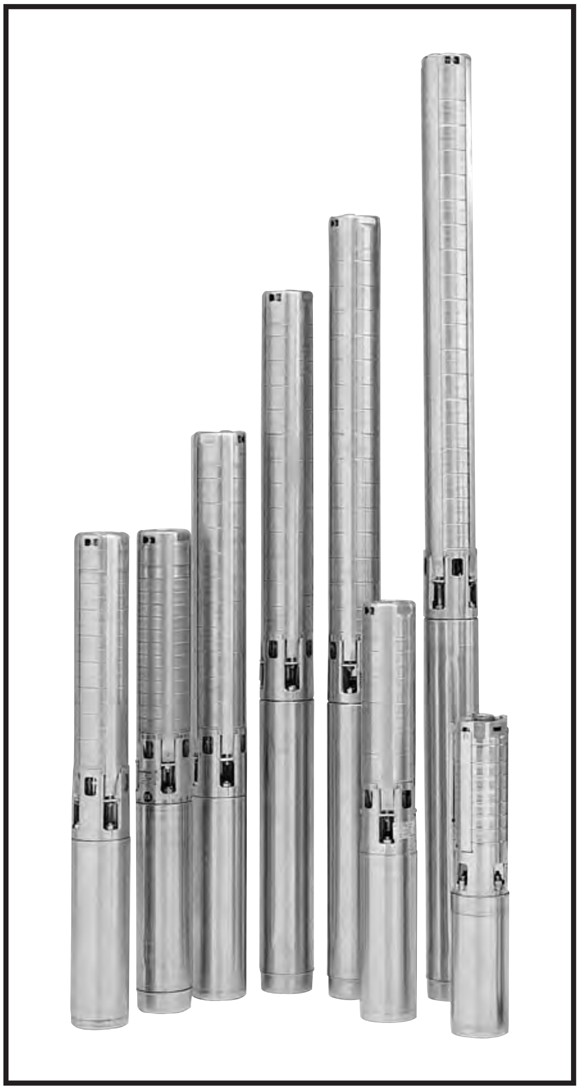
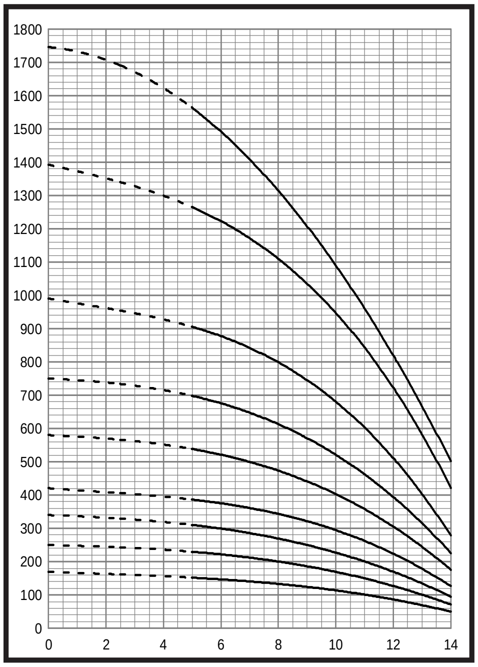
Easy Selection Chart
Performance Curves and Technical Data
4-Inch Submersible Pumps





Performance Curves

Materials of Construction

Grundfos Stainless Steel Submersible Pumps

4" Submersible Easy Selection Charts.

5 GPM

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE

(1.2 TO 7 GPM)

PUMP OUTLET
1 " NPT

			DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET																								
PUMP MODEL	**HP**	**PSI**	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**	**340**	**400**	**460**	**520**	**600**	**700**	**800**	**900**	**1000**	**1100**
5S03-9	**1/3**	0				7.1	6.7	6.2	5.8	5.3	4.8	4.3	3.2	2.1													
		20		7.0	6.6	6.1	5.7	5.2	4.6	4.0	2.8	1.6															
		30		6.5	6.0	5.6	5.1	4.6	3.8	2.9	1.5																
		40	6.7	6.0	5.5	5.1	4.4	3.8	2.4																		
		50	6.2	5.5	4.9	4.4	3.4	2.5	1.3																		
		60	5.6	4.9	4.2	3.5	1.9																				
SHUT-OFF PSI:			102	94	85	76	68	59	50	42	33	24	16	7													
5S05-13	**1/2**	0						7.1	6.8	6.4	6.1	5.8	5.5	5.2	4.8	4.5	3.9	2.3									
		20			7.3	7.0	6.7	6.3	6.0	5.7	5.4	5.1	4.7	4.3	3.7	3.1	2.0										
		30		7.2	6.9	6.6	6.3	6.0	5.7	5.4	5.0	4.7	4.2	3.7	2.8	2.0											
		40	7.2	6.9	6.6	6.3	5.9	5.6	5.3	5.0	4.6	4.2	3.5	2.8	1.6												
		50	6.8	6.5	6.2	5.9	5.6	5.3	4.9	4.6	4.0	3.5	2.6	1.6													
		60	6.5	6.2	5.8	5.5	5.2	4.9	4.5	4.0	3.3	2.6	1.3														
SHUT-OFF PSI:			152	143	134	126	117	108	100	91	82	74	65	56	48	39	30	13									
5S07-18	**3/4**	0								7.1	6.9	6.7	6.4	6.2	6.0	5.8	5.6	5.1	4.2	2.7							
		20						7.1	6.8	6.6	6.4	6.2	5.9	5.7	5.5	5.3	5.0	4.5	3.2								
		30					7.0	6.8	6.6	6.3	6.1	5.9	5.7	5.5	5.2	5.0	4.7	4.0	2.5								
		40			7.2	7.0	6.8	6.5	6.3	6.1	5.9	5.6	5.4	5.2	4.9	4.7	4.4	3.5	1.5								
		50		7.2	7.0	6.7	6.5	6.3	6.1	5.8	5.6	5.4	5.1	4.9	4.6	4.3	3.9	2.9									
		60	7.1	6.9	6.7	6.5	6.2	6.0	5.8	5.6	5.3	5.1	4.9	4.6	4.3	3.9	3.4	2.1									
SHUT-OFF PSI:			213	204	195	187	178	169	161	152	143	135	126	117	109	100	91	74	48	22							
5S10-22	**1**	0										7.1	6.9	6.7	6.6	6.4	6.2	5.8	5.3	4.7	3.8	1.7					
		20								7.1	6.9	6.7	6.5	6.3	6.1	6.0	5.8	5.4	4.8	4.0	2.8						
		30							7.0	6.8	6.7	6.5	6.3	6.1	5.9	5.7	5.6	5.2	4.6	3.6	2.1						
		40						7.0	6.8	6.6	6.5	6.3	6.1	5.9	5.7	5.5	5.4	5.0	4.3	3.1	1.3						
		50				7.2	7.0	6.8	6.6	6.4	6.2	6.1	5.9	5.7	5.5	5.3	5.1	4.7	3.9	2.5							
		60			7.1	6.9	6.8	6.6	6.4	6.2	6.0	6.0	5.7	5.5	5.3	5.1	4.9	4.4	3.5	1.7							
SHUT-OFF PSI:					245	237	228	219	211	202	194	185	176	168	159	150	142	124	98	72	46	12					
5S15-26	**1 1/2**	0												7.1	7.0	6.8	6.7	6.4	5.9	5.4	4.9	4.1	2.1				
		20										7.1	6.9	6.8	6.6	6.5	6.3	6.0	5.5	5.1	4.5	3.4					
		30									7.1	6.9	6.7	6.6	6.4	6.3	6.1	5.8	5.4	4.8	4.2	2.9					
		40								7.0	6.9	6.7	6.6	6.4	6.3	6.1	6.0	5.6	5.2	4.6	5.6	2.4					
		50							7.0	6.9	6.7	6.5	6.4	6.2	6.1	5.9	5.8	5.5	5.0	4.4	3.6	1.7					
		60						7.0	6.8	6.7	6.5	6.4	6.2	6.1	5.9	5.8	5.6	5.3	4.8	4.1	3.1						
SHUT-OFF PSI:								269	260	252	243	234	226	217	208	200	191	174	148	122	96	61	18				
5S15-31	**1 1/2**	0														7.1	7.0	6.7	6.3	5.9	5.5	6.7	4.1	2.6			
		20												7.1	6.9	6.8	6.7	6.4	6.0	5.6	5.2	4.6	3.5	1.6			
		30											7.0	6.9	6.8	6.6	6.5	6.2	5.9	5.5	5.1	4.4	3.2	0.9			
		40										7.0	6.9	6.8	6.6	6.5	6.4	6.1	5.7	5.3	4.9	4.2	2.8				
		50								7.1	7.0	6.9	6.7	6.6	6.5	6.3	6.2	6.0	5.6	5.2	4.7	4.0	2.3				
		60							7.1	7.0	6.8	6.7	6.6	6.5	6.3	6.2	6.1	5.8	5.4	5.0	4.5	3.7	1.7				
SHUT-OFF PSI:									320	311	303	294	285	277	268	259	251	233	207	181	155	121	77	34			

See 5S performance curves for higher head models.
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

7S EASY SELECTION CHART

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

7 GPM

FLOW RANGE

(3 TO 10 GPM)

PUMP OUTLET
1 " NPT

			DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET																							
PUMP MODEL	**HP**	**PSI**	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**	**340**	**400**	**460**	**520**	**600**	**700**	**800**	**900**	**1000**	**1100**
7S03-8	**1/3**	20	10.0	9.5	8.7	8.0	7.2	6.4	5.0	3.7	1.8																
		30	9.3	8.7	7.9	7.1	6.1	5.1	2.6																		
		40	8.5	7.8	7.0	6.1	4.5	2.9	1.5																		
		50	7.6	6.9	5.8	4.7	2.3																				
		60	6.7	5.8	3.9	2.0																					
SHUT-OFF PSI:			86	77	69	60	52	43	34	26	17	8															
7S05-11	**1/2**	0					9.9	9.5	8.9	8.4	7.8	7.3	6.7	6.0	5.0	4.0											
		20			9.8	9.3	8.8	8.2	7.7	7.1	6.5	5.8	4.7	3.5	1.8												
		30	10.1	9.7	9.2	8.7	8.1	7.6	7.0	6.4	5.6	4.7	2.9														
		40	9.6	9.2	8.6	8.1	7.5	6.9	6.2	5.6	4.3	3.0	1.5														
		50	9.1	8.5	8.0	7.4	6.8	6.2	5.3	4.3	2.2																
		60	8.4	7.9	7.3	6.8	6.0	5.3	3.8	2.3																	
SHUT-OFF PSI:			122	113	105	96	87	79	70	61	53	44	35	27	18	10											
7S07-15	**3/4**	0						10.2	9.9	9.5	9.2	8.8	8.4	8.0	7.6	7.1	6.7	5.6	2.9								
		20				10.1	9.8	9.4	9.0	8.6	8.2	7.8	7.4	7.0	6.5	6.1	5.4	3.6									
		30			10.0	9.7	9.4	9.0	8.6	8.2	7.8	7.4	6.9	6.5	5.9	5.4	4.5	1.8									
		40		10.0	9.7	9.3	8.9	8.5	8.1	7.7	7.3	6.9	6.4	5.9	5.2	4.5	3.2	1.0									
		50	9.9	9.6	9.2	8.9	8.5	8.1	7.6	7.2	6.8	6.4	5.8	5.2	4.2	3.2	1.6										
		60	9.5	9.2	8.8	8.4	8.0	7.6	7.2	6.7	6.2	5.7	4.9	4.2	2.8	1.4											
SHUT-OFF PSI:			170	101	153	144	135	127	118	110	101	92	84	75	66	58	49	32	6								
7S10-19	**1**	0								10.1	9.8	9.6	9.3	9.0	8.7	8.4	8.0	7.4	6.4	4.8							
		20						10.0	9.8	9.5	9.2	8.9	8.6	8.3	7.9	7.6	7.3	6.6	5.3	2.8							
		30					10.0	9.7	9.5	9.2	8.9	8.5	8.2	7.9	7.6	7.3	6.9	6.2	4.6	1.4							
		40				10.0	9.7	9.4	9.1	8.8	8.5	8.2	7.8	7.5	7.2	6.9	6.5	5.6	3.7								
		50		10.2	9.9	9.7	9.4	9.1	8.8	8.4	8.1	7.8	7.5	7.2	6.8	6.5	6.0	5.0	2.4								
		60	10.1	9.9	9.6	9.3	9.0	8.7	8.4	8.1	7.8	7.4	7.1	6.8	6.4	6.0	5.5	4.2									
SHUT-OFF PSI:			218	209	200	192	183	174	166	157	148	140	131	123	114	105	97	79	53	27							
7S15-26	**1 1/2**	0											10.1	9.9	9.7	9.5	9.3	8.8	8.1	7.4	6.7	5.5					
		20									10.0	9.8	9.6	9.4	9.2	9.0	8.8	8.3	7.6	6.9	6.1	4.4					
		30								10.0	9.8	9.6	9.4	9.2	9.0	8.7	8.5	8.0	7.3	6.6	5.7	3.7					
		40						10.1	10.0	9.8	9.6	9.4	9.1	8.9	8.7	8.5	8.2	7.8	7.1	6.3	5.2	2.9					
		50					10.1	9.9	9.7	9.6	9.3	9.1	8.9	8.7	8.4	8.2	8.0	7.5	6.8	5.9	4.7	1.9					
		60				10.1	9.9	9.7	9.5	9.3	9.1	8.9	8.6	8.4	8.2	7.9	7.7	7.2	6.5	5.5	4.1						
SHUT-OFF PSI:						274	265	257	248	239	231	222	213	205	196	187	179	161	135	110	84	49					
7S20-32	**2**	0	0										10.6	10.5	10.4	10.4	10.3	10.1	9.6	9.1	8.4	7.3	5.7				
		20	46.2								10.5	10.5	10.4	10.3	10.3	10.2	10.0	9.8	9.2	8.6	7.8	6.6	4.8				
		30	69.3							10.5	10.5	10.4	10.3	10.2	10.1	10.0	9.9	9.6	9.0	8.3	7.5	6.2	4.3				
		40	92.4						10.5	10.5	10.4	10.3	10.2	10.1	10.0	9.9	9.7	9.4	8.8	8.0	7.2	5.8	3.9				
		50	116						10.5	10.4	10.3	10.2	10.1	10.0	9.8	9.7	9.5	9.1	8.5	7.7	6.8	5.4	3.3				
		60	139					10.5	10.4	10.3	10.2	10.1	10.0	9.8	9.7	9.5	9.3	8.9	8.2	7.4	6.4	5.0					
SHUT-OFF PSI:							343	334	326	317	308	300	291	282	274	265	256	239	213	187	161	126	83				

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

10 GPM

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE

(5 TO 14 GPM)

PUMP OUTLET
1 1/4" NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

PUMP MODEL	HP	PSI	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
10S03-6	**1/3**	20	14.0	13.2	12.4	10.6	8.9	5.3																			
		30	13.2	11.8	10.4	8.4																					
		40	11.9	10.1	8.3																						
		50	9.8	7.5																							
		60	7.7	3.9																							
SHUT-OFF PSI:			64	55	47	38	29	21	12	3																	
10S05-9	**1/2**	0				14.1	13.4	12.4	11.4	10.4	9.5	8.3	6.6	3.5													
		20		13.9	13.1	12.1	11.1	10.1	9.2	7.9	5.8	2.0															
		30	13.8	13.0	12.0	11.0	10.0	9.0	7.6	5.3	1.2																
		40	12.8	11.8	10.8	9.8	8.8	7.3	4.8																		
		50	11.7	10.7	9.7	8.6	7.0	4.3																			
		60	10.5	9.5	8.4	6.7	3.7																				
SHUT-OFF PSI:			100	92	83	74	66	57	48	40	31	23	14	5													
10S07-12	**3/4**	0					14.3	13.8	13.2	12.5	11.7	11.0	10.2	9.5	8.7	7.6	6.0										
		20			14.2	13.6	12.9	12.2	11.5	10.7	10.0	9.3	8.4	7.2	5.4	2.6											
		30		14.1	13.5	12.9	12.1	11.4	10.6	9.9	9.2	8.2	7.0	5.0	2.0												
		40	14.0	13.4	12.8	12.0	11.3	10.5	9.8	9.0	8.1	6.7	4.7	1.4													
		50	13.3	12.6	11.9	11.1	10.4	9.7	8.9	7.9	6.5	4.2															
		60	12.5	11.8	11.0	10.3	9.6	8.8	7.7	6.2	3.8																
SHUT-OFF PSI:			137	129	120	111	103	94	85	77	68	59	51	42	33	25	16										
10S10-15	**1**	0							14.1	13.6	13.1	12.5	11.9	11.3	10.7	10.1	9.6	8.2	3.8								
		20					13.9	13.5	12.9	12.3	11.7	11.1	10.5	10.0	9.4	8.7	7.9	5.2									
		30				13.9	13.4	12.8	12.2	11.6	11.0	10.5	9.9	9.3	8.6	7.7	6.6	2.6									
		40		14.2	13.8	13.3	12.7	12.1	11.5	10.9	10.4	9.8	9.2	8.5	7.6	6.3	4.6										
		50	14.1	13.7	13.2	12.6	12.1	11.4	10.9	10.3	9.7	9.1	8.3	7.4	6.1	4.3	1.7										
		60	13.6	13.1	12.6	12.0	11.4	10.8	10.2	9.6	9.0	8.2	7.2	5.9	3.9												
SHUT-OFF PSI:			174	165	157	148	139	131	122	113	105	96	87	79	70	61	53	35	10								
10S15-21	**1 1/2**	0									14.2	13.9	13.6	13.3	12.9	12.5	12.0	11.2	9.9	8.5	6.3						
		20							14.1	13.9	13.5	13.1	12.7	12.3	11.9	11.5	11.0	10.2	8.9	6.9	2.9						
		30						14.1	13.8	13.5	13.1	12.7	12.3	11.8	11.4	11.0	10.5	9.7	8.3	5.7							
		40					14.1	13.8	13.4	13.0	12.6	12.2	11.8	11.3	10.9	10.5	10.1	9.2	7.5	4.1							
		50				14.0	13.7	13.3	13.0	12.5	12.1	11.7	11.3	10.8	10.4	10.0	9.6	8.7	6.5	2.0							
		60		14.2	14.0	13.6	13.3	12.9	12.5	12.1	11.6	11.2	10.8	10.4	9.9	9.5	9.1	8.0	5.1								
SHUT-OFF PSI:				237	229	220	211	203	194	185	177	168	159	151	142	133	125	107	81	55	29						
10S20-27	**2**	0												14.1	13.9	13.7	13.4	12.8	11.8	10.8	9.8	8.3	4.7				
		20										14.1	13.8	13.6	13.3	13.0	12.7	12.0	11.0	10.0	9.0	7.1	1.5				
		30									14.0	13.8	13.5	13.3	12.9	12.6	12.3	11.6	10.6	9.7	8.6	6.2					
		40							14.2	14.0	13.8	13.5	13.2	12.9	12.6	12.2	11.9	11.2	10.3	9.3	8.1	5.2					
		50						14.2	14.0	13.7	13.5	13.2	12.8	12.5	12.2	11.9	11.5	10.9	9.9	8.9	7.4	3.8					
		60					14.1	13.9	13.7	13.4	13.1	12.8	12.5	12.1	11.8	11.5	11.1	10.5	9.5	8.4	6.6	2.1					
SHUT-OFF PSI:							285	276	268	259	250	242	233	224	216	207	198	181	155	129	103	68	25				
10S30-34	**3**	0																13.8	13.2	12.5	11.9	10.9	9.6	7.9	4.8		
		20														13.9	13.7	13.3	12.7	12.0	11.3	10.3	8.9	6.7	2.7		
		30													13.9	13.7	13.5	13.1	12.4	11.7	11.0	10.0	8.5	6.0	1.3		
		40											14.0	13.8	13.7	13.5	13.3	12.8	12.2	11.5	10.8	9.7	8.0	5.1			
		50										14.0	13.8	13.6	13.4	13.2	13.0	12.6	11.9	11.2	10.5	9.4	7.5	4.2			
		60										13.8	13.6	13.4	13.2	13.0	12.8	12.3	11.6	10.9	10.2	9.0	6.9	3.1			
SHUT-OFF PSI:												332	324	315	306	298	289	272	246	220	194	159	116	73	29		

See 10S performance curves for higher head models.
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

16S EASY SELECTION CHART

16 GPM

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE

(10 TO 20 GPM)

PUMP OUTLET
1 1/4 " NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

PUMP MODEL	HP	PSI	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
16S05-5	1/2	20	20.3	18.2	14.1	10.0	5.0																				
		30	17.3	14.4	8.0	1.6																					
		40	12.7	8.0	4.0																						
		50	6.5																								
		60	2.9																								
SHUT-OFF PSI:			58	49	40	32	23	14																			
16S07-8	3/4	0					20.5	19.2	17.5	15.8	12.8	9.8	5.2														
		20			20.1	18.8	16.9	15.2	11.8	8.5	4.3																
		30	21.2	19.9	18.4	16.9	14.3	11.8	7.5	3.2	1.6																
		40	19.7	18.3	16.3	14.3	10.8	7.2	3.6																		
		50	17.9	16.3	13.5	10.7	6.2	1.7																			
		60	15.7	13.5	9.6	5.8	2.9																				
SHUT-OFF PSI:			97	88	80	71	62	54	45	36	28	19	10														
16S10-10	1	0						20.8	19.8	18.8	17.3	15.9	13.7	11.4	8.0	4.7											
		20				20.5	19.4	18.3	16.8	15.3	12.9	10.5	7.0	3.5	1.8												
		30			20.3	19.3	18.1	16.8	14.8	12.8	9.8	6.7	3.3														
		40		20.2	19.1	18.0	16.4	14.8	12.2	9.6	5.9	2.3															
		50	20.0	19.0	17.7	16.3	14.2	12.0	8.8	5.6	2.8																
		60	18.8	17.6	15.8	14.1	11.3	8.6	4.8																		
SHUT-OFF PSI:			123	115	106	97	89	80	71	63	54	45	37	28	19	11											
16S15-14	1 1/2	0								21.0	20.3	19.6	18.8	18.0	16.9	15.8	14.3	10.7	3.3								
		20							20.1	19.3	18.5	17.7	16.6	15.4	13.8	12.2	10.0	5.1									
		30					20.7	20.0	19.2	18.4	17.4	16.5	15.1	13.7	11.8	9.8	7.3	2.4									
		40				20.6	19.8	19.1	18.3	17.4	16.0	15.0	13.3	11.6	9.3	7.0	4.3										
		50			20.4	19.8	18.9	18.2	17.2	16.1	14.7	13.2	11.2	9.1	6.5	3.9	2.0										
		60		20.3	19.6	18.8	18.0	17.1	15.8	14.5	12.8	11.0	8.6	6.3	3.4												
SHUT-OFF PSI:				167	158	149	141	132	123	115	106	97	89	80	71	63	54	37	28								
16S20-18	2	0										21.2	20.6	20.0	19.5	18.9	18.2	16.7	13.5	8.8	2.7						
		20									20.4	19.8	19.3	18.7	18.0	17.3	16.4	14.3	10.0	4.2							
		30								20.3	19.8	19.2	18.6	17.9	17.2	16.3	15.3	12.8	7.9	1.9							
		40							20.3	19.7	19.1	18.5	17.8	17.1	16.1	15.2	13.9	11.1	5.7								
		50						20.2	19.6	19.0	18.3	17.7	16.8	16.0	14.9	13.8	12.3	9.2	3.2								
		60					20.1	19.5	18.9	18.3	17.5	16.8	15.8	14.8	13.5	12.3	10.6	7.0									
SHUT-OFF PSI:							194	186	177	168	160	151	142	134	125	116	108	90	65	39	13						
16S30-24	3	0																19.6	18.3	16.5	14.2	9.8	2.1				
		20													20.3	19.9	19.5	18.6	17.0	14.8	11.8	6.5					
		30												20.3	19.8	19.4	19.0	18.0	16.3	13.7	10.4	4.7					
		40											20.2	19.8	19.3	18.9	18.4	17.3	15.3	12.5	8.9	2.8					
		50										20.2	19.8	19.3	18.8	18.3	17.8	16.7	14.3	11.3	7.3						
		60									20.1	19.7	19.2	18.8	18.3	17.8	17.2	15.8	13.3	9.8	5.5						
SHUT-OFF PSI:											239	230	221	213	204	195	187	169	143	117	91	57	13				
16S50-38	5	0																			21.5	20.4	18.7	16.5	13.4	8.9	2.1
		20																			20.9	19.6	17.7	15.2	11.5	6.1	
		30																		21.4	20.5	19.2	17.2	14.5	10.5	4.5	
		40																		21.1	20.2	18.8	16.7	13.7	9.3	2.7	
		50																	21.6	20.7	19.8	18.4	16.1	12.8	8.0	0.8	
		60																	21.3	20.4	19.4	17.9	15.4	11.9	6.6		
SHUT-OFF PSI:																			314	288	262	227	184	141	98	54	11

See 16S performance curves for higher head models.
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

25 GPM

SELECTION CHARTS

FLOW RANGE

PUMP OUTLET
1 1/2" NPT

(Ratings are in GALLONS PER MINUTE-GPM)

(18 TO 32 GPM)

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

PUMP MODEL	HP	PSI	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
25S05-3	1/2	20	18.6	6.5	3.3																						
		30	10.5																								
		40																									
		50																									
		60																									
SHUT-OFF PSI:			31	22	13	5																					
25S07-5	3/4	0			34.5	29.8	23.9	18.1																			
		20	32.9	28.6	21.8	15.1	7.5																				
		30	27.1	22.5	12.3	2.0																					
		40	19.5	11.8	5.8																						
		50	10.1																								
		60	4.1																								
SHUT-OFF PSI:			57	48	39	31	22	13																			
25S10-7	1	0					31.3	28.5	24.3	20.2	12.7	5.1															
		20		33.2	30.3	27.6	22.9	18.3	10.4	2.5	1.3																
		30	33.0	29.9	26.5	23.1	13.0	9.6	4.8																		
		40	29.4	26.6	21.3	16.2	8.2																				
		50	25.3	21.5	14.3	7.0	3.5																				
		60	19.7	13.9	7.0																						
SHUT-OFF PSI:			83	74	65	57	48	39	31	22	13	5															
25S15-9	1 1/2	0						32.2	30.0	27.9	24.8	21.6	16.3	10.8													
		20				31.5	29.3	27.2	23.7	20.3	14.5	8.8	4.4														
		30			31.3	29.1	26.4	23.7	18.9	14.2	7.8	1.5															
		40		30.8	28.6	26.3	22.6	18.8	12.8	6.8	3.4																
		50	30.6	28.4	25.5	22.5	17.4	12.3	6.2																		
		60	27.8	25.5	21.3	17.2	11.0	4.8	2.4																		
SHUT-OFF PSI:			109	100	91	83	74	65	57	48	39	31	22	13													
25S20-11	2	0						33.1	31.1	29.3	27.6	25.1	22.5	18.5	14.5	9.3											
		20					32.5	30.6	28.8	27.0	24.3	21.5	17.3	13.0	7.8	2.5											
		30				32.0	30.3	28.7	26.4	24.2	20.6	16.9	12.0	7.0	3.5												
		40			31.8	30.1	28.2	26.3	23.3	20.4	15.9	11.4	6.3														
		50		31.5	29.8	28.1	25.7	23.3	19.4	15.6	10.4	5.3	2.7														
		60	31.3	29.6	27.6	25.6	22.4	19.3	14.5	9.8	4.9																
SHUT-OFF PSI:			135	126	118	109	100	92	83	74	66	57	48	40	31	23											
25S30-15	3	0										32.3	31.0	29.8	28.4	27.1	25.2	20.7									
		20								31.8	30.6	29.3	28.0	26.6	24.6	22.7	19.8	13.5									
		30						33.0	31.7	30.4	29.2	27.8	26.2	24.5	22.1	19.7	16.4	9.3									
		40					32.8	31.5	30.3	29.0	27.5	26.0	24.0	21.9	19.0	16.1	12.4	4.9									
		50				32.6	31.3	30.0	28.7	27.4	25.7	23.8	21.3	18.8	15.3	12.0	8.2	2.2									
		60			32.4	31.1	29.8	28.6	27.0	25.5	23.3	21.2	18.1	15.0	11.3	7.6	3.8										
SHUT-OFF PSI:					170	161	152	144	135	126	118	109	100	92	83	74	66	48									
25S50-26	5	0																32.5	30.3	28.0	25.3	19.9	10.2				
		20															32.3	30.8	28.6	25.9	22.5	15.8	5.0				
		30														32.1	31.3	29.9	27.7	24.7	20.8	13.5	2.5				
		40													32.0	31.3	30.5	29.1	26.7	23.3	18.9	11.0					
		50											32.7	31.8	31.2	30.4	29.7	28.2	25.5	21.8	16.8	8.5					
		60										32.5	31.8	31.0	30.3	29.6	28.8	27.3	24.3	20.0	14.6	5.8					
SHUT-OFF PSI:												253	245	236	227	219	210	193	167	141	115	80	37				

See 25S performance curves for higher head models.
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

40S EASY SELECTION CHART

40 GPM

SELECTION CHARTS FLOW RANGE PUMP OUTLET

(Ratings are in GALLONS PER MINUTE-GPM) (24 TO 55 GPM) 2 " NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

PUMP MODEL	HP	PSI		20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
40S10-3	1	20	46.2	33.0																								
		30	69.3																									
		40	92.4																									
		50	116																									
		60	139																									
SHUT-OFF PSI:			0	28	19	11	2																					
40S15-5	1 1/2	0	0				52.0	41.0	24.0																			
		20	46.2	57.0	50.0	37.0	18.0																					
		30	69.3	48.0	34.0	15.0																						
		40	92.4	31.0	11.0																							
		50	116	7.0																								
		60	139																									
SHUT-OFF PSI:			0	52	44	35	26	18	9																			
40S20-7	2	0	0					54.0	49.0	40.0	29.0	15.0																
		20	46.2			53.0	46.0	37.0	25.0	10.0																		
		30	69.3		52.0	45.0	35.0	23.0	8.0																			
		40	92.4	51.0	44.0	33.0	21.0	5.0																				
		50	116	42.0	32.0	18.0	2.0																					
		60	139	30.0	16.0																							
SHUT-OFF PSI:			0	77	68	59	51	42	33	25	16	7																
40S30-9	3	0	0							53.0	47.0	41.0	32.0	22.0														
		20	46.2					51.0	45.0	38.0	29.0	19.0																
		30	69.3				50.0	44.0	37.0	28.0	17.0																	
		40	92.4		54.0	50.0	43.0	35.0	26.0	15.0																		
		50	116	54.0	49.0	42.0	34.0	24.0	13.0																			
		60	139	48.0	41.0	33.0	23.0	11.0																				
SHUT-OFF PSI:			0	102	94	85	76	68	59	50	42	33	24	16	7													
40S50-12	5	0	0									53.0	49.0	44.0	39.0	32.0	25.0	16.0										
		20	46.2							52.0	48.0	43.0	37.0	30.0	22.0	13.0												
		30	69.3						51.0	47.0	42.0	36.0	29.0	21.0	12.0													
		40	92.4					51.0	46.0	41.0	35.0	28.0	20.0	11.0														
		50	116			54.0	50.0	45.0	40.0	34.0	26.0	18.0	9.0															
		60	139		53.0	49.0	45.0	39.0	33.0	25.0	17.0	8.0																
SHUT-OFF PSI:			0		130	122	113	104	96	87	78	70	61	52	44	35	26	18										
40S50-15	5	0	0											52.0	49.0	46.0	42.0	37.0	26.0									
		20	46.2									51.0	48.0	45.0	40.0	35.0	30.0	24.0										
		30	69.3								51.0	48.0	44.0	40.0	35.0	29.0	23.0	16.0										
		40	92.4							51.0	47.0	43.0	39.0	34.0	28.0	21.0	14.0											
		50	116						50.0	47.0	43.0	38.0	33.0	27.0	20.0	13.0												
		60	139					50.0	46.0	42.0	37.0	32.0	26.0	19.0	12.0													
SHUT-OFF PSI:			0					141	132	124	115	107	98	89	81	72	63	55	37	11								
40S75-21	7 1/2	0	0																49.0	41.0	29.0	15.0						
		20	46.2													53.0	51.0	48.0	43.0	32.0	19.0							
		30	69.3												52.0	50.0	48.0	45.0	39.0	27.0	13.0							
		40	92.4											52.0	50.0	48.0	45.0	42.0	35.0	22.0	6.0							
		50	116										52.0	50.0	47.0	44.0	41.0	38.0	30.0	16.0								
		60	139									51.0	49.0	47.0	44.0	41.0	38.0	34.0	25.0	10.0								
SHUT-OFF PSI:			0									181	172	163	155	146	137	129	111	85	59	33						
40S75-25	7 1/2	0	0																	51.0	45.0	37.0	23.0					
		20	46.2																52.0	47.0	39.0	29.0	14.0					
		30	69.3															54.0	50.0	44.0	35.0	25.0						
		40	92.4														54.0	52.0	48.0	41.0	32.0	21.0						
		50	116													53.0	52.0	50.0	45.0	38.0	28.0							
		60	139												53.0	51.0	49.0	47.0	43.0	34.0	24.0							
SHUT-OFF PSI:			0												203	194	186	177	160	134	108	82	47					
*40S100-30 40S100-30	10	0	0																		53.0	49.0	41.0	27.0				
		20	46.2																	54.0	50.0	44.0	35.0	20.0				
		30	69.3																	52.0	48.0	42.0	32.0	16.0				
		40	92.4																	51.0	46.0	39.0	28.0	12.0				
		50	116																	49.0	43.0	36.0	25.0	8.0				
		60	139																52.0	47.0	41.0	33.0	21.0					
SHUT-OFF PSI:																			222	196	170	144	110	66	23			

*** 6" Motor**

See 40S performance curves for higher head models.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

60 GPM

SELECTION CHARTS

(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE

(40 TO 75 GPM)

PUMP OUTLET

2 " NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

PUMP MODEL	HP	PSI	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
60S20-4	**2**	20	72.3	64.5	38.6	12.7	6.3																				
		30	58.6	44.9	22.4																						
		40	30.4																								
		50	17.9																								
		60																									
SHUT-OFF PSI:			46	37	29	20	11	3																			
60S30-5	**3**	0				74.8	66.8	58.8	34.3																		
		20	77.8	72.9	63.8	54.8	27.4																				
		30	76.0	64.3	47.3	30.0	15.0																				
		40	60.4	49.9	25.0																						
		50	40.4	19.4	9.8																						
		60	22.0																								
SHUT-OFF PSI:			60	51	42	34	25	16	8																		
60S50-7	**5**	0					77.5	73.8	68.4	63.1	52.2	41.3															
		20			76.3	72.4	66.6	61.1	48.3	35.8	17.9																
		30		76.0	71.3	66.5	57.8	49.2	24.6																		
		40	75.1	71.0	64.6	58.2	43.8	29.4	14.8																		
		50	69.7	64.6	54.8	44.9	22.5																				
		60	62.3	55.3	38.7	22.0	11.0																				
SHUT-OFF PSI:			88	80	71	62	54	45	36	28	19	10															
60S50-9	**5**	0							74.8	71.7	67.3	63.0	55.6	48.2	32.8	17.3											
		20					73.8	70.5	65.9	61.3	53.0	44.8	27.5	10.2	5.1												
		30			76.5	73.5	69.6	65.7	59.4	53.2	40.7	28.1	14.0														
		40		76.2	72.8	69.3	64.3	59.4	50.3	41.0	20.5																
		50	75.5	72.5	68.3	64.2	57.3	50.4	36.3	22.2	11.1																
		60	71.7	68.1	62.7	57.3	47.1	36.8	18.4																		
SHUT-OFF PSI:			115	106	98	89	81	72	63	55	46	37	29	20	11	3											
***60S75-13**	**7 1/2**	0									77.3	75.4	73.1	70.7	67.8	64.8	60.7	50.0	21.5								
		20							76.8	74.8	72.3	69.9	66.8	63.8	59.3	55.0	47.9	28.9									
		30						76.6	74.3	72.1	69.3	66.6	62.8	59.2	53.3	47.7	38.2	14.3									
		40					76.2	74.1	71.6	69.1	65.8	62.7	57.9	53.3	45.6	37.9	25.0	6.0									
		50				75.9	73.6	71.3	68.4	65.6	61.7	57.7	51.6	45.4	35.0	24.7	12.3										
		60			75.5	73.3	70.8	68.2	64.8	61.4	56.3	51.3	43.1	34.8	20.8	6.8											
SHUT-OFF PSI:					152	143	134	126	117	108	100	91	82	74	65	56	48	30	4								
***60S100-18**	**10**	0													76.5	75.0	73.3	69.8	63.1	52.6	35.8						
		20											76.1	74.6	72.8	71.2	69.2	64.7	55.8	40.0	14.2						
		30										75.9	74.3	72.7	70.8	68.9	66.7	61.6	50.9	31.5							
		40									75.7	74.1	72.3	70.6	68.5	66.5	63.9	58.0	45.0	20.7							
		50								75.4	73.8	72.1	70.2	68.3	66.0	63.7	60.7	53.6	37.5	10.0							
		60							75.2	73.6	71.8	70.0	67.8	65.8	63.1	60.5	56.8	48.2	28.3								
SHUT-OFF PSI:									186	177	169	160	152	143	134	126	117	100	74	46	22						

*** 6" Motor**

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

75S EASY SELECTION CHART

75 GPM

SELECTION CHARTS
(Ratings are in GALLONS PER MINUTE-GPM)

FLOW RANGE
(45 TO 95 GPM)

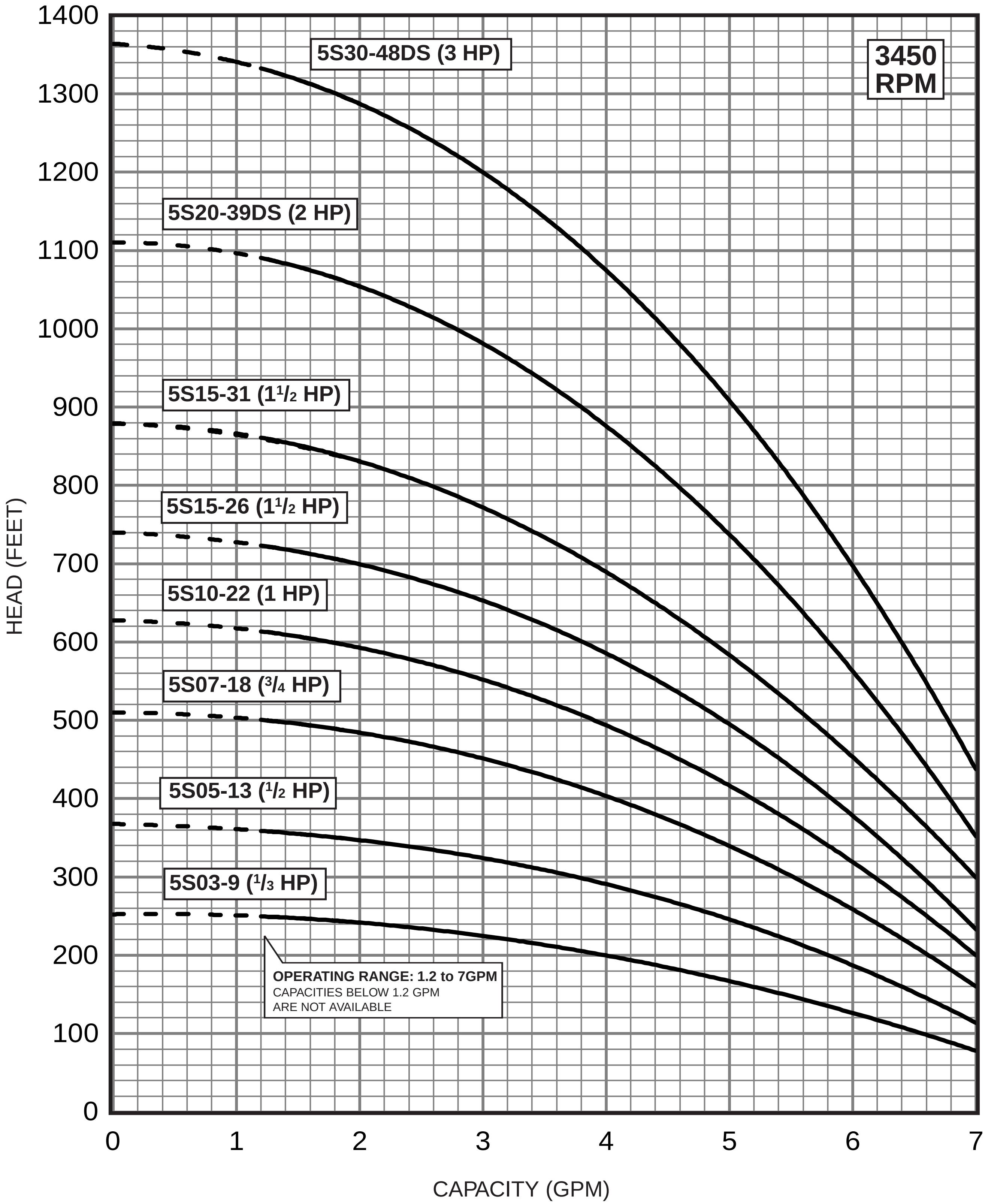
PUMP OUTLET
2" NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

PUMP MODEL	HP	PSI	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
75S20-3	2	20	69.6	45.8	22.9																						
		30	36.2																								
		40	12.4																								
		50																									
		60																									
SHUT-OFF PSI:			32	23	14	6																					
75S30-5	3	0			89.8	90.2	78.8	67.6																			
		20	96.3	86.8	74.8	62.9	31.5																				
		30	85.8	74.2	51.8	29.5	14.8																				
		40	70.2	57.1	28.6																						
		50	35.3																								
		60	24.2																								
SHUT-OFF PSI:			58	49	41	32	23	15																			
75S50-8	5	0						93.3	86.5	79.6	72.0	64.5	46.9	29.4													
		20			97.4	91.3	84.7	77.5	69.4	61.3	40.3	19.4	9.8														
		30		96.9	90.1	83.3	76.3	69.3	56.3	43.1	21.6																
		40	95.5	89.1	82.3	75.4	66.5	57.5	28.8																		
		50	88.0	81.2	73.9	66.7	51.2	35.8	17.9																		
		60	80.2	73.3	63.2	53.0	26.5																				
SHUT-OFF PSI:			98	90	81	72	64	55	46	38	29	20	12	3													
*75S75-11	7 1/2	0								97.8	93.3	88.8	84.3	79.8	75.1	70.4	63.7	43.4									
		20						96.5	92.0	87.4	82.9	78.3	73.5	68.8	61.4	54.0	38.8	11.8									
		30					95.7	91.3	86.8	82.2	77.6	73.1	67.3	61.4	50.3	39.3	19.7										
		40				95.2	90.6	86.0	81.5	77.0	72.0	67.0	58.9	50.8	33.5	16.3	8.2										
		50			94.3	89.9	85.3	80.8	76.2	71.6	65.3	59.0	46.6	34.2	17.1												
		60	97.9	93.8	89.2	84.6	80.1	75.6	70.3	65.2	56.1	47.0	23.5														
SHUT-OFF PSI:			151	142	133	125	116	107	99	90	81	73	64	55	47	38	29	12									
*75S100-15	10	0											96.7	93.4	90.0	86.5	83.2	76.3	64.7	40.9							
		20									95.7	92.4	88.9	85.5	82.1	78.7	75.2	67.4	49.3	12.5							
		30								95.3	91.8	88.4	85.0	81.5	78.2	74.8	70.9	61.6	37.1								
		40						98.0	94.7	91.3	87.8	84.4	81.0	77.7	74.1	70.6	66.0	54.0	19.9								
		50					97.3	94.3	90.8	87.3	83.9	80.5	77.1	73.7	69.7	65.8	59.8	43.5									
		60				97.0	93.7	90.3	86.8	83.3	80.0	76.6	73.0	69.3	64.5	59.6	51.5	21.7									
SHUT-OFF PSI:						178	170	161	152	144	135	126	118	109	100	92	83	66	40	14							

*** 6" Motor** Performance is the same at Best Efficiency Point only, consult factory for actual performance.
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

FLOW RANGE: 1.2 - 7 GPM **OUTLET SIZE: 1" NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 3450 RPM.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 2 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
5S03-9	A	1/3	4"	1" NPT	22.3	8.8	13.5	3.8	3.9	27
5S05-13	A	1/2	4"	1" NPT	26.4	9.5	16.9	3.8	3.9	31
5S07-18	A	3/4	4"	1" NPT	31.7	10.7	21.0	3.8	3.9	34
5S10-22	A	1	4"	1" NPT	36.1	11.8	24.3	3.8	3.9	42
5S15-26	A	1 1/2	4"	1" NPT	41.2	13.6	27.6	3.8	3.9	46
5S15-31	A	1 1/2	4"	1" NPT	47.1	13.6	33.5	3.8	3.9	58
5S20-39DS	A	2	4"	1" NPT	55.2	15.1	40.1	3.8	3.9	65
5S30-48DS	A	3	4"	1" NPT	70.0	20.6	45.8	3.8	3.9	90

NOTES: All models suitable for use in 4" wells.
Weights include pump end with motor in lbs.

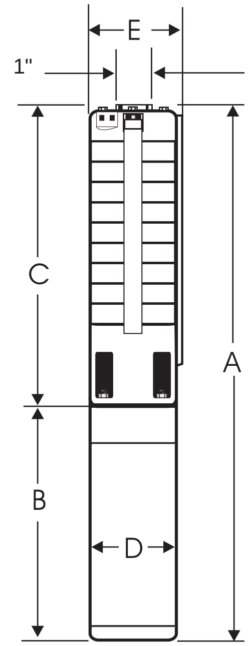


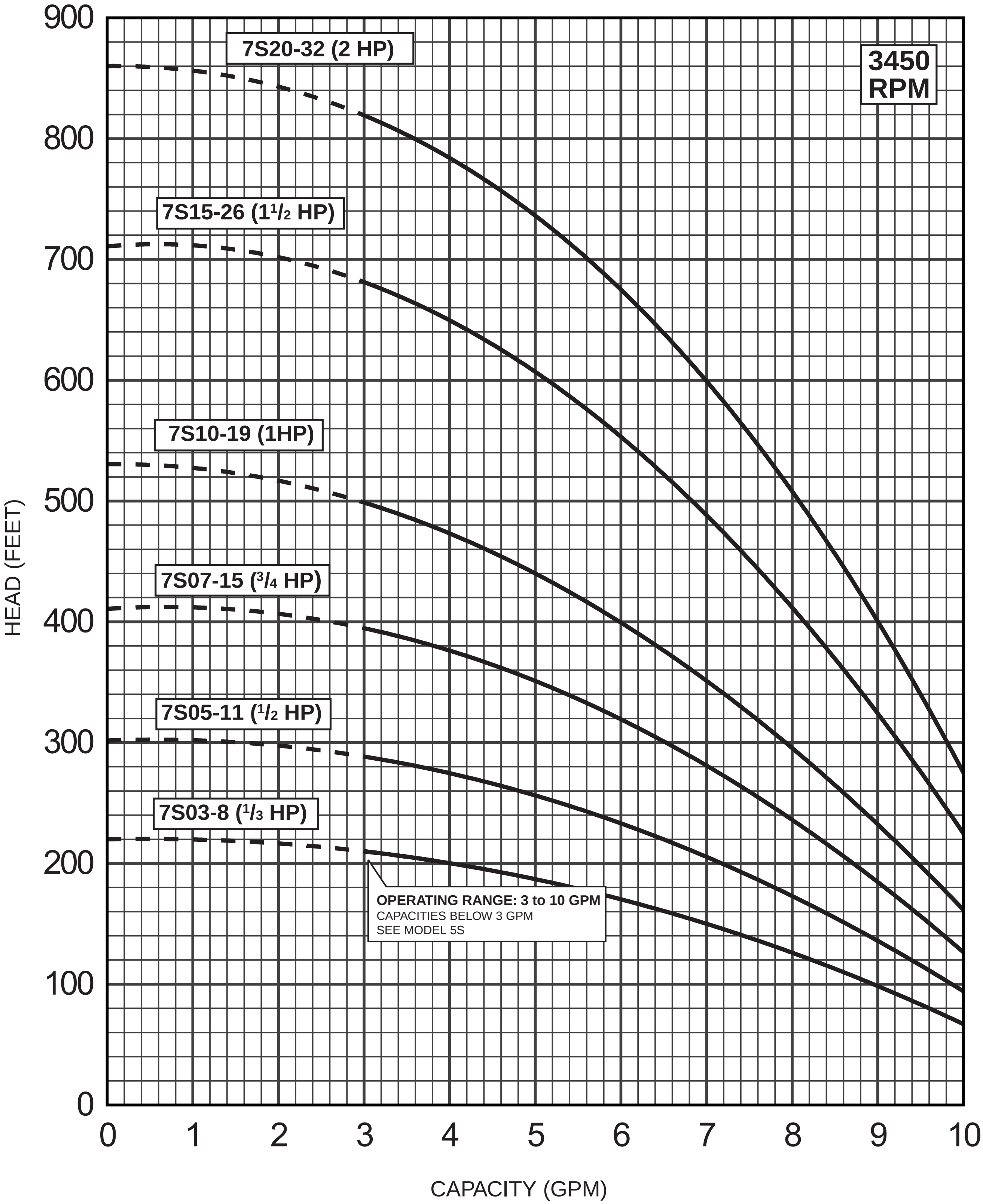
Fig. A

MATERIALS OF CONSTRUCTION

COMPONENT	SPLINED SHAFT (9-26 Stgs.)	CYLINDRICAL SHAFT (31-48 Stgs.)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel
Pump Shaft	304 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	316 Stainless Steel
Coupling	329/420/431 Stainless Steel	329/420/431 Stainless Steel
Check Valve Seat	NBR/304 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR/304 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/PBT (Valox®)	NBR/PPS (Ryton®)
Intermediate Bearings	NBR	304 Stainless Steel
Shaft Washer	Not Required	LCP (Vectra®)
Split Cone	Not Required	304 Stainless Steel
Split Cone Nut	Not Required	316 Stainless Steel

NOTES: Specifications subject to change without notice.
Valox® is a registered trademark of General Electric Co.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
Ryton® is a registered trademark of Phillips 66.

FLOW RANGE: 3 -10 GPM **OUTLET SIZE: 1" NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 3450 RPM.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 2 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
7S03-8	A	1/3	4"	1" NPT	21.5	8.8	12.7	3.8	3.9	27
7S05-11	A	1/2	4"	1" NPT	24.7	9.5	15.2	3.8	3.9	30
7S07-15	A	3/4	4"	1" NPT	29.2	10.7	18.5	3.8	3.9	33
7S10-19	A	1	4"	1" NPT	33.6	11.8	21.8	3.8	3.9	36
7S15-26	A	1 1/2	4"	1" NPT	41.2	13.6	27.6	3.8	3.9	46
7S20-32	A	2	4"	1" NPT	48.5	14.0	34.5	3.8	3.9	59

NOTES: All models suitable for use in 4" wells.
Weights include pump end with motor in lbs.

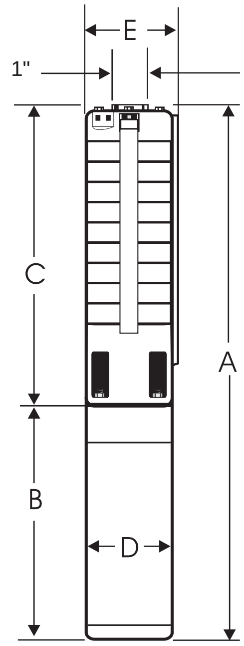


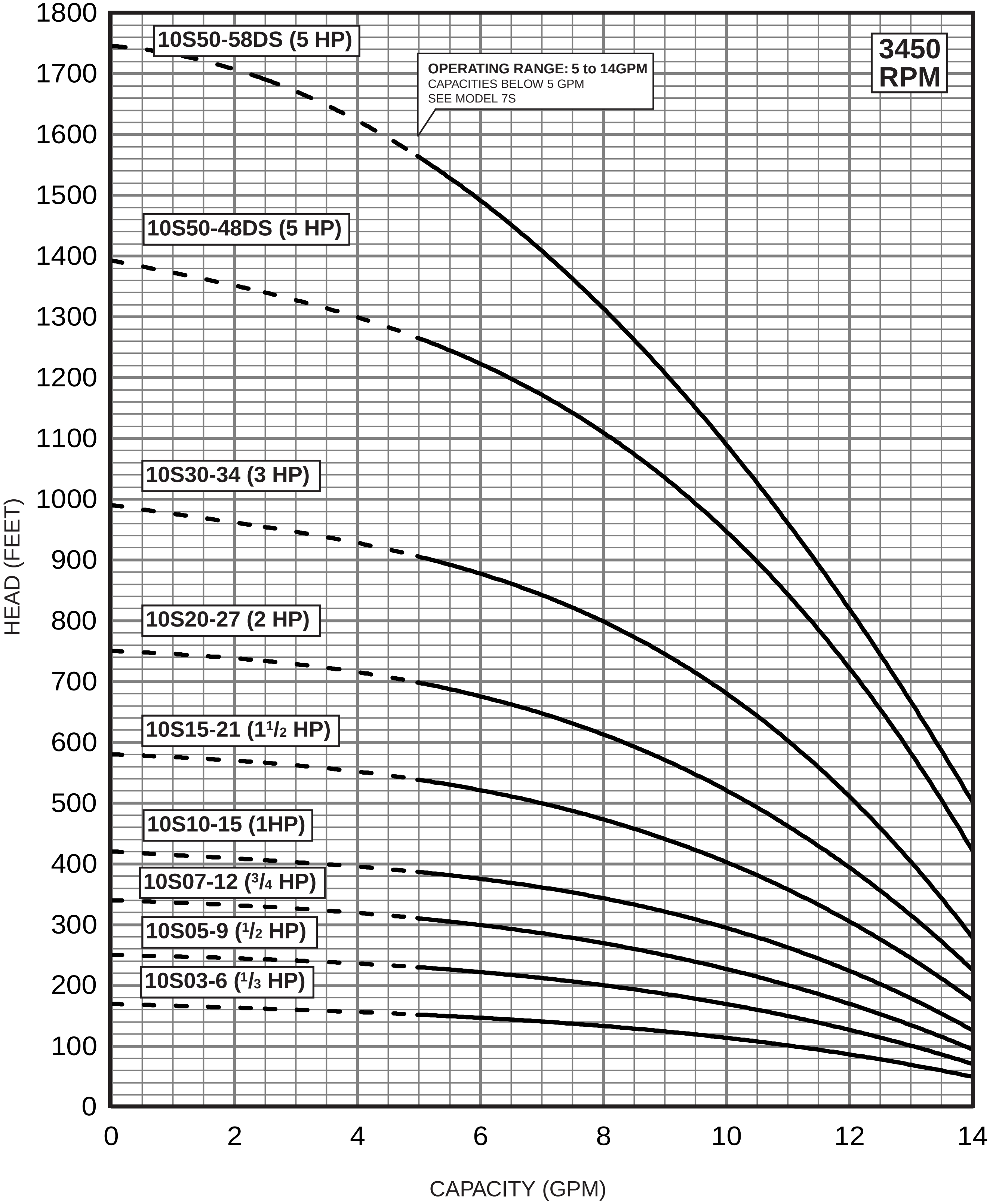
Fig. A

MATERIALS OF CONSTRUCTION

COMPONENT	SPLINE SHAFT
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel
Impeller	304 Stainless Steel
Suction Interconnector	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Pump Shaft	304 Stainless Steel
Straps	304 Stainless Steel
Cable Guard	304 Stainless Steel
Priming Inducer	304 Stainless Steel
Coupling	316/431 Stainless Steel
Check Valve Seat	NBR/304 Stainless Steel
Top Bearing	NBR
Impeller Seal Ring	NBR/PBT (Valox ®)
Intermediate Bearings	NBR

NOTES: Specifications subject to change without notice.
Valox® is a registered trademark of General Electric Co.

FLOW RANGE: 5 -14 GPM **OUTLET SIZE: 1¼ " NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 3450 RPM.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 2 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
10S03-6	A	1/3	4"	1 1/4" NPT	19.9	8.8	11.1	3.8	3.9	26
10S05-9	A	1/2	4"	1 1/4" NPT	23.0	9.5	13.5	3.8	3.9	29
10S07-12	A	3/4	4"	1 1/4" NPT	26.7	10.7	16.0	3.8	3.9	32
10S10-15	A	1	4"	1 1/4" NPT	30.3	11.8	18.5	3.8	3.9	34
10S15-21	A	1 1/2	4"	1 1/4" NPT	37.1	13.6	23.5	3.8	3.9	44
10S20-27	A	2	4"	1 1/4" NPT	43.5	15.1	28.4	3.8	3.9	49
10S30-34	A	3	4"	1 1/4" NPT	54.7	20.6	34.1	3.8	3.9	83
10S50-48DS	A	5	4"	1 1/4" NPT	71.3	23.6	47.7	3.8	3.9	115
10S50-58DS*	B	5	4"	1 1/4" MPT	88.2	23.6	64.5	3.8	4.3	142

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs.
* Built into sleeve 1 1/4" MPT discharge, 5" min. well dia.

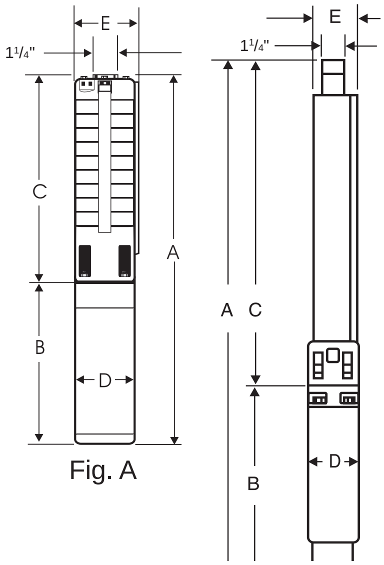


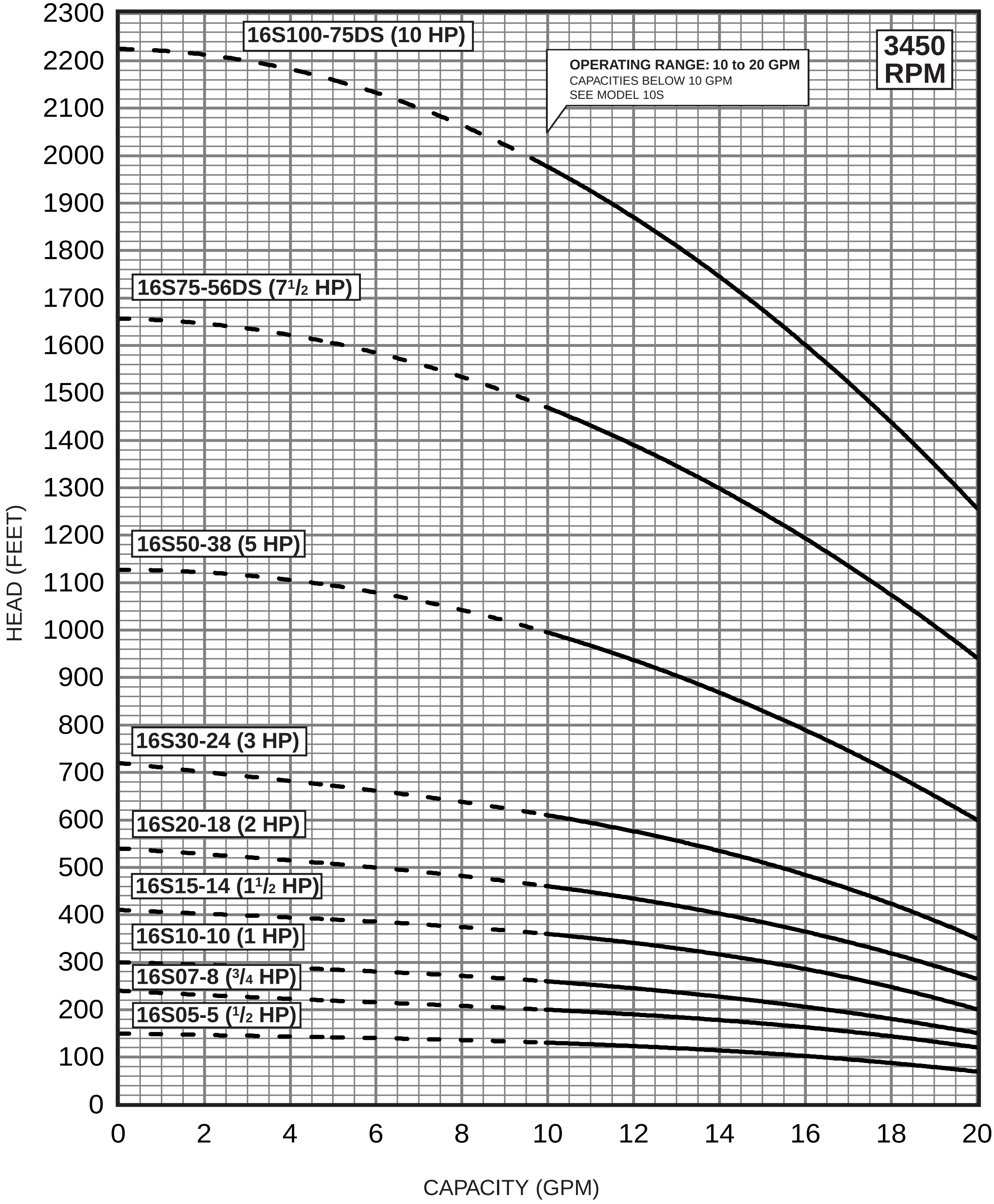
Fig. A
Fig. B

MATERIALS OF CONSTRUCTION

COMPONENT	SPLINED SHAFT (6-27 Stgs.)	CYLINDRICAL SHAFT (34-48 Stgs.)	DEEP SET (58 Stgs.)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Pump Shaft	304 Stainless Steel	431 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Coupling	316/431 Stainless Steel	316/431 Stainless Steel	316/431 Stainless Steel
Check Valve Seat	NBR/304 Stainless Steel	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/PBT (Valox®)	NBR/PPS (Ryton®)	NBR/PPS (Ryton®)
Intermediate Bearings	NBR	304 Stainless Steel	NBR/316 Stainless Steel
Shaft Washer	Not Required	LCP (Vectra®)	LCP (Vectra®)
Split Cone	Not Required	304 Stainless Steel	304 Stainless Steel
Split Cone Nut	Not Required	316 Stainless Steel	304 Stainless Steel
Sleeve	Not Required	Not Required	316 Stainless Steel
Sleeve Flange	Not Required	Not Required	Zincless Bronze*

NOTES: Specifications subject to change without notice.
Valox® is a registered trademark of General Electric Co.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
Ryton® is a registered trademark of Phillips 66.
*** Stainless Steel option available.**

FLOW RANGE: 10 -20 GPM **OUTLET SIZE: 1 1/4 " NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, .5 -5 HP/3450 RPM.
6" MOTOR STANDARD,7.5 -10HP/3450 RPM.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 2 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
16S05-5	A	1/2	4"	1 1/4" NPT	19.7	9.5	10.2	3.8	3.9	27
16S07-8	A	3/4	4"	1 1/4" NPT	23.4	10.7	12.7	3.8	3.9	29
16S10-10	A	1	4"	1 1/4" NPT	26.2	11.8	14.4	3.8	3.9	32
16S15-14	A	1 1/2	4"	1 1/4" NPT	32.8	15.1	17.7	3.8	3.9	36
16S20-18	A	2	4"	1 1/4" NPT	36.0	15.1	20.9	3.8	3.9	40
16S30-24	A	3	4"	1 1/4" NPT	46.5	20.6	25.9	3.8	3.9	64
16S50-38	A	5	4"	1 1/4" NPT	61.1	23.6	37.5	3.8	3.9	94
16S75-56DS*	B	7 1/2	6"	1 1/4" MPT	93.0	24.2	68.8	5.4	4.6	220
16S100-75DS*	B	10	6"	1 1/4" MPT	109.9	25.4	84.5	5.4	4.6	245

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs..
* Built into sleeve 1¼" MPT discharge, 6" min. well dia.

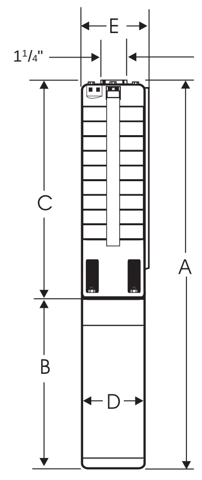


Fig. A

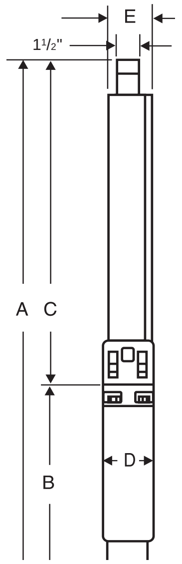


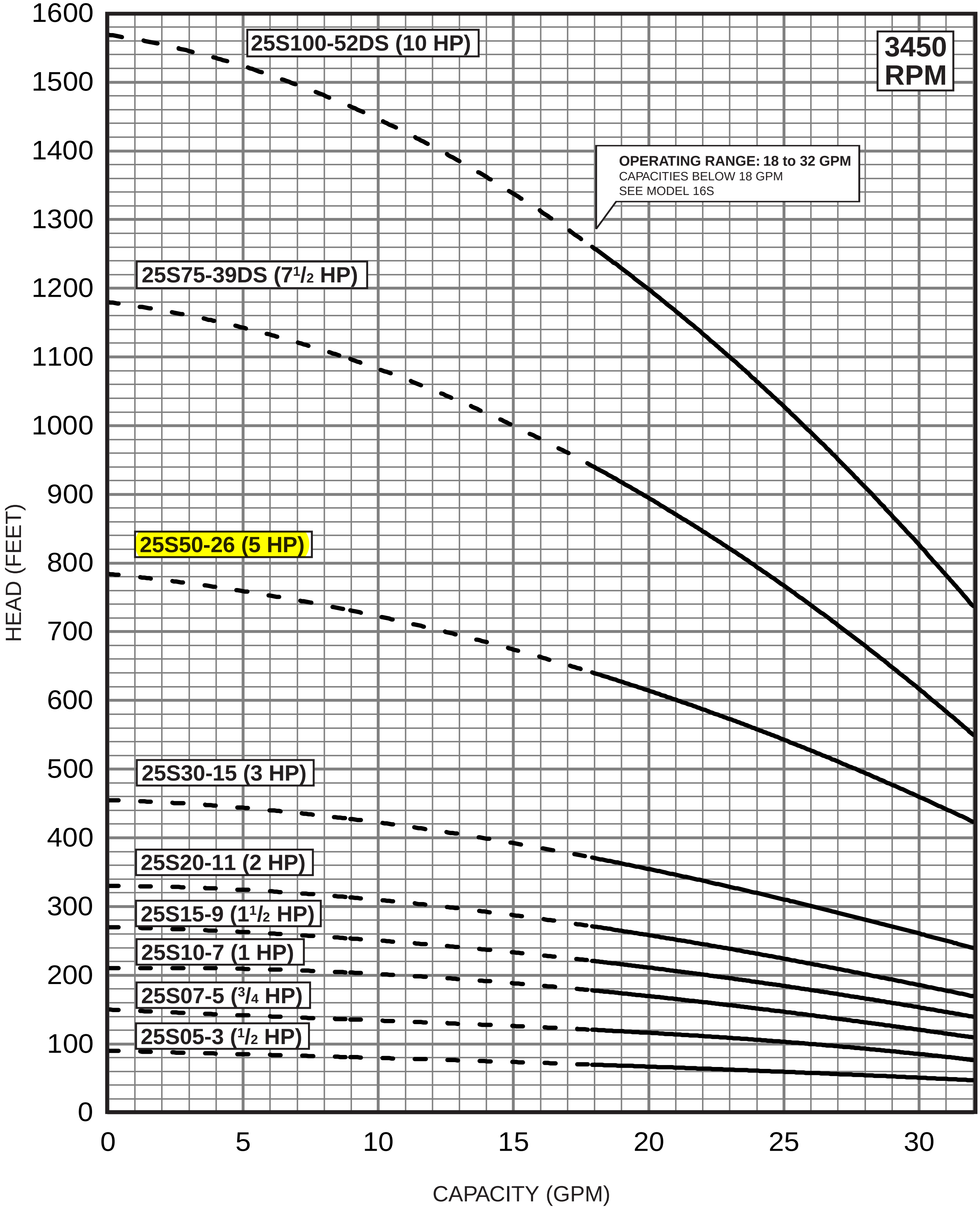
Fig. B

MATERIALS OF CONSTRUCTION

COMPONENT	SPLINED SHAFT (5-24 Stgs.)	CYLINDRICAL SHAFT (38 Stgs.)	DEEP SET (56-75 Stgs)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Pump Shaft	304 Stainless Steel	431 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Coupling	316/431 Stainless Steel	316/431 Stainless Steel	329/416 Stainless Steel**
Check Valve Seat	NBR/304 Stainless Steel	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/PBT (Valox®)	NBR/PPS (Ryton®)	NBR/PPS (Ryton®)
Intermediate Bearings	NBR	304 Stainless Steel	NBR/316 Stainless Steel
Shaft Washer	Not Required	LCP (Vectra®)	LCP (Vectra®)
Split Cone	Not Required	304 Stainless Steel	304 Stainless Steel
Split Cone Nut	Not Required	316 Stainless Steel	304 Stainless Steel
Sleeve	Not Required	Not Required	316 Stainless Steel
Sleeve Flange	Not Required	Not Required	304 Stainless Steel
Coupling Key	Not Required	Not Required	302/304 Stainless Steel**

NOTES: Specifications are subject to change without notice.
Valox® is a registered trademark of General Electric Co.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
Ryton® is a registered trademark of Phillips 66.
***Stainless Steel option available.**
** If using 4" non-standard motors, refer to 329/420/431 Stainless Steel for coupling.
A coupling key is not required.

FLOW RANGE: 18 -32 GPM OUTLET SIZE: 1½ " NPT NOMINAL DIA. 4"



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, .5 -5 HP/3450 RPM.
6" MOTOR STANDARD,7.5 -10HP/3450 RPM.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 2 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
25S05-3	A	1/2	4"	1 1/2" NPT	18.1	9.5	8.6	3.8	3.9	26
25S07-5	A	3/4	4"	1 1/2" NPT	20.9	10.7	10.2	3.8	3.9	28
25S10-7	A	1	4"	1 1/2" NPT	23.7	11.8	11.9	3.8	3.9	29
25S15-9	A	1 1/2	4"	1 1/2" NPT	27.1	13.6	13.5	3.8	3.9	34
25S20-11	A	2	4"	1 1/2" NPT	30.3	15.1	15.2	3.8	3.9	37
25S30-15	A	3	4"	1 1/2" NPT	39.1	20.6	18.5	3.8	3.9	59
25S50-26	A	5	4"	1 1/2" NPT	51.2	23.6	27.6	3.8	3.9	76
25S75-39DS	A	7 1/2	6"	1 1/2" NPT	66.8	24.2	42.6	5.4	4.6	168
25S100-52DS*	B	10	6"	1 1/2" MPT	90.9	25.4	65.5	5.4	5.4	226

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs.
* Built into sleeve 1 1/2" MPT discharge, 6" min. well dia.

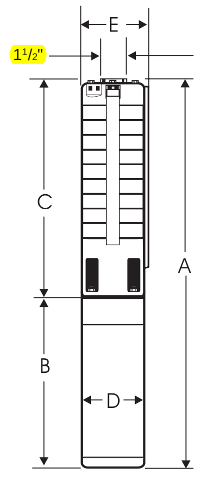


Fig. A

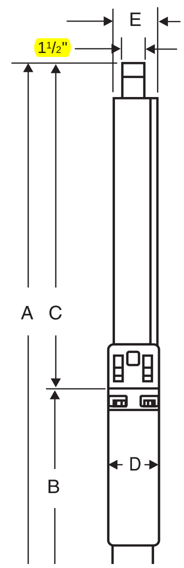


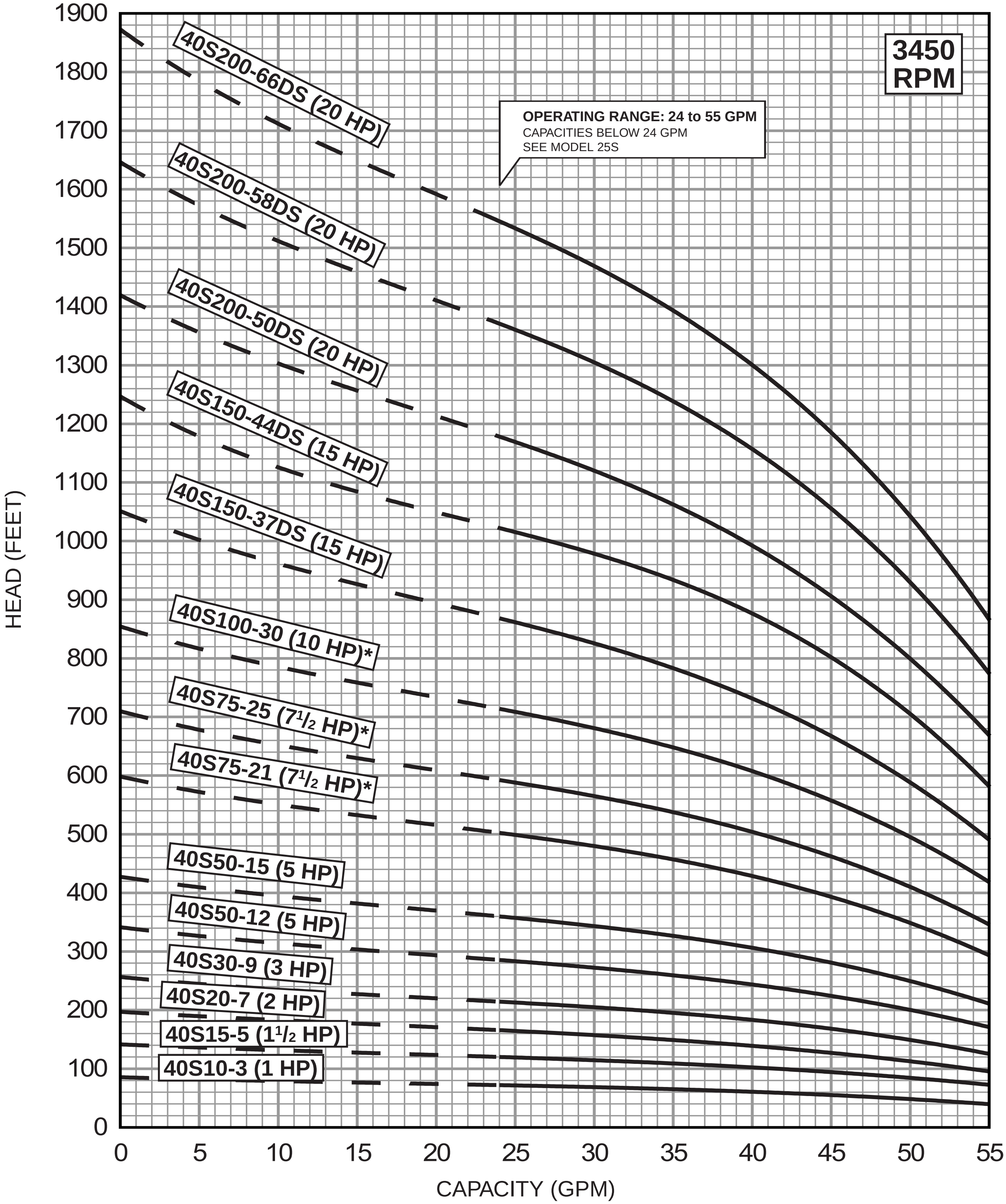
Fig. B

MATERIALS OF CONSTRUCTION

COMPONENT	SPLINED SHAFT (3-26 Stgs.)	CYLINDRICAL SHAFT (39 Stgs.)	DEEP SET (52 Stgs)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Pump Shaft	304 Stainless Steel	431 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	304 Stainless Steel	304 Stainless Steel
Coupling	316/431 Stainless Steel	316/431 Stainless Steel	329/416 Stainless Steel**
Check Valve Seat	NBR/304 Stainless Steel	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/PBT (Valox®)	NBR/PPS (Ryton®)	NBR/PPS (Ryton®)
Intermediate Bearings	NBR	304 Stainless Steel	NBR/316 Stainless Steel
Shaft Washer	Not Required	LCP (Vectra®)	LCP (Vectra®)
Split Cone	Not Required	304 Stainless Steel	304 Stainless Steel
Split Cone Nut	Not Required	316 Stainless Steel	304 Stainless Steel
Sleeve	Not Required	Not Required	316 Stainless Steel
Sleeve Flange	Not Required	Not Required	304 Stainless Steel
Coupling Key	Not Required	Not Required	302/304 Stainless Steel**

NOTES: Specifications are subject to change without notice.
Valox® is a registered trademark of General Electric Co.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
Ryton® is a registered trademark of Phillips 66.
***Stainless Steel option available.**
** If using 4" non-standard motors, refer to 329/420/431 Stainless Steel for coupling.
A coupling key is not required.

FLOW RANGE: 24 - 55 GPM **OUTLET SIZE: 2 " NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 1-10 HP/3450 RPM.
6" MOTOR STANDARD,15-20 HP/3450 RPM.
* Also available with 6" motor.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 5 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
40S10-3	A	1	4"	2" NPT	24.6	11.8	12.8	3.8	3.9	32
40S15-5	A	1 1/2	4"	2" NPT	29.7	13.6	16.1	3.8	3.9	37
40S20-7	A	2	4"	2" NPT	34.5	15.1	19.4	3.8	3.9	41
40S30-9	A	3	4"	2" NPT	43.3	20.6	22.7	3.8	3.9	65
40S50-12	A	5	4"	2" NPT	51.3	23.6	27.7	3.8	3.9	78
40S50-15	A	5	4"	2" NPT	56.2	23.6	32.6	3.8	3.9	84
40S75-21*	A	7 1/2	4"	2" NPT	74.6	29.6	45.0	3.8	3.9	120
40S75-25*	A	7 1/2	4"	2" NPT	81.2	29.6	51.6	3.8	3.9	124
40S100-30*	A	10	4"	2" NPT	103.7	43.9	59.8	3.8	3.9	181
40S150-37DS	A	15	6"	2" NPT	99.5	28.0	71.5	5.4	5.4	244
40S150-44DS	A	15	6"	2" NPT	111.0	28.0	83.0	5.4	5.4	340
40S200-50DS**	B	20	6"	2" MPT	136.0	30.6	105.4	5.4	5.5	319
40S200-58DS**	B	20	6"	2" MPT	149.2	30.6	118.6	5.4	5.5	334
40S200-66DS**	B	20	6"	2" MPT	162.4	30.6	131.8	5.4	5.5	394

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs.
* Also available with 6" motor.
** Built into sleeve 2" MPT discharge, 6" min. well dia.

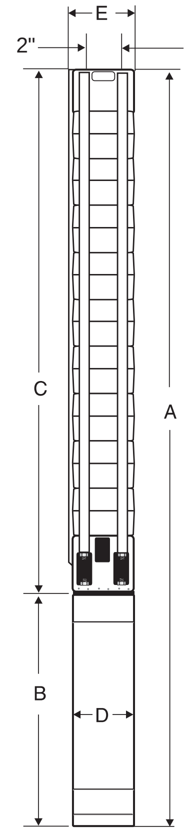


Fig. A

MATERIALS OF CONSTRUCTION

COMPONENT	CYLINDRICAL SHAFT (3-44 Stgs.)	DEEP SET (50-66 Stgs.)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel
Pump Shaft	431 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	304 Stainless Steel
Coupling	316/431 Stainless Steel **	329/ 416 Stainless Steel
Check Valve Seat	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Intermediate Bearings	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Shaft Washer	LCP (Vectra®)	LCP (Vectra®)
Split Cone	304 Stainless Steel	304 Stainless Steel
Split Cone Nut	304 Stainless Steel	304 Stainless Steel
Sleeve	Not Required	316 Stainless Steel
Sleeve Flange	Not Required	304 Stainless Steel

NOTES: Specifications are subject to change without notice.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
***Stainless Steel option available.**

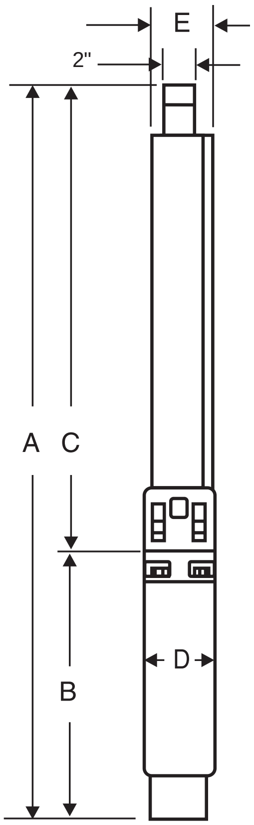
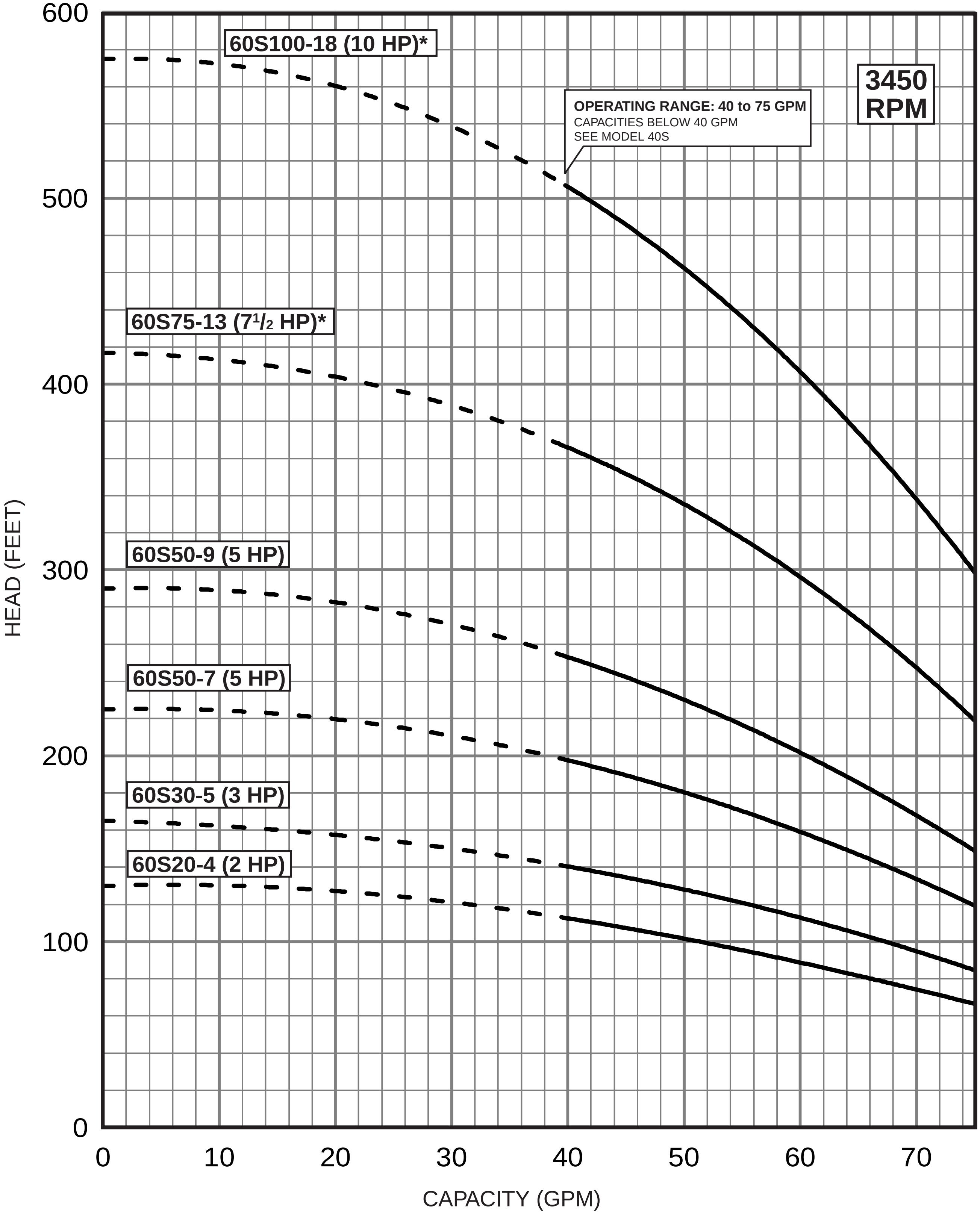


Fig. B

FLOW RANGE: 40 -75 GPM **OUTLET SIZE: 2 " NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 3450 RPM.
* Also available with 6" motor.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 5 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
60S20-4	A	2	4"	2" NPT	32.6	15.1	17.5	3.8	3.9	39
60S30-5	A	3	4"	2" NPT	40.7	20.6	20.1	3.8	3.9	64
60S50-7	A	5	4"	2" NPT	48.8	23.6	25.2	3.8	3.9	75
60S50-9	A	5	4"	2" NPT	53.9	23.6	30.3	3.8	3.9	80
60S75-13*	A	7 1/2	4"	2" NPT	70.1	29.6	40.5	3.8	3.9	105
60S100-18*	A	10	4"	2" NPT	97.3	43.9	53.4	3.8	3.9	160

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs..
* Also available with 6" motor.

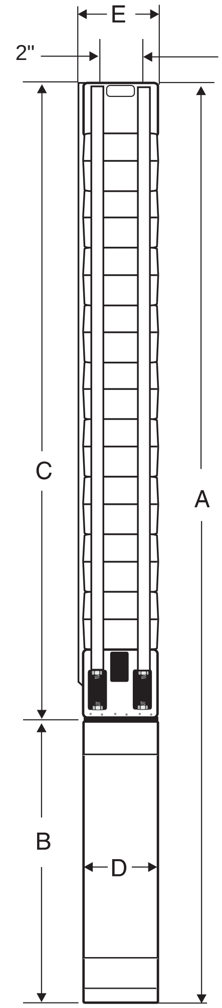


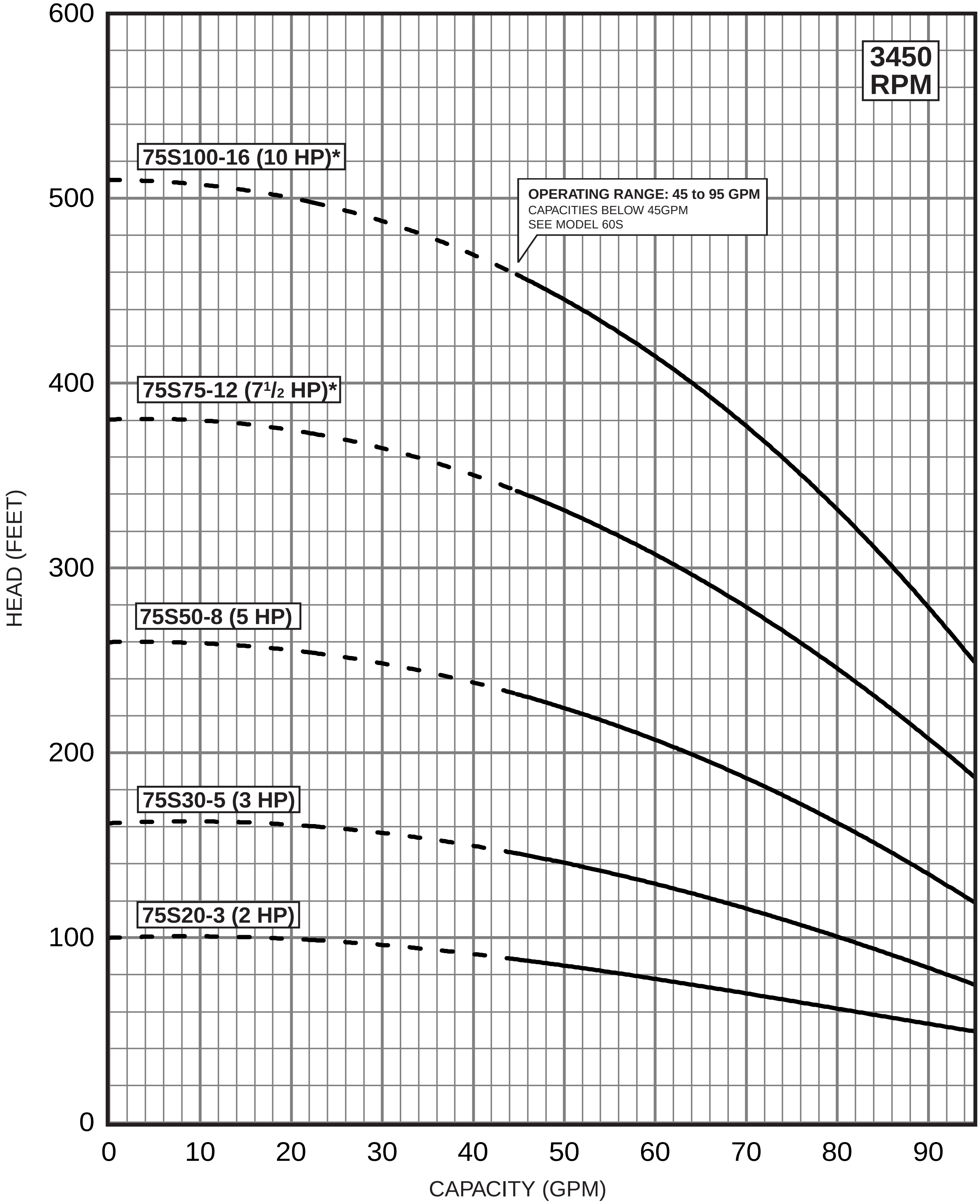
Fig. A

MATERIALS OF CONSTRUCTION

COMPONENT	CYLINDRICAL SHAFT (4-18 Stgs.)
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel
Impeller	304 Stainless Steel
Suction Interconnector	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Pump Shaft	431 Stainless Steel
Straps	304 Stainless Steel
Cable Guard	304 Stainless Steel
Priming Inducer	304 Stainless Steel
Coupling	316/431 Stainless Steel**
Check Valve Seat	NBR/316 Stainless Steel
Top Bearing	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/316 Stainless Steel
Intermediate Bearings	NBR/316 Stainless Steel
Shaft Washer	LCP (Vectra®)
Split Cone	304 Stainless Steel
Split Cone Nut	304 Stainless Steel

NOTES: Specifications are subject to change without notice.
Vectra® is a registered trademark of Hoechast Calanese Corporation.

FLOW RANGE: 45 - 95 GPM **OUTLET SIZE: 2" NPT** **NOMINAL DIA.: 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD,2-10 Hp 3450 RPM.
* Also available with 6" motor, performance is the same only at Best Effeciency point.
Consult factory for actual performance.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 5 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
75S20-3	A	2	4"	2" NPT	30.0	15.1	14.9	3.8	3.9	38
75S30-5	A	3	4"	2" NPT	40.7	20.6	20.1	3.8	3.9	64
75S50-8	A	5	4"	2" NPT	51.4	23.6	27.8	3.8	3.9	78
75S75-12*	A	7 1/2	4"	2" NPT	67.5	29.6	37.9	3.8	3.9	100
75S100-16*	A	10	4"	2" NPT	92.1	43.9	48.2	3.8	3.9	155

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs.
* Also available with 6" motor, performance is the same only at Best Efficiency point. Consult factory for actual performance.

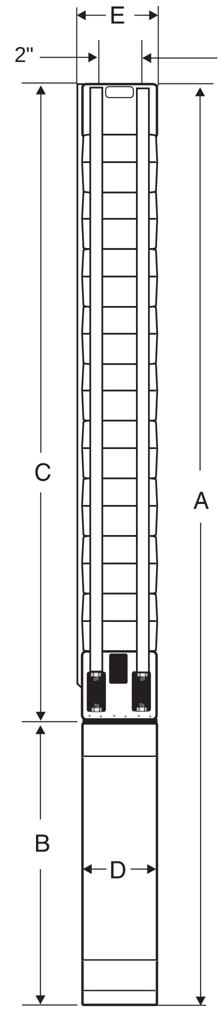


Fig. A

MATERIALS OF CONSTRUCTION

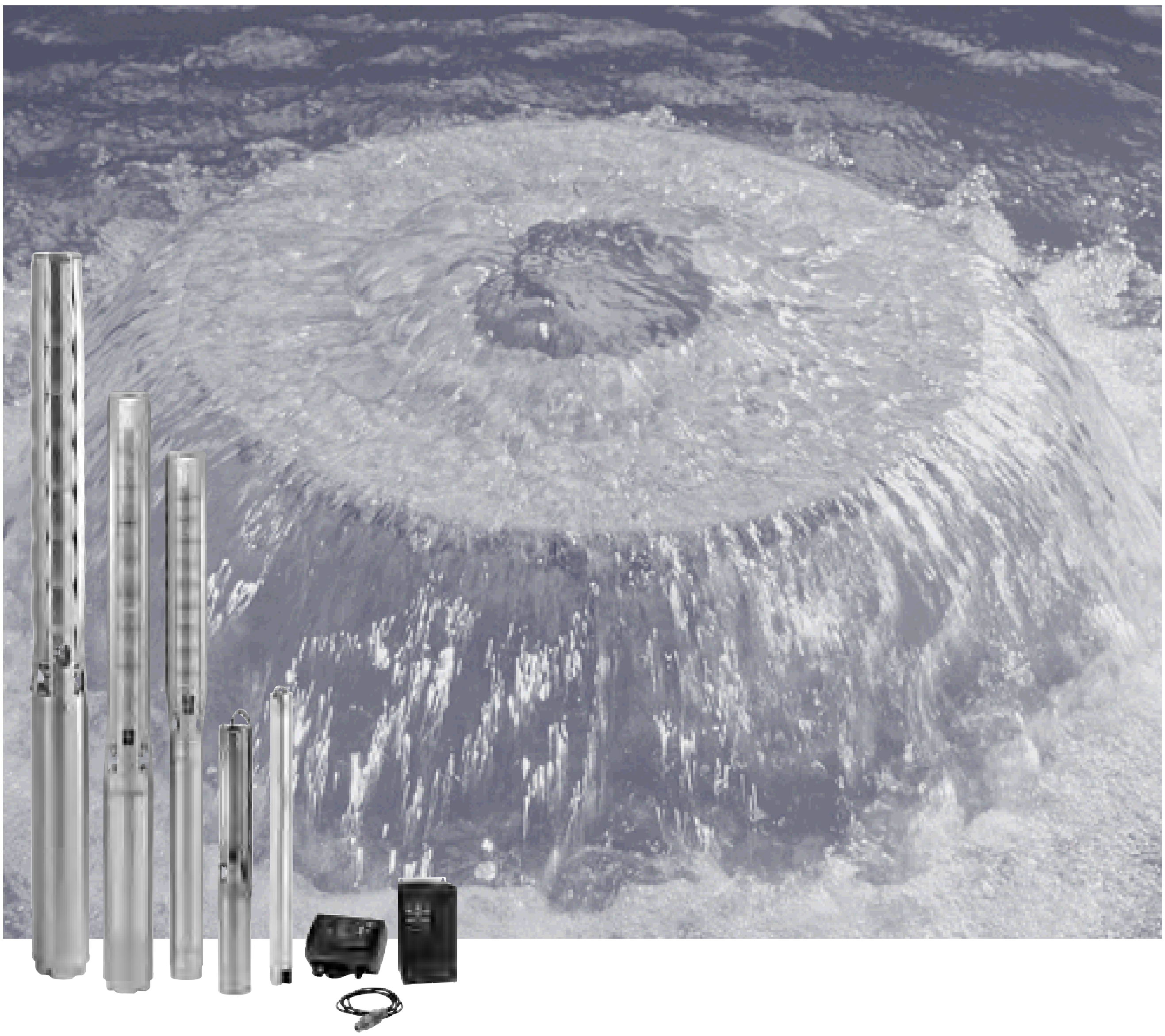
COMPONENT	CYLINDRICAL SHAFT (3-16 Stgs.)
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel
Impeller	304 Stainless Steel
Suction Interconnector	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Pump Shaft	431 Stainless Steel
Straps	304 Stainless Steel
Cable Guard	304 Stainless Steel
Priming Inducer	304 Stainless Steel
Coupling	316/431 Stainless Steel**
Check Valve Seat	NBR/316 Stainless Steel
Top Bearing	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/316 Stainless Steel
Intermediate Bearings	NBR/316 Stainless Steel
Shaft Washer	LCP (Vectra®)
Split Cone	304 Stainless Steel
Split Cone Nut	304 Stainless Steel

NOTES: Specifications are subject to change without notice.
Vectra® is a registered trademark of Hoechast Calanese Corporation.

GRUNDFOS **PRODUCT GUIDE**

SQ, SQE, SP

Stainless steel submersible pumps and accessories
60 Hz



BE > THINK > INNOVATE >

GRUNDFOS®

Mission

- to successfully develop, produce, and sell high quality pumps and pumping systems worldwide, contributing to a better quality of life and healthier environment

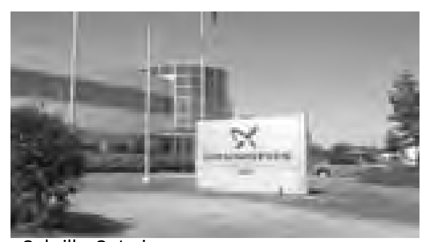

Bjerringbro, Denmark


Fresno, California


Olathe, Kansas

Monterrey, Mexico


Allentown, Pennsylvania


Oakville, Ontario

- One of the 3 largest pump companies in the world with over 11,000 employees worldwide
- World headquarters in Denmark
- North American headquarters in Kansas City - Manufacturing in Fresno, California
- 60 companies in 40 countries
- More than 10 million pumps produced annually worldwide
- North American companies operating in USA, Canada and Mexico
- Continuous reinvestment in growth and development enables the company to

  BE responsible, **THINK** ahead, and **INNOVATE**

Submittal Data Sheet

Company name: ______________________
Prepared by: ______________________
Phone number: (   )   -
Fax number: (   )   -
Date: __________ Page 1 of: __________
Quote number: ______________________

Client Information

Project title: ______________ Client name: ______________
Reference number: ______________ Client number: ______________
Client contact: Client phone no: (   )   -

Location Information

For: ______________ Unit: ______________
Site: ______________ Service: ______________
Address: City: State: Zip Code:

Technical Data

Flow (GPM) ______________
Head (Ft) ______________
Motor ______________
Max Fluid Temp ______________
Min Fluid Temp ______________
Max Working Pressure ______________
Min Required Inlet Pressure ______________
Connection Type and Size ______________

Motor Information

HP: ______________
Phase: ______________
Voltage: ______________
Enclosure: ______________

Pump Information

Model Information from Type Key and Codes: ______________
Quantity Required: ______________ Example: SP 150S
Minimum required flow: ______________ NPSH required at duty point: ______________

Product Guide additional information pages

Materials page number: ______________ Performance curve page number: ______________
Technical data page number: Motor data page number:

Custom-built pump information (optional): ______________

Additional Information ______________

TABLE OF CONTENTS

STAINLESS STEEL CONSTRUCTION

Grundfos submersibles feature rugged and durable stainless steel construction for all vital pump components. Impellers, diffusers, shafts, vanes, cable guards, couplings...even the nuts and bolts are stainless steel. Grundfos' 4-inch pump systems include the stainless steel pump, motor, and control box and are delivered ready to install.

Computer-aided design and manufacturing techniques ensure that each *pump* is built to exacting tolerance and performs to industry-leading standards. Grundfos state-of-the-art production equipment includes extensive use of robotics and advanced quality assurance procedures. You can rely on quality Grundfos' groundwater products for outstanding pump performance and best value.

SUBMERSIBLES

4-INCH and LARGER WELLS
The 4-inch submersibles line covers all flow requirements from 1.2 to 95 gpm and heads to 2000 feet. This broad range ensures proper pump selection for all domestic groundwater system applications.

6, 8, & 10-INCH and LARGER WELLS
For high flow requirements, this submersible line includes 6, 8, and 10-inch models for flows up to 1,400 gpm and heads to 2100 feet.

Grundfos offers 18 models of submersible pumps designed for domestic and industrial applications with flow rates from five to 1,400 gpm. Horsepower range extends from 1/3 hp to 250 hp. These pumps are marketed through more than 300 distributors and nearly 2,000 dealers nationwide.

THE STAINLESS STEEL ADVANTAGE

TOP PUMP PERFORMANCE
Grundfos pumps are built to work hard with every component designed for maximum hydraulic efficiency. With the inherently smooth surfaces of fabricated stainless steel, peak performance is maintained over many years of service.

RELIABLE OPERATION
Highly advanced design and manufacturing techniques minimize the number of moving parts. This, plus Grundfos' use of rugged stainless steel construction, make GRUNDFOS groundwater pumps the toughest, most reliable pumps on the market. With Grundfos you can rely on getting the water you need, when you need it.

LONG PUMP LIFE
Stainless steel is the best available material to resist wear and corrosion in water system applications. Compare Grundfos' stainless steel construction to the best the other manufactures have to offer. Grundfos stainless steel pumps are designed to operate efficiently and effectively for a long, long time.

SQ/SQE SUBMERSIBLE PUMPS

3-Inch SQ/SQE Submersible Well Pumps
3-Inch and Larger Wells

SQ/SQE pumps are suitable for both continuous and intermittent operation for a variety of applications:
- Domestic water supply
- Small waterworks
- Irrigation
- Tank applications

SQ, SQE pumps offer the following features:
- Dry-Run protection
- High efficiency pump and motor
- Protection against up-thrust
- Soft-start
- Over-voltage and under-voltage protection
- Overload protection
- Over-temperature protection
- High starting torque

Additionally, the SQE pumps offer:
- Constant pressure control
- Variable speed
- Electronic control and communication

The SQ and SQE pump models incorporate an innovative motor design. With the use of permanent-magnet technology within the motor, the SQ/SQE pumps deliver unmatched performance. By combining permanent-magnet motors and Grundfos's own micro frequency converter, we are now able to control and communicate with the pump in ways never before possible. A few of the features that come out of this combination are Constant Pressure Control, Soft-Start, and integrated Dry-Run protection. These are just a few of the many features that the SQ/SQE pumps can offer.

The SQ pump models operate at a constant speed much like today's conventional pumps. The difference between it and traditional pumps is you get all the benefits of an electronically controlled permanent-magnet motor that cannot be accomplished with a conventional induction motor. The SQ pumps are available for single phase power. They use a simple 2-wire design making installation easy.

The SQE uses the Grundfos "Smart Motor". Like the SQ model, we still use the high efficiency permanent magnet motor, but we give this motor the ability to communicate. The "Smart Motor" communicates via the CU301 status box through the power leads. It is not necessary to run any additional wires down the well. By being able to communicate with the pump you can have Constant Pressure Control and the ability to change the pump performance while the pump is installed in the well. Like the SQ motor, this is also a 2-wire motor designed for single-phase operation.

TYPE KEYS

SP Example 10 S 05 - 9

- Rated gallons per minute — 10
- Material of construction — S
- Horsepower — 05
- Number of pump stages — 9

SQ/SQE Example 10 SQ E 05 - 160

- Rated gallons per minute — 10
- Basic version (without communication) — SQ
- Electronic communication — E
- Horsepower — 05
- Total Dynamic Head in (ft) at rated flow — 160

GRUNDFOS **INSTRUCTIONS**

SP4"

4-Inch Stainless Steel Submersible Pumps

(US) Installation and operating instructions

WATER QUALITY
DRINKING WATER
SYSTEM COMPONENTS
ANSI/NSF 61
65 GM
30°C/86°F
PUMP END ONLY

Please leave these instructions with the pump for future reference.

BE > THINK > INNOVATE >

GRUNDFOS

SAFETY WARNING

WARNING: Reduced risk of electric shock during operation of this pump requires the provision of acceptable grounding. If the means of connection to the supply connected box is other than grounded metal conduit, ground the pump back to the service by connecting a copper conductor (at least the size of the circuit supplying the pump) to the grounding screw provided within the wiring compartment.

NOTICE: This product is designes for pumping water only. Third party agency evalustions are based on pumping water only.

Pre-Installation Checklist

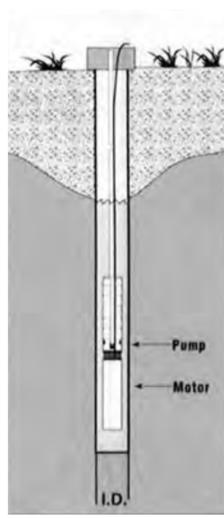
1. Well Preparation

If the pump is to be installed in a new well then the well should be fully developed and bailed or blown free of cuttings and sand. The stainless steel construction of the GRUNDFOS submersibles make it resistant to abrasion; however, no pump made of any material can forever withstand the destructive wear that occurs when constantly pumping sandy water.

If this pump is used to replace an oil-filled submersible or oil-lubricated line-shaft turbine in an existing well, the well must be blown or bailed clear of oil.

2. Make Sure You Have The Right Pump

Determine the maximum depth of the well, and the draw-down level at the pump's maximum capacity. Pump selection and setting depth should be based on this data.



3. Pumped Fluid Requirements

CAUTION: Submersible well pumps are designed for pumping clear, cold water; free of air or gases. Decreased pump performance and life expectancy can occur if the water is not cold, clear or contains air or gasses. Water temperature should not exceed 102°F.

A check should be made to ensure that the installation depth of the pump will always be at least three feet below the maximum drawdown level of the well. The bottom of the motor should never be installed lower than the top of the screen or within five feet of the well bottom.

Ensure that the requirement for minimum flow past the motor is met, as shown in the table below:

Minimum Water Flow Requirements for Submersible Pump Motors

MINIMUM DIAMETER	CASING OR SLEEVE I.D. IN INCHES	MIN. GPM FLOW PASSING THE MOTOR
4-Inch	4	1.2
	5	7
	6	13
	7	21
	8	30

NOTES: For proper motor cooling, a flow inducer or sleeve must be used if the water enters the well above the motor or if there is insufficient water flow past the motor. The minimum water velocity past 4" motors is 0.25 feet per second.

PRE-INSTALLATION CHECKLIST

4. Splicing the Motor Cable

If the splice is carefully made, it will be as efficient as any other portion of the cable, and will be completely watertight. There are a number of cable splicing kits available today – epoxy filled, rubber-sealed and so on. Many perform well if the manufacturer's directions are followed carefully. If one of these kits is not used, we recommend the following method for splicing the motor cable.

Examine the motor cable and drop cable carefully for damage. Cut the motor leads off in a staggered manner. Cut the ends of the drop cable so that the ends match up with the motor leads. Be sure to match the colors. Strip back and trim off one-half inch of insulation from each lead, making sure to scrape the wire bare to obtain a good connection. Be careful not to damage the copper conductor when stripping off the insulation. Insert a properly sized Sta-kon-type connector on each pair of leads, again making sure that colors are matched. Using Sta-kon crimping pliers, indent the lugs. Be sure to squeeze down hard on the pliers, particularly when using large cable. Form a piece of electrical insulation putty tightly around each Sta-Kon. The putty should overlap on the insulation of the wire. Use a good quality tape such as ***#33 Scotch Waterproof*** or ***Plymouth Rubber Company Slipknot Grey***. Wrap each wire and joint tightly for a distance of about 2-1/2 inches on each side of the joint. Make a minimum of four passes over each joint and overlap each pass approximately one inch to assure a completely watertight seal.

INSTALLATION PROCEDURES

1. Attach the Pump to the Motor

When attaching the pump to the motor we recommend the pump be bolted down in a cross pattern around the four bolts. Starting from the back (opposite the cable opening) and using a cross pattern, tighten the motor bolts to 13.5 ft-lbs, using progressive tightening until torque is met. (See figure 1 for example).

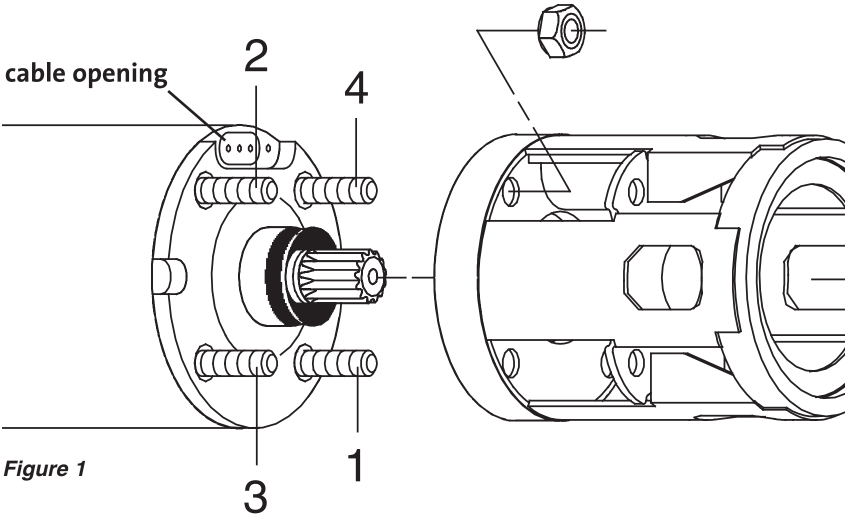


Figure 1

INSTALLATION PROCEDURES

2. Attach the Pump to the Pipe

A back-up wrench should be used when riser pipe is attached to the pump. The pump should only be gripped by the flats on the top of the discharge chamber. Under no circumstances grip the body of the pump, cable guard or motor. When tightened down, the threaded end of the first section of the riser pipe or the nipple must not come in contact with the check valve retainer in the discharge chamber of the pump. After the first section of the riser pipe has been attached to the pump, the lifting cable or elevator should be clamped to the pipe. Do not clamp the pump. When raising the pump and riser section, be careful not to place bending stress on the pump by picking it up by the pump-end only. It is recommended that plastic-type riser pipe be used only with the smaller domestic submersibles. The manufacturer or representative should be contacted to ensure the pipe type and physical characteristics are suitable for this use. Use the correct joint compound recommended by the specific pipe manufacturer. Besides making sure that points are fastened, we recommend the use of a torque arrestor when using plastic pipe.

3. Lower the Pump Into the Well

Make sure the electrical cables are not cut or damaged in any way when the pump is being lowered in the well. Do not use the power cables to support the weight of the pump.

To protect against surface water entering the well and contaminating the water source, the well should be finished off above grade utilizing a locally approved well seal or pitless adaptor unit. We recommend that steel riser pipes always be used with the larger submersibles. A pipe thread compound should be used on all joints. Make sure that the joints are adequately tightened in order to resist the tendency of the motor to loosen the joints when stopping and starting.

The drop cable should be secured to the riser pipe at approximately every 10 ft/3 m to prevent sagging, looping and possible cable damage. Nylon cable clips or waterproof tape may be used. The cable splice should be protected by securing it with clips or tape just above each joint.

Figure 2

Figure 3

IMPORTANT: *Plastic pipe tends to stretch under load. This stretching must be taken into account when securing the cable to the riser pipe. Leave three to four inches of slack between clips or taped points. This tendency for plastic pipe to stretch will also affect the calculation of the pump setting depth. As a general rule, you can estimate that plastic pipe will stretch to approximately 2% of its length. When plastic riser pipe is used, it is recommended that a safety cable be attached to the pump to lower and raise it. The discharge chamber of GRUNDFOS 4-inch submersibles is designed to accommodate this cable. (See Figures 2 & 3.)*

Check Valves: A check valve should always be installed at the surface of the well and one at a maximum of 25 feet above static water level. In addition, for installations deeper than 200 feet, check valves should be installed at no more than 200 foot intervals.

4. Electrical Connections

WARNING: Reduced risk of electric shock during operation of this pump requires the provision of acceptable grounding. If the means of connection to the supply connected box is other than grounded metal conduit, ground the pump back to the service by connecting a copper conductor (at least the size of the circuit supplying the pump) to the grounding screw provided within the wiring compartment.

Verification of the electrical supply should be made to ensure the voltage, phase and frequency match that of the motor. Motor electrical data can be found on page 6. If voltage variations are larger than ± 10%, do not operate the pump. Single-phase motor control boxes should be connected as shown on the wiring diagram mounted on the inside cover of the control box supplied with the motor. The type of wire used between the pump control boxes should be approved for submersible pump application. The conductor insulation should be type RW, RUW, TW or equivalent.

A high-voltage surge arrestor should be used to protect the motor against lightning and switching surges. Lightning voltage surges in power lines are caused when lightning strikes somewhere in the area. Switching surges are caused by the opening and closing of switches on the main high-voltage distribution power lines.

The correct voltage-rated surge arrestor should be installed on the supply (line) side of the control box or starter (See Figure 4a & 4b). The arrestor must be grounded in accordance with the National Electric Code and local governing regulations.

PUMPS SHOULD NEVER BE STARTED UNLESS THE PUMP IS TOTALLY SUBMERGED. SEVERE DAMAGE MAY BE CAUSED TO THE PUMP AND MOTOR IF THEY ARE RUN DRY.
The control box shall be permanently grounded in accordance with the National Electric Code and local governing codes or regulations. The ground wire should be a bare stranded copper conductor at least the same size as the drop cable wire size. Ground wire should be as short a distance as possible and securely fastened to a true grounding point. True grounding points are considered to be: a grounding rod driven into the water strata; steel well casing submerged into the water lower than the pump setting level; and steel discharge pipes without insulating couplings. If plastic discharge pipe and well casing are used, a properly sized bare copper wire should be connected to a stud on the motor and run to the control panel. Do not ground to a gas supply line. Connect the grounding wire to the ground point first, then to the terminal in the control box.

Single Phase Hookup

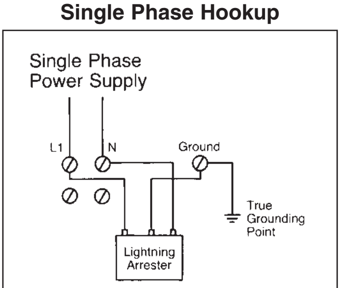


Figure 4a

Three Phase Hookup

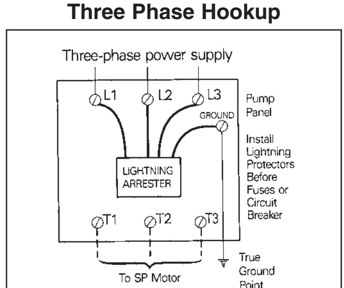
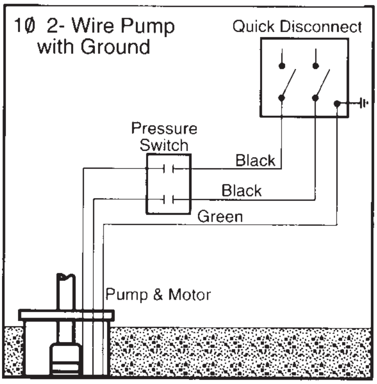


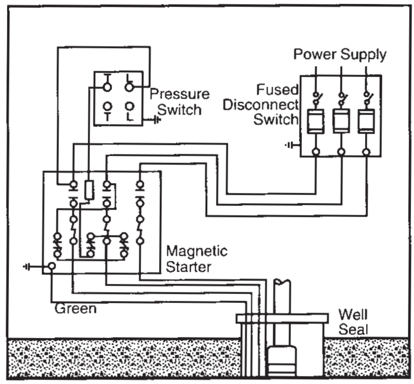
Figure 4b

INSTALLATION PROCEDURES

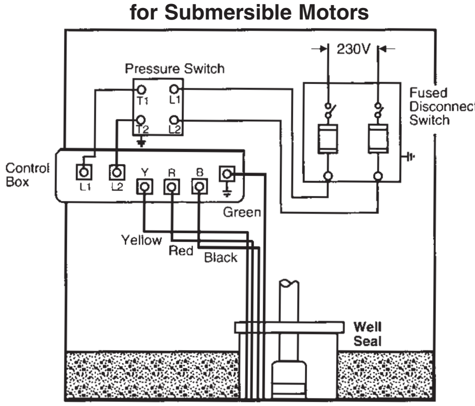
Single-Phase 2-Wire Wiring Diagram for Submersible Motors



Three-Phase Wiring Diagram for Submersible Motors



Single-Phase 3-Wire Control Box for Submersible Motors



4. Starting the Pump for the First Time

A. Attach a temporary horizontal length of pipe to the riser pipe.
B. Install a gate valve and another short length of pipe to the temporary pipe.
C. Adjust the gate valve one-third of the way open.
D. Verify that the electrical connections are in accordance with the wiring diagram.
E. After proper rotation has been checked, start the pump and let it operate until the water runs clear of sand, silt and other impurities.
F. Slowly open the valve in small increments as the water clears until the valve is all the way open. The pump should not be stopped until the water runs clear.
G. If the water is clean and clear when the pump is first started, the valve should still be opened until it is all the way open.

MOTOR INFORMATION

Grundfos motors specifications

1- Phase motors

HP	Ph	Volt	Service factor	Amperage		Full load		Max. thrust (lbs)	Line-to-Line resistance ( )		KVA code	Nameplate no.
				SF	Start	Eff. (%)	Pwr fact.		Blk-Yel	Red-Yel		
4-inch, single phase, 2-wire motors (control box not required)												
1/3	1	230	1.75	4.6	25.7	59	77	900	6.8-8.2		S	79952101
1/2	1	115	1.60	12.0	55	62	76	900	1.1-1.3		R	79922102
1/2	1	230	1.60	6.0	34.5	62	76	900	5.2-6.3		R	79952102
3/4	1	230	1.50	8.4	40.5	62	75	900	3.2-3.8		N	79952103
1	1	230	1.40	9.8	48.4	63	82	900	2.5-3.1		M	79952104
1 1/2	1	230	1.30	13.1	62	64	85	900	1.9-2.3		L	79952105
4-inch, single phase, 3-wire motors												
1/3	1	115	1.75	9.0	29	59	77	900	1.55-1.9	2.4-3	M	79423101
1/3	1	230	1.75	4.6	14	59	77	900	6.8-8.3	17.3-21.1	L	79453101
1/2	1	115	1.60	12.0	42.5	61	76	900	0.9-1.1	1.9-2.35	L	79423102
1/2	1	230	1.60	6.0	21.5	62	76	900	4.7-5.7	15.8-19.6	L	79453102
3/4	1	230	1.50	8.4	31.4	62	75	900	3.2-3.9	14-17.2	L	79453103
1	1	230	1.40	9.8	37	63	82	900	2.6-3.1	10.3-12.5	K	79453104
1.5	1	230	1.30	11.6	45.9	69	89	900	1.9-2.3	7.8-9.6	H	79453105
2	1	230	1.25	13.2	57	72	86	1500	1.5-1.8	3.4-4.1	G	79454506
3	1	230	1.15	17.0	77	74	93	1500	1.2-1.4	2.45-3	F	79454507
5	1	230	1.15	27.5	110	77	92	1500	0.65-0.85	2.1-2.6	F	79454509

3-Phase motors

HP	Ph	Volt	Service factor	Amperage		Full load		Max. thrust (lbs)	Line-to-Line resistance ( )		KVA code	Nameplate no.
				SF	Start.	Eff. (%)	Pwr fact.		Blk-Yel	Red-Yel		
4-inch, three phase, 3-wire motors												
		230	1.30	7.3	40.3	75	72	900	3.9		K	79302005
1 1/2	3	460	1.30	3.7	20.1	75	72	900	15.9		K	79362005
		575	1.30	2.9	16.1	75	72	900	25.2		K	79392005
		230	1.25	8.7	48	76	75	900	3.0		J	79302006
3	3	460	1.25	4.4	24	76	75	900	12.1		J	79362006
		575	1.25	3.5	19.2	76	75	900	18.8		J	79392006
		230	1.15	12.2	56	77	75	900	2.2		H	79302006
3	3	460	1.15	6.1	28	77	75	900	9.0		H	79362007
		575	1.15	4.8	22	77	75	900	13.0		H	79395507
		208/230	1.15	18.6/17.4	108	80	82	1500	1.2		H	79304509
5	3	440/460	1.15	8.65/8.65	54	80	82	1500	5.0		H	79354509
		575	1.15	7.9	54	80	82	1500	7.3		H	79394509
		208/230	1.15	27.0/25.0	130	81	82	1500	0.84		H	79305511
7 1/2	3	440/460	1.15	12.8/12.6	67	81	82	1500	3.24		J	79355511
		575	1.15	10.6	53	81	82	1500	5.2		J	79395511
10	3	440/460	1.15	18.0/18.6	90	81	80	1500	1.16		H	79355512
		575	1.15	14.4	72	81	80	1500	1.84		H	79395512

*All Grundfos 4” motors have a ground (green wire)

GRUNDFOS Control Box SA-SPM5

RATING		GRUNDFOS MOTOR MODEL	GRUNDFOS CONTROL BOX	GRUNDFOS STANDARD #’s	GRUNDFOS RUN CAP/DELUXE #’s
HP	VOLT				
1/3	115	MS402B	SA-SPM5	91126150	–
1/3	230	MS402B	SA-SPM5	91126151	–
1/2	115	MS402B	SA-SPM5	91126152	–
1/2	230	MS402B	SA-SPM5	91126153	–
3/4	230	MS402B	SA-SPM5	91126154	–
1	230	MS402B	SA-SPM5	91126155	91126211
1.5	230	MS402B	SA-SPM5	91126212	91126213
2	230	MS4000	SA-SPM5	91126214	91126215
3	230	MS4000	SA-SPM5	91126216	91126217
5	230	MS4000	SA-SPM5	91126218	91126219

MOTOR INFORMATION

The key to long submersible motor life is good cooling. Most submersible pumps rely on moving heat away from the motor by forced convection. The ambient/produced fluid is typically drawn by the motor in the course of pumping to accomplish this task. Submersible motors used in the water supply industry are typically designed to operate at full load in water up to 30°C (86°F), provided the flow velocity can be maintained at a minimum of 0.5 feet per second (fps).

Required Cooling Flow and Velocity

AWWA specifications state the maximum motor diameter and the minimum inside diameter of the well shall be in such relationship that under any operating condition the water velocity past the motor shall not exceed 12 fps (3.7 m/s) nor be less than 0.5 fps (0.15 m/s). The AWWA specification are principally applicable to motors 6-inch and larger, as most 4-inch motor designs are based on a minimum cooling flow velocity of 0.25 fps (0.08 m/s) at rated ambient temperature. Table 8 relates flow, casing and motor size requirements to accomplish minimum cooling velocity.

Table 8: Minimum Submersible Cooling Flow Requirements

Casing/Sleeve I.D. (inches)	4" Motor (0.25 fps)	6" Motor (0.5 fps)
	(gpm)	
4	1.2	–
5	7.0	–
6	13	9
7	20	25
8	30	45
10	50	90
12	80	140
14	110	200
16	150	280
18	–	380

Notes:
1. Minor irregularities associated with motor shape and diameter variations between manufactures are not accounted for in the table.
2. At the velocity specified in the table the temperature differential between the motor surface and ambient water will range from 5° - 15°C (10-30°F).

Some submersible motor manufactures require no cooling fluid flow past the motor, when the produced fluid temperature is 20°C (68°F) or less. Cooling by free convection in such cases, is only permitted in the vertical position and is contingent on no adverse operating conditions present such as; poor power, high stop/start frequency, presence of incrustating deposits on the motor surface, etc. Detramental operating conditions are difficult to identify or predict, and for this reason, the minimum cooling flow should be provided whenever possible - regardless of the ambient fluid temperature.

Typical Motor Jacket/Shroud Configurations.

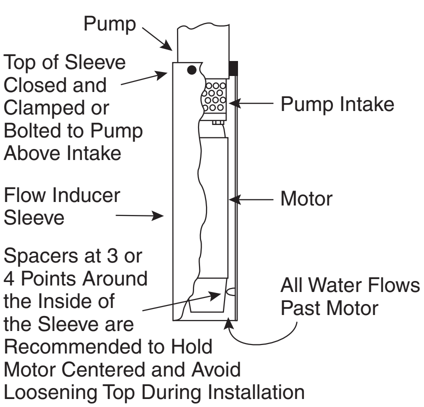
The motor shroud is generally of the next nominal diameter of standard pipe larger than the motor or the pump, depending on the shroud configuration used. The tubular/pipe material can be plastic or thin walled steel (corrosion resistant materials preferred). The cap/top must accommodate power cable without damage and provide a snug fit, so that only a very small amount of fluid can be pulled through the top of the shroud. The fit should not be completely water tight as ventilation is often required to allow escape of the air or gas that might accumulate. The shroud body should be stabilized to prevent rotation and maintain the motor centered within the shroud. The shroud length should extend to a length of 1-2 times the shroud diameter beyond the bottom of the motor when possible. Shrouds are typically attached immediately above the pump intake or at the pump/column correction.

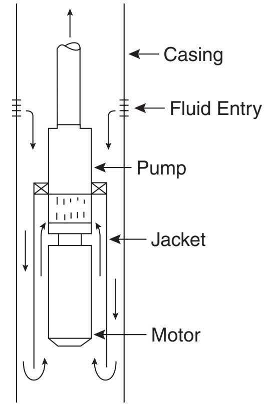
A typical motor sleeve/shroud selection example is sited below and illustrated in Figure 8:

If a well feeds water from above the pump, has a casing/chamber too small to allow a motor jacket/sleeve on the pump, and does not have adequate level and flow to allow raising the pump above the inflow, it is difficult to properly cool the motor. When possible, the casing depth should be increased to allow flow to come from below the motor. If this is not practical, adequate flow past the motor can usually be attained by employing a motor jacket with a stringer pipe or by using a jet tube.

Figure 8: Typical Motor Jacket Installation Scenarios

Typical Flow Inducer Sleeve Cutaway View





MOTOR INFORMATION

Single-Phase 60 Hz

MOTOR RATING		COPPER WIRE SIZE (AWG)								
VOLTS	HP	14	12	10	8	6	4	2	0	00
115	1/3	130	210	340	540	840	1300	1960	2910	
	1/2	100	160	250	390	620	960	1460	2160	
230	1/3	550	880	1390	2190	3400	5250	7960		
	1/2	400	650	1020	1610	2510	3880	5880		
	3/4	300	480	760	1200	1870	2890	4370	6470	
	1	250	400	630	990	1540	2380	3610	5360	6520
	1-1/2	190	310	480	770	1200	1870	2850	4280	5240
	2	150	250	390	620	970	1530	2360	3620	4480
	3	120	190	300	470	750	1190	1850	2890	3610
	5	180	280	450	710	1110	1740	2170		

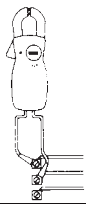
Three-Phase 60 Hz

MOTOR RATIN		COPPER WIRE SIZE (AWG)						
VOLTS	HP	14	12	10	8	6	4	2
208	1-1/2	310	500	790	1260			
	2	240	390	610	970	1520		
	3	180	290	470	740	1160	1810	
		5170	280	4690	1080			1660
230	1-1/2	360	580	920	1450			
	2	280	450	700	1110	1740		
	3	210	340	540	860	1340	2080	
	5		200	320	510	800	1240	1900
460	1-1/2	1700						
	2	1300	2070					
	3	1000	1600	2520				
	5	590	950	1500	2360			
575	1-1/2	2620						
	2	2030						
	3	1580	2530					
	5	920	1480	2330				

FOOTNOTES:

1. If aluminum conductor is used, multiply lengths by 0.5. Maximum allowable length of aluminum is considerably shorter than copper wire of same size.
2. The portion of the total cable which is between the service entrance and a 3Ø motor starter should not exceed 25% of the total maximum length to ensure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.
3. Cables #14 to #0000 are AWG sizes, and 250 to 300 are MCM sizes.

SUPPLY VOLTAGE



How to Measure

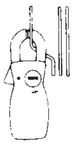
By means of a voltmeter, which has been set to the proper scale, measure the voltage at the control box or starter. On single-phase units, measure between line and neutral.

What it Means

When the motor is under load, the voltage should be within ± 10% of the nameplate voltage. Larger voltage variation may cause winding damage. Large variations in the voltage indicate a poor electrical supply and the pump should not be operated until these variations have been corrected.

If the voltage constantly remains high or low, the motor should be changed to the correct supply voltage.

CURRENT MEASUREMENT



How to Measure

By use of an ammeter, set on the proper scale, measure the current on each power lead at the control box. See page 6, for motor amp draw information.

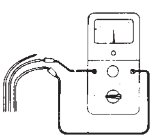
Current should be measured when the pump is operating at a constant discharge pressure with the motor fully loaded.

What it Means

If the amp draw exceeds the listed service factor amps (SFA), check for the following:

1. Loose terminals in control box or possible cable defect. Check winding and insulation resistances.
2. Too high or low supply voltage.
3. Motor windings are shorted.
4. Pump is damaged causing a motor overload.

WINDING RESISTANCE



How to Measure

Turn off power and disconnect the drop cable leads in the control box. Using an ohmmeter, set the scale selectors to Rx1 for values under 10 ohms and Rx10 for values over 10 ohms.

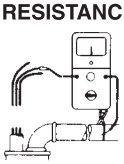
Zero-adjust the meter and measure the resistance between leads. Record the values. Motor resistance values can be found on page 6.

What it Means

If all the ohm values are normal, and the cable colors correct, the windings are not damaged. If any one ohm value is less than normal, the motor may be shorted. If any one ohm value is greater than normal, there is a poor cable connection or joint. The windings or cable may also be open.

If some of the ohm values are greater than normal and some less, the drop cable leads are mixed. To verify lead colors, see resistance values on page 6.

INSULATION RESISTANCE



How to Measure

Turn off power and disconnect the drop cable leads in the control box. Using an ohm or mega ohmmeter, set the scale selector to Rx 100K and zero-adjust the meter. Measure the resistance between the lead and ground (discharge pipe or well casing, if steel).

What it Means

For ohm values, refer to table below. Motors of all Hp, voltage, phase and cycle duties have the same value of insulation resistance.

OHM VALUE	MEGAOHM VALUE	CONDITION OF MOTOR AND LEADS
		Motor not yet installed:
2,000,000 (or more)	2.0	New Motor.
1,000,000 (or more)	1.0	Used motor which can be reinstalled in the well.
		Motor in well (Ohm readings are for drop cable plus motor):
500,000 - 1,000,000	0.5 - 1.0	A motor in reasonably good condition.
20,000 - 500,000	0.02 - 0.5	A motor which may have been damaged by lightning or with damaged leads. Do not pull the pump for this reason.
10,000 - 20,000	0.01 - 0.02	A motor which definitely has been damaged or with damaged cable. The pump should be pulled and repairs made to the cable or the motor replaced. The motor will still operate, but probably not for long.
less than 10,000	0 - 0.01	A motor which has failed or with completely destroyed cable insulation. The pump must be pulled and the cable repaired or the motor replaced. The motor will not run in this condition.

TROUBLESHOOTING

Pump Won't Start

POSSIBLE CAUSE	CHECK THIS BY...	CORRECT THIS BY...
No power at the motor	Check for voltage at the control box or panel.	If there is no voltage at the control panel, check the feeder panel for tripped circuits and reset those circuits.
Fuses are blown or the circuit breakers have tripped	Turn off the power and remove the fuses. Check for continuity with an ohmmeter.	Replace the blown fuses or reset the circuit breaker. If the new fuses blow or the circuit breaker trips, the electrical installation, motor, and wires must be check for defects.
(3-phase motors only) **Motor starter overloads are burned or have tripped**	Check for voltage on the line and load side of the starter. Check the amp draw and make sure the heater is sized correctly.	Replace any burned heaters or reset. Inspect the starter for other damage. If the heater trips again, check the supply voltage. Ensure that heaters are sized correctly and the trip setting is appropriately adjusted.
(3-phase motors only) **Starter does not energize**	Energize the control circuit and check for voltage at the holding coil.	If there is no voltage, check the control circuit fuses. If there is voltage, check the holding coil for weak connections. Ensure that the holding coil is designed to operate with the available control voltage. Replace the coil if defects are found.
Defective controls	Check all safety and pressure switches for defects. Inspect the contacts in control devices.	Replace worn or defective parts or controls.
Motor or cable is defective	Turn off the power and disconnect the motor leads from the control box. Measure the lead-to-lead resistance with an ohmmeter (set to R x 1). Measure the lead-to-ground values with an ohmmeter (set to R x 100K).	If an open or grounded winding is found, remove the motor from the well and recheck the measurements with the lead separated from the motor. Repair or replace the motor or cable.
(1-phase motors only) **Defective capacitor**	Turn off the power and discharge the capacitor by shorting the leads together. Check it with an analog ohmmeter (set to R x 100k).	When the meter is connected to the capacitor, the needle should jump toward 0 (zero) ohms and slowly drift back to infinity (Ą). Replace capacitor if it is defective.
Defective pressure switch or the tubing to it is plugged	Watch the pressure gauges as the pressure switch operates. Remove the tubing and blow through it.	Replace as necessary.
The pump is mechanically bound or stuck	Turn off the power and manually rotate the pump shaft. Also check the motor shaft rotation, the shaft height, and the motor's amp draw (to see if it indicates a locked rotor).	If the pump shaft doesn't rotate, remove the pump and examine it. If necessary, dismantle it and check the impellers and seal for obstruction. Check for motor corrosion.

Pump Does Not Produce Enough Flow (GPM)

POSSIBLE CAUSE	CHECK THIS BY...	CORRECT THIS BY...
(3-phase motors only) **Shaft is turning in the wrong direction**	Check to make sure the electrical connections in the control panel are correct.	Correct the wiring. For single phase motors, check the wiring diagram on the motor. For three phase motors, simply switch any two power leads.
Pump is operating at the wrong speed (too slow)	Check for low voltage and phase imbalance.	Replace defective parts or contact power company, as applicable.
Check valve is stuck (or installed backwards)	Remove the check valve.	Re-install or replace.
Parts or fittings in the pump are worn **– or –** **Impellers or Inlet Strainer is clogged**	Install a pressure gauge near the discharge port, start the pump, and gradually close the discharge valve. Read the pressure at shutoff. (Do not allow the pump to operate for an extended period at shutoff.)	Convert the PSI you read on the gauge to Feet of Head by: **PSI x 2.31 ft/PSI = ______ ft.** **Specific Gravity** Add to this number the number of feet (vertically) from the gauge down to the water's pumping level. Refer to the pump curve for the model you are working with to determine the shutoff head you should expect for that model. If that head is close to the figure you came up with (above), the pump is probably OK. If not, remove the pump and inspect impellers, chambers, etc.
The water level in the well may be too low to supply the flow desired **– or –** **Collapsed well**	Check the drawdown in the well while the pump is operating.	If the pumping water level (including drawdown) is not **AT LEAST 3 FEET** above the pump's inlet strainer, either: 1. Lower the pump further down the well. 2. Throttle back the discharge valve to decrease the flow, thereby reuding drawdown.
Broken shaft or coupling	Pull pump and inspect.	Replace as necessary.
There are leaks in the fittings or piping	Pull the pump out of the well.	The suction pipe, valves, and fittings must be made tight. Repair any leaks and retighten all loose fittings.

TROUBLESHOOTING

Fuses Blow or Heaters Trip

POSSIBLE CAUSE	CHECK THIS BY...	CORRECT THIS BY...
Improper voltage	Check the voltage at the control box or panel.	If the voltage varies by more than 10% (+ or -), contact the power company.
	If the incoming voltage is OK, check the wire size and the distance between the pump motor and the pump control panel.	Rewire with correct gauge. Undersized wire and a great distance between the control panel and the pump motor increases resistance and decreases the voltage by the time it reaches the pump motor.
The starter overloads are set too low	Cycle the pump and measure the amperage.	Increase the heater size or adjust the trip setting. Do not, however, exceed the recommended rating.
(3-phase motors only) **The three-phase current is imbalanced**	Check the current draw on each lead to the motor.	The current draw on each lead must be within 5% of each other (+ or -). If they are not, check the wiring.
The wiring or connections are faulty	Check to make sure the wiring is correct and there are no loose terminals.	Tighten any loose terminals and replace any damaged wire.
(1-phase motors only) **Capacitor is defective**	Turn off the power and discharge the capacitor. Check the capacitor with an ohmmeter (set at R x 100k). See page 15 for instructions.	When the meter is connected to the capacitor, the needle should jump toward 0 (zero) ohms and then slowly drift back to infinity (¥). Replace capacitor if it is defective.
Fuse, heater, or starter are the wrong size	Check the fuses and heaters against the motor manufacturer's specification charts.	Replace as necessary.
The control box location is too hot	Touch the box with your bare hand during the hottest part of the day – you should be able to keep your hand on it without burning.	Shade, ventilate, or move the control box so its environment does not exceed 120°F.
(1-phase motors only) **Wrong control box**	Check requirements for the motor against the control box specifications.	Replace as necessary.
Defective pressure switch	Watch gauges as pressure switch operates.	Replace as necessary.
The motor is shorted or grounded.	Turn off the power and disconnect the wiring. Measure the lead-to-lead resistance with an ohmmeter (set to R x 1). Measure the lead-to-ground values with an ohmmeter (set to R x 100K) or a megaohmmeter. Compare these measurements to the rated values for your motor.	If you find an open or grounded winding, remove the motor and recheck the leads. If OK, check the leads for continuity and for bad splice.
Poor motor cooling	Find the internal diameter of the well casing (or sleeve, if used). For proper cooling, the flow of water **must not be less than the GPM shown across the bottom scale on page __.**	Throttle up the pump flow (GPM) so proper cooling is possible. – or – Pull the pump out of the well and add a sleeve with a smaller internal diameter.

Pump Cycles Too Often

POSSIBLE CAUSE	CHECK THIS BY...	CORRECT THIS BY...
The pressure switch is defective or is not properly adjusted	Check the pressure setting on the switch. Check the voltage across closed contacts.	Readjust the pressure switch or replace it if defective.
The tank is too small	Check the tank size and amount of air in the tank. The tank volume should be approximately 10 gallons for each Gallon-Per-Minute of pump capacity. At the pump cut-in pressure, the tank should be about 2/3 filled with air.	Replace the tank with one that is the correct size.
There is insufficient air charging of the tank or piping is leaking	Pump air into the tank or diaphragm chamber. Check the diaphragm for leaks. Check the tank and piping for leaks with soapy water. Check the air-to-water ratio in the tank.	Repair as necessary.
Plugged snifter valve or bleed orifice (causing pressure tank to be waterlogged)	Examine them for dirt or erosion.	Repair or replace as necessary.
Leak in the pressure tank or piping	Apply soapy water to pipes and tank, then watch for bubbles, indicating leaks.	Repair or replace as necessary.
The level control is defective or is not properly set	Check the setting and operation of the level control.	Readjust the level control setting (according to the manufacturer's instructions) or replace it if defective.
Pump is oversized for the application. It is outpumping the yield of the well and pumping itself dry.	Check the yield of the well (determined by the well-test) against the pump's performance curve.	Reduce the flow by throttling back the valve. – or – Change the pump.

LIMITED WARRANTY

Products manufactured by GRUNDFOS are warranted to the original user only to be free of defects in material and workmanship for a period of 24 months from date of installation, but not more than 30 months from date of manufacture. GRUNDFOS' liability under this warranty shall be limited to repairing or replacing at GRUNDFOS' option, without charge, F.O.B. GRUNDFOS' factory or authorized service station, any product of GRUNDFOS' manufacture. GRUNDFOS will not be liable for any costs of removal, installation, transportation, or any other charges which may arise in connection with a warranty claim. Products which are sold but not manufactured by GRUNDFOS are subject to the warranty provided by the manufacturer of said products and not by GRUNDFOS' warranty. GRUNDFOS will not be liable for damage or wear to products caused by abnormal operating conditions, accident, abuse, misuse, unauthorized alteration or repair, or if the product was not installed in accordance with GRUNDFOS printed installation and operating instructions.

To obtain service under this warranty, the defective product must be returned to the distributor or dealer of GRUNDFOS products from which it was purchased together with proof of purchase and installation date, failure date, and supporting installation data. Unless otherwise provided, the distributor or dealer will contact GRUNDFOS or an authorized service station for instructions. Any defective product to be returned to GRUNDFOS or a service station must be sent freight prepaid; documentation supporting the warranty claim and/or a Return Material Authorization must be included if so instructed.

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BE > THINK > INNOVATE >

Being responsible is our foundation
Thinking ahead makes it possible
Innovation is the essence

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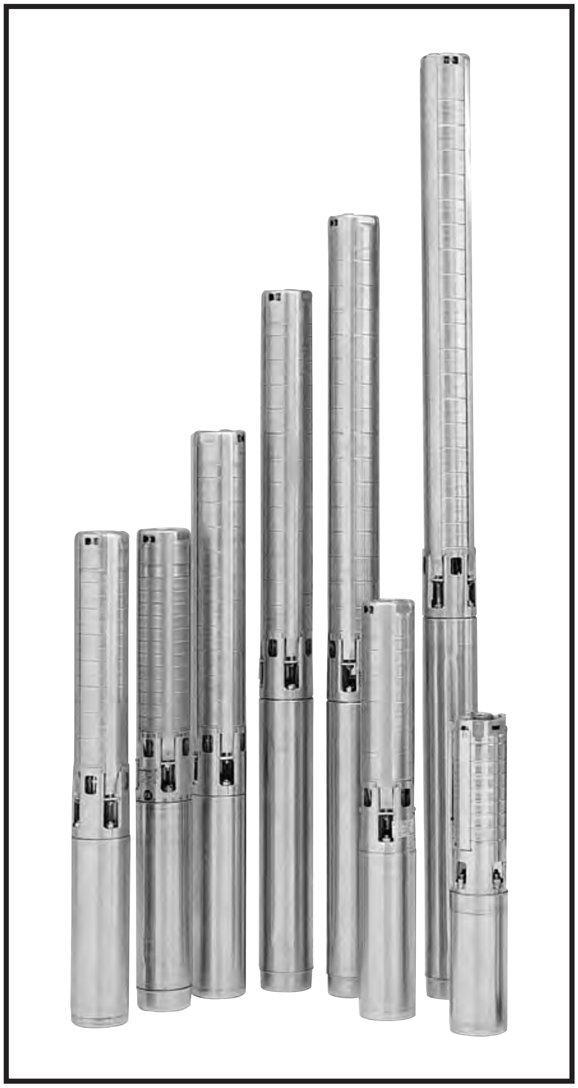
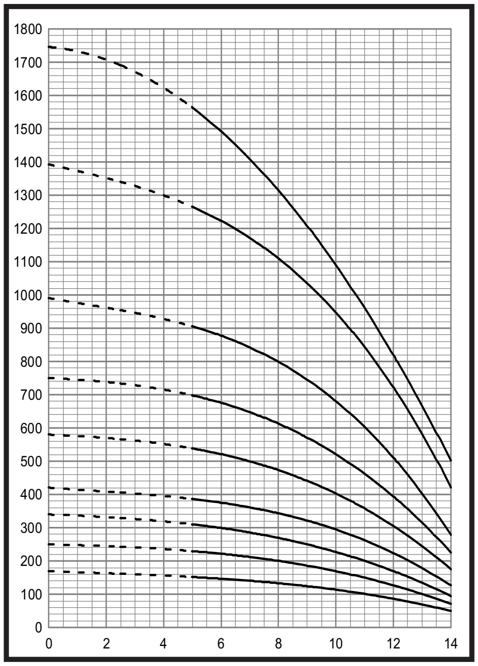
L-SP-TL-048 Rev. 2/06(US)

CS-EXW01 AND CS-EXW02 PUMP SPECIFICATIONS

Easy Selection Chart
Performance Curves and Technical Data

4-Inch Submersible Pumps





Performance Curves

Materials of Construction

Grundfos Stainless Steel Submersible Pumps

4" Submersible

Easy Selection Charts.

40S EASY SELECTION CHART

40 GPM

SELECTION CHARTS FLOW RANGE PUMP OUTLET

(Ratings are in GALLONS PER MINUTE-GPM) (24 TO 55 GPM) 2 " NPT

DEPTH TO PUMPING WATER LEVEL (LIFT) IN FEET

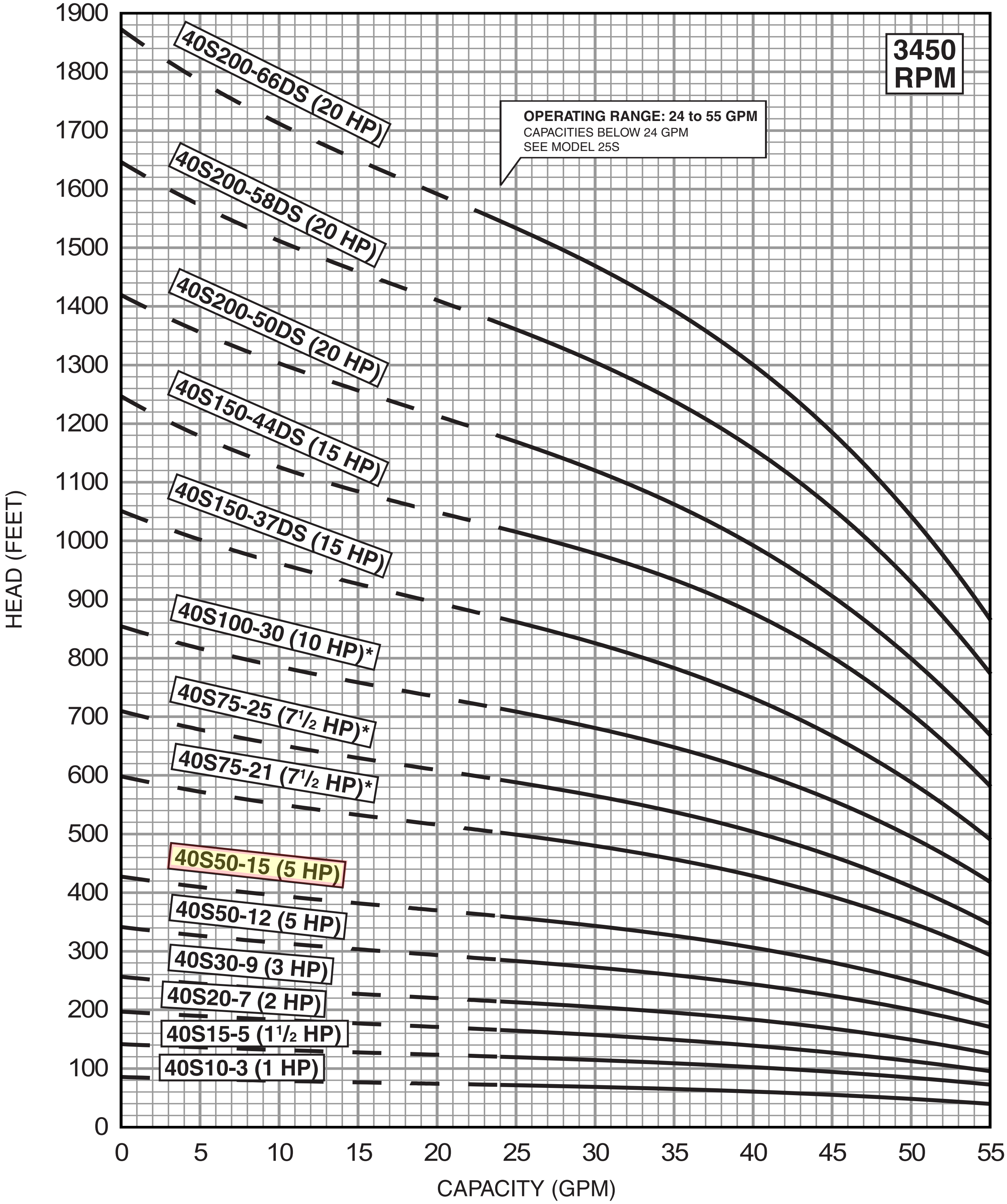
PUMP MODEL	HP	PSI		20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	340	400	460	520	600	700	800	900	1000	1100
40S10-3	1	20	46.2	33.0																								
		30	69.3																									
		40	92.4																									
		50	116																									
		60	139																									
SHUT-OFF PSI:			0	28	19	11	2																					
40S15-5	1 1/2	0	0				52.0	41.0	24.0																			
		20	46.2	57.0	50.0	37.0	18.0																					
		30	69.3	48.0	34.0	15.0																						
		40	92.4	31.0	11.0																							
		50	116	7.0																								
		60	139																									
SHUT-OFF PSI:			0	52	44	35	26	18	9																			
40S20-7	2	0	0					54.0	49.0	40.0	29.0	15.0																
		20	46.2			53.0	46.0	37.0	25.0	10.0																		
		30	69.3		52.0	45.0	35.0	23.0	8.0																			
		40	92.4	51.0	44.0	33.0	21.0	5.0																				
		50	116	42.0	32.0	18.0	2.0																					
		60	139	30.0	16.0																							
SHUT-OFF PSI:			0	77	68	59	51	42	33	25	16	7																
40S30-9	3	0	0							53.0	47.0	41.0	32.0	22.0														
		20	46.2					51.0	45.0	38.0	29.0	19.0																
		30	69.3				50.0	44.0	37.0	28.0	17.0																	
		40	92.4		54.0	50.0	43.0	35.0	26.0	15.0																		
		50	116	54.0	49.0	42.0	34.0	24.0	13.0																			
		60	139	48.0	41.0	33.0	23.0	11.0																				
SHUT-OFF PSI:			0	102	94	85	76	68	59	50	42	33	24	16	7													
40S50-12	5	0	0									53.0	49.0	44.0	39.0	32.0	25.0	16.0										
		20	46.2							52.0	48.0	43.0	37.0	30.0	22.0	13.0												
		30	69.3						51.0	47.0	42.0	36.0	29.0	21.0	12.0													
		40	92.4					51.0	46.0	41.0	35.0	28.0	20.0	11.0														
		50	116			54.0	50.0	45.0	40.0	34.0	26.0	18.0	9.0															
		60	139		53.0	49.0	45.0	39.0	33.0	25.0	17.0	8.0																
SHUT-OFF PSI:			0		130	122	113	104	96	87	78	70	61	52	44	35	26	18										
40S50-15	5	0	0											52.0	49.0	46.0	42.0	37.0	26.0									
		20	46.2									51.0	48.0	45.0	40.0	35.0	30.0	24.0										
		30	69.3								51.0	48.0	44.0	40.0	35.0	29.0	23.0	16.0										
		40	92.4							51.0	47.0	43.0	39.0	34.0	28.0	21.0	14.0											
		50	116						50.0	47.0	43.0	38.0	33.0	27.0	20.0	13.0												
		60	139					50.0	46.0	42.0	37.0	32.0	26.0	19.0	12.0													
SHUT-OFF PSI:			0					141	132	124	115	107	98	89	81	72	63	55	37	11								
40S75-21	7 1/2	0	0																49.0	41.0	29.0	15.0						
		20	46.2													53.0	51.0	48.0	43.0	32.0	19.0							
		30	69.3												52.0	50.0	48.0	45.0	39.0	27.0	13.0							
		40	92.4											52.0	50.0	48.0	45.0	42.0	35.0	22.0	6.0							
		50	116										52.0	50.0	47.0	44.0	41.0	38.0	30.0	16.0								
		60	139									51.0	49.0	47.0	44.0	41.0	38.0	34.0	25.0	10.0								
SHUT-OFF PSI:			0									181	172	163	155	146	137	129	111	85	59	33						
40S75-25	7 1/2	0	0																	51.0	45.0	37.0	23.0					
		20	46.2																52.0	47.0	39.0	29.0	14.0					
		30	69.3															54.0	50.0	44.0	35.0	25.0						
		40	92.4														54.0	52.0	48.0	41.0	32.0	21.0						
		50	116													53.0	52.0	50.0	45.0	38.0	28.0							
		60	139												53.0	51.0	49.0	47.0	43.0	34.0	24.0							
SHUT-OFF PSI:			0												203	194	186	177	160	134	108	82	47					
*40S100-30 40S100-30	10	0	0																		53.0	49.0	41.0	27.0				
		20	46.2																	54.0	50.0	44.0	35.0	20.0				
		30	69.3																	52.0	48.0	42.0	32.0	16.0				
		40	92.4																	51.0	46.0	39.0	28.0	12.0				
		50	116																	49.0	43.0	36.0	25.0	8.0				
		60	139																52.0	47.0	41.0	33.0	21.0					
SHUT-OFF PSI:																			222	196	170	144	110	66	23			

*** 6" Motor**

See 40S performance curves for higher head models.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

FLOW RANGE: 24 - 55 GPM **OUTLET SIZE: 2 " NPT** **NOMINAL DIA. 4"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 1-10 HP/3450 RPM.
6" MOTOR STANDARD,15-20 HP/3450 RPM.
* Also available with 6" motor.

Performance conforms to ISO 9906. 1999 (E) Annex A
Minimum submergance is 5 feet.

DIMENSIONS AND WEIGHTS

MODEL NO.	FIG.	HP	MOTOR SIZE	DISCH. SIZE	DIMENSIONS IN INCHES A	B	C	D	E	APPROX. SHIP WT.
40S10-3	A	1	4"	2" NPT	24.6	11.8	12.8	3.8	3.9	32
40S15-5	A	1 1/2	4"	2" NPT	29.7	13.6	16.1	3.8	3.9	37
40S20-7	A	2	4"	2" NPT	34.5	15.1	19.4	3.8	3.9	41
40S30-9	A	3	4"	2" NPT	43.3	20.6	22.7	3.8	3.9	65
40S50-12	A	5	4"	2" NPT	51.3	23.6	27.7	3.8	3.9	78
40S50-15	A	5	4"	2" NPT	56.2	23.6	32.6	3.8	3.9	84
40S75-21*	A	7 1/2	4"	2" NPT	74.6	29.6	45.0	3.8	3.9	120
40S75-25*	A	7 1/2	4"	2" NPT	81.2	29.6	51.6	3.8	3.9	124
40S100-30*	A	10	4"	2" NPT	103.7	43.9	59.8	3.8	3.9	181
40S150-37DS	A	15	6"	2" NPT	99.5	28.0	71.5	5.4	5.4	244
40S150-44DS	A	15	6"	2" NPT	111.0	28.0	83.0	5.4	5.4	340
40S200-50DS**	B	20	6"	2" MPT	136.0	30.6	105.4	5.4	5.5	319
40S200-58DS**	B	20	6"	2" MPT	149.2	30.6	118.6	5.4	5.5	334
40S200-66DS**	B	20	6"	2" MPT	162.4	30.6	131.8	5.4	5.5	394

NOTES: All models suitable for use in 4" wells, unless otherwise noted.
Weights include pump end with motor in lbs.
* Also available with 6" motor.
** Built into sleeve 2" MPT discharge, 6" min. well dia.

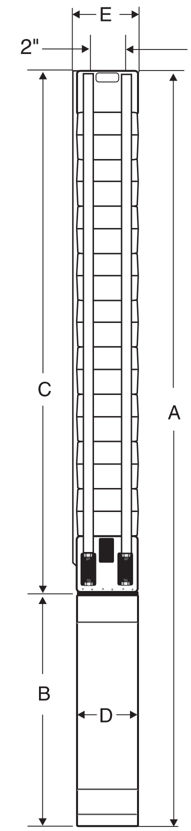


Fig. A

MATERIALS OF CONSTRUCTION

COMPONENT	CYLINDRICAL SHAFT (3-44 Stgs.)	DEEP SET (50-66 Stgs.)
Check Valve Housing	304 Stainless Steel	304 Stainless Steel
Check Valve	304 Stainless Steel	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel	304 Stainless Steel
Impeller	304 Stainless Steel	304 Stainless Steel
Suction Interconnector	304 Stainless Steel	304 Stainless Steel
Inlet Screen	304 Stainless Steel	304 Stainless Steel
Pump Shaft	431 Stainless Steel	431 Stainless Steel
Straps	304 Stainless Steel	304 Stainless Steel
Cable Guard	304 Stainless Steel	304 Stainless Steel
Priming Inducer	304 Stainless Steel	304 Stainless Steel
Coupling	316/431 Stainless Steel **	329/ 416 Stainless Steel
Check Valve Seat	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Top Bearing	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Impeller Seal Ring	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Intermediate Bearings	NBR/316 Stainless Steel	NBR/316 Stainless Steel
Shaft Washer	LCP (Vectra®)	LCP (Vectra®)
Split Cone	304 Stainless Steel	304 Stainless Steel
Split Cone Nut	304 Stainless Steel	304 Stainless Steel
Sleeve	Not Required	316 Stainless Steel
Sleeve Flange	Not Required	304 Stainless Steel

NOTES: Specifications are subject to change without notice.
Vectra® is a registered trademark of Hoechast Calanese Corporation.
***Stainless Steel option available.**

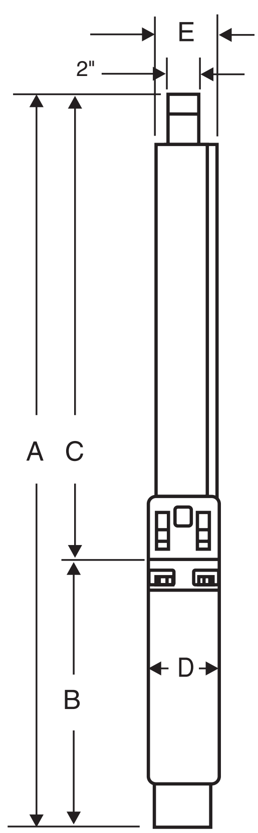


Fig. B

SYMCOM PUMPSAVER SPECIFICATIONS

www.SymCom.com
...your electronic control & protection specialists

SINGLE-PHASE
PUMPSAVER CATALOG

PumpSaver® Plus
ELECTRONIC PUMP
CONTROL & PROTECTION

Having issues with your SymCom product?
Call our **Technical Support Team** with
your questions.

800-843-8848
technicalsupport@symcom.com

To Our Customers:

Many times, issues with a product are the result of an incorrect setting. By calling us, SymCom's Technical Support Team, the issue can be eliminated. With our experienced staff, we can go over the settings with you to ensure that everything is set correctly. We are well versed in all products and applications for SymCom products. Chances are, we have run into your issue before.

The best way to fix an issue is to have you at the unit when you call, that way, we can make sure that all issues are fixed the first time. In the event that we determine your unit is not functioning properly, we will issue you a return material authorization (RMA) number to send the unit in for evaluation. If the unit is determined to be faulty and covered under warranty, we will replace the unit at no charge to you. No need to contact your distributor for a replacement. A new unit will be sent to you directly if it is covered under warranty.

So call our friendly support staff today for any and all of your questions regarding your SymCom products.

Best Regards,

SymCom Technical Support Team

Note: The use of flow restrictors, unusually high head pressures, or low water conditions at the time of calibration may interfere with the detection of dead-head and dry-well conditions.

SymCom's Model 235P PumpSaver®Plus is designed to protect 5-15 hp, 230V, single-phase pumps from dry-well, dead-head, jammed impeller and overvoltage and undervoltage conditions.

A calibration adjustment allows the Model 235P to be calibrated to your specific pumping applications, thereby reducing the possibility of false or nuisance tripping. A unique microcontroller-based voltage and current-sensing circuit constantly monitors the incoming power for fluctuations causing overcurrent and undercurrent. When an abnormality, such as loss of suction is detected, the PumpSaver®Plus deactivates its output relay and directly disconnects the pump motor.

The PumpSaver®Plus communicates with a hand-held diagnostics tool called the Informer (sold separately). The Informer displays parameters including calibration points, trip points, run time and last faults. An IR Kit-12 (12" fiber optic kit) allows the Informer to access these parameters even when the PumpSaver®Plus is enclosed in a control box. This is valuable for troubleshooting the pump while it is running.

An external current transformer is required for operation (sold separately).

Size	Current	CT*
5 - 7½ HP	27.5 - 42.1	50:5
10 HP	51	75:5
15 HP	75	100:5

NOTE: The PumpSaver®Plus models have a sensitivity adjustment for the dry-well trip point. After calibration is done, you can adjust the sensitivity for the dry-well/dead-head trip point from 70-90% of the full load. This makes the unit even more adaptable to varying pumping applications. If you have a very low producing well, you increase the sensitivity closer to the 90% mark, or if you have a very heavy producing well, you would decrease the sensitivity around the 70% mark.

Specifications

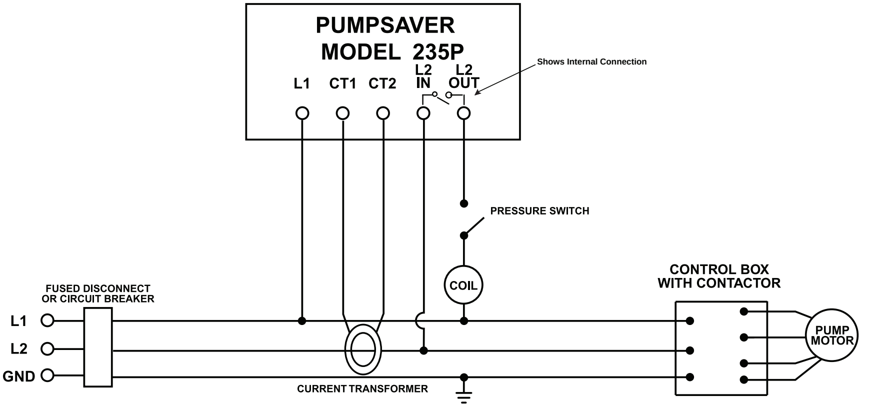
Functional Specifications	
Adjustments/Settings	
Overcurrent	125% of calibration point
Underload (dry-well)	Adjustable (70 to 90% of calibrated run power)
Overvoltage	265VAC
Undervoltage	190VAC
Number of restarts allowed in a 60-sec. period (rapid-cycling)	4
Trip Delay Times	
Overcurrent	5 seconds
Dry-well	4 seconds
Restart Delay Times	
Over/undervoltage	2 seconds
All other faults	Manual, 2-225 Minutes
Input Characteristics	
Supply Voltage	230VAC
Load Range	5 – 15 hp
Frequency	50/60Hz (Note: 50Hz will increase all delay timers by 20%)
Output Characteristics	
Output Contact Rating-SPST	A300, 720VA@240VAC (10 amps max.)
General Characteristics	
Operating Temperature	-40° to 55° C (-40° to 131° F)
Maximum Input Power	5 W
Wire Gauge	Solid or Stranded 10 - 22AWG
Terminal Torque	13 in.-lbs.
Standards Passed	
Electrostatic Discharge (ESD)	IEC 61000-4-2, Level 2, 4kV contact, 6kV air
Surge Immunity	IEC 61000-4-5, Level 4, 4kV line-to-line and line-to-ground
Safety Marks	
cUL Listed	UL508, C22.2 No. 14
Dimensions	5.26" W x 2.93" H x 2.90" D
Weight	14 oz.
Mounting Methods	#8 screws

For a typical wiring diagram see page 35.
For installation instructions see page 36.
For product dimensions see page 54.

How to order:

235P* (5 - 15hp, 230VAC)

* current transformer sold separately



Model 235P

Size	Current	CT*
5 - 7½ HP	27.5 - 42.1	50:5
10 HP	51	75:5
15 HP	75	100:5

* external current transformers sold separately

PUMPSAVER®PLUS
INSTALLATION INSTRUCTIONS

The PumpSaver®Plus INSIDERs fit inside 1/3 – 3hp, 230V Franklin™, Pentek®, Grundfos®or CentriPro™ control boxes. PumpSavers are designed to protect single-phase pumps from dry-well, dead-head, rapid-cycling, jammed impeller, and over/undervoltage conditions. Typical applications include residential waterwells, commercial waterwells, irrigation wells, and golf course and other sprinkler systems.

CONNECTIONS
(INSIDERs)
Refer to specific connection instructions depending on the particular control box being used:

Grundfos® control box	- page 28
Pentek® control box	– page 31
Franklin™ control box	– page 32
CentriPro™ control box	– page 33

(111P / 233P / 235P)
NOTE: Use in conjunction with UL listed or recognized thermal or solid-state overload relays only.

1 Mount the PumpSaver®Plus Model 111P / 233P / 235P in a convenient location in or near the pump control box. If the location is wet or dusy, a NEMA 3R, 4 or 12 enclosure should be used.
2. Refer to Typical Wiring Diagram for 111P / 233P / 235P on pages 34 and 35.

NOTE: For Model 235P, one line from the fused disconnect must pass through the current transformer.

The Model 235P will NOT function without an external CT (sold separately).

NOTE: If the Model 235P immediately trips out upon completion of the calibration process, the current transformer may be installed incorrectly. Switch the CT1 and CT2 connections at the unit, then repeat the calibration process.

CALIBRATION / RESTART DELAY
(INSIDERs)

1. Turn RESTART DELAY/CALIBRATION to the CAL position and close the box cover.
2. Apply power to the system. The pump should run for approximately 10 seconds and then shut off—this indicates the INSIDER has calibrated.
3. Remove power from the system. Open the control box and set the appropriate dry-well recovery time with the RESTART DELAY / CALIBRATION knob.
4. Shut the control box and re-apply power to the system.

(111P / 233P / 235P)
NOTE: The Model 111P / 233P / 235P should be calibrated during normal pumping conditions.

1. Turn the RESTART DELAY/CALIBRATION knob fully counter-clockwise to the CAL. position.
2. Apply power- the pump will run for approximately 10 seconds then shut off.
3. Set the RESTART DELAY/CALIBRATION knob to the desired restart delay (dry-well recovery time) - the pump will turn on.

CALIBRATING WHILE PUMPING

The Model 111P / 233P / 235P can also be calibrated while the pump is running. Turn the RESTART DELAY/CALIBRATION knob to CAL. while pumping. Wait for the pump to turn off (approximately 10 seconds), then adjust the RESTART DELAY/CALIBRATION knob to the desired setting.

MANUAL RESET MODE (111P / 233P / 235P only)

Set the RESTART DELAY/CALIBRATION knob to RESET for manual reset mode. If the 111P / 233P / 235P trips off due to a voltage or load problem, the RESTART DELAY/CALIBRATION knob must be rotated out of the RESET position to restart the pump, and then can be placed back in the RESET position for subsequent manual reset mode.

NOTE: Any restart delay can be bypassed by rotating the RESTART DELAY/CALIBRATION knob to the RESET position and back to the desired restart delay setting.

NOTE: The restart delay can be changed at any time. The next trip will follow the new restart delay setting.

OPERATION

The PumpSaver®Plus units monitor pump loads in amps and kilowatts. When the current (amps) exceeds approximately 125% of calibrated current, or power (kW) drops below the adjustable underload trip point, the PumpSaver®Plus units —after the trip delay—will turn off the pump. The PumpSaver®Plus units will automatically restart the pump after the selected restart delay time (unless in the manual reset mode).
The calibration is stored in permanent memory. The PumpSaver®Plus does not need to be recalibrated if power is lost.

SENSITIVITY

The PumpSaver®Plus units have an adjustment knob to set the underload trip sensitivity. Setting SENSITIVITY to the middle position (straight up) is equivalent to SymCom's standard underload trip level. Adjust the SENSITIVITY knob to increase/decrease underload sensitivity up to approximately ±10% of the standard trip. It may be necessary to increase the sensitivity if the PumpSaver®Plus does not trip on dry-run or dead-head or it is known that the water level in the well is very low relative to the pumps capabilities.

WARNING: Decreasing the SENSITIVITY may compromise the PumpSaver's ability to detect dry-run and/or dead-head conditions.

RUN HOURS

The PumpSaver®Plus units record pump run hours. Run hours can be displayed by a PumpSaver®Plus Informer. Run hours can be reset on the PumpSaver®Plus units.—please read the instruction fully before performing the procedure.
NOTE: Turn the SENSITIVITY knob <u>completely</u> to the left (counter-clockwise) or <u>completely</u> to the right (clockwise) when directed.

WARNING: ENSURE POWER IS APPLIED TO THE **INSIDERs** IN A SAFE MANNER WHEN PERFORMING THE FOLLOWING PROCEDURE.

To Reset Run Hours:

1. Remove power to the PumpSaver®Plus.
2. Set the RESTART DELAY/CALIBRATION knob to RESET and the SENSITIVITY knob to th middle (12:00) position.
3. Apply power to the PumpSaver®Plus—the CAL. LIGHT will turn on.
4. Turn the SENSITIVITY knob to the right—the CAL. LIGHT will turn off and the RUN LIGHT will turn on.
5. Turn the SENSITIVITY knob to the left—both lights will turn on.
6. Turn the SENSITIVITY knob to the right.
7. After 10 seconds, the CAL. and RUN LIGHTS will blink twice indicating the run hours have successfully been reset.

RAPID CYCLING

Rapid cycling is defined as more than 4 restarts in a 60-second period. The PumpSaver®Plus is capable of detecting a rapid-cycle condition whether a control device, such as a pressure switch, is installed before* or after it. Upon detecting either form of rapid cycling, the PumpSaver®Plus will lock-out, preventing damage to the pump. To reset the PumpSaver®Plus, remove and re-apply power.

RAPID CYCLING (Line Side / Upstream)

Rapid cycling of the line side of the PumpSaver®Plus may be caused by several naturally occurring conditions which are indistinguishable from true rapid cycling. For this reason, once tripped, Symcom's protection will wait 30 minutes and restart. If any restart is successful (pump runs for more than I minute), the rapid cycle counter will reset to zero. If the PumpSaver®Plus encounters rapid cycle 4 times without a successful restart, the PumpSaver®Plus will lock-out and require a manual reset. To reset the PumpSaver®Plus, remove and re-apply power.

*Protection against rapid cycling of a control device installed before the PumpSaver®Plus is disabled by default. Read the following instructions fully before performing the procedure to enable this feature.

NOTE: Turn the SENSITIVITY knob completely to the left (counter-clockwise) or completely to the right (clockwise) when directed.

To Enable Rapid-Cycle Protection when a Control Device is Installed BEFORE the PumpSaver®Plus: (to disable, follow the same procedure)

1. Remove power to the PumpSaver®Plus.
2. Set the RESTART DELAY/ CALIBRATION knob to RESET and the SENSITIVITY knob to the middle (12:00) position.
3. Apply power to the PumpSaver®Plus —the CAL. LIGHT will turn on.
4. Turn the SENSITIVITY knob to the right—the CAL. LIGHT will turn off, RUN LIGHT will turn on.
5. Turn the SENSITIVITY knob to the left—both lights will turn on.
6. Turn the SENSITIVITY knob right—left—right—left—right.
7. After 2 seconds, the CAL. and RUN LIGHTS will blink once indicating line side rapid-cycle protection has been enabled.

RAPID CYCLING (Load Side / Downstream)
Load side rapid cycling of the pump will immediately result in a manual lock-out. The pump will not restart automatically. To reset the PumpSaver®Plus, remove and re-apply power.

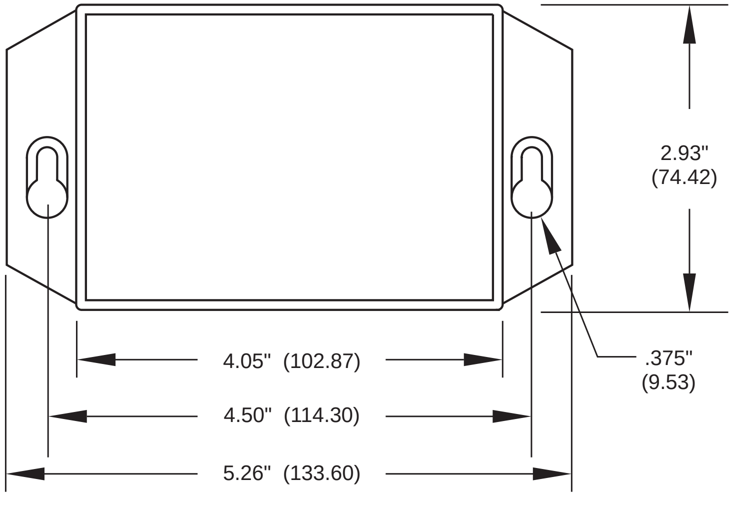
Note: Protection against rapid cycling of a control device installed after the PumpSaver®Plus is always enabled. Disabling line side detection will not disable load side detection.

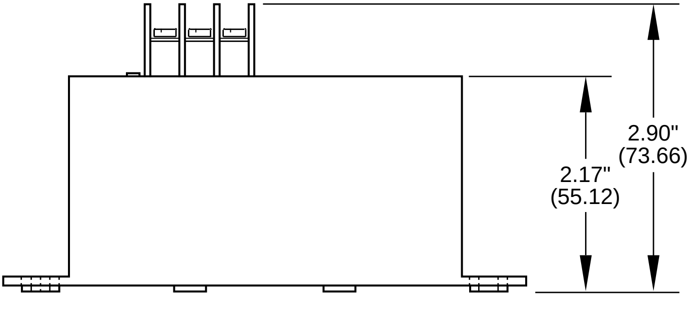
USING AN INFORMER

The PumpSaver®Plus units are equipped with an infrared LED that will communicate to a SymCom Informer—a hand-held, battery operated, diagnostic tool. An Informer IR Kit is required for the PumpSaver®Plus Insider units to communicate to the Informer. The Informer will display the model number; run time; pump starts; restart delay setting; restart delay timer; real-time voltage, current and power; dry-well and overload trip points; calibration voltage; last 20 faults; voltage, current, power and run time for the last 20 faults; highest/lowest voltage and current since calibration; and the CT size if applicable. The Informer can be used on any single-phase PumpSaver®Plus equipped with an infrared LED transmitter—Models 111-Insider-P; 231-Insider-P; 232-Insider; 111P; 233P; 234-P; 235P and 236-P.

INFORMER TROUBLESHOOTING GUIDE

The Informer does not activate when the ON button is pressed.	Battery Polarity Reversed - Verify the + and – terminals on the battery match the markings inside the battery compartment.
	Low Battery - Replace the battery.
The COMM STATUS light is off and all display values remain at zero.	Weak Signal – Ensure the Informer is aimed directly at the PumpSaver's infrared LED and is within the operating distance.
	PumpSaver®Plus not transmitting - Verify the PumpSaver®Plus is energized and the green RUN light is illuminated.
	Sunlight - Verify the sun is not shining directly onto the Informer's infrared receiver.
The COMM STATUS light is blinking.	Weak Signal – Ensure the Informer is aimed directly at the PumpSaver's infrared LED and is within the operating distance. OR If using an older Informer (version 1.xx or earlier) with a PumpSaver®Plus, this is a normal condition.
The displayed values fluctuate radically.	Weak Signal – Ensure the Informer is aimed directly at the PumpSaver's infrared LED and is within the operating distance.
The Informer displays values even after communication is lost.	This Is Normal - The Informer holds the last values it received before communication was lost. (until the auto shut off)





(605) 348.5580 / (800) 843.8848 / Fax (605) 348.5685
customerservice@symcom.com / technicalsupport@symcom.com

Voltage/Current/Power Monitors - Overload Relays
SymCom's 777 family of products are UL listed as Electronic Overload Relays. The KW/HP units are also power monitors that can calculate a Power reading for use with many software solutions.

Communication & I/O Modules
Units that are used for converting the information coming from a 777 family or 601 family product to Modbus, Devicenet, 4-20mA or Profibus signal to be sent over a network.

Remote Monitors
SymCom's remote monitors are used in conjunction with the 777 and 601 families to display real-time voltages and currents. Fault codes are listed on an easy to read display. Using a remote monitor will also help by making it safer for employees to gather real-time information without having to open the electrical panel.

Solutions Software
Used to monitor, log information, control and change configurations and setpoints on the 777 and 601 family of products.

Voltage Monitors, single-phase & 3-phase
Used to monitor incoming line voltages for High or Low voltage, Reverse-phase, Unbalanced voltage and Single-Phased voltages.

Current Monitors, single-phase & 3-phase
Used to monitor current levels in a motor for High or Low current, Unbalanced current and Single-Phased currents.

Alternating Relays
Unit will alternate between two pumps so they will have equal running time, thus not wearing one pump out prematurely.

Intrinsically-Safe Relays
Units designed to be used in hazardous applications where explosive materials are present.

Pump Controllers
Used to control from 2 to 4 pumps in multiple pump applications. Has the ability to be used in pump-up or pump-down configurations. Different models have multiple uses. SymCom also provides Intrinsically- Safe pump controllers.

Load Sensors
Can be used as proof relays to detect tool wear, feed rates and loss of prime on pumps by detecting current levels. Many different configurations can be used for differing uses.

Auxiliary Products
TIMERS - On-delay timer that starts its timer when power is applied. Output contact is energized when the timing is complete, anywhere from 6 seconds to 10 minutes or 0.5 to 12 seconds.
CURRENT TRANSFORMERS - Donut or foot mounted CT used for transmitting current signal from the main conductors to the SymCom units where required.

For warranty information,
please see **Terms and Conditions** at
www.symcom.com

www.SymCom.com

... your electronic control & protection specialists

2880 North Plaza Drive, Rapid City, SD 57702
(800) 843-8848 • (605) 348-5580 • fax: (605) 348-5685
customerservice@symcom.com • technicalsupport@symcom.com

APPENDIX C

Product Information:

Price® Pump Co. XT150 Centrifugal Pump and Baldor Pump Motor

PRICE XT150 CENTRIFUGAL PUMP

General Terms Of Sale For Products

1. GENERAL

A. Seller's price is based on these sales terms and conditions. This contract shall represent the final, complete and exclusive statement of the agreement between the parties and may not be modified, supplemented, explained or waived by parol evidence, any Terms and Conditions contained in Buyer's purchase order or request for quotation, any course of dealings between the parties, Seller's performance or delivery, or in any other way. The Terms and Conditions of this contract may only be modified or waived in a written document signed by an Officer of Seller. These terms are intended to cover all activity of Seller and Buyer hereunder, including sales and use of products, parts and work and all related matters (references to products include parts and references to work include construction, installation and start-up). Any reference by Seller to Buyer's specifications and similar requirements are only to describe the products and work covered hereby and no warranties or other terms therein shall have any force of effect. Any information provided by Seller, including but not limited to suggestions as to specific equipment does not imply any guarantee of specific suitability and/or material compatibility in a particular application since many factors outside the control of Seller may affect the suitability of products in a particular application. Catalogs, circulars and similar pamphlets of the Seller are issued for general information purposes only and shall not be deemed to modify the provisions hereof.

B. The agreement formed hereby and the language herein shall be construed and enforced under the Uniform Commercial Code as in effect in the State of California on the date hereof.

2. TAXES

Any sales, use or other similar type taxes imposed on this sale or on this transaction are not included in the price. Such taxes shall be billed separately to the Buyer. Seller will accept a valid exemption certificate from the Buyer if applicable; however, if an exemption certificate previously accepted is not recognized by the governmental taxing authority involved and the Seller is required to pay the tax covered by such exemption certificate. Buyer agrees to promptly reimburse Seller for the taxes paid.

3. PERFORMANCE, INSPECTION AND ACCEPTANCE

A. Unless Seller specifically assumes installation, construction or start-up responsibility, all products shall be finally inspected and accepted within thirty (30) days after arrival at point of delivery. Products not covered by the foregoing and all work shall be finally inspected and accepted with thirty (30) days after completion of the applicable work by Seller. All claims whatsoever by Buyer (including claims for shortages) excepting only those provided for under the WARRANTY AND LIMITATION OF LIABILITY and PATENTS Clauses hereof must be asserted in writing by Buyer within said thirty (30) day period or they are waived. If this contract involves partial performance, all such claims must be asserted within said thirty- (30) day period for each partial performance. There shall be no revocation of acceptance. Rejection may be only for defects substantially impairing the value of products or work and Buyer's remedy for lesser defects shall be those provided for under the WARRANTY AND LIMITATION OF LIABILITY Clause.

B. Seller shall not be responsible for non-performance or for delays in performance occasioned by any causes beyond Seller's reasonable control, including, but not limited to, labor difficulties, delays of vendors or carriers, fires, governmental actions, or shortages of material, components, labor, or manufacturing facilities. Any delays so occasioned shall affect a corresponding extension of Seller's performance dates, which are, in any event, understood to be approximate. In no event shall Buyer be entitled to incidental or consequential damages for late performance or for a failure to perform. Seller reserves the right to make partial shipments and to ship products, parts or work which may be completed prior to the scheduled performance date.

C. In the event that Seller has agreed to mount motors, turbines, gears, or other products which are not manufactured by Seller and which are not an integral part of Seller's manufactured product, and a delay in the delivery of such products to Seller occurs that will cause a delay in Seller's performance date, Seller reserves the right to ship its product upon completion of manufacture and to refund an equitable portion of the amount originally included in the purchase price for mounting without incurring liability for non-performance.

D. Seller reserves to itself the right to change its specifications, drawings and standards if such changes will not impair the performance of its products, and parts, and further that such products, and parts, will meet any of Buyer's specifications and other specific product requirements which are a part of this agreement.

E. The manufacture and inspection of products and parts shall be to Seller's Engineering and Quality Assurance standards plus such other inspections, tests of documentation as are specifically agreed to by Seller. Requirements for any additional inspection, tests, documentation, or Buyer witness of manufacture, test, and/or inspection shall be subject to additional charges.

4. TITLE AND RISK OF LOSS

Title and risk of loss shall pass to buyer upon delivery of products at the designated Ex Works place (Incoterms 1990) unless other wise agreed by the parties.

5. EROSION AND CORROSION

It is specifically understood that products and parts sold hereunder are not warranted for operation with erosive or corrosive fluids. No product or part shall be deemed to be defective by reason of failure to resist erosive or corrosive action of any fluid and Buyer shall have no claim whatsoever against Seller therefore.

6. WARRANTY AND LIMITATION OF LIABILITY

A. Seller warrants only that its product and parts, when shipped, will be free from defects in materials and workmanship. With respect to products and parts not manufactured by Seller, Seller's only obligation shall be to assign to Buyer, to the extent possible, whatever warranty Seller requires from the manufacturer. All claims for defective products or parts under this warranty must be made in writing immediately upon discovery and, in any event, within one (1) year after initial start-up or eighteen (18) months after shipment, whichever first occurs, and all claims for defective work must be made in writing immediately upon discovery and in any event, within one (1) year of completion thereof by Seller.

Defective items must be held for Seller's inspection and returned to the original f.o.b. point upon request.

THE FOREGOING IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES WHATSOEVER, EXPRESS, IMPLIED AND STATUTORY, INCLUDING WITHOUT LIMITATION, THE IMPLIED, WARRANTIES OF MERCHANTABILITY AND FITNESS.

B. ANY PRODUCT (S) SOLD HEREUNDER WHICH IS NOT MANUFACTURED BY SELLER IS NOT WARRANTED BY SELLER and shall be covered only by the express warranty, if any, of the manufacturer thereof.

C. Upon Buyer's submission of a claim as provided above and its substantiation, Seller shall at its option either (i) repair or replace its product, part or work at the original place of delivery, or (ii) refund an equitable portion of the purchase price.

D. THE FOREGOING IS SELLER'S ONLY OBLIGATION AND BUYER'S EXCLUSIVE REMEDY FOR BREACH OF WARRANTY AND, EXCEPT FOR GROSS NEGLIGENCE, WILLFUL MISCONDUCT, AND REMEDIES PERMITTED UNDER THE PERFORMANCE, INSPECTION AND ACCEPTANCE AND THE PATENTS CLAUSES HEREOF, THE FOREGOING IS BUYER EXCLUSIVE REMEDY AGAINST SELLER FOR ALL CLAIMS ARISING HEREUNDER OR RELATING HERETO WHETHER SUCH CLAIMS ARE BASED ON BREACH OF CONTRACT. TORT (INCLUDING NEGLIGENCE) OR OTHER THEORIES. BUYER'S FAILURE TO SUBMIT A CLAIM AS PROVIDED ABOVE SHALL SPECIFICALLY WAIVE ALL CLAIMS FOR DAMAGES OR OTHER RELIEF, INCLUDING BUT NOT LIMITED TO CLAIMS BASED ON LATENT DEFECTS. IN NO EVENT SHALL BUYER BE ENTITLED TO INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, NOR FOR DAMAGES FOR LOSS OF USE, LOST PROFITS OR REVENUE, INTEREST, LOST GOODWILL, WORK OR PRODUCTION STOPPAGE, IMPAIRMENT OF OTHER GOODS, INCREASED EXPENSES OF OPERATION, OR THE COST OF PURCHASING REPLACEMENT POWER OR OTHER SERVICES BECAUSE OF SERVICE INTERRUPTIONS. FURTHERMORE, IN NO EVENT SHALL SELLER'S TOTAL LIABILITY FOR DAMAGES OF BUYER EXCEED THE PURCHASE PRICE OF THE PRODUCTS OR PARTS MANUFACTURED BY SELLER AND UPON WHICH SUCH LIABILITY IS BASED. ANY ACTION ARISING HEREUNDER RELATED HERETO, WHETHER BASED ON BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE) OR OTHER THEORIES, MUST BE COMMENCED WITHIN ONE (1) YEAR AFTER THE CAUSE OF ACTION ACCRUES OR IT SHALL BE BARRED.

7. PURCHASER'S REPRESENTATIONS & WARRANTIES

Purchaser represents and warranties that the products(s) covered by this contract shall not be used in or in connection with a nuclear facility or application. The parties agree that this representation and warranty is material and is being relied on by seller. This provision may be modified in a separate writing signed by an officer of PPC.

8. PATENTS

Seller agrees to assume the defense of any suit for infringement of any patents brought against Buyer to the extent of such suit charges infringement of an apparatus or product claim by Seller's product in and of itself, provided (i) said product is built entirely to Seller's design, (ii) Buyer notifies Seller in writing of the filing of such suit within ten (10) days after the service of process thereof, and (iii) Seller is given complete control of the defense of such suit, including the right to defend, settle and make changes in the product for the purpose of avoiding infringement of any process or method claims, unless infringement of such claims is the result of following specific instruction furnished by Seller.

9. EXTENT OF SUPPLY

Only products as listed in Seller's proposal are included in this agreement. It must not be assumed that Seller has included anything beyond same.

10. MANUFACTURING SOURCES

To maintain delivery schedules, Seller reservplants on a world-wide basis.

11. TERMS OF PAYMENT

Net 30 days from date of invoice.

Effective: January 1, 1999

Price® Pump Company

Type XT/XL

Installation, Operating and Maintenance Manual

Caution:
Before installing, repairing or performing maintenance on this pump, read these instructions completely.

If pump has been used to pump hazardous materials be certain that all materials have been removed prior to working on the pump.

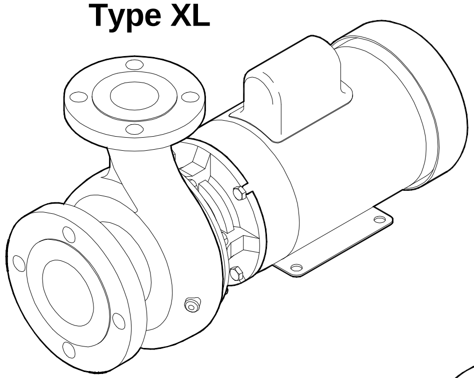
Warning!!
Ground motor before connection to electrical power supply!! Failure to ground motor can cause severe or fatal electrical shock hazard!!

Do not ground to gas supply line!!

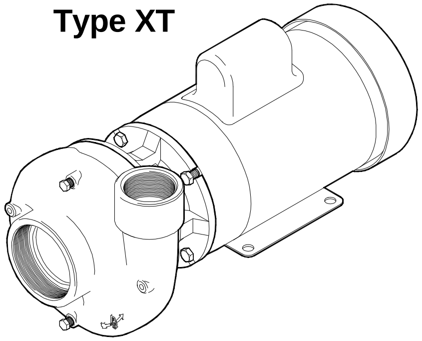
Match voltage to nameplate voltage on motor. Incorrect voltage can cause fire or seriously damage motor, voiding warranty.

Before disassembling be certain all liquid is removed from the pump.

Type XL



Type XT



Close Coupled Motor Pumps

These pumps require no special care in mounting, although it is suggested that they be firmly bolted to a level surface. Adequate air movement over motor will help prevent overloads.

Power Frame Mounted Pumps

These pumps must be mounted on a rigid steel base that will not warp or flex. Each pump must be mounted such that **the pump shaft centerline is on center with the driver shaft centerline.** Pad and/or shims will be required on either pump, driver or both. The two shafts should not touch each other and the distance between them depends on the coupling used to connect them. **Misalignment will cause bearing failure and void warranty. Pumps are rough aligned at the factory but must be realigned after shipment and installation.** Pulley driven pump must have pulleys inline and good belt tightness practices followed.

Direction of Rotation

Note: Motor shaft rotation is viewed from the suction end of pump. A rotational arrow is shown on the front of the pump volute casing. Incorrect rotation can cause pump damage, failure or reduced performance, voiding warranty. It is best to check rotation by momentarily energizing or jogging the motor prior to filling pump with liquid.

Warning! Do not operate pump without liquid for more than a few seconds, as damage will result to mechanical seal.

PLUMBING

All piping should be supported independently of the pump. Piping should not exert any stress on the pump connections.

Suction Piping Horizontal Pumps

Suction line must provide adequate suction pressure and smooth liquid flow for proper pump operation. Air entrapment in the suction line because of leaks or improper design may cause the pump to lose prime and fail. This pump is not self-priming, therefore the suction must be flooded at start up. Also, the suction line must provide sufficient pressure and smooth flow to pump inlet to prevent pump cavitation. A length of straight pipe a minimum of 5 times the pump inlet diameter and preferably 10 times the diameter should be installed in the suction line where it enters the pump. Elbows, fittings or valves installed close to the suction can disrupt liquid flow and cause malfunction. Suction lines must be at least the same size as the pump inlet or larger if possible.

School of Pumpology

Visit Our Web Site
www.pricepump.com

* Check out The Centrifugal Pump University and take the Interactive Pump Test.
* Find technical information for all Price Pump models.
* Locate a local distributor at www.pumpnet.com
* Printable I&O Manuals in PDF Format.

Parts List Type XT/XL Cont.

	All Models	
H2.	T.9 Teflon® Single Seal/Seat (opt)	0123
	Seat Pin T.9 (not shown)	0890
H3.	T.21 Double Seal/Seat (opt)	Specify P/N
	Double Seal Plate (2 rqd)	0309
	Plate Gasket, Teflon® (2 rqd)	0505
	Plate Bolts (6 rqd)	0977
H4.	Seal Quench (opt):	
	Buna Lip Seal	0756
	Viton® Lip Seal	0757
	Teflon® Lip Seal	0758
	Lip Seal Plate	0309-2
	Plate Gasket, Teflon®	0505
	Plate Bolts (3 rqd)	0977
H5.	T.9 Teflon® Double Seal/Seat (opt)	0670
	Double Seal Plate (2 rqd)	0309-1
	Plate Gasket, Teflon® (2 rqd)	0505
	Plate Bolts (6 rqd)	0977
	Seat Pin T.9 (2 rqd not shown)	0890

	All Models	
J.	Impeller Lockdown	0978
K.	Lockdown Gasket, Teflon®	0245
L.	Motor Bolts	
	All Bronze pumps (4 rqd)	0587
	Stainless Steel pumps (4 rqd)	0593
	AI & CIBF pumps (4 rqd) and	0593
	order Washers (4 rqd)	1137
M.	Sleeve Gasket, Teflon®	0245
N.	Impeller Shaft Key	0135
P1.	JM Motor	Specify P/N
P3.	Air Motor	Specify P/N
P4.	Power Frame	5480

Price Pump Co. recommends against using foot valves in the suction line to maintain liquid in the pump when it's not operating. If foot valves are used due to suction lift conditions they must be properly maintained to avoid leaks resulting from wear or fouling. Suction piping must be designed to prevent air from being trapped in high spots in the piping. This condition may cause the pump to vapor lock as the air bubble moves into the pump.

Discharge Piping

For flow and discharge head control it is advisable to install a valve (globe, ball, or other adjustable and non-leak type) in the discharge line close to the pump. The valve may be closed during system repairs to prevent backflow. By installing a check valve in the discharge line backflow can also be prevented during maintenance or during periods of pump stoppage.

OPERATION

Priming-

All centrifugal pumps must be filled with liquid prior to start up. For the pump illustrated in this manual completely fill the volute and suction lines prior to operation. It is suggested that during initial start up the discharge valve be closed and then opened as the motor develops full rpm's. If pump does not build up pressure as motor speed increases, shut down and make sure that liquid flow into pump is not restricted (see "Troubleshooting").

Note: A centrifugal pump's flow and head (pressure) will vary with the amount of resistance (friction and flow restrictions) in the discharge line. As a valve on the discharge line opens the flow and motor amp draw will increase and head will drop. As a valve on the discharge is closed the flow and amp draw will decrease and the head will increase. If resistance in the discharge line is not sufficient the pump will operate at a condition of maximum (or "choked") flow, also sometimes called "end of performance curve." Maximum horsepower is required to operate at this point and motor overload may result. If excessive amp draw and motor overload is recurring, reduce the system flow by installing a valve on the discharge line and restricting flow. Alternatively, reduce pump head by trimming impeller to a smaller diameter. Consult local Price Pump dealer for assistance.

TROUBLESHOOTING

1. Pump fails to build pressure:
Check for:
a. Pump not primed.
b. Incorrect rotation.
c. Driver speed too low.
d. Suction line restricted.
e. Driver failure.
f. Plugged or damaged impeller.
g. Pump or impeller undersized.
h. Pump cavitation.
i. Improper impeller clearance.

2. Pump fails to provide enough flow.
Check for:
a. System resistance too high.
b. Pump undersized.
c. Pump not primed.
d. Driver speed too low.
e. Poor suction conditions.
f. Improper impeller clearance.

3. Excessive noise or vibration during operation.
Check for:
a. Motor bearing failing.
b. Pump cavitating.
c. Improper impeller clearance.

4. Leaking mechanical seal.
Check for:
a. Improper assembly.
b. Worn or cracked seal faces.
c. Abrasive material in fluid.
d. Liquid flashing at seal faces (fluid temperature too high).
e. Seal pressure rating too low for the service.
f. Chemical attack of seal parts.
g. Seal operated dry or with a liquid having poor lubricating properties.

5. Pump gradually loses pressure and head.
Check for:
a. Increasing temperature causing cavitation or liquid vaporization.
b. Driver failure.
c. Suction lift too high.
d. Air entering suction line.

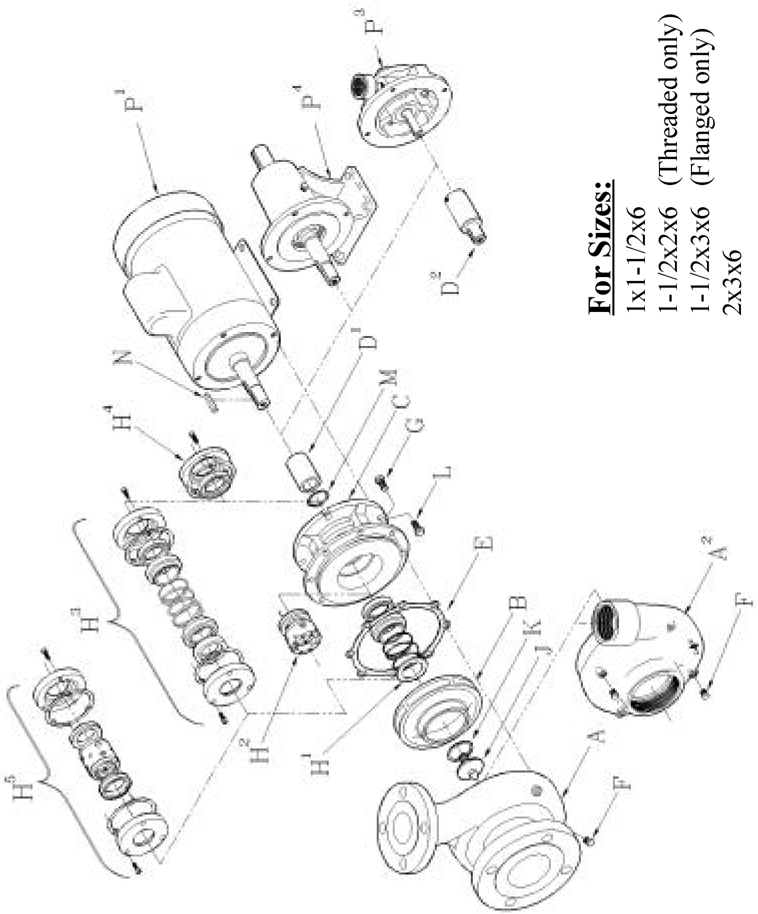
6. Motor/pump overheating.
Check for:
a. Excessive flow and amp draw (Throttle discharge).
b. Low voltage or frequency.
c. Flow too low with resulting heat rise.
d. Bearing failure.
e. System temperature too high.

Parts List Type XT/XL

		AI Threaded	BF Threaded	AB Threaded	SS Threaded	SS Flanged
A.	Volute					
	XT/XL 100	2601	2601	2603	2629	2605
	XT/XL 150	2607	2607	2609	2626	2611
	XT/XL200	2613	2613	2615	2627	2617
B.	Impeller Specify diameter					
	XT/XL100	2602-dia	2604-dia	2604-dia	2606-dia	2606-dia
	XT/XL150	2608-dia	2610-dia	2610-dia	2612-dia	2612-dia
	XT/XL200	2614-dia	2616-dia	2616-dia	2618-dia	2618-dia
	Note: For Dbl seal add DS (Sample: 2614DS-dia)					
C.	Bracket (std)	0131	0131	0132	0979	0979
	Double Seal	0131-1	0131-1	N/A	0979-1	0979-1
	Single Flush	0131-2	0131-2	0132-2	0979-2	0979-2
	Quench	0131-3	0131-3	N/A	0979-3	0979-3
	Internal Flush	0131-4	0131-4	N/A	0979-4	0979-4
D1.	Shaft Sleeve	0127	0126	0126	0127	0127
D2.	Stub Shaft 5/8" ID	0329-1	0329-1	0329-1	0329-1	0329-1
D3.	Stub Shaft 7/8" ID	0328-1	0328-1	0328-1	0328-1	0328-1
E.	Volute Gasket	0124	0124	0124	0301	0301
F.	Pipe Plug	0557	0557	0558	0559	0559
G.	Volute Bolts	0583	0583	0587	0724	0724
H1.	T.21 Seal/Seat	0121	0121	0121	0122	0122

Continued on next page

Type XT/XL Parts List



For Sizes:
1x1-1/2x6
1-1/2x2x6 (Threaded only)
1-1/2x3x6 (Flanged only)
2x3x6

AI = All Iron
BF = Bronze Fitted
AB = All Bronze
SS = Stainless Steel

TYPE XT/XL MAINTENANCE AND REPAIR

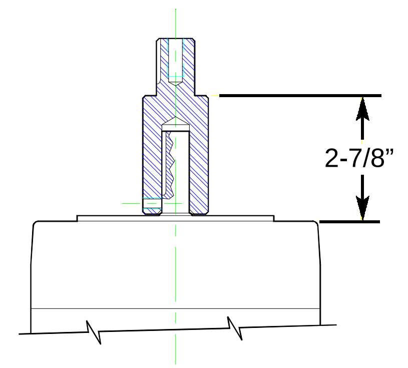
DISASSEMBLY

1. Disconnect power source from motor.
2. Disconnect electrical connections, tagging wires carefully to preserve correct rotation. Loosen pump base.
3. Remove pump and motor assembly to repair area. Observe position of all parts prior to disassembly. (Note: volute may be left in piping.)
4. Remove 8 volute bolts and remove volute from pump.
5. Remove impeller. Remove impeller lockdown by turning CCW. Slide impeller off of the shaft. Save shaft key.
6. Remove seal head from the shaft. On type 9 seal, loosen set screws and slide seal from shaft. On type 21, remove seal by sliding it off of the shaft.
7. Remove the four motor bolts and remove bracket from motor.
8. Remove seal seat from bracket. Use wooden or plastic dowel to tap the seat from the bracket. Diagram A
9. Remove shaft or shaft sleeve. Heat shaft sleeve to approximately 300°F and use a bearing puller to remove the sleeve.

REASSEMBLY

1. Clean seal cavity of the bracket thoroughly.
2. Thoroughly clean pump shaft. Assure that the shaft is not grooved and that there is no evidence of pitting or fretting. Polish the shaft with extra fine emery cloth and clean the keyway.

3a. On 56C motors, (stub shaft pumps only), ensure all debris and burrs are removed from the motor shaft. Align halfdog setscrew with motor keyway while sliding stub shaft over the motor shaft. Set height (diagram A). Tighten all set screws.



Reassembly Instructions continued on next page →

3b. On JM style motors, apply Loctite RC/609 to inside diameter of shaft sleeve. Install shaft sleeve onto motor shaft making sure that the groove for the Teflon® sleeve gasket is facing the pump end. Clean excess Loctite from shaft. Be sure sleeve is seated against motor shaft shoulder.

4. For Type 21, 8, and 9 seals: Place the bracket on a firm surface with the seat cavity (pump end) up. Then place a small amount of vegetable oil on the seat cup or "O" ring seat. Place the seat in the seal cavity with the polished face up toward the pump end. Evenly push seat into seat cavity with fingers, then then gently tap seat into place with a wooden dowel or plastic rod (2" outside diameter). To help ensure the seat is not damaged, place the cardboard disk supplied with the seal under the end of the dowel to prevent damaging the seat face.

5. Place bracket on motor (aligning the base if applicable). Secure bracket to motor with four motor bolts and washers.

6. Install seal head assembly:

For Type 21:

a. Lubricate shaft and elastomer with vegetable oil.

b. Install rotary seal head onto pump shaft and slide toward seat using a twisting motion until carbon face touches seal seat.

c. For 145JM through 215JM frame pumps, install new sleeve gasket into shaft sleeve. For 254JM through 256JM, install new gasket into hub of impeller.

d. Install seal spring and retainer over shaft sleeve.

e. Install impeller onto motor shaft being careful to align keyway of impeller with keyway in motor shaft. Push impeller on until impeller bottoms out on shaft sleeve. Install key in keyway.

f. Install impeller lockdown gasket and impeller lockdown. Tighten securely.

For Type 8 or Type 9:

a. Do not remove metal clips from seal head assembly. Place seal on shaft sleeve sliding gently past shoulder.

b. Slide seal head toward seat until carbon face contacts ceramic seat. Tighten seal head setscrews to shaft sleeve using short arm allen wrench supplied with seal or repair kit. Remove clips in seal head and discard.

c. For 145JM through 215JM frame pumps, install new sleeve gasket into shaft sleeve. for 254JM through 256JM, install new gasket into hub of impeller.

d. Install impeller onto motor shaft, being careful to align keyway of impeller with keyway in motor shaft. Push impeller on until impeller bottoms out on shaft sleeve. Install key in keyway.

e. Install impeller lockdown gasket and impeller lockdown. Tighten securely.

7. Install new volute gasket. Ensure that all of the mating surfaces of the gasket joint are cleaned to bare metal.
8. Install volute and secure with 8 bolts and tighten evenly.

9. Rotate pump shaft by hand to ensure impeller does not rub against volute.

10. Return pump to installation, reconnect electric connections.

11. Start pump momentarily to observe shaft rotation. If rotation corresponds to the rotation arrow on the pump, it may be put into service. If rotation is incorrect, switch any two leads on 3-phase motors to change rotation. Check wiring diagram of motor for single phase rotation correction.

12. Remove top pipe plug (if applicable) from the front of volute and prime pump thoroughly, making sure all air is purged. Turn shaft one revolution and then refill. Replace the pipe plug.

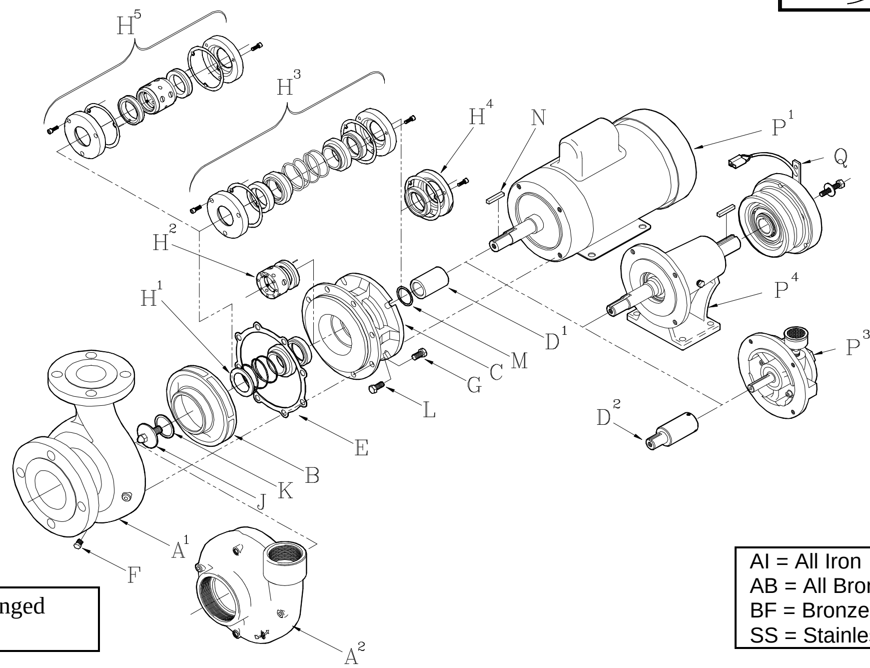
13. Start pump allowing adequate time to purge all air from system. Observe any gauges, flow meters, etc., to see if pump performs properly.

PRICE PUMP CO.

XT/XL PARTS LIST

Effective: May 17, 2001

For Sizes:
1 x 1½ - 6
1½ x 2 - 6 (Threaded Only)
1½ x 3 - 6 (Flanged Only)
2 x 3 - 6



Note: Pumps available in Threaded or Flanged Connections as noted below

AI = All Iron
AB = All Bronze
BF = Bronze Fitted
SS = Stainless Steel

		AI Threaded	BF Threaded	AB Threaded	SS Threaded	SS Flanged
A.	Volute					
	1 x 1-1/2 - 6 (XT100 Threaded, XL100 Flanged)	2601	2601	2603	2629	2605
	1-1/2 x 2 - 6 (XT150 Threaded)	2607	2607	2609	2626	
	1/2 x 3 - 6 (XL150 Flanged)					2611
	2 x 3 - 6 (XT200 Threaded, XL200 Flanged)	2613	2613	2615	2627	2617
B.	Impeller Specify diameter **					
	1 x 1-1/2 - 6 (XT100 Threaded, XL100 Flanged)	2602-dia	2604-dia	2604-dia	2606-dia	2606-dia
	1-1/2 x 2 - 6 (XT150 Threaded)	2608-dia	2610-dia	2610-dia	2612-dia	
	1-1/2 x 3 - 6 (XL150 Flanged)					2612-dia
	2 x 3 - 6 (XT200 Threaded, XL200 Flanged)	2614-dia	2616-dia	2616-dia	2618-dia	2618-dia
	Note: For Dbl seal add DS (Sample: 2614**DS**-dia)					
C.	Bracket (std)	0131	0131	0132	0979	0979
	Double Seal	0131-1	0131-1	N/A	0979-1	0979-1
	Single Flush	0131-2	0131-2	0132-2	0979-2	0979-2
	Quench	0131-3	0131-3	N/A	0979-3	0979-3
	Internal Flush	0131-4	0131-4	N/A	0979-4	0979-4
	Bracket for 213/215 JM	3405	3405	N/A	3388	3388
	O-ring	3405-0	3405-0	N/A	N/A	N/A
	Double Seal	2405-1	3405-1	N/A	3388-1	3388-1
	Single Flush	3405-2	3405-2	N/A	3388-2	3388-2
	Quench	3405-3	3405-3	N/A	3388-3	3388-3
	Internal Flush	3405-4	3405-4	N/A	3388-4	3388-4
	Internal Flush w/ Quench	3405-5	3405-5	N/A	3388-5	3388-5
D^1.	Shaft Sleeve (for std JM motor)	0127	0126	0126	0127	0127
D^2.	Stub Shaft 5/8" ID (56C) opt	0329-1	0329-1	0329-1	0329-1	0329-1
D^3.	Stub Shaft 7/8" ID (143TC/145TC/182C/184C) option (Not Shown)	0328-1	0328-1	0328-1	0328-1	0328-1
E.	Volute Gasket	0124 (Syn Fiber)	0124 (Syn Fiber)	0124 (Syn Fiber)	0301 (PTFE)	0301 (PTFE)
F.	Pipe Plug (2 rqd Threaded, 1 rqd Flanged)	0557	0557	0558	0559	0559
G.	Volute Bolts (8 rqd)	0583	0583	0587	0724	0724
H^1.	T.21 Single Seal/Seat	0121 (std B*)	0121 (std B*)	0121 (std B*)	0122 (std V*)	0122 (std V*)

B* = Buna V* = Fluorocarbon

**For Double Seal Impellers (add "DS"to Impeller P/N For Example: 2602DS)

Continued on Back…

Price® Pump Company
21775 8th Street East ◆ P.O. Box Q ◆ Sonoma, CA 95476-0329 ◆ (707) 938-8441 ◆ Fax (707) 938-0764

XT/XL PARTS LIST

Effective: May 17, 2001
Continued

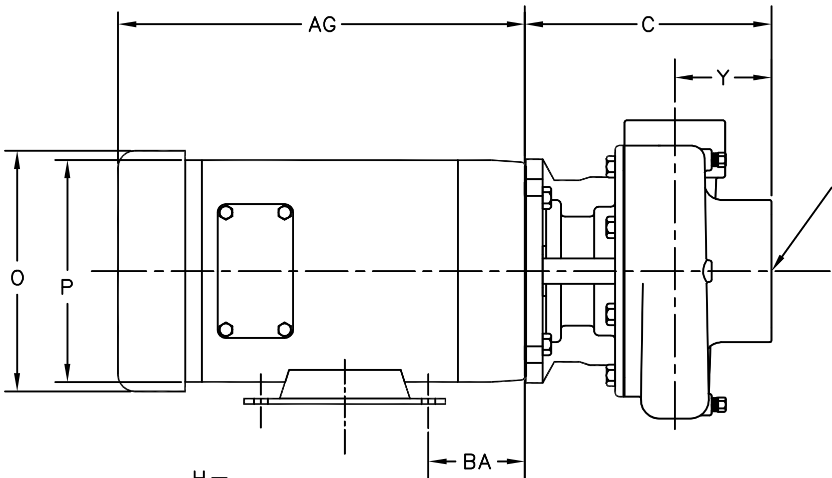
		All Models
H2.	T.9 PTFE Single Seal/Seat (opt)	0123
	Seat Pin T.9 (not shown)	0890
H3.	T.21 Double Seal/Seat (opt)	Specify P/N
	Double Seal Plate (2 rqd)	0309
	Plate Gasket, PTFE (2 rqd)	0505
	Plate Bolts (6 rqd)	0977
H4.	Seal Quench (opt):	
	Buna Lip Seal	0756
	Fluorocarbon Lip Seal	0757
	PTFE Lip Seal	0758
	Lip Seal Plate	0309-2
	Plate Gasket, PTFE	0505
	Plate Bolts (3 rqd)	0977
H5.	T.9 PTFE Double Seal/Seat (opt)	0670
	Double Seal Plate (2 rqd)	0309-1
	Plate Gasket, PTFE (2 rqd)	0505
	Plate Bolts (6 rqd)	0977
	Seat Pin T.9 (2 rqd not shown)	0890
J.	Impeller Lockdown	0978
K.	Lockdown Gasket, PTFE	0245

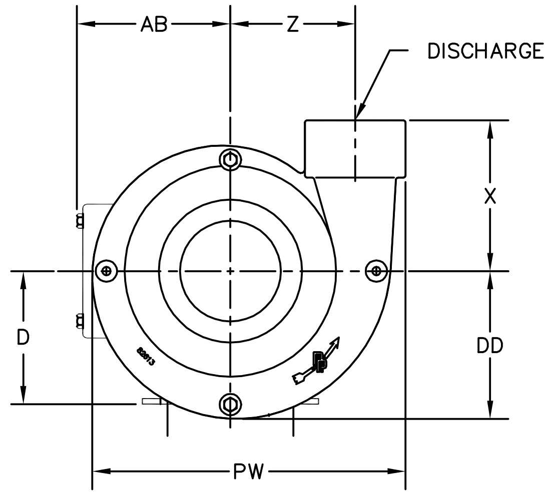
		All Models
L.	Motor Bolts	
	All Bronze pumps (4 rqd)	0587
	Stainless Steel pumps (4 rqd)	0593
	AI & BF pumps (4 rqd) and	0593
	order Washers (4 rqd)	1137
	Motor Bolts for 3405 & 3388 brackets	
	All Bronze pumps	N/A
	Stainless Steel pumps (4req)	1189
	AI & BF pumps (4 req) and	1189
	order Washers (4 req)	1199
M.	Sleeve Gasket, PTFE	0245
N.	Impeller Shaft Key	0135
P1.	JM Motor	Specify P/N
P2.	‘C’ Face Motor (not shown)	Specify P/N
	Base Plate (not shown)	0199
P3.	Air Motor	Specify P/N
P4.	Power Frame	5480
Q.	12 Volt Clutch (opt)	1983
	Key for Clutch (2 ea)	0136
	Lockbolt for Clutch	0567
	Lockbolt Washer for Clutch	0564

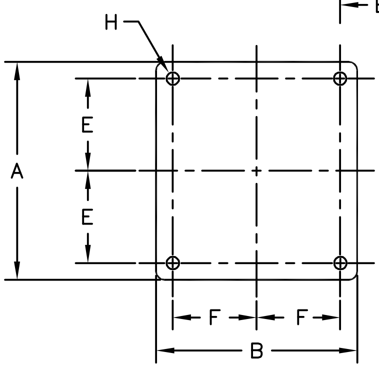
XL/XT Repair Parts Kits

All Iron	P/N 0659	Syn. Fiber Gasket - SS Shaft Sleeve - Sleeve Gasket - Loctite - Imp. Lockdown Gasket
CIBF	P/N 0658	Syn. Fiber Gasket - BR Shaft Sleeve - Sleeve Gasket - Loctite - Imp. Lockdown Gasket
SS	P/N 1019	PTFE Gasket - SS Shaft Sleeve - Sleeve Gasket - Loctite - Imp. Lockdown Gasket
	Note: Seal/seat must be ordered in addition to repair kit.	
	Options: 1½” T.21 & T.9 Single & Double.	

DESCRIPTION	REF. NO.	DATE	REV.
XTCIJM CLOSE COUPLED MOTOR PUMP ASSEMBLY	O-XTCIJM	1/28/93	C







	PUMP END DIMENSIONS						PIPE THREAD – NPT	
MODEL	C	DD	PW	X	Y	Z	DISCHARGE	SUCTION
XT 1x1½ x6	6 5/8	4"	8 3/8	4"	2 3/8	3 1/2	1" x 11 ½	1½ x 11 ½
XT 1½ x2x6	7 9/16	4 1/8	8 3/4	4 1/4	3 1/4	3 5/8	1½ x 11 ½	2" x 11 ½
XT 2x3x6	7 5/16	4 7/16	9 5/16	4 1/2	2 7/8	3 3/4	2" x 11 ½	3" x 8

NOTES
ALL DIMENSIONS ARE ROUNDED TO THE NEAREST 1/8 INCH.

			JM MOTOR END DIMENSIONS									ODP		TEFC & EXP. PRF	
HP	RPM	FRM	A	B	D	E	F	H	BA	O	P	AB	AG	AB	AG
1 1/2	3600	143JM	6-1/2	5-15/16	3-1/2	2-3/4	2	11/32	2-7/8	6-7/8	6-5/8	5-1/4	8-3/4	6-3/4	11-1/4
2	3600	145JM					2-1/2								
3	3600	145JM													
5	3600	182JM	8-1/2	6-1/2	4-1/2	3-3/4	2-1/4	13/32	3-1/2	8-7/16	7-7/8	5-7/8	11-1/8	7-3/8	14-3/4
7 1/2	3600	184JM					2-3/4								
10	3600	213 (W/ 184 FACE)	9-1/2	8	5-1/4	4-1/4	3-1/2	13/32	3-1/8	10-1/16	9-9/16	N/A		7-3/8	14-7/16
15	3600	213 (W/ 184 FACE)													

NOTE: MOTOR DIMENSIONS WILL VARY BY MODEL AND MAKE. DIMENSIONS ARE TO BE USED FOR REFERENCE ONLY.

FACTORY FAX TRANSMITTAL DRAWING

PRICE PUMP CO.
#1 Pump Way P.O. Box Q
Sonoma, CA 95476 (707) 938-8441
707-FAX 938-0764

60 Hz

PRICE PUMP CO.
SONOMA, CALIFORNIA

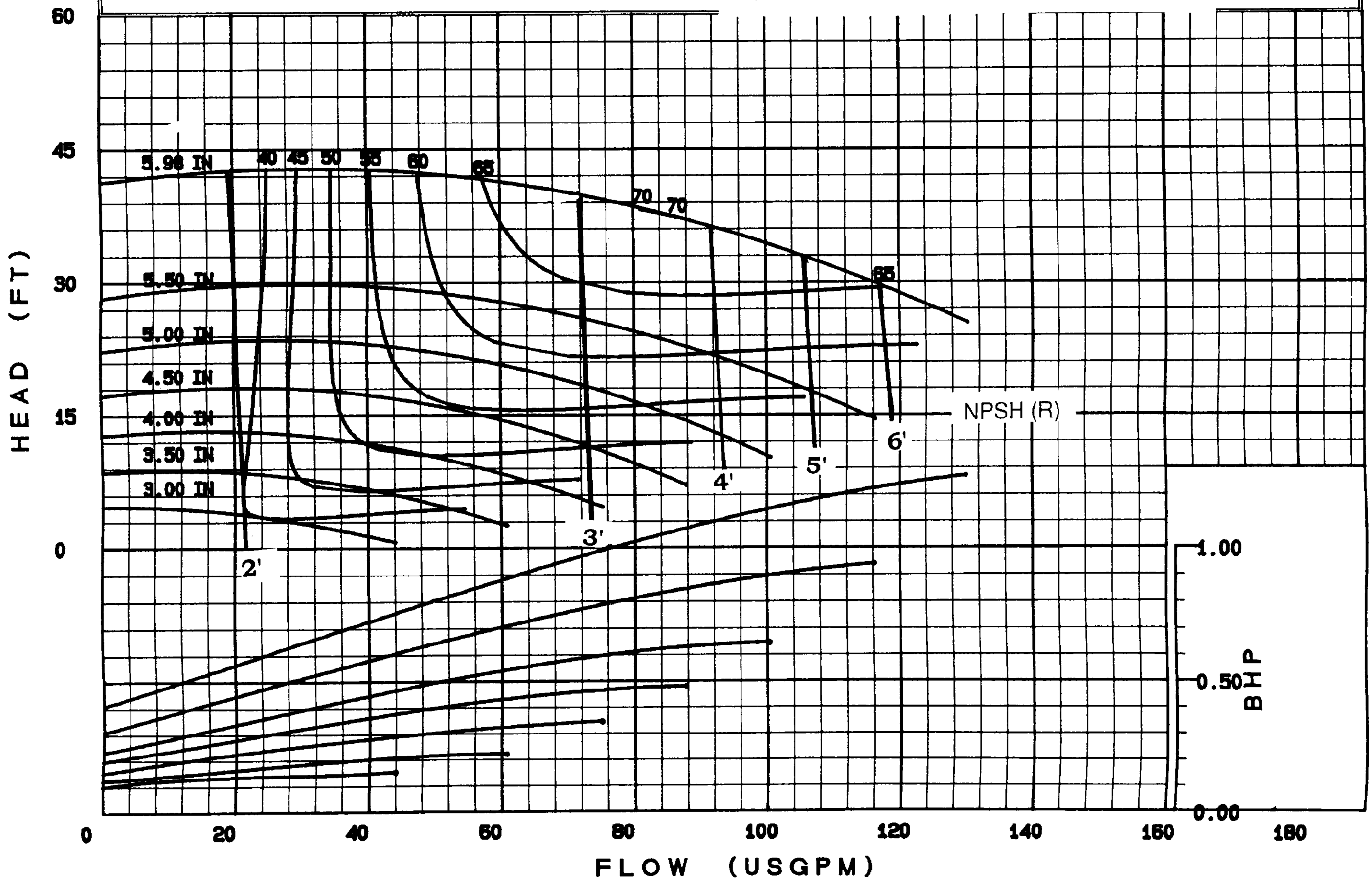
Ph. (707) 938-8441 Fax (707) 938-0764

CURVE NUMBER: X000033-57-1 MODEL: XL/XT150 SIZE: *1-1/2x3x6 **1-1/2x2x6 RPM: 1750

IMPELLER DIA: VARIOUS MIN. IMPELLER DIA: 3.00" MAX. IMPELLER DIA: 5.98" MAX. SOLIDS: .19"

CUSTOMER: CUSTOMER'S P.O.:

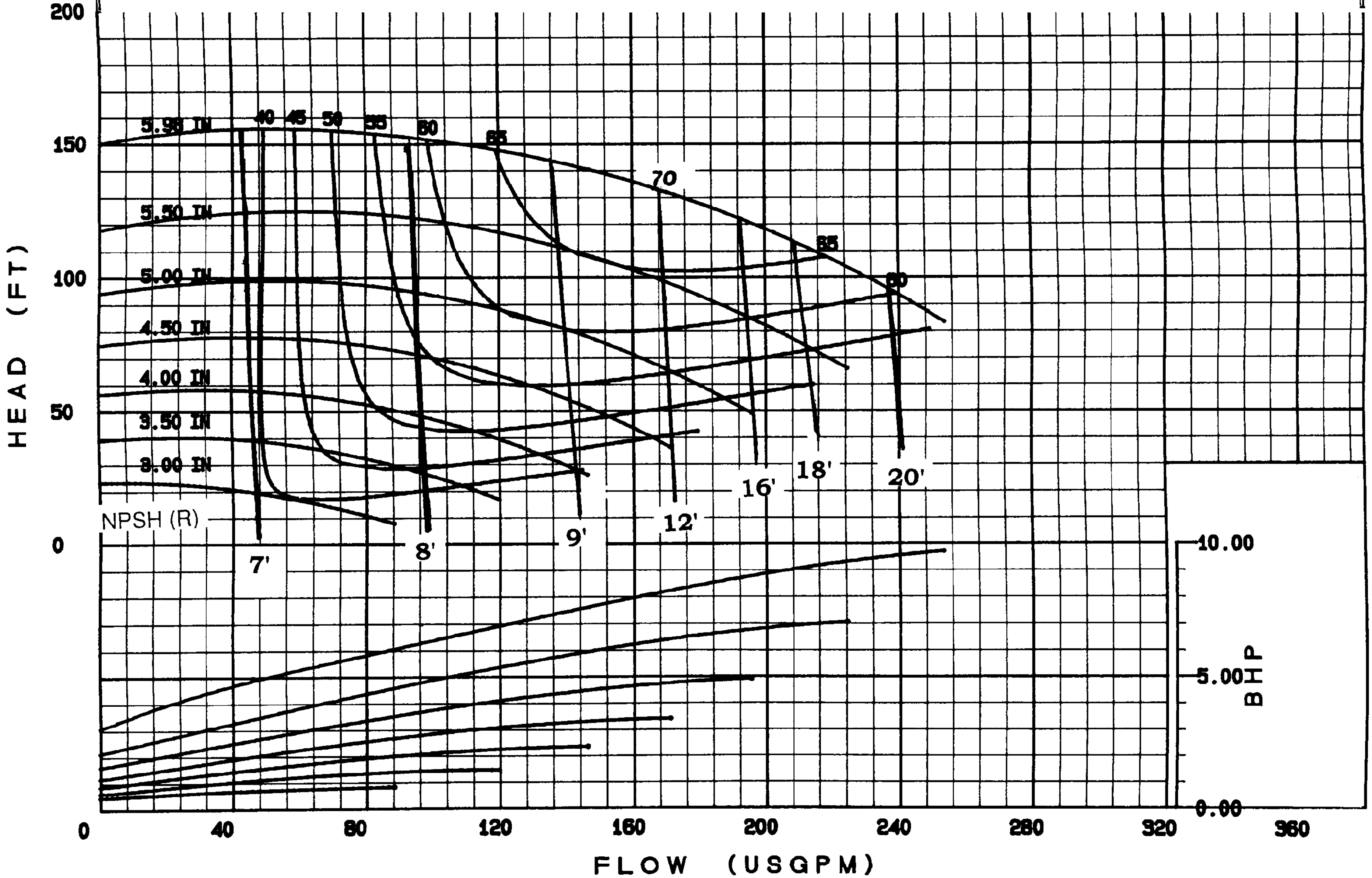
TEST DATE: 8/01/94 VERIFIED: 5/24/01 REMARKS: *XL150=FLANGED PORTS **XT150=THREADED PORTS



60 Hz

PRICE PUMP CO.
SONOMA, CALIFORNIA
Ph. (707) 938-8441 Fax (707) 938-0764

CURVE NUMBER: X000031-55-1 MODEL: XL/XT150 SIZE: *1-1/2x3x6 **1-1/2x2x6 RPM: 3500
IMPELLER DIA: VARIOUS MIN. IMPELLER DIA: 3.00" MAX. IMPELLER DIA: 5.98" MAX. SOLIDS: .19"
CUSTOMER: CUSTOMER'S P.O.:
TEST DATE: 8/01/94 VERIFIED: 5/24/01 REMARKS: *XL150=FLANGED PORTS **XT150=THREADED PORTS



BALDOR PUMP MOTOR

General Information

- Overview
- Specifications
- Performance Data
- Parts List
- Dimensional Dwg
- Connection Diag
- Product Literature

More Information

- Locate Distributor
- Baldor Sales Offices

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AC Motors | Pump |

Specifications: JMWDM3711T

Catalog Number:	JMWDM3711T
Specification Number:	37H883T968
Horsepower:	10
Voltage:	208-230/460
Hertz:	60
Phase:	3
Full Load Amps:	26.2-23.8/11.9
Usable at 208 Volts:	N/A
RPM:	3450
Frame Size:	215JM
Service Factor:	1.15
Rating:	40C AMB-CONT
Locked Rotor Code:	H
NEMA Design Code:	B
Insulation Class:	F
Full Load Efficiency:	87.5
Power Factor:	90
Enclosure:	TEFC
Baldor Type:	3730M
DE Bearing:	6309
ODE Bearing:	6206
Electrical Specification Number:	37WGT968
Mechanical Specification Number:	37H883
Base:	RG
Mounting:	F1

* For certified information, contact your local Baldor office.

Performance Data: JMWDM3711T

Product Nameplate Data :					
Rated Output	10 HP	Hertz	60	NEMA Nom. Eff.	87.5
Volts	208-230/460	Phase	3	Power Factor	90
Full Load Amps	26.2-23.8/11.9	NEMA Design Code	B	Service Factor	1.15
Speed	3450	LR KVA Code	H	Rating - Duty	40C AMB-CONT

(Typical performance - Not guaranteed values)

General Characterstics at 460 V, 60 Hz, 10 HP			
Full Load Torque	15.1 LB-FT	Starting Current	87.2 Amps
Start Configuration	DOL	No-Load Current	3.5 Amps
Break Down Torque	57.2 LB-FT	Line-line Resistance @ 25° C	1.04 Ohms
Pull-Up Torque	29.5 LB-FT	Temperature Rise, C @ FL (in deg)	65
Locked-Roter Torque	34.2 LB-FT	Temp. Rise @ S.F. Load (in deg)	76

Load Characteristics at 460 V, 60 Hz , 10 HP							
% of Rated Load	25	50	75	100	125	150	S.F.
Power Factor	67	82	88	90	91	91	91
Efficiency	75.6	84.2	87.3	87.8	87.4	86.2	87.6
Speed (rpm)	3570	3546	3521	3493	3462	3427	3474
Line Amperes	4.76	6.87	9.33	11.9	14.7	17.7	13.6

* For certified information, contact your local Baldor office.

JMWDM3711T Replacement Parts List

Print Page | Close Window

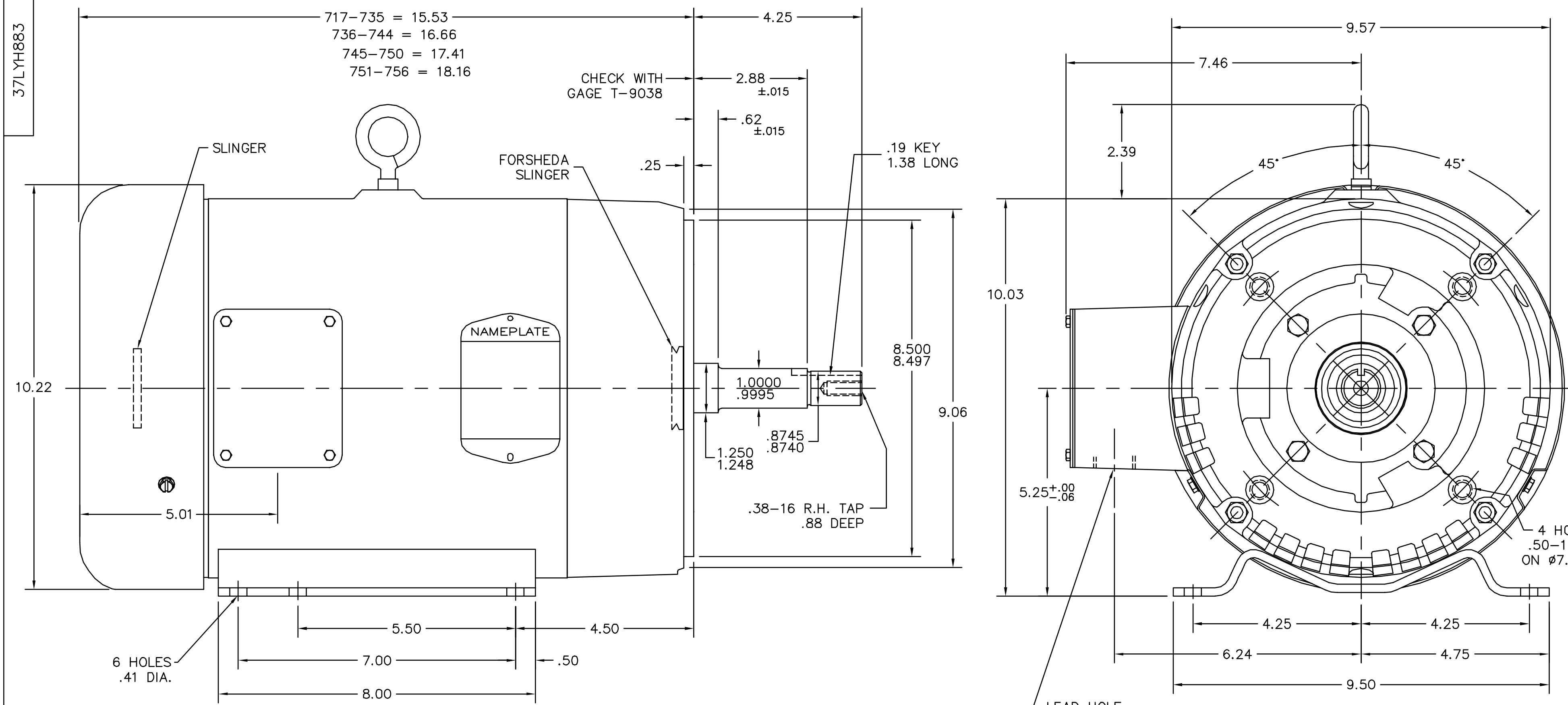
Catalog Number	JMWDM3711T
Specification Number	37H883T968
Description	10HP,3450RPM,3PH,60HZ,215,JM,3730M,TEFC
Plant	BALDOR FT SMITH/REC WHSE #5

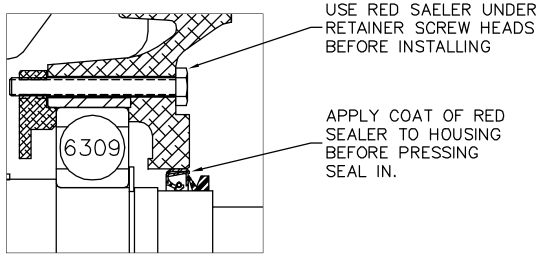
Replacement Parts

Material Number	Description	Qty.	List Price	Units
37FN3002A01	EXT FAN, PLASTIC	1	$ 24.00	EA
37CB1001A01W	WHITE EPOXY CONDUIT BOX, MACH	1	$ 45.00	EA
37CB1001W	37CB1001 W/WHITE EPOXY	1	$ 45.00	EA
37GS1016A01	NEOPRENE KOBX GASKET W/LIP (WHITE)	1	*CALL	EA
37EP3101A94MW	FRONT TEFC L&M 206 BRG W/O GRSR (WHITE)	1	$ 120.00	EA
37EP3101A94DW	FRONT TEFC L&M 206 BRG W/O GRSR	1	$ 149.00	EA
37EP3401T08MW	FACE MT EP, ENCL, 213TC-215TC, W/WHITE E	1	$ 108.00	EA
37EP3401T08DW	DRILLED EP W/WHITE EPOXY	1	$ 109.00	EA
07FH4011	WASHDOWN IEC FH W/AUTOPHORETIC PRIMER	1	$ 17.00	EA
36CB4518	36 LIPPED CB LID AUTOPHORETIC	1	$ 3.00	EA
37GS3010	1/16"WHITE LID GASKET	1	$ 2.00	EA
HA3104S14	THRUBOLT 12.125LG SS	4	$ 12.00	EA

* Please contact your **nearest Baldor Sales Office** to obtain price on these items.

37LYH883





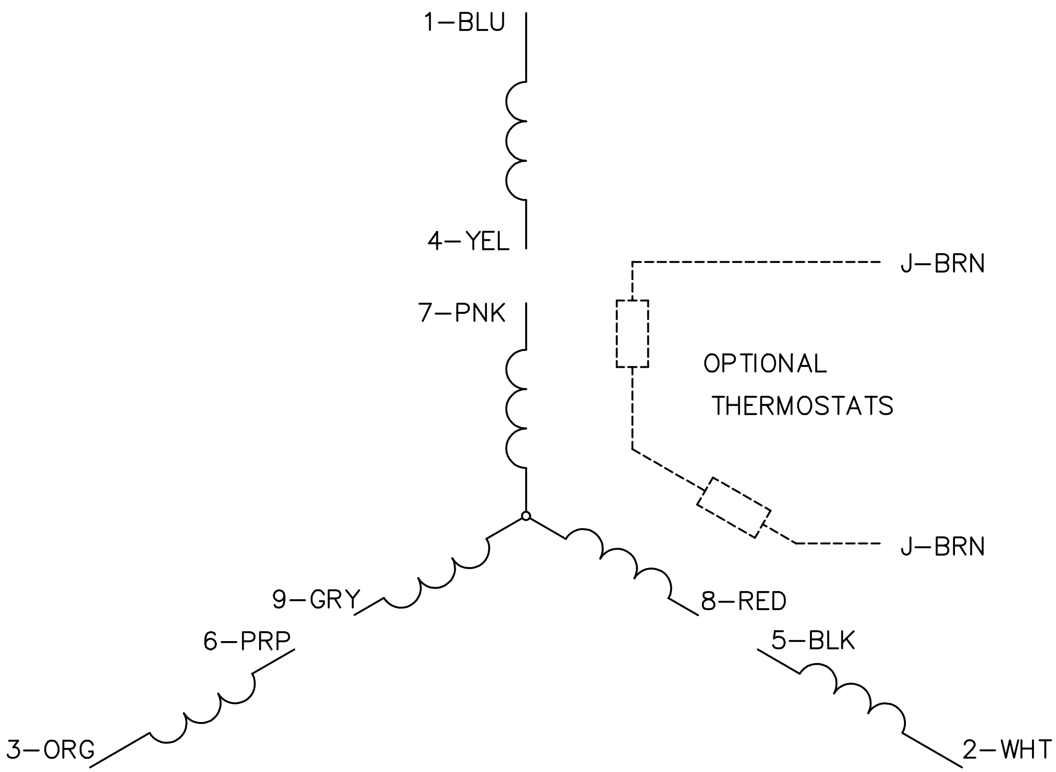
SEAL DETAIL

CUSTOMER IS RESPONSIBLE FOR DETERMINING THAT MOTOR PERFORMANCE IS SUITABLE IN THE APPLICATION.

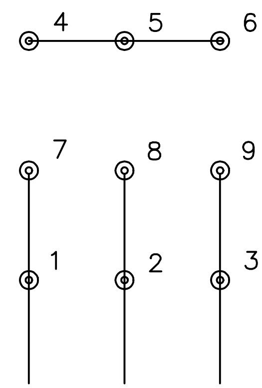
REV. DESC: CORRECT GRAPHICS FOR SLINGER ON FR.END PER BOM			BALDOR ELECTRIC Co.
REV. LTR: A	VERSION: 01	TDR: 000000402212	
FILE: \AAA\00093\192	REVISED: 10:45:29 07/13/2006	BY: ENODIDO	HOR 213-5JM TEFC 37M WD
MTL: –			

37LYH883

CD0005

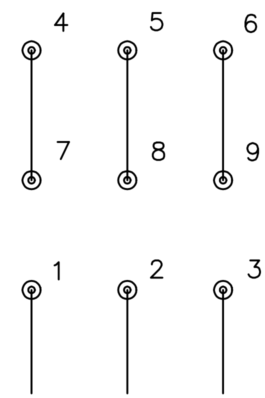


LOW VOLTAGE
(2Y)



LINE

HIGH VOLTAGE
(1Y)



LINE

NOTES:

1. INTERCHANGE ANY TWO LINE LEADS TO REVERSE ROTATION.
2. OPTIONAL THERMOSTATS ARE PROVIDED WHEN SPECIFIED.
3. ACTUAL NUMBER OF INTERNAL PARALLEL CIRCUITS MAY BE A MULTIPLE OF THOSE SHOWN ABOVE.
4. LEAD COLORS ARE OPTIONAL. LEADS MUST ALWAYS BE NUMBERED AS SHOWN.

REV. DESC: REVISE TO SHOW OPTIONAL COLORS				BALDOR ELECTRIC Co.
REV. LTR: E	BY: JLP	REVISED: 01/19/99 10:15	TDR: 0171435	
CD0005		FILE: AAA00005140	MDL: –	3PH, DV, 9 LEADS
		MTL: –		

CD0005

APPENDIX D

Product Information:

Krystil Klear Filtration Model 88 Bag Filter

Model 88 Single Liquid Bag Housing

Features and Options	Housing Operation	Vessel Construction
Specifications	Build a Part Number	Schematics and Dimensions

Krystil Klear's model 88 Single Series of Liquid Bag Housings offer two depths, a 15" and a 30" housing depending upon the needed surface area and volume of fluid to be filtered.

Contact a Sales Representative About this Product

FEATURES

- **Carbon, 304, or 316 stainless steel material**
- **150 PSI pressure rating**
- **Low pressure drop**
- **Quick swing closure with eye nuts**
- **Viton seals - lid & basket**
- **Differential, drain, and vent ports**
- **Adjustable support legs**
- **316 stainless steel strainer basket**
- **2-part epoxy finish on carbon vessels**

Our 88 series effectively removes dirt, pipe scale, and other contaminants from process liquids such as water, chemical, and petroleum products. Quality construction and design assure protection for all down-stream equipment.

SPECIFICATIONS

Housing lid has a 3-bolt swing closure with a vent port. Connections are (__) inch (NPT) (FLG) with a (side inlet and bottom outlet)(side inlet and side outlet)(side inlet and 90 degree bottom outlet). Housing is supplied with two differential pressure ports to measure the differential pressure across the filter bag. A two-part epoxy finish is applied on the carbon steel vessels to maximize the life of the housing; stainless steel vessels are supplied with a satin finish. Basket material is constructed of 316 stainless steel with 9/64" perforations to act as a strainer or to accept a #1 or #2 size liquid bag. Basket seals onto a Viton o-ring in the basket support. Adjustable tripod leg assembly is supplied with housing. Vessels are rated at a 150 pounds per square inch design.

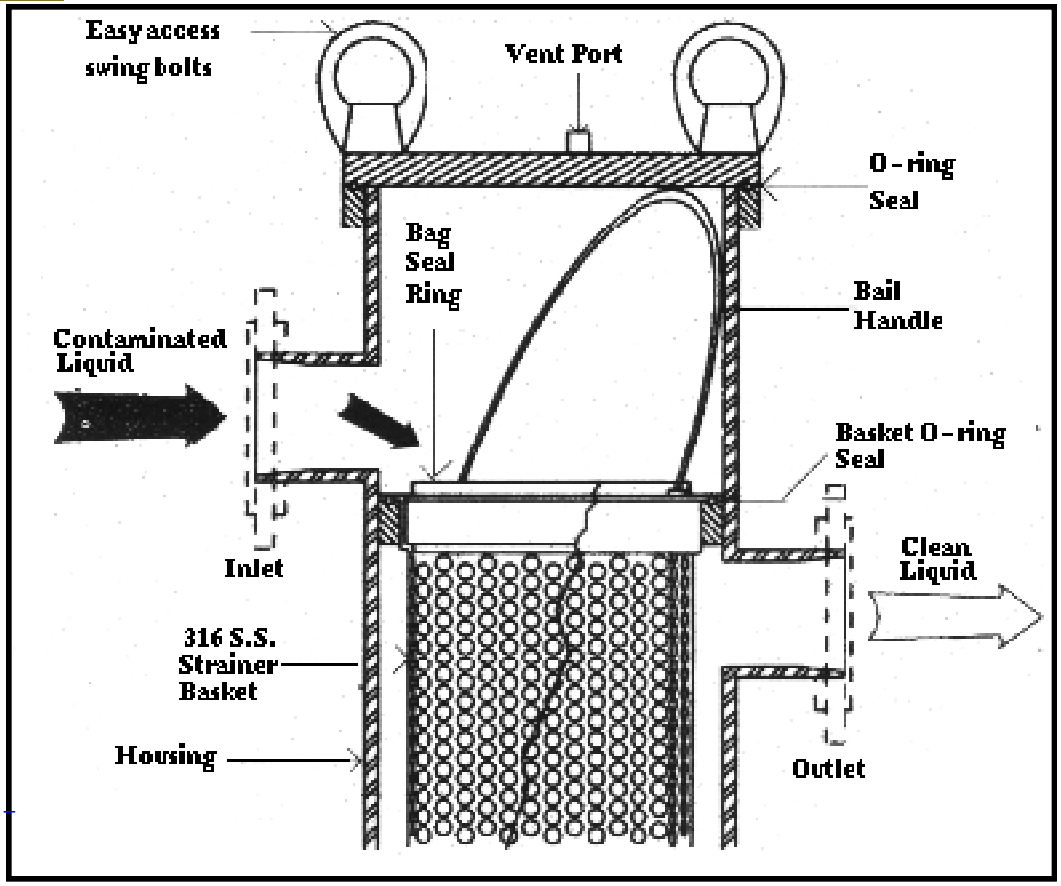
Contact a Sales Representative About this Product

Basket Data for Model 88 with flow rates to 220 gpm

Depth Nominal (inches)	Diameter (inches)	Surface Area (sq. ft.)	Volume (cu. in.)
15	6.7	2.3	500
30	6.7	4.4	1000

Housing Operation Diagram

Unfiltered liquid enters the housing above the filter bag or strainer basket; flows down into the housing; and continues through the element. Solids are trapped inside the filter bag or strainer and easily removed when the housing is serviced. Our standard o-ring seal between the basket and the housing ensures a postive seal to prevent bypass.



Contact a Sales Representative About this Product

Basket Data for Model 88 with flow rates to 220 gpm

Depth Nominal (inches)	Diameter (inches)	Surface Area (sq. ft.)	Volume (cu. in.)
15	6.7	2.3	500
30	6.7	4.4	1000

VESSEL CONSTRUCTION

Our model 88 single vessels are designed for operating up to 150 PSI at 300 degrees Fahrenheit. The housing design provides a large sump area at the bottom of the basket for particulate accumulation. This design utilizes the filter more efficiently and prolongs the element life.

The **316 S.S. basket** seals onto a viton o-ring to eliminate particulate bypass between the basket and seat. Optional **mesh-lined strainer baskets** and **o-rings** are available. Please refer to their individual brochures in our liquid catalog.

Contact a Sales Representative
About this Product

A **vent** in the housing lid and a **drain port** in the housing speed evacuation and filling. **Gauge ports** are located on the body of the housing to install gauges for monitoring the differential pressure across the bag. Permanently piped housings are opened with simple tools without disturbing the piping. **Swing bolts** with eye-nuts allow easy opening and closing of the swing-lid. No need to remove any hardware.

As a standard finish, all vessels are blast cleaned and painted inside and out with a **2-part epoxy**. Stainless steel vessels are supplied with a satin finish.

Dimensions

All dimensions are approximate...

88-15

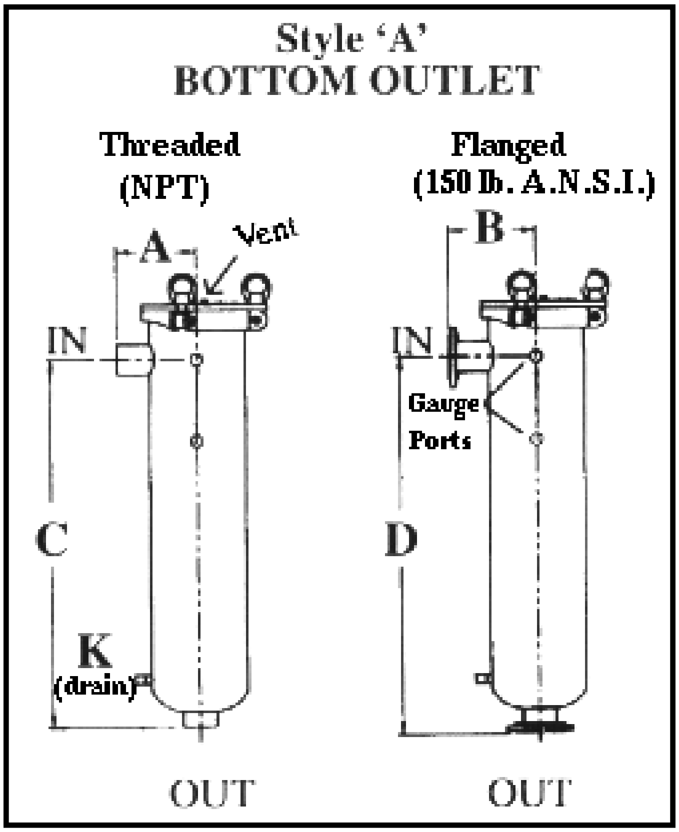
Pipe Size	A	B	C	D	E	F	G	H	I	J	K	wt.
2	5.3	6.7	24.7	25.9	7.0	24.7	26.2	3.4	25.7	2.3	1	105-125# skid wt.
3	5.4	7.1	24.7	26.5	7.0	24.7	26.5	5.0	26.3	3.1		
4	5.4	7.1	24.7	26.6	7.0	24.7	29.1	6.3	26.9	3.8		

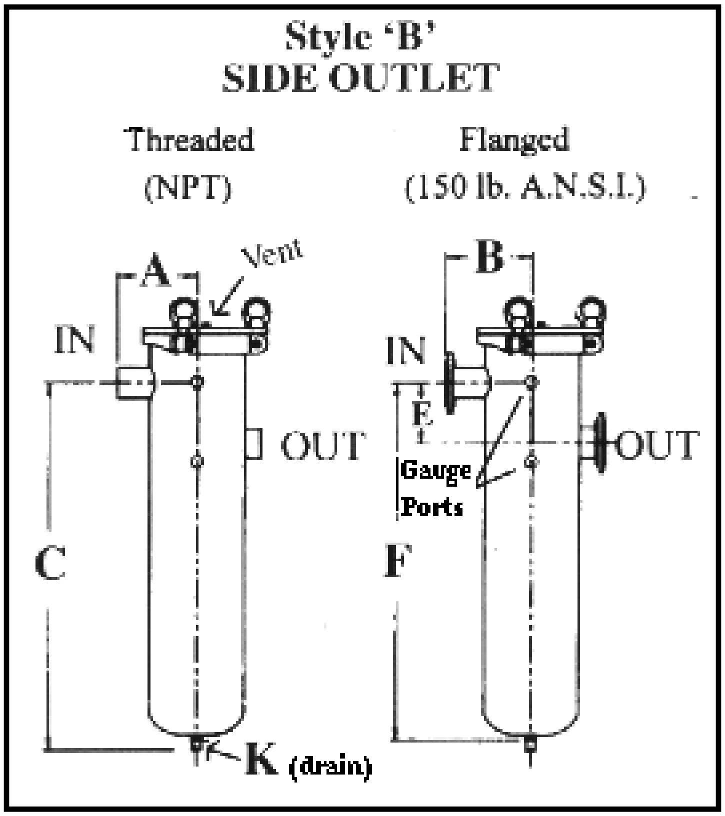
Contact a Sales Representative About this Product

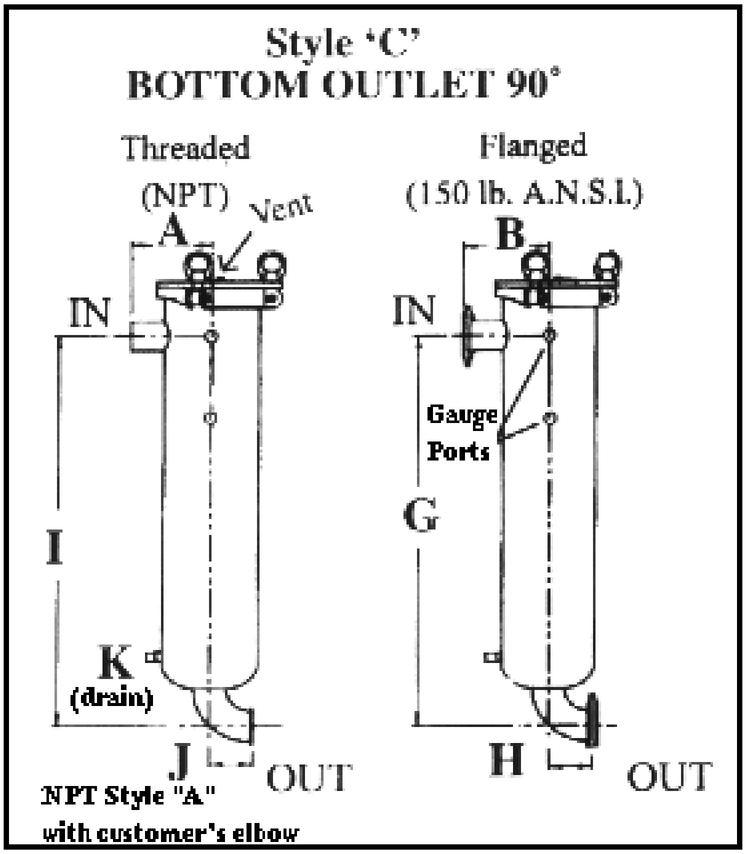
88-30

Pipe Size	A	B	C	D	E	F	G	H	I	J	K	wt.
2	5.3	6.7	36.2	37.4	7.0	36.2	37.7	3.4	37.2	2.3	1	125-145# skid wt.
3	5.4	7.1	36.2	38.0	7.0	36.2	39.2	5.0	38.7	3.1		
4	5.4	7.1	36.2	38.1	7.0	36.2	40.6	6.3	38.9	3.8		

Adjustable support legs have 12" bolt circle and a 16" height adjustment.


Style 'A'
BOTTOM OUTLET
Threaded
(NPT)
Flanged
(150 lb. A.N.S.I.)
A
Vent
B
IN
IN
Gauge
Ports
C
D
K
(drain)
OUT
OUT


Style 'B'
SIDE OUTLET
Threaded
(NPT)
Flanged
(150 lb. A.N.S.I.)
A
Vent
IN
OUT
C
K (drain)
B
IN
E
OUT
Gauge
Ports
F

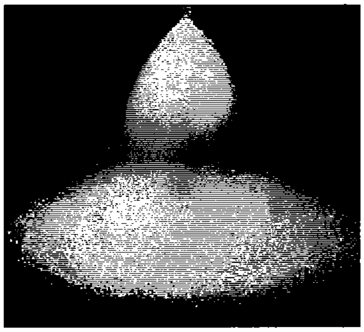

Style 'C'
BOTTOM OUTLET 90°
Threaded
(NPT)
Vent
A
IN
I
K
(drain)
J
OUT
NPT Style "A"
with customer's elbow
Flanged
(150 lb. A.N.S.I.)
B
IN
Gauge
Ports
G
H
OUT

APPENDIX E

Product Information:

FullJet ® Standard Type G Spray Nozzles

B3 - FullJet® Spray Nozzles, Standard Spray



Features and Benefits

- Solid cone-shaped spray pattern with round impact area.
- Uniform distribution over a wide range of flow rates and pressures.
- Medium- to large-sized drops.
- Unique vane design with large flow passages provides superior control and uniform distribution.
- Removable caps and vanes for easy inspection and cleaning on most models.
- Removable vane has location marks for proper positioning after cleaning.
- Set screws in some models secure the vane in the nozzle to prevent dislocation caused by vibration.
- Polypropylene material option offers exceptional chemical and corrosion resistance and resists caking and buildup.
- Wall-mounted options for installation on room exterior, vessel or pipeline.
- For installations with space limitations, right-angle mounting options allow for mounting at a 90° angle.

G

Removable cap and vane
1/8" to 1/2" NPT or BSPT (F)

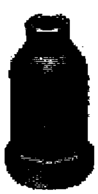
GG

Removable cap and vane
1/8" to 1/2" NPT or BSPT (M)

H

One-piece body
3/4" to 1" NPT or BSPT (F)

H



Removable vane/cast body
1-1/4" to 8" NPT or BSPT (F)

H

Removable vane/Polypropylene
1-1/2" to 2" NPT or BSPT (F)
Maximum temperature rating is
150°F (66°C)

HF

Removable vane/cast body
4" to 10" flange connection

HH

One-piece body
1/8" to 1" NPT or BSPT (M)

GD

Wall-mounted
Removable cap and vane
1/8" to 1/2" NPT or BSPT (F)

B5 - FullJet® Spray Nozzles, Standard Spray

Performance Data

*At the stated pressure in psi.

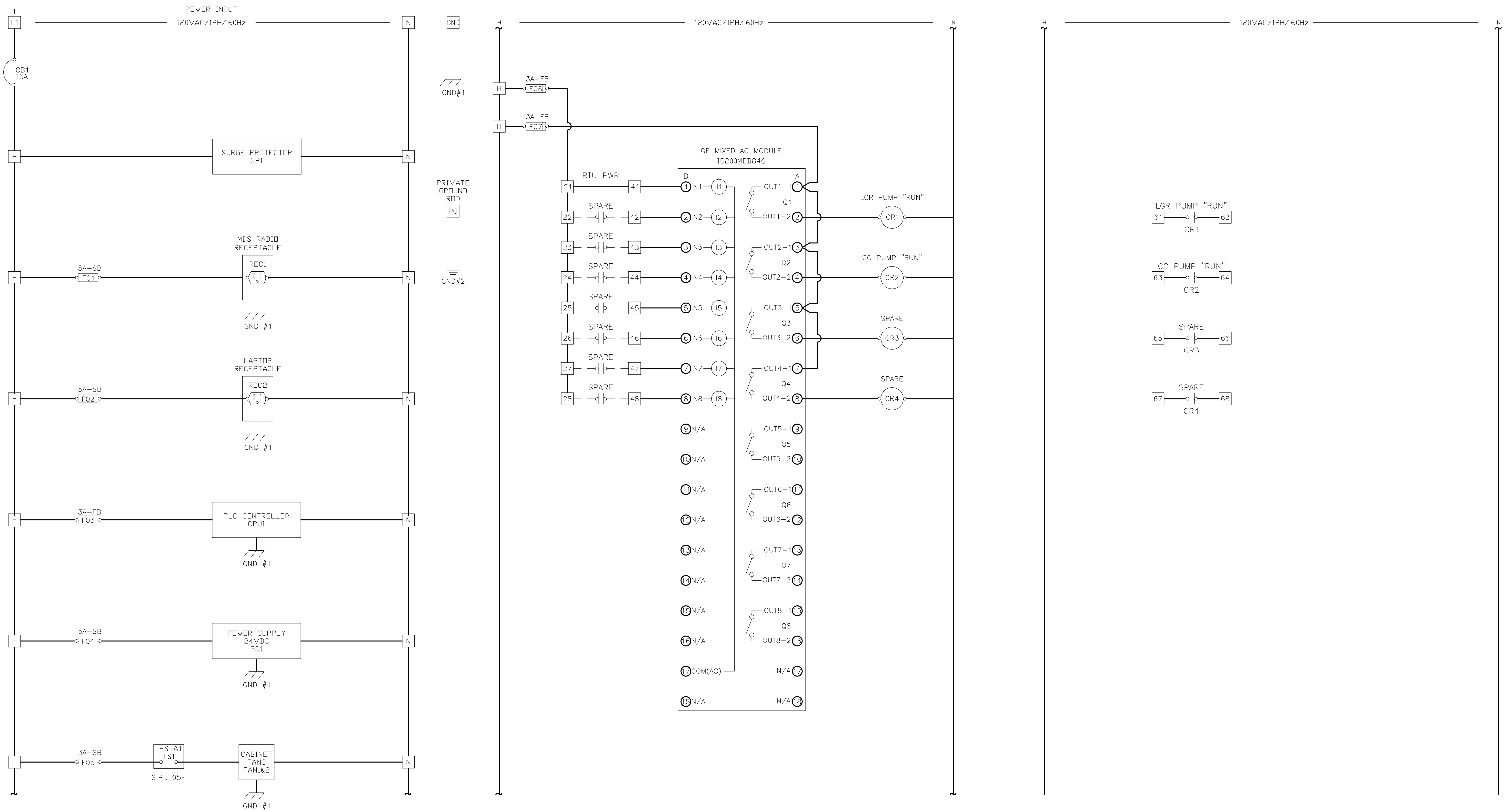
Inlet Conn. (in.)	Nozzle Type: Standard Type G	GG	H	HH	Wall Mounted GD	HD	GGD	Angle GA	GGA	Capacity Size	Orifice Dia. Nom. (in.)	Max. Free Passage Dia. (in.)	Capacity (gallons per minute)* 5	7	10	20	30	40	60	80	100	150	Spray Angle (°)* 7	20	80
1/8	•	•		•	•		•			1	.031	.025	.07	.08	.10	.14	.17	.19	.23	.26	.29	.35	–	58	53
	•	•		•						1.5	.047	.025	.11	.13	.15	.21	.25	.28	.34	.39	.43	.52	52	65	59
	•	•		•	•		•	•	•	2	.047	.040	.15	.17	.20	.28	.33	.38	.46	.52	.58	.70	43	50	46
	•	•		•	•		•	•	•	3	.063	.040	.22	.25	.30	.41	.50	.57	.68	.78	.87	1.0	52	65	59
	•	•		•	•		•	•	•	3.5	.063	.050	.25	.30	.35	.48	.58	.66	.80	.91	1.0	1.2	43	50	46
								•	•	3.9	.078	.040	.28	.33	.39	.54	.65	.74	.89	1.0	1.1	1.4	77	84	79
	•	•		•	•		•	•	•	5	.078	.050	.36	.42	.50	.69	.83	.95	1.1	1.3	1.4	1.7	52	65	59
								•	•	6.1	.094	.050	.44	.52	.61	.84	1.0	1.2	1.4	1.6	1.8	2.1	69	74	68
1/4	•	•		•	•		•	•	•	6.5	.094	.063	.47	.55	.65	.89	1.1	1.2	1.5	1.7	1.9	2.3	45	50	46
	•	•		•	•		•	•	•	10	.109	.063	.73	.85	1.0	1.4	1.7	1.9	2.3	2.6	2.9	3.5	58	67	61
								•	•	12.5	.125	.063	.91	1.1	1.3	1.7	2.1	2.4	2.9	3.3	3.6	4.3	69	74	68
3/8	•	•		•	•		•	•	•	9.5	.109	.094	.69	.81	.95	1.3	1.6	1.8	2.2	2.5	2.7	3.3	45	50	46
	•	•		•	•		•	•	•	15	.141	.094	1.1	1.3	1.5	2.1	2.5	2.8	3.4	3.9	4.3	5.2	64	67	61
								•	•	20	.156	.109	1.5	1.7	2.0	2.8	3.3	3.8	4.6	5.2	5.8	7.0	76	80	73
	•	•		•				•	•	22	.188	.109	1.6	1.9	2.2	3.0	3.6	4.2	5.0	5.7	6.3	7.6	87	90	82
1/2	•	•			•		•	•	•	16	.141	.125	1.2	1.4	1.6	2.2	2.7	3.0	3.6	4.2	4.6	5.6	48	50	46
	•	•		•	•		•	•	•	25	.188	.125	1.8	2.1	2.5	3.4	4.1	4.7	5.7	6.5	7.2	8.7	64	67	61
	•	•						•	•	32	.203	.141	2.3	2.7	3.2	4.4	5.3	6.1	7.3	8.3	9.2	11.1	72	75	68
	•	•		•				•	•	40	.250	.141	2.9	3.4	4.0	5.5	6.6	7.6	9.1	10.4	11.5	13.9	88	91	83
								•	•	50	.266	.156	3.6	4.2	5.0	6.9	8.3	9.5	11.4	13.0	14.4	17.4	91	94	86
3/4			•	•		•				2.5	.188	.172	2.1	2.5	2.9	4.1	4.9	5.6	6.7	7.7	8.5	10.2	48	50	46
			•	•		•				4.0	.250	.172	3.4	4.0	4.7	6.5	7.8	8.9	10.7	12.3	13.6	16.4	67	70	63
			•	•		•				7.0	.375	.203	6.0	7.0	8.2	11.3	13.7	15.6	18.8	21	24	29	89	92	84
1			•	•		•				4.2	.234	.219	3.6	4.2	4.9	6.8	8.2	9.4	11.3	12.9	14.3	17.2	48	50	46
			•	•		•				7.0	.328	.219	6.0	7.0	8.2	11.3	13.7	15.6	18.8	21	24	29	67	68	62
			•	•						8.0	.375	.219	6.9	8.0	9.4	13.0	15.6	17.8	21	25	27	33	72	81	82
			•	•						10	.469	.219	8.6	10.0	11.8	16.2	19.5	22	27	31	34	41	78	90	94
			•	•						12	.469	.250	10.3	12.0	14.1	19.4	23	27	32	37	41	49	89	92	84

Maximum Free Passage Diameter is the maximum diameter as listed of foreign matter that can pass through the nozzle without clogging.

APPENDIX F

Automation System Design

RTU 903-1: GAC SHACK, CS-MW16-LGR, CS-MW16-CC, AND WEATHER STATION



REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-1
LINE-TO-LINE
WIRING DIAGRAM

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
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DWG. NO.	2829
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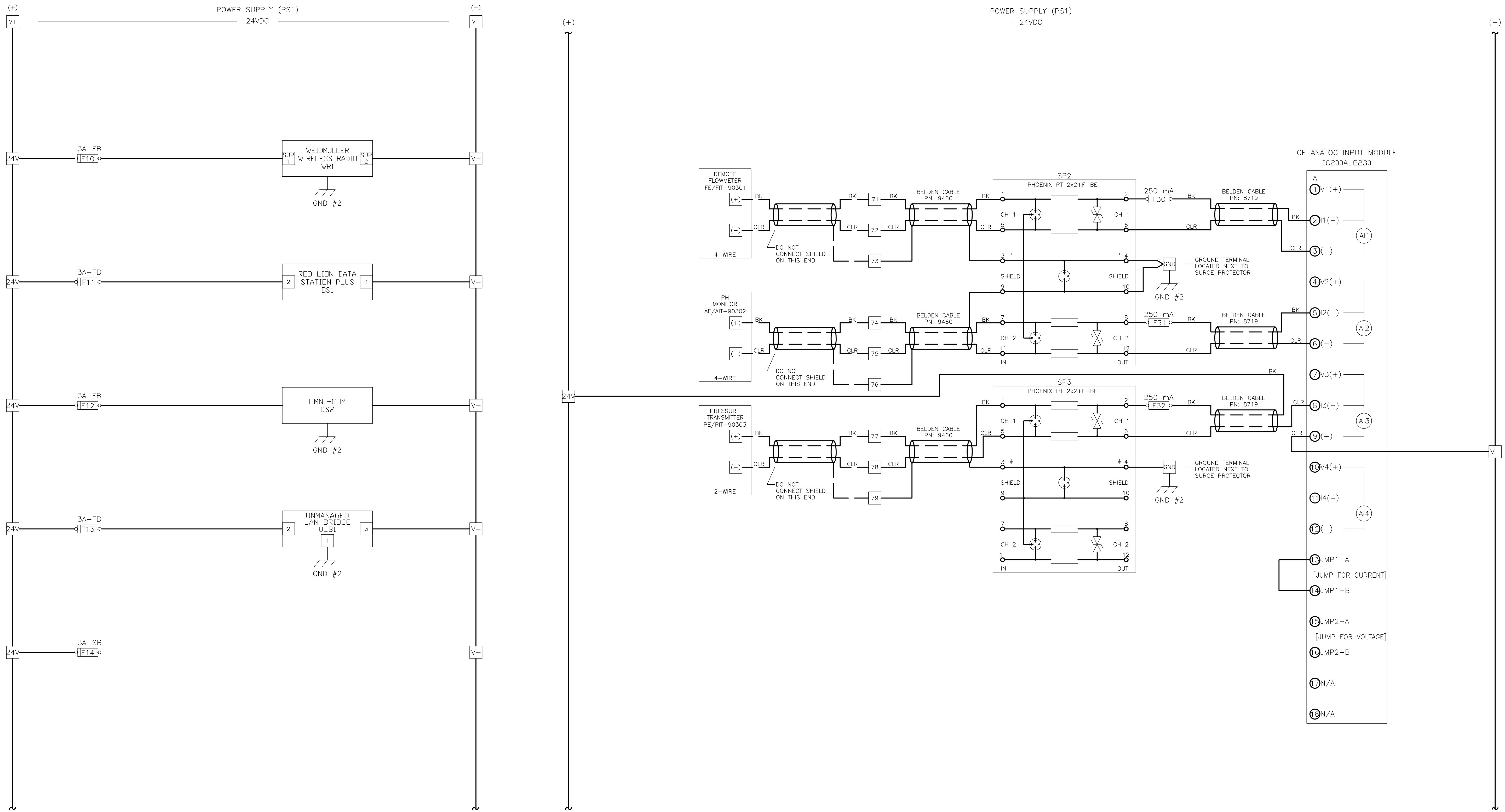
OF	9



REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY BIOREACTOR

SHEET TITLE
RTU 903-1 LINE-TO-LINE WIRING DIAGRAM

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
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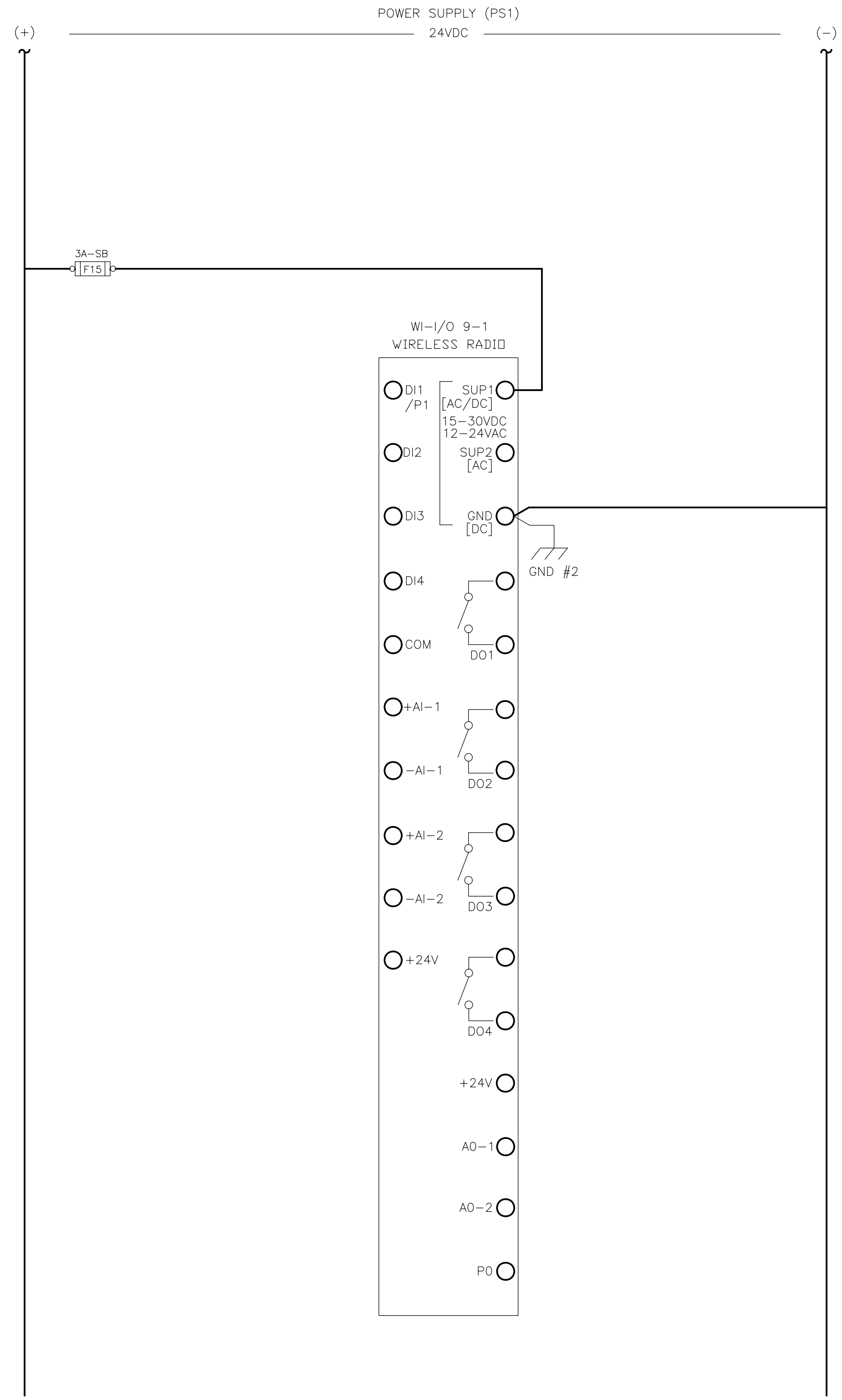
OF	9



REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-1
LINE-TO-LINE
WIRING DIAGRAM

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
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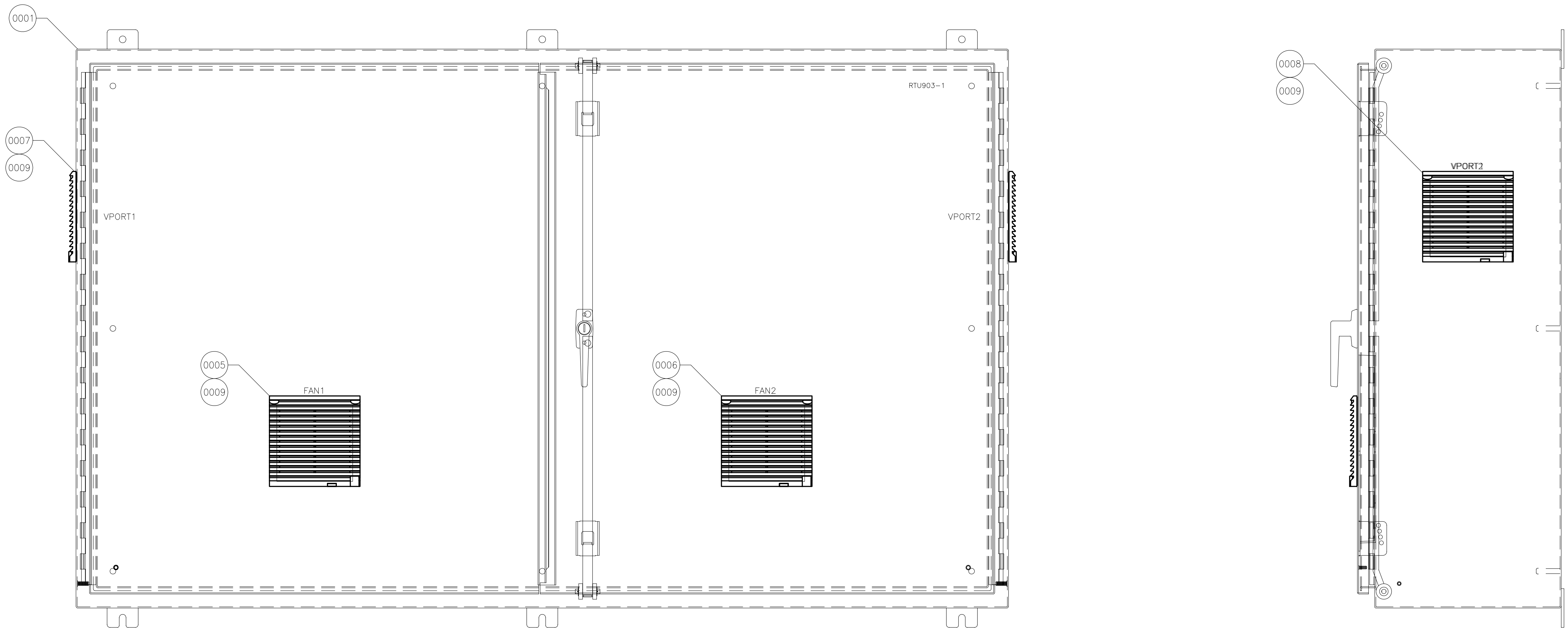
SH	3
OF	9



REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-1
ENCLOSURE LAYOUT

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-3

DWG. NO.	SH	OF
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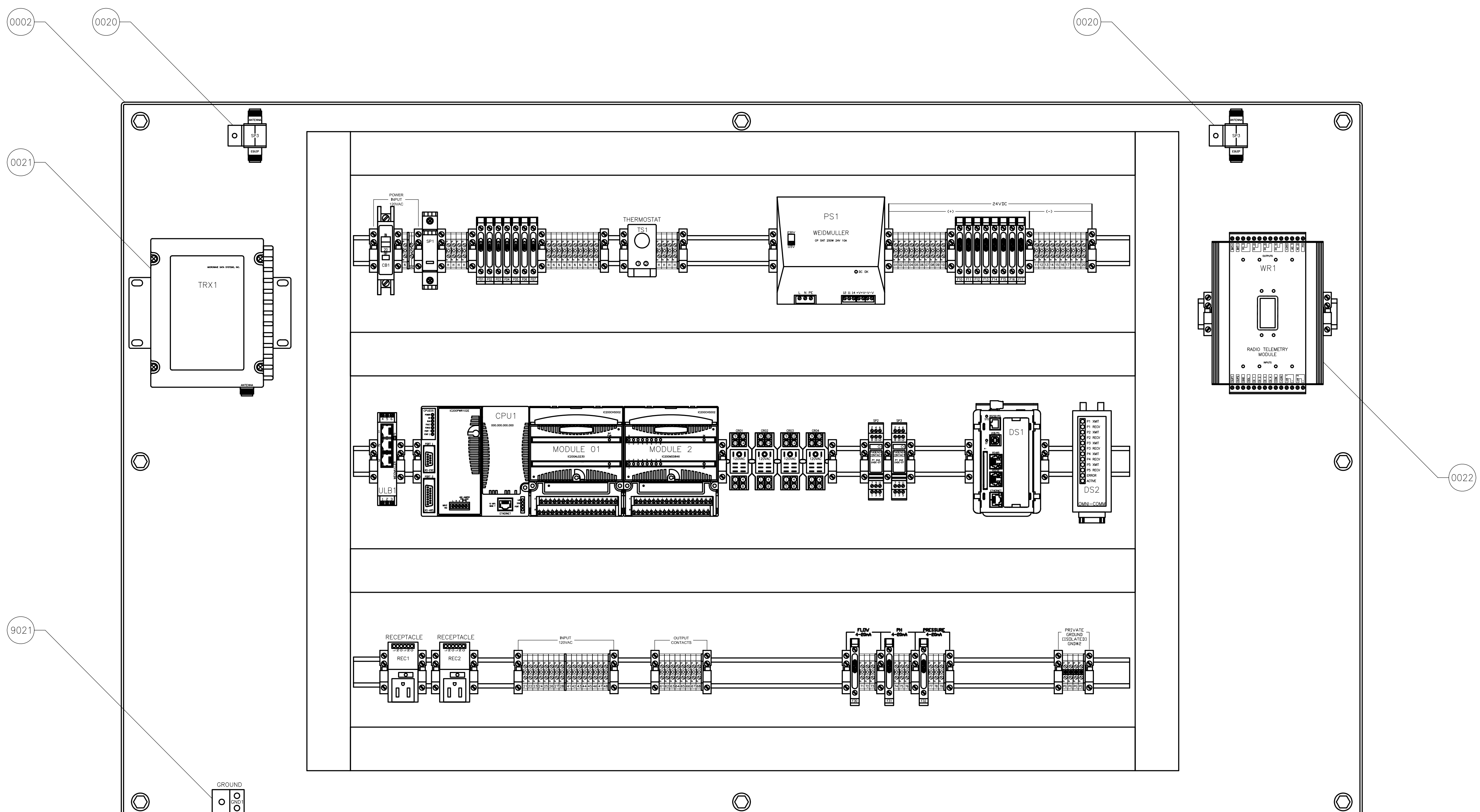

REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-1
BACK PANEL LAYOUT

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-3

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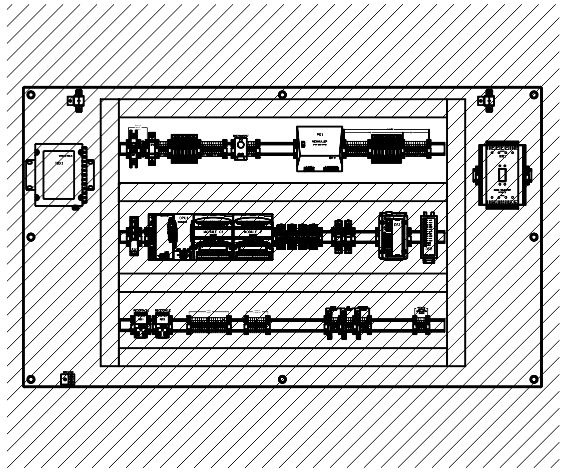
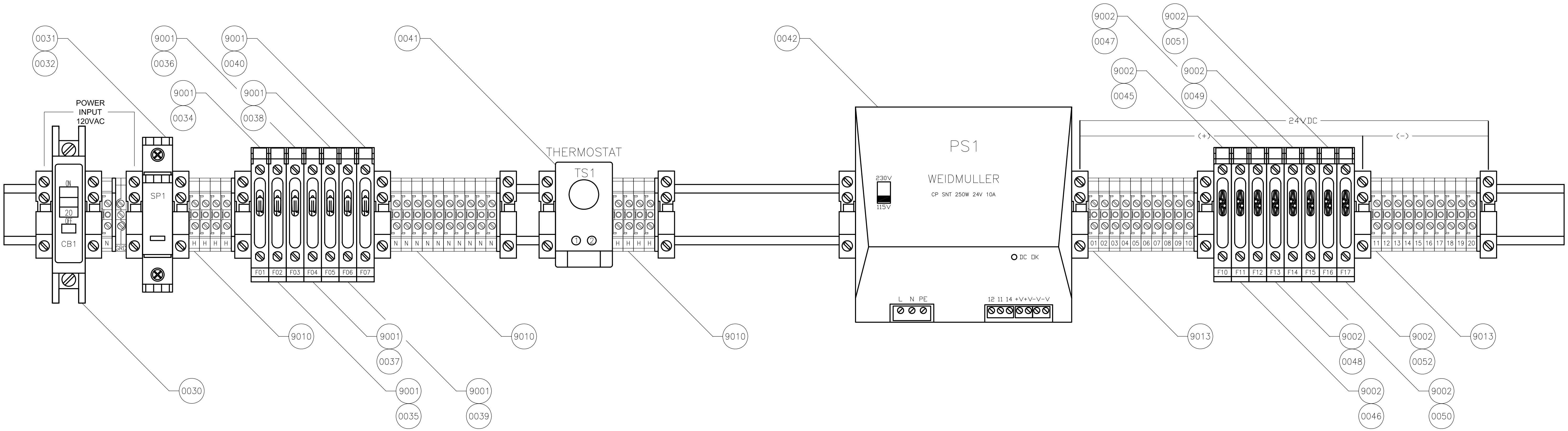
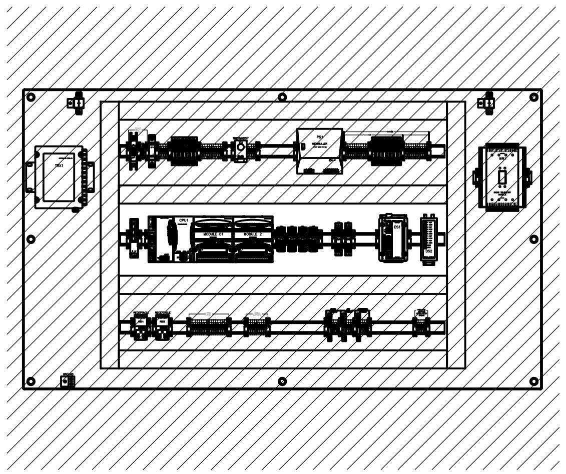


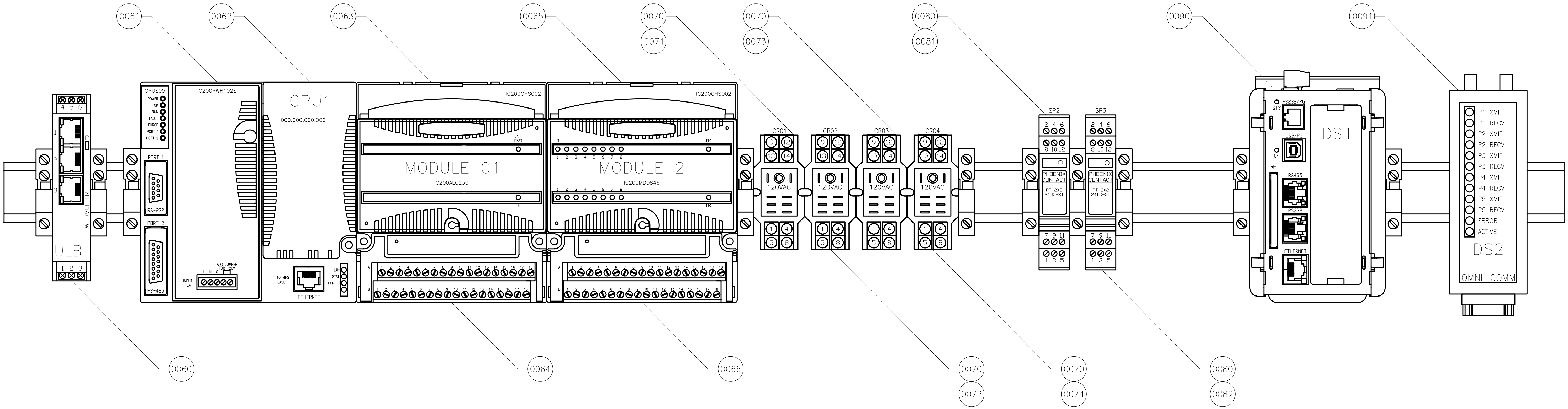


REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION
11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER	PROJECT TITLE	SHEET TITLE	
	CAMP STANLEY BIOREACTOR	RTU 903-1 BACK PANEL LAYOUT	DATE: 8/10/2009 SCALE: N/A DRAWN BY: RMF CAD FILE SCI2829_RTU903-3 DWG. NO. 2829 SH 6 OF 9





REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

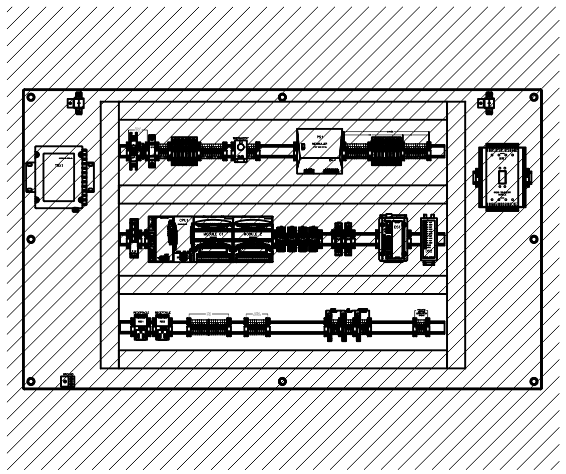
11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

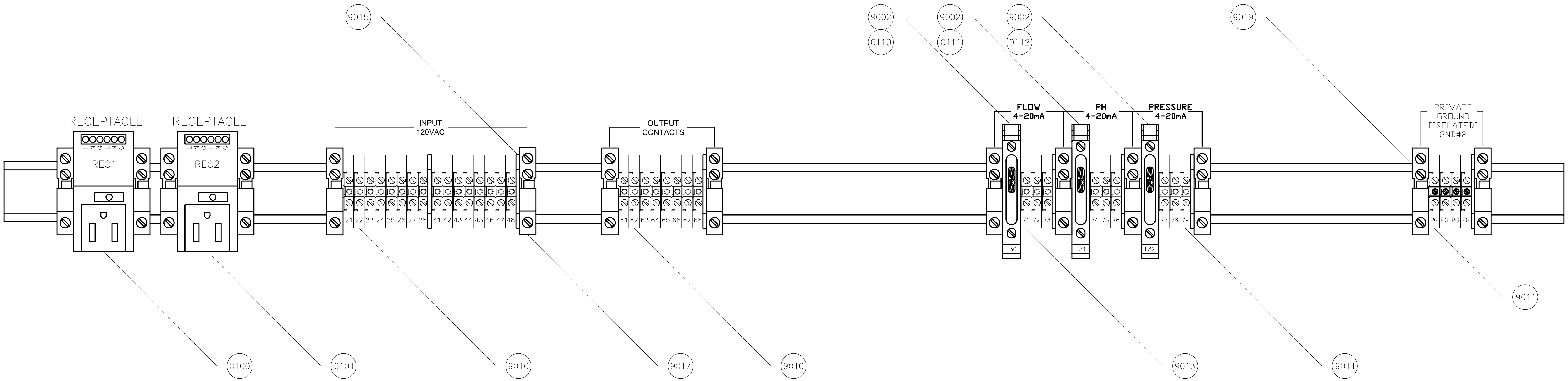
ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-1
BACK PANEL LAYOUT

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-3
DWG. NO.	2829
SH	7
OF	9





REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-1
BACK PANEL LAYOUT

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-3

DWG. NO.	SH	OF
2829	8	9

BILL OF MATERIAL						
ITEM_ID	DEVICE_ID	COUNT	MFG_#	DESCRIPTION	MFG_NAME	PART_KEY_#
0001	RTU903-1	1	A366012WFLP	ENCLOSURE, 36"HX60"WX12"D, NEMA12	HOFFMAN	
0002	RTU903-1	1	A60P36	BACK PANEL, 36"HX60"W, STEEL	HOFFMAN	
0005	FAN1	1	3322.117	FAN, FILTER UNIT, 39CFM, 115VAC, 0.24A, 50/60HZ, 19W, NEMA 12, LIGHT GREY, 13F-131F, 49DB(A), 124MM	RITTAL	837000
0006	FAN2	1	3322.117	FAN, FILTER UNIT, 39CFM, 115VAC, 0.24A, 50/60HZ, 19W, NEMA 12, LIGHT GREY, 13F-131F, 49DB(A), 124MM	RITTAL	837000
0007	VPORT1	1	SK3322-007	FILTER UNIT, HOLDER ONLY, 124MM	RITTAL	835000
0008	VPORT2	1	SK3322-007	FILTER UNIT, HOLDER ONLY, 124MM	RITTAL	835000
0009		4	3322.700	REPLACEMENT FILTER PADS, FOR 5.8"SQ FANS	RITTAL	840000
0020	SP3	2	IS-50NX-C2	BROADBAND DC BLOCKED PROTECTOR, 125-1000MHZ, 50 OHM, 50-375W, VSWR: 1.1:1, SURGE 50KA, N-FEMALE X N-FEMALE	POLYPHASER	
0020		2	AGC-2	FUSE, FAST ACTING FURRULE, 2A, 250VAC, 1/4"X1.25"	BUSSMANN	
0021	TRX1	1	MDS 9810	DATA TRANSCEIVER, RS232 INPUT, 13.8VDC	MOCROWAVE DATA SYSTEMS	
0021		2	AGC-1	FUSE, FAST ACTING FURRULE, 1A, 250VAC, 1/4"X1.25"	BUSSMANN	
0022	WR1	1	WI-I/O 9-1	WIRELESS RADIO, DIN-RAIL MOUNT, 15-30VDC, 4 INPUTS, 2- 4-20MA INPUTS, 4 OUTPUTS, 2- 4-20MA OUTPUTS, RS232/RS485	WEIDMULLER	XXXXXX
0022		2	AGC-2	FUSE, FAST ACTING FURRULE, 2A, 250VAC, 1/4"X1.25"	BUSSMANN	
0023		2	AGC-2	FUSE, FAST ACTING FURRULE, 2A, 250VAC, 1/4"X1.25"	BUSSMANN	
0030	CB1	1	QOU120	CIRCUIT BREAKER, 20A, UL489, 10K AIR, 1-#14-#2, CU OR AL	SQD	
0031		1	PU II 1S	HOLDER, SURGE PROTECTION	WEIDMULLER	
0032	SP1	1	PU II 1	SURGE PROTECTION MODULE, 130VAC, IN:20KA, IMAX:40KA, L-N	WEIDMULLER	8859950000
0034		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0035		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0036		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0037		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0038		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0039		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0040		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0041	TS1	1	SKT011419NO	THERMOSTAT, DIN-RAIL MOUNT, 30-140F, HYSTERESIS +/-4F, 15A, 120VAC	HAMMOND	
0042	PS1	1	CP SNT 250W 24V 10A	POWER SUPPLY, TS-35 DIN-RAIL MOUNT, 88-132VAC, 176-264VAC, 3.6A@115VAC/2A@230VAC, 50/60HZ, 24-28VDC, 10.0A, 250W	WEIDMULLER	8708670000
0060	ULB1	1	IE-SW3-WAVE	UNMANAGED LAN BRIDGE, 3-PORT, 4W/ 10-35VDC, 6VA 10-24VAC, 32-140F, CLASS 1 DIV 2	WEIDMULLER	8897710000
0061		1	IC200PWR102E	POWER SUPPLY, 120/240VAC. 27VA, 50/60HZ, EXPANDED 3.3VDC	GE FANUC	IC200PWR102E
0062	CPU1	1	CPUE05	PLC CPU MODULE	GE FANUC	IC200CPUE05-CG
0063		1	IC200CHS002	BOX STYLE I/O CARRIER, AWG: 22-14, 2A/ POINT, 8A/ POWER OR GND, 264VAC MAX	GE FANUC	IC200CHS002
0064	MODULE 01	1	IC200ALG230	ANALOG MODULE, 4-CH, 12 BIT, VOLTAGE/CURRENT	GE FANUC	IC200ALG230
0065		1	IC200CHS002	BOX STYLE I/O CARRIER, AWG: 22-14, 2A/ POINT, 8A/ POWER OR GND, 264VAC MAX	GE FANUC	IC200CHS002
0066	MODULE 2	1	IC200MDD846	MIXED MODULE, 8-INPUT, 8-OUTPUT, 120VAC INPUT, RELAY OUTPUT	GE FANUC	IC200MDD846
0070		4	RH2B-ULC-AC120V	RELAY, 2PDT, COIL: 120VAC/ 9.2MA, 1/6HP, W/INDICATOR & CHECK BUTTON	IDEC	
0071		1	SH2B-05	RELAY MOUNTING SOCKET, DIN RAIL, 2PDT, 300V/10A, 2-#12	IDEC	
0072		1	SH2B-05	RELAY MOUNTING SOCKET, DIN RAIL, 2PDT, 300V/10A, 2-#12	IDEC	
0073		1	SH2B-05	RELAY MOUNTING SOCKET, DIN RAIL, 2PDT, 300V/10A, 2-#12	IDEC	
0074		1	SH2B-05	RELAY MOUNTING SOCKET, DIN RAIL, 2PDT, 300V/10A, 2-#12	IDEC	
0080		2	PT 2X2-24DC-ST	PROTECTIVE PLUG, 2 2-CORE FLOATING SIGNALS, 24VDC, MAX CORE SURGE 10KA @ (8-20US)	PHOENIX	2838228
0081		1	PT 2X2+F-BE	BASE, GAS-FILLED SURGE ARRESTOR, 2 2-WIRE FLOATING SIGNALS, 600V/ 450MA, DIN RAIL	PHOENIX	2839224
0082		1	PT 2X2+F-BE	BASE, GAS-FILLED SURGE ARRESTOR, 2 2-WIRE FLOATING SIGNALS, 600V/ 450MA, DIN RAIL	PHOENIX	2839224
0090	DS1	1	IE-SW3-WAVE	DATA STATION PLUS, PROTOCOL CONVERTER, 24VDC@200MA, 1A MAX, W/ WEB SERVER & DATA LOGGER	WEIDMULLER	8897710000
0091	DS2	1	266-500-220	PROTOCOL CONVERTER, 24VDC@40MA, 4 - RS232/485 INPUT PORTS, 1 RS232/485 OUTPUT PORT	MILLE APPLIED RESEARCH	
0100	REC1	1	991548	RECEPTACLE, SIMPLEX 15A, 120VAC, UL, T35 DIN RAIL MOUNT	WEIDMULLER	991548
0101	REC2	1	991548	RECEPTACLE, SIMPLEX 15A, 120VAC, UL, T35 DIN RAIL MOUNT	WEIDMULLER	991548
0110		1	AGC-1/4	FUSE, FAST ACTING FURRULE, 250MA, 250VAC, 1/4"X1.25"	BUSSMANN	
0111		1	AGC-1/4	FUSE, FAST ACTING FURRULE, 250MA, 250VAC, 1/4"X1.25"	BUSSMANN	
0112		1	AGC-1/4	FUSE, FAST ACTING FURRULE, 250MA, 250VAC, 1/4"X1.25"	BUSSMANN	
9001		7	UK 6,3-HESILA 250	FUSE BLOCK, ILL 110-250V, 600V/10A, 26-8AWG	PHOENIX	3004249
9002		11	UK 6,3-HESILED 24	FUSE BLOCK, ILL 15-30V, 600V/10A, 26-8AWG	PHOENIX	3004265
9010		43	UK 5 N	TERMINAL BLOCK, GRAY, 600V/30A, 30-10AWG	PHOENIX	3004362
9011		7	UK 5 N GN	TERMINAL BLOCK, GREEN, 600V/30A, 30-10AWG	PHOENIX	3003965
9013		26	UK 5 N OG	TERMINAL BLOCK, ORANGE, 600V/30A, 30-10AWG	PHOENIX	3002908
9014		1	UKLKG 5	GROUND TERMINAL, 26-10AWG	PHOENIX	0441504
9015		13	D-UK 4/10	END COVER PLATE, GRAY	PHOENIX	3003020
9017		40	E/UK	END CLAMP, GRAY	PHOENIX	1201442
9019		1	FBI 10-6	CROSS CONNECTOR/JUMPER, 10 POSITION, AL	PHOENIX	0203250
9021	GND1	1	K2A25U	GROUNDING LUG, 2 CONDUCTOR, 1/0-14AWG	BURNDY	

REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

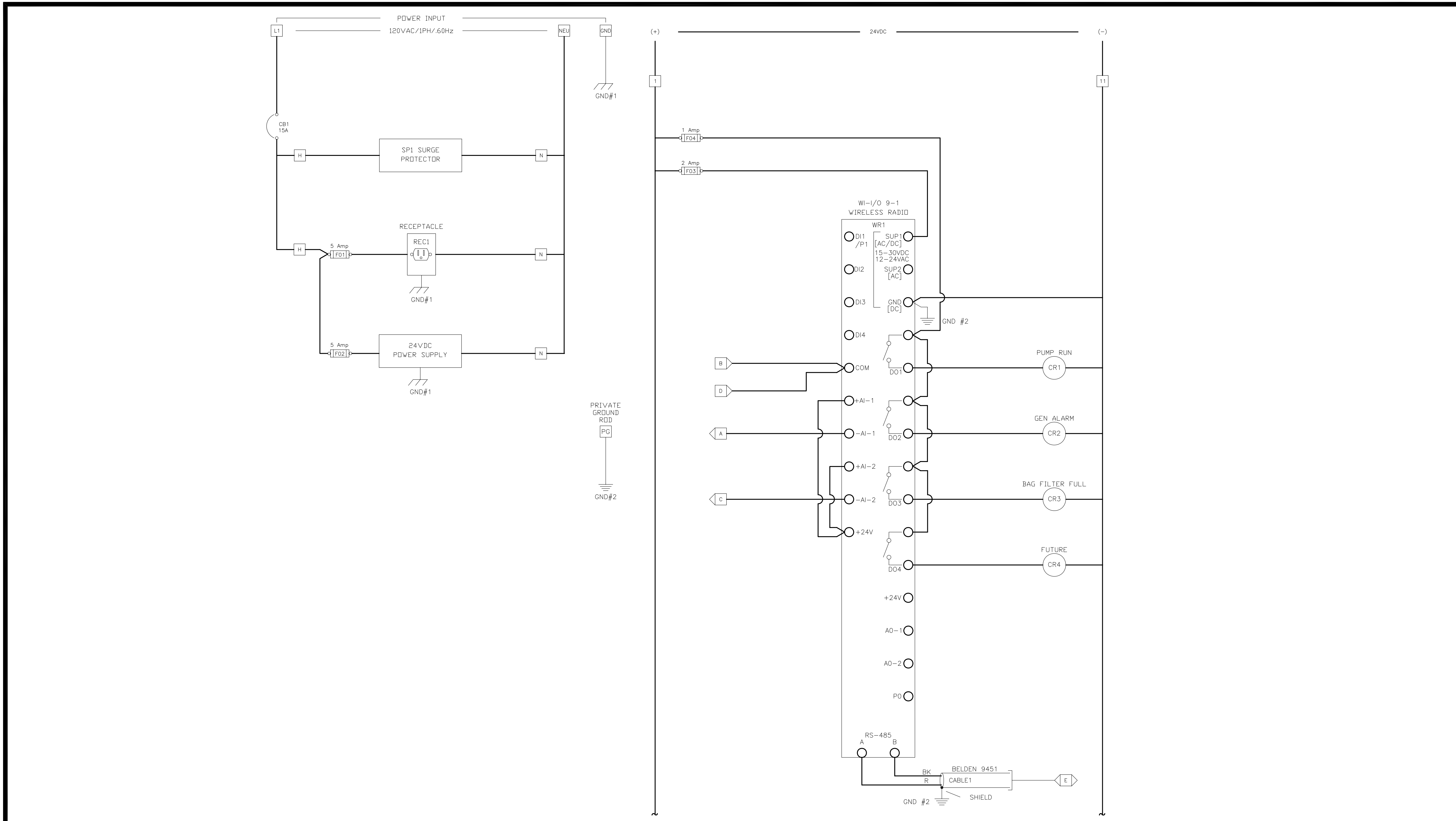
ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-1
BILL OF MATERIALS

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-3
DWG. NO.	2829
SH	9
OF	9

RTU 903-2: BIOREACTOR TANK AND TRANSFER PUMP



REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

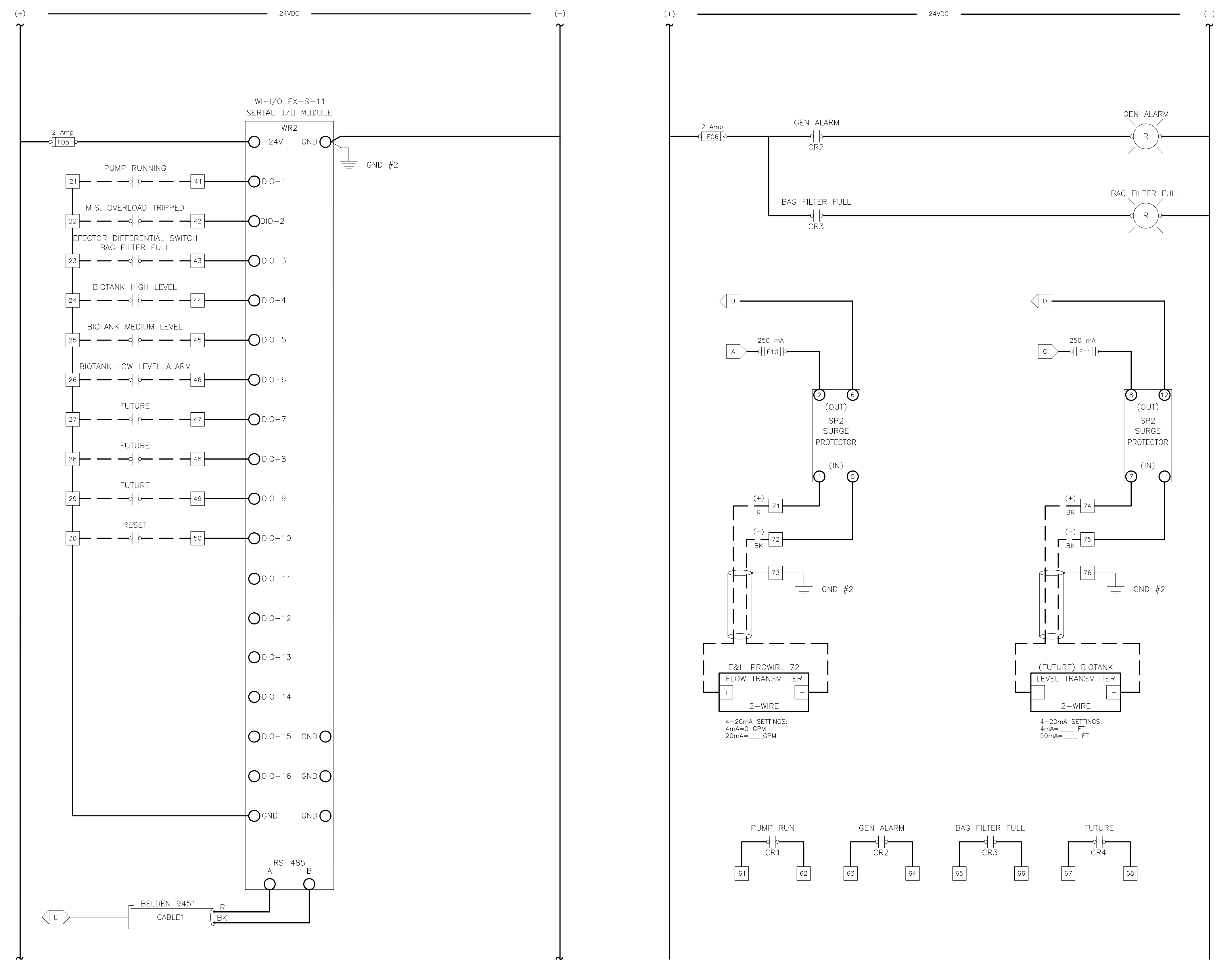
11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-2
PROCESS TANK WIRING DIAGRAM

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-2
DWG. NO.	2829
SH	1
OF	6



REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

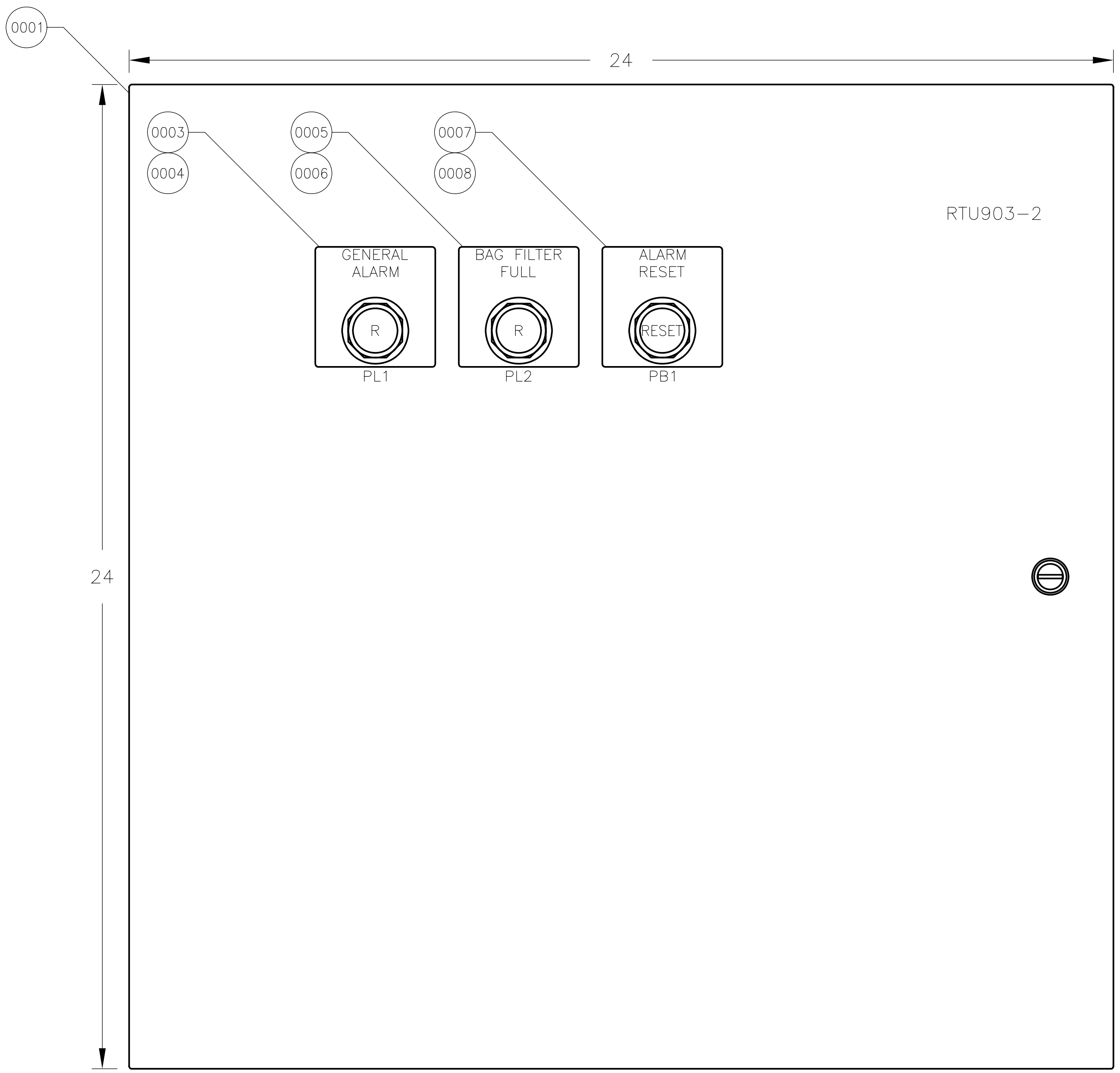
11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

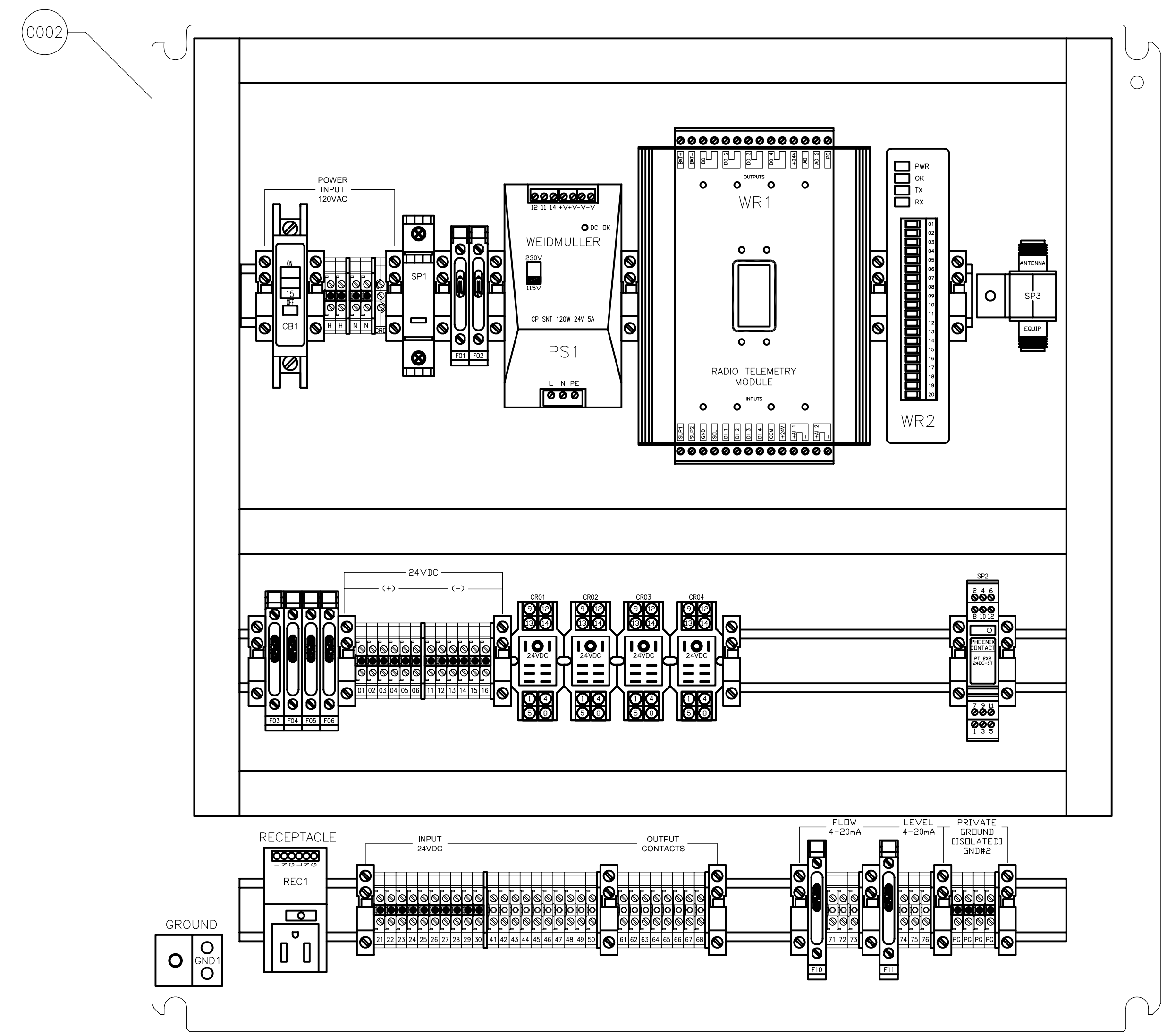
ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-2
PROCESS TANK WIRING DIAGRAM

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-2
DWG. NO.	2829
SH	2
OF	6





REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

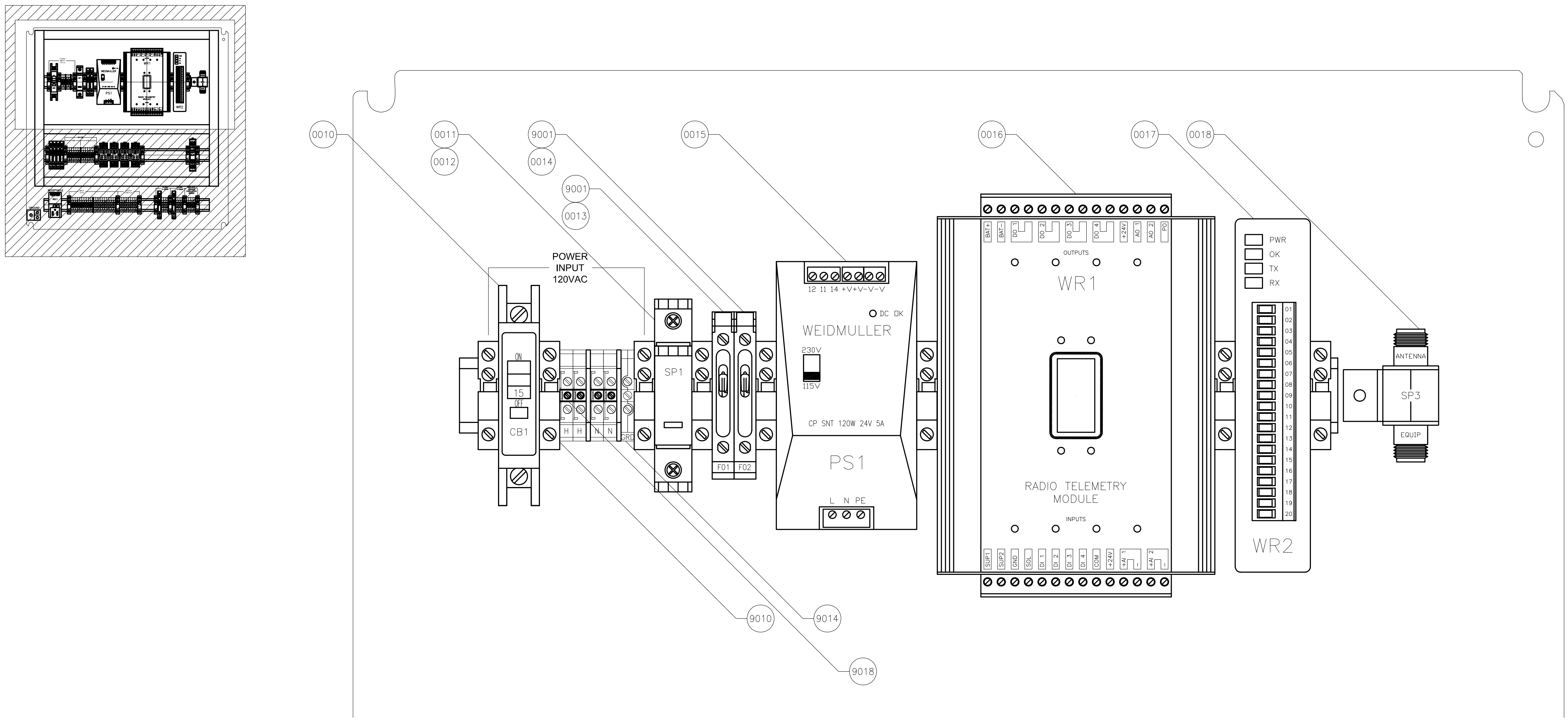
11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-2
PROCESS TANK BACK PANEL LAYOUT

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-2
DWG. NO.	2829
SH	3
OF	6



REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

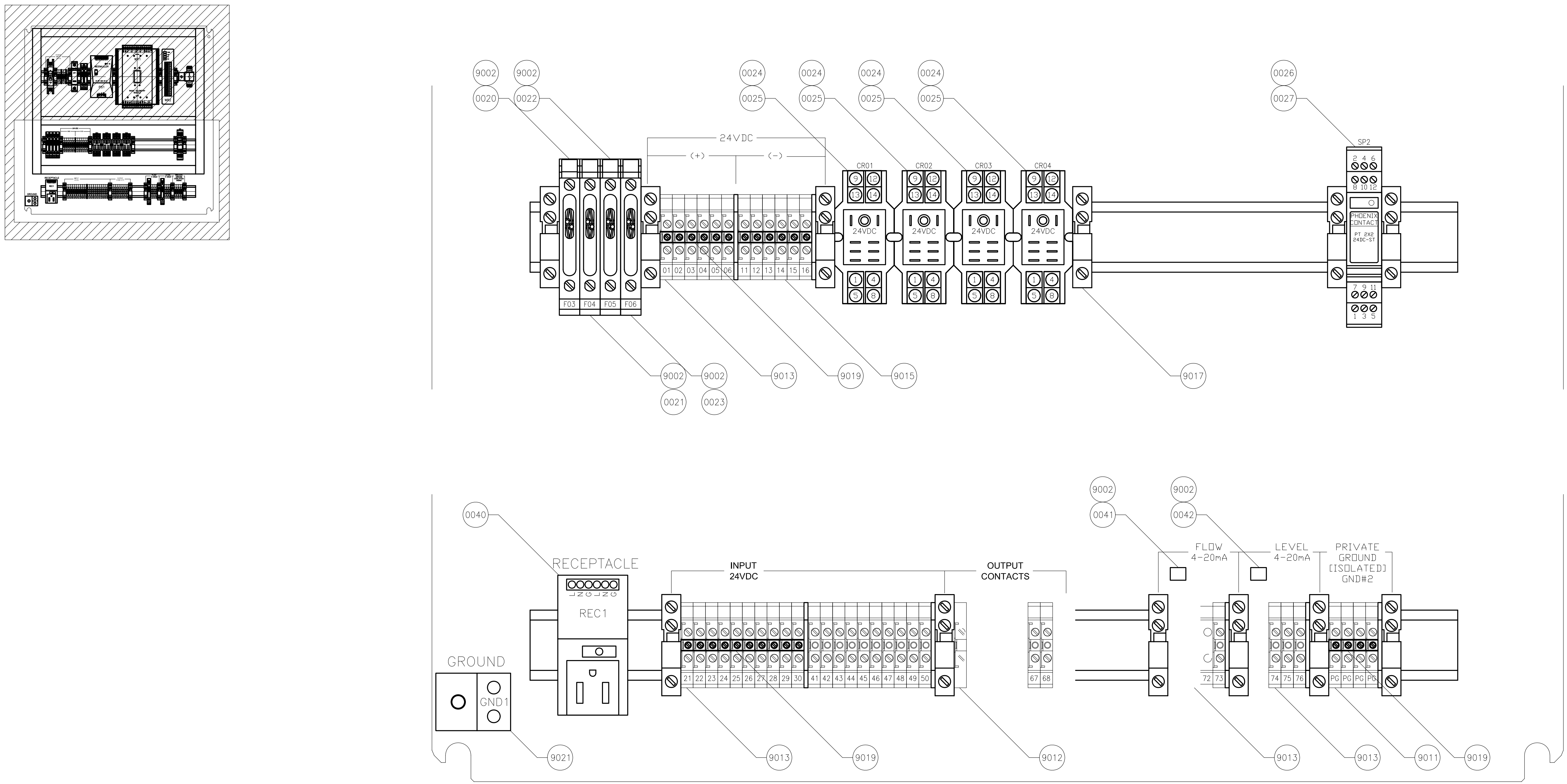
11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-2
PROCESS TANK PARTS LAYOUT

DATE:	8/10/09
SCALE:	1:2
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-2
DWG. NO.	2829
SH	4
OF	6



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ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-2
PROCESS TANK PARTS LAYOUT

DATE:	8/10/09
SCALE:	1:2
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-2
DWG. NO.	2829
SH	5
OF	6

BILL OF MATERIAL						
ITEM_ID	DEVICE_ID	COUNT	MFG_#	DESCRIPTION	MFG_NAME	PART_KEY_#
0001	RTU903-2	1	CSD242410SS	CONCEPT ENCLOSURE, 24"HX24"WX10"D NEMA 4, 304SS	HOFFMAN	
0002	RTU903-2	1	CP2424	CONCEPT ENCLOSURE BACK PANEL, 24"X24"	HOFFMAN	
0003	PL1	1	800T-QBH24R	PUSH BUTTON PILOT LED, 30.5MM, 24VDC, RED LENS, 1NO / 1NC	AB	
0004	PL1	1		PLASTIC LABEL, 30.5MM PILOT LAMP, RED W/WHITE LETTERING, 2.4"WX2.4"H	SCI	999999
0005	PL2	1	800T-QBH24R	PUSH BUTTON PILOT LED, 30.5MM, 24VDC, RED LENS, 1NO / 1NC	AB	
0006	PL2	1		PLASTIC LABEL, 30.5MM PILOT LAMP, RED W/WHITE LETTERING, 2.4"WX2.4"H	SCI	999999
0007	PB1	1	800T-A707WA	PUSH BUTTON OPERATOR, METAL, 30.5MM, FLUSH HEAD, BLUE W/WHITE LETTERING, 1-NO / 1-NC	AB	
0008	PB1	1		PUSH BUTTON LABEL, PLASTIC, RED W/WHITE LETTERING, 2.4"WX2.4"H	SCI	999999
0010	CB1	1	QOU115	CIRCUIT BREAKER, 15A, UL489, 10K AIR, 1-#14-#2, CU OR AL	SQD	
0011	SP1	1	PU II 1	SURGE PROTECTION MODULE, 130VAC, IN:20KA, IMAX:40KA, L-N	WEIDMULLER	8859950000
0012		1	PU II 1S	HOLDER, SURGE PROTECTION	WEIDMULLER	
0013		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0014		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0015	PS1	1	CP SNT 120W 24V 5A	POWER SUPPLY, TS-35 DIN-RAIL MOUNT, 88-132VAC, 176-264VAC, 3A@115VAC/2A@230VAC, 50/60HZ, 24-28VDC, 5.0A, 120W	WEIDMULLER	
0016	WR1	1	WI-I/O 9-1	WIRELESS RADIO, DIN-RAIL MOUNT, 15-30VDC, 4 INPUTS, 2- 4-20MA INPUTS, 4 OUTPUTS, 2- 4-20MA OUTPUTS, RS232/RS485	WEIDMULLER	8708670000
0017	WR2	1	WI-I/O-EX-S-11	EXPANSION I/O MODULE, 10.8-30VDC, 16 I/O INPUT/OUTPUTS, DIN RAIL MOUNTING	WEIDMULLER	67200005038-11
0018	SP3	1	IS-50NX-C2	BROADBAND DC BLOCKED PROTECTOR, 125-1000MHZ, 50 OHM, 50-375W, VSWR: 1.1:1, SURGE 50KA, N-FEMALE X N-FEMALE	POLYPHASER	
0020		1	AGC-2	FUSE, FAST ACTING FURRULE, 2A, 250VAC, 1/4"X1.25"	BUSSMANN	
0021		1	AGC-1	FUSE, FAST ACTING FURRULE, 1A, 250VAC, 1/4"X1.25"	BUSSMANN	
0022		1	AGC-2	FUSE, FAST ACTING FURRULE, 2A, 250VAC, 1/4"X1.25"	BUSSMANN	
0023		1	AGC-2	FUSE, FAST ACTING FURRULE, 2A, 250VAC, 1/4"X1.25"	BUSSMANN	
0024		4	SH2B-05	RELAY MOUNTING SOCKET, DIN RAIL, 2PDT, 300V/10A, 2-#12	IDEC	
0025		4	RH2B-ULC-DC24V	RELAY, 2PDT, COIL: 24VDC/ 36.9MA, 1/6HP, W/INDICATOR & CHECK BUTTON	IDEC	
0026		1	PT 2X2+F-BE	BASE, GAS-FILLED SURGE ARRESTOR, 2 2-WIRE FLOATING SIGNALS, 600V/ 450MA, DIN RAIL	PHOENIX	2839224
0027		1	PT 2X2-24DC-ST	PROTECTIVE PLUG, 2 2-CORE FLOATING SIGNALS, 24VDC, MAX CORE SURGE 10KA @ (8-20US)	PHOENIX	2838228
0040	REC1	1	991548	RECEPTACLE, SIMPLEX 15A, 120VAC, UL, T35 DIN RAIL MOUNT	WEIDMULLER	991548
0041		1	AGC-1/4	FUSE, FAST ACTING FURRULE, 250MA, 250VAC, 1/4"X1.25"	BUSSMANN	
0042		1	AGC-1/4	FUSE, FAST ACTING FURRULE, 250MA, 250VAC, 1/4"X1.25"	BUSSMANN	
9001		2	UK 6,3-HESILA 250	FUSE BLOCK, ILL 110-250V, 600V/10A, 26-8AWG	PHOENIX	3004249
9002		6	UK 6,3-HESILED 24	FUSE BLOCK, ILL 15-30V, 600V/10A, 26-8AWG	PHOENIX	3004265
9010		4	UK 5 N	TERMINAL BLOCK, GRAY, 600V/30A, 30-10AWG	PHOENIX	3004362
9011		6	UK 5 N GN	TERMINAL BLOCK, GREEN, 600V/30A, 30-10AWG	PHOENIX	3003965
9012		8	UK 5 N YE	TERMINAL BLOCK, YELLOW, 600V/30A, 30-10AWG	PHOENIX	3003952
9013		36	UK 5 N OG	TERMINAL BLOCK, ORANGE, 600V/30A, 30-10AWG	PHOENIX	3002908
9014		1	UKLKG 5	GROUND TERMINAL, 26-10AWG	PHOENIX	0441504
9015		10	D-UK 4/10	END COVER PLATE, GRAY	PHOENIX	3003020
9017		21	E/UK	END CLAMP, GRAY	PHOENIX	1201442
9018		2	FBI 2-6	CROSS CONNECTOR/JUMPER, 2 POSITION, AL	PHOENIX	0203438
9019		1	FBI 10-6	CROSS CONNECTOR/JUMPER, 10 POSITION, AL	PHOENIX	0203250
9019		2	FBI 10-6	CROSS CONNECTOR/JUMPER, 10 POSITION, AL	PHOENIX	0203250
9019		1	FBI 10-6	CROSS CONNECTOR/JUMPER, 10 POSITION, AL	PHOENIX	0203250
9021	GND1	1	K2A25U	GROUNDING LUG, 2 CONDUCTOR, 1/0-14AWG	BURNDY	

REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION
11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

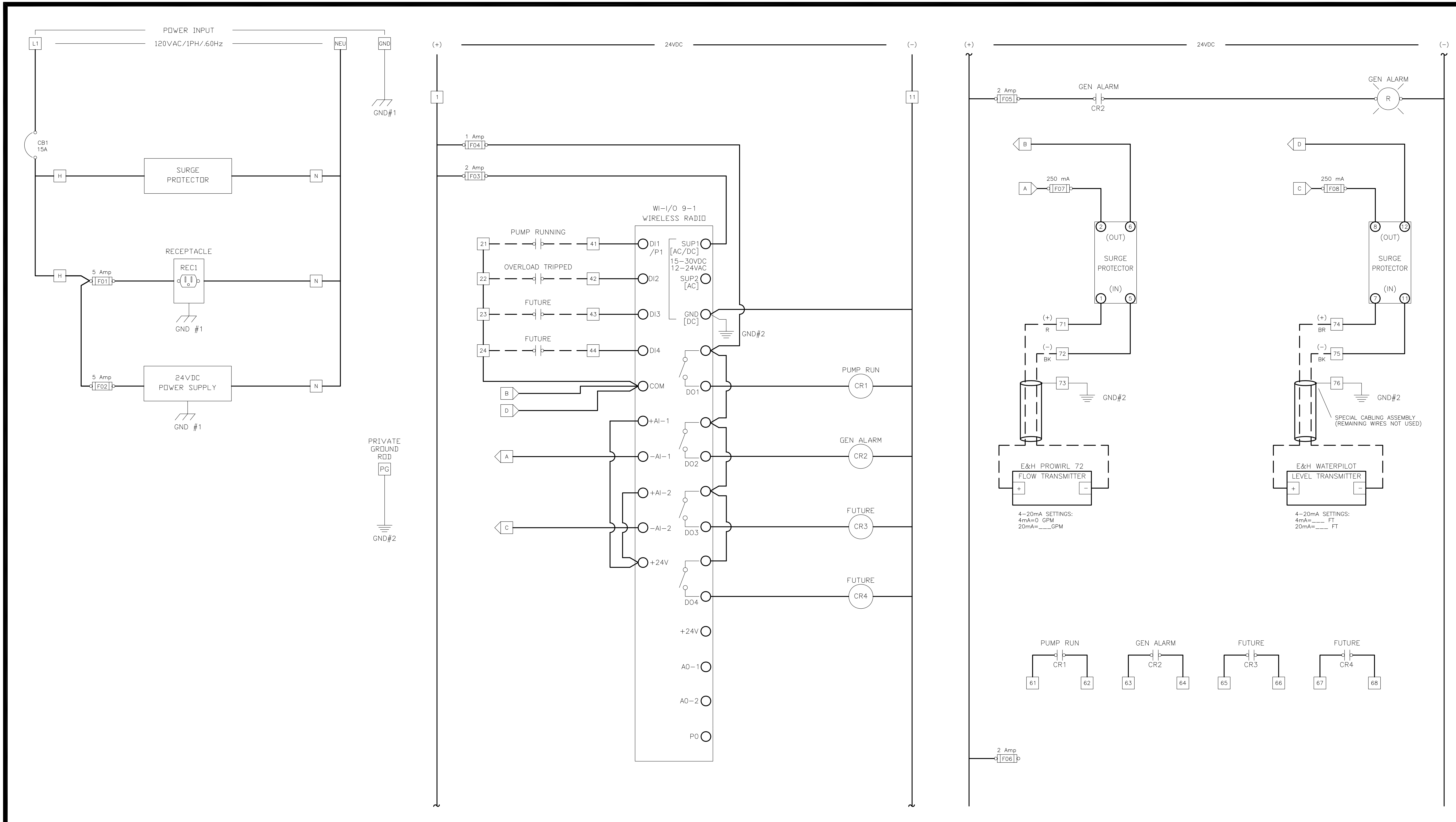
ENGINEER

PROJECT TITLE: CAMP STANLEY BIOREACTOR

SHEET TITLE: RTU 903-2 PROCESS TANK BILL OF MATERIALS

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-2
DWG. NO.	2829
SH	6
OF	6

RTU 903-3: CS-EXW01



REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

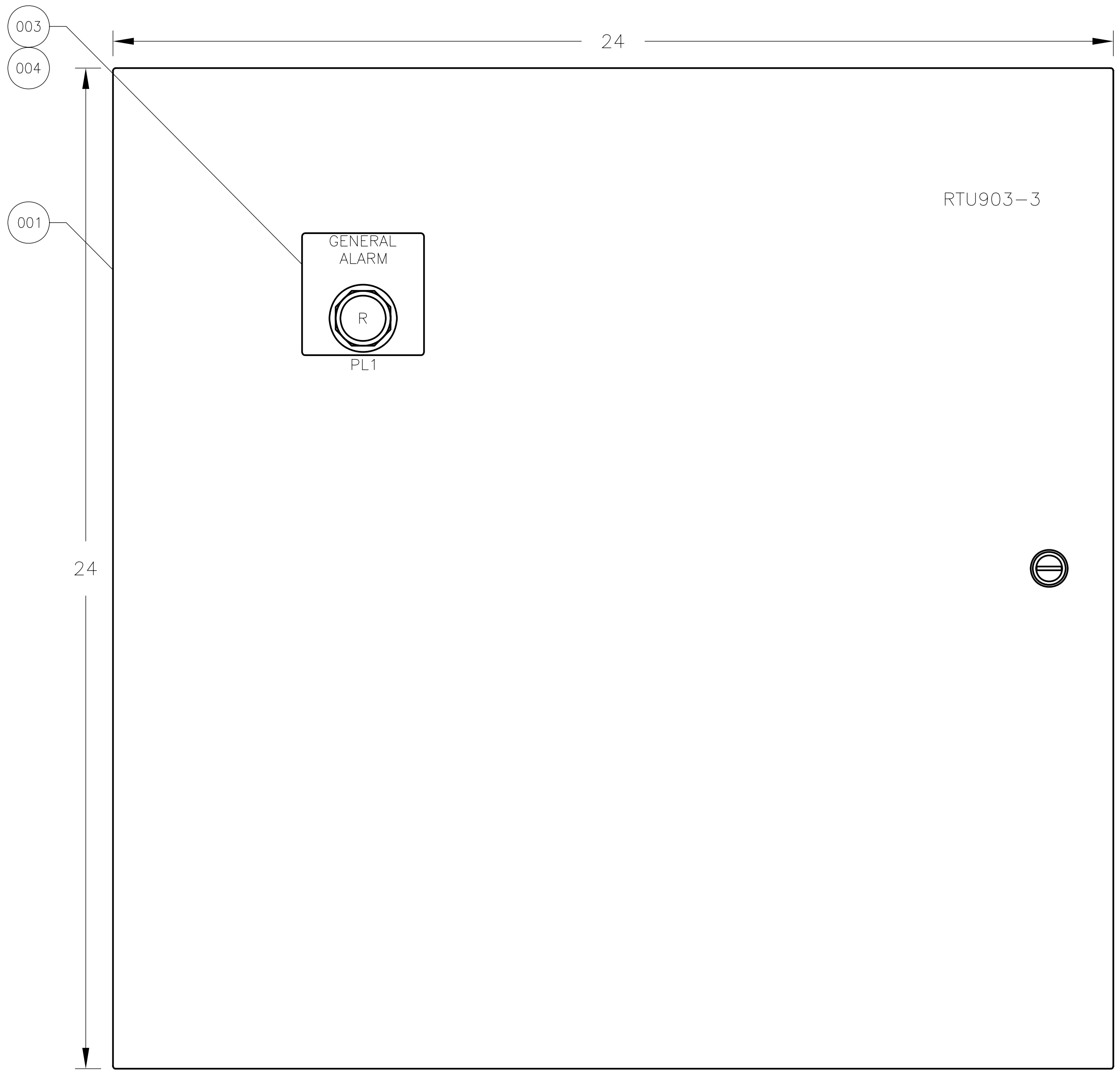
11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

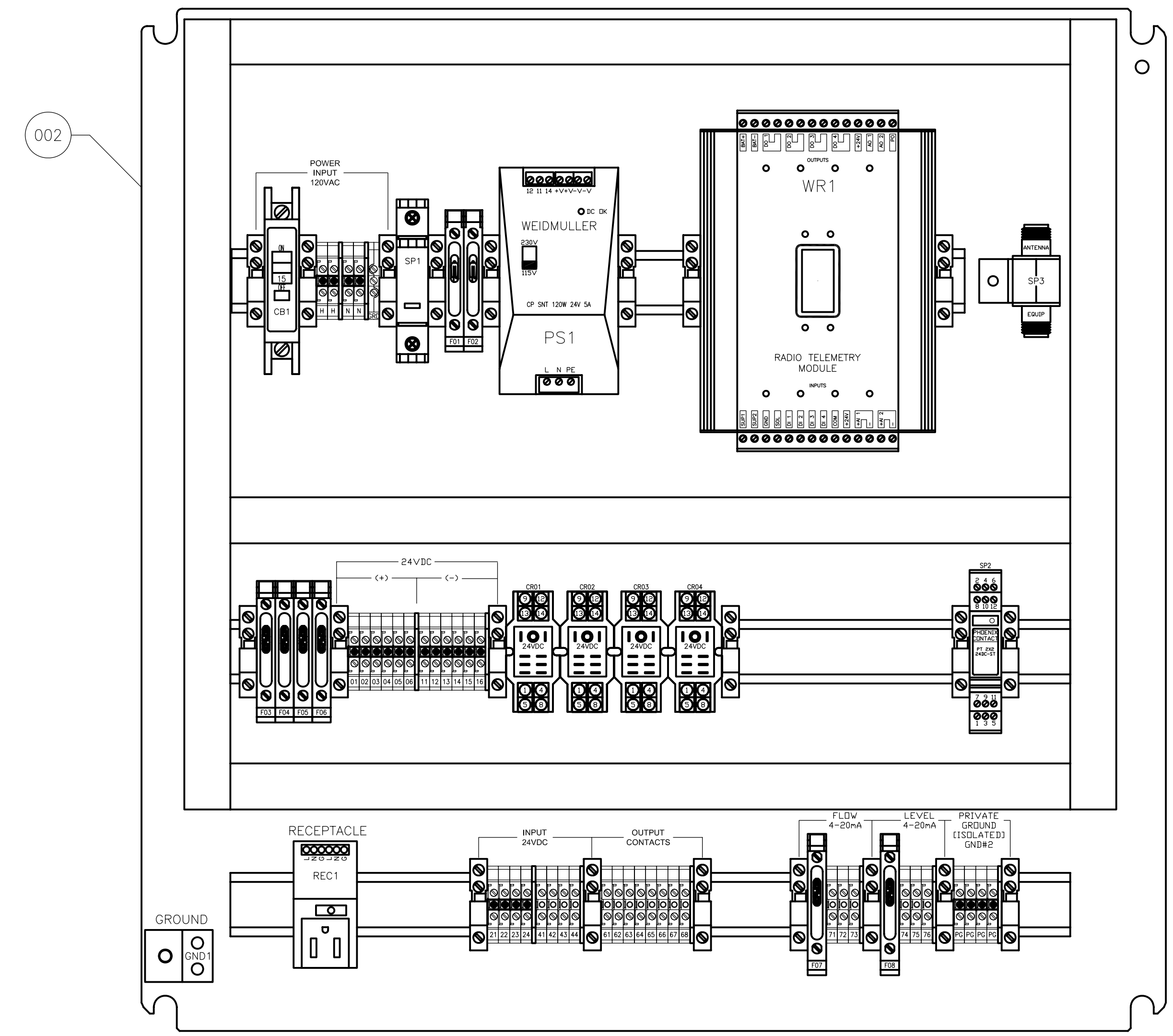
ENGINEER

PROJECT TITLE: CAMP STANLEY BIOREACTOR

SHEET TITLE: RTU 903-3 WELL #1 WIRING DIAGRAM

DATE:	8/10/2009
SCALE:	N/A
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-3
DWG. NO.	2829
SH	1
OF	5





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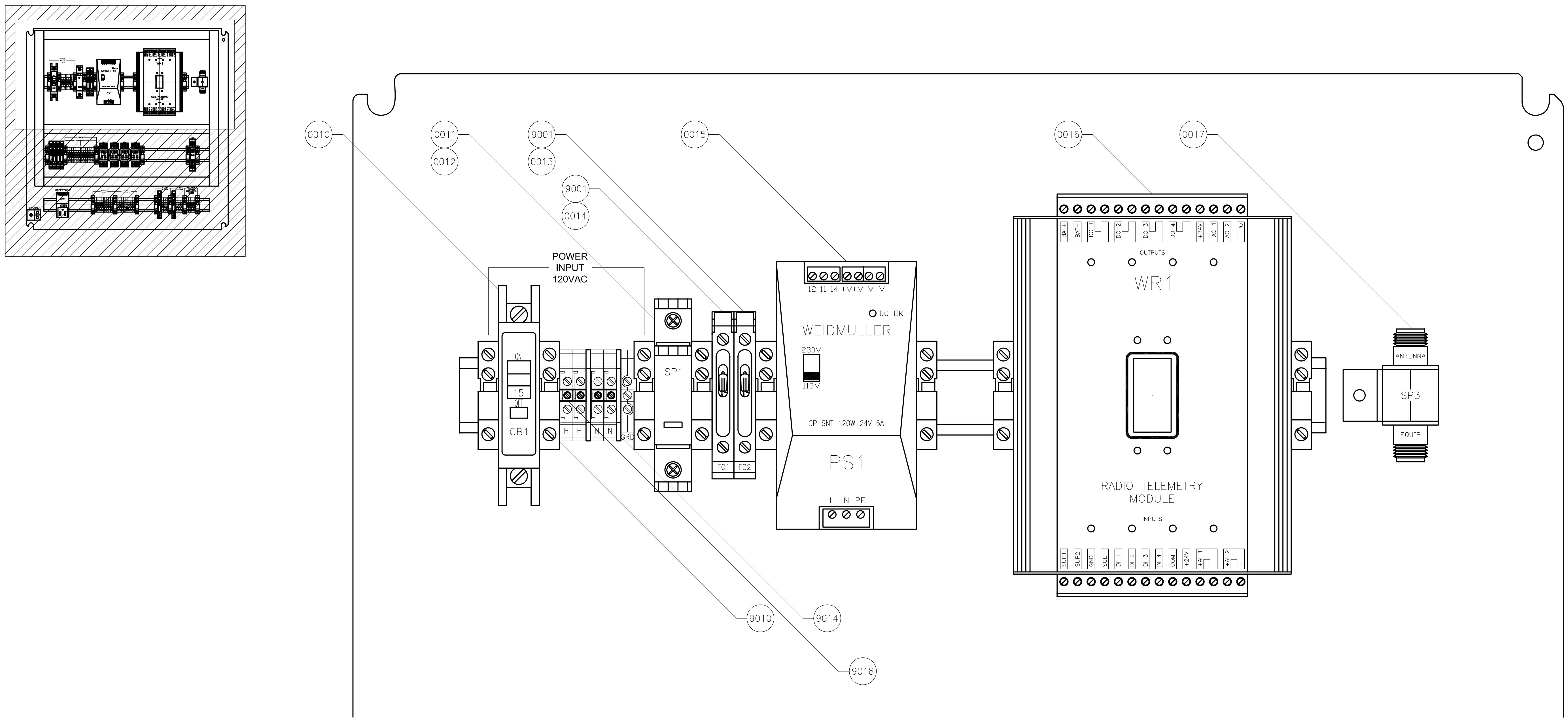
			SYSTEM CONTROLS & INSTRUMENTATION 11218 IH-10 EAST CONVERSE, TEXAS 78109 PHONE (210) 661-9901		CAMP STANLEY BIOREACTOR	RTU 903-3 WELL #1 BACK PANEL LAYOUT	DATE: 8/10/2009 SCALE: N/A DRAWN BY: RMF CAD FILE SCI2829_RTU903-3 DWG. NO. 2829 SH 2 OF 5



REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE: CAMP STANLEY BIOREACTOR

SHEET TITLE: RTU 903-3 WELL #1 PARTS LAYOUT

DATE:	8/10/09
SCALE:	1:2
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-3
DWG. NO.	2829
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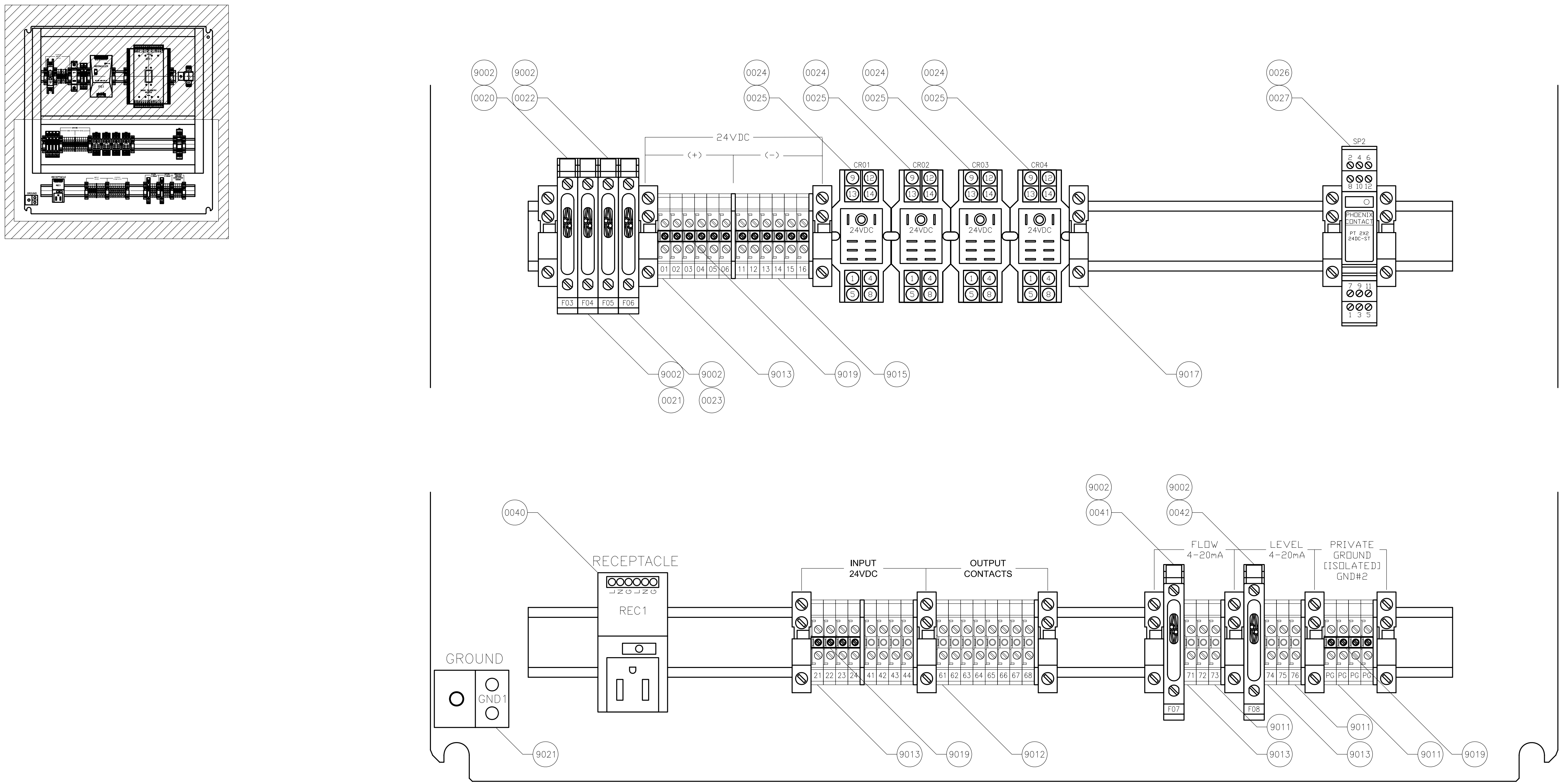
OF	5



REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION

11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-3
WELL #1 PARTS LAYOUT

DATE:	8/10/09
SCALE:	1:2
DRAWN BY:	RMF
CAD FILE	SCI2829_RTU903-3

DWG. NO.	SH	OF
2829	4	5

BILL OF MATERIAL						
ITEM_ID	DEVICE_ID	COUNT	MFG_#	DESCRIPTION	MFG_NAME	PART_KEY_#
0001	RTU903-3	1	CSD242410SS	CONCEPT ENCLOSURE, 24"HX24"WX10"D NEMA 4, 304SS	HOFFMAN	
0002	RTU903-3	1	CP2424	CONCEPT ENCLOSURE BACK PANEL, 24"X24"	HOFFMAN	
0003	PL1	1	800T-QBH24R	PUSH BUTTON PILOT LED, 30.5MM, 24VDC, RED LENS, 1NO / 1NC	AB	
0004	PL1	1		PLASTIC LABEL, 30.5MM PILOT LAMP, RED W/WHITE LETTERING, 2.4"WX2.4"H	SCI	999999
0010	CB1	1	QOU115	CIRCUIT BREAKER, 15A, UL489, 10K AIR, 1-#14-#2, CU OR AL	SQD	
0011		1	PU II 1S	HOLDER, SURGE PROTECTION	WEIDMULLER	
0012	SP1	1	PU II 1	SURGE PROTECTION MODULE, 130VAC, IN:20KA, IMAX:40KA, L-N	WEIDMULLER	8859950000
0013		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0014		1	MDL-5	FUSE, TIME DELAY FURRULE, 5A, 250VAC, 1/4"X1.25"	BUSSMANN	
0015	PS1	1	CP SNT 120W 24V 5A	POWER SUPPLY, TS-35 DIN-RAIL MOUNT, 88-132VAC, 176-264VAC, 3A@115VAC/2A@230VAC, 50/60HZ, 24-28VDC, 5.0A, 120W	WEIDMULLER	
0016	WR1	1	WI-I/O 9-1	WIRELESS RADIO, DIN-RAIL MOUNT, 15-30VDC, 4 INPUTS, 2- 4-20MA INPUTS, 4 OUTPUTS, 2- 4-20MA OUTPUTS, RS232/RS485	WEIDMULLER	8708670000
0017	SP3	1	IS-50NX-C2	BROADBAND DC BLOCKED PROTECTOR, 125-1000MHZ, 50 OHM, 50-375W, VSWR: 1.1:1, SURGE 50KA, N-FEMALE X N-FEMALE	POLYPHASER	
0020		1	AGC-2	FUSE, FAST ACTING FURRULE, 2A, 250VAC, 1/4"X1.25"	BUSSMANN	
0021		1	AGC-1	FUSE, FAST ACTING FURRULE, 1A, 250VAC, 1/4"X1.25"	BUSSMANN	
0022		1	AGC-2	FUSE, FAST ACTING FURRULE, 2A, 250VAC, 1/4"X1.25"	BUSSMANN	
0023		1	AGC-2	FUSE, FAST ACTING FURRULE, 2A, 250VAC, 1/4"X1.25"	BUSSMANN	
0024		4	SH2B-05	RELAY MOUNTING SOCKET, DIN RAIL, 2PDT, 300V/10A, 2-#12	IDEC	
0025		4	RH2B-ULC-DC24V	RELAY, 2PDT, COIL: 24VDC/ 36.9MA, 1/6HP, W/INDICATOR & CHECK BUTTON	IDEC	
0026		1	PT 2X2+F-BE	BASE, GAS-FILLED SURGE ARRESTOR, 2 2-WIRE FLOATING SIGNALS, 600V/ 450MA, DIN RAIL	PHOENIX	2839224
0027		1	PT 2X2-24DC-ST	PROTECTIVE PLUG, 2 2-CORE FLOATING SIGNALS, 24VDC, MAX CORE SURGE 10KA @ (8-20US)	PHOENIX	2838228
0040	REC1	1	991548	RECEPTACLE, SIMPLEX 15A, 120VAC, UL, T35 DIN RAIL MOUNT	WEIDMULLER	991548
0041		1	AGC-1/4	FUSE, FAST ACTING FURRULE, 250MA, 250VAC, 1/4"X1.25"	BUSSMANN	
0042		1	AGC-1/4	FUSE, FAST ACTING FURRULE, 250MA, 250VAC, 1/4"X1.25"	BUSSMANN	
9001		2	UK 6,3-HESILA 250	FUSE BLOCK, ILL 110-250V, 600V/10A, 26-8AWG	PHOENIX	3004249
9002		6	UK 6,3-HESILED 24	FUSE BLOCK, ILL 15-30V, 600V/10A, 26-8AWG	PHOENIX	3004265
9010		4	UK 5 N	TERMINAL BLOCK, GRAY, 600V/30A, 30-10AWG	PHOENIX	3004362
9011		6	UK 5 N GN	TERMINAL BLOCK, GREEN, 600V/30A, 30-10AWG	PHOENIX	3003965
9012		8	UK 5 N YE	TERMINAL BLOCK, YELLOW, 600V/30A, 30-10AWG	PHOENIX	3003952
9013		24	UK 5 N OG	TERMINAL BLOCK, ORANGE, 600V/30A, 30-10AWG	PHOENIX	3002908
9014		1	UKLKG 5	GROUND TERMINAL, 26-10AWG	PHOENIX	0441504
9015		10	D-UK 4/10	END COVER PLATE, GRAY	PHOENIX	3003020
9017		21	E/UK	END CLAMP, GRAY	PHOENIX	1201442
9018		2	FBI 2-6	CROSS CONNECTOR/JUMPER, 2 POSITION, AL	PHOENIX	0203438
9019		2	FBI 10-6	CROSS CONNECTOR/JUMPER, 10 POSITION, AL	PHOENIX	0203250
9019		2	FBI 10-6	CROSS CONNECTOR/JUMPER, 10 POSITION, AL	PHOENIX	0203250
9021	GND1	1	K2A25U	GROUNDING LUG, 2 CONDUCTOR, 1/0-14AWG	BURNDY	

REV #	DATE	REVISION

SYSTEM CONTROLS & INSTRUMENTATION
11218 IH-10 EAST
CONVERSE, TEXAS 78109
PHONE (210) 661-9901

ENGINEER

PROJECT TITLE
CAMP STANLEY
BIOREACTOR

SHEET TITLE
RTU 903-3
WELL #1 BILL OF MATERIALS

DATE: 8/10/2009
SCALE: N/A
DRAWN BY: RMF
CAD FILE SCI2829_RTU903-3
DWG. NO. 2829
SH 5 OF 5

APPENDIX G

Product Information:

GPI TM150
Endress+Hauser Prowirl 72F
FT420 Flow Computer

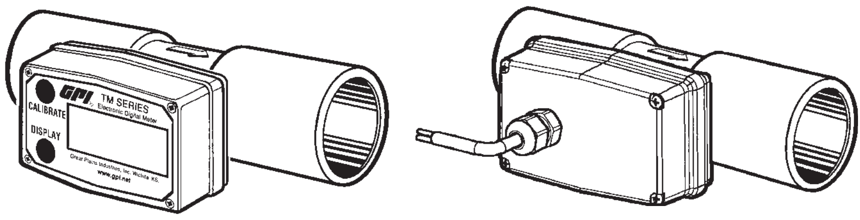
GPI TM150 Turbine Meter

SAVE THESE INSTRUCTIONS

GREAT PLAINS INDUSTRIES, INC.
"A Great Plains Ventures Subsidiary"
5252 East 36th Street North
Wichita, KS USA 67220-3205
TEL: 316-686-7361
FAX: 316-686-6746
www.gpi.net
1-888-996-3837

TM Series Electronic Water Meters

User Manual



TM Meter with Computer Display *TM Digital Pulse Meter*

TABLE OF CONTENTS

ENGLISH

IMPORTANT NOTICE

Use TM Series meters with water and other chemicals compatible with wetted components (see Specifications Section). Do not use to meter fuel or incompatible chemicals. TM Series meters are available with either a computer for local electronic display, or a conditioned signal output module to provide a digital signal to customer interfacing equipment. TM Series meters with computer display measure in gallons or litres. Refer to the Calibration Section for details.

These meters are not legal for trade applications.

TM Series meters are very sensitive to electric noise if operated within 1 to 2 inches of some electric motors or other sources of electronic noise.

INSTALLATION

Connections

Install your meter in-line either horizontally or vertically or at the end of the hose adjacent to the nozzle. Installation to metal connections is not recommended. Install as follows:

1. Plan to install turbine with a minimum straight pipe length as follows:
   - Upstream from the turbine, allow a minimum straight pipe length of 10 times the internal diameter of the turbine.
   - Downstream from the turbine, allow a minimum straight pipe length of 5 times the internal diameter of the turbine.
2. For Spigot (Pipe) End use only primer and solvents approved for PVC gluing.

For NPT Fittings wrap all connections with 3 to 4 wraps of thread tape. Make sure the tape does not intrude into the flow path.

3. Attach meter with arrow pointed in the direction of flow.
4. For NPT Fittings - Hand tighten the meter at the housing ends. Do no use a wrench or similar tool to tighten. This can damage the housing.

Conditioned Signal Output Module Wiring

This conditioned signal output module can be wired to provide an open collector signal output or 6-volt square wave output.

Open Collector Signal Output

To achieve an open collector signal output, reference Wiring Diagram 1. The terminal block is located on the back side of the module. The module is factory assembled for open collector signal output. Please provide the (820 ohm minimum) resistor.

Ten feet (3m) of cable is provided with the module. Trim it to desired length or extend it as necessary. Distances up to 5,000 feet (1,524m) can be achieved for open collector signal output.

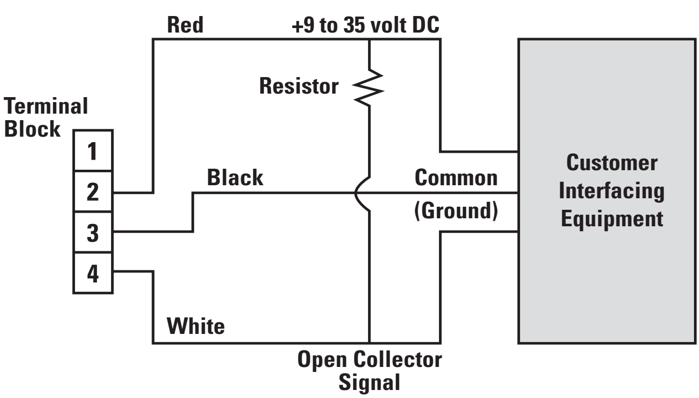
Square Wave Output

To achieve square wave output, reference Wiring Diagram 2 and use an Electronic Digital Meter Battery Kit (sold separately) for battery power. The terminal block and battery location are located on the back side of the module. Access as follows:

1. Remove the four Phillips-head screws from the front of the module and lift the module from the turbine.
2. To change terminal block connections, loosen the appropriate screws. Reconnect the wires in the proper positions and tighten the screws.
3. Install the batteries. Make sure the positive post is in the correct position.
4. Position the module on the turbine housing. To avoid moisture damage, make sure the seal is fully seated. Tighten the four screws on the front of the module.

Wiring Diagram 1

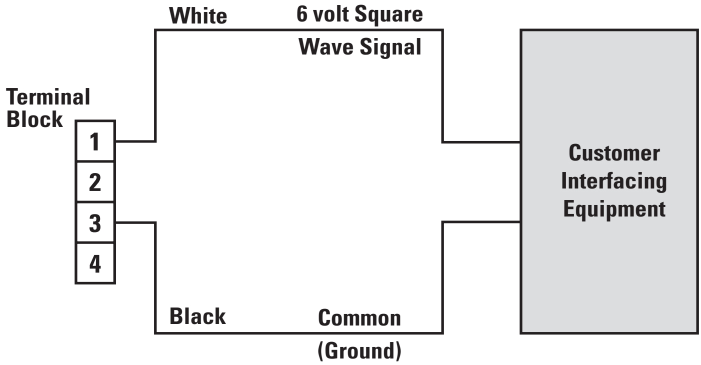
OPEN COLLECTOR SIGNAL OUTPUT



The terminal block is identified as follows:
Pin #1 6 volt square wave (not used)
Pin #2 +9 to 35 volt DC Input
Pin #3 Common Ground
Pin #4 Open Collector signal Output

Wiring Diagram 2

SQUARE WAVE OUTPUT



The terminal block is identified as follows:

Pin #1 6 volt square wave
Pin #2 +9 to 35 volt DC Input (not used)
Pin #3 Common Ground
Pin #4 Open Collector signal Output (not used)

Ten feet (3m) of cable is provided with the module. Trim the cable to desired length or extend it as necessary.

Verify Meter Accuracy

Before using, check the meter's accuracy and verify calibration.

1. Make sure there is no air in the system by starting the flow until it runs steadily. Then, stop the flow using a valve or nozzle.
2. Meter an exact known volume into an accurate container. For best results, meter with one continuous full stream.
3. Check the volume against the display or recording equipment. If the amount metered is accurate, further calibration is not necessary. If not, refer to the Calibration Section for further instructions.

OPERATION

Computer Display – Batch and Cumulative Totals

The computer maintains two totals. The Cumulative Total provides continuous measurement and cannot be manually reset. The Batch Total can be reset to measure flow during a single use. The Cumulative Total is labeled with TOTAL 1 LOCKED indicating that this total is locked and cannot be manually zeroed. Batch Total is labeled with TOTAL 2.

When the Cumulative Total reaches a maximum reading of 999,999, it will automatically reset to zero.

Press the DISPLAY button briefly to switch between the batch, cumulative total, and flowrate.

NOTE: Totalization counts total units without differentiating between gallons, litres or field calibrated units.

Flowrate Feature

To use this feature, press and release DISPLAY until FLOWRATE appears to the left of the bottom line.

When FLOWRATE is displayed, the numbers on the middle line reflect the rate of flow, for example, the current gallons per minute (GPM) or litres per minute (LPM).

Activate the Meter

Turn the computer display ON by starting water flow or briefly pressing the DISPLAY button. The Batch or Cumulative Total from last use will be displayed.

Press DISPLAY briefly to display the Batch Total. Hold the DISPLAY button down for 3 seconds to reset the Batch Total to zero.

The computer display is programmed to turn off automatically if not used for 4 minutes.

Factory and Field Calibration Curves

All calibration information is visible to the user as words in the upper part of the display, above the numeric digits.

All units are configured with a "factory" calibration curve. Both gallons and litres are available ("GAL" or "LTR" will be displayed). Use the CALIBRATE and DISPLAY buttons to switch between gallons and litres. This curve is NOT user adjustable: the word "PRESET" is displayed to show this. (The factory calibration is stored permanently in the computer's memory.)

The "field" calibration curve may be set by the user, and can be changed or modified at any time using the calibration procedure described below in the Calibration Section. Totals or flowrate derived from the field calibration are visible when the field calibration setting is selected ("CAL B" will be visible on the top line).

Selecting a Different Calibration Setting

You can switch between GAL and LTR modes at will without "corrupting" totalizer contents. For example, the computer can totalize 10.00 gallons. If the user switches to LTR mode, the display will immediately change to "37.85" (the same amount in units of litres). GAL / LTR switching also works in FLOWRATE mode.

To select a different calibration setting, first press and hold the CALIBRATE button. Continue to hold it while also pressing and releasing the DISPLAY button. (You may then also release the CALIBRATE button.) The flag indicators in the top line of the display will change to show the newly selected calibration setting. Calibration settings change in this order: GAL, LTR, CAL B, GAL, etc. While fluid is flowing, only the GAL and LTR selections may be made. However, when NO fluid flow is occurring, any setting may be selected.

CALIBRATION

Before Beginning Field Calibration

For the most accurate results, dispense at a flowrate which best simulates your actual operating conditions. Avoid "dribbling" more fluid or repeatedly starting and stopping the flow. This can result in less accurate calibrations.

Make sure you meet the meter's minimum flowrate requirements:

TM Series Meters

1/2 inch meter	1 GPM (3.8 LPM)
3/4 inch meter	2 GPM (7.5 LPM)
1 inch meter	5 GPM (18.8 LPM)
1-1/2 inch meter	10 GPM (37.5 LPM)
2 inch meter	20 GPM (75 LPM)

The use of a uniformly dependable, accurate calibration container is highly recommended for the most accurate results. Due to high flowrate, it is strongly recommended that calibration be completed with a combination of volume and weight using fine resolution scales.

For best results, the meter should be installed and purged of air before field calibration.

Field Calibration with Computer Display

Field Calibration and Factory Calibration are defined in the previous section. Factory calibration settings are custom programmed into each computer during production, using water at 70°F (21°C). Readings using the standard factory calibration curves may not be accurate in some situations, for example, under extreme temperature conditions or with fluids other than water.

For improved accuracy under such conditions, the GPI flow computer allows for "field" calibration, that is, user entry of custom calibration parameters. A "single point" calibration may yield acceptable accuracy in the middle of the flow range, but five or more calibration points may yield a higher level of accuracy, especially at the lower end of the flow range. Up to 15 custom calibration points can be entered.

Dispense/Display Field Calibration Procedures

1. Hold down CALIBRATE while pressing and releasing DISPLAY until the field calibration curve appears ("CAL B" message will be displayed). Release both buttons.
2. To calibrate, press and hold the CALIBRATE button. While continuing to hold CALIBRATE, also press and hold the DISPLAY button. Hold both buttons for about 3 seconds until you see a blinking "dd CAL" message. Once the "dd CAL" message appears, release both buttons. You are now in field calibration mode.
3. Once the buttons have been released from Step 2, the display will show the blinking message "run 01". If you want to exit the calibration now before dispensing any fluid, go to Step 11.
4. If you want to continue with the calibration, but have not dispensed any fluid yet, make your final preparations to your pumping system, but don't start pumping yet.
5. Start your pumping system so that fluid flows through the meter. The display will stop blinking and show the "run 01" message. Dispense into a container that allows you to judge the amount of fluid pumped. When you have pumped the desired amount (for example, 10 gallons), stop the fluid flow quickly.
6. Once the flow has stopped, briefly press and release both buttons. At this point the computer display will change to "0000.00" with the left-hand digit blinking.
7. Enter the volume (amount) of fluid that you dispensed (for example, if your 10-gallon container is full, enter "10.0" for gallons or "37.85" for litres). To enter numbers, use the CALIBRATE button to change the value of the digit that is blinking and use the DISPLAY button to shift the "blink" to the next digit.
8. Once the correct number is entered, briefly press and release both buttons. The display will now change to a blinking "run 02" message. You have installed the new cal-curve point. You are ready to end calibration (Step 10) or enter another new calibration point (Step 9).
9. To enter another calibration point, go back and repeat Steps 3 through 8. It is possible to set up to 15 cal-curve points, and the "run ##" message will increment each time you repeat the calibration process (run 01, run 02, run 03, etc., up to run 15).
10. To end calibration, press and hold both buttons for about 3 seconds until you see the "CAL End" message. After you release the buttons the computer will resume normal operations with the new cal point(s) active.
11. If you HAVE NOT dispensed any fluid, you can exit calibration without changing the cal curve. If the message "run 01" is showing and you have not dispensed any fluid, hold both buttons for about 3 seconds until you see a "CAL End" message. After you release the buttons, the computer will resume normal operation and the old curve (if you entered one in the past) is still intact.

Calibration with Conditioned Signal Output Module

The K-factor of your meter appears on the calibration report as the number of pulses per gallon. The factor is determined during production using water at 70°F (21°C). This K-factor may be used for "single point" calibration and provide acceptable accuracy. However, readings may not be accurate when using this calibration method in some situations. One example is when using the meter under extreme temperature conditions or with fluids other than water.

For improved accuracy under such conditions, we recommend that a K-factor specific to the application be determined and used for calibration. A "single point" calibration may yield acceptable accuracy in the middle of the flow range, but five or more calibration points may yield a high level of accuracy, especially at the lower end of the flow range.

MAINTENANCE

Proper handling and care will extend the life and service of the meter.

Turbine Rotor

The meter is virtually maintenance-free. However, it is important the rotor moves freely. Keep the meter clean and free of contaminants.

If the rotor does not turn freely, apply a penetrating lubricant on the rotor, shaft, and bearings. Remove any debris or deposits from the rotor using a soft brush or small probe. Be careful not to damage the turbine rotor or supports.

⚠ CAUTION

Blowing compressed air through the turbine assembly could damage the rotor.

Battery Replacement

The computer display is powered by two 3-volt lithium batteries which may be replaced while the meter is installed. When batteries are removed or lose power, the batch and cumulative totals reset to zero but the field and factory calibrations are retained.

If the display becomes dim or blank, replace the batteries as follows:

1. Remove the four Phillips-head screws from the face of the meter and lift the faceplate from the turbine.
2. Remove the old batteries and clean any corrosion from the terminals.
3. Install new batteries. Make sure the positive post is in the correct position.
4. When the batteries are replaced, the faceplate will power ON. Check the display to ensure normal functions have resumed before assembling again.
5. Reseat batteries, if necessary, and position the faceplate on the turbine housing. To avoid moisture damage, make sure the seal is fully seated. Tighten the four screws on the faceplate.

SPECIFICATIONS

Inlet and Outlet:

Spigot (Pipe) End Models:

TM050/TM050-P	1/2 inch Schd. 80, Spigot (Pipe)
TM075/TM075-P	3/4 inch Schd. 80, Spigot (Pipe)
TM100/TM100-P	1 inch Schd. 80, Spigot (Pipe)
TM150/TM150-P	1-1/2 inch Schd. 80, Spigot (Pipe)
TM200/TM200-P	2 inch Schd. 80, Spigot (Pipe)

NPT Models:

TM050-N/TM050-N-P	1/2 inch NPT
TM075-N/TM075-N-P	3/4 inch NPT
TM100-N/TM100-N-P	1 inch NPT
TM150-N/TM150-N-P	1-1/2 inch NPT
TM200-N/TM200-N-P	2 inch NPT

Design Type: Turbine

Wetted Components:

Housing: PVC
Journal Bearings: Ceramic
Shaft: Tungsten Carbide
Rotor and Supports: PVDF
Retaining Washer: Stainless Steel

Fitting Types: Spigot - Schd. 80 or NPT (female)

Max. Working Pressure: 225 PSIG @ 73°F

U.S. Measurement

Unit of Measure: Gallon

Flow Range:

1/2 inch	1 - 10 GPM
3/4 inch	2 - 20 GPM
1 inch	5 - 50 GPM
1-1/2 inch	10 - 100 GPM
2 inch	20 - 200 GPM

Accuracy with Computer: ± 3.0% (Accuracy can be improved with field calibration)

Operating Temperature: +32° to +140° F (Do not allow fluid to freeze inside meter.)

Storage Temperature: –40° to +158° F

Product Weight:*

	Spigot (Pipe)	NPT
1/2 inch	.38 lbs.	.55 lbs.
3/4 inch	.43 lbs.	.67 lbs.
1 inch	.49 lbs.	.84 lbs.
1-1/2 inch	.66 lbs.	1.38 lbs.
2 inch	.78 lbs.	1.78 lbs.

Dimensions - Inches (W x H x L):**

	Without Fitting	With Fitting
1/2"	2.0 x 2.6 x 3.8	2.0 x 2.8 x 5.5
3/4"	2.0 x 2.7 x 3.8	2.0 x 2.9 x 5.5
1"	2.0 x 3.1 x 4.1	2.0 x 3.3 x 6.2
1-1/2"	2.1 x 3.7 x 5.4	2.3 x 3.9 x 7.6
2"	2.4 x 4.2 x 5.5	3.5 x 4.5 x 7.9

* Weight with computer display. Conditioned signal output module adds .30 lbs.

** Dimensions with computer display. Conditioned signal output module adds 1.1 inch to height.

Metric Measurement

Unit of Measure: Litre

Flow Range:

1/2 inch	3.8 - 38 LPM
3/4 inch	7.6 - 76 LPM
1 inch	19 - 190 LPM
1-1/2 inch	38 - 380 LPM
2 inch	76 - 760 LPM

Accuracy with Computer: ± 3.0% (Accuracy can be improved with field calibration)

Operating Temperature: 0° to +60° C (Do not allow fluid to freeze inside meter.)

Storage Temperature: –40° to +70° C

Product Weight:*

	Spigot (Pipe)	NPT
1/2 inch	.172 kg	.249 kg
3/4 inch	.195 kg	.304 kg
1 inch	.222 kg	.381 kg
1-1/2 inch	.299 kg	.626 kg
2 inch	.354 kg	.807 kg

Dimensions - cm (W x H x L):**

	Without Fitting	With Fitting
1/2"	5.0 x 6.6 x 9.6	5.0 x 7.1 x 13.9
3/4"	5.0 x 6.8 x 9.6	5.0 x 7.3 x 13.9
1"	5.0 x 7.8 x 10.4	5.0 x 8.3 x 15.7
1-1/2"	5.8 x 9.3 x 13.7	5.8 x 9.9 x 19.3
2"	6.0 x 10.6 x 13.9	8.8 x 11.4 x 20.0

* Weight with computer display. Conditioned signal output module adds .136 kg.

** Dimensions with computer display. Conditioned signal output module adds 2.8 cm to height.

PARTS

The following replacement parts and accessories are available for the TM Series meters:

Part No.	Description
113435-1	Conditioned Signal Output Module
113520-1	Battery Replacement Kit
116000-1	Calibration Container, Large (5 gallon)
125508-03	1/2 inch, Turbine Assy Kit
125508-04	1/2 inch NPT, PVC Turbine Assy Kit
125510-03	3/4 inch, Turbine Assy Kit
125510-04	3/4 inch NPT, PVC Turbine Assy Kit
125512-03	1 inch, Turbine Assy Kit
125512-04	1 inch NPT, PVC Turbine Assy Kit
125514-03	1-1/2 inch, Turbine Assy Kit
125514-04	1-1/2 inch NPT, PVC Turbine Assy Kit
125516-03	2 inch, Turbine Assy Kit
125516-04	2 inch NPT, PVC Turbine Assy Kit
901002-52	Seal
Computer Kits:	
125509-03	1/2 inch, Computer Assy Kit
125511-03	3/4 inch, Computer Assy Kit
125513-03	1 inch, Computer Assy Kit
125515-03	1-1/2 inch, Computer Assy Kit
125517-03	2 inch, Computer Assy Kit

SERVICE

For warranty consideration, contact your local distributor. If you need further assistance, contact the GPI Customer Service Department at:

1-800-835-0113

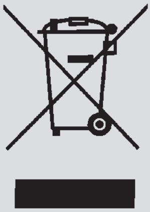
You will need to:

- Provide information from the decal on your meter.
- Receive a Return Authorization number.
- Flush any fluid from the meter before shipping to the factory.
- If possible leave customer installed fittings or ample length of bare pipe for reinstallation.

⚠ CAUTION

Do not return the meter without specific authority from the GPI Customer Service Department. Due to strict regulations governing transportation, handling, and disposal of hazardous or flammable liquids, GPI will not accept meters for rework unless they are completely free of liquid residue.

WEEE DIRECTIVE



The Waste Electrical and Electronic Equipment (WEEE) directive (2002/96/EC) was approved by the European Parliament and the Council of the European Union in 2003. This symbol indicates that this product contains electrical and electronic equipment that may include batteries, printed circuit boards, liquid crystal displays or other components that may be subject to local disposal regulations at your location. Please understand those regulations and dispose of this product in a responsible manner.

ESPAÑOL

AVISO IMPORTANTE

Utilizar los medidores de los Series del TM con agua y otros productos químicos que son compatibles con los componentes que se exponen al líquido (véase la sección de especificaciones). No utilizar este medidor con combustible u otros productos qulmicos incompatibles. Los medidores de la serie de TM están disponibles con una computadora para la visualización electrónica local, o un módulo de salida condicionado de la señal que proporcione una señal numérica al equipo de interconexión del cliente. Los medidores de las Series TM miden en galones o litros. Referirse a la sección de la calibración para mayores detalles.

Estos medidores no son legales para las aplicaciones comerciales.

Los medidores de las Series TM son muy sensibles a interferencia electrónica si funcionan a 1 o 2 pulgadas de algunos motores eléctricos o de otras fuentes del uso electrónico.

INSTALACIÓN

Conexiones

Instalar su medidor en línea, u horizontalmente, o verticalmente, o en el extremo de la manguera adyacente al inyector. No se recomienda la instalación a las conexiones de metal. Siga estos pasos para instalar:

1. Planee instalar la turbina con una longitud mínima de la pipa recta de esta manera:
   - Contra la corriente de la turbina, permita a una longitud mínima de la pipa recta de 10 veces el diámetro interno de la turbina.
   - Con la corriente de la turbina, permita una longitud mínima de la pipa recta de 5 veces el diámetro interno de la turbina.
2. <u>Para Espiga (de tubo) Fin</u> utilizar solamente los solventes aprobados para pegar PVC.
   <u>Para Las Conexiones Del NPT</u> cubrir las conexiones de pipa con la cinta del Teflon® 3 a 4 veces. Cerciorarse de que la cinta no imponga en la trayectoria del flujo.

3. Unir el medidore con la flecha señalada en la dirección del flujo.

4. Para Las Conexiones Del NPT utilizar solamente sus manos para apretar las conexiones del medidore. No utilizar una llave inglesa o una herramienta similar para apretar. Esto puede dañar la cubierta.

Señal de Salida Condicionada Cableado De Módulo

Este módulo de Señal de salida condicionada se puede conectar para proporcionar una salida de colector abierta o de señal de onda cuadra-da de 6-voltios.

Señal de Salida De Colector Abierto

Para alcanzar una señal de salida de colector abierto, refierase por favor al digrama eléctrico 1. El bloque de terminales está situado en el lado trasero del módulo. El módulo viene montado de fábrica para señal de colector abierta. Por favor proporcionar el resistor de un minimo de 820 ohmios.

Diez pies (3m) de cable se proporcionan con el módulo. Ajustar el cable a la longitud deseada o extender el cable cuanto le sea necesario. Se puede alcanzar una señal de salida de colector abierto hasta distancias de 5.000 pies (1,524m).

Salida de corrente de Onda Cuadrada

Para lograr una salida de corriente de onda cuadrada, refierase por favor al digrama eléctrico 2 y utilize un kit electrónico de bateria del medidor digital (vendido por separado) para la fuente de energia de la bateria. El bloque de terminales y la localización de la bateria están situados en el lado trasero del modulo. Acceda al módulo de la siguiente manera:

1. Quitar los cuatro tornillos de cabeza Phillips del frente del módulo. Levantar el módulo de la turbina.

2. Para cambiar las conexiones del bloque de terminales, aflojar los tornillos apro-piados. Volver a conectar los alambres en las posiciones apropiadas y apretar los tornillos.

3. Instalar las baterias. Cerciorarse de que el poste positivo esté en la posición correcta.

4. Colocar el módulo en la cubierta de la turbina. Para evitar daños causados por la humedad, cerciorarse de que el anillo esté asentado completamente. Apretar los cuatro tornillos en el frente del módulo.

Diez pies (3m) de cable se proporcionan con el módulo. Ajustar el cable a la longitud deseada o extender el cable cuanto le sea necesario.

Verificar La Exactitud Del Metro

Antes de usar, comprobar la exactitud del metro y verificar la calibración.

1. Cerciorarse de que no haya aire en el sistema comenzando el flujo hasta que funciona constantemente. Entonces, detenga el flujo usando una válvula o un inyector.

2. Con el medidor, mida un volumen exacto en un envase exacto. Para mejores resultados, medir con una corriente complete y continua.

3. Comprobar el volumen con lo indicado en la pantalla o el equipo de grabación. Si la cantidad medida es exacta, no es necesario mayor calibración. Si no, referir a la sección de la calibración.

OPERACIÓN

Pantalla De la Computadora – lotes y totales acumulativos

El computadora mantiene dos totales. El total acumulativo proporciona la medida continua y no puede ser reajustado manualmente. El total de hornada se puede reajustar para medir el flujo durante una sola vez. El total acumulativo se etiqueta con el TOTAL 1 LOCKED. Esto indica que el total esta bloqueado y no puede ser puesto a cero manualmente. El total de hornada se etiqueta con el TOTAL 2.

Cuando el total acumulativo alcanza una lectura máxima de 999.999, se reajustará automáticamente a cero.

Presionar el botón de DISPLAY brevemente para cambiar entre la hornada, el total acumulativo, y el índice de flujo.

NOTA: Totalization cuenta las unidades totales sin distinguir entre los galones, los litros o las unidades calibradas de campo.

Atributo Del Indice De Flujo

Para utilizar este atributo, presionar y soltar el “DISPLAY” hasta que “FLOWRATE” aparezca abajo a la izquierda.

Cuando aparece “FLOWRATE”, los números en la linea de el centro reflejan el Índice de flujo. Por ejemplo, los galones por minuto (GPM) o litros por minuto (LPM).

Activar El Medidor

Encienda el pantalla de la computadora comenzando el flujo del agua o brevemente presionando el botón del DISPLAY. El lote o el total acumulativo del uso pasado será exhibido.

Presionar el botón del DISPLAY brevemente para exhibir el total de hornada. Oprima el botón de DISPLAY por 3 segundos para reajustar el total de hornada a cero.

El medidor se apaga automáticamente si no es usado durante 4 minutos.

Curvas De Calibración De La Fábrica y Del Campo

Toda la información de la calibración es visible al usuario como palabras en la parte superior de la exhibición, sobre los dígitos numéricos.

Todas las unidades se configuran con una curva de calibración de la “fábrica”. Los galones y los litros están disponibles. (el “GAL” o el “LTR” será visible). Utilizar los botones del CALIBRATE y del DISPLAY para cambiar entre los galones y los litros. Esta curva de calibración no es ajustable por el usuario. La palabra PRESET se exhibe para demostrar esto. (La calibración de la fábrica se almacena permanentemente en la memoria de computadora.)

La curva de calibración de “campo” se puede fijar por el usuario. La calibración se puede cambiar o modificar en cualquier momento usando los procedimientos de la calibración descritos en la sección de la calibración. Los totales o el índice de flujo derivados de la calibración de campo son visibles cuando se selecciona el ajuste de la calibración de campo (la “CAL B” será visible en la línea superior).

Seleccionar un Ajuste Diverso De La Calibración

Usted puede cambiar entre los modos del GAL y del LTR a voluntad sin afectar los totales. Por ejemplo, la computadora puede sumar 10,00 galones. Si el usuario cambia al modo del LTR, la exhibición cambiará inmediatamente a “37,85” (la misma cantidad en las unidades de los litros). La conmutación del GAL/LTR también trabaja en el modo del FLOWRATE.

Para seleccionar un ajuste diverso de CALIBRATE, oprima y sostenga el botón de la CALIBRATE. Continuar presionando el botón mientras que también presiona y suelta el botón de DISPLAY. (usted puede entonces también soltar el botón de CALIBRATE.) Los indicadores de la bandera de la línea superior de la exhibición cambiarán para demostrar el nuevo ajuste seleccionado de la calibración. Los ajustes de la calibración se cambian en este orden: GAL, LTR, CAL B, GAL, etc. Mientras que está fluyendo el líquido, sólo las selecciones del galón y del litro pueden ser hechas. Sin embargo, cuando no está fluyendo NINGÚN líquido, cualquier selección puede ser hecha.

CALIBRACIÓN

Antes De Comenzar La Calibración

Para resultados más exactos, dispense un índice de flujo que simule lo mejor posible sus condiciones de funcionamiento reales. Evite “de gotear” más líquido o en varias ocasiones, o el comenzar y de parar el flujo. Estas acciones darán lcomo resultado calibraciones menos exactas.

Cerciorese de reunir todos los requisitos mínimos del índice de flujo del medidor:

Metros de la Serie TM
Medidores de 1/2 pulgada de 1 GPM (3,8 LPM)
Medidores de 3/4 pulgada de 2 GPM (7,5 LPM)
Medidores de 1 pulgada de 5 GPM (18,8 LPM)
Medidores de 1-1/2 pulgadas de 10 GPM (37,5 LPM)
Medidores de 2 pulgadas de 20 GPM (75 LPM)

Se recomienda para resultados más exactos de la calibración el uso de un envase uniforme, confiable, y exacto. Debido al alto indice de flujo, se recomienda que la calibración esté terminada con una combinación de volumen y de peso usando escalas de alta resolución.

Para mejores resultados, el medidor se debe instalar y purgar del aire antes de la calibración de campo.

Calibración De Campo Con La Pantalla De La Computadora

La calibración de campo y la calibración de fábrica se explican en la sección anterior. La calibración de campo y la calibración de fábrica se explican en la sección anterior. Los ajustes de la calibración de la fábrica se programan especificamente en cada flujó-medidor durante su producción usando agua a 70°F (21°C). Las lecturas que utilizan las curvas de calibración estándares de la fábrica pueden no ser exactas en algunas situaciones. Por ejemplo, cuando se encuentran bajo condiciones de temperatura extremas, o con los liquidos con excepción del agua.

Para la exactitud mejorada bajo tales condiciones, la computadora GPI de flujo tienen en cuenta la calibración del "campo" (es decir un apunte del usuario dentro de los parámetros de calibración especiales). La calibración de "un solo punto" puede rendir una exactitud aceptable en medio de la gama del flujo. Cinco o más puntos de calibración pueden rendir un nivel más alto de exactitud, especialmente en el extremo inferior de la gama del flujo. Hasta 15 puntos de calibración especiales pueden ser inforporados.

Dispensar/Presentar Los Procedimientos De La Calibración De Campo

1. Mantener oprimido el botón del CALIBRATE mientras que presiona y suelta el boton DISPLAY hasta que aparece la curva de calibración de campo (mensaje de "CAL B" será exhibido). Suelte ambos botones.
2. Para calibrar, presionar y sostener el botón del CALIBRATE. Mientras que continúa oprimiendo el CALIBRATE, también presionar y sostener el botón del DISPLAY. Sostener ambos botones por cerca de 3 segundos hasta que usted vea el mensaje de "dd-CAL" en centelleo. Una vez que mensaje del "dd-CAL", aparezca, suelte ambos botones. Usted ahora está en el modo de la calibración de campo.
3. Una vez que los botones se hayan soltado (el paso 2), la exhibición demostrará el mensaje del centelleo "RUN 01". Si usted desea salir del proceso de la calibración antes de dispensar cualquier líquido, ir al paso 11.
4. Si usted desea continuar con la calibración, pero no ha dispensado ningún líquido todavía, hacer las preparaciones finales a su sistema de bombeo, pero no comenzar a bombear todavía
5. Comience su sistema de bombeo de modo que el líquido atraviese el medidor. La exhibición parará el centelleo y demostrará el mensaje del " RUN 01". Dispense el líquido en un envase que permita que usted juzgue la cantidad de líquido bombeada. Cuando usted ha bombeado la cantidad deseada (por ejemplo, 10 galones), detenga el flujo fdel liquido inmediatamente.
6. El flujo ha parado; brevemente presione y suelte una vez ambos botones. En este momento la exhibición de la computadora cambiará al "0000.00" con el centelleo a la izquierda del dígito.
7. Introduzca el volumen (cantidad) de líquido que usted ha dispensado (por ejemplo, si su envase de los 10-gallon esté lleno, introducir "10,0" para los galones o "37,85" para los litros). Para incorporar los números, utilizar el botón del CALIBRATE para cambiar el valor del dígito que está en centelleo. Utilizar el botón del DISPLAY para cambiar de puesto el "centelleo" al dígito siguiente.

8. Una vez que se incorpore el número correcto, presionar y soltar brevemente ambos botones. La exhibición ahora cambiará a un mensaje “RUN 02” en centelleo. Usted ahora ha instalado el nuevo punto de la cal-curva. Usted esta listo para terminar la calibración (paso 10) o incorporar otro nuevo punto de calibración (paso 9).
9. Para incorporar otro punto de calibración, vuelva a repetir los pasos del 3 al 8. Es posible fijar hasta 15 puntos de la cal-curva, y “run ##” del funcionamiento incrementará cada vez que usted repite el proceso de la calibración (run 01, run 02, run 03, etc., hasta el run 15).
10. Para terminar el proceso de la calibración, presionar y sostener ambos botones por cerca de 3 segundos hasta que usted vea el mensaje del “CAL End”. Después de que usted suelte los botones, la computadora reasumirá las operaciones normales con el nuevo punto(s) activos calibrados.
11. Si usted no ha dispensado ningún líquido, usted puede salir de la calibración sin cambiar la curva. Si el mensaje “run 01” está mostrando y usted no ha dispensado ningún líquido, sostenga ambos botones por cerca de 3 segundos hasta que usted vea el mensaje en un extremo del “CAL End”. Después de soltar los botones, la computadora reasumirá la operación normal y la vieja curva (si usted introdujo una en el pasado) sigue intacta.

Calibración Con El Módulo De Señal De Salida Condicionada

El factor K de su medidor aparece en el informe de la calibración como el número de pulsos por galón. El factor se determina durante la producción usando el agua a 70°F (21°C). Este factor K se puede utilizar para la calibración de “un solo punto” y proporcionará una exactitud aceptable. Sin embargo, las lecturas pueden no ser exactas cuando usted utiliza este método de la calibración en algunas situaciones. Un ejemplo es cuando usted utiliza el metro bajo condiciones de temperatura extremas o lo utiliza con los liquidos con excepción del agua.

Para mejorar la exactitud durante tales condiciones, recomendamos que un factor K especifico de uso esté determinado y utilizado para la calibración. Una calibración de “un solo punto” puede rendir una exactitud aceptable en el centro de la gama del flujo, pero cinco o más puntos de calibración pueden rendir un alto nivel de exactitud, especialmente en el extremo inferior de la gama del flujo.

MANTENIMIENTO

La utilización y el cuidado apropiados ampliarán la vida y el servicio del medidor.

Rotor De Turbina

El medidor practicamente no tiene necesidad de mantenimiento. Sin embargo, es importante que los movimientos del rotor ocurran libremente. Mantener el medidor limpio y libre de contaminantes.

Si el rotor no da vuelta libremente, aplicar un lubricante penetrante en el rotor, el eje, y los rodamientos. Quitar cualquier desecho o depósito del rotor usando un cepillo suave o una punta de prueba pequeña. Tenga cuidado de no dañar el rotor de turbina o los soportes.

⚠ PRECAUCIÓN

El aire comprimido a través del montaje de la turbina podría dañar el rotor.

Reemplazo De La Batería

El pantalla de la computadora funciona a través de dos baterías del litio de 3-voltios que puedan ser substituidas mientras que el medidor está instalado. Cuando las baterías se quitan o pierden la potencia, la hornada y los totales acumulativos seran reajustados a cero, pero las calibraciones de campo y de la fábrica se conservan.

Si la exhibición del medidor llega a estar débil o en blanco, substituir las baterías de esta manera:

1. Quitar los cuatro tornillos de la cara del metro y levantar la placa frontal de la turbina.
2. Quitar las viejas baterías y limpiar cualquier corrosión de los terminales.

3. Instalar las baterías nuevas. Cerciorarse de que el poste positivo esté en la posición correcta.

4. Cuando se substituyen las baterías, la placa frontal estará encendida. Comprobar la exhibición para asegurarse de que las funciones normales han resumido antes de montar otra vez.

5. Volver a sentar las baterías, en caso necesario, colocar la placa frontal en la cubierta de la turbina. Evite el daño causado por la humedad, cerciorarse de que el anillo esté asentado completamente. Apretar los cuatro tornillos en la placa frontal.

ESPECIFICACIONES

Entrada y Enchufe:

Modelos de Espiga (de tubo)

TM050/TM050-P	1/2 pulgada de 80, Espiga (de tubo)
TM075/TM075-P	3/4 pulgada de 80, Espiga (de tubo)
TM100/TM100-P	1 pulgada de 80, Espiga (de tubo)
TM150/TM150-P	1-1/2 pulgada de 80, Espiga (de tubo)
TM200/TM200-P	2 pulgada de 80, Espiga (de tubo)

Modelos de NPT

TM050-N/TM050-N-P	1/2" de NPT
TM075-N/TM075-N-P	3/4" de NPT
TM100-N/TM100-N-P	1" de NPT
TM150-N/TM150-N-P	1-1/2" de NPT
TM200-N/TM200-N-P	2" de NPT

Tipo Del Diseño: Turbina

Componentes Mojados:
Cubierta: PVC
Rodamientos: De Cerámica
Eje: Carburo De Tungsteno
Rotory Soportes: PVDF
Arandela De Retención: Acero Inoxidable

Tipo De Las Guarniciones: Espiga - de 80 o NPT (hembra)

Máxima Presión De Funcionamiento:
225 PSIG a los 73°F

Medidas De Estados Unidos

Unidad De La Medida: Galón

Gama Del Flujo:

1/2 pulgada	1 - 10 GPM
3/4 pulgada	2 - 20 GPM
1 pulgada	5 - 50 GPM
1-1/2 pulgada	10 - 100 GPM
2 pulgada	20 - 200 GPM

Exactitud con la Computadora: ±3.0% (la exactitud se puede mejorar con la calibración del campo)

Temperatura De Funcionamiento:
+32° a +140° F (No permitir que el líquido se congele dentro del metro.)

Temperatura Del Almacenaje:
-40° a +158° F

Peso Del Producto:*

	Espiga (de tubo)	NPT
1/2 pulgada	.38 lbs.	.55 lbs.
3/4 pulgada	.43 lbs.	.67 lbs.
1 pulgada	.49 lbs.	.84 lbs.
1-1/2 pulgada	.66 lbs.	1.38 lbs.
2 pulgada	.78 lbs.	1.78 lbs.

Dimensiones - Pulgadas
(Grosor x Altura x Longitud):**

	Sin conexión	Con conexión
1/2"	2.0 x 2.6 x 3.8	2.0 x 2.8 x 5.5
3/4"	2.0 x 2.7 x 3.8	2.0 x 2.9 x 5.5
1"	2.0 x 3.1 x 4.1	2.0 x 3.3 x 6.2
1-1/2"	2.1 x 3.7 x 5.4	2.3 x 3.9 x 7.6
2"	2.4 x 4.2 x 5.5	3.5 x 4.5 x 7.9

* El peso con la pantalla de la computadora. El módulo de señal de salida condicionada agrega .30 libras.

** Las dimensiones con la pantalla de la computadora. El módulo señal de salida condicionada agrega 1.1 pulgadas a la altura.

Medida Métrica

Unidad De La Medida: Litro

Gama Del Flujo:

1/2 pulgada	3,8 - 38 LPM
3/4 pulgada	7,6 - 76 LPM
1 pulgada	19 - 190 LPM
1-1/2 pulgada	38 - 380 LPM
2 pulgada	76 - 760 LPM

Exactitud con la Computadora: ±3.0% (la exactitud se puede mejorar con la calibración del campo)

Temperatura De Funcionamiento:
0° a +60° C (No permitir que el líquido se congele dentro del metro.)

Temperatura Del Almacenaje:
-40° a +70° C

Peso Del Producto:*

	Espiga (de tubo)	NPT
1/2 pulgada	.172 kg	.249 kg
3/4 pulgada	.195 kg	.304 kg
1 pulgada	.222 kg	.381 kg
1-1/2 pulgada	.299 kg	.626 kg
2 pulgada	.354 kg	.807 kg

Dimensiones - Centímetro (Grosor x Altura x Longitud): **

	Sin conexión	Con conexión
1/2"	5.0 x 6.6 x 9.6	5.0 x 7.1 x 13.9
3/4"	5.0 x 6.8 x 9.6	5.0 x 7.3 x 13.9
1"	5.0 x 7.8 x 10.4	5.0 x 8.3 x 15.7
1-1/2"	5.8 x 9.3 x 13.7	5.8 x 9.9 x 19.3
2"	6.0 x 10.6 x 13.9	8.8 x 11.4 x 20.0

* El peso con la pantalla de la computadora. El módulo de señal de salida condicionada agrega .136 kg.

** Las dimensiones con la pantalla de la computadora. El módulo señal de salida condicionada agrega 2.8 cm a la altura.

PIEZAS

Las piezas y los accesorios siguientes de recambio están disponibles para los medidores de los Series del TM:

Parte No.	Descripción
113435-1	Señal de salida condicionada cableado de módulo
113520-1	Systema de reemplazo de la batería
116000-1	Envase de calibración, grande (5 galones)
125508-03	1/2" - kit de la asamblea de la turbina
125508-04	1/2" NPT, PVC - kit de la asamblea de la turbina
125510-03	3/4" - kit de la asamblea de la turbina
125510-04	3/4" NPT, PVC - kit de la asamblea de la turbina
125512-03	1" - kit de la asamblea de la turbina
125512-04	1" NPT, PVC - kit de la asamblea de la turbina
125514-03	1-1/2" - kit de la asamblea de la turbina
125514-04	1-1/2" NPT, PVC - kit de la asamblea de la turbina
125516-03	2" - kit de la asamblea de la turbina
125516-04	2" NPT, PVC - kit de la asamblea de la turbina
901002-52	Anillo

Kits De la Computadora:

125509-03	1/2" - kit de la asamblea de la computadora
125511-03	3/4" - kit de la asamblea de la computadora
125513-03	1" - kit de la asamblea de la computadora
125515-03	1-1/2" - kit de la asamblea de la computadora
125517-03	2" - kit de la asamblea de la computadora

SERVICIO

Para la consideración de la garantía, contacte con su distribuidor local. Si usted necesita ayuda adicional, contacte con el departamento de servicios al cliente de GPI:

1-800-835-0113

Usted necesitará:

- Proporcionar la información de la etiqueta en su medidor.
- Recibir un número de la autorización de devolución.
- Limpiar cualquier líquido con un chorro de agua del medidor antes de enviar a la fábrica.
- Si es posible, dejar las guarniciones instaladas por el cliente o una longitud amplia de la pipa pelada para la reinstalación.

⚠ PRECAUCIÓN

No devolver el metro sin la autoridad específica del departamento de servicios al cliente de GPI. Debido a las regulaciones terminantes gubernamentales GPI no aceptará los medidores para la reanudación a menos que estén totalmente libres de residuos líquidos peligrosos o inflamables, o líquidos de todos tipos durante el transporte, la dirección, y la disposición.

WEEE DIRECTIVA

La Directiva 2002/96/CE del Parlamento Europeo y del Consejo de la Unión Europea sobre Residuos de Aparatos Eléctricos y Electrónicos (RAEE) fue aprobada por el Parlamento Europeo y el Consejo de la Union Europea en 2003. Este símbolo indica que este producto contiene equipo eléctrico y electrónico que puede incluir baterías, tableros de circuito impresos, indicadores de crystal líquido u otros componentes que pueden estar sujetos a regulaciones locales de desecho. Por favor informese acerca de estas reglas y deseche de este producto de manera responasble.

D E U T S C H

WICHTIGE HINWEISS

Die TM Series Meßinstrumente mit Wasser und anderen Chemikalien benutzen, die mit Bestandteilen kompatibel sind, die Flüssigkeit (Spezifikationen Abschnitt sehen). Dieses Meßinstrument mit Kraftstoff oder anderen inkompatiblen Chemikalien nicht benutzen. TM Series Meßinstrumente sind entweder mit einem Computer für lokale elektronische Anzeige oder einer konditionierten Signalaus-gabebaugruppe vorhanden, die ein digitales Signal zu Kunde Schnittstellenmodul. TM Series mißt in Gallonen oder Litern. Auf den Kalibrie-rungsabschnitt für Einzelheit beziehen.

Diese Meßinstrumente sind nicht für den Handel zulässig.

TM Series Meßinstrumente sind gegen elektronische Störung sehr empfindlich, wenn sie innerhalb 2,5 bis 5 cm einiger Elektromotoren oder anderer Quellen des elektronischen Gebrauches bedient werden.

AUFSTELLUNG

Anschlüsse

Ihr Meßinstrument inline entweder am Ende des Schlauches neben der Düse horizontal oder vertikal anbringen. Installation zu Metallan-schlüssen wird nicht empfohlen. Diesen Schritten folgen, um anzubringen:

1. Planen, die Turbine mit einer minimalen Länge geraden Rohres anzubringen:
   – Gegen den Strom von der Turbine, einer minimalen Länge des geraden Rohres von 10mal dem internen Durchmesser der Turbine erlauben.
   – Stromabwärts von der Turbine, eine minimale Länge des geraden Rohres von 5mal dem inneren Durchmesser der Turbine erlauben.

2. Für Zentrierring (Pipe) Ende nur Spachtelmasse und Lösungsmittel verwenden, die zum Kleben von PVC erlaubt sind.
   Für NPT Befestigungen spule Teflon® Klebeband 3 bis 4 mal um die Pipe-Verbindungen. Sicherstellen, daß das Klebeband nicht das Innere des Rohres berührt.
3. Das Meßinstrument mit dem Pfeil anbringen, der in die Richtung des Flusses zeigt.
4. Für NPT Befestigungen nur Ihre Hände benutzen um die Pipe-Verbindun. Wenn Sie die Anschlüsse festziehen, sich erinnern, keine Werkzeuge zu benutzen.

Konditioniertes Signal Ausgeben Baugruppenverdrahtung

Diese konditionierte Signalausgabebaugruppe kann verdrahtet werden, um einen geöffneten Kollektorsignal-Ausgang oder Welle des Quadrats 6-volt Ausgang zur Verfügung zu stellen.

Öffnen Kollektor-Signal-Ausgang

Um einen geöffneten Kollektor Ausgang zu erzielen, Bezugsbauschaltplan 1 signalisieren. Der Klemmenblock ist auf der Rückseite des Moduls. Das Modul ist die Fabrik, die für geöffneten Kollektorsignalausgang. Zusammengebaut wird Den (820-Ohm-Minimum) Widerstand bitte zur Verfügung stellen.

10 Fuß (3m) Kabel wird mit dem Modul. Versehen Das Kabel zur gewünschten Länge trimmen oder das Kabel wie benötigt verlängern. Abstände bis 5.000 Fuß (1,524m) könne für geöffneten Kollektorsignalausgang erzielt werden.

Quadratischer Welle Ausgang

Um Quadratischen Welle Ausgang zu erzielen, Bezugsbauschaltplan 2 signalisieren und einen elektronischen Digital Meßinstrument-Batterie-Installationssatz (separat verkauft) für die Batterieleistung benutzen. Der Klemmenblock und die Batterieposition sind auf der Rückseite des Moduls. Zugang wie folgt:

1. Die vier Kreuzkopfschrauven von der Frontseite des Moduls entfernen. Das Modul von der Turbine anheben.
2. Um die Klemmenblockanschlüsse zu ändern, die passenden Schrauben lösen. Die Leitungen in den korrekten Positionen wieder anschließen und die Schrauben festziehen.
3. Die Batterien anbringen. Sicherstellen, daß der positive Pfosten in der richtigen Position ist.
4. Das Modul auf das Turbinegehäuse in Position bringen. Um Feuchtigkeit Beschädigung zu vermeiden, sicherstellen daß der dichtung völlig setzt. Die vier Schrauben an der Frontseite des Moduls festziehen.

10 Fuß (3m) Kabel wird mit dem Modul versehen. Das Kabel zur gewünschten Länge trimmen oder das Kabel wie benötigt verlängern.

MeßinstrumentGenauigkeit Überprüfen

Bevor Sie verwenden, die Genauigkeit des Meßinstruments überprüfen und die Kalibrierung überprüfen.

1. Überprüfen, daß es keine Luft in der Anlage gibt, indem Sie den Fluß beginnen, bis er ständig läuft. Dann den Fluß mit einem Ventil oder einer Düse stoppen.
2. Das Meßinstrument ein genau bekanntes Volumen in einen genauen Behälter abgeben lassen. Für beste Resultate mit einem ununterbrochenen vollen Strom messen.
3. Das Volumen gegen die Anzeige Oder die Aufnahmeausrüstung überprüfen. Wenn die Menge, die gemessen wird, genau ist, ist weitere Kalibrierung nicht notwendig. Wenn nicht, auf den Kalibrierungsabschnitt für weitere Anweisungen beziehen.

BETRIEB

Computer-Anzeige – Reihe und kumulative Gesamtmengen

Das Fließgeschwindigkeit-Eigenschaft behält zwei Gesamtmengen bei. Die kumulative Gesamtmenge liefert ununterbrochenes Maß und kann nicht manuell zurückgestellt werden. Die Zwischensumme kann zurückgestellt werden, um den Fluß während eines einzelnen Gebrauches zu messen. Die kumulative

Gesamtmenge wird mit TOTAL 1 LOCKED beschriftet. Dieses zeigt an, daß die Gesamtmenge verschlossen ist und nicht manuell auf Null eingestellt werden kann. Zwischensumme wird mit TOTAL 2 beschriftet.

Wenn die kumulative Gesamtmenge eine maximale Anzeige von 999.999 erreicht, stellt sich sie automatisch bis null zurück.

Die DISPLAY Anzeigentaste kurz betätigen, um zwischen Reihe, kumulative Gesamtmenge und Fließgeschwindigkeit zu schalten.

ANMERKUNG: Totalization zählt die Gesamtmaßeinheiten, ohne zwischen Gallonen, Litern oder nachgeeichten Maßeinheiten zu unterscheiden.

Fließgeschwindigkeit-Eigenschaft

Diese Funktion zu benutzen, betätigen und freizugeben “DISPLAY” bis “FLOWRATE” zu erscheint auf der linken Seite des Endergebnisses.

Wenn “FLOWRATE” angezeigt wird, reflektieren die Zahlen auf der mittleren Linie die Durchflußgeschwindigkeit, Z.B. die gegenwärtigen Gallonen pro Minute (GPM) oder Liter pro Minute (LPM).

Das Meßinstrument betätigen

Das Computeranzeige einschalten, indem Sie den Wasserfluß beginnen oder indem Sie kurz die DISPLAY-Taste betätigen. Die Reihe oder die kumulative Gesamtmenge vom letzten Gebrauch werden angezeigt.

Die DISPLAY-Taste kurz betätigen, um die Zwischensumme anzuzeigen. Die DISPLAY-Taste 3 Sekunden lang niederhalten, um die Zwischensumme auf Null zurückzustellen.

Das Meßinstrument ist so programmiert, das es sich automatisch abschaltet, wenn es 4 Minuten lang nicht in Betrieb ist.

Fabrik- und Nacheichungskurven

Alle Kalibrierungsinformationen sind als Wörter im oberen Teil der Anzeige, über den numerischen Stellen sichtbar.

Alle Maßeinheiten werden mit einer “Fabrik” Eichkurve hergestellt. Sie können entweder Gallonen oder Liter wählen (“GAL” oder “LTR” sind sichtbar). Die CALIBRATE und DISPLAY Tasten benutzen, um zwischen Gallonen und Liter zu schalten. Diese Eich-kurve ist NICHT vom Benutzer verstellbar. Das Wort PRESET Wird angezeigt, um dieses zu zeigen. (die Fabrikkali-brierung wird dauerhaft im Computerspeicher gespeichert.)

Die “Nacheichungskurve” kann vom Benutzer eingestellt werden. Die Kalibrierung kann jederzeit mit den Kalibrierungsverfahren, die im Kalibrierungsabschnitt beschrieben sind, geändert oder umgesteuert werden. Gesamtmengen oder Fließgeschwindigkeiten, die auf Nacheichung beruhen, werden sichtbar, wenn die Nacheichungseinstellung vorgewählt wird (“CAL B” ist auf der oberen Linie sichtbar).

Eine andere Kalibrierungseinstellung vorwählen

Sie können mit Leichtigkeit von GAL zum LTR Modus wechseln, ohne die Gesamtmengen zu verderben. Z.B. kann der Computer 10,00 Gallonen zusammenzählen. Wenn der Benutzer zum LTR-Modus schälter, auf ändert die Anzeige sofort “37,85” (die gleiche Menge in den Maßeinheiten von Litern). GAL/LTR-Schaltung arbeitet auch im FLOWRATE-Modus.

Um eine andere Kalibrierungseinstellung zu wählen, zuerst die CALIBRATE Taste drücken und halten. Weiterhin halten, Uahrend Sie die DISPLAY Taste ebenfalls pressen und freigeben. (Sie können die KALIBRIEREN-TASTE dann auch freigeben.) Die Markierungsfahnenanzeiger auf der obersten Linie ändern sich, sodass sie die neugewählte Kalibrierung anzeigen. Die Kalibrierungseinstellungen ändern sich in dieser Reihenfolge: GAL, LTR, CAL B, GAL, usw. Während die Flüssigkeit fließt, können nur GAL oder LTR gewahlt werden. Jedoch wenn KEINE Flüssigkeit fließt, kann irgendeine Vorwähl betätigt werden.

KALIBRIERUNG

Vor Dem Beginn, Kalibrierung auffangen

Für die genauesten Resultate an einer Fließgeschwindigkeit zuführen, die gut Ihre tatsächlichen Betriebsbedingungen. Simuliert Vermeiden, mehr Flüssigkeit “zu tröpfein” oder wiederholt den Fluß zu beginnen und zu stoppen. Dieses kann weniger genaue Kalibrierungen ergeban.

Stellen Sie Treffen die minimalen Fließgeschwindigkeitanforderungen des Meßinstruments sicher:

TM Series Meßinstrumente

1/2 Zoll	1 GPM (3,8 LPM)
3/4 Zoll	2 GPM (7,5 LPM)
1 Zoll	5 GPM (18,8 LPM)
1-1/2 Zoll	10 GPM (37,5 LPM)
2 Zoll	20 GPM (75 LPM)

Der Gebrauch eines gleichmäßig zuverlässigen, genauen Kalibrierung Behälters wird in hohem Grade für die genauesten Resultate empfohlen. Wegen der hohen Fließgeschwindigkeit, wird es stark empfohlen, daß Kalibrierung mit einer Kombination des Volumens und des Gewichts mit feine Auflösung Skalen durchgeführt wird.

Für beste Resultate sollte das Meßinstrument angebracht werden und bereinigt worden von der Luft vor Kalibrierung auffangen.

Kalibrierung mit Computer-Anzeige auffangen

Kalibrierung auffangen und Fabrik-Kalibrierung werden im vorhergehenden Abschnitt definiert. Die Fabrikkalibrierungseinstellung ist in jeden Strömungsmesser zur Zeit der Herstellung einprogrammiert worden, indem Wasser von 70°F (21°C) verwendet wurde. Anzeigen, die die Standardfabrikeichkurven benutzen, können möglicherweise nicht in einigen Situationen genau sein, Z.B. unter extremen Temperaturbedingungen. Wenn Sie ander Flüssigkeiten ausgenommen Wasser benutzen, können Sie Bereich-Kalibrieren das Meßinstrument.

Für verbesserte Genauigkeit unter solchen Bedingungen, erlaubt der Computer Nachei-chung, d.h., kundenspezifischen Kalibrierung-sparameter können eingegeben werden. Kalibrierung auf eine "einzelnen Punk" kann akzeptable Genauigkeit in der Mitt der Durchflußmenge ergeben, fünf oder mehr Kalibrierstellen können ein höheres Niveau der Genauigkeit, besonders am untereren Ende der Durchflußmenge erbringen. Bis 15 kundenspezifische Kalibrierstellen können eingetragen werden.

Zuführen/Anzeige auffangen Kalibrierung Verfahren

1. Die CALIBRATE-Taste heruntergedrückt halten während Sie DISPLAY betätigen und freigeben, bis die Nacheichungs-kurve erscheint ("CAL B" wird angezeigt). Beide der Tasten freigeben.
2. Zum Kalibrieren, die CALIBRATE-Taste betätigen und halten. Fortfahren, CALIBRATE Zu halten, die DISPLAY-Taste auch betätigen und halten. Beide der Tasten für ungefähr 3 Sekunden halten, bis Sie die blinkende Anzeige "dd-CAL" sehen. Sobald "dd-CAL" erscheint, beide der Tasten freigeben. Sie sind jetzt im Nacheichungsmodus.
3. Sobald die Tasten von Schritt 2 freigegeben worden sind, erscheint die Blinkenanzeige "run 01". Wenn Sie den Kalibrierungsprozeß jetzt beenden möchten, bevor Sie irgendeine Flüssigkeit zuführen, zu Schritt 11 gehen.
4. Wenn Sie mit der Kalibrierung fortfahren möchten, aber noch keine Flüssigkeit zugeführt haben, die abschließenden Vorbereitungen an Ihrem Pumpsystem ausführen ohne mit pumpen anzufangen.
5. Ihr Pumpsystem anlassen, damit Flüssigkeit das Meßinstrument durchfließt. Die Anzeige stoppt zu blinken und zeigt die Anzeige "run 01". Flüssigkeit in einen Behälter zuführen, der Ihnen erlaubt, die Menge der Flüssigkeit zu beurteilen. Wenn Sie die gewünschte Menge (zum Beispiel, 10 Gallonen) gepumpt haben, den Fluß schnell stoppen.
6. Wenn die Flüßigkeit aufgehört hat, zu fliessen, beide Tasten kurz betätigen und freigeben. An diesem Punkt ändert sich die Computeranzeige zum "0000.00" mit dem linken Stellenblinken.
7. Das Volumen (Menge) der Flüssigkeit eintragen, die Sie gepumpt haben (wenn Ihr 10-Gallonen-Behälter voll ist, "0,0" für Gallonen oder "37,85" für Liter zum Beispiel eintragen). Um die Zahlen einzutragen, die CALIBRATE-Taste benutzen, um den Wert der Stelle zu ändern, die blinkt. Die DISPLAY-Taste benutzen, um das "Blinzeln" auf die folgende Stelle zu verschieben.

8. Sobald die korrekte Zahl eingetragen ist, beide der Tasten kurz betätigen und freigeben. Die Anzeige ändert sich jetzt zum blinkenden “run 02”. Sie haben jetzt den neuen Calkurvenpunkt angebracht. Sie sind bereit, Kalibrierung (Schritt 10) zu beenden oder eine andere neue Kalibrierstelle (Schritt 9) einzutragen.
9 Um eine andere Kalibrierstelle einzutragen, zurück gehen und Schritte 3 bis 8 wiederholen. Es ist möglich, bis 15 Calkurvenpunkte einzustellen, und die “run ##” erhöht sich jede Mal, wenn Sie den Kalibrierungsprozeß wiederholen (run 01, run 02, run 03, usw., bis run 15).
10. Um den Kalibrierungsprozeß zu beenden, beide der Tasten für ungefähr 3 Sekunden betätigen und halten, bis Sie Anzeige “CAL End” sehen. Nachdem Sie die Tasten freigeben, nimmt der Computer Normalbetriebe mit dem neuen aktiven cal-point(s) wieder auf.
11. Wenn Sie keine Flüssigkeit zugeführt haben, können Sie Kalibrierung beenden, ohne die cal-Kurve zu ändern. Wenn “run 01” angezeigt ist und sie keine Flüßigkeit ausgelassen haben, beide Tasten ungefähr 3 Sekunden lang halten, bis Sie Anzeige “CAL End” sehen. Nach dem Sie die Tasten freigeben, nimmt der Computer Normalbetrieb wieder auf und die alte Kurve (wenn Sie vorher eine eingaben), ist noch intakt.

Kalibrierung mit konditionierter Signal-Ausgabebaugruppe

Der K-Faktor Ihres Meßinstruments erscheint auf dem Kalibrierung Report als die Zahl Impulsen pro Gallone. Der Faktor wird während der Produktion mit Wasser an 70°F (21°C) festgestellt. Dieser K-Faktor kann für Kalibrierung “des einzelnen Punktes” verwendet werden und wird eine annehmbare Genauigkeit liefern. Jedoch können die Messwerte möglicherweise nicht genau sein, wenn Sie diese Kalibrierung Methode in einigen Situationen verwenden. Ein Beispiel ist, wenn Sie das Meßinstrument unter extremen Temperaturbedingungen benutzen oder mit Flüssigkeiten anders als Wasser verwenden.

Für verbesserte Genauigkeit unter solchen Bedingungen, empfehlen wir, daß ein K-Faktor Besondere zur Anwendung für die Kalibrierung festgestellt und verwendet wird. Eine Kali-brierung “des einzelnen Punktes” kann eine annehmbare Genauigkeit mitten in der Fluß-strecke erbringen, aber fünf oder mehr Kalibrierstellen können ein hohes Niveau der Genauigkeit, besonders am untereren Ende der Fluß-strecke erbringen.

WARTUNG

Die korrekte Behandlung und die Wartung verlängern das Leben und den Service des Meßinstruments.

Turbinenrotor

Das Meßinstrument ist praktisch wartungsfrei. Jedoch ist es wichtig, dass sich der Rotor frei bewegen kann. Das Meßinstrument sauber halten und von Verunreinigung freihalten.

Wenn der Läufer sich nicht frei dreht, ein Durchdringungsschmiermittel auf dem Läufer, der Welle und den Wellenlagern anwenden. Allen möglichen Rückstand oder Ablagerungen vom Läufer mit einer weichen Bürste oder einem kleinen Fühler entfernen. Achtgeben, daß Sie nicht den Turbinenrotor oder die Stützen beschädigen.

⚠ VORSICHT

Pressluft durch die Turbine blasen kann den Rotor beschädigen.

BatterieAustausch

Das Computeranzeige wird durch zwei 3-Volt Lithium Batterien angetrieben, die ausgetauscht werden können, während das Meßinstrument installiert ist. Die Zwischensummen und kumulativen Gesamtmengen stellen sich auf Null zurück, wenn die Batterien schwach werden oder entfernt worden sind. Die Fabrik- und Nacheichung bleibt erhalten.

Wenn die Meßinstrumentanzeige sich verdunkelt oder ausgeht, die Batterien austauschen, wie folgt:

1. Die vier Kreuzschlitzschrauben von der Vorderseite des Meßinstruments entfernen und die Frontplatte von der Turbine anheben.
2. Die alten Batterien entfernen und jede mögliche Korrosion von den Klemmen säubern.
3. Neue Batterien anbringen. Überprüfen, daß der positive Pfosten in der richtigen Position ist.
4. Wenn die Batterien ausgetauscht sind,zeigt die Frontplatte “POWER ON”. Die Anzeige überprüfen, um normale Funktionen sicherzustellen, bevor Sie wieder zusammenbauen.
5. Falls nötig, Batterieeinsetzung berichtigen, und die Frontplatte auf das Turbinegehäuse in Position bringen. Um Feuchtigkeitsbeschädigung zu vermeiden, überprüfen, daß der dichtung völlig sitzt. Die vier Schrauben an der Frontplatte festziehen.

SPEZIFIKATIONEN

Eingang und Anschluß:

Zentrierring (Pipe) Ende

TM050/TM050-P	1/2" Zeitplan 80, Zentrierring (Pipe) ende
TM075/TM075-P	3/4" Zeitplan 80, Zentrierring (Pipe) ende
TM100/TM100-P	1" Zeitplan 80, Zentrierring (Pipe) ende
TM150/TM150-P	1-1/2" Zeitplan 80 Zentrierring (Pipe) ende
TM200/TM200-P	2" Zeitplan 80, Zentrierring (Pipe) ende

Für NPT Befestigungen

TM050-N/TM050-N-P	1/2 Zoll NPT
TM075-N/TM075-N-P	3/4 Zoll NPT
TM100-N/TM100-N-P	1 Zoll NPT
TM150-N/TM150-N-P	1-1/2 Zoll NPT
TM200-N/TM200-N-P	2 Zoll NPT

DesignBaumuster: Turbine

Naßgemachte Bauteile:

Gehäuse: PVC
Achslager: Keramisch
Welle: Hartmetall
Läufer und Halterungen: PVDF
Haltering: Rostfreier Stahl

Verbindungstyp: Zentrierring - Zeitplan 80 oder NPT (*Hohlgewinde)

Max. FunktionsDruck: 150 PSIG @ 73°F

U.S. Maß

Maßeinheit der Maßnahme: Gallone

FlußStrecke:

1/2 Zoll	1 - 10 GPM
3/4 Zoll	2 - 20 GPM
1 Zoll	5 - 50 GPM
1-1/2 Zoll	10 - 100 GPM
2 Zoll	20 - 200 GPM

Genauigkeit mit Computer: ± 3.0% (Genauigkeit kann mit verbessert werden auffangen Kalibrierung)

Betriebstemperatur: +32° zu +140° F (Flüssigkeit nicht innerhalf des Meßinstruments einfrieren lassen.)

SpeicherTemperatur: -40° zu +158° F

Gewicht des Produktes:*

	Zentrierring (Pipe)	NPT
1/2 Zoll	.38 lbs.	.55 lbs.
3/4 Zoll	.43 lbs.	.67 lbs.
1 Zoll	.49 lbs.	.84 lbs.
1-1/2 Zoll	.66 lbs.	1.38 lbs.
2 Zoll	.78 lbs.	1.78 lbs.

Abmessungen - Zoll (W x H x L):**

	Ohne Befestigungen	Mit Befestigungen
1/2"	2.0 x 2.6 x 3.8	2.0 x 2.8 x 5.5
3/4"	2.0 x 2.7 x 3.8	2.0 x 2.9 x 5.5
1"	2.0 x 3.1 x 4.1	2.0 x 3.3 x 6.2
1-1/2"	2.1 x 3.7 x 5.4	2.3 x 3.9 x 7.6
2"	2.4 x 4.2 x 5.5	3.5 x 4.5 x 7.9

* Das Gewicht mit der Computeranzeige. Die konditionierte Signalausgabebaugruppe addiert .30 Pfund.

** Die Maße mit der Computeranzeige. Konditionierte Signalausgabebaugruppe fügt 1.1 Zoll Höhe. hinzu.

Metrisches Maß

Maßeinheit: Liter

FlußStrecke:

1/2 Zoll	3,8 - 38 LPM
3/4 Zoll	7,6 - 76 LPM
1 Zoll	19 - 190 LPM
1-1/2 Zoll	38 - 380 LPM
2 Zoll	76 - 760 LPM

Genauigkeit mit Computer: ±3.0% (Genauigkeit kann mit verbessert werden auffangen Kalibrierung)

Betriebstemperatur: 0° zu +60° C (Flüssigkeit nicht innerhalf des Meßinstruments einfrieren lassen.)

SpeicherTemperatur: -40° zu +70° C

Gewicht des Produktes: *

	Zentrierring (Pipe)	NPT
1/2 Zoll	.172 kg	.249 kg
3/4 Zoll	.195 kg	.304 kg
1 Zoll	.222 kg	.381 kg
1-1/2 Zoll	.299 kg	.626 kg
2 Zoll	.354 kg	.807 kg

Abmessungen - Zentimeter (W x H x L):**

	Ohne Befestigungen	Mit Befestigungen
1/2"	5.0 x 6.6 x 9.6	5.0 x 7.1 x 13.9
3/4"	5.0 x 6.8 x 9.6	5.0 x 7.3 x 13.9
1"	5.0 x 7.8 x 10.4	5.0 x 8.3 x 15.7
1-1/2"	5.8 x 9.3 x 13.7	5.8 x 9.9 x 19.3
2"	6.0 x 10.6 x 13.9	8.8 x 11.4 x 20.0

* Das Gewicht mit der Computeranzeige. Die konditionierte Signalausgabebaugruppe addiert 136 Kilogramm.

** Die Maße mit der Computeranzeige. Konditionierte Signalausgabebaugruppe fügt 2.8 Zentimeter Höhe. hinzu

TEILE

Die folgenden Ersatzteile und die Zusatzgeräte sind für die TM Series Meßinstrumente vorhanden:

Teil Nr.	Beschreibung
113435-1	Konditioniertes Signal-Ausgabebau-gruppe
113520-1	Batterie AustauschInstallationssatz
116000-1	Kalibrierungsbehälter, groß (5 Gallone)
125508-03	1-/2 Zoll, Turbineeinheitsinstallationssatz
125508-04	1-/2 Zoll, NPT, PVC, Turbineeinheitsinstallationssatz
125510-03	3/4 Zoll, Turbineeinheitsinstallationssatz
125510-04	3/4 Zoll, NPT, PVC, Turbineeinheitsinstallationssatz
125512-03	1 Zoll, Turbineeinheitsinstallationssatz
125512-04	1 Zoll, NPT, PVC, Turbineeinheitsinstallationssatz
125514-03	1-1/2 Zoll, Turbineeinheitsinstallationssatz
125514-04	1-1/2 Zoll, NPT, PVC, Turbineeinheitsinstallationssatz
125516-03	2 Zoll, Turbineeinheitsinstallationssatz
125516-04	2 Zoll, NPT, PVC, Turbineeinheitsinstallationssatz
901002-52	Dichtung

Computereinheitsinstallationssatz:

125509-03	1-/2 Zoll, Computereinheitsinstallationssatz
125511-03	3/4 Zoll, Computereinheitsinstallationssatz
125513-03	1 Zoll, Computereinheitsinstallationssatz
125515-03	1-1/2 Zoll, Computereinheitsinstallationssatz
125517-03	2 Zoll, Computereinheitsinstallationssatz

SERVICE

Für Garantiansprüche mit Ihrem lokalen Verteiler in Verbindung treten. Wenn Sie weitere Unterstützung benötigen, mit der GPI-Kundendienstabteilung in Verbindung treten:

1-800-835-0113

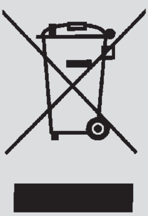
Sie benötigen:

- Informationen vom Abziehbild auf Ihrem Meßinstrument zur Verfügung stellen.
- Eine Rückholermächtigungszahl empfangen.
- Jede mögliche Flüssigkeit vom Meßinstrument spülen, bevor Sie zur Fabrik versenden.
- Wenn möglich, Abnehmer-angebrachte Befestigungen oder eine reichliche Länge des Rohres für Wiedereinbau belassen.

⚠ VORSICHT

Das Meßinstrument nicht ohne die spezifische Berechtigung der GPI-Kundendienstabteilung zurückbringen. Wegen der strengen Regelungen des Transportes, der Behandlung und der Beseitigung der gefährlichen oder feuergefährlichen Flüssigkeiten, nimmt GPI nicht Meßinstrumente für Überarbeitung an, es sei denn, class sie vom flüssigen Überrest vollständig frei sind.

WEEE RICHTLINIE



Der Richtlinie 2002/96/EG über Elektro- und Elektronik-Altgeräte (WEEE) des Europäischen Parlaments bzw. des EU-Ministerrats. Dieses simbol zeigt an, daß dieses Produkt elektrische und elektronische Ausrüstung, die Batterien mit einschließen kann, Printplatte verschalt, Flüssigkristall-Sichtanzeigen oder andere Bestandteile enthält, die abhängig von Einheimischvergeudung Regelungen sein können. Bitte verstehen Sie jene Regelungen wenn Sie dieses Produkt sich entledigen.

ITALIANO

AVVISO IMPORTANTE

Usare i tester dei Series del TM con acqua ed altri prodotti chimici che sono compatibili con le parti che sono esposti a liquido (vedere la sezione di specifiche). Non utilizzare questo tester con combustibile o altri prodotti chimici incompatibili. I tester di serie de TM sono disponib ili con un calcolatore per visualizzazione elettronica locale, o un modulo di uscita condizionato del segnale che fornisce un segnale numerico all'apparecchiatura di collegamento del cliente. I Series di TM misura la misura con un contatore nei galloni o nei litri. Riferirsi alla sezione di taratura per i particolari.

Questi tester non sono per le applicazioni commerciali.

I tester dei Series del TM sono molto sensibili ad interferenza elettronica se sono funzionati all'interno di 1 - 2 pollici di alcuni motori elettrici o di altre fonti di uso elettronico

INSTALLAZIONE

Collegamenti

Installare il vostro tester in linea orizzontalmente o verticalmente o all'estremità del tubo flessibile adiacente all'ugello. L'installazione ai collegamenti del metallo non è suggerita. Seguire questi punti per installare:

1. Progettare installare la turbina con una lunghezza minima del tubo diritto:
   - A monte dalla turbina, concedere ad una lunghezza minima di un tubo diritto di 10 volte il diametro interno della turbina.
   - A valle dalla turbina, concedere ad una lunghezza minima di un tubo diritto di 5 volte il diametro interno della turbina.

2. Per Spigot (Tuboture) scade usare soltanto più solventi approvati per l'incollatura del PVC.
   Per i Montaggi Del NPT circondare i collegamenti di tubo con nastri adesivi del Teflon® 3 -4 volte.

3. Fissare il tester con la freccia indicata nel senso del flusso.

4. Per i Montaggi Del NPT utilizzare soltanto le vostre mani per stringere i collegamenti. Non utilizzare gli attrezzi per stringere. Ciò può causare danni.

Segnale Condizionato Produrre Cablaggio Di Modulo

Questo modulo di segnale condizionato del può essere legato per fornire del collettore dell' segnale aperta o dell'onda del quadrato di 6-volti.

Collettore dell'Segnale Aperta

Per raggiungere Collettore dell' Segnale Aperta, Riferiscasi allo schema elettrico di riferimento 1. Il blocchetto terminali è situato dal lato posteriore del modulo. Il modulo è fabbrica montata per collettore dell' segnale aperta. Fornire prego il resistore di minimo di 820 Ohm.

Dieci piedi (3m) di cavo è fornito del modulo. Assettare il cavo alla lunghezza voluta o estendere il cavo come necessario. Le distanze fino a 5.000 piedi (1,524m) possono essere realizzate per l'collettore dell' segnale aperta.

Segnale Dell'Onda Quadrata

Per raggiungere segnale Dell'Onda Quadrata, Riferiscasi allo schema elettrico di riferimento 2 ed usare un corredo elettronico della batteria del tester di Digital (venduto esclusivamente) per la potenza della batteria. Il blocchetto terminali e la posizione della batteria sono situati dal modulo. Accesso come segue:

1. Rimuovere le quattro viti Phillips dalla parte anteriore del modulo. Alzare il modulo dalla turbina.
2. Per cambiare i collegamenti del blocchetto terminali, allentare le viti adatte. Ricollegare i legare nelle posizioni adequate e stringere le viti.
3. Installare le batterie. Assicurarsi che l'alberino positivo è nella posizione corretta.
4. Posizionare il modulo sull'alloggiamento della turbina. Evitare danni dell'umidità, assicurarsi che l'anello completamente è messo. Stringere le quattro viti sulla parte anteriore del modulo.

Dieci piedi (3m) di cavo è fornito del modulo. Assettare il cavo alla lunghezza voluta o estendere il cavo come necessario.

Verificare L'Esattezza Del Tester

Prima di utilizzare, controllare l'esattezza del tester e verificare la taratura.

1. Assicurarsi che non ci è aria nel sistema iniziando la quantità di fluido fino a che non funzioni costantemente. Allora, arrestare il flusso usando una valvola o un ugello.
2. Per mezzo del tester, misurare un volume conosciuto esatto in un contenitore esatto. Per i risultati migliori, misurare con un flusso pieno continuo.
3. Controllare il volume contro l'esposizione o l'apparecchiatura di registrazione. Se l'importo misurato è esatto, ulteriore calibratura non è necessaria. Se non, riferirsi alla sezione di taratura per ulteriori istruzioni.

FUNZIONAMENTO

Visualizzatore del computer - Partita e totali comulativi

Il computer effettua due totali. Il totale cumulativo fornisce la misura continua e non può essere ripristinato manualmente. Il totale in lotti può essere ripristinato per misurare il flusso durante il monouso. Il totale cumulativo è identificato con il del TOTAL 1 LOCKED. Ciò indica che il totale è locked e non può essere azzerato manualmente. Il totale in lotti è identificato con il TOTAL 2.

Quando il totale cumulativo raggiunge una lettura massima di 999.999, si ripristinerà automaticamente a zero.

Premere il tasto dell' DISPLAY brevemente per commutare fra il batch, il totale cumulativo ed il debito.

NOTA: Totalization conta le unità totali senza differenziare fra i galloni, i litri o le unità campotaratura.

Caratteristica indice di flusso

Usare questa caratteristica, premere e liberare "DISPLAY" fino "FLOWRATE" compare alla sinistra della linea inferiore.

Quando "FLOWRATE" è visualizzato, i numeri sulla linea centrale riflettono la portata. Per esempio, i galloni correnti per il minuto (gal/mn) o litri al minuto (LPM).

Attivare il Tester

Accendere il visualizzatore del computer iniziando il flusso dell' acqua o brevemente premendo il tasto del DISPLAY. Partita o il totale cumulativo dall'ultimo uso sarà visualizzato.

Premere il tasto del DISPLAY brevemente per visualizzare il totale in lotti. Tenere il tasto dell' DISPLAY affinchè 3 secondi ripristinino il totale in lotti a zero.

Il tester è programmato per spenga di automaticamente se non usato per 4 minuti.

Curve di calibratura del campo e della fabbrica

Tutte le informazioni di taratura sono visibili all'utente come parole nella parte superiore dell'esposizione, sopra le cifre numeriche.

Tutte le unità sono configurate con una curva di taratura "della fabbrica". Potete scegliere i galloni o i litri ("GAL" o "LTR" sarà visibile). Utilizzare i tasti del DISPLAY el del CALIBRATE per alternarsi fra i galloni ed i litri. Questa curva di taratura non è utente registrabile. La parola PRESET é visualizzata per mostrare questa. (la taratura della fabbrica sarà immagazzinata permanente nella memoria del calcolatore.)

La curva di taratura "del campo" può essere regolata dall'utente. La taratura può essere cambiata o modificata in qualunque momento seguendo le procedure di taratura descritte nella sezione di taratura. I totali o il debito hanno derivato dalla taratura del campo sono visibili quando la regolazione di taratura del campo è selezionata ("CAL B" sarà visibile sulla linea superiore).

Selezione della regolazione differente di calibratura

Si può commutare fra i modi del LTR e del GAL alla volontà senza "corrompere" i totali. Per esempio, il calcolatore può ammontare a 10,00 galloni. Se l'utente commuta al modo del LTR, l'esposizione immediatamente cambierà "a 37,85" (la stessa quantità nelle unità dei litri). La commutazione del GAL/LTR inoltre funziona nel modo del FLOWRATE.

Per selezionare una regolazione differente di taratura, una prima pressa e tenere il tasto di taratura (CALIBRATE). Continuare a tenere il tasto mentre però premendo e liberando il tasto dell'Esposizione (DISPLAY). (si può allora anche liberare il tasto di CALIBRATE.) Gli indicatori della bandierina nella linea superiore dell' esposizione cambieranno per mostrare la regolazione recentemente selezionata di taratura. Le regolazioni di taratura cambiano in questo ordine: GAL, LTR, CAL B, GAL, ecc. Mentre il liquido sta fluendo, solo le selezioni di LTR e di GAL possono essere fatte. Tuttavia, quando NESSUN liquido sta fluendo, qualsiasi selezione può essere fatta.

CALIBRATURA

Prima Di Cominciare Calibratura Del Campo

Per i risultati più esatti, erogare ad un debito che simula il più bene le vostre condizioni di gestione reali. Evitare di "gocciolare" più liquido o ripetutamente iniziare ed arrestare il flusso. Queste azioni provocheranno le calibrature meno esatte.

Vi assicurate raduno i requisiti minimi di debito del tester:

Tester Di Series di TM
Tester di 1/2 Pollice 1 GPM (3,8 LPM)
Tester da 3/4 di Pollice 2 GPM (7,5 LPM)
Tester da 1 Pollice 5 GPM (18,8 LPM)
Tester di 1-1/2 Pollice 10 GPM (37,5 LPM)
Tester da 2 Pollici 20 GPM (75 LPM)

Usando un contenitore credibile e ed esatto di taratura altamente è suggerito per i risultati più esatti. Dovuto l' alto debito, è suggerito vivamente che la calibratura è completata con una combinazione di volume e di peso usando le scale di alta risoluzione.

Per i risultati migliori, il tester dovrebbe essere installato ed eliminato l'inceppo di aria prima della taratura del campo.

Calibratura del campo con il visualizzatore del computer

La calibratura del campo e la calibratura della fabbrica sono definite nella sezione precedente. Le regolazioni di calibratura della fabbrica l'abitudine si è programmata in ogni flussometro durante la loro produzione usando l'acqua a 70°F (21°C). Le letture che usano le curve di taratura standard della fabbrica non possono essere esatte in alcune situazioni. Per esempio, quando nelle condizioni termiche estreme. Potete campo calibrare il tester se decidete misurare i liquidi tranne acqua.

Per esattezza migliorata in tali circostanze, i GPI fluiscono calcolatore tengono conto la taratura "del campo" (entrata di utente dei parametri di taratura su ordinazione) A "che la taratura del singolo punto" può rendere un'esattezza accettabile nel mezzo della gamma di flusso. Cinque o il più punti di taratura possono rendere un livello elevato di esattezza, particolarmente all'estremità più inferiore della gamma di flusso. Fino a 15 punti di taratura su ordinazione possono essere inseriti.

Erogare/Procedure Di Calibratura Campo Dell'Esposizione

1. Mantenere il tasto del CALIBRATE mentre premere e liberare il DISPLAY si abbottonano fino a che la curva di taratura del campo non compaia (messaggio di "CAL B" sarà visualizzata). Liberare entrambi i tasti.
2. Per calibrare, premere e tenere il tasto del CALIBRATE. Mentre continuano a tenere il CALIBRATE, inoltre premere e tenere il tasto del DISPLAY. Tenere entrambi i tasti per circa 3 secondi fino a che non vediate messaggio del "dd-CAL" di lampeggiamento. Una volta che il messaggio del "dd-CAL" compare, liberare entrambi i tasti. Siete ora nel modo di taratura del campo.
3. Una volta che i tasti sono stati liberati da punto 2, l'esposizione mostrerà che il messaggio di lampeggiamento "run 01". Se desiderate ora rimuovere il processo di taratura prima dell' erogazione del qualsiasi liquido, passare al punto 11.
4. Se desiderate continuare con la taratura, ma non avete erogato alcun liquido ancora, fare le vostre preparazioni finali al vostro sistema di pompaggio, ma non iniziare a pompare ancora.
5. Iniziare il vostro sistema di pompaggio in modo che il liquido attraversi il tester. L'esposizione smetterà di lampeggiare e mostrerà il messaggio di "run 01". Erogare il liquido in un contenitore che permette che giudichiate la quantità di liquido pompata. Quando avete pompato l'importo voluto (per esempio, 10 galloni), arrestare rapidamente la quantità di fluido.
6. Una volta il flusso ha arrestato, brevemente preme e libera entrambi i tasti. A questo punto il visualizzatore del computer cambierà a "0000.00" con il lampeggiamento a mano sinistra della cifra.
7. Entrare nel volume (importo) di liquido quello che avete erogato (per esempio, se il vostro contenitore di 10-gallon è pieno, impostare "10,0" per i galloni o "37,85" per i litri). Per entrare nei numeri, utilizzare il tasto del CALIBRATE per cambiare il valore della cifra che sta lampeggiando. Utilizzare il tasto del DISPLAY per spostare "il lampeggio" alla cifra seguente.
8. Una volta che il numero corretto è inserito, brevemente premere e liberare entrambi i tasti. L'esposizione ora cambierà ad un messaggio "run 02" di lampeggiamento. Ora avete installato il nuovo punto della caloria-curva. Siete pronti a concludere la taratura (punto 10) o ad entrare in un altro nuovo punto di taratura (punto 9).
9. Entrare in un altro punto di taratura, andare indietro e ripetere punti da 3 a 8. È possibile da installare a 15 punti della caloria-curva e il messaggio del "run ##" di funzionamento increment ogni volta ripetete il processo di taratura (run 01, run 02, run 03, ecc., fino al run 15).
10. Per concludere il processo di taratura, premere e tenere entrambi i tasti per circa 3 secondi fino a che non vediate messaggio dell "CAL End". Dopo che liberiate i tasti il calcolatore riprenderà i funzionamenti normali con il nuovo point(s) di caloria attivo.
11. Se non avete erogato alcun liquido, si può rimuovere la taratura senza cambiare la curva di caloria. Se il messaggio "run 01" sta mostrando e non avete erogato alcun liquido, tenete entrambi i tasti per circa 3 secondi fino a che non vedeste il messaggio dell' "CAL End". Dopo voi liberare i tasti, il calcolatore riprenderà il funzionamento normale e la vecchia curva (se impostaste uno nel passato) è ancora intatta.

Calibratura con il modulo di Segnale Condizionato Produrre

Il fattore K del vostro tester compare sul rapporto di calibratura come il numero di impulsi per il gallone. Il fattore è determinato durante la produzione usanto l'acqua a 70°F (21°C). Questo fattore K può essere usato per "la calibratura del singolo punto" e fornirà un'esattezza accettabile. Tuttavia, le letture non possono essere esatte quando usate questo metodo di calibrature in alcune situazioni. Un esempio è quando utilizzate il tester nelle condizioni termiche estreme o usate con i liquidi tranne acqua.

Per esattezza migliorata in tali circostanze, suggeriamo che un fattore K specifico all'applicazione è determinato ed usato per la calibratura. "Una calibratura del singolo punto" può rendere un'esattezza accettabile nel mezzo della gamma di flusso, ma cinque o il più punti di calibratura possono rendere un livello elevato di esattezza, particolarmente all'estremità più inferiore della gamma di flusso.

MANUTENZIONE

Il maneggiamento e la cura adeguati estenderanno la durata ed il servizio del tester.

Rotore Di Turbina

Il tester è virtualmente manutenzione-free. Tuttavia, è liberamente importante i movimenti del rotore. Mantenere il tester pulito ed esente dagli agenti inquinanti.

Se il rotore non gira liberamente, applicare un lubrificante penetrante sul rotore, sull'albero e sui cuscinetti. Rimuovere tutti i residui o depositi dal rotore usando una spazzola molle o una piccola sonda. Fare attenzione non danneggiare il rotore di turbina o i supporti.

⚠ ATTENZIONE

Appiattito fornisc tramite il complessivo della turbina ha potuto danneggiare il rotore.

Rimontaggio Della Batteria

Il visualizzatore del computer è alimentato da due batterie del litio 3-volt che possono essere sostituite mentre il tester è installato. Quando le batterie sono rimosse o perdono l'alimentazione, il batch ed i totali cumulativi ripristinati a zero ma le calibrature della fabbrica e del campo sono mantenuti.

Se l'esposizione del tester diventa fioca o in bianco, sostituire le batterie come segue:

1. Rimuovere le quattro viti della Phillips-testa dalla faccia del tester ed alzare la piastra frontale dalla turbina.
2. Rimuovere le vecchie batterie e liberare tutta la corrosione dai terminali.
3. Installare le nuove batterie. Assicurarsi che l'alberino positivo è nella posizione corretta.
4. Quando le batterie sono sostituite, la piastra frontale alimenterà SOPRA. Controllare l'esposizione per accertare le funzioni normali hanno ripreso prima del montaggio ancora.
5. Riposizionare le batterie, se necessario e posizionare la piastra frontale sull'alloggiamento della turbina. Evitare danni dell' umidità, assicurarsi che l'anello completamente è messo. Stringere le quattro viti sulla piastra frontale.

SPECIFICHE

Ingresso e Presa:

Montaggi Spigot (Tuboture) scade

TM050/TM050-P	1/2" Programma 80, Spigot (Tuboture)
TM075/TM075-P	3/4" Programma 80, Spigot (Tuboture)
TM100/TM100-P	1" Programma 80, Spigot (Tuboture)
TM150/TM150-P	1-1/2" Programma 80, Spigot (Tuboture)
TM200/TM150-P	2" Programma 80, Spigot (Tuboture)

Montaggi Del NPT

TM050-N/TM050-N-P	1/2 pollice NPT
TM075-N/TM075-N-P	3/4 pollice NPT
TM100-N/TM100-N-P	1 pollice NPT
TM150-N/TM150-N-P	1-1/2 pollice NPT
TM200-N/TM200-N-P	2 pollice NPT

Tipo Di Disegno: Turbina

Componenti Bagnati:

Alloggiamento: PVC
Cuscinetti: Di Ceramica
Albero: Carburo Di Tungsteno
Rotore e Supporti: PVDF
Fermo: Acciaio Inossidabile

Tipo Dei Collegamento: Spigot - Programma 80, o NPT (femmina)

Massimo Pressione Di Esercizio: 225 PSIG @ 73°F

Misura Degli Stati Uniti

Unità Della Disura: Gallone

Gamma Di Flusso:

1/2 pollice	1 - 10 GPM
3/4 pollice	2 - 20 GPM
1 pollice	5 - 50 GPM
1-1/2 pollice	10 - 100 GPM
2 pollice	20 - 200 GPM

Esattezza con il computer: ±3.0% (esattezza può essere migliorata con la calibratura del campo)

Temperatura Di Funzionamento: +32° a +140° F (Non lasciare che il liquido congeli all'inerno del tester.)

Temperatura Di Immagazzinaggio: -40° a +158° F

Peso Del Prodotto:*

	Spigot (Tuboture)	NPT
1/2 pollice	.38 lbs.	.55 lbs.
3/4 pollice	.43 lbs.	.67 lbs.
1 pollice	.49 lbs.	.84 lbs.
1-1/2 pollice	.66 lbs.	1.38 lbs.
2 pollice	.78 lbs.	1.78 lbs.

Dimensioni - Pollici (Larghezza, Altezza, Lunghezza):**

	Senza Montaggio	Con Montaggio
1/2"	2.0 x 2.6 x 3.8	2.0 x 2.8 x 5.5
3/4"	2.0 x 2.7 x 3.8	2.0 x 2.9 x 5.5
1"	2.0 x 3.1 x 4.1	2.0 x 3.3 x 6.2
1-1/2"	2.1 x 3.7 x 5.4	2.3 x 3.9 x 7.6
2"	2.4 x 4.2 x 5.5	3.5 x 4.5 x 7.9

* Il peso con il visualizzatore del computer. Il modulo di segnale condizionato produrre aggiunge .30 libbre.

** Le dimensioni con il visualizzatore del computer. Il modulo di segnale condizionato produrre aggiunge 1.1 pollice ad altezza.

Misura Metrica

Unità Della Misura: Litro

Gamma Di Flusso:

1/2 pollice	3,8 - 38 LPM
3/4 pollice	7,6 - 76 LPM
1 pollice	19 - 190 LPM
1-1/2 pollice	38 - 380 LPM
2 pollice	76 - 760 LPM

Esattezza con il computer: ± 3.0% (esattezza può essere migliorata con la calibratura del campo)

Temperatura Di Funzionamento: 0° a +60° C (Non lasciare che il liquido congeli all'inerno del tester.)

Temperatura Di Immagazzinaggio: -40° a +70° C

Peso Del Prodotto:*

	Spigot (Tuboture)	NPT
1/2 pollice	.172 kg	.249 kg
3/4 pollice	.195 kg	.304 kg
1 pollice	.222 kg	.381 kg
1-1/2 pollice	.299 kg	.626 kg
2 pollice	.354 kg	.807 kg

Dimensioni - Centimetro (Larghezza, Altezza, Lunghezza):**

	Senza Montaggio	Con Montaggio
1/2"	5.0 x 6.6 x 9.6	5.0 x 7.1 x 13.9
3/4"	5.0 x 6.8 x 9.6	5.0 x 7.3 x 13.9
1"	5.0 x 7.8 x 10.4	5.0 x 8.3 x 15.7
1-1/2"	5.8 x 9.3 x 13.7	5.8 x 9.9 x 19.3
2"	6.0 x 10.6 x 13.9	8.8 x 11.4 x 20.0

** Il peso con il visualizzatore del computer. Il modulo di segnale condizionato produrre aggiungil 136 chilogrammo.

*** Le dimensioni con il visualizzatore del computer. Il modulo di segnale condizionato produrre aggiunge 2.8 centimetri ad altezza.

PARTI

Le seguenti parti ed accessori di ricambio sono disponibili per i tester dei Series del TM:

Parte No.	Descrizione
113435-1	Segnale Condizionato Cablaggio Di Modulo
113520-1	Corredo Del Rimontaggio Della Batteria
116000-1	Contenitore Di Taratura, Grande (5 galloni)
125508-03	1/2 Pollice, Corredo Dell' Assemblea Della Turbina
125508-04	1/2 Pollice, NPT, PVC, Corredo Dell'Assemblea Della Turbina
125510-03	3/4 Di Pollice, Corredo Dell' Assemblea Della Turbina
125510-04	3/4 Di Pollice, NPT, PVC, Corredo Dell'Assemblea Della Turbina
125512-03	1 Pollice, Corredo Dell' Assemblea Della Turbina
125512-04	1 Pollice, NPT, PVC, Corredo Dell'Assemblea Della Turbina
125514-03	1-1/2 Pollice, Corredo Dell' Assemblea Della Turbina
125514-04	1-1/2 Pollice, NPT, PVC, Corredo Dell'Assemblea Della Turbina
125516-03	2 Pollici, Corredo Dell' Assemblea Della Turbina
125516-04	2 Pollici, NPT, PVC, Corredo Dell'Assemblea Della Turbina
901002-52	Anello
Corredo Del Calcolatore:	
125509-03	1/2 Pollice, Corredo Dell' Assemblea Del Calcolatore
125511-03	3/4 Di Pollice, Corredo Dell' Assemblea Del Calcolatore
125513-03	1 Pollice, Corredo Dell' Assemblea Del Calcolatore
125515-03	1-1/2 Pollice, Corredo Dell' Assemblea Del Calcolatore
125517-03	2 Pollici, Corredo Dell' Assemblea Del Calcolatore

SERVIZIO

Per considerazione della garanzia, mettersi in contatto con il vostro distributore locale. Se avete bisogno di ulteriore assistenza, mettersi in contatto con il reparto di servizio del cliente di GPI a:

1-800-835-0113

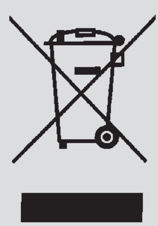
Avrete bisogno di:

- Fornire le informazioni dalla decalcomania sul vostro tester.
- Ricevere un numero di ritorno di autorizzazione.
- Irrigare tutto il liquido dal tester prima della spedizione alla fabbrica.
- Se possibile, lasciare i montaggi cliente-installati o una lunghezza ampia del tubo nudo per reinstallazione.

⚠ ATTENZIONE

Non restituire il tester senza l'autorità specifica dal reparto di servizio del cliente di GPI. dovuto le regolazioni rigorose governare il trasporto, il maneggiamento e l'eliminazione dei liquidi pericolosi o infiammabili, GPI non accetterà i tester per la ripresa a meno che siano completamente esenti da residuo liquido.

WIII DIRETTIVA



La direttiva 2002/96/EC del Parlamento europeo e del Consiglio dell'Unione europea sui rifiuti di apparecchiature elettriche ed elettroniche (RAEE) e stato aprovatto del Parlamento europeo e del Consiglio dell'Unione europea. Questo simbolo indica che questo prodotto contiene l'apparecchiatura elettrica ed elettronica che può includere le batterie, i bordi stampati del circuito, i display a cristalli liquidi o altri componenti che possono essere conforme alle regolazioni locali di eliminazione. Prego capire quelle regolazioni e disfare di questo prodotto in un modo responsabile.

FRANÇAIS

NOTIFICATION IMPORTANTE

Utilisez les compteurs de Séries de TM avec l'eau et d'autres produits chimiques qui sont compatibles avec les composants qui sont exposés au fluide (voir la section de caractéristiques). N'utilisez pas ce compteur avec du carburant ou d'autres produits chimiques incompatibles. Les compteurs de la série de TM sont disponibles avec un ordinateur pour la visualisation électronique locale, ou module du signal de sortie conditionné qui fournit un signal numérique à l'équipement d'interface de client. Les Séries de TM dosent la mesure en gallons ou litres. Référez-vous à la section de calibrage pour des détails.

Ces compteurs ne sont pas légaux pour les applications commerciales.

Les compteurs de Séries de TM sont très sensibles à l'interférence électronique s'ils sont actionnés à moins de 1 à 2 pouces de quelques moteurs électriques ou d'autres sources de bruit électronique.

INSTALLATION

Raccordements

Installez votre compteur en ligne horizontalement ou verticalement ou à l'extrémité du tuyau à côté du bec. L'installation aux raccordements en métal n'est pas recommandée. Suivez ces étapes pour installer:

1. Projetez installer la turbine avec une longueur minimum de pipe droite :
   - En amont de la turbine, permettez à une longueur minimum de la pipe droite de 10 fois le dia diamètre interne de la turbine.
   - En aval de la turbine, permettez à une longueur minimum de la pipe droite de 5 fois le diamètre interne de la turbine.
2. Pour des Spigot (Pipeau) Fin employez seulement mieux habillé et les dissolvants approuvés pour le collage de PVC.
   Pour des Raccordements de NPT enveloppez tous les raccordements de pipe avec la bande adhésive de Teflon® 3 ou 4 fois. Ne laissez pas le Teflon® glisser à l'intérieur de la pipe.
3. Attachez le compteur avec la flèche dirigée dans la direction de l'écoulement.
4. Pour des Raccordements de NPT utilisez vos mains pour serrer le compteur aux extrémités des raccordements. N'utilisez aucun outil pour serrer. Ceci peut endommager le logement.

Le Signal de Sortie Conditionné Le Câblage de Module

Ce module du signal de sortie conditionné peut être installer pour fournir un signal ouvert collecteur de sortie ou un signal carré de sortie de 6-V.

Le Signal Ouvert Collecteur de Sortie

Pour obtenir un signal ouvert collecteur de sortie, référez le diagramme de câblage 1. Le bloc terminal est situé de l'arrière du module. Le module est usine assemblée pour le signal ouvert collecteur de sortie. Fournissez la résistance (de minimum de 820 ohms).

Dix pieds (3m) de câble est fourni avec le module. Coupez le câble à la longueur désirée ou prolongez le câble selon les besoins. Les distances jusqu'a 5.000 pieds (1,524m) peuvent être obtenues pour le signal ouvert collecteur de sortie.

Le Signal Carré de Sortie

Pour obtenir le signal carré de sortie, référez le diagramme de câblage 2 et utilisez un kit électronique de batterie de compteur numérique (vendu séparément) pour la puissance de batterie. Le bloc terminal et l'endroit de batterie sont situés de'arière du module. Accès comme suit:

1. Enlevez les quatre vis Phillips de'avant du module. Soulevez le module de la turbine.

2. Pour changer les raccordements du block terminal, desserrez les vis appropriées. Rebranchez les fils en les positions appropriées et serrez les vis.
3. Installez les batteries. Assurez-vous que le poteau positif est en la position correcte.
4. Placez le module sur le logement de la turbine. Pour éviter les dommages d'humidité, vérifiez que le rondelle est entièrement sécurise. Serrez les quatre vis sur l'avant du module.

Dix pieds (3m) de câble est fourni avec le module. Coupez le câble à la longueur désirée ou prolongez le câble selon les besoins.

Vérifiez L'Exactitude de Compteurs

Avant l'utilisation, vérifiez l'exactitude du compteur et vérifiez le calibrage.

1. Assurez-vous qu'il n'y a aucun d'air dans le système en commençant l'écoulement de fluide jusqu'à ce qu'il fonctionne de façon constante. Puis, arrêtez l'écoulement en utilisant une valve ou un bec.
2. Mesurez un volume connu exact dans un récipient précis. Pour les meilleurs résultats, dosez avec un plein jet continu.
3. Vérifiez le volume contre l'écran ou l'équipement d'enregistrement. Si la quantité dosée est précise, le calibrage n'est pas nécessaire. Si pas, référez-vous à la section de calibrage pour des instructions complémentaires.

OPÉRATION

L'Ecran d'Ordinateur - La Groupe et les Totaux Cumulatifs

Le compteur maintient deux totaux. Le total cumulatif fournit la mesure continue et ne peut pas être manuellement remis à zéro. Le total de contrôle peut être remis à zéro pour mesurer l'écoulement pendant un à usage unique. Le total cumulatif est marqué avec le TOTAL 1 LOCKED. Ceci indique que le total est verrouillé et ne peut pas être manuellement mis à zéro. Le total de contrôle est marqué avec le TOTAL 2.

Quand le total cumulatif atteint une lecture maximum de 999.999, il remettra à zéro automatiquement à zéro.

Appuyez sur le bouton DISPLAY brièvement pour commuter entre le groupe, le total cumulatif, et le débit.

NOTE : Le compte totalization nombre toutes les unités sans différencier entre les gallons, les litres ou les unités champ-calibrées.

La Caractéristique du Débit

Pour utiliser cette caractéristique. Serrez et libérez DISPLAY jusqu'au FLOWRATE apparaît à la gauche du résultat inférieur.

Quand le FLOWRATE est montré, les nombres sur la ligne moyenne reflètent le débit, par exemple, les gallons par minute (GPM) ou les litres par minute (LPM).

Activez le Compteur

Mettez le L'ecran d'ordinateur ON en commençant l'écoulement de l'eau ou en appuyant sur brièvement le bouton de DISPLAY. Le groupe ou le total cumulatif de la dernière utilisation sera montré.

Appuyez sur le bouton de DISPLAY brièvement pour montrer le total de contrôle. Maintenez le bouton de DISPLAY pendant 3 secondes pour remettre le total de contrôle à zéro.

L'écran d'ordinateur est programmé pour s'arrêter automatiquement si non utilisé pendant 4 minutes.

Les Courbes Calibrage d'Usine et de Domaine

Toute l'information de calibrage est évidente à l'utilisateur comme mots dans la partie supérieure de l'affichage, au-dessus des chiffres numériques.

Toutes les unités sont configurées avec une courbe de calibrage "d'usine". Les gallons et les litres sont disponibles ("GAL" ou "LTR" sera évident). Utilisez les boutons de CALIBRATE et de DISPLAY pour commuter entre les gallons et les litres. Cette courbe de calibrage n'est pas utilisateur réglable. Le mot PRESET est montré pour montrer ceci. (Le calibrage d'usine est stocké de manière permanente dans la mémoire d'ordinateur.)

La courbe de calibrage de “champ” peut être placée par l’utilisateur, et peut être changé ou modifié à tout moment en utilisant les procédures de calibrage décrites dans la section de calibrage. Les totaux ou le débit ont dérivé du calibrage de champ sont évidents quand l’arrangement de calibrage de champ est choisi (“CAL B” sera évidente sur la ligne supérieure).

La Sélection d’un Réglage de Calibrage Différent

Vous pouvez commuter entre les modes de GAL et de LTR à la volonté sans contenu “de corruption” les totaux. Par exemple, l’ordinateur peut se monter à 10.00 gallons. Si l’utilisateur commute au mode de LTR, l’affichage changera immédiatement en “37.85” (la même quantité dans les unités des litres). La commutation de GAL/LTR fonctionne également en mode de FLOWRATE.

Pour choisir un arrangement différent de calibrage, une première, pressez et teniz le bouton de CALIBRATE. Continuez à tenir le bouton tout en également poussant et en libérant le bouton de DISPLAY. (Vous pouvez alors également libérer le bouton de CALIBRATE.) Les indicateurs dans la ligne supérieure de l’affichage changeront pour montrer le réglage nouvellement choisi de calibrage. Les arrangements de calibrage changent dans cet ordre: GAL, LTR, CAL B, GAL, etc… Tandis que le fluide coule, seulement les choix de GAL et de LTR peuvent être faits. Cependant, quand AUCUN fluide ne coule, n’importe quel réglage peut être choix.

CALIBRAGE

Avant de Commencer le Calibrage de Champ

Pour les résultats les plus précis, distribuez au débit qui simule mieux vos conditions de fonctionnement réelles. Évitez “de ruisseler” plus de fluide ou à plusieurs reprises de commencer et arrêter l’écoulement. Ces actions auront comme conséquence des calibrages moins précis.

Assurez-vous de répondre aux conditions minimum du débit du compteur:

Les Compteurs de Série de TM
Compteur de 1/2 pouce 1 GPM (3.8 LPM)
Compteur de 3/4 pouce 2 GPM (7.5 LPM)
Compteur de 1 pouce 5 GPM (18.8 LPM)
Compteur de 1-1/2 pouce 10 GPM (37.5 LPM)
Compteur de 2 pouces 20 GPM (75 LPM)

L’utilisation d’un récipient uniformément sûr et précis de calibrage est fortement recommandé pour les résultats les plus précis. En raison du débit élevé, on lui recommande vivement que le calibrage de champ soit accompli avec combinaison de volume et de poids en utilisant des balances de résolution fine.

Pour les meilleurs résultats, le compteur devrait être installé et purgé d’air avant le calibrage de champ.

Calibrage de Domaine avec l’Ecran d’Ordinateur

Le calibrage de domaine et le calibrage d’usine sont définis dans la section précédente. Les arrangements de calibrage d’usine sont programmés coutumes dans chaque ordinateur pendant leur production en utilisant l’eau à 70°F (21°C). Les lectures qui emploient les courbes de calibrage standard d’usine ne peuvent pas être précises dans quelques situations. Par exemple, dans des conditions extrêmes de la température ou avec les fluides autrement que l’eau.

Pour l’exactitude améliorée dans de telles conditions, l’ordinateur coulent de GPI tiennent compte du calibrage de “champ” (entrée d’utilisateur des paracompteurs de calibrage faits sur commande) Un calibrage de “seul point” peut rapporter une exactitude acceptable au milieu de la gamme d’écoulement, mois 5 points de calibrage ou plus peuvent rapporter un niveau plus élevé d’exactitude, particulièrement à l’extrémité inférieure de la gamme d’écoulement. Jusqu’à 15 points de calibrage faits sur commande peuvent être écrits.

Les Procédures de Distribuer/ Montrer de Calibrage de Champ

1. Maintenez le bouton de CALIBRATE tout en poussant et en libérent du DISPLAY jusqu'à ce que la courbe de calibrage de champ apparaisse (message de "CAL B" sera montré). Libérez les deux boutons.

2. Pour calibrer, pressez et tenez le bouton de CALIBRATE. Tout en continuant à tenir le CALIBRATE, également pressez et tenez le bouton de DISPLAY. Tenez les deux boutons pendant environ 3 secondes jusqu'à ce que vous voyiez un message clignotement "dd-CAL". Quand le message du "dd-CAL" apparaît, libérez les deux boutons. Vous êtes maintenant en mode de calibrage de champ.

3. Quand les boutons ont été libérés de l'étape 2, l'affichage montrera le message de clignotement "run 01". Si vous voulez sortir le procédé de calibrage maintenant avant de distribuer n'importe quel fluide, passez à l'étape 11.

4. Si vous voulez continuer le calibrage, mais n'as pas distribué n'importe quel fluide encore, faites vos préparations finales à votre système de pompage, mais ne commencez pas à pomper encore.

5. Commencez votre système de pompage de sorte que le fluide traverse le compteur. L'affichage cessera de clignoter et montrera le message de "run 01". Distribuez le fluide dans un récipient qui vous permet de juger la quantité de fluide pompée. Quand vous avez pompé la quantité désirée (par exemple, 10 gallons), arrêtez le flux de fluide rapidement.

6. Quand l'écoulement a arrêté, brièvement pressez et libérez tous les deux boutons. En ce moment l'affichage d'ordinateur changera en "0000.00" avec le chiffre à gauche clignotant.

7. Entrez le volume (quantité) de fluide cela que vous avez distribué (par exemple, si votre récipient de 10-gallon est plein, écrivez "10.0" pour des gallons ou "37.85" pour des litres). Pour écrire les nombres, utilisez le bouton de CALIBRATE pour changer la valeur du chiffre qui clignote. Utilisez le bouton de DISPLAY pour décaler le "clignotement" au prochain chiffre.

8. Quand le nombre correct est écrit, brièvement pressez et libérez tous les deux boutons. L'affichage changera maintenant en message de clignotement à "run 02". Vous avez maintenant installé le nouveau point de cal-courbe. Vous étes prêts à finir le calibrage (étape 10) ou à écrire un autre nouveau point de calibrage (étape 9).

9. Pour écrire un autre point de calibrage, retournez et répétez les étapes 3 à 8. Il est possible d'installer à 15 points de cal-courbe, et le message de "run ##" incrémentera chaque fois que vous répétez le procédé de calibrage (run 01, run 02, run 03, etc., jusqu'à la run 15).

10. Pour finir le calibrage, pressez et tenez tous les deux boutons pendant environ 3 secondes jusqu'à ce que vous voyiez le message "CAL End". Après que vous libérez les boutons l'ordinateur reprendra des opérations normales avec le nouveau point(s) de calibrage actif.

11. Si vous n'avez distribué aucun fluide, vous pouvez sortir le calibrage sans changer la courbe de calibrage. Si le message "run 01" et vous n'avez distribué aucun fluide, tenez les deux boutons pendant environ 3 secondes jusqu'à ce que vous voyiez le message de "CAL End". Après vous libérez les boutons, l'ordinateur reprendra l'opération normale et la vieille courbe (si vu écriviez un du passé) est encore intacte.

Le Calibrage avec le Signal de Sortie Conditionné

Le K-facteur de votre compteur apparaît sur le rapport de calibrage comme les nombres d'impulsions par gallon. Le facteur est déterminé pendant la production en utilisant l'eau à 70°F (21°C). Ce K-facteur peut être utilisé pour le calibrage de "Point Seul" et fournira une exactitude acceptable. Cependant, les indications ne peuvent être pas précises quand vous utilisez cette méthode de calibrage dans quelques situations. Par exemple, quand vous utilisez le compteur dans les conditions extrêmes de la température ou quand vous utilisez le compteur avec d'autres fluides que l'eau.

Pour l'exactitude améliorée dans de telles conditions, nous recommandons qu'un K-facteur spécifique à l'application soit déterminé et utilisé pour le calibrage. Un calibrage de “Point Seul” peut produire une exactitude acceptable au milieu de la gamme de débit, mais cinq ou plus points de calibrage peuvent produire un niveau élevé d'exactitude, particulièrement à l'extrémité inférieure de la gamme de débit.

ENTRETIEN

La manipulation et le soin appropriés prolongeront la vie et le service du compteur.

Rotor De Turbine

Le compteur est pratiquement exempt d'entretien.Cependant, il est important que les rotor bouge librement. Maintenez le compteur propre et exempt des contaminations.

Si le rotor ne tourne pas librement, appliquez un lubrifiant pénétrant sur le rotor, l'axe, et les roulements. Enlevez tous les débris ou gisements du rotor en utilisant une brosse molle ou une petite sonde. Faites attention à n'endommager pas le rotor de turbine ou les appuis.

⚠ ATTENTION

Soufflage d'air comprimé à la turbine pourrait endommager le rotor.

Le Remplacement de la Batterie

L'écran d'ordinateur est actionné par deux batteries du lithium 3-volt qui peuvent être remplacées tandis que le compteur est installé. Quand les batteries sont enlevées ou perdent la puissance, le groupe et les totaux cumulatifs remis à zéro mais les calibrages de champ et d'usine sont maintenus.

Si l'affichage de l'écran d'ordinateur devient faible ou blanc, remplacez les batteries comme suit :

1. Enlevez les quatre vis de “Phillips” d'avant du compteur et soulevez et la plaque avant de la turbine.
2. Enlevez les vieilles batteries et nettoyez toute corrosion des bornes.
3. Installez les nouvelles batteries. Assurez-vous que le poteau positif est en position correcte.
4. Quand les batteries sont remplacées, la plaque actionnerait ON. Vérifiez l'affichage pour assurer des fonctions normales ont repris avant de se réunir encore.
5. Repositionnez les batteries, si nécessaire, et placez la plaque avant sur le logement de turbine. Pour éviter des dommages d'humidité, vérifiez que l'rondelle entièrement sécurise. Serrez les quatre vis sur l'avant de la plaque.

CARACTÉRISTIQUES

Admission Et Sortie:

Spigot (Pipeau) Fin de Modèle

TM050/TM050-N	Programme 80, Spigot (Pipeau) De 1/2"
TM075/TM075-N	Programme 80, Spigot (Pipeau) De 3/4"
TM100/TM100-N	Programme 80, Spigot (Pipeau) De 1"
TM150/TM150-N	Programme 80, Spigot (Pipeau) De 1-1/2"
TM200/TM200-N	Programme 80, Spigot (Pipeau) De 2"

Raccordements de NPT de Modèle

TM050-N/TM050-N-P	NPT De 1/2"
TM075-N/TM075-N-P	NPT De 3/4"
TM100-N/TM100-N-P	NPT De 1"
TM150-N/TM150-N-P	NPT De 1-1/2"
TM200-N/TM200-N-P	NPT De 2"

Type de Plan: Turbine

Composants Mouillés:
Loger: PVC
Coussinets: En Céramique
Axe: Carbure De Tungstène
Rotor Et Supports: PVDF
Arrêtoir: Acier Inoxydable

Type de Garniture: Spigot - Programme 80, ou NPT (femelle)

Pression d'Utilisation Maximale:
225 PSIG @ 73°F

Mésure des U.S.

Unité de Mesure: Gallon

Chaîne de écoulement:

1/2 pouce	1 - 10 GPM
3/4 pouce	2 - 20 GPM
1 pouce	5 - 50 GPM
1-1/2 pouce	10 - 100 GPM
2 pouce	20 - 200 GPM

L'exactitude avec l'ordinateur: ± 3.0%
(l'exactitude peut être améliorée avec le calibrage de champ)

La Température de Fonctionnement:
+32° à +140° F (Ne laissez pas le fluide de geler à l'intérieur du compteur.)

La Température de Stockage:
-40° à +158° F

Les Poids de Produit:*

	Spigot (Pipeau)	NPT
1/2 pouce	.38 lbs.	.55 lbs.
3/4 pouce	.43 lbs.	.67 lbs.
1 pouce	.49 lbs.	.84 lbs.
1-1/2 pouce	.66 lbs.	1.38 lbs.
2 pouce	.78 lbs.	1.78 lbs.

Les Dimensions - Pouces (W x H x L):**

	Sans Raccord	Avec Raccord
1/2"	2.0 x 2.6 x 3.8	2.0 x 2.8 x 5.5
3/4"	2.0 x 2.7 x 3.8	2.0 x 2.9 x 5.5
1"	2.0 x 3.1 x 4.1	2.0 x 3.3 x 6.2
1-1/2"	2.1 x 3.7 x 5.4	2.3 x 3.9 x 7.6
2"	2.4 x 4.2 x 5.5	3.5 x 4.5 x 7.9

* Le poids avec l'écran d'ordinateur. Le signal de sortie conditionné ajoute .30 livres.

** Les dimensions avec l'écran d'ordinateur. Le signal de sortie conditionné ajoute 1.1 pouce à la hauteur.

Mesure Métrique

Unité de Mesure: Litre

Chaîne de l'Ecoulement:

1/2"	3.8 - 38 LPM
3/4"	7.6 - 76 LPM
1"	19 - 190 LPM
1-1/2"	38 - 380 LPM
2"	76 - 760 LPM

L'exactitude avec l'ordinateur: ± 3.0%
(l'exactitude peut être améliorée avec le calibrage de champ)

La Température de Fonctionnement:
0° à +60° C (Ne laissez pas le fluide de geler à l'intérieur du compteur.)

La Température de Stockage:
-40° à +70° C

Les Poids de Produit:*

	Spigot (Pipeau)	NPT
1/2 inch	.172 kg	.249 kg
3/4 inch	.195 kg	.304 kg
1 inch	.222 kg	.381 kg
1-1/2 inch	.299 kg	.626 kg
2 inch	.354 kg	.807 kg

Les Dimensions - cm (W x H x L):**

	Sans Raccord	Avec Raccord
1/2"	5.0 x 6.6 x 9.6	5.0 x 7.1 x 13.9
3/4"	5.0 x 6.8 x 9.6	5.0 x 7.3 x 13.9
1"	5.0 x 7.8 x 10.4	5.0 x 8.3 x 15.7
1-1/2"	5.8 x 9.3 x 13.7	5.8 x 9.9 x 19.3
2"	6.0 x 10.6 x 13.9	8.8 x 11.4 x 20.0

* Le poids avec l'écran d'ordinateur. Le signal de sortie conditionné ajoute 136 kilogramme.

** Les dimensions avec l'écran d'ordinateur. Le signal de sortie conditionné ajoute 2.8 centimètres à la hauteur.

PIÉCES

Les pièces et les accessoires de rechange suivants sont disponibles pour les compteurs de Séries de TM :

Le Numéro de Pièce	La Description
113435-1	Le Signal Conditionné Câblage de Module
113520-1	Kit de rechange de Batterie
116000-1	Récipient de calibrage, grand (5 gallons)
125508-03	1/2 pouce, kit d'Assemblée de turbine
125508-04	1/2 pouce, NPT, PVC, kit d'Assemblée de turbine
125510-03	3/4 pouce, kit d'Assemblée de turbine
125510-04	3/4 pouce, NPT, PVC, kit d'Assemblée de turbine
125512-03	1 pouce, kit d'Assemblée de turbine
125512-04	1 pouce, NPT, PVC, kit d'Assemblée de turbine
125514-03	1-1/2 pouce, kit d'Assemblée de turbine
125514-04	1-1/2 pouce, NPT, PVC, kit d'Assemblée de turbine
125516-03	2 pouces, kit d'Assemblée de turbine
125516-04	2 pouces, NPT, PVC, kit d'Assemblée de turbine
901002-52	Rondelle

Kits D'Ordinateur:

125509-03	pouce de 1/2, kit d'Assemblée d'ordinateur
125511-03	3/4 pouce, kit d'Assemblée d'ordinateur
125513-03	1 pouce, kit d'Assemblée d'ordinateur
125515-03	1-1/2 pouce, kit d'Assemblée d'ordinateur
125517-03	2 pouces, kit d'Assemblée d'ordinateur

SERVICE

Pour la considération de garantie, contactez votre distributeur local. Si vous avez besoin d'aide, contact le service à la clientèle de GPI à:

1-800-835-0113

Vous aurez besoin:

- Fournissez les informations du décalque sur votre compteur.
- Recevez un nombre de retour d'autorisation.
- Rincez n'importe quel fluide du compteur avant l'expédition à l'usine.
- S'il est possible, laissez les garnitures installées par client ou de la longueur suffisante de la pipe nue pour la réinstallation.

⚠ ATTENTION

Ne renvoyez pas le compteur sans autorité spécifique du département de service à la clientèle de GPI. En raison des règlements stricts régir le transport, la manipulation, et la disposition des liquides dangereux ou inflammables, GPI n'acceptera pas des compteurs pour la reprise à moins qu'ils soient complètement exempts de résidu liquide.

WEEE DIRECTIVE

Le Waste Electrical and Electronic Equipment (WEEE) directive (2002/96/EC) a été approuvé par le Parlement Européan et le Conseil de l'Union Européene en 2003. Ce symbole indique que ce produit contient l'équipement électrique et électronique qui peut inclure les batteries, les cartes électroniques les affichages à cristaux liquides ou d'autres composants qui peuvent être sujets à des règlements locaux de disposition à votre endroit. Veuillez comprendre ces règlements et débarassez-vous de ce produit d'une façon responsable.

Declaration of Conformity

Manufacturer’s Name:	Great Plains Industries, Inc.
Manufacturer’s Address:	5252 East 36th Street North Wichita, KS USA 67220-3205

Declares, that the product:

Product Name:	Conditioned Signal Module TM Water Meter / Pulse Out
Model Numbers:	0N-0278 TM***-P TM***-N-P

Model numbers include all combinations
of an alpha-numeric series as illustrated above.

Conform to the following Standards:

EMC:	EN 50081-1 (Reference EN 55022) EN 55082-1 EN 61000-3-2 EN 61000-3-3 EN 61000-4-2 EN 61000-4-3

Supplementary Information:
“The products comply with the requirements of the EMC Directive 89/336/EEC.”

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

Signature:	Grant Nutter
Full Name:	Mr. Grant Nutter
Position:	President Great Plains Industries, Inc.
Place:	Wichita, KS USA November 2007

Declaration of Conformity

Manufacturer's Name:	Great Plains Industries, Inc.
Manufacturer's Address:	5252 East 36th Street North Wichita, KS USA 67220-3205

Declares, that the product:

Product Name:	TM Series Water Meter
Model Numbers:	TM050 TM075 TM100 TM150 TM200

Model numbers may include the suffix "-N"
to indicate thread type.

Conform to the following Standards:

EMC:	EN 50081-1 (Reference EN 55022) EN 55082-1

Supplementary Information:
"The products comply with the requirements of the EMC Directive 89/336/EEC."

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

Signature:	Grant Nutter
Full Name:	Mr. Grant Nutter
Position:	President Great Plains Industries, Inc.
Place:	Wichita, KS USA November 2007

CE

Limited Warranty Policy

Great Plains Industries, Inc. 5252 E. 36th Street North, Wichita, KS USA 67220-3205, hereby provides a limited warranty against defects in material and workmanship on all products manufactured by Great Plains Industries, Inc. This product includes a 1 year warranty. Manufacturer's sole obligation under the foregoing warranties will be limited to either, at Manufacturer's option, replacing or repairing defective Goods (subject to limitations hereinafter provided) or refunding the purchase price for such Goods theretofore paid by the Buyer, and Buyer's exclusive remedy for breach of any such warranties will be enforcement of such obligations of Manufacturer. The warranty shall extend to the purchaser of this product and to any person to whom such product is transferred during the warranty period.

The warranty period shall begin on the date of manufacture or on the date of purchase with an original sales receipt. This warranty shall not apply if:

A. the product has been altered or modified outside the warrantor's duly appointed representative;
B. the product has been subjected to neglect, misuse, abuse or damage or has been installed or operated other than in accordance with the manufacturer's operating instructions.

To make a claim against this warranty, contact the GPI Customer Service Department at 316-686-7361 or 888-996-3837. Or by mail at:

Great Plains Industries, Inc.
5252 E. 36th St. North
Wichita, KS, USA 67220-3205

The company shall, notify the customer to either send the product, transportation prepaid, to the company at its office in Wichita, Kansas, or to a duly authorized service center. The company shall perform all obligations imposed on it by the terms of this warranty within 60 days of receipt of the defective product.

GREAT PLAINS INDUSTRIES, INC., EXCLUDES LIABILITY UNDER THIS WARRANTY FOR DIRECT, INDIRECT, INCIDENTAL AND CONSEQUENTIAL DAMAGES INCURRED IN THE USE OR LOSS OF USE OF THE PRODUCT WARRANTED HEREUNDER.

The company herewith expressly disclaims any warranty of merchantability or fitness for any particular purpose other than for which it was designed.

This warranty gives you specific rights and you may also have other rights which vary from U.S. state to U.S. state.

Note: In compliance with MAGNUSON MOSS CONSUMER WARRANTY ACT – Part 702 (governs the resale availability of the warranty terms).

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Endress+Hauser Prowirl 72F

Level | Pressure | Flow | Temperature | Liquid Analysis | Registration | Systems Components | Services | Solutions

Technical Information

Proline Prowirl 72F, 72W, 73F, 73W

Vortex flow measuring system
Reliable flow measurement of gas, steam and liquids

Application
For the universal measurement of the volume flow of gases, steam and liquids.
The mass flow of steam, water (as per IAPWS-IF97 ASME), natural gas (as per AGA NX-19/AGA8-DC92 detailed method/AGA8 Gross Method 1/SGERG–88), compressed air, other gases and liquids can also be measured with the aid of integrated temperature measurement and by reading in external pressure values (optional).

Maximum range of applications thanks to:
- Fluid temperature range from –200 to +400 °C
- Pressure ratings up to PN 250/Class 1500
- Sensor with integrated (optional) diameter reduction by one line size (R Style) or two line sizes (S Style)
- Dualsens version (optional) for redundant measurements with two sensors and electronics

Approvals for:
- ATEX, FM, CSA, TIIS, NEPSI, IEC
- HART, PROFIBUS PA, FOUNDATION Fieldbus
- Pressure Equipment Directive, SIL 2

Your benefits
The robust **Prowirl sensor**, tried and tested in over 100 000 applications, offers:
- High resistance to vibrations, temperature shocks, contaminated fluids and water hammer
- No maintenance, no moving parts, no zero-point drift ("lifetime" calibration)
- Software initial settings save time and costs

Additional possibilities:
- Complete saturated steam or liquid-mass measuring point in one single device
- Calculation of the mass flow from the measured variables volume flow and temperature in the integrated flow computer
- External pressure value read-in for superheated steam and gas applications (optional)
- External temperature value read-in for delta heat measurement (optional)

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Endress+Hauser
People for Process Automation

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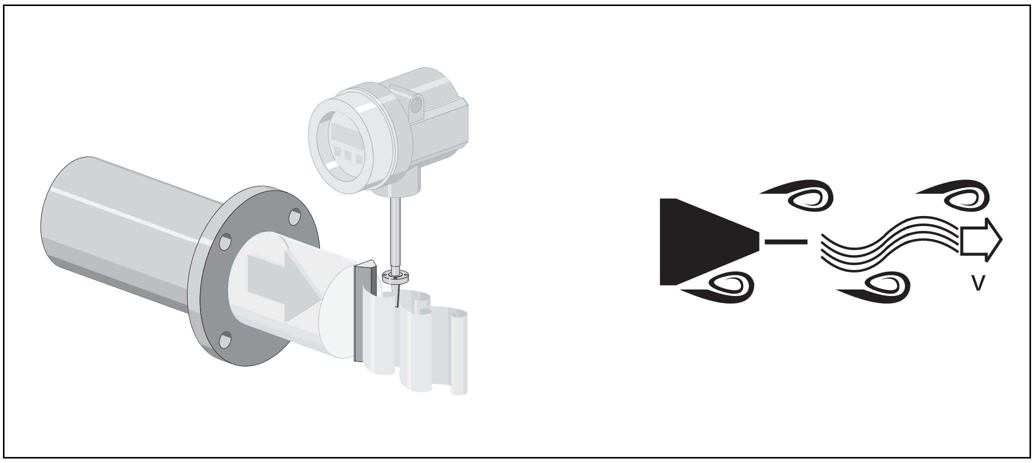
Function and system design

Measuring principle

Vortex meters work on the principle of the Karman vortex street. When fluid flows past a bluff body, vortices are alternately formed on both sides with opposite directions of rotation. These vortices each generate a local low pressure. The pressure fluctuations are recorded by the sensor and converted to electrical pulses. The vortices develop very regularly within the permitted application limits of the device. Therefore, the frequency of vortex shedding is proportional to the volume flow.



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The K-factor is used as the proportional constant:

$$\text{K-Factor} = \frac{\text{Pulses}}{\text{Unit Volume [dm}^3\text{]}}$$

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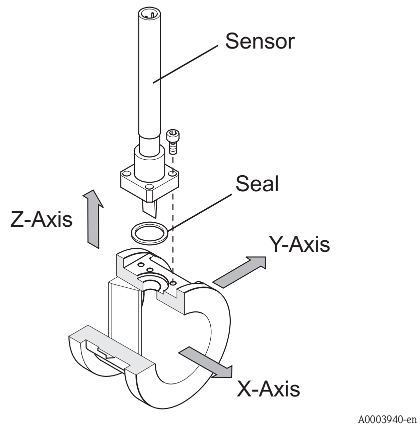
- Within the application limits of the device, the K-factor only depends on the geometry of the device. It is independent of the fluid velocity and the fluid properties viscosity and density. In this way, the K-factor is also independent of the type of matter that is to be measured, regardless of whether this is steam, gas or liquid.
- The primary measuring signal is already digital (frequency signal) and linear to the flow.
  After production, the K-factor is determined in the factory by means of calibration and is not subject to long-term or zero-point drift.
- The device does not contain any moving parts and does not require maintenance.

The capacitive sensor

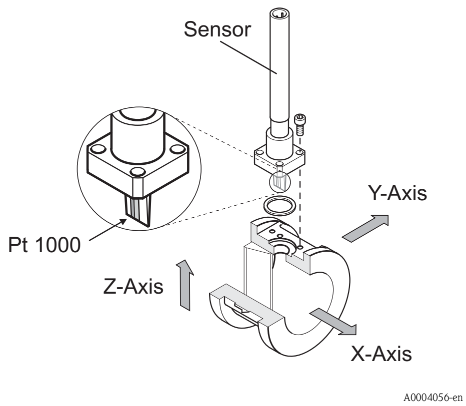
The sensor of a vortex flowmeter has a major influence on the performance, robustness and reliability of the whole measuring system.

The robust DSC sensor – with an integrated temperature measurement (Pt 1000) with Prowirl 73 – is burst-tested and vibration and temperature-shock-tested (temperature shocks of 150 K/s). The Prowirl uses the tried-and-tested capacitive measuring technology of Endress+Hauser applied in over 100 000 measuring points worldwide.

The DSC (differential switched capacitance) sensor patented by Endress+Hauser has complete mechanical balancing. It only reacts to the measured variable (vortex), not to vibrations. Even in the event of pipe vibrations, the smallest of flows can be reliably measured at low density thanks to the unimpaired sensitivity of the sensor. Thus, the wide turndown is also maintained even in the event of harsh operating conditions. Vibrations up to 1 g, in frequencies up to 500 Hz in every axis (X, Y, Z), do not affect the flow measurement. Due to its design, the capacitive sensor is also particularly mechanically resistant to temperature shocks and water hammers in steam lines.



DSC sensor, Prowirl 72



DSC sensor, Prowirl 73 with integrated thermometer (Pt 1000)

"Lifetime" calibration

Experience has shown that recalibrated Prowirl devices exhibit a very high degree of stability compared to their original calibration: The recalibration values were all within the original measuring accuracy specifications of the devices.
Various tests and simulation procedures carried out on devices by filing away the edges of Prowirl's bluff body found that there was no negative impact on the accuracy up to a rounding diameter of 1 mm.

Generally the following statements are true:
- Experience has shown that if the fluid is non-abrasive and non-corrosive (e.g. most water and steam applications), the meter's edges will never show rounding at the edges that is 1 mm or more.
- If the rounding of the meter's edges is always 1 mm or less, the meter will never show a calibration shift that is out of the meter's original specifications.
- Typically, the bluff body's edges exhibit a small rounding that is less than 1 mm. The meter, however, is calibrated with this rounded edge. Therefore, the meter will stay within the tolerance specifications as long as the additional wear and tear of the edge does not exceed an additional 1 mm.

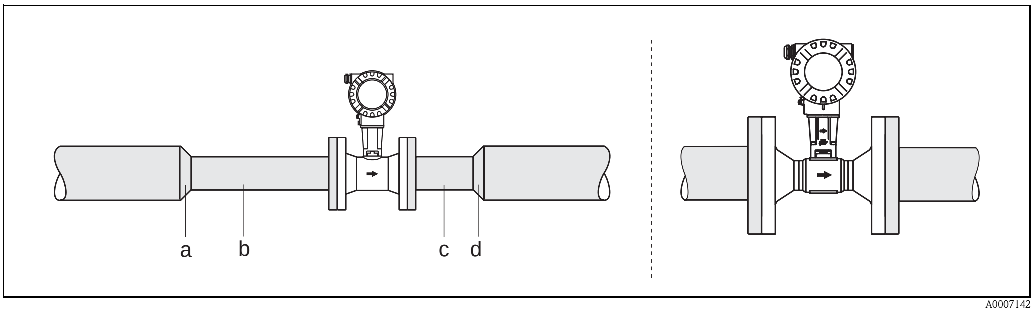
Thus, the Prowirl product line offers calibration for life if the measuring device is used in non-abrasive and non-corrosive fluids.

Sensor with integrated nominal diameter reduction

In many applications, the nominal diameter of the customer's pipe does not correspond to the nominal diameter that is optimum for a vortex meter as the flow velocity is too low for vortex formation after the bluff body. This is expressed in a signal loss in the lower flow range. To reduce the nominal diameter by one or two steps, and thus increase the flow velocity, it is common practice nowadays to fit such measuring points with the following adapters:

- Reducer (a)
- Straight pipe segment (b) as the inlet run (min. 15 × DN) in front of the vortex meter
- Straight pipe segment (c) as the outlet run (min. 5 × DN) after the vortex meter
- Expansion (d)

Endress+Hauser is now offering the Prowirl 72/73 vortex meter with integrated nominal diameter reduction for such applications.



Left: Traditional means for reducing pipeline section
Right: Nominal diameter reduction by using Prowirl with integrated line size reduction

Nomenclature for Prowirl vortex meters (flanged devices) with integrated nominal diameter reduction:
- Prowirl 72F/73F "R Style": single reduction of line size, e.g. from DN 80 to DN 50
- Prowirl 72F/73F "S Style": double reduction of line size, e.g. from DN 80 to DN 40 (S = "super" reduced).

These models offer the following benefits:

- Cost and time saving as the adapter pieces with inlet and outlet runs are completely replaced by one single device (additional inlet and outlet runs to be considered → 🗎 25)
- Measuring range extended for lower flow rates
- Lower risk (of incorrect measuring device layout) in the planning phase as R Style and S Style measuring devices have the same lengths as standard flanged devices. Each device type can be used alternatively without making complicated changes to the layout.
- Accuracy specifications identical to those for standard devices.

Temperature measurement (Prowirl 73)

In addition to the volume flow, the Prowirl 73 also measures the fluid temperature. The temperature is measured by means of a temperature sensor Pt 1000 which is located in the paddle of the DSC sensor, i.e. directly in the fluid (→ 🗎 4).

Flow computer (Prowirl 73)

The electronics of the measuring device have an integral flow computer. With the aid of this flow computer other process variables can be calculated from the primary measured variables (volume flow and temperature), e.g.:
- The mass flow and heat flow of saturated steam and water in accordance with IAPWS-IF97/ASME
- The mass flow and heat flow of superheated steam (at constant pressure or pressure read in via HART/ PROFIBUS PA/FOUNDATION Fieldbus) in accordance with IAPWS-IF97/ASME
- The mass flow and corrected volume flow of gases (at constant pressure or pressure read in via HART/ PROFIBUS PA/FOUNDATION Fieldbus), e.g. compressed air and natural gas AGA NX-19 (see below). Additional gases can be programmed using the real gas equation.
  In the case of 4 to 20mA HART devices, the following gases are preprogrammed:

Ammonia	Helium 4	Nitrogen
Argon	Hydrogen (normal)	Oxygen
Butane	Hydrogen chloride	Propane
Carbon dioxide	Hydrogen sulfide	Xenon
Chlorine	Krypton	Mixtures of up to 8 components of these gases
Ethane	Methane	
Ethylene (ethene)	Neon	

The heat flow (energy) of these gases is calculated as per ISO 6976 - based on the net calorific value or gross calorific value.

- Optional: natural gas AGA NX-19 (corrected volume flow and mass flow);
  Only for 4 to 20 mA HART: AGA8-DC92/ISO 12213-2/AGA8 Gross Method 1/SGERG-88 (corrected volume flow, mass flow, heat flow). For AGA8 Gross Method 1 and SGERG-88, the gross calorific value or the net calorific value can be entered to calculate the heat flow (energy). For AGA8-DC92 and ISO 12213-2, the data for the gross calorific value and net calorific value are stored in the device according ISO 6976.
- The mass flow of any liquid (linear equation). The gross calorific value or the net calorific value can be entered to calculate the heat flow (energy).
- Delta heat between saturated steam and condensate (second temperature value read in via HART) in accordance with IAPWS-IF97/ASME,
- Delta heat between warm water and cold water (second temperature value read in via HART) in accordance with IAPWS-IF97/ASME,
- In saturated steam measurements, the pressure of the steam can also be calculated from the measured temperature and output in accordance with IAPWS-IF97/ASME.

The mass flow is calculated as the product of volume flow x operating density. In the case of saturated steam, water and other liquids, the operating density is a function of the temperature. In the case of superheated steam and all other gases, the operating density is a function of the temperature and pressure.
The corrected volume flow is calculated as the product of volume flow x operating density, divided by the reference density. In the case of water and other liquids, the operating density is a function of the temperature. In the case of all other gases, the operating density is a function of the temperature and pressure.
The heat flow is calculated as the product of volume flow x operating density. In the case of saturated steam and water, the operating density is a function of the temperature. In the case of superheated steam, natural gas AGA8-DC92, natural gas ISO 12213-2, natural gas AGA8 Gross Method 1 and natural gas SGERG-88, the operating density is a function of the temperature and pressure.

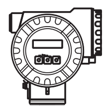
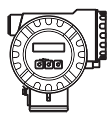
Diagnostic functions (Prowirl 73)

Extensive diagnostic options, such as retracing fluid and ambient temperatures, extreme flows etc., are also optionally available for the measuring device.

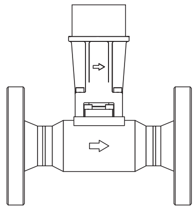
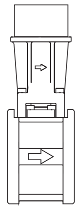
Measuring system

The measuring system comprises a sensor and a transmitter. Two versions are available:
- Compact version: sensor and transmitter form a mechanical unit.
- Remote version: sensor is mounted separate from the transmitter (up to max. 30 m).

Transmitter

Prowirl 72  A0009906	▪ Two-line liquid crystal display ▪ Configuration using pushbuttons ▪ Quick Setup for rapid commissioning ▪ Volume flow and calculated variables (mass flow or corrected volume flow)
Prowirl 73  A0009906	▪ Two-line liquid crystal display ▪ Configuration using pushbuttons ▪ Quick Setup for rapid commissioning ▪ Volume flow and temperature as well as calculated variables (mass flow, heat flow or corrected volume flow)

Sensor

F  A0009921	■ Flanged version ■ Range of nominal diameters DN 15 to 300 (½" to 12") ■ Material of measuring tube: e.g. – Stainless steel, A351-CF3M – Alloy C-22 (only for Prowirl 72)
W  A0009922	■ Wafer version (flangeless version) ■ Range of nominal diameters DN 15 to 150 (½" to 6") ■ Material of measuring tube: e.g. stainless steel, A351-CF3M

Input

Measured variable

Prowirl 72

- Volumetric flow (volume flow) is proportional to the frequency of vortex shedding after the bluff body.
- The following can be output as the output variable:
  - Volume flow
  - Mass flow or corrected volume flow (if process conditions are constant)

Prowirl 73

- Volumetric flow (volume flow) is proportional to the frequency of vortex shedding after the bluff body.
- The temperature can be output directly and is used to calculate the mass flow for example.
- The following can be output as the output variable:
  - The measured process variables volume flow and temperature
  - The calculated process variables mass flow, heat flow or corrected volume flow

Measuring range

The measuring range depends on the fluid and the nominal diameter.

Start of measuring range

Depends on the density and the Reynolds number (Re_{min} = 4000, Re_{linear} = 20 000).
The Reynolds number is dimensionless and is the ratio of inertial forces to viscous forces of the fluid. It is used for characterizing the flow. The Reynolds number is calculated as follows:

$$Re = \frac{4 \cdot Q\ [m^3/s] \cdot \rho\ [kg/m^3]}{\pi \cdot di\ [m] \cdot \mu\ [Pa{\cdot}s]}$$

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Re = Reynolds number; Q = flow; di = internal diameter; m = dynamic viscosity, r = density

$$\text{DN 15...25} \rightarrow v_{min.}{}^{*} = \frac{6}{\sqrt{\rho\ [kg/m^3]}}\ [m/s] \qquad \text{DN 40...300} \rightarrow v_{min.}{}^{*} = \frac{7}{\sqrt{\rho\ [kg/m^3]}}\ [m/s]$$

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** with amplification 5*

Full scale value

Liquids: v_{max} = 9 m/s
Gas/steam: see table

Nominal diameter	v_{max}
Standard version: DN 15 (½") R Style: DN 25 (1") > DN 15 (½") S Style: DN 40 (1½") >> DN 15 (½")	46 m/s or Mach 0.3 (depending on which value is smaller)
Standard version: DN 25 (1"), DN 40 (1½") R Style: – DN 40 (1½") > DN 25 (1") – DN 50 (2") > DN 40 (1½") S Style: – DN 80 (3") >> DN 40 (1½")	75 m/s or Mach 0.3 (depending on which value is smaller)
Standard version: DN 50 (2") to 300 (12") R Style: – DN 80 (3") > DN 50 (2") – Nominal diameters larger than DN 80 (3") S Style: – DN 100 (4") >> DN 50 (2") – Nominal diameters larger than DN 100 (4")	120 m/s or Mach 0.3 (depending on which value is smaller) Calibrated range: up to 75 m/s

Note!
By using the selection and planning program "Applicator", you can determine the exact values for the fluid you use. You can obtain the Applicator from your Endress+Hauser sales center or on the Internet under www.endress.com.

K-factor range

The table is used for orientation purposes. The range in which the K-factor can be is indicated for individual nominal diameters and designs.

Nominal diameter		K-factor range (pulses/dm³)	
DIN/JIS	ANSI	72F/73F	72W/73W
DN 15	½"	390 to 450	245 to 280
DN 25	1"	70 to 85	48 to 55
DN 40	1½"	18 to 22	14 to 17
DN 50	2"	8 to 11	6 to 8
DN 80	3"	2.5 to 3.2	1.9 to 2.4
DN 100	4"	1.1 to 1.4	0.9 to 1.1
DN 150	6"	0.3 to 0.4	0.27 to 0.32
DN 200	8"	0.1266 to 0.1400	–
DN 250	10"	0.0677 to 0.0748	–
DN 300	12"	0.0364 to 0.0402	–

Measuring range for gases [m³/h or Nm³/h]

In the case of gases, the start of the measuring range depends on the density. With ideal gases, the density [ρ] or corrected density [ρ_N] can be calculated using the following formulae:

$$\rho\ [\mathrm{kg/m^3}] = \frac{\rho_N\ [\mathrm{kg/Nm^3}] \cdot P\ [\mathrm{bar\ abs}] \cdot 273.15\ [\mathrm{K}]}{T\ [\mathrm{K}] \cdot 1.013\ [\mathrm{bar\ abs}]} \qquad \rho_N\ [\mathrm{kg/Nm^3}] = \frac{\rho\ [\mathrm{kg/m^3}] \cdot T\ [\mathrm{K}] \cdot 1.013\ [\mathrm{bar\ abs}]}{P\ [\mathrm{bar\ abs}] \cdot 273.15\ [\mathrm{K}]}$$

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The following formulae can be used to calculate the volume [Q] or corrected volume [Q_N] in the case of ideal gases:

$$Q\ [\mathrm{m^3/h}] = \frac{Q_N\ [\mathrm{Nm^3/h}] \cdot T\ [\mathrm{K}] \cdot 1.013\ [\mathrm{bar\ abs}]}{P\ [\mathrm{bar\ abs}] \cdot 273.15\ [\mathrm{K}]} \qquad Q_N\ [\mathrm{Nm^3/h}] = \frac{Q\ [\mathrm{m^3/h}] \cdot P\ [\mathrm{bar\ abs}] \cdot 273.15\ [\mathrm{K}]}{T\ [\mathrm{K}] \cdot 1.013\ [\mathrm{bar\ abs}]}$$

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T = Operating temperature, P = operating pressure

Input signal

HART input functionality

Prowirl 73 (4 to 20 mA/HART version) is able to read in an external pressure, temperature or density value. The following order options are required for this purpose:

- Prowirl 73: output/input → option W (4–20 mA HART) or A (4–20 mA HART + frequency)
- 2 × active barrier RN221N–x1 (for x: A = for non-hazardous areas, B = ATEX, C = FM, D = CSA)
- If reading in pressure: 1 × Cerabar M or Cerabar S in burst mode (Cerabar can be set to burst mode using a HART handheld DXR275 or DXR375. Cerabar S Evolution can also be set to the burst mode via "FieldCare". Alternatively, Cerabar can also be ordered with the burst mode ready activated as a special product with the following order number: Cerabar M: TSPSC2821/52025523; Cerabar S: TSPSC2822/52025523.

When this functionality is used, the following signals can be made available to the control system, e.g. in an application with superheated steam:
- Pressure as 4 to 20 mA signal
- Temperature as 4 to 20 mA signal or frequency signal (only for Prowirl 73, option A (4 to 20 mA HART + frequency))
- Mass flow as pulse or frequency signal (only for Prowirl 73; output/input → option A)

Pressure input (PROFIBUS PA, FOUNDATION Fieldbus)

An external pressure value function block can be read in with Prowirl 73 (bus version). The following order options are required for this purpose:

PROFIBUS PA:
- Prowirl 73 → output/input → option H (PROFIBUS PA)
- Cerabar M → electronics/display → option P or R; → ceramic sensor → option 2F, 2H, 2M, 2P or 2S
  Cerabar S Evolution → output/operation → option M, N or O; → d:sensor range → option 2C, 2E, 2F, 2H, 2K, 2M, 2P or 2S

FOUNDATION Fieldbus (FF):
- Prowirl 73 → output/input → option K (FOUNDATION Fieldbus)
- Cerabar S Evolution → output/operation → option P, Q or R; → d:sensor range → option 2C, 2E, 2F, 2H, 2K, 2M, 2P or 2S

Output

Prowirl 72

By means of the outputs in the 4 to 20 mA/HART version of Prowirl 72, the volume flow and, if process conditions are constant, the calculated mass flow and corrected volume flow can be output via the current output and optionally via the pulse output or as a limit value via the status output.

Prowirl 73

By means of the outputs in the 4 to 20 mA/HART version of Prowirl 73, the following measured variables can generally be output:

	4 to 20 mA HART measuring devices				Profibus - PA (4 AI Blocks)	Foundation Fieldbus FF (7 AI Blocks)
	Current output	Frequency output (only for output option A)	Pulse output (only for output option A)	Status output (only for output option A)		
Saturated steam	■ Volume flow/ mass flow/heat flow ■ Temperature ■ Saturation steam pressure	■ Volume flow/ mass flow/heat flow ■ Temperature ■ Saturation steam pressure	■ Volume ■ Mass ■ Heat	■ Volume flow/ mass flow/heat flow limit value ■ Temperature limit value ■ Totalizer limit value ■ Velocity limit value ■ Calculated saturated steam pressure limit value	■ Volume flow/ mass flow/heat flow ■ Temperature ■ Saturation steam pressure ■ Specific enthalpy ■ Frequency ■ Flow velocity ■ Totalizer ■ Optional: – Reynolds number – Electronics temperature	■ Volume flow/ mass flow/heat flow ■ Temperature ■ Saturation steam pressure ■ Specific enthalpy ■ Frequency ■ Flow velocity ■ Totalizer ■ Optional: – Reynolds number – Electronics temperature
Superheated steam	■ Volume flow/ mass flow/heat flow ■ Temperature ■ External pressure (if it can be read in)	■ Volume flow/ mass flow/heat flow ■ Temperature ■ External pressure (if it can be read in)	■ Volume ■ Mass ■ Heat	■ Volume flow/ mass flow/heat flow limit value ■ Temperature limit value ■ Totalizer limit value ■ Velocity limit value ■ External pressure limit value (if it can be read in)	■ Volume flow/ mass flow/heat flow ■ Temperature ■ Specific enthalpy ■ Frequency ■ Flow velocity ■ Totalizer ■ Optional: – Reynolds number – Electronics temperature	■ Volume flow/ mass flow/heat flow ■ Temperature ■ Specific enthalpy ■ Frequency ■ Flow velocity ■ Totalizer ■ Optional: – Reynolds number – Electronics temperature
Water	■ Volume flow/ mass flow/heat flow/corrected volume flow ■ Temperature ■ External pressure (if it can be read in)	■ Volume flow/ mass flow/heat flow/corrected volume flow ■ Temperature ■ External pressure (if it can be read in)	■ Volume ■ Mass ■ Heat ■ Corrected volume	■ Volume flow/ mass flow/heat flow/corrected volume flow limit value ■ Temperature limit value ■ Totalizer limit value ■ Velocity limit value ■ External pressure limit value (if it can be read in)	■ Volume flow/ mass flow/heat flow/corrected volume flow ■ Temperature ■ Specific enthalpy ■ Frequency ■ Flow velocity ■ Totalizer ■ Optional: – Reynolds number – Electronics temperature	■ Volume flow/ mass flow/heat flow/corrected volume flow ■ Temperature ■ Specific enthalpy ■ Frequency ■ Flow velocity ■ Totalizer ■ Optional: – Reynolds number – Electronics temperature

	4 to 20 mA HART measuring devices				Profibus - PA (4 AI Blocks)	Foundation Fieldbus FF (7 AI Blocks)
	Current output	**Frequency output (only for output option A)**	**Pulse output (only for output option A)**	**Status output (only for output option A)**		
Compressed air	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume ▪ Mass ▪ Corrected volume	▪ Volume flow/ mass flow/heat flow/corrected volume flow limit value ▪ Temperature limit value ▪ Totalizer limit value ▪ Velocity limit value ▪ External pressure limit value (if it can be read in)	▪ Volume flow/ mass flow/ corrected volume flow ▪ Temperature ▪ Compressibility ▪ Frequency ▪ Flow velocity ▪ Totalizer ▪ Optional: – Reynolds number – Electronics temperature	▪ Volume flow/ mass flow/ corrected volume flow ▪ Temperature ▪ Compressibility ▪ Frequency ▪ Flow velocity ▪ Totalizer ▪ Optional: – Reynolds number – Electronics temperature
Ar, NH3, C4H10, CO2, CO, Cl2, C2H6, C2H4, He 4, H2 (normal), HCl, H2S, Kr, CH4, Ne, N2, O2, C3H8, Xe*	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume ▪ Mass ▪ Heat ▪ Corrected volume	▪ Volume flow/ mass flow/ corrected volume flow limit value ▪ Temperature limit value ▪ Totalizer limit value ▪ Velocity limit value ▪ External pressure limit value (if it can be read in)	No data → Use real gas equation	No data → Use real gas equation
Mixtures of up to 8 of the components above	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume ▪ Mass ▪ Heat ▪ Corrected volume	▪ Volume flow/ mass flow/ corrected volume flow limit value ▪ Temperature limit value ▪ Totalizer limit value ▪ Velocity limit value ▪ External pressure limit value (if it can be read in)	No data → Use real gas equation	No data → Use real gas equation
Real gas equation	▪ Volume flow/ mass flow/ corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume flow/ mass flow/ corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume ▪ Mass ▪ Corrected volume	▪ Volume flow/ mass flow/ corrected volume flow limit value ▪ Temperature limit value ▪ Totalizer limit value ▪ Velocity limit value ▪ External pressure limit value (if it can be read in)	▪ Volume flow/ mass flow/ corrected volume flow ▪ Temperature ▪ Frequency ▪ Flow velocity ▪ Totalizer ▪ Optional: electronics temperature	▪ Volume flow/ mass flow/ corrected volume flow ▪ Temperature ▪ Frequency ▪ Flow velocity ▪ Totalizer ▪ Optional: electronics temperature

* Argon, ammonia, butane, carbon dioxide, carbon monoxide, chlorine, ethane, ethylene (ethene), helium 4, hydrogen (normal), hydrogen chloride, hydrogen sulfide, krypton, methane, neon, nitrogen, oxygen, propane, xenon

	4 to 20 mA HART measuring devices				Profibus - PA (4 AI Blocks)	Foundation Fieldbus FF (7 AI Blocks)
	Current output	**Frequency output (only for output option A)**	**Pulse output (only for output option A)**	**Status output (only for output option A)**		
Natural gas AGA NX-19	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume ▪ Mass ▪ Heat ▪ Corrected volume	▪ Volume flow/ mass flow/ corrected volume flow limit value ▪ Temperature limit value ▪ Totalizer limit value ▪ Velocity limit value ▪ External pressure limit value (if it can be read in)	▪ Volume flow/ mass flow/ corrected volume flow ▪ Temperature ▪ Supercompressibi-lity ▪ Frequency ▪ Flow velocity ▪ Totalizer ▪ Optional: – Reynolds number – Electronics temperature	▪ Volume flow/ mass flow/ corrected volume flow ▪ Temperature ▪ Supercompressibi-lity ▪ Frequency ▪ Flow velocity ▪ Totalizer ▪ Optional: – Reynolds number – Electronics temperature
Natural gas AGA8-DC92 detailed method	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume ▪ Mass ▪ Heat ▪ Corrected volume	▪ Volume flow/ mass flow/heat flow/corrected volume flow limit value ▪ Temperature limit value ▪ Totalizer limit value ▪ Velocity limit value ▪ External pressure limit value (if it can be read in)	No data → Use natural gas AGA NX-19 or real gas equation	No data → Use natural gas AGA NX-19 or real gas equation
Natural gas ISO 12213-2	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume ▪ Mass ▪ Heat ▪ Corrected volume	▪ Volume flow/ mass flow/heat flow/corrected volume flow limit value ▪ Temperature limit value ▪ Totalizer limit value ▪ Velocity limit value ▪ External pressure limit value (if it can be read in)	No data → Use natural gas AGA NX-19 or real gas equation	No data → Use natural gas AGA NX-19 or real gas equation
Natural gas AGA8 Gross Method 1	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume flow/ mass flow/heat flow/corrected volume flow ▪ Temperature ▪ External pressure (if it can be read in)	▪ Volume ▪ Mass ▪ Heat ▪ Corrected volume	▪ Volume flow/ mass flow/heat flow/corrected volume flow limit value ▪ Temperature limit value ▪ Totalizer limit value ▪ Velocity limit value ▪ External pressure limit value (if it can be read in)	No data → Use natural gas AGA NX-19 or real gas equation	No data → Use natural gas AGA NX-19 or real gas equation
* Argon, ammonia, butane, carbon dioxide, carbon monoxide, chlorine, ethane, ethylene (ethene), helium 4, hydrogen (normal), hydrogen chloride, hydrogen sulfide, krypton, methane, neon, nitrogen, oxygen, propane, xenon						

	4 to 20 mA HART measuring devices				Profibus - PA (4 AI Blocks)	Foundation Fieldbus FF (7 AI Blocks)
	Current output	Frequency output (only for output option A)	Pulse output (only for output option A)	Status output (only for output option A)		
Natural gas SGERG-88	■ Volume flow/ mass flow/heat flow/corrected volume flow ■ Temperature ■ External pressure (if it can be read in)	■ Volume flow/ mass flow/heat flow/corrected volume flow ■ Temperature ■ External pressure (if it can be read in)	■ Volume ■ Mass ■ Heat ■ Corrected volume	■ Volume flow/ mass flow/heat flow/corrected volume flow limit value ■ Temperature limit value ■ Totalizer limit value ■ Velocity limit value ■ External pressure limit value (if it can be read in)	No data → Use natural gas AGA NX-19 or real gas equation	No data → Use natural gas AGA NX-19 or real gas equation
User-defined liquid	■ Volume flow/ mass flow/heat flow/corrected volume flow ■ Temperature	■ Volume flow/ mass flow/heat flow/corrected volume flow ■ Temperature	■ Volume ■ Mass ■ Heat ■ Corrected volume	■ Volume flow/ mass flow/ corrected volume flow limit value ■ Temperature limit value ■ Totalizer limit value ■ Velocity limit value	■ Volume flow/ mass flow/ corrected volume flow ■ Temperature ■ Frequency ■ Flow velocity ■ Totalizer ■ Optional: electronics temperature	■ Volume flow/ mass flow/ corrected volume flow ■ Temperature ■ Frequency ■ Flow velocity ■ Totalizer ■ Optional: electronics temperature
Water delta heat application	■ Volume flow/ mass flow/heat flow/corrected volume flow ■ Temperature ■ External temperature	■ Volume flow/ mass flow/heat flow/corrected volume flow ■ Temperature ■ External temperature	■ Volume ■ Mass ■ Heat ■ Corrected volume	■ Volume flow/ mass flow/heat flow/corrected volume flow limit value ■ Temperature limit value ■ Totalizer limit value ■ Velocity limit value ■ External temperature limit value	No data	No data
Saturated steam delta heat application	■ Volume flow/ mass flow/heat flow ■ Temperature ■ External temperature	■ Volume flow/ mass flow/heat flow ■ Temperature ■ External temperature	■ Volume ■ Mass ■ Heat	■ Volume flow/ mass flow/heat flow limit value ■ Temperature limit value ■ Totalizer limit value ■ Velocity limit value ■ External temperature limit value	No data	No data
* Argon, ammonia, butane, carbon dioxide, carbon monoxide, chlorine, ethane, ethylene (ethene), helium 4, hydrogen (normal), hydrogen chloride, hydrogen sulfide, krypton, methane, neon, nitrogen, oxygen, propane, xenon						

If configured, the following calculated measured variables can also be displayed via the local display in Prowirl 73:
- Density
- Specific enthalpy
- Saturation steam pressure (for saturated steam)
- Z-factor
- Flow velocity

Output signal

Prowirl 72

Current output:

- 4 to 20 mA with HART,
- Full scale value and time constant (0 to 100 s) can be set

Pulse/status output:

- Open collector, passive, galvanically isolated
  - Non-Ex, Ex d/XP version: U_{max} = 36 V, with 15 mA current limiting, R_i = 500 Ω
  - Ex i/IS and Ex n version: U_{max} = 30 V, with 15 mA current limiting, R_i = 500 Ω

The pulse/status output can be configured as:

- Pulse output:
  - Pulse value and polarity can be selected
  - Pulse width can be configured (0.005 to 2 s)
  - Pulse frequency max. 100 Hz
- Status output:
  Can be configured for error messages or flow limit values
- Vortex frequency:
  - Direct output of unscaled vortex pulses 0.5 to 2850 Hz
    (e.g. for connecting to an RMC621 flow computer)
  - Pulse ratio 1:1
- PFM signal (pulse/frequency modulation):
  With external connection via flow computer RMC621 or RMS621

PROFIBUS PA interface:

- PROFIBUS PA in accordance with EN 50170 Volume 2, IEC 61158-2 (MBP), galvanically isolated
- Current consumption = 16 mA
- Error current FDE (fault disconnection electronic) = 0 mA
- Data transmission rate: supported baudrate = 31.25 kBit/s
- Signal encoding = Manchester II
- Function blocks: 1 × Analog Input, 1 × totalizer
- Output data: volume flow, calculated mass flow, corrected volume flow, totalizer
- Input data: positive zero return (ON/OFF), totalizer control
- Bus address can be set at the device via DIP switches

FOUNDATION Fieldbus interface:

- FOUNDATION Fieldbus H1, IEC 61158-2, galvanically isolated
- Current consumption = 16 mA
- Error current FDE (fault disconnection electronic) = 0 mA
- Data transmission rate: supported baudrate = 31.25 kBit/s
- Signal encoding = Manchester II
- Function blocks: 2 × Analog Input, 1 × Discrete Output
- Output data: volume flow, calculated mass flow, corrected volume flow, totalizer
- Input data: positive zero return (ON/OFF), totalizer reset
- Link Master (LM) functionality is supported

Prowirl 73

Current output:

- 4 to 20 mA with HART,
- Full scale value and time constant (0 to 100 s) can be set

Frequency output, pulse/status output:

- Frequency output (optional): open collector, passive, galvanically isolated
  - Non-Ex, Ex d/XP version: U_{max} = 36 V, with 15 mA current limiting, R_i = 500 Ω
  - Ex i/IS and Ex n version: U_{max} = 30 V, with 15 mA current limiting, R_i = 500 Ω

The pulse/status output can be configured as:
- Frequency output:
  - End frequency 0 to 1000 Hz (fmax = 1250 Hz)
- Pulse output:
  - Pulse value and polarity can be selected
  - Pulse width can be configured (0.005 to 2 s)
  - Pulse frequency max. 100 Hz
- Status output:
  Can be configured for error messages or flow values, temperature values, pressure limit values
- Vortex frequency:
  - Direct output of unscaled vortex pulses 0.5 to 2850 Hz (e.g. for connecting to an RMC621 flow computer)
  - Pulse ratio 1:1

PROFIBUS PA interface:

- PROFIBUS PA in accordance with EN 50170 Volume 2, IEC 61158-2 (MBP), galvanically isolated
- Current consumption = 16 mA
- Error current FDE (fault disconnection electronic) = 0 mA
- Data transmission rate: supported baudrate = 31.25 kBit/s
- Signal encoding = Manchester II
- Function blocks: 4 × Analog Input, 2 × totalizer
- Output data: volume flow, mass flow, corrected volume flow, heat flow, temperature, density, specific enthalpy, calculated steam pressure (saturated steam), operating Z-factor, vortex frequency, electronics temperature, Reynolds number, velocity, totalizer
- Input data: positive zero return (ON/OFF), totalizer control, absolute pressure, display value
- Bus address can be set at the device via DIP switches

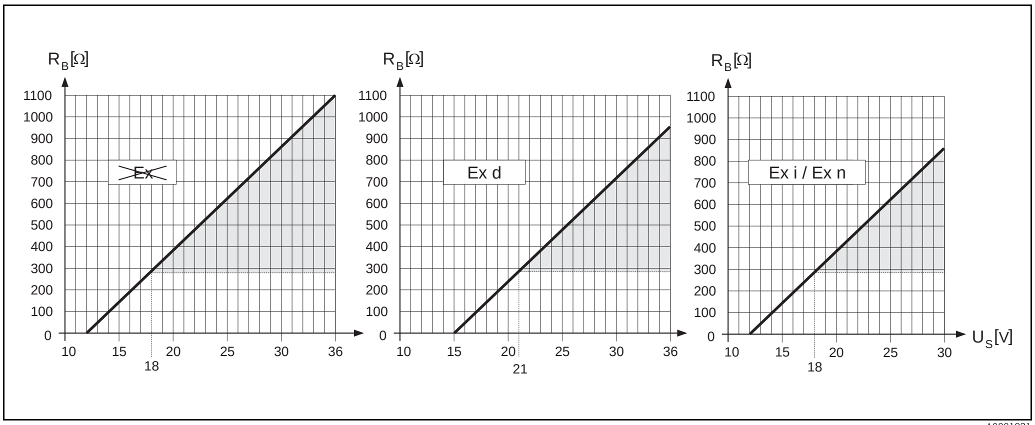
FOUNDATION Fieldbus interface:

- FOUNDATION Fieldbus H1, IEC 61158-2, galvanically isolated
- Current consumption = 16 mA
- Error current FDE (fault disconnection electronic) = 0 mA
- Data transmission rate: supported baudrate = 31.25 kBit/s
- Signal encoding = Manchester II
- Function blocks: 6 × Analog Input, 1 × Discrete Output, 1 × Analog Output
- Output data: volume flow, mass flow, corrected volume flow, heat flow, temperature, density, specific enthalpy, calculated steam pressure (saturated steam), operating Z-factor, vortex frequency, electronics temperature, Reynolds number, velocity, totalizer 1 + 2
- Input data: positive zero return (ON/OFF), totalizer reset, absolute pressure
- Link Master (LM) functionality is supported

Signal on alarm

- Current output: error response can be selected (e.g. in accordance with NAMUR Recommendation NE 43)
- Pulse output: error response can be selected
- Status output: "not conducting" in event of fault

Load



The area shaded gray refers to the permitted load (for HART: min. 250 **Ω***)*
The load is calculated as follows:

$$R_B = \frac{(U_S - U_{Kl})}{(I_{max} - 10^{-3})} = \frac{(U_S - U_{Kl})}{0.022}$$

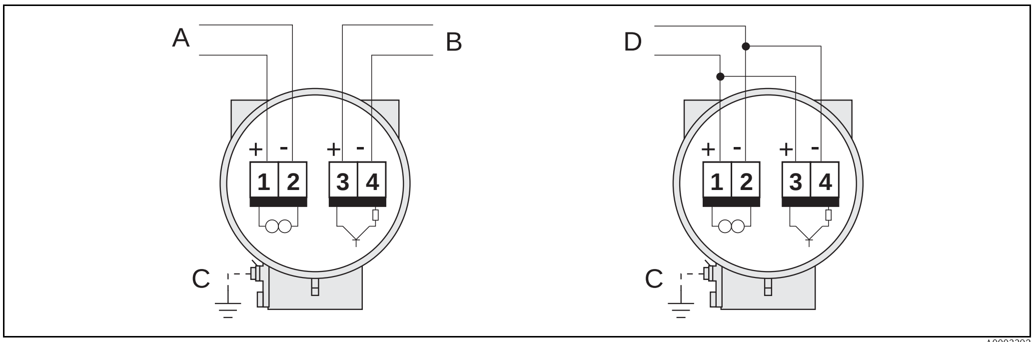
R_B	*Load, load resistance*
U_S	*Supply voltage: non-Ex = 12 to 36 V DC; Ex d /XP= 15 to 36 V DC; Ex i /IS and Ex n = 12 to 30 V DC*
U_{Kl}	*Terminal voltage: non-Ex = min. 12 V DC; Ex d/XP = min. 15 V DC; Ex i/IS and Ex n = min. 12 V DC*
I_{max}	*Output current (22.6 mA)*

Low flow cut off Switch points for low flow cut off can be selected as required.

Galvanic isolation All electrical connections are galvanically isolated from one another.

Power supply

Electrical connection



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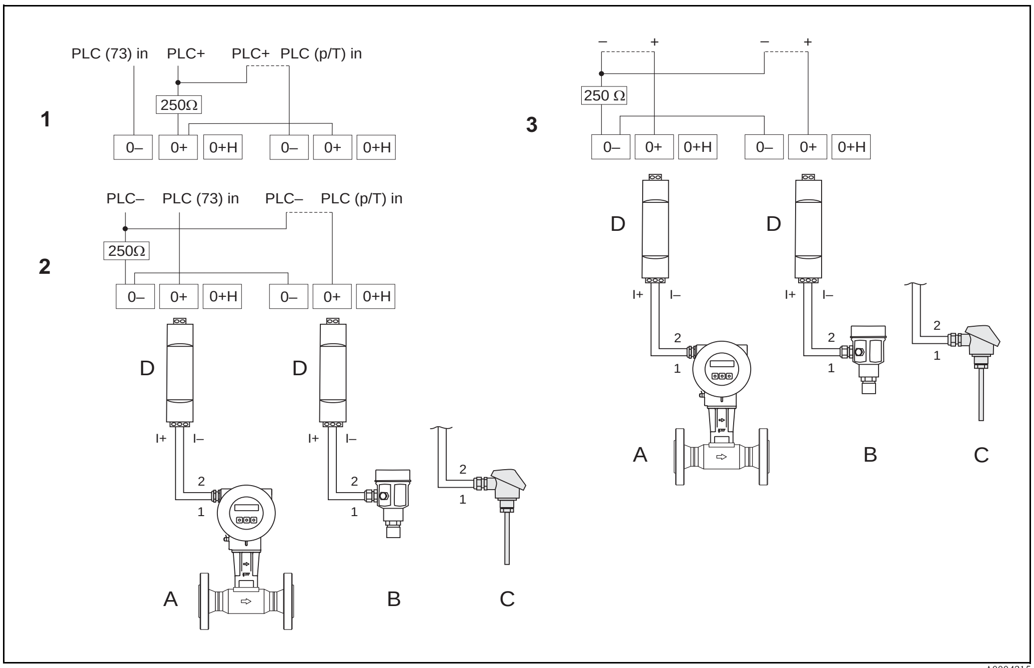
A – *HART: power supply, current output*
– PROFIBUS PA: 1 = PA+, 2 = PA–
– FOUNDATION Fieldbus: 1 = FF+, 2 = FF–

B *Optional pulse output (not for PROFIBUS PA and FOUNDATION Fieldbus), can also be operated as:*
– Status output
– Only Prowirl 73: frequency output
– Only Prowirl 73: as a PFM output (pulse/frequency modulation) together with an RMC621 or RMS621 flow computer

C *Ground terminal (relevant for remote version)*

D *Only Prowirl 72: PFM (pulse/frequency modulation) wiring for connecting to flow computer RMC621 or RMS621*

Wiring HART input



A0004215

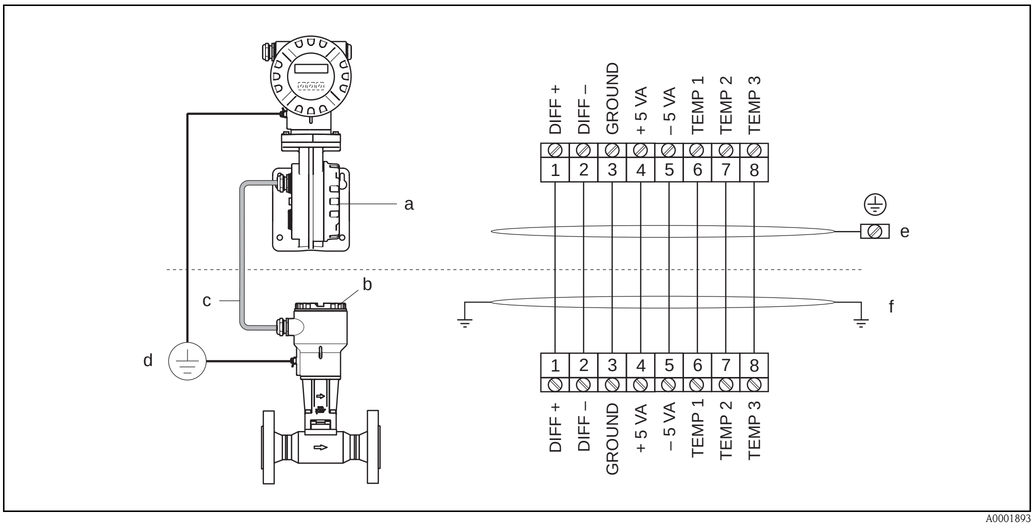
1 *Connection diagram for PLC with common "plus"*
Dotted line = alternative wiring when only the signal of the Prowirl 73 is fed to the PLC.

2 *Connection diagram for PLC with common "minus"*
Dotted line = alternative wiring when only the signal of the Prowirl 73 is fed to the PLC.

3 *Connection diagram without PLC*
Dotted line = wiring without connection to external components (e.g. recorder, displays, Fieldgate, etc.)

A = Prowirl 73, B = pressure sensor (Cerabar M), C = temperature sensor (Omnigrad TR10) or other external measuring devices (HART-enabled and burst-enabled), D = active barrier RN221N

Wiring remote version



Connecting the remote version

a = Connection compartment cover (transmitter)
b = Connection compartment cover (sensor)
c = Connecting cable (signal cable)
d = Identical potential matching for sensor and transmitter
e = Connect shielding to ground terminal in transmitter housing and keep as short as possible
f = Connect shielding to cable strain relief clamp in connection housing

Wire colors (color code according to DIN 47100):
Terminal number: 1 = white; 2 = brown; 3 = green; 4 = yellow, 5 = gray; 6 = pink; 7 = blue; 8 = red

Supply voltage

HART:

- Non-Ex: 12 to 36 V DC (with HART: 18 to 36 V DC)
- Ex i/IS and Ex n: 12 to 30 V DC (with HART: 18 to 30 V DC)
- Ex d/XP: 15 to 36 V DC (with HART: 21 to 36 V DC)

PROFIBUS PA and FOUNDATION Fieldbus:

- Non-Ex: 9 to 32 V DC
- Ex i/IS and Ex n: 9 to 24 V DC
- Ex d/XP: 9 to 32 V DC
- Current consumption → PROFIBUS PA: 16 mA, FOUNDATION Fieldbus: 16 mA

Cable entries

Power supply and signal cables (outputs):
- Cable entry M20 × 1.5 (6 to 12 mm)
- Thread for cable entry: ½" NPT, G ½", G ½" Shimada
- Fieldbus connector

Cable specifications

- Permitted temperature range:
  Between –40 °C and the max. ambient temperature permitted plus 10 °C

Power supply failure

- Totalizer stops at the last value determined.
- All settings are kept in the EEPROM.
- Error messages (incl. value of operated hours counter) are stored.

Performance characteristics

Reference operating conditions

Error limits following ISO/DIN 11631:
- 20 to 30 °C
- 2 to 4 bar
- Calibration rig traceable to national calibration standards
- Calibration with the process connection corresponding to the standard in question.

Maximum measured error

Prowirl 72

- Liquid:
  <0.75% o.r. for Re > 20 000
  <0.75% o.f.s for Re between 4000 and 20 000
- Gas/steam:
  <1% o.r. for Re > 20 000 and v < 75 m/s
  <1% o.f.s for Re between 4000 and 20 000

o.r. = of reading, o.f.s = of full scale value, Re = Reynolds number

Prowirl 73

- Volume flow (liquid):
  <0.75% o.r. for Re > 20 000
  <0.75% o.f.s for Re between 4000 and 20 000
- Volume flow (gas/steam):
  <1% o.r. for Re > 20 000 and v < 75 m/s
  <1% o.f.s for Re between 4000 and 20 000
- Temperature:
  <1°C (T > 100 °C, saturated steam and for liquids at ambient temperature);
  <1% o.r. [K] (gas)
  Rise time 50% (agitated under water, following IEC 60751): 8 s
- Mass flow (saturated steam):
  – For flow velocities 20 to 50 m/s, T > 150 °C (423 K)
    <1.7% o.r. (2% o.r. for remote version) for Re > 20 000
    <1.7% o.f.s (2% o.f.s for remote version) for Re between 4000 and 20 000
  – For flow velocities 10 to 70 m/s, T > 140 °C (413 K)
    <2% o.r. (2.3% o.r. for remote version) for Re > 20 000
    <2% o.f.s (2.3% o.f.s for remote version) for Re between 4000 and 20 000
- Mass flow of superheated steam and gas (air, natural gas AGA NX-19, AGA8-DC92, ISO 12213-2, AGA8 Gross Method 1, SGERG-88, preprogrammed gases - does not apply to the real gas equation):

  ✎ Note!
  A Cerabar S device has to be used for the measuring errors listed below. The measured error used to calculate the error in the measured pressure is 0.15%.

  <1.7% o.r. (2.0% o.r. for remote version) for Re > 20 000 and process pressure < 40 bar abs
  <1.7% o.f.s. (2.0% for remote version) for Re between 4000 and 20 000 and process pressure < 40 bar abs
  <2.6% o.r. (2.9% o.r. for remote version) for Re > 20 000 and process pressure < 120 bar abs
  <2.6% o.f.s. (2.9% o.r. for remote version) for Re between 4000 and 20 000 and process pressure < 120 bar abs
- Mass flow (water):
  <0.85% o.r. (1.15% o.r. for remote version) for Re > 20 000
  <0.85% o.f.s (1.15% o.f.s for remote version) for Re between 4000 and 20 000
- Mass flow (customer-defined liquids):
  To specify the system accuracy, Endress+Hauser requires information on the type of liquid and its operating temperature, or information in tabular form on the dependency between the liquid density and temperature.
  Example: Acetone is to be measured at fluid temperatures between 70 and 90 °C. The parameters TEMPERATURE VALUE (here 80 °C), DENSITY VALUE (here 720.00 kg/m^3) and EXPANSION COEFFICIENT (here 18.0298 x 10E-4 1/°C) have to be entered in the transmitter for this purpose. The overall system uncertainty, which is smaller than 0.9% for the example cited above, is made up of the following measuring uncertainties: Uncertainty of volume flow measurement, uncertainty of temperature measurement, uncertainty of the density-temperature correlation used (incl. the resulting uncertainty of density).
- Mass flow (other fluids):
  Depends on the pressure value specified in the device functions and the fluid selected.
  An individual error observation must be carried out.

o.r. = of reading, o.f.s = of full scale value, Re = Reynolds number

Diameter mismatch correction

Both Prowirl 72 and 73 can correct shifts in the calibration factor - e.g. caused by a change in the diameter between the device flange (e.g. ANSI, 2", Sched. 80) and the mating pipe (ANSI, 2", Sched. 40). The diameter mismatch should only be corrected within the limit values listed below, for which test measurements have also been performed.

Flange connection:
- DN 15 (½"): ±20% of the internal diameter
- DN 25 (1"): ±15% of the internal diameter
- DN 40 (1½"): ±12% of the internal diameter
- DN ≥ 50 (2"): ±10% of the internal diameter

Wafer:
- DN 15 (½"): ±15% of the internal diameter
- DN 25 (1"): ±12% of the internal diameter
- DN 40 (1½"): ±9% of the internal diameter
- DN ≥ 50 (2"): ±8% of the internal diameter

If the standard internal diameter of the process connection ordered for the measuring device and the internal diameter of the mating pipe differ, an additional measuring uncertainty of typically 0.1% o.r. (of reading) must be added for every 1 mm diameter deviation.

Repeatability

±0.25% o.r. (of reading)

Reaction time/step response time

If all the configurable functions for filter times (flow damping, display damping, current output time constant, frequency output time constant, status output time constant) are set to 0, a reaction time/step response time of 200 ms must be reckoned with for vortex frequencies as of 10 Hz. For other settings, a reaction time/step response time of 100 ms must always be added to the total filter reaction time for vortex frequencies as of 10 Hz.

Influence of ambient temperature

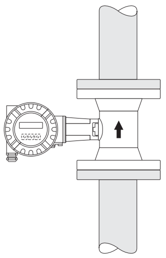
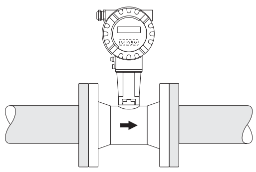
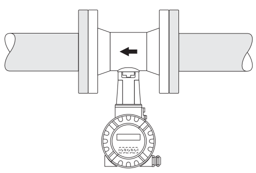
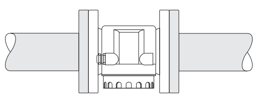
Current output (additional error, in reference to the span of 16 mA):
- Zero point (4 mA):
  Average Tk: 0.05%/10K, max. 0.6% over the entire temperature range –40 to +80 °C
- Span (20 mA):
  Average Tk: 0.05%/10K, max. 0.6% over the entire temperature range –40 to +80 °C

Digital outputs (pulse output, PFM, HART, frequency output; Prowirl 73 only)
Due to the digital measuring signal (vortex pulse) and further digital processing, there is no interface-related error from changing ambient temperature.

Operating conditions: installation

Installation instructions

Vortex meters require a fully developed flow profile as a prerequisite for correct volume flow measurement.
Make sure that the direction of the arrow on the nameplate of the sensor matches the direction of flow (direction of fluid flow through the pipe).
The device can generally be installed in any position in the piping. However, note the following points:

Orientation		High fluid temperature (TM) ≥ 200 °C	Low fluid temperature (TM)
Fig. A: Vertical orientation	 A0009522	Recommended (①)	Recommended (①)
Fig. B: Horizontal orientation Transmitter head up	 A0009523	Not permitted for Prowirl 73 W DN 100 (4")/DN 150 (6") (②)	Recommended (③)
Fig. C: Horizontal orientation Transmitter head down	 A0009524	Recommended (④)	
Fig. D: Horizontal orientation Transmitter head at front with display pointing downwards	 A0009525	Recommended (④)	Recommended (③)

① In the case of liquids, there should be upward flow in vertical pipes to avoid partial pipe filling (see Fig. A).

Caution!
Disruption in flow measurement!
To guarantee the flow measurement of liquids, the measuring tube must always be completely full in pipes with vertical downward flow.

② Caution!
Danger of electronics overheating!
If fluid temperature is ≥200 °C, orientation B is not permitted for the wafer version (Prowirl 73 W) with nominal diameters DN 100 (4") and DN 150 (6").

In order to ensure that the maximum permissible ambient temperature for the transmitter is not exceeded (→ 27), we recommend the following orientations:

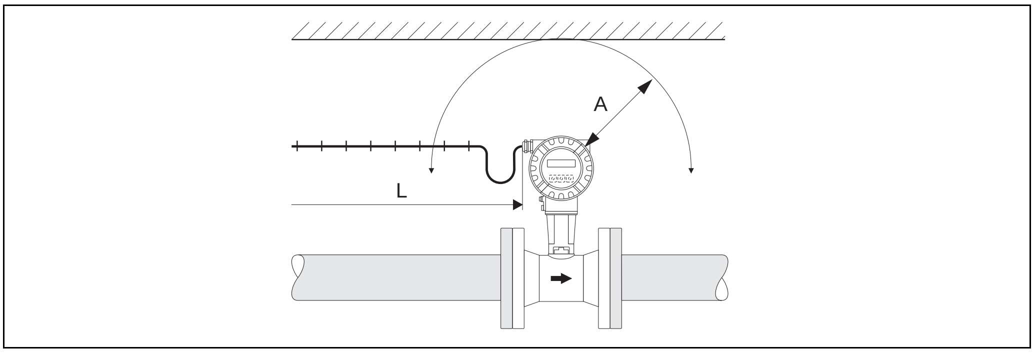
③ Select orientation C or D for hot fluids (e.g. steam or fluid temperature (TM) ≥200 °C

④ Select orientation B or D for very cold fluids (e.g. liquid nitrogen).

Minimum spacing and cable length

To ensure problem-free access to the measuring device for service purposes, we recommend you observe the following dimensions:

- Minimum spacing (A) in all directions = 100 mm
- Necessary cable length (L): L + 150 mm



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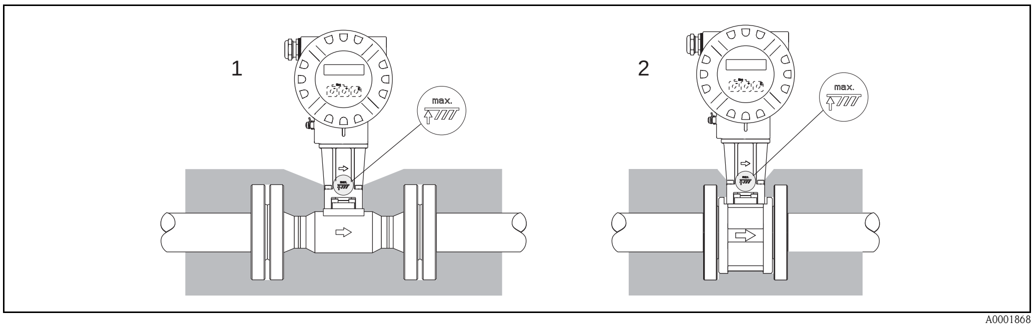
Rotating the electronics housing and the display

The electronics housing can be rotated continuously 360° on the housing support. The display unit can be rotated in 45° stages. This means you can read off the display comfortably in all orientations.

Piping insulation

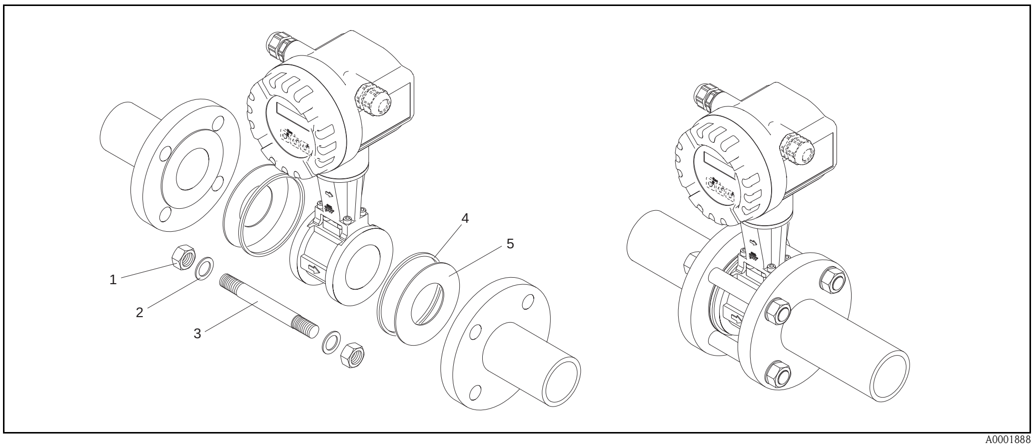
When insulating, please ensure that a sufficiently large area of the housing support is exposed.
The uncovered part serves as a radiator and protects the electronics from overheating (or undercooling).
The maximum insulation height permitted is illustrated in the diagrams. These apply equally to both the compact version and the sensor in the remote version.



1 = Flanged version
2 = Wafer version

Wafer version mounting set

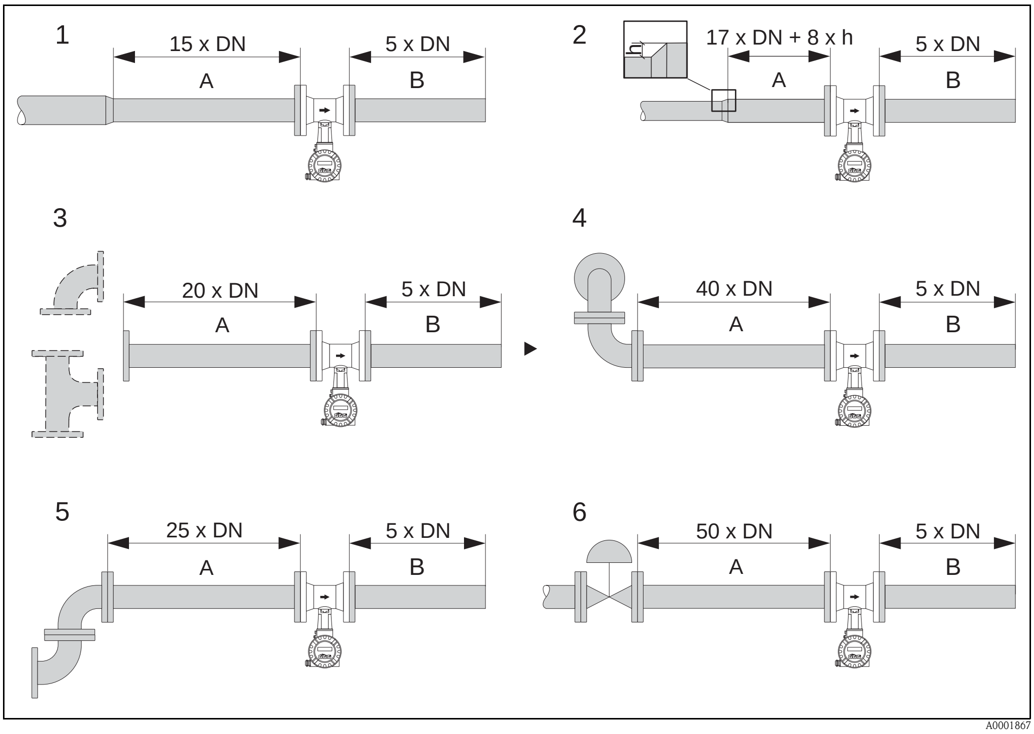
The centering rings supplied are used to mount and center the wafer-style devices. A mounting set consisting of tie rods, seals, nuts and washers can be ordered separately.



Mounting wafer version
1 = Nut
2 = Washer
3 = Tie rod
4 = Centering ring (is supplied with the device)
5 = Seal

Inlet and outlet run

As a minimum, the inlet and outlet runs shown below must be observed to achieve the specified accuracy of the device. The longest inlet run shown must be observed if two or more flow disturbances are present.



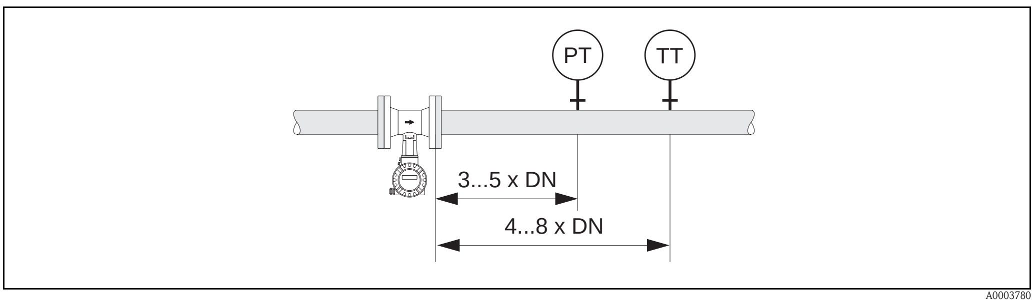
Minimum inlet and outlet runs with various flow obstructions

A = Inlet run
B = Outlet run
h = Difference in expansion
1 = Reduction
2 = Extension
3 = 90° elbow or T-piece
4 = 2 × 90° elbow, 3-dimensional
5 = 2 × 90° elbow
6 = Control valve

Note!
A specially designed perforated plate flow conditioner can be installed if it is not possible to observe the inlet runs required (→ 26).

Outlet runs with pressure and temperature measuring points

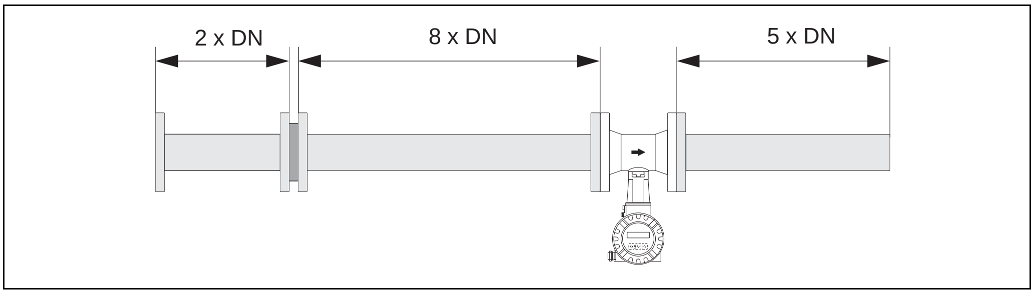
If pressure and temperature measuring points are installed after the device, please ensure there is a large enough distance between the device and the measuring point so there are no negative effects on vortex formation in the sensor.



PT = Pressure measuring point
TT = Temperature measuring point

Perforated plate flow conditioner

A specially designed perforated plate flow conditioner, available from Endress+Hauser, can be installed if it is not possible to observe the inlet runs required. The flow conditioner is fitted between two piping flanges and centered with the mounting bolts. Generally, this reduces the inlet run required to 10 x DN with complete accuracy.



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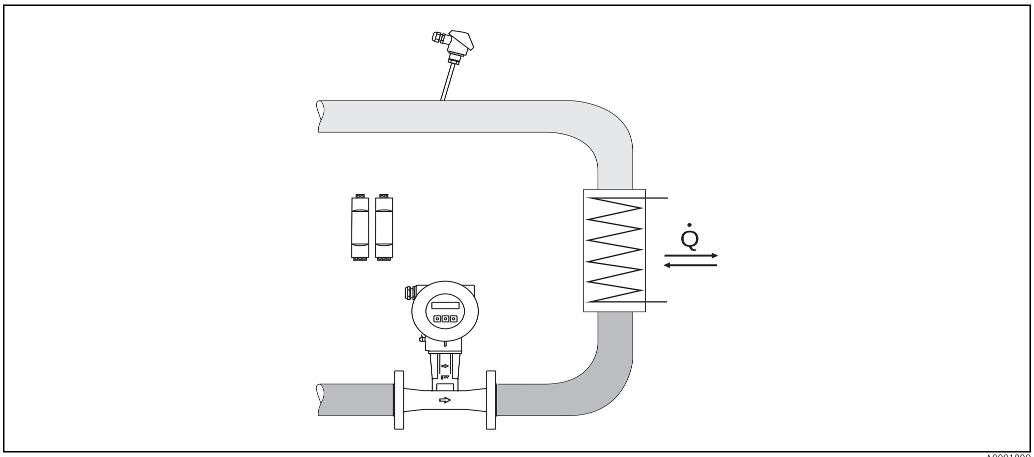
The pressure loss for flow conditioners is calculated as follows:
Δp [mbar] = 0.0085 · ρ [kg/m³] · v² [m/s]

Example with steam
p = 10 bar abs
t = 240 °C → ρ = 4.39 kg/m³
v = 40 m/s
$\Delta p = 0.0085 \cdot 4.39 \cdot 40^2 = 59.7$ mbar

Example with H_2O condensate (80 °C)
ρ = 965 kg/m³
v = 2.5 m/s
$\Delta p = 0.0085 \cdot 965 \cdot 2.5^2 = 51.3$ mbar

Installation for delta heat measurement (Prowirl 73 HART)

- The second temperature measurement takes place by means of a separate sensor and is read in via HART.
- Prowirl 73 generally has to be installed on the steam side for saturated steam delta heat measurement.
- For water-delta heat measurement, Prowirl 73 can be installed on both the cold side and the warm side.
- The inlet and outlet runs specified above must be observed.



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Layout for delta heat measurement of saturated steam and water

Operating conditions: environment

Ambient temperature range

- Compact version:
  - Standard: –40 to +70 °C
  - EEx-d/XP version: –40 to +60 °C
  - ATEX II 1/2 GD version/dust ignition-proof: –20 to +55 °C
  - Display can be read between –20 and +70 °C
- Remote version sensor:
  - Standard:–40 to +85 °C
  - ATEX II 1/2 GD version/dust ignition-proof: –20 to +55 °C
- Remote version transmitter:
  - Standard: –40 to +80 °C
  - EEx-d/XP version: –40 to +60 °C
  - ATEX II 1/2 GD version/dust ignition-proof: –20 to +55 °C
  - Display can be read between –20 and +70 °C
  - Version up to –50 °C on request

When mounting outside, protect from direct sunlight with a protective cover (order number 543199-0001), especially in warmer climates with high ambient temperatures.

Storage temperature

- Standard: –40 to +80 °C
- ATEX II 1/2 GD version/dust ignition-proof: –20 to +55 °C
- Version up to –50 °C on request

Degree of protection

IP 67 (NEMA 4X) in accordance with EN 60529

Vibration resistance

Acceleration up to 1 g, 10 to 500 Hz, following IEC 60068-2-6

Electromagnetic compatibility (EMC)

To IEC/EN 61326 and NAMUR Recommendation NE 21.

Operating conditions: process

Medium temperature range

Prowirl 72

DSC sensor (differential switched capacitor; capacitive sensor)	
DSC standard sensor	–40 to +260 °C
DSC high/low temperature sensor	–200 to +400 °C
DSC sensor Inconel (PN 63 to 160, Class 600, JIS 40K)	–200 to +400 °C
DSC sensor titanium Gr. 5 (PN 250, Class 900 to 1500 and butt-weld version)	–50 to +400 °C
DSC sensor Alloy C-22	–200 to +400 °C
Seals	
Graphite	–200 to +400 °C
Viton	–15 to +175 °C
Kalrez	–20 to +275 °C
Gylon (PTFE)	–200 to +260 °C
Sensor	
Stainless steel	–200 to +400 °C
Alloy C-22	–40 to +260 °C

Special version for high fluid temperatures (on request)	–200 to +450 °C –200 to +440 °C, Ex version

Prowirl 73

DSC sensor (differential switched capacitor; capacitive sensor)

DSC standard sensor	–200 to +400 °C
DSC sensor Inconel (PN 63 to 160, Class 600, JIS 40K in development)	–200 to +400 °C

Seals

Graphite	–200 to +400 °C
Viton	–15 to +175 °C
Kalrez	–20 to +275 °C
Gylon (PTFE)	–200 to +260 °C

Sensor

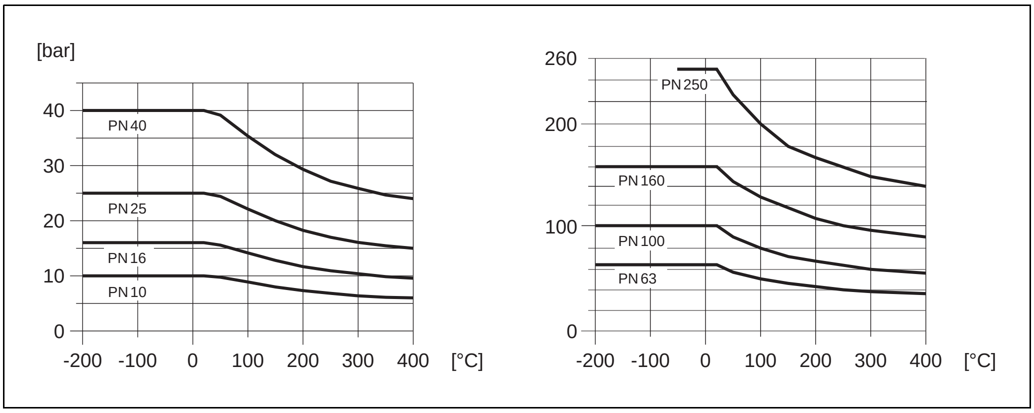
Stainless steel	–200 to +400 °C
Special version for high fluid temperatures (on request)	–200 to +450 °C –200 to +440 °C, Ex version

Medium pressure

Prowirl 72

Pressure-temperature curve to EN (DIN), stainless steel

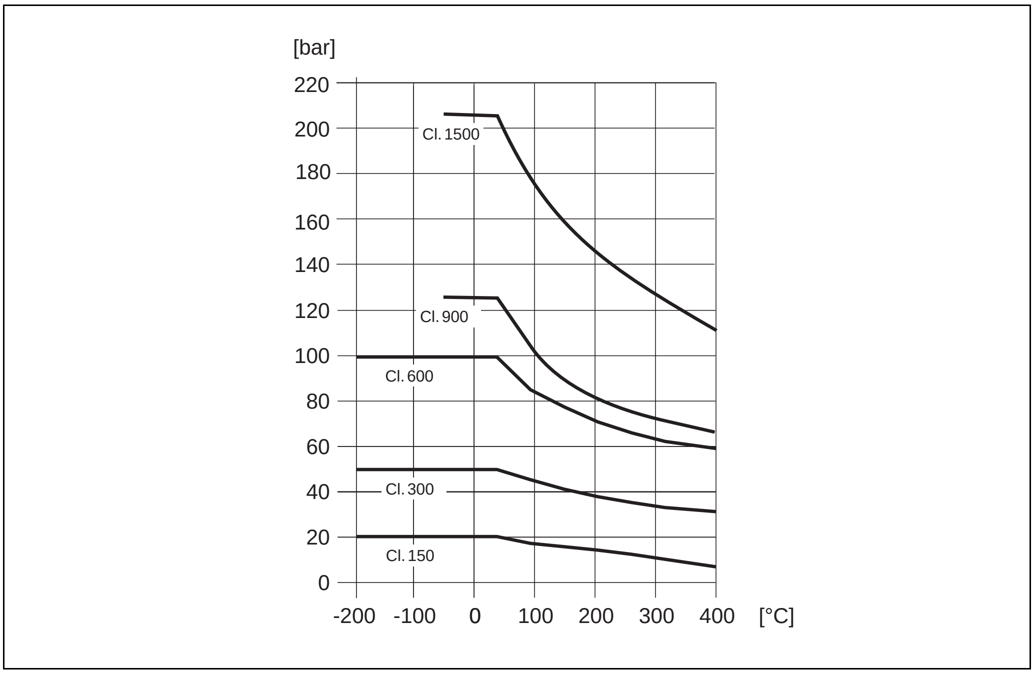
PN 10 to 40 → Prowirl 72W and 72F
PN 63 to 250 → Prowirl 72F



A0003238-en

Pressure-temperature curve to ANSI B16.5, stainless steel

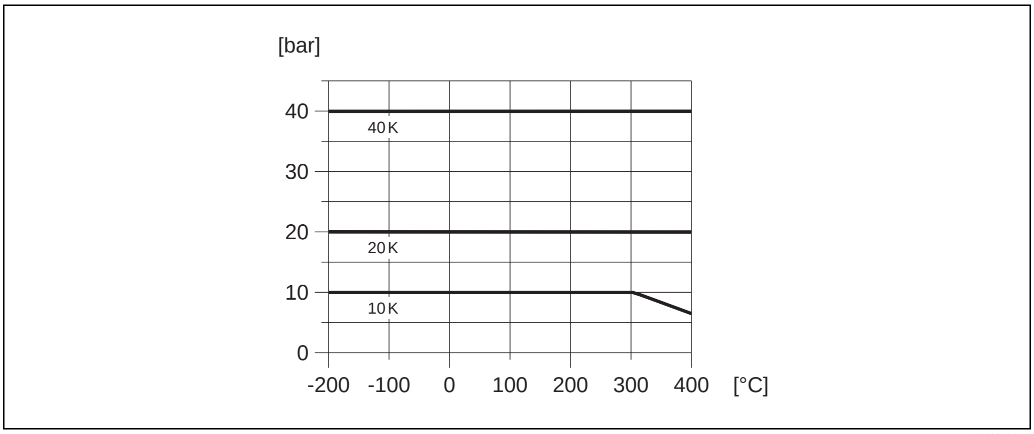
Class 150 to 300 → Prowirl 72W and 72F
Class 600 to 1500 → Prowirl 72F



A0003402-en

Pressure-temperature curve to JIS B2220, stainless steel:

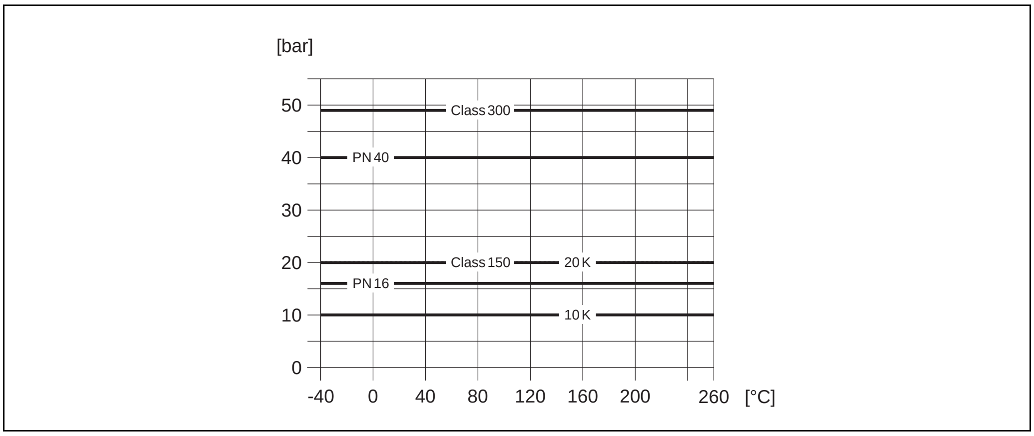
10 to 20K → Prowirl 72W and 72F
40K → Prowirl 72F



A0003404-en

Pressure-temperature curve to EN (DIN), ANSI B16.5 and JIS B2220, Alloy C-22

PN 16 to 40, Class 150 to 300, 10 to 20K → Prowirl 72F

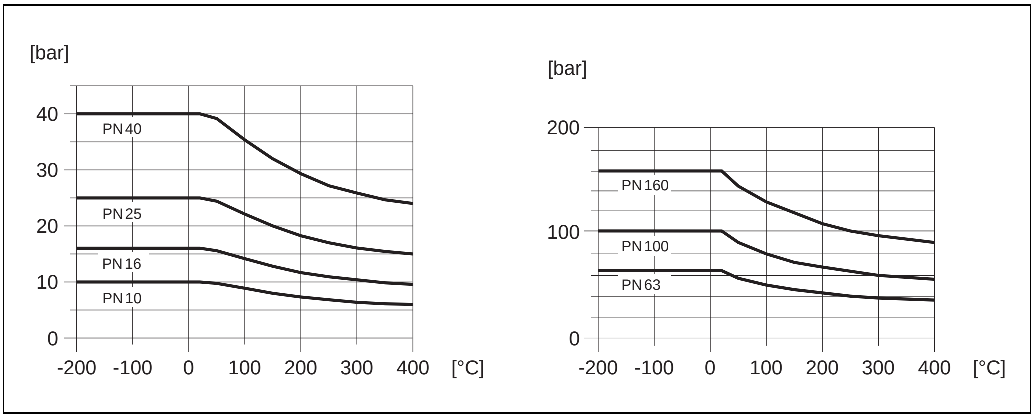


A0003395-en

Prowirl 73

Pressure-temperature curve to EN (DIN), stainless steel

PN 10 to 40 → Prowirl 73W and 73F
PN 63 to 160 → Prowirl 73F (in development)

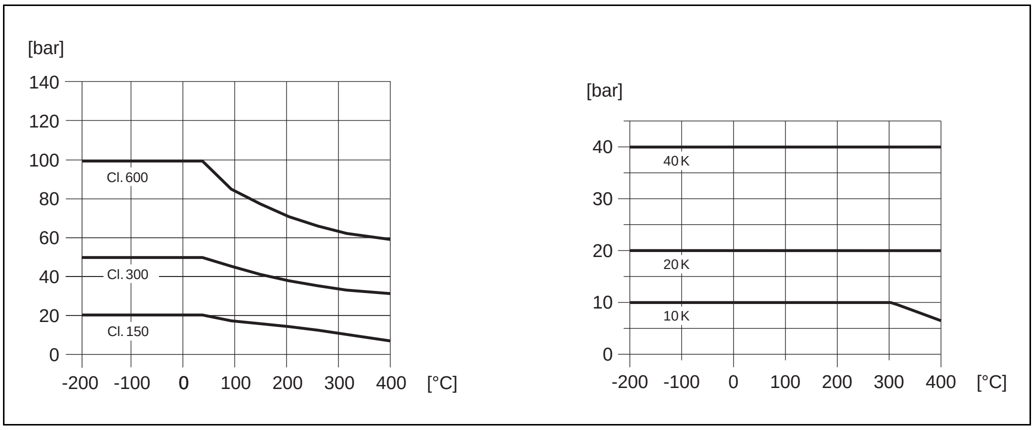


A0007085-en

Pressure-temperature curve to ANSI B16.5 and JIS B2220, stainless steel

ANSI B16.5:
Class 150 to 300 → Prowirl 73W and 73F
Class 600 → Prowirl 73F (in development)

JIS B2220:
10 to 20K → Prowirl 73W and 73F
40K → Prowirl 73F (in development)



A0001923-en

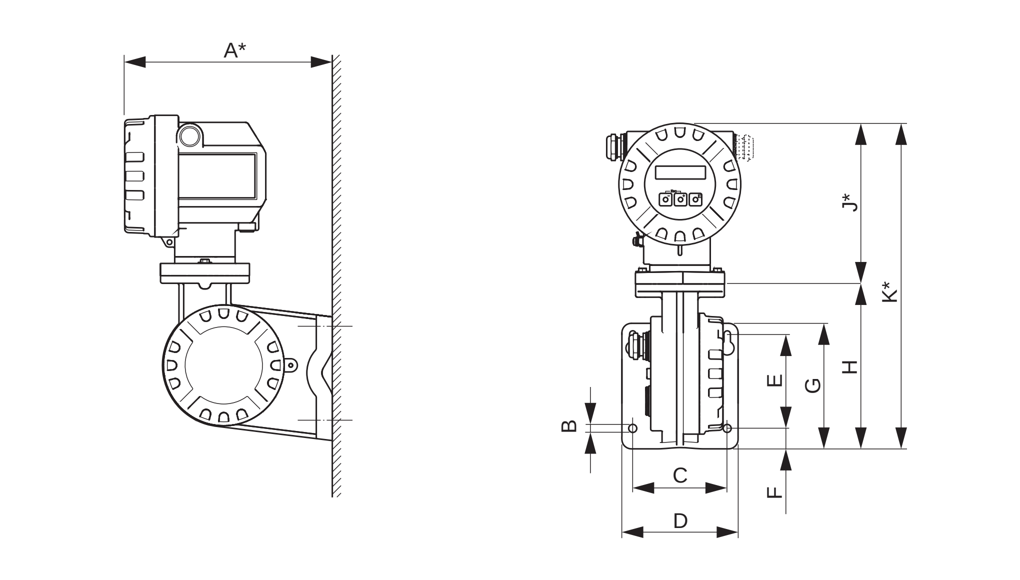
Pressure loss

The pressure loss can be determined with the aid of the Applicator. The Applicator is software for selecting and planning flowmeters. The software is available both via the Internet (www.applicator.com) and on a CD-ROM for local PC installation.

Mechanical construction

Design, dimensions

Dimensions of transmitter, remote version



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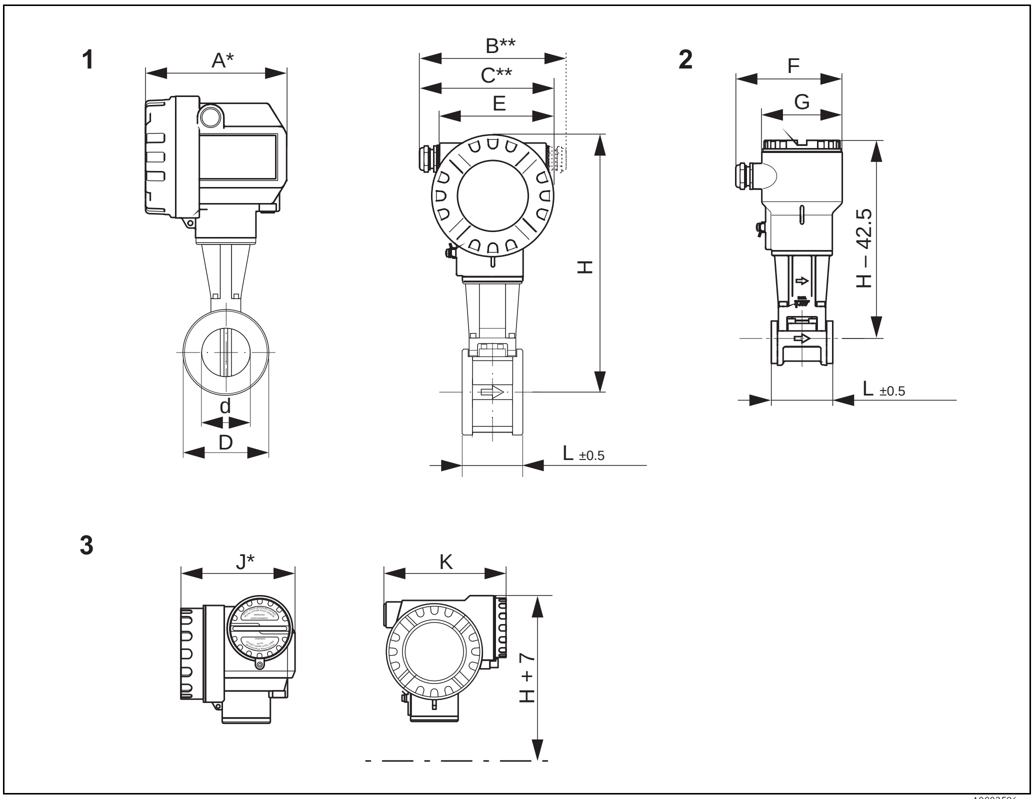
A	B	C	D	E	F	G	H	J	K
[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
232	∅ 8.6 (M8)	100	123	100	23	144	170	170	340

* The following dimensions differ depending on the version:
– The dimension 232 mm changes to 226 mm in the blind version (without local operation).
– The dimension 170 mm changes to 183 mm in the Ex d/XP version.
– The dimension 340 mm changes to 353 mm in the Ex d/XP version.

Note!
The transmitter housing has one cable gland or cable entry. Measuring devices with a pulse, frequency or status output have two cable glands or cable entries (devices with TIIS approval only have one cable gland).

Dimensions of wafer versions
Prowirl 72W, 73W

Wafer version for flanges to:
- EN 1092-1 (DIN 2501), PN 10 to 40
- ANSI B16.5, Class 150 to 300, Sch. 40
- JIS B2220, 10 to 20K, Sch. 40



1 = Standard as well as Ex i/IS and Ex n version
2 = Remote version
3 = Ex d version (transmitter)

A [mm]	B [mm]	C [mm]	E [mm]	F [mm]	G [mm]	J [mm]	K [mm]
149	161 to 181	141 to 151	121	105	95	151	157

* The dimensions change as follows in the blind version (without local operation):
– Standard, Ex i/IS and Ex n version: The dimension 149 mm changes to 142 mm in the blind version.
– Ex d/XP version: The dimension 151 mm changes to 144 mm in the blind version.
** The dimension depends on the cable gland used.

✎ Note!
The transmitter housing has one cable gland or cable entry. Measuring devices with a pulse, frequency or status output have two cable glands or cable entries (devices with TIIS approval only have one cable gland).

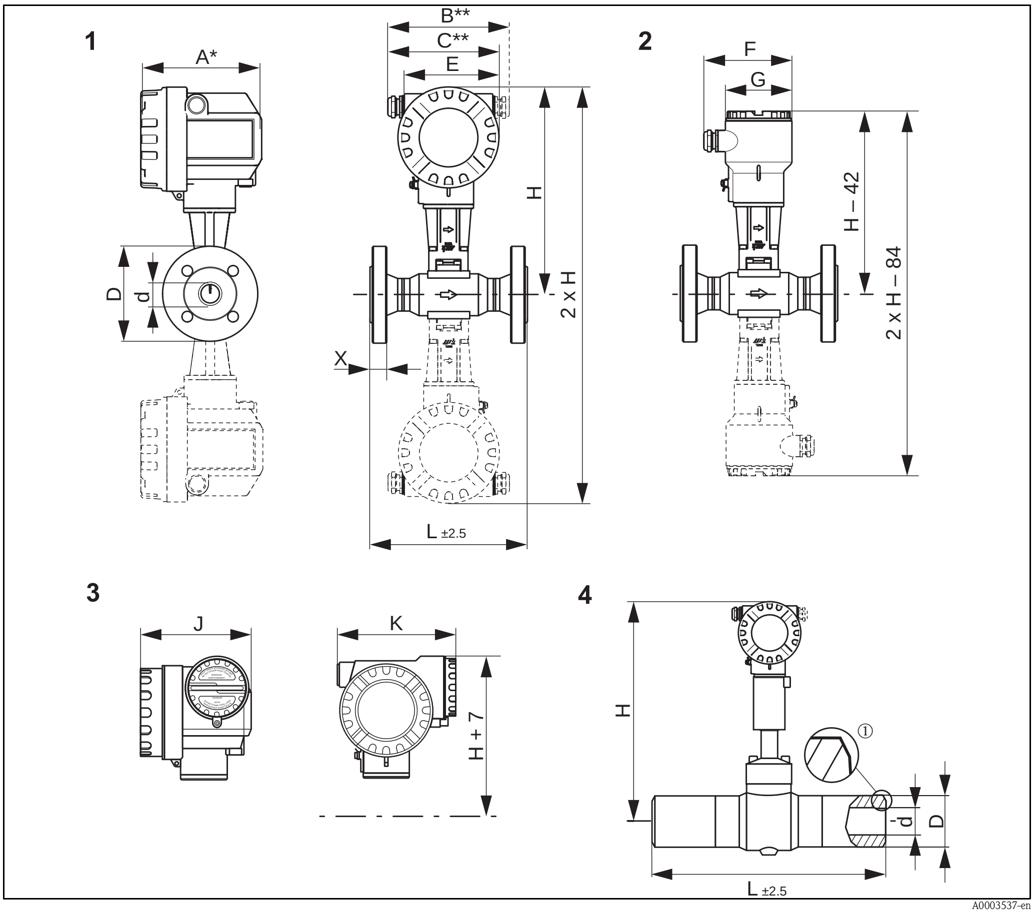
DN		d	D	H[1]	L	Weight[2]
DIN/JIS	ANSI	mm	mm	mm	mm	kg
15	½"	16.5	45.0	247	65	3.0
25	1"	27.6	64.0	257	65	3.2
40	1½"	42.0	82.0	265	65	3.8
50	2"	53.5	92.0	272	65	4.1
80	3"	80.3	127.0	286	65	5.5
100 (DIN)	–	104.8	157.2	299	65	6.5
100 (JIS)	4"	102.3	157.2	299	65	6.5
150	6"	156.8	215.9	325	65	9.0

[1] The dimension H increases by 29 mm for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (version with extended temperature range).
[2] The weight data refer to the compact version. The weight increases by 0.5 kg for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (version with extended temperature range).

Dimensions of flanged versions (standard devices)
Prowirl 72F, 73F

Flange connection dimensions in accordance with flange standard:
- EN 1092-1 (DIN 2501), Ra = 6.3 to 12.5 µm
- Raised face to:
  - EN 1092-1 Form B1 (DIN 2526 Form C), PN 10 to 40, Ra = 6.3 to 12.5 µm, optional with groove to EN 1091-1 Form D (DIN 2512 Form N)
  - EN 1092-1 Form B2 (DIN 2526 Form E), PN 63 to 100, Ra = 1.6 to 3.2 µm[1) 2)]
  - DIN 2526 Form E, PN 160 to 250[3)], Ra = 1.6 to 3.2 µm[1)]
- ANSI B16.5, Class 150 to 1500, Ra = [1) 2)]125 to 250 µin[2)]
- JIS B2220, 10 to 40K[1)], Ra = 125 to 250 µin

1) Prowirl 73F: PN 63 to 160, Class 600 and 40K in development
2) Prowirl 73F: only Class 150 to 600
3) Prowirl 73F: only PN 160



1 = Standard, Ex i and Ex n version ; d: connection pipe internal diameter
2 = Remote version
3 = Ex d /XP version (transmitter)
4 = Butt-weld version (only available for Prowirl 72)

① Groove type 22 in accordance with DIN 2559
Dotted line: Dualsens version

A [mm]	B [mm]	C [mm]	E [mm]	F [mm]	G [mm]	J [mm]	K [mm]
149	161 to 181	141 to 151	121	105	95	151	161

A [mm]	B [mm]	C [mm]	E [mm]	F [mm]	G [mm]	J [mm]	K [mm]
* The dimensions below change as follows in the blind version (without local operation): – Standard, Ex i/IS and Ex n version: The dimension 149 mm changes to 142 mm in the blind version. – Ex d/XP version: The dimension 151 mm changes to 144 mm in the blind version. ** The dimension depends on the cable gland used. Note! The transmitter housing has one cable gland or cable entry. Measuring devices with a pulse, frequency or status output have two cable glands or cable entries (devices with TIIS approval only have one cable gland).							

Flanged versions (standard devices) to EN 1092-1 (DIN 2501)
Prowirl 72F, 73F

DN	Pressure rating	d [mm]	D [mm]	H[3] [mm]	L [mm]	X [mm]	Weight[4] [kg]
15[5]	PN 40	17.3	95.0	248	200	16	5
	PN 160[2]	17.3	105.0	288	200	23	7
	PN 250[1]	16.1	130.0	310	248	26	15
	Butt-weld[1]	16.1	23.4	310	248	–	9
25[5]	PN 40	28.5	115.0	255	200	18	7
	PN 100[2]	28.5	140.0	295	200	27	11
	PN 160[2]	27.9	140.0	295	200	27	11
	PN 250[1]	26.5	150.0	310	248	28	16
	Butt-weld[1]	24.3	35.6	310	248	–	9
40	PN 40	43.1	150.0	263	200	18	9
	PN 100[2]	42.5	170.0	303	200	31	15
	PN 160[2]	41.1	170.0	303	200	31	15
	PN 250[1] [5]	38.1	185.0	315	278	34	21
	Butt-weld[1] [5]	38.1	48.3	315	278	–	9
50	PN 40	54.5	165.0	270	200	20	11
	PN 63[2]	54.5	180.0	310	200	33	17
	PN 100[2]	53.9	195.0	310	200	33	19
	PN 160[2]	52.3	195.0	310	200	33	19
	PN 250[1] [5]	47.7	200.0	306	288	38	23
	Butt-weld[1] [5]	47.7	60.3	306	288	–	9
80	PN 40	82.5	200.0	283	200	24	16
	PN 63[2]	81.7	215.0	323	200	39	24
	PN 100[2]	80.9	230.0	323	200	39	27
	PN 160[2]	76.3	230.0	323	200	39	27
	PN 250[1] [5]	79.6	255.0	311	325	46	41
	Butt-weld[1] [5]	79.6	101.6	311	325	–	13
100	PN 16	107.1	220.0	295	250	20	18
	PN 40	107.1	235.0	295	250	24	21
	PN 63[2]	106.3	250.0	335	250	49	39
	PN 100[2]	104.3	265.0	335	250	49	42
	PN 160[2]	98.3	265.0	335	250	49	42
	PN 250[1] [5]	98.6	300.0	323	394	54	64
	Butt-weld[1] [5]	98.6	127.0	323	394	–	21

Flanged versions (standard devices) to EN 1092-1 (DIN 2501) Prowirl 72F, 73F							
DN	Pressure rating	d [mm]	D [mm]	H[3] [mm]	L [mm]	X [mm]	Weight[4] [kg]
150	PN 16	159.3	285.0	319	300	22	30
	PN 40	159.3	300.0	319	300	28	37
	PN 63[2]	157.1	345.0	359	300	64	86
	PN 100[2]	154.1	355.0	359	300	64	88
	PN 160[2]	146.3	355.0	359	300	64	88
	PN 250[1] [5]	142.8	390.0	339	566	68	152
	Butt-weld[1] [5]	142.8	177.8	339	566	–	53
200	PN 10	207.3	340.0	348	300	42	63
	PN 16	207.3	340.0	348	300	42	62
	PN 25	206.5	360.0	348	300	42	68
	PN 40	206.5	375.0	348	300	42	72
250[5]	PN 10	260.4	395	375	380	48	88
	PN 16	260.4	405	375	380	48	92
	PN 25	258.8	425	375	380	48	100
	PN 40	258.8	450	375	380	48	111
300[5]	PN 10	309.7	445	398	450	51	121
	PN 16	309.7	460	398	450	51	129
	PN 25	307.9	485	398	450	51	140
	PN 40	307.9	515	398	450	51	158

[1] In contrast to the other versions, devices have a sensor in the bluff body. Only available for 72F.
[2] Pressure ratings are in development for Prowirl 73.
[3] The dimension H increases by 29 mm for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure ratings up to PN 40, Cl. 300, 20K).
[4] The weight data refer to the compact version. The weight increases by 0.5 kg for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure rating up to PN 40, Cl. 300, 20K). The weight is increased by 6 kg for the Dualsens version.
[5] Not available as Dualsens version.

Flanged versions (standard devices) to ANSI B16.5 Prowirl 72F, 73F								
DN	Pressure rating		d mm	D mm	H[3] mm	L mm	X mm	Weight[4] kg
½" [5]	Schedule 40	Cl. 150	15.7	88.9	248	200	11.2	5
		Cl. 300	15.7	95.0	248	200	14.2	5
	Schedule 80	Cl. 150	13.9	88.9	248	200	11.2	5
		Cl. 300	13.9	95.0	248	200	14.2	5
		Cl. 600[2]	13.9	95.3	288	200	23	6
		Cl. 1500[1]	14.0	120.6	310	262	22.3	13
		Butt-weld[1]	14.0	21.3	310	248	–	9
1" [5]	Schedule 40	Cl. 150	26.7	107.9	255	200	15.7	6
		Cl. 300	26.7	123.8	255	200	19.1	7
	Schedule 80	Cl. 150	24.3	107.9	255	200	15.7	6
		Cl. 300	24.3	123.8	255	200	19.1	7
		Cl. 600[2]	24.3	124.0	295	200	27	9
		Cl. 1500[1]	24.3	149.3	310	287.7	28.4	17
		Butt-weld[1]	24.3	33.4	310	248	–	9

Flanged versions (standard devices) to ANSI B16.5 Prowirl 72F, 73F								
DN	Pressure rating		d mm	D mm	H[3)] mm	L mm	X mm	Weight[4)] kg
1½"	Schedule 40	Cl. 150	40.9	127.0	263	200	17.5	8
		Cl. 300	40.9	155.6	263	200	20.6	10
	Schedule 80	Cl. 150	38.1	127.0	263	200	17.5	8
		Cl. 300	38.1	155.6	263	200	20.6	10
		Cl. 600[2)]	38.1	155.4	303	200	31	13
		Cl. 1500[1) 5)]	38.1	177.8	315	305.8	31.7	20
		Butt-weld[1) 5)]	38.1	48.3	315	278	–	9
2"	Schedule 40	Cl. 150	52.6	152.4	270	200	19.1	10
		Cl. 300	52.6	165.0	270	200	22.4	12
	Schedule 80	Cl. 150	49.2	152.4	270	200	19.1	10
		Cl. 300	49.2	165.0	270	200	22.4	12
		Cl. 600[2)]	49.2	165.1	310	200	33	14
		Cl. 1500[1) 5)]	49.3	215.9	306	344	38.1	30
		Butt-weld[1) 5)]	47.7	60.3	306	288	–	9
3"	Schedule 40	Cl. 150	78.0	190.5	283	200	23.9	15
		Cl. 300	78.0	210.0	283	200	28.4	19
	Schedule 80	Cl. 150	73.7	190.5	283	200	23.9	15
		Cl. 300	73.7	210.0	283	200	28.4	19
		Cl. 600[2)]	73.7	209.6	323	200	39	22
		Cl. 900[1) 5)]	73.7	241.3	311	349	38.1	37
		Cl. 1500[1) 5)]	73.7	266.7	311	380.4	47.7	49
		Butt-weld[1) 5)]	73.7	95.7	311	325	–	13
4"	Schedule 40	Cl. 150	102.4	228.6	295	250	24.5	22
		Cl. 300	102.4	254.0	295	250	31.8	30
	Schedule 80	Cl. 150	97.0	228.6	295	250	24.5	22
		Cl. 300	97.0	254.0	295	250	31.8	30
		Cl. 600[2)]	97.0	273.1	335	250	49	43
		Cl. 900[1) 5)]	97.3	292.1	323	408	44.4	57
		Cl. 1500[1) 5)]	97.3	311.1	323	427	53.8	71
		Butt-weld[1) 5)]	97.3	125.7	323	394	–	21
6"	Schedule 40	Cl. 150	154.2	279.4	319	300	25.4	34
		Cl. 300	154.2	317.5	319	300	36.6	50
	Schedule 80	Cl. 150	146.3	279.4	319	300	25.4	34
		Cl. 300	146.3	317.5	319	300	36.6	50
		Cl. 600[2)]	146.3	355.6	359	300	64	87
		Cl. 900[1) 5)]	131.8	381.0	339	538	55.6	131
		Cl. 1500[1) 5)]	146.3	393.7	339	602	82.5	173
		Butt-weld[1) 5)]	146.3	168.3	339	566	–	53
8"	Schedule 40	Cl. 150	202.7	342.9	348	300	42	64
		Cl. 300	202.7	381.0	348	300	42	76
10" [5)]	Schedule 40	Cl. 150	254.5	406.4	375	380	48	92
		Cl. 300	254.5	444.5	375	380	48	109
12" [5)]	Schedule 40	Cl. 150	304.8	482.6	398	450	60	143
		Cl. 300	304.8	520.7	398	450	60	162

Flanged versions (standard devices) to ANSI B16.5 Prowirl 72F, 73F							
DN	Pressure rating	d mm	D mm	H[3)] mm	L mm	X mm	Weight[4)] kg

[1)] In contrast to the other versions, devices have a sensor in the bluff body.
Only available for 72F.
[2)] Pressure ratings are in development for Prowirl 73.
[3)] The dimension H increases by 29 mm for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure ratings up to PN 40, Cl. 300, 20K).
[4)] The weight data refer to the compact version. The weight increases by 0.5 kg for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure rating up to PN 40, Cl. 300, 20K). The weight is increased by 6 kg for the Dualsens version.
[5)] Not available as Dualsens version.

Flanged versions (standard devices) to JIS B2220 Prowirl 72F, 73F								
DN	Pressure rating		d [mm]	D [mm]	H[2)] [mm]	L [mm]	X [mm]	Weight[3)] [kg]
15[4)]	Schedule 40	20K	16.1	95	248	200	14	5
	Schedule 80	20K	13.9	95	248	200	14	5
	Schedule 80	40K[1)]	13.9	115	288	200	23	8
25[4)]	Schedule 40	20K	27.2	125	255	200	16	7
	Schedule 80	20K	24.3	125	255	200	16	7
	Schedule 80	40K[1)]	24.3	130	295	200	27	10
40	Schedule 40	20K	41.2	140	263	200	18	9
	Schedule 80	20K	38.1	140	263	200	18	9
	Schedule 80	40K[1)]	38.1	160	303	200	31	14
50	Schedule 40	10K	52.7	155	270	200	16	10
	Schedule 40	20K	52.7	155	270	200	18	10
	Schedule 80	10K	49.2	155	270	200	16	10
	Schedule 80	20K	49.2	155	270	200	18	10
	Schedule 80	40K[1)]	49.2	165	310	200	33	15
80	Schedule 40	10K	78.1	185	283	200	18	14
	Schedule 40	20K	78.1	200	283	200	22	15
	Schedule 80	10K	73.7	185	283	200	18	14
	Schedule 80	20K	73.7	200	283	200	22	15
	Schedule 80	40K[1)]	73.7	210	323	200	39	24
100	Schedule 40	10K	102.3	210	295	250	18	18
	Schedule 40	20K	102.3	225	295	250	24	21
	Schedule 80	10K	97.0	210	295	250	18	18
	Schedule 80	20K	97.0	225	295	250	24	22
	Schedule 80	40K[1)]	97.0	240	335	250	49	36
150	Schedule 40	10K	151.0	280	319	300	22	33
	Schedule 40	20K	151.0	305	319	300	28	40
	Schedule 80	10K	146.3	280	319	300	22	33
	Schedule 80	20K	146.3	305	319	300	28	40
	Schedule 80	40K[1)]	146.6	325	359	300	64	77
200	Schedule 40	10K	202.7	330	348	300	42	58
	Schedule 40	20K	202.7	350	348	300	42	64
250[4)]	Schedule 40	10K	254.5	400	375	380	48	90
	Schedule 40	20K	254.5	430	375	380	48	104

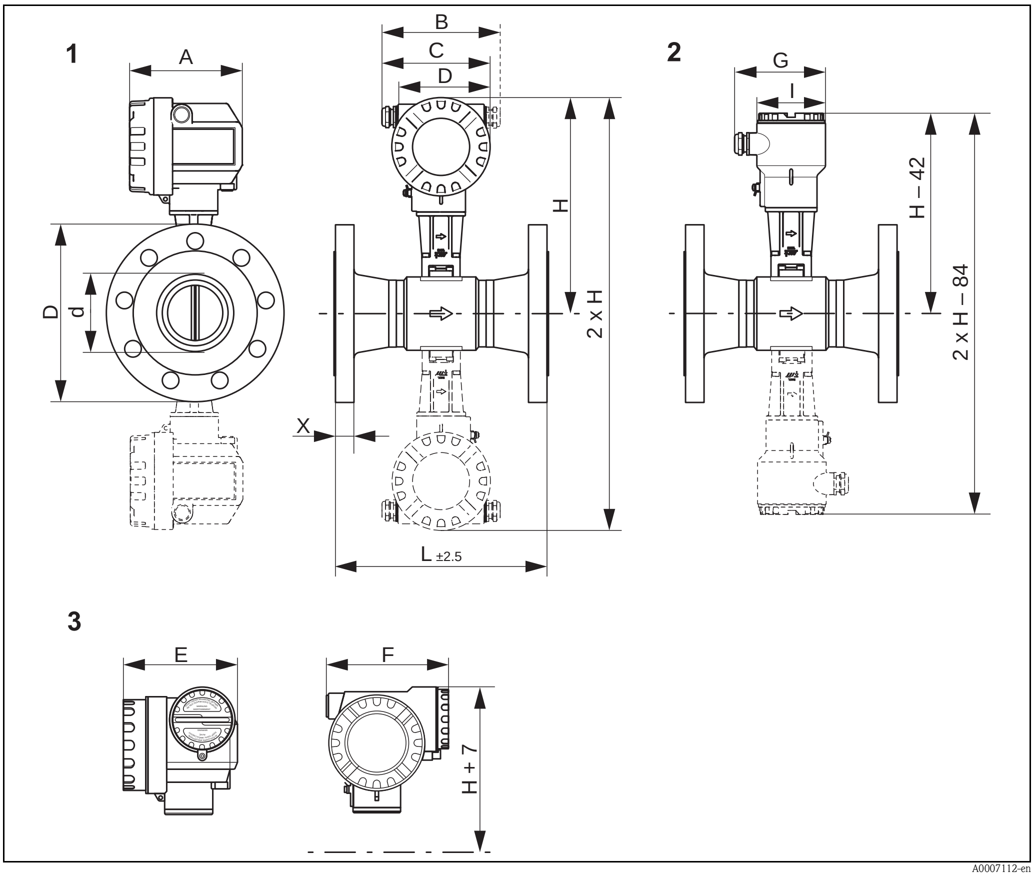
Flanged versions (standard devices) to JIS B2220 Prowirl 72F, 73F								
DN	Pressure rating		d [mm]	D [mm]	H[2)] [mm]	L [mm]	X [mm]	Weight[3)] [kg]
300[4)]	Schedule 40	10K	304.8	445	398	450	51	119
	Schedule 40	20K	304.8	480	398	450	51	134

1) Pressure rating 40K for Prowirl 73 in development.
2) The dimension H increases by 29 mm for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure ratings up to PN 40, Cl. 300, 20K).
3) The weight data refer to the compact version. The weight increases by 0.5 kg for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure rating up to PN 40, Cl. 300, 20K). The weight is increased by 6 kg for the Dualsens version.
4) Not available as Dualsens version.

Dimensions of flanged versions "R Style" (single reduction of line size) Prowirl 72F, 73F

Versions with integrated line size reduction (hydraulically effective cross-section smaller than connection nominal diameter) offering improved measurement in the lower flow range.

Flange connection dimensions in accordance with flange standard:
- EN 1092-1 (DIN 2501), Ra = 6.3 to 12.5 µm
- Raised face to:
  EN 1092-1 Form B1 (DIN 2526 Form C), PN 10 to 40, Ra = 6.3 to 12.5 µm,
  optional with groove to EN 1091-1 Form D (DIN 2512 Form N)
- ANSI B16.5, Class 150 to 300, Ra = 125 to 250 µin
- JIS B2220, 10 to 20K, Ra = 125 to 250 µin



1 = Standard, Ex i and Ex n version ; d: connection pipe internal diameter
2 = Remote version
3 = Ex d /XP version (transmitter)

Dotted line: Dualsens version

A [mm]	B [mm]	C [mm]	E [mm]	F [mm]	G [mm]	J [mm]	K [mm]
149	161 to 181	141 to 151	121	105	95	151	161

* The dimensions below change as follows in the blind version (without local operation):
– Standard, Ex i/IS and Ex n version: The dimension 149 mm changes to 142 mm in the blind version.
– Ex d/XP version: The dimension 151 mm changes to 144 mm in the blind version.
** The dimension depends on the cable gland used.

Note!
The transmitter housing has one cable gland or cable entry. Measuring devices with a pulse, frequency or status output have two cable glands or cable entries (devices with TIIS approval only have one cable gland).

Flanged versions (R Style) to EN 1092-1 (DIN 2501) Prowirl 72F, 73F								
DN	Inner diameter	Pressure rating	d [mm]	D [mm]	H[1)] [mm]	L [mm]	X [mm]	Weight[2)] [kg]
25[3)]	15	PN 40	22.0	115	248	200	18.0	6
40[3)]	25	PN 40	30.0	150	255	200	21.0	10
50	40	PN 40	45.0	165	263	200	22.0	12
80	50	PN 40	56.5	200	270	200	25.0	16
100	80	PN 16	87.0	220	283	250	22.0	20
		PN 40	87.0	235	283	250	26.5	23
150	100	PN 16	112.0	285	295	300	25.0	36
		PN 40	112.0	300	295	300	31.0	42
200	150	PN 10	146.3	340	319	300	24.0	48
		PN 16	146.3	340	319	300	24.0	48
		PN 25	146.3	360	319	300	30.0	55
		PN 40	146.3	375	319	300	36.5	63

1) The dimension H increases by 29 mm for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure ratings up to PN 40, Cl. 300, 20K).
2) The weight data refer to the compact version. The weight increases by 0.5 kg for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure rating up to PN 40, Cl. 300, 20K). The weight is increased by 6 kg for the Dualsens version.
3) Not available as Dualsens version.

Flanged versions (R Style) to ANSI B16.5 Prowirl 72F, 73F									
DN	Inner diameter	Pressure rating		d mm	D mm	H[1)] mm	L mm	X mm	Weight[2)] kg
1" [3)]	½"	Sched. 40	Cl. 150	22.0	108.0	248	200	18	6
		Sched. 40	Cl. 300	22.0	124.0	248	200	22.0	8
		Sched. 80	Cl. 150	22.0	108.0	248	200	18.5	6
		Sched. 80	Cl. 300	22.0	124.0	248	200	22.0	8
1½" [3)]	1"	Sched. 40	Cl. 150	30.0	127.0	255	200	18.0	7
		Sched. 40	Cl. 300	30.0	155.4	255	200	25.0	10
		Sched. 80	Cl. 150	30.0	127.0	255	200	18.0	7
		Sched. 80	Cl. 300	30.0	155.4	255	200	25.0	10
2"	1½"	Sched. 40	Cl. 150	45.0	152.4	263	200	20.0	10
		Sched. 40	Cl. 300	45.0	165.1	263	200	25.0	12
		Sched. 80	Cl. 150	45.0	152.4	263	200	20.0	10
		Sched. 80	Cl. 300	45.0	165.1	263	200	25.0	12
3"	2"	Sched. 40	Cl. 150	56.5	190.5	270	200	23.9	15
		Sched. 40	Cl. 300	56.5	209.6	270	200	28.9	22
		Sched. 80	Cl. 150	56.5	190.5	270	200	23.9	15
		Sched. 80	Cl. 300	56.5	209.6	270	200	28.9	22
4"	3"	Sched. 40	Cl. 150	87.0	228.6	283	250	24.5	22
		Sched. 40	Cl. 300	87.0	254.0	283	250	31.8	31
		Sched. 80	Cl. 150	87.0	228.6	283	250	24.5	22
		Sched. 80	Cl. 300	87.0	254.0	283	250	31.8	31

Flanged versions (R Style) to ANSI B16.5 Prowirl 72F, 73F										
DN	Inner diameter	Pressure rating		d mm	D mm	H[1] mm	L mm	X mm	Weight[2] kg
6"	4"	Sched. 40	Cl. 150	112.0	279.4	295	300	25.5	38
		Sched. 40	Cl. 300	112.0	317.5	295	300	38.5	55
		Sched. 80	Cl. 150	112.0	279.4	295	300	26.0	38
		Sched. 80	Cl. 300	112.0	317.5	295	300	39.0	55
8"	6"	Sched. 40	Cl. 150	146.3	342.9	319	300	28.4	55
		Sched. 40	Cl. 300	146.3	381	319	300	41.1	75

[1] The dimension H increases by 29 mm for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure ratings up to PN 40, Cl. 300, 20K).
[2] The weight data refer to the compact version. The weight increases by 0.5 kg for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure rating up to PN 40, Cl. 300, 20K). The weight is increased by 6 kg for the Dualsens version.
[3] Not available as Dualsens version.

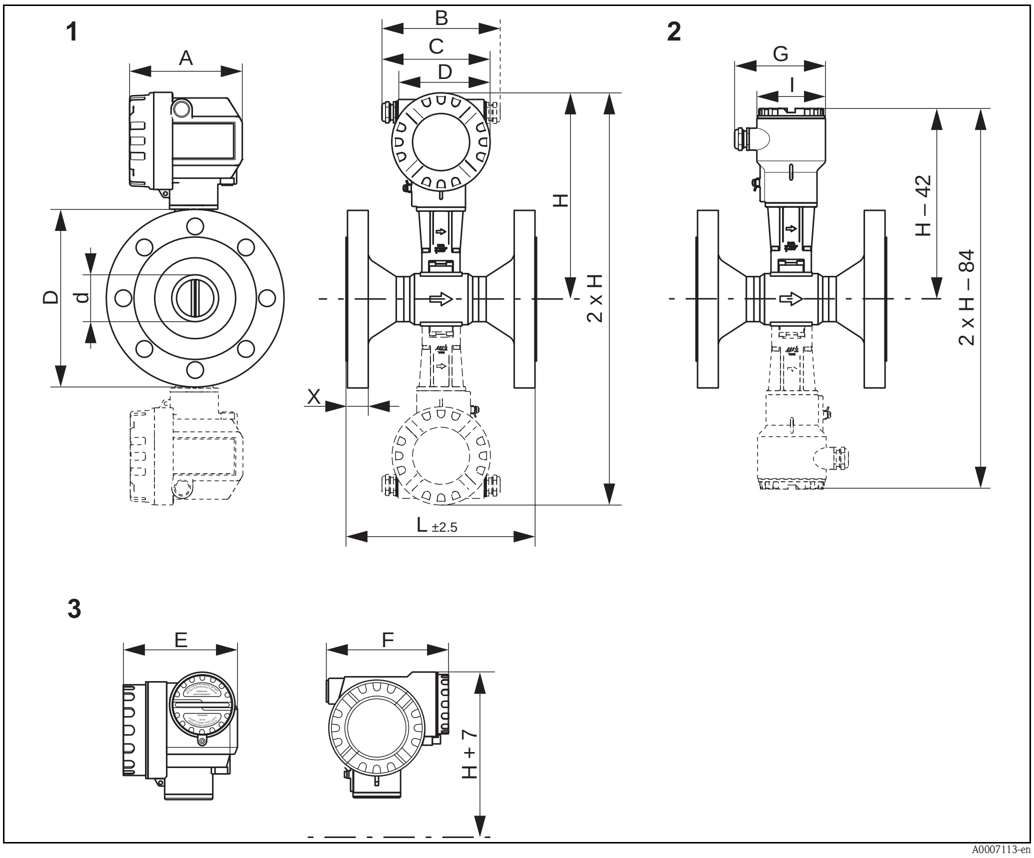
Flanged versions (R Style) to JIS B2220 Prowirl 72F, 73F										
DN	Inner diameter	Pressure rating		d [mm]	D [mm]	H[1)] [mm]	L [mm]	X [mm]	Weight[2)] [kg]
25[3)]	15	Sched. 40	20K	22.0	125	248	200	18.5	7
		Sched. 80	20K	22.0	125	248	200	18.5	7
40[3)]	25	Sched. 40	20K	30.0	140	255	200	18.5	8
		Sched. 80	20K	30.0	140	255	200	19.0	8
50	40	Sched. 40	10K	45.0	155	263	200	20.0	10
		Sched. 40	20K	45.0	155	263	200	22.0	10
		Sched. 80	10K	45.0	155	263	200	20.0	10
		Sched. 80	20K	45.0	155	263	200	22.0	10
80	50	Sched. 40	10K	56.5	185	270	200	22.0	13
		Sched. 40	20K	56.5	200	270	200	26.5	16
		Sched. 80	10K	56.5	185	270	200	22.0	13
		Sched. 80	20K	56.5	200	270	200	27.0	16
100	80	Sched. 40	10K	87.0	210	283	250	22.0	17
		Sched. 40	20K	87.0	225	283	250	25.5	20
		Sched. 80	10K	87.0	210	283	250	22.0	17
		Sched. 80	20K	87.0	225	283	250	26.0	20
150	100	Sched. 40	10K	112.0	280	295	300	31.0	36
		Sched. 40	20K	112.0	305	295	300	37.5	46
		Sched. 80	10K	112.0	280	295	300	31.5	36
		Sched. 80	20K	112.0	305	295	300	37.5	46
200	150	Sched. 40	10K	146.3	330	319	300	26.5	45
		Sched. 40	20K	146.3	350	319	300	31	53

1) The dimension H increases by 29 mm for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure ratings up to PN 40, Cl. 300, 20K).
2) The weight data refer to the compact version. The weight increases by 0.5 kg for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure rating up to PN 40, Cl. 300, 20K). The weight is increased by 6 kg for the Dualsens version.
3) Not available as Dualsens version.

Dimensions of flanged versions "S Style" (double reduction of line size) Prowirl 72F, 73F

Versions with integrated line size reduction (hydraulically effective cross-section smaller than connection nominal diameter) offering improved measurement in the lower flow range.

Flange connection dimensions in accordance with flange standard:
- EN 1092-1 (DIN 2501), Ra = 6.3 to 12.5 µm
- Raised face to:
  EN 1092-1 Form B1 (DIN 2526 Form C), PN 10 to 40, Ra = 6.3 to 12.5 µm,
  optional with groove to EN 1091-1 Form D (DIN 2512 Form N)
- ANSI B16.5, Class 150 to 300, Ra = 125 to 250 µin
- JIS B2220, 10 to 20K, Ra = 125 to 250 µin



1 = Standard, Ex i and Ex n version ; d: connection pipe internal diameter
2 = Remote version
3 = Ex d/XP version (transmitter)

Dotted line: Dualsens version

A [mm]	B [mm]	C [mm]	E [mm]	F [mm]	G [mm]	J [mm]	K [mm]
149	161 to 181	141 to 151	121	105	95	151	161

* The dimensions below change as follows in the blind version (without local operation):
– Standard, Ex i/IS and Ex n version: The dimension 149 mm changes to 142 mm in the blind version.
– Ex d/XP version: The dimension 151 mm changes to 144 mm in the blind version.
** The dimension depends on the cable gland used.

✎ Note!
The transmitter housing has one cable gland or cable entry. Measuring devices with a pulse, frequency or status output have two cable glands or cable entries (devices with TIIS approval only have one cable gland).

Flanged versions (S Style) to EN 1092-1 (DIN 2501) Prowirl 72F, 73F								
DN	Inner diameter	Pressure rating	d [mm]	D [mm]	H[1)] [mm]	L [mm]	X [mm]	Weight[2)] [kg]
40[3)]	15	PN 40	22	150	248	200	21.0	9
50[3)]	25	PN 40	30	165	255	200	21.0	11
80	40	PN 40	45	200	263	200	25.5	16
100	50	PN 16	62	220	270	250	24.0	19
		PN 40	62	235	270	250	27.5	22
150	80	PN 16	92	285	283	300	25.0	32
		PN 40	92	300	283	300	32.0	42
200	100	PN 10	112	340	295	300	26.0	48
		PN 16	112	340	295	300	27.0	48
		PN 25	112	360	295	300	33.5	59
		PN 40	112	375	295	300	38.5	69
250	150	PN 10	202.7	395	319	380	24	64
		PN 16	202.7	405	319	380	27	66.5
		PN 25	202.7	425	319	380	32	79
		PN 40	202.7	450	319	380	39	103

1) The dimension H increases by 29 mm for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure ratings up to PN 40, Cl. 300, 20K).
2) The weight data refer to the compact version. The weight increases by 0.5 kg for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure rating up to PN 40, Cl. 300, 20K). The weight is increased by 6 kg for the Dualsens version.
3) Not available as Dualsens version.

Flanged versions (S Style) to ANSI B16.5 Prowirl 72F, 73F									
DN	Inner dia-meter	Pressure rating		d mm	D mm	H[1)] mm	L mm	X mm	Weight[2)] kg
1½" [3)]	½"	Sched. 40	Cl. 150	22	127.0	248	200	19.0	8
		Sched. 40	Cl. 300	22	155.4	248	200	27.0	11
		Sched. 80	Cl. 150	22	127.0	248	200	19.5	8
		Sched. 80	Cl. 300	22	155.4	248	200	27.0	11
2" [3)]	1"	Sched. 40	Cl. 150	30	152.4	255	200	21.0	10
		Sched. 40	Cl. 300	30	165.1	255	200	26.0	13
		Sched. 80	Cl. 150	30	152.4	255	200	21.0	10
		Sched. 80	Cl. 300	30	165.1	255	200	26.0	13
3"	1½"	Sched. 40	Cl. 150	45	190.5	263	200	25.0	17
		Sched. 40	Cl. 300	45	209.6	263	200	37.9	22
		Sched. 80	Cl. 150	45	190.5	263	200	25.0	17
		Sched. 80	Cl. 300	45	209.6	263	200	37.9	22
4"	2"	Sched. 40	Cl. 150	62	228.6	270	250	26.5	23
		Sched. 40	Cl. 300	62	254.0	270	250	31.8	31
		Sched. 80	Cl. 150	62	228.6	270	250	26.5	23
		Sched. 80	Cl. 300	62	254.0	270	250	31.8	31
6"	3"	Sched. 40	Cl. 150	92	279.4	283	300	26.5	40
		Sched. 40	Cl. 300	92	317.5	283	300	41.5	60
		Sched. 80	Cl. 150	92	279.4	283	300	27.0	40
		Sched. 80	Cl. 300	92	317.5	283	300	42.0	60

Flanged versions (S Style) to ANSI B16.5
Prowirl 72F, 73F

DN	Inner dia-meter	Pressure rating		d mm	D mm	H[1] mm	L mm	X mm	Weight[2] kg
8"	4"	Sched. 40	Cl. 150	112	342.9	295	300	28.4	61
		Sched. 40	Cl. 300	112	381.0	295	300	47.5	92
10"	6"	Sched. 40	Cl. 150	202.7	406.4	319	380	31.4	91
		Sched. 40	Cl. 300	202.7	444.5	319	380	46.9	129

1) The dimension H increases by 29 mm for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure ratings up to PN 40, Cl. 300, 20K).
2) The weight data refer to the compact version. The weight increases by 0.5 kg for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure rating up to PN 40, Cl. 300, 20K). The weight is increased by 6 kg for the Dualsens version.
3) Not available as Dualsens version.

Flanged versions (S Style) to JIS B2220
Prowirl 72F, 73F

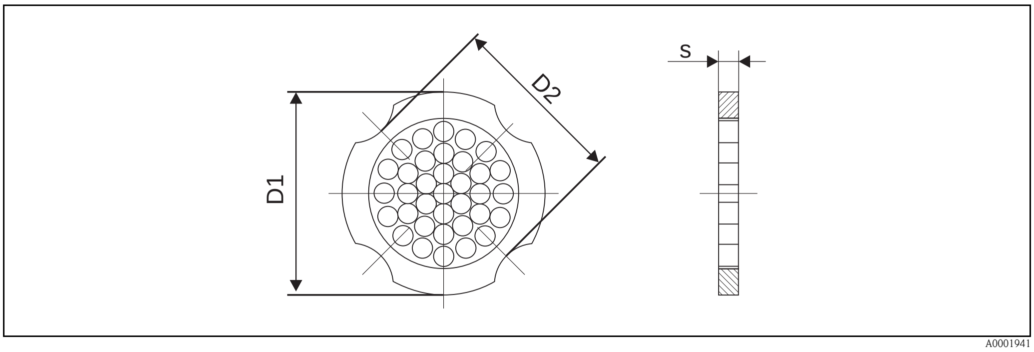
DN	Inner dia-meter	Pressure rating		d [mm]	D [mm]	H[1] [mm]	L [mm]	X [mm]	Weight[2] [kg]
40[3]	15	Sched. 40	20K	22	140	248	200	20.5	8
		Sched. 80	20K	22	140	248	200	20.5	8
50[3]	25	Sched. 40	10K	30	155	255	200	20.5	9
		Sched. 40	20K	30	155	255	200	21.0	11
		Sched. 80	10K	30	155	255	200	20.5	9
		Sched. 80	20K	30	155	255	200	21.0	11
80	40	Sched. 40	10K	45	185	263	200	22.0	13
		Sched. 40	20K	45	200	263	200	25.5	17
		Sched. 80	10K	45	185	263	200	22.0	13
		Sched. 80	20K	45	200	263	200	25.5	17
100	50	Sched. 40	10K	62	210	270	250	25.5	17
		Sched. 40	20K	62	225	270	250	29.0	21
		Sched. 80	10K	62	210	270	250	26.0	17
		Sched. 80	20K	62	225	270	250	29.5	21
150	80	Sched. 40	10K	92	280	283	300	31.0	34
		Sched. 40	20K	92	305	283	300	38.5	45
		Sched. 80	10K	92	280	283	300	31.5	34
		Sched. 80	20K	92	305	283	300	39.0	45
200	100	Sched. 40	10K	112	330	295	300	33.5	50
		Sched. 40	20K	112	350	295	300	43.5	67
250	150	Sched. 40	10K	202.7	400	319	380	30.5	73
		Sched. 40	20K	202.7	430	319	380	37	95

1) The dimension H increases by 29 mm for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure ratings up to PN 40, Cl. 300, 20K).
2) The weight data refer to the compact version. The weight increases by 0.5 kg for Prowirl 72 (high-temperature version and for the version with a DSC sensor made of Alloy C-22) and for Prowirl 73 (pressure rating up to PN 40, Cl. 300, 20K). The weight is increased by 6 kg for the Dualsens version.
3) Not available as Dualsens version.

Dimensions of flow conditioner to EN (DIN)/ANSI/JIS (accessory)

Dimensions to:
- EN 1092-1 (DIN 2501)
- ANSI B16.5
- JIS B2220

Material 1.4404 (316L) or 1.4435 (316L), in compliance with NACE MR0175-2003 and MR0103-2003.



D1: The flow conditioner is fitted at the external diameter between the bolts.
D2: The flow conditioner is fitted at the indentations between the bolts.

Flow conditioner to EN (DIN)					
DN	Pressure rating	Centering diameter [mm]	D1/D2 *	s [mm]	Weight [kg]
15	PN 10 to 40 PN 63	54.3 64.3	D2 D1	2.0	0.04 0.05
25	PN 10 to 40 PN 63	74.3 85.3	D1 D1	3.5	0.12 0.15
40	PN 10 to 40 PN 63	95.3 106.3	D1 D1	5.3	0.3 0.4
50	PN 10 to 40 PN 63	110.0 116.3	D2 D1	6.8	0.5 0.6
80	PN 10 to 40 PN 63	145.3 151.3	D2 D1	10.1	1.4
100	PN 10/16 PN 25/40 PN 63	165.3 171.3 176.5	D2 D1 D2	13.3	2.4
150	PN 10/16 PN 25/40 PN 63	221.0 227.0 252.0	D2 D2 D1	20.0	6.3 7.8 7.8
200	PN 10 PN 16 PN 25 PN 40	274.0 274.0 280.0 294.0	D1 D2 D1 D2	26.3	11.5 12.3 12.3 15.9
250	PN 10/16 PN 25 PN 40	330.0 340.0 355.0	D2 D1 D2	33.0	25.7 25.7 27.5
300	PN 10/16 PN 25 PN 40	380.0 404.0 420.0	D2 D1 D1	39.6	36.4 36.4 44.7
* D1 → The flow conditioner is fitted at the external diameter between the bolts. D2 → The flow conditioner is fitted at the indentations between the bolts.					

Flow conditioner to ANSI						
DN		Pressure rating	Centering diameter [mm]	D1/D2 *	s [mm]	Weight [kg]
15	½"	Cl. 150 Cl. 300	50.1 56.5	D1 D1	2.0	0.03 0.04
25	1"	Cl. 150 Cl. 300	69.2 74.3	D2 D1	3.5	0.12
40	1½"	Cl. 150 Cl. 300	88.2 97.7	D2 D2	5.3	0.3
50	2"	Cl. 150 Cl. 300	106.6 113.0	D2 D1	6.8	0.5
80	3"	Cl. 150 Cl. 300	138.4 151.3	D1 D1	10.1	1.2 1.4
100	4"	Cl. 150 Cl. 300	176.5 182.6	D2 D1	13.3	2.7
150	6"	Cl. 150 Cl. 300	223.9 252.0	D1 D1	20.0	6.3 7.8
200	8"	Cl. 150 Cl. 300	274.0 309.0	D2 D1	26.3	12.3 15.8
250	10"	Cl. 150 Cl. 300	340.0 363.0	D1 D1	33.0	25.7 27.5
300	12"	Cl. 150 Cl. 300	404.0 402.0	D1 D1	39.6	36.4 44.6
* D1 → The flow conditioner is fitted at the external diameter between the bolts. D2 → The flow conditioner is fitted at the indentations between the bolts.						

Flow conditioner to JIS					
DN	Pressure rating	Centering diameter [mm]	D1/D2 *	s [mm]	Weight [kg]
15	10K	60.3	D2	2.0	0.06
	20K	60.3	D2	2.0	0.06
	40K	66.3	D1	2.0	0.06
25	10K	76.3	D2	3.5	0.14
	20K	76.3	D2	3.5	0.14
	40K	81.3	D1	3.5	0.14
40	10K	91.3	D2	5.3	0.31
	20K	91.3	D2	5.3	0.31
	40K	102.3	D1	5.3	0.31
50	10K	106.6	D2	6.8	0.47
	20K	106.6	D2	6.8	0.47
	40K	116.3	D1	6.8	0.5
80	10K	136.3	D2	10.1	1.1
	20K	142.3	D1	10.1	1.1
	40K	151.3	D1	10.1	1.3
100	10K	161.3	D2	13.3	1.8
	20K	167.3	D1	13.3	1.8
	40K	175.3	D1	13.3	2.1
150	10K	221.0	D2	20.0	4.5
	20K	240.0	D1	20.0	5.5
	40K	252.0	D1	20.0	6.2
200	10K	271.0	D2	26.3	9.2
	20K	284.0	D1	26.3	9.2

Flow conditioner to JIS					
DN	Pressure rating	Centering diameter [mm]	D1/D2 *	s [mm]	Weight [kg]
250	10K	330.0	D2	33.0	15.8
	20K	355.0	D2	33.0	19.1
300	10K	380.0	D2	39.6	26.5
	20K	404.0	D1	39.6	26.5
* D1 → The flow conditioner is fitted at the external diameter between the bolts. D2 → The flow conditioner is fitted at the indentations between the bolts.					

Weight

- Weight of Prowirl 72W, 73W → 🗎 33 ff.
- Weight of Prowirl 72F, 73F → 🗎 35 ff.
- Weight of flow conditioner to EN (DIN)/ANSI/JIS → 🗎 48 ff.

Material

Transmitter housing

- Powder-coated die-cast aluminum AlSi10Mg
  - In accordance with EN 1706/EN AC-43400 (EEx d/XP version: cast aluminum EN 1706/EN AC-43000)

Sensor

- Flanged version
  - Stainless steel, A351-CF3M (1.4404), in compliance with NACE MR0175-2003 and MR0103-2003
  - Pressure ratings PN 250, Class 900 to 1500 and butt-weld version (only for Prowirl 72) 1.4571 (316Ti; UNS S31635); in compliance with NACE MR0175-2003 and MR0103-2003
- Alloy C-22 version (only for Prowirl 72)
  - Alloy C-22 2.4602 (A 494-CX2MW/N 26022); in compliance with NACE MR0175-2003 and MR0103-2003
- Wafer version
  - Stainless steel, A351-CF3M (1.4404), in compliance with NACE MR0175-2003 and MR0103-2003

Flanges

- EN (DIN)
  - Stainless steel, A351-CF3M (1.4404), in compliance with NACE MR0175-2003 and MR0103-2003
  - DN 15 to 150 with pressure ratings to PN 40 and all devices with integrated diameter reduction (R Style, S Style): construction with weld-on flanges made of 1.4404 (AISI 316L).
    PN 63 to 160 (in development for Prowirl 73), nominal diameters DN 200 to 300: fully cast construction A351-CF3M (1.4404 (AISI 316L)), in compliance with NACE MR0175-2003 and MR0103-2003
  - Pressure rating PN 250 (only for Prowirl 72) 1.4571 (316Ti, UNS S31635); in compliance with NACE MR0175-2003 and MR0103-2003
- ANSI and JIS
  - Stainless steel, A351-CF3M, in compliance with NACE MR0175-2003 and MR0103-2003
  - ½ to 6" with pressure ratings to Class 300 and DN 15 to 150 with pressure ratings to 20K and all devices with integrated diameter reduction (R Style, S Style): construction with weld-on flanges made of 316/316L, in compliance with NACE MR0175-2003 and MR0103-2003.
    Class 600 (in development for Prowirl 73), DN 15 to 150 with pressure rating 40K, (in development for Prowirl 73), nominal diameters 8 to 12": fully cast construction A351-CF3M; in compliance with NACE MR0175-2003 and MR0103-2003
  - Pressure ratings Class 900 to 1500: 316/316L; in compliance with NACE MR0175-2003 and MR0103-2003 (only Prowirl 72)
- Alloy C-22 version (EN/DIN/ANSI/JIS)
  - Alloy C-22 2.4602 (A 494-CX2MW/N 26022); in compliance with NACE MR0175-2003 and MR0103-2003

DSC sensor (differential switched capacitor)

- Wetted parts (marked as "wet" on the DSC sensor flange):
  - Standard for pressure ratings up to PN 40, Class 300, JIS 40K:
    Stainless steel 1.4435 (316L), in compliance with NACE MR0175-2003 and MR0103-2003
  - Pressure ratings PN 63 to 160, Class 600, 40K (in development for Prowirl 73):
    Inconel 2.4668/N 07718 (B637) (Inconel 718); in compliance with NACE MR0175-2003 and MR0103-2003
  - Pressure ratings PN 250, Class 900 to 1500 and butt-weld version (only for Prowirl 72):
    titanium Gr. 5 (B-348; UNS R50250; 3.7165)
  - Alloy C-22 sensor (only for Prowirl 72):
    Alloy C-22, 2.4602/N 06022; in compliance with NACE MR0175-2003 and MR0103-2003

Non-wetted parts

- Stainless steel 1.4301 (304)

Support

- Stainless steel, 1.4308 (CF8)
- Pressure ratings PN 250, Class 900 to 1500 and butt-weld version (only for Prowirl 72): 1.4305 (303)

Seals

- Graphite
  - Pressure rating PN 10 to 40, Class 150 to 300, JIS 10 to 20K: Sigraflex Folie Z
    (BAM-tested for oxygen applications)
  - Pressure rating PN 63 to 160, Class 600, JIS 40K: Sigraflex Hochdruck™ with stainless steel sheet reinforcement made of 316(L)
    (BAM-tested for oxygen applications, "high quality in terms of TA Luft (German Clean Air Act)"
  - Pressure rating PN 250, Class 900 to 1500: Grafoil with perforated stainless steel reinforcement made of 316
- Viton
- Kalrez 6375
- Gylon (PTFE) 3504 (BAM-tested for oxygen applications, "high quality in terms of TA Luft (German Clean Air Act)"

Human interface

Display elements

Liquid crystal display, double-spaced, plain text display, 16 characters per line
Display can be configured individually, e.g. for measured variables and status values, totalizers

Operating elements (HART)

Local operation with three keys (+, −, E)
Quick Setup for quick commissioning
Operating elements accessible also in Ex-zones

Remote operation

Operation via:
- HART
- PROFIBUS PA
- FOUNDATION Fieldbus
- FieldCare (software package from Endress+Hauser for complete configuration, commissioning and diagnosis)

Certificates and approvals

CE mark

The measuring system described in these Operating Instructions complies with the legal requirements of the EU Directives. Endress+Hauser confirms this by affixing the CE mark to it and by issuing the CE Declaration of Conformity.

C-tick mark	The measuring system meets the EMC requirements of the "Australian Communications and Media Authority (ACMA)".
Ex-approval	■ Ex i/IS and Ex n: – ATEX/CENELEC II1/2G, EEx ia IIC T1 to T6 (T1 to T4 for PROFIBUS PA and FOUNDATION Fieldbus) II1/2GD, EEx ia IIC T1 to T6 (T1 to T4 for PROFIBUS PA and FOUNDATION Fieldbus) II1G, EEx ia IIC T1 to T6 (T1 to T4 for PROFIBUS PA and FOUNDATION Fieldbus) II2G, EEx ia IIC T1 to T6 (T1 to T4 for PROFIBUS PA and FOUNDATION Fieldbus) II3G, EEx nA IIC T1 to T6 X (T1 to T4 X for PROFIBUS PA and FOUNDATION Fieldbus) – FM Class I/II/III Div. 1/2, Group A to G; Class I Zone 0, Group IIC – CSA Class I/II/III Div. 1/2, Group A to G; Class I Zone 0, Group IIC Class II Div. 1, Group E to G Class III – NEPSI Ex ia IIC Ex nA ■ Ex d/XP: – ATEX/CENELEC II1/2G, EEx d [ia] IIC T1 to T6 (T1 to T4 for PROFIBUS PA and FOUNDATION Fieldbus) II1/2GD, EEx ia IIC T1 to T6 (T1 to T4 for PROFIBUS PA and FOUNDATION Fieldbus) II2G, EEx d [ia] IIC T1 to T6 (T1 to T4 for PROFIBUS PA and FOUNDATION Fieldbus) – FM Class I/II/III Div. 1, Groups A to G – CSA Class I/II/III Div. 1, Groups A to G Class II Div. 1, Groups E to G Class III – TIIS Ex d [ia] IIC T1 Ex d [ia] IIC T4 More information on the Ex-approvals can be found in the separate Ex-documentation.
Pressure measuring device approval	All measuring devices, including those with a nominal diameter smaller than or equal to DN 25, correspond to Article 3(3) of the EC Directive 97/23/EC (Pressure Equipment Directive) and have been designed and manufactured according to good engineering practice. For nominal diameters greater than DN 25 (depending on the fluid and process pressure), there are additional optional approvals according to category II/III.
Certification FOUNDATION Fieldbus	The flowmeter has successfully passed all test procedures and is certified and registered by the Fieldbus FOUNDATION. The device thus meets all the requirements of the following specifications: ■ Certified to FOUNDATION Fieldbus Specification ■ The device meets all the specifications of the FOUNDATION Fieldbus-H1. ■ Interoperability Test Kit (ITK), revision status 4.5 (device certification number available on request): The device can also be operated with certified devices of other manufacturers. ■ Physical Layer Conformance Test of the Fieldbus FOUNDATION
Certification PROFIBUS PA	The flowmeter has successfully passed all test procedures and is certified and registered by the PNO (PROFIBUS User Organization). The device thus meets all the requirements of the following specifications: ■ Certified to PROFIBUS PA Profile Version 3.0 (device certification number: on request) ■ The device can also be operated with certified devices of other manufacturers (interoperability)

Other standards and guidelines

- EN 60529
  Degrees of protection by housing (IP code)

- EN 61010-1
  Safety requirements for electrical equipment for measurement, control and laboratory use

- IEC/EN 61326
  Electromagnetic compatibility (EMC requirements)

- NAMUR NE 21
  Electromagnetic compatibility (EMC) of industrial process and laboratory control equipment

- NAMUR NE 43
  Standardization of the signal level for the breakdown information of digital transmitters with analog output signal

- NAMUR NE 53
  Software of field devices and signal-processing devices with digital electronics

- NACE Standard MR0103-2003
  Standard Material Requirements - Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments

- NACE Standard MR0175-2003
  Standard Material Requirements - Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment

- VDI 2643
  Measurement of fluid flow by means of vortex flowmeters.

- ANSI/ISA-S82.01
  Safety Standard for Electrical and Electronic Test, Measuring, Controlling and
  Related Equipment - General Requirements. Pollution degree 2, Installation Category II

- CAN/CSA-C22.2 No. 1010.1-92
  Safety Standard for Electrical Equipment for Measurement and Control and Laboratory Use. Pollution degree 2, Installation Category II

- The International Association for the Properties of Water and Steam – Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam

- ASME International Steam Tables for Industrial Use (2000)

- American Gas Association (1962)
  A.G.A. Manual for the Determination of Supercompressibility Factors for Natural Gas - PAR Research Project NX-19.

- American Gas Association Transmission Measurement Committee Report No. 8 (AGA8),
  November 1992. American Petroleum Institute MPMS Chapter 14.2: *Compressibility and Supercompressibility for Natural Gas and Other Hydrocarbon Gases.*

- ISO 12213 Natural gas (2006) - Calculation of compression factor
  - Part 2: Calculation using molar composition analysis (ISO 12213-2)
  - Part 3: Calculation using physical properties (ISO 12213-2)

- GERG Groupe Européen des Recherches Gazières (1991): Technical Monograph TM 5 - Standard GERG Virial Equation for Field Use. Simplification of the input data requirements for the GERG Virial Equation - an alternative means of compressibility factor calculation for natural gases and similar mixtures. Publishing house of Verein Deutscher Ingenieure (Association of German Engineers), Düsseldorf.

- ISO 6976-1995: Natural gas — Calculation of calorific values, density, relative density and Wobbe index from composition.

- Gas Processors Association GPA Standard 2172-96
- American Petroleum Institute API MPMS 14.5 (1996). Calculation of Gross Heating Value, Relative Density and Compressibility Factor for Natural Gas Mixtures from Compositional Analysis.

Functional safety

Prowirl 72: SIL 2 in accordance with IEC 61508/IEC 61511-1

Prowirl 73: SIL 1

Following the link **http://www.endress.com/sil** you will find an overview of all Endress+Hauser devices for SIL applications including parameters like SFF, MTBF, PFD_{avg} etc.

Ordering information

Ordering information and detailed information on the order code can be obtained from your Endress+Hauser Service Organization.

Additional ordering information for Prowirl 72

Prowirl 72 can also be ordered as a preconfigured unit. For this purpose, the following information is needed when ordering:
- Operating language
- Type of fluid: liquid, gaseous or vaporous.
- 20-mA value: measured value at which a current of 20 mA should be set.
  Optional: time constant and failsafe mode (min. current, max. current, etc.)
- Optionally also pulse value, pulse duration, output signal and failsafe mode if the measuring device has a pulse output.
- Average operating density incl. unit if the flow is to be output in mass units.
- Operating and reference density of the fluid including the unit if the flow is to be output in corrected volume units.
- Optional: assignment of the first and second line on the local display and desired unit for the totalizer.

The measuring device can be reset to the delivery state indicated in the order at any time.

Additional ordering information for Prowirl 73

Prowirl 73 can also be ordered as a preconfigured unit. For this purpose, the following information is needed when ordering:
- Operating language
- Type of fluid: saturated steam, superheated steam, water, compressed air, natural gas AGA NX-19 (optional), real gas, customer-defined liquid, gas volume, liquid volume, water delta heat (only for 4 to 20 mA HART), saturated steam delta heat (only for 4 to 20 mA HART).
- Average operating pressure (in bar absolute) or whether the pressure should be read into Prowirl 73 from an external sensor (possible for superheated steam, compressed air, natural gas AGA NX-19, real gas).
- Average ambient pressure (in bar absolute) if the pressure is read into Prowirl 73 from an external pressure sensor.
- Reference pressure and temperature if corrected volume units are selected as an output.
- For applications with natural gas AGA NX-19, mol-% nitrogen and mol-% carbon dioxide are also required as is the "specific gravity" (ratio of the density of natural gas to that of air at reference operating conditions).
- For real gas applications, the operating Z-factor, the reference Z-factor and the reference density are also required.
- For customer-defined liquid applications, the average operating temperature, the density the fluid has at this temperature and the linear expansion coefficient of the fluid are also required. These values can also be calculated by Endress+Hauser if the customer specifies the fluid and operating temperature or if the dependency between the fluid density and the temperature is made available in tabular form.
- 4-mA value: measured value (e.g. 50 kg/h) at which a current of 4 mA should be output, incl. unit.
- 20-mA value: measured value (e.g. 1000 kg/h) at which a current of 20 mA should be output, incl. unit, time constant and failsafe mode (min. current, max. current etc.)
- Pulse value incl. unit (if the measuring device has a pulse output), pulse duration, output signal and failsafe mode.
- Optional: assignment of the first and second line on the local display and desired unit for the totalizer. In addition, you can also tell us what fault values apply for temperature and pressure, where applicable.

- Optional: configuration of the extended diagnostic functions, e.g. maximum/minimum temperature, maximum flow velocity, etc.

The measuring device can be reset to the delivery state indicated in the order at any time.

Product structure for flanged devices "R Style" and "S Style" (with diameter reduction)

R Style		Single reduction of line size (>)
7*F	**RF** -************	DN 25 (1") > DN 15 (½")
	RG -************	DN 40 (1½") > DN 25 (1")
	RJ -************	DN 50 (2") > DN 40 (1½")
	RK -************	DN 80 (3") > DN 50 (2")
	RM-************	DN 100 (4") > DN 80 (3")
	RN -************	DN 150 (6") > DN 100 (4")
	RR-************	DN 200 (8") > DN 150 (6")
S Style		Double reduction of line size (>>)
7*F	**SF** -************	DN 40 (1½") >> DN 15 (½")
	SG -************	DN 50 (2") >> DN 25 (1")
	SJ -************	DN 80 (3") >> DN 40 (1½")
	SK -************	DN 100 (4") >> DN 50 (2")
	SM-************	DN 150 (6") >> DN 80 (3")
	SN -************	DN 200 (8") >> DN 100 (4")
	SR -************	DN 250 (10") >> DN 150 (6")

Accessories

Various accessories, which can be ordered separately from Endress+Hauser, are available for the transmitter and the sensor. Detailed information on the order code in question can be obtained from your Endress+Hauser representative.

Device-specific accessories

Accessory	Description	Order code
Transmitter Proline Prowirl 72/73	Transmitter for replacement or for stock. Use the order code to define the following specifications: ■ Approvals – Degree of protection/version – Cable entry – Display/operation – Software ■ Outputs/inputs	72XXX - XXXXX ****** 73XXX - XXXXX ******

Measuring principle-specific accessories

Accessory	Description	Order code
Mounting kit for Prowirl 72/73W	Mounting kit for wafer comprising: ■ Threaded studs ■ Nuts incl. washers ■ Flange seals	DKW** - ***
Mounting kit for transmitter	Mounting kit for remote version, suitable for pipe and wall mounting.	DK5WM - B
Memograph M graphic display recorder	The Memograph M graphic display recorder provides information on all the relevant process variables. Measured values are recorded correctly, limit values are monitored and measuring points analyzed. The data are stored in the 256 MB internal memory and also on a DSD card or USB stick. Memograph M boasts a modular design, intuitive operation and a comprehensive security concept. The ReadWin® 2000 PC software is part of the standard package and is used for configuring, visualizing and archiving the data captured. The mathematics channels which are optionally available enable continuous monitoring of specific energy consumption, boiler efficiency and other parameters which are important for efficient energy management.	RSG40 - ************
Flow conditioner	To reduce the inlet run downstream of flow disturbances.	DK7ST - ***
Pressure transmitter Cerabar T	Cerabar T is used to measure the absolute and gauge pressure of gases, steams and liquids (compensation with RMC621 for example).	PMC131 - **** PMP131 - ****
Pressure transmitter Cerabar M	Cerabar M is used to measure the absolute and gauge pressure of gases, steams and liquids. ■ Can also be used for reading external pressure values into Prowirl 73 via the burst mode. ■ Can also be ordered with ready-activated burst mode (special product with version 9=TSPSC2821). ■ Can also be used for reading external pressure values into Prowirl 73 via PROFIBUS PA (only absolute pressure).	PMC41 - *********** PMP41 - *********** PM*4* - ******H/J9***

Accessory	Description	Order code
Pressure transmitter Cerabar S	Cerabar S is used to measure the absolute and gauge pressure of gases, steams and liquids. ■ Can also be used for reading external pressure values into Prowirl 73 via the burst mode. ■ Can also be ordered with ready-activated burst mode (special product with version 9=TSPSC2822). ■ Can also be used for reading external pressure values into Prowirl 73 via PROFIBUS PA or FOUNDATION Fieldbus (only absolute pressure).	PMC71 - *********** PMP71 - *********** PM*7* - *A/B/C********9
RTD temperature Omnigrad TR10	Multipurpose temperature sensor, mineral-insulated insert with protection well and transmitter housing. Together with a HART-compatible transmitter, it can be used for to read the temperature into Prowirl 73 in the burst mode.	TR10 - *******R/T**** THT1-L**
Active barrier RN221N	Active barrier with power supply for safe separation of 4 to 20 mA standard signal circuits: ■ Galvanic isolation of 4 to 20 mA circuits ■ Elimination of ground loops ■ Power supply of two-wire transmitters ■ Can be used in Ex area (ATEX, FM, CSA, TIIS) ■ HART input-compatible (e.g. for reading in an external pressure value) Note! If RN221N - *3 is used for the HART input, this results in an error message for Prowirl 73 and can not be used for pressure compensation.	RN221N - *1
Process display RIA250	Multifunctional 1-channel display unit: ■ Universal input ■ Transmitter power supply ■ Limit relay ■ Analog output	RIA250 - ******
Process display RIA251	Digital display unit for looping into 4 to 20 mA current loop; can be used in Ex area (ATEX, FM, CSA).	RIA251 - **
Field display RIA261	Digital field display unit for looping into 4 to 20 mA current loop; can be used in Ex area (ATEX, FM, CSA).	RIA261 - ***
Process transmitter RMA422	Multifunctional 1-2 channel top-hat rail device with intrinsically safe current inputs and transmitter power supply, limit value monitoring, mathematic functions (e.g. difference ascertain) and 1-2 analog outputs. Optional: intrinsically safe inputs, can be used in Ex area (ATEX). Possible applications: leak detection, delta heat (between two Prowirl measuring points), totalizing (of flows in two pipes) etc.	RMA422 - *******
Overvoltage protection HAW562Z	Overvoltage protection for restricting overvoltage in signal lines and components.	51003575
Overvoltage protection HAW569	Overvoltage protection for restricting overvoltage for direct mounting to Prowirl 73 and other devices.	HAW569 - **1A
Heat computer RMS621	Steam and heat computer for industrial energy balancing of steam and water. Calculation of the following applications: ■ Steam mass ■ Steam heat quantity ■ Net steam heat quantity ■ Steam delta heat ■ Water heat quantity ■ Water delta heat Simultaneous calculation of up to three applications per device.	RMS621-*********

Accessory	Description	Order code
Energy Manager RMC621	Universal Energy Manager for gas, liquids, steam and water. Calculation of volumetric flow and mass flow, standard volume, heat flow and energy.	RMC621 - **********
Application Manager RMM621	Electronic recording, display, balancing, control, saving, event and alarm monitoring of analog and digital input signals. Values and states determined are output by means of analog and digital output signals. Remote transmission of alarms, input values and calculated values using a PSTN or GSM modem.	RMM621 - **********
Conversion kits	Several conversion kits are available, e.g.: ▪ Conversion of Prowirl 77 to Prowirl 72 or 73 ▪ Conversion of a compact version to a remote version	DK7UP - **
Weather protection cover	Protective hood against direct sunshine.	543199-0001

Communication-specific accessories

Accessory	Description	Order code
HART Field Communicator DXR375	Handheld terminal for remote configuration and for obtaining measured values via the current output HART (4 to 20 mA) and FOUNDATION Fieldbus (FF). Contact your Endress+Hauser representative for more information.	DXR375 - *******
Fieldgate FXA320	Gateway for remote interrogation of HART sensors and actuators via Web browser: ▪ 2-channel, analog input (4 to 20 mA) ▪ 4 binary inputs with event counter function and frequency measurement ▪ Communication via modem, Ethernet or GSM ▪ Visualization via Internet/Intranet in Web browser and/or WAP cellular phone ▪ Limit value monitoring with alarms sent by e-mail or SMS ▪ Synchronized time-stamping of all measured values	FXA320 - *****
Fieldgate FXA520	Gateway for remote interrogation of HART sensors and actuators via Web browser: ▪ Web server for remote monitoring of up to 30 measuring points ▪ Intrinsically safe version [EEx ia]IIC for applications in Ex area ▪ Communication via modem, Ethernet or GSM ▪ Visualization via Internet/Intranet in Web browser and/or WAP cellular phone ▪ Limit value monitoring with alarms sent by e-mail or SMS ▪ Synchronized time-stamping of all measured values ▪ Remote diagnosis and remote configuration of connected HART devices Note! If Fieldgate FXA520 is used for the HART input, this results in an error message for Prowirl 73 and is not recommended.	FXA520 - ****

Accessory	Description	Order code
Fieldgate FXA720	Gateway for remote interrogation of PROFIBUS sensors and actuators via Web browser: – Web server for remote monitoring of up to 30 measuring points – Intrinsically safe version [EEx ia]IIC for applications in Ex area – Communication via modem, Ethernet or GSM – Visualization via Internet/Intranet in Web browser and/or WAP cellular phone – Limit value monitoring with alarms sent by e-mail or SMS – Synchronized time-stamping of all measured values – Remote diagnosis and remote configuration of connected HART devices	FXA720 - ****

Service-specific accessories

Accessory	Description	Order code
Applicator	Software for selecting and planning flowmeters. The Applicator can be downloaded from the Internet or ordered on CD-ROM for installation on a local PC. Contact your Endress+Hauser representative for more information.	DXA80 - *
Fieldcheck	Tester/simulator for testing flowmeters in the field. When used in conjunction with the "FieldCare" software package, test results can be imported into a database, printed out and used for official certification. Contact your Endress+Hauser representative for more information.	50098801
FieldCare	FieldCare is Endress+Hauser's FDT-based plant asset management tool. It can configure all intelligent field units in your system and helps you manage them. By using the status information, it is also a simple but effective way of checking their status and condition.	See the product page on the Endress+Hauser Web site: www.endress.com
FXA193	Service interface from the measuring device to the PC for operation via FieldCare.	FXA193 – *

Documentation

- Operating Instructions Proline Prowirl 72
- Operating Instructions Proline Prowirl 72 PROFIBUS PA
- Operating Instructions Proline Prowirl 72 FOUNDATION Fieldbus
- Operating Instructions Proline Prowirl 73
- Operating Instructions Proline Prowirl 73 PROFIBUS PA
- Operating Instructions Proline Prowirl 73 FOUNDATION Fieldbus
- Related Ex-documentation: ATEX, FM, CSA etc.
- Supplementary documentation on "Information on the Pressure Equipment Directive"

Registered trademarks

- GYLON®
  Registered trademark of Garlock Sealing Technologies, Palmyar, NY, USA
- HART®
  Registered trademark of the HART Communication Foundation, Austin, USA
- INCONEL®
  Registered trademark of Inco Alloys International Inc., Huntington, USA
- KALREZ®, VITON®
  Registered trademarks of E.I. Du Pont de Nemours & Co., Wilmington, USA
- FieldCare®, Fieldcheck®, Applicator®
  Registered or registration-pending trademarks of Endress+Hauser Flowtec AG, Reinach, CH

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TI070D/06/en/11.08
71081835
FM+SGML 6.0 ProMoDo

SeaMetrics FT420 Flow Computer

FT400-Series

FLOW COMPUTER INSTRUCTIONS

- [redacted]
- FT420

FT400-SERIES FLOW COMPUTER INSTRUCTIONS

ISO 9001:2000 CERTIFIED

SeaMetrics

The Leader in Flow Meter Value

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TABLES AND DIAGRAMS

GENERAL INFORMATION

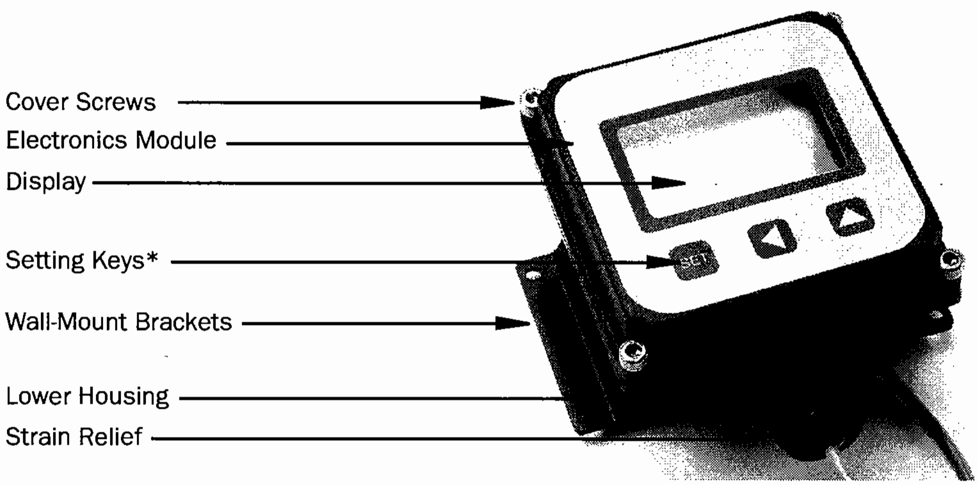
The FT400-Series flow computers are microcontroller-based indicator/transmitters that display flow rate and total and provide output signals. The FT415 is battery-powered and provides a scalable pulse output. The FT420 is powered by external DC voltage and has both pulse and 4-20 mA analog outputs. The FT420 is a "two-wire" or "loop-powered" device, meaning that the 4-20 mA output signal doubles as its power supply. Because of this, it is designed to operate on less than 4 mA of current.

The addition of a dual-relay output board allows for certain applications requiring dry contact output (e.g., certain metering pumps and water treatment controls). Dual relays provide exactly the same pulse output as the standard unit, and each can signal one external device. A non-resettable total is also available. The FT420 can be ordered in a plastic enclosure with a 115 Vac power supply for use with mechanical meters, or with a built-in 115 Vac/12-24 Vdc dual power supply for magmeters.

Both the FT415 and the FT420 can be factory-mounted on the meter (-M) or remotely wall mounted with the brackets provided (-W). The FT420 is also available as a panel mount (-P) with an open back for easy installation in the user's own electrical enclosure. Most FT400's can be converted from wall-to-meter or meter-to-wall mount configurations after installation if needed.

Housings for the -W and -M models are rugged cast aluminum, gasketed for maximum environmental protection. A membrane keypad allows settings to be changed without removing the cover. (Password protection, a standard feature, can be used to prevent settings from being changed.)

FEATURES



*Includes password protection for tamper prevention when needed

SPECIFICATIONS		FT415	FT420
Power		Lithium "C", 3.6 Vdc, replaceable, 3-5 year life	4 mA DC (4-20 mA loop), 12-32 Vdc
Display	**Rate**	6-digit autorange, 1/2" character height	6-digit autorange, 1/2" character height
	Total	8-digit, 5/16" character height	8-digit, 5/16" character height
Output	**Pulse**	0.1 second open collector pulse (scaled) Sensor pulse (unscaled) High alarm or low alarm	0.1 second open collector pulse (scaled) Sensor pulse (unscaled) High alarm or low alarm
	Analog	None	4-20 mA loop; 24-32 Vdc
Pulse Output Range		0.1 - 9999999.9 units/pulse	0.1 - 9999999.9 units/pulse
Input		Micropower GMR Sensor (square wave)	Open collector/switch @ 5 Vdc
Input Range		1.0 - 2,500 pulses/second	1.0 - 10,000 pulses/second
K-Factor Range		.001 - 99999.999	.001 - 99999.999
Flow Alarm Output Range		.01 - 999999.99	.01 - 999999.99
Temperature		0° C - 70° C (32° - 158° F)	0° C - 70° C (32° - 158° F)
Environmental		NEMA 4X	NEMA 4X

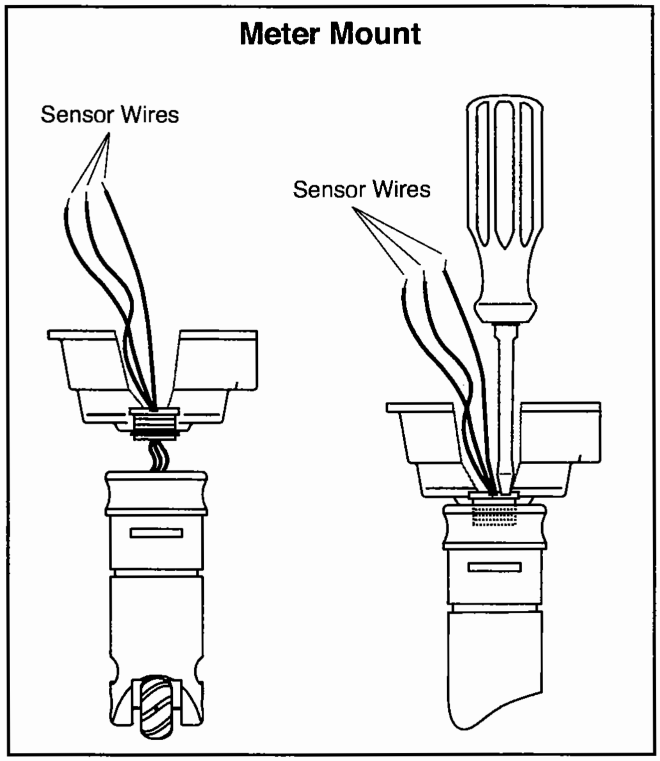
Wall Mount. To mount an FT400-Series indicator to the wall, hold the unit in the desired position, mark the holes in the mounting feet, drill and mount with screws. With the FT420W-65 option, first remove the front cover to gain access to the mounting screw holes.

A meter-mounted FT400-Series can be converted to a wall mount using an MK20 mounting kit.

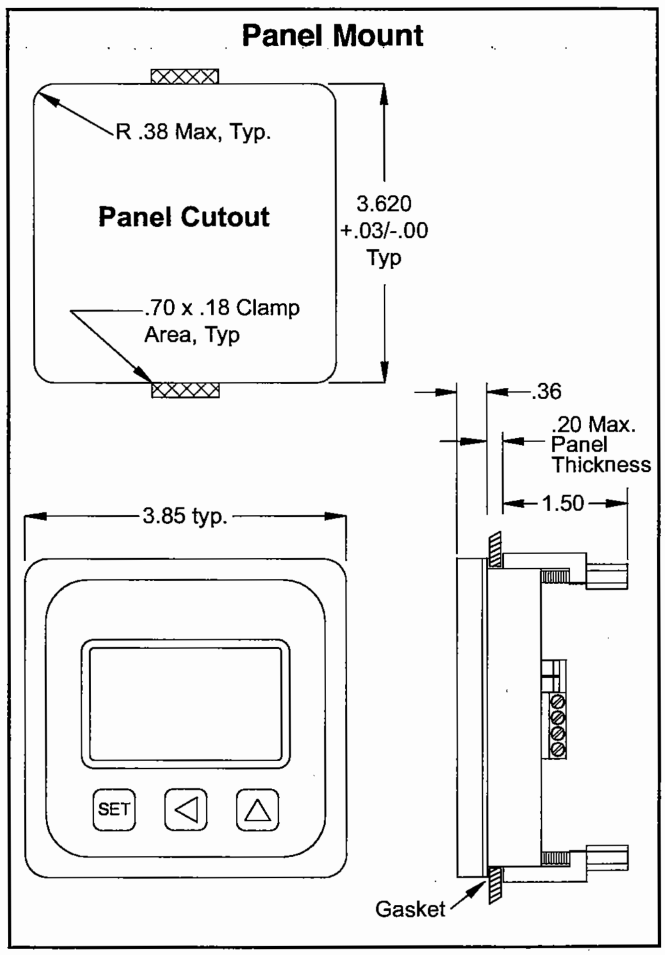
Meter Mount. If the FT400-Series indicator was ordered as an -M model, the housing is already directly mounted to the flow sensor and needs no further installation.

An FT400-Series module can be converted from a wall-to a meter-mount using the MK10 adapter kit that includes a lower housing and associated hardware as follows:

1) Remove the strain relief through which the flow sensor cable runs.
2) Cut the cable to about 6" in length. Carefully strip the cable jacket to expose the three colored wires (red, white, and black) inside.
3) Route the wires through the threaded connector pre-installed in the bottom of the housing.
4) Start the threaded connector into the female thread on the top of the flow sensor. Be sure to match the oblong shape on the bottom of the housing to the depression on the top of the flow sensor.
5) Using an ordinary screwdriver inserted in one side of the slot (see drawing), tighten the screw as much as possible.
6) Strip the wire ends, make the connections to the FT400-Series indicator as shown in Connections Diagrams, and then use the cover screws to attach the indicator to the top of the housing.



Panel Mount (FT420 Only). Using the "Panel Cutout" drawing as a guide, cut a square hole in the panel. Remove the clamps from the back of the FT420P and insert the indicator unit through the cutout, taking care that the panel sealing gasket is in place between the front of the panel and the flange of the indicator. Hold the indicator in place while starting the screw of one of the two clamps. Finger tighten the screw, then install the other clamp. When both are in place, firmly tighten the clamps with a small wrench or nut driver.



Connections. To connect the FT400-Series flow computer to a flow sensor or an external device such as a chemical metering pump, follow the Standard Connections diagrams on pages 4-6.

If the FT420's 4-20 mA current signal is not required, connect the power terminals to any Vdc current source.

Dual Relay Output (Option -98). If you purchase the FT420 with option 98, the required component will come preinstalled, and no extra procedures are required.

If you are retrofitting an existing installation of an FT420 with the dual relay board, please follow the instructions below:

1) Peel the backing off of the double-stick tape and affix it to the bottom of the relay board (part #30221).
2) Carefully attach the board to the FT420 as shown in the FT420-98 Connection diagram on page 5. Be sure that the red wire faces the "Sensor Input" side of the FT420, and that the white wire faces the "Pulse Output" side.
3) Connect the white wire to the "Pulse Scaled" positive terminal, and the red wire to the "Power 4-20 mA" positive terminal.
4) Connect devices to the relays as desired.

-98 Relay Board Specifications

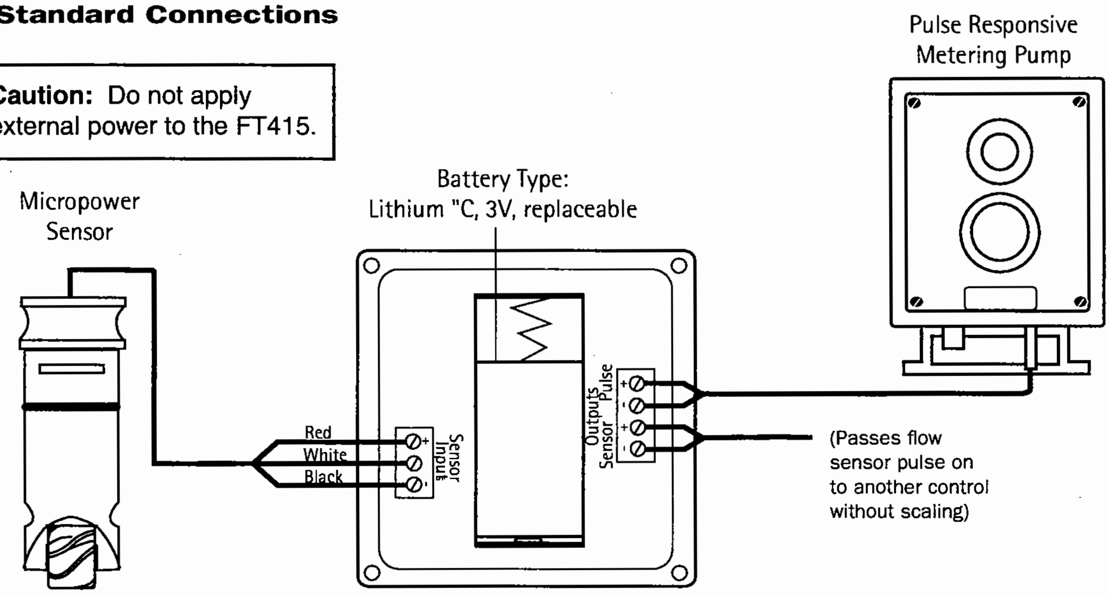
Input Voltage	7-30 Vdc	
Output Current (both outputs)		
Input Voltage	50 C	85 C
12 Vdc	120 mA	70 mA
24 Vdc	120 mA	80 mA
Max Pulses/Second		5
Contact Time Per Output		100 ms

Caution: If output is being used to control an external device, such as a metering pump, do not connect the device until programming is completed. If malfunction or incorrect programming of the output could cause personal injury or property damage, separate safeguards must be installed to prevent such injury or damage.

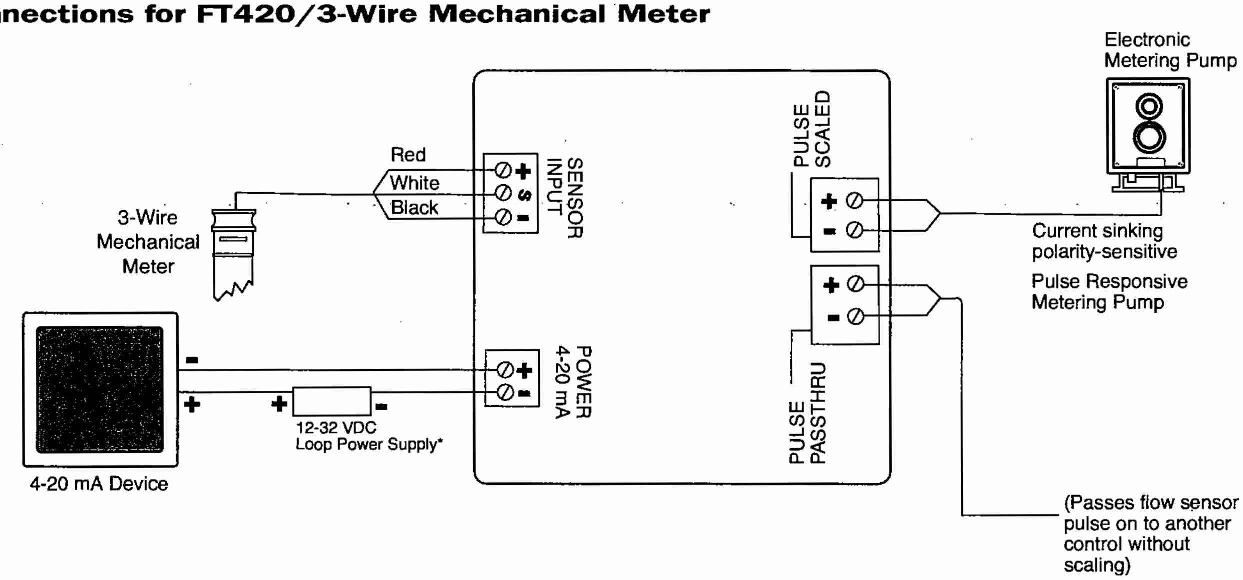
CONNECTION DIAGRAMS

FT415 Standard Connections

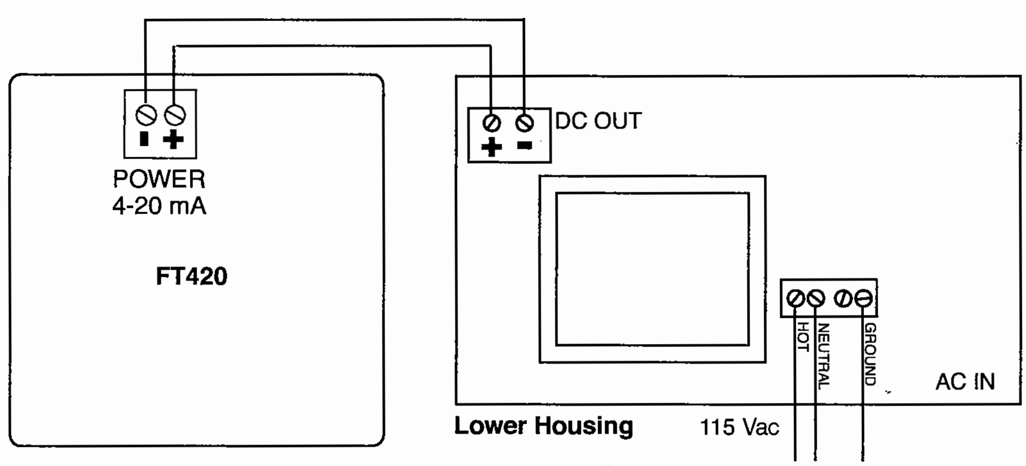
Caution: Do not apply external power to the FT415.



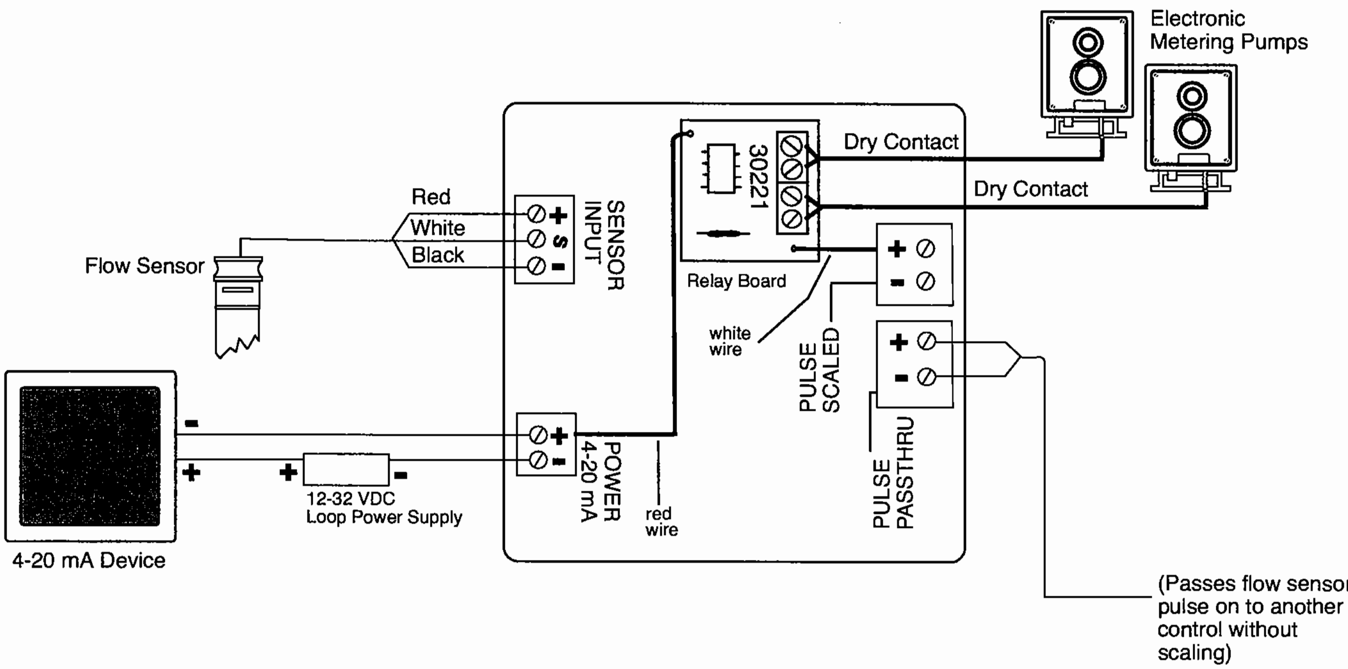
Connections for FT420/3-Wire Mechanical Meter



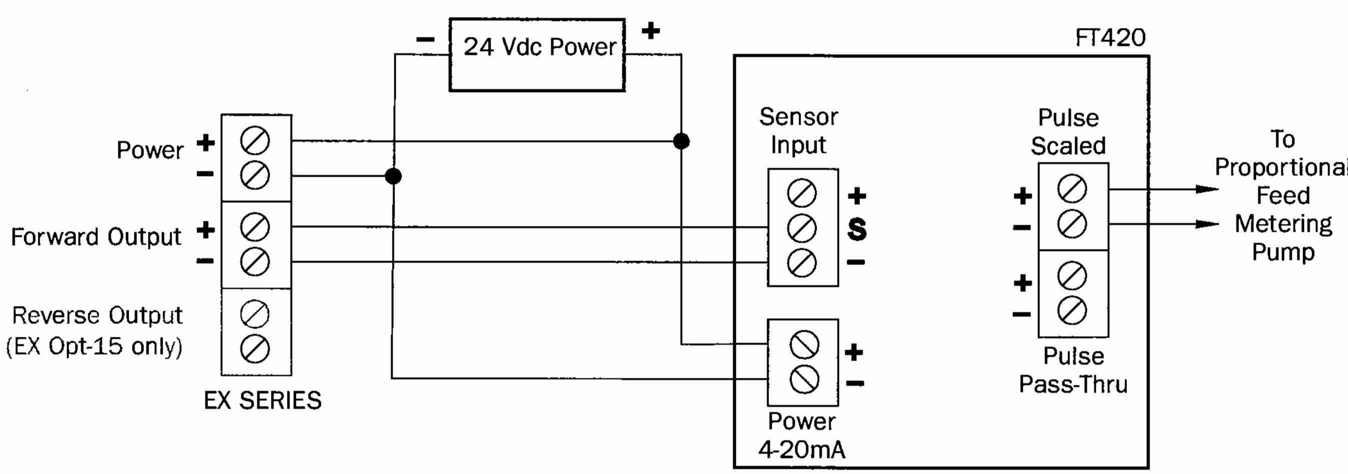
Connections for FT420-65 (115 Vac Option)



Connections for FT420-98 (Dual Relay Output Option)



Connections for FT420/EX Magmeter

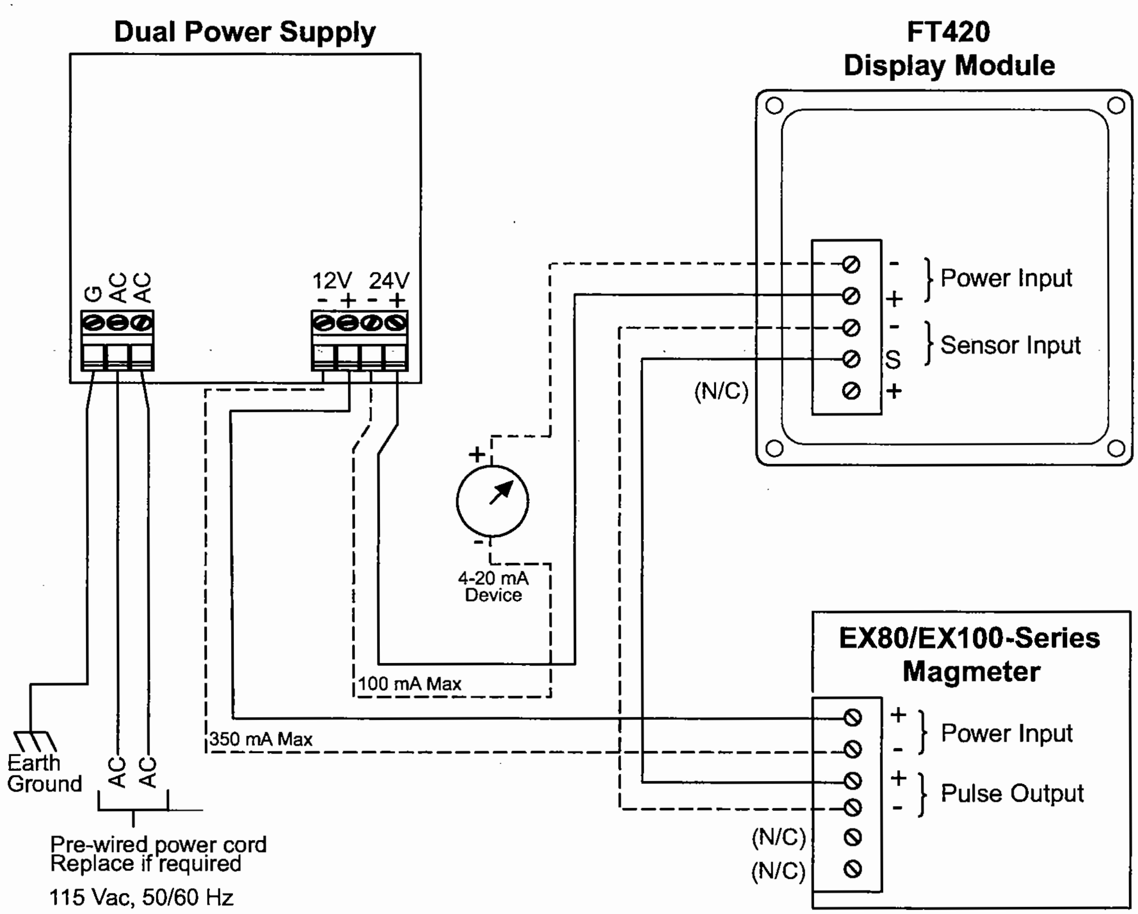


Connections for FT420/EX Magmeter/Dual Power Supply

A dual power supply is required when a 4-20 mA output is needed.

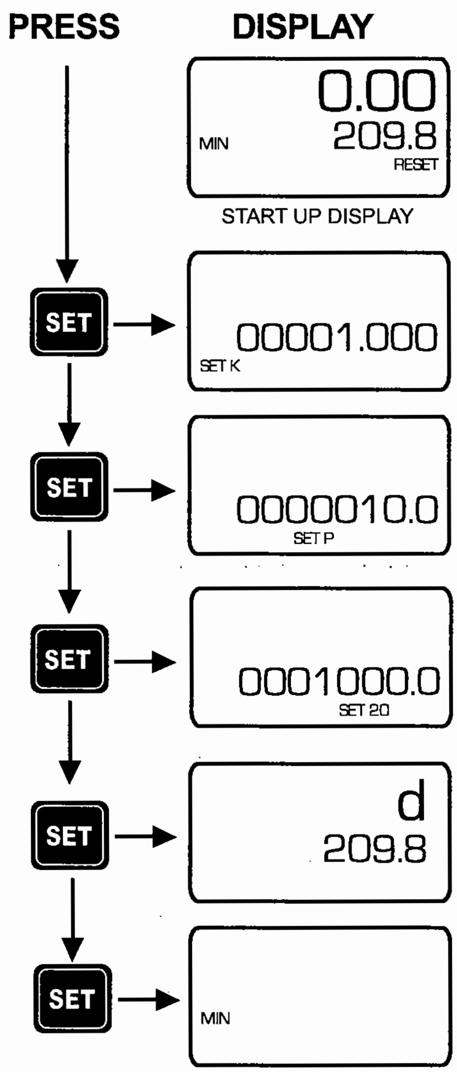
Caution 1: Important! Do not connect power to the power supply until all connections have been made and confirmed correct, and the cover has been put back into place.

Caution 2: It is essential for safety and proper operation to use a ground connection for the 115 Vac power. Do not use this power supply without proper grounding.



QUICK SETTINGS OVERVIEW

See following page for step-by-step instructions on changing these settings



Large digits display instantaneous flow rate (GPM). Small digits display total flow (since last reset).

K is the number of pulses the flow sensor provides for every gallon of flow. Find it on the fitting (80-Series) or chart (100/200-Series) or on the SeaMetrics website.

P is the number of gallons per pulse desired on the scalable pulse output. (Example: P=1 is one pulse per gallon.) Skip without changing if you are not using the pulse output.

20 is the 20 mA maximum analog output. Set the flow rate you want to match maximum output. Example: 250 gpm maximum expected flow, "set 20" to 250. The analog output will scale to 4 mA at zero flow, 20 mA at 250 gpm*. **This setting appears on the FT420 ONLY.**

d is the decimal point. It toggles back and forth with the ▲. Set as many decimal places as needed. For higher flows, no decimal allows maximum number of whole digits.

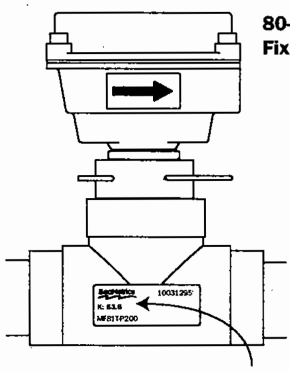
MIN is the time base, for example, gallons *per minute*. Use the ▲ to select sec/min/hour/day.

***NOTE:** Use the up arrow key to reach your desired digit. Then press the left arrow key to move to the next digit. Repeat the process until the entire number is entered.

K-FACTOR

At a minimum, every FT400-Series flow computer must be programmed with the "K-factor". (This is the number of pulses that the meter produces per gallon of flow.) If you wish the FT400 to read in units other than gallons, see below.

The K-factor on any SeaMetrics flow sensor fitting or in-line meter can be found on the model-serial label. The line reading K = xxxx gives the desired number. For depth-adjustable sensors (101,201,115,215 models), look in the instruction manual under your pipe size. For EX meters, use the calculator on our website.



80-Series Fixed Depth Meter

Find Your K-Factor Here

READING IN OTHER UNITS

Changing Volume Units. The default K-factor units are pulses per gallon. To read your total in metric or other units instead, the standard K-factor must be converted to the desired volume units. For example, to read in pulses per liter, the K-factor must be multiplied by the applicable number shown below.

NOTE: Both rate & total will read in whatever units you choose.

To Convert K to:	Multiply by:
Liters	.26418
Cubic Meters	264.18
Fluid Ounces	.0078
Cubic Feet	7.48

Changing Time Units: To read your rate in liters per second (for example), convert the K-factor volume units as shown above and change the time units to Seconds, using the Set Time Unit instructions at right.

Set K. Begin by pressing the SET key once. The prompt SET K should appear on the display. The digit to the far right will be blinking. Use the up arrow key to reach your desired value. Then press the left arrow key to move to the next digit. Repeat the process until the entire number is entered. (Note that the decimal is fixed at three places. If you only have two decimal places for your K-factor, enter a zero for the third digit.) Press SET to advance. (**Note:** If unable to set K-factor, the unit is "locked" to prevent tampering. Please contact your Distributor for assistance.)

Set P/Flow Alarm. At this screen you may select between pulse output (P) or flow alarm (A) functions. If the pulse output and flow alarm features are not being used, this step can be skipped. The P (pulse output) setting does not affect anything if it is not being used.

Set P is the default that appears on a new FT400-Series. On an FT400 that has been previously set up with flow alarm function, an A will appear on this screen. To move between P and A screens, firmly press all three keys for 5-10 seconds, then use the up arrow to scroll through the three options: P, AL HI (high flow alarm) and AL LO (low flow alarm).

Set P. From this screen, follow the same process as for Set K to enter the desired pulse rate. This is the number of gallons (or whatever units are programmed) between pulses. (**Note:** Using the pulse output function disables the high and low flow alarm functions.)

Set Flow Alarm. From the A screen, use the up arrow key to choose either AL HI or AL LO and then press the SET key to set the alarm rate. Use the up arrow and left arrow as above to reach the desired digits. (**Note:** Using the flow alarm function disables the pulse output function.)

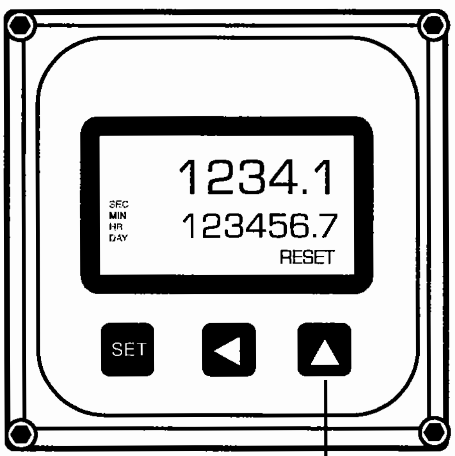
Set 20 mA (FT420 Only). Press the SET key to advance to SET 20, to set the flow rate, in volume units per time unit, at which 20 mA is desired. Use the up arrow key to reach your desired value. Then press the left arrow key to move to the next digit. Repeat the process until the entire number is entered. The processor will automatically scale the 4-20 mA loop accordingly, with 4 mA at zero flow.

Set Decimal Point. Press the SET key again for the D prompt. Pressing the up arrow key switches among no decimal place, one decimal place and two decimal places.

Set Time Unit. When the SET key is pressed again, a blinking time unit appears. Press the up arrow key to select SEC (seconds), MIN (minutes), HR (hours) or DAY (days) (for example, gal/min, or gal/hr).

To return to normal operation after entering settings, press SET again. When the unit is connected to an operating flow sensor, the rate (larger digits) and total (smaller digits) indicator numbers should appear in the display.

Resettable/Non-Resettable Totalizer. Unless the unit has been ordered with the non-reset option, a RESET prompt is visible in the lower right corner above the up arrow key, when the display is in use. Press the up arrow key at any time to reset the totalizer to zero. (**Note:** If you need to reset a unit that has been ordered with a non-resettable totalizer, contact your distributor.)



This key resets total to zero when in normal run mode.

CAUTION: Do not touch up Arrow button unless you intend to RESET Total to Zero. TOTAL IS NOT RECOVERABLE.

Operation of 4-20 mA Output (FT420 Only). If the 4-20 mA output is in use and is correctly connected, the signal should vary between 4 mA and 20 mA in proportion to the flow, with the top flow rate set by the user (see Settings, page 8). At no time should the signal drop below 4 mA. A reading between 0 and 4 mA indicates a fault of some type, typically in the loop power supply or the connections (see Troubleshooting, back page). In the rare instance that the 4-20 signal fluctuates excessively ("paints") it may need to be damped by additional averaging. Contact Seametrics for information on how to increase filtering.

Operation of the Pulse Output. If the pulse output is being used (either standard electronic or relay-type), it should pulse for 0.1 second every time the set number of gallons has been totalized. If a pulse-responsive metering pump is properly connected to this output, it should stroke periodically. If this does not occur, see Troubleshooting, back page.

FT415 Battery Change. The expected average life of the battery ranges between 3-5 years depending on the frequency of the input. The battery is easily pulled and replaced. When the battery is removed, all of the settings will be retained.

CAUTION: During a battery change, the totalizer will reset to a previous total, which represents the last auto-backup (auto backups occur at approximately 4 minute intervals). If it is necessary to save the exact current total at the time of the battery change, save before removing the battery as follows:
1) Simultaneously press the SET and up arrow keys
2) Press SET again
3) Again simultaneously press the SET and up arrow keys

TROUBLESHOOTING

Problem	Probable Cause	Try...
Display blank	No power to the unit	Check for minimum 12 Vdc at power terminals
	Short in sensor circuit	Disconnect sensor, see if display returns (zero flow rate)
	Battery dead or loose (FT415 only)	Wiggle battery, replace if over three years old
Display missing segments	Damaged display module	Contact distributor for return/replacement
Display reading meaningless characters	Unit's microcontroller crashed	Disconnect and reconnect power, if problem repeats, contact distributor for return/replacement
	Battery nearly dead	Replace battery if over three years old
Display reads normally, flow rate incorrect	Wrong K-factor or time base entered	Enter correct K-factor from meter, fitting, or manual
Display reads normally, incorrect pulse output	Wrong pulse output setting	Use "Set P" to correct pulse output setting
	Polarity reversed on pulse output terminals	Reverse leads
Display reads normally but no (or incorrect) 4-20 mA output (FT420 only)	Wrong 20 mA setting	Use "Set 20" to correct target top flow rate
	Inadequate loop power supply voltage	Check voltage (For 4-20 mA applications, 24 Vdc recommended)
	Polarity incorrect in 4-20 mA loop circuit	Compare to Connections diagram
Display reads zero when there is flow	Flow sensor failed	Consult flow sensor manual for how to test
	Break in flow sensor circuit	Check for continuity with multimeter
	Flow sensor not battery-compatible	Check flow sensor model number for "micropower option"
Display reads flow rate when there is none	Long flow sensor wire, running parallel to power wires	Reroute wire or change to shielded wire
	Flow sensor malfunction	See flow sensor manual to check
	Flow "jitter" (oscillating slosh) reads as flow	Consult factory for "anti-jitter" setting

SeaMetrics

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LT-13314-B
10/9/06

SeaMetrics

IP80 Series Flow Sensor Instructions

General Information

The IP80 Series are impeller-type insertion meters designed for use in pipe sizes 1/2" to 8". High-quality jewel bearings and nickel-bound tungsten carbide shaft are used for maximum life and extreme low friction. Bodies are machined from solid rod for maximum precision. Low-flow performance is superior. The rotation of the rotor is detected by a non-drag Hall-effect sensor. Output is a pulse-type square wave, which can be sent long distances (up to 2,000 feet) without a transmitter. This signal can be connected directly to SeaMetrics controls, as well as PLC's, counters, and computer cards.

SeaMetrics IP meters are ideal for chemical proportioning applications. If no display is required, a simple divider such as the PD10 provides adjustable pump pacing. For rate and total display, as well as pump pacing, the FT415/420 flow indicator can be mounted directly on the IP80 Series, or remotely on a wall or panel.

The IP80 Series require special fittings, since they are not depth-adjustable as are the IP 100/200 series meters. Installation in the fitting ensures correct depth placement in the pipe. Fittings are available in PVC, brass, and stainless steel. Sensors are available in brass, 316 stainless steel, PVC, and polypropylene. In plastic pipe 3"-8", use an IP82 sensor, which is 1.00" longer than the IP81 to accommodate the larger fittings.

Specifications

Sensor		
	Hall Effect Sensor	12 VDC current sinking pulse
Materials		
	Sensor Body	PVC, Polypro, Brass, or 316 SS
	Rotor	Kynar
	Shaft	Nickel-bound tungsten carbide, ceramic optional
	Bearings	Ruby jewel
Maximum Pressure		
	PVC	175 PSI (12 bar) at 75° *
	Polypro	175 PSI (12 bar) at 75° *
	Brass	200 PSI (14 bar)
	316 SS	250 PSI (17 bar)
Maximum Temperature		
	PVC,Polypro	130° F (55° C)*
	Brass, SS	200° F (93° C)
Accuracy		1-1/2% FS

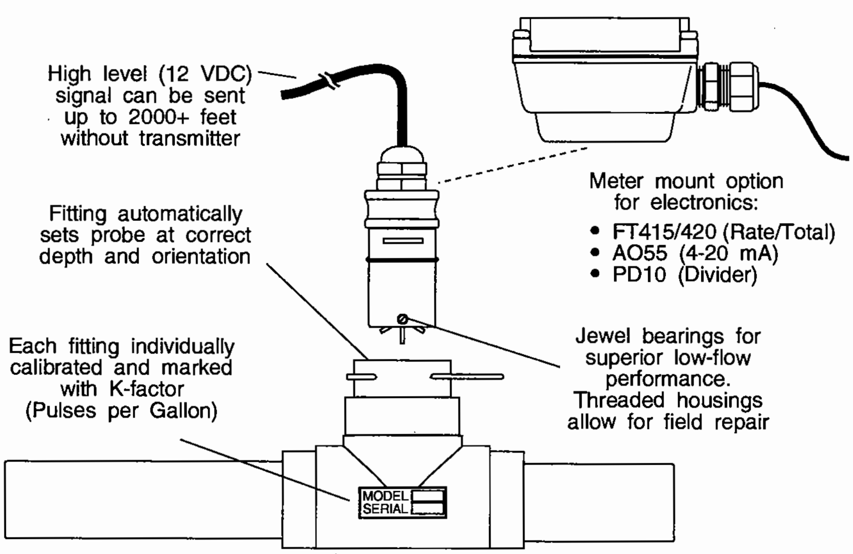
Flow Range (GPM)

	1/2"	3/4"	1"	1-1/2"	2"	3"	4"	6"	8"
Min	0.28	0.5	0.8	1.9	3.1	6.9	12	27	47
Max	28	50	80	190	314	691	1200	2700	4700

Cable #22 AWG 3-con, 18'

* (see Pressure vs. Temperature chart)

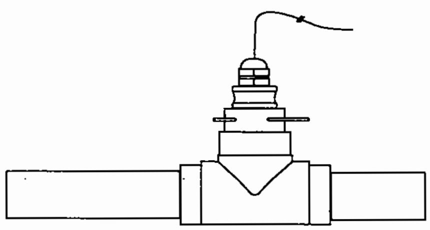
Features



Installation

These water meters are not recommended for installation downstream of the boiler feedwater pump where installation fault may expose the meter to boiler pressure and temperature. Maximum recommended temperature is 130°F (Plastic), 200°F (Metal).

Fitting Installation. IP80 Series meters require special fittings. The meter fitting must first be installed in the pipeline. Straight pipe of at least ten times the diameter upstream of the meter and five diameters downstream are strongly recommended. Inadequate straight pipe, especially downstream of an elbow, change in pipe diameter, or partially-opened valve, can result in significant inaccuracy. Typically this inaccuracy is in the form of the meter reading high. Some IP80 Series meter fittings are supplied with upstream straight pipe.

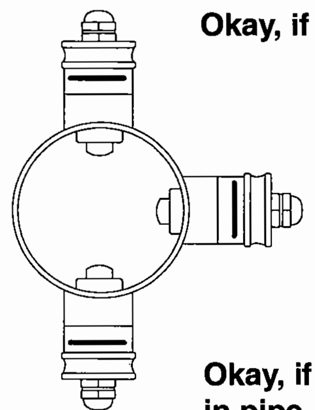


In the larger sizes, the length provided is less than ten diameters upstream and five downstream. It is not advisable to connect directly to the end of these fittings with a flow-disturbing device such as a valve or elbow. If possible, straight pipe should be added to these fittings.

Caution: Never remove the u-clip retainer when the pipe is under pressure. Always remove pressure from the pipe before attempting to remove the meter. Removal under pressure may result in damage or serious injury.

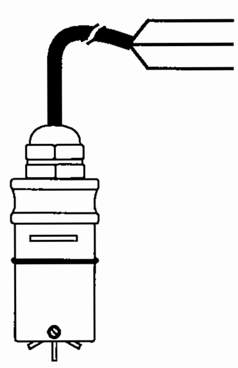
A PVC fitting is usually installed by solvent welding. The stainless steel and brass meter fittings have female pipe threads, requiring the appropriate male threaded fittings. Saddle fittings (size 3" and above) require a hole to be cut in the pipe. The recommended hole size is 1-3/4".

Meter Installation. After the meter fitting is installed in the pipeline, the meter can be installed in the fitting. Press the meter into the fitting as far as it will go. Then retain the meter in place by inserting the u-pin. This pin can be installed from either side. It is sometimes necessary to rotate the probe back and forth slightly to start the pin into the slots on the probe. Slide the pin in as far as it will go.



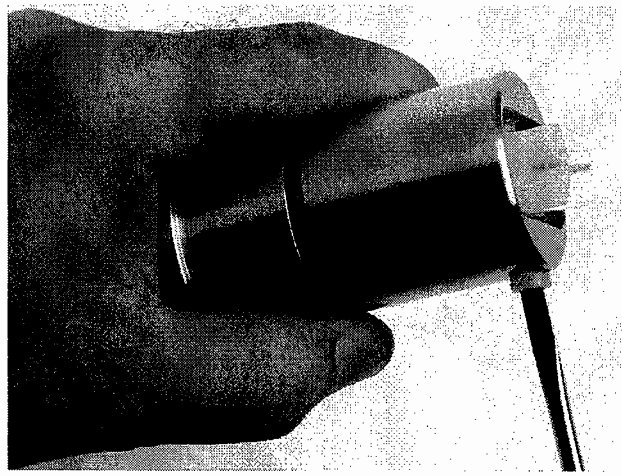
Meter Connection. See the "IP80 Series Connections" diagram for meter connections. Unless the meter is supplied pre-connected to a meter-mounted FT415/420 flow indicator, three leads must be connected. These three leads are color coded. The red wire is 6-24 VDC positive, the black is negative, and the white wire is the signal lead.

IP80 Series Connections



K-factor. If the IP80 Series meter is ordered with its fitting, the meter is factory calibrated in the fitting. A K-factor (meter factor) is indicated on the side of the fitting. This represents the actual number of pulses per gallon the meter produced during the factory flow test. This number can entered into an FT415/420 or FT5210 flow indicator to make it read properly. If a pulse divider is being used, the K-factor is the starting point for calculating the divider number.

Maintenance and Repair



Rotor Replacement. Rotors are easily field-replaced. Shaft and rotor are a single unit, and are not replaced separately. If replacement is due only to normal shaft wear, bearing replacement is probably not necessary. If the rotor has been damaged by impact, the bearings should also be replaced. Rotor and bearings can be ordered as a kit, Part No.25901. Follow these steps:

1. Unscrew the threaded bearing housings to expose the shaft ends. If bearings are being replaced, back them completely out.

2. Remove the rotor. Put the new rotor in its place.

3. Thread in one bearing housing part way, then the other. Take care to start the end of the shaft into the bearing hole before tightening further.

4. Screw in bearing housings until they bottom. **Note: Do not use excessive force.**

5. Check for free spin. Blowing lightly on the rotor should result in it spinning rapidly and coasting to a smooth stop.

Sensor Replacement. It is very unusual for a sensor to require replacement in normal use. The primary cause of sensor failure is overvoltage (inadvertent connection of line voltage, for example) or incorrect polarity on hookup. The sensor is replaced by removing the the strain relief, then threading out the sensor retainer plug. Remove the entire sensor capsule by pulling on the cable. The new sensor capsule can then be installed. It is important to orient the sensor capsule properly. Replace the retainer plug, and then replace and tighten the strain relief.

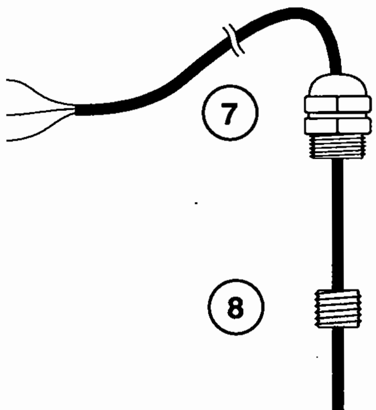
Troubleshooting Guide

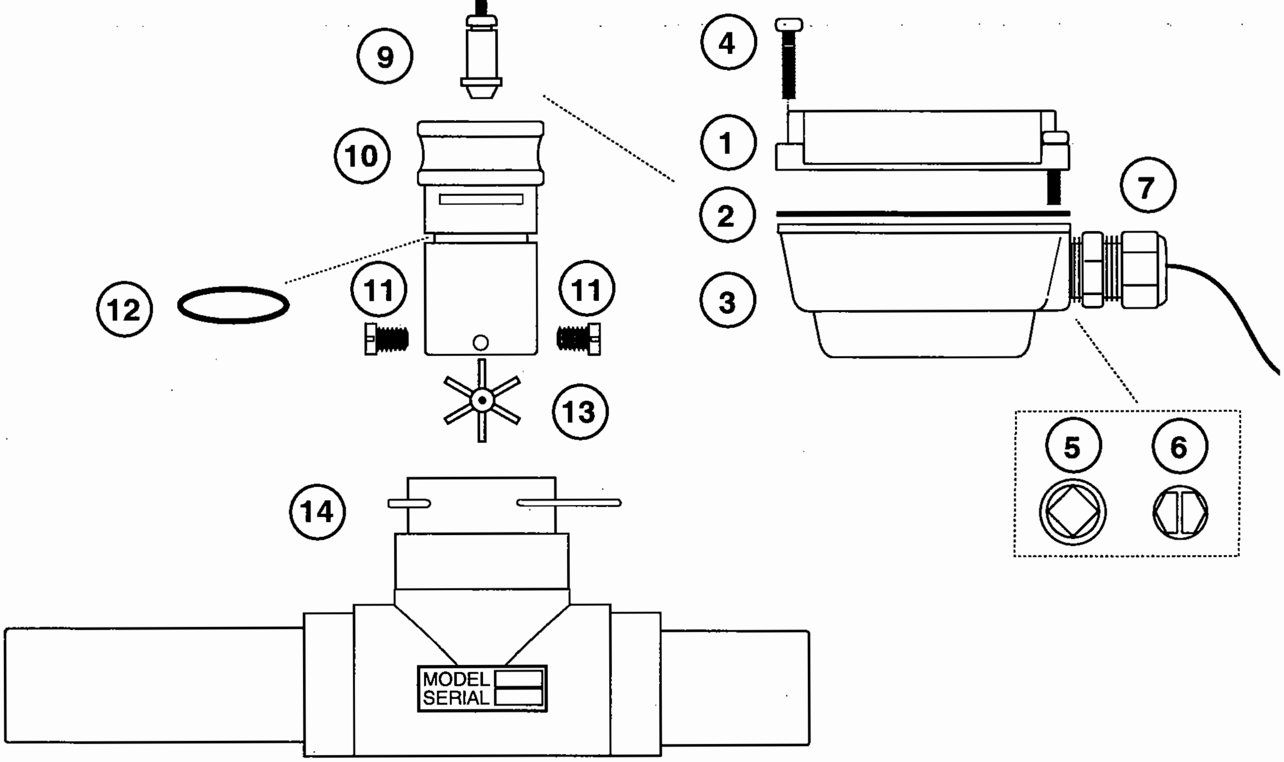
Problem	Probable Cause	To Check	To Repair
No signal after installation	Insufficient flow	See Min. GPM for size	Contact SeaMetrics
	Bad connections to control electronics	Check connections at control. Check polarity: red (+), black (-), white (signal)	Re-connect if necessary
	Incompatible control	Does control: 1) provide 6-24VDC power; 2) accept current sinking inputs	Contact SeaMetrics
	Damaged or missing rotor	Remove meter and check visually for free spinning	Obtain new rotor and replace
Inaccurate metering	Not enough straight pipe between meter and flow disturbance	See recommendations, measure	Move meter away from flow disturbance or field calibrate

Fittings Compatibility Chart		
Material	[redacted]	**IP82**
Bronze	1"- 4" Tee	3"- 8" Braze fitting
PVC	1/2"- 2" Tee	3"- 8" Saddle
Polypro	N/A	3"- 8" Tee
Stainless steel	1/2"- 2" Tee	3"- 8" Weld fitting
Carbon steel	1/2"- 2" Tee	3"- 8" Weld fitting

IP80 Series Parts Listing		
1	Upper housing	26181
2	Gasket	26211
3	Lower housing	29930
4	Housing screw	26229
5	Plug, steel	26073
6	Plug, plastic	26079
7	Strain Relief	7655
8	Sensor Retainer	25321
9	Sensor	26310
10	Body	*
11	Bearing assembly (2)	25901
12	O-ring	25081
13	Rotor	11130
14	Fitting	*

* Consult distributor or price pages





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APPENDIX H

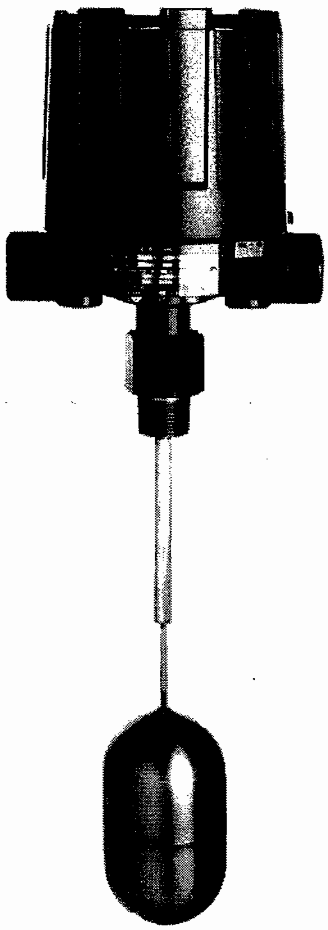
Product Information:

Magnetrol Liquid Level Switch model T21 and Displacer Type
Endress+Hauser FMU40 Ultrasonic Meter
In-Situ LevelTroll 500
Endress+Hauser WaterPilot FMX 167

Magnetrol Liquid Level Switch T21

Top Mounting

Installation and Operating Manual



Liquid

Level

Switches

Models [redacted] & T21

Magnetrol®

STI

Read this Manual Before Installing

This manual provides information on the Top Mounting Liquid Level Switch. It is important that all instructions are read carefully and followed in sequence. Detailed instructions are included in the Installation section of this manual.

Conventions Used in this Manual

Certain conventions are used in this manual to convey specific types of information. General technical material, support data, and safety information are presented in narrative form. The following styles are used for notes, cautions, and warnings.

NOTES

Notes contain information that augments or clarifies an operating step. Notes do not normally contain actions. They follow the procedural steps to which they refer.

Cautions

Cautions alert the technician to special conditions that could injure personnel, damage equipment, or reduce a component's mechanical integrity. Cautions are also used to alert the technician to unsafe practices or the need for special protective equipment or specific materials. In this manual, a caution box indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

WARNINGS

Warnings identify potentially dangerous situations or serious hazards. In this manual, a warning indicates an imminently hazardous situation which, if not avoided, could result in serious injury or death.

Safety Messages

Follow all standard industry procedures for servicing electrical equipment when working with or around high voltage. Always shut off the power supply before touching any components.

WARNING! Explosion hazard. Do not connect or disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

Low Voltage Directive

For use in Category II installations. If equipment is used in a manner not specified by manufacturer, protection provided by equipment may be impaired.

Notice of Trademark, Copyright, and Limitations

Magnetrol and Magnetrol logotype and STI and STI logotype are registered trademarks of Magnetrol International.

Performance specifications are effective with date of issue and are subject to change without notice. Magnetrol reserves the right to make changes to the product described in this manual at any time without notice. Magnetrol makes no warranty with respect to the accuracy of the information in this manual.

Warranty

All Magnetrol/STI mechanical level and flow controls are warranted free of defects in materials or workmanship for five full years from the date of original factory shipment.

If returned within the warranty period; and, upon factory inspection of the control, the cause of the claim is determined to be covered under the warranty; then, Magnetrol/STI will repair or replace the control at no cost to the purchaser (or owner) other than transportation.

Magnetrol/STI shall not be liable for misapplication, labor claims, direct or consequential damage or expense arising from the installation or use of equipment. There are no other warranties expressed or implied, except special written warranties covering some Magnetrol/STI products.

Quality Assurance

The quality assurance system in place at Magnetrol/STI guarantees the highest level of quality throughout the company. Magnetrol/STI is committed to providing full customer satisfaction both in quality products and quality service.

Magnetrol's quality assurance system is registered to ISO 9001 affirming its commitment to known international quality standards providing the strongest assurance of product/service quality available.

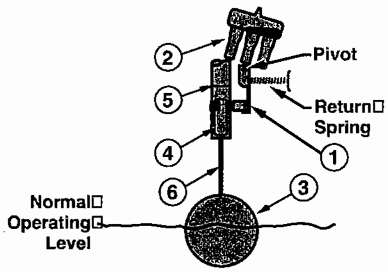
Magnetrol®

STI

Top Mounting
Liquid Level Switches

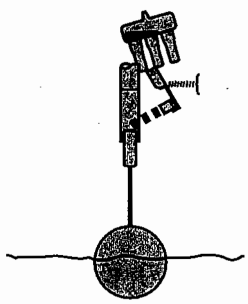
1.0 Introduction

[redacted] and T21 level switches are float operated units designed for top mounting to a tank or vessel by means of threaded or flanged pipe connections. T20 standard units are equipped with a single switch mechanism for high or low level alarm or control applications. T21 tandem units are equipped with two switch mechanisms, each operated by a separate float, for applications requiring widely spaced separate high and low level switch actuation.



Rising Level

Figure 1



Falling Level

Figure 2

1.1 Principle of Operation

The simple and foolproof operation of the top mounted float switches is illustrated in figures 1 and 2.

A magnetic attraction sleeve ④ is fixed at the top of a rigid float stem ⑥. As the float and stem assembly ③ ⑥ move s with the level of the liquid, the attraction sleeve is moved into or out of the field of the switch magnet ①. The presence or the absence of the attraction sleeve causes the switch magnet and attached switch ② to move and change state. A non-magnetic barrier tube ⑤ isolates the process media from the switch without interfering with the field of the switch magnet and provides a static pressure boundary to the process.

2.0 Installation

This section provides detailed procedures for properly installing top mounted level switches.

Caution: If equipment is used in a manner not specified by the manufacturer, protection provided by the equipment may be impaired.

2.1 Unpacking

Unpack the instrument carefully. Inspect all units for damage. Report any concealed damage to carrier within 24 hours. Check the contents of the packing slip against purchase order. Check and record the model number against serial number for future reference when ordering parts.

Model Number: ____________________

Serial Number: ____________________

It is recommended that for critical alarm functions, an additional level switch be installed as a high–high or low–low level alarm for maximum protection.

Caution: Operation of all buoyancy type level devices should be done in such a way as to minimize the action of dynamic forces on the float or displacer sensing element. Good practice for reducing the likelihood of damage to the control is to equalize pressure across the device very slowly.

Ensure that no tubes, rods, or other obstacles in the tank or vessel which could interfere with the operation of float(s).

Caution: This instrument is intended for use in Installation Category II, Pollution Degree 2.

Adjust the process connection as required to bring control to a vertical position. Magnetrol controls must be mounted within three degrees (3°) of vertical in all directions. A three degree slant is noticeable by eye, but installation should be checked with a spirit level on top and/or sides of float stem or enclosing tube.

NOTE: Do not insulate switch mechanism housing.

On controls equipped with pneumatic switch assemblies, consult bulletin on mechanism furnished for air (or gas) piping instructions.

Switch Series Letter	Description	Bulletin No.
A	Standard Mercury Switch	42-683
B, C, D	Dry Contact Switch	
E	Vibration Resistant Mercury Switch	
F	Hermetically Sealed Snap Switch	
HS	Hermetically Sealed Snap Switch	42-694
J	Bleed Type Pneumatic Switch	42-685
K	Non-Bleed Type Pneumatic Switch	42-686

2.4 Wiring

Caution: All Top Mounting units are shipped from the factory with the enclosing tube tightened and the switch housing set screw locked to the enclosing tube. Failure to loosen the set screw prior to repositioning the supply and output connections may cause the enclosing tube to loosen, resulting in possible leakage of the process liquid or vapor.

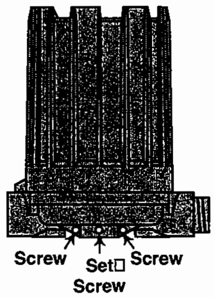


Figure 3
Housing Set Screws

Top mounting controls are shipped with the conduit entry of the switch housing placed 180° opposite the tank connections to simplify installation in most cases. If the location of the conduit entry on the level switch is appropriate to the installation, proceed to Step 4 to begin wiring the unit. If another configuration is desired, the switch housing can be easily rotated by first following Steps 1, 2, and 3.

NOTE: A switch or circuit breaker shall be installed in close proximity to equipment and within easy reach of operator. It shall be marked as the disconnecting device for the equipment.

1. Loosen set screw(s) at base of switch housing. Refer to Figure 3.
2. Switch housing may be rotated 360° to allow correct positioning of conduit outlet.
3. Tighten set screw(s) at base of switch housing.
4. Unscrew and remove switch housing cover. The threads have been lubricated to facilitate removal.

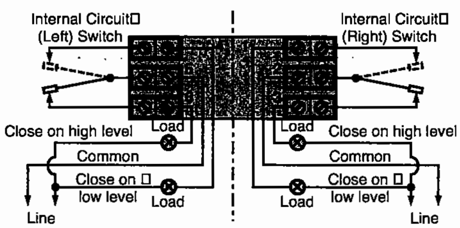


Figure 4
Terminal Connections
DPDT Switch Mechanism
Series A, B, C, D, and E

NOTE: For supply connections use wire with a minimum rating of 75° C, as required by process conditions. Use a minimum of 14 AWG wire for power and ground field wires. On high temperature applications (above 250° F [121° C] at mounting flange or bushing), high temperature wire should be used between control and first junction box located in a cooler area. On non-hazardous applications, flexible conduit may be used between the control and the first junction box.

5. The switch terminals are located next to the conduit outlet to facilitate wiring. Bring supply wires through conduit outlet. Route extra wire around enclosing tube under the baffle plate, and connect them to the proper terminals. Refer to the wiring diagram, Figure 4, or your switch bulletin for this information.

6. Dress wiring to ensure no interference or contact with tilt of switch, or replacement of switch housing cover.

NOTE: Observe all applicable electrical codes and proper wiring procedures.

Prevent moisture seepage into the enclosure by installing approved seal-drain fittings in the conduit run leading into the unit.

Caution: In hazardous areas, do not power the unit until the conduit is sealed and the enclosure cover is screwed down securely.

7. Replace housing cover.
8. If control has been furnished with an explosion proof or moisture proof switch housing, it must be sealed at the conduit outlet with a suitable compound or non-hardening sealant to prevent entrance of air.
9. Test switch action by varying liquid level in the tank or vessel. The upper switch on Model T21 units is actuated by movement of the lower float, while the lower switch is actuated by the upper float.

NOTE: If switch mechanism fails to function properly, check vertical alignment of control housing and consult installation bulletin on switch mechanism furnished.

10. Check cover to base fit to be certain gasketed joint is tight. A positive seal is necessary to prevent infiltration of moisture laden air or corrosive gasses into switch housing.

The standard differential of the single float Model T20 may be field adjusted. Adjustment may be necessary if a wider differential needs to be set to overcome switch chatter caused by the process.

The differential, or the amount of level travel between switch-on and switch-off, may be adjusted by repositioning the lower jam nuts on the float stem. The standard factory setting is for a minimum amount of play (gap) between the top jam nuts and the attraction sleeve as shown in Figure 6.

NOTE: For assistance in computing level differential change for a specific control, consult the factory giving the model and serial numbers of the control.

Caution: Maximum differential adjustment is 0.50 inch.

NOTE: To widen the differential 0.50 inch, the lower jam nuts must be set proportionately lower on the stem (i.e. in this example 0.50 inch).

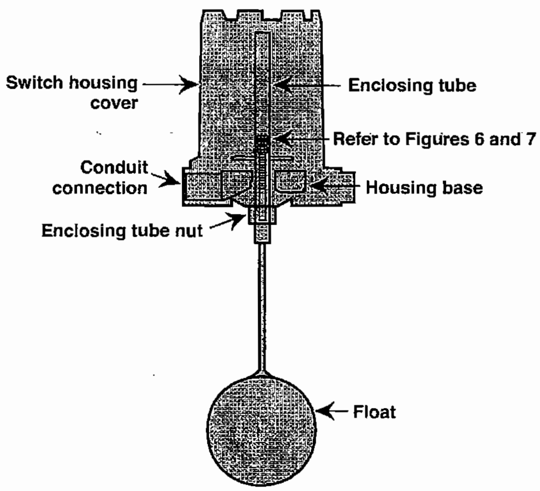


Figure 5

Caution: Before attempting any work on the control, pull disconnect switch, or otherwise assure that electrical circuit(s) through the control is deactivated. Close operating medium supply valve on controls equipped with pneumatic switch mechanisms.

1. Determine what change in differential is necessary.
2. Make sure power source is turned off.
3. Unscrew and remove switch housing cover.
4. Disconnect power supply wires from switch mechanism. Pull wires out of conduit connection opening in housing base. Refer to Figure 5.
5. Perform system shut-down procedures as required to relieve pressure from tank or vessel and drain off liquid head, if required. Allow unit to cool.

NOTE: The amount of level travel between switch-on and switch-off actuation (differential) may be field adjusted by repositioning the lower jam nuts on the float stem. The standard factory setting is for a minimum amount of play (gap) between the top jam nuts and the attraction sleeve, as shown in Figure 6. This setting may be increased to a maximum of 0.50" (13 mm), as shown in Figure 7.

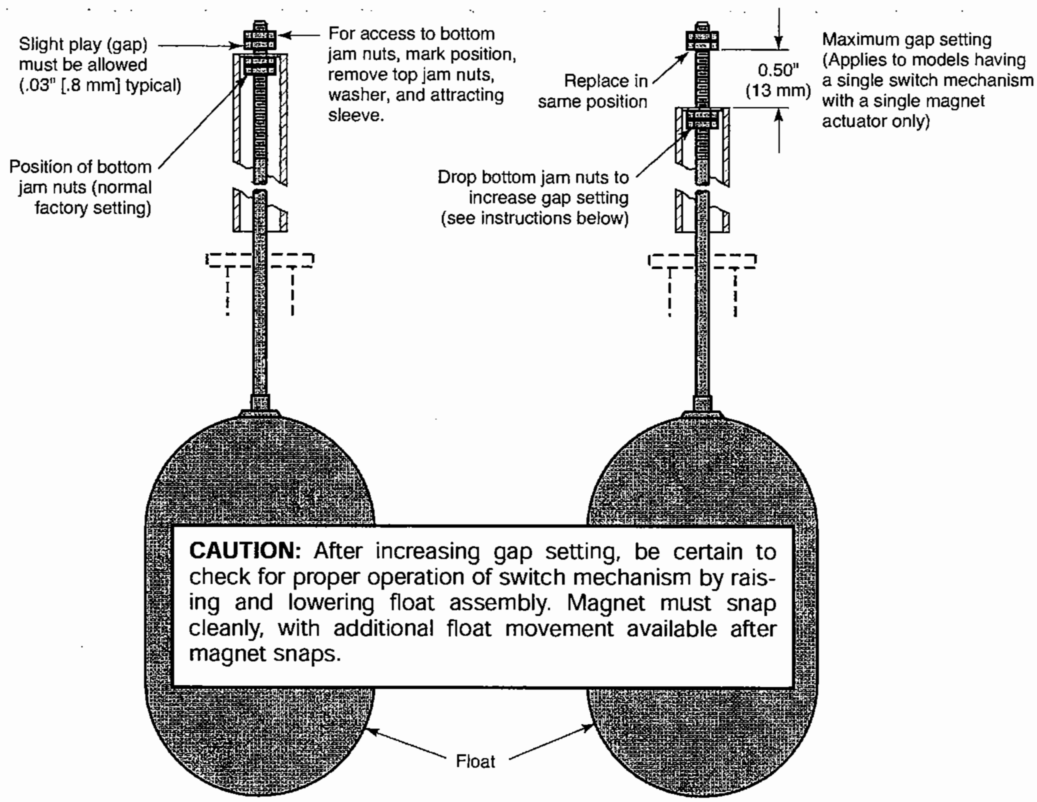
6. Remove switch housing assembly by loosening the enclosing tube nut, which is located immediately below housing base. Refer to Figure 5.

7. With switch housing and enclosing tube removed, jam nuts and attraction sleeve are accessible. Measure position of upper jam nuts from stem end; then loosen and remove upper jam nuts, guide washer, and attraction sleeve.
8. Loosen and adjust lower jam nuts to desired position. Make certain jam nuts are retightened securely.

NOTE: Use new enclosing tube gasket in assembly of switch housing to the mounting bushing or flange. Refer to **Sections 5.4.1.1** and **5.4.2.1** for enclosing tube gasket part numbers.

9. Test switch actuation by varying liquid level in tank or vessel.

Caution: Instructions given are for standard base model units which use a single magnet switch mechanism only. No differential adjustment should be attempted on tandem float models in the field. Switch actuation levels have been set at the factory to meet specific customer specifications. Variations in actual conditions from design conditions usually requires special control modifications. Consult with the factory or local representative for assistance.



CAUTION: After increasing gap setting, be certain to check for proper operation of switch mechanism by raising and lowering float assembly. Magnet must snap cleanly, with additional float movement available after magnet snaps.

Figure 6
Normal Factory Setting (minimum differential)

Figure 7
Differential adjustment

[illegible]

Periodic inspections are a necessary means to keep your level control in good working order. This control is a safety device to protect the valuable equipment it serves. Therefore, a systematic program of "preventive maintenance" must be implemented when the control is placed into service. If the following sections on "what to do" and "what to avoid" are observed, your control will provide reliable protection of your equipment for many years.

[illegible]

4.1.1 Keep control clean

Be sure the switch housing cover is always in place on the control. This cover is designed to keep dust and dirt from interfering with switch mechanism operation. In addition, it protects against damaging moisture and acts as a safety feature by keeping bare wires and terminals from being exposed. Should the housing cover or any seals become damaged or misplaced, obtain a replacement immediately.

4.1.2 Inspect switch mechanisms, terminals, and connections monthly

1. Mercury switches may be visually inspected for short circuit damage. Check for small cracks in the glass tube containing the mercury. Such cracks can allow entrance of air into the tube causing the mercury to "oxidize". This is noticeable as the mercury will appear dirty or dull, and will not break into clean, round pools. If these conditions exist, replace the mercury switch immediately.
2. Dry contact switches should be inspected for excessive wear on actuating lever or misalignment of adjustment screw at point of contact between screw and lever. Such wear can cause false switch actuating levels. See switch mechanism bulletin supplied with control should switch adjustment or replacement be necessary.
3. DO NOT operate your control with defective or maladjusted switch mechanisms (refer to bulletin on switch mechanisms furnished for service instructions.)

4. Level controls may sometimes be exposed to excessive heat or moisture. Under such conditions, insulation on electrical wiring may become brittle, eventually breaking or pealing away. The resulting "bare" wires can cause short circuits.

NOTE: Check wiring carefully and replace at the first sign of brittle insulation.

5. Vibration may sometimes cause terminal screws to work loose. Check all terminal connections to be certain that screws are tight.
6. On units with pneumatic switches, air (or gas) lines subjected to vibration, may eventually crack or become loose at connections causing leakage. Check lines and connections carefully and repair or replace, if necessary.

NOTE: As a matter of good practice, spare switches should be kept on hand at all times.

4.1.3 Inspect entire unit periodically

Isolate control from vessel. Raise and lower liquid level to check for switch contact and reset.

1. Never leave switch housing cover off the control longer than necessary to make routine inspections.
2. Never place a jumper wire across terminals to "cut-out" the control. If a "jumper" is necessary for test purposes, be certain it is removed before placing control into service.
3. Never attempt to make adjustments or replace switches without reading instructions carefully. Certain adjustments provided for in level controls should not be attempted in the field. When in doubt, consult the factory or your local representative.
4. Never use lubricants on pivots of switch mechanisms. A sufficient amount of lubricant has been applied at the factory to ensure a lifetime of service. Further oiling is unnecessary and will only tend to attract dust and dirt which can interfere with mechanism operation.

5.0 Reference Information

5.1 Troubleshooting

Usually the first indication of improper operation is failure of the controlled equipment to function, i.e.: pump will not start (or stop), signal lamps fail to light, etc. When these symptoms occur, whether at time of installation or during routine service thereafter, check the following potential external causes first.

a. Fuses may be blown.

b. Reset button(s) may need resetting.

c. Power switch may be open.

d. Controlled equipment may be faulty.

e. Wiring leading to control may be defective.

If a thorough inspection of these possible conditions fails to locate the trouble, proceed next to a check of the control's switch mechanism.

5.1.1 Check switch mechanism

1. Pull disconnect switch or otherwise disconnect power to the control.
2. Remove switch housing cover.
3. Disconnect power wiring from switch assembly.
4. Swing magnet assembly in and out by hand to check carefully for any sign of binding. Assembly should require minimal force to move it through its full swing.
5. If binding exists, magnet may be rubbing enclosing tube. If magnet is rubbing, loosen magnet clamp screw and shift magnet position. Retighten magnet clamp screw.
6. If switch magnet assembly swings freely and mechanism still fails to actuate, check installation of control to be certain it is within the specified three (3°) degrees of vertical. (Use spirit level on side of enclosing tube in two places, 90° apart.

7. If mechanism is equipped with a mercury switch, examine glass mercury tube closely as previously described in **Section 4.0 Preventive Maintenance**. If switch is damaged, replace it immediately. If microswitch, check continuity with ohmmeter.
8. If switch mechanism is operating satisfactorily, proceed to check sensing unit.

5.1.2 Check complete unit

1. Reconnect power supply and carefully actuate switch mechanism manually (using a non-conductive tool) to determine whether controlled equipment will operate.

Caution: With electrical power on, care should be taken to avoid contact with switch leads and connections at terminal block.

2. If controlled equipment responds to manual actuation test, trouble may be located in the level sensing portion of the control–float(s), stem(s), and magnetic attraction sleeve(s).

NOTE: Ensure that liquid is entering the storage tank or vessel. A valve may be closed or a pipe line plugged.

Caution: Be certain to pull disconnect switch or otherwise ensure that electrical circuit(s) through control is deactivated. Close operating medium supply valve on controls equipped with pneumatic switch mechanisms.

3. With liquid in tank or vessel, raise the liquid level above the set points. Magnets should "pull-in" on rising level. On Model T21 the lower float actuates the upper switch, and the upper float actuates the lower switch. If magnets fail to "pull-in", lower the level and purge pressure.
   a. Disconnect wiring from supply side of switch mechanism(s) and remove electrical conduit or operating medium line connections to switch housing.
   b. Remove switch housing assembly by loosening hex nut, which is located immediately below housing base.
4. With switch housing assembly removed, inspect attraction sleeve(s) and inside of enclosing tube for excessive corrosion or solids buildup, which could restrict movement, preventing sleeve(s) from reaching field of switch magnet(s).
5. If differential has been changed in the field by repositioning the lower jam nuts on the float stem, check tightness and position of the jam nuts. Refer to Figure 6.

NOTE: Differential adjustment affects a change in the amount of level travel between switch-on and switch-off actuation. Do not attempt adjustment without first consulting factory for assistance in computing level differential change for your control.

6. Check float to be certain it is buoyant in the liquid (tank or vessel must have adequate liquid level). If float is determined to be filled with liquid, or it is collapsed, it must be replaced immediately. Do not attempt to repair a float.

   If all components in the control are in operating condition, the trouble must be (and should be) located external to the control. Repeat inspection of external conditions previously described.

   When communicating about your control, be certain to always specify the complete Model and Serial numbers.

Agency Approvals

AGENCY	MODEL APPROVED	APPROVAL CLASSES
FM	All with an electric switch mechanism and a housing listed as NEMA 4X/7/9	Class I, Div 1, Groups C & D Class II, Div 1, Groups E, F & G
	All with an electric switch mechanism and a housing listed as NEMA 4X/7/9 Class I, Div 1, Group B	Class I, Div 1, Groups B, C & D Class II, Div 1, Groups E, F & G
CSA	All with a Series A, E, F, HS or H1 electric switch mechanism and a housing listed as CSA TYPE 4X	Class I, Div 2, Groups B, C & D
	All with an electric switch mechanism and a housing listed as NEMA 4X/7/9	Class I, Div 1, Groups C & D Class II, Div 1, Groups E, F & G
	All with an electric switch mechanism and a housing listed as NEMA 4X/7/9 Class I, Div 1, Group B	Class I, Div 1, Groups B, C & D Class II, Div 1, Groups E, F & G
ATEX / IEC Ex ②	All with an electric switch mechanism and an ATEX housing①	ATEX II 2 G EEx d IIC T6 IEC Ex Ex d IIC T6
CE	Low Voltage Directives 73/23/EEC & 93/68/EEC Per Harmonized Standard: EN 61010-1/1993 & Amendment No. 1	Installation Category II Pollution Degree 2

① Dual stage units with 'HS' switches are not ATEX approved.

② IEC Installation Instructions:

The cable entry and closing devices shall be Ex d certified suitable for the conditions of use and correctly installed.

For ambient temperatures above +55° C or for process temperatures above +150° C, suitable heat resistant cables shall be used.

Heat extensions (between process connection and housing) shall never be insulated.

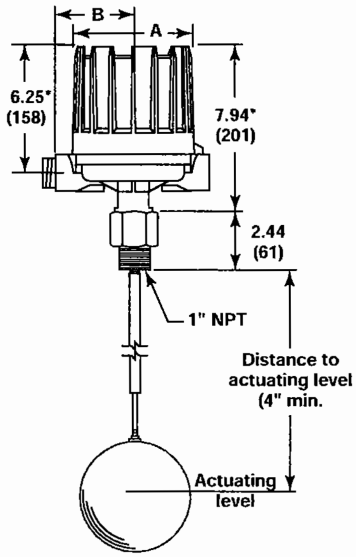
Special conditions for safe use:

When the equipment is installed in process temperatures higher than +85° C the temperature classification must be reduced according to the following table as per IEC60079-0.

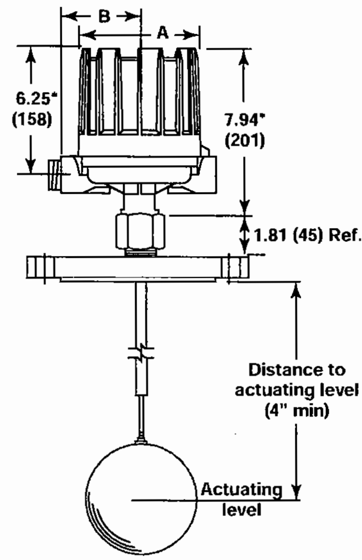
Maximum Process Temperature	Temperature Classification
< 85° C	T6
< 100° C	T5
< 135° C	T4
< 200° C	T3
< 300° C	T2
< 450° C	T1

These units are in comformity with IECEx KEM 05.0020X
Classification Ex d IIC T6
$T_{ambient}$ -40° C to +70° C

5.3.1 Physical inches (mm)

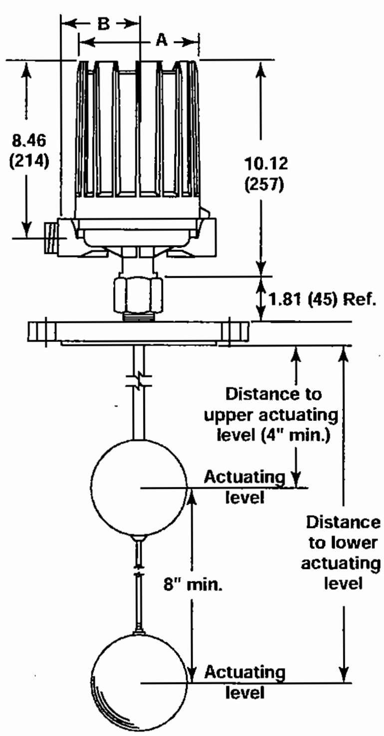


Model T20 with 1" NPT



Model T20 with flange

* These dimensions increase by 2.19 (55) when unit is supplied with an HS switch with terminal block.



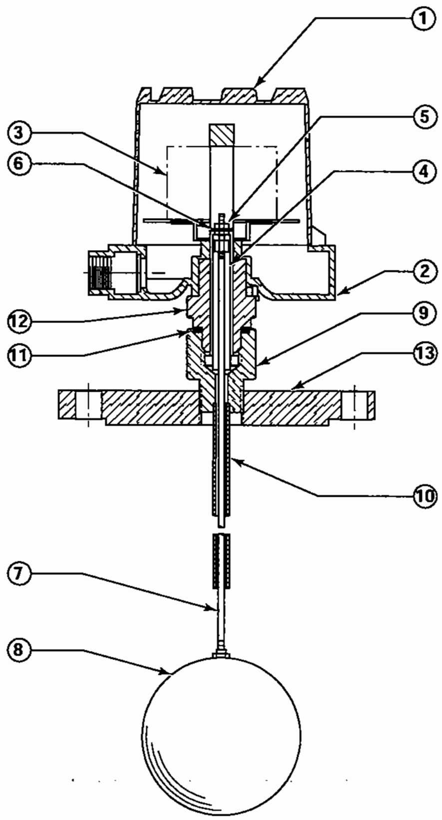
Model T21 with flange

Housing ①	A	B	Conduit Connections
NEMA 4X/7/9, Group B	5.93 (151)	3.87 (98)	1" NPT dual entry
NEMA 1 ② Pneumatics	4.70 (119)	5.00 (127)	¼" NPT single entry

① All housings rotatable 360°.
② Pneumatic switches available with Series T20 units only.

Distance To	Maximum	Minimum
Upper level	40" (1016)	4" (102)
Lower level	48" (1219)	12" (305)

NOTE: On Model T21 the lower float actuates upper switch mechanism. The upper float actuates the lower switch mechanism.



5.4.1 Model T20 Parts Identification

Item	Description
1	Housing cover
2	Housing base
3	Switch mechanism
4	Attraction sleeve
5	Jam nuts
6	Guide washer(s)
7	Float stem
8	Float
9	Adaptor bushing
10	Stem guide tube
11	Enclosing tube gasket
12	Enclosing tube
13	Mounting flange

5.4.1.1 Model T20

	T20-1	T20-4
Housing cover	See below	
Housing base	See below	
Switch mechanism	See below	
Stem kit, includes items 4, 5, 6 & 7	Consult factory	
Float: 3" x 5"	Z07-1202-003	
4.00"	Z07-1102-008	
4.50"	Z07-1102-009	
Adaptor bushing	004-5734-110	004-5734-123
Float stem	Consult factory	
Stem guide tube	Consult factory	
Enclosing tube gasket	012-1301-002	
Enclosing tube	Z32-6325-001	Z32-6326-002
Mounting flange	See below	

5.4.1.2 Mounting flanges

	125 lb cast iron	150 lb forged steel	300 lb forged steel	150 lb forged 304	150 lb forged 316
4" flange	Z04-5840-001	Z04-5840-011	Z04-5840-016	004-5840-021	004-5840-026
5" flange	Z04-5840-002	Z04-5840-012	Z04-5840-017	004-5840-022	004-5840-027
6" flange	Z04-5840-003	Z04-5840-013	Z04-5840-018	004-5840-023	004-5840-028
8" flange	Z04-5840-004	Z04-5840-014	Z04-5840-019	004-5840-024	004-5840-029

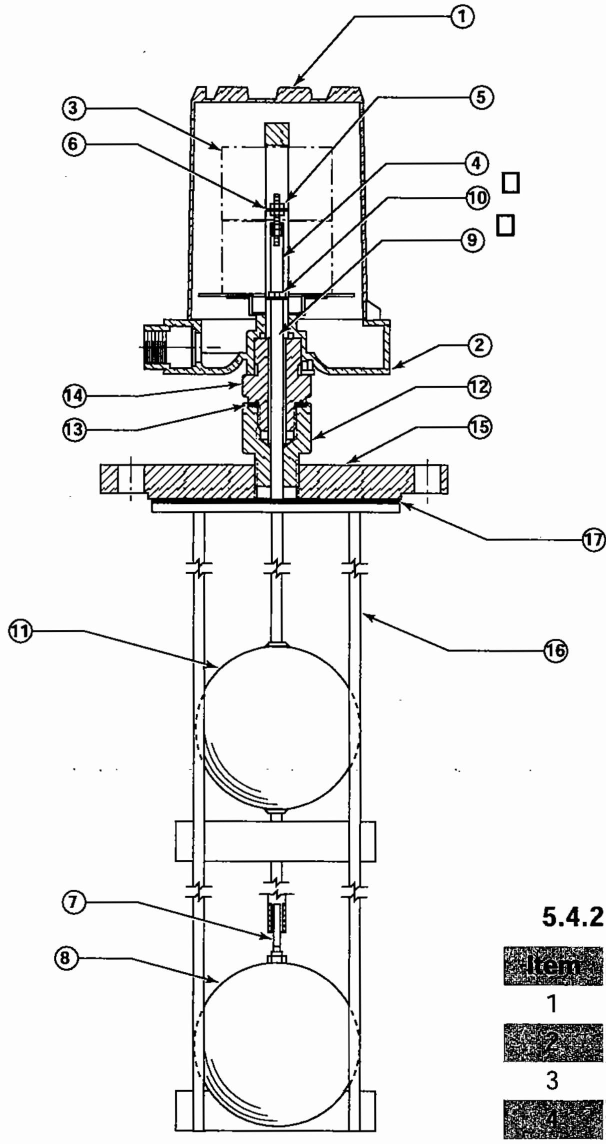
5.4.1.3 Switch and housing reference

	Series Type	Bulletin#
Mercury	A, 3	42-683
Anti-vibration mercury	E, 2	42-683
Dry contact	B, C, D	42-683
Hermetically sealed	F	42-683
Hermetically sealed	HS	42-694
Bleed type pneumatic	J	42-685
Non-bleed type pneumatic	K	42-486

Important: When ordering spare parts, please specify:
A. Model and serial numbers.
B. Name and part number of replacement part or assembly.

All replacement parts are for standard models only. Consult your local representative for ordering assistance on all specially modified models (model numbers preceded by an X).

5.4 Replacement Parts



5.4.2 Model T21 Parts Identification

Item	Description
1	Housing cover
2	Housing base
3	Switch mechanism
4	Upper attraction sleeve
5	Jam nuts
6	Guide washer(s)
7	Upper stem assembly
8	Lower float
9	Lower attraction sleeve, stop tube, and washers
10	Retaining nuts
11	Upper float and tube assembly
12	Adaptor bushing
13	Enclosing tube gasket
14	Enclosing tube
15	Mounting flange
16	Float guide cage (optional)
17	Float guide cage gasket (optional)

5.4.2.1 Model T21

	T21-1	T21-4
Housing cover	See below	
Housing base	See below	
Switch mechanism	See below	
Float stem kit: includes items 4, 5, 6 & 7	Consult factory	
Lower float: 3" x 5"	Z07-1201-003	Z07-1202-003
4.00"	Z07-1101-015	Z07-1102-008
4.50"	Z07-1102-009	
Upper float and tube assembly kit: includes items 9, 10 & 11	Consult factory	
Adaptor bushing	Z04-5734-110	004-5734-123
Enclosing tube gasket	012-1301-002	
Enclosing tube	Z32-6325-004	Z32-6325-005
Guide cage kits: includes items 17 & 18	Consult factory	
Mounting flange	See below	

5.4.2.2 Mounting flanges

	125 lb cast iron	150 lb forged steel	300 lb forged steel	150 lb forged 304	150 lb forged 316
4" flange	Z04-5840-001	Z04-5840-011	Z04-5840-016	004-5840-021	004-5840-026
5" flange	Z04-5840-002	Z04-5840-012	Z04-5840-017	004-5840-022	004-5840-027
6" flange	Z04-5840-003	Z04-5840-013	Z04-5840-018	004-5840-023	004-5840-028
8" flange	Z04-5840-004	Z04-5840-014	Z04-5840-019	004-5840-024	004-5840-029

5.4.2.3 Switch and housing reference

	Series type	Bulletin#
Mercury	A, 3	42-683
Anti-vibration mercury	E, 2	42-683
Dry contact	B, C, D	42-683
Hermetically sealed	F	42-683
Hermetically sealed	HS	42-694
Bleed type pneumatic	J	42-685
Non-bleed type pneumatic	K	42-486

Important: When ordering spare parts, please specify:

A. Model and serial numbers.
B. Name and part number of replacement part or assembly.

All replacement parts are for standard models only. Consult your local representative for ordering assistance on all specially modified models (model numbers preceded by an X).

5.5 Model Numbers

5.5.1 Model T20

IMPORTANT: Actuating level(s), in either the rising or falling state, and specific gravity must be provided upon placement of order.

MODEL NUMBER CODE AND MATERIALS OF CONSTRUCTION

Model No.	Set Points	Tank Connection	Float and Trim	Sleeve
T20-1	1—Single float	Carbon steel	300 Series SS	400 Series SS
T20-4		316 SS	316 SS	316 SS

IMPORTANT: The maximum available insertion depth is governed by the liquid specific gravity and selected float size as given in the table below. The minimum insertion depth is four inches.

MAXIMUM INSERTION LENGTH inches (mm)

Liquid Specific Gravity	Float Size 3.00 x 5.00 (76 x 127)	4.00 (102)	4.50 (114)
1.00	39 (991)	48 (1219)	48 (1219)
0.90	20 (508)	33 (838)	48 (1219)
0.80	—	11 (279)	48 (1219)
0.70	—	—	38 (965)
0.60	—	—	6 (152)

FLOAT PRESSURE RATINGS

Float Size	Pressure Rating psig (bar) @ 100° F (38° C)	@ Maximum Temperature
3.00 x 5.00 (76 x 127)	500 psig (34 bar)	300 psig @ +750° F (21 bar @ +399° C)
4.00 (102) Diameter	600 psig (41 bar)	400 psig @ +750° F (28 bar @ +399° C)
4.50 (114) Diameter	500 psig (34 bar)	340 psig @ +750° F (23 bar @ +399° C)

TANK CONNECTION AND FLOAT SIZE

Tank Connection ①	Float Diameter 3.00 x 5.00 (76 x 127)	4.00 (102)	4.50 (114)
1" NPT	B2A	B2B	B2C
4" 125 lb. C.I. flange ② ③	H2A	—	—
4" 150 lb. F.S. flange	H3A	—	—
5" 125 lb. C.I. flange ② ③	J2A	J2B	J2C
5" 150 lb. F.S. flange	J3A	J3B	J3C
6" 125 lb. C.I. flange ② ③	K2A	K2B	K2C
6" 150 lb. F.S. flange	K3A	K3B	K3C
6" 300 lb. F.S. flange	—	—	K4C
8" 125 lb. C.I. flange ② ③	L2A	L2B	L2C
8" 150 lb. F.S. flange	L3A	L3B	L3C

5.5.1 Model T20 (continued)

ELECTRIC SWITCH MECHANISM AND ENCLOSURE

Switch Description	Maximum Process ④ Temperature ° F (° C)	One Set Point	T20-1 Models		T20-4 Models	
			NEMA 4X/7/9 Aluminum Enclosure ⑤⑥			
			Class I, Div. 1, Groups C & D	Class I, Div. 1, Group B	Class I, Div. 1, Groups C & D	Class I, Div. 1, Group B
Series A Mercury	550 (288)	SPDT DPDT	AKP ANP	AKT ANT	AKQ ANQ	AKS ANS
Series 3 Mercury with Beaded Leads	750 (399)	SPDT DPDT	3KP 3NP	3KT 3NT	3KQ 3NQ	3KS 3NS
Series B Snap	250 (121)	SPDT DPDT	BKP BNP	BKT BNT	BKQ BNQ	BKS BNS
Series C Snap	450 (232)	SPDT DPDT	CKP CNP	CKT CNT	CKQ CNQ	CKS CNS
Series D Snap for DC Current	250 (121)	SPDT DPDT	DKQ DNQ	DKS DNS	DKQ DNQ	DKS DNS
Series E Mercury Vibration Resistant	550 (288)	SPDT DPDT	EKP ENP	EKT ENT	EKQ ENQ	EKS ENS
Series 2 Mercury Vibration Resistant	750 (399)	SPDT DPDT	2KP 2NP	2KT 2NT	2KQ 2NQ	2KS 2NS
Series HS Snap Hermetically Sealed w/Wiring Leads	550 ⑦ (288)	SPDT DPDT	HMC HMF	HEK ⑧ HET ⑧	HMC HMF	HEK ⑧ HET ⑧
Series HS Snap Hermetically Sealed w/Term. Block	550 ⑦ (288)	SPDT DPDT	HM3 HM7	HM4 HM8	HM3 HM7	HM4 HM8

PNEUMATIC SWITCH MECHANISM AND ENCLOSURE

Switch Description	Maximum Supply Pressure	Maximum Process Temperature	Bleed Orifice Diameter	NEMA 1
Series J Bleed Type	100 psig (7 bar)	400° F (204° C)	.063 (1.6 mm)	JDE
	60 psig (4 bar)		.094 (2.4 mm)	JEE
	100 psig (7 bar)	700° F (371° C)	.055 (1.4 mm)	JFE
Series K Non-Bleed	100 psig (4 bar)	400° F (204° C)	—	KOE
	40 psig (3 bar)		—	KOG

① Flanges are ANSI standard. Forged steel flanges have standard raised face.

② Not available with Model T20-4.

③ Available only in cast iron.

④ Process temperature based on +100° F (+38° C) ambient.

⑤ Uncontrolled housing heater or drain available in NEMA 4X/7/9 enclosure.

⑥ Consult factory for NEMA 4X/7/9 cast iron housings.

⑦ On steam applications, temperature down-rated to +400° F (+204° C) process at +100° F (+38° C) ambient.

⑧ CSA approval does not apply to Series HE switches.

5.5.2 Model T21

IMPORTANT: Actuating level(s), in either the rising or falling state, and specific gravity must be provided upon placement of order.

MODEL NUMBER CODE AND MATERIALS OF CONSTRUCTION

Model No.	Set Points	Tank Connection	Float and Trim	Sleeve
T21-1	2—Tandem float	Carbon steel	300 Series SS	400 Series SS
T21-4		316 SS	316 SS	316 SS

IMPORTANT: The maximum available insertion depth is governed by the liquid specific gravity and selected float size as given in the table below. The minimum insertion depth is four inches. The minimum distance between the top and bottom insertion depths is eight inches.

MAXIMUM INSERTION LENGTH inches (mm)

Liquid Specific Gravity	Float Size 3.00 x 5.00 (76 x 127) Upper	3.00 x 5.00 (76 x 127) Lower	4.00 (102) Upper	4.00 (102) Lower	4.50 (114) Upper	4.50 (114) Lower
1.00	21 (533)	48 (1219)	32 (813)	48 (1219)	40 (1016)	48 (1219)
0.90	9 (229)	30 (762)	18 (457)	44 (1118)	40 (1016)	48 (1219)
0.80	—	—	4 (102)	21 (533)	40 (1016)	48 (1219)
0.70	—	—	—	—	21 (533)	48 (1219)

FLOAT PRESSURE RATINGS

Float Size	Pressure Rating psig (bar) @ 100° F (38° C)	@ Maximum Temperature
3.00 x 5.00 (76 x 127)	500 psig (34 bar)	300 psig @ +750° F (21 bar @ +399° C)
4.00 (102) Diameter	600 psig (41 bar)	400 psig @ +750° F (28 bar @ +399° C)
4.50 (114) Diameter	500 psig (34 bar)	340 psig @ +750° F (23 bbar @ +399° C)

TANK CONNECTION AND FLOAT SIZE

Tank Connection ①	Float Diameter 3.00 x 5.00 (76 x 127)	4.00 (102)	4.50 (114)
4" 125 lb. C.I. flange ② ③	H2A	—	—
4" 150 lb. F.S. flange	H3A	—	—
5" 125 lb. C.I. flange ② ③	J2A	J2B	J2C
5" 150 lb. F.S. flange	J3A	J3B	J3C
6" 125 lb. C.I. flange ② ③	K2A	K2B	K2C
6" 150 lb. F.S. flange	K3A	K3B	K3C
6" 300 lb. F.S. flange	—	—	K4C
8" 125 lb. C.I. flange ② ③	L2A	L2B	L2C
8" 150 lb. F.S. flange	L3A	L3B	L3C

① Flanges are ANSI standard. Forged steel flanges have standard raised face.
② Not available with -4 Materials of Construction.
③ Available only in cast iron.
④ Process temperature based on +100° F (+38° C) ambient.
⑤ Uncontrolled housing heater or drain available in NEMA 4X/7/9 enclosure.
⑥ Consult factory for NEMA 4X/7/9 cast iron housings.
⑦ On steam applications, temperature down-rated to +400° F (+204° C) process at +100° F (+38° C) ambient.

5.5.2 Model T21 (continued)

ELECTRIC SWITCH MECHANISM AND ENCLOSURE

Switch Description	Maximum Process ④ Temperature ° F (° C)	One Set Point	T21-1 Models		T21-4 Models	
			NEMA 4X/7/9 Aluminum Enclosure ⑤⑥			
			Class I, Div. 1, Groups C & D	Class I, Div. 1, Group B	Class I, Div. 1, Groups C & D	Class I, Div. 1, Group B
Series A Mercury	550 (288)	SPDT DPDT	ALA AOA	ALJ AOJ	ALB AOB	ALK AOK
Series 3 Mercury with Beaded Leads	750 (399)	SPDT DPDT	3LA 3OA	3LJ 3OJ	3LB 3OB	3LK 3OK
Series B Snap	250 (121)	SPDT DPDT	BLA BOA	BLJ BOJ	BLB BOB	BLK BOK
Series C Snap	450 (232)	SPDT DPDT	CLA COA	CLJ COJ	CLB COB	CLK COK
Series D Snap for DC Current	250 (121)	SPDT DPDT	DLB DOB	DLK DOK	DLB DOB	DLK DOK
Series E Mercury Vibration Resistant	550 (288)	SPDT DPDT	ELA EOA	ELJ EOJ	ELB EOB	ELK EOK
Series 2 Mercury Vibration Resistant	750 (399)	SPDT DPDT	2LA 2OA	2LJ 2OJ	2LB 2OB	2LK 2OK
Series HS Snap Hermetically Sealed w/Wiring Leads	550 ⑦ (288)	SPDT DPDT	HMN HMY	HMP HMZ	HMN HMY	HMP HMZ

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ASSURED QUALITY & SERVICE COST LESS

Service Policy

Owners of Magnetrol controls may request the return of a control or any part of a control for complete rebuilding or replacement. They will be rebuilt or replaced promptly. Controls returned under our service policy must be returned by Prepaid transportation. Magnetrol will repair or replace the control at no cost to the purchaser (or owner) other than transportation if:

1. Returned within the warranty period; and
2. The factory inspection finds the cause of the claim to be covered under the warranty.

If the trouble is the result of conditions beyond our control; or, is NOT covered by the warranty, there will be charges for labor and the parts required to rebuild or replace the equipment.

In some cases it may be expedient to ship replacement parts; or, in extreme cases a complete new control, to replace the original equipment before it is returned. If this is desired, notify the factory of both the model and serial numbers of the control to be replaced. In such cases, credit for the materials returned will be determined on the basis of the applicability of our warranty.

No claims for misapplication, labor, direct or consequential damage will be allowed.

Return Material Procedure

So that we may efficiently process any materials that are returned, it is essential that a "Return Material Authorization" (RMA) number be obtained from the factory, prior to the material's return. This is available through Magnetrol's local representative or by contacting the factory. Please supply the following information:

1. Company Name
2. Description of Material
3. Serial Number
4. Reason for Return
5. Application

Any unit that was used in a process must be properly cleaned in accordance with OSHA standards, before it is returned to the factory.

A Material Safety Data Sheet (MSDS) must accompany material that was used in any media.

All shipments returned to the factory must be by prepaid transportation.

All replacements will be shipped F.O.B. factory.

Magnetrol®

5300 Belmont Road • Downers Grove, Illinois 60515-4499 • 630-969-4000 • Fax 630-969-9489 • www.magnetrol.com
145 Jardin Drive, Units 1 & 2 • Concord, Ontario Canada L4K 1X7 • 905-738-9600 • Fax 905-738-1306
Heikensstraat 6 • B 9240 Zele, Belgium • 052 45.11.11 • Fax 052 45.09.93
Regent Business Ctr., Jubilee Rd. • Burgess Hill, Sussex RH15 9TL U.K. • 01444-871313 • Fax 01444-871317

STI®

5300 Belmont Road • Downers Grove, Illinois 60515-4499 • 630-969-4028 • Fax 630-969-9489 • www.sticontrols.com

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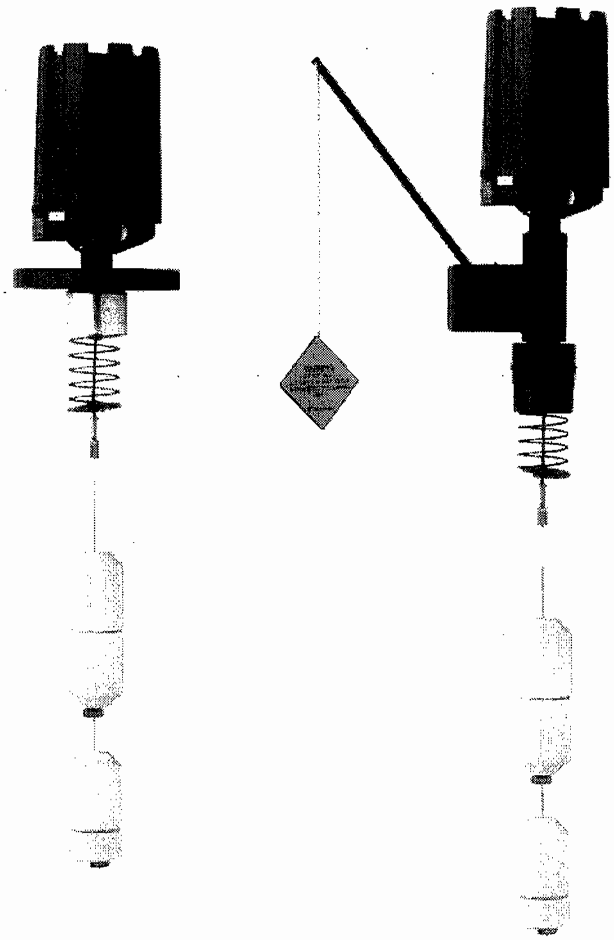
Magnetrol Liquid Level Switch – Displacer Type

Displacer Type

Installation and Operating Manual



Liquid Level and Proof-er® Switches

Magnetrol®

STI®

Read this Manual Before Installing

This manual provides information on the External Cage Displacer Liquid Level Switch. It is important that all instructions are read carefully and followed in sequence. Detailed instructions are included in the Installation section of this manual.

Conventions Used in this Manual

Certain conventions are used in this manual to convey specific types of information. General technical material, support data, and safety information are presented in narrative form. The following styles are used for notes, cautions, and warnings.

Notes

Notes contain information that augments or clarifies an operating step. Notes do not normally contain actions. They follow the procedural steps to which they refer.

Cautions

Cautions alert the technician to special conditions that could injure personnel, damage equipment, or reduce a component's mechanical integrity. Cautions are also used to alert the technician to unsafe practices or the need for special protective equipment or specific materials. In this manual, a caution box indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

Warnings

Warnings identify potentially dangerous situations or serious hazards. In this manual, a warning indicates an imminently hazardous situation which, if not avoided, could result in serious injury or death.

Safety Messages

Follow all standard industry procedures for servicing electrical equipment when working with or around high voltage. Always shut off the power supply before touching any components.

WARNING! Explosion hazard. Do not connect or disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

Low Voltage Directive

For use in Installation Category II, Pollution Degree 2. If equipment is used in a manner not specified by the manufacturer, protection provided by the equipment may be impaired.

Notice of Trademark, Copyright, and Limitations

Magnetrol reserves the right to make changes to the product described in this manual at any time without notice. Magnetrol makes no warranty with respect to the accuracy of the information in this manual.

Warranty

All Magnetrol/STI mechanical level and flow controls are warranted free of defects in materials or workmanship for five full years from the date of original factory shipment.

If returned within the warranty period; and, upon factory inspection of the control, the cause of the claim is determined to be covered under the warranty; then, Magnetrol/STI will repair or replace the control at no cost to the purchaser (or owner) other than transportation.

Magnetrol/STI shall not be liable for misapplication, labor claims, direct or consequential damage or expense arising from the installation or use of equipment. There are no other warranties expressed or implied, except special written warranties covering some Magnetrol/STI products.

Quality Assurance

The quality assurance system in place at Magnetrol/STI guarantees the highest level of quality throughout the company. Magnetrol/STI is committed to providing full customer satisfaction both in quality products and quality service.

Magnetrol's quality assurance system is registered to ISO 9001 affirming its commitment to known international quality standards providing the strongest assurance of product/service quality available.

Magnetrol®

STI®

Displacer Type Liquid Level and Proof-er® Switches

[illegible]

Displacement type level switches offer the industrial user a wide choice of alarm and control configurations. These units utilize simple buoyancy principle and are well suited for simple or complex applications.

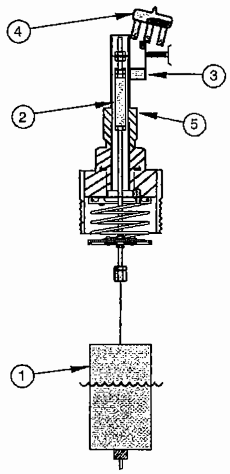


Figure 1
Switch position on rising level

1.1 Principle of Operation

1.1.1 Displacer Controls

The design of displacer operated level switches is based upon the principle that a magnetic field will not be affected by non-magnetic materials such as 316 stainless steel. In this case, the displacer moves a magnetic attraction sleeve within a non-magnetic enclosing tube and actuates a magnetic switch mechanism. The enclosing tube provides a pressure seal to the chamber and, therefore, to the process.

[illegible]

A spring is loaded with a weighted displacer ① which is heavier than the liquid. Immersion of the displacers caused by rising liquid level imparts buoyancy forces on the displacer allowing the spring to compress. The attraction sleeve ② attached to the spring, moves upward into the field of a permanent magnet ③. The movement of the magnet toward the sleeve causes the switch ④ to actuate. A non-magnetic barrier tube ⑤ provides a static pressure boundary between the switch mechanism and the displacer assembly. As the liquid level falls, the displacer lowers, causing the spring to extend, and moving the attraction sleeve out of the magnetic field of the switch mechanism. This allows the switch to again change position and to break or make. See Figures 1 and 2.

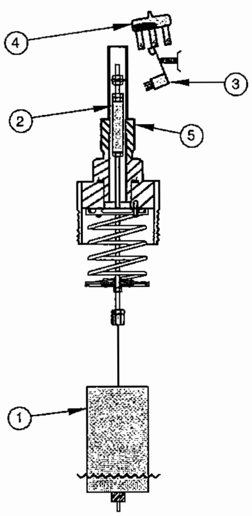


Figure 2
Switch position on falling level

[illegible]

The purpose of the Proof-er is to check the operation of a displacer control without having to raise the level in the tank. This is accomplished by pulling downward on the Proof-er cable. This causes the spring loaded lever arm to lift the switch actuator, simulating a high or high–high level condition. When the cable is released, the Proof-er returns the actuator to its original position resuming normal operation.

Caution: If equipment is used in a manner not specified by manufacturer, protection provided by equipment may be impaired.

Top mounting displacer units are shipped from the factory with the displacer and cable assembly removed from the head assembly and packed separately in the same container.

Caution: If reshipping to another location, displacer assembly must again be removed from the control to prevent damage.

Unpack the instrument carefully. Inspect all units for damage. Report any concealed damage to carrier within 24 hours. Check the contents of the packing slip and purchase order. Check and record the serial number for future reference when ordering parts.

Caution: The threaded connection link and stem protruding from the head assembly are extremely fragile. DO NOT handle or place control in a position so that any amount of force is placed on the stem. Proper operation of the control requires that the stem is not damaged or bent.

Caution: Displacer spring and stem are fragile. DO NOT drop displacers into tank. Hand feed cable into position to avoid bending stem.

Caution: This instrument is intended for use in Installation Category II, Pollution Degree 2.

Adjust the displacers on the displacer cable for the desired switch actuating levels (instruction tag is attached to cable). Screw displacer cable fitting to threaded connection link protruding from the underside of control.

Be sure there are no tubes, rods, or other obstacles in the tank or vessel to interfere with the operation of the displacers. No guides into the tank are necessary unless liquid turbulence is excessive, in which case a guide pipe or tube should be at least 1 inch larger than the displacer diameter, open at the bottom end, and with several vent holes located above the maximum high level of the liquid.

Check the installation of pipe or tube to be certain it is plumb.

Caution: Before attaching Magnetrol control to tank or vessel, using a level, check to see that tank mounting flange is within 3° of horizontal in all directions. Proper operation of the control depends on the switch housing being plumb.

Caution: Level controls are shipped from the factory with the enclosing tube tightened and the middle set screw, on the housing base, locked to the enclosing tube. Failure to loosen the set screw prior to repositioning the conduit connection may cause the enclosing tube to loosen, resulting in the possible leakage of the process liquid or vapor.

NOTE: If control is equipped with pneumatic switch mechanism, disregard these instructions and refer to instruction bulletin on mechanism furnished for air (or gas) connections.

Most switch enclosures are designed to provide 360° positioning of the conduit outlet by loosening the set screw(s) located at the bottom of the switch housing base. To rotate conduit entry:

1. Loosen set screw(s) at base of switch housing. Refer to Figure 2.
2. Rotate switch housing so that conduit entry is positioned as desired.
3. Tighten set screws at base of housing.

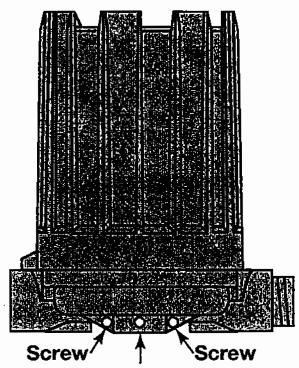


Figure 2
NEMA 4X, NEMA 4X/7/9, NEMA 4X/7/9 Group B

At the factory, terminal blocks are positioned next to the conduit entry to facilitate wiring. If repositioning of the switch mechanisms is desired:

1. Unscrew and remove switch housing cover. The threads have been lubricated to facilitate removal.
2. Loosen the frame mounting screw on each switch mechanism. Refer to Figure 3.
3. Carefully rotate the baffle plate and all switch mechanisms together until the terminal blocks are in the desired position.

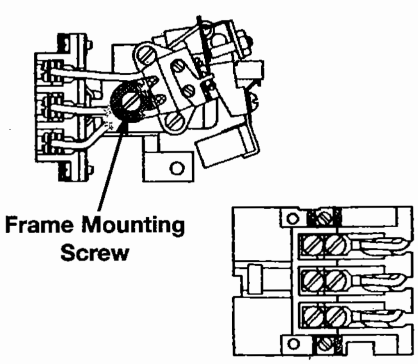
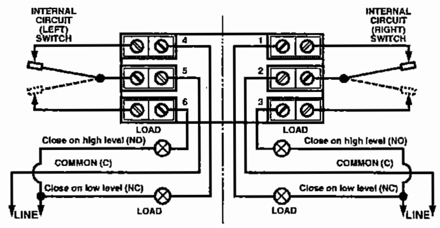


Figure 3
Switch Mechanism

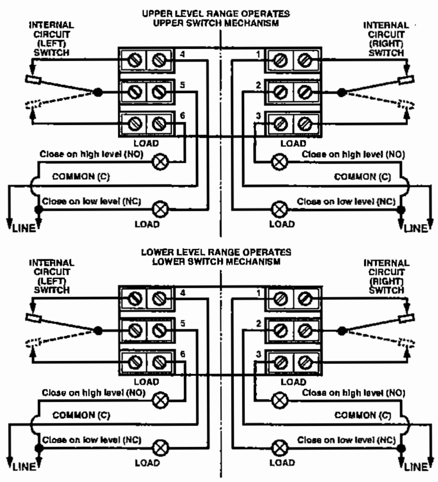
NOTE: On dual and triple stage controls the correct spacing of the mechanisms is maintained using brackets that connect the mechanisms. Take care when rotating the baffle plate and mechanisms to rotate them as a unit and not one at a time. This will ensure that the brackets and mechanisms will not be damaged during repositioning.

4. Ensure that the terminal blocks are aligned vertically to prevent stress on the brackets and mechanisms.
5. Tighten the frame mounting screw on each switch mechanism.



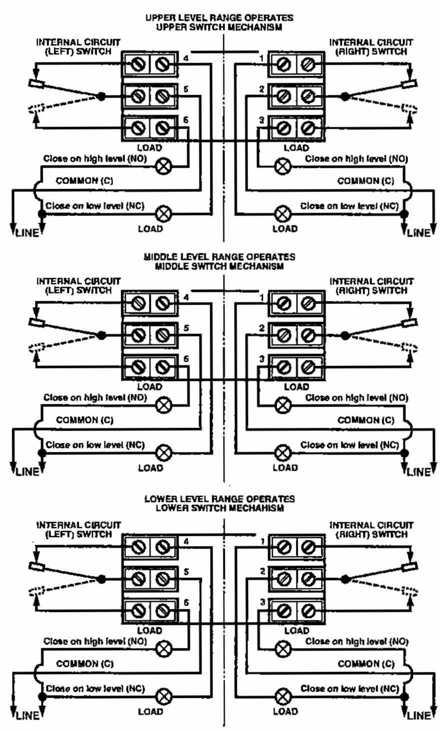
NOTES: 1. Double pole action is obtained by simultaneous operation of the right and left side single pole switches.
2. Rising Level Closes Contacts 5 & 6 and 2 & 3.
3. Falling Level Closes Contacts 4 & 5 and 1 & 2.

Figure 4 – Single Stage with DPDT contacts



NOTES: 1. Double pole action is obtained by simultaneous operation of the right and left side single pole switches.
2. Rising Level Closes Contacts 5 & 6 and 2 & 3.
3. Falling Level Closes Contacts 4 & 5 and 1 & 2.

Figure 5 – Dual Stage with DPDT contacts



NOTES: 1. Double pole action is obtained by simultaneous operation of the right and left side single pole switches.
2. Rising Level Closes Contacts 5 & 6 and 2 & 3.
3. Falling Level Closes Contacts 4 & 5 and 1 & 2.

Figure 6 – Triple Stage with DPDT contacts

NOTE: On high temperature applications above +250° F (+121° C), high temperature wire should be used between control and first junction box located in a cooler area. On non-hazardous applications, flexible conduit may be used between the control and the first junction box.

6. Bring supply wires through conduit entry. Route extra wire around enclosing tube under baffle plate, and connect then to the appropriate terminals. Refer to Figures 4–9 for wiring diagrams, or refer to wiring information in specific switch manuals. Switch instruction manual numbers are as follows:

Switch Series Letter	Description	Bulletin No.
A, T	Standard Mercury Switch	42-683
B, C, D, O, Q	Dry Contact Switch	
E, N	Vibration Resistant Mercury Switch	
HS	Hermetically Sealed Snap Switch	42-694
J	Bleed Type Pneumatic Switch	42-685
K	Non-Bleed Type Pneumatic Switch	42-686

NOTE: For models with a Series HS switch with high temperature lead wire, the leads are routed out through the conduit opening by the factory. A suitable conduit box should be provided for the connection of the leads to the control wiring.

7. Dress wiring to ensure no interference or contact with tilt of switch, or replacement of switch housing cover.

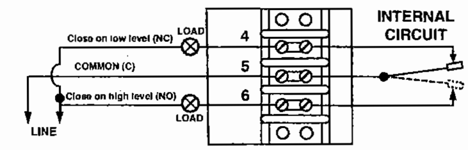
NOTE: Observe all applicable electrical codes and proper wiring procedures.

Prevent moisture seepage into the enclosure by installing approved seal-drain fittings in the conduit run leading into the unit.

Caution: In hazardous areas, do not power the unit until the conduit is sealed and the enclosure cover is screwed down securely.

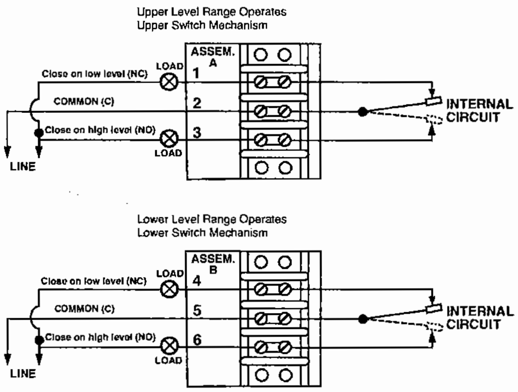
8. Test switch action by varying liquid level or manually moving displacers.
9. Replace housing cover.
10. If control has been furnished with an explosion proof or moisture proof (gasketed) switch housing, it must be sealed at the conduit outlet with a suitable compound or non-hardening sealant to prevent entrance of air.

NOTE: If switch mechanism fails to function properly, check vertical alignment of control housing and consult installation bulletin on switch mechanism furnished.



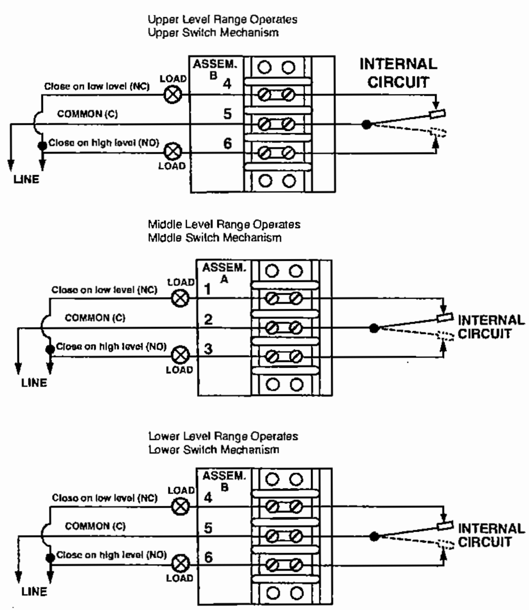
NOTES: 1. Rising level closes contacts 5 & 6.
2. Falling level closes contacts 4 & 5.

Figure 7 – Single Stage with SPDT contacts



NOTES: 1. Rising level closes contacts 5 & 6 and 2 & 3.
2. Falling level closes contacts 4 & 5 and 1 & 2.

Figure 8 – Dual Stage with SPDT contacts



NOTES: 1. Rising level closes contacts 5 & 6 and 2 & 3.
2. Falling level closes contacts 4 & 5 and 1 & 2.

Figure 9 – Triple Stage with SPDT contacts

11. Check cover to base fit to be certain gasketed joint is tight. A positive seal is necessary to prevent infiltration of moisture laden air or corrosive gasses into switch housings.

3.0 Preventive Maintenance

Periodic inspections are a necessary means to keep your level control in good working order. This control is a safety device to protect the valuable equipment it serves. A systematic program of "preventive maintenance" must be implemented when the control is placed into service. If the following sections on "What to do" and "What to avoid" are observed, your control will provide reliable protection of your equipment for many years.

3.1 What to do

3.1.1 Keep control clean

Be sure the switch housing cover is always in place on the control. This cover is designed to keep dust and dirt from interfering with switch mechanism operation. It protects against damaging moisture and acts as a safety feature by keeping bare wires and terminals from being exposed. Should the housing cover or any seal become damaged or misplaced, obtain a replacement immediately.

3.1.2 Inspect switch mechanisms, terminals, and connections monthly

1. Mercury switches may be visually inspected for short circuit damage. Check for small cracks in the glass tube containing the mercury. Such cracks can allow entrance of air into the tube causing the mercury to "oxidize". This is noticeable as the mercury will appear dirty or dull, and will not break into clean, round pools. If these conditions exist, replace the mercury switch immediately.
2. Dry contact switches should be inspected for excessive wear on actuating lever or misalignment of adjustment screw at point of contact between screw and lever. Such wear can cause false switch actuating levels. See switch mechanism bulletin supplied with control should switch adjustment or replacement be necessary.
3. DO NOT operate your control with defective or maladjusted switch mechanisms (refer to bulletin on switch mechanisms furnished for service instructions.)

4. Level controls may sometimes be exposed to excessive heat or moisture. Under such conditions, insulation on electrical wiring may become brittle, eventually breaking or pealing away. The resulting "bare" wires can cause short circuits.

NOTE: Check wiring carefully and replace at the first sign of brittle insulation.

5. Vibration may sometimes cause terminal screws to work loose. Check all terminal connections to be certain that screws are tight.

6. On units with pneumatic switches, air (or gas) lines subjected to vibration, may eventually crack or become loose at connections causing leakage. Check lines and connections carefully and repair or replace, if necessary.

NOTE: As a matter of good practice, spare switches should be kept on hand at all times.

1. Never leave switch housing cover off the control longer than necessary to make routine inspections.

2. Never place a jumper wire across terminals to "cut-out" the control. If a "jumper" is necessary for test purposes, be certain it is removed before placing control into service.

3. Never attempt to make adjustments or replace switches without reading instructions carefully. Certain adjustments provided for in level controls should not be attempted in the field. When in doubt, consult the factory or your local representative.

4. Never use lubricants on pivots of switch mechanisms. A sufficient amount of lubricant has been applied at the factory to ensure a lifetime of service. Further oiling is unnecessary and will only tend to attract dust and dirt which can interfere with mechanism operation.

5. Never attempt to readjust magnetic attraction sleeve. It is factory set, and tampering may cause failure of control while in service, even if manual operation activates switch.

[illegible]

[illegible]

Usually the first indication of improper operation is failure of the controlled equipment to function, i.e., pump will not start (or stop), signal lamps fail to light, etc. When these symptoms occur, whether at time of installation or during routine service thereafter, check the following potential external causes first.

a. Fuses may be blown.
b. Reset button(s) may need resetting.
c. Power switch may be open.
d. Controlled equipment may be faulty.
e. Wiring leading to control may be defective.

If a thorough inspection of these possible conditions fails to locate the trouble, proceed next to a check of the control's switch mechanism.

4.1.1 Check switch mechanism

1. Pull disconnect switch or otherwise disconnect power to the control.
2. Remove switch housing cover.
3. Disconnect power wiring from switch assembly.
4. Swing magnet assembly in and out by hand to check carefully for any sign of binding. Assembly should require minimal force to move it through its full swing.
5. If binding exists, magnet may be rubbing enclosing tube. If magnet is rubbing, loosen magnet clamp screw and shift magnet position. Retighten magnet clamp screw.
6. If switch magnet assembly swings freely and mechanism still fails to actuate, check installation of control to be certain it is within the specified three degrees of vertical. (Use spirit level on side of enclosing tube in two places, 90° apart.)

7a. If mechanism is equipped with a mercury switch, examine glass mercury tube closely as previously described in Section 3.0 Preventive Maintenance. If switch is damaged, replace it immediately.

7b. If mechanism is equipped with a microswitch, check continuity with ohmmeter.

NOTE: As a matter of good practice, spare switches should be kept on hand at all times.

8. If switch mechanism is operating satisfactorily, proceed to check sensing unit.

4.1.2 Test control's performance

1. Reconnect power supply and carefully actuate switch mechanism manually, using a non-conductive tool on electrical switch mechanism, to determine whether controlled equipment will operate.

Caution: With electrical power on, care should be taken to avoid contact with switch leads and connections at terminal block.

2. If controlled equipment responds to manual actuation test, trouble may be located in level sensing portion of the control (displacers, spring, stem, and magnetic attracting sleeve).

NOTE: Check first to be certain liquid is entering tank or vessel. A valve may be closed or pipe line plugged.

3. With liquid in tank or vessel, proceed to check level sensing action by removing switch housing assembly.

Caution: Be certain to pull disconnect switch or otherwise assure that electrical circuit(s) through control is deactivated. Close operating medium supply valve on controls equipped with pneumatic switch mechanisms

   a. Disconnect wiring from supply side of switch mechanism(s) and remove electrical conduit or operating medium line connections to switch housing.
   b. Relieve pressure from vessel and allow unit to cool.
   c. Remove switch housing assembly by loosening set screws located at the bottom of the housing base.

4. With switch housing assembly removed, inspect attraction sleeve and inside of enclosing tube for excessive corrosion or solids buildup which could restrict movement, preventing sleeve from reaching field of switch magnet.
5. Inspect displacer stem and spring assembly to assure it is not damaged. If stem or spring is bent or otherwise damaged, movement of the attraction sleeve inside the e-tube will be restricted, preventing proper function of the control.
6. If trouble is still not located, proceed to remove the entire sensing unit from the tank or vessel by unbolting head flange or unscrewing mounting bushing. Inspect displacer assembly and all internal parts for any signs of damage. Check assembly for binding by supporting head flange or mounting bushing over the edge of a bench and move displacer assembly by hand.

NOTE: When in doubt about the condition or performance of a control, contact the factory or consult your local representative.

4.1.3 Proof-er

If the Proof-er is not functioning properly, listed below are potential problems and corrective action.

1. Proof-er does not return to the down position after it is activated.

CAUSE	REMEDY
Defective return spring.	Replace Spring.
Buildup between the shaft and housing restricting movement.	Clean Proof-er to remove buildup.
Handle stops are not adjusted properly.	Adjust handle stop screws in or out to allow the handle to move to the proper position.

2. Switch will not trip when Proof-er is activated.

CAUSE	REMEDY
The switch mechanism is defective and not the Proof-er.	Check switch mechanism.
Handle stops are not adjusted properly.	Adjust handle stop screws in or out to allow the handle to move to the proper position.

Agency Approvals

AGENCY	APPROVED MODEL	APPROVAL CLASSES
FM APPROVED	All with an electric switch mechanism and a housing listed as Type 4X/7/9	Class I, Div 1, Groups C & D Class II, Div 1, Groups E, F & G
	All with an electric switch mechanism and a housing listed as Type 4X/7/9 Class I, Div 1, Group B	Class I, Div 1, Groups B, C & D Class II, Div 1, Groups E, F & G
CSA	All with a Series A, E, 2, 3 or HS electric switch mechanism and a housing listed as CSA Type 4X	Class I, Div 2, Groups B, C & D
	All with an electric switch mechanism and a housing listed as Type 4X/7/9 ①	Class I, Div 1, Groups C & D Class II, Div 1, Groups E, F & G
	All with an electric switch mechanism and a housing listed as Type 4X/7/9 Class I, Div 1, Group B	Class I, Div 1, Groups B, C & D Class II, Div 1, Groups E, F & G
ATEX / IEC Ex ③	All with an electric switch mechanism and an ATEX housing ②	ATEX II 2 G EEx d IIC T6 IEC Ex Ex d IIC T6
CE	Low Voltage Directives 73/23/EEC & 93/68/EEC Per Harmonized Standard: EN 61010-1/1993 & Amendment No. 1	Installation Category II Pollution Degree 2

① With housing drain, CSA drops Group E and FM drops Group C.

② Models B10 and B15 with 'HS' switches and all Model C10 and C15 are not ATEX approved.

③ IEC Installation Instructions:

The cable entry and closing devices shall be Ex d certified suitable for the conditions of use and correctly installed.

For ambient temperatures above +55° C or for process temperatures above +150° C, suitable heat resistant cables shall be used.

Heat extensions (between process connection and housing) shall never be insulated.

Special conditions for safe use:

When the equipment is installed in process temperatures higher than +85° C the temperature classification must be reduced according to the following table as per IEC60079-0.

Maximum Process Temperature	Temperature Classification
< 85° C	T6
< 100° C	T5
< 135° C	T4
< 200° C	T3
< 300° C	T2
< 450° C	T1

These units are in comformity with IECEx KEM 05.0020X
Classification Ex d IIC T6
$T_{ambient}$ -40° C to +70° C

4.3.1 Basic Electrical Ratings

Displacer	Switch Series and Non-Inductive Ampere Rating									
	A	B	C	D	E	HS	N	O	Q	T
120 VAC	13.00	15.00	15.00	10.00	4.00	5.00	13.00	15.00	15.00	4.00
240 VAC	6.50	15.00	15.00	—	2.00	5.00	6.50	15.00	15.00	2.00
24 VDC	10.00	6.00	10.00	10.00	—	5.00	—	—	6.00	—
120 VDC	10.00	0.50	1.00	10.00	4.00	0.50	10.00	1.00	0.50	4.00
240 VDC	5.00	0.25	0.50	3.00	2.00	0.25	5.00	0.50	0.25	2.00

4.3.2 Pressure/Temperature Ratings

Threaded Models*	800 psig @ +100° F (55 bar @ +38° C) 250 psig @ +400° F (17 bar @ +204° C)
Flanged Models	Limited to the pressure rating of the selected flange or displacer. Cast iron flanges are flat face type conformi ng to ANSI dimensional specifications
Low Pressure Proof-er Models	25 psig @ +200° F (1.7 bar @ +93° C)
Medium Pressure Proof-er Models	125 psig @ +300° F (8.6 bar @ +149° C)

*Models with stainless steel displacers are rated 720 psig @ +100° F (50 bar @ +38° C)

4.3.3 Model A10 Dimensional Data and Actuating Levels

Inches (mm)

Model A10

Displacer Type	Outline Dimensions			
	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	5.00 (127)	122.00 (3098)	7.00 (177)	124.00 (3149)
Stainless Steel or Karbate	4.75 (120)	122.00 (3098)	6.75 (171)	124.00 (3149)

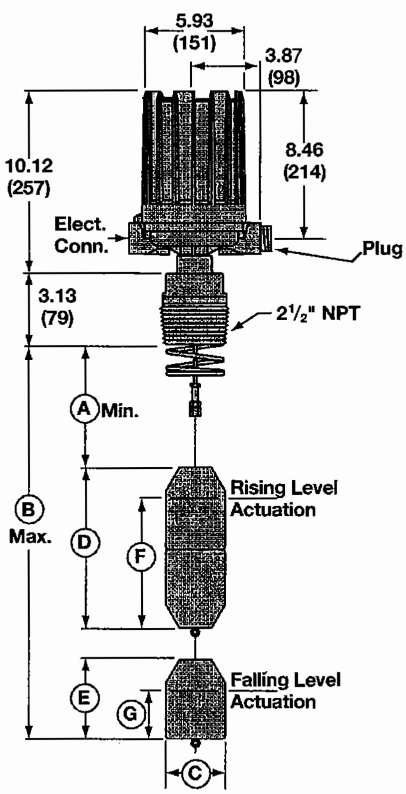
Displacer Type	C	D	E
Porcelain	2.56 (65)	7.25 (184)	3.62 (91)
Stainless Steel or Karbate	2.50 (63)	9.00 (228)	4.50 (114)

Electrical Connections
NEMA 4X/7/9, Group B: 1" NPT NEMA 1 Pneumatic: ¼" NPT

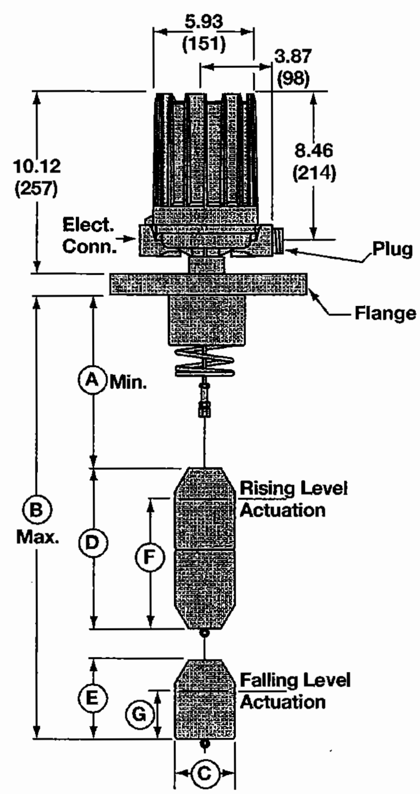
A10 Standard actuating levels and liquid specific gravity

Displacer Type	Liquid Temp. °F	0.60		0.70		0.80		0.90		1.00	
		F	G	F	G	F	G	F	G	F	G
Porcelain	100	5.30 (134)	1.50 (38)	4.10 (104)	1.20 (30)	3.20 (81)	1.10 (27)	2.50 (63)	1.00 (25)	2.00 (50)	0.90 (22)
	200	—	—	4.80 (121)	2.00 (50)	3.80 (96)	1.80 (45)	3.00 (76)	1.60 (40)	2.50 (63)	1.50 (38)
	300	—	—	—	—	4.30 (109)	2.40 (60)	3.40 (86)	2.10 (53)	2.90 (73)	1.90 (48)
	400	—	—	—	—	—	—	3.40 (86)	2.60 (66)	2.90 (73)	2.40 (60)
Stainless Steel or Karbate	100	7.00 (177)	2.40 (60)	5.30 (134)	2.00 (50)	4.10 (104)	1.80 (45)	3.10 (78)	1.60 (40)	2.40 (60)	1.40 (35)
	200	—	—	5.90 (149)	2.80 (71)	4.70 (119)	2.50 (63)	3.60 (91)	2.20 (55)	2.80 (71)	2.00 (50)
	300	—	—	—	—	5.10 (129)	3.10 (78)	4.00 (101)	2.70 (68)	3.20 (81)	2.40 (60)
Stainless Steel	400	—	—	—	—	—	—	4.40 (111)	3.20 (81)	3.60 (91)	2.90 (73)
	500	—	—	—	—	—	—	—	—	3.90 (99)	3.30 (83)

Note: All levels ±0.25" (6).



Model A10
with Threaded Mounting



Model A10
with Flanged Mounting

4.3.4 Model A15 Dimensional Data and Actuating Levels

Inches (mm)

Model A15

Displacer Type	Outline Dimensions			
	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	5.62 (142)	122.00 (3098)	7.62 (193)	124.00 (3149)
Stainless Steel or Karbate	5.62 (142)	122.00 (3098)	7.62 (193)	124.00 (3149)

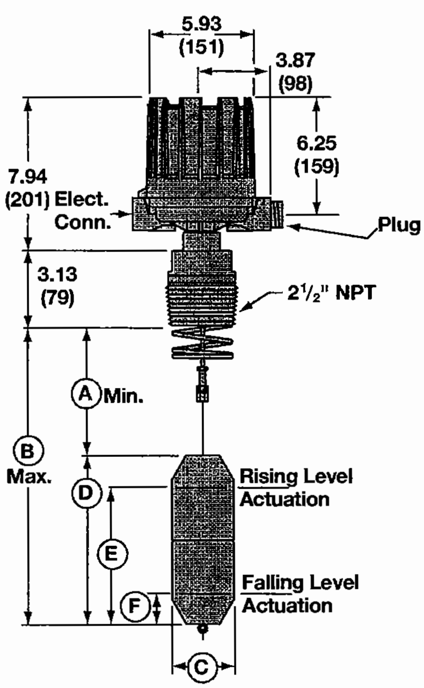
Displacer Type	C	D
Porcelain	2.56 (65)	7.25 (184)
Stainless Steel or Karbate	2.50 (63)	9.00 (228)

Electrical Connections
NEMA 4X/7/9, Group B: 1" NPT NEMA 1 Pneumatic: ¼" NPT

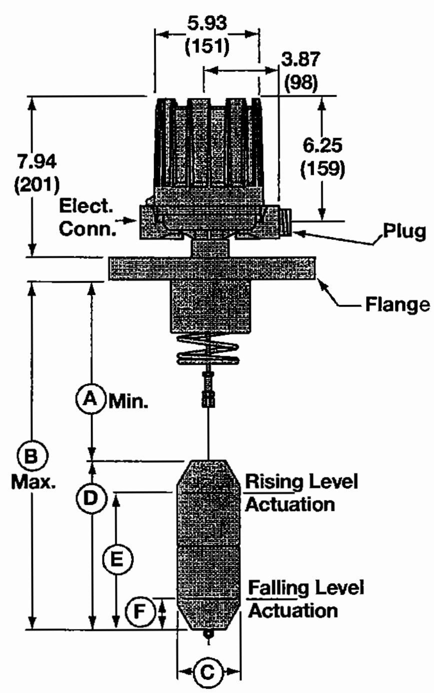
A15 Standard actuating levels and liquid specific gravity

Displacer Type	Liquid Temp. °F	0.50		0.60		0.70		0.80		0.90		1.00	
		E	F	E	F	E	F	E	F	E	F	E	F
Porcelain	100	—	—	5.10 (129)	2.10 (53)	4.50 (114)	1.70 (43)	3.90 (99)	1.70 (43)	3.50 (88)	1.50 (38)	3.20 (81)	1.40 (35)
	200	—	—	5.60 (142)	2.60 (66)	4.90 (124)	2.10 (53)	4.30 (109)	2.10 (53)	3.80 (96)	1.80 (45)	3.50 (88)	1.70 (43)
	300	—	—	—	—	5.20 (132)	2.40 (60)	4.50 (114)	2.30 (58)	4.10 (104)	2.10 (53)	3.70 (93)	1.90 (48)
	400	—	—	—	—	5.60 (142)	2.80 (71)	4.80 (121)	2.60 (66)	4.30 (109)	2.30 (58)	3.90 (99)	2.10 (53)
	500	—	—	—	—	—	—	5.10 (129)	2.90 (73)	4.60 (116)	2.60 (66)	4.20 (106)	2.40 (60)
Stainless Steel or Karbate	100	5.40 (137)	2.00 (50)	4.50 (114)	1.60 (40)	3.90 (99)	1.40 (35)	3.40 (86)	1.20 (30)	3.00 (76)	1.10 (27)	2.70 (68)	1.00 (25)
	200	6.00 (152)	2.60 (66)	5.00 (127)	2.10 (53)	4.30 (109)	1.80 (45)	3.70 (93)	1.60 (40)	3.30 (83)	1.40 (35)	3.00 (76)	1.30 (33)
	300	6.40 (162)	3.00 (76)	5.30 (134)	2.40 (60)	4.60 (116)	2.10 (53)	4.00 (101)	1.80 (45)	3.60 (91)	1.70 (43)	3.20 (81)	1.50 (38)
Stainless Steel	400	6.90 (175)	3.50 (88)	5.70 (144)	2.80 (71)	4.90 (124)	2.40 (60)	4.30 (109)	2.10 (53)	3.80 (96)	1.90 (48)	3.40 (86)	1.70 (43)
	500	—	—	6.10 (154)	3.20 (81)	5.20 (132)	2.80 (71)	4.60 (116)	2.40 (60)	4.10 (104)	2.20 (55)	3.70 (93)	2.00 (50)

Note: All levels ±0.25" (6).



Model A15
with Threaded Mounting



Model A15
with Flanged Mounting

4.3.5 Model B10 Dimensional Data

Inches (mm)

Model B10

Displacer Type	Outline Dimensions			
	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	4.88 (123)	122.00 (3098)	6.88 (174)	124.00 (3149)
Stainless Steel or Karbate	4.75 (120)	122.00 (3098)	6.75 (171)	124.00 (3149)

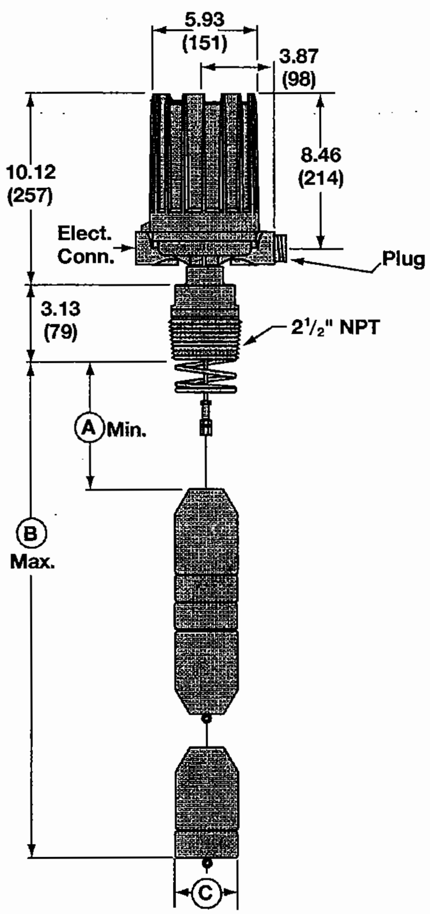
Model B10 with displacer arrangements 1 and 2

Displacer Type	C	D	E
Porcelain	2.56 (65)	10.04 (255)	5.02 (127)
Stainless Steel or Karbate	2.50 (63)	12.00 (304)	6.00 (152)

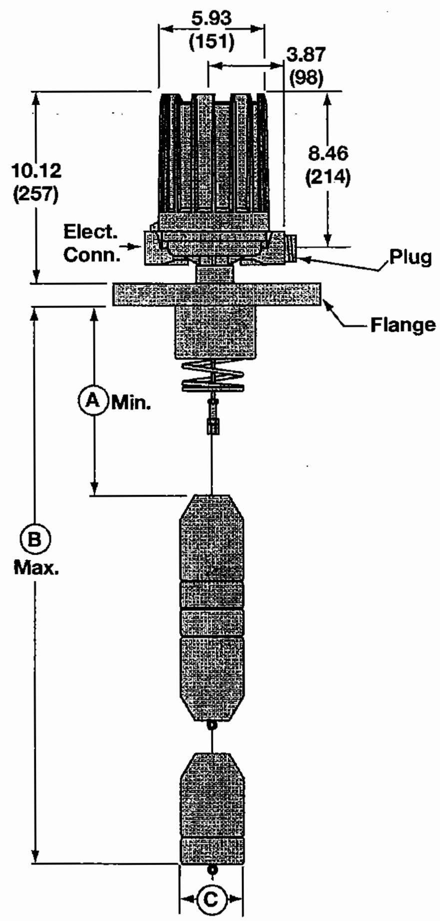
Model B10 with displacer arrangements 3, 4, and 5

Displacer Type	C	D	E	F
Porcelain	2.56 (65)	5.02 (127)	5.02 (127)	5.02 (127)
Stainless Steel or Karbate	2.50 (63)	6.00 (152)	6.00 (152)	6.00 (152)

Electrical Connections
NEMA 4X/7/9 Group B: 1" NPT



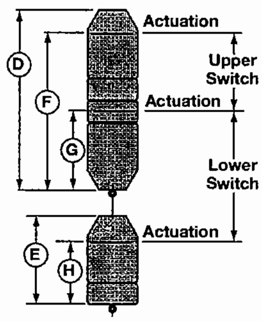
Model B10
with Threaded Mounting



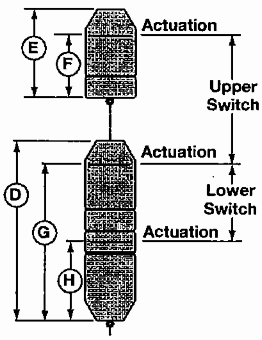
Model B10
with Flanged Mounting

4.3.6 Model B10 Actuating Levels

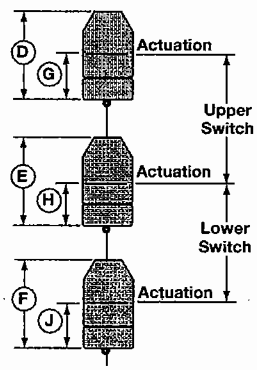
Inches (mm)



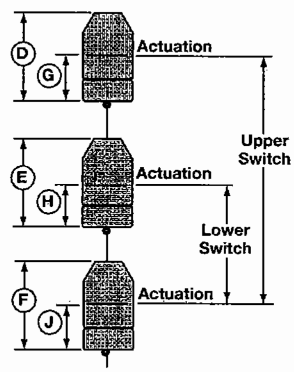
Model B10
Displacer Arrangement 1



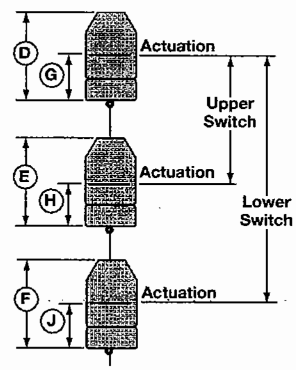
Model B10
Displacer Arrangement 2



Model B10
Displacer Arrangement 3



Model B10
Displacer Arrangement 4



Model B10
Displacer Arrangement 5

B10 Standard actuating levels and liquid specific gravity with displacer arrangement 1

Displacer Type	Liquid Temp. ° F	Level	0.60 – 0.64	0.65 – 0.71	0.72 – 0.73	0.74 – 0.82	0.83 – 0.92	0.93 – 1.00	1.01 – 1.07
Porcelain	100	F	7.79 – 7.04 (197 – 178)	7.66 – 6.65 (194 – 168)	7.22 – 7.06 (133 – 179)	6.91 – 5.81 (175 – 147)	6.73 – 5.65 (180 – 143)	5.55 – 4.86 (140 – 123)	4.97 – 4.53 (126 – 115)
		G	2.62 – 2.19 (56 – 55)	2.88 – 2.28 (73 – 57)	2.91 – 2.81 (73 – 71)	2.71 – 2.03 (68 – 51)	2.99 – 2.28 (75 – 57)	2.21 – 1.76 (56 – 44)	1.90 – 1.63 (48 – 41)
		H	2.01 – 1.89 (51 – 48)	1.86 – 1.70 (47 – 43)	1.68 – 1.65 (42 – 41)	1.63 – 1.47 (41 – 37)	1.45 – 1.31 (36 – 33)	1.30 – 1.21 (33 – 30)	1.02 – 0.97 (25 – 24)
	200	F	7.91 (200)	7.72 – 6.71 (196 – 170)	6.56 – 6.41 (166 – 162)	6.73 – 5.66 (170 – 143)	6.37 – 5.33 (161 – 135)	6.15 – 5.42 (156 – 137)	5.02 – 4.57 (127 – 116)
		G	3.06 (77)	2.95 – 2.34 (74 – 59)	2.25 – 2.16 (57 – 54)	2.54 – 1.87 (64 – 47)	2.63 – 1.95 (66 – 49)	2.81 – 2.32 (71 – 58)	1.94 – 1.67 (49 – 42)
		H	2.76 (70)	2.72 – 2.49 (69 – 63)	2.45 – 2.42 (62 – 61)	2.39 – 2.15 (60 – 54)	2.13 – 1.92 (54 – 48)	1.90 – 1.77 (48 – 44)	1.58 – 1.49 (40 – 37)
	300	F	—	—	—	7.48 – 6.34 (189 – 161)	7.04 – 5.93 (178 – 150)	6.75 – 5.98 (171 – 151)	5.57 – 5.10 (141 – 129)
		G	—	—	—	3.29 – 2.55 (83 – 64)	3.30 – 2.56 (83 – 65)	3.41 – 2.87 (86 – 72)	2.50 – 2.19 (63 – 55)
		H	—	—	—	3.14 – 2.83 (79 – 71)	2.80 – 2.53 (71 – 64)	2.50 – 2.32 (63 – 58)	2.13 – 2.01 (54 – 51)
	400	F	—	—	—	—	—	—	6.12 – 5.62 (155 – 142)
		G	—	—	—	—	—	—	3.05 – 2.72 (77 – 69)
		H	—	—	—	—	—	—	2.68 – 2.53 (68 – 64)

Note: All levels ±0.25" (6).

4.3.6 Model B10 Actuating Levels (cont.)

Inches (mm)

B10 Standard actuating levels and liquid specific gravity with displacer arrangement 1

Displacer Type	Liquid Temp. ° F	Level	1.08 – 1.12	1.13 – 1.17	1.18 – 1.27	1.28 – 1.30	1.31 – 1.39	1.40 – 1.50
Porcelain	100	F	4.47 – 4.20 (113 – 106)	4.90 – 4.64 (124 – 117)	4.57 – 4.05 (116 – 102)	3.99 – 3.89 (101 – 98)	4.23 – 3.82 (107 – 97)	3.77 – 3.33 (95 – 84)
		G	1.59 – 1.43 (40 – 36)	2.16 – 1.99 (54 – 50)	1.94 – 1.60 (49 – 40)	1.57 – 1.50 (39 – 38)	1.86 – 1.59 (47 – 40)	1.56 – 1.26 (39 – 32)
		H	0.96 – 0.92 (24 – 23)	0.92 – 0.88 (23 – 22)	0.88 – 0.81 (22 – 20)	0.81 – 0.80 (20 – 20)	0.79 – 0.74 (20 – 18)	0.74 – 0.69 (18 – 17)
	200	F	4.66 – 4.39 (118 – 111)	4.33 – 4.08 (109 – 103)	4.32 – 3.81 (109 – 96)	4.29 – 4.18 (108 – 106)	4.13 – 3.73 (104 – 94)	3.93 – 3.47 (99 – 88)
		G	1.79 – 1.62 (45 – 41)	1.58 – 1.43 (40 – 36)	1.69 – 1.36 (42 – 34)	1.87 – 1.80 (47 – 45)	1.76 – 1.49 (44 – 37)	1.71 – 1.40 (43 – 35)
		H	1.48 – 1.42 (37 – 36)	1.41 – 1.36 (35 – 34)	1.35 – 1.25 (34 – 31)	1.24 – 1.23 (31 – 31)	1.22 – 1.15 (30 – 29)	1.14 – 1.06 (28 – 26)
	300	F	5.18 – 4.89 (131 – 124)	4.82 – 4.56 (122 – 115)	4.79 – 4.25 (121 – 107)	4.73 – 4.61 (120 – 117)	4.56 – 4.13 (115 – 104)	4.32 – 3.84 (109 – 97)
		G	2.31 – 2.12 (58 – 53)	2.08 – 1.91 (52 – 48)	2.16 – 1.80 (54 – 45)	2.31 – 2.23 (58 – 56)	2.19 – 1.90 (55 – 48)	2.11 – 1.78 (53 – 45)
		H	1.99 – 1.92 (50 – 48)	1.90 – 1.84 (48 – 46)	1.82 – 1.69 (45 – 42)	1.68 – 1.66 (42 – 42)	1.64 – 1.55 (41 – 39)	1.54 – 1.43 (39 – 36)
	400	F	5.70 – 5.39 (144 – 136)	5.32 – 5.04 (135 – 128)	5.26 – 4.69 (133 – 119)	5.17 – 5.04 (131 – 128)	4.98 – 4.53 (126 – 115)	4.72 – 4.22 (119 – 107)
		G	2.82 – 2.62 (71 – 66)	2.57 – 2.39 (65 – 60)	2.63 – 2.24 (66 – 56)	2.74 – 2.66 (69 – 67)	2.61 – 2.30 (66 – 58)	2.51 – 2.15 (63 – 54)
		H	2.51 – 2.42 (63 – 61)	2.40 – 2.32 (60 – 58)	2.30 – 2.13 (58 – 54)	2.12 – 2.08 (53 – 52)	2.07 – 1.95 (52 – 49)	1.94 – 1.81 (49 – 45)
	500	F	6.22 – 5.89 (157 – 149)	5.81 – 5.52 (147 – 140)	5.74 – 5.13 (145 – 130)	5.60 – 5.47 (142 – 138)	5.41 – 4.93 (137 – 125)	5.12 – 4.59 (130 – 116)
		G	3.34 – 3.12 (84 – 79)	3.07 – 2.86 (77 – 72)	3.11 – 2.68 (78 – 68)	3.18 – 3.09 (80 – 78)	3.04 – 2.70 (77 – 68)	2.91 – 2.52 (73 – 64)
		H	3.03 – 2.92 (76 – 74)	2.89 – 2.79 (73 – 70)	2.77 – 2.57 (70 – 65)	2.55 – 2.51 (64 – 63)	2.50 – 2.35 (63 – 59)	2.33 – 2.18 (59 – 55)

Displacer Type	Liquid Temp. ° F	Level	0.50 – 0.58	0.59 – 0.71	0.72 – 0.79	0.80 – 0.85	0.86 – 1.00	1.01 – 1.03
Stainless Steel and Karbate	100	F	9.91 – 7.72 (251 – 196)	9.19 – 6.62 (233 – 168)	8.44 – 7.16 (214 – 181)	7.66 – 6.86 (194 – 174)	6.71 – 4.93 (170 – 125)	4.82 – 4.61 (122 – 117)
		G	3.46 – 2.16 (86 – 54)	3.72 – 2.08 (94 – 52)	3.96 – 3.07 (100 – 77)	3.63 – 3.07 ((92 – 77)	2.96 – 1.71 (75 – 43)	1.63 – 1.48 (41 – 37)
		H	2.51 – 2.16 (63 – 54)	2.13 – 1.77 (54 – 44)	1.74 – 1.59 (44 – 40)	1.57 – 1.48 (39 – 37)	1.46 – 1.25 (37 – 31)	1.24 – 1.22 (31 – 30)
	200	F	10.22 – 7.98 (259 – 202)	7.74 – 7.44 (196 – 188)	7.50 – 6.30 (190 – 160)	6.15 – 5.44 (156 – 138)	6.97 – 5.15 (177 – 130)	—
		G	3.76 – 2.42 (95 – 61)	2.27 – 1.89 (57 – 48)	3.02 – 2.22 (76 – 56)	2.12 – 1.64 (53 – 41)	3.22 – 1.93 (81 – 49)	—
		H	3.67 – 3.16 (93 – 80)	3.11 – 2.58 (78 – 65)	2.55 – 2.32 (64 – 58)	2.29 – 2.16 (58 – 54)	2.13 – 1.84 (54 – 46)	—
	300	F	—	9.68 – 7.25 (245 – 184)	8.31 – 7.04 (211 – 178)	6.88 – 6.12 (174 – 155)	7.65 – 5.73 (194 – 145)	—
		G	—	4.30 – 2.70 (109 – 68)	3.83 – 2.96 (97 – 75)	2.84 – 2.32 (72 – 58)	3.89 – 2.51 (98 – 63)	—
		H	—	4.03 – 3.40 (102 – 86)	3.36 – 3.06 (85 – 77)	3.02 – 2.84 (76 – 72)	2.81 – 2.42 (71 – 61)	—

continued on page 16

4.3.6 Model B10 Actuating Levels (cont.)

Inches (mm)

B10 Standard actuating levels and liquid specific gravity with displacer arrangement 1 (cont.)

Displacer Type	Liquid Temp. ° F	Level	0.50 – 0.58	0.59 – 0.71	0.72 – 0.79	0.80 – 0.85	0.86 – 1.00	1.01 – 1.03
Stainless Steel	400	F	—	—	9.11 – 7.77 (231 – 197)	7.60 – 6.80 (193 – 172)	8.32 – 6.32 (211 – 160)	—
		G	—	—	4.63 – 3.69 (117 – 93)	3.57 – 3.01 (90 – 76)	4.57 – 3.09 (116 – 78)	—
		H	—	—	4.16 – 3.79 (105 – 96)	3.75 – 3.53 (95 – 89)	3.48 – 3.00 (88 – 76)	—
	500	F	—	—	—	—	9.00 – 6.90 (228 – 175)	—
		G	—	—	—	—	5.24 – 3.67 (133 – 93)	—
		H	—	—	—	—	4.16 – 3.58 (105 – 90)	—

Note: All levels ±0.25" (6).

B10 Standard actuating levels and liquid specific gravity with displacer arrangement 2

Displacer Type	Liquid Temp. ° F	Level	0.60 – 0.64	0.65 – 0.71	0.72 – 0.73	0.74 – 0.82	0.83 – 0.92	0.93 – 1.00	1.01 – 1.07
Porcelain	100	F	2.77 – 2.01 (70 – 51)	2.63 – 1.62 (66 – 41)	2.67 – 2.51 (67 – 63)	2.58 – 1.42 (65 – 36)	3.16 – 1.94 (80 – 49)	1.82 – 1.04 (45 – 26)	1.69 – 1.23 (42 – 31)
		G	7.27 – 6.84 (184 – 173)	7.54 – 6.93 (191 – 176)	7.56 – 7.46 (192 – 189)	7.36 – 6.68 (186 – 169)	7.64 – 6.93 (194 – 176)	6.86 – 6.41 (174 – 162)	5.15 – 4.89 (130 – 124)
		H	2.67 – 2.53 (67 – 64)	3.29 – 3.05 (83 – 77)	3.73 – 3.68 (94 – 93)	3.64 – 3.32 (92 – 84)	4.32 – 3.93 (109 – 99)	3.90 – 3.65 (99 – 92)	2.42 – 2.31 (61 – 58)
	200	F	3.15 (80)	2.96 – 1.93 (75 – 49)	1.77 – 1.62 (44 – 41)	2.64 – 1.47 (67 – 37)	2.79 – 1.61 (70 – 40)	2.79 – 1.94 (70 – 49)	1.56 – 1.11 (39 – 28)
		G	7.71 (195)	7.60 – 6.99 (193 – 177)	6.90 – 6.81 (175 – 172)	7.19 – 6.52 (182 – 165)	7.28 – 6.60 (184 – 167)	7.46 – 6.97 (189 – 177)	5.19 – 4.92 (131 – 124)
		H	3.40 (86)	3.36 – 3.10 (85 – 78)	3.07 – 3.03 (77 – 76)	3.46 – 3.16 (87 – 80)	3.96 – 3.61 (100 – 91)	4.50 – 4.21 (114 – 106)	2.46 – 2.35 (62 – 59)
	300	F	—	—	—	3.39 – 2.15 (86 – 54)	3.47 – 2.22 (88 – 56)	3.39 – 2.50 (86 – 63)	2.11 – 1.63 (53 – 41)
		G	—	—	—	7.94 – 7.20 (201 – 182)	7.95 – 7.21 (201 – 183)	8.06 – 7.53 (204 – 191)	5.75 – 5.45 (146 – 138)
		H	—	—	—	4.21 – 3.84 (106 – 97)	4.63 – 4.21 (117 – 106)	5.10 – 4.77 (129 – 121)	3.02 – 2.87 (76 – 72)
	400	F	—	—	—	—	—	—	2.67 – 2.15 (67 – 54)
		G	—	—	—	—	—	—	6.30 – 5.97 (160 – 151)
		H	—	—	—	—	—	—	3.57 – 3.39 (90 – 86)

Note: All levels ±0.25" (6).

4.3.6 Model B10 Actuating Levels (cont.)

Inches (mm)

B10 Standard actuating levels and liquid specific gravity with displacer arrangement 2 (cont.)

Displacer Type	Liquid Temp. ° F	Level	1.08 – 1.12	1.13 – 1.17	1.18 – 1.27	1.28 – 1.30	1.31 – 1.39	1.40 – 1.50
Porcelain	100	F	1.16 – 0.89 (29 – 22)	2.04 – 1.75 (51 – 44)	1.68 – 1.10 (42 – 27)	1.04 – 0.92 (26 – 23)	2.05 – 1.56 (52 – 39)	1.50 – 0.97 (38 – 24)
		G	4.84 – 4.68 (122 – 118)	5.41 – 5.24 (137 – 133)	5.20 – 4.85 (132 – 123)	4.82 – 4.75 (122 – 120)	5.11 – 4.84 (129 – 122)	4.81 – 4.51 (122 – 114)
		H	2.29 – 2.22 (58 – 56)	2.97 – 2.88 (75 – 73)	2.86 – 2.68 (72 – 68)	2.66 – 2.63 (67 – 66)	3.01 – 2.85 (76 – 72)	2.84 – 2.67 (72 – 67)
	200	F	1.68 – 1.38 (42 – 35)	1.31 – 1.05 (33 – 26)	1.71 – 1.13 (43 – 28)	1.75 – 1.62 (44 – 41)	1.56 – 1.09 (39 – 27)	1.53 – 1.00 (38 – 25)
		G	5.04 – 4.88 (128 – 123)	4.84 – 4.68 (122 – 118)	4.94 – 4.62 (125 – 117)	5.12 – 5.05 (130 – 128)	5.01 – 4.75 (127 – 120)	4.96 – 4.65 (125 – 118)
		H	2.49 – 2.41 (63 – 61)	2.39 – 2.33 (60 – 59)	2.60 – 2.44 (66 – 61)	2.97 – 2.93 (73 – 70)	2.91 – 2.76 (73 – 70)	2.99 – 2.82 (75 – 77)
	300	F	2.19 – 1.88 (55 – 47)	1.81 – 1.52 (45 – 38)	2.19 – 1.57 (55 – 39)	2.18 – 2.05 (50 – 37)	1.98 – 1.49 (50 – 37)	1.93 – 1.37 (49 – 34)
		G	5.56 – 5.37 (141 – 136)	5.33 – 5.16 (135 – 131)	5.41 – 5.06 (137 – 128)	5.56 – 5.48 (138 – 130)	5.44 – 5.15 (138 – 130)	5.36 – 5.03 (136 – 127)
		H	3.01 – 2.91 (76 – 73)	2.89 – 2.80 (73 – 71)	3.07 – 2.88 (77 – 73)	3.40 – 3.36 (84 – 80)	3.33 – 3.16 (84 – 80)	3.39 – 3.19 (86 – 81)
	400	F	2.71 – 2.38 (68 – 60)	2.30 – 2.00 (58 – 50)	2.66 – 2.01 (67 – 51)	2.62 – 2.48 (61 – 48)	2.41 – 1.90 (61 – 48)	2.33 – 1.74 (59 – 44)
		G	6.08 – 5.87 (154 – 149)	5.82 – 5.64 (147 – 143)	5.89 – 5.49 (149 – 139)	5.99 – 5.91 (152 – 150)	5.87 – 5.55 (149 – 140)	5.76 – 5.40 (146 – 137)
		H	3.52 – 3.41 (89 – 86)	3.38 – 3.28 (85 – 83)	3.55 – 3.32 (90 – 84)	3.84 – 3.79 (97 – 96)	3.76 – 3.56 (95 – 90)	3.79 – 3.56 (96 – 90)
	500	F	3.23 – 2.88 (82 – 73)	2.80 – 2.48 (71 – 62)	3.13 – 2.45 (79 – 62)	3.05 – 2.91 (77 – 73)	2.84 – 2.30 (72 – 58)	2.73 – 2.11 (69 – 53)
		G	6.59 – 6.37 (167 – 161)	6.32 – 6.12 (160 – 155)	6.36 – 5.93 (161 – 150)	6.43 – 6.34 (163 – 161)	6.29 – 5.95 (159 – 151)	6.16 – 5.77 (156 – 146)
		H	4.04 – 3.91 (102 – 99)	3.88 – 3.76 (98 – 95)	4.02 – 3.76 (102 – 95)	4.28 – 4.21 (108 – 106)	4.19 – 3.97 (106 – 100)	4.19 – 3.93 (106 – 99)

Note: All levels ±0.25" (6).

4.3.6 Model B10 Actuating Levels (cont.)

Inches (mm)

B10 Standard actuating levels and liquid specific gravity with displacer arrangement 2

Displacer Type	Liquid Temp. ° F	Level	0.50 – 0.58	0.59 – 0.71	0.72 – 0.79	0.80 – 0.85	0.86 – 1.00	1.01 – 1.03
Stainless Steel and Karbate	100	F	3.77 – 1.60 (95 – 40)	4.10 – 1.38 (104 – 35)	4.43 – 2.97 (112 – 75)	4.58 – 3.60 (24 – 91)	3.42 – 1.26 (86 – 31)	1.13 – 0.88 (28 – 22)
		G	9.46 – 8.16 (240 – 207)	9.72 – 8.08 (246 – 205)	9.96 – 9.07 (252 – 230)	9.63 – 9.07 (244 – 230)	8.96 – 7.71 (227 – 195)	7.63 – 7.48 (193 – 189)
		H	3.73 – 3.21 (94 – 81)	4.86 – 4.04 (123 – 102)	5.97 – 5.44 (151 – 138)	6.05 – 5.69 (153 – 144)	5.63 – 4.84 (143 – 122)	4.79 – 4.70 (121 – 119)
	200	F	4.22 – 1.98 (107 – 50)	1.74 – 1.44 (44 – 36)	3.74 – 2.35 (94 – 59)	2.17 – 1.33 (55 – 33)	3.89 – 1.66 (98 – 42)	—
		G	9.76 – 8.42 (247 – 213)	8.27 – 6.88 (210 – 174)	9.02 – 8.22 (229 – 208)	8.12 – 7.64 (206 – 194)	9.22 – 7.93 (234 – 201)	—
		H	4.03 – 3.47 (102 – 88)	3.41 – 2.84 (86 – 62)	5.04 – 4.59 (128 – 116)	4.53 – 4.27 (115 – 108)	5.88 – 5.06 (149 – 128)	—
	300	F	—	4.87 – 2.26 (123 – 57)	4.55 – 3.08 (115 – 78)	2.89 – 2.02 (73 – 51)	4.56 – 2.24 (115 – 56)	—
		G	—	10.30 – 8.70 (261 – 220)	9.83 – 8.96 (249 – 227)	8.84 – 8.32 (224 – 211)	9.89 – 8.51 (251 – 216)	—
		H	—	5.52 – 4.66 (140 – 118)	5.84 – 5.33 (148 – 135)	5.26 – 4.95 (133 – 125)	6.56 – 5.64 (166 – 131)	—
Stainless Steel	400	F	—	—	5.35 – 3.82 (135 – 97)	3.62 – 2.70 (91 – 68)	5.24 – 2.82 (133 – 71)	—
		G	—	—	10.63 – 9.69 (270 – 246)	9.57 – 9.01 (243 – 228)	10.57 – 9.09 (183 – 157)	—
		H	—	—	6.65 – 6.06 (168 – 153)	5.99 – 5.63 (152 – 143)	7.24 – 6.22 (183 – 157)	—
	500	F	—	—	—	—	5.91 – 3.41 (150 – 86)	—
		G	—	—	—	—	11.24 – 9.67 (285 – 245)	—
		H	—	—	—	—	7.91 – 6.80 (200 – 172)	—

Note: All levels ±0.25" (6).

B10 Standard actuating levels and liquid specific gravity with displacer arrangements 3, 4, and 5

Displacer Type	Liquid Temp. ° F	Level	0.60 – 0.64	0.65 – 0.71	0.72 – 0.73	0.74 – 0.82	0.83 – 0.92	0.93 – 1.00	1.01 – 1.07
Porcelain	100	G	2.77 – 2.01 (70 – 51)	2.63 – 1.62 (66 – 41)	2.67 – 2.51 (67 – 63)	2.58 – 1.42 (65 – 36)	3.16 – 1.94 (80 – 49)	1.82 – 1.04 (45 – 26)	1.69 – 1.23 (42 – 31)
		H	2.24 – 1.81 (56 – 45)	2.51 – 1.90 (63 – 48)	2.53 – 2.43 (64 – 61)	2.34 – 1.66 (59 – 42)	2.62 – 1.91 (66 – 48)	1.84 – 1.38 (46 – 35)	1.53 – 1.26 (38 – 32)
		J	2.01 – 1.89 (51 – 48)	1.86 – 1.70 (47 – 43)	1.68 – 1.65 (42 – 41)	1.63 – 1.47 (41 – 37)	1.45 – 1.31 (36 – 33)	1.30 – 1.21 (33 – 30)	1.02 – .097 (25 – 24)
	200	G	3.15 (80)	2.96 – 1.93 (75 – 49)	1.77 – 1.62 (44 – 41)	2.64 – 1.47 (67 – 37)	2.79 – 1.61 (70 – 40)	2.79 – 1.94 (70 – 49)	1.56 – 1.11 (39 – 28)
		H	2.69 (68)	2.57 – 1.96 965 – 49)	1.87 – 1.78 (47 – 45)	2.16 – 1.50 (54 – 38)	2.25 – 1.58 (57 – 40)	2.44 – 1.94 (61 – 49)	1.40 – 1.14 (35 – 28)
		J	2.76 (70)	2.72 – 2.49 (69 – 63)	2.45 – 2.42 (62 – 61)	2.39 – 2.15 (60 – 54)	2.13 – 1.92 (54 – 48)	1.90 – 1.77 (48 – 44)	1.58 – 1.49 (40 – 37)
	300	G	—	—	—	3.39 – 2.15 (86 – 54)	3.47 – 2.22 (88 – 56)	3.39 – 2.50 (86 – 63)	2.11 – 1.63 (53 – 41)
		H	—	—	—	2.92 – 2.18 (74 – 55)	2.93 – 2.18 (74 – 55)	3.04 – 2.50 (77 – 63)	1.95 – 1.66 (49 – 42)
		J	—	—	—	3.14 – 2.83 (79 – 71)	2.80 – 2.53 (71 – 64)	2.50 – 2.32 (63 – 58)	2.13 – 2.01 (54 – 51)
	400	G	—	—	—	—	—	—	2.67 – 2.15 (67 – 54)
		H	—	—	—	—	—	—	2.68 – 2.34 (68 – 59)
		J	—	—	—	—	—	—	2.68 – 2.53 (68 – 64)

4.3.6 Model B10 Actuating Levels (cont.)

Inches (mm)

B10 Standard actuating levels and liquid specific gravity with displacer arrangements 3, 4, and 5 (cont.)

Displacer Type	Liquid Temp. ° F	Level	1.08 – 1.12	1.13 – 1.17	1.18 – 1.27	1.28 – 1.30	1.31 – 1.39	1.40 – 1.50
Porcelain	100	G	1.16 – 0.89 (29 – 22)	2.04 – 1.75 (51 – 44)	1.68 – 1.10 (42 – 27)	1.04 – 0.92 (26 – 23)	2.05 – 1.56 (52 – 39)	1.50 – 0.97 (38 – 24)
		H	1.22 – 1.06 (30 – 26)	1.78 – 1.61 (45 – 40)	1.57 – 1.23 (39 – 31)	1.19 – 1.12 (30 – 28)	1.49 – 1.21 (37 – 30)	1.18 – 0.89 (29 – 22)
		J	0.96 – 0.92 (24 – 23)	0.92 – 0.88 (23 – 22)	0.88 – 0.81 (22 – 20)	0.81 – 0.80 (20 – 20)	0.79 – 0.74 (20 – 18)	0.74 – 0.69 (18 – 17)
	200	G	1.68 – 1.38 (42 – 35)	1.31 – 1.05 (33 – 26)	1.71 – 1.13 (43 – 28)	1.75 – 1.62 (44 – 41)	1.56 – 1.09 (39 – 27)	1.53 – 1.00 (38 – 25)
		H	1.42 – 1.25 (36 – 31)	1.21 – 1.06 (30 – 26)	1.31 – 0.99 (33 – 25)	1.50 – 1.42 (38 – 36)	1.39 – 1.12 (35 – 28)	1.33 – 1.03 (33 – 26)
		J	1.48 – 1.42 (37 – 36)	1.41 – 1.36 (35 – 34)	1.35 – 1.25 (34 – 31)	1.24 – 1.23 (31 – 31)	1.22 – 1.15 (30 – 29)	1.14 – 1.06 (28 – 26)
	300	G	2.19 – 1.88 (55 – 47)	1.81 – 1.52 (45 – 38)	2.19 – 1.57 (55 – 39)	2.18 – 2.05 (50 – 37)	1.98 – 1.49 (50 – 37)	1.93 – 1.37 (49 – 34)
		H	1.93 – 1.75 (49 – 44)	1.70 – 1.53 (43 – 38)	1.79 – 1.43 (45 – 36)	1.93 – 1.85 (49 – 46)	1.81 – 1.52 (45 – 38)	1.73 – 1.40 (43 – 35)
		J	1.99 – 1.92 (50 – 48)	1.90 – 1.84 (48 – 46)	1.82 – 1.69 (45 – 42)	1.68 – 1.66 (42 – 42)	1.64 – 1.55 (41 – 39)	1.54 – 1.43 (39 – 36)
	400	G	2.71 – 2.38 (68 – 60)	2.30 – 2.00 (58 – 50)	2.66 – 2.01 (67 – 51)	2.62 – 2.48 (61 – 48)	2.41 – 1.90 (61 – 48)	2.33 – 1.74 (59 – 44)
		H	2.45 – 2.25 (62 – 57)	2.20 – 2.01 (55 – 51)	2.26 – 1.87 (57 – 47)	2.37 – 2.28 (60 – 57)	2.24 – 1.92 (56 – 23)	2.13 – 1.77 (54 – 44)
		J	2.51 – 2.42 (63 – 61)	2.40 – 2.32 (60 – 58)	2.30 – 2.13 (58 – 54)	2.12 – 2.08 (53 – 52)	2.07 – 1.95 (52 – 49)	1.94 – 1.81 (49 – 45)
	500	G	3.23 – 2.88 (82 – 73)	2.80 – 2.48 (71 – 62)	3.13 – 2.45 (79 – 62)	3.05 – 2.91 (77 – 73)	2.84 – 2.30 (72 – 58)	2.73 – 2.11 (69 – 53)
		H	2.97 – 2.75 (75 – 69)	2.69 – 2.49 (68 – 63)	2.73 – 2.31 (69 – 58)	2.80 – 2.71 (71 – 68)	2.67 – 2.33 (67 – 59)	2.53 – 2.15 (64 – 54)
		J	3.03 – 2.92 (76 – 74)	2.89 – 2.79 (73 – 70)	2.77 – 2.57 (70 – 65)	2.55 – 2.51 (64 – 63)	2.50 – 2.35 (63 – 59)	2.33 – 2.18 (59 – 55)

Note: All levels ±0.25" (6).

4.3.6 Model B10 Actuating Levels (cont.)

Inches (mm)

B10 Standard actuating levels and liquid specific gravity with displacer arrangements 3, 4, and 5

Displacer Type	Liquid Temp. ° F	Level	0.50 – 0.58	0.59 – 0.71	0.72 – 0.79	0.80 – 0.85	0.86 – 1.00	1.01 – 1.03
Stainless Steel and Karbate	100	G	3.77 – 1.60 (95 – 40)	4.10 – 1.38 (104 – 35)	4.43 – 2.97 (112 – 75)	4.58 – 3.60 (24 – 91)	3.42 – 1.26 (86 – 31)	1.13 – 0.88 (28 – 22)
		H	3.46 – 2.16 (87 – 54)	3.72 – 2.08 (94 – 52)	3.96 – 3.07 (100 – 77)	3.63 – 3.07 (92 – 77)	2.96 – 1.71 ((75 – 43)	1.45 – 1.31 (36 – 33)
		J	2.51 – 2.16 (63 – 54)	2.13 – 1.77 (54 – 44)	1.74 – 1.59 (44 – 40)	1.57 – 1.48 (39 – 37)	1.46 – 1.25 (37 – 31)	1.24 – 1.22 (31 – 30)
	200	G	4.22 – 1.98 (107 – 50)	1.74 – 1.44 (44 – 36)	3.74 – 2.35 (94 – 59)	2.17 – 1.33 (55 – 33)	3.89 – 1.66 (98 – 42)	—
		H	3.76 – 2.42 (95 – 61)	2.27 – 1.89 (57 – 48)	3.02 – 2.22 (76 – 56)	2.12 – 1.64 (53 – 41)	3.22 – 1.93 (81 – 49)	—
		J	3.67 – 3.16 (93 – 80)	3.11 – 2.58 (78 – 65)	2.55 – 2.32 (64 – 58)	2.29 – 2.16 (58 – 54)	2.13 – 1.84 (54 – 46)	—
	300	G	—	4.87 – 2.26 (123 – 57)	4.55 – 3.08 (115 – 78)	2.89 – 2.02 (73 – 51)	4.56 – 2.24 (115 – 56)	—
		H	—	4.30 – 2.70 (109 – 68)	3.83 – 2.96 (97 – 75)	2.84 – 2.32 (72 – 58)	3.89 – 2.51 (98 – 63)	—
		J	—	4.03 – 3.40 (102 – 86)	3.36 – 3.06 (85 – 77)	3.02 – 2.84 (76 – 72)	2.81 – 2.42 (71 – 61)	—
Stainless Steel	400	G	—	—	5.35 – 3.82 (135 – 97)	3.62 – 2.70 (91 – 68)	5.24 – 2.82 (133 – 71)	—
		H	—	—	4.63 – 3.69 (117 – 93)	3.57 – 3.01 (90 – 76)	4.57 – 3.09 (116 – 78)	—
		J	—	—	4.16 – 3.79 (105 – 96)	3.75 – 3.53 (95 – 89)	3.48 – 3.00 (88 – 76)	—
	500	G	—	—	—	—	5.91 – 3.41 (150 – 86)	—
		H	—	—	—	—	5.24 – 3.67 (133 – 93)	—
		J	—	—	—	—	4.16 – 3.58 (105 – 90)	—

Note: All levels ±0.25" (6).

4.3.7 Model B15 Dimensional Data

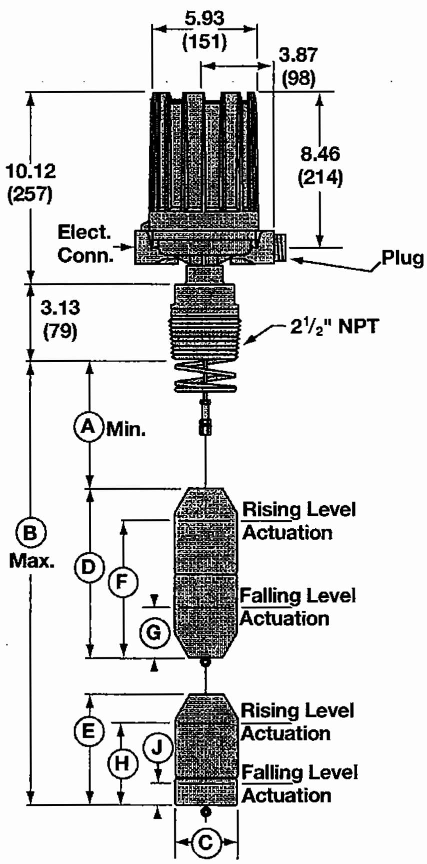
Inches (mm)

Model B15

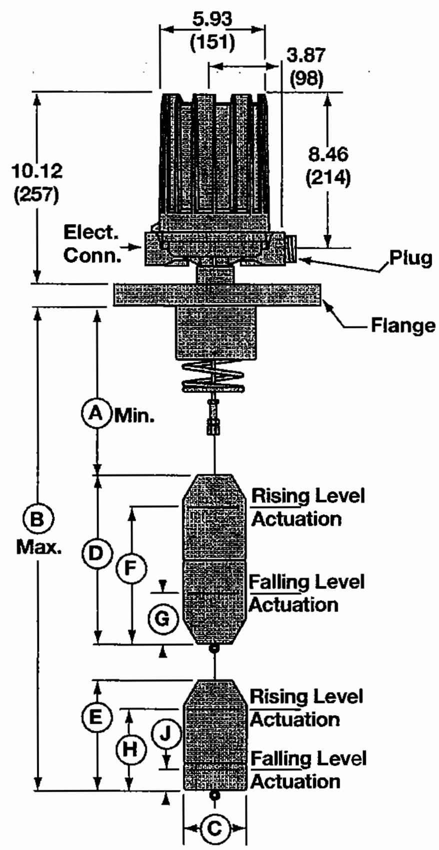
Displacer Type	Outline Dimensions			
	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	5.50 (139)	123.00 (3124)	7.50 (190)	125.00 (3175)
Stainless Steel or Karbate	5.88 (149)	123.00 (3124)	7.88 (200)	125.00 (3175)

Displacer Type	C	D	E
Porcelain	2.56 (65)	7.25 (184)	5.02 (127)
Stainless Steel or Karbate	2.50 (63)	10.50 (266)	6.00 (152)

Electrical Connections
NEMA 4X/7/9 Group B: 1" NPT



Model B15
with Threaded Mounting



Model B15
with Flanged Mounting

4.3.8 Model B15 Actuating Levels

Inches (mm)

B15 Standard actuating levels and liquid specific gravity

Displacer Type	Liquid Temp. °F	0.70				0.80			
		F	G	H	J	F	G	H	J
Stainless Steel or Karbate	100	9.50 (241)	5.00 (127)	4.90 (124)	1.30 (33)	7.60 (193)	3.70 (93)	4.30 (109)	1.10 (27)
	200	—	—	—	—	8.20 (208)	4.30 (109)	5.00 (127)	1.80 (45)

Displacer Type	Liquid Temp. °F	0.95				1.00			
		F	G	H	J	F	G	H	J
Porcelain	100	5.50 (139)	2.00 (50)	3.70 (93)	1.00 (25)	5.00 (127)	1.70 (43)	3.50 (88)	0.80 (20)
Stainless Steel	100	5.50 (139)	2.00 (50)	3.70 (93)	1.00 (25)	4.90 (124)	1.70 (43)	3.40 (86)	0.90 (22)
	200	6.00 (152)	2.70 (68)	4.20 (106)	1.50 (38)	5.40 (137)	2.20 (55)	4.00 (101)	1.50 (38)
	300	6.40 (162)	3.10 (78)	4.70 (119)	2.00 (50)	5.70 (144)	2.50 (63)	4.40 (111)	1.90 (48)
	400	—	—	—	—	6.10 (154)	2.90 (73)	4.90 (124)	2.40 (60)
Karbate	100	5.50 (139)	2.00 (50)	3.70 (93)	1.00 (25)	4.90 (124)	1.70 (43)	3.40 (86)	0.90 (22)
	200	6.00 (152)	2.70 (68)	4.20 (106)	1.50 (38)	5.40 (137)	2.20 (55)	4.00 (101)	1.50 (38)
	300	6.40 (162)	3.10 (78)	4.70 (119)	2.00 (50)	5.70 (144)	2.50 (63)	4.40 (111)	1.90 (48)

Note: All levels ±0.25" (6).

4.3.9 Model C10 Dimensional Data

Inches (mm)

Model C10 with all displacer arrangements

Displacer Type	Outline Dimensions			
	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	6.38 (965)	123.00 (3124)	8.38 (212)	125.00 (3175)
Stainless Steel or Karbate	5.75 (146)	123.00 (3124)	7.75 (196)	125.00 (3175)

Model C10 with displacer arrangements A, B, and C

Displacer Type	C	D	E	F	G
Porcelain	2.56 (65)	6.42 (163)	5.02 (127)	5.02 (127)	3.62 (91)
Stainless Steel or Karbate	2.50 (63)	6.00 (152)	6.00 (152)	4.50 (114)	4.50 (114)

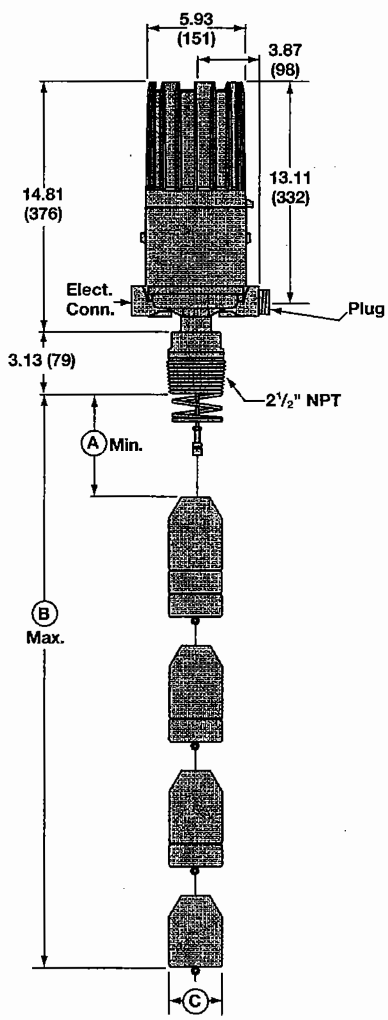
Model C10 with displacer arrangements D and F

Displacer Type	C	D	E	F
Porcelain	2.56 (65)	14.44 (367)	5.02 (127)	3.62 (91)
Stainless Steel or Karbate	2.50 (63)	12.00 (304)	4.50 (114)	4.50 (114)

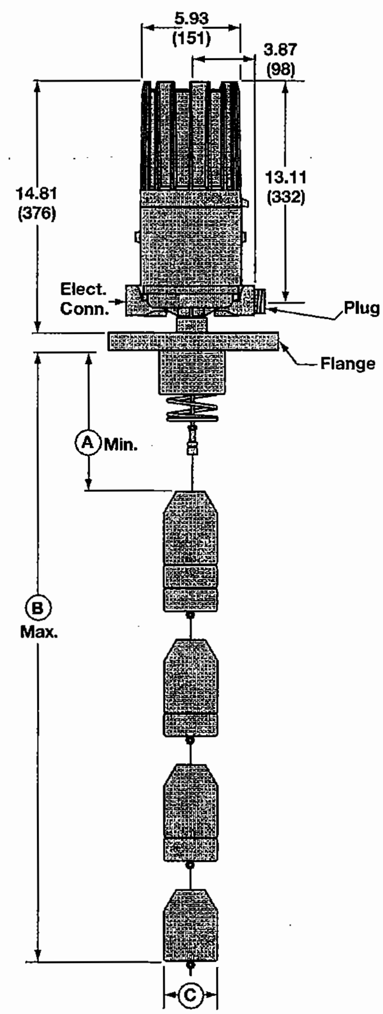
Model C10 with displacer arrangements E and G

Displacer Type	C	D	E	F
Porcelain	2.56 (65)	6.42 (153)	5.02 (127)	8.65 (219)
Stainless Steel or Karbate	2.50 (63)	6.00 (152)	6.00 (152)	9.00 (228)

Electrical Connections
NEMA 4X/7/9 Group B: 1" NPT



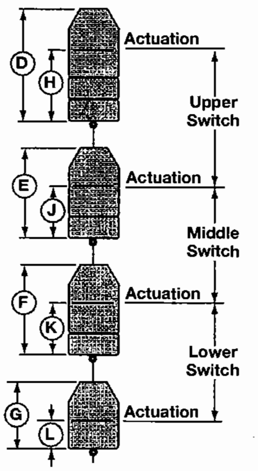
Model C10
with Threaded Mounting



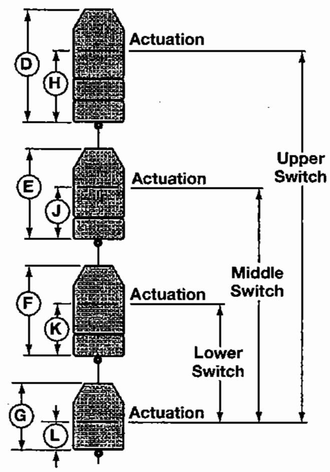
Model C10
with Flanged Mounting

4.3.10 Model C10 Actuating Levels

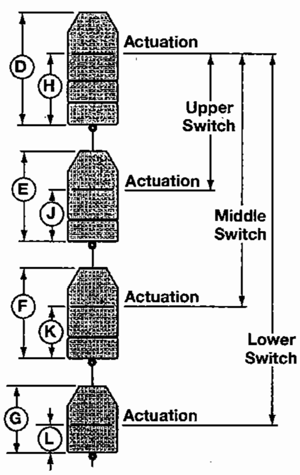
Inches (mm)



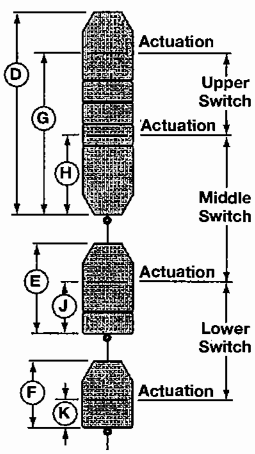
Model C10
Displacer Arrangement A



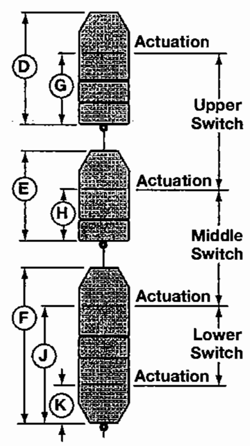
Model C10
Displacer Arrangement B



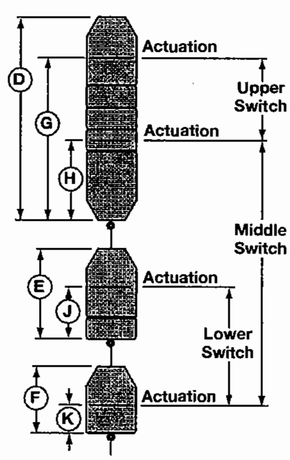
Model C10
Displacer Arrangement C



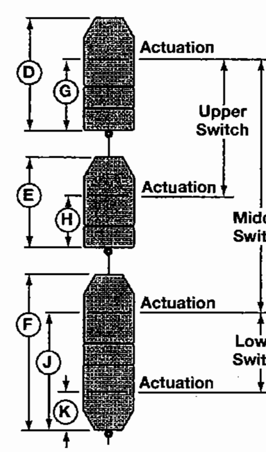
Model C10
Displacer Arrangement D



Model C10
Displacer Arrangement E



Model C10
Displacer Arrangement F



Model C10
Displacer Arrangement G

4.3.10 Model C10 Actuating Levels (cont.)

Inches (mm)

C10 Standard actuating levels and liquid specific gravity with displacer arrangements A, B, and C

Displacer Type	Liquid Temp. °F	0.58				0.60				0.70				0.80			
		H	J	K	L	H	J	K	L	H	J	K	L	H	J	K	L
Porcelain	100	—	—	—	—	—	—	—	—	2.50 (63)	2.20 (55)	2.20 (55)	2.00 (50)	2.30 (58)	2.00 (50)	1.90 (48)	1.70 (43)
Stainless Steel or Karbate	100	4.50 (114)	3.70 (93)	3.20 (81)	2.30 (58)	3.80 (96)	3.20 (81)	3.00 (76)	2.20 (55)	4.20 (106)	3.80 (96)	2.10 (53)	1.90 (48)	1.80 (45)	2.20 (55)	1.30 (33)	1.70 (43)
	200	—	—	—	—	—	—	—	—	—	—	—	—	3.20 (81)	2.90 (73)	2.50 (63)	2.30 (58)

Displacer Type	Liquid Temp. °F	0.90				1.00				1.10				1.20			
		H	J	K	L	H	J	K	L	H	J	K	L	H	J	K	L
Porcelain	100	3.0 (76)	2.4 (61)	2.7 (69)	1.5 (38)	1.4 (36)	1.4 (36)	2.1 (53)	1.4 (36)	3.0 (76)	2.6 (66)	2.5 (64)	1.2 (30)	1.7 (43)	1.7 (43)	2.1 (53)	1.1 (28)
	200	—	—	—	—	3.2 (81)	2.7 (69)	2.8 (71)	1.7 (43)	1.7 (43)	1.7 (43)	2.3 (58)	1.6 (41)	—	—	—	—
Stainless Steel or Karbate	100	3.1 (79)	3.2 (81)	2.5 (64)	1.5 (38)	1.3 (33)	1.9 (48)	1.8 (46)	1.3 (33)	3.1 (79)	3.2 (81)	2.5 (64)	1.3 (33)	1.6 (41)	2.2 (56)	1.9 (48)	1.2 (30)
	200	3.6 (91)	3.6 (91)	1.7 (43)	2.0 (51)	1.7 (43)	2.3 (58)	1.1 (28)	1.8 (46)	—	—	—	—	—	—	—	—
	300	3.4 (86)	3.0 (76)	2.4 (61)	2.7 (69)	1.6 (41)	1.8 (46)	1.7 (43)	2.4 (61)	—	—	—	—	—	—	—	—

C10 Standard actuating levels and liquid specific gravity with displacer arrangements D and F

Displacer Type	Liquid Temp. °F	0.58				0.60				0.70				0.80			
		H	J	K	L	H	J	K	L	H	J	K	L	H	J	K	L
Porcelain	100	—	—	—	—	—	—	—	—	7.50 (190)	2.60 (66)	2.20 (55)	2.00 (50)	6.90 (175)	2.40 (60)	1.90 (48)	1.70 (43)
Stainless Steel or Karbate	100	9.90 (251)	3.70 (93)	3.20 (81)	2.30 (58)	9.20 (233)	3.20 (81)	3.00 (76)	2.20 (55)	8.90 (226)	3.80 (96)	2.10 (53)	1.90 (48)	6.70 (170)	2.20 (55)	1.30 (33)	1.70 (43)
	200	—	—	—	—	—	—	—	—	—	—	—	—	7.40 (187)	2.90 (73)	2.50 (63)	2.30 (58)

Displacer Type	Liquid Temp. °F	0.90				1.00				1.10				1.20			
		H	J	K	L	H	J	K	L	H	J	K	L	H	J	K	L
Porcelain	100	6.60 (167)	2.80 (71)	2.70 (68)	1.50 (38)	5.20 (132)	1.80 (45)	2.10 (53)	1.40 (35)	6.10 (154)	3.00 (76)	2.50 (63)	1.20 (30)	5.00 (127)	2.10 (53)	2.10 (53)	1.10 (27)
	200	—	—	—	—	6.20 (157)	3.10 (78)	2.80 (71)	1.70 (43)	5.20 (132)	2.10 (53)	2.30 (58)	1.60 (40)	—	—	—	—
Stainless Steel or Karbate	100	7.20 (182)	3.20 (81)	2.50 (63)	1.50 (38)	5.50 (139)	1.90 (48)	1.80 (45)	1.30 (33)	6.40 (162)	3.20 (81)	2.50 (63)	1.30 (33)	5.20 (132)	2.20 (55)	1.90 (48)	1.20 (30)
	200	7.60 (193)	3.60 (91)	1.70 (43)	2.00 (50)	5.90 (149)	2.30 (58)	1.10 (27)	1.80 (45)	—	—	—	—	—	—	—	—
	300	7.00 (177)	3.00 (76)	2.40 (60)	2.70 (68)	5.40 (137)	1.80 (45)	1.70 (43)	2.40 (60)	—	—	—	—	—	—	—	—

Note: All levels ±0.25" (6).

4.3.10 Model C10 Actuating Levels (cont.)

Inches (mm)

C10 Standard actuating levels and liquid specific gravity with displacer arrangements E and G

Displacer Type	Liquid Temp. °F	0.58				0.60				0.70				0.80			
		H	J	K	L	H	J	K	L	H	J	K	L	H	J	K	L
Porcelain	100	—	—	—	—	—	—	—	—	2.50 (63)	2.20 (55)	5.80 (147)	1.90 (48)	2.30 (58)	2.00 (50)	5.50 (139)	2.10 (53)
Stainless Steel or Karbate	100	4.50 (114)	3.70 (93)	7.70 (195)	2.80 (71)	3.80 (96)	3.20 (81)	7.50 (190)	2.70 (68)	4.20 (106)	3.80 (96)	6.60 (167)	2.50 (63)	1.80 (45)	2.20 (55)	5.80 (147)	2.20 (55)
	200	—	—	—	—	—	—	—	—	—	—	—	—	3.20 (81)	2.90 (73)	7.00 (177)	3.40 (86)

Displacer Type	Liquid Temp. °F	0.90				1.00				1.10				1.20			
		H	J	K	L	H	J	K	L	H	J	K	L	H	J	K	L
Porcelain	100	3.00 (76)	2.40 (60)	6.30 (160)	3.20 (81)	1.40 (35)	1.40 (35)	5.70 (144)	1.90 (48)	3.00 (76)	2.60 (66)	6.10 (154)	3.60 (91)	1.70 (43)	1.70 (43)	5.70 (144)	3.40 (86)
	200	—	—	—	—	3.20 (81)	2.70 (68)	6.40 (162)	3.60 (91)	1.70 (43)	1.70 (43)	5.90 (149)	3.40 (86)	—	—	—	—
Stainless Steel or Karbate	100	3.10 (78)	3.20 (81)	7.00 (177)	3.80 (96)	1.30 (33)	1.90 (48)	6.30 (160)	3.40 (86)	3.10 (78)	3.20 (81)	7.00 (177)	4.40 (111)	1.60 (40)	2.20 (55)	6.40 (162)	4.00 (101)
	200	3.60 (91)	3.60 (91)	6.20 (157)	3.00 (76)	1.70 (43)	2.30 (58)	5.60 (142)	2.70 (68)	—	—	—	—	—	—	—	—
	300	3.40 (86)	3.00 (76)	6.90 (175)	3.70 (93)	1.60 (40)	1.80 (45)	6.20 (157)	3.30 (83)	—	—	—	—	—	—	—	—

Note: All levels ±0.25" (6).

4.3.11 Model C15 Dimensional Data

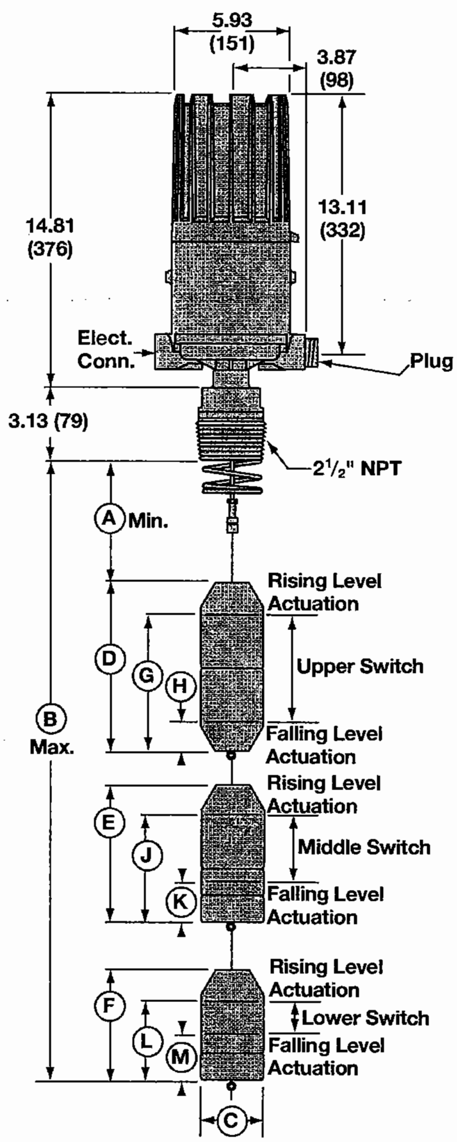
Inches (mm)

Model C15

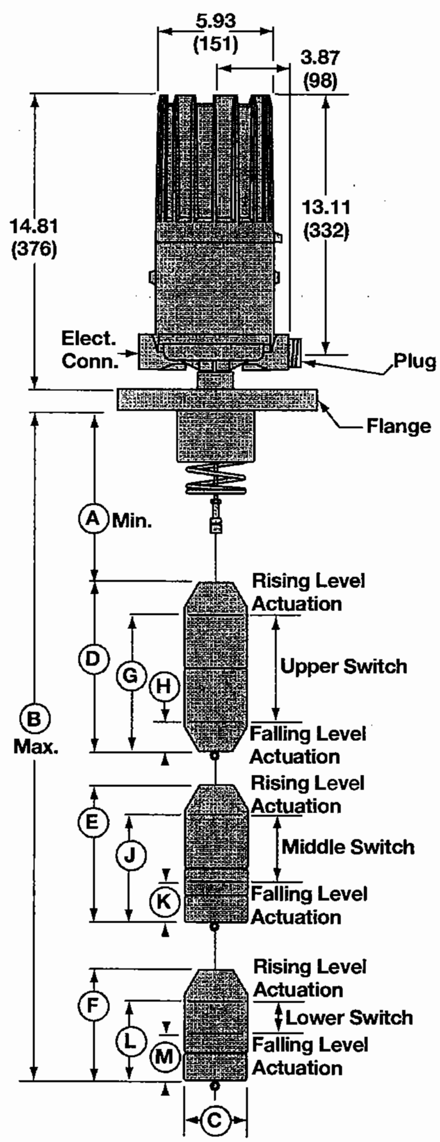
OUTLINE DIMENSIONS				
Displacer Type	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	7.75 (196)	125.00 (3175)	9.75 (247)	127.00 (3225)
Stainless Steel or Karbate	7.25 (184)	124.00 (3149)	9.25 (234)	126.00 (3200)

Displacer Type	C	D	E	F
Porcelain	2.56 (65)	7.25 (184)	6.42 (163)	5.02 (127)
Stainless Steel or Karbate	2.50 (63)	9.00 (228)	7.50 (190)	6.00 (152)

Electrical Connections
NEMA 4X/7/9 Group B: 1" NPT



Model C15
with Threaded Mounting



Model C15
with Flanged Mounting

4.3.12 Model C15 Actuating Levels

Inches (mm)

C15 Standard actuating levels and liquid specific gravity

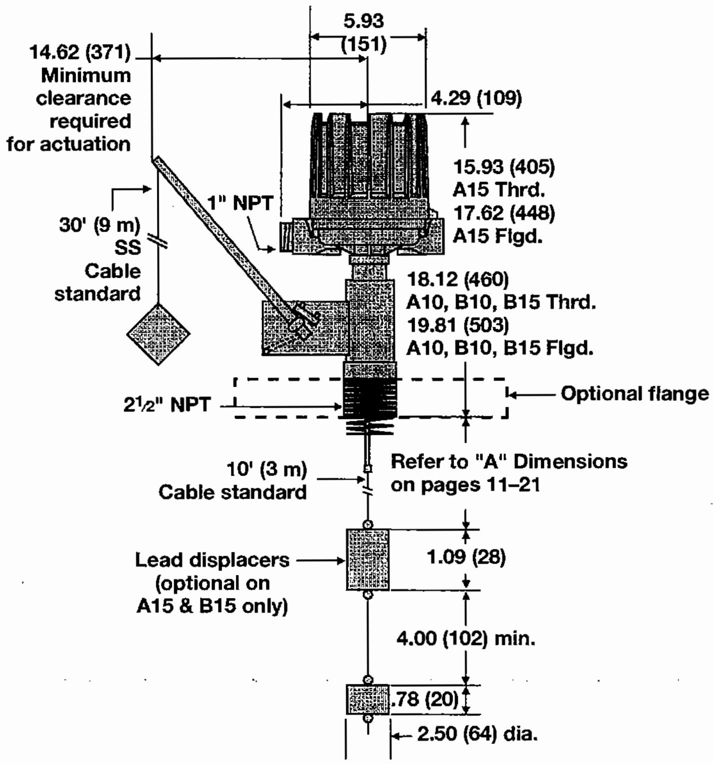
Displacer Type	Liquid Temp. °F	0.65						0.70						0.80					
		G	H	J	K	L	M	G	H	J	K	L	M	G	H	J	K	L	M
Porcelain	0 to +130	—	—	—	—	—	—	—	—	—	—	—	—	6.20 (157)	1.40 (35)	5.30 (134)	1.00 (25)	3.80 (96)	0.90 (22)
Stainless Steel or Karbate	0 to +130	7.70 (195)	2.20 (55)	6.10 (154)	2.00 (50)	4.90 (124)	1.40 (35)	6.70 (170)	1.60 (40)	5.50 (139)	1.60 (40)	4.60 (116)	1.30 (33)	6.50 (165)	2.00 (50)	5.20 (132)	1.60 (40)	4.30 (109)	1.10 (27)

Displacer Type	Liquid Temp. °F	0.90						1.00						1.10					
		G	H	J	K	L	M	G	H	J	K	L	M	G	H	J	K	L	M
Porcelain	0 to +130	6.20 (157)	1.90 (48)	5.00 (127)	1.40 (35)	3.60 (91)	1.00 (25)	4.60 (116)	0.70 (17)	4.00 (101)	0.80 (20)	3.30 (83)	0.90 (22)	4.20 (106)	1.10 (27)	3.80 (96)	1.00 (25)	3.10 (78)	0.90 (22)
Stainless Steel or Karbate	0 to +130	6.60 (167)	2.60 (66)	5.20 (132)	1.80 (45)	4.00 (101)	1.20 (30)	4.60 (116)	1.00 (25)	4.00 (101)	1.00 (25)	3.60 (91)	1.10 (27)	—	—	—	—	—	—

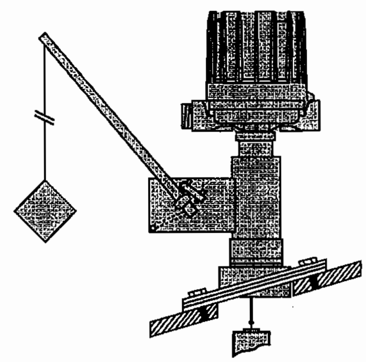
Displacer Type	Liquid Temp. °F	1.20						1.25					
		G	H	J	K	L	M	G	H	J	K	L	M
Porcelain	0 to +130	4.50 (114)	1.60 (40)	3.70 (93)	1.10 (27)	2.90 (73)	0.90 (22)	3.90 (99)	1.10 (27)	3.30 (83)	0.90 (22)	2.80 (71)	0.80 (20)

4.3.13 Proof-er Dimensional Data

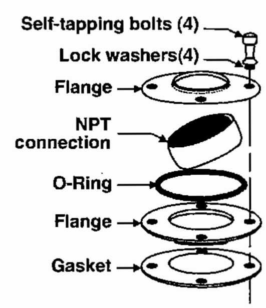
Inches (mm)



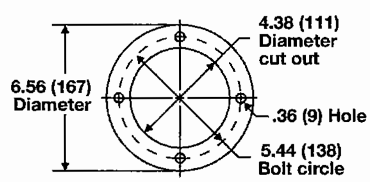
TYPICAL PROOF-ER INSTALLATION WITH VERSA FLANGE



VERSA FLANGE ASSEMBLY
PART NUMBER 089-5207-001

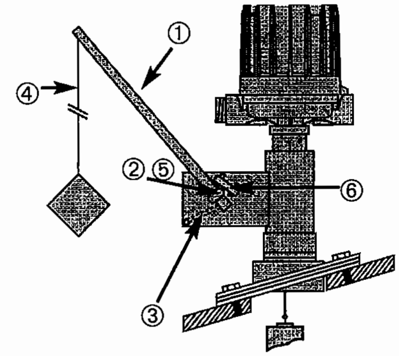


VERSA FLANGE BOLT CIRCLE



4.3.14 Proof-er Replacement Parts

		Proof-er Replacement Part Number	
Item	**Description**	**Low Pressure**	**Medium Pressure**
1	Handle	004-4011-001	004-0490-001
2	O-Ring	Not Required	012-2205-001
3	Spring	013-2502-001	
4	Cable Assembly	089-5807-001	
5	O-Ring Cover	Not Required	004-0489-001
6	Nut	010-2107-004	Not Required



Item No.	Description		A10	A15	B10/B15	C10/C15
1	Enclosing Tube	Standard	Z32-6325-007	Z32-6325-001	Z32-6325-007	Z32-6301-029
		316 SS	Z32-6325-008	Z32-6325-002	Z32-6325-008	Z32-6302-029
2	E-Tube Gasket		012-1301-002			
3	Spring and Stem Kit ①	Standard	089-5327-001	089-5325-001	Consult Factory	
		316 SS	089-5328-001	089-5326-001	Consult Factory	
4	Body Bushing		089-6707-001			
5	Flange and Spring Protector		Specify size and rating. Furnish serial number of control.			

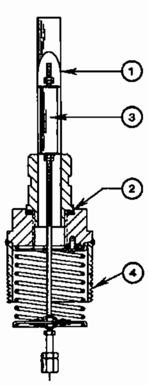
① 316 SS Spring and Stem Kit includes 316 SS sheathed magnetic sleeve.

4.4.1 Displacer Replacement Parts

Displacer Material		A10	A15	B10	B15	C10	C15
Porcelain②		089-6141-001	089-6142-001	089-6143-001	089-6144-001	089-6153-001	089-6156-001
Karbate②		089-6145-001	089-6146-001	089-6147-001	089-6148-001	089-6154-001	089-6157-001
Stainless Steel②		089-6149-001	089-6150-001	089-6151-001	089-6152-001	089-6155-001	089-6158-001
10 feet (3m) Cable	316 SS	089-5802-003③					
with Displacer	Hastelloy	089-5803-003③					
Clamps only	Monel	089-5804-003③					

② Kits contain 10 feet (3m) 316 SS cable.
③ For Model C10 with operating sequences A, B, or C order kits:
89-5802-004 (316 SS), 89-5803-004 (Hastelloy), or 89-5804-004 (Monel).

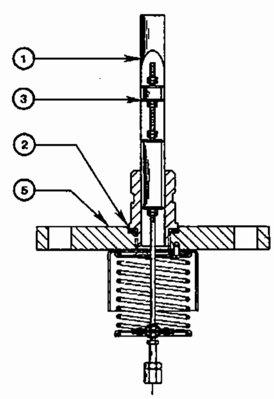
NOTE: Refer to pages 11, 12, 13, 21, 23 & 27 for dimensional specifications of displacers.



Threaded Connection Model
(Typical Single Switch Model)

Flanged Connection Model
(Typical Dual Switch Model)

CAUTION: *Location of magnetic sleeve must be maintained for proper switch actuation. Do NOT attempt to alter differential or [illegible] by repositioning jam nuts.*



4.5.1 A10 & A15 Single Switch Models

PART NUMBER CODE AND SPECIFIC GRAVITY LIMITS*

Part Number Code	Description	Liquid Temp. °F	Liquid Temp. °C	Series A thru E, J and K Switches: Porcelain	Stainless Steel	Karbate
A10①	Wide Differential, 1 switch	100	38	0.60 to 1.20	0.60 to 1.20	0.60 to 1.20
		200	93	0.70 to 1.20	0.70 to 1.20	0.70 to 1.20
		300	149	0.80 to 1.20	0.80 to 1.20	0.80 to 1.20
		400	204	1.00 to 1.20	0.90 to 1.20	—
		500	260	1.10 to 1.20	1.00 to 1.20	—
A15	Narrow Differential, 1 switch	100	38	0.60 to 2.40	0.40 to 1.65	0.40 to 1.65
		200	93	0.62 to 2.40	0.40 to 1.65	0.45 to 1.65
		300	149	0.65 to 2.40	0.50 to 1.65	0.50 to 1.65
		400	204	0.70 to 2.40	0.55 to 1.65	—
		500	260	0.75 to 2.40	0.60 to 1.65	—

MATERIALS OF CONSTRUCTION

Code	Support Spring	Trim	E-Tube Mtg. Nut	Displacer Clamps/ Susp. Cable	Magnetic Sleeve	Process Connection
1	Inconel 600	300 Series SS	Carbon Steel	316 SS	400 Series SS	Carbon Steel ⑩
2 ①	Inconel 600	316 SS	316 SS	316 SS	316 SS	Carbon Steel⑩
4 ①						316 SS
5 ①	Inconel 600	300 Series SS	Carbon Steel	Monel	400 Series SS	Carbon Steel⑩
6 ①				Hastelloy		
M ①② NACE Const.	Inconel X750	316 SS	316 SS	316 SS	316 SS	316 SS
N ①② NACE Const.	Inconel X750	300 Series SS	316 SS	316 SS	316 SS	Carbon Steel

TANK CONNECTION

Tank Connection	Code
2½" NPT Threaded ③	E2
3" 125 lb. Cast Iron Flange ④⑤⑥	G2
3" 150 lb. Steel Flange ⑤⑦	G3
4" 125 lb. Cast Iron Flange ④⑥	H2
4" 150 lb. Steel Flange ⑦	H3
4" 300 lb. Steel Flange ⑦	H4
6" 125 lb. Cast Iron Flange ④⑥	K2
6" 150 lb. Steel Flange ⑦	K3
6" 300 lb. Steel Flange ⑦	K4

DISPLACER MATERIAL AND PROOF-ER OPTION

Proof-er** Type	Displacer Material: Porcelain	316 SS	Karbate	Floating Roof Weight Mat'l: Lead
Without Proof-er	A	B	C	K ④
Low Pressure ③	D ④	E ④	F ④	L ④
Medium Pressure ③	G ④	H ④	J ④	—

A	1		—					—				

* Specific gravity limits do not apply to floating roof top units not to be used in liquid.

**Proof-er option constructed of carbon steel material.

4.5.1 A10 & A15 Single Switch Models (continued)

ELECTRIC SWITCH MECHANISM AND ENCLOSURE ⑧ FOR MODELS A10 AND A15

Switch Description	Max.⑨ Process Temp. ° F (°C)	One Set Point	A10 Codes			A15 Codes		
			Aluminum Polymer Coated NEMA 4X/7/9 ⑩					
			Class I, Div. 1, Groups C & D	Class I, Div. 1, Group B	ATEX	Class I, Div. 1, Groups C & D	Class I, Div. 1, Group B	ATEX
Series A Mercury Switch	500 (260)	SPDT	AKB	AKK	AC9	AKQ	AKS	AA9
		DPDT	ANB	ANK	AF9	ANQ	ANS	AB9
Series B Snap Switch	250 (121)	SPDT	BKB	BKK	BC9	BKQ	BKS	BA9
		DPDT	BNB	BNK	BF9	BNQ	BNS	BB9
Series C Snap Switch	450 (232)	SPDT	CKB	CKK	CC9	CKQ	CKS	CA9
		DPDT	CNB	CNK	CF9	CNQ	CNS	CB9
Series D Snap Switch For DC Current Applications	250 (121)	SPDT	DKB	DKK	DC9	DKQ	DKS	DA9
		DPDT	DNB	DNK	DF9	DNQ	DNS	DB9
Series E Vibration Resistant Mercury Switch	500 (260)	SPDT	EKB	EKK	EC9	EKQ	EKS	EA9
		DPDT	ENB	ENK	EF9	ENQ	ENS	EB9
Series HS Hermetically Sealed Snap Switch w/Wiring Leads	500⑪ (260)	SPDT	HMJ	HMK	—	HMC	HEK⑫	—
		DPDT	HMS	HMT	—	HMF	HET⑫	—
Series HS Hermetically Sealed Snap Switch w/Terminal Block	500⑪ (260)	SPDT	HM3	HM4	HA9	HM3⑬	HM4⑬	HA9
		DPDT	HM7	HM8	HB9	HM7⑬	HM8⑬	HB9

PNEUMATIC SWITCH MECHANISM AND ENCLOSURE FOR MODELS A10 AND A15

Switch Description	Maximum Supply Pressure		Maximum⑨ Process Temperature		Bleed Orifice Diameter		A10 Codes	A15 Codes
	psig	bar	° F	° C	Inches	mm	NEMA 1	NEMA 1
Series J Bleed Type Pneumatic Switch	100	7	400	204	.063	1.6	JGF	JDE
	60	4	400	204	.094	2.3	JHF	JEE
Series K Non-Bleed Pneumatic Switch	100	7	400	204	—	—	KOF	KOE

① Not available with displacer material and proof-er option codes K, L.

② Not available with displacer material and proof-er option codes D, E, F, G, H, J, K and L.

③ Pressure/temperature ratings on page 10. Flanges are ANSI type.

④ Not available with material of construction codes M and N.

⑤ Not available with displacer material and Proof-er option codes K, L.

⑥ Not available with material of construction code 4.

⑦ 316 SS flange is provided with material of construction code 4 and M.

⑧ Consult factory for NEMA 4X/7/9 cast iron housings.

⑨ Process temperature based on +100° F (+38° C) ambient.

⑩ Uncontrolled housing heater or drain available in NEMA 4X/7/9 enclosures. Consult factory for standard part numbers.

⑪ On steam applications, temperature down rated to +400° F (+204° C) process at +100° F (+38° C) ambient. Available with a 6" tall cover only.

⑫ CSA approval does not apply to these switch designations.

⑬ Available with a 6" tall cover only.

⑭ 125# flanges will be cast iron.

A	1		—					—				

4.5.2 B10 & B15 Dual Switch Models

PART NUMBER CODE AND SPECIFIC GRAVITY LIMITS*

Part Number Code	Description	Liquid Temp.		Series A thru E, J and K Switches		
		° F	° C	Porcelain	Stainless Steel	Karbate
B10	Wide Differential, 2 switches	100	38	0.60 to 1.50	0.50 to 1.00	0.50 to 1.00
		200	93	0.64 to 1.50	0.50 to 1.00	0.50 to 1.00
		300	149	0.80 to 1.50	0.60 to 1.00	0.60 to 1.00
		400	204	1.00 to 1.50	0.72 to 1.00	—
		500	260	1.10 to 1.50	0.84 to 1.00	—
B15	Narrow Differential, 2 switches	100	38	0.95 to 1.20	0.70 to 1.20	0.70 to 1.20
		200	93	1.10 to 1.20	0.80 to 1.20	0.80 to 1.20
		300	149	—	0.90 to 1.20	0.90 to 1.20
		400	204	—	1.00 to 1.20	—
		500	260	—	1.04 to 1.20	—

MATERIALS OF CONSTRUCTION

Code	Support Spring	Trim	E-Tube Mtg. Nut	Displacer Clamps/ Susp. Cable	Magnetic Sleeve	Process Connection
1	Inconel 600	300 Series SS	Carbon Steel	316 SS	400 Series SS	Carbon Steel ⑬
2 ①	Inconel 600	316 SS	316 SS	316 SS	316 SS	Carbon Steel ⑬
4 ①						316 SS
5 ①	Inconel 600	300 Series SS	Carbon Steel	Monel	400 Series SS	Carbon Steel ⑬
6 ①				Hastelloy		
M ①② NACE Const.	Inconel X750	316 SS	316 SS	316 SS	316 SS	316 SS
N ①② NACE Const.	Inconel X750	300 Series SS	316 SS	316 SS	316 SS	Carbon Steel

TANK CONNECTION

Tank Connection	Code
2½" NPT Threaded ③	E2
3" 125 lb. Cast Iron Flange ④⑤⑥	G2
3" 150 lb. Steel Flange ⑤⑦	G3
4" 125 lb. Cast Iron Flange ④⑥	H2
4" 150 lb. Steel Flange ⑦	H3
4" 300 lb. Steel Flange ⑦	H4
6" 125 lb. Cast Iron Flange ④⑥	K2
6" 150 lb. Steel Flange ⑦	K3
6" 300 lb. Steel Flange ⑦	K4

DISPLACER MATERIAL AND PROOF-ER OPTION

Proof-er** Type	Displacer Material			Floating Roof Weight Mat'l Model B15 Only
	Porcelain	316 SS	Karbate	Lead
Without Proof-er	A	B	C	K ④
Low Pressure ③	D ④	E ④	F ④	L ④

B	1		—					—			

* Specific gravity limits do not apply to floating roof top units not to be used in liquid.

**Proof-er option constructed of carbon steel material.

4.5.2 B10 & B15 Dual Switch Models (continued)

ELECTRIC SWITCH MECHANISM AND ENCLOSURE ⑧ FOR MODELS B10 AND B15

Switch Description ⑨	Max. ⑩ Process Temp. ° F (°C)	Two Set Points	Switch Enclosure NEMA 4X/7/9 ⑪ Class I, Div. 1, Groups C & D	Switch Enclosure NEMA 4X/7/9 ⑪ Class I, Div. 1, Group B	ATEX
Series A Mercury Switch	500 (260)	SPDT	ALB	ALK	AD9
		DPDT	AOB	AOK	AG9
Series B Snap Switch	250 (121)	SPDT	BLB	BLK	BD9
		DPDT	BOB	BOK	BG9
Series C Snap Switch	450 (232)	SPDT	CLB	CLK	CD9
		DPDT	COB	COK	CG9
Series D Snap Switch For DC Current Applications	250 (121)	SPDT	DLB	DLK	DD9
		DPDT	DOB	DOK	DG9
Series E Vibration Resistant Mercury Switch	500 (260)	SPDT	ELB	ELK	ED9
		DPDT	EOB	EOK	EG9
Series HS Hermetically Sealed Snap Switch w/Wiring Leads	500 ⑫ (260)	SPDT	HMN	HMP	—
		DPDT	HMY	HMZ	—

① Not available with displacer material and proof-er option codes K, L.
② Not available with displacer material and proof-er option codes D, E, F, K and L.
③ Pressure/temperature ratings on page 10. Flanges are ANSI type.
④ Not available with material of construction codes M and N.
⑤ Not available with displacer material and Proof-er option codes K, L.
⑥ Not available with material of construction code 4.
⑦ 316 SS flange is provided with material of construction code 4 and M.
⑥ Not available with displacer material and Proof-er option codes K, L.
⑧ Consult factory for NEMA 4X/7/9 cast iron housings.
⑨ Pneumatic switch mechanisms and enclosures are unavailable for Models B10 and B15 switches.
⑩ Process temperature based on +100° F (+38° C) ambient.
⑪ Uncontrolled housing heater or drain available in NEMA 4X/7/9 enclosures. Consult factory for standard part numbers.
⑫ On steam applications, temperature down rated to +400° F (+204° C) process at +100° F (+38° C) ambient.
⑬ 125# flanges will be cast iron.

B	1		—					—			

4.5.3 C10 & C15 Triple Switch Models

PART NUMBER CODE AND SPECIFIC GRAVITY LIMITS**

<table>
<tr><th rowspan="2">Part Number Code</th><th rowspan="2">Description</th><th colspan="2">Liquid Temp.</th><th colspan="3">Series A thru E, J and K Switches</th></tr>
<tr><th>° F</th><th>° C</th><th>Porcelain</th><th>Stainless Steel</th><th>Karbate</th></tr>
<tr><td rowspan="3">C10</td><td rowspan="3">Wide Differential, 3 switches</td><td>100</td><td>38</td><td>0.65 to 1.20</td><td>0.58 to 1.20</td><td>0.58 to 1.20</td></tr>
<tr><td>200</td><td>93</td><td>0.95 to 1.10</td><td>0.76 to 1.00</td><td>0.76 to 1.00</td></tr>
<tr><td>300</td><td>149</td><td>—</td><td>0.82 to 1.00</td><td>0.82 to 1.00</td></tr>
<tr><td>C15*</td><td>Narrow Differential, 3 switches</td><td>130</td><td>54</td><td>0.80 to 1.25</td><td>0.65 to 1.00</td><td>0.65 to 1.00</td></tr>
</table>

* Consult factory for high temperatures

** Each C10/C15 instrument is factory calibrated to operate for a given specific gravity within the minimum and maximum values listed

MATERIALS OF CONSTRUCTION

<table>
<tr><th>Code</th><th>Support Spring</th><th>Trim</th><th>E-Tube Mtg. Nut</th><th>Displacer Clamps/ Susp. Cable</th><th>Magnetic Sleeve</th><th>Process Connection</th></tr>
<tr><td>1</td><td>Inconel 600</td><td>300 Series SS</td><td>Carbon Steel</td><td>316 SS</td><td>400 Series SS</td><td>Carbon Steel ⑦</td></tr>
<tr><td>2 ①</td><td rowspan="2">Inconel 600</td><td rowspan="2">316 SS</td><td rowspan="2">316 SS</td><td rowspan="2">316 SS</td><td rowspan="2">316 SS</td><td>Carbon Steel ⑦</td></tr>
<tr><td>4 ①</td><td>316 SS</td></tr>
<tr><td>5 ①</td><td rowspan="2">Inconel 600</td><td rowspan="2">300 Series SS</td><td rowspan="2">Carbon Steel</td><td>Monel</td><td rowspan="2">400 Series SS</td><td rowspan="2">Carbon Steel ⑦</td></tr>
<tr><td>6 ①</td><td>Hastelloy</td></tr>
<tr><td>M ①②
NACE Const.</td><td>Inconel X750</td><td>316 SS</td><td>316 SS</td><td>316 SS</td><td>316 SS</td><td>316 SS</td></tr>
<tr><td>N ①②
NACE Const.</td><td>Inconel X750</td><td>300 Series SS</td><td>316 SS</td><td>316 SS</td><td>316 SS</td><td>Carbon Steel</td></tr>
</table>

TANK CONNECTION

Tank Connection	Code
2½" NPT Threaded ①	E2
3" 125 lb. Cast Iron Flange ②	G2
3" 150 lb. Steel Flange ③	G3
4" 125 lb. Cast Iron Flange ②	H2
4" 150 lb. Steel Flange ③	H3
4" 300 lb. Steel Flange ③	H4
6" 125 lb. Cast Iron Flange ②	K2
6" 150 lb. Steel Flange ③	K3
6" 300 lb. Steel Flange ③	K4

DISPLACER MATERIAL

Displacer Material		
Porcelain	316 SS	Karbate
A	B	C

C	1		—					—			

4.5.3 C10 & C15 Triple Switch Models (continued)

ELECTRIC SWITCH MECHANISM AND ENCLOSURE ⑥ FOR MODELS C10 AND C15

Switch Description ④	Maximum ⑤ Process Temp. ° F (° C)	Three Set Points	Aluminum Polymer Coated Switch Enclosure NEMA 4X/7/9			
			Class I, Div. 1, Groups C & D	Aluminum With Heater	Aluminum With Drain	Aluminum Class I, Div. 1, Group B
Series N Mercury Switch	300 (149)	SPDT	NMB	NRB	NWB	NMN
		DPDT	NKB	NLB	NNB	NKN
Series O Snap Switch	300 (149)	SPDT	OMB	Not Available	OWB	OMN
		DPDT	OKB		ONB	OKN
Series Q Snap Switch	250 (121)	SPDT	QMB	QRB	QWB	QMN
		DPDT	QKB	QLB	QNB	QKN
Series T Vibration Resistant Mercury Switch	300 (149)	SPDT	TMB	TRB	TWB	TMN
		DPDT	TKB	TLB	TNB	TKN

① Pressure/temperature ratings on page 10. Flanges are ANSI type.
② Not available with material of construction codes 4, M and N.
③ 316 SS flange is provided with material of construction code 4 and M.
④ Pneumatic switch mechanisms and enclosures are unavailable for Models C10 and C15 switches.
⑤ Process temperature based on +100° F (+38° C) ambient.
⑥ Consult factory for NEMA 4X/7/9 cast iron housings.
⑦ 125# flanges will be cast iron.

C 1 — —

ASSURED QUALITY & SERVICE COST LESS

Service Policy

Owners of Magnetrol controls may request the return of a control or any part of a control for complete rebuilding or replacement. They will be rebuilt or replaced promptly. Controls returned under our service policy must be returned by Prepaid transportation. Magnetrol will repair or replace the control at no cost to the purchaser (or owner) other than transportation if:

1. Returned within the warranty period; and
2. The factory inspection finds the cause of the claim to be covered under the warranty.

If the trouble is the result of conditions beyond our control; or, is NOT covered by the warranty, there will be charges for labor and the parts required to rebuild or replace the equipment.

In some cases it may be expedient to ship replacement parts; or, in extreme cases a complete new control, to replace the original equipment before it is returned. If this is desired, notify the factory of both the model and serial numbers of the control to be replaced. In such cases, credit for the materials returned will be determined on the basis of the applicability of our warranty.

No claims for misapplication, labor, direct or consequential damage will be allowed.

Return Material Procedure

So that we may efficiently process any materials that are returned, it is essential that a "Return Material Authorization" (RMA) number be obtained from the factory, prior to the material's return. This is available through Magnetrol's local representative or by contacting the factory. Please supply the following information:

1. Company Name
2. Description of Material
3. Serial Number
4. Reason for Return
5. Application

Any unit that was used in a process must be properly cleaned in accordance with OSHA standards, before it is returned to the factory.

A Material Safety Data Sheet (MSDS) must accompany material that was used in any media.

All shipments returned to the factory must be by prepaid transportation.

All replacements will be shipped F.O.B. factory.

Magnetrol

5300 Belmont Road • Downers Grove, Illinois 60515-4499 • 630-969-4000 • Fax 630-969-9489 • www.magnetrol.com
145 Jardin Drive, Units 1 & 2 • Concord, Ontario Canada L4K 1X7 • 905-738-9600 • Fax 905-738-1306
Heikensstraat 6 • B 9240 Zele, Belgium • 052 45.11.11 • Fax 052 45.09.93
Regent Business Ctr., Jubilee Rd. • Burgess Hill, Sussex RH15 9TL U.K. • 01444-871313 • Fax 01444-871317

STI

5300 Belmont Road • Downers Grove, Illinois 60515-4499 • 630-969-4028 • Fax 630-969-9489 • www.sticontrols.com

BULLETIN: 45-610.19
EFFECTIVE: May 2006
SUPERSEDES: December 2005

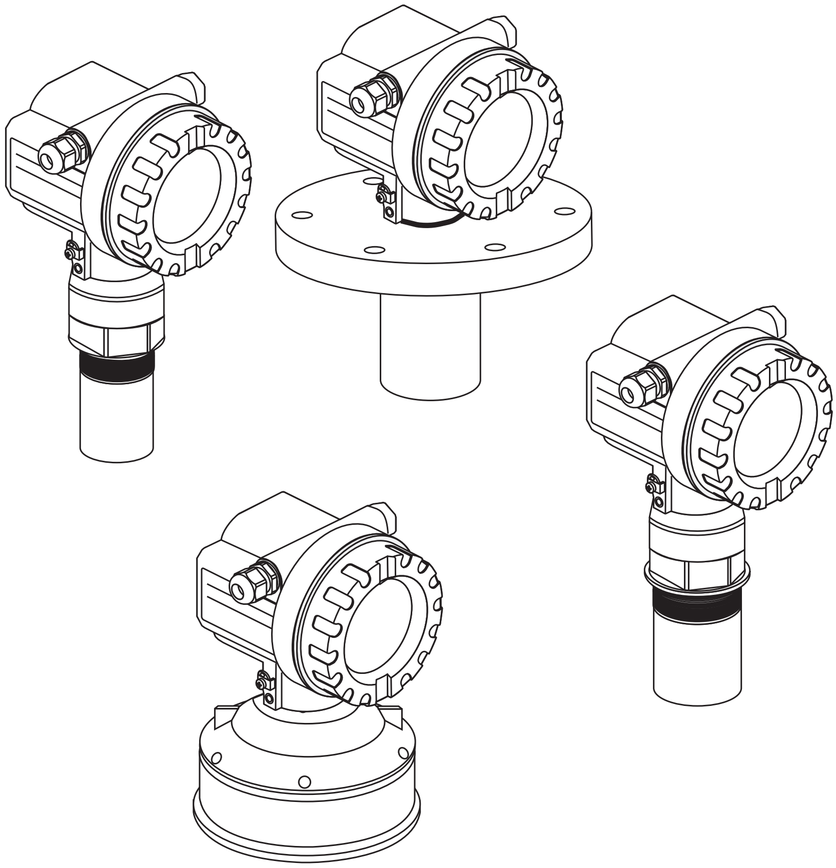
Endress+Hauser FMU40 Ultrasonic Meter

Level Pressure Flow Temperature Liquid Analysis Registration Systems Components Services Solutions

Operating Instructions

Prosonic M FMU40/~~41/42/43~~

Ultrasonic Level Measurement

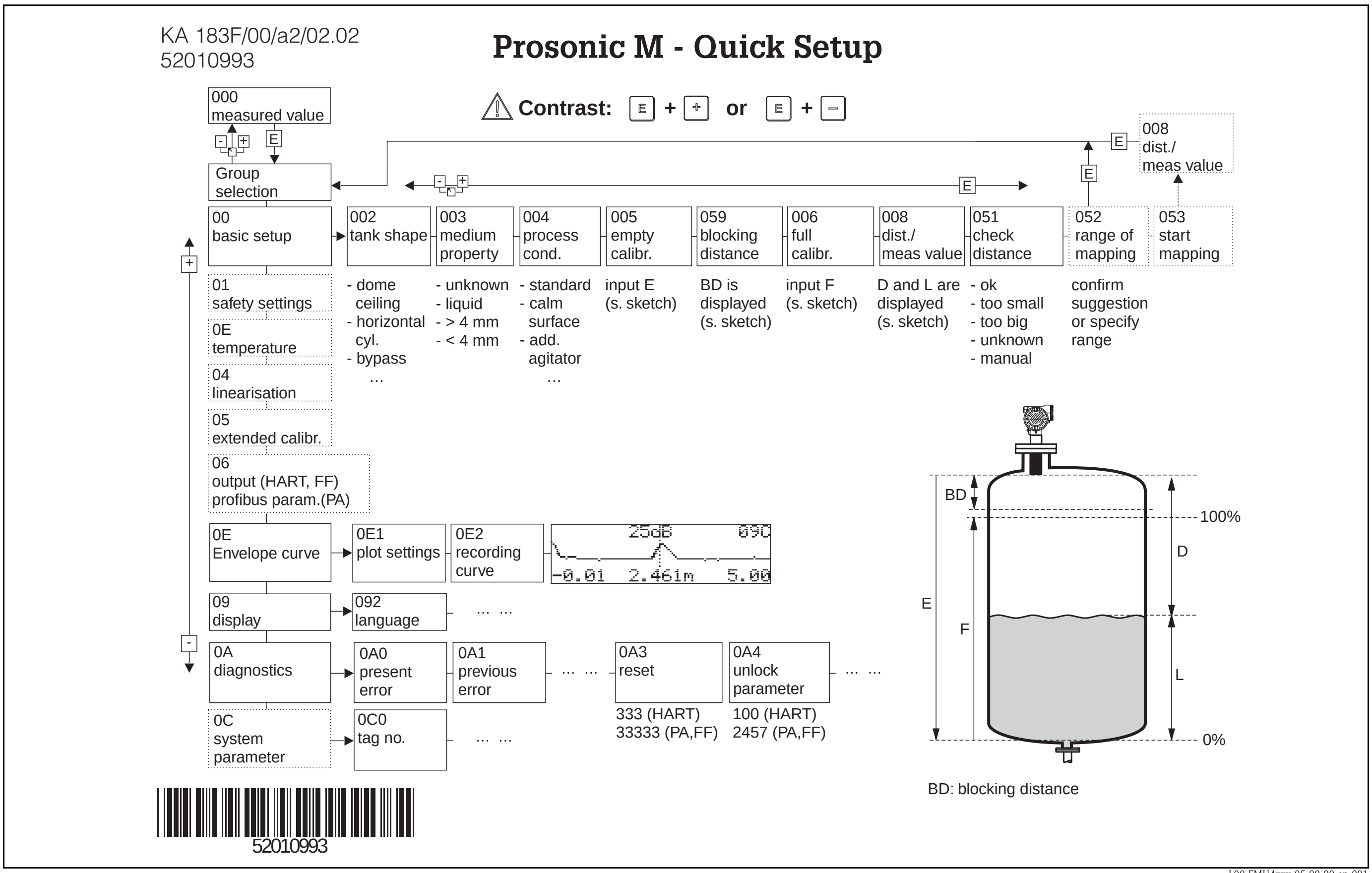


BA238F/00/en/08.06
52010986

Valid as of software version:
V 01.02.00 (amplifier)
V 01.02.00 (communication)

Endress+Hauser
People for Process Automation

Short instructions



L00-FMU4xxx-05-00-00-en-001

Contents of the operating instructions

This operating instructions describes the installation and commissioning of the Prosonic M ultrasonic level transmitter. It contains all the functions required for a normal measuring operation. Also, the Prosonic M provides additional functions for optimising the measuring point and for converting the measured value. These functions are not included in this operating instructions.

You can find an **overview of all the device functions** in the Appendix.

You can find a **detailed description of all the device functions** in the operating instructions BA 240F/00/en "Prosonic M - Description of Instrument Functions". This is located on the supplied documentation CD-ROM.

Table of contents

1 Safety instructions

1.1 Designated use

The Prosonic M is a compact measuring device for continuous, non-contact level measurement. Depending on the sensor, the measuring range is up to 15 m in fluids and up to 7 m in bulk solids. By using the linearisation function, the Prosonic M can also be used for flow measurements in open channels and measuring weirs.

1.2 Installation, commissioning, operation

The Prosonic M is fail-safe and is constructed to the state-of-the-art. It meets the appropriate standards and EC directives. However, if you use it improperly or other than for its designated use, it may pose application-specific hazards, e.g. product overflow due to incorrect installation or configuration. Installation, electrical connection, start-up, operation and maintenance of the measuring device must therefore be carried out exclusively by trained specialists authorised by the system operator. Technical personnel must have read and understood these operating instructions and must adhere to them. You may only undertake modifications or repair work to the device when it is expressly permitted by the operating instructions.

1.3 Hazardous area

Measuring systems for use in hazardous environments are accompanied by separate "Ex documentation", which is an integral part of this Operating Manual. Strict compliance with the installation instructions and ratings as stated in this supplementary documentation is mandatory.

- Ensure that all personnel are suitably qualified.
- Observe the specifications in the certificate as well as national and local standards and regulations.

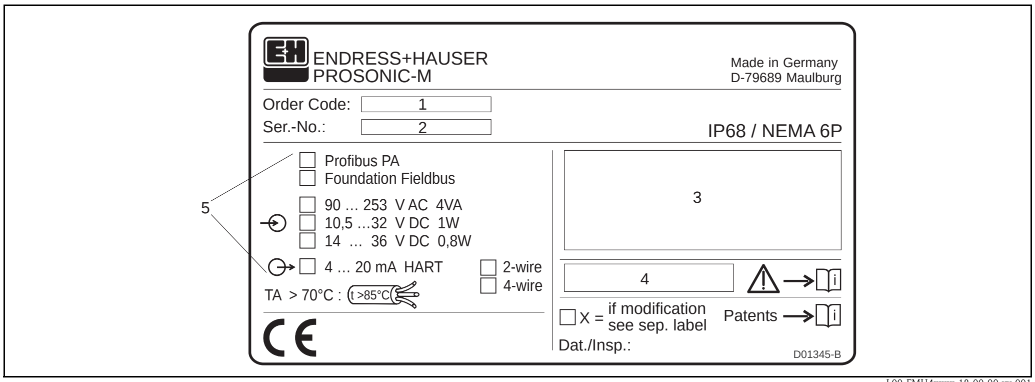
1.4 Notes on safety conventions and symbols

In order to highlight safety-relevant or alternative operating procedures in the manual, the following conventions have been used, each indicated by a corresponding symbol in the margin.

Safety conventions	
	Warning! A warning highlights actions or procedures which, if not performed correctly, will lead to personal injury, a safety hazard or destruction of the instrument
	Caution! Caution highlights actions or procedures which, if not performed correctly, may lead to personal injury or incorrect functioning of the instrument
	Note! A note highlights actions or procedures which, if not performed correctly, may indirectly affect operation or may lead to an instrument response which is not planned
Explosion protection	
	Device certified for use in explosion hazardous area If the device has this symbol embossed on its name plate it can be installed in an explosion hazardous area
	Explosion hazardous area Symbol used in drawings to indicate explosion hazardous areas. Devices located in and wiring entering areas with the designation "explosion hazardous areas" must conform with the stated type of protection.
	Safe area (non-explosion hazardous area) Symbol used in drawings to indicate, if necessary, non-explosion hazardous areas. Devices located in safe areas still require a certificate if their outputs run into explosion hazardous areas
Electrical symbols	
	Direct voltage A terminal to which or from which a direct current or voltage may be applied or supplied
~	**Alternating voltage** A terminal to which or from which an alternating (sine-wave) current or voltage may be applied or supplied
	Grounded terminal A grounded terminal, which as far as the operator is concerned, is already grounded by means of an earth grounding system
	Protective grounding (earth) terminal A terminal which must be connected to earth ground prior to making any other connection to the equipment
	Equipotential connection (earth bonding) A connection made to the plant grounding system which may be of type e.g. neutral star or equipotential line according to national or company practice
t >85°C	**Temperature resistance of the connection cables** States, that the connection cables must be resistant to a temperature of at least 85 °C.

2 Identification

2.1 Nameplate



L00-FMU4xxxx-18-00-00-yy-001

1: Order Code; 2: Serial number; 3: Designation according to Directive 94/9/EC and designation of the type of protection (only for certified device variants); 4: Reference to additional safety-relevant documentation (only for certified device variants); 5: Communication variant and supply voltage (the appropriate option is highlighted)

2.2 Product structure FMU 40

	Certificates						
	A						Variant for non-hazardous area
	1						ATEX II 1/2 G or II 2 G; EEX ia IIC T6
	4						ATEX II 1/2 G or II 2 G; EEX d [ia] IIC T6
	G						ATEX II 3G EEx nA II T6
	2						ATEX II 1/2D, Alu blind cover
	5						ATEX II 1/3D
	S						FM IS Cl. I,II,III Div. 1 Gr. A-G / NI Cl. I Div. 2
	T						FM XP Cl. I,II,III Div. 1 Gr. A-G
	U						CSA IS Cl. I,II,III Div. 1 Gr. A-G / NI Cl. I Div. 2
	V						CSA XP Cl. I,II,III Div. 1 Gr. A-G
	N						CSA General Purpose
	K						TIIS Ex ia II C T6
	Y						Special certificate
		Process connection					
		R					G 1½“ threadISO 228
		N					NPT 1½“ - 11,5 thread
		Y					Special version
			Power supply/communication				
			B				2 wire, 4...20mA-loop/HART
			H				4 wire, 10,5...32VDC / 4-20mA HART
			G				4 wire, 90...253VAC / 4-20mA HART
			D				2 wire, PROFIBUS PA
			F				2 wire, Foundation Fieldbus
			Y				Special version
				Display / on-site operation			
				1			Without LC display
				2			With LC display VU 331 incl. on-site operation
				3			Prepared for remote display FHX 40
				9			Special version
					Housing		
					A		Aluminium F12 housing coated to IP 68
					C		Aluminium T12 housing coated to IP 68; with separate terminal compartment
					D		Aluminium T12 housing coated to IP 68; with separate terminal compartment; with overvoltage protection
					9		Special version
						Screw union/entry	
						2	M20x1.5 screw union
						3	G 1/2“ entry
						4	NPT 1/2“ entry
						5	M12 PROFIBUS-PA plug-in connector
						6	7/8" FF plug
						9	Special version
FMU 40 -							Product designation

2.3 Product structure FMU 41

Certificates	
A	Variant for non-hazardous area
1	ATEX II 1/2 G or II 2 G; EEX ia IIC T6
4	ATEX II 1/2 G or II 2 G; EEX d [ia] IIC T6
G	ATEX II 3G EEx nA II T6
2	ATEX II 1/2D, Alu blind cover
5	ATEX II 1/3D
S	FM IS Cl. I,II,III Div. 1 Gr. A-G / NI Cl. I Div. 2
T	FM XP Cl. I,II,III Div. 1 Gr. A-G
U	CSA IS Cl. I,II,III Div. 1 Gr. A-G / NI Cl. I Div. 2
V	CSA XP Cl. I,II,III Div. 1 Gr. A-G
N	CSA General Purpose
K	TIIS Ex ia II C T6
Y	Special certificate

Process connection	
R	G 2“ threadISO 228
N	NPT 2“ - 11,5 thread
Y	Special version

Power supply/communication	
B	2 wire, 4...20mA-loop/HART
H	4 wire, 10,5...32VDC / 4-20mA HART
G	4 wire, 90...253VAC / 4-20mA HART
D	2 wire, PROFIBUS PA
F	2 wire, Foundation Fieldbus
Y	Special version

Display / on-site operation	
1	Without LC display
2	With LC display VU 331 incl. on-site operation
3	Prepared for remote display FHX 40
9	Special version

Housing	
A	Aluminium F12 housing coated to IP 68
C	Aluminium T12 housing coated to IP 68 with separate terminal compartment
D	Aluminium T12 housing coated to IP 68; with separate terminal compartment; with overvoltage protection
9	Special version

Screw union/entry	
2	M20x1.5 screw union
3	G 1/2“ entry
4	NPT 1/2“ entry
5	M12 PROFIBUS-PA plug-in connector
6	7/8" FF plug
9	Special version

FMU 41 -							Product designation

2.4 Product structure FMU 42

Certificates		
	A	Variant for non-hazardous area
	1	ATEX II 1/2 G EEX ia IIC T6
	4	ATEX II 1/2 G EEX d [ia] IIC T6
	G	ATEX II 3G EEx nA II T6 (in preparation)
	S	FM IS Cl. I,II,III Div. 1 Gr. A-G / NI Cl. I Div. 2
	T	FM XP Cl. I,II,III Div. 1 Gr. A-G
	U	CSA IS Cl. I,II,III Div. 1 Gr. A-G / NI Cl. I Div. 2
	V	CSA XP Cl. I,II,III Div. 1 Gr. A-G
	N	CSA General Purpose
	K	TIIS Ex ia II C T6 (in preparation)
	Y	Special certificate
Process connection		
	M	mounting bracket FAU20
	P	DN80/ANSI 3"/JIS10K80, PP, Universal flange
	Q	DN80/ANSI 3"/JIS10K80, PVDF, Universal flange
	S	DN80/ANSI 3"/JIS10K80, 316L, Universal flange
	T	DN100/ANSI 4"/JIS16K100, PP, Universal flange
	U	DN100/ANSI 4"/JIS16K100, PVDF, Universal flange
	V	DN100/ANSI 4"/JIS16K100, 316L, Universal flange
	Y	Special version
Power supply/communication		
	B	2 wire, 4...20mA-loop/HART
	H	4 wire, 10,5...32VDC / 4-20mA HART
	G	4 wire, 90...253VAC / 4-20mA HART
	D	2 wire, PROFIBUS PA
	F	2 wire, Foundation Fieldbus
	Y	Special version
Display / on-site operation		
	1	Without LC display
	2	With LC display VU 331 incl. on-site operation
	3	Prepared for remote display FHX 40
	9	Special version
Housing		
	A	Aluminium F12 housing coated to IP 68
	C	Aluminium T12 housing coated to IP 68, with separate terminal compartment
	D	Aluminium T 12 housing coated to IP 68, with separate terminal compartment; with overvoltage protection
	Y	Special version
Gland/Entry		
	2	M20x1.5 gland
	3	G 1/2“ entry
	4	NPT 1/2“ entry
	5	M12 PROFIBUS-PA plug
	6	7/8" FF plug
	9	Special version
Sealing Sensor/Flange		
	2	VITON flat sealing
	3	EPDM flat sealing
	9	special version
Additional options		
	A	Additional options not selected
FMU 42 -		Product designation

2.5 Product structure FMU 43

	Certificates	
	A	Variant for non-hazardous area
	2	ATEX II 1/2 D or II 2 D, Aluminium Deckel
	5	ATEX II 1/3 D or II 3 D, Sichtdeckel
	M	FM DIP Class II, III, Div. 1, Gr. E,F,G NI
	N	CSA General Purpose
	P	CSA DIP, Class II, III, Div. 1, Gr. E,F,G NI
	Y	Special version

		Process connection/material	
		P	Flange DN 100/ANSI 4"/JIS 16K100, PP (universal slip-on flange included)
		S	Flange DN 100/ANSI 4"/JIS 16K100, SS 316TI (universal slip-on flange included)
		K	Without slip-on flange/without mounting bracket (customer mounting equipment)
		M	With mounting bracket
		Y	Special version

			Power supply/communication	
			H	4 wire, 10,5...32VDC / 4-20mA HART
			G	4 wire, 90...253VAC / 4-20mA HART
			D	2 wire, PROFIBUS PA
			F	2 wire, Foundation Fieldbus
			Y	Special version

				Display / on-site operation	
				1	Without LC display
				2	With LC display VU 331 incl. on-site operation
				3	Prepared for remote display FHX 40
				9	Special version

					Housing	
					A	Aluminium F12 housing coated to IP 68
					9	Special version

						Screw union/entry	
						2	M20x1.5 screw union
						3	G 1/2“ entry
						4	NPT 1/2“ entry
						5	M12 PROFIBUS-PA plug-in connector
						6	7/8" FF plug
						9	Special version
FMU 43 -							Product designation

2.6 Scope of delivery

2.6.1 Instrument and accessories

- Instrument according to the version ordered
- "ToF Tool - FieldTool Package" (2 CD-ROMs)
- for FMU 40/41 in the versions FMU 40 *R**** and FMU 41 *R****: counter nut (PC)
- for FMU 40/41: sealing ring (EPDM)
- for gland M20x1.5:
  - 1 cable gland for 2-wire instruments
  - 2 cable glands for 4-wire instruments

  The cable glands are mounted on delivery.

2.6.2 Supplied documentation

Short instructions (KA 183F, in the instrument)

intended as a memory jogger for users who are familiar with the operating concept of Endress+Hauser Time-of-Flight instruments.

Operating instructions (BA 238F, this booklet)

This describes the installation and commissioning of the Prosonic M. The operating menu includes all the functions which are required for standard measurement tasks. Any additional functions are **not** included.

Description of Instrument Functions (BA 240F)

contains a detailed description of all the functions of the Prosonic M. You can find this document as a pdf file on the supplied ToF Tool - FieldTool CD-ROM 1.

Safety instructions

Additional safety instructions (XA, ZE, ZD) are supplied with certified device versions. Refer to the nameplate for the names of the safety instructions that apply to your device version.

2.7 Certificates and approvals

CE mark, declaration of conformity
The device is designed to meet state-of-the-art safety requirements, has been tested and left the factory in a condition in which it is safe to operate. The device complies with the applicable standards and regulations as listed in the EC declaration of conformity and thus complies with the statutory requirements of the EG directives. Endress+Hauser confirms the successful testing of the device by affixing to it the CE mark.

2.8 Registered trademarks

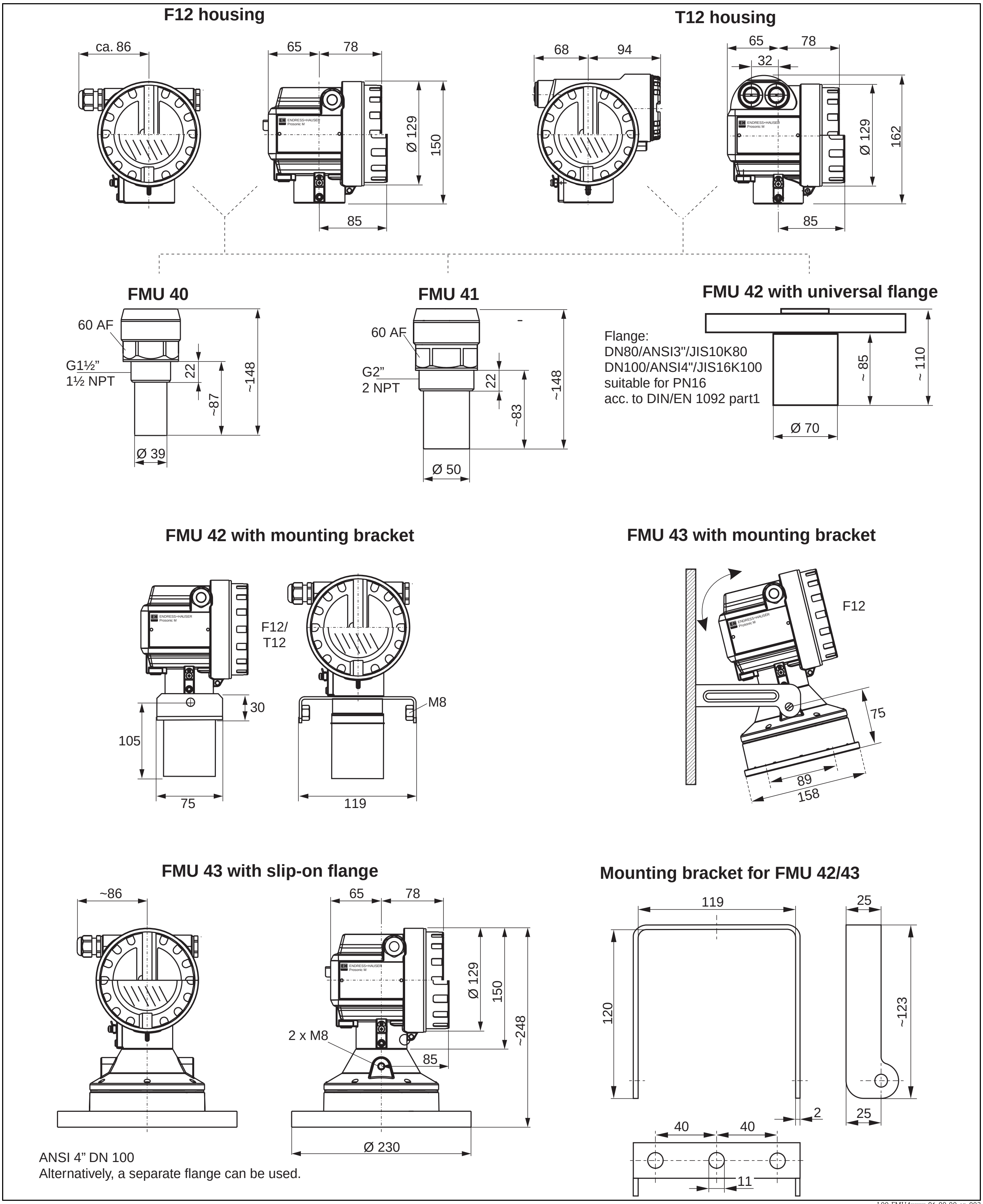
ToF®
Registered trademark of the company Endress+Hauser GmbH+Co. KG, Maulburg, Germany

PulseMaster®
Registered trademark of the company Endress+Hauser GmbH+Co. KG, Maulburg, Germany

PROFIBUS®
Registered trademark of the PROFIBUS Trade Organisation, Karlsruhe, Germany

3 Installation

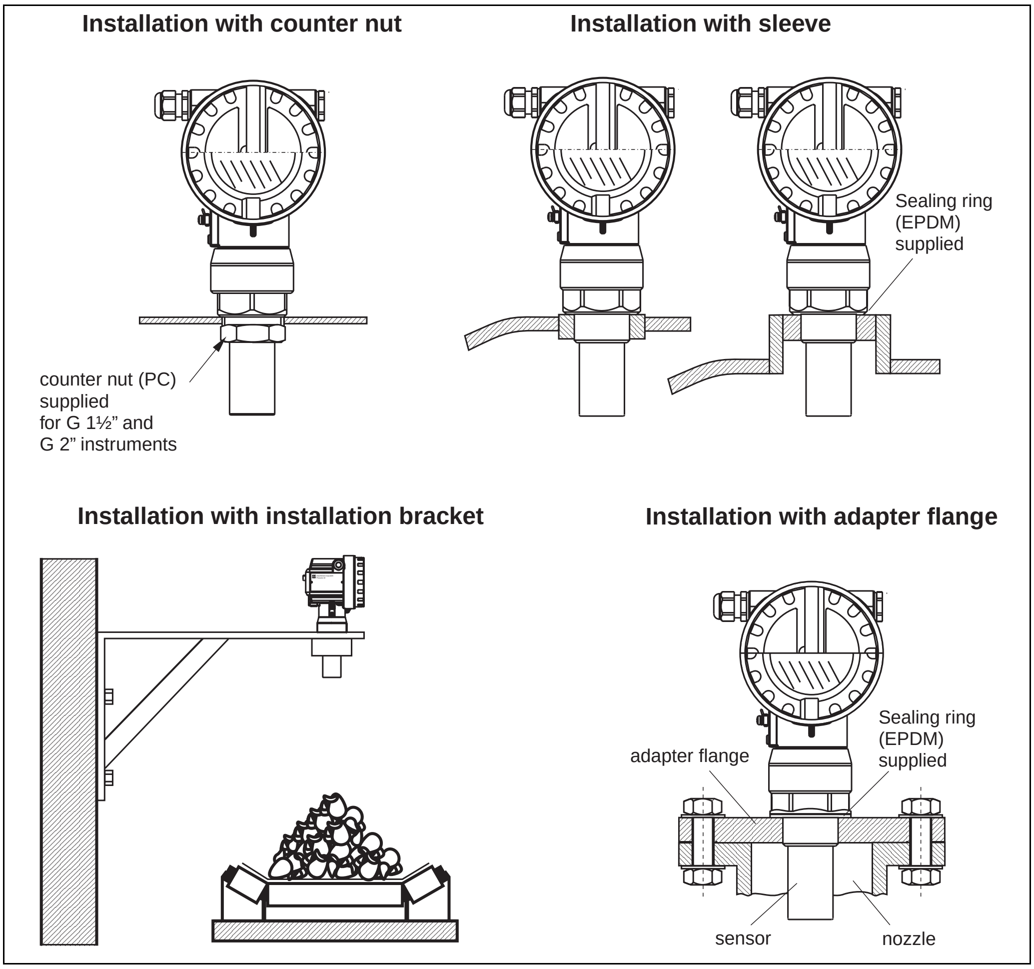
3.1 Dimensions



L00-FMU4xxxx-06-00-00-en-003

3.2 Installation variants

3.2.1 Installation variants FMU 40, FMU 41



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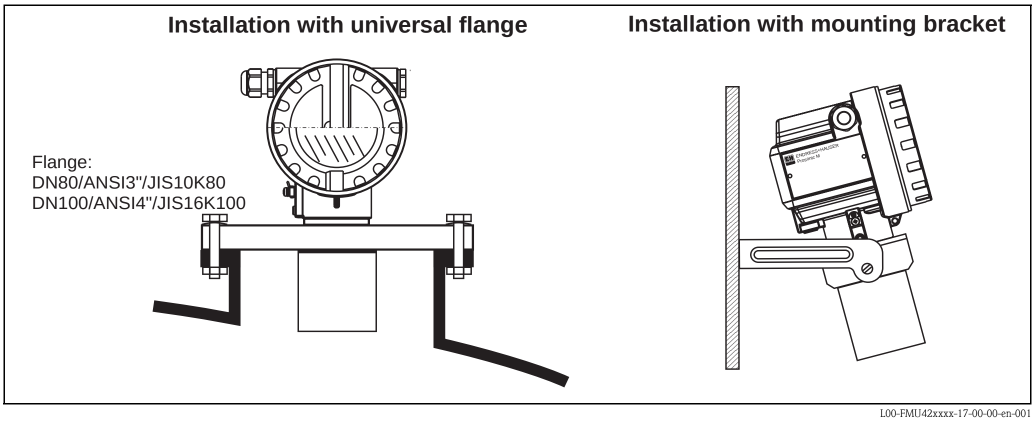
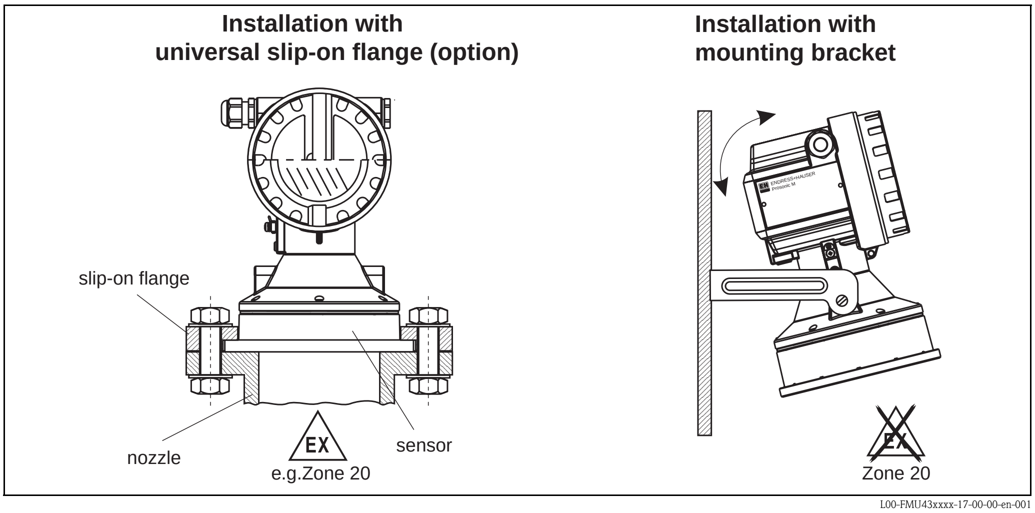
For installation bracket or adapter flange s. chapter "Accessories".

3.2.2 Installation variants FMU 42

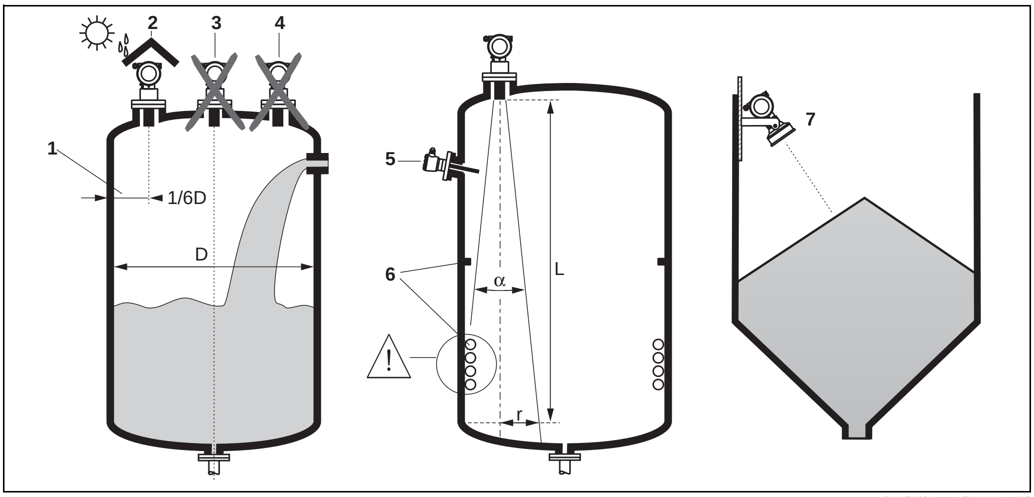


3.2.3 Installation variants FMU 43



3.3 Installation conditions

3.3.1 Installation conditions for level measurements



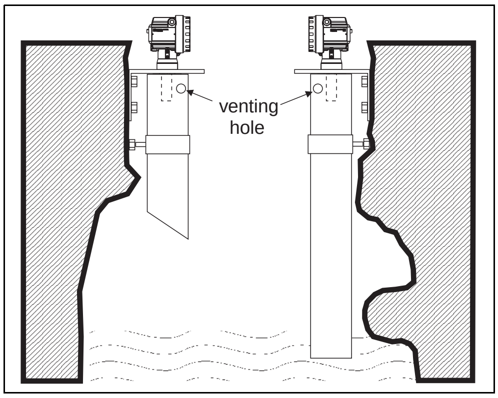
L00-FMU4xxxx-17-00-00-de-005

- Do not install the sensor in the middle of the tank (3). We recommend leaving a distance between the sensor and the tank wall (1) measuring 1/6 of the tank diameter.
- Use a protective cover, in order to protect the device from direct sun or rain (2).
- Avoid measurements through the filling curtain (4).
- Make sure that equipment (5) such as limit switches, temperature sensors, etc. are not located within the emitting angle α. In particular, symmetrical equipment (6) such as heating coils, baffles etc. can influence measurement.
- Align the sensor so that it is vertical to the product surface (7).
- Never install two ultrasonic measuring devices in a tank, as the two signals may affect each other.
- To estimate the detection range, use the 3 dB emitting angle α.

Sensor	α	L_{max}	r_{max}
FMU 40	11°	5 m	0,48 m
FMU 41	11°	8 m	0,77 m
FMU 42	9°	10 m	0,96 m
FMU 43	6°	15 m	0,79 m

3.3.2 Installation in narrow shafts

In narrow shafts with strong interference echoes, we recommend using an ultrasound guide pipe (e.g. PE or PVC wastewater pipe) with a minimum diameter of 100 mm.
Make sure that the pipe is not soiled by accumulated dirt. If necessary, clean the pipe at regular intervals.

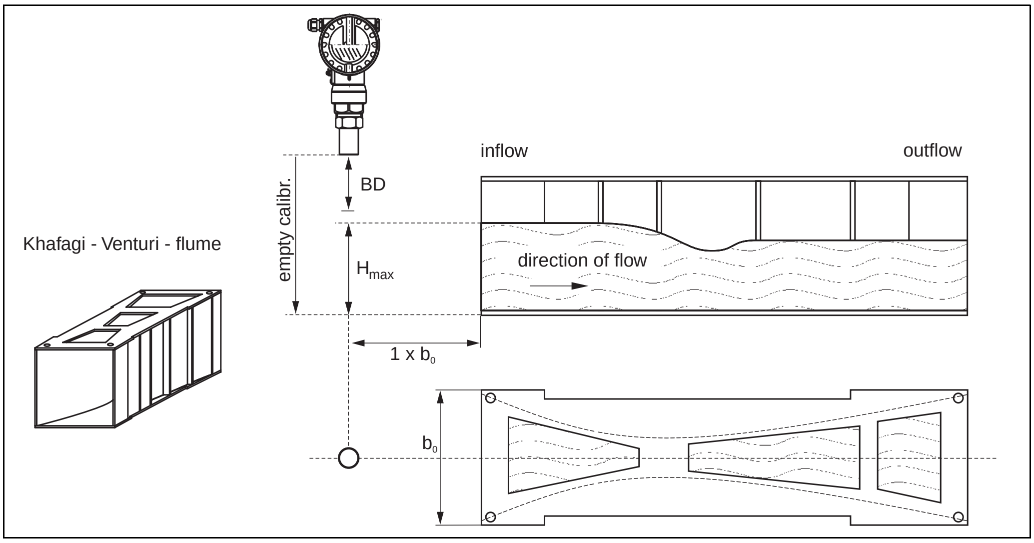


L00-FMU4xxxx-17-00-00-en-010

3.3.3 Installation conditions for flow measurements

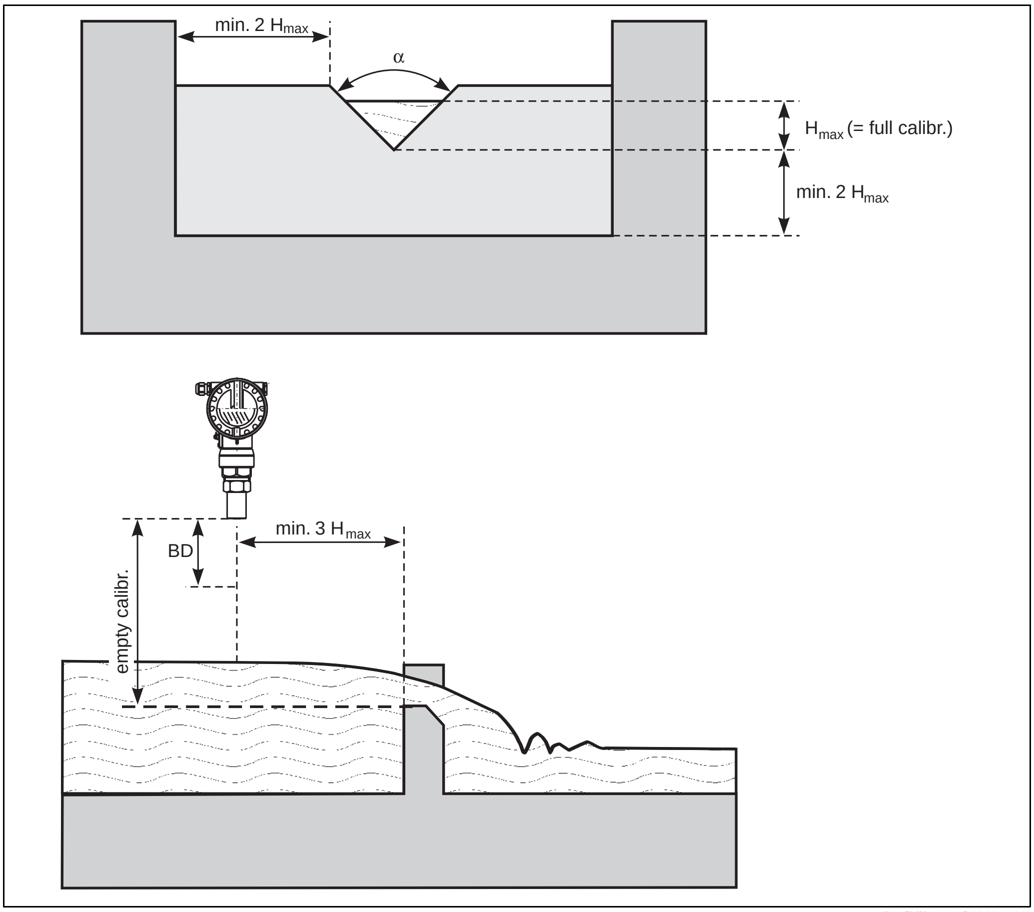
- Install the Prosonic M at the inflow side, as close above the maximum water level H_{max} as possible (take into account the blocking distance BD).
- Position the Prosonic M in the middle of the channel or weir.
- Align the sensor membrane parallel to the water surface.
- Keep to the installation distance of the channel or weir.
- You can enter the "Flow to Level" linearisation curve ("Q/h curve") using ToF Tool or manually via the on-site display.

Example: Khafagi-Venturi flume



L00-FMU4xxxx-17-00-00-en-003

Example: Triangular weir

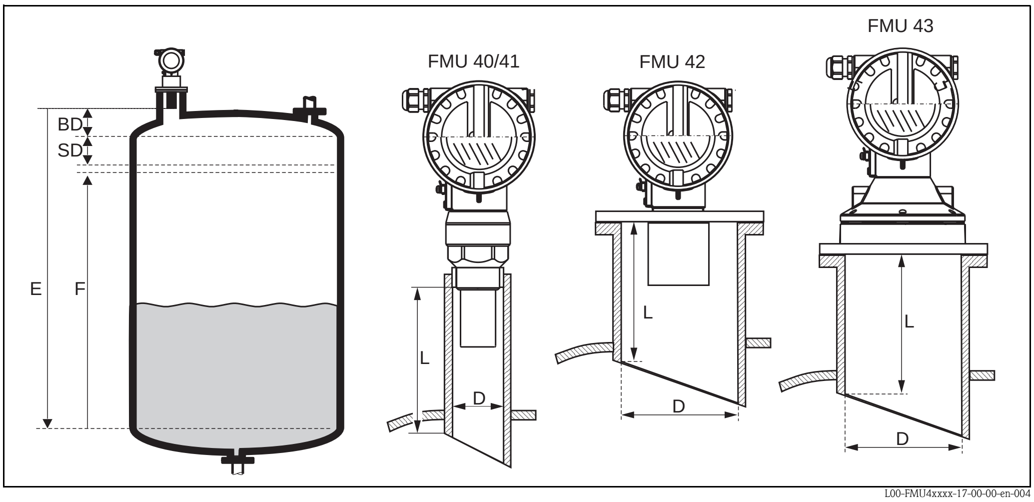


L00-FMU4xxxx-17-00-00-en-012

3.4 Measuring range

3.4.1 Blocking distance, Nozzle mounting

Install the Prosonic M at a height so that the blocking distance BD is not undershot, even at maximum fill level. Use a pipe nozzle if you cannot maintain the blocking distance in any other way. The interior of the nozzle must be smooth and may not contain any edges or welded joints. In particular, there should be no burr on the inside of the tank side nozzle end. Note the specified limits for nozzle diameter and length. To minimise disturbing factors, we recommend an angled socket edge (ideally 45°).



BD: blocking distance; SD: safety distance; E: empty calibration; F: full calibration (span); D: nozzle diameter; L: nozzle length

Sensor	BD	Max. range liquids	Max. range bulk materials	nozzle diameter	max. nozzle length
FMU 40	0.25 m	5 m	2 m	50 mm	approx. 80 mm
				80 mm	approx. 240 mm
				100 mm	approx. 300 mm
FMU 41	0.35 m	8 m	3.5 m	80 mm	approx. 240 mm
				100 mm	approx. 300 mm
FMU 42	0.4 m	10 m	5 m	80 mm	approx. 250 mm
				100 mm	approx. 300 mm
FMU 43	0.6 m	15 m	7 m	min. 100 mm	approx. 300 mm

Caution!
If the blocking distance is undershot, it may cause device malfunction.

3.4.2 Safety distance

If the level rises to the safety distance SD, the device switches to warning or alarm status.
The size of SD can be set freely in the **"Safety distance" (015)** function.The **"in safety distance" (016)** function defines how the device reacts if the level enters the safety distance.

There are three options:
- **Warning**: The device outputs an error message but continues measurement.
- **Alarm**: The device outputs an error message. The output signal assumes the value defined in the **"Output on alarm" (011)** function (MAX, MIN, user-specific value or holds the last value). As soon as the level drops below the safety distance, the device recommences measurement.
- **Self holding**: The device reacts in the same way as for an alarm. However, the alarm condition continues after the level drops below the safety distance. The device only recommences measurement when you cancel the alarm using the **"Ackn. alarm" (017)** function.

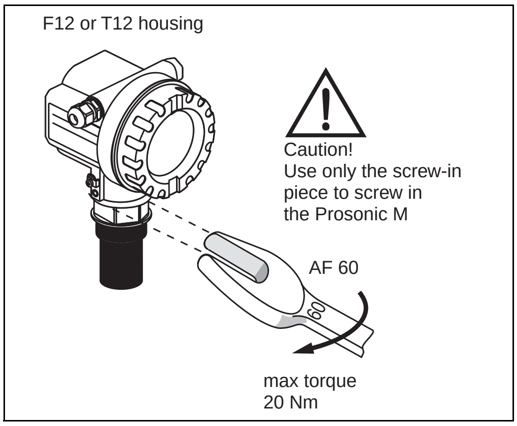
3.4.3 Range

The sensor range is dependent on the measuring conditions. Refer to Technical Information TI 365F/00/en for an estimation. The maximum range is shown in the above diagram (valid for good conditions).

Sensor	maximum range
FMU 40	5 m
FMU 41	8 m
FMU 42	10 m
FMU 43	15 m

3.5 Installation hint for FMU 40/41

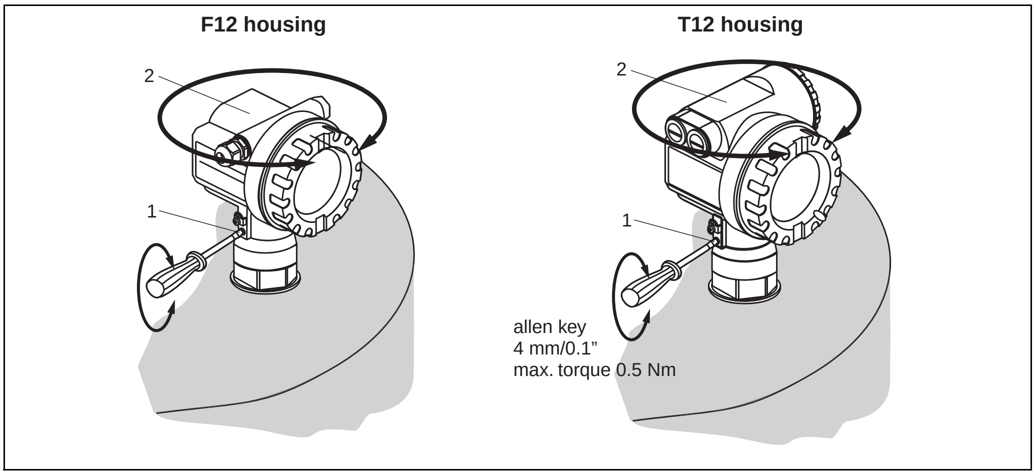
Screw the Prosonic M at the screw-in piece using an 60 AF spanner.
Maximum torque: 20 Nm.



L00-FMU4xxxx-17-00-00-en-009

3.6 Turn housing

After mounting, the housing can be turned 350° in order to simplify access to the display and the terminal compartment. Proceed as follows to turn the housing to the required position:
- Undo the fixing screws (1)
- Turn the housing (2) in the required direction
- Tighten up the fixing screws (1). Maximum torque 0.5 Nm.
- Loctite can be used for securing the screw.



L00-FMU4xxxx-17-00-00-en-013

3.7 Installation check

After installing the device, carry out the following checks:
- Is the device damaged (visual inspection)?
- Does the device correspond to the measuring point specifications for process temperature, process pressure, ambient temperature, measuring range etc.
- If available: Are the measuring point number and labelling correct (visual inspection)?
- Is the measuring device sufficiently protected against precipitation and direct sunlight?
- Are the cable glands tightened correctly?
- After aligning the housing, check the process seal at the nozzle or flange.

4 Wiring

4.1 Electrical connection

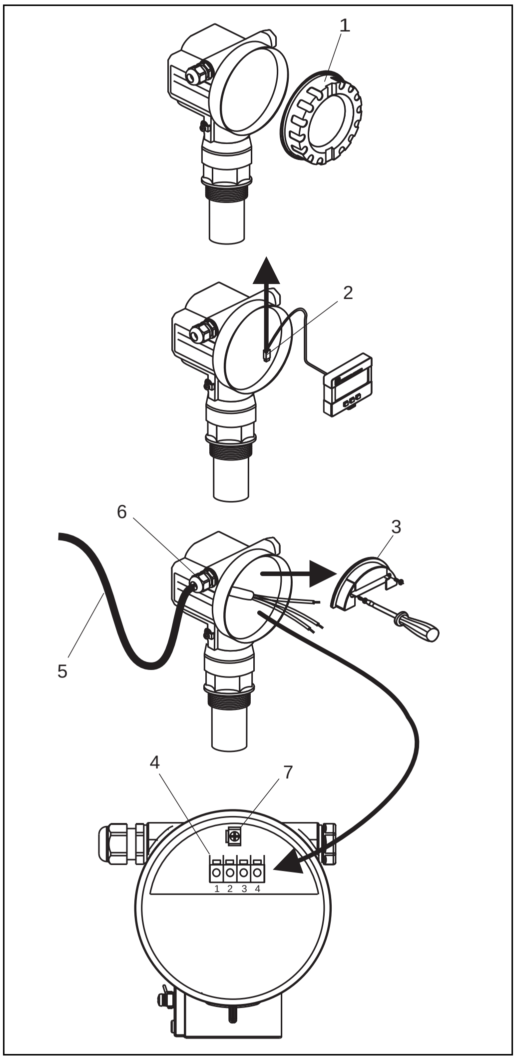
Caution!
Before connection please note the following:
- The power supply must be identical to the data on the nameplate.
- Switch off power supply before connecting up the instrument.
- Connect equipotential bonding to transmitter ground terminal before connecting up the instrument (s. section "Potential matching")

Warning!
When you use the measuring system in hazardous areas, make sure to comply with national standards and the specifications in the safety instructions (XA's). Make sure you use the specified cable gland.

4.1.1 Wiring in the housing F12

1. Unscrew housing cover (1).
2. Remove display (2) if fitted.
3. Remove cover plate (3) from terminal compartment.
4. Pull out terminal module (4) slightly using pulling loop.
5. Insert cable (5) through gland (6).

   Caution!
   If possible, insert the cable from above and let a draining loop in order to avoid intrusion of humidity.
6. Connect cable screen to the grounding terminal (7) within the terminal compartment.
7. Make connection according to terminal assignment (see below).
8. Re-insert terminal module (4).
9. Tighten cable gland (6).
10. Tighten screws on cover plate (3).
11. Insert display (2) if fitted.
12. Screw on housing cover (1).
13. Switch on power supply.

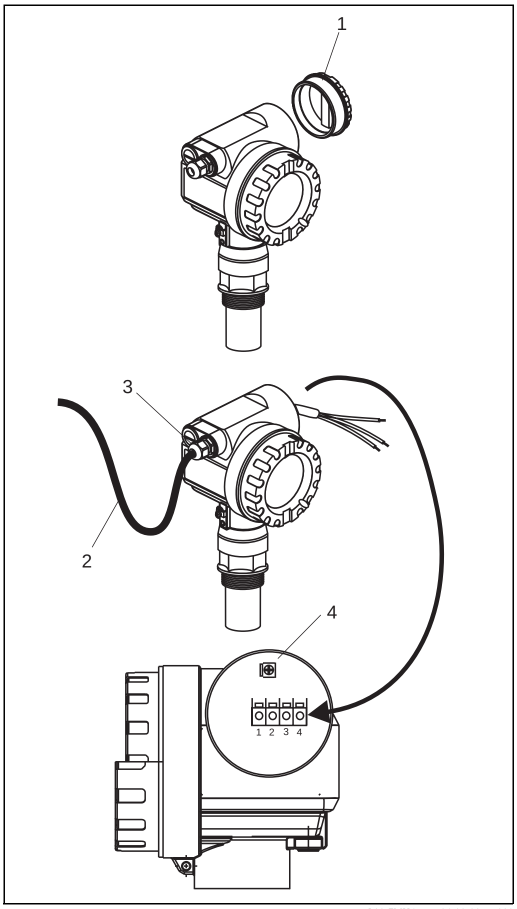


L00-FMU4xxxx-04-00-00-yy-008

4.1.2 Wiring in the housing T12

1. Unscrew the cover (1) of the separate connection room.
2. Insert cable (2) through gland (3).

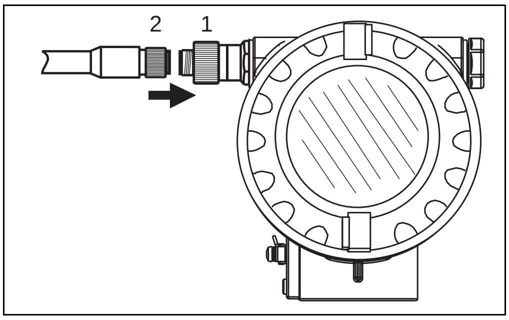
   Caution!
   If possible, insert the cable from above and let a draining loop in order to avoid intrusion of humidity.
3. Connect cable screen to the grounding terminal (4) within the connection room.
4. Make connection according to the terminal assignment (see below).
5. Tighten cable gland (3).
6. Screw on housing cover (1).
7. Switch on power supply.



L00-FMU4xxxx-04-00-00-yy-009

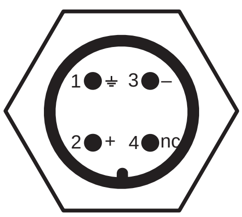
4.1.3 Wiring with M12 plug

1. Insert plug (1) into bushing (2).
2. Screw firmly.
3. Ground instrument according to the desired safety concept.



L00-FMU4xxxx-04-00-00-yy-010

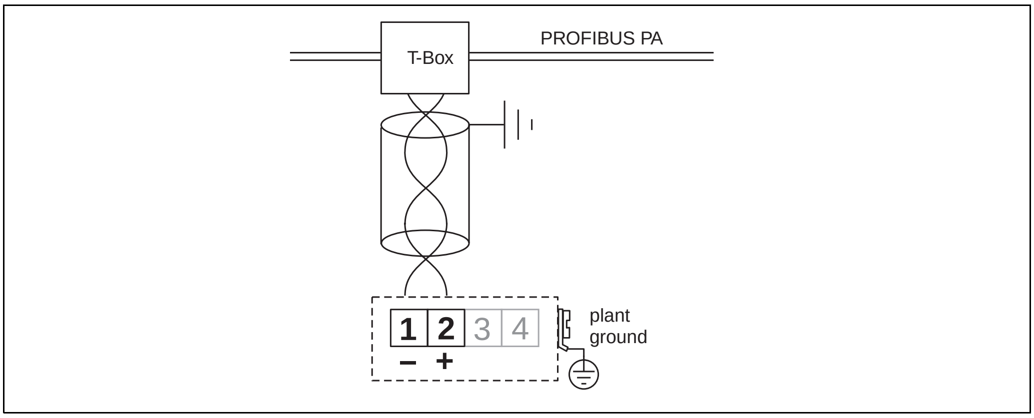
Pin assignment of the M12 plug connector (PROFIBUS PA plug)



L00-FMxxxxxx-04-00-00-yy-016

Pin	Meaning
1	Ground
2	PA +
3	PA –
4	not connected

4.2 Terminal assignment



L00-FMxxxxxx-04-00-00-en-012

4.3 Cable specifications PROFIBUS

Twisted, screened pairs must be used. The following specification must be met for explosion hazardous application (EN 50 020, FISCO model):

- Loop-resistance (DC): 15…150 Ω/km,
- Specific inductance: 0.4…1 mH/km,
- Specific capacitance: 80…200 nF/km

The following cable types can be used, for example

Non-Ex-area:
- Siemens 6XV1 830-5BH10 (black),
- Kerpen CEL-PE/OSCR/PVC/FRLA FB-02YS(ST)YFL (grey)
- Belden 3076F (orange)

Ex-area:
- Siemens 6XV1 830-5AH10 (blue),
- Belden 3076F, Kerpen CEL-PE/OSCR/PVC/FRLA FB-02YS(ST)YFL (blue)

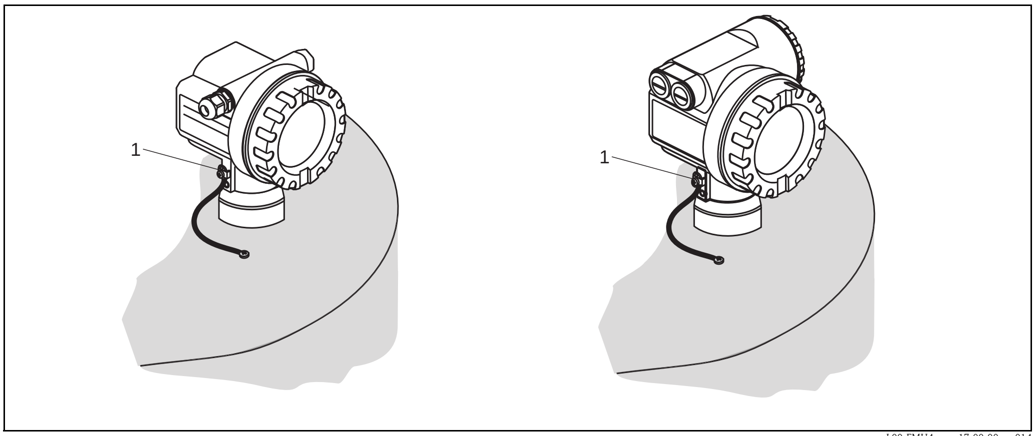
4.4 Supply voltage

The following values are the voltages across the terminals directly at the instrument:

Type	minimum terminal voltage	maximum terminal voltage
standard	9 V	32 V
EEx ia (FISCO model	9 V	17,5 V
EEx ia (Entity concept)	9 V	24 V

The current consumption is approx. 13 mA for the range of voltages given above.

4.5 Recommended connection



1: external ground terminal of the transmitter

For maximum EMC protection please observe the following points:
- As the metal housing of the Prosonic M is isolated from the tank by the plastic sensor, a low-impedance connection between the housing and tank/bracket/flange should be installed in order to ensure electromagnetic compatibility (EMC).
  For optimum EMC the connection should be as short as possible. Ideally, a ground strap should be used.
- The external ground terminal on the transmitter must be connected to ground.
- The continuity of the cable screening between tapping points must be ensured.
- If potential equalisation is present between the individual grounding points, ground the screening at each cable end or connect it to the device housing (as short as possible).
- If there are large differences in potential between grounding points, the grounding should run via a capacitor that is suitable for high frequency use (e.g. ceramic 10 nF/250 V~).

Caution!
Applications, which are subject to the explosion prevention, permit only under special conditions the repeated grounding of the protective screen , see to EN 60 079-14..

Note!
Further recommendations concerning the structure and equipotential bonding of the network can be found in Operating Instructions BA 198F "PROFIBUS-DP/-PA: Guidlines for planning and commissioning" and in the PROFIBUS-PA sapecifications EN 50170 (DIN 19245).

4.6 Checking the connection

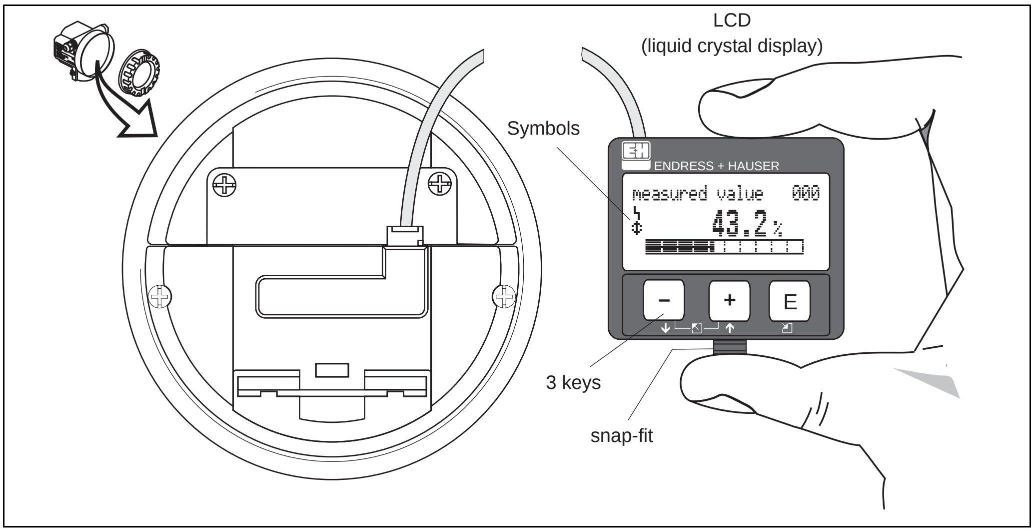
After wiring the device, carry out the following checks:
- Are the terminals correctly assigned?
- Is the cable gland tight?
- Is the M12 connector screwed tight?
- Is the housing cover fully screwed on?
- If power supply available: Does a display appear on the display module?

5 Operation

5.1 Display and operating elements

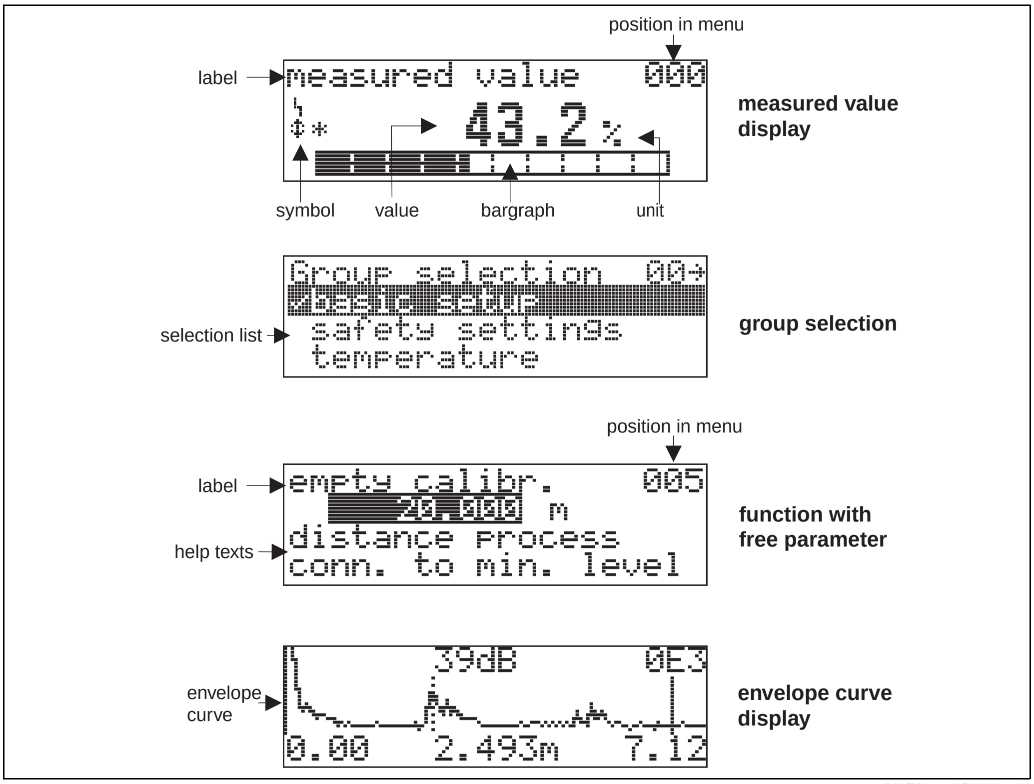
5.1.1 On-site display VU 331

The LCD module VU 331 for display and operation is located beneath the housing cover. The measured value is legible through the glass in the cover. Open the cover to operate the device.



L00-FMxxxxxx-07-00-00-en-001

5.1.2 Display appearance

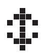


L00-FMxxxxxx-07-00-00-en-002

In the measured value display, the bargraph corresponds to the output.
The bargraph is segmented in 10 bars. Each completely filled bar represents a change of 10% of the adjusted span.

5.1.3 Display symbols

The following table describes the symbols that appear on the liquid crystal display:

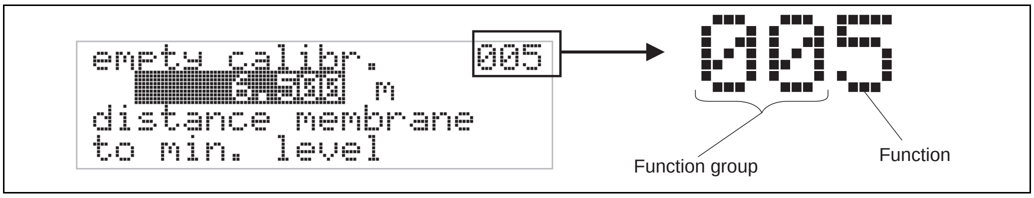
Sybmol	Meaning
	**ALARM_SYMBOL** This alarm symbol appears when the instrument is in an alarm state. If the symbol flashes, this indicates a warning.
	**LOCK_SYMBOL** This lock symbol appears when the instrument is locked,i.e. if no input is possible.
	**COM_SYMBOL** This communication symbol appears when a data transmission via e.g. HART, PROFIBUS PA or FOUNDATION Fieldbus is in progress.

5.1.4 Function of the keys

Key(s)	Meaning
+ or ↑	Navigate upwards in the selection list Edit numeric value within a function
– or ↓	Navigate downwards in the selection list Edit numeric value within a function
Esc: – + or ↖	Navigate to the left within a function group
E	Navigate to the right within a function group, confirmation.
+ and E or – and E	Contrast settings of the LCD
+ and – and E	Hardware lock / unlock After a hardware lock, an operation of the instrument via display or communication is not possible! The hardware can only be unlocked via the display. An unlock parameter must be entered to do so.

5.2 Function codes

For easy orientation within the function menus, for each function a position is shown on the display.



L00-FMU4xxxx-07-00-00-en-001

The first two digits identify the function group:

- **basic setup** **00**
- **safety settings** **01**
- **linearisation** **04**

. . .

The third digit numbers the individual functions within the function group:

- **basic setup** **00** →
  - **tank shape** **002**
  - **medium property** **003**
  - **process cond.** **004**

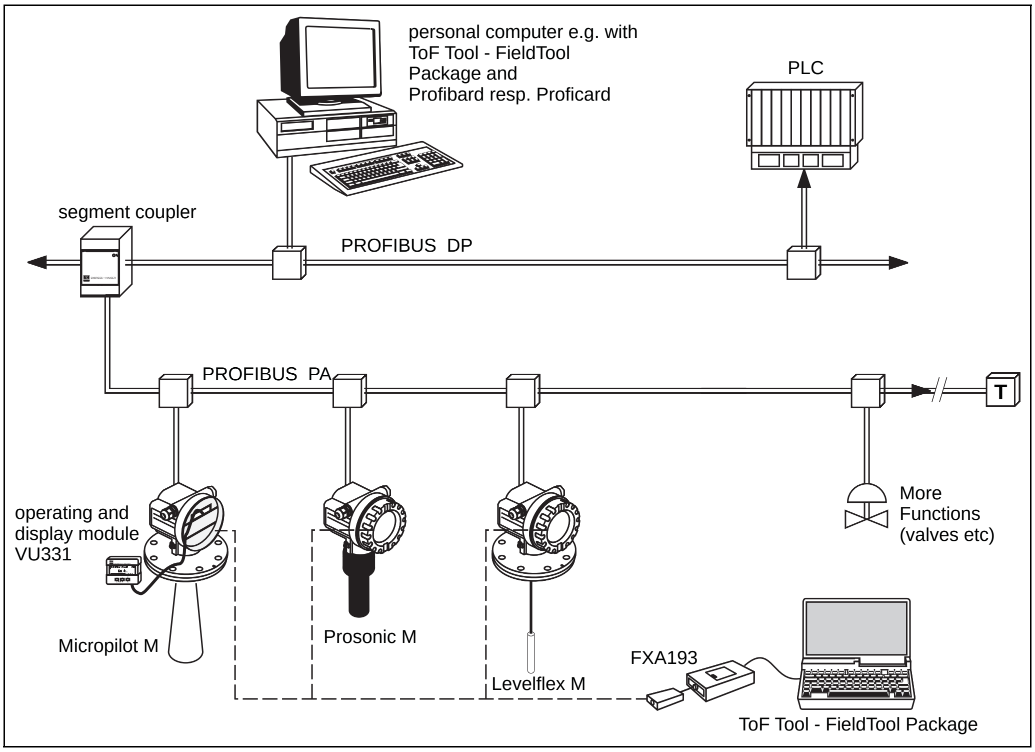
  . . .

Hereafter the position is always given in brackets (e.g. "**tank shape**" **(002)**) after the described function.

5.3 PROFIBUS PA interface

5.3.1 System integration using PROFIBUS PA

A maximum of 32 transmitters (8 if mounted in an explosion hazardous location EEx ia IIC according to FISCO-model) can be connected to the bus.The segment coupler provides the operating voltage to the bus. Both on-site as well as remote operation are possible.



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5.3.2 Device address

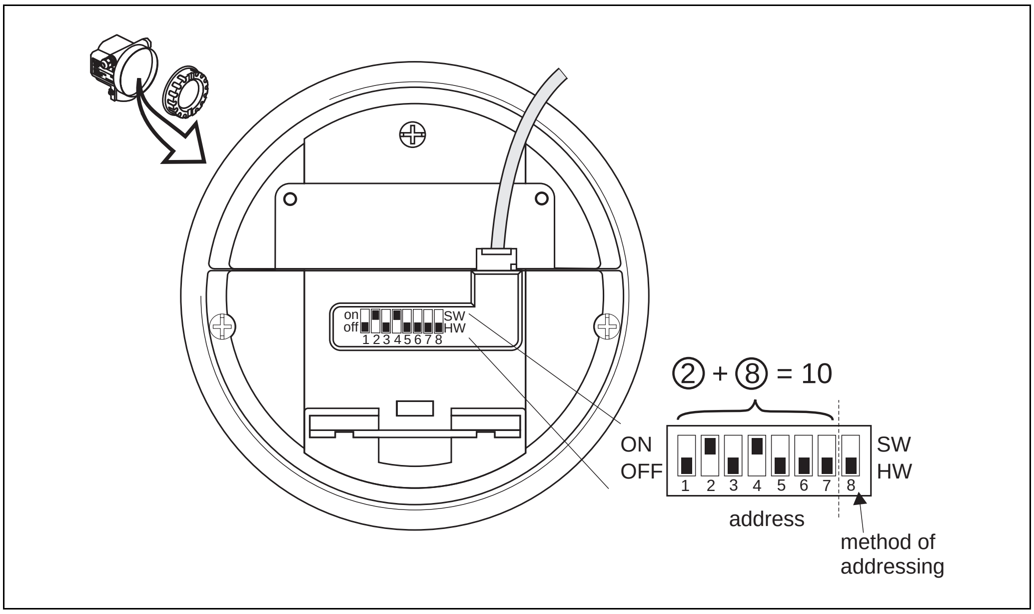
Selecting the device address

- Every PROFIBUS-PA device must be given an address. If the address is not set correctly, the device will not be recognised by the process control system.
- A device address may appear only once within a particular PROFIBUS-PA network, see BA 198F.
- Valid device addresses are in the range 1 and 126. All devices are delivered from the factory with the software address 126.
- The default address can be used to check the function of the device and connect it to an operating PROFIBUS-PA system. Afterwards the address must be changed to allow other devices to be connected to the network.

Software addressing

Software addressing comes into operation, when DIP-switch 8 is in the position "ON". BA 198F/00/en, chap. 5.7 describes, how to set the address in this case.
In ToF Tool, the address can be set via the "**Set address**" function in the "**Device**" menu.

Hardware addressing



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Hardware addressing comes into operation, when DIP switch 8 is in the position "HW (OFF)". In this case the address is determined by the position of DIP-switches 1 to 7 according to the following table:

Switch No.	1	2	3	4	5	6	7
Value in position "OFF"	0	0	0	0	0	0	0
Value in Position "ON"	1	2	4	8	16	32	64

The new address becomes valid 10 seconds after switching.
It results a new device restart.

5.3.3 Device database and type files

A device database file (GSD) contains a description of the properties of the PROFIBUS-PA device, e.g. the supported transmission rates and the type and format of the digital information output to the PLC.
Additional bitmap files are required in order to represent the device by an icon in the network design software.
Every device is allocated an identity code by the PROFIBUS User Organisation (PNO). This appears in the device data base file name (.gsd).

The Prosonic M has the ID number 0x152C(hex) = 5420 (dec).

Sources of supply

- Internet (ftp-Server): ftp://194.196.152.203/pub/communic/gsd
- www.endress.de
  click on "Download" and enter "GSD" into the "Search for" field. A list appears containing the links to all available GSD files.
- CD-ROM with GSD files for all E+H devices. Order-Code: 50097200
- GSD library of the PROFIBUS User Organisation (PNO):http: //www.PROFIBUS.com

Directory structure

The files are organized in the following structure:

```
Prosonic_M/PA/Profile3/Revision1.0/
    ├── BMP/
    │     ├── Eh152C_d.bmp
    │     ├── Eh152C_n.bmp
    │     └── Eh152C_s.bmp
    ├── DIB/
    │     ├── Eh152C_d.dib
    │     ├── Eh152C_n.dib
    │     └── Eh152C_s.dib
    ├── GSD/
    │     ├── Extended/Eh3x152C.gsd
    │     └── Standard/Eh3_152C.gsd
    ├── Typdat5x/Eh3152Cx.200
    └── Info/
          ├── Liesmich.pdf
          └── Readme.pdf
```

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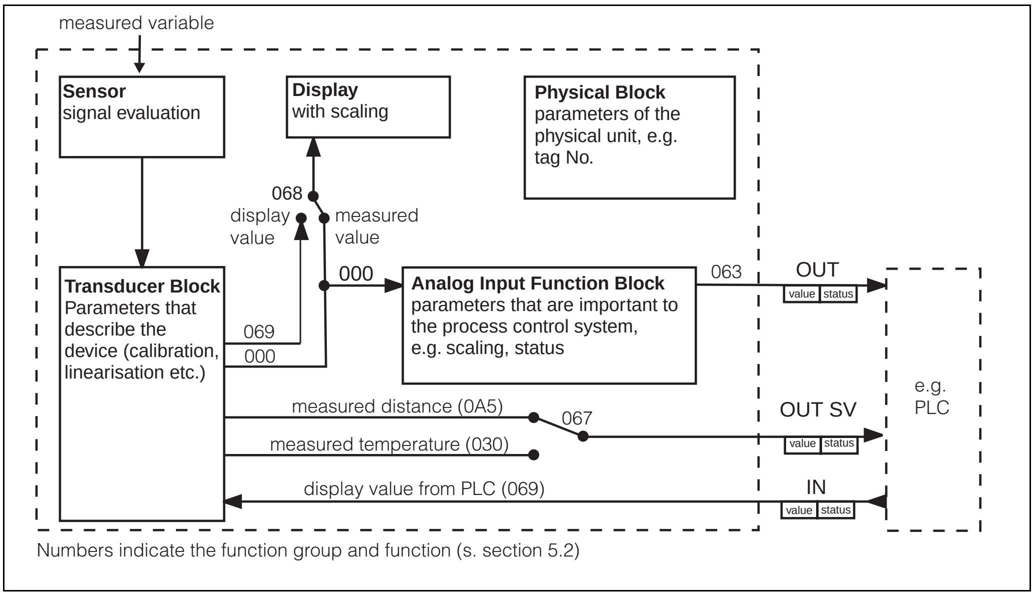
- The GSD files in the directory "Extended" are needed for the network design software STEP 7 of the S7-300/400 PLC family.
- The GSD files in the directory "Standard" are used for PLCs, which do not support an identifier format but only an identifier byte (e.g. PLC5 of Allen-Bradley)
- For the network design tool COM ET200 with Siemens S5 instead of an GSD file the Type file "EH_152Cx.200" and instead of the BMP files the DIB files have to be used.

Universal Database File

As an alternative to the device specific GSD file, the PNO provides an universal database file with the designation PA139700.gsd for devices with one analogue input block. This file supports the transmission of the main value. Transmission of a second cyclic value or a display value is not supported.
When the universal database is used, the option **"profile"** must be selected in the function **"Ident number" (061)**.

5.3.4 Cyclic data exchange

Block model of the Prosonic M



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The block model shows, which data are exchanged continously (i.e. by cyclic data transfer) between the Prosonic M and the PLC. The numbers refer to the function groups and functions.

- After linearization and integration in the transducer block the **"measured value"(000)** is transmitted to the Analog-Input Block. There, it may be scaled and checked for limit transgression, and is written out to the PLC. The parameters of the Analog-Input Block are not available when operating via ToF Tool.
- The function **"select V0H0" (068)** determines, if the main value, or a read in value from the PLC is shown on the display in the field for the main value.
- The function **"second cyclic value" (067)** determines, if the **"measured distance" (0A5)** or the **"measured temperature" (030)** is transmitted as the second cyclic value.

Modules for the cyclic data telegram

For the cyclic data telegram the Prosonic provides the following modules:

1. **Main Process Value**
   This is the main measured value scaled by the Analog Input Block (063).
2. **2nd Cyclic Value**
   This is the measured distance between the sensor mebrane and the product surface (0A5) or the measured temperature (030).
3. **Display Value**
   This is a value which can be transferred from the PLC to the Prosonic M in order to be shown on the display.
4. **FREE PLACE**
   This module must be applied during configuration (see below), if the 2nd cyclic value or the display value are not to appear in the data telegram.

Configuration of the cyclic data telegram

Use the configuration software of your PLC in order to compose the data telegram from these modules in one of the following ways:

1. **Main value**
   In order to transmit the main measured value, selct the module **Main Process Value.**
2. **Main value and second cyclic value**
   In order to transmit the main value and the second cyclic value (temperature or measured distance), select the modules in the following order: **"Main Process Value"**, **"2nd Cyclic Value"**, **"FREE PLACE"**.
3. **Main value and display value**
   In order to transmitt the main value and to receive a display value select the modules in the following order: **"Main Process Value"**, **"FREE PLACE"**, **"Display Value"**.
4. **Main value, second cyclic value and display value**
   In order to transmit the main value and the second cyclic value and to receive a display value, select the modules in the following order: **"Main Process Value"**, **"2nd Cyclic Value"**, **"Display Value"**.

The exact way of performing the configuration depends on the configuration software of the PLC.

Structure of the input data (instrument -> SPS)

The input data are transmitted according to the following structure:

Index Input data	Data	Access	Format/Remarks
0, 1, 2, 3	Main value (level)	read	32 bit floating point number (IEEE-754)
4	Status code for main value	read	see. "Status codes"
5, 6, 7, 8 (optional)	Secondary value (measured distance)	read	32 bit floating point number (IEEE-754)
9 (optional)	Status code for secondary value	read	s. "Status codes"

Structure of the output data (SPS Æ Prosonic M)

The output data are transmitted according to the following structure:

Index Output data	Data	Access	Format/Remarks
0, 1, 2, 3	Display value	write	32 bit floating point number (IEEE-754)
4	Status code for Display value	write	s. "Status codes"

IEEE-754 Floating Point Number

The measured value is transmitted as a IEEE 754 floating point number, whereby:
Measured value = $(-1)^{VZ}$ x $2^{(E-127)}$ x (1+F)

Byte 1								Byte 2							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}
	Exponent (E)								Mantissa (F)						

Byte 3								Byte 4							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}
Mantissa (F)															

Example:

40 F0 00 00 (hex) = 0**100 0000 1**111 0000 0000 0000 0000 0000 (bin)
= $(-1)^0$ x $2^{(129-127)}$ x $(1 + 2^{-1} + 2^{-2} + 2^{-3})$
= 1 x 2^2 x (1 + 0.5 + 0.25 + 0.125)
= 1 x 4 x 1.875
= 7.5

Stauts codes

The status codes comprise one byte and have got the following meaning:

Status-Code	Device status	Significance	Primary value	Secondary value
0C Hex	BAD	device error		X
0F Hex	BAD	device error	X	
1F Hex	BAD	out-of-service (target mode)	X	
40 Hex	UNCERTAIN	non-specific		X
47 Hex	UNCERTAIN	last usable value (Fail-safe-Mode aktiv)	X	
4B Hex	UNCERTAIN	Substitute set (fail-Safe mode active)	X	
4F Hex	UNCERTAIN	initial value (fail-Safe mode active)	X	
5C Hex	UNCERTAIN	Configuration error (limits not set correctly)	X	
80 Hex	GOOD	OK	X	X
84 Hex	GOOD	Active block alarm (static revision counter incremented)	X	
89 Hex	GOOD	LOW_LIM (alarm active)	X	
8A Hex	GOOD	HI_LIM (alarm active)	X	
8D Hex	GOOD	LOW_LOW_LIM (alarm active)	X	
8E Hex	GOOD	HI_HI_LIM (alarm active)	X	

If a stauts other than "GOOD" is sent to the device, the display indicates an error.

5.3.5 Acyclic data exchange

Acyclic data exchange allows device parameters to be changed independently of the communication between the device and a PLC.
Acyclic data exchange is used
- to transmit device parameters during commissioning and maintenance;
- to display measured values that are not acquired in cyclic traffic.

There are two types of acyclic data exchange:

Acyclic communication with a Class 2 master (MS2AC)

In the case of MS2AC, a Class 2 master opens a communication channel via a so-called service access point (SAP) in order to access the device. Class 2 masters are for example:
- ToF Tool
- FieldCare
- PDM

Before data can be exchanged via PROFIBUS, however, the Class 2 master must be made aware of the parameters contained within the field device. This can be done by:
- a device description (DD)
- a device type manager (DTM)
- a software component within the master, which accesses the parameters via slot and index addresses.

Note!
- The DD or DTM is supplied by the device manufacturer.
- The number of Class 2 masters that can simultaneously access a device, is determined by the number of SAPs that the device can provide.
- The use of a Class 2 master increases the cycle time of the bus system. This must be taken into consideration when the control system or PLC is programmed.

Acyclic communication with a Class 1 master (MS1AC)

In the case of MS1AC, a Class 1 master that is already communicating cyclically with a device opens a communication channel via SAP 0x33, a special access point for MS1AC. As is the case for a Class 2 master, the parameter is read or written via the slot and index.

Note!
- At the time of writing, there are only a few PROFIBUS masters that support this type of communication.
- Not all PROFIBUS field devices support MS1AC.

Caution!
Permanent writing of parameters, e.g. with every cycle of the application program, must be avoided, since this can drastically reduce the life of the device.
Acyclic write parameters are stored electrically in the RAM (EEPROM, Flash...). The RAM modules are design for a limited number of write operations only. In standard operation without MS1AC, i.e. during parametrisation of the device, the number of write operations is negligible when compared to the limit. If the application program is badly designed, however, this limit can be reached quickly, and the RAM will fail

5.3.6 Slot/index tables

Device management

Parameter	E+H Matrix (CW II)	Slot	Index	Size [bytes]	Type	Read	Write	Storage Class
Directory object header		1	0	12	Array of UNSIGNED16	X		constant
Composite list directory entries		1	1	24	Array of UNSIGNED16	X		constant
GAP Directory continuous		1	2-8					
GAP reserved		1	9-15					

Analog Input Block

Parameter	E+H Matrix (CW II)	Slot	Index	Size [bytes]	Type	Read	Write	Storage Class
Standard parameters								
Block Data		1	16	20	DS-32*	X		constant
Static revision		1	17	2	UNSIGNED16	X		non-vol.
Device tag		1	18	32	OSTRING	X	X	static
Strategy		1	19	2	UNSIGNED16	X	X	static
Alert key		1	20	1	UNSIGNED8	X	X	static
Target Mode		1	21	1	UNSIGNED8	X	X	static
Mode		1	22	3		X		dynamic non-vol. constant
Alarm summary		1	23	8		X		dynamic
Batch		1	24	10		X	X	static
Gap		1	25					
Block parameters								
Out		1	26	5	DS-33*	X		dynamic
PV Scale		1	27	8	Array of FLOAT	X	X	static
Out Scale		1	28	11	DS-36*	X	X	static
Linearisation type		1	29	1	UNSIGNED8	X	X	static
Channel		1	30	2	UNSIGNED16	X	X	static
Gap		1	31					
PV fail safe time		1	32	4	FLOAT	X		non-vol.
Fail safe type		1	33	1	UNSIGNED8	X	X	static
Fail safe value		1	34	4	FLOAT	X	X	static
Alarm Hysteresis		1	35	4	FLOAT	X	X	static
Gap		1	36					
HI HI Limit		1	37	4	FLOAT	X	X	static
Gap		1	38					
HI Limit		1	39	4	FLOAT	X	X	static
Gap		1	40					
LO Limit		1	41	4	FLOAT	X	X	static

Parameter	E+H Matrix (CW II)	Slot	Index	Size [bytes]	Type	Read	Write	Storage Class
Gap		1	42					
LO LO Limit		1	43	4	FLOAT	X	X	static
Gap		1	44-45					
HI HI Alarm		1	46	16	DS-39*	X		dynamic
HI Alarm		1	47	16	DS-39*	X		dynamic
LO Alarm		1	48	16	DS-39*	X		dynamic
LO LO Alarm		1	49	16	DS-39*	X		dynamic
Simulate		1	50	6	DS-51*	X	X	non-vol.
Out unit text		1	51	16	OSTRING	X	X	static
Gap reserved		1	52-60					

Physical Block

Parameter	E+H Matrix (CW II)	Slot	Index	Size [bytes]	Type	Read	Write	Storage Class
Standard parameters								
Block Data		0	16	20	DS-32*	X		constant
Static revision		0	17	2	UNSIGNED16	X		non-vol.
Device tag		0	18	32	OSTRING	X	X	static
Strategy		0	19	2	UNSIGNED16	X	X	static
Alert key		0	20	1	UNSIGNED8	X	X	static
Target mode		0	21	1	UNSIGNED8	X	X	static
Mode		0	22	3	DS-37*	X		dynamic non-vol. constant
Alarm summary		0	23	8	DS-42*	X		dynamic
Block parameters								
Software revision		0	24	16	OSTRING	X		constant
Hardware revision		0	25	16	OSTRING	X		constant
Device manufacturer ID		0	26	2	UNSIGNED16	X		constant
Device ID		0	27	16	OSTRING	X		constant
Device serial number		0	28	16	OSTRING	X		constant
Diagnosis		0	29	4	OSTRING	X		dynamic
Diagnosis extension		0	30	6	OSTRING	X		dynamic
Diagnosis mask		0	31	4	OSTRING	X		constant
Diagnosis mask ext.		0	32	6	OSTRING	X		constant
Device certification		0	33	32	OSTRING	X	X	non-vol.
Security locking		0	34	2	UNSIGNED16	X	X	non-vol.
Factory reset		0	35	2	UNSIGNED16		X	non-vol.
Descriptor		0	36	32	OSTRING	X	X	static
Device message		0	37	32	OSTRING	X	X	static
Device instal. date		0	38	8	OSTRING	X	X	static
Gap reserved		0	39					
Ident number select		0	40	1	UNSIGNED8	X	X	static

Parameter	E+H Matrix (CW II)	Slot	Index	Size [bytes]	Type	Read	Write	Storage Class
HW write protection		0	41	1	UNSIGNED8	X	X	static
Gap reserved		0	42-48					
Gap		0	49-53					
E+H parameters								
error code		0	54	2	UNSIGNED16	X		dynamic
last error code		0	55	2	UNSIGNED16	X	X	dynamic
Up Down features		0	56	1	OSTRING	X		constant
Up Down control		0	57	1	UNSIGNED8		X	dynamic
Up Down param		0	58	20	OSTRING	X	X	dynamic
Bus address		0	59	1	UNSIGNED8	X		dynamic
Device SW No.		0	60	2	UNSIGNED16	X		dynamic
set unit to bus		0	61	1	UNSIGNED8	X	X	static
input value		0	62	6	FLOAT+U8+U8	X		dynamic
Select Main value		0	63	1	UNSIGNED8	X	X	dynamic
PA profile revision		0	64	16	OSTRING	X		constant
Gap		0	65-69					
Gap reserved		0	119-125					

E+H specific level transducer block

Parameter	E+H Matrix (CW II)	Slot	Index	Size [bytes]	Type	Read	Write	Storage Class
Standard parameters								
Block data		1	130	20	DS-32*	X		constant
Static revision		1	131	2	UNSIGNED16	X		non-vol.
Device tag		1	132	32	OSTRING	X	X	static
Strategy		1	133	2	UNSIGNED16	X	X	static
Alert key		1	134	1	UNSIGNED8	X	X	static
Target mode		1	135	1	UNSIGNED8	X	X	static
Mode		1	136	3	DS-37*	X		dynamic non-vol. static
Alarm summary		1	137	8	DS-42*	X		dynamic
E+H parameters								
Measured value	V0H0	1	138	4	FLOAT	X		dynamic
tank shape	V0H2	1	140	1	UNSIGNED8	X	X	static
medium cond.	V0H3	1	141	1	UNSIGNED8	X	X	static
process cond.	V0H4	1	142	1	UNSIGNED8	X	X	static
empty calibration	V0H5	1	143	4	FLOAT	X	X	static
full calibration	V0H6	1	144	4	FLOAT	X	X	static
output on alarm	V1H0	1	148	1	UNSIGNED8	X	X	static
outp. echo loss	V1H2	1	150	1	UNSIGNED8	X	X	static
ramp %span/min	V1H3	1	151	4	FLOAT	X	X	static

Parameter	E+H Matrix (CW II)	Slot	Index	Size [bytes]	Type	Read	Write	Storage Class
delay time	V1H4	1	152	2	UNSIGNED16	X	X	static
safety distance	V1H5	1	153	4	FLOAT	X	X	static
in safety dist.	V1H6	1	154	1	UNSIGNED8	X	X	static
ackn. alarm	V1H7	1	155	1	UNSIGNED8	X	X	static
measured temp.	V2H0	1	158	1	UNSIGNED8	X	X	static
max. temp. limit	V2H1	1	159	1	UNSIGNED8	X	X	static
max. meas. temp.	V2H2	1	160	1	UNSIGNED8	X	X	static
on high temp.	V2H3	1	161	1	UNSIGNED8	X	X	static
def. temp. sens.	V2H4	1	162	2	ENUM	X	X	static
level/ullage	V3H0	1	168	1	UNSIGNED8	X	X	static
linearisation	V3H1	1	169	1	UNSIGNED8	X	X	static
customer unit	V3H2	1	170	2	UNSIGNED16	X	X	static
table no.	V3H3	1	171	1	UNSIGNED8	X	X	static
input level	V3H4	1	172	4	FLOAT	X	X	static
input volume	V3H5	1	173	4	FLOAT	X	X	static
max. scale	V3H6	1	174	4	FLOAT	X	X	static
diameter vessel	V3H7	1	175	4	FLOAT	X	X	static
check distance	V4H1	1	179	1	UNSIGNED8	X	X	static
range of mapping	V4H2	1	180	4	FLOAT	X	X	static
start mapping	V4H3	1	181	1	UNSIGNED8	X	X	static
pres. map. dist.	V4H4	1	182	4	FLOAT	X		dynamic
cust. Tank map	V4H5	1	183	1	UNSIGNED8	X	X	static
echo quality	V4H6	1	184	1	UNSIGNED8	X		dynamic
offset	V4H7	1	185	4	FLOAT	X	X	static
output damping	V4H8	1	186	4	FLOAT	X	X	static
blocking dist.	V4H9	1	187	4	FLOAT	X	X	static
instrument_addr.	V5H0	1	188	1	UNSIGNED8	X		dynamic
ident number	V5H1	1	189	1	UNSIGNED8	X	X	static
set unit to bus	V5H2	1	190	1	UNSIGNED8	X	X	static
out value	V5H3	1	191	4	FLOAT	X		dynamic
out status	V5H4	1	192	1	UNSIGNED8	X		dynamic
simulation	V5H5	1	193	1	UNSIGNED8	X	X	static
simulation value	V5H6	1	194	4	FLOAT	X	X	static
2nd cyclic value	V5H7	1	195	1	UNSIGNED8	X	X	static
select V0H0	V5H8	1	196	1	UNSIGNED8	X	X	static
display value	V5H9	1	197	4	FLOAT	X		dynamic
display contrast	V6H1	1	199	1	UNSIGNED8	X	X	static
language	V6H2	1	200	1	UNSIGNED8	X	X	static
back to home	V6H3	1	201	2	INT16	X	X	static
format display	V6H4	1	202	1	UNSIGNED8	X	X	static
no. decimals	V6H5	1	203	1	UNSIGNED8	X	X	static
sep. character	V6H6	1	204	1	UNSIGNED8	X	X	static
display test	V6H7	1	205	1	UNSIGNED8	X	X	static

Parameter	E+H Matrix (CW II)	Slot	Index	Size [bytes]	Type	Read	Write	Storage Class
present error	V9H0	1	228	2	U16	X		dynamic
previous error	V9H1	1	229	2	U16	X		dynamic
clear last error	V9H2	1	230	1	UNSIGNED8	X	X	static
reset	V9H3	1	231	2	UNSIGNED16	X	X	static
unlock parameter	V9H4	1	232	2	UNSIGNED16	X	X	static
measured dist.	V9H5	1	233	4	FLOAT	X		dynamic
measured level	V9H6	1	234	4	FLOAT	X		dynamic
application par.	V9H8	1	236	1	UNSIGNED8	X		dynamic
tag no.	VAH0	1	238	32	STRING	X		const.
profile version	VAH1	1	239	32	STRING	X	X	static
protocol+sw-no.	VAH2	1	240	32	STRING	X		const
serial no.	VAH4	1	242	32	STRING	X	X	static
distance unit	VAH5	1	243	2	UNSIGNED16	X	X	static
temperature unit	VAH6	1	244	2	ENUM	X	X	static
download mode	VAH8	1	246	1	UNSIGNED8	X	X	static

Data strings

In der Slot/Index table some data types, e.g. DS-33 are marked by an asterisk. These are data strings according to the PROFIBUS-PA specifications part 1, Version 3.0. They contain several elements, which are addressed by an additional subindex. The following table gives an example.

Data type	Subindex	Type	Size [bytes]
DS-33	1	FLOAT	4
	5	UNSIGNED8	1

5.3.7 Parameter access via Commuwin II

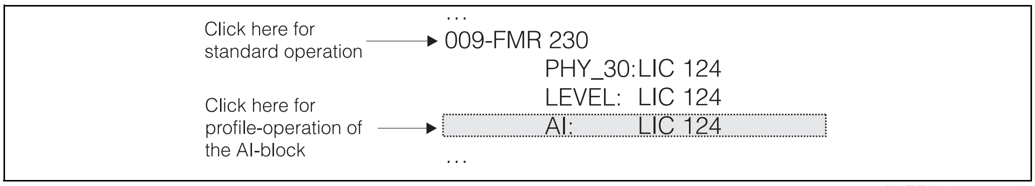
The block parameters can be accessed by a PROFIBUS-DP Class 2 master, for example, Commuwin II. Commuwin II runs on an IBM-compatible computer or laptop. The computer must be equipped with a PROFIBUS interface, i.e. PROFIBOARD for PCs and PROFICARD for laptops. During the system integration, the computer is registered as a Class 2 master.

Connection

- Profiboard for connection to a PC
- Proficard for connection to a Laptop

Generating the device list

- The PA-DPV1 server must be installed. The connection to Commuwin II is opened selecting the PA-DPV1 server in the "Open connection" function in the "Connect" menu. The empty device list appears.
- The function "Display with tags" in the "Connect" menu generates the live list with measuring point tags.
- Two operation modes are possible:
  – The **E+H standard operation** is selected by clicking on the device name
  – The **profile operation** is selected by clicking on the tag for the appropriate block
- The settings are entered in the device menu.



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Device menu

The device menu allows matrix or graphical operation to be selected.

- In the case of **matrix operation**, the device or profile parameters are displayed in a matrix. For the standard operation this is the E+H standard matrix. For the profile operation this is the matrix of the selected blockA parameter can be changed when the corresponding matrix field is selected.
- In the case of **graphical operation**, the operating sequence is shown in a series of templates with parameters. For profile operation, the pictures Diagnosis, Scaling, Simulation and Block are of interest.

The meaning and the parametrization of the parameters is described in Chapter 6.

Note!
The instrument can also be operated locally using the keys. If operation is prevented by the keys being locked locally, parameter entry via communication is not possible either.

Note!
Further information on Commuwin II is given in the Operating Manual BA 124F/00/en

5.3.8 Parameter access via ToF Tool

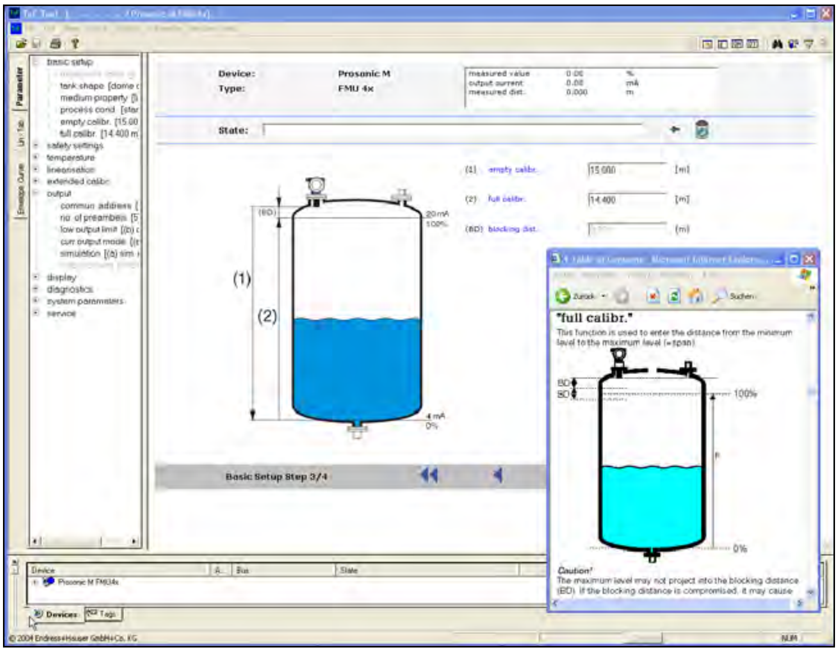
The ToF Tool is a graphical operation software for instruments from Endress+Hauser. It is used to support commissioning, securing of data, signal analysis and documentation of the instruments. It is compatible with the following operating systems: WinNT4.0, Win2000 and WinXP.

The ToF Tool supports the following functions:
- Online configuration of transmitters
- Signal analysis via envelope curve
- Linearisation table (graphically supported creation, editing, importing and exporting)
- Loading and saving of instrument data (Upload/Download)
- Documentation of measuring point

Note!
Further information you may find on the CD-ROM, which is enclosed to the instrument.

Note!
The parameters of the Analog-Input block are presently not accessible via ToF Tool.

Menu-guided commissioning

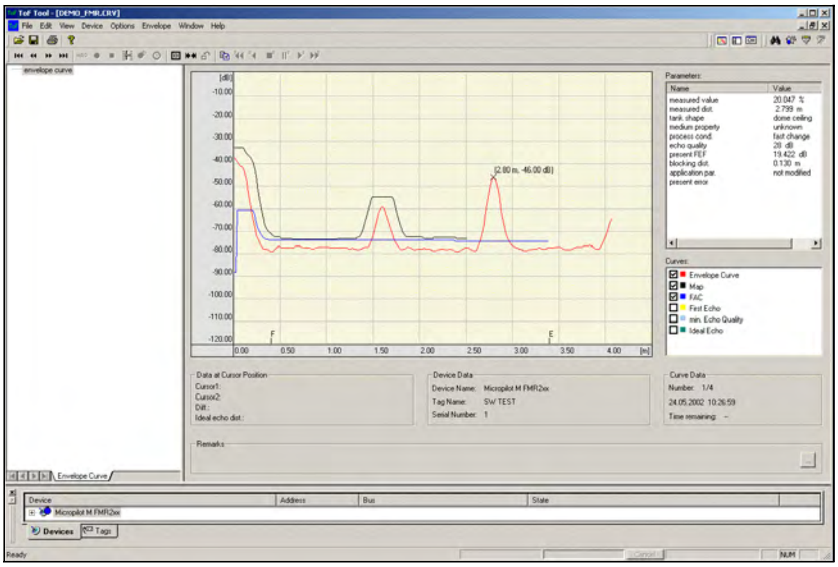


L00-FMU4xxxx-19-00-00-en-003

- You can find the function groups and functions of the device in the **navigation bar**.
- You can find the input fields for the parameters in the **main window**.
- If you click on a parameter name, the **Help pages** open with precise explanations of the required input.

Signal analysis via envelope curve

The ToF Tool offers easy analysis of the envelope curve via the "Envelope" menu:



L00-FMU4xxxx-19-00-00-en-004

Connection options:

- Service-interface with adapter FXA 193
- Profiboard for connection to a Laptop
- Proficard for connection to a PC

5.3.9 Scaling of the output data

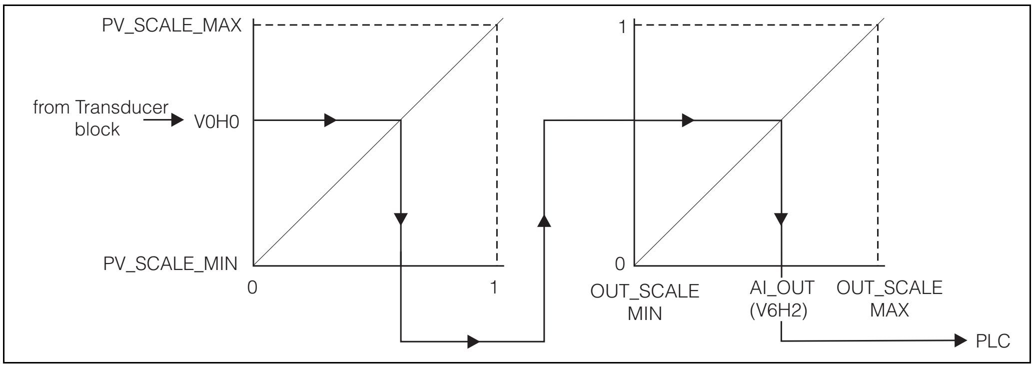
The on-site display and the digital output are working independently of each other.

On-site display

The on-site display always displayes the main value V0H0 directly from the Transducer Block.

Digital output

For the digital output this value is rescaled in two steps:



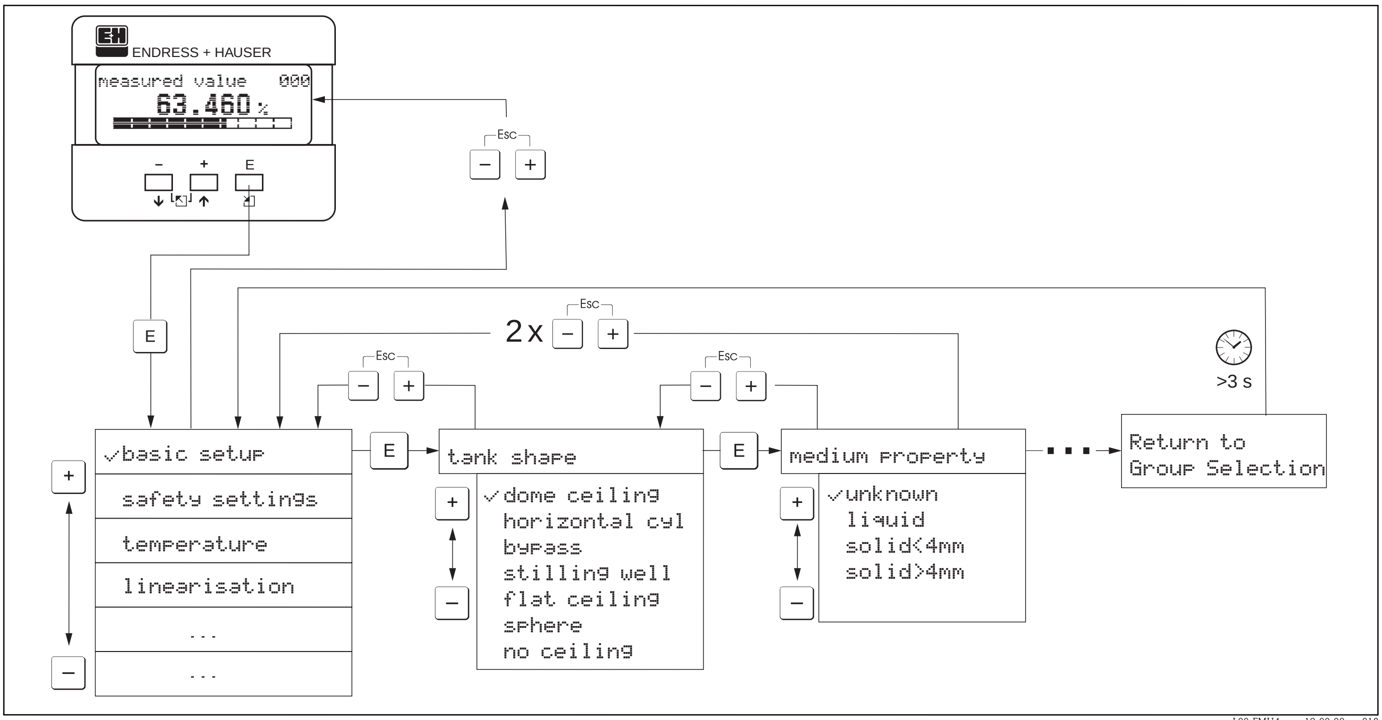
L00-FMUx3xxx-05-00-00-en-001

1. In a first step, the main value is mapped to the interval [0;1]. PV_SCALE_MIN and PV_SCALE_MAX determine the limits of this mapping.
2. In a second step, the interval [0,1] is mapped to the interval [OUT_SCALE_MIN, OUT_SCALE_MAX]. The value resulting from this mapping is transfered via V6H2 to the PLC.

Note!
The scaling of the ouptut value is required by the Profibus profiles. It prevents uncontrolled jumps of the output value when one changes the unit of the measuring value in the Transducer Block. If units are changed, PV_SCALE_MIN and PV_SCALE_MAX automatically adapt themselves in such a way that the output value remains unchanged. Only after confirming the change by the "**Set unit to bus**" **(062)** function,
OUT_SCALE_MIN is set equal to PV_SCALE_MIN and
OUT_SCALE_MAX equal to PV_SCALE_MAX.
Thereby the new unit also becomes effective at the output.

Caution!
If a linearisation has been carried out, it must be confirmed by the "**Set unit to bus**" **(062)** function in order to become effective at the digital output.

5.4 Operation using the on-site display VU 331



L00-FMU4xxxx-19-00-00-en-018

1. Change from Measured Value Display to **Group Selection** by pressing E.
2. Press – or + to select the required **Function Group** and confirm by pressing E.
   The active selection is marked by a 3 in front of the menu text.
3. Activate Edit mode with + or – .

   Selection menus

   a. Select the required **Parameter** in selected **function** with – oder + .

   b. E confirms selection; 3appears in front of the selected parameter.

   c. E confirms the edited value; system quits edit mode.

   d. + and – (= +–) interrupts selection; system quits edit mode.

   Typing in numerals and text

   a. Press + or – to edit the first character of the **numeral / text**.

   b. E positions the cursor at the next character; continue with a. until you have completed your input.

   c. If a ↵ symbol appears at the cursor, press E to accept the value entered; system quits edit mode.

   d. If a ← symbol appears at the cursor, press E to return to the previous character (e.g. for correction of entries).

   e. + and – (= +–) interrupts selection; system quits edit mode.
4. Press E to select the next **function**.
5. Press + and – (= +–) once; return to previous **function**.
   Press + and – (= +–) twice; return to **Group Selection**.
6. Press + and – (= +–) to return to **Measured value display**.

5.5 Lock/unlock configuration

5.5.1 Software security locking

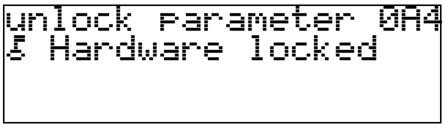
Enter a number ≠ 2457 in the **"unlock parameter" (0A4)** function in the **"diagnostics" (0A)** function group.
The symbol appears on the display. Inputs are no longer possible.

If you try to change a parameter, the device jumps to the **"unlock parameter" (0A4)** function.
Enter "2457"
Now change the parameters.

5.5.2 Hardware security locking

Press [–], [+] and [E] simultaneously.
Inputs are no longer possible.

If you try to change a parameter, the following appears:



L00-fmrxf0a4-20-00-00-de-001

Press [–], [+] and [E] simultaneously. The **"unlock parameter" (0A4)** function appears.
Enter "2457"
Now change the parameters.

Note!
A hardware locking can **only** be unlocked again via the display by pressing the [+], [–] and [E] keys at the same time again. It is **not** possible to unlock the hardware by communication.

5.6 Resetting the customer parameters

It is advisable to reset the customer parameters if you want to use a device with an unknown history.

Effects of resetting:
- All customer parameters are reset to their default values.
- Customer interference echo suppression is **not** deleted.
- Linearisation is switched to **"linear"**, but the table values are kept. The table can be switched back on in the **"linearisation" (04)** function group in the **"linearisation" (041)** function.

In order to carry out the reset, enter the number "33333" in the **"reset" (0A3)** function in the **"diagnostics" (0A)** function group.

Caution!
A reset may lead to impairment of the measurement. As a rule, a basic calibration is required after a reset.

Note!
The default values of each parameter are shown in bold in the menu overview in the appendix.

5.7 Resetting an interference echo suppression (tank map)

It is always advisable to reset the interference echo suppression (tank mapping) when:
- a device with an unknown history is used
- an incorrect suppression was input.

Proceed as follows:

1. Switch to the **"extended calibr." (05)** function group and to the **"selection" (050)** function.
2. Select **"extended map."**
3. Then proceed to the **"cust. tank map" (055)** function.
4. Select
   - **"reset"**, to delete (reset) the existing interference echo suppression.
   - **"inactive"** to deactivate an existing interference echo suppression. The suppression remains saved.
   - **"active"** to reactivate an existing interference echo suppression.

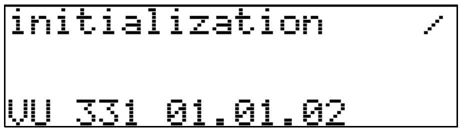
6 Commissioning

Commission the Prosonic M in the following stages:
- Installation check
- Power-up device
- Basic calibration
- Measuring signal check using the envelope curve

The chapter describes the commissioning process using the on-site display. Commissioning using ToF Tool is identical. Access to the device functions using ToF Tool is described on Page 21. You can find detailed information in the Tof Tool operating instructions (BA 224F/00/en) on the supplied CD-ROM.

6.1 Power up instrument

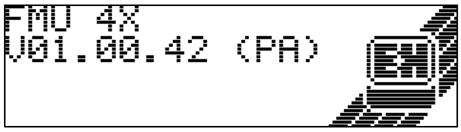
After switching on the supply voltage, the instrument is first initialised.



L00-fmp-fxxx-20-00-00-en-003

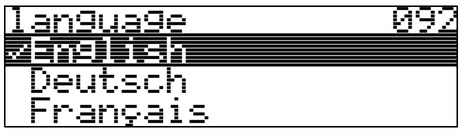
Then the following appear for approximately five seconds:
- Device type
- Software version
- Type of digital communication signal

Press E to exit this display.



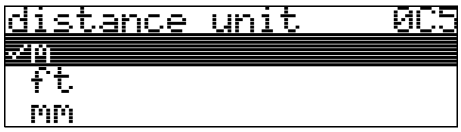
L00-fmuxfxxx-20-00-00-de-002

On first power-up, you are requested to select the language for the display texts.



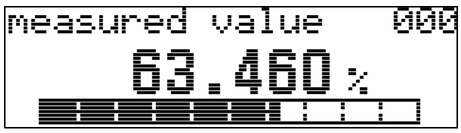
L00-fmrxf092-20-00-00-en-001

Then you are requested to select the unit of length for your measurements.



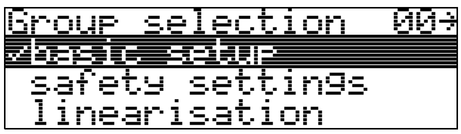
L00-fmrxf0c5-20-00-00-en-001

A measured value is displayed. This is NOT equivalent to the level in your tank. Firstly carry out a basic calibration.



L00-fmrxf000-20-00-00-en-001

Press E to switch to the group selection.
Press E again to start the basic calibration.



L00-fmrxfg00-20-00-00-en-001

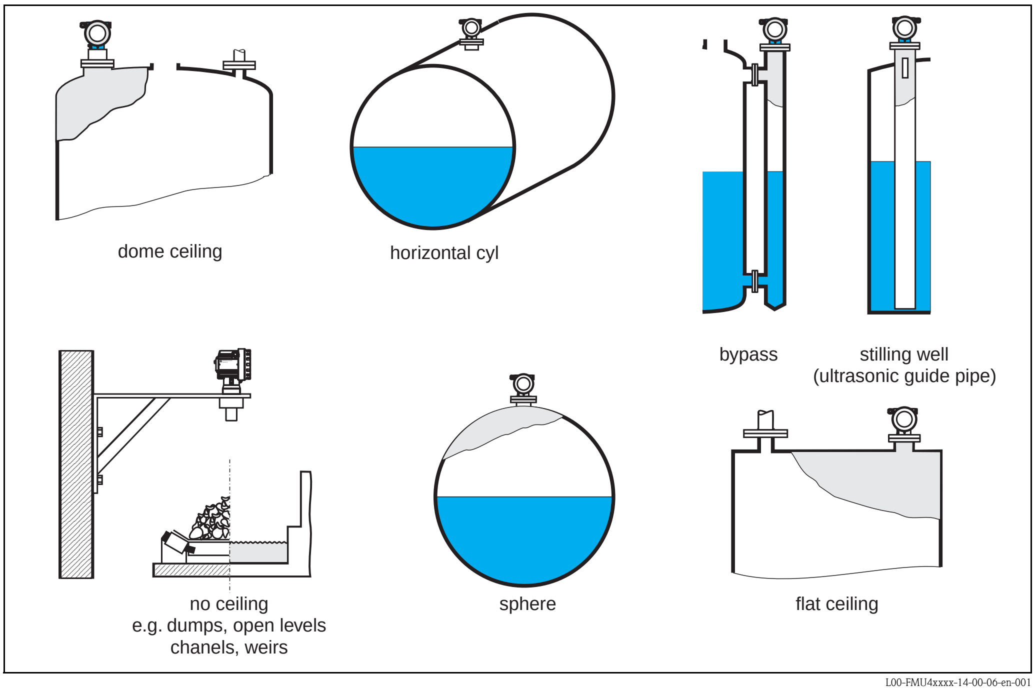
6.2 Basic calibration

The **"Basic setup" (00)** function group lists all the functions which are required for a standard measurement task to commission the Prosonic M. When you have completed your input for a function, the next function appears automatically. In this way, you are guided through the complete calibration.

6.2.1 Measuring point settings

Function "tank shape" (002)

In this function, select one of the following options:



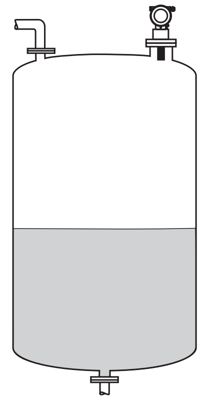
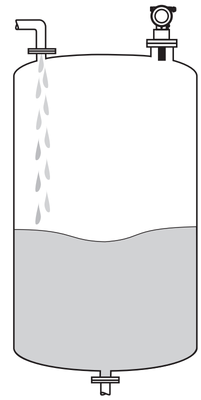
Function "medium property" (003)

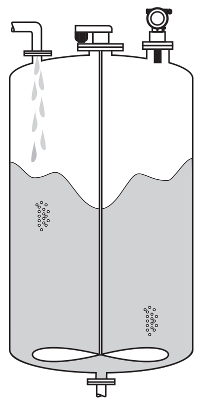
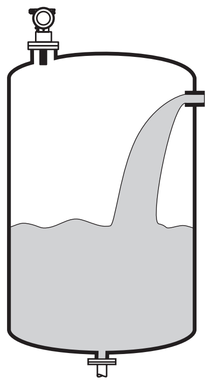
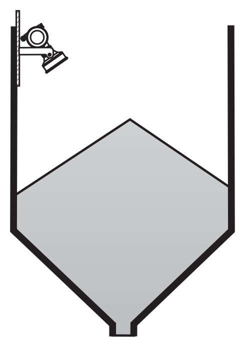
Set the medium type in this function.

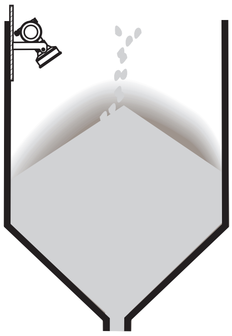
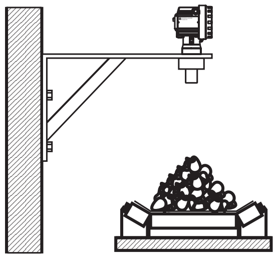
You have the following options:
- unknown (e.g. pasty media such as greases, creams, gels etc.)
- liquid
- solid, grain size < 4mm (fine)
- solid, grain size > 4mm (coarse)

Function "process conditions" (004)

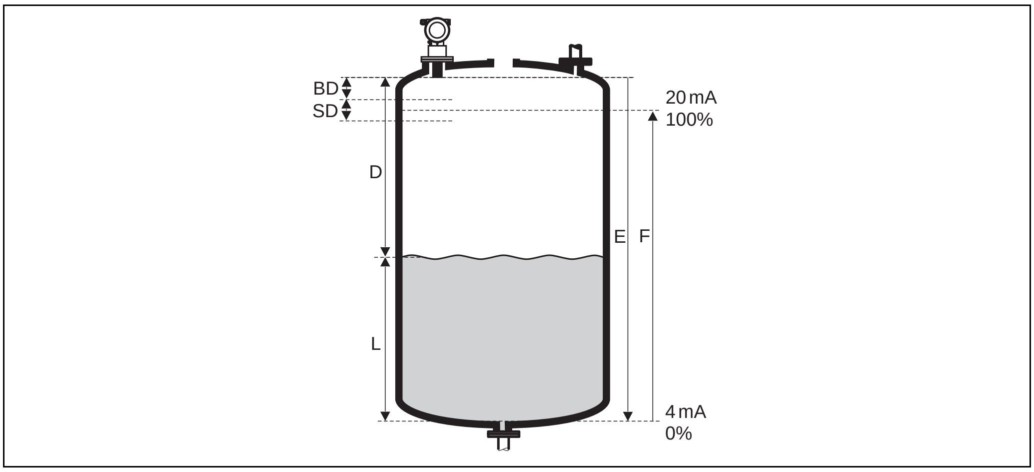
For this function, you have the following options:

standard liquids	calm surface	turb. surface
For all fluid applications which do not fit in any of the following groups.	Storage tanks with immersion tube or bottom filling	Storage / accumulation tanks with uneven surface due to free filling, mixing nozzles or small bottom stirrers
	 L00-FMU4xxxx-14-00-00-xx-001	 L00-FMU4xxxx-14-00-00-xx-002
The filters and output damping are set to average values.	The averaging filters and output damping are set to large values. -> Stable measured value -> Accurate measurement -> Slow reaction time	Special filters for stabilising the input signal are activated. -> Stable measured value -> Medium reaction time

add. agitator	fast change	standard solid
Moving surfaces (poss. with vortex formation) due to agitators	Rapid level change, particularly in small tanks	For all bulk solids applications which do not fit in any of the following groups.
 L00-FMU4xxxx-14-00-00-xx-003	 L00-FMU4xxxx-14-00-00-xx-004	 L00-FMU4xxxx-14-00-00-xx-006
Special filters for stabilising the input signal are set to large values. -> Stable measured value -> Medium reaction time	The averaging filters are set to small values. -> Rapid reaction time -> Possibly unstable measured value	The filter and output damping are set to average values.

solid dusty	conveyor belt	Test: no filter
Dusty bulk solids	Bulk solids with rapid level change	All the filters can be switched off for purposes of service and diagnosis.
 L00-FMU4xxxx-14-00-00-xx-007	 L00-FMU4xxxx-14-00-00-xx-005	
The filters are set to detect even relatively weak signals.	The averaging filters are set to small values. -> Rapid reaction time Possibly unstable measured value	All filters off

6.2.2 Empty and full calibration



L00-FMU4xxxx-19-00-00-yy-019

Function "empty calibration" (005)

In this function, enter the distance E from the sensor membrane to the minimum level (zero point).

Caution!
With dished boiler heads or conical outflows, the zero point should not be deeper than the point at which the ultrasonic wave impinges on the tank bottom.

Function "blocking distance" (059)

In this function the blocking distance (BD) of the sensor is displayed.

Caution!
When entering the full calibration (span), please take into account, that the maximum level may not project into the blocking distance (BD)

Note!
After basic calibration, enter a safety distance (SD) in the **"safety distance" (015)** function. If the level is within this safety distance, the Prosonic M signals a warning or an alarm, depending on your selection in the **"in safety distance" (016)** function.

Function "full calibration" (006)

In this function, enter the span F, i.e. the distance from the minimum level to the maximum level.

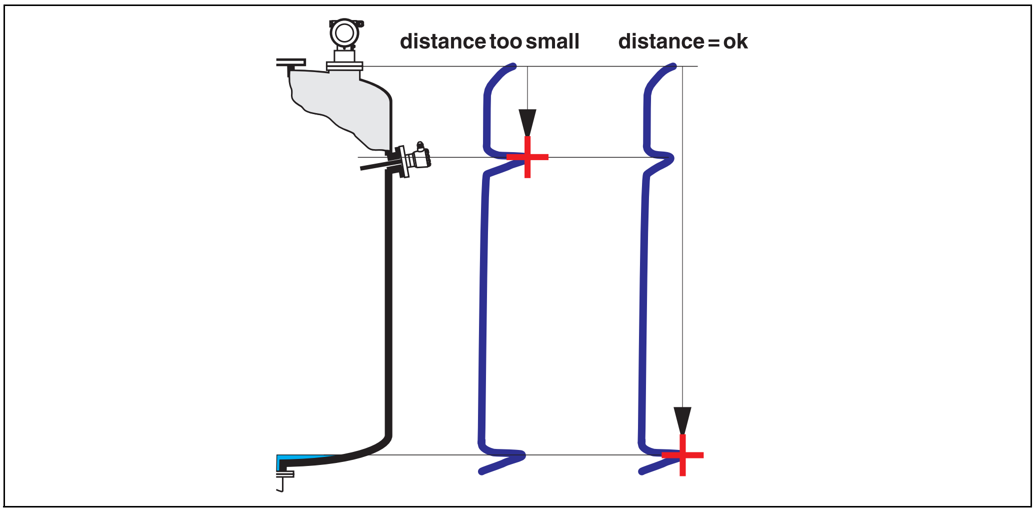
6.2.3 Interference echo suppression (tank mapping)

Function "dist./measured value" (008)

In the **"dist./meas.value" (008)** function, the measured distance D from the sensor membrane to the product surface is displayed together with level L. Check these values.

Function "check distance" (051)

The mapping is initialized by this function.



L00-FMR2xxxx-14-00-06-en-010

Select
- **"distance=ok"** if the correct distance is displayed. Any echoes closer to the sensor will be suppressed by the following interference echo suppression.
- **"dist. too small"** if the displayed distance is too small. In this case, the signal comes from an interference echo which will be suppressed.
- **"dist. too big"** if the displayed distance is too large. This error cannot be cancelled by suppressing the interference echo. This means that the following two functions are skipped. Check the application parameters **"tank shape" (002)**, **"medium proerty" (003)** and **"process cond." (004)** and the **"empty calibr."(005)** in the **"basic setup" (00)** function group.
- **"dist. unknown"** if you do not know the actual distance. This means that the following two functions are skipped.
- **"manual"** if you want to specify the suppression area yourself in the following function.

Function "range of mapping" (052)

The suggested suppression area is displayed in this function. The reference point is always the sensor membrane. You can still edit the value. With manual suppression, the default value is 0 m.

Caution!
The suppression range must end 0.5 m in front of the echo of the actual level. With an empty tank, do not enter E but E – 0.5 m.

Function "start mapping" (053)

You have the following options for this function:
- **off**: Nothing is suppressed.
- **on**: Starts suppression.

✎ Note!
If a mapping already exists, it will be overwritten up to the distance specified in the **"range of mapping" (052)** function. Beyond this distance the existing mapping remains unchanged.

Function dist./measured value (008)

After suppression, the measured distance D from the sensor membrane to the product surface is displayed together with the level. Check that the values correspond to the actual level and/or the actual distance.

The following cases may occur:
- Distance correct – Level correct -> End of basic calibration
- Distance incorrect – Level incorrect -> An additional interference echo suppression must be carried out. Go back to the **"check distance" (051)** function.
- Distance correct – Level incorrect -> Check the value of the **"empty calibr." (005)** function.

Rücksprung zur Gruppenauswahl

Nach der Störechoausblendung ist der Grundabgleich beendet und das Gerät springt automatisch in die Gruppenauswahl zurück.

6.3 Envelope curve

After the basic setup, an evaluation of the measurement with the aid of the envelope curve ("**envelope curve**" **(0E)** function group) is recommended.

6.3.1 Funxtion "plot settings" (0E1)

In this function, select whether you want to display
- just the envelope curve
- The envelope curve and the echo evaluation line FAC
- The envelope curve and interference echo suppression (map)

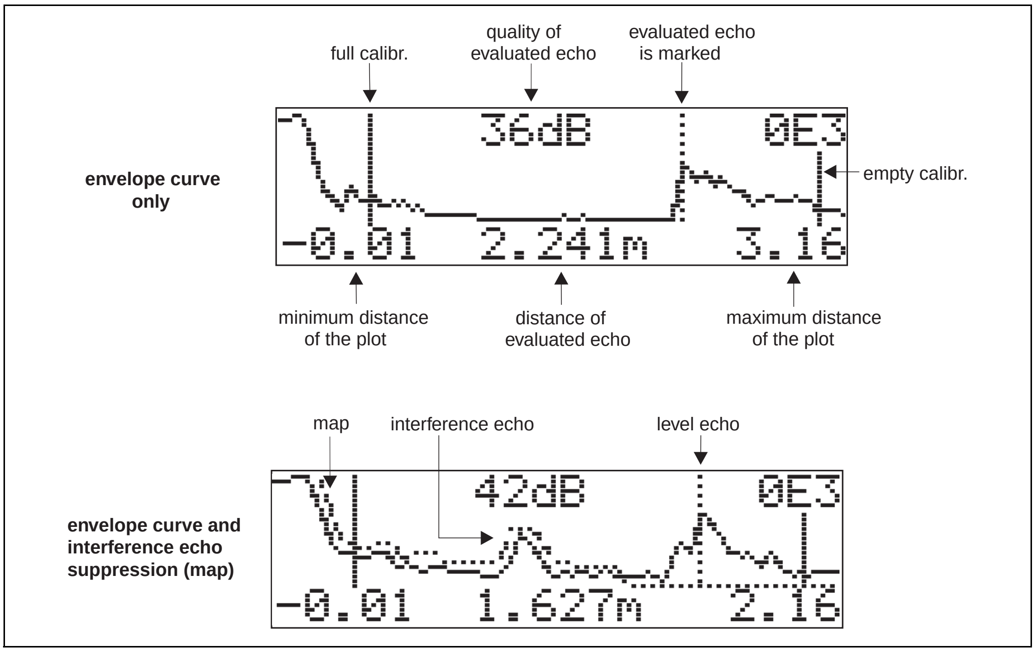
Note!
The FAC and the interference echo suppression (map) are explained in BA 240F "Prosonic M – Description of Instrument Functions"

6.3.2 Function "recording curve" (0E2)

In this function, specify whether you want to display
- an individual envelope curve
- The current envelope curve, with cyclical refreshment.

6.3.3 Function "envelope curve display" (0E3)

The envelope curve is displayed in this function. You can use it to obtain the following information:



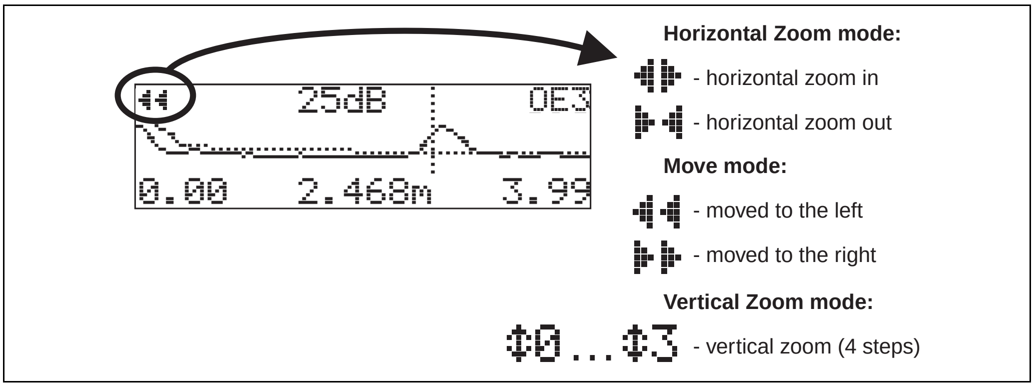
L00-FMU4xxxx-07-00-00-en-003

Check that the following conditions are fulfilled:
- The echo quality at the end of measuring range should be at least 10dB.
- There should be practically no interference echoes in front of the level signal.
- If interference echoes cannot be avoided, they must be below the suppression curve.

Note!
If the cyclical envelope curve display is still active on the display, the measured value is updated at a slower cycle time. We therefore advise you to exit the envelope curve display after optimising the measuring point. To do this, press E. (The instrument does not leave the envelope curve display automatically.)

6.3.4 Navigation in the envelope curve display

Using navigation, the envelope curve can be scaled horizontally and vertically and shifted to the left or the right. The active navigation mode is indicated by a symbol in the top left hand corner of the display.

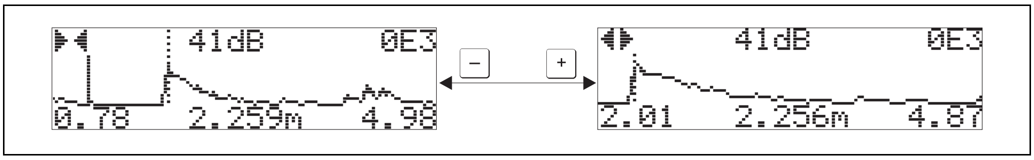


L00-FMxxxxxx-07-00-00-en-004

Horizontal Zoom mode

Firstly, go into the envelope curve display. Then press + or – to switch to the envelope curve navigation. You are then in Horizontal Zoom mode. Either or is displayed.

- + increases the horizontal scale.
- – reduces the horizontal scale.

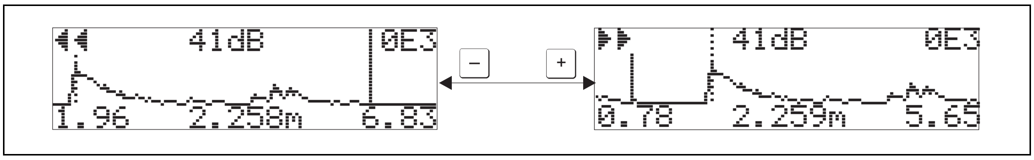


L00-FMxxxxxx-07-00-00-yy-007

Move mode

Then press E to switch to Move mode. Either or is displayed.

- + shifts the curve to the right.
- – shifts the curve to the left.



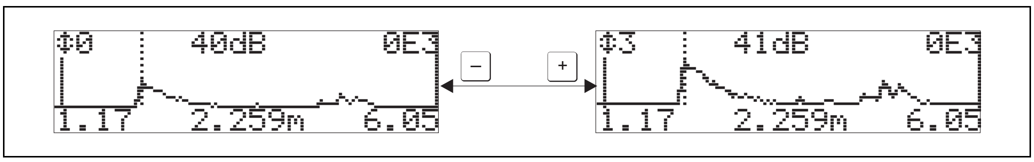
L00-FMxxxxxx-07-00-00-yy-008

Vertical Zoom mode

Press E once more to switch to Vertical Zoom mode. 1 is displayed. You now have the following options.

- + increases the vertical scale.
- – reduces the vertical scale.

The display icon shows the current zoom factor (0 to 3).



L00-FMxxxxxx-07-00-00-yy-009

Exiting the navigation

- Press E again to run through the different modes of the envelope curve navigation.
- Press + and − to exit the navigation. The set increases and shifts are retained. Only when you reactivate the "**recording curve**" **(0E2)** function the display settings return to their standard values.

7 Troubleshooting

7.1 System error messages

7.1.1 Current error

Errors which the Prosonic M detects during commissioning or operation are displayed:

- In the **"measured value" (000)** function
- In the **"diagnostics" (0A)** function group in the **"present error" (0A0)** function
  Only the highest priority error is displayed; in the case of multiple errors, you can scroll between the different error messages by pressing + or -.
- by the status of the main value

7.1.2 Last error

The last error is displayed in the **"diagnostics" (0A)** function group in the **"previous error" (0A1)** function. This display can be deleted in the **"clear last error" (0A2)** function.

7.1.3 Types of error

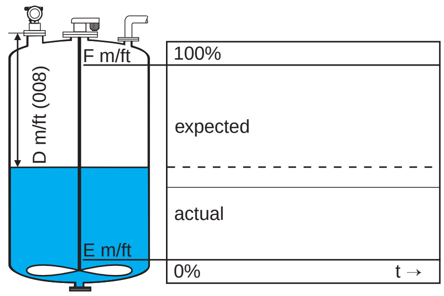
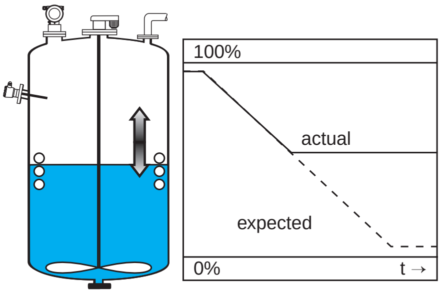
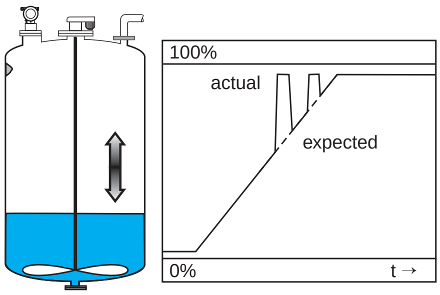
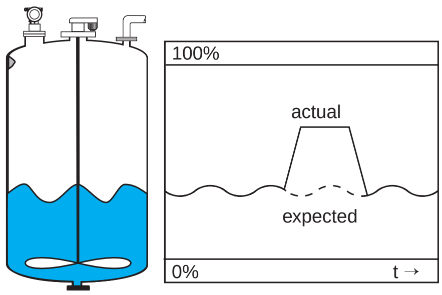
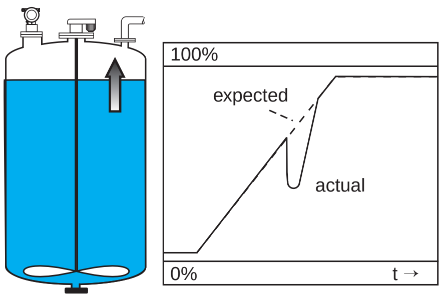
Type of error	Symbol	Meaning
Alarm (A)	continuous	The output signal assumes a value which can be set using the **"output on alarm" (010)** function: ■ MAX: 110% ■ MIN: -10% ■ Hold: last value is on hold ■ User-specific value
Warning (W)	flashing	The device continues measurement. An error message is displayed.
Alarm/Warning (E)	You can define whether the error should behave as an alarm or as a warning.	

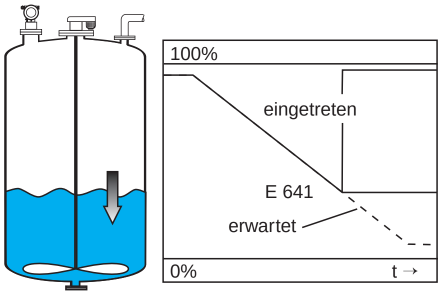
7.1.4 Error codes

Code	Error description	Action
A102 A110 A152 A160	checksum error	Reset; If alarm still present after reset, replace electronics
W103	initialising	If the message does not disappear after several seconds, replace the electronics
A106	downloading	Wait; Message disappears after load sequence
A111 A113 A114 A115 A121 A125 A155 A164 A171	electronics defect	Reset; Check system for EMC, improve as necessary If alarm still present after reset, replace electronics
A116	download error	Check connection; Restart download
W153	initialising	Wait a few seconds; if error is still displayed, switch the power off and on again
A231	sensor defect	Check connection, if necessary replace HF module or electronics

Code	Error description	Action
A281	interruption temperature sensor	Exchange sensor
A502	Sensor type not detected	Exchange sensor and/or electronics
A512	recording of mapping	Alarm disappears after a few seconds
A521	new sensor type detected	Reset
W601	linearisation curve not monotone	Correct table (enter monotonously increasing table)
W611	less than 2 linea-risation points	Enter additional value pairs
W621	simulation on	Switch simulation mode off [**"output" (06)** function group, **"simulation" (065)** function]]
E641	no usable echo	Check basic calibration
E651	level in safety distance - risk of overspill	Error disappears when the level leaves the safety distance. Possibly reset the lock. [**"safety settings" (01)** function group, **"ackn. alarm" (017)** function]]
A661	Sensor overtemperature	
A671	Linearisation incomplete	Activate linearisation table
W681	current out of range	Carry out basic calibration; check linearisation
W691	Filling noise detected, level ramp is active	

7.2 Application errors

Error	Example	Elimination
Measured value (00) is incorrect but measured distance (008) is correct	 L00-FMR2xxxx-19-00-00-en-019	1. Check empty calibration (005) and full calibration (006). 2. Check linearisation – level/ullage (040) – max. scale(046) – diameter vessel(047) – linearisation table
Measured value (000) and measured distance (008) are incorrect		1. For measurements in bypass or stilling well: Select the according option in the **"tank shape" (002)** function. 2. Carry out interference echo suppression.
No change in measured value on filling/ emptying	 L00-FMR2xxxx-19-00-00-en-014	1. Carry out interference echo suppression. 2. Clean sensor if necessary 3. If necessary, select better installation position 4. If necessary due to wide interference echoes, set function "detection window" (0A7) to "off".
With an uneven surface (e.g. filling, emptying, running agitator) the measured value may jump sporadically to higher levels	 L00-FMR2xxxx-19-00-00-en-015  L00-FMR2xxxx-19-00-00-en-016	1. Carry out interference echo suppression 2. Set the process cond. (004) to "calm surface" or "add. agitator" 3. Increase output damping (058). 4. If necessary, select a different installation position and/or a larger sensor
On filling/emptying the measured value drops	 L00-FMR2xxxx-19-00-00-en-017	1. Check tank shape (002), e.g. "dome ceiling" or "horizontal cyl." 2. If possible, do not select a central installation position 3. Possible user stilling well/echo guide pipe

Error	Example	Elimination
E 641 (echo loss)	 L00-FMR2xxxx-19-00-00-en-018	1. Check application parameters (002), (003) and (004) 2. If necessary, select a different installation position and/or a larger sensor 3. Align the sensor parallel to the product surface (particularly for bulk solids applications)

8 Maintenance and repairs

8.1 Exterior cleaning

When cleaning the exterior, always use cleaning agents that do not attack the surface of the housing and the seals.

8.2 Repairs

The Endress+Hauser repair concept assumes that the measuring devices have a modular design and that customers are able to undertake repairs themselves.
Spare parts are contained in suitable kits. They contain the related replacement instructions.
All the spare parts kits which you can order from Endress+Hauser for repairs are listed with their order numbers in the section "Spare parts".
For more information on service and spare parts, contact the Service Department at Endress+Hauser.

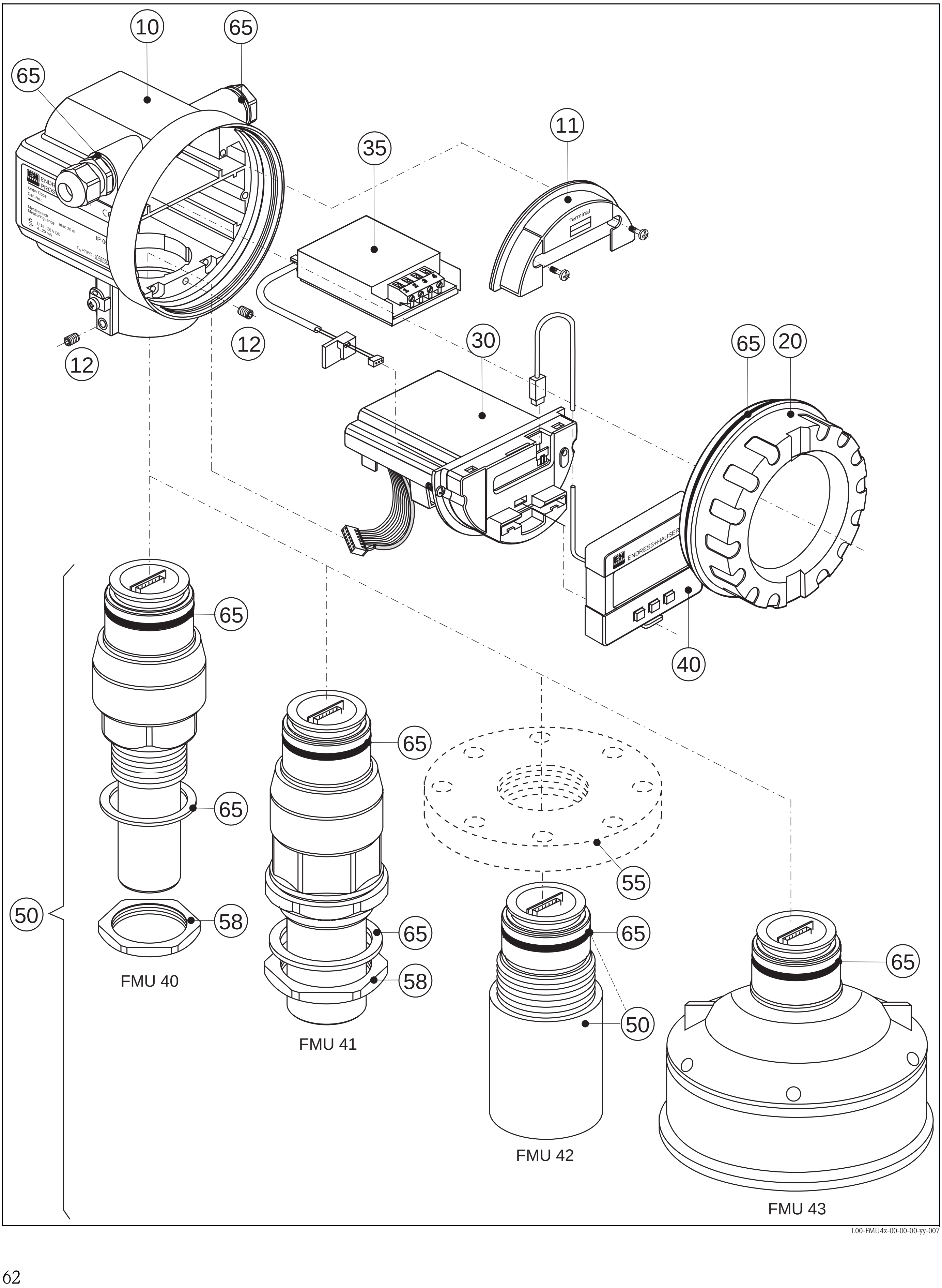
8.3 Repairs to Ex-approved devices

When carrying out repairs to Ex-approved devices, please note the following:
- Repairs to Ex-approved devices may only be carried out by trained personnel or by the Endress+Hauser Service.
- Comply with the prevailing standards, national Ex-area regulations, safety instructions (XA) and certificates.
- Only use original spare parts from Endress+Hauser.
- When ordering a spare part, please note the device designation on the nameplate. Only replace parts with identical parts.
- Carry out repairs according to the instructions. On completion of repairs, carry our the specified routine test on the device.
- Only Endress+Hauser Service may convert a certified device into a different certified variant.
- Document all repair work and conversions.

8.4 Replacement

After a complete instrument or electronic module has been replaced, the parameters can be downloaded into the instrument again via the communication interface. Prerequisite to this is that the data were uploaded to the PC beforehand using the ToF Tool / Commuwin II. Measurement can continue without having to carry out a new setup. Only a linearisation and a tank map (interference echo suppression) have to be recorded again.

8.5 Spare parts (housing type F12)



L00-FMU4x-00-00-00-yy-007

10 Housing

543120-0022 Housing F12, aluminium, G1/2

543120-0023 Housing F12, aluminium, NPT1/2

543120-0024 Housing F12, aluminium, M20

52001992 Housing F12, aluminium, M20, PA connector

52008556 Housing F12, aluminium, M20, FF connector

52013350 Housing F12, aluminium, coated, M20, 4-wire

52013351 Housing F12, aluminium, coated, M20, metal

52013348 Housing F12, aluminium, coated, G1/2, 4-wire

52013349 Housing F12, aluminium, coated, NPT1/2, 4-wire

11 Hood for terminal compartment

52006026 Cover for the connection compartment F12

52019062 Cover for the connection compartment F12, FHX40

12 Set of screws

535720-9020 Set of screws for housing F12/T12

20 Cover

52005936 Cover F12/T12 aluminium, inspection glass, seal

517391-0011 Cover F12/T12 aluminium, coated, seal

30 Electronics

71025600 electronics FMU4x, Ex, 2-wire HART, V4.0

71025602 electronics FMU4x, Ex, 4-wire HART, V4.0

71025603 electronics FMU4x, Ex, PROFIBUS PA, V4.0

52023759 Electronics Prosonic M, Ex, FF, V2.04

35 Terminal module / power unit

52006197 Terminal module 4-pin, HART, 2-wire with connecting cable

52012156 Terminal module 4-pin, PROFIBUS PA, Foundation Fieldbus

52013304 Power unit, 10.5...32V DC (housing F12) for electronics, 4-wire

52013305 Power unit, 90 ...250V AC (housing F12) for electronics, 4-wire

52015585 Power unit, CSA, 10.5...32V DC (housing F12) for electronics, 4-wire

52015586 Power unit, CSA, 90...250V AC (housing F12) for electronics, 4-wire

40 Display

52005585 Display/operating module VU331

50 Probe with process connection

52010509 Sensor FMU40 G1-1/2

52010507 Sensor FMU40 NPT1-1/2

52010510 Sensor FMU41 G2

52010508 Sensor FMU41 NPT2

52023965 Sensor FMU42

52013543 Sensor FMU43 4", gasket

55 Flanges

52023919 Flange, Uni-DN80/ANSI 3"/JIS 80A, PP

52023920 Flange, Uni-DN80/ANSI 3"/JIS 80A, PVDF

52023921 Flange, Uni-DN80/ANSI 3"/JIS 80A, 316L

52023922 Flange, Uni-DN100/ANSI 4"/JIS 100A, PP

52023923 Flange, Uni-DN100/ANSI 4"/JIS 100A, PVDF

58 Hexagon nut

52000599 Hexagon nut (SW60) G1-1/2, bk, PC

52000598 Hexagon nut (SW70) G2, bk, PC

65 Sealing kit

52010526 Sealing kit FMU4x

Miscellaneous

52010545 Nameplate Prosonic M, modification

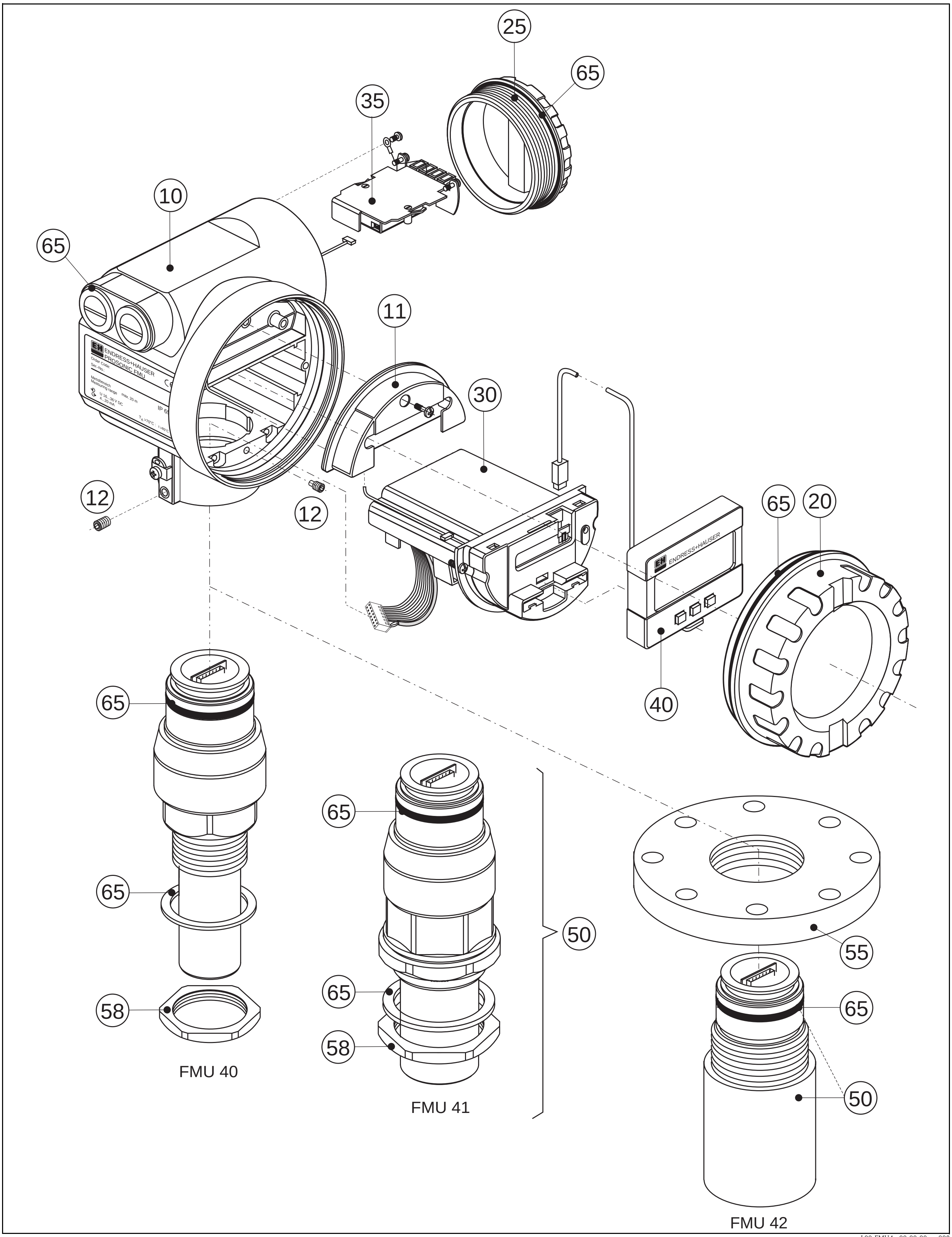
Spare parts for FHX40

52018204 Adaption kit housing F12, 2-wire, FHX40

52018205 Adaption kit housing F12, 4-wire, FHX40

52016334 Cable FHX40, 20m

8.6 Spare parts (housing type T12)



L00-FMU4x-00-00-00-yy-008

10 Housing

543180-1023 Housing T12, aluminium, NPT1/2, PEL

52006204 Housing T12, aluminium, G1/2, PEL, cover

52006205 Housing T12, aluminium, M20, PEL, cover

11 Hood for terminal compartment

52005643 Hood T12

12 Set of screws

535720-9020 Set of screws for housing F12/T12

20 Cover

517391-0011 Cover F12/T12 aluminium, coated, seal

52005936 Cover F12/T12 aluminium, inspection glass, seal

25 Cover for the connection compartment

518710-0020 Cover T3/T12, aluminium, coated, seal

30 Electronics

71025600 electronics FMU4x, Ex, 2-wire HART, V4.0

71025603 electronics FMU4x, Ex, PROFIBUS PA, V4.0

52023759 Electronics Prosonic M, Ex, FF, V2.04

35 Terminal module / power unit

52013302 Terminal module Ex d, 4-pin, 2-wire, HART, T12

52013303 Terminal module Ex d, 2-pin, 2-wire, PROFIBUS PA, Foundation Fieldbus, T12

52018949 Terminal module EEx ia, 4-pin, HART, T12, OVP

52018950 Terminal module EEx ia, 4-pin, PROFIBUS PA, Foundation Fieldbus, T12, OVP

40 Display

52005585 Display/operating module VU331

50 Probe with process connection

52010509 Sensor FMU40 G1-1/2

52010507 Sensor FMU40 NPT1-1/2

52010510 Sensor FMU41 G2

52010508 Sensor FMU41 NPT2

52023965 Sensor FMU42

55 Flanges

52023919 Flange, Uni-DN80/ANSI 3"/JIS 80A, PP

52023920 Flange, Uni-DN80/ANSI 3"/JIS 80A, PVDF

52023921 Flange, Uni-DN80/ANSI 3"/JIS 80A, 316L

52023922 Flange, Uni-DN100/ANSI 4"/JIS 100A, PP

52023923 Flange, Uni-DN100/ANSI 4"/JIS 100A, PVDF

52023924 Flange, Uni-DN100/ANSI 4"/JIS 100A, 316L

58 Hexagon nut

52000598 Hexagon nut (SW70) G2, bk, PC

52000599 Hexagon nut (SW60) G1-1/2, bk, PC

65 Sealing kit

52010526 Sealing kit FMU4x

Miscellaneous

52010545 Nameplate Prosonic M, modification

8.7 Return

The following procedures must be carried out before a transmitter is sent to Endress+Hauser e.g. for repair or calibration:

- Remove all residue which may be present. Pay special attention to the gasket grooves and crevices where fluid may be present. This is especially important if the fluid is dangerous to health, e.g. corrosive, poisonous, carcinogenic, radioactive, etc.
- Always enclose a duly completed "Declaration of contamination" form (a copy of the “Declaration of contamination” is included at the end of this operating manual). Only then can Endress +Hauser transport, examine and repair a returned device.
- Enclose special handling instructions if necessary, for example a safety data sheet as per EN 91/ 155/EEC.

Additionally specify:

- An exact description of the application.
- The chemical and physical characteristics of the product.
- A short description of the error that occurred (specify error code if possible)
- Operating time of the device.

8.8 Disposal

In case of disposal please seperate the different components according to their material consistence.

8.9 Software history

Software version / date	Changes to software	Changes to documentation
V 01.02.00 / 01.2002 V 01.02.02 / 03.2003	Original software Compatible with: ▪ ToF Tool ▪ Commuwin II (version 2.05.03 and higher ▪ HART Communicator DXR 275 (from OS 4.6) with Rev. 1, DD 1	
V 01.02.04/02.2004	▪ FMU 42 added ▪ compatible with HART Communicator DXR 375	FMU 42 added
V 01.04.00/07.2006	▪ "detection window" function added can be operated via: ▪ ToF Tool from version 4.50 ▪ HART Communicator DXR375 with Rev. 1, DD1	"detection window" added Version: 07.06

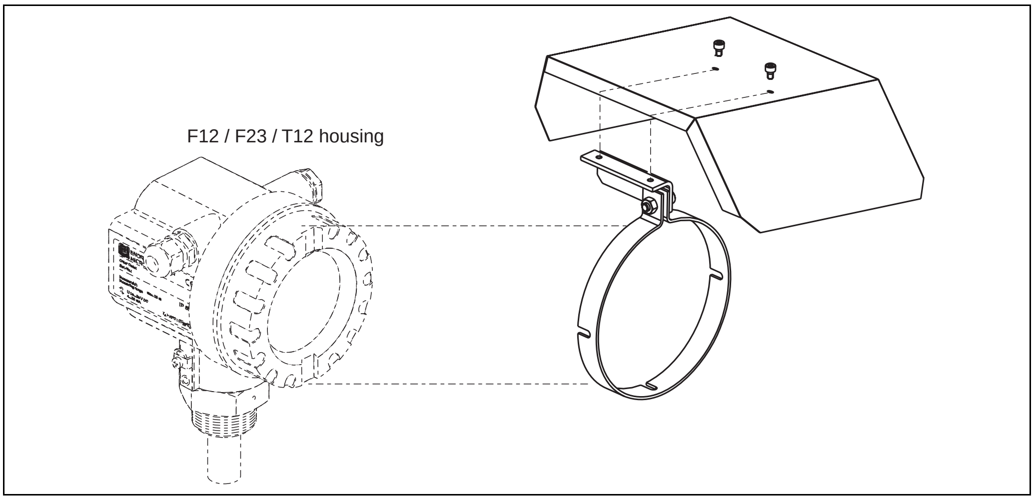
8.10 Contact addresses of Endress+Hauser

Contact addresses can be found on our homepage: www.endress.com/worldwide. If you have any questions, please do not hesitate to contact your Endress+Hauser representative.

9 Accessories

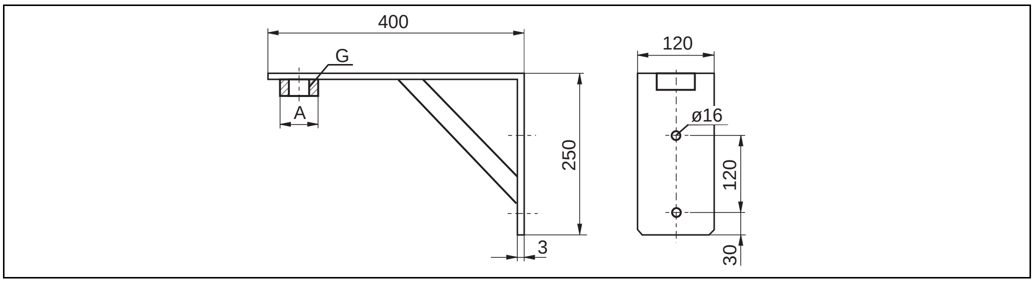
9.1 Weather protection cover

A Weather protection cover made of stainless steel is recommended for outdoor mounting (order code: 543199-0001). The shipment includes the protective cover and tension clamp.



L00-FMR2xxxx-00-00-06-en-001

9.2 Installation bracket for FMU 40/41

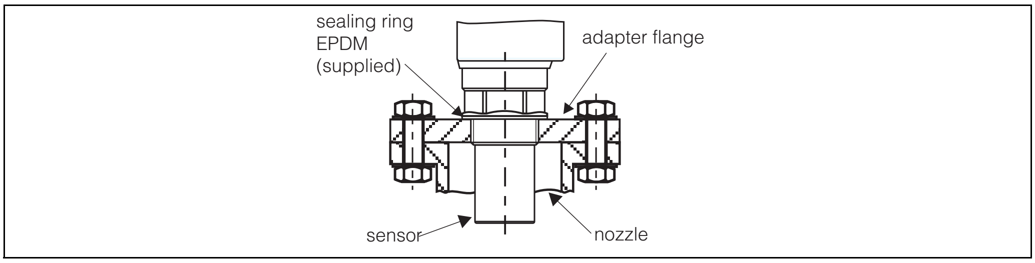


L00-FMU4x-00-00-00-de-001

- for FMU 40, G1½: Order No. 942669-0000
- for FMU 41, G2: Order No. 942669-0001

suited for NPT 1½" and 2" as well

9.3 Adapter flange



L00-FMUX3XXX-00-00-00-en-001

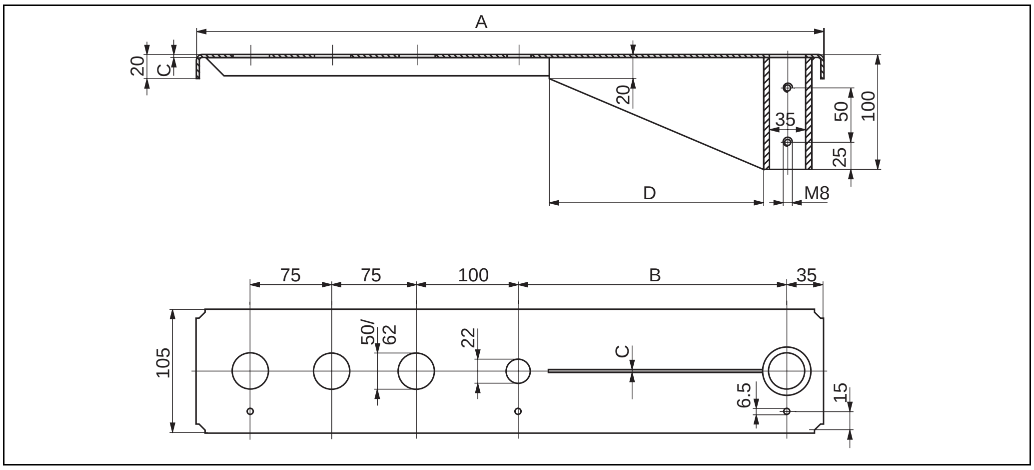
9.3.1 Version with metrical thread (FAU 70 E)

	Process Connection			
	12	DN 50 PN 16 A, flange EN1092-1 (DIN2527 B)		
	14	DN 80 PN 16 A, flange EN1092-1 (DIN2527 B)		
	15	DN 100 PN 16, A, flange EN1092-1 (DIN2527 B)		
		Sensor Connection		
		3	Thread ISO228 G1-1/2	
		4	Thread ISO228 G2	
			Flange Material	
			2	316L
			7	Polypropylene
FAU 70 E				Product designation

9.3.2 Version with conical thread(FAU 70 A)

	Process Connection			
	22	2" 150lbs FF, flange ANSI B16.5		
	24	3" 150lbs FF, flange ANSI B16.5		
	25	4" 150lbs FF, flange ANSI B16.5		
		Sensor Connection		
		5	Thread NPT1-1/2	
		6	Thread NPT2	
			Flange Material	
			2	316L
			7	Polypropylene
FAU 70 A				Product designation

9.4 Cantilever

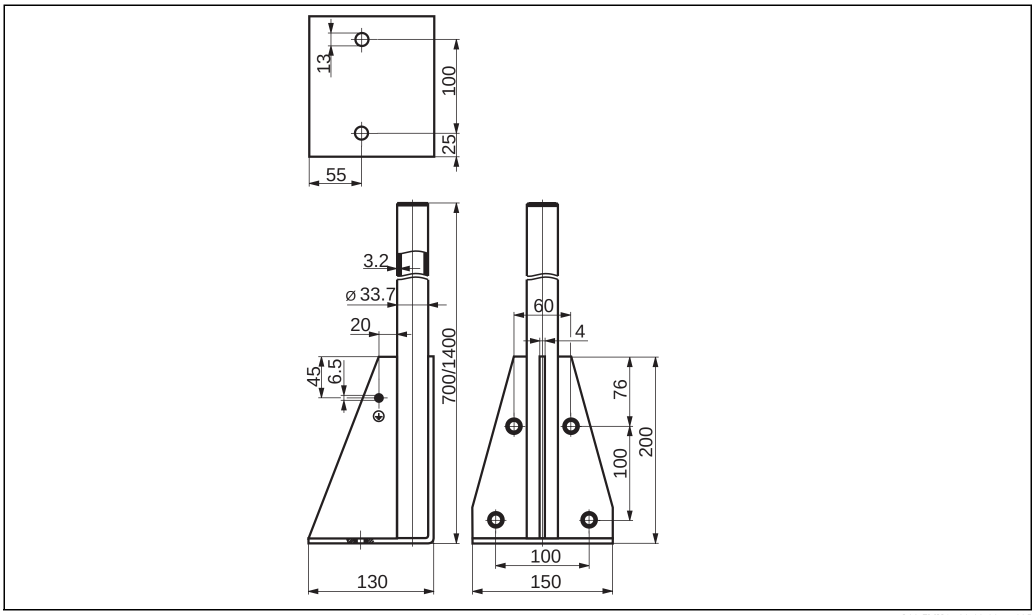


L00-FMU4xxxx-06-00-00-yy-005

A	B	C	D	for Sensor	Material	Order Code
585 mm	250 mm	2 mm	200 mm	FMU 40	1.4301 (AISI 304)	52014132
					galv. steel	52014131
				FMU 41	1.4301 (AISI 304)	52014136
					galv. steel	52014135
1085 mm	750 mm	3 mm	300 mm	FMU 40	1.4301 (AISI 304)	52014134
					galv. steel	52014133
				FMU 41	1.4301 (AISI 304)	52014138
					galv. steel	52014137

- The 50 mm or 62 mm orifices serve for the mounting of the FMU 40 or FMU 41 sensor, respecitvely.
- The 22 mm orifice may be used for an additional sensor.

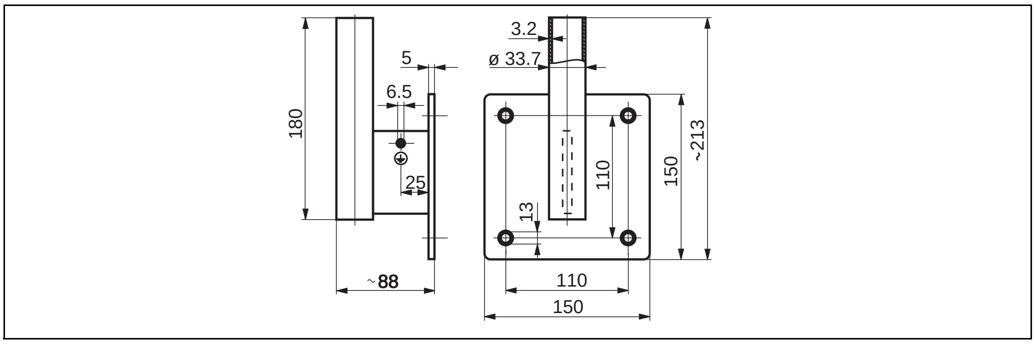
9.5 Mounting Frame



L00-FMU4x-00-00-00-yy-005

Height	Material	Order Code
700 mm	galv. steel	919791-0000
700 mm	1.4301 (AISI 304)	919791-0001
1400 mm	galv. steel	919791-0002
1400 mm	1.4301 (AISI 304)	919791-0003

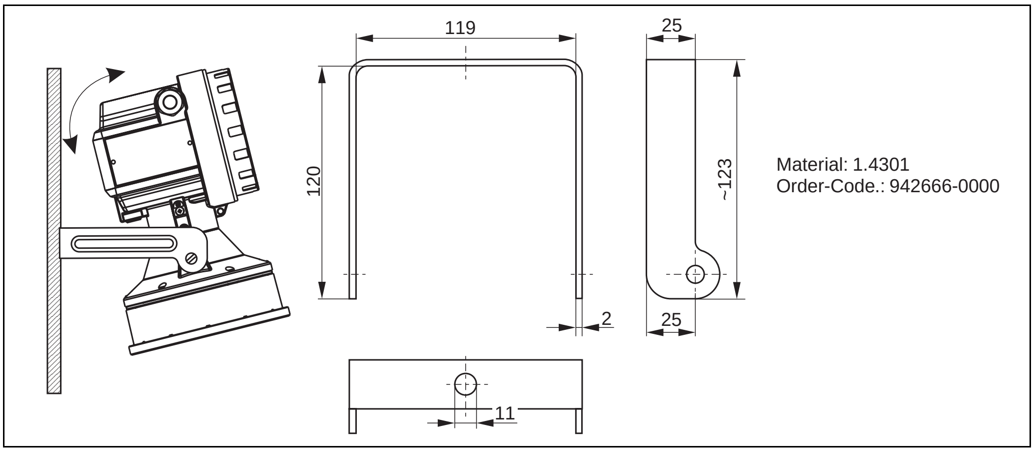
9.6 Wall Bracket



L00-FMU4x-00-00-00-yy-006

Material	Order Code
galv. steel	919792-0000
316Ti/1.4571	919792-0001

9.7 Mounting bracket for FMU 43



L00-FMU4x-00-00-00-en-003.eps

9.8 Commubox FXA291

The Commubox FXA291 connects Endress+Hauser field instruments with CDI interface (= Endress+Hauser Common Data Interface) to the USB interface of a personal computer or a notebook. For details refer to TI405C/07/en.

Note!
For the following Endress+Hauser instruments you need the "ToF Adapter FXA291" as an additional accessory:

- Cerabar S PMC71, PMP7x
- Deltabar S PMD7x, FMD7x
- Deltapilot S FMB70
- Gammapilot M FMG60
- Levelflex M FMP4x
- Micropilot FMR130/FMR131
- Micropilot M FMR2xx
- Micropilot S FMR53x, FMR540
- Prosonic FMU860/861/862
- Prosonic M FMU4x
- Tank Side Monitor NRF590 (with additional adapter cable)

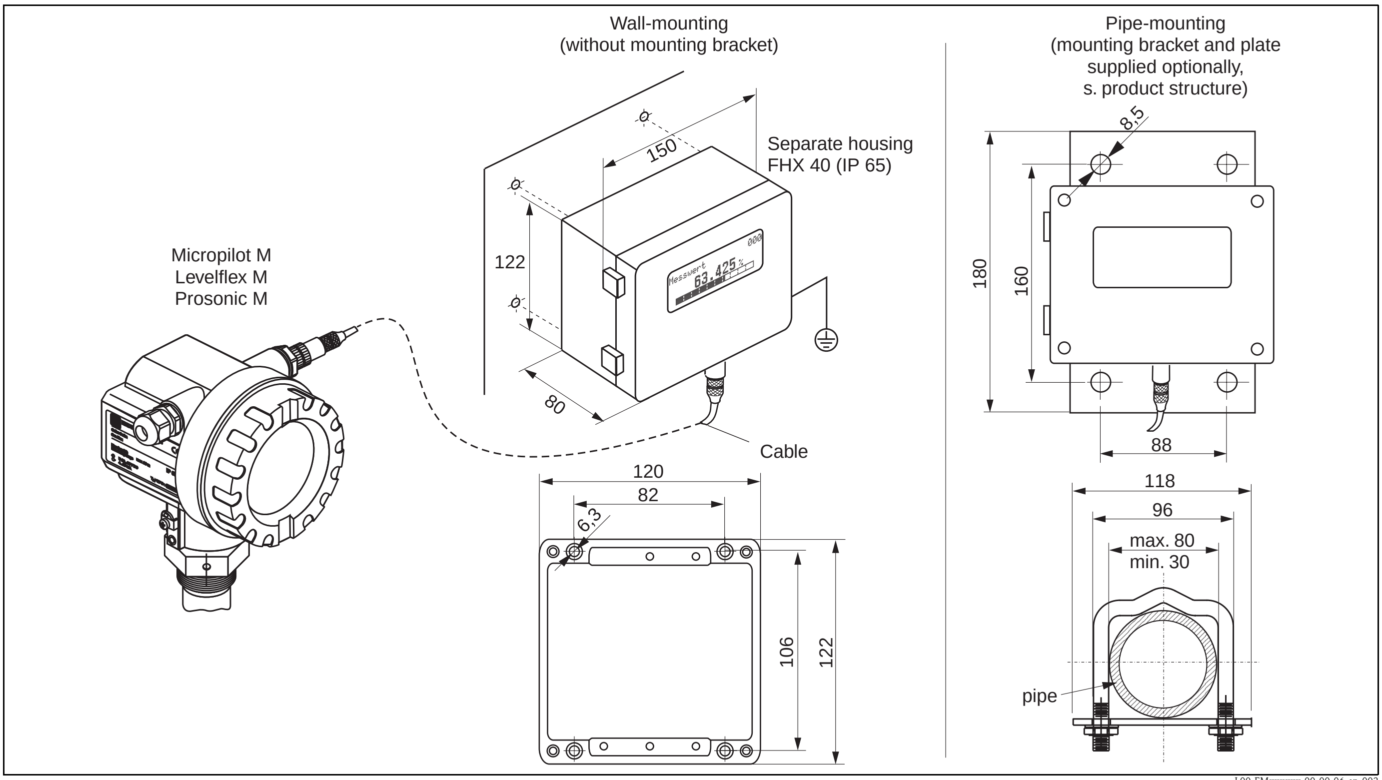
9.9 ToF Adapter FXA291

The ToF Adapter FXA291 connects the Commubox FXA291 via the USB interface of a personal computer or a notebook to the following Endress+Hauser instruments:

- Cerabar S PMC71, PMP7x
- Deltabar S PMD7x, FMD7x
- Deltapilot S FMB70
- Gammapilot M FMG60
- Levelflex M FMP4x
- Micropilot FMR130/FMR131
- Micropilot M FMR2xx
- Micropilot S FMR53x, FMR540
- Prosonic FMU860/861/862
- Prosonic M FMU4x
- Tank Side Monitor NRF590 (with additional adapter cable)

For details refer to KA271F/00/a2.

9.10 Remote display FHX40



L00-FMxxxxxx-00-00-06-en-003

9.10.1 Technical data (cable and housing) and product structure:

Max. cable length	20 m (65 ft)
Temperature range	-30 °C...+70 °C (-22 °F...158 °F)
Degree of protection	IP65 acc. to EN 60529 (NEMA 4)
Materials	Housing: AlSi12; cable glands: nickle plated brass
Dimensions [mm] / [inch]	122x150x80 (HxWxD) / 4.8x5.9x3.2

	Approval:			
	A	Nn-hazardous area		
	1	ATEX II 2 G EEx ia IIC T6, ATEX II 3D		
	S	FM IS Cl.I Div.1 Gr.A-D		
	U	CSA IS Cl.I Div.1 Gr.A-D		
	N	CSA General Purpose		
	K	TIIS ia IIC T6 (in preparation)		
		Cable:		
		1	20m/65ft; for HART	
		5	20m/65ft; for PROFIBUS PA/FOUNDATION Fieldbus	
			Additional option:	
			A	Basic version
			B	Mounting bracket, pipe 1"/ 2"
FHX40 -				Complete product designation

For connection of the remote display FHX40 use the cable which fits the communication version of the respective instrument.

10 Technical Data

10.1 Technical data at a glance

10.1.1 Input

Measured variable

The distance D between the sensor membrane and the product surface is measured.

Using the linearisation function, the device uses D to calculate:
- level L in any units
- volume V in any units
- flow Q across measuring weirs or open channels in any units

Maximum range/blocking distance

Sensor	Maximum range in liquids[1]	Maximum range in solids[1]	blocking distance
FMU 40	5 m	2 m	0,25 m
FMU 41	8 m	3,5 m	0,35 m
FMU 42	10 m	5 m	0,4 m
FMU 43	15 m	7 m	0,6 m

[1]The actual range is dependent on the measuring conditions. Refer to Technical Information TI 365F/00/en for an estimation.

10.1.2 Output

Output signal

PROFIBUS PA

Signal on alarm

- Error symbol, error code and plain text description on the on-site display
- Status byte of the digital signal input

10.1.3 Auxiliary energy

Cable entry

- Cable gland M20x1.5 (recommended cable diameter 6 ... 10 mm)
- Cable entry G½ or ½ NPT
- PROFIBUS M12 plug

Supply voltage

9 V ... 32 V
There may be additional restrictions for devices with an explosion protection certificate. Refer to the notes in the appropriate safety instructions (XA).

Current consumption

approx. 12 mA for the range of voltages given above

10.1.4 Performance characteristics

Reaction time

The reaction time depends on the parameter settings (min. 2s).

Reference operating conditions

- Temperature = +20 °C
- Pressure = 1013 mbar abs.
- Humidity = 50 %
- Ideal reflective surface (e.g. calm, smooth fluid surface)
- No interference reflections within signal beam
- Set application parameters:
  - Tank shape = flat ceiling
  - Medium property = liquid
  - process conditions = calm surface

Measured value resolution

Sensor	Measured value resolution
FMU 40	1 mm
FMU 41	1 mm
FMU 42	2 mm
FMU 43	2 mm

Measuring error

Typical specifications for reference operating conditions (include linearity, repeatability, and hysteresis):

Sensor	Measuring error
FMU 40	±2mm or 0.2% of set measuring distance (empty calibration)[1]
FMU 41	± 2 mm or 0,2% of set measuring distance (empty calibration)[1]
FMU 42	± 4 mm or 0,2% of set measuring distance (empty calibration)[1]
FMU 43	± 4 mm or 0,2% of set measuring distance (empty calibration)[1]

[1]whichever is greater

10.1.5 Ambient conditions

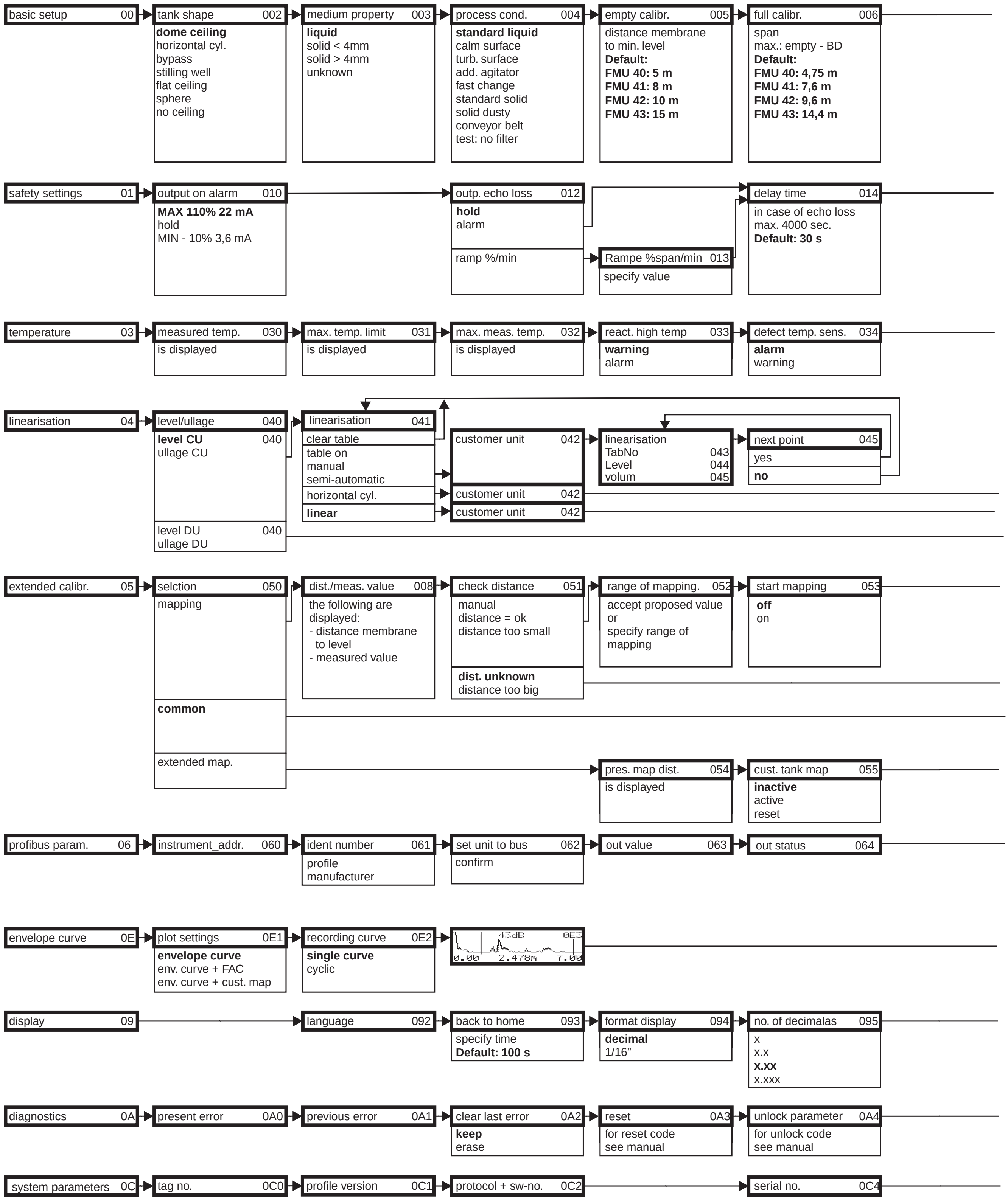
Ambient temperature	-40 °C ... +80 °C The functionality of the LC display becomes restricted at Tu<-20 °C and Tu>+60 °C. If the device is operated outdoors in strong sunlight, you should use a protective cover.
Storage temperature	-40 °C ... +80 °C
Climate class	DIN EN 60068-2-38 (Test Z/AD) DIN/IEC 68 T2-30Db
Ingress protection	▪ With closed housing, tested according to – IP 68, NEMA 6P (24h at 1.83m under water surface) – IP 66, NEMA 4x ▪ With open housing: IP 20, NEMA 1 (also ingress protection of the display)
Vibration resistance	DIN EN 60068-2-64 / IEC 68-2-64: 20…2000 Hz, 1 $(m/s^2)^2/Hz$; 3 x 100 min
Electromagnetic compatibility (EMC)	▪ Interference emission to EN 61326, Equipment Class B ▪ Interference immunity to EN 61326, Appendix A (Industrial) and NAMUR Recommendation NE 21 (EMC). ▪ A standard installation cable is sufficient if only the analogue signal is used. Use a screened cable when working with a superimposed communication signal (HART).

10.1.6 Process conditions

Process temperature	-40°C ... +80°C A temperature sensor is integrated in the sensor for correction of the temperature-dependent time-of-flight.
Process pressure	▪ FMU 40/41: 0.7 bar ... 3bar abs. ▪ FMU 42/43: 0.7 bar ... 2.5bar abs. ✎ Note! For pressures less than 0.7 bar please contact Endress+Hauser

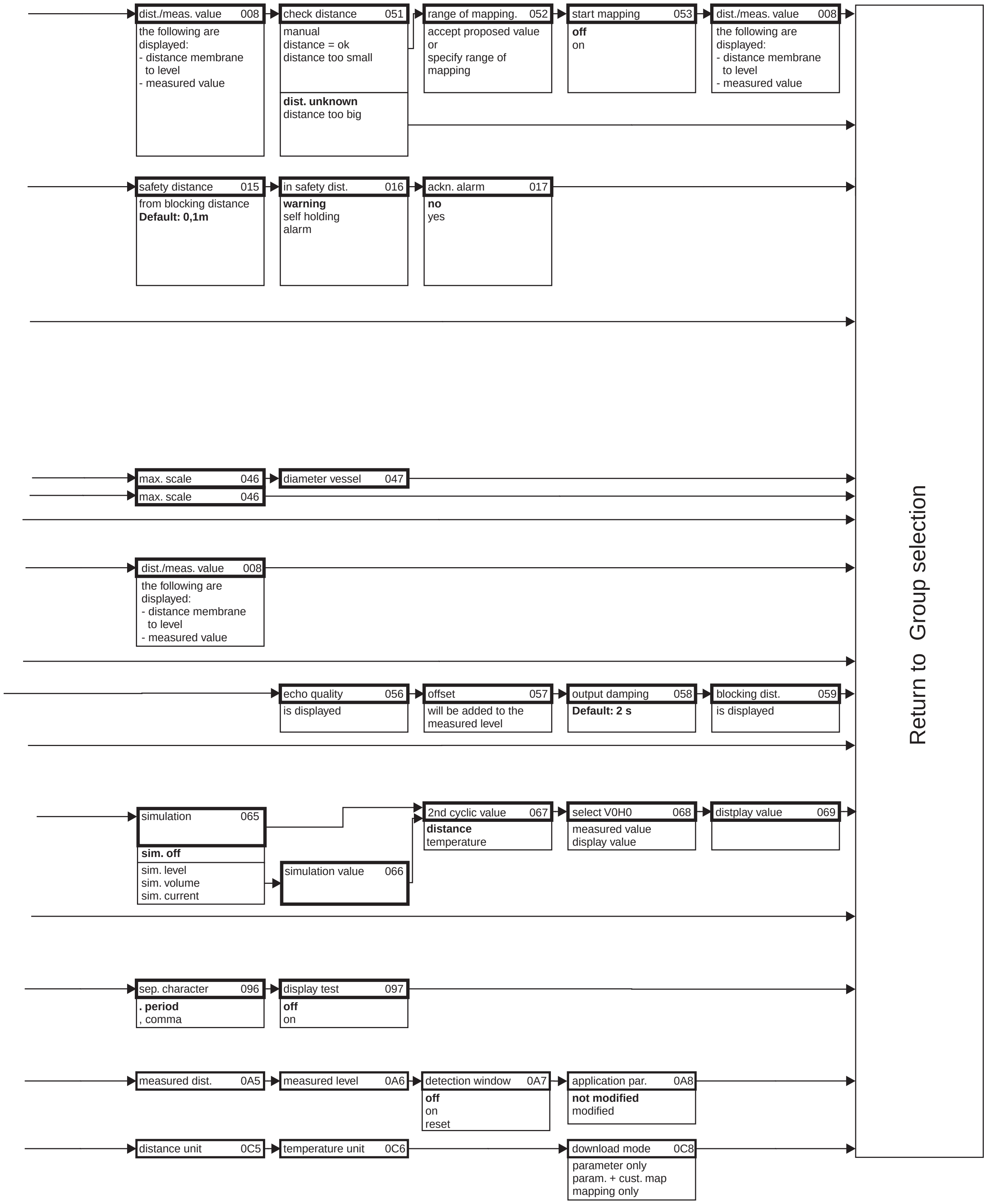
11 Appendix

11.1 Operating menu



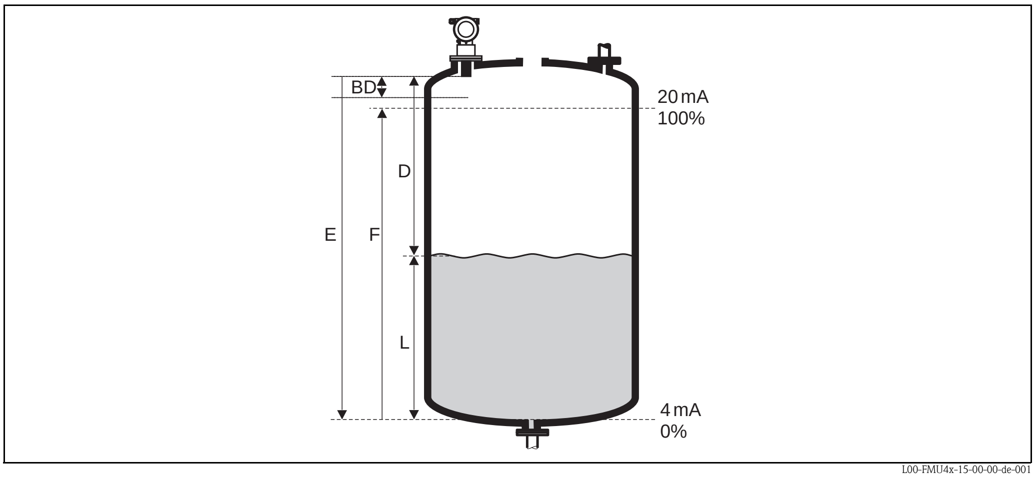
Note! The Default values of the parameters are typed in bold face.

L00-FMU4xxxx-19-00-01-en-016



L00-FMU4xxxx-19-00-02-en-016

11.2 Measuring principle



E: Empty distance; F: Span (full distance); D: Distance from sensor membrane – product surface; L: Level; BD: Blocking distance

Sensor	BD	Max. range fluids	Max. range bulk materials
FMU 40	0.25 m	5 m	2 m
FMU 41	0.35 m	8 m	3.5 m
FMU 42	0.4 m	10 m	5 m
FMU 43	0.6 m	15 m	7 m

11.2.1 Time-of-flight method

The sensor of the Prosonic M transmits ultrasonic pulses in the direction of the product surface. There, they are reflected back and received by the sensor. The Prosonic M measures the time t between pulse transmission and reception. The instrument uses the time t (and the velocity of sound c) to calculate the distance D between the sensor membrane and the product surface:

$D = c \cdot t/2$

As the device knows the empty distance E from a user entry, it can calculate the level as follows:

$L = E - D$

An integrated temperature sensor compensates for changes in the velocity of sound caused by temperature changes.

11.2.2 Interference echo suppression

The interference echo suppression feature on the Prosonic M ensures that interference echos (e.g. from edges, welded joints and installations) are not interpreted as a level echo.

11.2.3 Calibration

Enter the empty distance E and the span F to calibrate the device.

11.2.4 Blocking distance

Span F may not extend into the blocking distance BD. Level echos from the blocking distance cannot be evaluated due to the transient characteristics of the sensor.

Index

Endress+Hauser
People for Process Automation

Declaration of Hazardous Material and De-Contamination
Erklärung zur Kontamination und Reinigung

RA No. ☐☐☐☐☐☐☐☐

Please reference the Return Authorization Number (RA#), obtained from Endress+Hauser, on all paperwork and mark the RA# clearly on the outside of the box. If this procedure is not followed, it may result in the refusal of the package at our facility.
Bitte geben Sie die von E+H mitgeteilte Rücklieferungsnummer (RA#) auf allen Lieferpapieren an und vermerken Sie diese auch außen auf der Verpackung. Nichtbeachtung dieser Anweisung führt zur Ablehnung ihrer Lieferung.

Because of legal regulations and for the safety of our employees and operating equipment, we need the "Declaration of Hazardous Material and De-Contamination", with your signature, before your order can be handled. Please make absolutely sure to attach it to the outside of the packaging.
Aufgrund der gesetzlichen Vorschriften und zum Schutz unserer Mitarbeiter und Betriebseinrichtungen, benötigen wir die unterschriebene "Erklärung zur Kontamination und Reinigung", bevor Ihr Auftrag bearbeitet werden kann. Bringen Sie diese unbedingt außen an der Verpackung an.

Type of instrument / sensor
Geräte-/Sensortyp ____

Serial number
Seriennummer ________________________

☐ **Used as SIL device in a Safety Instrumented System /** *Einsatz als SIL Gerät in Schutzeinrichtungen*

Process data/ *Prozessdaten*

Temperature / *Temperatur*_____ [°F] _____ [°C]
Pressure / *Druck* _____ [psi] _____ [Pa]
Conductivity / *Leitfähigkeit* ________ [µS/cm]
Viscosity / *Viskosität* _____ [cp] _____ [mm^2/s]

Medium and warnings
Warnhinweise zum Medium

	Medium /concentration *Medium /Konzentration*	Identification CAS No.	flammable *entzündlich*	toxic *giftig*	corrosive *ätzend*	harmful/ irritant *gesundheits-schädlich/ reizend*	other * *sonstiges**	harmless *unbedenklich*
Process medium *Medium im Prozess*								
Medium for process cleaning *Medium zur Prozessreinigung*								
Returned part cleaned with *Medium zur Endreinigung*								

* explosive; oxidising; dangerous for the environment; biological risk; radioactive
* *explosiv; brandfördernd; umweltgefährlich; biogefährlich; radioaktiv*

Please tick should one of the above be applicable, include safety data sheet and, if necessary, special handling instructions.
Zutreffendes ankreuzen; trifft einer der Warnhinweise zu, Sicherheitsdatenblatt und ggf. spezielle Handhabungsvorschriften beilegen.

Description of failure / *Fehlerbeschreibung* ____
____
____

Company data / *Angaben zum Absender*

Company / *Firma* ______________________________
____
Address / *Adresse*
____
____

Phone number of contact person / *Telefon-Nr. Ansprechpartner:*
____
Fax / E-Mail ______________________________
Your order No. / *Ihre Auftragsnr.* ______________________________

"We hereby certify that this declaration is filled out truthfully and completely to the best of our knowledge.We further certify that the returned parts have been carefully cleaned. To the best of our knowledge they are free of any residues in dangerous quantities."
"Wir bestätigen, die vorliegende Erklärung nach unserem besten Wissen wahrheitsgetreu und vollständig ausgefüllt zu haben. Wir bestätigen weiter, dass die zurückgesandten Teile sorgfältig gereinigt wurden und nach unserem besten Wissen frei von Rückständen in gefahrbringender Menge sind."

P/SF/Konta XIV

(place, date / *Ort, Datum*) | Name, dept./*Abt.* (please print / *bitte Druckschrift*) | Signature / *Unterschrift* www.endress.com/worldwide

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People for Process Automation

BA238F/00/en/08.06
CCS/FM+SGML 6.0/ProMoDo

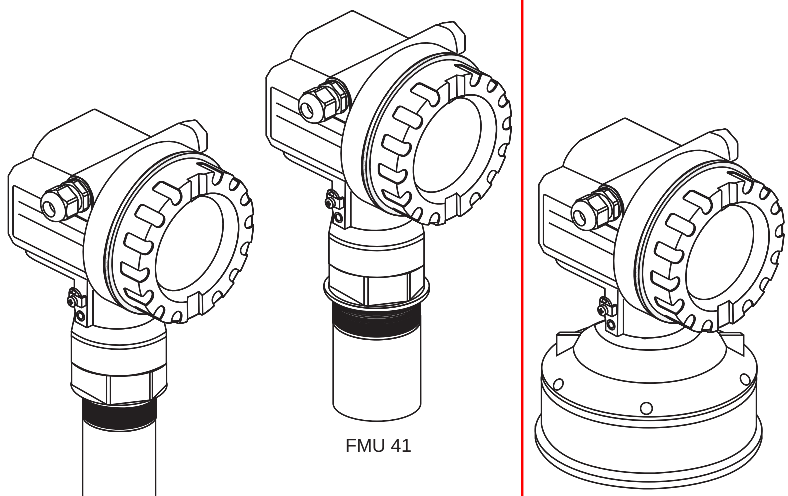
52010986

BA 240F/00/en/01.02
Nr. 52011048

Valid as of software version:
V 01.02.00 (amplifier)
V 01.02.00 (communication)

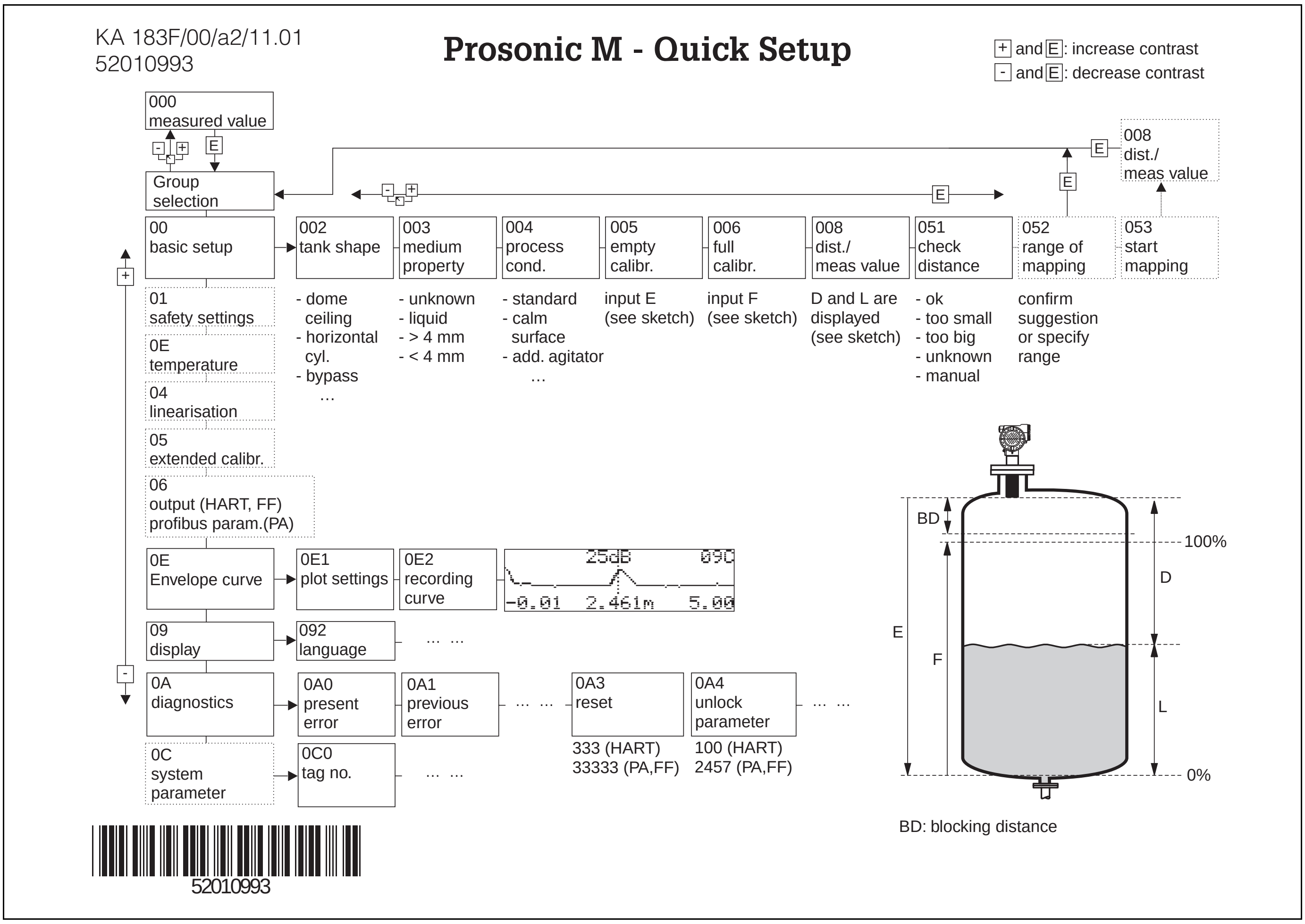
prosonic M
FMU 40/41/43 with HART, PROFIBUS-PA and Foundation Fieldbus Ultrasonic Level Measurement

Description of Instrument Functions



Endress+Hauser
The Power of Know How

Short instructions



Contents of the operating instructions

This operating instrucitons contain all functions off the Prosonic M operating menu. All types of devices (FMU 40/41/43) and all communication variants are considered.

Information on mounting, wiring, trouble shooting and maintenance can be found in the following documents which are supplied together with the instrument:

- BA 237F/00/en (HART)
- BA 238F/00/en (PROFIBUS-PA)
- BA 239F/00/en (Foundation Fieldbus)

These documents can also be found on the second ToF Tool CD-ROM "Device Desriptions + Documentation"

Table of contents

1 Notes on use

You have various options for accessing the descriptions of instrument functions or how to enter parameters.

1.1 Using the table of contents to locate a function description

All the functions are listed in the table of contents sorted by function group (e.g. basic setup, safety settings, etc.). You can access a more detailed description of a function by using a page reference / link.
The table of contents is on Page 3.

1.2 Using the graphic of the function menu to locate a function description

This guides you step by step from the highest level, the function groups, to the exact function description you require.

All the available function groups and instrument functions are listed in the table (see Page 11). Select your required function group or function. You can access an exact description of the function group or function by using a page reference.

1.3 Using the index of the function menu to locate a function description

To simplify navigation within the function menu, each function has a position which is shown in the display. You can access each function via a page reference in the function menu index (see page 79) which lists all the function names alphabetically and numerically.

1.4 General structure of the operating menu

The operating menu is made up of two levels:

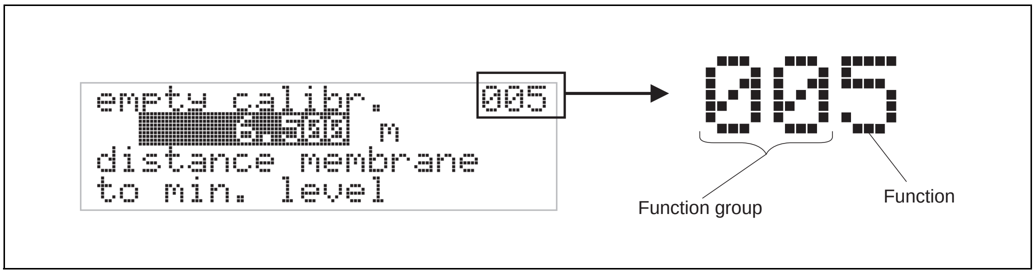
- **Function groups (00, 01, 03, …, 0C, 0D):**
  The individual operating Selection of the instrument are split up roughly into different function groups. The function groups that are available include, e.g.: "**basic setup**", "**safety settings**", "**output**", "**display**", etc.
- **Functions (001, 002, 003, …, 0D8, 0D9):**
  Each function group consists of one or more functions. The functions perform the actual operation or parameterisation of the instrument. Numerical values can be entered here and parameters can be selected and saved. The available functions of the “**basic setup (00)**” function group include, e.g.: "**tank shape (002)**", "**medium property (003)**", "**process cond. (004)**", "**empty calibr. (005)**", etc.

If, for example, the application of the instrument is to be changed, carry out the following procedure:

1. Select the “**basic setup (00)**” function group.
2. Select the "**tank shape (002)**" function (where the existing tank shape is selected).

1.4.1 Identifying the functions

For simple orientation within the function menus (see Page 11 ff.), for each function a position is shown on the display.



The first two digits identify the function group:

- **basic setup** **00**
- **safety settings** **01**
- **temperature** **03**

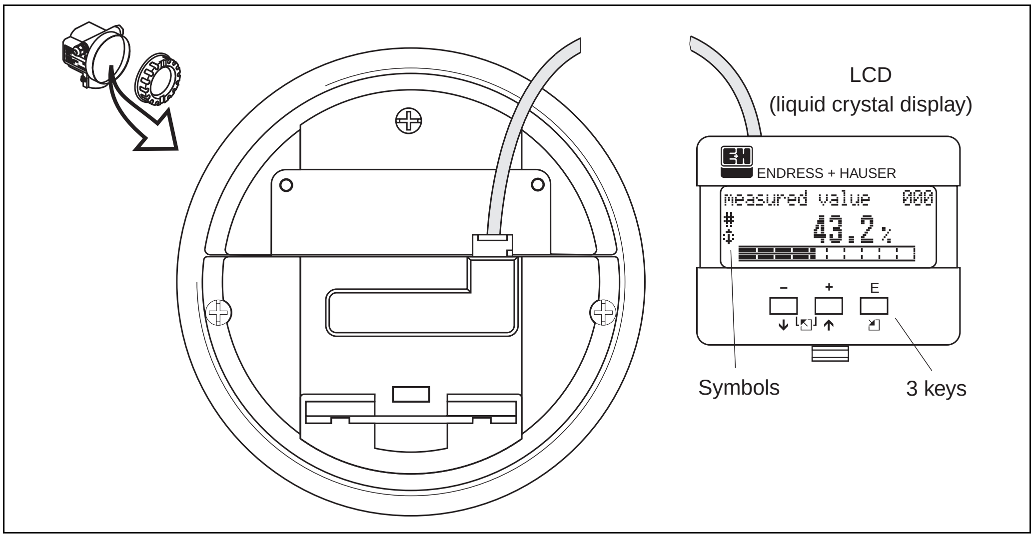
…

The third digit numbers the individual functions within the function group:

• **basic setup**	**00**	→	• **tank shape**	**002**
			• **medium property**	**003**
			• **process cond.**	**004**
			…	

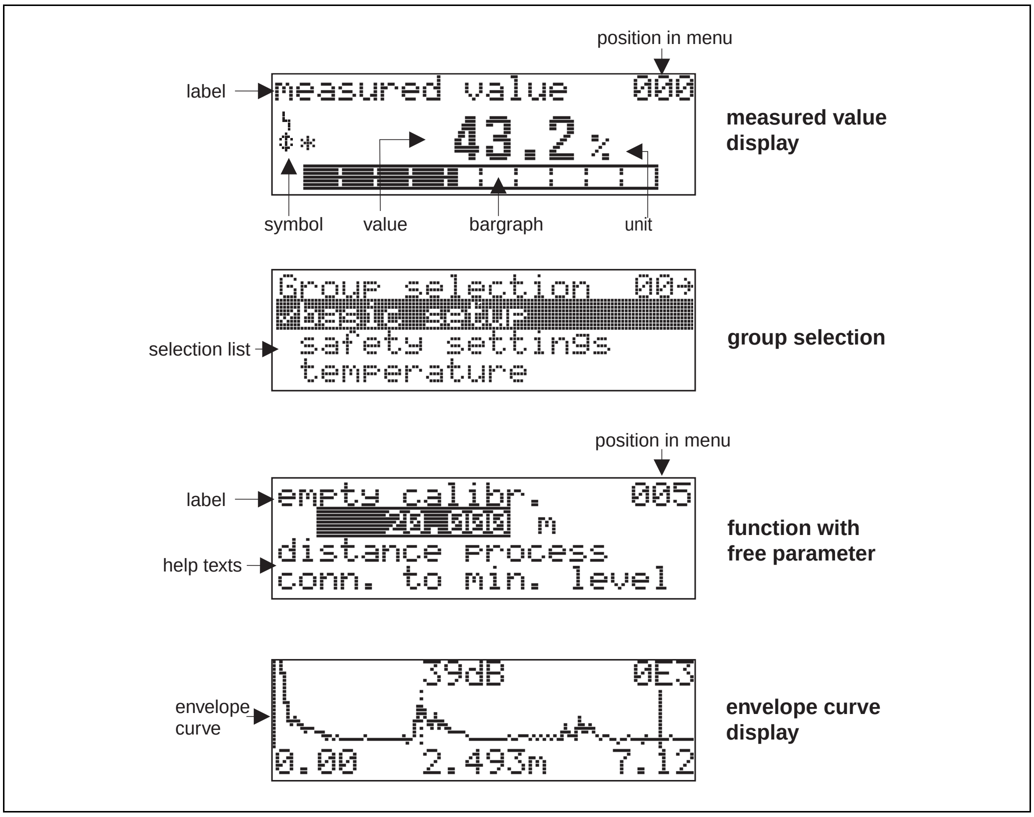
Hereafter the position is always given in brackets (e.g. "**tank shape**" **(002)**) after the described function.

1.5 Display and operating elements



1.5.1 Display

Liquid crystal display (LCD):
Four lines with 20 characters each. Display contrast adjustable through key combination.



1.5.2 Display symbols

The following table describes the symbols that appear on the liquid crystal display:

Symbols	Meaning
	**ALARM_SYMBOL** This alarm symbol appears when the instrument is in an alarm state. If the symbol flashes, this indicates a warning.
	**LOCK_SYMBOL** This lock symbol appears when the instrument is locked,i.e. if no input is possible.
	**COM_SYMBOL** This communication symbol appears when a data transmission via e.g. HART, PFOFIBUS-PA or Foundation Fieldbus is in progress.
	**SIMULATION_SWITCH_ENABLE** This communication symbol appears when simulation in FF is enabled via the DIP switch.

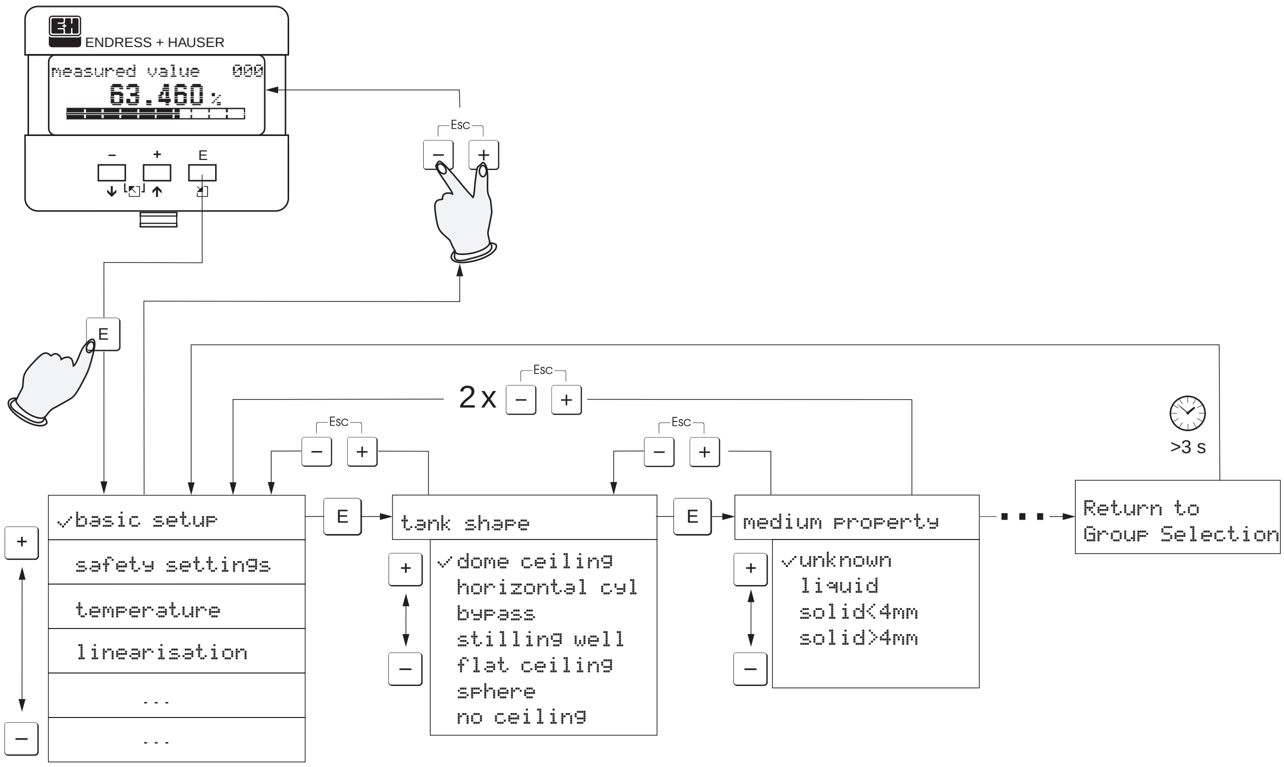
1.5.3 Key assignment

The operating elements are located inside the housing and are accessible for operation by opening the lid of the housing.

Function of the keys

Key(s)	Meaning
[+] or [↑]	Navigate upwards in the selection list Edit numeric value within a function
[–] or [↓]	Navigate downwards in the selection list Edit numeric value within a function
Esc [–] [+] or [↖]	Navigate to the left within a function group
[E] or [E]	Navigate to the right within a function group, confirmation.
[+] and [E] or [–] and [E]	Contrast settings of the LCD
[+] and [–] and [E]	Hardware lock / unlock After a hardware lock, an operation of the instrument via display or communication is not possible! The hardware can only be unlocked via the display. An unlock parameter must be entered to do so.

1.5.4 Operation with the VU 331



Selection and configuration in Operation menu:

1.) Change from Measured Value Display to **Group Selection** by pressing E

2.) Press − or + to select the required **Function Group** (e.g.. "basic setup (00)") and confirm by pressing E
➜ First f**unction** (e.g. "tank shape (002)") is selected.

Note!
The active selection is marked by a ✔ in front of the menu text.

3.) Activate Edit mode with + or −.

Selection menus:

a) Select the required **Parameter** in selected **function** (e.g. "tank shape (002)") with − or +.
b) E confirms selection ➜ ✔ appears in front of the selected parameter
c) E confirms the edited value ➜ system quits Edit mode
d) + / − (= Esc) interrupts selection ➜ system quits Edit mode

Typing in numerals and text:

a) Press + or − to edit the first character of the **numeral / text** (e.g. "empty calibr. (005)")
b) E positions the cursor at the next character ➜ continue with (a) until you have completed your input
c) if a ↵ symbol appears at the cursor, press E to accept the value entered
➜ system quits Edit mode
d) if a ← symbol appears at the cursor, press E to return to the previous character
(e.g. for correction of entries)
e) + / − (= Esc) interrupts the input, system quits Edit mode

4) Press E to select the next **function** (e.g. "medium property (003)")

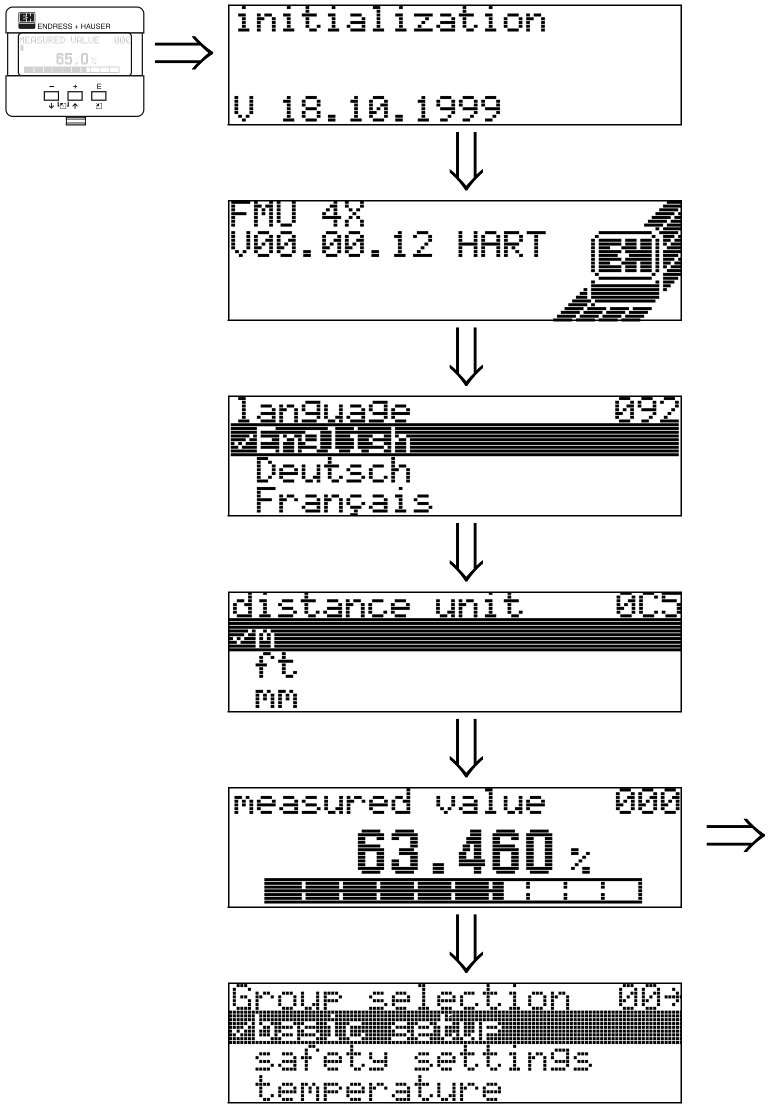
5) Press + / − (= Esc) once ➜ return to previous **function** (e.g. "tank shape (002)")
Press + / − (= Esc) twice ➜ return to **Group selection**

6) Press + / − (= Esc) to return to **Measured value display**

1.6 Commissioning

1.6.1 Switching on the measuring device

When the instrument is switched on for the first time, the following messages appear on the display:



After 5 s, the following message appears

After 5 s or after you have pressed E the following message appears

Select the language
(this message appears the first time the instrument is switched on)

Select the basic unit
(this message appears the first time the instrument is switched on)

The current measured value is displayed

After E is pressed, you reach the group selection.

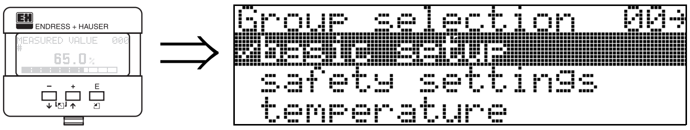
This selection enables you to perform the basic setup

2 Function menu Prosonic M

Function group		Function		Description
basic setup 00	⇒	measured value	000	Page 13
(see Page 13)		tank shape	002	Page 13
⇓		medium property	003	Page 14
		process cond.	004	Page 14
		empty calibr.	005	Page 16
		blocking dist.	059	Page 16
		full calibr.	006	Page 17
		display	008	Page 17
		check distance	051	Page 18
		range of mapping	052	Page 19
		start mapping	053	Page 19
		display	008	Page 20
safety settings 01	⇒	output on alarm	010	Page 21
(see Page 21)		output on alarm (HART only)	011	Page 23
⇓		outp. echo loss	012	Page 23
		ramp %span/min	013	Page 24
		delay time	014	Page 25
		safety distance	015	Page 25
		in safety dist.	016	Page 26
		ackn. alarm	017	Page 28
temperature 03	⇒	measured temp.	030	Page 29
(see Page 29)		max. temp. limit	031	Page 29
⇓		max. meas. temp.	032	Page 29
		react high temp.	033	Page 30
		defect temp. sens.	034	Page 30
linearisation 04	⇒	level/ullage	040	Page 31
(see Page 31)		linearisation	041	Page 32
⇓		customer unit	042	Page 36
		table no.	043	Page 37
		input level	044	Page 37
		input volume	045	Page 38
		max. scale	046	Page 38
		diameter vessel	047	Page 38
extended calibr. 05	⇒	selection	050	Page 39
(see Page 39)		check distance	051	Page 39
⇓		range of mapping	052	Page 40
		start mapping	053	Page 41
		pres. map dist.	054	Page 41
		cust. tank map	055	Page 42
		echo quality	056	Page 42
		offset	057	Page 43
		output damping	058	Page 43
		blocking dist.	059	Page 43

Function group		Function			Description
output **06**	⇒	commun. address (HART only)	060	→	Page 44
profibus param. **06**		instrument addr. (PROFIBUS-PA only)	060	→	Page 44
PROFIBUS-PA only		no. of preambels (HART only)	061	→	Page 45
(see Page 44)		ident number (PROFIBUS-PA only)	061	→	Page 45
⇓		thres. main val. (HART only)	062	→	Page 46
		set unit to bus (PROFIBUS-PA only)	062	→	Page 46
		current output mode (HART only)	063	→	Page 47
		out value (PROFIBUS-PA only)	063	→	Page 47
		fixed cur. value (HART only)	064	→	Page 48
		out status (PROFIBUS-PA only)	064	→	Page 48
		simulation	065	→	Page 49
		simulation value	066	→	Page 50
		output current (HART only)	067	→	Page 51
		2nd cyclic value (PROFIBUS-PA only)	067	→	Page 51
		4 mA value	068	→	Page 51
		select v0h0 (PROFIBUS-PA only)	068	→	Page 52
		20 mA value		→	Page 52
		display value (PROFIBUS-PA only)	069	→	Page 52
envelope **0E**	⇒	plot settings	0E1	→	Page 53
(see Page 53)		recording curve	0E2	→	Page 53
⇓		envelope curve display	0E3	→	Page 54
display **09**	⇒	language	092	→	Page 56
(see Page 56)		back to home	093	→	Page 56
⇓		format display	094	→	Page 57
		no.of decimals	095	→	Page 57
		sep. character	096	→	Page 57
		display test	097	→	Page 58
diagnostics **0A**	⇒	present error	0A0	→	Page 60
(see Page 59)		previous error	0A1	→	Page 60
⇓		clear last error	0A2	→	Page 60
		reset	0A3	→	Page 61
		unlock parameter	0A4	→	Page 62
		measured dist.	0A5	→	Page 63
		measured level	0A6	→	Page 64
		application par.	0A8	→	Page 64
system parameter **0C**	⇒	tag no.	0C0	→	Page 65
(see Page 65)		device tag (Foundation Fieldbus only)	0C0	→	Page 65
⇓		Profile Version (PROFIBUS-PA only)	0C1	→	Page 65
		protocol+sw-no.	0C2	→	Page 65
		serial no.	0C4	→	Page 66
		device id (Foundation Fieldbus only)	0C4	→	Page 66
		distance unit	0C5	→	Page 66
		temperature unit	0C6	→	Page 67
		download mode	0C8	→	Page 67
service **D00**	⇒	service level	D00		Page 68

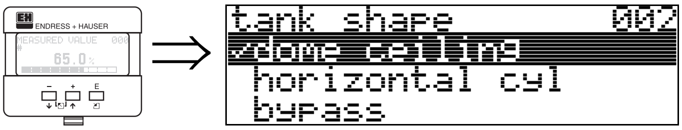
3 Function group "basic setup" (00)



3.1 Function "measured value" (000)

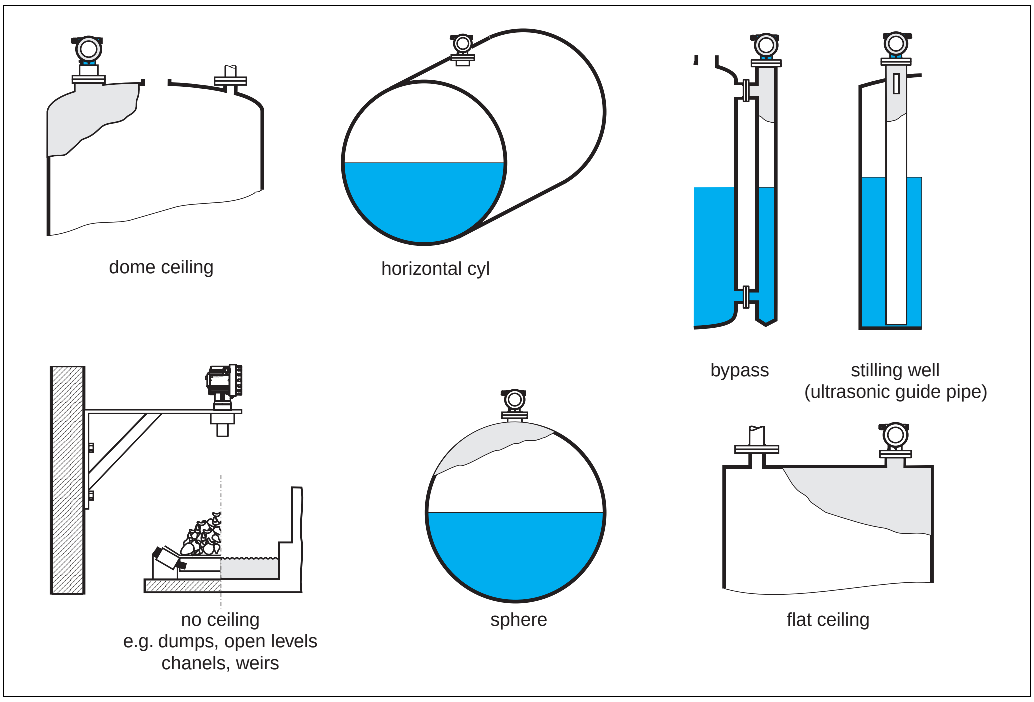
This function displays the current measured value in the selected unit (see "**customer unit**" **(042)** function). The number of places after decimal point can be selected in the "**no.of decimals**" **(095)** function.

3.2 Function "tank shape" (002)

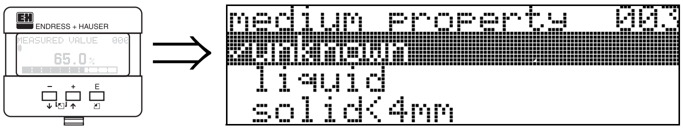


This function is used to select the tank shape.

Selection



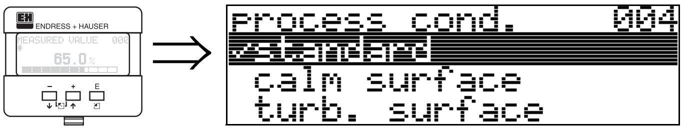
3.3 Function "medium property" (003)



This function is used to set the medium properties:

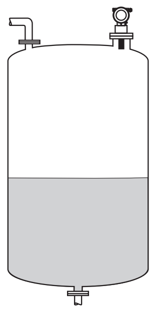
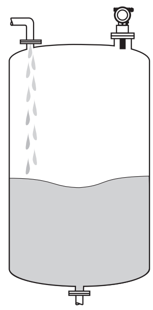
- **unknown** (e.g. pasty media such as greases, creams, gels etc.)
- liquid
- solid, grain size < 4mm (fine)
- solid, grain size > 4mm (coarse)

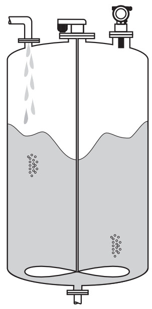
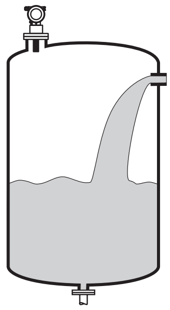
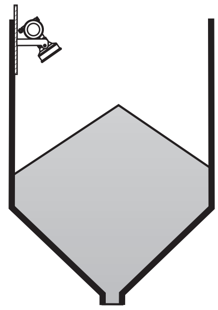
3.4 Function "process cond." (004)

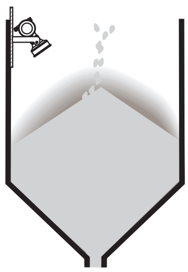
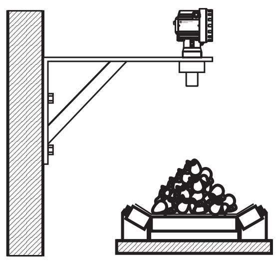


This function is used to select the process conditions.

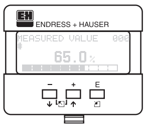
Selection:

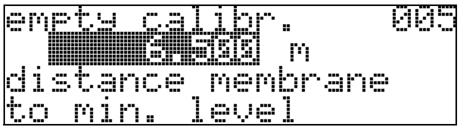
standard liquids	calm surface	turb. surface
For all fluid applications which do not fit in any of the following groups.	Storage tanks with immersion tube or bottom filling	Storage / accumulation tanks with uneven surface due to free filling, mixing nozzles or small bottom stirrers
		
The filters and output damping are set to average values.	The averaging filters and output damping are set to large values. -> Stable measured value -> Accurate measurement -> Slow reaction time	Special filters for stabilising the input signal are activated. -> Stable measured value -> Medium reaction time

add. agitator	fast change	standard solid
Moving surfaces (poss. with vortex formation) due to agitators	Rapid level change, particularly in small tanks	For all bulk solids applications which do not fit in any of the following groups.
		
Special filters for stabilising the input signal are set to large values. -> Stable measured value -> Medium reaction time	The averaging filters are set to small values. -> Rapid reaction time -> Possibly unstable measured value	The filter and output damping are set to average values.

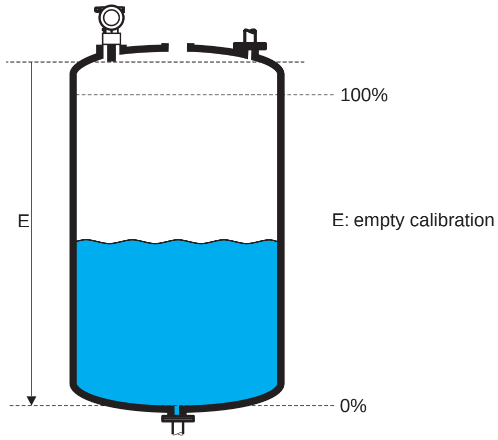
solid dusty	conveyor belt	Test: no filter
Dusty bulk solids	Bulk solids with rapid level change	All the filters can be switched off for purposes of service and diagnosis.
		
The filters are set to detect even relatively weak signals.	The averaging filters are set to small values. -> Rapid reaction time -> Possibly unstable measured value	All filters off

3.5 Function "empty calibr." (005)



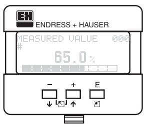


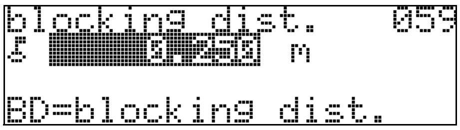
This function is used to enter the distance from the sensor membrane (reference point of the measurement) to the minimum level (=zero).



Caution!
For dish bottoms or conical outlets, the zero point should be no lower than the point at which the radar beam hits the bottom of the tank.

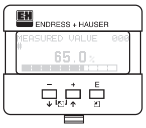
3.6 Function "blocking dist." (059)





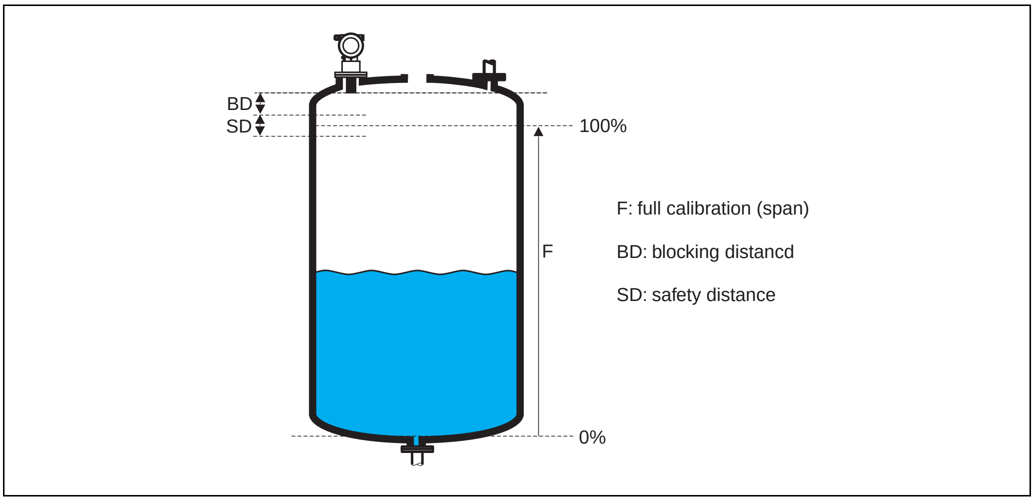
In this function the blocking distance is displayed. Level echoes within the blocking distance can not be detected by the Prosonic M. Make sure that the maximum level will never run into the blocking distance.

3.7 Function "full calibr." (006)



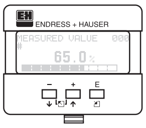
```
full calibr.        006
      4.750 m
span
max: empty - BD
```

This function is used to enter the distance from the minimum level to the maximum level (=span).



Caution!
The maximum level may not project into the blocking distance (BD). If the blocking distance is compromised, it may cause device malfunction.
After basic calibration, enter a safety distance (SD) in the **"safety distance" (015)** function. If the level is within this safety distance, the Prosonic M signals a warning or an alarm, depending on your selection in the **"in safety distance" (016)** function.

3.8 Display (008)

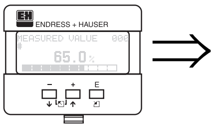


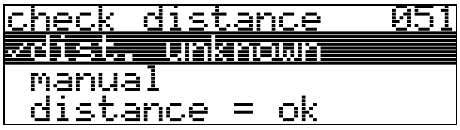
```
dist./meas.value 008
dist.      2.463 m
meas.v.   63.422 %
```

The **distance** measured from the sensor membrane to the product surface and the **level** calculated with the aid of the empty calibration are displayed. Check whether the values correspond to the actual level or the actual distance. The following cases can occur:

- Distance correct – level correct -> continue with the next function, "**check distance**" **(051)**
- Distance correct – level incorrect -> Check "**empty calibr.**" **(005)**
- Distance incorrect – level incorrect -> continue with the next function, "**check distance**" **(051)**

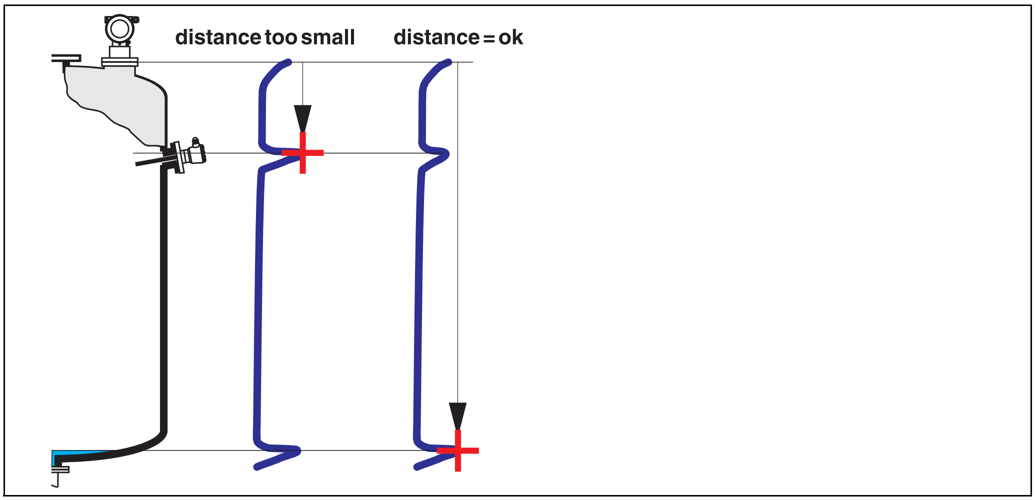
3.9 Function "check distance" (051)





This function triggers the mapping of interference echoes. To do so, the measured distance must be compared with the actual distance to the product surface. The following options are available for selection:

Selection:
- distance = ok
- dist. too small
- dist. too big
- **dist. unknown**
- manual



distance = ok
- mapping is carried out up to the currently measured echo
- The range to be suppressed is suggested in the "**range of mapping (052)**" function

Anyway, it is wise to carry out a mapping even in this case.

dist. too small
- At the moment, an interference is being evaluated
- Therefore, a mapping is carried out including the presently measured echoes
- The range to be suppressed is suggested in the "**range of mapping (052)**" function

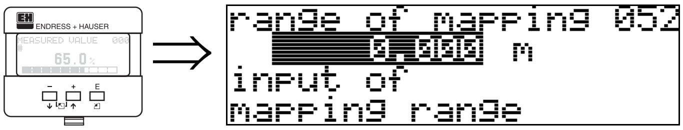
dist. too big
- This error cannot be remedied by interference echo mapping
- Check the application parameters **(002), (003), (004)** and "**empty calibr.**" **(005)**

dist. unknown
If the actual distance is not known, no mapping can be carried out.

manual
A mapping is also possible by manual entry of the range to be suppressed. This entry is made in the "**range of mapping (052)**" function.

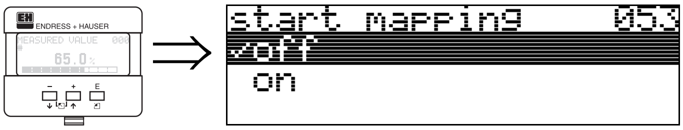
Caution!
The range of mapping must end 0.5 m (20") before the echo of the actual level. For an empty tank, do not enter E, but E – 0.5 m (20").

3.10 Function "range of mapping" (052)



This function displays the suggested range of mapping. The reference point is always the sensor membrane. This value can be edited by the operator.
For manual mapping, the default value is: 0 m.

3.11 Funktion "start mapping" (053)

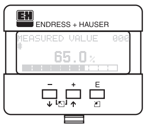


This function is used to start the interference echo mapping up to the distance given in "**range of mapping**" **(052)**.

Selection:
- **off**: no mapping is carried out
- on: mapping is started

Note!
If a mapping already exists, it is overwriten up to the distance specified in "**range of mapping**" **(052)**. Beyond this value the existing mapping remains unchanged.

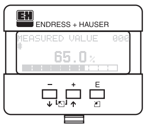
3.12 Display (008)



```
dist./meas.value 008
dist.      2.463 m
meas.v.   63.422 %
```

The distance measured from the reference point to the product surface and the level calculated with the aid of the empty alignment are displayed again. Check whether the values correspond to the actual level or the actual distance. The following cases can occur:

- Distance correct – level correct -> basic setup completed
- Distance incorrect – level incorrect -> a further interference echo mapping must be carried out "**check distance**" (**051)**.
- Distance correct – level incorrect -> check "**empty calibr.**" **(005)**



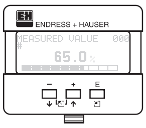
```
    Return to
 Group Selection
```

After 3 s, the following message appears

```
Group selection  00→
✓basic setup
 safety settings
 temperature
```

Note!
After the basic setup, an evaluation of the measurement with the aid of the envelope curve ("**display**" **(09)** function group) is recommended.

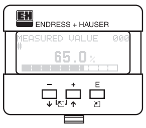
4 Function group "safety settings" (01)



⇒

```
Group selection  01
✓safety settings
 temperature
 linearisation
```

4.1 Function "output on alarm" (010)



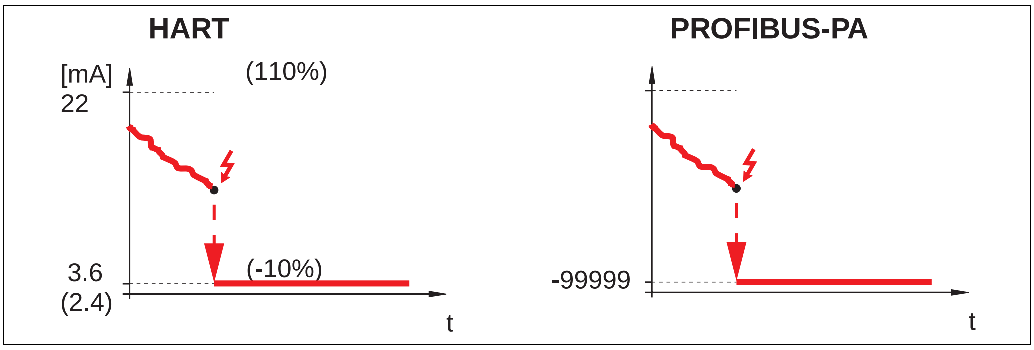
⇒

```
output on alarm  010
✓MAX 110% 22mA
 hold
 user specific
```

This function is used to select the reaction of the device on an alarm.

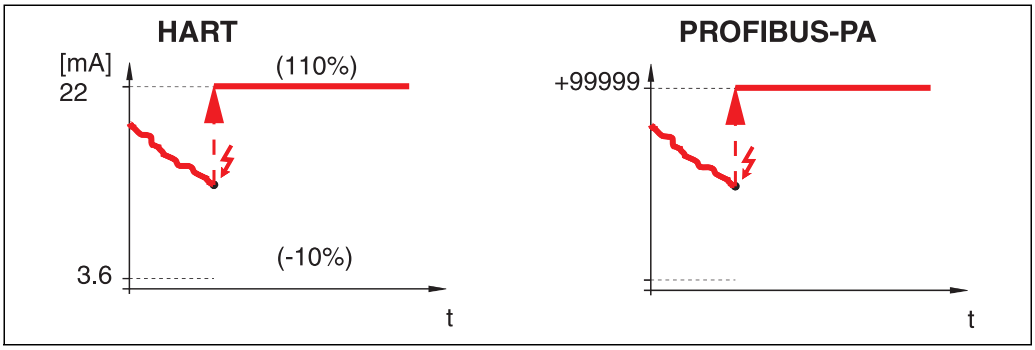
Selection:
- MIN (<= 3.6mA)
- **MAX (22mA)**
- hold
- user specific

MIN (<= 3.6 mA)



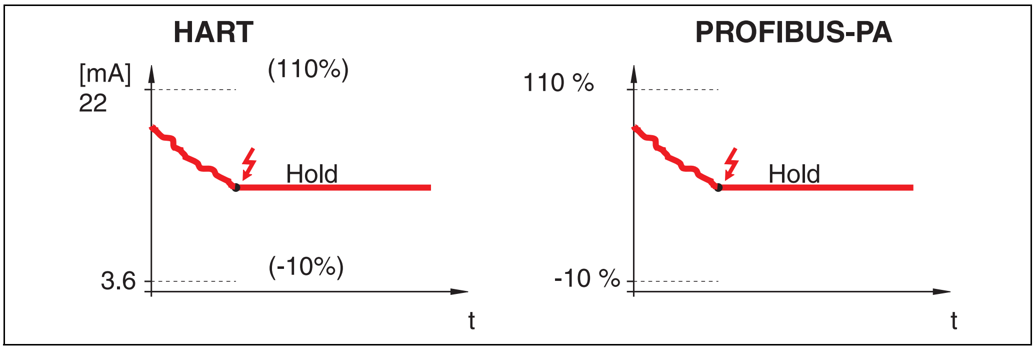
If the instrument is in alarm state, the output changes as follows:
- HART: MIN-Alarm 3.6 mA (2.4 mA for four-wire instruments)
- PROFIBUS-PA: MIN-Alarm -99999

MAX (22mA)



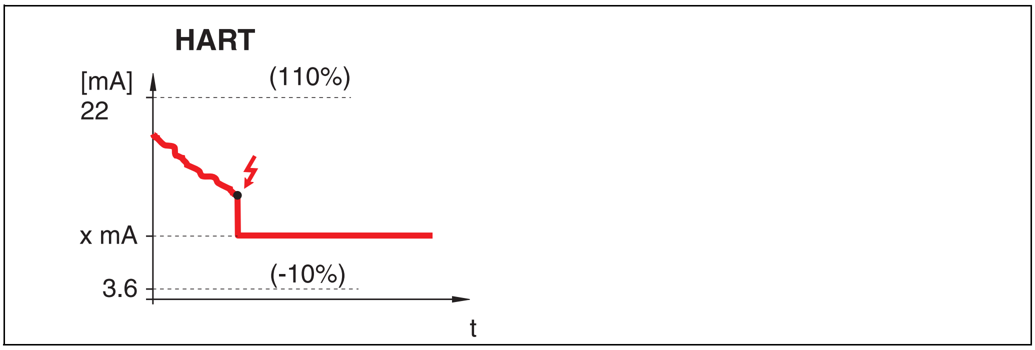
If the instrument is in alarm state, the output changes as follows:
- HART: MAX-Alarm 22 mA
- PROFIBUS-PA: MAX-Alarm +99999

hold



If the instrument is in alarm state, the last measured value is held.

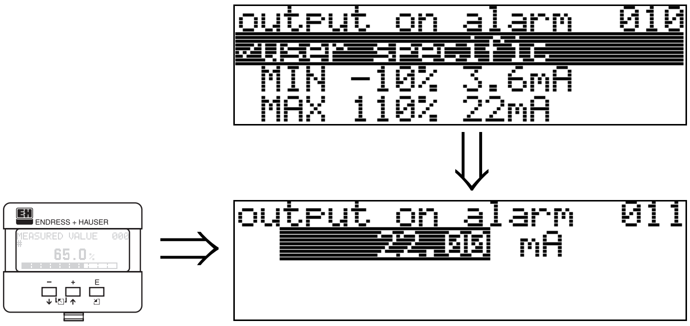
user specific



If the instrument is in an alarm state, the output is set to the value configured in "**output on alarm**" **(011)** (x mA).

Caution!
This selection is available for HART devices only!

4.2 Function "output on alarm" (011), HART only



The current (in mA) which will be output in case of an alarm. This function is active when you selected "**user specific**" in the "**output on alarm**" **(010)** function.

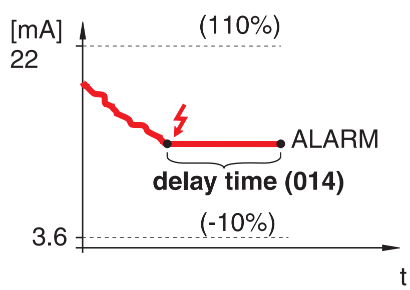
Caution!
This function is available for HART devices only!

4.3 Function "outp. echo loss" (012)

Use this function to set the output response on echo loss.

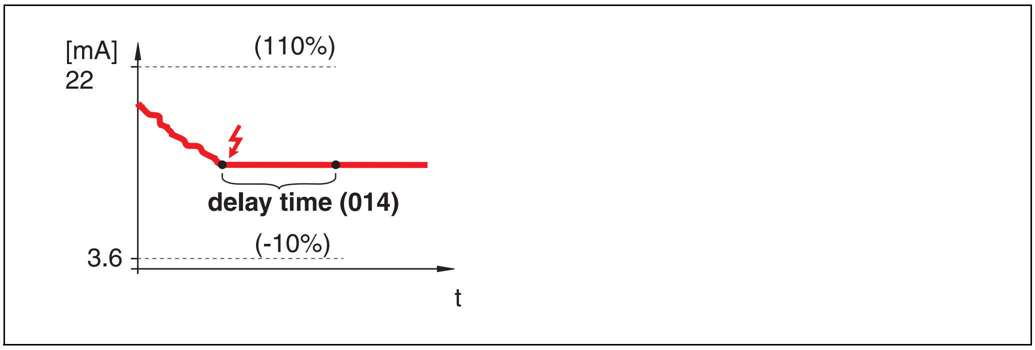
Selection:
- alarm
- **hold**
- ramp %/min

alarm



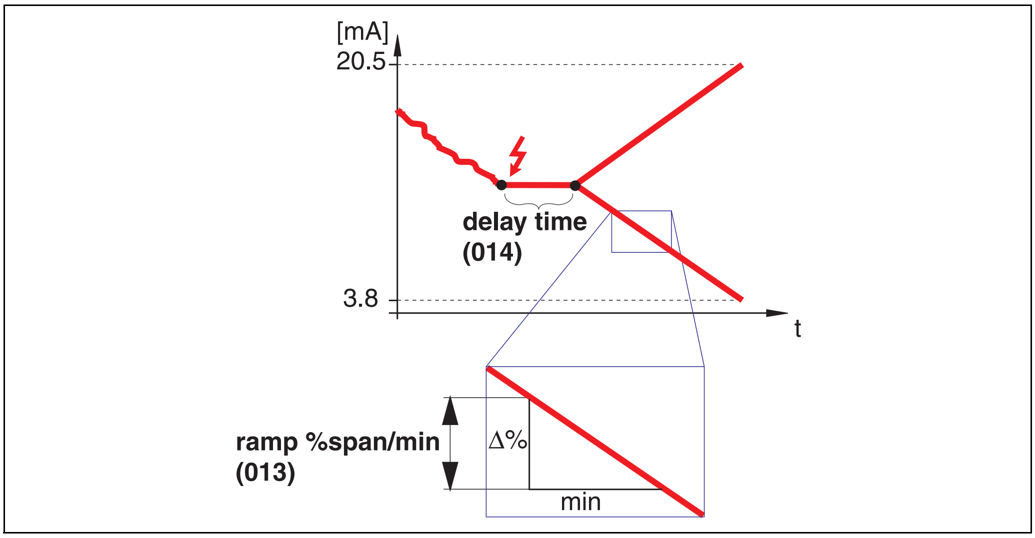
On echo loss, the instrument switches to alarm state after an adjustable "**delay time**" **(014)**. The output response depends on the configuration set in "**output on alarm**" **(010)**.

hold



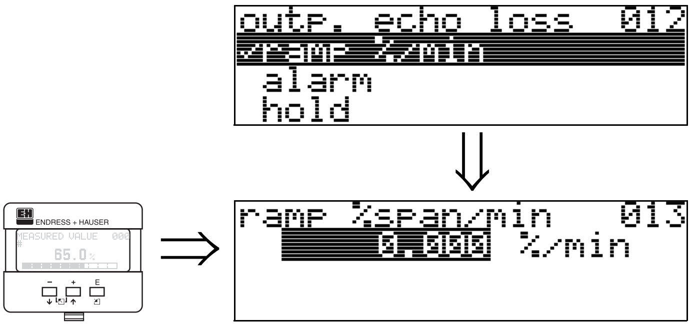
On echo loss, a warning is generated after a definable "**delay time**" **(014)**. Output is held.

ramp %/min



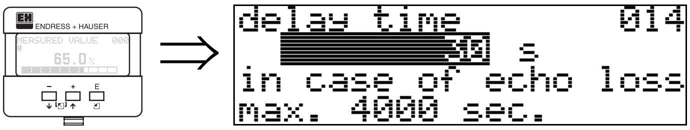
On echo loss, a warning is generated after a definable "**delay time**" **(014)**. The output is changed towards 0% or 100% depending on the slope defined in "**ramp %span/min**" **(013)**.

4.4 Function "ramp %span/min" (013)



Ramp slope which defines the output value on echo loss. This value is used if "**ramp %span/min**" is selected in "**outp. echo loss**" **(012)**. The slope is given in % of the measuring range per minute.

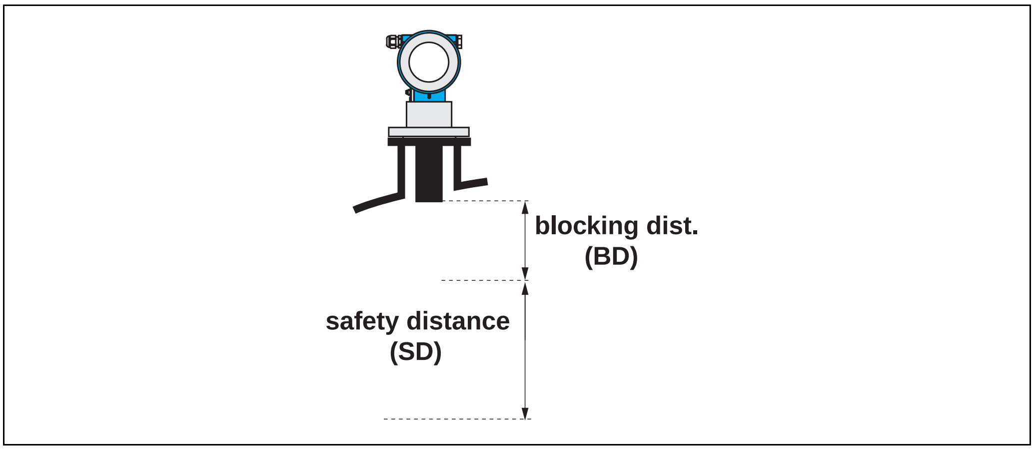
4.5 Function "delay time" (014)

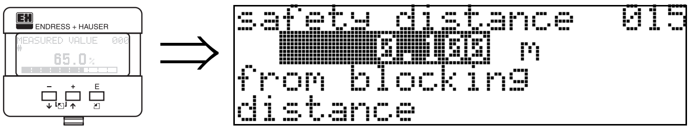


Use this function to enter the delay time (Default = 30 s) after which a warning is generated on echo loss, or after which the instrument switches to alarm state.

4.6 Function "safety distance" (015)

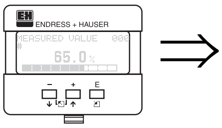
A configurable safety distance is placed before the "**blocking dist.**" **(059)** (Page 43). This distance warns you that any further level increase would make the measurement invalid, because the blocking distance would be compromised.

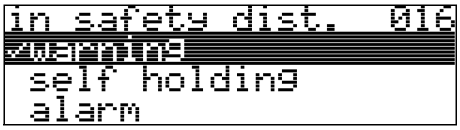




Enter the size of the safety distance here. The default value is: 0.1 m.

4.7 Function "in safety dist." (016)

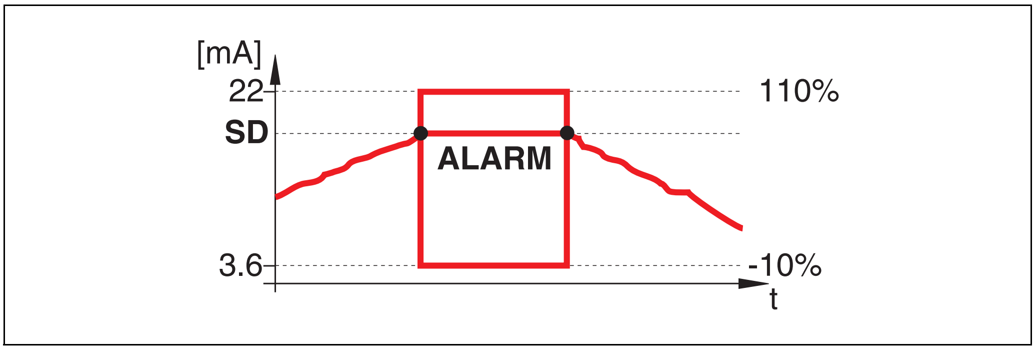




This function defines the response when the level enters the safety distance .

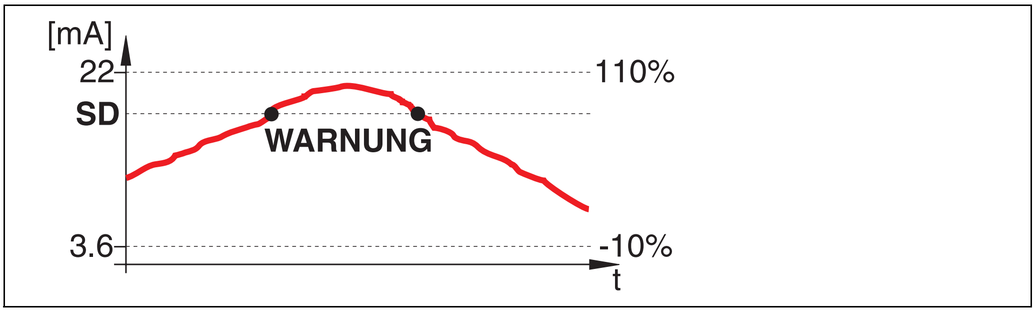
Selection:
- alarm
- **warning**
- self holding

alarm



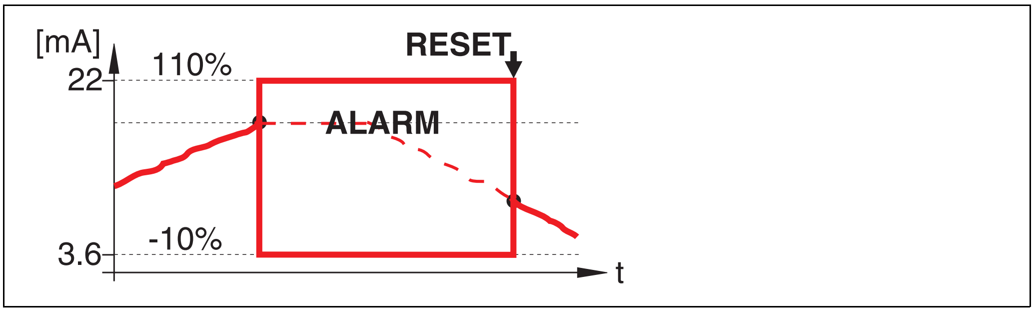
Instrument enters the defined alarm state ("**output on alarm**" **(011)**). The alarm message **E651** - "**level in safety distance** - **risk of overspill**" is displayed.
If the level drops out of the safety distance, the alarm warning disappears and the instrument starts to measure again.

warning



Instrument displays a warning **E651** - "**level in safety distance** - **risk of overspill**", but continues to measure. If the level leaves the safety distance, the warning disappears.

self holding



Instrument switches to defined alarm state ("**output on alarm**" **(011)**). The alarm message **E651** - "**level in safety distance - risk of overspill**" is displayed.
If the level leaves the safety distance, the measurement continues only after a reset of the self holding (function: "**ackn. alarm**" **(017)**).

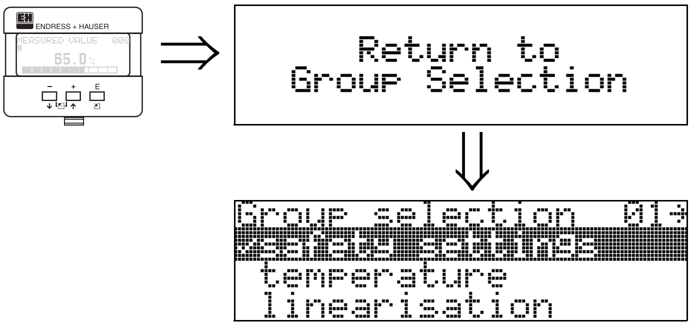
4.8 Function "ackn. alarm" (017)

This function acknowledges an alarm in case of "**self holding**".

Selection:
- **no**
- yes

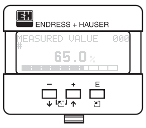
no
The alarm is not acknowledged.

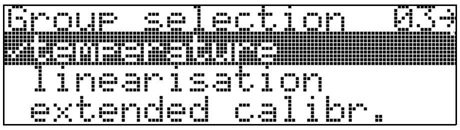
yes
Acknowledgement takes place.



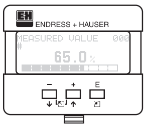
After 3 s, the following message appears

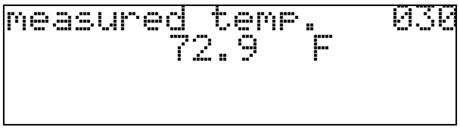
5 Function group "temperature" (03)





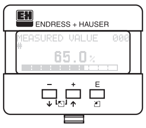
5.1 Function "measured temp." (030)

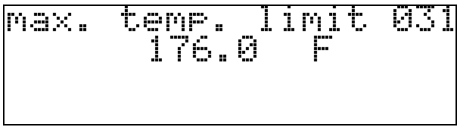




In this function the temperature at the sensor is displayed. The temperature unit is determined by the function **"temperature unit" (0C6)**.

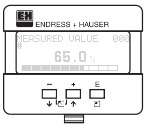
5.2 Function "max. temp. limit" (031)

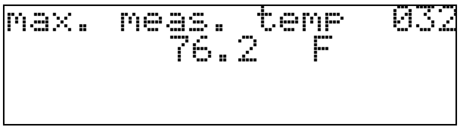




In this function the maximum permitted temperature of the sensor is displayed. The temperature unit is determined by the function **"temperature unit" (0C6)**. If this temperature is exceeded, the sensor may become damaged.

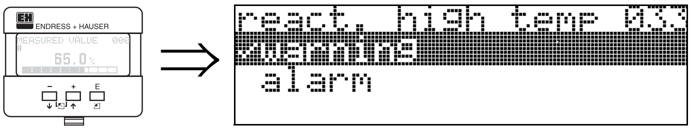
5.3 Function "max. meas. temp." (032)





In this function the maximum temperature, which has ever been measured at the senosr, is displayed. The temperature unit is determined by the function **"temperature unit" (0C6)**. This function is not influenced by a reset of the parameters.

5.4 Function "react high temp." (033)

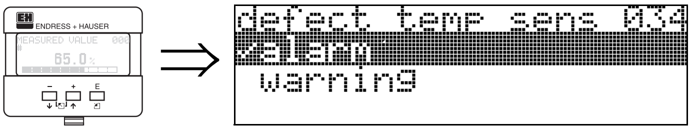


In this function you determine, how the Prosonic M will react if the maximum permitted temperature of the sensor is exceeded.
You may choose one of the following options:

Warning
The instrument continues measuring. An error message is displayed.

Alarm
The current output adopts the value defined in the funcion **"output on alarm" (010)**. Additionally an error message is displayed.

5.5 Function "defect temp. sens." (034)

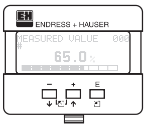


In this function you determine, how the Prosonic M will react, if the maximum permitted temperature of the sensor is exceeded.
You may choose one of the following options:

Alarm
The current output adopts the value defined in the funcion **"output on alarm" (010)**. Additionally an error message is displayed.

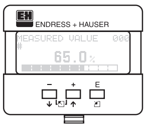
Warning
The instrument continues measuring. An error message is displayed.

6 Function group "linearisation" (04)



```
Group selection   04÷
✓linearisation
 extended calibr.
 output
```

6.1 Function "level/ullage" (040)



```
level/ullage      040
✓level CU
 level DU
 ullage CU
```

Selection:
- **level CU**
- level DU
- ullage CU
- ullage DU

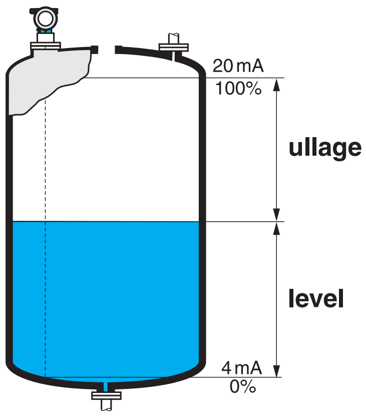
level CU
Level in customer units. The measured value can be linearised.
The "**linearisation**" **(041)** default value is set to a linear 0...100%.

level DU
Level in the selected "**distance unit**" **(0C5)**.

ullage CU
Ullage in customer units. The value can be linearised.
The "**linearisation**" **(041)** default value is set to a linear 0...100%.

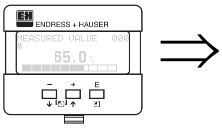
ullage DU
Ullage in the selected "**distance unit**" **(0C5)**.

Note!
Reference point for the ullage is "full calibr." (=span).



6.2 Function "linearisation" (041)

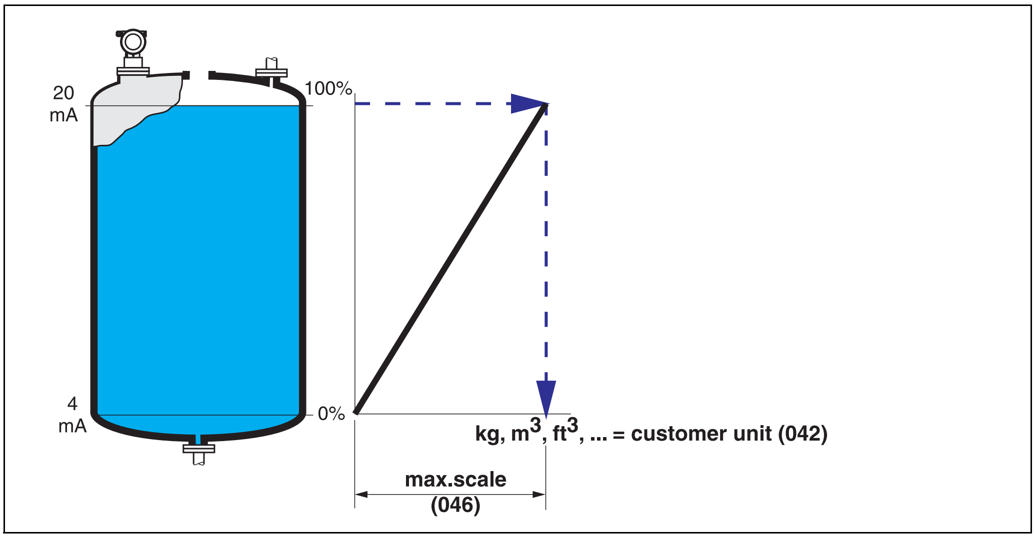
Linearisation defines the ratio of level to container volume or product weight and allows a measurement in customer units, e.g. metres, hectolitres etc. The measured value in (000) is then displayed in the selected unit.



This function is used to select the linearisation modes.

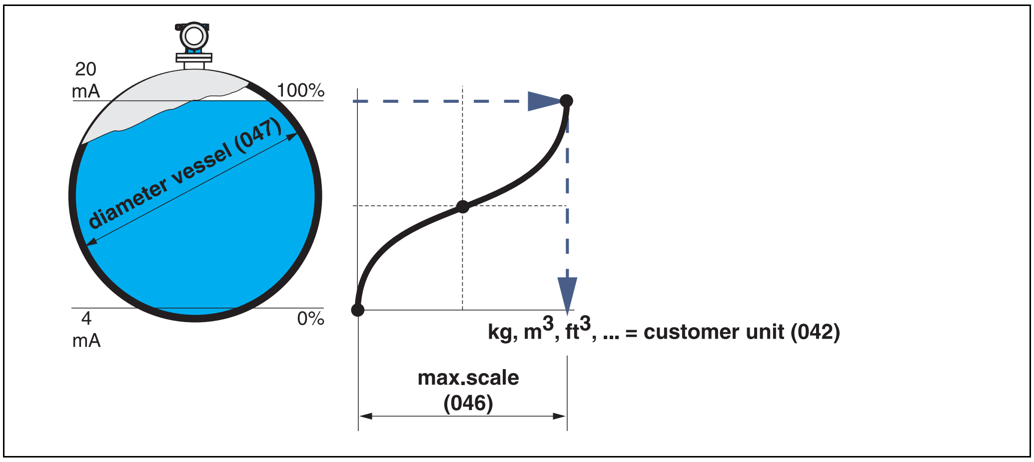
Selection:
- **linear**
- horizontal cyl
- manual
- semi-automatic
- table on
- clear table

linear
The tank is linear e.g. a cylindrical vertical tank. You can measure in customer units by entering a maximum volume/weight.
You can select the "**customer unit**" **(042)**. Define the volume value corresponding to the calibration in "**max. scale**" **(046)**. This value corresponds to an output of 100% (= 20 mA for HART).



horizontal cyl

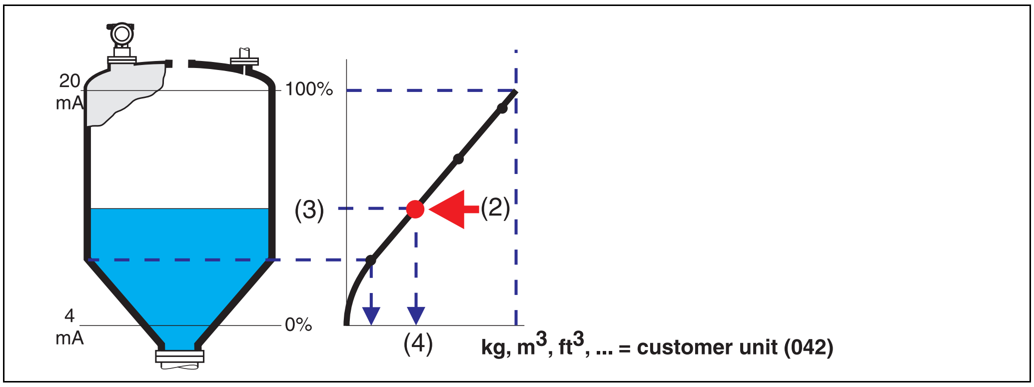
The volume, mass etc. are calculated automatically in cylindrical horizontal tanks by entering the "**diameter vessel**" **(047)**, the "**customer unit**" **(042)** and the "**max. scale**" **(046)**. The "**max. scale**" **(046)** corresponds to an output of 100% (= 20 mA for HART).



manual

If the level is not proportional to the volume or weight within the set measuring range, you can enter a linearisation table in order to measure in customer units. The requirements are as follows:

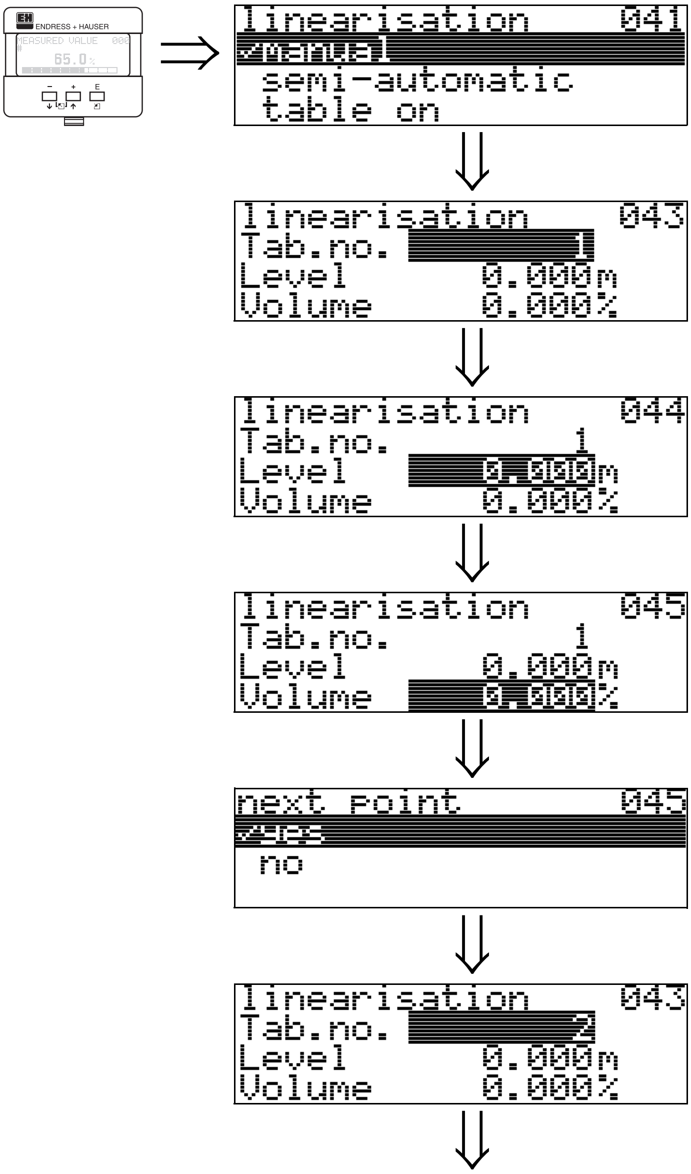
- The 32 (max.) value pairs for the linearisation curve points are known.
- The level values must be given in ascending order. The curve is monotonously increasing.
- The level heights for the first and last points on the linearisation curve correspond to empty and full calibration respectively.
- The linearisation takes place in the basic setup unit ("**distance unit**" **(0C5)**).



Each point (2) in the table is described by a value pair: level (3) and, for example, volume (4). The last value pair defines the 100% output (= 20 mA for HART).

Note!

The manual linearisation mode can also be used for flow measurements. To do this, simply enter the respective flow level (instead of the volume) into the table. You can find the appropriate flow values in the Q/h table of your channel or weir.



Select the table point (Point 1).

Enter the level belonging to Point 1.

Enter the corresponding volume.

Enter a further table point?

Next table point.

...
Continue until "**next point**" **(045)** is answered with no.

Note!
After making entries into the table, activate it with "**table on**".
The 100% value (=20 mA for HART) is defined by the last point in the table.

Note!
Before confirming 0.00 m as the level or 0.00% as the volume, activate the Edit mode with + or -.

Entries can be made into the linearisation table in ToF Tool using the table editor.
You can also display the contents graphically.

semi-automatic
The tank is filled in stages when the linearisation curve is entered semi-automatically. The Prosonic M automatically detects the level and the corresponding volume/weight has to be entered.
The procedure is similar to manual table entry, where the level value for each table point is given automatically by the instrument.

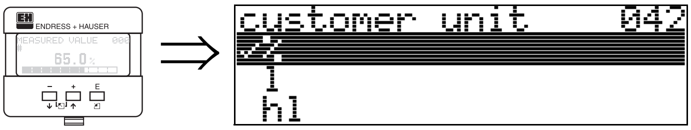
Note!
If the tank is emptied (out litres), pay attention to the following points:
- The number of points must be known in advance.
- The first table number = (32 - number of points).
- Entries in "**Tab. no.**" **(043)** are made in reverse order (last entry = 1).

table on
An entered linearisation table only becomes effective when activated.

clear table
Before making entries into the linearisation table, any existing tables must be deleted. The linearisation mode automatically switches to linear.

Note!
A linearisation table can be deactivated by selecting "**linear**" or "**horizontal cyl**" (or the "**level/ullage**" **(040)** function = "**level DU**", "**ullage DU**"). It is not deleted and can be reactivated at any time by selecting "**table on**".

6.3 Function "customer unit" (042)

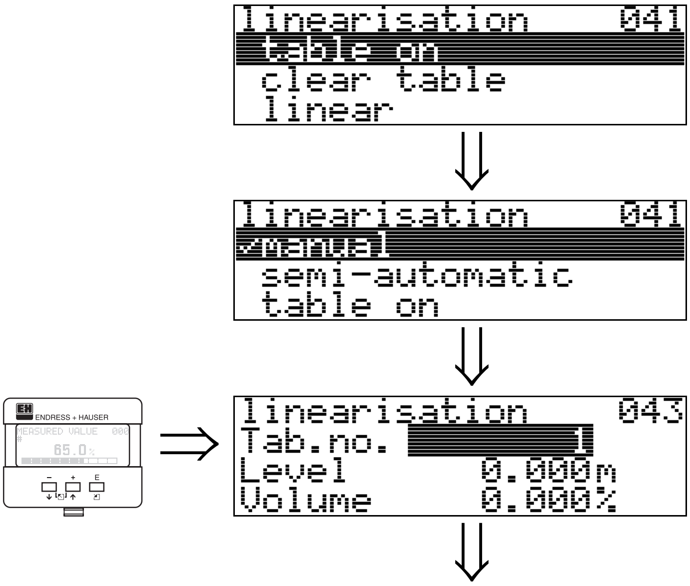


You can select the customer unit with this function.

Selection:
- **%**
- Volume: l, hl, m3, dm3, cm3, ft3, usgal, i gal
- Weight: kg, t, lb, ton
- Length: m, ft, mm, inch
- Flow: l/s, l/min, l/h, m3/s, m3/min, m3/h, ft3/s, gal/s, gal/m, gal/hr, mgal/d, igal/s, igal/min, igal/h

Dependence
The units of the following parameters are changed:
- measured value (000)
- input volume (045)
- max. scale (046)
- simulation value (066)

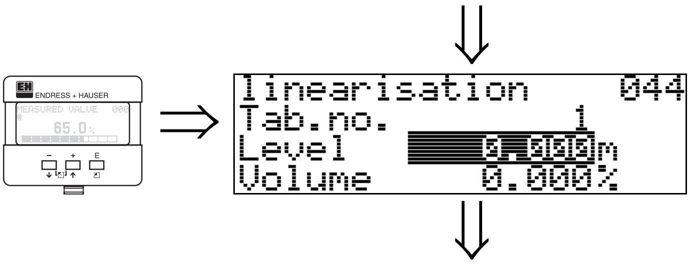
6.4 Function "table no." (043)



Position of the value pair in the linearisation table.

Dependence
Updates "**input level**" **(044)** , "**input volume**" **(045)**.

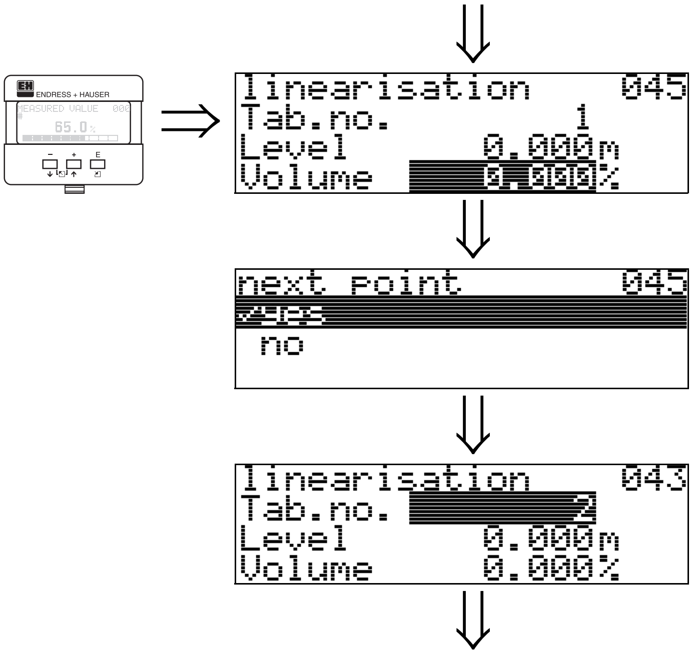
6.5 Function "input level" (044)



You can enter the level for each point of the linearisation curve with this function. When the linearisation curve is entered semi-automatically, Micropilot detects the level automatically.

User input:
Level in "**distance unit**" **(0C5)**.

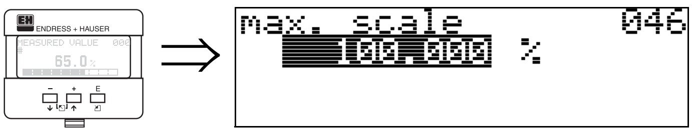
6.6 Function "input volume" (045)



Specify the volume for each point of the linearisation curve with this function.

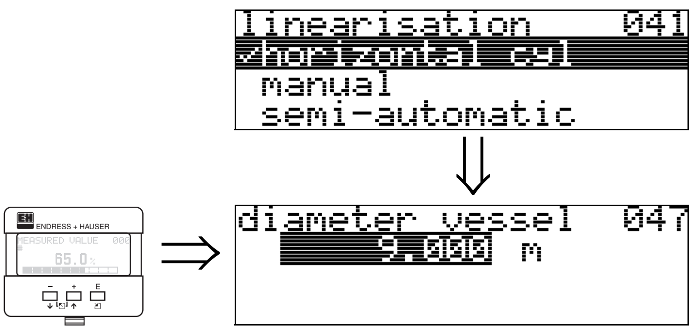
User input:
Volume in "**customer unit**" **(042)**.

6.7 Function "max. scale" (046)



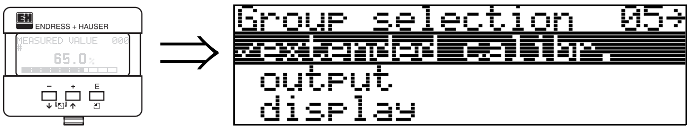
You can enter the end value of the measuring range with this function. This input is necessary if you selected "**linear**" or "**horizontal cyl**" in the "**linearisation**" **(041)** function.

6.8 Function "diameter vessel" (047)



Enter the tank diameter with this function. This entry is necessary if you selected "**horizontal cyl**" in the "**linearisation**" **(041)** function.

7 Function group "extended calibr." (05)



7.1 Function "selection" (050)

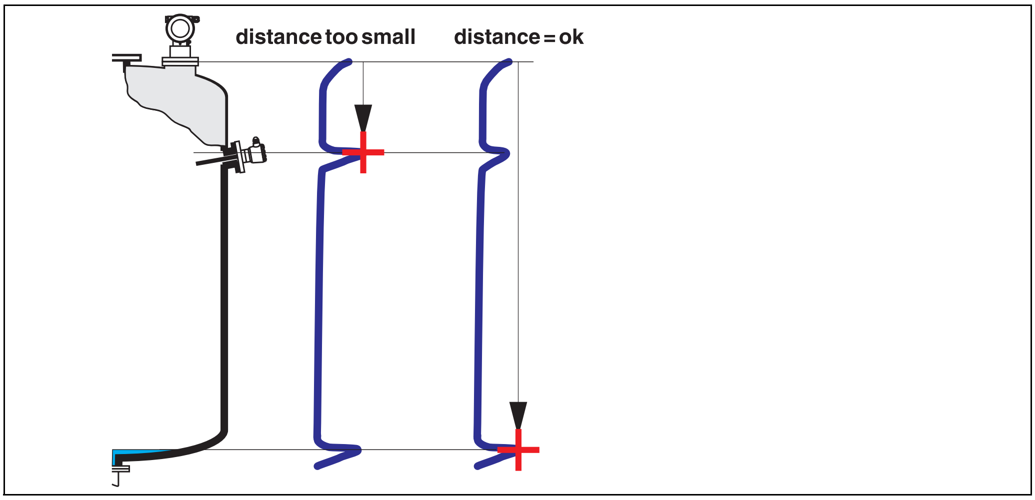
Select the function of the extended calibration.

Selection:
- **common**
  leads to the functions **"echo quality" (056)**, **"offset" (057)**, **"output damping" (058)** and **"blocking distance" (059)**
- mapping
  leads to the functions for an interference echo suppression (tank map): **(051) ... (053)**
- extended map
  leads to the functions **" pres. map. dist." (054)** and **"cust. tank map" (055)**

7.2 Function "check distance" (051)

This function triggers the mapping of interference echoes. To do so, the measured distance must be compared with the actual distance to the product surface. The following options are available for selection:

Selection:
- distance = ok
- dist. too small
- dist. too big
- **dist. unknown**
- manual



distance = ok
- mapping is carried out up to the currently measured echo
- The range to be suppressed is suggested in the "**range of mapping (052)**" function

Anyway, it is wise to carry out a mapping even in this case.

dist. too small
- At the moment, an interference is being evaluated
- Therefore, a mapping is carried out including the presently measured echoes
- The range to be suppressed is suggested in the "**range of mapping (052)**" function

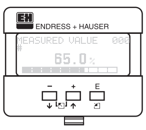
dist. too big
- This error cannot be remedied by interference echo mapping
- Check the application parameters **(002), (003), (004)** and "**empty calibr.**" **(005)**

dist. unknown
If the actual distance is not known, no mapping can be carried out.

manual
A mapping is also possible by manual entry of the range to be suppressed. This entry is made in the "**range of mapping (052)**" function.

Caution!
The range of mapping must end 0.5 m (20") before the echo of the actual level. For an empty tank, do not enter E, but E – 0.5 m (20").

7.3 Function "range of mapping" (052)

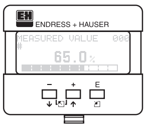


⇒

```
range of mapping 052
      0.000 m
input of
mapping range
```

This function displays the suggested range of mapping. The reference point is always the sensor membrane. This value can be edited by the operator.
For manual mapping, the default value is: 0 m.

7.4 Function "start mapping" (053)



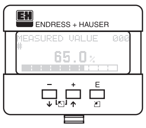
```
start mapping      053
✓off
 on
```

This function is used to start the interference echo mapping up to the distance given in "**range of mapping**" **(052)**.

Selection:
- **off**: no mapping is carried out
- on: mapping is started

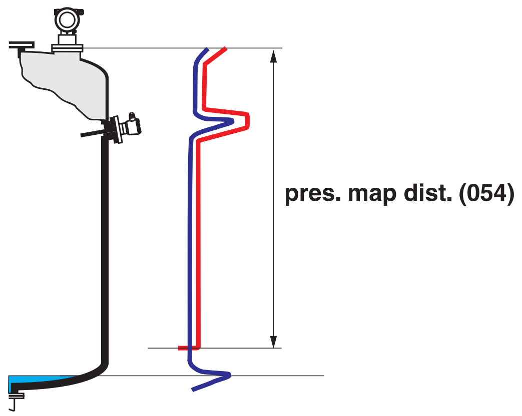
Caution!
If a mapping already exists, it is overwriten up to the distance specified in "**range of mapping**" **(052)**. Beyond this value the existing mapping remains unchanged.

7.5 Function "pres. map dist." (054)

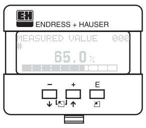


```
pres. map dist.    054
      0.000  m
```

Displays the distance up to which a mapping has been recorded.
A value of 0 indicates that no mapping was recorded so far.



7.6 Function "cust. tank map" (055)



This function displays the evaluation mode using the customer tank map.

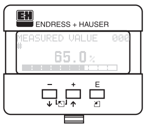
Selection:
- **inactive**
- active
- reset

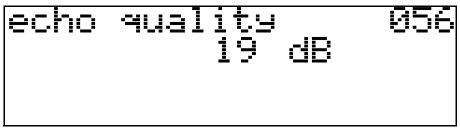
inactive
No tank mapping has been recorded, or map is switched off. Evaluation is only using FAC (Page 71).

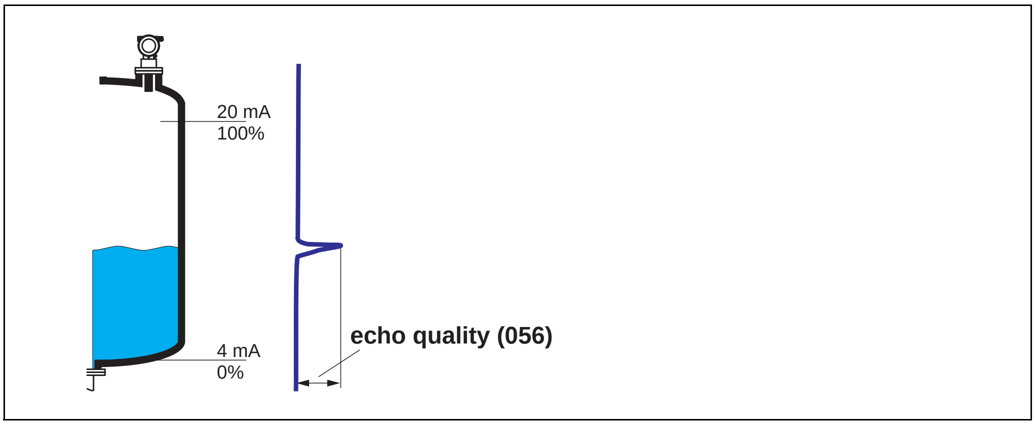
active
Evaluation is using the customer tank map (Page 70).

reset
Deletes the complete tank map.

7.7 Function "echo quality" (056)



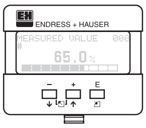




The echo quality is the benchmark for measurement reliability. It describes the amount of reflected energy and depends primarily on the following conditions:
- Surface characteristics (waves, foam etc.)
- Distance between sensor and product

Low values increase the probability that the echo is lost through a change in measurement conditions, e.g. turbulent surface, foam, large measuring distance.

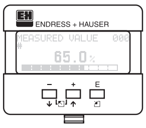
7.8 Function "offset" (057)



```
offset                057
       0.000  m
will be added to the
measured level
```

This function corrects the measured level by a constant value. The entered value is added to the measured level.

7.9 Function "output damping" (058)



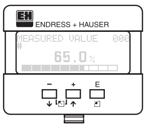
```
output damping      058
          5.0  s
```

Influences the time an output requires to react to a sudden level jump (63% of steady state). A high value attenuates, for example, the influences of rapid changes on the measured variable.

User input:
0...255 s

The default value depends on the selected application parameters "**tank shape**" **(002)**, "**medium property**" **(003)** and "**process cond.**" **(004)**.

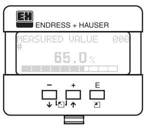
7.10 Function "blocking dist." (059)



```
blocking dist.      059
       0.250  m

BD=blocking dist.
```

In this function the blocking distance is displayed. Level echoes within the blocking distance can not be detected by the Prosonic M. Make sure that the maximum level will never run into the blocking distance.



```
     Return to
  Group Selection
```

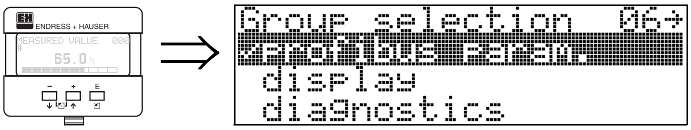
⇓

After 3 s, the following message appears

```
Group selection   05
extended calibr.
 output
 display
```

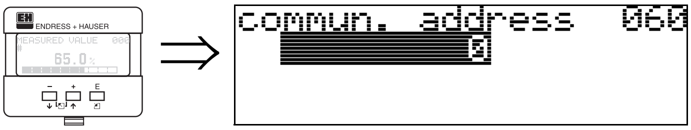
8 Function group "output" (06), - "profibus param." (06), PROFIBUS-PA only

Display at HART and Foundation Fieldbus instrument



Display at PROFIBUS-PA instrument

8.1 Function "commun. address" (060), HART only



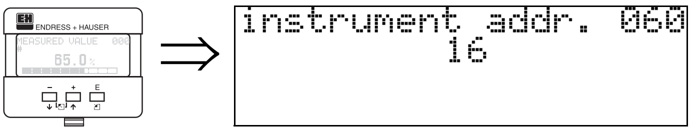
Enter the communication address for the instrument with this function.

- Standard: 0
- Multidrop: 1-15

The output current is constant at 4mA in multidrop mode.

Caution!
This function is available for HART devices only!

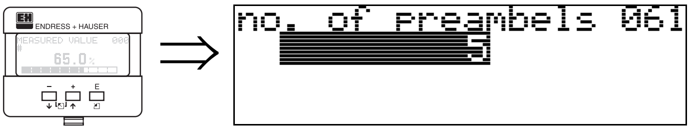
8.2 Function "instrument addr." (060), PROFIBUS-PA only



The PA bus address is displayed in this field. The address is set either directly on the instrument using DIP switches (see instrument operating instructions) or using a special SetSlaveAddress command via the bus, e.g. by the ToF Tool.

Caution!
This function is available for PROFIBUS-PA devices only!

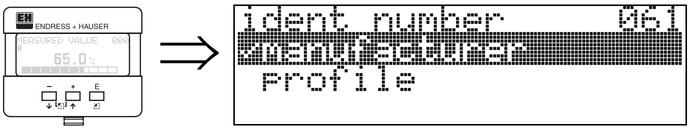
8.3 Function "no. of preambels" (061), HART only



Enter the number of preambles for the HART protocol with this function.
An increase in the value is advisable for "bad" lines with communications problems.

Caution!
This user input is available for HART devices only!

8.4 Function "ident number" (061), PROFIBUS-PA only



- **manufacturer**
- profile

manufacturer
Set to152C hex according to manufacturer (PNO registered).

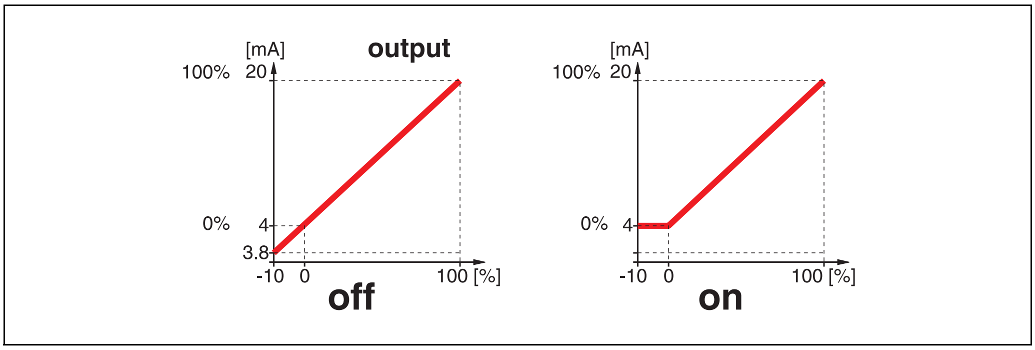
profile
Setting defined as in PA Profile 3.0: 9700 hex - instrument with one AI block.

Caution!
This function is available for PROFIBUS-PA devices only!

8.5 Function "thres. main val." (062), HART only

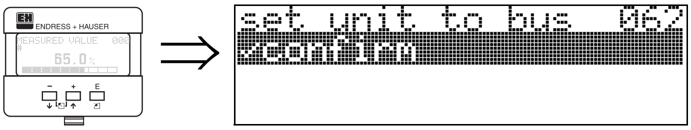
The output of negative level values can be suppressed with this function.

Selection:
- **off**: minimum output -10% (3.8 mA for HART)
- on**:** minimum output 0% (4 mA for HART)



Caution!
This user input is available for HART devices only!

8.6 Function "set unit to bus" (062), PROFIBUS-PA only

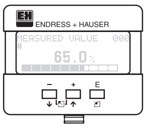


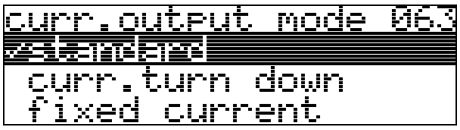
- confirm

After confirming this function, the unit of the measured variable is taken over in the AI block (PV scale -> Out scale).
This function must always be executed after changing the unit.

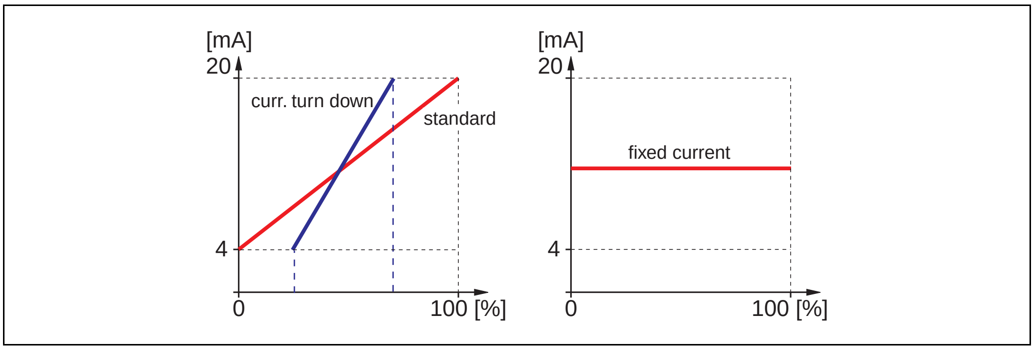
Caution!
This function is available for PROFIBUS-PA devices only!

8.7 Function "curr. output mode" (063), HART only





In this function you specify the mode of the current output.
You may choose one of the following options:



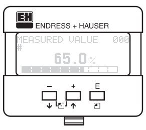
standard
The total measuring range (0 ... 100%) will be mapped to the current intervall (4 ... 20 mA).

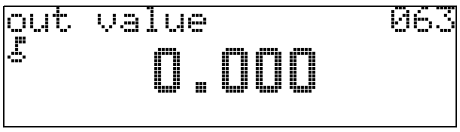
curr. turn down
Only a part of the measuring range will be mapped to the current intervall (4 ... 20 mA).
Use the functions **"4-mA-value" (068)** and **"20-mA-value" (069)** to define the concerning range.

fixed current
The current is fixed. The measured value is transmitted by the HART signal only. The value of the current is defined in the **"fixed current" (064)** function.

Caution!
This function is active for HART devices only.

8.8 Function "out value" (063), PROFIBUS-PA only





This displays the AI block output.

Caution!
This function is available for PROFIBUS-PA devices only!

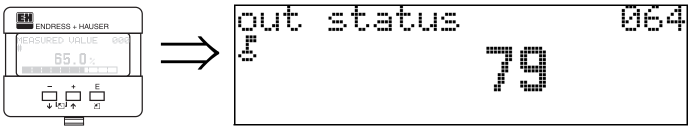
8.9 Function "fixed cur. value" (064), HART only

Set the fixed current value with this function. This entry is necessary when you have switched on the "**fixed current**" **(063)** function.

User input:
3,8...20,5 mA

Caution!
This user input is available for HART devices only!

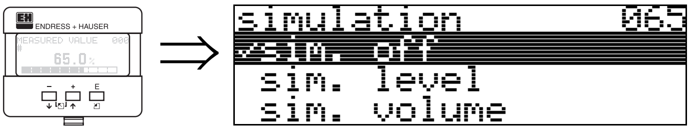
8.10 Function "out status" (064), PROFIBUS-PA only



Displays the current output status (for value, see operating instructions of relevant instrument).

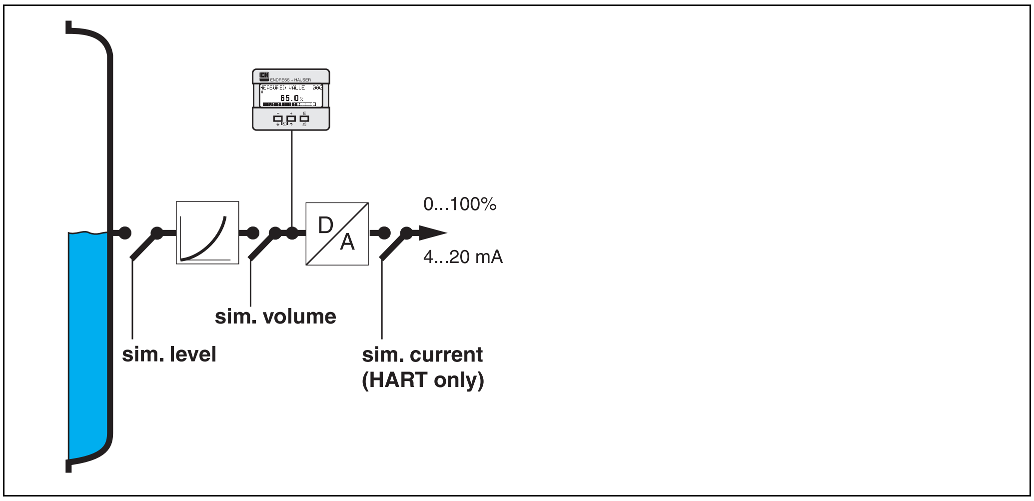
Caution!
This function is available for PROFIBUS-PA devices only!

8.11 Function "simulation" (065)



If necessary, linearisation, the output signal and the current output can be tested with the simulation function. You have the following simulation options:

Selection:
- **sim. off**
- sim. level
- sim. volume
- sim. current (HART only)



sim. off
Simulation is switched off.

sim. level
Enter the level value in "**simulation value**" **(066)**.
The functions
- measured value (000)
- measured level (0A6)
- output current" (067) - only with HART instruments!

follow the entered values.

sim. volume
Enter the volume value in "**simulation value**" **(066)**.
The functions
- measured value (000)
- output current" (067) - only with HART instruments!

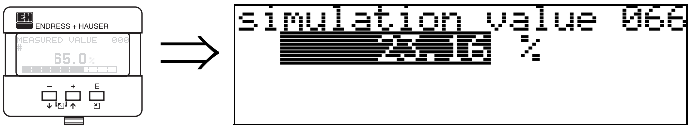
follow the entered values.

sim. current (HART only)
Enter the current value in "**simulation value**" **(066)**.
The function
- output current" (067) - only with HART instruments!

follows the entered values.

8.12 Function "simulation value" (066)

After selecting the "**sim. level**" option in the "**simulation**" **(065)** function, the following message appears in the display: you can enter the level.



After selecting the "**sim. volume**" option in the "**simulation**" **(065)** function, the following message appears in the display: you can enter the volume.

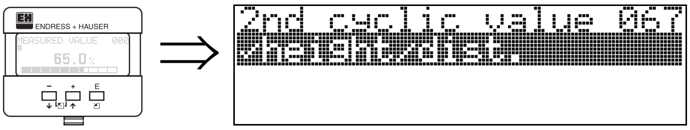
After selecting the "**sim. current**" option in the "**simulation**" **(065)** function, the following message appears in the display: Enter the output current (only for HART instruments).

8.13 Function "output current" (067), HART only

Displays the output current in mA.

Caution!
This function is available for HART devices only!

8.14 Function "2nd cyclic value" (067), PROFIBUS-PA only



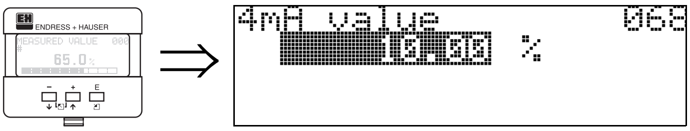
Selects the second cyclical value.

- height/dist.

The Prosonic M always transmits the distance as the second cyclical value.

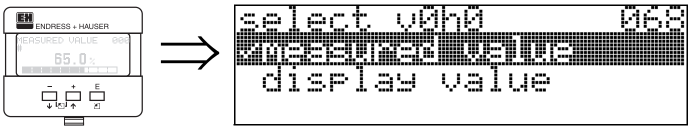
Caution!
This function is available for PROFIBUS-PA devices only!

8.15 Function "4mA-value" (068), HART only



In this function specify the level (or volume, weight, flow resp.), at which the output current should be 4 mA. This value will be used if you choose the option "curr. turn down" in the **"current output mode" (063)** function.

8.16 Function "select v0h0" (068), PROFIBUS-PA only



Selects the value displayed in "**measured value**" **(000)**.

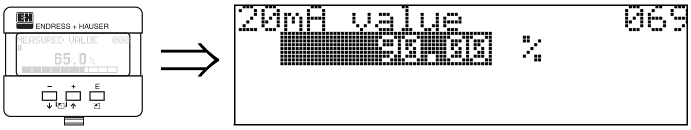
Selection:
- **measured value**
- display value

measured value
The configured measured value is displayed in the "**measured value**" **(000)** function.

display value
The value in "**display value**" **(069)** is displayed in the "**measured value**" **(000)** function.

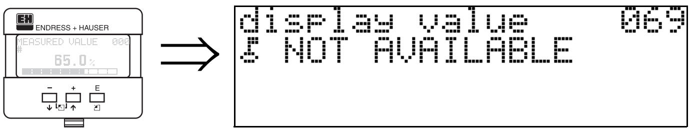
Caution!
This function is available for PROFIBUS-PA devices only!

8.17 Function "20mA-value" (069), HART only



In this function specify the level (or volume, weight, flow resp.), at which the output current should be 20 mA. This value will be used if you choose the option "curr. turn down" in the **"current output mode" (063)** function.

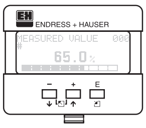
8.18 Function "display value" (069), PROFIBUS-PA only



This field can be set externally, e.g. from a PLC. The value is then displayed as the main measured variable in the display by selecting the "**select v0h0**" **(068)** = "**display value**" function.

Caution!
This function is available for PROFIBUS-PA devices only!

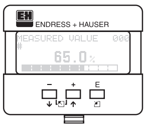
9 Function group "Enelope curve" (0E)



⇒

```
Group selection  0E→
✓envelope curve
 display
 diagnostics
```

9.1 Function "plot settings" (0E1)



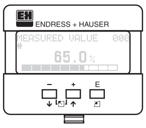
⇒

```
plot settings    0E1
✓envelope curve
 env.curve+FAC
 env.curve+cust.map
```

Here select which information is displayed in the LCD:
- **envelope curve**
- env.curve+FAC (on FAC see Page 71)
- env.curve+cust.map (i.e. customer tank map is also displayed, see Page 70)

9.2 Function "recording curve" (0E2)

This function defines whether the envelope curve is read as a
- **single curve**
  or
- cyclic.



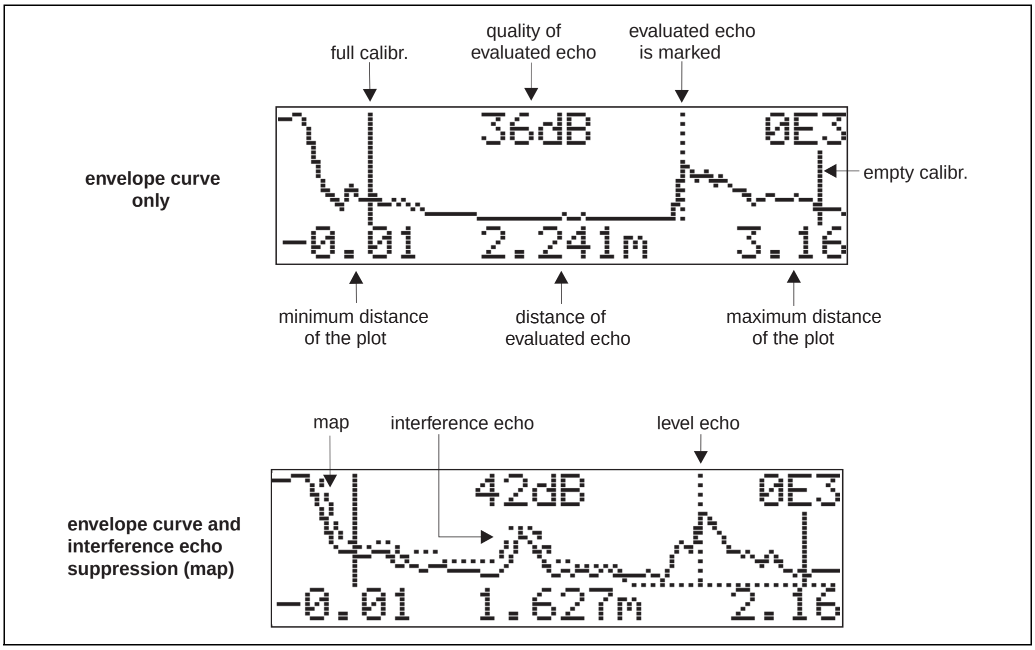
⇒

```
recording curve  0E2
✓single curve
 cyclic
```

Note!
If the cyclical envelope curve is active in the display, the measured variable is refreshed in a slower cycle time. It is therefore recommended to exit the envelope curve display after optimising the measuring point.

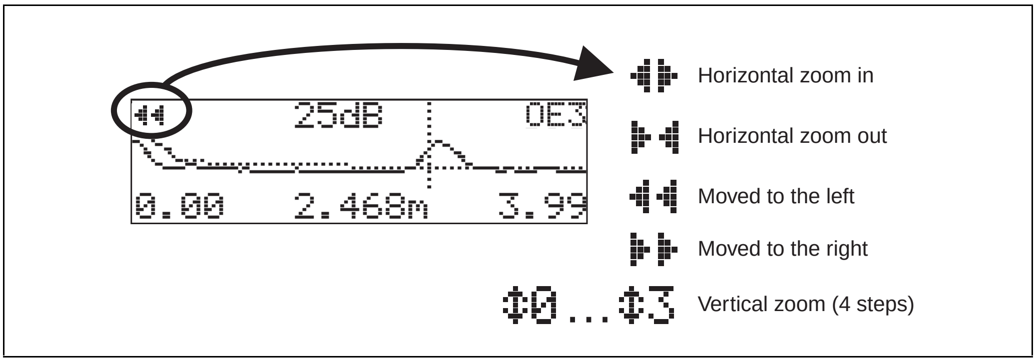
9.3 Function "envelope curve display" (0E3)

The envelope curve is displayed in this function. You can use it to obtain the following information:



Navigating in the envelope curve display

Using navigation, the envelope curve can be scaled horizontally and vertically and shifted to the left or the right. The active navigation mode is indicated by a symbol in the top left hand corner of the display.

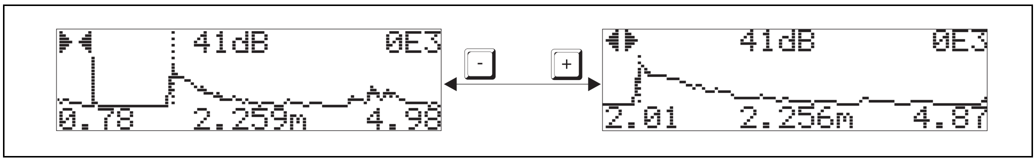


Horizontal Zoom mode

Firstly, go into the envelope curve display (see Page 31). Then press + or - to switch to the envelope curve navigation. You are then in Horizontal Zoom mode. Either or is displayed.

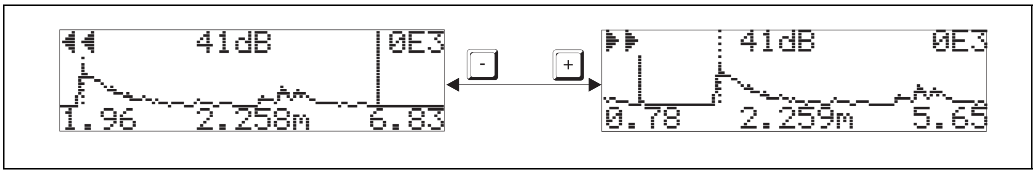
You now have the following options:

- + increases the horizontal scale.
- - reduces the horizontal scale.



Move mode

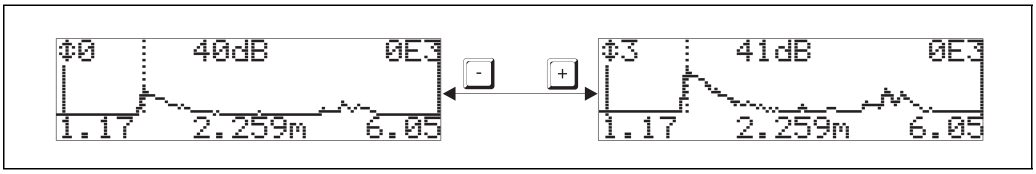
Then press E to switch to Move mode. Either ▸▸ or ◂◂ is displayed.
You now have the following options:
- + shifts the curve to the right.
- - shifts the curve to the left.



Vertical Zoom mode

Press E once more to switch to Vertical Zoom mode. ↕1 is displayed.
You now have the following options:
- + increases the vertical scale.
- - reduces the vertical scale.

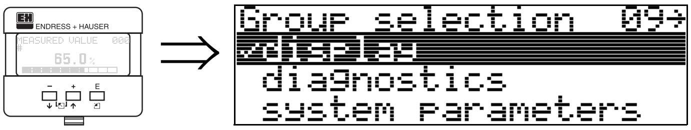
The display icon shows the current zoom factor (↕0 to ↕3).



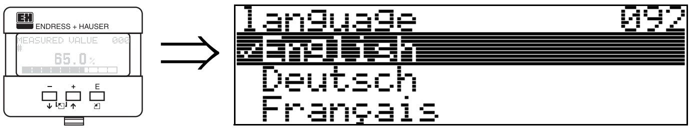
Exiting the navigation

- Press E again to run through the different modes of the envelope curve navigation.
- Press + and - to exit the navigation. The set increases and shifts are retained. Only when you reactivate the **"recording curve" (0E2)** function does the Prosonic use the standard display again.

10 Function group "display" (09)



10.1 Function "language" (092)



Selects the display language.

Selection:
- **English**
- Deutsch
- Français
- Español
- Italiano
- Nederlands

Dependence
All texts are changed.

Caution!
This function is not visualised in Commuwin II!

10.2 Function "back to home" (093)

If no entry is made using the display during the specified time period, the display returns to the measured value display.
9999 s means that there is no return.

User input:
3...9999 s

Caution!
This function is not visualised in Commuwin II!

10.3 Function "format display" (094)

Selects the display format.

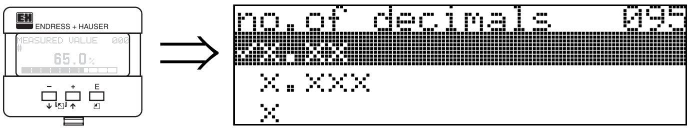
Selection:
- **decimal**
- 1/16''

decimal
The measured value is given in decimal form in the display (e.g. 10.70%).

1/16"
The measured value is given in the display in this format (e.g 5'05-14/16").
This option is only possible for "**distance unit**" **(0C5)** - "**ft**" and "**in**"!

Caution!
This function is not visualised in Commuwin II!

10.4 Function "no.of decimals" (095)



Selection:
- x
- x.x
- **x.xx**
- x.xxx

10.5 Function "sep. character" (096)

Selection:
- **.**
- ,

.
The decimal place is separated by a point.

,
The decimal place is separated by a comma.

10.6 Function "display test" (097)

All display pixels are switched on. If the whole LCD is dark, it is working correctly.

11 Function group "diagnostics" (0A)

In the "**diagnostics**" function group, you can display and confirm error messages.

Type of error

Errors that occur during commissioning or measuring are displayed immediately on the local display. If two or more system or process errors occur, the error with the highest priority is the one shown on the display.
The measuring system distinguishes between two types of error:

- **A (Alarm):**
  Instrument goes into a defined state (e.g. MAX)
  Indicated by a constant ϟ symbol.
  (For a description of the codes, see Page 73)
- **W (Warning):**
  Instrument continue measuring, error message is displayed.
  Indicated by a flashing ϟ symbol.
  (For a description of the codes, see Page 73)
- **E (Alarm / Warning):**
  Configurable (e.g. loss of echo, level within the safety distance)
  Indicated by a constant/flashing ϟ symbol.
  (For a description of the codes, see Page 73)

11.1 Function "present error" (0A0)

The present error is shown using this function.

11.2 Function "previous error" (0A1)

The last error presented is shown with this function.

11.3 Function "clear last error" (0A2)

Selection:
- **keep**
- erase

Caution!
This function can be performed on the display only!

11.4 Function "reset" (0A3)

Caution!
A reset sets the instrument back to the factory settings. This can lead to an impairment of the measurement. Generally, you should perform a basic setup again following a reset.

A reset is only necessary:
- if the instrument no longer functions
- if the instrument must be moved from one measuring point to another
- if the instrument is being de-installed /put into storage/installed

Entry ("reset" (0A3)):
- 333 = customer parameters (HART)
- 33333 = customer parameters (PROFIBUS-PA and Foundation Fieldbus)

333 = reset customer parameters for HART
33333 = reset customer parameters for PROFIBUS-PA and Foundation Fieldbus
This reset is recommended whenever an instrument with an unknown 'history' is to be used in an application:
- The Micropilot is reset to the default values.
- The customer specific tank map is not deleted.
- A linearisation is switched to "**linear**" although the table values are retained. The table can be reactivated in the "**linearisation**" **(04)** function group.

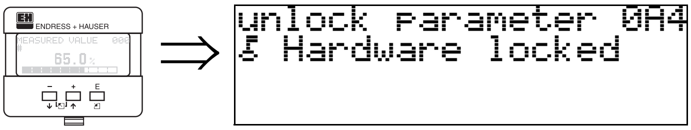
List of functions that are affected by a reset:

- tank shape (002)
- empty calibr. (005)
- full calibr. (006)
- output on alarm (010)
- output on alarm (011)
- outp. echo loss (012)
- ramp %span/min (013)
- delay time (014)
- safety distance (015)
- in safety dist. (016)
- level/ullage (040)
- linearisation (041)
- customer unit (042)
- diameter vessel (047)
- range of mapping (052)
- pres. Map dist (054)
- offset (057)
- low output limit (062)
- fixed current (063)
- fixed cur. value (064)
- simulation (065)
- simulation value (066)
- format display (094)
- distance unit (0C5)
- download mode (0C8)

The tank map can also be reset in the "**cust. tank map**" **(055)** function of the "**extended calibr.**" **(05)** function group.

This reset is recommended whenever an instrument with an unknown 'history' is to be used in an application or if a faulty mapping was started:
- The tank map is deleted. The mapping must be recommenced.

11.5 Function "unlock parameter" (0A4)



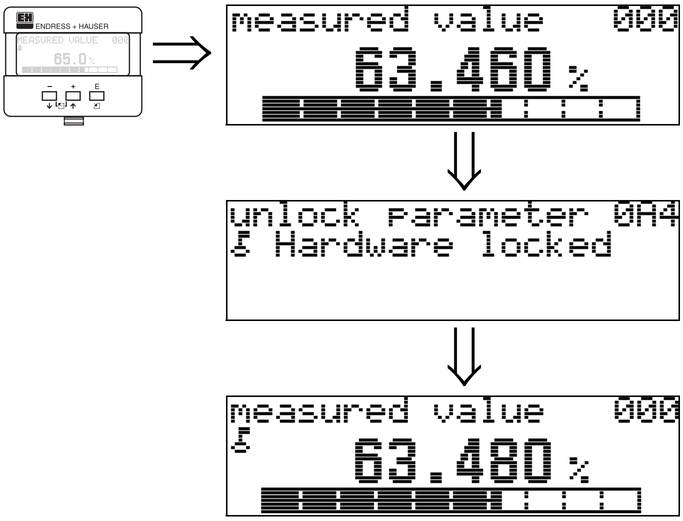
Set-up can be locked and unlocked with this function.

11.5.1 Locking of the configuration mode

The Micropilot can be protected in two ways against unauthorised changing of instrument data, numerical values or factory settings:

"**unlock parameter**" **(0A4):**
A value **<> 100 for HART** (e.g. 99) or **<> 2457 for PROFIBUS-PA and Foundation Fieldbus** (e.g. 2456) must be entered in "**unlock parameter**" **(0A4)** in the "**diagnostics**" **(0A)** function group. The lock is shown on the display by the symbol and can be released again either via the display or by communication.

Hardware lock:
The instrument is locked by pressing the [+] and [–] and [E] keys at the same time.
The lock is shown on the display by the symbol and can **only** be unlocked again via the display by pressing the [+] and [–] and [E] keys at the same time again. It is **not** possible to unlock the hardware by communication.
All parameters can de displayed even if the instrument is locked.



[+] and [–] and [E] press simultaneous

The LOCK_SYMBOL appears on the LCD.

11.5.2 Unlocking of configuration mode

If an attempt is made to change parameters when the instrument is locked, the user is automatically requested to unlock the instrument:

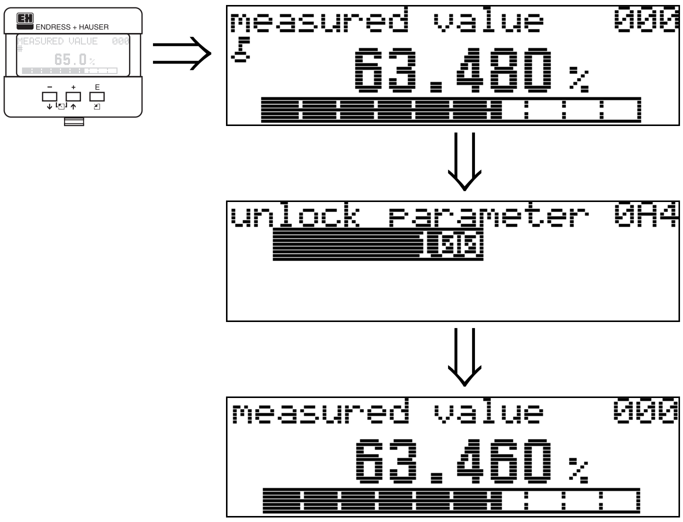
"**unlock parameter**" **(0A4):**
By entering the unlock parameter (on the display or via communication)

100 = for HART devices
2457 = for PROFIBUS-PA and Foundation Fieldbus devices

the Micropilot is released for operation.

Hardware-Verriegelung:
After pressing the + and – and E keys at the same time, the user is asked to enter the unlock parameter

100 = for HART devices
2457 = for PROFIBUS-PA and Foundation Fieldbus devices.

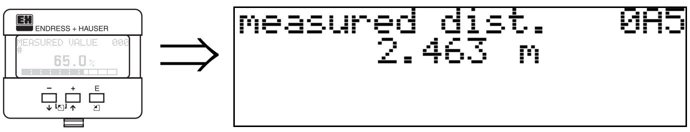


+ and – and E press simultaneous

Please enter unlock code and confirm with E.

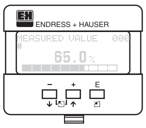
Caution!
Changing certain parameters such as all sensor characteristics, for example, influences numerous functions of the entire measuring system, particularly measuring accuracy. There is no need to change these parameters under normal circumstances and consequently, they are protected by a special code known only to the E+H service organization. Please contact Endress+Hauser if you have any questions.

11.6 Function "measured dist." (0A5)



Display of measured distance in the selected "**distance unit**" **(0C5)**.

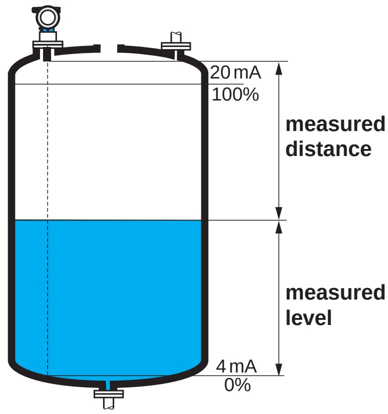
11.7 Function "measured level" (0A6)



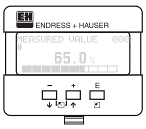
⇒

```
measured level    0A6
     2.541  m
```

Display of measured level in the selected "**distance unit**" **(0C5)**.



11.8 Function "application par." (0A8)

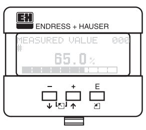


⇒

```
application par.  0A8
✓not modified
 modified
```

Displays whether or not one of the settings dependent on the "**tank shape**" **(002)**, "**medium property**" **(003)** and "**process cond.**" **(004)** application parameters has been changed or not.
If, for example, the "**output damping**" **(058)** is changed, the "**application par.**" shows "**modified**".

Display:
- **not modified**
- modified



⇒

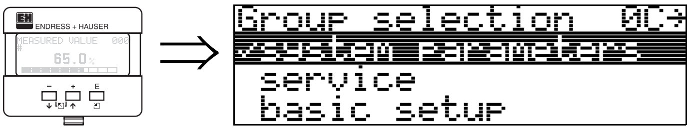
```
    Return to
 Group Selection
```

⇓

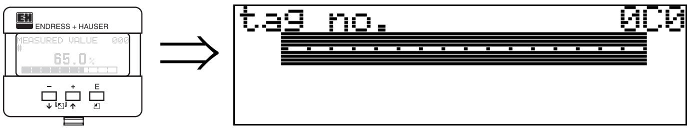
After 3 s, the following message appears

```
Group selection   0A→
✓diagnostics
 system parameters
 service
```

12 Function group "system parameters" (0C)



12.1 Function "tag no." (0C0)



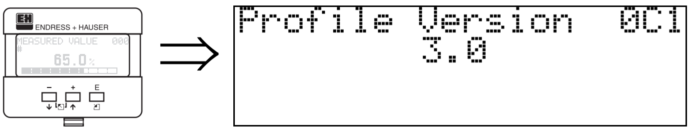
You can define the tag number with this function.

User input:
- 16 alphanumeric characters for HART instruments (8 using the HART universal command)
- 32 alphanumeric characteristics for PROFIBUS-PA instruments

12.2 Function "device tag" (0C0), Foundation Fieldbus only

This function displays the tag number.

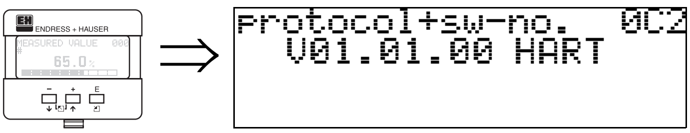
12.3 Function "Profile Version" (0C1), PROFIBUS-PA only



The PA Profile version is shown using this function (Profile 3.0).

Caution!
This function is available for PROFIBUS-PA devices only!

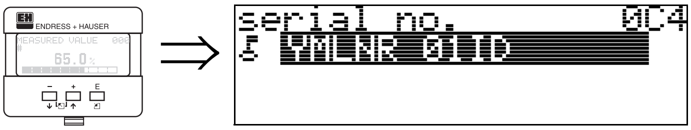
12.4 Function "protocol+sw-no." (0C2)



This function shows the protocol and the hardware and software version: Vxx.yy.zz.prot.

Display:
xx: hw-version
yy: sw-version
zz: sw-revision
prot: protocoll type (e.g. HART)

12.5 Function "serial no." (0C4)



This function displays the instrument serial number.

12.6 Function "device id" (0C4), Foundation Fieldbus only

This function displays the instrument serial number.

12.7 Function "distance unit" (0C5)

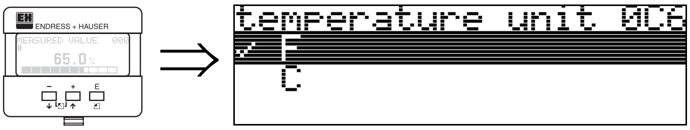
You can select the basic distance unit with this function.

Selection:
- **m**
- ft
- mm
- inch

Dependence
m, mm: "**format display**" **(094)** can only be "**decimal**".

The units are changed for the following parameters:
- empty calibr. (005)
- full calibr. (006)
- safety distance (015)
- input level (044)
- diameter vessel (047)
- range of mapping (052)
- cust. tank map (055)
- offset (057)
- simulation value (066)
- measured dist. (0A5)
- measured level(0A6)

12.8 Function "temperature unit" (0C6)



In this function you select the temperature unit.

Selection:
- °C
- **°F**

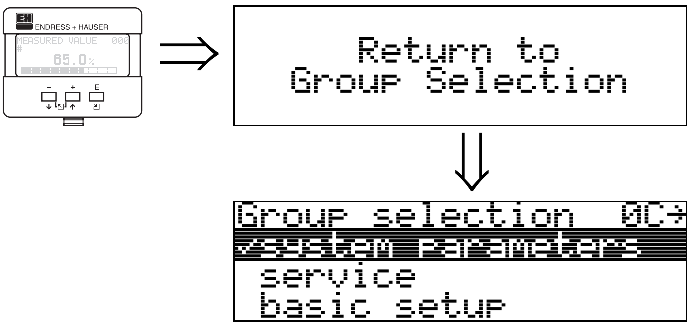
The unit is changed for the following functions
- Function **"measured temp." (030)**
- Function **"max. temp. limit" (031)**
- Function **"max. meas. temp" (032)**

12.9 Function "download mode" (0C8)

This parameter defines which values are written to the instrument during a ToF Tool or Commuwinn II configuration download.

Selection:
- **parameter only**
- param+cust.map
- mapping only

Note!
This parameter must not be described explicitly in ToF Tool. The various possibilities can be selected from the download dialog.



After 3 s, the following message appears

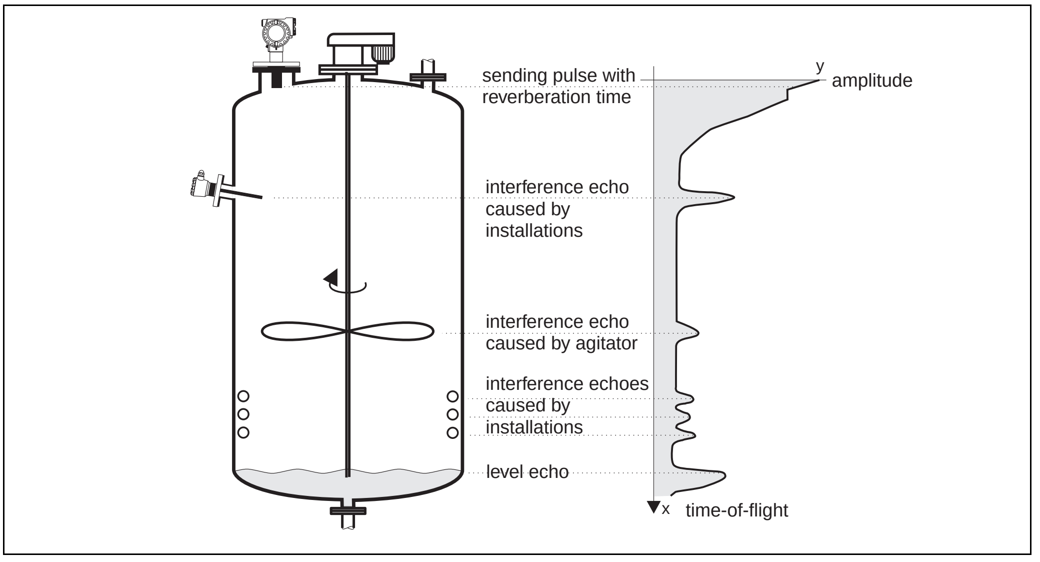
13 Function group "service" (0D)

You can find a detailed description of the "Service" function group as well as a detailed overview of the function menu in the Service Manual: SM 10F for Prosonic M.

14 Signal evaluation

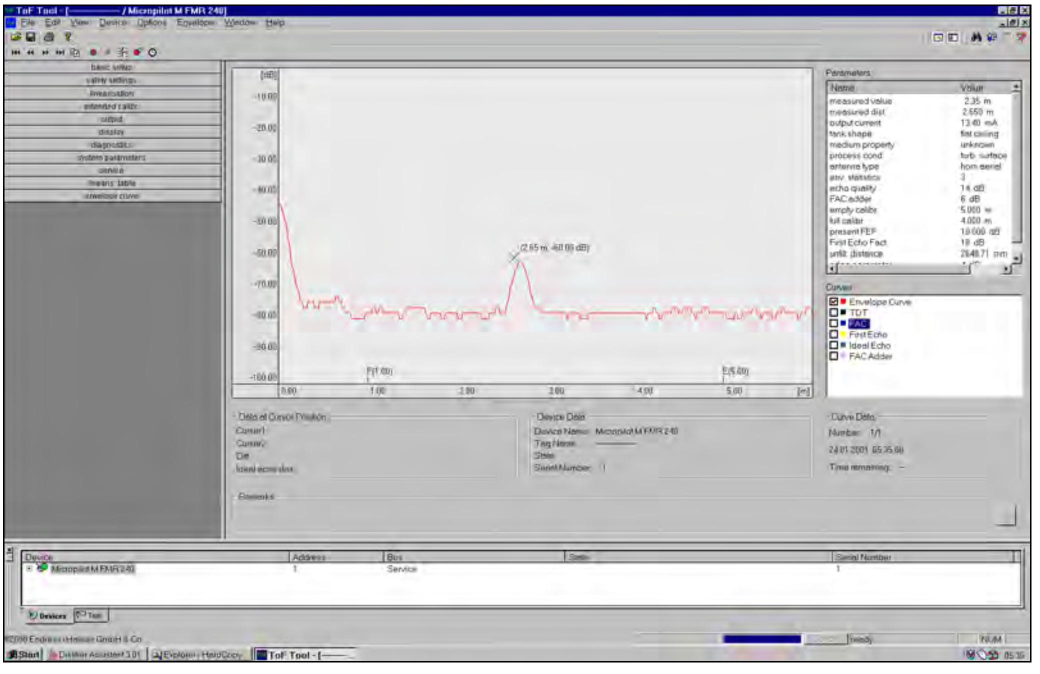
14.1 Envelope curve

The echo of an ultrasonic impulse does not only contain the desired echo from the product surface, but also interference echoes (e.g. from tank fittings or multiple reflections). In order to identify these echoes one plots the logarithmic amplitude of the echo versus the time-of-flight of the ultrasonic impulse. This plot is called **envelope curve**.



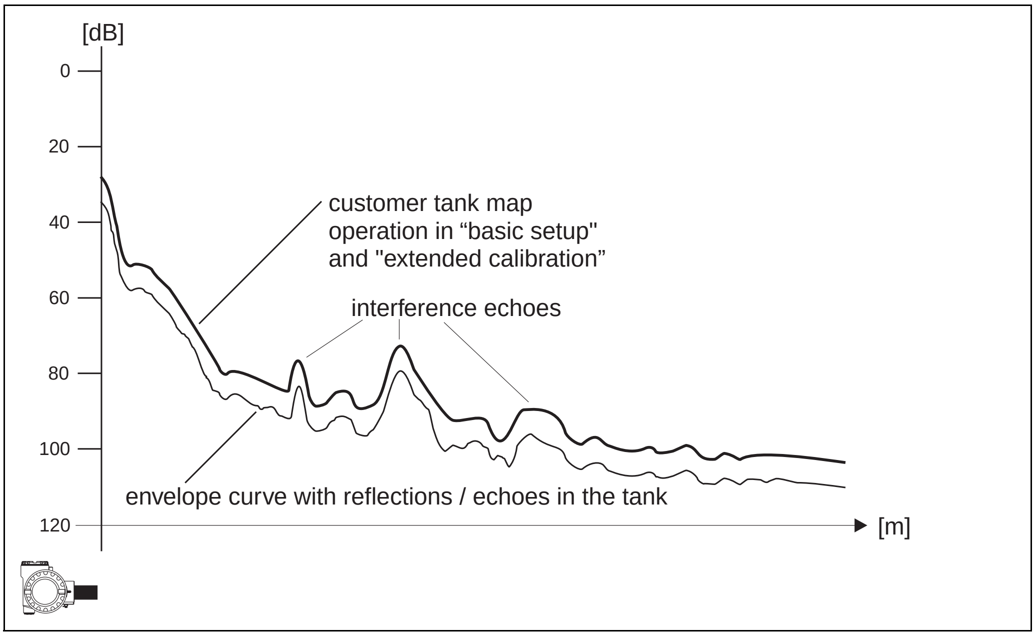
The envelope curve can be displayed in the **"envelope curve" (0E)** function group (see Page 52).

In the ToF Tool the envelope curve may also be displayed in the "envelope" menu:



14.2 Interference echo suppression (tank mapping)

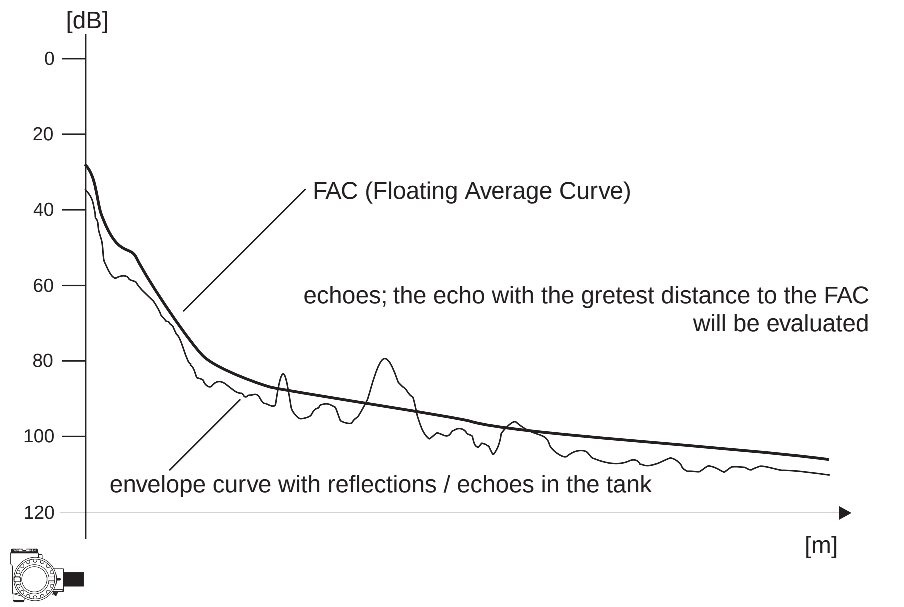
The interference echo suppression of the Prosonic M makes sure that interference echoes are not interpreted as the level echo by fault.
In order to carry out the interference echo suppression one must record a time-of-flight dependent threshold (**TDT**), which is also called the **tank map**.
All maxima of the envelope curve which are situated below the TDT are discarded by the signal evaluation procedures.



It is recommended to record the tank map when the vessel is as possible empty. Then, the map will inclue all echoes except the level echo.
But even, if it is not possible to empty the vessel during the commissioning of the Prosonic M, you should perform the map. In this case it is recommended to repeat the record of the mapping at a later time - when the vessel is as possible empty.

The tank map is recorded in the function group **"extended calibration" (05)**. Select the option "mapping" in the **"selection" (050)** function.

14.3 Floating Average Curve (FAC)



The function of the Floating Average Curve (FAC) is similar to the interference echo suppression.
The main difference is, that the tank map is recorded only once whilst the FAC adjusts itself continuously to the changing measuring conditions.
By this procedure changes of the interference echoes (e.g. by build-up) can be compensated for.
In contrast to the tank map, the FAC can only register small interference echoes.
The FAC is always used in the signal evaluation, even if the tank map has been deactivated.
In the envelope curve, the maximum with the largest distance to the FAC is interpreted as the level echo.

15 Trouble shooting

15.1 System error messages

Current error

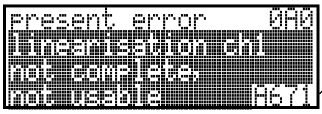
Errors which the Prosonic M detects during commissioning or operation are displayed:
- In the **"measured value" (000)** function
- In the **"diagnostics" (0A)** function group in the **"present error" (0A0)** function (only the highest priority error is displayed; in the case of multiple errors, you can scroll between the different error messages by pressing $\boxed{+}$ or $\boxed{-}$.)

Last error

The last error is displayed in the **"diagnostics" (0A)** function group in the **"previous error" (0A1)** function. This display can be deleted in the **"clear last error" (0A2)** function.

Types of errors

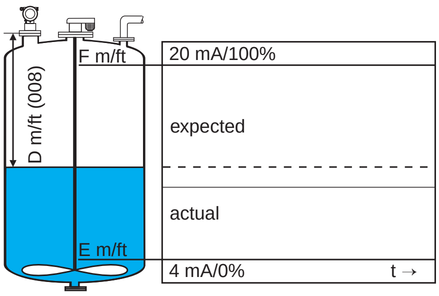
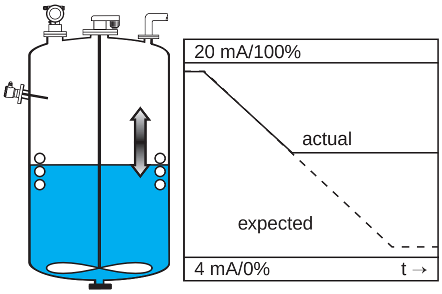
<table>
<tr><th>Type of error</th><th>Symbol</th><th>Meaning</th></tr>
<tr><td>Alarm (A)</td><td>Continuous</td><td>The output signal assumes a value which can be set using the "output on alarm" (010) function:
• MAX: 110%, 22mA
• MIN: -10%, 3.8mA
• Hold: last value is on hold
• User-specific value</td></tr>
<tr><td>Warning (W)</td><td>Flashing</td><td>The device continues measurement. An error message is displayed.</td></tr>
<tr><td>Alarm/Warning (E)</td><td colspan="2">You can define whether the error should behave as an alarm or as a warning.</td></tr>
</table>

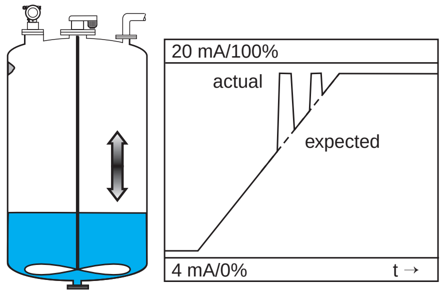


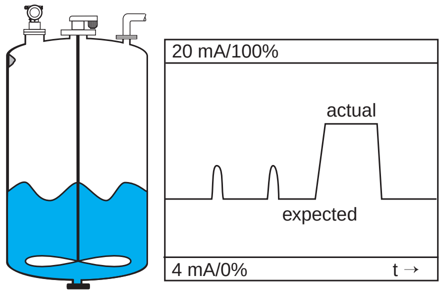
Error codes

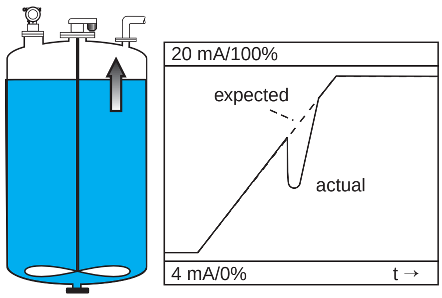
Code	Error description (on the display)	Action
A101 A102 A110 A152 A160	checksum error	Reset; If alarm still present after reset, replace electronics
W103	initialising	If the message does not disappear after several seconds, replace the electronics
A106	downloading	Wait Message disappears after load sequence
A111 A113 A114 A115 A121 A125 A155 A164 A171	electronics defect	Reset; Check system for EMC, improve as necessary If alarm still present after reset, replace electronics
A116	download error	Check connection Restart download
W153	initialising	Wait a few seconds; if error is still displayed, switch the power off and on again
A231	sensor defect	Check connection, if necessary replace HF module or electronics
A281	interruption temperature sensor	Exchange sensor
A502	Sensor type not detected	Exchange sensor and/or electronics
W511	no factory calibration	Carry out factory calibration
A512	recording of mapping	Alarm disappears after a few seconds
A521	new sensor type detected	Reset
W601	linearisation curve not monotone	Correct table (enter monotonously increasing table)
W611	less than 2 linea-risation points	Enter additional value pairs
W621	simulation on	Switch simulation mode off [**"output" (06)** function group, **"simulation" (065)** function]
E641	no usable echo	Check basic calibration (see Page 26)
E651	level in safety distance - risk of overspill	Error disappears when the level leaves the safety distance. Possibly reset the lock. [**"safety settings" (01)** function group, **"ackn. alarm" (017)** function]
A661	Sensor overtemperature	
A671	Linearisation incomplete	Activate linearisation table
W681	current out of range	Carry out basic calibration; check linearisation
W691	Filling noise detected, level ramp is active	

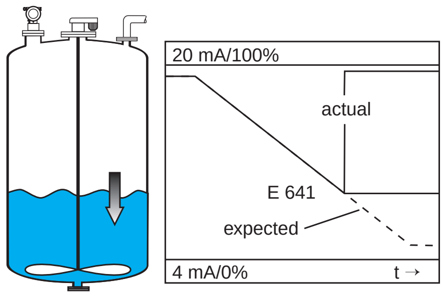
15.2 Application errors

Error	Output	Possible cause		Elimination
A warning or alarm is present.	Depending on the configuration	See Error Codes table (Page 73)		1. See Error Codes table (Page 73)
Measured value (00) is incorrect		Measured distance (008) OK?	yes →	1. Check empty calibration (005) and full calibration (006). 2. Check linearisation: → level/ullage (040) → max. scale(046) → diameter vessel(047) → Check table
		no ↓ Measurement in bypass or stilling well?	yes →	1. In tank shape(002) is bypass or stiliing well selected?
		no ↓ An interference echo might be under evaluation.	yes →	1. Carry out interference echo suppression → basic setup
No change in measured value on filling/ emptying		Interference echoes from fixings, nozzles or build-up on sensor membrane		1. Carry out interference echo suppression → basic setup 2. Clean sensor if necessary 3. If necessary, select better installation position

<table>
<tr><th>Error</th><th>Output</th><th>Possible cause</th><th></th><th>Elimination</th></tr>
<tr>
<td>With an uneven surface (e.g. filling, emptying, running agitator) the measured value may jump sporadically to higher levels</td>
<td>




</td>
<td>Signal is weakened by uneven surface — periodically interference echos, e.g. from internals, are stronger</td>
<td></td>
<td>1. Carry out interference echo suppression ⟶ basic setup
2. Set the process cond. (004) to "calm surface" or "add. agitator"
3. Increase output damping (058)
4. If necessary, select a different installation position and/or a larger sensor</td>
</tr>
<tr>
<td>On filling/ emptying the measured value drops</td>
<td>


</td>
<td>Multiple echoes</td>
<td>yes ⟶</td>
<td>1. Check tank shape (002), e.g. "dome ceiling" or "horizontal cyl."
2. In the blocking distance range (059) there is no echo evaluation
3. If possible, do not select a central installation position
4. Possible user stilling well/echo guide pipe</td>
</tr>
<tr>
<td>E 641 (echo loss)</td>
<td>


</td>
<td>Level echo is too weak.
Possible causes:
• Uneven surface through filling/ emptying
• Active agitator
• Foam
• Sensor not aligned parallel to product surface</td>
<td>yes ⟶</td>
<td>1. Check application parameters (002), (003) and (004)
2. If necessary, select a different installation position and/or a larger sensor
3. Align the sensor parallel to the product surface (particularly for bulk solids applications)</td>
</tr>
</table>

Index function menu

Function group

Function

Europe

Austria
❑ Endress+Hauser Ges.m.b.H.
Wien
Tel. (01) 88056-0, Fax (01) 88056-35

Belarus
❑ Belorgsintez
Minsk
Tel. (0172) 508473, Fax (0172) 508583

Belgium / Luxembourg
❑ Endress+Hauser N.V.
Brussels
Tel. (02) 2480600, Fax (02) 2480553

Bulgaria
INTERTECH-AUTOMATION
Sofia
Tel. (02) 664869, Fax (02) 9631389

Croatia
❑ Endress+Hauser GmbH+Co.
Zagreb
Tel. (01) 6637785, Fax (01) 6637823

Cyprus
I+G Electrical Services Co. Ltd.
Nicosia
Tel. (02) 484788, Fax (02) 484690

Czech Republic
❑ Endress+Hauser GmbH+Co.
Praha
Tel. (026) 6784200, Fax (026) 6784179

Denmark
❑ Endress+Hauser A/S
Søborg
Tel. (70) 131132, Fax (70) 132133

Estonia
ELVI-Aqua
Tartu
Tel. (7) 441638, Fax (7) 441582

Finland
❑ Endress+Hauser Oy
Helsinki
Tel. (0204) 83160, Fax (0204) 83161

France
❑ Endress+Hauser S.A.
Huningue
Tel. (389) 696768, Fax (389) 694802

Germany
❑ Endress+HauserMesstechnik GmbH+Co.
Weil am Rhein
Tel. (07621) 975-01, Fax (07621) 975-555

Great Britain
❑ Endress+Hauser Ltd.
Manchester
Tel. (0161) 2865000, Fax (0161) 9981841

Greece
I & G Building Services Automation S.A.
Athens
Tel. (01) 9241500, Fax (01) 9221714

Hungary
Mile Ipari-Elektro
Budapest
Tel. (01) 4319800, Fax (01) 4319817

Iceland
BIL ehf
Reykjavik
Tel. (05) 619616, Fax (05) 619617

Ireland
Flomeaco Company Ltd.
Kildare
Tel. (045) 868615, Fax (045) 868182

Italy
❑ Endress+Hauser S.p.A.
Cernusco s/N Milano
Tel. (02) 92192-1, Fax (02) 92192-362

Latvia
Rino TK
Riga
Tel. (07) 315087, Fax (07) 315084

Lithuania
UAB "Agava"
Kaunas
Tel. (07) 202410, Fax (07) 207414

Netherlands
❑ Endress+Hauser B.V.
Naarden
Tel. (035) 6958611, Fax (035) 6958825

Norway
❑ Endress+Hauser A/S
Tranby
Tel. (032) 859850, Fax (032) 859851

Poland
❑ Endress+Hauser Polska Sp. z o.o.
Warszawy
Tel. (022) 7201090, Fax (022) 7201085

Portugal
Tecnisis - Tecnica de Sistemas Industriais
Linda-a-Velha
Tel. (21) 4267290, Fax (21) 4267299

Romania
Romconseng S.R.L.
Bucharest
Tel. (01) 4101634, Fax (01) 4112501

Russia
❑ Endress+Hauser Moscow Office
Moscow
Tel. (095) 1587564, Fax (095) 1589871

Slovakia
Transcom Technik s.r.o.
Bratislava
Tel. (7) 44888684, Fax (7) 44887112

Slovenia
❑ Endress+Hauser D.O.O.
Ljubljana
Tel. (01) 5192217, Fax (01) 5192298

Spain
❑ Endress+Hauser S.A.
Sant Just Desvern
Tel. (93) 4803366, Fax (93) 4733839

Sweden
❑ Endress+Hauser AB
Sollentuna
Tel. (08) 55511600, Fax (08) 55511655

Switzerland
❑ Endress+Hauser Metso AG
Reinach/BL 1
Tel. (061) 7157575, Fax (061) 7111650

Turkey
Intek Endüstriyel Ölcü ve Kontrol Sistemlerilstanbul
Tel. (0212) 2751355, Fax (0212) 2662775

Ukraine
Photonika GmbH
Kiev
Tel. (44) 26881, Fax (44) 26908

Yugoslavia Rep.
Meris d.o.o.
Beograd
Tel.(11) 4441966, Fax (11) 4441966

Africa

Egypt
Anasia
Heliopolis/Cairo
Tel. (02) 4179007, Fax (02) 4179008

Morocco
Oussama S.A.
Casablanca
Tel. (02) 241338, Fax (02) 402657

South Africa
❑ Endress+Hauser Pty. Ltd.
Sandton
Tel. (011) 26280000, Fax (011) 2628062

Tunisia
Controle, Maintenance et Regulation
Tunis
Tel. (01) 793077, Fax (01) 788595

America

Argentina
❑ Endress+Hauser Argentina S.A.
Buenos Aires
Tel. (01) 145227970, Fax (01) 145227909

Bolivia
Tritec S.R.L.
Cochabamba
Tel. (042) 56993, Fax (042) 50981

Brazil
❑ Samson Endress+Hauser Ltda.
Sao Paulo
Tel. (011) 50313455, Fax (011) 50313067

Canada
❑ Endress+Hauser Ltd.
Burlington, Ontario
Tel. (905) 6819292, Fax (905) 6819444

Chile
❑ Endress+Hauser Chile Ltd.
Santiago
Tel. (02) 321-3009, Fax (02) 321-3025

Colombia
Colsein Ltda.
Bogota D.C.
Tel. (01) 2367659, Fax (01) 6104186

Costa Rica
EURO-TEC S.A.
San Jose
Tel. (02) 961542, Fax (02) 961542

Ecuador
Insetec Cia. Ltda.
Quito
Tel. (02) 269148, Fax (02) 461833

Guatemala
ACISAAutomatizacionYControlIndustrial S.A.
Ciudad de Guatemala, C.A.
Tel. (03) 345985, Fax (03) 327431

Mexico
❑ Endress+Hauser S.A. de C.V.
Mexico City
Tel. (5) 5682405, Fax (5) 5687459

Paraguay
Incoel S.R.L
.Asuncion
Tel. (021) 213989, Fax (021) 226583

Uruguay
Circular S.A.
Montevideo
Tel. (02) 925785, Fax (02) 929151

USA
❑ Endress+Hauser Inc.
Greenwood, Indiana
Tel. (317) 535-7138, Fax (317) 535-8498

Venezuela
Controval C.A.
Caracas
Tel. (02) 9440966, Fax (02) 9444554

Asia

China
❑ Endress+Hauser Shanghai
Instrumentation Co. Ltd.
Shanghai
Tel. (021) 54902300, Fax (021) 54902303

❑ Endress+Hauser Beijing Office
Beijing
Tel. (010) 68344058, Fax: (010) 68344068

Hong Kong
❑ Endress+Hauser HK Ltd.
Hong Kong
Tel. 25283120, Fax 28654171

India
❑ Endress+Hauser (India) Pvt. Ltd.
Mumbai
Tel. (022) 8521458, Fax (022) 8521927

Indonesia
PT Grama Bazita
Jakarta
Tel. (21) 7975083, Fax (21) 7975089

Japan
❑ Sakura Endress Co. Ltd.
Tokyo
Tel. (0422) 540613, Fax (0422) 550275

Malaysia
❑ Endress+Hauser (M) Sdn. Bhd.
Petaling Jaya, Selangor Darul Ehsan
Tel. (03) 7334848, Fax (03) 7338800

Pakistan
Speedy Automation
Karachi
Tel. (021) 7722953, Fax (021) 7736884

Philippines
❑ Endress+Hauser Philippines Inc.
Metro Manila
Tel. (2) 3723601-05, Fax (2) 4121944

Singapore
❑ Endress+Hauser (S.E.A.) Pte., Ltd.
Singapore
Tel. 5668222, Fax 5666848

South Korea
❑ Endress+Hauser (Korea) Co., Ltd.
Seoul
Tel. (02) 6587200, Fax (02) 6592838

Taiwan
Kingjarl Corporation
Taipei R.O.C.
Tel. (02) 27183938, Fax (02) 27134190

Thailand
❑ Endress+Hauser Ltd.
Bangkok
Tel. (2) 9967811-20, Fax (2) 9967810

Vietnam
Tan Viet Bao Co. Ltd.
Ho Chi Minh City
Tel. (08) 8335225, Fax (08) 8335227

Iran
PATSA Co.
Tehran
Tel. (021) 8754748, Fax(021) 8747761

Israel
Instrumetrics Industrial Control Ltd.
Tel-Aviv
Tel. (09) 8357090, Fax (09) 8350619

Jordan
A.P. Parpas Engineering S.A.
Amman
Tel. (06) 4643246, Fax (06) 4645707

Kingdom of Saudi Arabia
Anasia Ind. Agencies
Jeddah
Tel. (02) 6710014, Fax (02) 6725929

Lebanon
Network Engineering
Jbeil
Tel. (3) 944080, Fax (9) 548038

Sultanate of Oman
Mustafa & Sultan Sience & Industry Co. L.L.C.
Ruwi
Tel. 602009, Fax 607066

United Arab Emirates
Descon Trading EST.
Dubai
Tel. (04) 2653651, Fax (04) 2653264

Yemen
YemenCompany for Ghee and Soap Industry
Taiz
Tel. (04) 230664, Fax (04) 212338

Australia + New Zealand

Australia
ALSTOM Australia Limited
Milperra
Tel. (02) 97747444, Fax (02) 97744667

New Zealand
EMC Industrial Group Limited
Auckland
Tel. (09) 4155110, Fax (09) 4155115

All other countries

❑ Endress+Hauser GmbH+Co. KG
Instruments International
Weil am Rhein
Germany
Tel. (07621) 975-02, Fax (07621) 975-345

http://www.endress.com

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In-Situ LevelTroll 500

In-Situ Inc.®

Level TROLL®

OPERATOR'S MANUAL

Level **TROLL** 300

Level **TROLL** 500

Level **TROLL** 700

Baro**TROLL**

September 2006

Revision history	Beta draft June 10, 2005 (Level TROLL 500) Initial release, June 27, 2005 Rev. 001, August 17, 2005 Rev. 002, April 2006 (Level TROLL 300, 500, 700, BaroTROLL) Rev. 003, September 2006

Mailing & Shipping Address:	*Phone:*	970 498 1500
In-Situ Inc.	*Fax:*	970 498 1598
221 East Lincoln Avenue	*Internet:*	www.in-situ.com
Fort Collins, CO 80524	*Support Line:*	800 446 7488
USA		*(US & Canada)*

In-Situ Inc.

Contents

1 INTRODUCTION

SYSTEM DESCRIPTION

Your new Level TROLL is a compact, modular system for measuring level and temperature in natural groundwater and surface water, as well as industrial, waste, and other installations. Components include the instrument body, vented and non-vented cables, communication cables, external power accessories, desiccants and other installation accessories, and software.

HOW TO USE THIS MANUAL

This operator's manual is designed as both a start-up guide and a permanent reference for the Level TROLL's features and applications.

Section 1: Introduction to the Level TROLL Operator's Manual and to In-Situ Inc. — Warranty Provisions — Instrument Repair & Return Recommendations

Section 2: Components and features of the Level TROLL system — Accessories — Product Specifications

Section 3: Getting Started — Attaching Cable — Installing & Launching the Software

Section 4: Using Win-Situ — Connecting for the First Time — Setting the Clock — Setting a Device Site — Preparing to Log Data —Disconnecting

Section 5: About the Pressure (Level) Sensor: The two basic types of pressure sensors — Factory and field calibration

Section 6: Field Installation — Guidelines and Precautions for Long-Term Deployment of the Level TROLL

Section 7: The BaroTROLL

Section 8: Connecting for use with SDI-12, Analog (4-20 mA), and Modbus loggers and controllers

Section 9: Care & Maintenance

Section 10: Troubleshooting

CONVENTIONS

Throughout this operator's manual you will see the following symbols.

The check mark highlights a tip about a convenient feature of the Level TROLL

The exclamation point calls your attention to a requirement or important action that should not be overlooked

CERTIFICATION

The Level TROLL complies with all applicable directives required by CE and the FCC and found to comply with EN 61326, ICES-003, and FCC Part 15 specifications. Declarations of conformity may be found at end of this manual.

UNPACKING AND INSPECTION

TIP: Please save packing materials for future storage and shipping of your Level TROLL. The shipping boxes have been performance-tested and provide protection for the instrument and its accessories.

Your Level TROLL was carefully inspected before shipping. Check for any physical damage sustained during shipment. Notify In-Situ and file a claim with the carriers involved if there is any such damage; do not attempt to operate the instrument. Accessories may be shipped separately and should also be inspected for physical damage and the fulfillment of your order.

SERIAL NUMBER

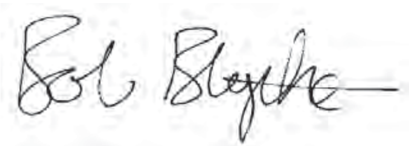
The serial number is engraved on the body of the Level TROLL. It is also programmed into the instrument and displayed when the instrument is connected to a computer running Win-Situ 5 or Win-Situ Mobile. We recommend that owners keep a separate record of this number. Should your Level TROLL be lost or stolen, the serial number is often necessary for tracing and recovery, as well as any insurance claims. If necessary, In-Situ maintains complete records of original owner's names and serial numbers.

TO OUR CUSTOMERS . . .

Thank you for your purchase of an In-Situ product. We are glad you chose us and our products to help you with your environmental monitoring needs. In-Situ Inc. has been designing and manufacturing world-class environmental monitoring instrumentation for over 25 years in the Rocky Mountains of the United States. As it was in the beginning, our expectation is that this product will provide you with many trouble-free years of use. To that end, we pride ourselves on delivering the best customer service and support possible—24 hours a day, 7 days a week. We believe that this level of commitment to you, our customer, is imperative in helping you ensure clean, safe groundwater and surface water resources across the globe. We also understand the need for accurate, reliable assessments and we continue to make significant investments in Research and Development to ensure that we deliver the latest product and technological innovations to support your needs.

Whether you are gathering information about your body of water for a few moments, or over a period of years, you can rely upon us to provide you with a quality product and outstanding customer support at a fair price and have that product delivered to you when and where you need it.

We want your experience with In-Situ Inc. to be pleasant and professional, whether you are renting from us, or purchasing from us. We would be pleased to hear from you and learn more about your needs, and your experiences with our products. Again, we thank you for choosing In-Situ Inc. and we look forward to serving your needs now, and in the future.



Bob Blythe, President and CEO
In-Situ Inc.
bblythe@in-situ.com

WHAT WE PROVIDE

WARRANTY PROVISIONS

In-Situ Inc. warrants all products sold against defects in materials and workmanship under normal operating conditions. Consult the separate warranty for specific warranties that may apply.

Maintenance & calibration plans as well as extended warranties are available for U.S. customers. Contact your In-Situ representative for complete information.

FIRMWARE & SOFTWARE UPGRADES

The Level TROLL is upgradeable. Contact In-Situ Inc. for details.

HOW TO CONTACT US

Technical Support:	800 446 7488
	Toll-free 24 hours a day in the U.S. and Canada
Address:	In-Situ Inc. 221 E. Lincoln Ave. Fort Collins, CO 80524 USA
Phone:	970 498 1500
Fax:	970 498 1598
Internet:	www.in-situ.com
e-mail:	support@in-situ.com

TO OBTAIN REPAIR SERVICE (U.S.)

If you suspect that your Level TROLL is malfunctioning and repair is required, you can help assure efficient servicing by following these guidelines:

1. Call or e-mail In-Situ Technical Support (support@in-situ.com). Have the product model and serial number handy.

2. Be prepared to describe the problem, including how the instrument was being used and the conditions noted at the time of the malfunction.

3. If Tech Support determines that service is needed, they will ask that your company pre-approve a specified dollar amount for repair charges. When the pre-approval is received, Tech Support will assign an RMA (Return Material Authorization) number.

TIP: *Please keep your RMA number for future reference.*

4. Clean the Level TROLL and cable. Decontaminate thoroughly if it has been used in a toxic or hazardous environment. See the Cleaning Guidelines and form on page 13.

5. Carefully pack your Level TROLL in its original shipping box, if possible. Include a statement certifying that the instrument and cable have been decontaminated, and any supporting information.

6. Mark the RMA number clearly on the outside of the box with a marker or label.

7. Send the package, shipping prepaid, to

   In-Situ Inc.
   ATTN: Repairs
   221 E. Lincoln Ave.
   Fort Collins, CO 80524

The warranty does not cover damage during transit. We recommend the customer insure all shipments. Warranty repairs will be shipped back prepaid.

Outside the U.S.

Contact your international In-Situ distributor for repair and service information.

GUIDELINES FOR CLEANING RETURNED EQUIPMENT

If an instrument returned for servicing shows evidence of having been deployed in a toxic or hazardous environment, Customer Service personnel will require written proof of decontamination before they can service the unit.

Please help us protect the health and safety of our employees by cleaning and decontaminating equipment that has been subjected to any potential biological or health hazards, and labeling such equipment. Unfortunately, *we cannot service your equipment without such notification*. Please complete and sign the form on page 13 (or a similar statement certifying that the equipment has been cleaned and decontaminated) and send it along to us with each downhole instrument.

- We recommend a good cleaning solution, such as Alconox®, a glassware cleaning product available from In-Situ (Catalog No. 0029810) and laboratory supply houses.
- Clean all cabling. Remove all foreign matter.
- Clean cable connector(s) with a clean, dry cloth. Do not submerge.
- Clean the probe body—including the nose cone, cable head, and protective caps. Remove all foreign matter.

***TIP:** Alconox® is available from In-Situ Inc. (Catalog No. 29810).*

If an instrument is returned to our Service Center for repair or recalibration without a statement that it has been cleaned and decontaminated, or in the opinion of our Service Representatives presents a potential health or biological hazard, we reserve the right to withhold service until proper certification has been obtained.

Decontamination & Cleaning Statement

Company Name ________________________________ Phone ________________

Address ____

City __________________________ State ____________ Zip ________________

Instrument Type __________________________ Serial Number ___________________

Contaminant(s) (if known) ____

____

Decontamination procedure(s) used ____

____

Cleaning verified by ______________________________ Title __________________

Date ______________________

In-Situ Inc.

2 SYSTEM COMPONENTS

BODY

There are no user-serviceable parts in the Level TROLL body.

The completely sealed Level TROLL contains pressure and temperature sensors, real-time clock, microprocessor, sealed lithium battery, data logger, and memory. Options include a vented or non-vented pressure sensor in a variety of ranges.

CABLE

***TIP:** Cable markings include VF = vent-free, HF = halogen-free*

Several basic cable types are used in the Level TROLL system.

- RuggedCable™, TPU-jacketed (Thermoplastic PolyUrethane)
    - vented or non-vented
    - Halogen-Free vented or non-vented (LSZH-rated, low smoke zero halide)
- Vented FEP* cable
- Stainless steel suspension wire for deployment of a non-vented instrument
- Communication cables for programming the device/downloading the logged data

** FEP (fluorinated ethylene propylene) is the generic equivalent of DuPont Teflon®*

RuggedCable™

Cable includes conductors for power and communication signals, a strength member, and a Kellems® grip to anchor the Level TROLL securely. Available in standard and custom lengths.

Uphole and downhole ends are identical “female” bayonet-type Twist-Lock connectors that mate with the Level TROLL body, TROLL Com communication cable, desiccants, and other accessories. Available in rugged all-titanium or standard carbon-filled ABS plastic.

Vented cable is designed for use with vented pressure/ level sensors (gauged measurements). The cable vent tube insures that atmospheric pressure is the reference pressure applied to the sensor diaphragm. Vented cable includes a small desiccant cap.

Non-vented cable may be used with non-vented pressure/level sensors (absolute measurements).

RuggedCable “Stripped & Tinned”

to PLC
or logger

to Level
TROLL

In place of the “uphole” Twist-Lock connector, this cable ends in bare conductors for wiring to a logger or controller using SDI-12, analog (4-20 mA), or Modbus communication protocols. Vented cable includes an outboard desiccant to protect against condensation.

to PLC
or logger

to RuggedCable

Also available in a shorter length ending in a “male” Twist-Lock connector to mate with RuggedCable.

For connections, refer to wiring diagrams in Section 7.

Suspension Wire

FEP-coated stainless steel suspension cable is ideal for deployment of instruments with non-vented pressure sensors: Level TROLL 300, non-vented Level TROLL 500 or 700, and BaroTROLL.

to Level
TROLL

Small Desiccant

Vented cable includes a clear cap of indicating silica gel desiccant to protect the cable and electronics from condensation. The desiccant is blue when active. It will absorb moisture from the top down and for best results should be replaced before the entire volume has lost its color. Replacements are available from In-Situ Inc. or your distributor.

TIP: *Protect new desiccant from moisture until ready to use.*

Large Desiccant

The optional high-volume desiccant pack may last up to 20 times longer than the small desiccant in humid environments. It attaches to vented Level TROLL cable in the same way. Refill kits are also available from In-Situ Inc. or your distributor.

Outboard Desiccant

Vented "stripped & tinned" cable includes an outboard desiccant pack attached to the cable vent tube. Same size as large desiccant. Replacements and refills are available.

Accessory	Catalog No.
Small desiccant (3)	52230
Large desiccant	51810
Outboard desiccant (replacement)	51380
Refill kit for large & outboard desiccant	29140

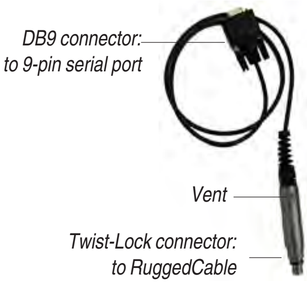
COMMUNICATION CABLES

Comm cables provide an interface between the Level TROLL and a desktop/laptop PC or handheld PDA for profiling, programming, and downloading.

The computer connectors are not submersible.

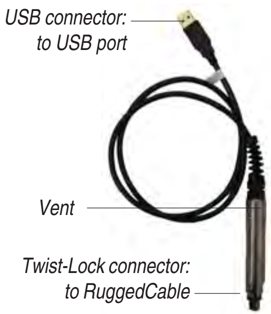
For Connection to Cable

TROLL Com, RS232



Vented polyurethane cable (0.9 m, 3 ft), connects the Level TROLL's RuggedCable to a PC’s serial port. Converts the Level TROLL's RS485 signal to a standard RS232 signal for communication via the serial port on a host computer. Weatherproof, withstands a temporary immersion. Cable vents into unit, protected by a hydrophobic membrane.

USB TROLL Com



Same as the RS232 TROLL Com but connects the Level TROLL’s RuggedCable to a USB port.

Accessory	Catalog No.
TROLL Com, RS232	51460
USB to serial adapter	31090
USB TROLL Com	52500

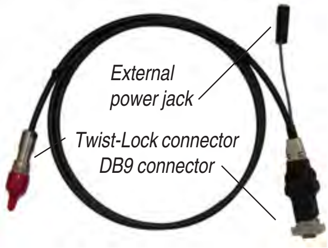
For Direct Connection to Level TROLL

These connect a Level TROLL directly to a serial or USB port for programming and downloading. A good choice for permanent connection to a PC, or for programming a non-vented Level TROLL that will be deployed without RuggedCable.

Programming Cable (RS232)

The computer connectors are not submersible.

Vented polyurethane or halogen-free polyurethane cable (1.8 m, 6 ft) combines the functions of the RuggedCable and TROLL Com; connects the Level TROLL directly to a serial port; includes RS485/RS232 converter and external power input jack; ideal for profiling.



Direct USB TROLL Com

"Female" connector attaches directly to the Level TROLL. No external power input. The non-locking connector is not designed for submersion, but may be used for brief dips into shallow water--hold on to the Level TROLL, not the cable.

Accessory	Catalog No.
USB TROLL Com, direct to Level TROLL	52510
Programming cable	51840
Programming cable, halogen-free	51850

POWER COMPONENTS

TIP: Win-Situ 5 can display the approximate percentage of internal battery life remaining when the Level TROLL is connected to a computer.

INTERNAL POWER

The Level TROLL operates on 3.6 VDC, supplied by a completely sealed, non-replaceable AA lithium battery. Battery life depends on sampling speed. Typical battery life is 5 years or 2,000,000 data records, whichever occurs first.

EXTERNAL POWER

External Battery Pack

The sealed, submersible TROLL Battery Pack (lithium) supplies 14.4 V. When this power source is connected, the Level TROLL will use the external battery source first and switch to the internal batteries when external battery power is depleted. Battery life depends on sampling speed.

TIP: When a Level TROLL is used as an Analog (4-20 mA), SDI-12, or Modbus device, power is supplied by the data logger or controller to which the Level TROLL is wired.

0.5 sec sampling interval	1.2 months
1 sec sampling interval	2.3 months
1 min sampling interval or longer	1 year

AC Adapter

Use only In-Situ's AC adapter. Damage to the Level TROLL caused by the use of third-party converters is not covered by the warranty.

In-Situ's AC adapter provides 24 VDC, 0.75 A, AC input 100-250 V, includes North American power cord. The Programming Cable includes an external power input for connection to this adapter.

Accessory	Catalog No.
External Battery Pack	51450
AC Adapter	52440

INSTALLATION ACCESSORIES

NPT Adapter

Twist-Lock Hanger

- 1/4” NPT Adapter: allows Level TROLL installation in piping
- Twist-Lock Hanger: titanium or stainless steel hanger to suspend a non-vented Level TROLL or BaroTROLL while taking data; no venting, no communication capabilities
- Cable Extender: connects two lengths of RuggedCable
- Wellcaps, locking and vented
- Well Docks: top-of-well support for 2”, 4”, or 6” well
- Panel-mounted bulkhead for connection to RuggedCable

Cable Extender

Accessory	Catalog No.
NPT Adapter	51470
Twist-Lock Hanger, titanium for Level TROLL 500, 700, Baro	51480
Twist-Lock Hanger, stainless steel for Level TROLL 300	55050
Cable Extender	51490
Locking Wellcap, 2”	20360
Locking Wellcap, 2” vented	20370
Locking Wellcap, 4”	20380
Locking Wellcap, 4” vented	20390
Top-of-well installation ring	WELLDOCK2”, 4”, 6”
Bulkhead connector	53240
Weighted nose cone	57570

Weighted nose cone

Locking Wellcap

Well Dock

CONTROL SOFTWARE

TIP: Win-Situ connects through a serial COM port. If your computer does not have one, a USB-to-serial adapter is available from In-Situ Inc. (Catalog No. 31090).

Win-Situ® 5 is easy-to-use software for programming the Level TROLL.

Win-Situ provides instrument control for direct reads and profiling, long-term data logging, data downloads, data viewing, data export to popular spreadsheet programs, choice of units and other display options, battery/memory usage tracking, interface to networks and telemetry.

Minimum system requirements: 400 MHz Pentium® II processor, 128 Mb RAM, 100 Mb free disk space, Internet Explorer® 6.01 or higher, Windows® 2000 Professional SP4 or higher, or Windows XP Professional SP1 or higher, CD-ROM drive, and a serial communications port.

Complete information on using the software is available from Win-Situ's Help menu.

Win-Situ® Mobile (formerly Pocket-Situ 5) provides Win-Situ's features and functions on a field-portable platform. Requirements: supported PDA with Microsoft Pocket PC 2003 (Windows Mobile) or later operating system, serial communications port, and at least 16 Mb for data storage (SD card, CF card, or the device's built-in non-volatile memory). For installation and file exchange, Microsoft® ActiveSync® must be installed on an office desktop or laptop computer.

Accessory	Catalog No.
Win-Situ 5 (no license required)	51980
Win-Situ Mobile license for RuggedReader	47520
Win-Situ Mobile license (upgrade from Pocket-Situ 4)	47550

PRODUCT SPECIFICATIONS

	Level TROLL 300	Level TROLL 500	Level TROLL 700
Operating Temperature	-5 to 50°C (23 to 122°F)	-20 to 80°C (-4 to 176°F)	-20 to 80°C (-4 to 176°F)
Storage Temperature	-40 to 80°C (-40 to 176°F)	-40 to 80°C (-40 to 176°F)	-40 to 80°C (-40 to 176°F)
Dimensions			
O.D.	0.82" (20.82 mm)	0.72" (18.3 mm)	0.72" (18.3 mm)
Length	9.0" (22.9 cm)	8.5" (21.6 cm)	8.5" (21.6 cm)
Weight	0.54 lb (0.24 kg)	0.43 lb (0.197 kg)	0.43 lb (0.197 kg)
Material			
Housing	316L Stainless steel	Titanium	Titanium
Nose Cone	Black Delrin®	Black Delrin®	Black Delrin®
Output Options	RS232 (with TROLL Com), Modbus (RS485), SDI-12, 4-20mA	RS232 (with TROLL Com), Modbus (RS485), SDI-12, 4-20mA	RS232 (with TROLL Com), Modbus (RS485), SDI-12, 4-20mA
Power			
Internal Battery	3.6V lithium	3.6V lithium	3.6V lithium
Battery Life	5 yrs or 1M data records	5 yrs or 2M data records	5 yrs or 2M data records
External Power	8-36 VDC	8-36 VDC	8-36 VDC
Memory	1 MB	2 MB	4 MB
Data Records	50,000	100,000	350,000
Fastest Logging Rate	1 per sec	2 per sec	4 per sec
Real-Time Sampling Rate			
Modbus	2 per sec	2 per sec	2 per sec
SDI-12	2 per sec	2 per sec	2 per sec
4-20 mA update rate	2 per sec	2 per sec	2 per sec
Max. no. of logs	2	2	50
Log Types	Linear, Fast Linear	Linear, Fast Linear	Linear, Fast Linear, Linear Average, Step Linear, Event, True Logarithmic

	Level TROLL 300	Level TROLL 500	Level TROLL 700
Pressure/Level Sensor			
Type	Silicon strain gauge	Silicon strain gauge	Silicon strain gauge
Material	Stainless steel	Titanium	Titanium
Accuracy*			
@ 15°	± 0.2% FS	± 0.05% FS	± 0.05% FS
-5 to +50°C	± 0.2% FS	± 0.1% FS	± 0.1% FS
-20 to -5 & +50 to +80°C	NA	± 0.25% FS typical	± 0.25% FS typical
Resolution	± 0.01% FS or better	± 0.005% FS or better	± 0.005% FS or better
Range			
Non-Vented (PSIA)	30, 100, 300	30, 100, 300, 500	30, 100, 300, 500
Vented (PSIG)	––	5, 15, 30, 100, 300, 500	5, 15, 30, 100, 300, 500
Max. pressure	2X range	2X range	2X range
Burst pressure	3X range	3X range	3X range
Temperature Sensor			
Material	Silicon	Silicon	Silicon
Accuracy	± 0.25°C	± 0.1°C	± 0.1°C
Resolution	0.1°C	0.01°C	0.01°C

** FS = full scale. Accuracy with 4-20 mA output option: ± 0.25% FS typical*

Range and Usable Depth

Non-Vented Level TROLL

Range	Effective Range**		Usable Depth	
PSIA	PSIA	kPa	Meters	Feet
30	15.5	106.9	0-10.9	0-35.8
100	85.5	589.5	0-60.1	0-197.3
300	285.5	1968	0-200.7	0-658.7
500	485.5	3347	0-341.3	0-1120

*** At sea level (14.5 PSI atmospheric pressure).*

Vented Level TROLL

Range		Usable Depth	
PSIG	kPa	Meters	Feet
5	34.5	0-3.5	0-11.5
15	103.4	0-11	0-35
30	206.8	0-21	0-69
100	689.5	0-70	0-231
300	2068	0-210	0-692
500	3447	0-351	0-1153

BaroTROLL

Same as Level TROLL 500 specs, **except** Pressure Range: 0 to 16.5 PSIA (1.14 bar, 33.59 in Hg), Log Types: Linear, Fastest Logging Rate: 1 per minute

Cable

Jacket options	Polyurethane, halogen-free (HF) polyurethane, FEP*
Connector	Titanium or carbon-filled ABS plastic, 18.5 mm (0.73 in) O.D.
Conductors	6 conductors, 24 AWG, polypropylene insulation
Diameter	6.7 mm (0.265 in)
Break strength	127 kg (280 lb)
Minimum bend radius (vented cable)	2X cable diameter (13.5 mm, 0.54 in)
Weight	Vented, regular & HF: 14 kg/300 m (32.3 lb/1000 ft) Non-vented, regular & HF: 16 kg/300 m (35.6 lb/1000 ft) Vented FEP: 23 kg/300 m (52 lb/1000 ft)

Suspension Wire

Material	304 stainless steel, 7 x 7 strand
Coating	Recycled FEP*, 0.5 mm (0.020 in) thick
Weight	4.3 kg /300 m (9.75 lb/1000 ft)
Overall O.D.	2.2 mm (approx. 1/16 in)
Break strength	122 kg (270 lb)

** FEP = fluorinated ethylene propylene, the generic equivalent of DuPont Teflon®*

3 GETTING STARTED

This section provides a quick overview of the initial steps necessary to get the instrument ready to log data.

You will need—

- Level TROLL or BaroTROLL
- Cable
  - RuggedCable and TROLL Com communication cable (for devices that will be deployed on RuggedCable),
    or
  - Programming Cable (for devices that will be deployed on suspension wire)
- In-Situ Software/Resource CD
- Desktop / laptop PC
- Optional: RuggedReader® handheld PDA
- Software License Certificate for licensed software (Win-Situ Mobile)

A. CONNECT THE RUGGEDCABLE OR PROGRAMMING CABLE TO THE LEVEL TROLL

1. Remove the protective caps from the Level TROLL and cable.

TIP: *Retain the dust caps to protect the pins and o-ring from damage when cable is not attached.*

Level TROLL (or TROLL Com) *Cable*

2. Take a moment to look at the connectors. Each has a flat side.

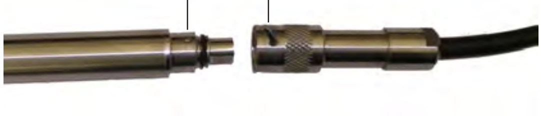
Flat *Flat*

Level TROLL (or TROLL Com)

Cable

Note the pins on the body connector (one on each side) and the slots on the cable connector (one on each side).

pin *slot*

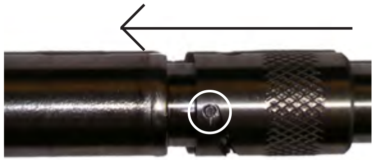


3. Slide back the sleeve on the cable connector.

4. Orient the “flats” so they will mate up, and insert the Level TROLL connector firmly into the cable connector.

Level TROLL *Cable*

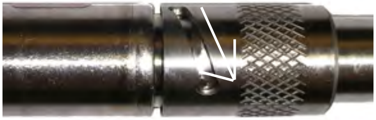
5. Slide the sleeve on the cable toward the Level TROLL body until the pin on the body pops into the round hole in the slot on the cable connector.



Level TROLL *Cable*

6. Grasp the knurled (textured) section of the cable connector in one hand and the Level TROLL body in the other. Push and twist firmly so that the pin on the body connector slides along the slot on the cable connector and locks securely into the other hole.

Be sure you hear the "click." The "click" ensures the cable is securely attached.



Level TROLL *Cable*

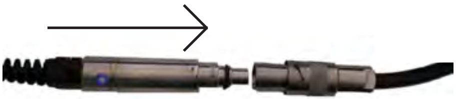
If you connected RuggedCable, continue to step B. If you connected a Programming Cable, skip to step C.

B. CONNECT THE TROLL COM TO THE RUGGEDCABLE

1. Remove the desiccant from the free end of the RuggedCable (if present) by grasping the knurled (textured) section of the cable connector in one hand and the desiccant in the other. Twist in opposite directions to unlock the desiccant from the cable.

2. Slide back the sleeve on the cable connector. Locate the “flats” on the cable connector and the TROLL Com connector as before.

3. Orient the “flats” so they will mate up, and insert the TROLL Com connector firmly into the cable connector.



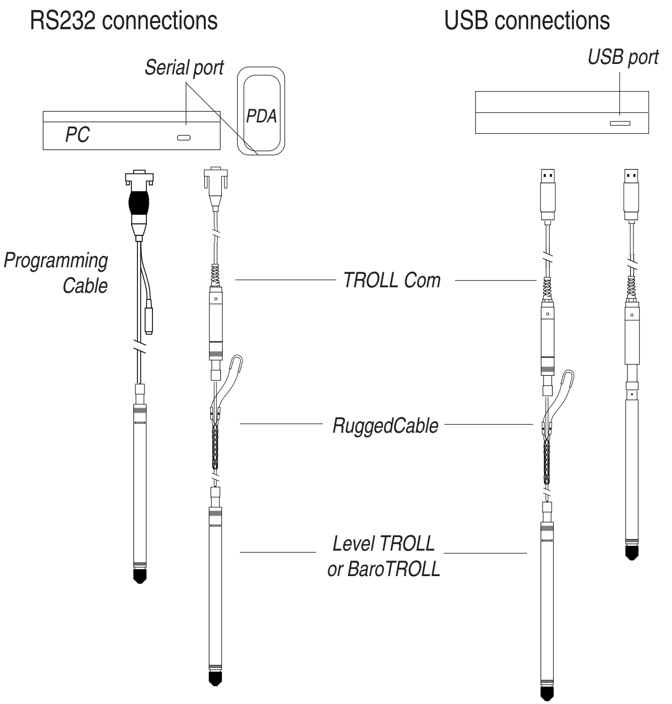
4. Slide the metal sleeve on the cable toward the TROLL Com body until the pin on the body pops into the hole in the slot on the cable connector.

Be sure you hear the “click.” The “click” ensures the cable is securely attached.

5. Grasp the knurled (textured) section of the cable connector in one hand and the TROLL Com body in the other. Push and twist firmly so that the pin on the body slides along the slot on the cable connector and snaps securely into the other hole.

C. CONNECT TO THE HOST PC

Attach the TROLL Com or Programming Cable to a PC's RS232 serial port or USB port.



D. INSTALL THE SOFTWARE

Install Win-Situ 5 from the In-Situ software/resource CD or from the In-Situ website:

1. Insert the In-Situ software/resource CD in your computer's CD drive.
2. Select Win-Situ 5, then click on Setup. Follow the instructions to install Win-Situ 5 to your local hard drive.

For communication using a RuggedReader handheld in the field, install the desktop component of Win-Situ Mobile (formerly called Pocket-Situ 5) on the same desktop/laptop computer:

1. Return to the website or the CD main menu and select Win-Situ Mobile. Click on Setup and follow the instructions to install the Win-Situ Software Manager to your local hard drive.
2. Connect the RuggedReader to the desktop computer, establish a connection in Microsoft ActiveSync®, launch the Win-Situ Software Manager, and follow the instructions to install Win-Situ Mobile on the RuggedReader.

***TIP:** If the CD menu does not display auto–matically, choose Run from the Windows Start Menu and type D:\ISISoftwareCD.html, where* D *is your CD-ROM drive letter.*

***TIP:** Insure Microsoft ActiveSync is installed on the desktop or laptop PC and a Guest connection or partnership has been established between the computers.*

E. LAUNCH THE SOFTWARE

Start Win-Situ by double-clicking the shortcut 

created on the desktop during installation.

The next section of this manual provides a brief overview of Win-Situ. For more detailed information, see Win-Situ's Help menu.

4 USING WIN-SITU

Win-Situ® 5 is In-Situ's instrument control software for Level TROLLs. Use Win-Situ to

- display real-time readings from the connected Level TROLL, in meter, tabular, or graphic format
- program the device to log data; download the logged data
- customize the output of a pressure/level sensor to record draw-down, surface water elevation, gauge height, stage height, etc.
- set communication options in the device—Modbus, SDI-12, analog, IP, telemetry, etc.

__TIP:__ Win-Situ® Mobile provides Win-Situ's features and functionality in a convenient field-worthy platform.

CONNECT TO THE LEVEL TROLL

1. Start Win-Situ by double-clicking the shortcut created on the desktop during installation.

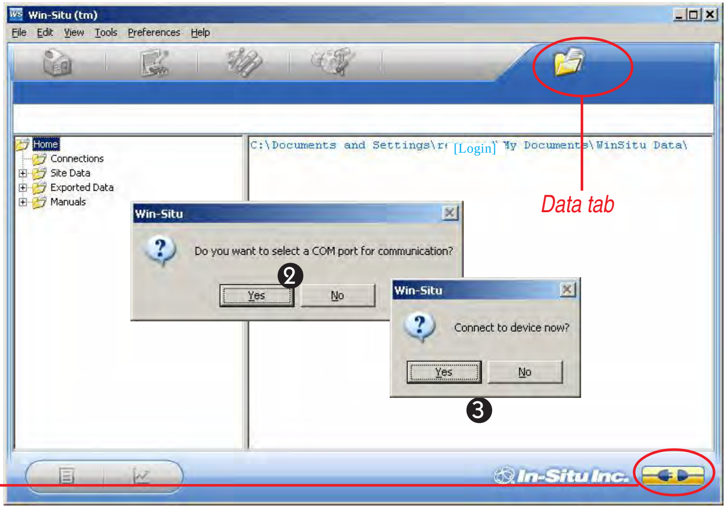
Win-Situ launches and displays the Data area ("tab").

2. Check the COM port (optional). When you launch for the first time, the software may ask if you want to select a COM port. Do one of the following:
   - Answer Yes to the prompt, then check or change the port in the Comm Settings dialog, and click OK  to close it, or
   - Answer No to bypass this step.

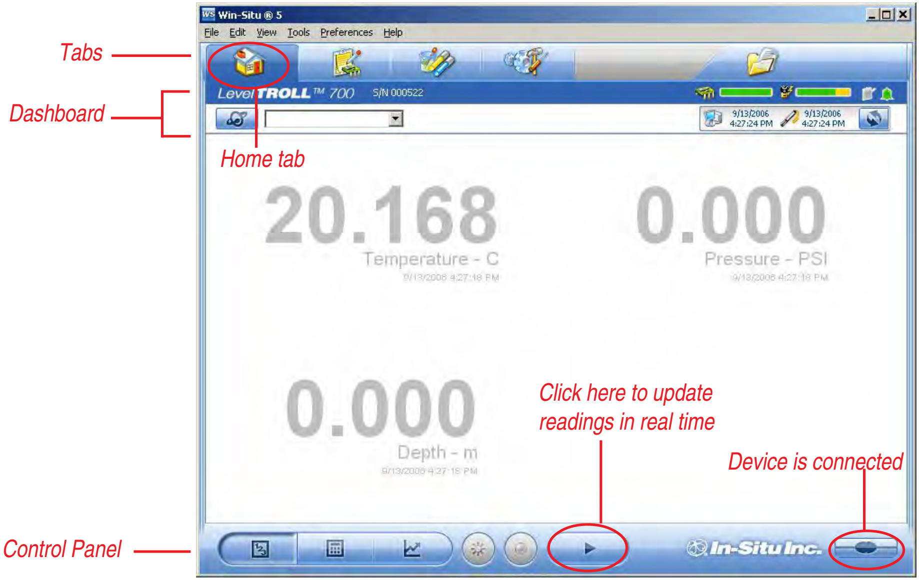
3. Win-Situ asks if you want to connect to the Level TROLL (the "device"). If the Level TROLL is connected to your computer as described in the previous section, answer Yes.

***TIP:** The port is usually COM 1 for direct serial connection. This is Win-Situ's default.*

***TIP:** You can turn off the "Connect now?" prompt: Select Preferences menu > General Settings, deselect "Prompt for connect at startup," click OK. In this case, connect to the device by clicking the Connect button* 



4. The software connects and displays current temperature, pressure, and level/depth readings (temperature and pressure for a BaroTROLL).



THE HOME SCREEN

- Note the **Tabs** at the top of the screen— this is the Home tab, which displays current readings from the connected device.
- The **Dashboard** (status area) below the tabs displays the device model and serial number, battery and memory capacity, the device clock and the computer clock, and other device information.
- The **Control Panel** at the bottom contains action buttons. You can start updating the readings in real time by pressing .

CUSTOMIZING THE HOME SCREEN DISPLAY

Changing Units

1. Click the Sensors tab , select the level/pressure sensor.

2. Click the Configure button  in the control panel.
3. In the Sensor Setup screen, select a parameter, then select a unit. Repeat for each parameter as necessary.
4. Click OK  to change the units and return to the Sensors tab.

Changing the Rate at Which the Readings Update

Also called the “poll rate,” this can range from 1 to 30 seconds.

1. Select Preferences menu > Home View Settings.
2. Adjust the Poll Rate. Default: 5 seconds.

Changing the Significant Digits

To change the number of significant digits displayed for each reading:

1. Select Preferences menu > General Settings.
2. Under Parameter Defaults, select the significant digits for each parameter.

Real-Time Graphing

To view a real-time trend graph: click the graph button 

To view a graph with a data table below it, select Preferences menu > Graph Settings. Check ☑ the Data Panel option. Click OK.

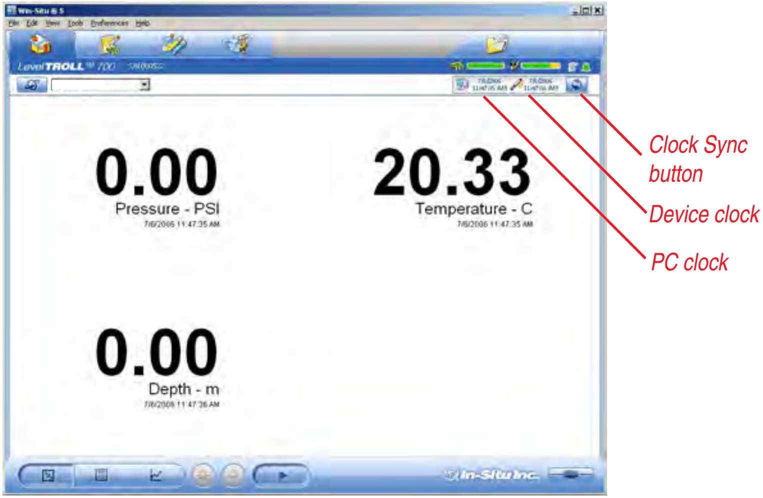
Now you're ready to give the Level TROLL some specific information through the software. Win-Situ provides many options. At a minimum:

- set the Level TROLL clock
- enter a name for the site where the Level TROLL will collect data
- enter data logging instructions

A brief overview is provided here. For more detailed information, see Win-Situ's Help menu.

SETTING THE CLOCK

Data collection schedules depend on the device's real-time clock. Both the device clock and the system (PC) clock are shown on the dashboard. The clocks update every 2 seconds. If the device clock differs by more than 2 seconds from the system clock, the device clock is displayed in red. To synchronize the clocks, click the Sync button.



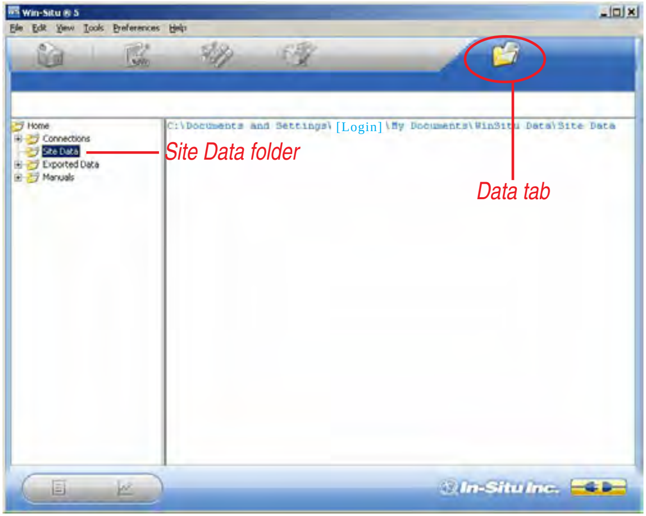
ADDING A NEW SITE

TIP: *For complete information on Sites, see Win-Situ's On-Line Help.*

Logged data are organized and filed by the **site** where the data were logged. This feature can help you manage data from multiple sites. You can create as many sites as you like, with or without a Level TROLL connected. Sites are stored in the site database in your Win-Situ working directory and are available to select for any Level TROLL, any log.

You will need a site when setting up a data log. Here are the steps to set up a new site:

1. On the Data tab, click the Site Data folder.
2. Select File menu > New > Site.

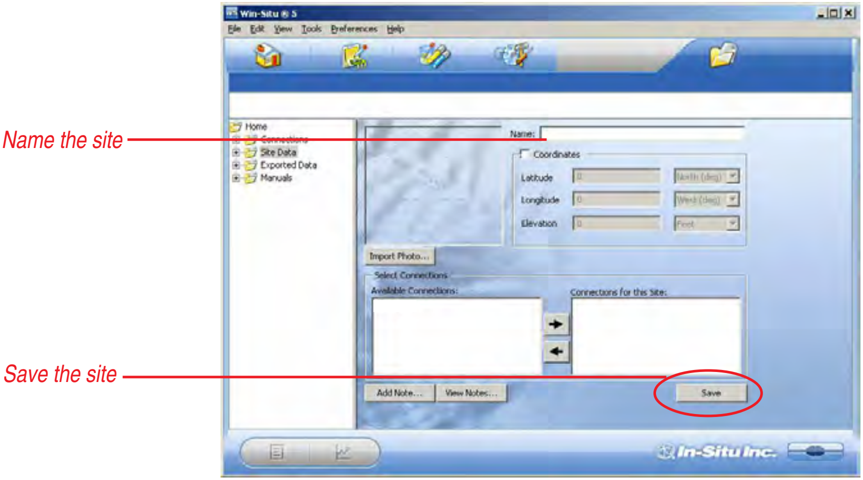


3. In the Site Information screen, enter a name for the site. A short, descriptive name is best—for example, a project, well, water body, gauging station, town, nearby landmark, etc. Length is limited to 32 characters.

   A site name the only required field, but there are many additional options for identifying a site. To include site Coordinates, check ☑ Coordinates, then enter Latitude (0.00 to 90.00, select North or South from listbox), Longitude (0.00 to 180.00, select East or West) and Elevation (select Feet or Meters). You can add a short descriptive Note, import a site Photo (bitmap), and/or specify a custom Connection. (If any connections have been defined, they will be displayed.)

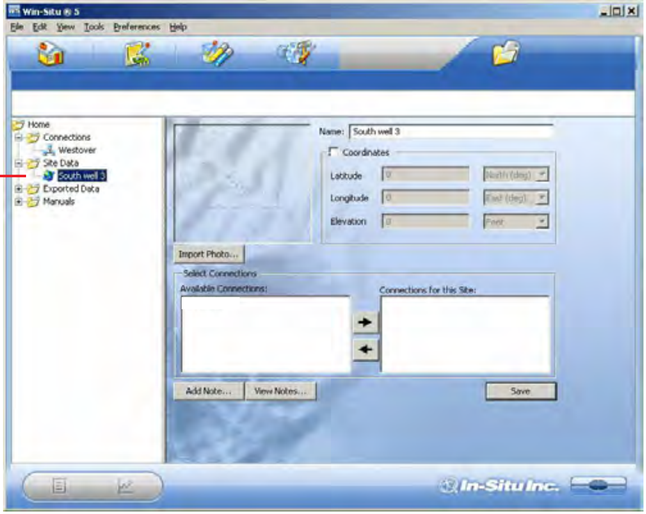
> ***TIP:*** *The site coordinates are optional. They are used to uniquely identify a data site. They are not used elsewhere by the software.*

4. When finished, click **Save** to save the site.



The new site will appear in the Site Data folder, and Win-Situ will add it to the site database in the working directory on your computer. It is now available to select for any device, any log.

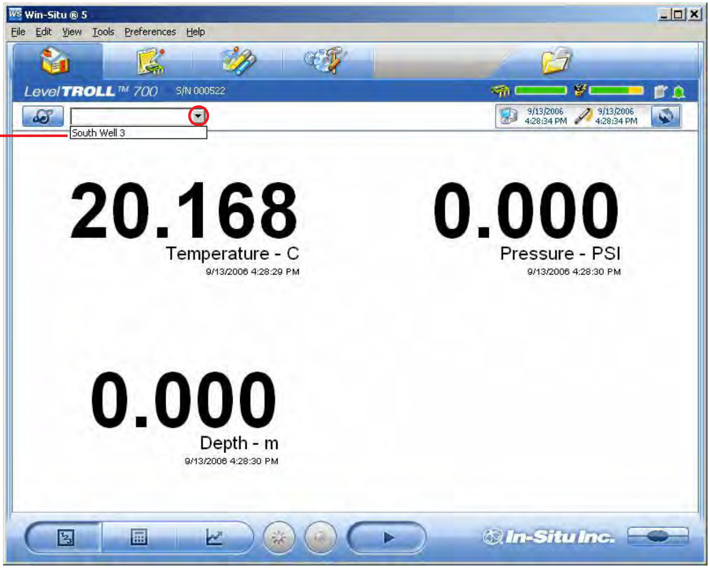
New site appears in Site Data folder



5. To set this new site in the connected Level TROLL: Return to the Home tab, click the down arrow beside the site box, and select your new site.

   This site now becomes the "current" site for the connected Level TROLL, and is available to use in data logs.

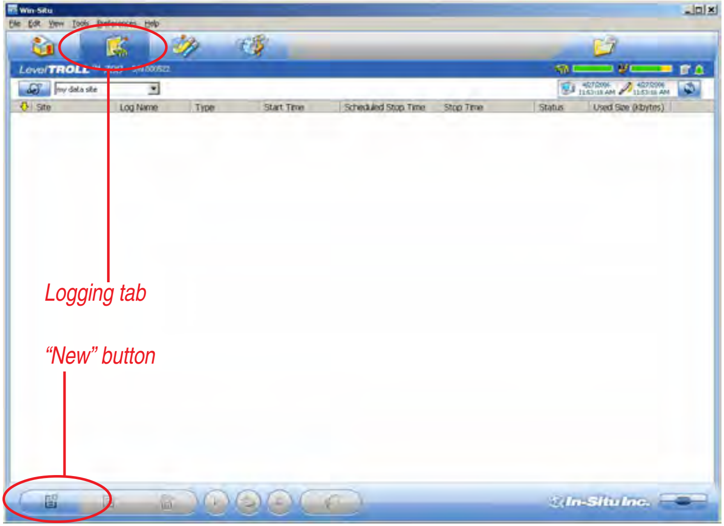
Select the new site



PREPARING TO LOG DATA

1. To program the device to log data, first select the Logging tab.

2. Click the "New" button.



TIP: For more complete information on setting up data logs, see Win-Situ's Help menu.

TIP: For a Level TROLL 300 or other non-vented Level TROLL that will be deployed on wire, be sure to select a Scheduled Start so the log will start by itself, without a communication connection.

The Logging Setup Wizard will prompt you through the configuration of a data log—including the site, log name, parameters to measure, sample schedule, start time, stop time, output (depth or level), and other options. For details on setting the pressure sensor output, refer to Win-SItu's Help menu, or Section 5 in this manual.

To Start logging:

- A "Pending" (scheduled) log will start at its programmed time
- You can start a "Ready" (manual) log at any time while connected by selecting the log and pressing "Start"

> ***TIP:*** *As an alternative to the log control buttons, right-click a log to display a short context menu of available actions.*

To Stop logging:

- Select the log and press the "Stop" button
- Or suspend (temporarily stop) it with the "Pause" button

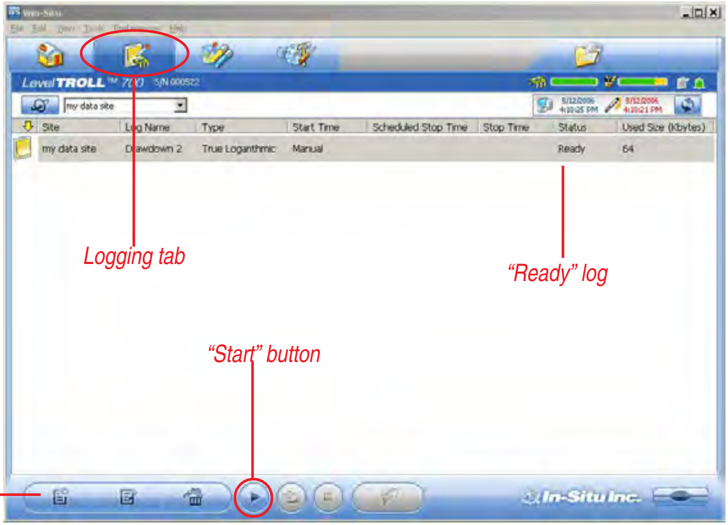
To Download the log to the connected PC:

- Select the log and press the "Download" button

To View the log after downloading:

- Go to the Data tab and select the log; for a graph press

> ***TIP:*** *The available log control buttons will vary depending on the status of the log selected.*



DISCONNECTING

After the Level TROLL is programmed to log data, you're ready to

- Exit the software (File menu > Exit).
- Disconnect the TROLL Com from the cable connector, by grasping the knurled (textured) section of the cable connector in one hand and the TROLL Com in the other. Twist in opposite directions to unlock the TROLL Com from the cable.
- Vented cable: Attach desiccant to the cable connector—line up the flat sides of the connectors, push, twist, and click to lock the desiccant to the cable. Remove red dust cap (if present) from the desiccant's vent.
- Non-vented Level TROLL or BaroTROLL: Attach a Twist-Lock hanger to prevent flooding, and suspension wire (if using).
- Install the instrument in its field location. See Section 6 for guidelines.

Be sure to remove the desiccant dust cap (if present) before deployment to allow air to reach the cable's vent tube.

5 ABOUT THE PRESSURE/ LEVEL SENSOR

A pressure transducer senses changes in pressure, measured in force per square unit of surface area, exerted by water or other fluid on an internal media-isolated strain gauge. Common measurement units are pounds per square inch (PSI) or newtons per square meter (pascals).

NON-VENTED (ABSOLUTE) VS. VENTED (GAUGED) SENSORS

A non-vented or “absolute” pressure sensor measures all pressure forces exerted on the strain gauge, including atmospheric pressure. Its units are **PSIA** (pounds per square inch “absolute”), measured with respect to zero pressure.

Non-vented pressure measurements are useful in vacuum testing, in short-term testing when atmospheric pressure would not be expected to change, in very deep aquifers where the effects of atmospheric pressure are negligible, and in unconfined aquifers that are open to the atmosphere.

With vented or "gauged" pressure sensors, a vent tube in the cable applies atmospheric pressure to the back of the strain gauge. The basic unit for vented measurements is **PSIG** (pounds per square inch "gauge"), measured with respect to atmospheric pressure. Vented sensors thus exclude the atmospheric or barometric pressure component.

This difference between absolute and gauged measurements may be represented by a simple equation:

$$P_{gauge} = P_{absolute} - P_{atmosphere}$$

PRESSURE, DEPTH, AND LEVEL

Output options for pressure measurement are completely software-selectable. Each log configuration presents the following choices:

- Pressure in PSI or kPa
- Depth in feet or meters
- Water Level with a reference (an "offset")
  - Surface Elevation reference
  - Depth to Water (drawdown) reference

Pressure is a simple check box. For depth or level, the software presents additional options:

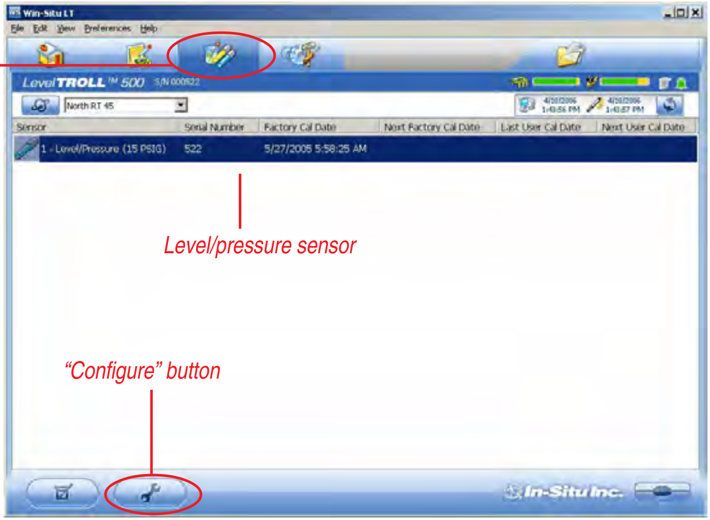
- The type of Level measurement you wish to log
- The Level Reference you wish to use
- The type of water you will be monitoring in (fresh, brackish, or saline). Or choose the **Advanced** button for a pressure-to-level conversion that compensates pressure readings for fluid density, latitude, and elevation

CONFIGURING DEPTH AND LEVEL

TIP: When you configure level using the Sensors tab, the settings are stored in the Level TROLL and are available for use in Modbus, SDI-12, and analog communications, as well as in Win-Situ. Different configuration may be selected when setting up a log.

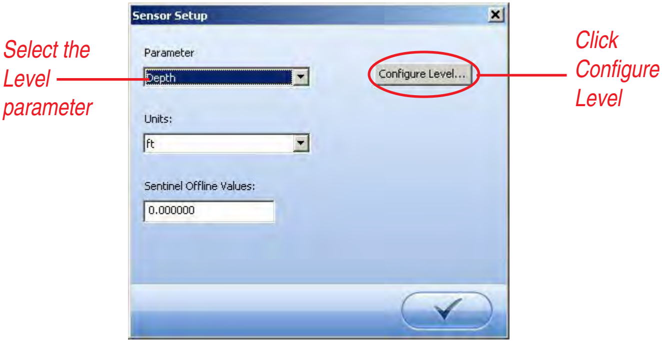
This procedure stores the configuration settings in the Level TROLL. When setting up a log, the same options are presented.

1. While connected to the Level TROLL in software, click the Sensors tab.
2. Select the level/pressure sensor and click the "Configure" button . (Not available for a BaroTROLL.)

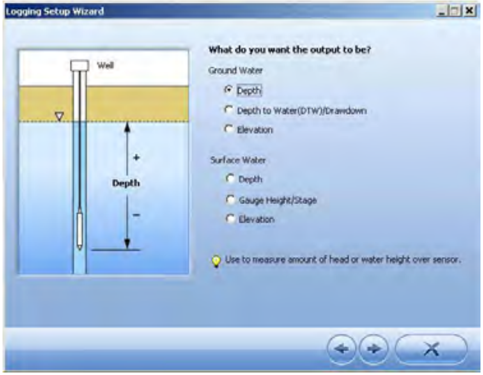


TIP: *The Level TROLL measures three parameters—Pressure, Temperature, and Level—on one sensor. A BaroTROLL does not measure Level, so the Configure Level option is not available.*

3. In the Sensor Setup window, select the Level parameter, then click Configure Level. The Level parameter shown is the one currently stored in the device (device's default or the most recent choice). You will have a chance to change this in a moment.



4. In the Level Configuration Wizard, select the options you want. Each choice includes an illustration. For more information, see Win-Situ's On-Line Help.



PRESSURE SENSOR CALIBRATION

FACTORY RECALIBRATION

Pressure sensor accuracy can be adversely affected by improper care and handling, lightning strikes and similar surges, exceeding operating temperature and pressure limits, physical damage or abuse, as well as normal drift in the device's electronic components. Aside from damage to the sensor, the need for factory recalibration is dependent upon the amount of drift a customer is willing to tolerate. Factory calibration every 12-18 months is recommended. Contact In-Situ Customer Service for information on the factory maintenance and calibration plan.

FIELD RECALIBRATION

The following procedure may be used, **with caution,** to "zero" the offset of a vented pressure sensor to correct for electronic drift. The drifted offset is visible when the sensor is in air and reading other than zero.

TIP: *Field recalibration is not available for a BaroTROLL.*

It is recommended you **do not** zero the offset if it is outside the specified accuracy of your pressure sensor, as shown in the table below. If the reading in air deviates from zero by more than the amounts shown, you may want to consider a factory recalibration.

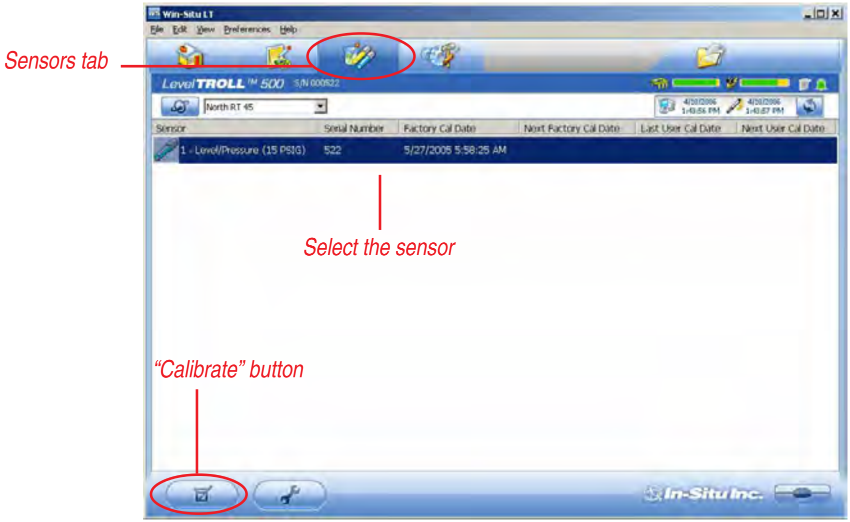
Sensor range	Accuracy (-5°C to +50°C)	Acceptable Offset from zero
5 PSI	± 0.1% FS	± 0.005 PSI
15 PSI	± 0.1% FS	± 0.015 PSI
30 PSI	± 0.1% FS	± 0.03 PSI
100 PSI	± 0.1% FS	± 0.10 PSI
300 PSI	± 0.1% FS	± 0.30 PSI
500 PSI	± 0.1% FS	± 0.50 PSI

Field Recalibration Procedure

1. With the Level TROLL connected in software, select the **Sensors** tab.
2. Select the pressure sensor and click the **Calibrate** button.

   You will be prompted to ensure the device is in air.
3. With the device in air, click **Calibrate**.

The current pressure reading will be set to zero.



BAROMETRIC COMPENSATION OF NON-VENTED PRESSURE/LEVEL DATA USING BAROMERGE™

Win-Situ BaroMerge can post-correct absolute (non-vented) level sensor data to eliminate barometric pressure from the measurements. BaroMerge provides 3 options:

- Fixed Correction – A single offset value is applied to all selected log data. Use this option if you know what the barometric pressure was during the log, and it did not change
- Manual Entry – Specify 2 or more correction values to apply to the log data. Use this option if you know that barometric pressure changed during the log
- BaroTROLL log file – Absolute level sensor data are corrected by barometric pressure values logged by an In-Situ BaroTROLL during the same general time period

Launching BaroMerge

BaroMerge may be launched as a stand-alone application from the program group In-Situ Inc., or accessed from Win-Situ's Tools menu when both are installed on the same system.

Input

In the Fixed Correction and Manual Entry options, it is important to know the barometric pressure for the general time period covered by the log or logs you want to correct.

BaroMerge uses a Wizard-like interface consisting of three main steps:

1. First, choose the type of compensation/correction you wish to use

2. Then, choose the absolute (non-vented) log file or files you wish to correct. BaroMerge displays these automatically
3. Click OK and the barometric compensation is applied

Output

Your original log file is not changed. A new, corrected log file with the same name and path is created. The original ".wsl" extension is replaced by "-BaroMerge.wsl".

For help on using Win-Situ BaroMerge, press F1 at any BaroMerge screen.

For more detailed information on barometric compensation see the tech notes installed with Win-Situ. They are accessible in Win-Situ from the Data tab. They are also on the In-Situ software/resource CD, and available in the Downloads section of the In-Situ website at *www.In-Situ.com/downloads.*

6 FIELD INSTALLATION

POSITION THE LEVEL TROLL

Lower the Level TROLL gently to approximately the desired depth. Position the instrument below the lowest anticipated water level, but not so low that its range might be exceeded at the highest anticipated level. Refer to the tables below for usable depth.

Note that a Baro TROLL is not designed for submersion. Position it above water level near a submerged Level TROLL.

Vented Level TROLL

Range		Usable Depth	
PSIG	kPa	Meters	Feet
5	34.5	0-3.5	0-11.5
15	103.4	0-11	0-35
30	206.8	0-21	0-69
100	689.5	0-70	0-231
300	2068	0-210	0-692
500	3447	0-351	0-1153

Non-Vented Level TROLL

Range	Effective Range*		Usable Depth	
PSIA	PSIA	kPa	Meters	Feet
30	15.5	106.9	0-10.9	0-35.8
100	85.5	589.5	0-60.1	0-197.3
300	285.5	1968	0-200.7	0-658.7
500	485.5	3347	0-341.3	0-1120

** At sea level (14.5 PSI atmospheric pressure).*

CHECK THE INSTRUMENT'S DEPTH

At this point, if convenient, you can connect the Level TROLL to a PC, launch the software, and take a reading. If the instrument is at the desired depth, secure it in position as suggested below. If not, reposition the Level TROLL as necessary.

If you requested the software to “Remind me later” to set a Level Reference, enter the level reference after installation when prompted.

Kellems grip

SECURE THE CABLE

The RuggedCable has a handy device called a Kellems® grip near the surface end. You can slide it along the cable to the desired position by compressing it. When you pull on it, it tightens and stops sliding. You may need to pull on both ends of the Kellems grip to properly tighten it and keep it from slipping.

Use the loop of the Kellems grip to anchor the cable to a convenient stationary object. It works well with In-Situ’s “well dock” installation ring. Simply insert the loop into the locking clip on the well dock, and position the assembly on the top of a well.

INSTALLATION TIPS

- Never let a probe “free fall” down a well. The resulting shock wave when it hits the water surface can damage the strain gauge (the “waterhammer” effect).
- It is always wise to check the level of water above the probe, then move it and read again to be sure that the probe is giving a reasonable reading and showing change. It might not be

located where you think it is — for example, it could be wedged against the casing with a loop of cable hanging below it. A probe in such a position might become dislodged and move while logging, giving a false change in level. *A secure placement is critical to accurate measurements.*

The minimum bend radius for vented cable is 13.5 mm (0.54 in).

- Do not allow the vented cable to kink or bend. If the internal vent tube is obstructed, water level measurements can be adversely affected. The recommended minimum bend radius is 13.5 mm (0.54 in), which is twice the cable diameter.
- For accurate measurements, the instrument should remain immobile while logging data.

Do not submerge the connector at the uphole end of the cable.

- Be sure the “uphole” cable end is capped—desiccant cap on the vented cable connector, soft dust cap on non-vented cable—and positioned above the highest anticipated water level. Avoid areas that may flood.

STABILIZATION TIME

Allow the Level TROLL to stabilize to the water conditions for *about an hour* before logging data. A generous stabilization time is always desirable, especially in long-term deployments. Even though the cable is shielded, temperature stabilization, stretching, and unkinking can cause apparent changes in the probe reading. If you expect to monitor water levels to the accuracy of the probe, it’s worth allowing the extra time for the probe to stabilize to its environment.

INSTALLATION OF A LEVEL TROLL 300 OR OTHER NON-VENTED LEVEL TROLL

TIP: *Be sure to program a non-vented Level TROLL or BaroTROLL before attaching the Twist-Lock Hanger, as this accessory has no communication capability.*

All Level TROLL 300s and non-vented Level TROLL 500s and 700s include non-vented (absolute, PSIA) pressure sensors and do not require vented cable for proper operation. They may be deployed on non-vented RuggedCable or with a Twist-Lock Hanger and economical stainless steel suspension wire while logging data.

- Because the Twist-Lock Hanger has no communication capabilities, program the Level TROLL in advance, and download the data the same way
- Logged pressure data will show the effects of changes in barometric pressure (unlike vented Level TROLLs). However, post-processing tools such as Win-Situ BaroMerge may be used to eliminate the effects of barometric pressure changes from the data, if required.

DO NOT submerge a non-vented Level TROLL 500 or 700 without first attaching a Twist-Lock Hanger, or a cable, as the unit could be damaged by flooding.

Although the Level TROLL 300 is completely sealed from flooding, a Hanger is recommended.

7 BAROTROLL

TIP: For more detailed information on barometric compensation see the tech notes installed with this manual and accessible in Win-Situ from the My Data tab. They are also on the In-Situ software/ resource CD, and available in the Downloads section of the In-Situ website at www.In-Situ.com

In-Situ's BaroTROLL® is a special model of non-vented Level TROLL designed to log barometric pressure from 0 to 16.5 PSIA (1.14 bar, 33.59 in Hg) at the surface near a submerged non-vented Level TROLL. BaroTROLL data may then be used to correct the Level TROLL data for barometric pressure fluctuations.

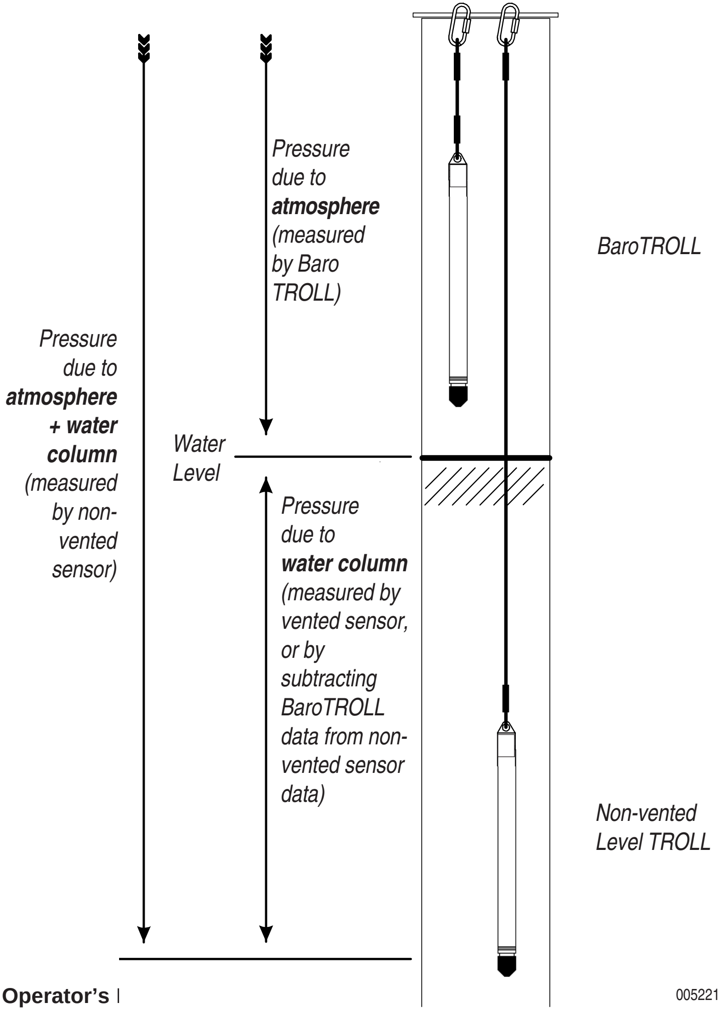
PROGRAMMING

- Program before installation. Be sure to sync the clock.
- Schedule a log with the same start time as that in the paired non-vented Level TROLL. Select the same sample interval.

INSTALLATION

After programming, install the BaroTROLL in a protected location above water level. Install the BaroTROLL near the submerged non-vented unit. One possibility is shown below, using a Twist-Lock Hanger and suspension wire.

- Be sure to attach the Twist-Lock Hanger before installation to prevent flooding.


Pressure due to **atmosphere** (measured by Baro TROLL)
Pressure due to **atmosphere + water column** (measured by non-vented sensor)
Water Level
Pressure due to **water column** (measured by vented sensor, or by subtracting BaroTROLL data from non-vented sensor data)
BaroTROLL
Non-vented Level TROLL

In-Situ Inc.

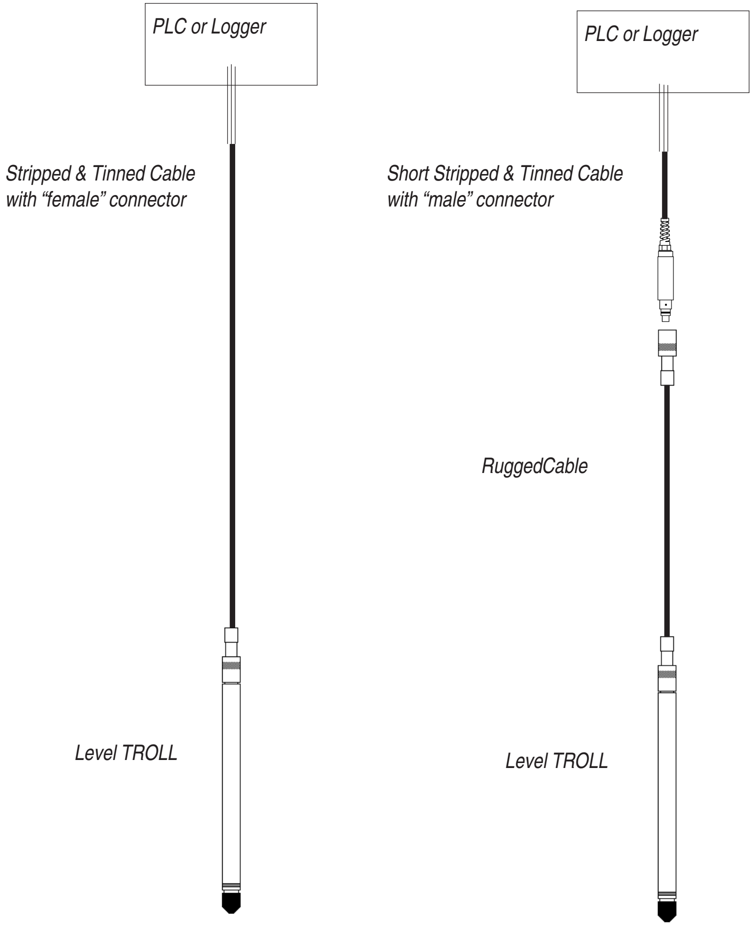
8 ANALOG, SDI-12 & MODBUS CONNECTIONS

The Level TROLL may be connected to a controller or logger for communication via:

- Analog (4-20 mA)
- SDI-12
- RS485 Modbus
- RS232 Modbus (with a customer-supplied converter)

RuggedCable™ Stripped & Tinned has a "female" Twist-Lock connector on one end to mate with the Level TROLL body. The uphole end terminates in bare wires for connection to a PLC or data logger.

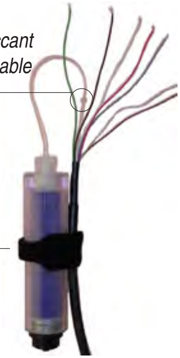
Also available in a shorter length ending in a "male" Twist-Lock connector to mate with RuggedCable.


PLC or Logger
Stripped & Tinned Cable
with "female" connector
Level TROLL
PLC or Logger
Short Stripped & Tinned Cable
with "male" connector
RuggedCable
Level TROLL

DESICCANT

Vented cable includes removable outboard desiccant to protect the cable vent tube and Level TROLL electronics from condensation in high-humidity environments.

The desiccant may be removed from the vent tube, if needed, to trim the conductor wires. Pull the vent tube extender off the cable vent tube to remove, replace desiccant after trimming and connecting wires.

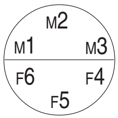


WIRING

Refer to diagrams on the following pages. Trim back and insulate unused wires. The shield should be wired to a chassis ground or earth ground.

RuggedCable (TPU)

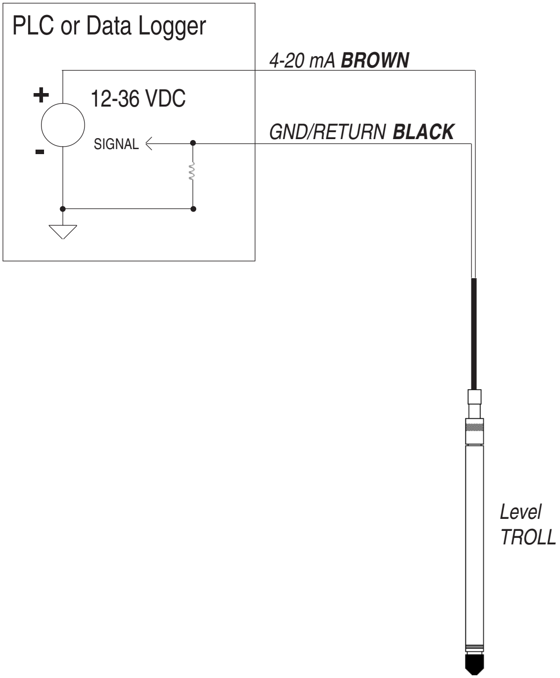
Signal	Color	Pin
Gnd/Return	BLACK	6
Ext Power	RED	5
4-20 mA	BROWN	4
RS485(–)	GREEN	3
RS485(+)	BLUE	2
SDI-12	WHITE	1

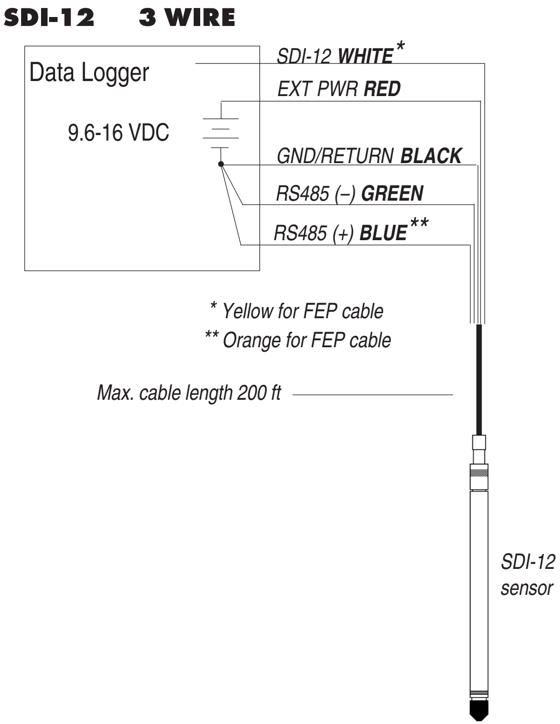


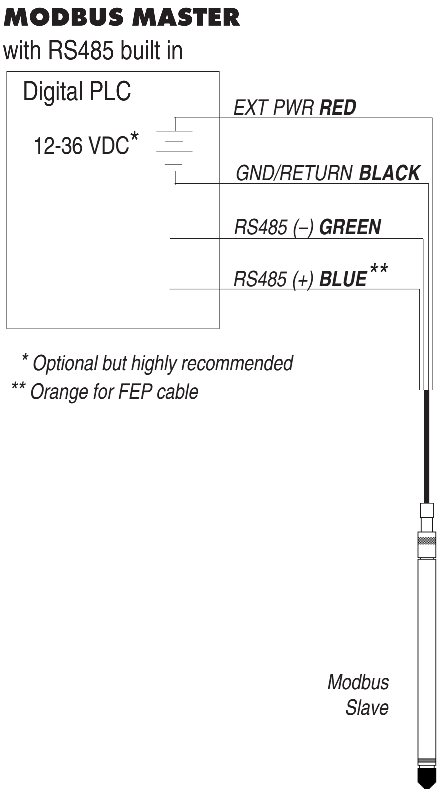
FEP Cable

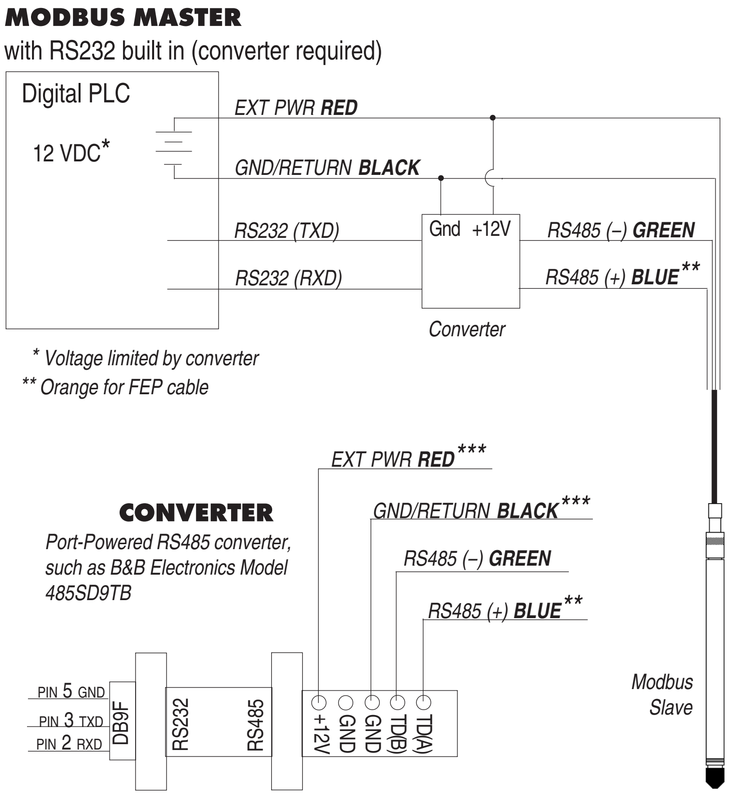
Signal	Color
Gnd/Return	BLACK
Ext Power	RED
4-20 mA	BROWN
RS485(–)	GREEN
RS485(+)	ORANGE
SDI-12	YELLOW

ANALOG (4-20 mA) 2 WIRE




SDI-12 3 WIRE
Data Logger
9.6-16 VDC
SDI-12 WHITE*
EXT PWR RED
GND/RETURN BLACK
RS485 (–) GREEN
RS485 (+) BLUE**
* Yellow for FEP cable
** Orange for FEP cable
Max. cable length 200 ft
SDI-12
sensor


MODBUS MASTER
with RS485 built in
Digital PLC
12-36 VDC*
EXT PWR RED
GND/RETURN BLACK
RS485 (–) GREEN
RS485 (+) BLUE**
* Optional but highly recommended
** Orange for FEP cable
Modbus
Slave



***Required if port power is not available

POWER CONNECTIONS

The Red wire provides power for Modbus and SDI-12 modes. The Brown wire provides power for the 4-20 mA mode. If power is present on the Brown wire and not on the Red wire, the device enters the 4-20 mA mode automatically and stays in the 4-20 mode until power is removed from the Brown wire or is applied to the Red wire. The Red wire has priority — if power is applied to both wires at the same time, the device will operate in Modbus or SDI-12 modes but not in 4-20.

COMMUNICATIONS

The device automatically switches between Modbus and SDI-12 modes depending on which of the two interfaces has activity. Modbus and SDI-12 cannot be used at the same time — whichever one is currently in use will block communication on the other.

USING WIN-SITU

Win-Situ provides options for configuring analog/SDI-12 communications (Setup tab) and Modbus communications (File menu > Settings). In addition, the Level TROLL is capable of internal logging (programmed in Win-Situ) while participating in a Modbus, SDI-12 or analog network. However, Win-Situ cannot communicate with the Level TROLL while it is transmitting Modbus, SDI-12 or analog data, and conversely, the instrument cannot receive or respond to Modbus, SDI-12 or analog commands while connected to a PC serial port.

This “redundant logging” feature means

- if the PLC or recorder somehow “loses” data, the Level TROLL data can be retrieved using Win-Situ.

- if the PLC or recorder ceases to function due to power loss, the Level TROLL will continue to collect data using its own internal batteries and clock.

A port-powered RS485 converter like that shown for Modbus connections may be used for temporary connection of the Level TROLL to a serial port on a PC.

FOR MORE INFORMATION

For additional information on Modbus and SDI-12 communications, including the SDI-12 commands, see the tech notes and application notes installed with this manual and accessible in Win-Situ from the My Data tab. They are also on the In-Situ software/resource CD, and available in the Downloads section of the In-Situ website at www.In-Situ.com.

In-Situ Inc.

9 CARE & MAINTENANCE

OPERATING CONSIDERATIONS

The Level TROLL has been designed to withstand harsh field conditions. However, as with any electronic instrument, it can be permanently damaged if used outside its operating specifications.

TEMPERATURE

The Level TROLL 500 and Level TROLL 700 operate within a temperature range of -20°C to +80°C (-4°F to 176°F). The Level TROLL 300's temperature range is -5°C to 50°C (23°F to 122°F)

PRESSURE RANGE

The Level TROLL can withstand pressures of up to two times (2X) the rated range of the pressure sensor without damage, although it may not read correctly at such pressure. If the pressure range is exceeded by 3X, the sensor will be destroyed.

CALIBRATION

Accuracy can be adversely affected by improper care and handling, lightning strikes and similar surges, exceeding operating temperature and pressure limits, physical damage or abuse. Factory calibration every 12-18 months is recommended. Contact In-Situ Customer Service for information on the factory maintenance and calibration plan.

STORAGE

Store the Level TROLL clean and dry. Place the protective red dustcap on the cable end, or store with cable attached to protect the connector pins and o-ring.

Store the instrument where it will be safe from mechanical shocks that may occur, such as rolling off a bench onto a hard surface.

Protect the instrument from temperature extremes. Store within a temperature range of -40°C to +80°C (-40°F to +176°F).

GENERAL MAINTENANCE

CLEANING—BODY AND FRONT END

When the nose cone is removed, the sensitive pressure sensor diaphragm is completely exposed. Do not touch this area with any object! Replace the nose cone as soon as possible.

Nose cone in place

Nose cone removed

Clean the Level TROLL body with water and a soft brush, or soak overnight in a mild acidic solution, such as household vinegar, or clean in an ultrasonic bath with a good concentrated detergent solution.

If the ports in the front end are clogged with silt or mud, try the following:

- Swish the instrument vigorously in a bucket of clean water
- Apply a gentle squeeze of water from a wash bottle
- In severe cases, remove the nose cone and clean out the holes with a soft brush or pipe cleaner

To avoid damage to the pressure sensor diaphragm, *do not insert any object into the sensor opening or attempt to dig out dirt or other materials.*

Damage caused by digging or scraping in the pressure sensor opening to remove silt, mud, etc. is not covered by the warranty.

If contamination cannot be removed using the recommendations above, please contact In-Situ Inc. for cleaning.

Do not submerge the cable connector; do not immerse in any fluid.

TWIST-LOCK CONNECTORS

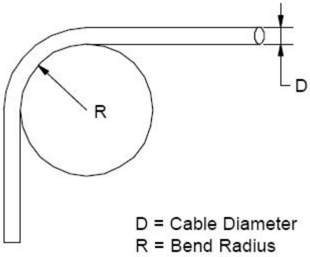
Keep the pins on all connectors free of dirt and moisture by using the soft protective dustcap when cable is not attached.

CABLE VENT TUBE (VENTED CABLE)

Vented cable assures that atmospheric pressure is the reference pressure to the vented pressure sensor diaphragm. *The vent tube should not be blocked, kinked, or otherwise obstructed.* Such obstructions will cause barometric pressure to appear in measurements, and errors will be introduced due to thermal expansion and contraction of air within the vent tube and probe body.

The minimum bend radius for vented cable is 13.5 mm (0.54 in).

The recommended minimum bend radius is 13.5 mm (0.54 in), which is twice the cable diameter.



__TIP:__ If batteries are completely exhausted, remember that external power and battery pack options are available.

BATTERIES

Internal batteries in the Level TROLL are not user-replaceable. The approximate percentage remaining is displayed on the Dashboard when the Level TROLL is connected in software.

10 TROUBLESHOOTING

TROUBLESHOOTING CONNECTIONS

Problem: Win-Situ cannot connect to the Level TROLL

Probable Cause: Wrong COM port selected, incompatible Communication settings, loose or dirty cable connections, low batteries

Suggested Remedy: Check the following:

- all cable connections are tight, connectors are clean and dry
- the cable is securely attached to the instrument
- the correct COM port is selected (select Comm Settings from Win-Situ's Preferences menu to check this)
- the software settings are correct for the device (check Win-Situ's on-line Help for "Communication Settings")
- the internal battery has voltage remaining

Problem: Real-time readings are in the wrong units

Probable Cause: Default units are being used

Suggested Remedy: Click the Sensors tab, select the sensor, click the configure button  and select the desired units for each parameter in the Sensor Setup window. Click OK .

Problem: I cannot add a new log

Probable Cause 1: Only one "active" log can reside in the device at a time—an "active" log is a log that is Ready, Pending, Running, or Suspended as shown in the Status column of the Logging Tab

Probable Cause 2: The device has its maximum number of logs already stored—the Level TROLL 300, 500, and Baro TROLL have a capacity of 2 logs

Suggested Remedy: Download, and then delete a log you are through with. This will make room for an additional log on the device

Problem: I just defined a new log, but the software is telling me it exceeds the available memory

Probable Cause: The log as configured would exceed the device memory

Suggested Remedy: Edit the log and try these:

Select a longer sampling interval

If available, select the "Wrap data" option (later data will overwrite earlier data when the memory is full)

For a log with a scheduled start, select "None" as the stop condition, or select a stop time that is closer to the start time

In-Situ Inc.

Index

In-Situ Inc.
221 East Lincoln Avenue • Fort Collins, CO 80524 USA
1 800 446 7488 • 1 970 498 1500 (Tel)
1 970 498 1598 (Fax)
WWW.IN-SITU.COM

Declaration of Conformity

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: Level TROLL
Model: Level TROLL 300
Product Description: The Level TROLL measures and logs level and temperature in natural groundwater and surface water.

is in compliance with the following Directive

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use
- **Emissions**
  Class A requirements of EN 61326:1998, Electric Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

Todd Campbell

Todd Campbell
New Product Development Program Manager
In-Situ, Inc.
January 17, 2006

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WWW.IN-SITU.COM

Declaration of Conformity

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: Level TROLL
Model: Level TROLL 500
Product Description: The Level TROLL measures and logs level and temperature in natural groundwater and surface water.

is in compliance with the following Directive

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use

- **Emissions**
  Class A requirements of EN 61326:1998, Electric Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

Todd Campbell

Todd Campbell
New Product Development Program Manager
In-Situ, Inc.
January 17, 2006

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1 970 498 1598 (Fax)
WWW.IN-SITU.COM

Declaration of Conformity

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: Level TROLL
Model: Level TROLL 700
Product Description: The Level TROLL measures and logs level and temperature in natural groundwater and surface water.

is in compliance with the following Directive

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use
- **Emissions**
  Class A requirements of EN 61326:1998, Electric Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

Todd Campbell

Todd Campbell
New Product Development Program Manager
In-Situ, Inc.
January 17, 2006

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1 970 498 1598 (Fax)
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Declaration of Conformity

Manufacturer:	In-Situ, Inc. 221 East Lincoln Avenue Fort Collins, CO 80524 USA

Declares that the following product:

Product name:	Level TROLL
Product name:	Baro TROLL
Product Description:	The Baro TROLL measures and logs barometric pressure and temperature.

is in compliance with the following Directive

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use

- **Emissions**
  Class A requirements of EN 61326:1998, Electric Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

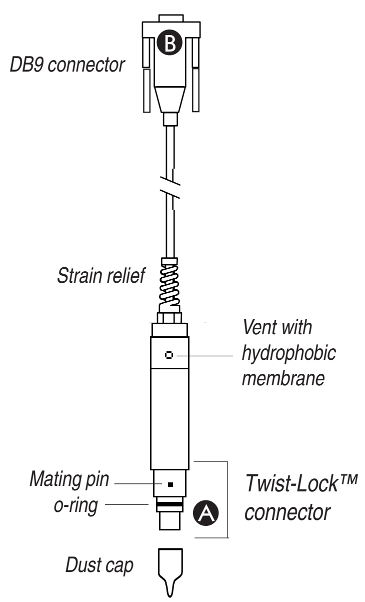
Todd Campbell

Todd Campbell
New Product Development Program Manager
In-Situ, Inc.
January 17, 2006

Information Sheet

Catalog No. 51460

TROLL COM™
COMMUNICATION INTERFACE



Tip: The desiccant protects the Level TROLL's vented cable from condensation during deployment. The TROLL Com enables connection to a PC for programming the Level TROLL. Be sure to re-attach the desiccant after programming, before deployment.

APPLICATION

Communication interface between a Level TROLL or MP TROLL 9500 and a desktop/laptop PC or handheld PDA. Contains a port-powered RS485 – RS232 converter. Vented deployment cable vents through the unit, protected by a hydrophobic membrane.

PHYSICAL DESCRIPTION

Wetted materials	Titanium, nylon, Viton®, polyurethane
Environmental rating	IP67 when connected (3 meters for 30 minutes), up to the DB9 connector
Dimensions	8.9 cm (3.5 in) long, 18.3 mm (0.72 in) O.D.
Input	MP TROLL 9500 RS485 Level TROLL RS485 Modbus
Output	RS232
Cable	Black polyurethane, 91 cm (3 ft) long
Temperature range	-5°C to 60°C (23°F to 140°F)
PC Interface	DB 9 pin, null modem (crossover), DTE to DTE

CONNECTIONS

A Mates with the Twist-Lock Connector on the instrument's RuggedCable™

B Connects to the 9-pin serial port on a PC or PDA

INSTALLATION

1. Remove the desiccant (if present) from the free end of the RuggedCable by grasping the knurled (textured) section of the cable connector in one hand and the desiccant in the other. Twist in opposite directions to unlock the desiccant from the cable.

2. Follow these steps to attach the TROLL Com to the cable:

   2a. Remove the protective caps from the TROLL Com and cable (if present).

(over)

TROLL COM

Catalog No. 51460

2b. Note that each connector has a flat side.

Flat Flat

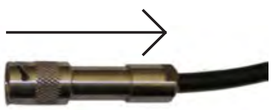
TROLL Com

Cable

Note the pins on the TROLL Com connector and the slots on the cable connector.

pin slot

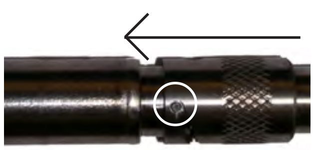
2c. Slide back the sleeve on the cable connector.



2d. Orient the "flats" so they will mate up, and insert the TROLL Com connector firmly into the cable connector.

TROLL Com Cable

2e. Slide the sleeve toward the TROLL Com until the pin on the TROLL Com pops into the round hole in the slot on the cable connector.



TROLL Com Cable

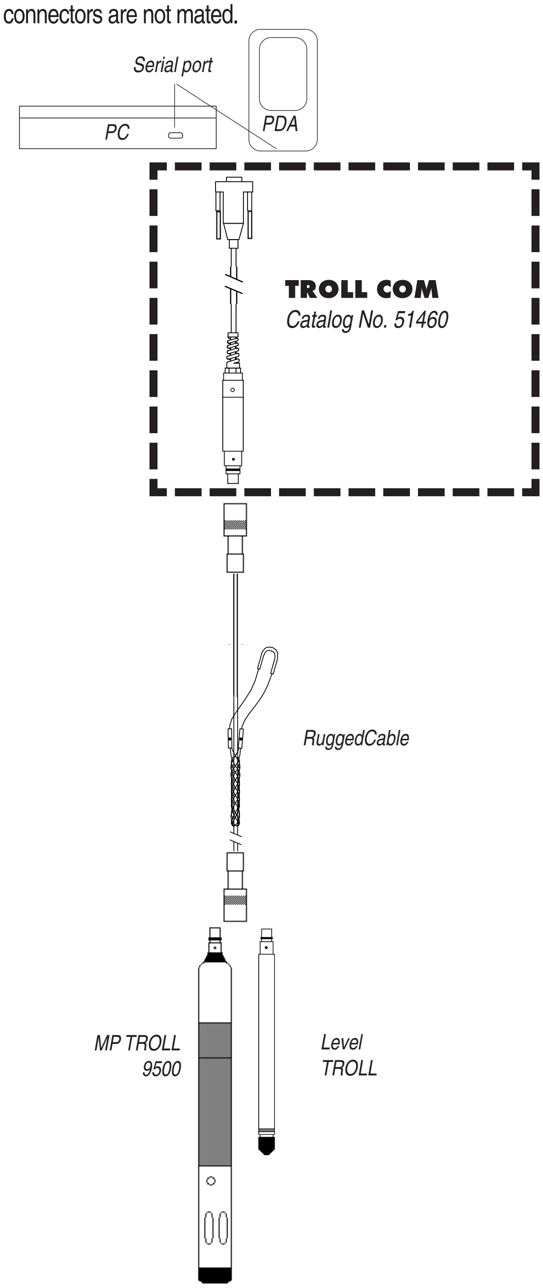
2f. Grasp the knurled (textured) section of the cable connector in one hand and the TROLL Com in the other, push and twist firmly so that the pin on the TROLL Com slides along the slot on the cable connector and locks securely into the other hole. The "click" ensures the connectors are securely mated.

TROLL Com Cable

3. Attach the DB9 connector on the TROLL Com to a PC's standard 9-pin RS232 serial port.

GUIDELINES AND PRECAUTIONS

- A serial cable, serial card, and/or a null-modem adapter may be needed with some PDAs
- The DB9 connector is not waterproof
- Soft dust caps protect the connectors during shipping. Keep the dust caps to protect the connector pins and o-ring when the connectors are not mated.



1 800 4INSITU
(toll-free, US and Canada) or 970 498 1500 **www.in-situ.com**

In-Situ Inc.

Endress+Hauser WaterPilot FMX167

BA 231P/24/ae/07.01
52010550

Waterpilot FMX 167
Hydrostatic Level Measurement

Operating Instructions

Endress+Hauser
The Power of Know How

Table of contents

1 Safety instructions

1.1 Intended application

The Waterpilot FMX 167 is a hydrostatic pressure sensor for measuring the level of fresh water, drinking water and wastewater. Versions with a Pt 100 resistance thermometer can also measure temperature. The optional temperature transmitter converts the Pt 100 signal into a 4-20 mA signal.

The manufacturer shall not accept any liability for damage arising from improper use or if the device is used for purposes for which it was not intended.

1.2 Installation, setup, operation

The Waterpilot FMX 167 and the temperature transmitter (optional) are designed as fail-safe to the state of the art and comply with prevailing regulations and EC directives. If the devices are not used properly or for purposes for which they were not intended, they may become hazards arising from the particular application, e.g. product overflow through incorrect installation or adjustment. For these reasons, only trained personnel authorized by the plant operator may install, connect electrically, set up, operate and maintain the measuring system. Trained personnel must have read and understood these Operating Instructions and follow the instructions. Any changes and repairs to the devices may only be performed if the Operating Instructions expressly permit this.

1.3 Operational safety

Explosion hazardous area:
If the measuring system is used in explosion hazardous areas, you must comply with the prevailing national standards. The device is supplied with a separate document on explosion hazards which is a component part of this documentation. Please comply with the installation instructions, connecting values and safety instructions contained therein.

- Make sure that personnel have received sufficient training.
- Please comply with the technical measuring and safety conditions at the measuring points.

Order Code (refer to Chapter 2 "Identification")
FMX 167 - ❑ ❑ ❑ ❑❑ ❑ ❑ ❑

Code	Certificate	Protection
B	ATEX	ATEX II 2 G EEx ia IIC T6
C	ATEX	ATEX II 3 G EEx nA II T6
D	FM	IS, Class I, Division 1, Groups A-D
E	CSA	IS, Class I, Division 1, Groups A-D

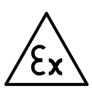
1.4 Safety warnings and symbols

In order to emphasize safety or alternative processes, we have defined the following safety warnings and appended a pictogram to each one.

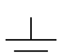
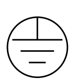
Safety warnings

Symbol	Meaning
	**Warning!** Warning indicates activities or processes which – if they are not performed properly – will lead to serious personal injury, a safety hazard or destruction of the device.
	**Caution!** Caution indicates activities or processes which – if they are not performed properly – will lead to personal injury or malfunctioning of the device.
	**Note!** Note indicates activities or processes which – if they are not performed properly – may have an indirect impact on functioning or an unforeseen response from the device.

Type of protection

	**Explosion-protected, type tested apparatus** If this symbol is on the device nameplate, the device may be used in explosion hazardous areas or in non explosion hazardous areas, depending on the approval.
	**Explosion hazardous area** This symbol in drawings in these Operating Instructions identifies an explosion hazardous area. – Devices which are located in a hazardous area or cables for such devices must be suitably protected.
	**Safe area (non explosion hazardous area)** This symbol in drawings in these Operating Instructions identifies a non explosion hazardous area. – Devices in a non explosion hazardous area must also be certified if connecting cables are routed in the explosion hazardous area.

Electrical symbols

	DC voltage A terminal to which a DC voltage is applied or through which a DC voltage flows.
	**AC voltage** A terminal to which a (sinusoidal) AC voltage is applied or through which an AC voltage flows.
	**Ground connection** A grounded terminal which is already grounded by a grounding system from the user's viewpoint.
	**Protective earth terminal** A terminal which must be grounded before any other connections are made.
	**Potential Equalization terminal** A terminal which must be connected with the equipment grounding system: this may be a potential matching line or a star-shaped grounding system, depending on national or corporate practice.

2 Identification

2.1 Device designation

- Waterpilot FMX 167 for hydrostatic level measurement, refer to Chapter 2.1.1.
- Waterpilot FMX 167 with optional Pt 100 resistance thermometer for simultaneous level and temperature measurement, refer to Chapter 2.1.1.
- Waterpilot FMX 167 with optional Pt 100 resistance thermometer and optional temperature transmitter TMT 181, refer to Chapters 2.1.1 and 2.1.2.

2.1.1 Nameplate of Waterpilot FMX 167

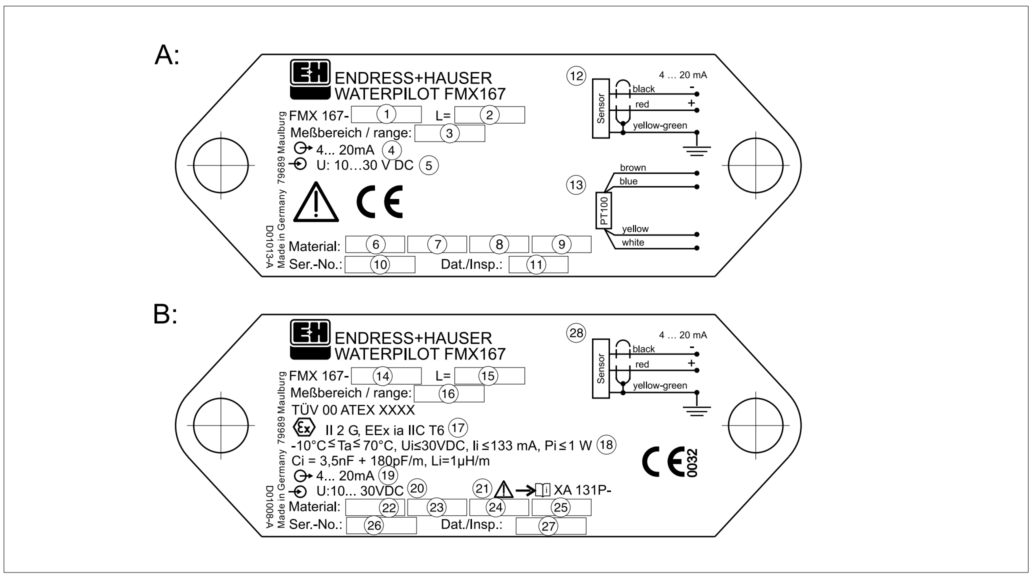


Fig. 1: Nameplates for Waterpilot FMX 167

Nameplate A: Example for non hazardous area

1 *Order Code*
The meaning of the individual letters and numbers is specified in the order confirmation. See page 31.
2 *Length of support cable*
3 *Measuring range*
4 *Current output: 4-20 mA*
5 *Auxiliary energy/Supply voltage: 10 - 30 V DC*
6 *Housing material: 1.4435 (AISI 316L)*
7 *Measuring cell material: aluminum oxide Al_2O_3*
8 *Support cable material: (PE) polyethylene*
9 *Seal material: 1: Viton, 2: EPDM*
10 *Serial No.*
11 *Test date/Tester*
12 *Wiring diagram of FMX 167*
13 *Wiring diagram of FMX 167 with Pt 100 if Waterpilot FMX 167 was ordered with Pt 100.*

Nameplate B: Example for hazardous area

14 *Order Code*
The meaning of the individual letters and numbers is specified in the order confirmation. See page 31.
15 *Length of support cable*
16 *Measuring range*
17 *Type of protection*
18 *Permissible ambient temperature range and other electrical data*
19 *Current output: 4-20 mA*
20 *Auxiliary energy/Supply voltage: 10 - 30 V DC*
21 *Reference to related Safety Instructions (e.g. XA 131P)*
22 *Housing material: 1.4435 (AISI 316L)*
23 *Measuring cell material: aluminum oxide Al_2O_3*
24 *Support cable material: (PE) polyethylene*
25 *Seal material: 1: Viton, 2: EPDM*
26 *Serial No.*
27 *Test date/Tester*

Note!
A sensor number and the measuring range are specified on each probe; in addition a certificate and the type of protection are specified on probes designed for explosion hazardous areas.
The nameplate does not specify the sensor number. If you need to assign a nameplate to a probe at a later date, please refer to the supplied calibration report. This is where the sensor and the serial number are specified.

Note!

2.1.2 Nameplate of Temperature Transmitter TMT 181

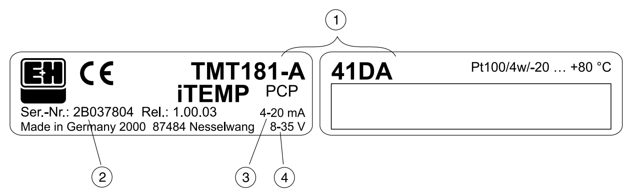


Fig. 2: Nameplate of Temperature Transmitter iTEMP® PCP TMT181

1 *Order Code of Temperature Transmitter TMT 181-A41DA*
 A: Variant for non-hazardous area
 4: 4-wire
 1: Sensor Pt 100
 D: Temperature transmitter with settings for –4 to +176°F (–20 to +80°C) range
 A: Label: standard version
2 *Serial No.*
3 *Current output: 4 to 20 mA*
4 *Supply voltage: 8 to 35 V DC*

2.2 Scope of supply

The scope of supply is comprised of:
- Waterpilot FMX 167, optionally with integrated Pt 100 temperature sensor
- Optional accessories, refer to Chapter 7

Supplied documentation:
- Operating Instructions (this manual)
- Calibration report
- For hazardous areas: additional "Safety Instructions" (XA…)
- For FM, CSA: Control Drawing or Installation Drawing
- Drinking water approval (optional)

2.2.1 CE symbol, Declaration of Conformity

The devices are designed fail-safe to the state of the art and left the factory in perfect condition with regard to safety. The devices comply with the prevailing standards and regulations contained in DIN EN 61010 "Safety requirements for electrical equipment for measurement, control and laboratory use".
The measuring system described in these Operating Instructions therefore meet the statutory requirements of EC directives. Endress+Hauser confirms the successful testing of the device by affixing the CE symbol.

3 Installation

3.1 Incoming acceptance

Check the following items upon receipt of the product:
- Check whether the packaging or its contents are damaged.
- Check the delivered products for completeness and compare the contents with your order data.

3.2 Installation guidelines

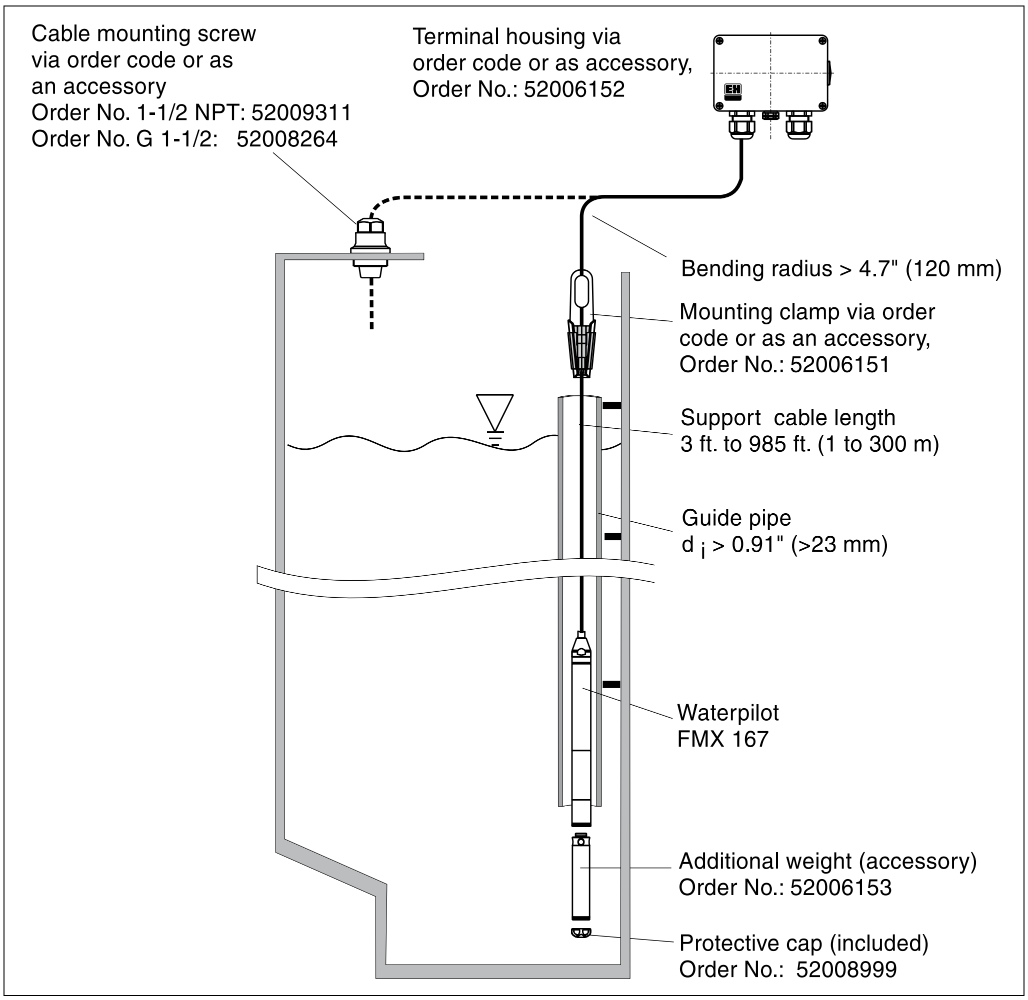


Fig. 3: Installation examples

The FMX 167 should be installed at a point that is free from flow or turbulence, or mounted in a guide tube with an inner diameter greater than 0.90" (23 mm). If the cable is terminated outdoors, a junction box from E+H is recommended (Part No. 52006152). The atmospheric pressure compensation tube (located inside cable) must be kept from blockage or kinking. The atmospheric compensation tube is protected from condensation by a teflon filter and an additional GORE-TEX® filter which is terminated in the junction box.

3.2.1 Installation dimensions

See Chapter 9.3 "Technical data, Dimensions" for the dimensions.

3.3 Installation instructions

3.3.1 Installing Waterpilot with a mounting clamp

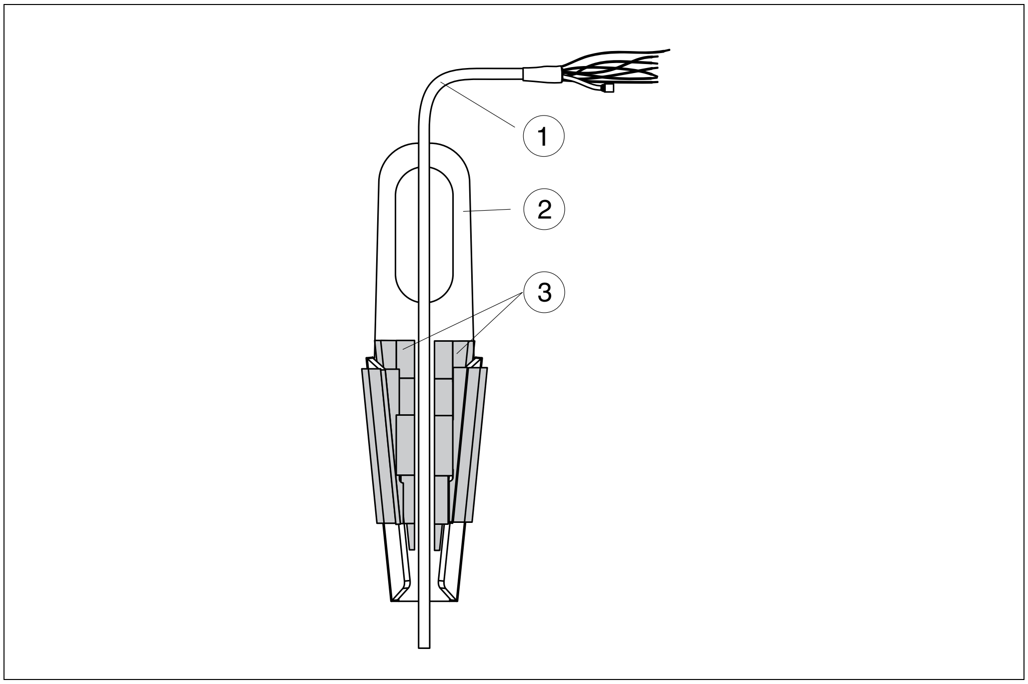


Fig. 4: Installing Waterpilot FMX 167 with a mounting clamp

1 Support cable
2 Mounting clamp
3 Clamping jaws

How to mount the mounting clamp:

1. Mount the mounting clamp (Pos. 2). When selecting the type of mounting, note the weight of the support cable (Pos. 2) and the device (refer to Chapter 9.1.).
2. Raise clamping jaws (Pos. 3). Place support cable (Pos. 1) acc. to Fig. 4 between clamping jaws.
3. Hold support cable (Pos. 1) tight and push clamping jaws (Pos. 3) back down. Set clamping jaws by tapping lightly.

Note!
By attaching a piece of electrical tape or a cable-tie to the cable, re-installation to identical depth is ensured after inspection or temporary removal.

Note!

3.3.2 Installing Waterpilot with cable mounting screw

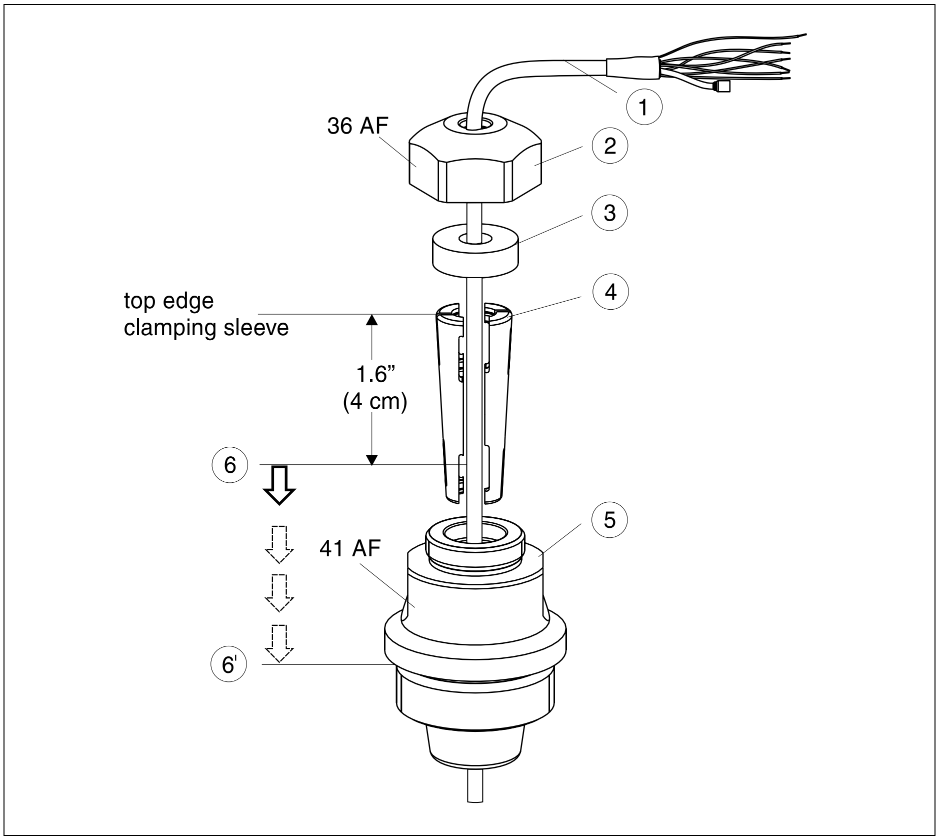


Fig. 5: Installing the Waterpilot FMX 167 with cable mounting screw, depicted here with G 1 1/2 thread

1 Support cable
2 Mounting screw cap nut
3 Sealing ring
4 Clamping sleeve
5 Mounting screw adapter
6 Required length of support cable and FMX 167 probe before assembly
6´ After assembly Pos. 6) is located next to the mounting screw with
G 1 1/2 thread: sealing surface of mounting screw adapter
1 1/2 NPT thread: thread run-out of mounting screw adapter

Note!

Note!
If you want to lower the level probe to a certain depth, place the top edge of the clamping sleeve 1.6" (4 cm) higher than the required depth. Then push the support cable and the clamping sleeve into the adapter as described in the following section, Step 6.

How to mount the cable mounting screw with G 1 1/2 or 1 1/2 NPT thread:

1. Mark required length of support cable, refer to "Note" on this page.
2. Insert probe through measuring opening and carefully lower on support cable. Hold support cable to prevent it from slipping.
3. Push adapter (Pos. 5) over support cable and screw tightly in measuring opening.
4. Push sealing ring (Pos. 3) and cap (Pos. 2) from top onto cable. Press sealing ring into cap.
5. Place clamping sleeve (Pos. 4) around support cable (Pos. 1) acc. to Figure 5.
6. Push support cable and clamping sleeve (Pos. 4) into adapter (Pos. 5).
7. Push cap (Pos. 2) and sealing ring (Pos. 3) onto adapter (Pos. 5) and screw tightly to adapter (Pos. 5).

Note!
Remove the cable mounting screw in the opposite sequence of operation to installation.

Note!

3.3.3 Mounting the terminal housing

Mount the optional terminal housing with four screws (M 4). See Chapter 9.3 "Dimensions" for the dimensions of the terminal housing. The drilling template for the housing is located in Chapter 10.2.

3.3.4 Mounting the Temperature Transmitter TMT 181

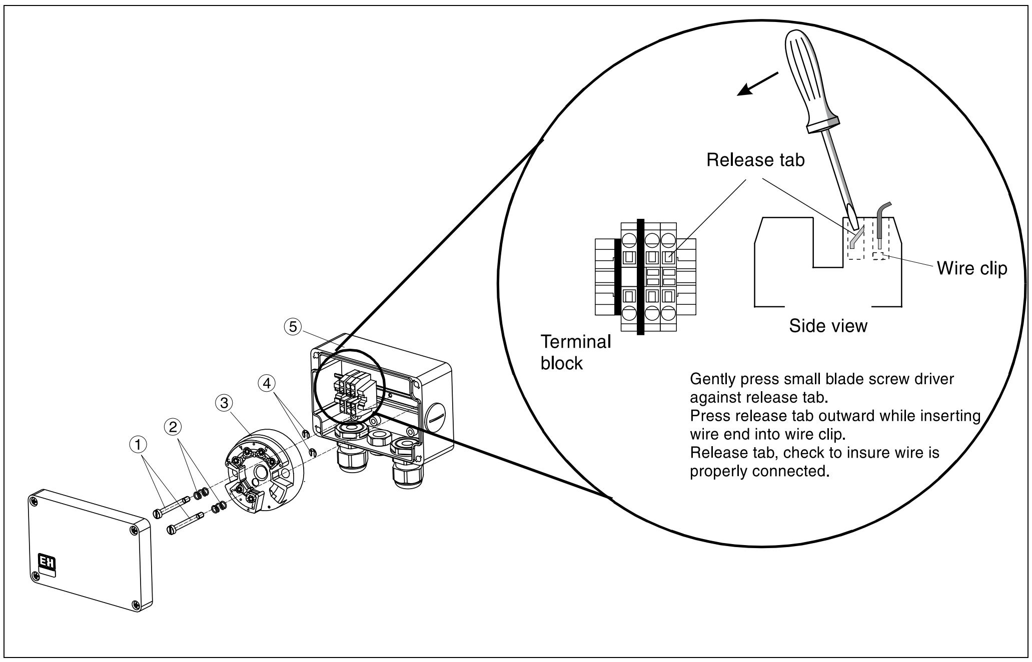


Fig. 6: Mounting the temperature transmitter, depicted here with terminal housing

1 Mounting screws
2 Mounting springs
3 Temperature Transmitter TMT 181
4 Screw retainers
5 Terminal housing

How to mount the temperature transmitter

1. Insert the mounting screws (Pos. 1) with the mounting springs (Pos. 2) through the boring of the temperature transmitter (Pos. 3).
2. Set the mounting screws with the screw retainers (Pos. 4).
   The screw retainers, mounting screws and springs are contained in the contents of the temperature transmitter.
3. Screw the temperature transmitter tightly in the field housing.

Caution!
Do not overtighten the mounting screws to avoid damage to the temperature transmitter.

Caution!

3.4 Checking the installation

Check that all screws are seated firmly.

4 Wiring

Warning!
When connecting devices with explosion protection certificates, please comply with national standards and the warnings and wiring diagrams in the additional explosion protection documentation accompanying these Operating Instructions. Also refer to Chapters 9.1 and 9.2, Section "Supplementary documentation". If you have any questions, please contact your nearest Endress+Hauser Service Organization.

4.1 Electrical connection

How to connect the devices:

- The supply voltage must match the specification on the nameplate, refer to Chapters 2.1.1 and 2.1.2.
- Switch off supply voltage before you connect the device.
- The cable must end in a dry room or in a proper terminal housing. The terminal housing with GORE-TEX® filter, NEMA 4/NEMA 4X (IP 66/IP 67) from Endress+Hauser is suitable for outdoor installation.
- Connect device according. to Figures 7 and 8. A polarity protection is integrated in the Waterpilot FMX 167 and the Temperature Transmitter TMT 181. Changing the polarities will not destroy the devices.

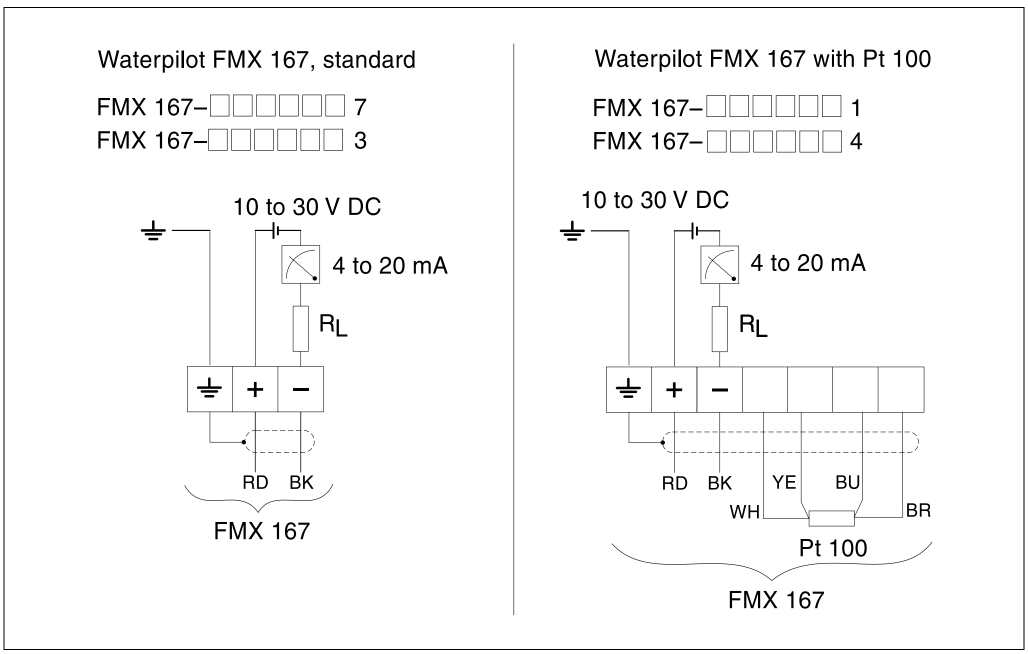


Fig. 7: Electrical connection: left for FMX 167, right for FMX 167 with Pt 100

Wire colors
RD = red
BK = black
WH = white
YE = yellow
BU = blue
BR = brown

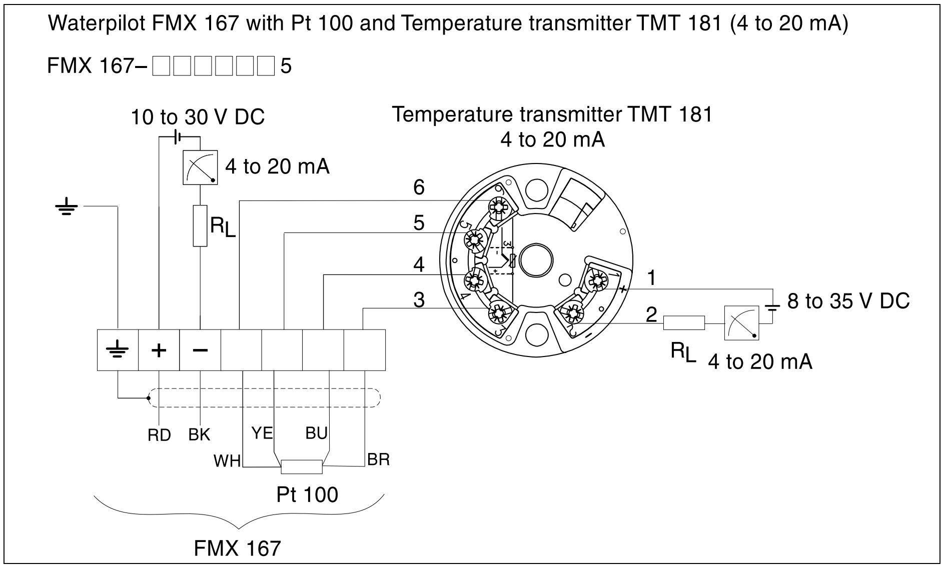


Fig. 8: Electrical connection: FMX 167 with Pt 100 and Temperature Transmitter TMT 181

Wire colors
RD = red
BK = black
WH = white
YE = yellow
BU = blue
BR = brown

Supply voltage

Certificate	Supply voltage		Supply voltage
	FMX 167	FMX 167 + Pt 100	Temperature transmitter
standard	10 to 30 V DC	10 to 30 V DC	8 to 35 V DC
EEx nA IIC T6	10 to 30 V DC	10 to 30 V DC	–
FM IS CSA IS EEx ia IIC T6	10 to 30 V DC	–	–

Cable specification

FMX 167 with Pt 100 (optional)	Temperature transmitter (optional)
– Commercially available installation cable – Terminals in terminal housing FMX 167: ≤14 AWG (2.5 mm^2).	– Commercially available installation cable – Terminals in terminal housing FMX 167: – ≤14 AWG (2.5 mm^2) – Transmitter terminals: max. 15 AWG (1.75 mm^2)

Note!
The support cable of the Waterpilot FMX 167 is shielded. In the following cases Endress+Hauser recommends use of a shielded cable for the cable extension:
– for large distances between support cable end and display and/or evaluation unit,
– for large distances between support cable end and temperature transmitter
– for directly connecting Pt 100 signals to the display and/or evaluation unit.

Note!

Power consumption/current drain

	FMX 167	FMX 167 + Pt 100	Temperature transmitter TMT 181
Power consumption	≤ 0.675 W at 30 V DC	≤ 0.675 W at 30 V DC	≤ 0.77 W at 35 V DC
Current drain	max. ≤ 22.5 mA min. ≥ 3.5 mA	max. ≤ 22.5 mA min. ≥ 3.5 mA Pt 100: ≤ 0.6 mA	max. ≤ 22 mA min. ≥ 3.5 mA

Load

The maximum load resistance is dependent on the supply voltage (U_b) and must be determined for every current loop separately. Refer to equations and diagrams for "FMX 167 with Pt 100 (optional)" and "Temperature transmitter".
The total resistance resulting from the resistances of the connected devices, the connecting cable and if necessary, the resistor of the support cable may not exceed the load resistance.

FMX 167 with Pt 100 (optional)	Temperature transmitter (optional) TMT 181
$R_{tot} \leq \frac{U_b - 10\ V}{0.0225\ A} - 2 \cdot 0.09\ \frac{\Omega}{m} \cdot l - R_{add}$	$R_{tot} \leq \frac{U_b - 8\ V}{0.022\ A} - R_{add}$

R_{tot} = Max. load resistance [Ω]
R_{add} = Additional resistances, e.g. resistance of evaluating device and/or the display instrument, line resistance [Ω]
U_b = Supply voltage [V]
l = Simple length of support cable [m] (cable resistance per wire ≤ 0.09 Ω/m)

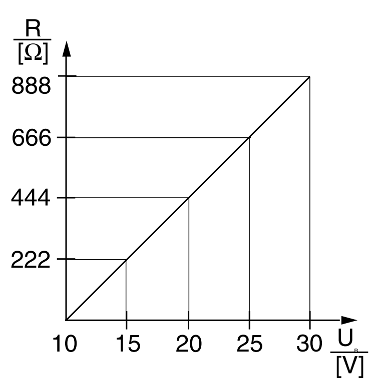


Fig. 9:
Load chart FMX 167 for estimating load resistance

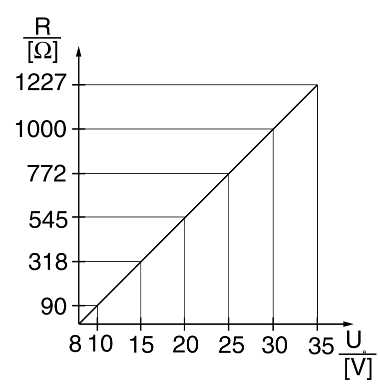


Fig. 10:
Load chart of temperature transmitter TMT 181 for estimating load resistance

Note!

Note!
Additional resistances, e.g. resistance of support cable, must then be subtracted from the value determined from the diagram, as shown in the equation.

4.2 Wiring the measuring unit

Overvoltage protection

Note!
In order to protect the Waterpilot FMX167 and the Temperature Transmitter TMT 181 from large transients, Endress+Hauser recommends the installation of an overvoltage protector upstream and downstream of the display and/or evaluation device as shown in the figure.
The Waterpilot FMX 167 has an integrated overvoltage protection to EN 61000 of ≤ 1.2 kV as standard.

Note!

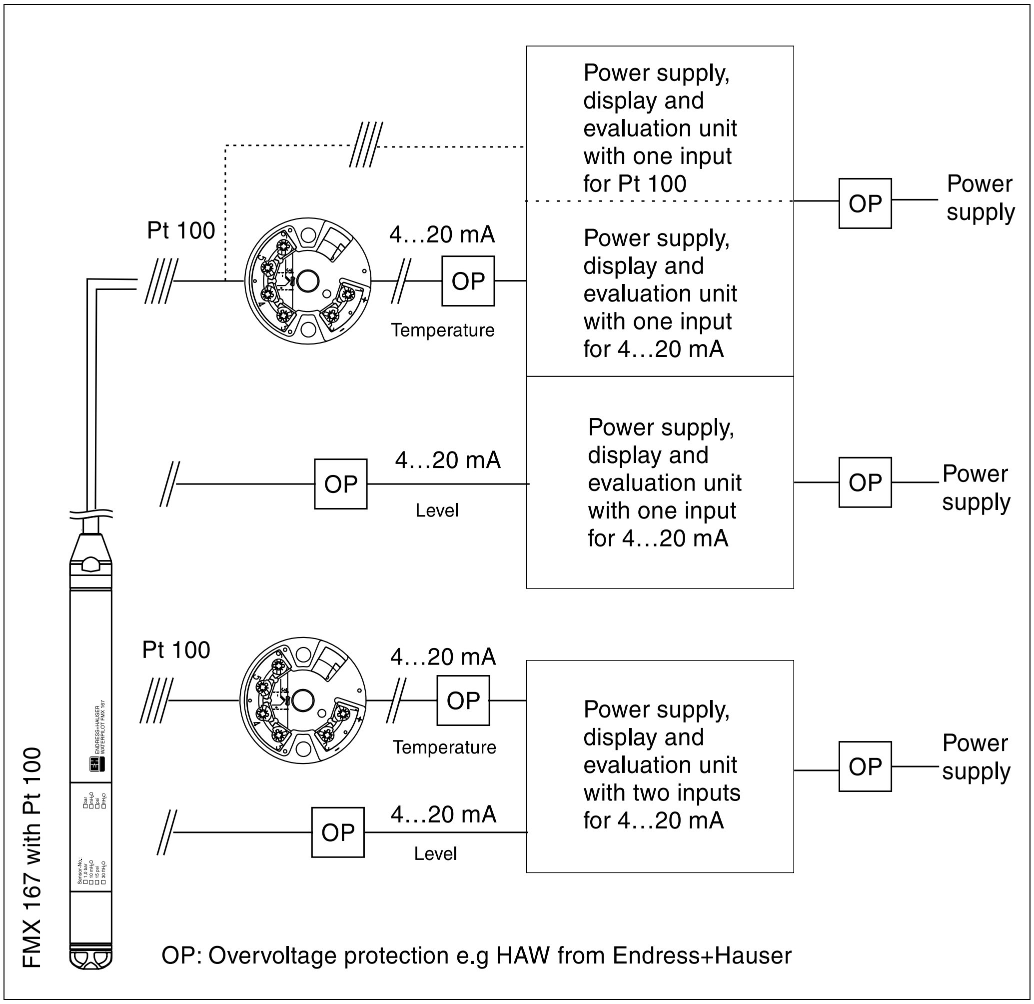


Fig. 11: Wiring the measuring unit

4.3 Checking the wiring

After wiring the measuring instrument, carry out the following inspections:
- Does the supply voltage match the specification on the nameplate?
- Is the device connected as shown in Figures 7 and 8?
- Are all the screws tightened?
- Optional terminal housing: are the conduit entries tight?

5 Operation

Note!

Note!
Endress+Hauser offers extensive measuring point solutions with display and/or evaluation units for the Waterpilot FMX 167 and the Temperature Transmitter TMT 181. For more information, please contact your nearest Endress+Hauser Service Organization. Please refer to the back page of this documentation for contact addresses.

6 Maintenance

No special maintenance work is required for the Waterpilot FMX 167 or for the optional Temperature Transmitter TMT 181.

Cleaning the device exterior
When cleaning the exterior of the measuring device, please note the following:
- Do not use a cleaning agent that is aggressive to the housing surface or the seal.
- Waterpilot FMX 167: avoid any mechanical damage to the membrane or the support cable.

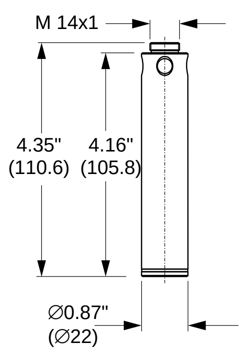
7 Accessories

There are a number of accessories available for the Waterpilot FMX 167. You can order them separately from Endress+Hauser.

Mounting clamp
Endress+Hauser offers a mounting clamp for simple mounting. Refer to page 26.
Material: 1.4435 (AISI 316L), Order No.: 52006151

Terminal housing
Terminal housing NEMA 4/NEMA 4X (IP 66/IP 67) with GORE-TEX® filter including three mounted terminals.
The terminal housing is also suitable for installing a temperature transmitter (Order No. 52008794) or for four additional terminals (Order No. 52008938).
Refer to page 27.
Order No.: 52006152

Additional weight



To prevent sideways movement leading to measuring errors or to ensure that the device lowers into a guide tube, Endress+Hauser provides additional weights. You can attach several weights to the FMX 167.

Material: 1.4435 (AISI 316L)
Weight: 10.6 oz. (300 g)
Order No.: 52006153

Temperature Transmitter TMT 181, 4-20 mA
Temperature transmitter, 2-wire, pre-set for measuring range from –4 to +176°F (–20 to +80°C).
This setting offers an easily displayable temperature range of (212°F) 100°C. Note that the Pt 100 resistance thermometer is designed for a temperature range of +14 to +158°F (–10 to +70°C). Refer to page 27.
Order No.: 52008794

Cable mounting screw
Endress+Hauser offers cable mounting screws to simplify the installation of the FMX 167.
Refer to page 26. Material: 1.4301 (AISI 304)
Order No. for cable mounting screw with G 1 1/2 A thread: 52008264
Order No. for cable mounting screw with 1 1/2 NPT thread: 52009311

Terminals
Four terminals in strip for FMX 167 terminal housing,
suitable for wire cross section of ≤14 AWG (0.08 to 2.5 mm^2)
Order No.: 52008938
Protective front cap (set of 5)
Order No.: 52008999

Membrane protective cap
5 pieces in set, refer to Fig. 3, page 8
Order No.: 52008999

Pressure compensation set
10 pieces in set, comprised of Teflon filter and sleeve for support cable,
refer to Fig. 3, page 8
Order No.: 52005578

8 Trouble-shooting

8.1 Faults on Waterpilot FMX 167 and Waterpilot FMX 167 with Pt 100 (optional)

Error description	Cause	Action
No measuring signal	Connection of 4-20 mA line incorrect	Connect device according to Chapter 4.1, Figs. 7 or 8
	No supply voltage over 4-20 mA line	Check current loop
	Supply voltage too low (min. 10 V DC)	Check supply voltage Total resistance greater than max. load resistance, refer to Chapter 4.1, page 14
	Waterpilot defective	Replace Waterpilot
Temperature measuring value inaccurate/incorrect (only with Waterpilot FMX 167 with Pt 100)	Pt 100 connected to 2-wire circuit, line resistance not compensated	Compensate line resistance Connect Pt 100 as 3-wire or 4-wire circuit

8.2 Faults of Temperature Transmitter TMT 181 (optional)

Error description	Cause	Action
No measuring signal	Connection of 4-20 mA line incorrect	Connect device according to Chapter 4.1, Fig. 8
	No supply voltage over 4-20 mA line	Check current loop
	Supply voltage too low (min. 8 V DC)	Check supply voltage Total resistance greater than max. load resistance, refer to Chapter 4.1, page 14
Error current ≤ 3.6 mA or ≥ 21 mA	Connection of Pt 100 incorrect	Connect device according to Chapter 4.1, Fig. 8
	Connection of 4-20 mA line incorrect	Connect device according to Chapter 4.1, Fig. 8
	No supply voltage over 4-20 mA line	Check current loop, refer to Chapter 4.1, Fig. 8
	Pt 100 element defective	Replace Waterpilot FMX 167
	Temperature transmitter defective	Replace temperature transmitter
Measuring value inaccurate/ incorrect	Pt 100 connected in 2-wire circuit, line resistance not compensated	Compensate line resistance Connect Pt 100 as 3-wire or 4-wire circuit

8.3 Spare Parts

Note!

Note!
You can order spare parts directly from your nearest Endress+Hauser Service Organization.

9 Technical Data

9.1 Technical Data Waterpilot FMX 167 and Waterpilot FMX 167 with Pt 100 (optional)

Applications

Applications	The Waterpilot FMX 167 is a hydrostatic pressure sensor for measuring the level of fresh water, drinking water and wastewater. The version with a Pt 100 resistance sensor measures temperature at the same time.

Input Parameters

Measured variable	• Hydrostatic pressure of a liquid • Pt 100: Temperature of a liquid
Measuring range	• Nine fixed pressure measuring ranges in psi, ftH_2O, bar and mH_2O, • Customer-specific measuring ranges between 1.5 and 300 psi (3 to 600 ftH_2O); factory-calibrated and special measuring ranges on request • Pt 100 (optional): Temperature measurement from –4 to +176°F (–20 to +80°C)

Output Parameters

Output signal	• 4-20 mA for hydrostatic pressure measured value, two-wire loop powered • Pt 100 (optional): temperature-dependent resistance of the Pt 100
Load	see Chapter 4.1, section "Load"

Auxiliary energy

Electrical connection	see Chapter 4.1, integrated polarity protection
Supply voltage	• 10 - 30 V DC, EEx nA and EEx ia: 10 - 30 V DC • Pt 100: 10 - 30 V DC, EEx nA: 10 - 30 V DC
Power consumption	≤ 0.675 W at 30 V DC
Current drain	• Max. current drain: ≤ 22.5 mA; Min. current drain: ≥ 3.5 mA • Pt 100 (optional): ≤ 0.6 mA
Residual ripple	No effect for 4-20 mA signal up to ± 5% residual ripple within permissible range

Performance characteristics

Reference operating conditions	DIN EN 60770 T_U= 77°F (25°C)
Accuracy	• Linearity including hysteresis and repeatability as per DIN EN 60770: ± 0.2% of Full Scale • Pt 100: max.: ±0.7 K (Class B to DIN EN 60751)
Long-term stability	±0.1 % of Full Scale per year
Influence of medium temperature	• Thermal change in zero signal and output span for typical temperature range +32 to +86°F (0 to +30°C): ± 0.4 % (± 0.5 %)* of span • Thermal change in zero signal and output span for the total medium temperature range +14 to +158°F (–10 to +70°C): ± 1.0 % (± 1.5 %)* of span • Maximum temperature coefficient (T_K) in zero signal and output span: 0.15 %/10 K (0.3 %/10 K)* of span * Specifications for sensors 1.5 psi (3 ft H_2O, 0.1 bar, 1 mH_2O), 10 psi (20 ft H_2O, 0.6 bar, 6 mH_2O)

Performance characteristics (continuation)

Warm-up period	20 ms
Rise time (T90-time)	• 80 ms • Pt 100 (optional): 160 s
Setting time	• 150 ms • Pt 100 (optional): 300 s

Ambient Conditions

Ambient temperature range	+14 to +158°F (–10 to +70°C), (= Medium temperature range)
Storage temperature	–40 to +176°F (–40 to +80°C)
Ingress protection	– NEMA 6P (IP 68), permanently submersible to 700 ftH_2O – Optional terminal housing: NEMA 4/NEMA 4X (IP 66/IP 67)
Electromagnetic compatibility	Interference emission to EN 61326; Equipment Class B Interference immunity to EN 61326, Appendix A (industrial usage)
Overvoltage protection	Integrated overvoltage protection to EN 61000-4-5 ≤ 1.2 kV Install overvoltage protection ≥ 1.2 kV, external if necessary.

Process Conditions

Medium temperature range	+14 to +158°F (–10 to +70°C) For devices approved for use in hazardous areas, see Safety Instructions.
Medium temperature limits	–4 to 158°F (–20 to +70°C) (You may operate the FMX 167 in this temperature range. The values quoted in the specifications may then be exceeded, e.g. measuring accuracy. Also refer to DIN 16086.)

Mechanical Construction

Construction, Dimensions	see Chapter 9.3
Weight	– Cable probe: 10 oz. (290 g) – Support cable: Approximately 2 oz/ft (52 g/m) – Mounting clamp: 6 oz. (170 g) – Cable mounting screw G 1 1/2 A: 1.7 lb. (0.77 kg) – Cable mounting screw 1 1/2 NPT: 1.6 lb. (0.72 kg) – Terminal housing: 8.3 oz. (235 g) – Additional weight: 10.6 oz. (300 g)
Materials	Cable probe: – Cable probe 1.4435 (AISI 316L) – Process ceramic: Al_2O_3 aluminum oxide ceramic – Seal (internal): EPDM or Viton – Protective cap: PE-HD (high-density polyethylene) – Support cable insulation: PE (polyethylene), for more details, see section "Support cable" optional: – Mounting clamp 1.4435 (AISI 316L) and glass fiber reinforced PA (polyamide) – Cable mounting screw G 1 1/2 A: 1.4301 (AISI 304) – Cable mounting screw 1 1/2 NPT: 1.4301 (AISI 304) – Additional weight: 1.4435 (AISI 316L) – Temperature transmitter: Housing PC (polycarbonate)

Mechanical Construction (continuation)

Support cable	Construction – Slip-resistant extension cable with strain-relief members made of Kevlar; shielded using aluminum-coated film; insulated with polyethylene (PE), black; copper wires, twisted – Pressure compensation tube with Teflon filter Cross section – FMX 167: 3 x 0.0004 in^2 (0.227 mm^2) + pressure compensation tube with Teflon filter – FMX 167 with Pt 100 (optional): 7 x 0.0004 in^2 (0.227 mm^2) + pressure compensation tube with Teflon filter – Total outer diameter: 0.315 inch ± 0.0098 inch (8.0 mm ± 0.25 mm) – Pressure compensation tube with Teflon filter: Outer diameter OD = 0.098 inch (2.5 mm), Internal diameter ID = 0.059 inch (1.5 mm) Cable resistance – Cable resistance per wire: ≤ 90 Ω/km Cable length – Max. free suspended length (mechanical stability under load): 3280 feet (1000 m) – Max. free length for non-Ex and EEx nA IIC T6: see Section "Load", Chapter 4.1 Max. free length for EEx ia IIC T6: see Safety Instructions (XA…) Further technical data – Minimum bending radius: 4.7 inch (120 mm) – Tensile strength: ≥ 269 lb force (1200 N) – Cable extraction force: ≥ 101 lb force (450 N) (The extension cable could be extracted from the cable probe at a tensile force ≥ 101 lb force (450 N).) – Approved for use with drinking water NSF 61 – Increased resistance to UV light
Terminals	– 3 standard terminals in terminal housing – 4-terminal strip available as accessory , Order No. 52008938 for wire cross section of 0.0001 in^2 to 0.004 in^2 (0.08 to 2.5 mm^2)

Certificates and Approvals

Explosion protection approval, Type of protection	– ATEX II 2G/EEx ia IIC T6 – ATEX II 3 G/EEx nA II T6 – FM: IS, Class I, Division 1, Groups A-D – CSA: IS, Class I, Division 1, Groups A-D Note: Waterpilot FMX 167 with integrated Pt 100 is not available for FM, IS, Class 1, Div. 1, Groups A-D; CSA, IS, Class 1, Div. 1, Groups A-D and ATEX. Waterpilot FMX 167 with integrated Pt 100 is available for CSA, General purpose and for the Standard version. All explosion protection data are contained in separate explosion protection documentation which you can also request. Explosion protection documents are supplied as standard for all devices approved for use in explosion hazadous areas.

Ordering Information

Ordering information	You will receive ordering information and Order Code details from Endress+Hauser Service Organization. Refer also to Technical Information Waterpilot FMX 167 (TI 351P/24/ae)

Supplementary Documentation

Supplementary Documentation	– System Information Waterpilot (SI 028P/00/en) – Technical Information Waterpilot FMX 167 (TI 351P/24/ae) – Safety Instructions, ATEX II 2 G/EEx ia IIC T6 (XA 131P/01/a3) – Safety Instructions, ATEX II 3 G/EEx nA II T6 (XA 132P/01/a3)

9.2 Technical Data Temperature Transmitter TMT 181 (optional)

Applications

Applications	The temperature transmitter TMT 181 converts the Pt 100 signal into a 4-20 mA.

Input Parameters

Measured variable	Temperature
Measuring range	The temperature transmitter is pre-set for a measuring range of –4 to +176°F (–20 to +80°C). This setting offers an easily displayable temperature range of 212°F (100°C). Please note that the Pt 100 resistance thermometer is designed for a temperature range of 14 to 158°F (-10 to +70°C)
Input signal	Pt 100 resistance signal, 4-wire

Output Parameters

Output signal	4 to 20 mA for temperature measured value, two-wire
Load	see Chapter 4.1, section "Load"

Auxiliary energy

Electrical connection	see Chapter 4.1, integrated polarity protection
Supply voltage	8 - 35 V DC, EEx ia: 9.6 - 30 V DC
Cable specifications	see Chapter 4.1, section "Cable specifications"
Power consumptionn	≤ 0.77 W at 35 V DC
Current drain	• Max. current drain: ≤ 22 mA Min. current drain: ≥ 3.5 mA • with optional Pt 100 of the FMX 167: ≤ 0.6 mA
Residual ripple	$U_{ss} \leq 5$ V at $U_B \geq 13$ V, $f_{max.}$= 1 KHz

Performance characteristics

Reference operating conditions	Calibration temperature: 73°F (23°C) ± 5K
Accuracy	• ±0.2 K • with optional Pt 100 of the FMX 167: max. ±0.9 K
Warm-up period	4 s

Ambient Conditions

Ambient temperature range	–40 to +185°F (–40 to +85°C)
Storage temperature	–40 to +212°F (– 40 to +100°C)
Ingress protection	– IP 00, moisture condensation permissible – When mounted in optional terminal housing: NEMA 4X (IP 66/IP 67)
Electromagnetic compatibility (EMC)	Interference emission to EN 61326; Equipment Class B Interference immunity to EN 61326, Appendix A (industrial usage)
Overvoltage protection	Install overvoltage protection, external if necessary.

Mechanical Construction

Construction, dimensions	see Chapter 9.3
Weight	1.4 oz. (40 g)
Material	Housing PC (polycarbonate)

Terminals	Connection terminals temperature transmitter: 15 AWG (1.75 mm^2)

Certificates and Approvals

Explosion protection approval, Type of protection	FM IS Class 1, Div. 1, Group A-D Non Incendive, Class 1, Div. 2, Group A-D Note: Waterpilot FMX 167 with integrated Pt 100 is not available for FM IS, Class 1, Div. 1, Groups A-D; CSA IS, Class 1, Div. 1, Groups A-D and ATEX. Waterpilot FMX 167 with integrated Pt 100 is available for CSA, General purpose and for the Standard version.

Ordering Information

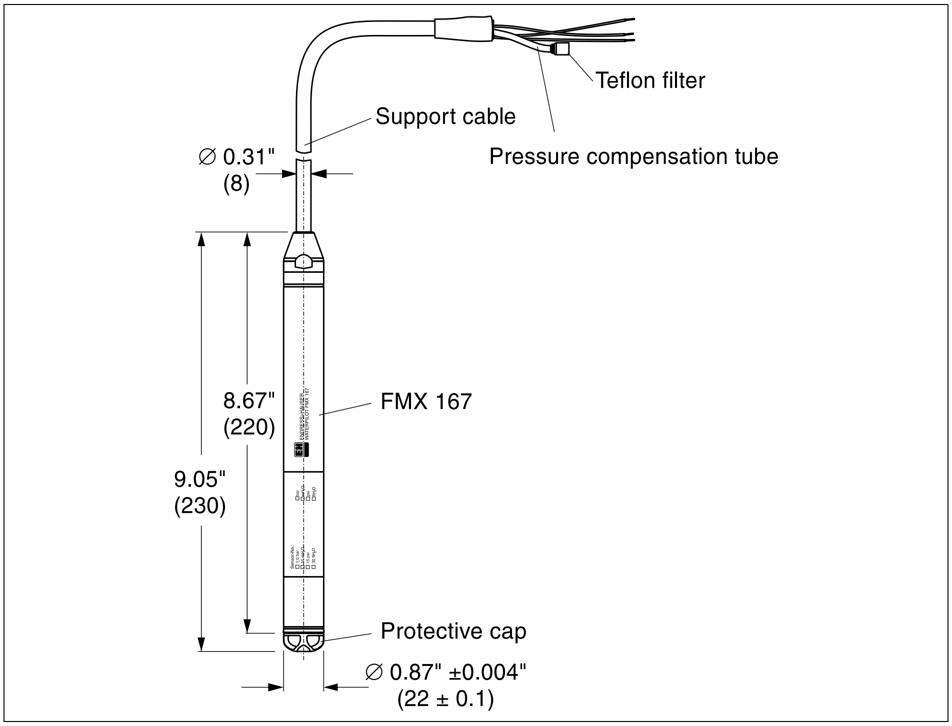
Ordering information	You will receive ordering information and Order Code details from Endress+Hauser Service Organization. See also Technical Information Temperature Head Transmitter iTEMP PCP TMT 181 (TI 070R/09/en).

Supplementary Documentation

Supplementary Documentation	– System Information Waterpilot (SI 028P/00/en) – System Information System Components (SI 006R/09/en) (Display, Power, Convert, Separate and Switch) – System Information Recorders with System Integration (SI 007R/09/en) – Technical Information Temperature Head Transmitter iTEMP PCP TMT 181 (TI 070R/09/en)

9.3 Dimensions

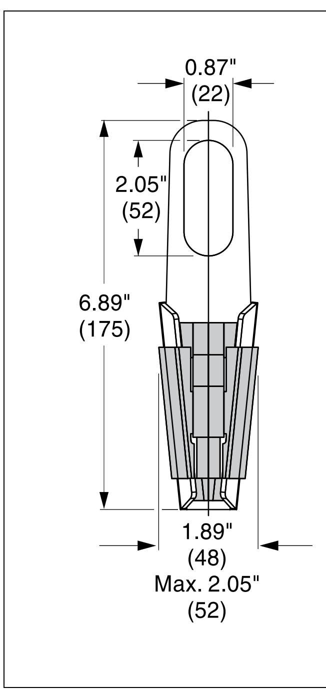
Dimensions of cable probe

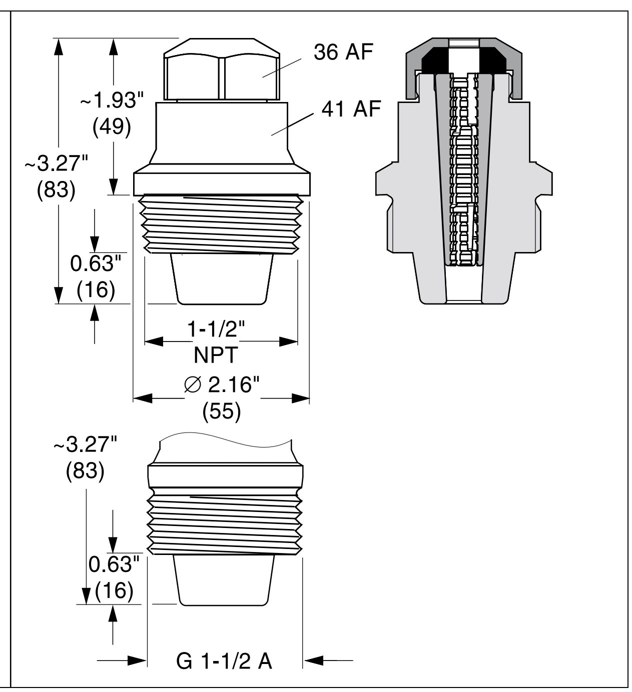


Dimensions of cable mounting screw G 1 1/2 A
FMX 167-❑3❑❑❑❑❑❑

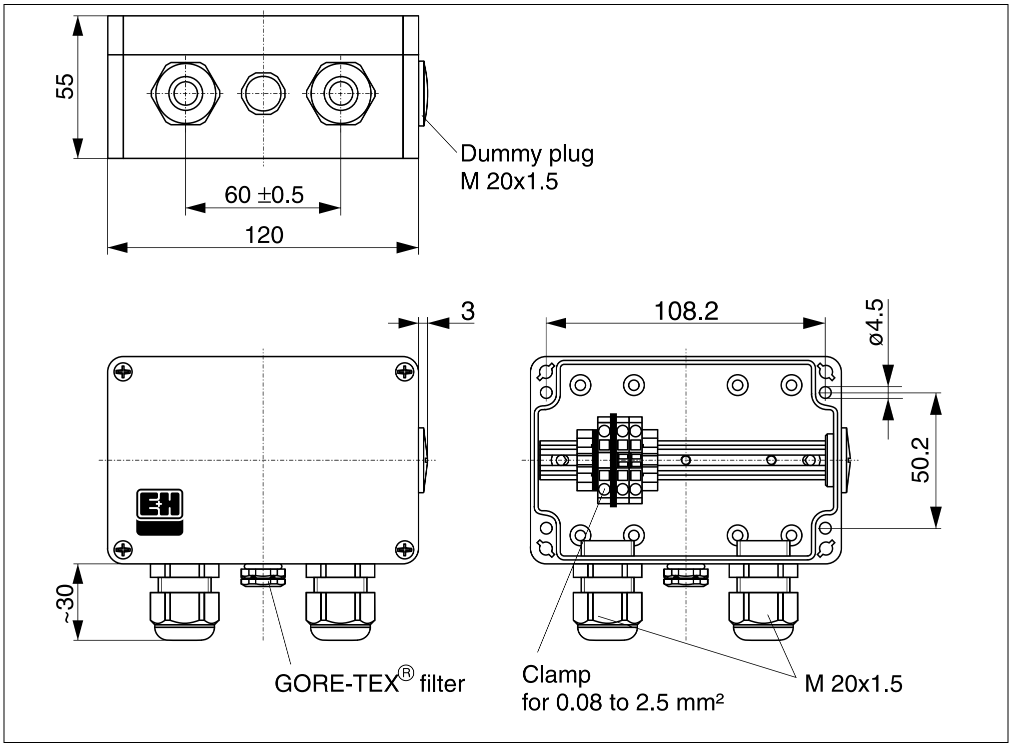
Dimensions of mounting clamp
FMX 167-❑2❑❑❑❑❑❑

Dimensions of cable mounting screw 1 1/2 NPT
FMX 167-❑4❑❑❑❑❑❑

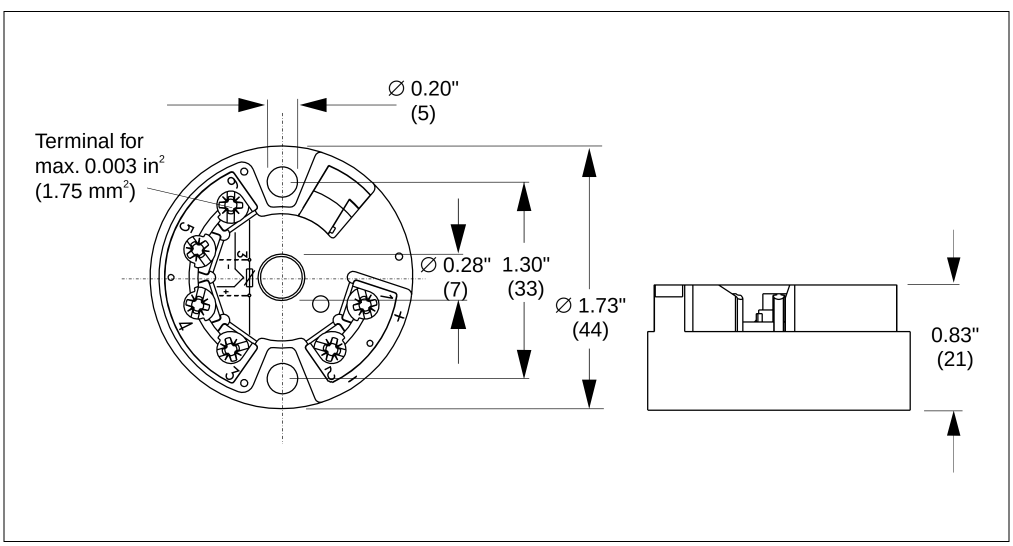




Dimensions terminal housing IP 66/IP 67 with filter
FMX 167 - ❑❑❑❑❑❑❑3:Terminal housing incl. 3 terminals,
FMX 167 - ❑❑❑❑❑❑❑4:Terminal housing incl. 7 terminals for FMX 167 with Pt 100,
FMX 167 - ❑❑❑❑❑❑❑5:Terminal housing incl. 3 terminals +
temperature transmitter TMT 181, 4-20 mA for FMX 167 with Pt 100



Dimensions temperature transmitter TMT 181 (4…20 mA)
FMX 167 - ❑❑❑❑❑❑❑5:Terminal housing incl. 3 terminals +
temperature transmitter TMT 181, 4-20 mA for FMX 167 with Pt 100



10 Appendix

10.1 Functions and system design

The FMX 167 is a submersible level transmitter with a ceramic pressure sensor for the level measurement of liquids. The Waterpilot is available with nine permanently calibrated measuring ranges from 3 to 600 ftH2O to ensure use in all standard applications (optional application specific range). Due to its compact outer diameter of only 0.87" (22 mm), it is ideal for use in 1" well casings. Options include output for temperature measurement.

The FMX 167 is a loop-powered self-contained 4-20 mA device. The hydrostatic column acts directly on the ceramic diaphragm. The deflection of the diaphragm generates a change in the capacitance of the sensor. The transmitter electronics, which is located in the 316L SS probe, converts the capacitance change to a repeatable and accurate 4-20 mA output signal.

A complete measuring system consists of the FMX 167 and a transmitter power supply unit (10 to 30 VDC). Endress+Hauser has a complete line of power supplies with displays and/or indicators.

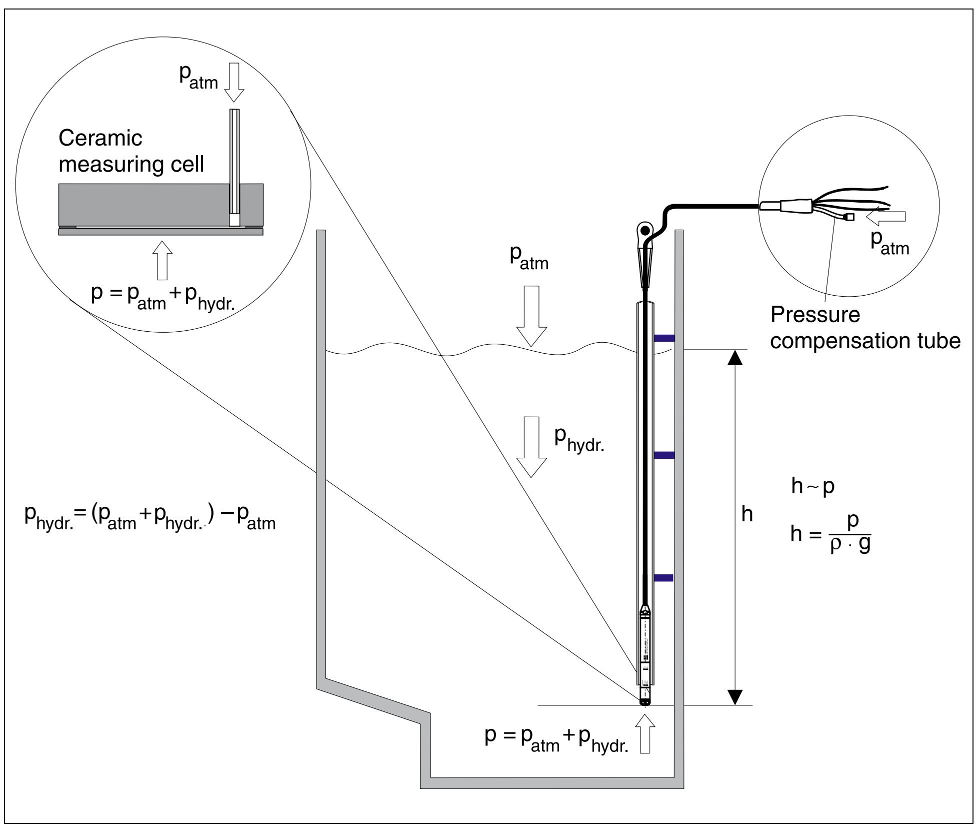


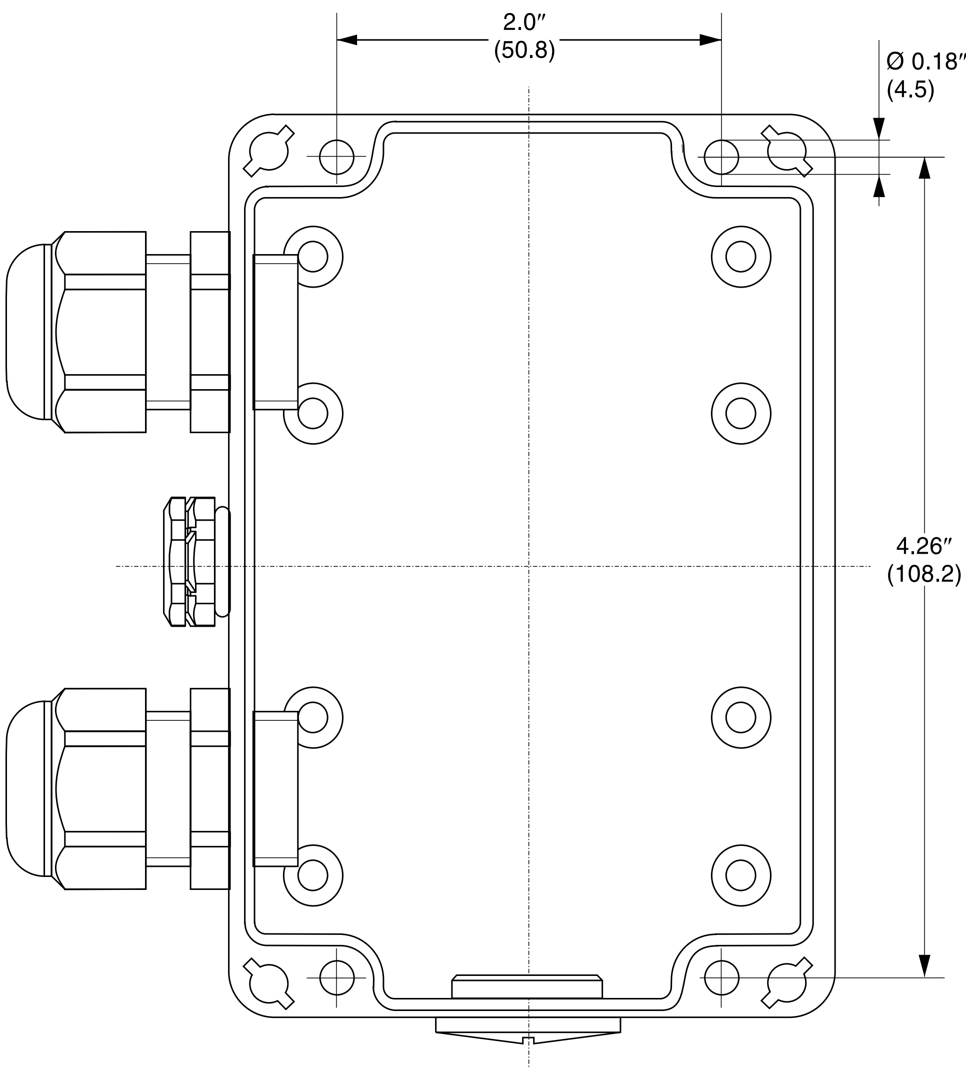
Fig. 12: Functions and system design

h = level height
p = total pressure = hydrostatic pressure + atmospheric pressure
ρ = medium density
g = gravitational acceleration
$p_{hydr.}$ = hydrostatic pressure
p_{atm} = atmospheric pressure

Temperature measurement with Pt 100 (optional)
Endress+Hauser offers an optional 4-wire Pt 100 resistance sensor for Waterpilot FMX 167 to measure level and temperature simultaneously. The Pt 100 belongs to Accuracy Class B to DIN EN 60751.

Temperature measurement with Pt 100 and Temperature Transmitter TMT 181 (optional)
To convert Pt 100 signals into a 4-20 mA signal Endress+Hauser also offers a temperature transmitter for mounting in the FMX 167 terminal housing.

10.2 Drilling template terminal housing



10.3 Control Drawing - Waterpilot FMX 167

Hazardous location

Class I, DIV. 1, Groups A, B, C, D
AEx ia IIC T6, Ta = 70°C
Class I, DIV. 2, Groups A, B, C, D

Non hazardous location

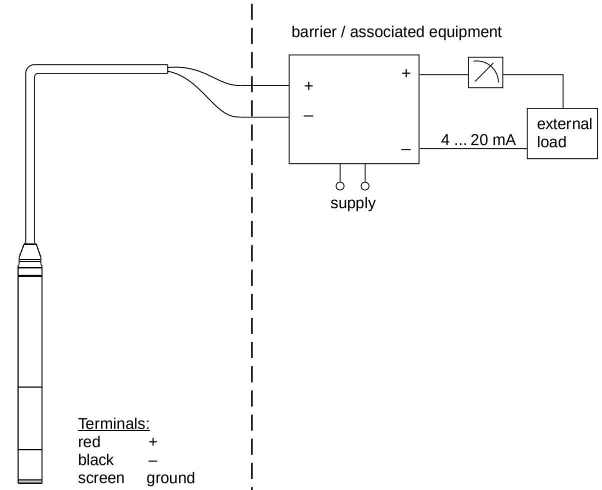


Table: Entity parameters sensor:

Vmax. = 30 VDC
I max. = 133 mA
Pmax. = 1 W
Ci see table
Li see table

Intrinsically safe (entity), Class I, DIV. 1, Groups A, B, C, D
Hazardous Location Installations

1. Control room equipment may not use or generate over 250 V
2. Use Factory Mutual Entity-approved intrinsic safety barrier with Voc or Vt ≤ Vmax, Isc or It ≤ Imax, Ca ≥ Ci + C_{cable}, La ≥ Li + L_{cable}
   Barrier must be incapable of delivering more than 1 Watt to a matched load.
   Transmitter entity parameters are as follows: Vmax = 30 VDC
   I max = 133 mA
   Pmax = 1 W

   Ci and Li per table:

Length of sensor cable	Ci (5.3 nF + 180pF/m)	Li (1 µH/m)
5 m	6.2 nF	5 µH
10 m	7.1 nF	10 µH
20 m	8.9 nF	20 µH
30 m	10.7 nF	30 µH
50 m	14.3 nF	50 µH
100 m	23.3 nF	100 µH
200 m	41.3 nF	200 µH
300 m	59.3 nF	300 µH

3. Installation should be in accordance with ANSI/ISA RP 12.6 "Installation of intrinsically safe systems for hazardous (classified) locations" and the National Electrical Code (ANSI/NFPA 70).
4. Warning: Substitution of Components may impair intrinsic safety.
5. Intrinsic safety barrier manufacturer's installation drawing must be followed, when installing this equipment: The configuration of the intrinsic safety barrier(s) must be FMRC approved.
6. Use supply wires suitable for 5°C above surrounding ambient.

Non-incendive Class I, DIV. 2, Groups A, B, C, D
Hazardous Location Installation

1. Install per National Electrical Code (NEC)
   DIV. 2 barrier required
   max. supply voltage 30 VDC

2. Warning: Explosion Hazard – Do not disconnect equipment unless power has been switched off or area is known to be non hazardous.
   Warning: Substitution of Components may impair suitability for Class I, DIV.2

Note: For non-incendive field circuit evaluations, the input current (Imax or Ii) of the receiving device need not match the output current (Isc or Io) of the barrier/associated equipment supplying the energy.

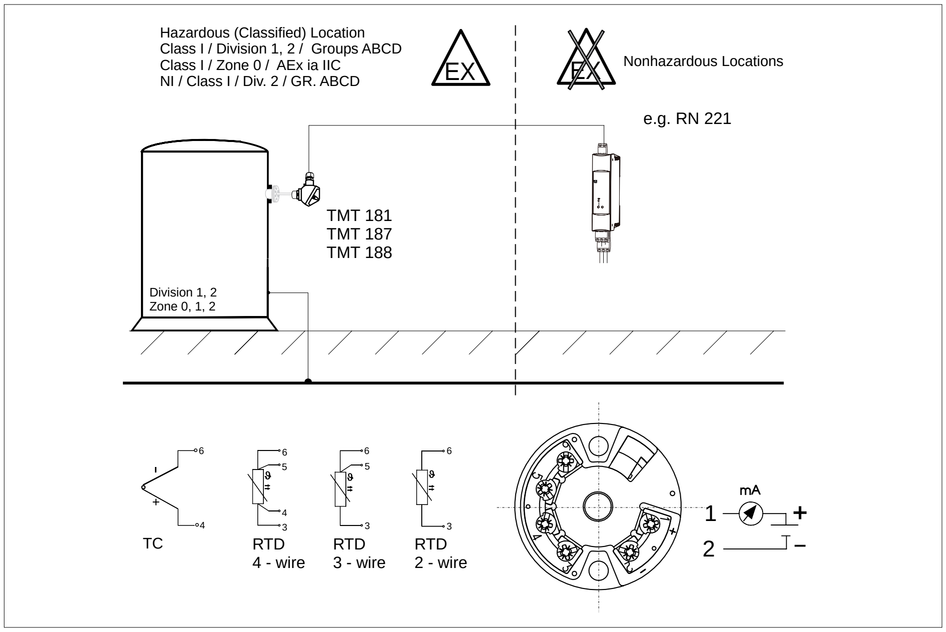
Agency controlled drawing.
No changes without prior agency approval.

ZD 063P-A/01/en/03.01/CCS
FM / A 30.10.00
52008498

Control drawing (IS)
960503-1009 A
Waterpilot FMX 167

Endress+Hauser

10.4 Control Drawing TMT 181



Installation Notes TMT 181, TMT 187, TMT 188

1) FMRC certified apparatus must be installed in accordance with manufacturer instructions.
2) FMRC certified associated apparatus must meet the following requirements:
   Uo or Voc < Ui or Vmax   Io or Isc < Ii or Imax   Po or Pmax < Pi or Pmax   Ca > Ci + Ccable   La > Li + Lcable
3) The installation must be in accordance with the National Electrical Code.
   NEC ANSI / NFPA 70, Article 504 and ANSI / ISA-RP 12.6
4) Use supply wires suitable for 5°C above surrounding.
5) The configuration of the headtransmitter TMT 181 is only pemitted in nonhazardous locations.
6) The voltage of the "tools" used for configuration should not exceed Um = 30 V. This can be achieved e.g. by a batterie powered laptop. An approved adapter with barrier (e.g. TMT181A) has to be used for configuration using a PC with mains connection (Um < 253V).

Warning:
- Substitution of Components may impair intrinsic safety

TMT 181 / TMT 187 / TMT 188			**IS / Class I / Division 1 / Groups ABCD / T4/T5/T6** **Class I / Zone 0 / AEx ia IIC / T4/T5/T6** **NI / Class I / Division 2 / Groups ABCD / T4/T5/T6**	
Supply circuit (Terminal 1 and 2)			Vmax = Ui < 30 VDC Imax = Ii < 100 mA Pmax = Pi < 750 mW Ci ~ 0 Li ~ 0	
Sensor circuit (Terminal 3 until 6)			Voc = Uo < 8.2 VDC Isc = Io < 4.6 mA P = Po < 9.35 mW	
Max. Connecting Values	Group A, B Group C Group D	Ex ia IIC Ex ia IIB Ex ia IIA	La = Lo = 4.5 mH La = Lo = 8.5 mH La = Lo = 1000 mH	Ca = Co = 974 nF Ca = Co = 1900 nF Ca = Co = 210 µF
Temperature range			T6: Ta = -40°C ... +55°C T5: Ta = -40°C ... +70°C T4: Ta = -40°C ... +85°C	

Nr.: 510 01932

DESIGN		Endress+Hauser 87484 Nesselwang, Germany
DRAWN	13.12.99 Kellermann	DOCUMENT PROTECTED BY DIN 34
APPROVED	07.12.00 Kellermann	
SCALE	TITLE Control Drawing FM TMT 181(7)(8)	DRAWING NO. 14 05 00 111
TOLERANCE	MATERIAL	REPL. FOR / REPL. BY / SHEET SIZE A4
A	Keller-mann / Keller-mann	01.09.00

Ordering Information

1 2 3 4 5 6 7

FMX 167 - ☐☐☐☐☐☐☐

1 Certificate

A	Standard	
B	ATEX II 2 G	EEx ia IIC T6
C	ATEX II 3 G	EEx nA IIC T6
D	FM approved	IS, Class I, Div. 1, Grps. A-D
E	CSA approved	IS, Class I, Div. 1, Grps. A-D
F	CSA	General purpose

2 Mechanical connection (cable suspension)

- 1 None
- 2 Mounting clamp, 316L SS
- 3 Cable mounting screw G 1-1/2 A, 304 SS
- 4 Cable mounting screw 1-1/2" NPT, 304 SS
- 9 Special version

3 Measuring cell tube material

- A 316L SS cell enclosure
- D 316L SS cell enclosure, with drinking water approval (NSF std. 61) for all parts in contact with the medium (only for probes with EPDM seals)
- Y Special version

4 Measuring range

				Max. overload
FA	0 to 3 ftH_2O	PA	0 to 1.5 psi	73 psi
FB	0 to 6 ftH_2O	PB	0 to 3 psi	73 psi
FC	0 to 15 ftH_2O	PC	0 to 6 psi	101 psi
FD	0 to 20 ftH_2O	PD	0 to 10 psi	145 psi
FE	0 to 30 ftH_2O	PE	0 to 15 psi	145 psi
FF	0 to 60 ftH_2O	PF	0 to 30 psi	261 psi
FG	0 to 150 ftH_2O	PG	0 to 60 psi	362 psi
FH	0 to 300 ftH_2O	PH	0 to 150 psi	580 psi
FK	0 to 600 ftH_2O	PK	0 to 300 psi	580 psi
BA	0 to 0.1 bar	MA	0 to 1 mH_2O	5 bar
BB	0 to 0.2 bar	MB	0 to 2 mH_2O	5 bar
BC	0 to 0.4 bar	MC	0 to 4 mH_2O	7 bar
BD	0 to 0.6 bar	MD	0 to 6 mH_2O	10 bar
BE	0 to 1.0 bar	ME	0 to 10 mH_2O	10 bar
BF	0 to 2.0 bar	MF	0 to 20 mH_2O	18 bar
BG	0 to 4.0 bar	MG	0 to 40 mH_2O	25 bar
BH	0 to 10.0 bar	MH	0 to 100 mH_2O	40 bar
BK	0 to 20.0 bar	MK	0 to 200 mH_2O	40 bar

- VV Adjusted to customer specifications from 0 _____ (full scale value) to _____ (units)
- YY Special version

5 Measuring cell seal

- 1 Viton
- 2 EPDM
- 9 Special version

6 Extension cable

- A Length in ________ meters, PE cable, can be shortened, from 1 to 300 m
- B 10 m PE cable, can be shortened
- C 20 m PE cable, can be shortened
- E 30 ft cable, PE, can be shortened
- F 60 ft cable, PE, can be shortened
- G Length in ________ feet, PE cable, can be shortened, from 1 to 985 ft
- Y Special version

7 Additional equipment

- 1 Probe with integrated Pt 100, 4-wire
- 3 Terminal housing with GORE-TEX® filter, NEMA 4X
- 4 Probe with integrated Pt 100, 4-wire and terminal housing with GORE-TEX® filter, NEMA 4X
- 5 Probe with integrated Pt 100, -4° to +176°F (-20° to +80°C), TMT 181 temperature transmitter, 4 to 20 mA, 2-wire in terminal housing with GORE-TEX® filter, NEMA 4X
- 7 No additional equipment

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IMPORTANT NOTICE
RETURN AUTHORIZATION POLICY

Endress + Hauser must pre-approve and assign a Return Authorization number to any instrument you plan to return. Please identify the Return Authorization number clearly on all shipping cartons and paperwork.

Please note that the issuance of a Return Authorization number does not automatically mean that credit will be issued, or that the return is covered by our warranty. An Endress + Hauser associate will contact you regarding the disposition of your returned equipment.

In order to serve you better, and to protect our employees from any potentially hazardous contaminants, Endress + Hauser must return unopened, at the sender's expense, all items that do not have a Return Authorization number.

To get a Return Authorization number, call

1-800-428-4344

Please be sure to include the following information when requesting a Return Authorization number. This information will help us speed up the repair and return process.

Customer name:
Customer address:
Customer phone number:
Customer contact:
Equipment type:
Original sales order or purchase order number:
Reason for return:
Failure description, if applicable:
Process material(s) to which the equipment has been exposed:

OSHA Hazard Communication Standard 29CFR 1910.1200 mandates that we take specific steps to protect our employees from exposure to potentially hazardous materials. Therefore, all equipment so exposed must be accompanied by a letter certifying that the equipment has been decontaminated prior to its acceptance by Endress + Hauser.

The employees of Endress + Hauser sincerely appreciate your cooperation in following this policy.

Address your equipment to:

Endress + Hauser
2350 Endress Place
Greenwood, IN 46143
Return Authorization number:

Effective November 1987

United States

Endress+Hauser
2350 Endress Place
Greenwood, IN 46143
Phone: (317) 535-7138
1-800-428-4344
FAX: (317) 535-8498

Regional Office
Endress+Hauser
P.O. Box 901
Harvey, LA 70059
Phone: (504) 366-3264
1-800-288-2364
FAX: (504) 366-3816

A.D. Instruments
Div. of Endress+Hauser
4711-A Nations Crossing Road
Charlotte, NC 28217
Phone: (704) 522-8415/8536
FAX: (704) 527-5005

Regional Office
Endress+Hauser
2901 West Sam Houston
Parkway North, Ste. C-250
Houston, TX 77043
Phone: (832) 590-6200
FAX: (832) 590-6202

Sterling IPC
Div. of Endress+Hauser
68950 Powell Road
Romeo, MI 48065
Phone: (810) 752-0700
FAX: (810) 752-0705

Regional Office
Endress+Hauser
942 Town Center
New Britain, PA 18901
Phone: (267) 880-1750
1-877-880-1750
FAX: (267) 880-1759

RPS Industries
Div. of Endress+Hauser
500 W. Central Avenue
Suite A
Brea, CA 92821
Phone: (714) 529-1925
FAX: (714) 529-2966

Canada

Endress+Hauser
Canada Ltd.
1440 Graham's Lane
Unit 1, Burlington
ON, L7S 1W3
Phone: (905) 681-9292
1-800-668-3199
FAX: (905) 681-9444

Endress+Hauser
Canada Ltée
6800 Côte de Liesse, Ste. 100
St. Laurent, Que H4T 2A7
Téléphone: (514) 733-0254
Télécopieur: (514) 733-2924

Endress+Hauser
Canada Ltd.
18103 - 105 Ave. NW #101
Edmonton, AB T5S 2L5
Phone: (780) 846-3222
FAX: (780) 486-3466

Mexico

Paseo del Pedregal No. 610
Col. Jardines del Pedregal
01900, Mexico D.F.
MEXICO
Phone: (525) 568-2405
FAX: (525) 568-7459

Endress+Hauser
The Power of Know How

BA 231P/24/ae/07.01

APPENDIX I

SCADA Control Components

CATALOG 12

Wireless Connectivity Solutions

Product Catalog

Weidmüller

Weidmuller Catalogs at a Glance

Catalog 1: Modular Terminal Blocks

- P-Series (Push-in technology)
- I-Series (IDC technology)
- Z-Series (Tension clamp technology)
- W-Series (Screw clamp technology)
- Stud Style (Screw clamp technology)
- Power Distribution Blocks and Fuse Blocks

Catalog 2: PCB Terminals and Connectors

- Space Saving Technologies
- Wide Variety of Clamping Technologies
- Pitches Ranging from 3.50 mm to 15.00 mm
- Orientations Ranging from 90˚ to 270˚

Catalog 3: RockStar®– Heavy Duty Connectors

- Inserts
- Modular System
- Housings IP65 and IP69K
- Cable Glands

Catalog 4: Electronics

- Interface Units
- Digital Signaling
- Analog Signaling
- Power Supplies
- Surge Protection
- Relays
- Optocouplers

Catalog 5: Enclosures and Cable Glands

- Enclosures
- Cable Glands
- Cabtite (Cable Entry System)

Catalog 6: Tools

- Cutting
- Stripping
- Crimping
- Screwdrivers
- Automatic Machines
- Ferrules

Catalog 7: Marking Systems

- Terminal Markers
- Wire and Cable Markers
- Device and Equipment Markers
- Printing Systems and Software

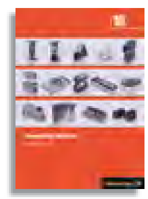
Catalog 8: Sensor Actuator Interface

- SAI Passive Blocks
- SAI Universal
- SAI ASI
- Cables and Connectors
- JACKPAC® IP67

Catalog 9: Industrial Ethernet

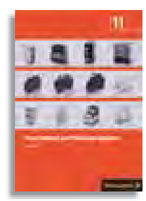
- Unmanaged Switches
- Managed Switches
- Routers
- Media Converters
- SteadyTEC®
- IE Connectors
- Accessories

Catalog 10: Connectivity Solutions Catalog



- Short Form Catalog
- Product Overview

Catalog 11: Power Delivery and Protection Solutions

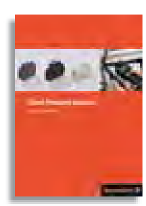


- Power Supplies
- DC/DC Converters
- Battery Back-up Units
- Diodes and Overvoltage Protection

Catalog 12: Wireless Connectivity Solutions

- Wireless Ethernet
- Wireless Gateways
- Wireless Transceivers
- Antennas and Accessories

Circuit Protection Solutions



- Branch Circuit Breakers
- Supplemental Circuit Breakers
- GFCI Circuit Breakers
- Accessories

CD ROM

- Pdf files of All Master Catalogs, Brochures, Datasheets

Contents

Types of Wireless Products

Product Overview

Weidmuller industrial wireless products provide secure and reliable solutions for a wide range of industries and applications, as an alternative for signal and data wiring. These products fall into four groups:

Wireless I/O, also known as radio telemetry, connect directly to sensor and control signals, and transmit the signal values by radio. The signals are either re-created as similar signals, or output as a data connection — Ethernet, Profibus, Modbus etc. Wireless I/O networks can be as simple as two units transferring a small number of signals from one point to another, or they can be complex data-acquisition networks with multiple “master” interfaces to external systems.

Wireless I/O

Wireless Gateways provide wireless connectivity between data buses - connectivity between devices using the same data bus, or between different data buses (Ethernet to Profibus to DeviceNet to Modbus etc). Wireless gateways are similar in operation to wireless modems, however gateways only provide a register interface to the data bus, transferring I/O registers only.

Wireless Gateways

Wireless Modems transmit serial or Ethernet data, providing a wireless extension of the data link. Example applications are PLC to PLC connections (point-to-point), connecting SCADA to a group of PLCs (point-to-multipoint), or forming a wireless PLC LAN (multidrop). Wireless modems transmit the data with minimal transformation.

Wireless Modems

Wireless GPRS Alarm Modems use GSM mobile technology to provide alarm and status information directly to a mobile device, SMS, email, or via fax. The GPRS Alarm Modem can be located anywhere GSM reception is available. Site, remote location, or plant monitoring can be conducted remotely without the need for onsite employees.

Wireless GPRS Modem

Wireless I/O Unidirectional Transmitter/Receiver Units – Introduction

Wireless Input/Output (I/O)

Wireless I/O connects directly to analog, discrete and pulse transducer signals. The signals are transmitted by radio and either re-created as output signals, or output via serial link or field-bus.

Weidmuller Wireless I/O units have the ability to form sophisticated peer-to-peer networks, with event-reporting messaging to optimize wireless density. Weidmuller products are designed for high reliability operation on open license-free radio bands.

WI-I/O 9-L Unidirectional Transmitter/Receiver Units

- Frequency hopping spread spectrum 902-928 MHz 1W license-free USA/Canada/Mexico
- Configurable sub-bands license-free South America, Australia/NZ, Asia, Europe

The Unidirectional Wireless I/O range of products is suitable for connecting to a single sensor or group of sensors and provides an economical solution for remote monitoring systems. The Unidirectional L products can also be used in more complex networks as signal transmitters or receivers.

Features

Matched transmitter/receiver pair of modules, or individual transmitter and receiver units

- Peer-to-peer communications. Exception reporting. Reliable self-checking messages. Highly secure data encryption.
- Multi-hop repeater functions - up to 5 intermediate units can be configured in any input-output link
- Factory configured as a matched Transmitter/Receiver pair or user-configurable with E-Series Windows configuration program

Transmitter unit

- Input-only transmitter unit - two digital/pulse inputs, one analog input and one thermocouple mV input
- Transmits to Receiver unit as a matched pair where the input signals are re-created as output signals, or can transmit to a Multi-I/O or Gateway unit
- Class 1 Div 2 hazardous areas approval
- Up to 3000 wireless units per network
- External inputs plus internally calculated values - analog setpoint status, pulse count, power supply voltage
- Thermocouple input –100 to +100mV with cold-junction compensation and linearization for J, K or T-type
- Setpoints status generated by comparing analog input to high and low setpoints
- Digital inputs can also be used as pulse count inputs
- Power supply 9 – 30Vdc, measured and available as a transmitted variable
- 24Vdc analog loop supply internally provided
- RS232 Configuration and diagnostics port

Receiver unit

- Output-only receiver unit - three digital contact outputs and one analog output
- Receives radio commands from Transmitter unit as a matched pair where the input signals are re-created as output signals, or can receive commands from a Multi-I/O or Gateway unit
- Class 1 Div 2 hazardous areas approval
- Up to 3000 wireless units per network
- Power supply 9 – 30Vdc; 24Vdc analog loop supply internally provided
- Communications failure indication and configurable output
- Outputs can be configured as retained or reset (fail-safe) on communications failure
- LED indication of radio signal strength
- RS232 Configuration and diagnostics port

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WI-I/O 9-L-T
Transmitter

WI-I/O 9-L-R
Receiver

Technical Data	WI-I/O 9-L-T Transmitter	WI-I/O 9-L-R Receiver
Transmitter Inputs:		
Digital:	two inputs, suitable for voltage free contacts / NPN, or voltage input 0-1 VDC on / >3 VDC off	
Pulse:	max rate 10 Hz, 50 msec on time. Pulse counted as 16 bit register.	
Analog:	0-20 mA (4-20mA, 0-10mA)	
"floating" differential input:		
resolution	16 bit	
accuracy	< 0.1 %	
Thermocouple	Millivolt (-100mV to +100mV), J, K or T type linearization with on-board cold-junction compensation	
Accuracy	greater than 1°C	
Receiver Outputs		
Digital		three relay contact outputs, 260V 1A
Analog		0-20mA
resolution		12 bit
accuracy		0.10%
Comms-Fail		Internal status based on configurable time-out value. Comms-fail status can be configured to a local output.
Fail-safe		On "comms-fail", outputs user-configurable as retained (last correct value) or reset (fail-safe)
Power Supply	9-30 VDC	9-30 VDC
Power consumption @12VDC	Receiver 100mA, Transmitter 40mA quiescent, during radio transmission (50 msec) 300mA	Receiver 100mA, Transmitter 40mA quiescent, during radio transmission (50 msec) 300mA
Analog loop supply internally generated	24VDC 30mA	24VDC 30mA
Internal monitoring of supply low voltage status	may be transmitted as an "input" (Transmitter unit only)	
Power consumption increases for pulse inputs > 10Hz.		
Serial Port	RS232 RJ45 female DCE, used for configuration and diagnostics	RS232 RJ45 female DCE, used for configuration and diagnostics

General Data		
Operating Temperature	-40 to 60°C (-40 to 140°F)	-40 to 60°C (-40 to 140°F)
Humidity	0 - 99% RH	0 - 99% RH
EMC Standards	FCC Part 15.247, RS210	FCC Part 15.247, RS210
Mounting	DIN-rail mounting	DIN-rail mounting
LED indication: Transmitter Unit	Power/OK, Radio TX , DIN1, DIN2, Analog Setpoint status	
LED indication: Receiver Unit		Power/OK, Radio RX, DO1, DO2, DO3, Communications Fail.
frequency hopping spread spectrum	902-928MHz, sub-bands available	902-928MHz, sub-bands available
Transmit power	1W	1W
Maximum line of sight range	20 miles (4W ERP), 15km (1W ERP); 3000 ft / 1000 m in obstructed industrial environments. Radio distances can be increased by up to 5 intermediate repeater units. Each transmission may be configured to be sent 1 to 5 times.	20 miles (4W ERP), 15km (1W ERP); 3000 ft / 1000 m in obstructed industrial environments. Radio distances can be increased by up to 5 intermediate repeater units. Each transmission may be configured to be sent 1 to 5 times.
Antenna connector	SMA female coaxial	SMA female coaxial
Dimensions mm (in)	100 x 22 x 120 (3.9 x 0.9 x 4.7)	100 x 22 x 120 (3.9 x 0.9 x 4.7)
Configuration	User configuration via serial port. Unidirectional units can be configured to network with Multi-I/O and Gateway units.	User configuration via serial port. Unidirectional units can be configured to network with Multi-I/O and Gateway units.
Diagnostics	Diagnostics features - read input values, write output values, radio signal strength, monitor communication messages.	Diagnostics features - read input values, write output values, radio signal strength, monitor communication messages.

Ordering Data	Type	Part No.	Type	Part No.
	WI-I/O 9-L-T	**6720005005**	WI-I/O 9-L-R	**6720005006**
Accessories: DB9 Male-RJ45 Serial configuration cable	WI-CSER-RJ45	**6720005108**	WI-CSER-RJ45	**6720005108**

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	WI-I/O 9-L-P1 **Set - 1 Transmitter, 1 Receiver**	**WI-I/O 9-L-P2** **Set with 2 WI-ANT-DPL-0-8**
		
Technical Data		
Transmitter Inputs:		
Digital:	two inputs, suitable for voltage free contacts / NPN, or voltage input 0-1 VDC on / >3 VDC off	two inputs, suitable for voltage free contacts / NPN, or voltage input 0-1 VDC on / >3 VDC off
Pulse:	max rate 10 Hz, 50 msec on time. Pulse counted as 16 bit register.	max rate 10 Hz, 50 msec on time. Pulse counted as 16 bit register.
Analog:	0-20 mA (4-20mA, 0-10mA)	0-20 mA (4-20mA, 0-10mA)
“floating” differential input:		
resolution	16 bit	16 bit
accuracy	< 0.1 %	< 0.1 %
Thermocouple	Millivolt (-100mV to +100mV), J, K or T type linearization with on-board cold-junction compensation	Millivolt (-100mV to +100mV), J, K or T type linearization with on-board cold-junction compensation
Accuracy	greater than 1°C	greater than 1°C
Receiver Outputs Digital	three relay contact outputs, 260V 1A	three relay contact outputs, 260V 1A
Analog	0-20mA	0-20mA
resolution	12 bit	12 bit
accuracy	0.10%	0.10%
Comms-Fail	Internal status based on configurable time-out value. Comms-fail status can be configured to a local output.	Internal status based on configurable time-out value. Comms-fail status can be configured to a local output.
Fail-safe	On “comms-fail”, outputs user-configurable as retained (last correct value) or reset (fail-safe)	On “comms-fail”, outputs user-configurable as retained (last correct value) or reset (fail-safe)
Power Supply	9-30 VDC	9-30 VDC
Power consumption @12VDC	Receiver 100mA, Transmitter 40mA quiescent, during radio transmission (50 msec) 300mA	Receiver 100mA, Transmitter 40mA quiescent, during radio transmission (50 msec) 300mA
Analog loop supply internally generated	24VDC 30mA	24VDC 30mA
Internal monitoring of supply low voltage status	may be transmitted as an “input” (Transmitter unit only)	may be transmitted as an “input” (Transmitter unit only)
Power consumption increases for pulse inputs > 10Hz.		
Serial Port	RS232 RJ45 female DCE, used for configuration and diagnostics	RS232 RJ45 female DCE, used for configuration and diagnostics
General Data		
Operating Temperature	-40 to 60°C (-40 to 140°F)	-40 to 60°C (-40 to 140°F)
Humidity	0 - 99% RH	0 - 99% RH
EMC Standards	FCC Part 15.247, RS210	FCC Part 15.247, RS210
Mounting	DIN-rail mounting	DIN-rail mounting
LED indication: Transmitter Unit	Power/OK, Radio TX , DIN1, DIN2, Analog Setpoint status	Power/OK, Radio TX , DIN1, DIN2, Analog Setpoint status
LED indication: Receiver Unit	Power/OK, Radio RX, DO1, DO2, DO3, Communications Fail.	Power/OK, Radio RX, DO1, DO2, DO3, Communications Fail. LEDs also used to provide radio signal strength indication
frequency hopping spread spectrum	902-928MHz, sub-bands available	902-928MHz, sub-bands available
Transmit power	1W	1W
Maximum line of sight range	20 miles (4W ERP), 15km (1W ERP); 3000 ft / 1000 m in obstructed industrial environments.Radio distances can be increased by up to 5 intermediate repeater units. Each transmission may be configured to be sent 1 to 5 times.	20 miles (4W ERP), 15km (1W ERP); 3000 ft / 1000 m in obstructed industrial environments. Radio distances can be increased by up to 5 intermediate repeater units. Each transmission may be configured to be sent 1 to 5 times.
Antenna connector	SMA female coaxial	SMA female coaxial
Dimensions mm (in)	100 x 22 x 120 (3.9 x 0.9 x 4.7)	100 x 22 x 120 (3.9 x 0.9 x 4.7)
Configuration	Factory configuration transmitter/receiver matched pair, AI to AO, 2DI to 2DO, SP status to DO3. User configuration via serial port. Unidirectional units can be configured to network with Multi-I/O and Gateway units.	Factory configuration transmitter/receiver matched pair, AI to AO, 2DI to 2DO, SP status to DO3. User configuration via serial port. Unidirectional units can be configured to network with Multi-I/O and Gateway units.
Diagnostics	Diagnostics features - read input values, write output values, radio signal strength, monitor communication messages.	Diagnostics features - read input values, write output values, radio signal strength, monitor communication messages.

Ordering Data	**Type**	**Part No.**	**Type**	**Part No.**
Kit Contents	WI-I/O 9-L-P1	**6720005007**	WI-I/O 9-L-P2	**6720005008**
	• 2 Dipole antennas (6720005083)		• 2 Dipole antennas (6720005080)	
	• 2 3ft. antenna connecting cables/brackets		• 2 15ft. antenna connecting cables/brackets	
	• 1 configuration cable		• 1 configuration cable	

WI-I/O 9 Multi I/O Units

- Large I/O capability with I/O expansion
- Two-way communications
- Use where communications is required in both directions or for large I/O requirements. Each network can handle multiple I/O applications.
- Frequency hopping spread spectrum
- 902-928 MHz 1W license-free USA/Canada
- Configurable sub-bands license-free
- Up to 95 wireless units per network
- Support up to 31 I/O expansion modules (WI-I/O-EX-1-S-XX) per wireless unit. See table below.
- Multi-hop repeater functions – up to 5 intermediate units
- Four I/O versions available:

WI-I/O 9	**-1**	**-2**	**-3**	**-4**
Digital inputs	4	4	0 Voltage-free contacts	4 – 16
Digital outputs	1 + 3 Relay + FET	1 FET	8 FET	4 - 16 FET
Analog inputs	2 4-20mA	6 0-20mA/0-10V	0	0
Analog outputs	2 4-20mA	0	8 0-20mA/0-10V	0
Pulse inputs	1 100Hz	4 1 x 1KHz, 3 x 100Hz	0	4 1 x 1KHz, 3 x 100Hz
Pulse outputs	1 100Hz	0	4 1 x 1KHz, 3 x 100Hz	4 1 x 1KHz, 3 x 100Hz

Note: Pulse and digital inputs are same connection point.

- Pulse inputs generate separate pulse count and rate value; pulse rates treated as internal analog registers with configurable maximum value.
- Wide voltage power supply, with integral UPS battery charger and solar regulator
- Power supply generates transmittable internal I/O values
- Multiple communication-failure diagnostics with output status
- Class 1 Div 2 approval
- Radio receive signal and background RF noise measurement / logging diagnostics
- Input measurement display and output “forcing” diagnostics
- Communication logging diagnostics
- Easy-to-use E-Series Windows configuration available at www.weidmuller.ca or weidmuller.com

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Technical Data	WI-I/O 9-1	WI-I/O 9-2
		
Inputs		
Digital: opto-isolated (5000V) inputs suitable for voltage free contacts or NPN transistor, contact wetting current 5 mA	four inputs	four inputs
Analog: "floating" differential inputs, common mode voltage 27V, 24VDC for powering external loops provided, digital filtering 1 sec.	two 4-20mA resolution 15 bit, accuracy 0.1%	six 0-20mA/0-10V resolution 12 bit, accuracy 0.1%
Pulse: as per digital inputs, Max pulse rate 100Hz, pulse width min 5ms	one input (DI1)	four input(DI1-4) - first pulse input (DI1) max 1000Hz, pulse width min 0.5ms
Outputs		
Digital	four relay contacts, Form A, AC, 50V 5A/ DC 30V 2A	one FET output 30VDC 500mA
Analog: current sink to common, max loop voltage 27V, max loop resistance 1000 ohms	two 4-20 mA resolution 15 bit, accuracy 0.1%	
Pulse: FET 30VDC 500mA max 100Hz	one	
Power Supply		
Battery supply	11.5-15.0 VDC	11.5-15.0 VDC
Normal supply	12-24 VAC or 15-30 VDC, over-voltage and reverse power protected	12-24 VAC or 15-30 VDC, over-voltage and reverse power protected
Battery charging circuit	included for 1.2-12 AHr sealed battery	included for 1.2-12 AHr sealed battery
Solar regulator	for direct connection of solar panel (up to 30W) and solar battery (100AHr)	for direct connection of solar panel (up to 30W) and solar battery (100AHr)
Internal monitoring	power fail, solar charge status, and battery voltage	power fail, solar charge status, and battery voltage
Notes	An internal DC/DC converter provides 24VDC 150mA for analog loop supply.	An internal DC/DC converter provides 24VDC 150mA for analog loop supply.
Serial Port		
RS232/RS485	serial port 9600 baud, 8 bits, no parity, 1 stop bit	serial port 9600 baud, 8 bits, no parity, 1 stop bit
RS232 connection	9pin DB9 female connector	9pin DB9 female connector
RS485 connection	max cable distance 2000 m terminal connections	max cable distance 2000 m terminal connections

General Data		
Operating Temperature	-40 to 60°C (-40 to 140°F)	-40 to 60°C (-40 to 140°F)
Humidity	0-99%RH	0-99%RH
EMC Standards	FCC Part 15, AS3548, 89/336/EEC, EN 301 489	FCC Part 15, AS3548, 89/336/EEC, EN 301 489
Approvals	Class 1 Div 2	Class 1 Div 2
Mounting	DIN rail mounting	DIN rail mounting
LED indication	For power supply, WDT, digital I/O	For power supply, WDT, digital I/O
Antenna connector	SMA female coaxial	SMA female coaxial
Dimensions mm (in)	130 x 185 x 60 (5.1 x 7.3 x 2.4)	130 x 185 x 60 (5.1 x 7.3 x 2.4)

Ordering Data	Type	Part No.	Type	Part No.
	WI-I/O 9-1	**6720005000**	WI-I/O 9-2	**6720005001**
Accessories: DB9 Male - DB9 Female Serial config. cable	WI-CSER-905-9	**6720005105**	WI-CSER-905-9	**6720005105**

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	WI-I/O 9-3	WI-I/O 9-4
		

Technical Data		
Inputs		
Digital: opto-isolated (5000V) inputs suitable for voltage free contacts or NPN transistor, contact wetting current 5 mA		up to 16 inputs (4 inputs + 12 selectable I/O) the 12 selectable inputs are surge protected but not isolated
Analog: "floating" differential inputs, common mode voltage 27V, 24VDC for powering external loops provided, digital filtering 1 sec.		
Pulse: as per digital inputs, Max pulse rate 100Hz, pulse width min 5ms		four input(DI1-4) - first pulse input (DI1) max 1000Hz, pulse width min 0.5ms
Outputs		
Digital	eight FET output 30VDC 500mA	up to 16 FET output (4 outputs + 12 selectable I/O)
Analog: current sink to common, max loop voltage 27V, max loop resistance 1000 ohms	eight 0-20 mA resolution 12 bit, accuracy 0.1%	
Pulse: FET 30VDC 500mA max 100Hz	four (DO1-4)	four (DO1-4)
Power Supply		
Battery supply	11.5-15.0 VDC	11.5-15.0 VDC
Normal supply	12-24 VAC or 15-30 VDC, over-voltage and reverse power protected	12-24 VAC or 15-30 VDC, over-voltage and reverse power protected
Battery charging circuit	included for 1.2-12 AHr sealed battery	included for 1.2-12 AHr sealed battery
Solar regulator	for direct connection of solar panel (up to 30W) and solar battery (100AHr)	for direct connection of solar panel (up to 30W) and solar battery (100AHr)
Internal monitoring	power fail, solar charge status, and battery voltage	power fail, solar charge status, and battery voltage
Notes	An internal DC/DC converter provides 24VDC 150mA for analog loop supply.	An internal DC/DC converter provides 24VDC 150mA for analog loop supply.
Serial Port		
RS232/RS485	serial port 9600 baud, 8 bits, no parity, 1 stop bit	serial port 9600 baud, 8 bits, no parity, 1 stop bit
RS232 connector	9pin DB9 female connector	9pin DB9 female connector
RS485 connector	max cable distance 2000 m terminal connections	max cable distance 2000 m terminal connections
General Data		
Operating Temperature	-40 to 60°C (-40 to 140°F)	-40 to 60°C (-40 to 140°F)
Humidity	0-99%RH	0-99%RH
EMC Standards	FCC Part 15, AS3548, 89/336/EEC, EN 301 489	FCC Part 15, AS3548, 89/336/EEC, EN 301 489
Approvals	Class 1 Div 2	Class 1 Div 2
Mounting	DIN rail mounting	DIN rail mounting
LED indication	For power supply, WDT, digital I/O	For power supply, WDT, digital I/O
Antenna Connector	SMA female coaxial	SMA female coaxial
Dimensions mm (in)	130 x 185 x 60 (5.1 x 7.3 x 2.4)	130 x 185 x 60 (5.1 x 7.3 x 2.4)

Ordering Data	Type	Part No.	Type	Part No.
	WI-I/O 9-3	**6720005002**	WI-I/O 9-4	**6720005003**
Accessories: DB9 Male - DB9 Female Serial config. cable	WI-CSER-905-9	**6720005105**	WI-CSER-905-9	**6720005105**

WI-I/O–EX-1-S Expansion I/O Units (Serial I/O)
Typical Applications

Expansion I/O for 905U-X wireless units and 240-X units

- up to 31 x 115S units can be connected to each wireless unit via RS485 (up to 2 km long).
  Serial I/O multiplexer
- transfer I/O via RS485— up to 32 units per multi-drop link.

Expansion I/O for Modbus devices

- up to 31 x 115S units can be connected to each Modbus master via RS485 (up to 2 km long).

Features

- Multi I/O channels— monitoring and control functions
- Connected via RS485 multi-drop
- Selectable communications via Modbus protocol (both RTU and ASCII formats)
- Sensor signals connected at one module (input signals) are transmitted to another module where the signals are re-created as output signals, or passed via serial to a host device such as a PLC or SCADA system
- Connect to 905U wireless I/O units for up to 31 serial addresses per wireless unit
- Connect 115S units together to form a serial multi-drop I/O system - up to 32 serial addresses per multi-drop link— no Master device is required to control communications
- Connect up to 99 x 115S units as multi-drop Modbus I/O
  (RS485 extenders/isolators required for more than 31 units per single multi-drop length)
- RS485 multi-drop up to 2 km (1 mile) depending on installation environment
- Three I/O versions available

WI-I/O-EX-1-S	**67200005038 -11**	**67200005039 -12**	**67200005040 -13**
Digital inputs	up to 16	up to 8 Voltage-free contacts	up to 8
Digital outputs	up to 16	up to 8 FET	up to 8
Analog inputs	0	4 “floating”/ 8 commoned 0-20mA / 0-10V	0
Analog outputs	0	0	8 sink / source 0-20mA / 0-10V
Pulse inputs	4 1KHz	0	0
Pulse outputs	8 100Hz	8 100Hz	8 100Hz

Note: Digital inputs and outputs are combined channels. When a channel is used as an output, it is not available as an input. Pulse and digital I/O are same connection.

- Peer-to-peer communications; Exception reporting; Reliable self-checking messages;
  Any input on any unit can be linked to any output on any unit. Inputs can be linked to multiple outputs;
  Serial communications 9.6Kb/s
- Alternate Modbus RTU or Modbus ASCII slave protocol, serial communications configurable up to 115.2Kb/s,
  7 or 8 data bit format
- External I/O plus internally calculated values - analog setpoint status, pulse rate and pulse total,
  power supply voltage, power supply alarm
- Setpoint status generated by comparing analog inputs to high and low setpoints
- Analog inputs selectable as “floating” dual-terminal inputs or commoned single-terminal inputs;
  Configurable current (0-10/0-20/4-20mA) or voltage (0-5/0-10/1-5V).
- Analog outputs selectable as single-terminal source or sink outputs. Configurable current (0-10/0-20/4-20mA)
  or voltage (0-5/0-10/1-5V). Configurable scaling, zero and span parameters.
- Pulse inputs generate separate pulse count value and a pulse rate value. Pulse rates are treated as internal analog registers with a configurable maximum value.
- Multiple communication-failure diagnostics with output status. Fail-to-transmit alarm and fail-to-receive alarm status.
- Class 1 Div 2 hazardous areas approval
- Input measurement display and output “forcing” diagnostics.
- Communication logging diagnostics.
- Easy-to-use E-Series Windows configuration available at www.weidmuller.ca or weidmuller.com

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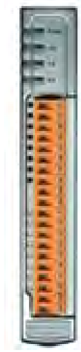
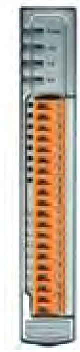
	WI-I/O-EX-1-S-11	WI-I/O-EX-1-S-12
		
Technical Data		
Inputs:		
Digital: suitable for voltage free contacts or NPN transistor, contact wetting current 5mA, inputs are surge protected	up to 16 selectable I/O	up to 8 selectable I/O
Analog: "floating" differential inputs, common mode voltage 27V, 24VDC for powering external loops provided, 0-20mA/ 0-10V resolution 12 bit, accuracy 0.1%		8 input channels, selectable as 4 dual-terminal floating inputs or 8 single-terminal commoned inputs.
Pulse: specifications as per digital inputs Max pulse rate 1kHz, pulse width min 0.5ms	4 inputs (DIO1-4)	
Outputs		
Digital: FET outputs, 30VDC 200mA	up to 16 selectable I/O	up to 8 selectable I/O
Pulse: specifications as per digital outputs Max pulse rate 100Hz, pulse width min 5ms	8 outputs (DIO1-8)	8 outputs (DIO1-8)
Power Supply	10.8 - 30VDC, over-voltage and reverse power protected Internal monitoring of supply voltage. These values may be transmitted to remote modules for monitoring. An internal DC/DC converter provides 24VDC 150mA for analog loop supply.	10.8 - 30VDC, over-voltage and reverse power protected Internal monitoring of supply voltage. These values may be transmitted to remote modules for monitoring. An internal DC/DC converter provides 24VDC 150mA for analog loop supply.
Serial Port		
RS485	serial port configurable up to 115.2Kb/s, 7/8 data bits, n/e/o parity, 1 / 2 stop bits	serial port configurable up to 115.2Kb/s, 7/8 data bits, n/e/o parity, 1 / 2 stop bits
RS232 connector	configuration port 9pin DB9 female connector, 9.6Kb/s, 8/n/1	configuration port 9pin DB9 female connector, 9.6Kb/s, 8/n/1
RS485 connector	max cable distance 2000 m terminal connections	max cable distance 2000 m terminal connections
General Data		
Operating Temperature	-40 to 60°C (-40 to 140°F)	-40 to 60°C (-40 to 140°F)
Humidity	0-99% RH	0-99% RH
EMC Standards	FCC Part 15, AS3548, 89/336/EEC	FCC Part 15, AS3548, 89/336/EEC
Approvals	Class 1 Div 2 hazardous areas	Class 1 Div 2 hazardous areas
Mounting	DIN rail mounting	DIN rail mounting
LED indication	power supply, processor OK, serial TX and RX, digital I/O	power supply, processor OK, serial TX and RX, digital I/O
Dimensions mm (in)	150 x 180 x 35 (5.91 x 7.09 x 1.38)	150 x 180 x 35 (5.91 x 7.09 x 1.38)

Ordering Data	Type	Part No.	Type	Part No.
	WI-I/O-EX-1-S-11	**6720005038**	WI-I/O-EX-1-S-12	**6720005039**

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WI-I/O-EX-1-S-13

Technical Data	
Inputs:	
Digital: suitable for voltage free contacts or NPN transistor, contact wetting current 5mA, inputs are surge protected	up to 8 selectable I/O
Outputs	
Digital: FET outputs, 30VDC 200mA	up to 8 selectable I/O
Analog: selectable as current/voltage source or current sink to common, max loop voltage 27V, max loop resistance 1000 ohms, 0 – 20mA/ 0 – 10V, 12 bit, accuracy 0.1%	8 channels
Pulse: specifications as per digital outputs Max pulse rate 100Hz, pulse width min 5ms	8 outputs (DIO1-8)
Power Supply	10.8 - 30VDC, over-voltage and reverse power protected Internal monitoring of supply voltage. These values may be transmitted to remote modules for monitoring. An internal DC/DC converter provides 20VDC 150mA for analog loop supply.
Serial Port	
RS485	serial port configurable up to 115.2Kb/s, 7/8 data bits, n/e/o parity, 1 / 2 stop bits
RS232 connector	configuration port 9pin DB9 female connector, 9.6Kb/s, 8/n/1
RS485 connector	max cable distance 2000 m terminal connections
General Data	
Operating Temperature	-40 to 60°C (-40 to 140°F)
Humidity	0-99% RH
EMC Standards	FCC Part 15, AS3548, 89/336/EEC
Approvals	Class 1 Div 2 hazardous areas
Mounting	DIN rail mounting
LED indication	power supply, processor OK, serial TX and RX, digital I/O
Dimensions mm (in)	150 x 180 x 35 (5.91 x 7.09 x 1.38)

Ordering Data	Type	Part No.
	WI-I/O-EX-1-S-13	**6720005040**

WI-I/O 9-K Transmitter (Single Sensor Units)

- Frequency hopping spread spectrum 902-928 MHz 1W, license-free USA/Canada/Mexico
- Configurable sub-bands license-free South America, Australia/NZ, Asia, Europe available on request

The Single Sensor Wireless I/O range of products is suitable for connecting to a single sensor or group of sensors and provides an economical solution for remote monitoring systems. Capable of being powered by battery-only supplies, these products are particularly suitable where power is not available.

Features

- Input-only unit - two digital/pulse one analog
- Networks with Multi-I/O and Gateway units
- Analog Loop Supply for field devices
- Sensor signals (inputs) are transmitted to a Multi-I/O module where the signals are re-created as output signals, or passed via serial or Ethernet data bus to a host device such as a PLC or SCADA system.
- Extremely low power consumption by reverting to "sleep" mode
- Multiple power supply options including battery-only supply
- Weatherproof IP66 / NEMA 4 enclosures
- Class 1 Div 2 hazardous areas approval
- Up to 3000 wireless units per network
- Any input on any unit can be wirelessly linked to any output on any unit. Inputs can be linked to multiple outputs.
- Peer-to-peer communications. Exception reporting. Reliable self-checking messages. Highly secure data encryption.
- Multi-hop repeater functions - up to 5 intermediate units can be configured in any input-output link
- External inputs plus internally calculated values - analog setpoint status, pulse rate and pulse total, power supply voltage, power supply alarm
- Setpoint status generated by comparing analog input to high and low setpoints.
- Pulse inputs generate separate pulse count value and a pulse rate value. Pulse rates are treated as internal analog registers with a configurable maximum value.
- Power supply generates internal I/O values that can be transmitted– low normal supply voltage status, low battery voltage status and battery voltage (analog)
- Can connect to up/down counter transducers such as shaft-encoders
- Easily configured to repeat the transmission several times to ensure that the transmission is received correctly
- Easy-to-use E-Series Windows configuration available at www.weidmuller.ca or weidmuller.com

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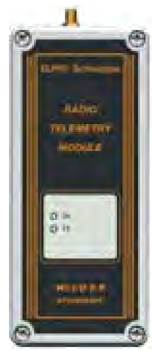
WI-I/O-9-K



Technical Data	
Inputs:	two digital/pulse inputs, suitable for voltage free contacts / NPN, or voltage input 0-1 VDC on / >3 VDC off
Digital:	status transmission on change of input signal and on time elapsed since last transmission - update time period 10 sec - 5days, a separate update time can be configured when the discrete input is “on”
Pulse:	Pulse rate up to 1000 Hz, 3 msec on time. Pulse counted as 16 bit register with a 16 bit overflow register (total count 32 bit). Transmissions occur when count change exceeds configured increase, or on time elapsed since last transmission; update time 10 sec - 5 days ; change transmissions may be suspended if increase exceeds a configured value to reduce radio traffic.
Up/Down Pulse Count	the two pulse inputs may be configured to a single count, to suit quadrature or incremental shaft encoder transducers.
Pulse Rate	calculated from rate of pulse input and treated as an internal analog input. Configurable scaling. Transmitted as per analog input.
Analog:	one analog input 0-25 mA (4-20mA, 0-10mA) 0-10V also available “floating” differential input
resolution	12 bit
accuracy	< 0.1 % measurement continuous or sampled
sample time configurable	1 min - 5 days
transducer warm-up time configurable	0.5-127 sec
analog value transmitted on change of input signal or time elapsed since last transmission,	
change sensitivity configurable	0.7-75%
update time configurable	0.1min - 5 days
Setpoint Status	high and low setpoints generate internal digital status setpoint status sets (on) when analog value < low setpoint and resets (off) when analog value > high setpoint status transmitted as per digital input
Power Supply	6 - 30VDC
Power consumption @12VDC	quiescent (sleep mode) 120µA, operating mode 10mA + analog loop
Power consumption during radio transmission (50 - 100 msec)	300mA @ 1W, 220µA @ 500mW 100mA @ 100mW, 50mA @ 10mW
Analog loop supply internally generated	Yes
Internal monitoring of supply low voltage status	may be transmitted to remote modules as an “input”
Power consumption increases for pulse inputs > 10Hz.	

General Data	
Operating Temperature	-40 to 60°C (-40 to 140°F)
Humidity	0 - 99% RH
EMC Standards	compliant 89/336 EEC, EN 300 683, AS3548, FCC Part 15
Approvals	Housing - IP66 NEMA4; FCC Part 15.247, RS210, Class 1, Div. 2
Mounting	
LED indication	Radio TX, Operation OK
frequency hopping spread spectrum	902-928MHz, sub-bands available
Transmit power	1 W
Maximum line of sight range	20miles (4W ERP), 15 km (1W ERP)
Receiver data sensitivity	108 dBm
Data rate	19.2 Kbs with forward error correction
Antenna connector	SMA female coaxial
Dimensions mm (in)	170 x 64 x 36 (6.7 x 2.5 x 1.4)

Ordering Data	Type	Part No.
	WI-I/O-9-K	**6720005004**
Battery Pack (optional)	WI-BP-I/O-9-K	**6720005112**
Plug and Lead-1 meter (included w/ radio)	WI-PLI-9-K	**6720005113**

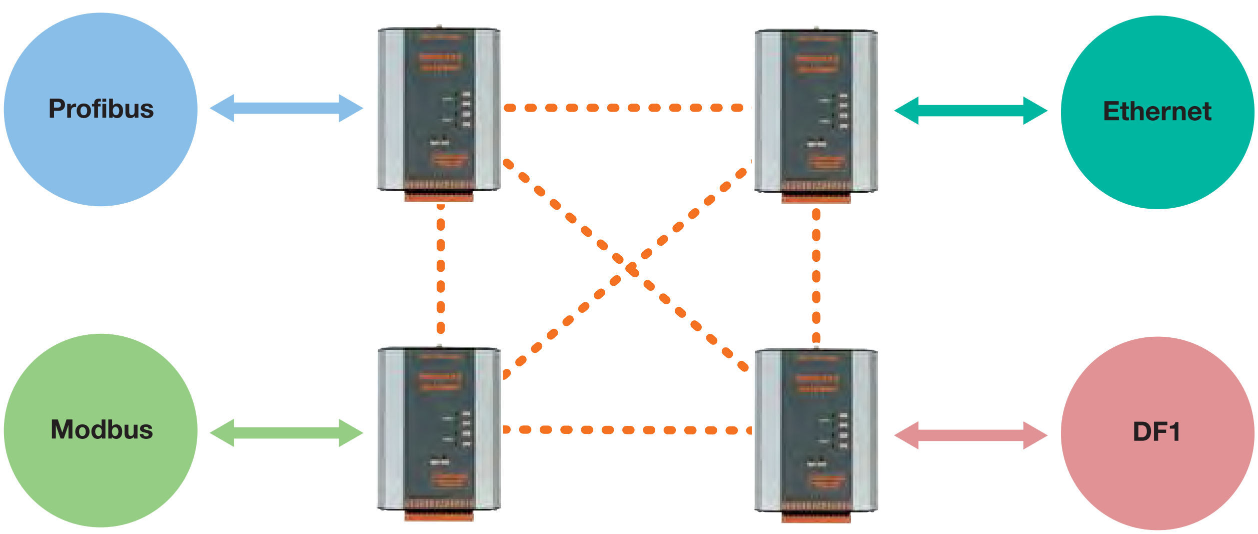
Wireless Gateways WI-GTWY-9

- Frequency hopping spread spectrum
- 902-928 MHz 1W license-free USA/Canada/Mexico
- Configurable sub-bands license-free South America, Australia/NZ, Asia, Europe available on request

Features

- Connects to data bus at full bus speed (e.g. 12Mb/s for Profibus, 100Mb/s for Ethernet)
- Provides Protocol Conversion (Profibus, Modbus, Ethernet, DeviceNet)
- Can interconnect master-slave, slave-slave and master-master
- Interconnects different data buses - wireless protocol conversion
- Provides a peer-to-peer wireless network using WIB-net
- High security data encryption
- Automatic acknowledgment and error-correction
- Multiple path routing
- Eight on-board discrete I/O, individually configurable as input or output
- Network configuration is performed with easy-to-use free software
- Wide range power supply with integral back-up battery-charging feature

Interconnection Flexibility



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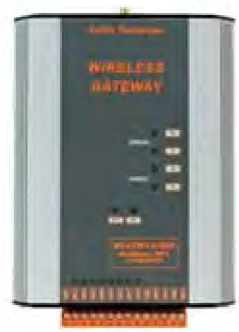
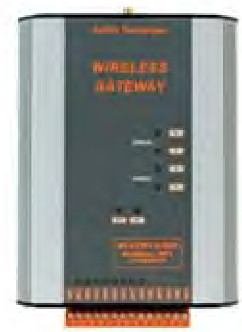
Radio communications can be configured for combination of event reporting (change-of-value), update time, read/write blocks and poll response. Radio message includes system addressing, unit addressing, error checking and configurable security encryption.Communication control includes message acknowledgments and up to four re-transmissions. Peer to peer addressing. Messages may be routed through four intermediate repeater addresses. Fail-to-transmit and fail-to-receive alarms configurable

WI-GTWY-9-MD1
Modbus (Master & Slave), DF1



WI-GTWY-9-PR1
Profibus DP Slave



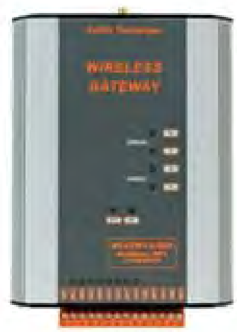
Technical Data		
Power Supply	9 - 30VDC / 12 - 24VAC Battery charging circuit included for 12V back-up battery, max charge current regulated to 0.7A (>12V supply) Normal current drain MD1 version 12V 150mA; 24V 90mA Other version 12V 270mA; 24V 170mA Add 5mA per active I/O	9 - 30VDC / 12 - 24VAC Battery charging circuit included for 12V back-up battery, max charge current regulated to 0.7A (>12V supply) Normal current drain MD1 version 12V 150mA; 24V 90mA Other version 12V 270mA; 24V 170mA Add 5mA per active I/O
Current drain during radio transmission	Add 12V 350mA; 24V 200mA to above	Add 12V 350mA; 24V 200mA to above
I/O Capacity	4300 I/O points (analog plus discrete)	416 I/O bytes up to 1952 DI/1952 DO, or up to122 AI/122 AO
Register Size	16 bit	16 bit
Number of remote WI-GTWY-9 addresses	500	500
General Data		
Operating Temperature	-40 to 60°C (-40 to 140°F)	0 to 60°C (30 to 140°F)
Humidity	0 - 99 %RH	0 - 95 %RH
EMC Standards	EN 301 489, FCC Part 15, Approved to FCC Part 15.247, RS210	EN 301 489, FCC Part 15, Approved to FCC Part 15.247, RS210
Approvals	Class 1 Div 2	Class 1 Div 2
Mounting	DIN rail mounting,	DIN rail mounting,
LED indication	for processor OK, radio TX and RX, serial TX and RX, active status	for processor OK, radio TX and RX, serial TX and RX, active status
Dimensions mm (in)	130 x 185 x 60 (5.1 x 7.3 x 2.4)	130 x 185 x 60 (5.1 x 7.3 x 2.4)
Wireless Communications	Modbus RTU (binary), master / slave configurable. RS232 or RS485, 300 - 19200 bits/sec.	Profibus-DP functionality according to EN 50170. Modbus RTU
	Allen-Bradley DF1 full-duplex. RS232 only, 300 - 19200 bits/sec.	RS-485 optically isolated with on-board DC/DC converter, automatic baudrate detection (9600 bit/s - 12 Mbit/s)
On-board I/O	Eight discrete I/O, individually configurable as input or output. Inputs suitable for voltage free contacts. Outputs are FET, 30VDC 500mA.	Eight discrete I/O, individually configurable as input or output. Inputs suitable for voltage free contacts. Outputs are FET, 30VDC 500mA.
Configuration	via free Windows software	via free Windows software
Diagnostics	on-line read/write of I/O registers, radio signal strength values from remote units, and off-line testing of data bus protocol.	on-line read/write of I/O registers, radio signal strength values from remote units, and off-line testing of data bus protocol.
Radio Transceiver		
Frequency hopping spread spectrum	902-908 MHz, sub-bands configurable	902-908 MHz, sub-bands configurable
Transmit power	1W	1W
Receiver data sensitivity	108dBm	108dBm
Maximum line-of-sight range	USA/Canada, 4W ERP, 20+ miles	USA/Canada, 4W ERP, 20+ miles
Data rate	19.2 Kb/s with forward-error correction	19.2 Kb/s with forward-error correction
Antenna connector	SMA female coaxial	SMA female coaxial

Ordering Data	**Type**	**Part No.**	**Type**	**Part No.**
	WI-GTWY-9-MD1	**6720005020**	WI-GTWY-9-PR1	**6720005021**
Accessories: DB9 Male - DB9 Female Serial config. cable	WI-CSER-905-9	**6720005105**	WI-CSER-905-9	**6720005105**

C US **C1D2**

Radio communications can be configured for combination of event reporting (change-of-value), update time, read/write blocks and poll response. Radio message includes system addressing, unit addressing, error checking and configurable security encryption.Communication control includes message acknowledgments and up to four re-transmissions. Peer to peer addressing. Messages may be routed through four intermediate repeater addresses. Fail-to-transmit and fail-to-receive alarms configurable

WI-GTWY-9-PR2
Profibus DP Master



WI-GTWY-9-ET1
Ethernet IP, Modbus TCP, TCP/IP functions

Technical Data	WI-GTWY-9-PR2	WI-GTWY-9-ET1
Power Supply	9 - 30VDC / 12 - 24VAC Battery charging circuit included for 12V back-up battery, max charge current regulated to 0.7A (>12V supply) Normal current drain MD1 version 12V 150mA; 24V 90mA Other version 12V 270mA; 24V 170mA Add 5mA per active I/O	9 - 30VDC / 12 - 24VAC Battery charging circuit included for 12V back-up battery, max charge current regulated to 0.7A (>12V supply) Normal current drain MD1 version 12V 150mA; 24V 90mA Other version 12V 270mA; 24V 170mA Add 5mA per active I/O
Current drain during radio transmission	Add 12V 350mA; 24V 200mA to above	Add 12V 350mA; 24V 200mA to above
I/O Capacity	2048 bytes input and 2048 bytes output up to 4300 discrete I/O points, or up to 1024 analog in / 1024 analog out	2048 bytes input and 2048 bytes output up to 4300 discrete I/O points, or up to 1024 analog in / 1024 analog out
Register Size	16 bit	16 bit
Number of remote WI-GTWY-9 addresses	500	500
General Data		
Operating Temperature	0 to 60°C (30 to 140°F)	0 to 60°C (30 to 140°F)
Humidity	0 - 95 %RH	0 - 95 %RH
EMC Standards	EN 301 489, FCC Part 15, Approved to FCC Part 15.247, RS210	EN 301 489, FCC Part 15, Approved to FCC Part 15.247, RS210
Approvals	Class 1 Div 2	Class 1 Div 2
Mounting	DIN rail mounting,	DIN rail mounting,
LED indication	for processor OK, radio TX and RX, serial TX and RX, active status	for processor OK, radio TX and RX, serial TX and RX, active status
Dimensions mm (in)	130 x 185 x 60 (5.1 x 7.3 x 2.4)	130 x 185 x 60 (5.1 x 7.3 x 2.4)
Wireless Communications	Profibus-DP functionality according to EN 50170. RS-485 optically isolated with on-board DC/DC converter, automatic baudrate detection (9600 bit/s - 12 Mbit/s)	10/100 Mbit/s, RJ45 connector, Transformer isolated interface Modbus/TCP class 0, class 1 and partially class 2 slave EtherNet/IP level 2 I/O Server Embedded Web system (Dynamic HTTP), on-board file system (1.4MB flash disc), user downloadable web pages through FTP server, Email functionality (SMTP)
On-board I/O	Eight discrete I/O, individually configurable as input or output. Inputs suitable for voltage free contacts. Outputs are FET, 30VDC 500mA.	Eight discrete I/O, individually configurable as input or output. Inputs suitable for voltage free contacts. Outputs are FET, 30VDC 500mA.
Configuration	via free Windows software	via free Windows software
Diagnostics	on-line read/write of I/O registers, radio signal strength values from remote units, and off-line testing of data bus protocol.	on-line read/write of I/O registers, radio signal strength values from remote units, and off-line testing of data bus protocol.
Radio Transceiver		
Frequency hopping spread spectrum	902-908 MHz, sub-bands configurable	902-908 MHz, sub-bands configurable
Transmit power	1W	1W
Receiver data sensitivity	108dBm	108dBm
Maximum line-of-sight range	USA/Canada, 4W ERP, 20+ miles	USA/Canada, 4W ERP, 20+ miles
Data rate	19.2 Kb/s with forward-error correction	19.2 Kb/s with forward-error correction
Antenna connector	SMA female coaxial	SMA female coaxial

Ordering Data	**Type**	**Part No.**	**Type**	**Part No.**
	WI-GTWY-9-PR2	**6720005022**	WI-GTWY-9-ET1	**6720005023**
Accessories: DB9 Male - DB9 Female Serial config. cable	WI-CSER-905-9	**6720005105**	WI-CSER-905-9	**6720005105**

C US C1D2

Radio communications can be configured for combination of event reporting (change-of-value), update time, read/write blocks and poll response. Radio message includes system addressing, unit addressing, error checking and configurable security encryption.Communication control includes message acknowledgments and up to four re-transmissions. Peer to peer addressing. Messages may be routed through four intermediate repeater addresses. Fail-to-transmit and fail-to-receive alarms configurable

WI-GTWY-9-DE1
DeviceNet Slave

WI-GTWY-9-M+1
Modbus Plus Slave

Technical Data	WI-GTWY-9-DE1	WI-GTWY-9-M+1
Power Supply	9 - 30VDC / 12 - 24VAC Battery charging circuit included for 12V back-up battery, max charge current regulated to 0.7A (>12V supply) Normal current drain MD1 version 12V 150mA; 24V 90mA Other version 12V 270mA; 24V 170mA Add 5mA per active I/O	9 - 30VDC / 12 - 24VAC Battery charging circuit included for 12V back-up battery, max charge current regulated to 0.7A (>12V supply) Normal current drain MD1 version 12V 150mA; 24V 90mA Other version 12V 270mA; 24V 170mA Add 5mA per active I/O
Current drain during radio transmission	Add 12V 350mA; 24V 200mA to above	Add 12V 350mA; 24V 200mA to above
I/O Capacity	512 bytes input and 512 bytes output up to 4300 discrete I/O points, or up to 256 analog in / 256 analog out	2048 bytes input and 2048 bytes output up to 4300 discrete I/O points, or up to 1024 analog in / 1024 analog out
Register Size	16 bit	16 bit
Number of remote WI-GTWY-9 addresses	500	500
General Data		
Operating Temperature	0 to 60°C (30 to 140°F)	0 to 60°C (30 to 140°F)
Storage Temperature		
Humidity	0 - 95 %RH	0 - 95 %RH
EMC Standards	EN 301 489, FCC Part 15, Approved to FCC Part 15.247, RS210	EN 301 489, FCC Part 15, Approved to FCC Part 15.247, RS210
Approvals	Class 1 Div 2	Class 1 Div 2
Mounting	DIN rail mounting,	DIN rail mounting,
LED indication	for processor OK, radio TX and RX, serial TX and RX, active status	for processor OK, radio TX and RX, serial TX and RX, active status
Dimensions mm (in)	130 x 185 x 60 (5.1 x 7.3 x 2.4)	130 x 185 x 60 (5.1 x 7.3 x 2.4)
Wireless Communications	DeviceNet 2.0 Slave, optically isolated RS422 with selectable baudrate between 125, 250 and 500 Kbit/sec.	Modbus RTU (binary), master / slave configurable. RS232 or RS485, 300 - 19200 bits/sec. Modbus Plus Slave, optically isolated RS485 with standard baudrate of 1 Mbit/sec, global data base transactions with routing for up to six networks.
On-board I/O	Eight discrete I/O, individually configurable as input or output. Inputs suitable for voltage free contacts. Outputs are FET, 30VDC 500mA.	Eight discrete I/O, individually configurable as input or output. Inputs suitable for voltage free contacts. Outputs are FET, 30VDC 500mA.
Configuration	via free Windows software	via free Windows software
Diagnostics	on-line read/write of I/O registers, radio signal strength values from remote units, and off-line testing of data bus protocol.	on-line read/write of I/O registers, radio signal strength values from remote units, and off-line testing of data bus protocol.
Radio Transceiver		
Frequency hopping spread spectrum	902-908 MHz, sub-bands configurable	902-908 MHz, sub-bands configurable
Transmit power	1W	1W
Receiver data sensitivity	108dBm	108dBm
Maximum line-of-sight range	USA/Canada, 4W ERP, 20+ miles	USA/Canada, 4W ERP, 20+ miles
Data rate	19.2 Kb/s with forward-error correction	19.2 Kb/s with forward-error correction
Antenna connector	SMA female coaxial	SMA female coaxial

Ordering Data	Type	Part No.	Type	Part No.
	WI-GTWY-9-DE1	**6720005024**	WI-GTWY-9-M+1	**6720005025**
Accessories: DB9 Male - DB9 Female Serial config. cable	WI-CSER-905-9	**6720005105**	WI-CSER-905-9	**6720005105**

Wireless Data Modems

Wireless data modems connect to serial or Ethernet links and transmit the data wirelessly. The modem controls the wireless messages and data ports to provide a “transparent” data transfer.

Wireless Serial Data (Radio Modems)

- RS232 and RS485 connections
- Industrial power supplies, industrial temperature rating

WI-MOD-9-D RADIO MODEM (SERIAL DATA)

- License-free operation in North and South America
- Wireless data up to 115.2 Kb/s
- 902-928 MHz, 1W, frequency hopping spread spectrum
- Typical line-of-sight distance 20 miles North America (4W ERP)
- One serial data port—
  RS232 and RS485 connections provided
- Serial data up to 115.2Kb/s
- Configuration by Hayes AT commands
  or Windows Configuration software

Modes of Operation

Transparent mode broadcast, “multi-drop” operation configurable error-checking, unlimited repeaters (store & forward).

Controlled mode addressable point-to-point operation, authentication and automatic re-tries, addressed repeater routing.

WI-MOD-9-E WIRELESS ETHERNET MODEM

Features

The WI-MOD-9-E is an ideal solution for Ethernet connections in process control and automation applications - PLCs, DCS, SCADA, data acquisition … it can handle multiple applications simultaneously.

- 10/100 BaseT Ethernet, wireless data up to 200 Kbits/sec.
- 902-928 MHz, 0.1 - 1W, frequency hopping
  spread spectrum
- Typical line-of-sight distance 20 miles (4W ERP),
  up to 60 miles using high gain antennas (4W ERP)
- Configurable as Access Point / Client; Bridge / Router
- Multiple layers of error-detection and correction
- Military-grade AES security encryption of wireless data
- Firewall protection and efficient wireless management
- Message filtering at MAC address level
- Two serial interfaces, RS232 and RS485
- Serial connectivity + Ethernet connectivity at the same time
- PPP and serial server functionality
- Serial Modbus to Modbus TCP conversion
- Discrete channel for status I/O, for failure status or external status transfer.
- Easy to use configuration and Powerful diagnostics
- Configuration and diagnostics via web-browser
- Remote configuration and diagnostics via the wireless link

WI-MOD-E WIRELESS ETHERNET MODEM

Features

- Uses Global 2.4GHz ISM band
- 10/100 BaseT Ethernet, wireless data up to 11 Mbits/sec.
- 802.11b compliant 2.4GHz DSSS, 100mW or 300mW
- Typical line-of-sight distance 5 miles North America
  (4W ERP)
- Configurable as Access Point / Client; Bridge / Router
- Security, reliability, redundancy …
- High RF output and superior receiver sensitivity gives excellent penetration in congested industrial environments
- Multiple layers of error-detection and correction
- Automatic changeover to another Access Point
  if the wireless link fails
- Military-grade AES security encryption of wireless data
- Industrial ratings down to –35°C
- Firewall protection and efficient wireless management …
- Message filtering at MAC address level
- Two serial interfaces, RS232 and RS485
- Serial connectivity + Ethernet connectivity at the same time
- PPP and serial server functionality
- Serial Modbus to Modbus TCP conversion
- Discrete channel for status I/O, for failure status
  or external status transfer.
- Easy to use configuration and Powerful diagnostics …
- Configuration and diagnostics via web-browser
- Remote configuration and diagnostics via the wireless link

IE-GPRS-I/O-NA GPRS Alarm Modem

Features

- Signalling and telecontrol system designed for automatic operation if required
- Dual band GSM/GPRS modem (GSM 900/1800MHz, 950/1900MHz)
- Permanently online
- Low-cost M2M rates
- 8 digital and 4 analog input ports, 4 digital output ports
- Immediate alarm signalling via SMS, FAX, e-mail or voice message in the event of limiting values being exceeded at the input ports
- Alarm via RS232 also possible
- 8-level recipient list with very flexible configuration options
- Integration of port statuses in message
- Integral cost monitoring
- Data logger (LAN and Internet) available

C US C1D2

WI-MOD-9-D
Radio 900MHz

Technical Data	
Power Supply	10 - 30 VDC or 10 - 24 VAC
Normal current drain	70mA/12VDC or 50mA/24VDC
Current when transmitting	350mA/12V or 250mA/ 24V
Low power mode current drain	20mA/12VDC or 15mA/24VDC
Serial Port	
Standard data rates	1200 to 115200 baud.
RS232 and RS485	standard interface connections provided, each connected to the same serial port. Serial interfaces are asynchronous non-return-zero (NRZ) format
Characters supported	7 or 8 data bits, even/odd/no parity, 1 or 2 stop bits
RS232 Connection	provides full duplex operation as a DCE device with RTS/CTS hardware handshaking- standard D9 connector
RS485 connection	provides half duplex operation for twisted pair multi-drop networks
Input and output buffers	2Kbytes

General Data	
Operating Temperature	-40 to 70°C (-40 to +158°F)
Humidity	0-99% non-condensing
EMC Standards	FCC Part 15 Class A and FCC Part 15.247
Approvals	Class 1, Div 2
Mounting	DIN rail mounting
LED indication	for unit OK, radio TX and RX, serial TX and RX, DCD (comms OK)
Dimensions mm (in)	115 x 165 x 32 (4.5 x 6.5 x 1.3)
Radio Transceiver	Frequency Hopping Spread Spectrum Transceiver
Frequency - USA/Canada	902 - 928 MHz
Hop Sequence	16 x 50
Transmit Power	1W
Expected line-of-sight range, depending on local conditions	USA/Canada 20+ miles
RF Data Transmission Rate	19200 baud, 57600 baud, 115200 baud (selectable)
Range may be extended by:	up to five intermediate repeaters in controlled mode unlimited repeaters in transparent mode
Antenna connection	SMA female coaxial
Data Transmission	
Transparent mode:	Data is transmitted with a system and group address. Data transmission begins as serial data is received—maximum packet size is 530 bytes. All modules with the correct system address, which receive the data packets, outputs the data—error checking is optional.
Controlled mode:	Data is transmitted in packets with a system address, source address, destination address, up to five intermediate repeater addresses, and a 16 bit CRC error-check. If the packet is received with a correct error check, only the destination module will output the data and will also return an ACK transmission. If the source module does not receive the ACK, it will retry a further four times. DCD provides communications status. Auto-connect and dial-up-control modes are available. CTS/RTS flow control provided based on input buffer availability.
Configuration	freeware software package or by Hayes AT commands
Diagnostics	Radio noise, signal strength and bit error rate (BER) diagnostics included. Radio signal strength value available on-line to host device.

Ordering Data	Type	Part No.
	WI-MOD-9-D	**6720005050**

C US C1D2

WI-MOD-9-E
Ethernet 900MHz

Technical Data	
Description: Ethernet	10/100 BaseT RJ45, IEEE 802.3 compliant. Bridge/router functions work with all Ethernet protocols
Embedded Protocols:	TCP/IP, UDP ARP, PPP, ICMP, HTTP, FTP, TFTP, TELNET
Serial	
RS232 V.24 DCE	1.2 to 115.2 Kb/s
RS485	1.2 to 115.2 Kb/s Serial server, PPP, Modbus to Modbus TCP conversion
Discrete I/O	One I/O channel
Input	Voltage-free contact
Output	FET 30VDC 500mA
Networking	Configurable as Access Point or Client, Bridge or Router Point-to-point, Point-to-multipoint, user configurable addressing Repeater functionality MAC Filtering - whitelist or blacklist

General Data	
Operating Temperature	-40 to 60°C (-40 to 140°F)
Humidity	99% non-condensing
Power Supply	10 – 30VDC
Current consumption	280mA (12V), 150mA (24V)
Transmit	(1W) 500mA (12V), 300mA (24V)
Approvals	FCC 15.247, RS210, Hazardous area Class 1 Div 2
Mounting	DIN rail mounting
LED indication	Power/OK, Radio Rx and Tx, Radio Link, LAN Link/Activity, Serial Activity, Digital I/O, LAN 10/100Mbit Link
Dimensions mm (in)	115 x 141 x 32 (4.5 x 5.55 x 1.4)
Weight	< 0.4 kg / 0.8 lb
Radio Transceiver	Frequency Hopping Spread Spectrum
Frequency - USA/Canada	902 - 928 MHz
Hop Sequence	16 x 50
Transmit Power	0.1 – 1W (20 – 30 dBm) configurable
Receiver sensitivity	108 dBm @ 10-6 BER
Data rates	19.2, 57.6, 115.2, 230 Kb/s or auto rate selection
Protocol	CSMA/CA with 32 bit CRC and auto-correction
Radio range	up to 60 miles / 100 km line-of-sight using high gain antennas (*up to 4W ERP permitted in USA/Canada) Range may be extended using repeater features
Antenna connection	SMA female coaxial
Security	128 bit AES encryption or 64 bit proprietary encryption (configurable) MAC filtering Password protected configuration
Configuration	HTTP with remote configuration via wireless link
Diagnostics	RSSI, channel noise, BER, connection monitoring and statistics

Ordering Data	Type	Part No.
	WI-MOD-9-E	**6720005051**

C US C1D2

	WI-MOD-E-100 Ethernet 2.4GHz 100mW	WI-MOD-E-300 Ethernet 2.4GHz 300mW
		
Technical Data		
Description: Ethernet	10/100 BaseT RJ45, IEEE 802.3	10/100 BaseT RJ45, IEEE 802.3
	Bridge/router functions work with all Ethernet protocols	Bridge/router functions work with all Ethernet protocols
Embedded Protocols:	TCP/IP, UDP ARP, PPP, ICMP, HTTP, FTP, TFTP, TELNET	TCP/IP, UDP ARP, PPP, ICMP, HTTP, FTP, TFTP, TELNET
Serial		
RS232 V.24 DCE	1.2 to 115.2 Kb/s	1.2 to 115.2 Kb/s
RS485	1.2 to 115.2 Kb/s	1.2 to 115.2 Kb/s
	Serial server, PPP, Modbus to Modbus TCP conversion	Serial server, PPP, Modbus to Modbus TCP conversion
Discrete I/O	One I/O channel (expandable with WI-I/O-EX-1-S-XX units)	One I/O channel (expandable with WI-I/O-EX-1-S-XX units)
Input	voltage-free contact	voltage-free contact
Output	FET 30VDC 500mA	FET 30VDC 500mA
Networking	Configurable as Access Point or Client, Bridge or Router	Configurable as Access Point or Client, Bridge or Router
	Point-to-Point, Point-to-Multipoint,	Point-to-Point, Point-to-Multipoint,
	user configurable addressing	user configurable addressing
	WDS Mesh repeater functionality	WDS Mesh repeater functionality
	MAC Filtering – whitelist or blacklist.	MAC Filtering – whitelist or blacklist.
	Serial gateway TELNET	Serial gateway TELNET
General Data		
Operating Temperature	-35 to 65°C (-30 to 150°F)	-35 to 65°C (-30 to 150°F)
Humidity	99% non-condensing	99% non-condensing
Power Supply	9 – 30VDC	9 – 30VDC
Current consumption	Current 240mA (12VDC), 150mA (24VDC)	Current 240mA (12VDC), 150mA (24VDC)
Approvals	FCC Part 15.247, CE ETS 300 328, RSS 210, Hazardous area Class 1 Div 2, IEC 60950	FCC Part 15.247, CE ETS 300 328, RSS 210, Hazardous area Class 1 Div 2, IEC 60950
Mounting	DIN rail mounting	DIN rail mounting
LED indication	Power / OK, Radio Rx and Tx, Radio Link, LAN link / Activity , Serial Activity, Digital I/O	Power / OK, Radio Rx and Tx, Radio Link, LAN link / Activity , Serial Activity, Digital I/O
Dimensions mm (in)	115 x 141 x 32 (4.5 x 5.6 x 1.4)	115 x 141 x 32 (4.5 x 5.6 x 1.4)
Weight	< 0.4 kg / 0.8 lb	< 0.4 kg / 0.8 lb
Wireless	2.400 – 2.484GHz Direct Sequence Spread Spectrum (DSSS), 13 selectable zones	2.400 – 2.484GHz Direct Sequence Spread Spectrum (DSSS), 13 selectable zones
	802.11b compliant, auto rate selection 1 Mb, 2Mb, 5.5Mb, 11Mb	802.11b compliant, auto rate selection 1 Mb, 2Mb, 5.5Mb, 11Mb
Radio Transceiver		
Transmit Power	100mW (20dBm), dependent on local regulations	300mW (25dBm), dependent on local regulations
Receiver sensitivity	96dBm @ 1MB/s, -91dBm @ 11Mb/s < 8% FER	96dBm @ 1MB/s, -91dBm @ 11Mb/s < 8% FER
Radio range	1km @ 100mW	3 miles @ 300mW
	Range may be extended using repeater features	Range may be extended using repeater features
Antenna connection: SMA female	Dual SMA female coaxial	Dual SMA female coaxial
Security	128 bit AES encryption (WPA2), TKIP (WPA1) or 40 bit / 140 bit WEP	128 bit AES encryption (WPA2), TKIP (WPA1) or 04 bit / 140 bit WEP
	MAC Address filtering	MAC Address filtering
	Password protected configuration	Password protected configuration
Configuration	HTTP with remote configuration via wireless link	HTTP with remote configuration via wireless link
	Web based system management - RF signal strength, Bit Error Rate, connection monitoring and statistics	Web based system management - RF signal strength, Bit Error Rate, connection monitoring and statistics
Diagnostics	PPP Protocol Access to diagnostics	PPP Protocol Access to diagnostics
	Firmware upgradeable via serial port	Firmware upgradeable via serial port

Ordering Data	**Type**	**Part No.**	**Type**	**Part No.**
	WI-MOD-E-100	**6720005052**	WI-MOD-E-300	**6720005053**

GPRS Alarm Modem

The GPRS Alarm Modem is designed to collect messages that are detected as activated switching contacts and analog limit values. Communication with the server is performed over a virtual dedicated line via GPRS as a point-to-point, multipoint or multi-drop connection. An Internet exchange server may log the states of the inputs and outputs permanently on the basis of event or time control. The server constitutes a relational database, i.e. external access is possible via SQL queries.

The exchange server is a service provided by Weidmuller.

The configurable alarms are issued via SMS, e-mail, voice messaging and/or fax.

The IE-GPRS-I/O implements telecontrol by remote-switching of the outputs via telephone/mobile telephone.

The IE-GPRS-I/O can be teleserviced and remote-configured.

The Weidmuller GPRS I/O has an aluminum housing just 45 mm wide and the following configurable features:

- Signaling and telecontrol system designed for automatic operation if required
- Dual band GSM/GPRS modem (GSM 900/1800MHz, 950/1900MHz)
- Permanently online
- Low-cost M2M rates
- 8 digital and 4 analog input ports, 4 digital output ports
- Immediate alarm signaling via SMS, FAX, e-mail or voice message in the event of limiting values being exceeded at the input ports
- Alarm via RS232 also possible
- 8-level recipient list with very flexible configuration options
- Integration of port statuses in message
- Integral cost monitoring
- Data logger (LAN and Internet) available
- Includes GPRS antenna in box

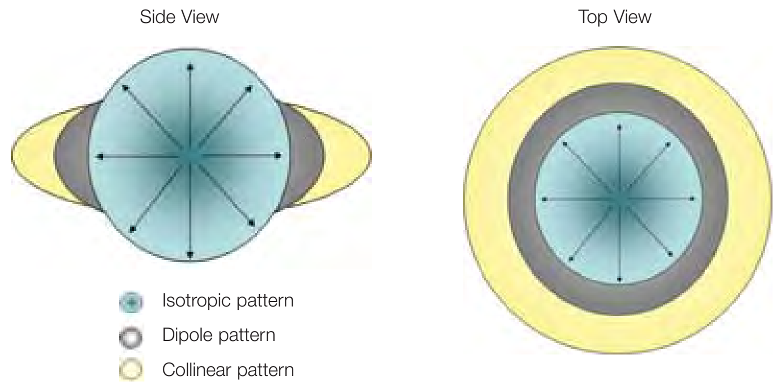
GPRS Alarm Modem

Technical Data	
Housing	Aluminum
Ports	8 digital inputs; 4 digital outputs; 4 analog inputs; 1xRS232 interface
AC input voltage, min.-max.	8-24VAC
DC input voltage, min.-max.	10-36VDC
Input power AC/DC	max. 5 VA AC / max. 5 W DC
Input frequency	47-63 Hz
Operating temperature	-10 to 55°C (14 to 131°F)
Storage temperature	-10 to 70°C (14 to 158°F)
Installation	TS35 DIN-Rail or Wall Mounted
Ingress protection class	IP 20
Data rate	max. 53.6 kbps
Functionality	SMTP; POP3; FTP; DNS; IPTCP; UDP sockets
Status indication	Power
Approvals	cULus, CE
Transmission rate	GPRS dependent
Dimensions mm (in)	137 x 45 x 155 (5.4 x 1.8 x 6.1)

Ordering Data		Type	Part No.
	950/1900 MHz	IE-GPRS-I/O -NA	**8903980000**
(Europe)	900/1800 MHz	IE-GPRS-I/O	**8850060000**

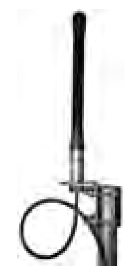
Antenna Basics

Antennas are designed and built to suit a particular frequency or frequency band. If you use an antenna designed for a different frequency, then it will only radiate a small portion of the generated RF power from the transmitter, and it will only absorb a small portion of the RF signal power for the receiver. *Using the correct frequency antenna is very important.*



Dipole and collinear antennas

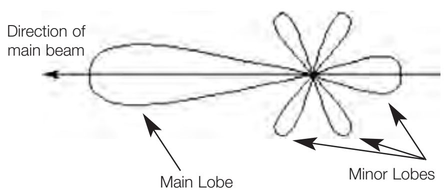
The polarity of these antennas is the same as the main axis, and they are normally installed vertically. Dipole and collinear antennas are called omni-directional as they transmit equally in all directions in the horizontal plane. The radio path is often made up of strong reflected signals over relatively short distances and the direction of incoming signals is not always obvious.



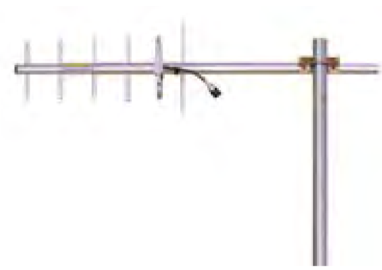
3dB Collinear Antenna

Yagi antennas

Yagi antennas are directional along the central beam of the antenna. The folded element is towards the back of the antenna, and the antenna should be "pointed" in the direction of the transmission. Yagis are normally available from 2-element up to 16-element Yagis. The more reflector elements added, the higher gain in the forward direction and the lower gain to the sides and rear. Also, as more elements are added, the directional angle becomes smaller as the gain is more tightly focused.



Typical Yagi directional pattern



Yagi Antenna

Frequency	Type	dB Gain	Dimension length mm(inches)	Type	Connection Type	Mounting Bracket	Part No.
900MHz	Dipole	Unity	90 (3.5")	WI-ANT-DEMO-900	SMA male*	N/A (Direct Radio Connection)	**6720005089**
900MHz	Dipole	Unity	400 (16")	WI-ANT-DPL-0-16	SMA male c/w 15ft cable	Included in Kit	**6720005080**
900MHz	Dipole	-2	150 (6")	WI-ANT-DPL-DJ900-1	SMA male c/w 3ft cable	Included in Kit	**6720005086**
900MHz	Omni	3	1308 (51.5")	WI-ANT-900MHZ-3DB OMNI NF	N-Type Female	Includes 6720005268 CLAMP/BRKT	**6720005228**
900MHz	Whip	3	355 (14")	WI-ANT-900MHZ-3DB STUB-MAG	For MAG Base	Only use w MAG base 6720005263	**6720005230**
900MHz	Whip	5	584 (23")	WI-ANT-900MHZ-5DB WHIP NF	N-Type Female	6"Ground Plane Included	**6720005227**
900MHz	Omni	6	1829 (72")	WI-ANT-900MHZ-6DB OMNI NF	N-Type Female	Includes 6720005268 CLAMP/BRKT	**6720005229**
900MHz	Yagi	6.5	330 (13")	WI-ANT-900MHZ-6.5DBYAGI-2' NF	N-Type Female	Includes 6720005266 CLAMP/BRKT	**6720005221**
900MHz	Colinear	8	1370 (54")	WI-ANT-CLR-900-8-54	N-Type Female	672005110	**6720005082**
900MHz	Yagi	10	610 (24")	WI-ANT-900MHZ-10DBYAGI-2' NF	N-Type Female	Includes 6720005266 CLAMP/BRKT	**6720005223**
900MHz	Yagi	12	940 (37")	WI-ANT-900MHZ-12DBYAGI-2' NF	N-Type Female	Includes 6720005266 CLAMP/BRKT	**6720005225**
900MHz	Yagi	14	1600 (63")	WI-ANT-900MHZ-14DBYAGI-2' NF	N-Type Female	Includes 6720005267 CLAMP/BRKT	**6720005226**
2.4GHz	Whip	2	113 (4.4")	WI-ANT-24GHZ-2DB DUCK SMA-M	SMA male*	N/A (Direct Radio Connection)	**6720005207**
2.4GHz	Whip	3	55 (2.17")	WI-ANT-24GHZ-3DB FOR MAGBASE	For MAG Base Only	Use w MAG base 6720005263	**6720005208**
2.4GHz	Omni	4	205 (8.1")	WI-ANT-24GHZ-4DB OMNI NF	N-Type Female	Includes 6720005210,FITS 2.0" MAST	**6720005200**
2.4GHz	Omni	6	295 (12")	WI-ANT-24GHZ-6DB OMNI NF	N-Type Female	Includes 6720005210,FITS 2.0" MAST	**6720005201**
2.4GHz	Omni	8	513 (2.2")	WI-ANT-24GHZ-8DB OMNI NF	N-Type Female	Includes 6720005210,FITS 2.0" MAST	**6720005204**
2.4GHz	Omni	10	914 (36")	WI-ANT-24GHZ-10DB OMNI NF	N-Type Female	Includes 6720005210,FITS 2.0" MAST	**6720005202**
2.4GHz	Yagi	10	114 (4.5")	WI-ANT-24GHZ-10DB YAGI NF	N-Type Female	Includes 6720005266 CLAMP/BRKT	**6720005205**
2.4GHz	Omni	12	1118 (44")	WI-ANT-24GHZ-12DB OMNI NF	N-Type Female	Includes 6720005211,FITS 2.0" MAST	**6720005203**
2.4GHz	Yagi	14	356 (14")	WI-ANT-24GHZ-14DB YAGI NF	N-Type Female	Includes6720005266 CLAMP/BRKT	**6720005206**

Additional Antennas/Cales/Accessories available on request from Weidmuller

* For Direct Radio Connection

Coaxial

If a coaxial cable connects to the antenna via connectors, it is very important to weatherproof the connection using sealing tape. Moisture ingress into a coaxial cable connection is the most common cause of problems with antenna installations. A three layer sealing process is recommended - an initial layer of adhesive PVC tape, followed by a second layer of self-vulcanising weatherproofing tape, with a final layer of adhesive PVC tape. Allowing a “loop” of cable before the connection is also a good idea. The loop takes any installation strain off the connection and also provides spare cable.

Coaxial Cable Kits

Length	dB Loss (900Mhz)	dB Loss (2.4Ghz)	Type	Connection Type	Part No.
2ft (24")	0.2	0.4	WI-ACC-LMR200-2FT SMA-M-NM	SMA male -> N-type male	**6720005260**
3ft	0.3	0.6	WI-ACC-LMR200-3FT SMA-M-NM	SMA male -> N-type male	**6720005259**
10ft	0.4	0.7	WI-ACC-LMR400-10FT NM-NM	N-Type male -> N-Type male	**6720005251**
25ft	1.0	1.7	WI-ACC-LMR400-25FT NM-NM	N-Type male -> N-Type male	**6720005252**
40ft	1.6	2.7	WI-ACC-LMR400-40FT NM-NM	N-Type male -> N-Type male	**6720005253**
55ft	2.1	3.7	WI-ACC-LMR400-55FT NM-NM	N-Type male -> N-Type male	**6720005254**
75ft	3.0	5.2	WI-ACC-LMR400-75FT NM-NM	N-Type male -> N-Type male	**6720005255**
100ft	3.8	6.7	WI-ACC-LMR400-100FT NM-NM	N-Type male -> N-Type male	**6720005256**
200ft	5	9.6	WI-ACC-LMR600-200FT NM-NM	N-Type male -> N-Type male	**6720005257**

Additional Antennas/Cables/Accessories available on request from Weidmuller

Connector Types

SMA Female

SMA Male

N-Type Female

N-Type Male

Connecting Cables for “L” Series

The 905U-L cable is used to connect and perform diagnostic and configuration with the unidirectional Transmitter/Receiver units including the 905U-L series. This high quality cable is fitted with a molded DB9 on one end and an RJ45 connector on the other.

Type	Description	Part No.
WI-CSER-RJ45	DB9 male-RJ45 Serial	**6720005108**

Connecting Cables for “L” Series

Serial to Serial Connectivity Cables

The DB9 Serial cable is used for all Weidmuller telemetry products, allowing connection to your computer or laptop’s RS232 port, for diagnostic and configuration. This high quality cable is fitted with a molded DB9 male and DB9 female connector. The cable connection is “straight-through”.

Type	Description	Part No.
WI-CSER-905-9	DB9 male -DB9 female Serial	**6720005105**

Serial to Serial Connectivity

Surge Protection

With wireless networks being very vulnerable to lightening and surges or transients, it is recommended to use surge protection for applications where the antenna is mounted outdoors. The surge protection would be between the antenna and the radio. Three types of surge protectors are available.

Frequency Range	dB Loss (900Mhz)	dB Loss (2.4Ghz)	Connection Type	Type	Part No.
DC-> 2400MHz	< 0.2	0.2	Direct radio connection SMA female->SMA male	WI-DIV-CCMA	**6720005111**
125->1000MHz	< 0.1	N/A	Bulkhead N-Type female->N-Type female	WI-ACC-125-1000MHZ SURGE NF-NF	**6720005261**
2000->6000MHz	N/A	0.2	Bulkhead N-Type female->N-Type female	WI-ACC-2-6GHZ SURGE NF-NF	**6720005262**

For indoor applications or areas where surge protection is not required a thru-panel bulkhead connector or Weidmuller's **Cabtite cable entry system** can be used.

6720005262

Bulkhead / Thru Panel Adapters

For connection of external antenna & cable assembly to the radio in a panel box.

Description	dB Loss (900Mhz)	dB Loss (2.4Ghz)	Type	Part No.
Bulkhead adapter N-Type female outside to N-Type female inside	0.2	0.3	WI-ACC-BULK-ADAPT NF-NF	**6720005250**

6720005250

Other Accessories

Description	dB Loss (900Mhz)	dB Loss (2.4Ghz)	Type	Part No.
Antenna MAG Base c/w 15ft cable SMA male	1.4	2.7	WI-ACC-MAGBASE 12' RG58 SMA-M	**6720005263**
Antenna MAG Base c/w 2ft cable N-Type female	0.3	1.2	WI-ACC-MAGBASE 2' RG58 NF	**6720005264**
Plug & Lead, 1m for WI-I/O-9-K			WI-PLI-9-K	**6720005113**
Battery Pack for WI-I/O-9-K			WI-BP-I/O-9-K	**6720005112**
Mtg bracket for 6720005082 8dB Colinear antenna			WI-BR-CLR-KIT	**6720005110**
Mounting Bracket ONLY FOR 900MHz - 6.5, 10, 12DBI YAGI			WI-ACC-900MHZ-YAGI-STR-BRKT	**6720005266**
Mounting Bracket FOR 6720005226			WI-ACC-900MHZ-14YAGI-STR-BRKT	**6720005267**
Mounting Bracket FOR 6720005228/6720005229			WI-ACC-900MHZ-OMNI-STR-BRKT	**6720005268**
Mounting Bracket for 2.4Ghz 4,6,10dB Omni antennas			WI-ACC-24GHZ-4610DB-STR-BRKT	**6720005210**
Mounting Bracket Angle Version of 6720005210			WI-ACC-24GHZ-4610DB-ANG-BRKT	**6720005209**
Mounting Bracket For 6720005203			WI-ACC-24GHZ-12DB-STR-BRKT	**6720005211**

Additional Antennas/Cables/Accessories available on request from Weidmuller

Power Supplies

Type	Part No.
CP-SNT 115,230VAC/12V,1.5A	**9928890012**
CP-SNT 115,230VAC/24V,1.0A - **Class 2 Approved**	**9928890024**
CP-SNT 115,230VAC/12-15VDC 3A	**9927480012**
CP-SNT 115,230VAC/24Vdc 2.3A - **Class 2 Approved**	**9927480024**
CP SNT 48W 12V 4A	**8754970000**
CP SNT 48W 24V 2A	**8739140000**

Consult Power Delivery Solutions catalogue for complete details.

Application Notes

Factors Affecting Distance & E.R.P

- Frequency (as frequency increases, distance decreases proportionally)
- Receiver sensitivity, antenna gain, cable loss
- Noise / interference (the noisier the environment the more careful you have to be with antenna placement)
- Transmitter power, antenna gain, cable loss
- Attenuation of radio signal
- Heights of antennas, Obstructions in radio path
- Other factors Atmospheric, Ground Mineralisation

In most applications it is desirable to have an overall dB gain as opposed to a loss to ensure good communication between radios.

Gain Sources	
Radios	1 W radio = 30dB Gain
	300mW radio = 24dB Gain
	100mW radio = 20dB Gain
Antennas	(see antenna selection chart for Antenna dB Gains)

Points of Loss	
Connection points	~0.1dB loss per connection
Jumper cables	see cable selection section
Surge Protection	see surge protection section
Bulkhead adapters	see Bulkhead Adapter section
Coaxial Cables	see cable selection section

*Sample assembly showing radios, power supply, surge arrestor (bottom of cabinet), terminals & relays.

Typical parts list for an assembly inlcude:

Type	Part No.
Radio	**6720005000**
Antenna	**6720005229**
Connecting cable from antenna (outdoor)	**6720005251**
Bulkhead adapter/surge protection	**6720005250 / 6720005252**
Jumper cable	**6720005260**
Power supply	**9927480024**
Other (eg. programming cable)	**6720005105**

WIBnet

WIBnet makes use of all the standard features of the Weidmuller Wireless radios.
- Exception-reporting transmission for maximum wireless efficiency.

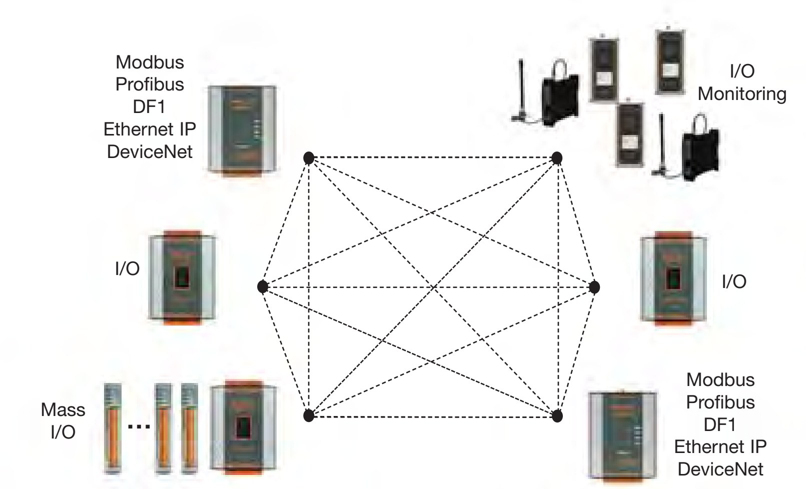
Wireless messages are only transmitted whenever a signal value changes, yielding effective real-time performance.
- Error-checking with automatic re-transmission for high reliability operation.
- Listen-before-transmit wireless operation to maximise the chance of successful transmission.
- Peer-to-peer networking, giving the maximum network flexibility.

WIBnet communications protocol is specifically designed for highly reliable and secure operation on open license-free radio bands.

WIBnet provides the following features:
- Any of the 900Mhz I/O or Gateway radios can be used on the WIBnet system
- Up to 95 radios can be put into one network

Messages can hop through multiple units to reach a destination providing each Wireless I/O unit has a reliable wireless link to at least one other unit. A wireless mesh forms to ensure reliable links are established within the whole network.

Wireless system flexibility and scalability



www.weidmuller.com

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Yemen

Weidmuller is the leading manufacturer of components for electrical connection technology to transmit energy, signals and data. The Weidmuller product portfolio ranges from terminal blocks, PCB connectors and terminals, protected components, Industrial Ethernet components, I/O components and relay sockets to power supplies and overvoltage protection modules suitable for all applications. Assemble Services, marking solutions with a variety of tools and software systems, round off the range. As an OEM supplier, the company sets global standards in the field of electrical connection technology.

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Bulletin No. DSP-E
Drawing No. LP0629
Released 2/09

MODEL DSP – DATA STATION PLUS

C UL US LISTED
IND. CONT. EQ.
34AD

C UL US LISTED
3PWL
PROGRAMMABLE
CONTROLLERS

FOR USE IN HAZARDOUS LOCATIONS:
Class I, Division 2, Groups A, B, C, and D

- *PROTOCOL CONVERSION FEATURE CONVERTS NUMEROUS PROTOCOLS SIMULTANEOUSLY*
- *COMPACTFLASH® SLOT ALLOWS PROCESS DATA TO BE LOGGED DIRECTLY TO CSV FILES*
- *VIRTUAL HMI OFFERS BUILT-IN PC-BASED SCADA FUNCTIONALITY*
- *WEBSERVER PROVIDES WORLDWIDE ACCESS TO DATA LOGS AND VIRTUAL HMI*
- *EXTENSIVE BUILT-IN DRIVER LIST ALLOWS EASY DATA MAPPING TO PLCs, PCs, AND SCADA SYSTEMS*
- *ALARM NOTIFICATIONS CAN BE SENT VIA EMAIL OR TEXT MESSAGES*
- *10 BASE-T/100 BASE-TX ETHERNET CONNECTION CAN CONNECT TO AN UNLIMITED NUMBER OF DEVICES VIA FOUR PROTOCOLS SIMULTANEOUSLY*

GENERAL DESCRIPTION

The Data Station Plus was designed to act as a nexus for industrial data collection and management. The unit offers multiple protocol conversion, data logging and remote machine access. With three built in serial ports and a 10 Base-T/100 Base-TX Ethernet port, the unit performs protocol conversion, allowing disparate devices to communicate seamlessly with one another. The Ethernet port supports up to four protocols simultaneously so even Ethernet to Ethernet protocols can be converted.

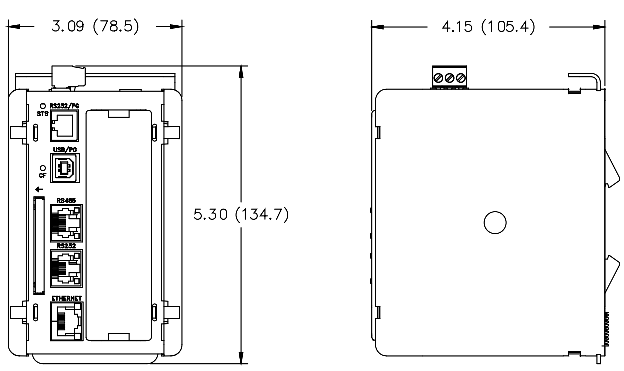
The CompactFlash card allows data to be collected and stored for later review. The files are stored in simple CSV file format allowing common applications, such as Microsoft Excel and Access, to view and manage the data. The free Websync utility provides a means to synchronize the files with a PC's hard drive for permanent storage. The CompactFlash card may also be used to load new configuration files into the Data Station.

The built-in web server allows log files to be retrieved manually, and also provides access to the unique "virtual HMI". The virtual HMI is programmed just like Red Lion's G3 series of HMI. Any standard web browser such as Internet Explorer or Netscape may be used to monitor or control the HMI from a PC anywhere in the world.

The USB port may be used for blazing fast file downloads, or to mount the Data Station's CompactFlash card as an external drive to your PC.

The Data Station's DIN rail mounting saves time and panel space and snaps easily onto standard top hat (T) profile DIN rail.

DIMENSIONS In inches (mm)



SOFTWARE

The Data Station is programmed with Crimson® 2.0 software for Windows® 2000 or later platforms. The software is an easy to use graphical interface which can be purchased as part of a kit that includes a manual and cables, or downloaded free of charge from www.redlion.net.

SAFETY SUMMARY

All safety related regulations, local codes and instructions that appear in the manual or on equipment must be observed to ensure personal safety and to prevent damage to either the instrument or equipment connected to it. If equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Do not use the controller to directly command motors, valves, or other actuators not equipped with safeguards. To do so can be potentially harmful to persons or equipment in the event of a fault to the controller. An independent and redundant temperature limit indicator with alarm outputs is strongly recommended.

CAUTION: Risk of Danger.
Read complete instructions prior to installation and operation of the unit.

WARNING - EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2

THIS EQUIPMENT IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C, D, OR NON-HAZARDOUS LOCATIONS ONLY

SPECIFICATIONS

1. **POWER**: 24 VDC ± 10%
   200 mA min., without expansion card
   1 Amp maximum with expansion card fitted
   Must use Class 2 or SELV rated power supply.
2. **COMMUNICATIONS**:
   USB/PG Port: Adheres to USB specification 1.1. Device only using Type B connection.

> WARNING - DO NOT CONNECT OR DISCONNECT CABLES WHILE POWER IS APPLIED UNLESS AREA IS KNOWN TO BE NON-HAZARDOUS. USB PORT IS FOR SYSTEM SET-UP AND DIAGNOSTICS AND IS NOT INTENDED FOR PERMANENT CONNECTION.

   Serial Ports: Format and Baud Rates for each port are individually software programmable up to 115,200 baud.
   RS232/PG Port: RS232 port via RJ12
   COMMS Ports: RS422/485 port via RJ45, and RS232 port via RJ12
   DH485 TXEN: Transmit enable; open collector, V_{OH} = 15 VDC, V_{OL} = 0.5 V @ 25 mA max.
   Ethernet Port: 10 BASE-T / 100 BASE-TX
   RJ45 jack is wired as a NIC (Network Interface Card).
3. **LEDs**:
   STS – Status LED indicates condition of Data Station.
   TX/RX – Transmit/Receive LEDs show serial activity.
   Ethernet – Link and activity LEDs.
   CF – CompactFlash LED indicates card status and read/write activity
4. **MEMORY**:
   On-board User Memory: 4 Mbytes of non-volatile Flash memory.
   On-board SDRAM:
   DSPSX: 2 Mbytes
   DSPGT: 8 Mbytes
   Memory Card: CompactFlash Type II slot for Type I and Type II cards.
5. **REAL-TIME CLOCK**: Typical accuracy is less than one minute per month drift. Crimson 2.0's SNTP facility allows synchronization with external servers.
   Battery: Lithium Coin Cell. Typical lifetime of 10 years at 25 ºC.
   A "Battery Low" system variable is available so that the programmer can choose specific action(s) to occur when the battery voltage drops below its nominal voltage.
   This unit is NOT field serviceable. All work must be done by a qualified technician.
6. **ENVIRONMENTAL CONDITIONS**:
   Operating Temperature Range: 0 to 50°C
   Storage Temperature Range: -30 to +70°C
   Operating and Storage Humidity: 80% max relative humidity, non-condensing, from 0 to 50°C
   Vibration According to IEC 68-2-6: Operational 5 to 150 Hz, in X, Y, Z direction for 1.5 hours, 2 g's.
   Shock According to IEC 68-2-27: Operational 30 g, 11 msec in 3 directions.
   Altitude: Up to 2000 meters
7. **CONSTRUCTION**: Case body is burgundy high impact plastic and stainless steel. Installation Category I, Pollution Degree 2.
8. **POWER CONNECTION**: Removable wire clamp screw terminal block.
   Wire Gage Capacity: 24 AWG to 12 AWG
   Torque: 4.45 to 5.34 in/lb (0.5 to 0.6 N-m)
9. **MOUNTING**: Snaps onto standard DIN style top hat (T) profile mounting rails according to EN50022 -35 x 7.5 and -35 x 15.
10. **CERTIFICATIONS AND COMPLIANCES**:
    SAFETY
    UL Listed, File #E302106, UL508, CSA 22.2 No. 14-M05
    LISTED by Und. Lab. Inc. to U.S. and Canadian safety standards
    UL Listed, File #E317425, ANSI/ISA 12.12.01-2007, CSA 22.2 No. 213-M1987
    LISTED by Und. Lab. Inc. to U.S. and Canadian safety standards
    IEC 61010-1, EN 61010-1: Safety requirements for electrical equipment for measurement, control, and laboratory use, Part 1.
    ELECTROMAGNETIC COMPATIBILITY
    Emissions and Immunity to EN 61326: 2006: Electrical Equipment for Measurement, Control and Laboratory use.

Immunity to Industrial Locations:

Electrostatic discharge	EN 61000-4-2	Criterion B
		4 kV contact discharge
		8 kV air discharge
Electromagnetic RF fields	EN 61000-4-3	Criterion A
		10 V/m
Fast transients (burst)	EN 61000-4-4	Criterion A
	power	2 kV
	I/O signal	1 kV
Surge	EN 61000-4-5	Criterion B
	power	1kV L-L,2 kV L-G
	signal	1kV
RF conducted interference	EN 61000-4-6	Criterion A
		3 V/rms
Emissions:		
Emissions	EN 55011	Class A

Notes:
1. Criterion A: Normal operation within specified limits.
2. Criterion B: Temporary loss of performance from which the unit self-recovers.

11. **WEIGHT**: 15.1 oz (456.4 g)

> WARNING - EXPLOSION HAZARD - DO NOT DISCONNECT EQUIPMENT UNLESS POWER HAS BEEN SWITCHED OFF OR AREA IS KNOWN TO BE NON-HAZARDOUS.

HARDWARE

INSTALLATION

DIN rail should be mounted horizontally so that the unit's ventilation holes are vertical in relation to cabinet orientation. A minimum clearance of 1 inch (25.4 mm) should be maintained above and below the unit in order to ensure proper thermal regulation.

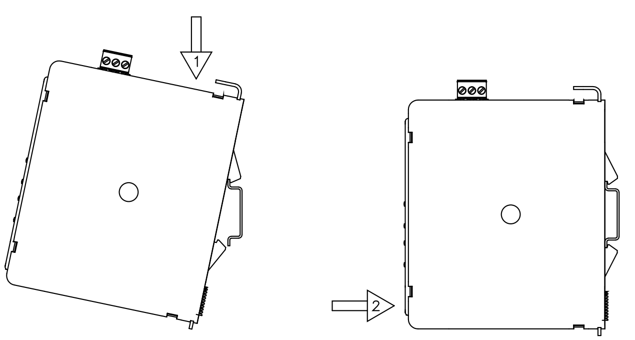
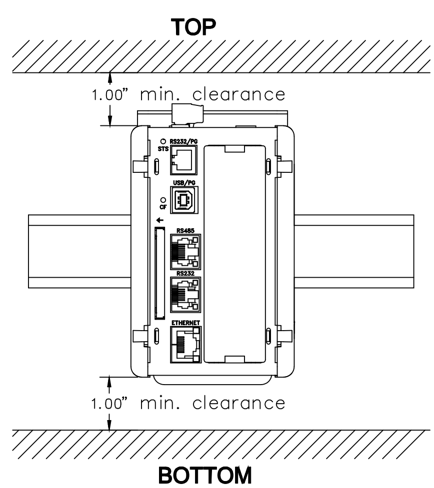
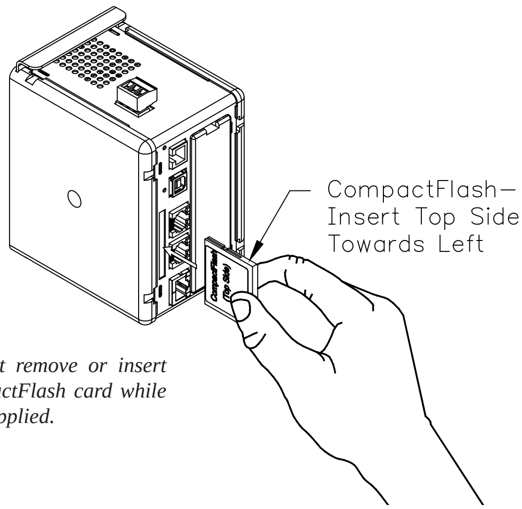


Figure 1 - Attach Data Station To DIN Rail



COMPACTFLASH® CARD

CompactFlash socket is a Type II socket that can accept either Type I or II cards. Use cards with a minimum of 4 Mbytes and a maximum of 2 Gbytes with the Data Station's CompactFlash socket. Cards are available at most computer and office supply retailers. CompactFlash can be used for configuration transfers, data logging, and trending.



Note: Do not remove or insert the CompactFlash card while power is applied.

Information stored on a CompactFlash card can be read by a card reader attached to a PC. This information is stored in IBM (Windows®) PC compatible FAT16 file format.

NOTE

For reliable operation in all of our products, Red Lion recommends the use of SanDisk®, SimpleTech, and SMART® brands of CompactFlash cards.

Industrial grade versions that provide up to two million write/erase cycles minimum are available from Red Lion.

POWER SUPPLY REQUIREMENTS

It is very important that the power supply is mounted correctly if the unit is to operate reliably. Please take care to observe the following points:

- The power supply must be mounted close to the unit, with usually not more than 6 feet (1.8 m) of cable between the supply and the Data Station. Ideally, the shortest length possible should be used.
- The wire used to connect the Data Station's power supply should be at least 22-gage wire. If a longer cable run is used, a heavier gage wire should be used. The routing of the cable should be kept away from large contactors, inverters, and other devices which may generate significant electrical noise.
- A power supply with a Class 2 or SELV rating is to be used. A Class 2 or SELV power supply provides isolation to accessible circuits from hazardous voltage levels generated by a mains power supply due to single faults. SELV is an acronym for "safety extra-low voltage." Safety extra-low voltage circuits shall exhibit voltages safe to touch both under normal operating conditions and after a single fault, such as a breakdown of a layer of basic insulation or after the failure of a single component has occurred.

Visit www.redlion.net for a complete list of our PSDR Series of Class 2 power supplies.

EMC INSTALLATION GUIDELINES

Although Red Lion Controls Products are designed with a high degree of immunity to Electromagnetic Interference (EMI), proper installation and wiring methods must be followed to ensure compatibility in each application. The type of the electrical noise, source or coupling method into a unit may be different for various installations. Cable length, routing, and shield termination are very important and can mean the difference between a successful or troublesome installation. Listed are some EMI guidelines for a successful installation in an industrial environment.

1. To reduce the chance of noise spikes entering the unit via the power lines, connections should be made to a clean source. Connecting to circuits that also power loads such as contactors, relays, motors, solenoids etc. should be avoided.
2. The unit should be mounted in a metal enclosure, which is properly connected to protective earth.
3. Use shielded (screened) cables for all Signal and Control inputs. The shield (screen) pigtail connection should be made as short as possible. The connection point for the shield depends somewhat upon the application. Listed below are the recommended methods of connecting the shield, in order of their effectiveness.
   a. Connect the shield to earth ground (protective earth) at one end where the unit is mounted.
   b. Connect the shield to earth ground at both ends of the cable, usually when the noise source frequency is over 1 MHz.
   c. Connect the shield to common of the Data Station and leave the other end of the shield unconnected and insulated from earth ground.
4. Never run Signal or Control cables in the same conduit or raceway with AC power lines, conductors feeding motors, solenoids, SCR controls, and heaters, etc. The cables should be run through metal conduit that is properly grounded. This is especially useful in applications where cable runs are long and portable two-way radios are used in close proximity or if the installation is near a commercial radio transmitter. Also, Signal or Control cables within an enclosure should be routed as far away as possible from contactors, control relays, transformers, and other noisy components.
5. Long cable runs are more susceptible to EMI pickup than short cable runs. Therefore, keep cable runs as short as possible.
6. In extremely high EMI environments, the use of external EMI suppression devices is effective. The following EMI suppression devices (or equivalent) are recommended:

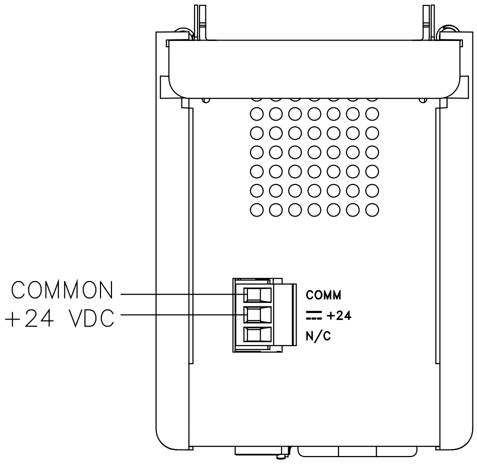
   Ferrite Suppression Cores for signal and control cables:
   - Fair-Rite part number 0443167251 (RLC part number FCOR0000)
   - TDK part number ZCAT3035-1330A
   - Steward part number 28B2029-0A0

   Line Filters for input power cables:
   - Schaffner part number FN610-1/07 (RLC part number LFIL0000)
   - Schaffner part number FN670-1.8/07
   - Corcom part number 1 VR3

Visit RLC's web site at www.redlion.net for more information on EMI guidelines, Safety and CE issues as they relate to Red Lion Controls products.

WIRING

POWER CONNECTION

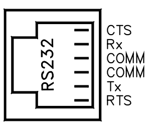


WARNING - EXPLOSION HAZARD - DO NOT DISCONNECT WHILE CIRCUIT IS ALIVE UNLESS AREA IS KNOW TO BE NON-HAZARDOUS.

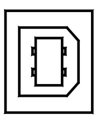
INPUT AND OUTPUT (I/O) WIRING MUST BE IN ACCORDANCE WITH CLASS I, DIV. 2 WIRING METHODS AND IN ACCORDANCE WITH THE AUTHORITY HAVING JURISDICTION.

PROGRAMMING PORTS

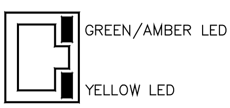
RS232/PG

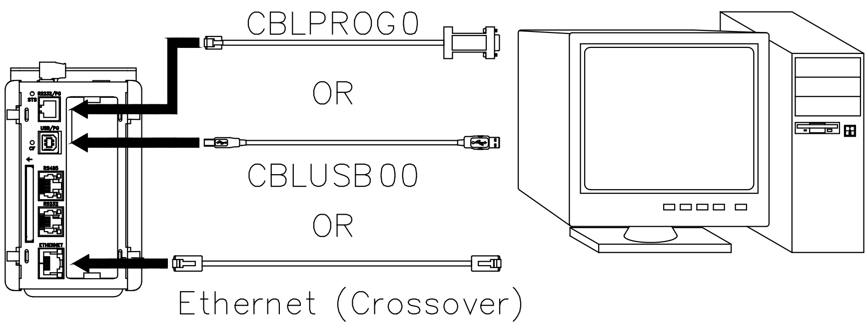


USB/PG



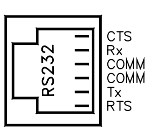
ETHERNET

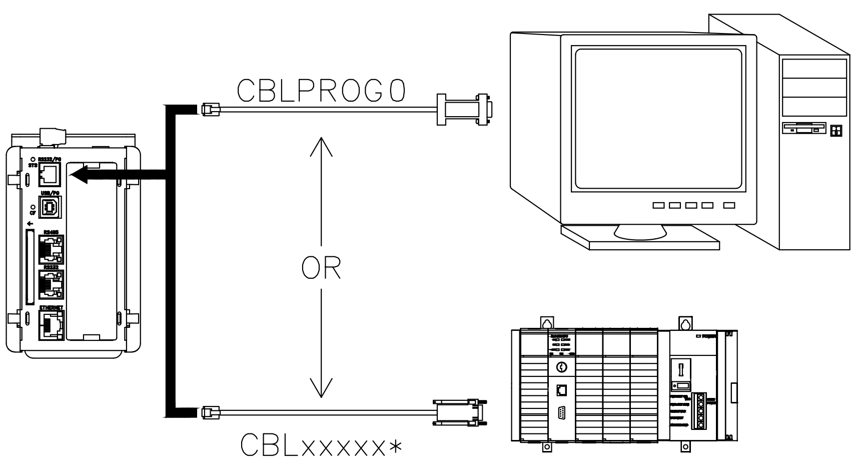




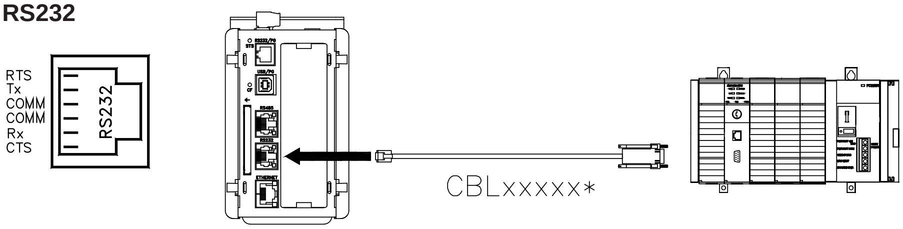
COMMUNICATION PORTS

RS232/PG



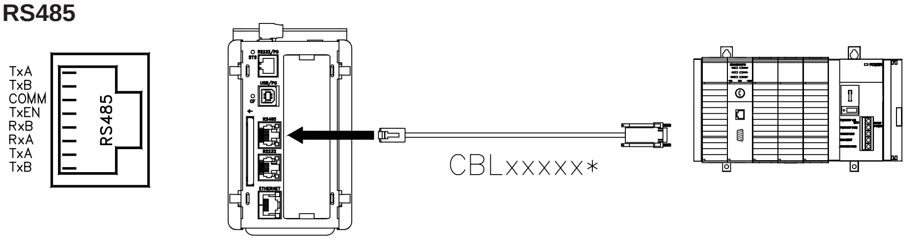


RS232



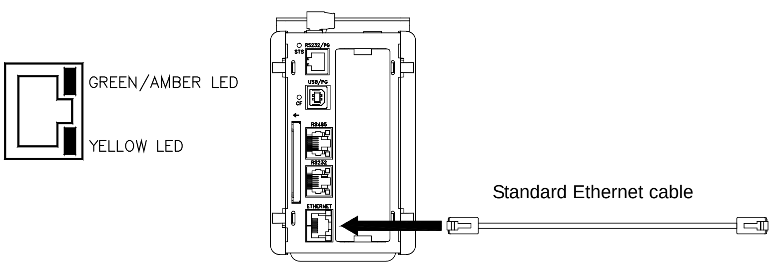
* Use appropriate communications cable. See Ordering Information for descriptions of the available cables.

RS485

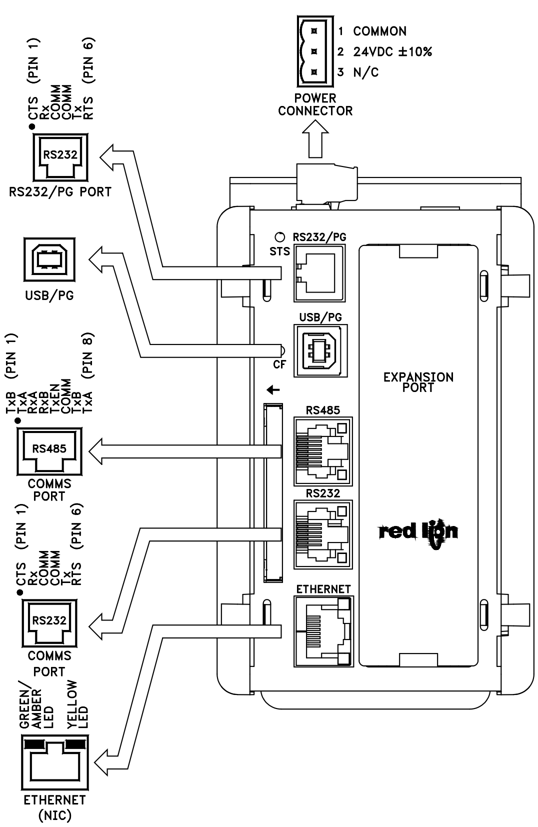


WARNING: Do **NOT** use a standard DH-485 cable to connect this port to Allen Bradley equipment.

PORT 3 - ETHERNET CONNECTION



DATA STATION PORT PIN OUTS



TROUBLESHOOTING

If for any reason you have trouble operating, connecting, or simply have questions concerning your new Data Station, contact Red Lion’s technical support. For contact information, refer to the back page of this bulletin for phone and fax numbers.

EMAIL: techsupport@redlion.net
Web Site: http://www.redlion.net

COMMUNICATING WITH THE DATA STATION

CONFIGURING A DATA STATION

The Data Station is configured using Crimson® 2.0 software. Crimson 2.0 is available as a free download from Red Lion's website, or it can be ordered on CD. Updates to the software for new features and drivers are posted on the website as they become available. By configuring the Data Station using the latest version of the software, you are assured that your unit has the most up to date feature set. Crimson® 2.0 software can configure the Data Station through the RS232/PG port, USB/PG port, Ethernet, or CompactFlash. The USB/PG port is connected using a standard USB cable with a Type B connector.

The driver needed to use the USB port will be installed with Crimson 2.0. The RS232/PG port uses a programming cable made by Red Lion to connect to the DB9 COM port of your computer. If making your own cable, refer to the "Data Station Port Pin Outs" for wiring information.

The CompactFlash can be used to program a Data Station by placing a configuration file and firmware on the CompactFlash card. The card is then inserted into the target Data Station and powered. Refer to the Crimson® 2.0 literature for more information on the proper names and locations of the files.

CABLES AND DRIVERS

Red Lion has a wide range of cables and drivers for use with many different communication types. A list of these drivers and cables along with pin outs is available from Red Lion's website. New cables and drivers are added on a regular basis. If making your own cable, refer to the "Data Station Port Pin Outs" for wiring information.

USB, DATA TRANSFERS FROM THE COMPACTFLASH CARD

WARNING - DO NOT CONNECT OR DISCONNECT CABLES WHILE POWER IS APPLIED UNLESS AREA IS KNOWN TO BE NON-HAZARDOUS. USB PORT IS FOR SYSTEM SET-UP AND DIAGNOSTICS AND IS NOT INTENDED FOR PERMANENT CONNECTION.

In order to transfer data from the CompactFlash card via the USB port, a driver must be installed on your computer. This driver is installed with Crimson 2.0 and is located in the folder C:\Program Files\Red Lion Controls\Crimson 2.0\Device\ after Crimson 2.0 is installed. This may have already been accomplished if your Data Station was configured using the USB port.

Once the driver is installed, connect the Data Station to your PC with a USB cable, and follow "Mounting the CompactFlash" instructions in the Crimson 2.0 user manual.

Note that using the USB port for frequent data transfers is not recommended. For frequent data transfers it is recommended that the Ethernet connection be used. Through the Ethernet connection a web page can be set up to view logged data. Refer to the Crimson 2.0 manual for details.

Note: The USB port is for system set-up and diagnostics and is not intended for permanent connection.

ETHERNET COMMUNICATIONS

Ethernet communications can be established at either 10 BASE-T or 100 BASE-TX. The Data Station's RJ45 jack is wired as a NIC (Network Interface Card). For example, when wiring to a hub or switch use a straight-through cable, but when connecting to another NIC use a crossover cable.

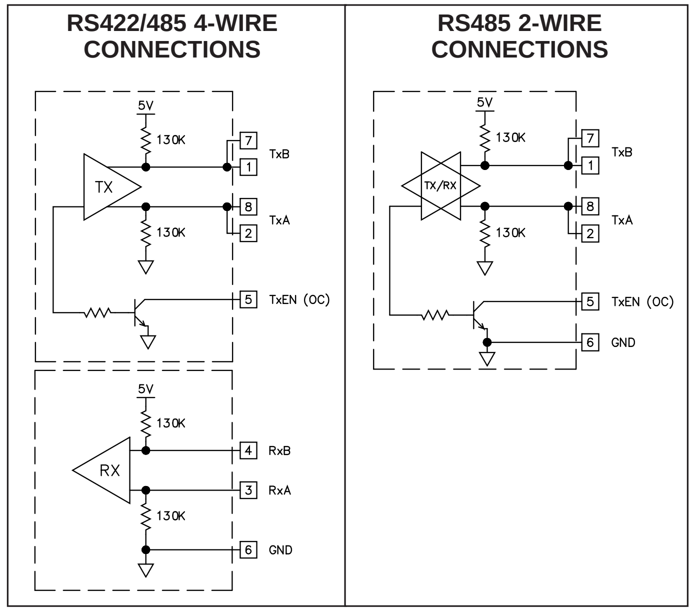
The Crimson 2.0 manual contains additional information on Ethernet communications.

RS232 PORTS

The Data Station has two RS232 ports. There is the RS232/PG port and the COMMS port. Although only one of these ports can be used for programming, both ports can be used for communications with a PLC. The RS232/PG port can be used for either master or slave protocols.

RS422/485 PORT

The Data Station has one RS422/485 port. This port can be configured to act as either RS422 or RS485.



Note: All Red Lion® devices connect A to A and B to B, except for Paradigm devices. Refer to www.redlion.net for additional information.

DH485 COMMUNICATIONS

The Data Station's RS422/485 COMMS port can also be used for Allen Bradley DH485 communications.

WARNING: DO NOT use a standard DH485 cable to connect this port to Allen Bradley equipment. A cable and wiring diagram are available from Red Lion.

LEDS

STS – STATUS LED

The green Status LED provides information regarding the state of the Data Station. This includes indication of the various stages of the start-up routine (power-up), and any errors that may occur.

Startup Routine

	INDICATION
Rapidly Flashing	Data Station is currently running the boot loader and/or being flash upgraded by Crimson.
Steady	Data Station is operating properly.

CF – COMPACTFLASH LED

LED	INDICATION
Off	No CompactFlash Card is present.
Steady	Valid CompactFlash card is present.
Flashing Rapidly	CompactFlash card is being checked.
Flickering	Unit is writing to the CompactFlash, either because it is storing data, or because the PC connected via the USB port has locked the drive. [1]
Flashing Slowly	Incorrectly formatted CompactFlash card present.

1. *Do not turn off power to the unit while this light is flickering. The unit writes data in two minute intervals. Later Microsoft operating systems will not lock the drive unless they need to write data; Windows 98 may lock the drive any time it is mounted, thereby interfering with logging. Refer to "Mounting the CompactFlash" in the Crimson 2.0 User Manual.*

USER COMMUNICATION PORTS - TX/RX LEDS

LED	INDICATION
GREEN	Transmitting
RED	Receiving

Note: LEDs are not available on the Programming Port: RS232/PG.

ETHERNET LEDS

LED	INDICATION
YELLOW (Solid)	Link Established
YELLOW (Flashing)	Network Activity
GREEN	10 BASE-T Communications
AMBER	100 BASE-TX Communications

ORDERING INFORMATION

TYPE	MODEL NO.	DESCRIPTION	PART NUMBER
Data Station Plus	DSP	Data Station with multiple protocol converter, data logger, web server with Virtual HMI up to QVGA (320 x 240) and expansion slot.	DSPSX000
		Data Station with multiple protocol converter, data logger, web server with Virtual HMI up to VGA (640 x 480) size and expansion slot with increased SDRAM.	DSPGT000
Communications Cables (10 feet)	CBL	RS-232 Programming Cable	CBLPROG0
		USB Cable	CBLUSB00
		Communications Cables [1]	CBLxxxxx
Software	SFCRM2	Crimson® 2.0 [2], Manual and Download Cable	SFCRM200
Power Supply	PSDR	DIN Rail Power Supply	PSDRxxxx
Accessories	XCCN	CANopen option card for Modular Controller or Data Station Plus	XCCN0000
	XCDN	DeviceNet option card for Modular Controller or Data Station Plus	XCDN0000
	XCPB	PROFIBUS option card for Modular Controller or Data Station Plus	XCPBDP00
	XCRS	RS232/485 option card for Modular Controller or Data Station Plus	XCRS0000
	G3CF	CompactFlash Card [4]	G3CFxxxx
	DR	DIN Rail Mountable Adapter Products [3]	DRxxxxxx

[1] Visit www.redlion.net for a list of communication drivers and cables.

[2] Use this part number to purchase the Crimson® software on CD with a printed manual, USB cable, and RS-232 cable. Otherwise, download free of charge from www.redlion.net.

[3] Red Lion offers RJ modular jack adapters. Refer to the DR literature for complete details.

[4] Industrial grade two million write cycles.

LIMITED WARRANTY

The Company warrants the products it manufactures against defects in materials and workmanship for a period limited to two years from the date of shipment, provided the products have been stored, handled, installed, and used under proper conditions. The Company's liability under this limited warranty shall extend only to the repair or replacement of a defective product, at The Company's option. The Company disclaims all liability for any affirmation, promise or representation with respect to the products.

The customer agrees to hold Red Lion Controls harmless from, defend, and indemnify RLC against damages, claims, and expenses arising out of subsequent sales of RLC products or products containing components manufactured by RLC and based upon personal injuries, deaths, property damage, lost profits, and other matters which Buyer, its employees, or sub-contractors are or may be to any extent liable, including without limitation penalties imposed by the Consumer Product Safety Act (P.L. 92-573) and liability imposed upon any person pursuant to the Magnuson-Moss Warranty Act (P.L. 93-637), as now in effect or as amended hereafter.

No warranties expressed or implied are created with respect to The Company's products except those expressly contained herein. The Customer acknowledges the disclaimers and limitations contained herein and relies on no other warranties or affirmations.

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APPENDIX J

Product Information:

Westbay® Manual

OPERATIONS MANUAL

Westbay MOSDAX Sampler Probe - Model 2531

Schlumberger
WATER SERVICES

NOTICE

Operation of Westbay System equipment should only be undertaken by qualified instrument technicians who have been trained by Westbay authorized personnel.

This document contains proprietary information. No part of this document may be photocopied, reproduced or translated to another language without the prior written consent of Westbay Instruments Inc. The information contained in this document is subject to change without notice.

DO NOT OPEN THE SAMPLER

All warranties expressed or implied will be void if, after examination by Westbay Instruments Inc. personnel, it is established that any of the instrument housings have been opened without prior authorization from Westbay Instruments Inc.

DO NOT LET THE SAMPLER FREEZE

Extreme care should be taken to avoid freezing the MOSDAX Sampler probe. Permanent transducer damage may result from freezing.

Manual Revision: 1.13 20 October 2006

Issued for Serial No.: ____________

Date: ____________

Signature: ____________

Contents

1. DESCRIPTION

1.1 MOSDAX Sampler Probe, Model 2531

The MOSDAX Sampler is a downhole probe designed to collect fluid pressure information and fluid samples from Westbay System monitoring wells. Each MOSDAX pressure sensor is calibrated over its full pressure range for nonlinearity and temperature variation. MOSDAX Sampler probes are available in a variety of pressure ranges to permit operation to various depths. The shoe and valve motors can be operated from the surface. The power for the shoe and valve motors is supplied from the surface.

1.2 MOSDAX Automated Groundwater Interface (MAGI), Model 2536

The MOSDAX Sampler can be operated directly by the keypad on the MOSDAX Automated Groundwater Interface (MAGI), or by a Hand Held Controller (HHC) connected to the MAGI, or with a computer running Microsoft Windows (2000 or higher) and Westbay software connected to the MAGI. The MAGI translates the signals between the computer or HHC and the MOSDAX Sampler. The MAGI requires 12 volt DC power to operate.

Older versions of MOSDAX sampling equipment may incorporate a Model 2522 MOSDAX PC Interface (MPCI) and HHC rather than a MAGI. For such systems, reference to the MAGI in this document can be considered as reference to the MPCI and HHC.

1.3 Cable Reels

The manual cable reel can operate all Westbay probes and tools to a depth of 300m (1,000 ft) on a single-conductor cable. The manual reel is hand operated with an internal brake to control the speed of descent of the probe in the well. The two-pin cable connects the MAGI to the reel and the signals pass through a slipring located in the hub of the reel into the control cable. For maintenance information, see the appropriate cable reel manual.

Motorized cable reels are available for deeper applications.

1.4 Sample Containers

Sample containers can be used with the MOSDAX Sampler. The nonvented stainless steel sample containers maintain samples under formation pressure while the sampler and container are brought to the surface.

2. PRESSURE PROFILING

2.1 Items Required

- MOSDAX Sampler Probe, Model 2531
- MAGI, Model 2536 with:
  - one two-pin data cable
  - one three-pin power cable
  - hand held controller with cable and user's guide (optional)
  - computer running Windows 2000 or higher with one nine-pin computer cable and MProfile software (optional)
- MOSDAX-compatible winch with cable
- Sheave with counter and tripod
- 12 VDC, 2 Amp power source (Battery pack, car/truck battery, or transformer)
- Water level measuring tape
- MProfile User's Guide for computer or the Handheld Controller Operations Manual
- Westbay Casing Log showing depths to ports and couplings in hole to be tested.

2.2 Surface Checks

1. Remove the MOSDAX Sampler from its storage case. Inspect the probe housing and body for any damage. Please contact Westbay for advice on any cover tube damage.
2. Assemble the tripod and counter over the well. Run the cable over the counter.
3. Connect the probe to the cable. Before attaching, inspect the O-ring at the top of the probe and lubricate with silicon. The O-ring should be clean and intact. Tighten the nut hand tight only.
4. Connect the two-pin cable from the MPCI to the cable reel. With the MPCI OFF connect the three-pin cable from the MPCI to the 12 v power supply.
5. Connect the 9 pin cable from computer or HHC to the MPCI and turn the MPCI ON.
6. Perform the following surface checks to ensure that the location arm and the shoe mechanisms are operating normally: Release the location arm. The location arm should extend smoothly. The number of revolutions used to release the location arm is displayed and should be 15 to 16 revolutions. If a smaller number of revolutions is reported, retract the arm and repeat. Place the probe in a piece of Westbay casing or coupling. Activate the shoe. The shoe should extend and hold the probe firmly in the coupling or casing. The display should indicate 16 to 19 revolutions. A reading of 23 revolutions indicates the probe is activated in open air. Retract the backing shoe.

7. Check that the face plate for sampling and the plastic plunger are installed on the sampler.
8. The probe is now ready to be lowered down the well.

2.3 Pressure Measurement Procedures

1. Obtain the completed Westbay Casing Log.
2. With the location arm retracted, lower the probe into the Westbay casing to immediately below the lowest measurement port coupling to be monitored. If magnetic collars have been installed on the well, the Collar Detect Command can be used to detect the collars. The Collar Detect Command is cancelled by pressing any key.
3. Release the location arm. The display should update and beep after the arm is released.
4. Raise the probe about 0.5 m (1.5 ft) above this measurement port. If the probe is accidentally lifted above the next higher coupling, it will be necessary to retract the location arm and lower the probe to below the measurement port and release the arm.
5. Lower the probe gently until the location arm rests in the measurement port.
6. Record the pressure and temperature inside the Westbay casing.
7. Optional: If a water level tape is available, measure and record the depth to water in the Westbay casing.
8. Activate the shoe. The pressure on the display should change to the formation pressure.
9. When the reading has stabilized, record the formation pressure.
10. Once the pressure has been recorded, retract the shoe.
11. Record the pressure of the fluid in the Westbay casing. This reading should be similar to that recorded in Step 6. If a large difference is noted between the readings, record the water level inside the Westbay casing again using the water level tape.
12. The three pressure readings plus the time and water level constitute a complete set of readings at a measurement port coupling.
13. Continue up the Westbay casing to obtain the pressure data from other measurement ports.
14. Take one last set of pressure and temperature readings at the surface. These readings should be similar to those recorded in Step 2.

CAUTION: If a water level tape was used, remove the water level tape from the Westbay casing before removing the sampler probe from the well to prevent them from becoming jammed.

3. FLUID SAMPLING

3.1 Items Required

- MOSDAX Sampler, Model 2531
- MAGI, Model 2536 with:
  - one two-pin data cable
  - one three-pin power cable
  - hand held controller with cable and user's guide (optional)
  - computer running Windows 2000 or higher with one nine-pin computer cable and MProfile software (optional)
- MOSDAX-compatible winch with cable
- Sample containers and connecting tubes
- Westbay Casing Log
- Groundwater Sampling Field Data Sheet
- 12 VDC, 2 amp power source (battery pack, car/truck, or transformer)
- Counter and tripod
- Westbay Sampling Kit including vacuum pump

3.2 Surface Checks and Preparation

1. Set up the MOSDAX Sampler probe following Steps 1 through 8 of Section 2.2.
2. Attach the sample containers.
3. Release the location arm. Locate the probe in the vacuum coupling.
4. Activate the shoe in the vacuum coupling.
5. Close the sampler valve. The motor should run about 5 seconds. The display should indicate one revolution.
6. Use the vacuum pump to apply a vacuum through the vacuum coupling. The vacuum should remain constant. If the vacuum is not maintained, inspect for leaks at the face seal of the probe, the connection to the pump and at the probe sampling valve.
7. Once a vacuum has been maintained, open the sampler valve. Apply a vacuum again to check that all connections are sealed.
8. Close the sampler valve. A vacuum has now been applied to the sample bottles.
9. Retract the shoe.

3.3 Drillhole Sampling

1. Check recent pressure logs of the hole and ensure that the head inside the Westbay casing is lower than the head outside the measurement port to be sampled.
2. After completing the surface checks, follow Steps 1 to 5 of Section 2.3 to locate the sampler at the measurement port in the monitoring zone to be sampled.
3. Record the pressure reading.
4. Activate the probe and record the formation pressure.
5. Open the sampler valve. The pressure should drop and then slowly increase as the bottles fill. When the pressure in the bottle equals the zone pressure from Step 4, the bottle is full. Wait a maximum of two minutes per sample bottle even if the pressures are not equal.
6. Close the sampler valve and retract the shoe.
7. Record the pressure reading. A reading the same as in Step 3 indicates that the sample is OK.
8. Reel the sampler to the surface and remove it from the Westbay casing.
9. **Do not open the sampler valve as damage to the probe or injury to the operator could occur.**
10. Remove the cap from the bottom sample bottle and open the valve on the bottle to release the pressure and to transfer the sample.
11. Open the sampler valve to allow the sample to flow from the bottles. Once the pressure in the sampler and bottles has decreased to atmospheric, the bottles may be disconnected to speed the process.
12. Take particular care in handling pressurized samples.

3.4 Rinsing Instructions

Rinse the sampler around the face seal and the bottom connector. With the sampler valve open, flush the interior of the sampler from the bottom connector. Rinse the sample bottles and connectors.

Note: Project specific procedures for decontaminating the sampler and sample bottles are the responsibility of the project manager and are not covered in this manual.

4. Care and Maintenance

The MOSDAX Sampler System must be routinely maintained for optimum performance. The procedures outlined here are required to keep the instrument operating properly. For any additional information or advice, please contact Westbay Instruments Inc.

4.1 MAGI

The MAGI should be cleaned to remove dirt and dust and inspected for damage or wear. If any part requires replacement, contact Westbay for information.

4.2 Cable Reels and Control Cable

The cable reels should be kept clean and protected from damage. The cable and cable head should be inspected for kinks and corrosion. Rehead the cable if necessary. For more information concerning cable reels and the control cable, refer to the appropriate reel manual.

4.3 MOSDAX Sampler Probe

1. Never allow the probe to freeze or the pressure transducer may be damaged.
2. Clean and inspect the probe for dents and scratches on the cover tube. Clean the threads with a nylon brush, such as a toothbrush. DO NOT use a wire brush. Protect the O-rings from damage and dirt.

4.3.1 Face Seal

Inspect the face seal and replace if damaged or worn.

1. Remove the two screws holding the face plate to the probe body and lift the face plate off.
2. Remove the face seal and plunger. Set the location arm assembly aside. Clean the plunger and probe body.
3. When reinstalling the face plate hold the face seal, plunger and location arm assembly in place. Replace the two screws the hold the face plate on the probe.

4.3.2 Location Arm

Release the location arm. Check that the arm moves smoothly and freely and check for damage and sharp edges due to wear. Replace the location arm if necessary.

1. Release the location arm. Remove the two screws and face plate (Section 4.3.1).
2. Remove the location arm with its spring and pivot pin. Clean and inspect all parts and replace if needed.
3. Insert the spring and pivot in the location arm and place the assembly in the probe body. Place the face plate over the face seal and location arm and tighten the two screws.

SECTION 4.3.2 SUPPLEMENT

WESTBAY Probe Location Arm replacement

a) It is easier when the arm is first extended to the "out" position (Fig. A). Do this before powering down and disconnecting the probe.

b) Remove the face seal slowly and stabilize the arm as it is under tension from the spring (Section 4.3.2.2) and may suddenly pop out. Observe the position and orientation of the parts as they are removed (Fig. B).

c) Insert the hook of bent leg of the spring into the tiny hole on the neck of the new arm and align the spring coil opening alongside the larger hole in the arm with the spring leg positioned directly against the arm and over the pivot facing out (Fig. C-1). The metal pivot pin goes through the hole in the arm and through the spring coil (Fig. C-2). The straight leg of the spring leads under the pivot into the smaller side slot on the side of the main arm aperture, parallel with the probe. Place the assembly into its space in the probe body (Fig. C-3). <u>The arm assembly has to be held in place while replacing the face seal</u> to counter the force of the slightly compacted spring (Fig.C-4).

d) Replace the face seal by sliding it toward the top of the probe and sliding the top edge into the slot while at the same time allowing the arm to protrude through the face seal. The arm should remain in the extended position while screwing down the face seal.

e) Check to see that the arm can be freely, manually pushed in and that it pops back out when released. Attach the probe to the cable and mechanically retract the arm using the MAGI commands.

Figure **A** - Arm is extended out at start of replacement operation.

Figure **B** - Disassembled face seal and location arm.

Figure **C-1 -** Orientation of spring relative to arm.

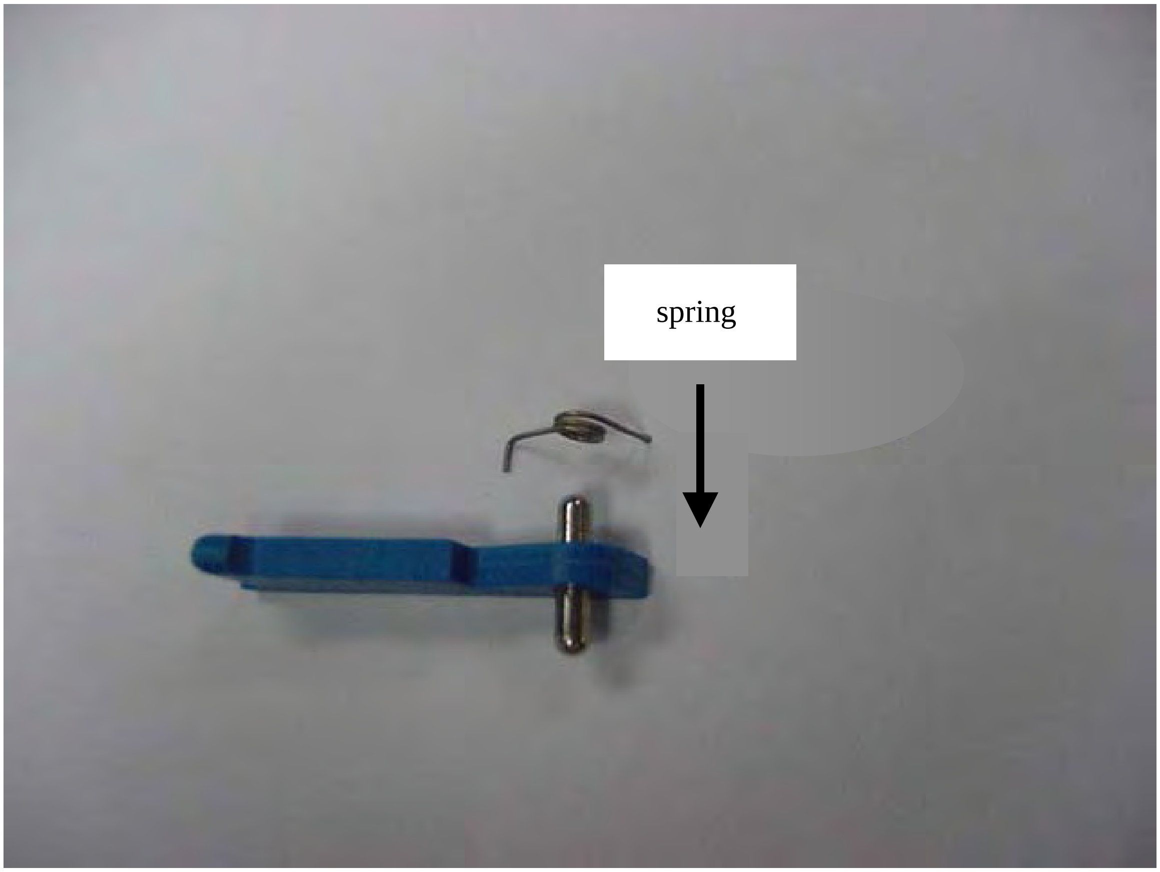


Figure **C-2 -** Position of spring and pivot in the arm.

Figure **C-3 -** Placement of arm assembly.

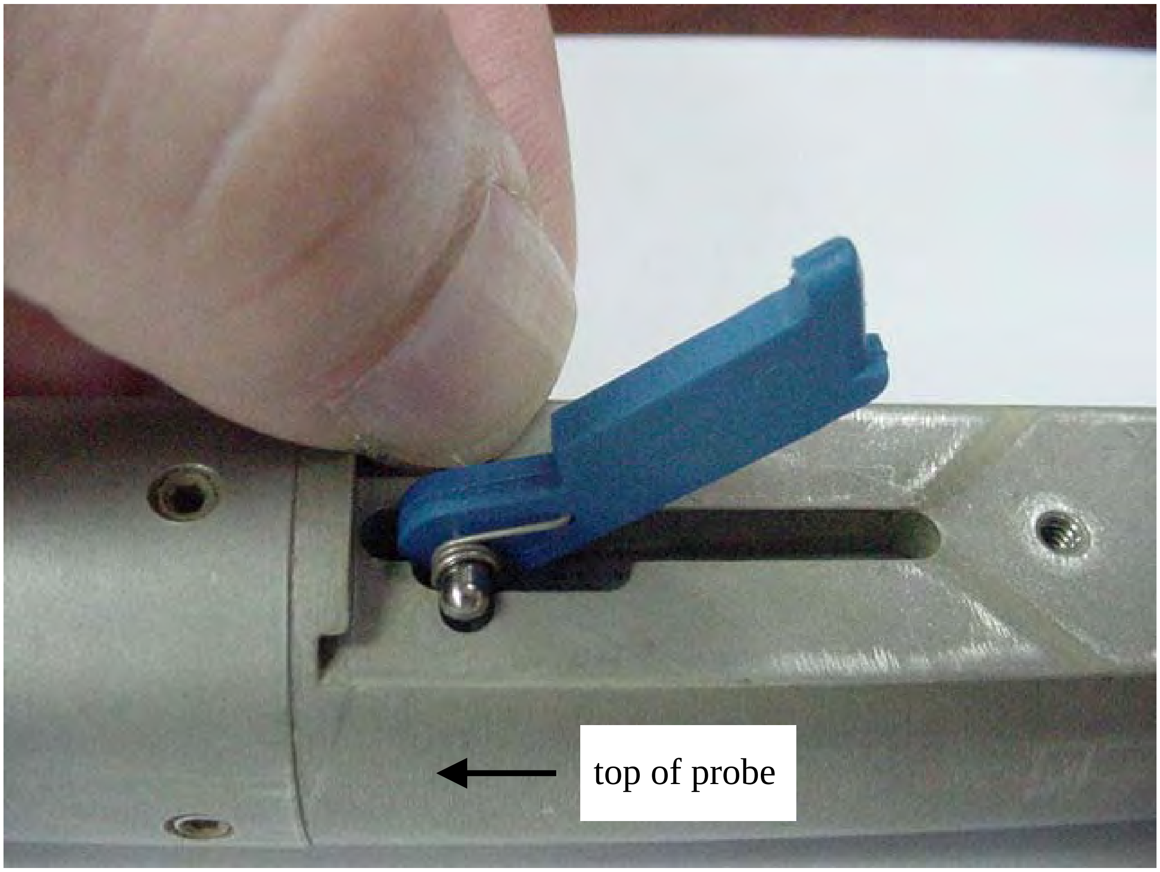
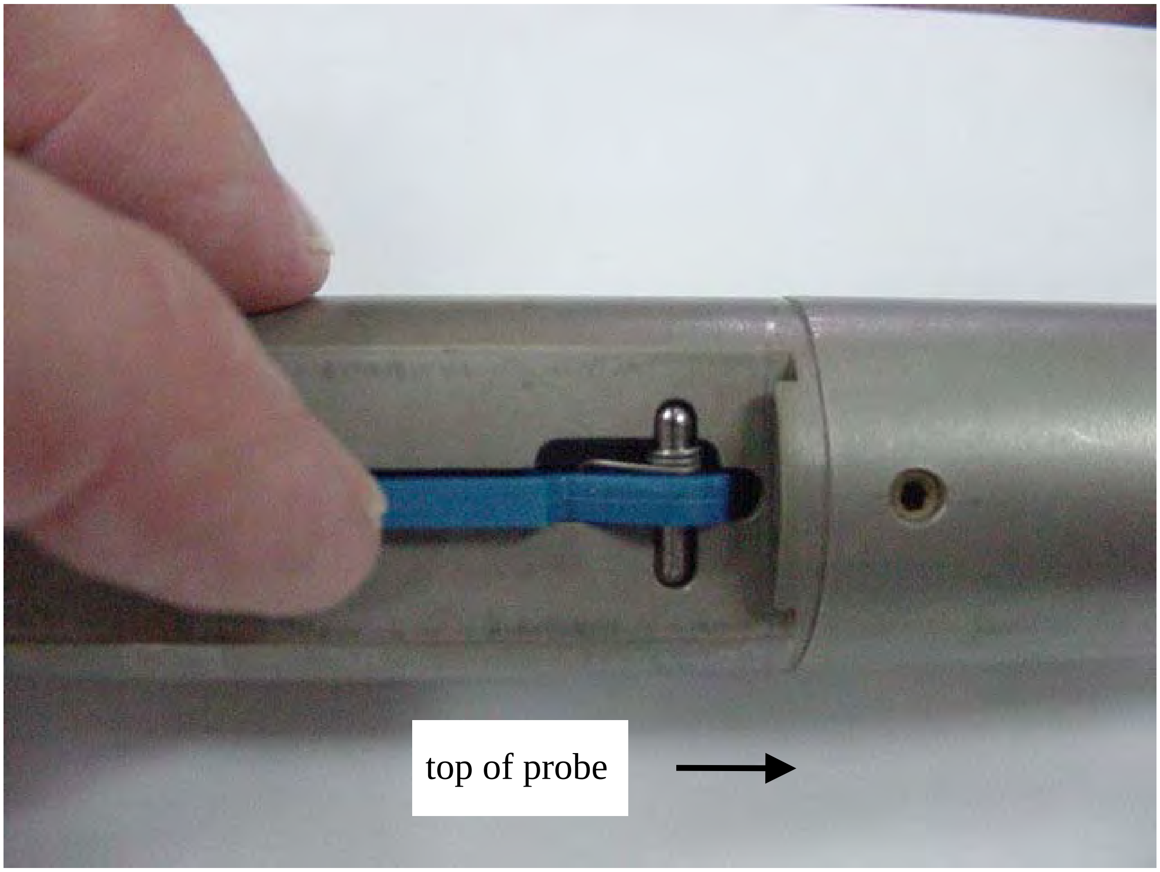


Figure **C-4 -** Top view of arm and spring placement.



Check that the arm is moving freely and the face seal insert and plunger are held securely in place.

4.3.3 Shoe Replacement

Activate the shoe and inspect for damage or wear. The shoe should rotate freely about the pivot pin. When the shoe is retracted it should retract quickly and smoothly back into the probe. The shoe may be replaced in the following manner:

1. Release the location arm and extend the shoe to expose the pivot pin.
2. Unscrew the shoe pivot pin from the lever arm and remove the shoe.
3. Place a new shoe in the lever arm and install the shoe pivot pin.

4.3.4 Actuator Nut

The actuator nut needs to be routinely cleaned to remove particles of grit which can interfere with its movement. Remove the actuator nut in the following manner:

1. Remove the two set screws that hold in the lever arm pivot pin. Using the Allen key, push the lever pivot pin out of the probe body.
2. Remove the set screws on the side of the probe body that holds the plastic support block.
3. Remove the screw closest to the top of the probe.
4. Lift out the lever arm, guide plate, shoe, spring and plastic support block as one unit.
5. Use the Clean Nut Command to remove the actuator nut from the actuator screw. Turn off the MPCI and remove the nut from the probe.
6. Clean the actuator nut with the cleaning tap. Use the Clean Nut Command and clean the actuator screw with a nylon brush. DO NOT use a wire brush.
7. Apply a thin coating of silicone lubricant to the actuator screw. Place the actuator nut in the probe body against the actuator screw and retract the arm to thread the nut onto the actuator screw. Allow the nut to travel along the full length of the screw. YOU MAY HAVE TO REPEAT THIS OPERATION.
8. Install the single unit from Step 4 in the probe body. Install the lever arm pin through the probe body, lever arm, and spring. Lock the pin in position with two set screws.
9. Install the top screw into the guide plate and install the set screws to secure the support block.

5. CALIBRATION

The Westbay System permits frequent or periodic calibration of the transducers used for pressure measurement. Contact Westbay for details.

6. SPARE PARTS LIST

Item	Part No. or Size	Qty
Face Seal Insert	200302	5
Plunger	(see Note 1)	5
Location Arm	252112	5
Shoe	252313	5
Pin 3 (Location Arm)	252320	2
Spring 2 (Location Arm)	252319	2
Pin 1 (Shoe)	252316	2
Spring 1 (Shoe Lever)	252318	2
Pan Head Screw	# 4-40 x 1/4 - inch	2
Pan Head Screw	# 6-32 x 3/16 - inch	2
Pan Head Screw	# 6-32 x 1/2 - inch	2
Hex Socket Head Screw	# 8-32 x 1/8 - inch	4
Hex Socket Head Screw	# 10-32 x 3/16 - inch	4
Hex Socket Set Screw	# 8-32 x 5/16 - inch	2
Allen Key	5/64 - inch	1
Allen Key	3/32 - inch	1
Actuator Nut Tap	208001	1
Cablehead Parts:		
O-ring	# 111 B	2
Termination Sleeve	251805	1
Termination Insert	251806	1
Feedthru Connector	251814	1
Bushing 1	251812	1
Bushing 2	251813	1
O-Ring	# 108 V	1
O-Ring	# 010 V	1
O-Ring	# 004 V	1
Boot	JF0602CF	1
Contact	JF0603CF	1
Cable Heading Tool	208100	1

1. Plunger appropriate to type of measurement port to be accessed.

Schlumberger WATER SERVICES

Groundwater Sampling
Field Data Sheet

Project: ____________________

Monitoring Well No.: ____________________

Sampling Zone No(s).: ____________________

Date: ____________________

Start Time: __________ Atm. Rdg: __________

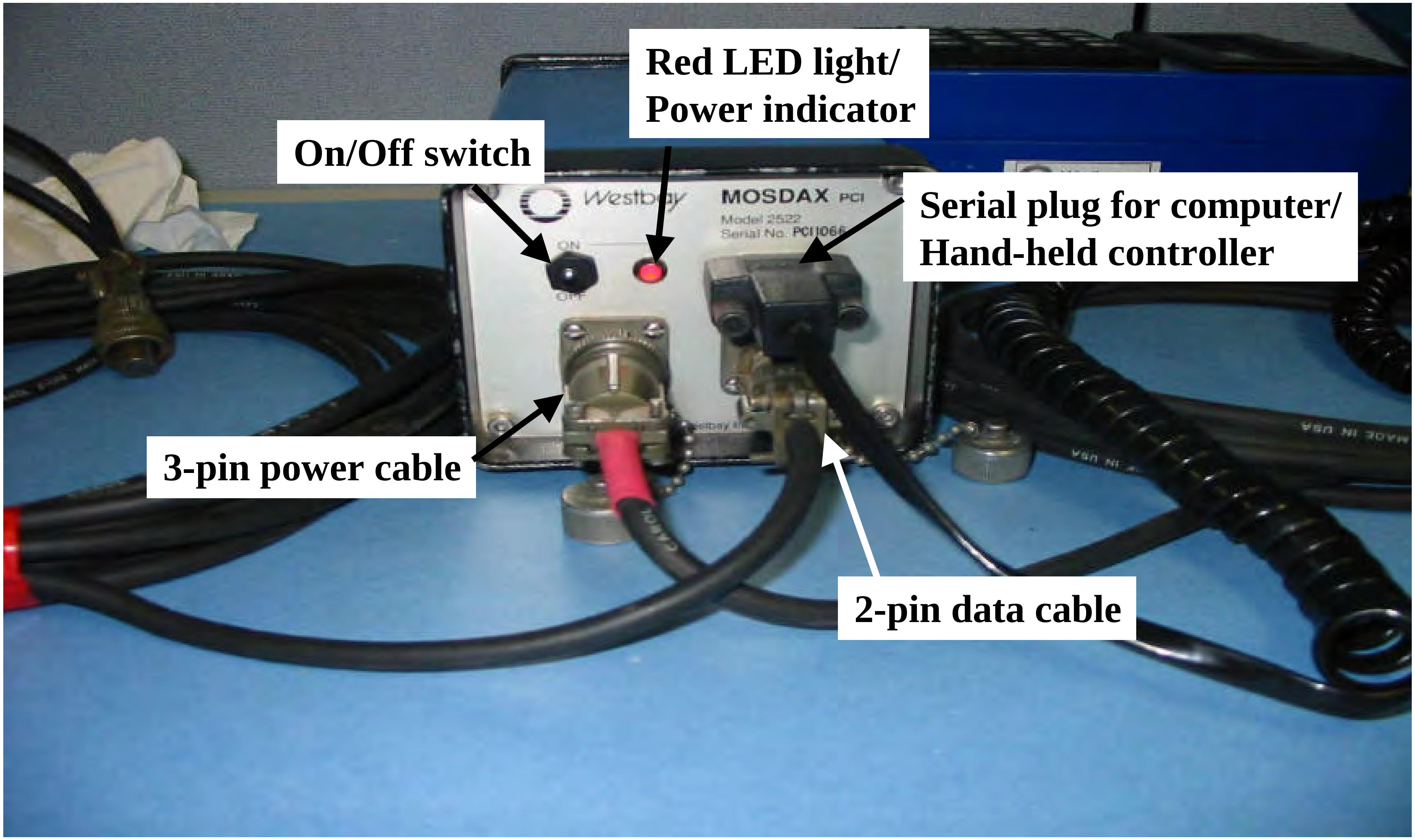
End Time: __________ Atm. Rdg: __________

Operators: ____________________

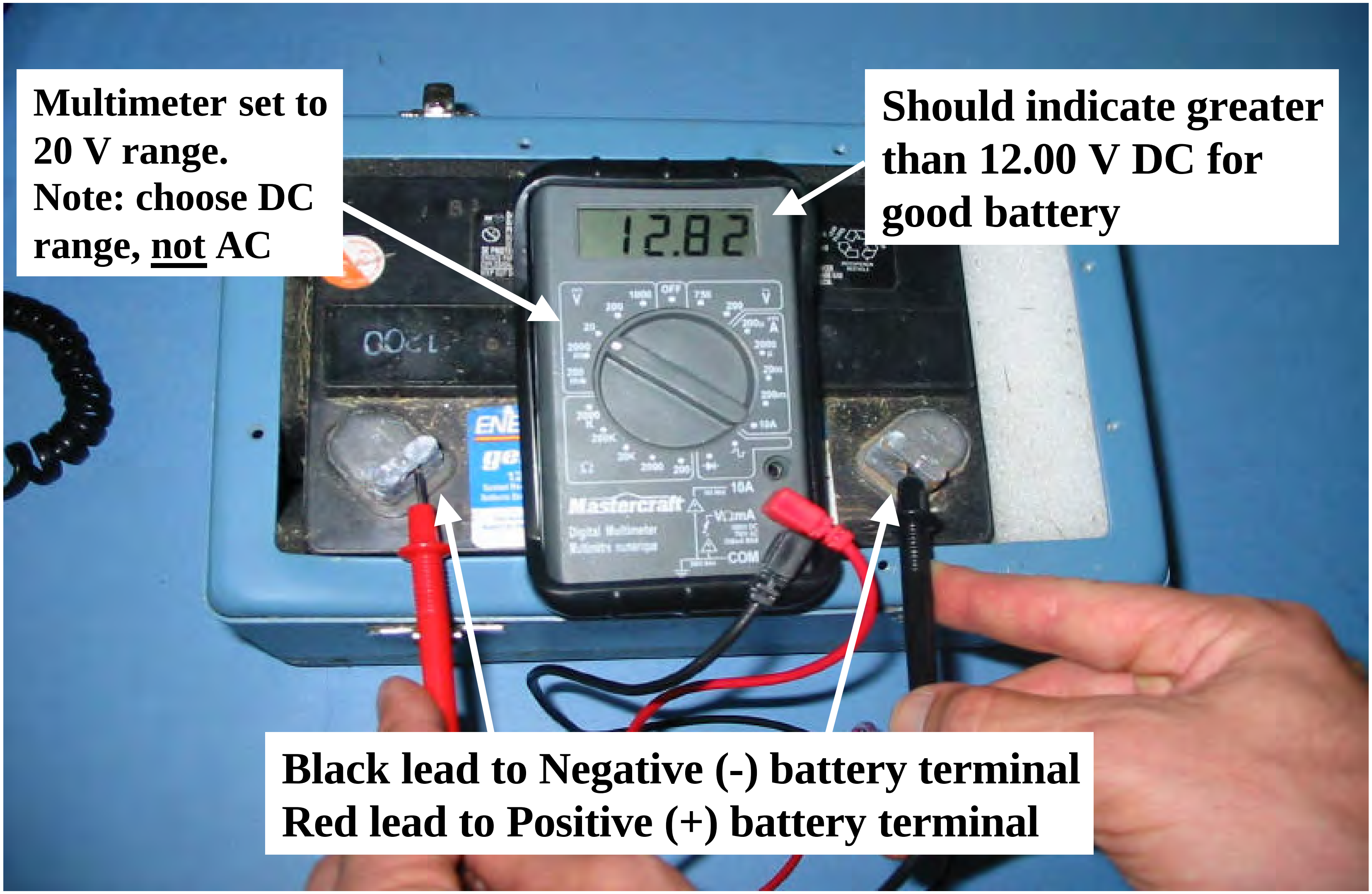
Port No.	Run No.	Surface Function Tests (probe in flushing collar)						Position Sampler			Sample Collection Checks (probe located at sampling zone in Westbay casing)								Comments (volume recovered)
		Shoe Out	Close Valve	Check Vacuum	Open Valve	Apply Vacuum	Close Valve	Locate Port	Arm Out	Land Probe	Pressure in Westbay ( )	Shoe Out	Zone Pressure ( )	Open Valve	Zone Pressure ( )	Close Valve	Shoe In	Pressure in Westbay ( )	

Additional Comments: (pH, turbidity, S.C., etc.)

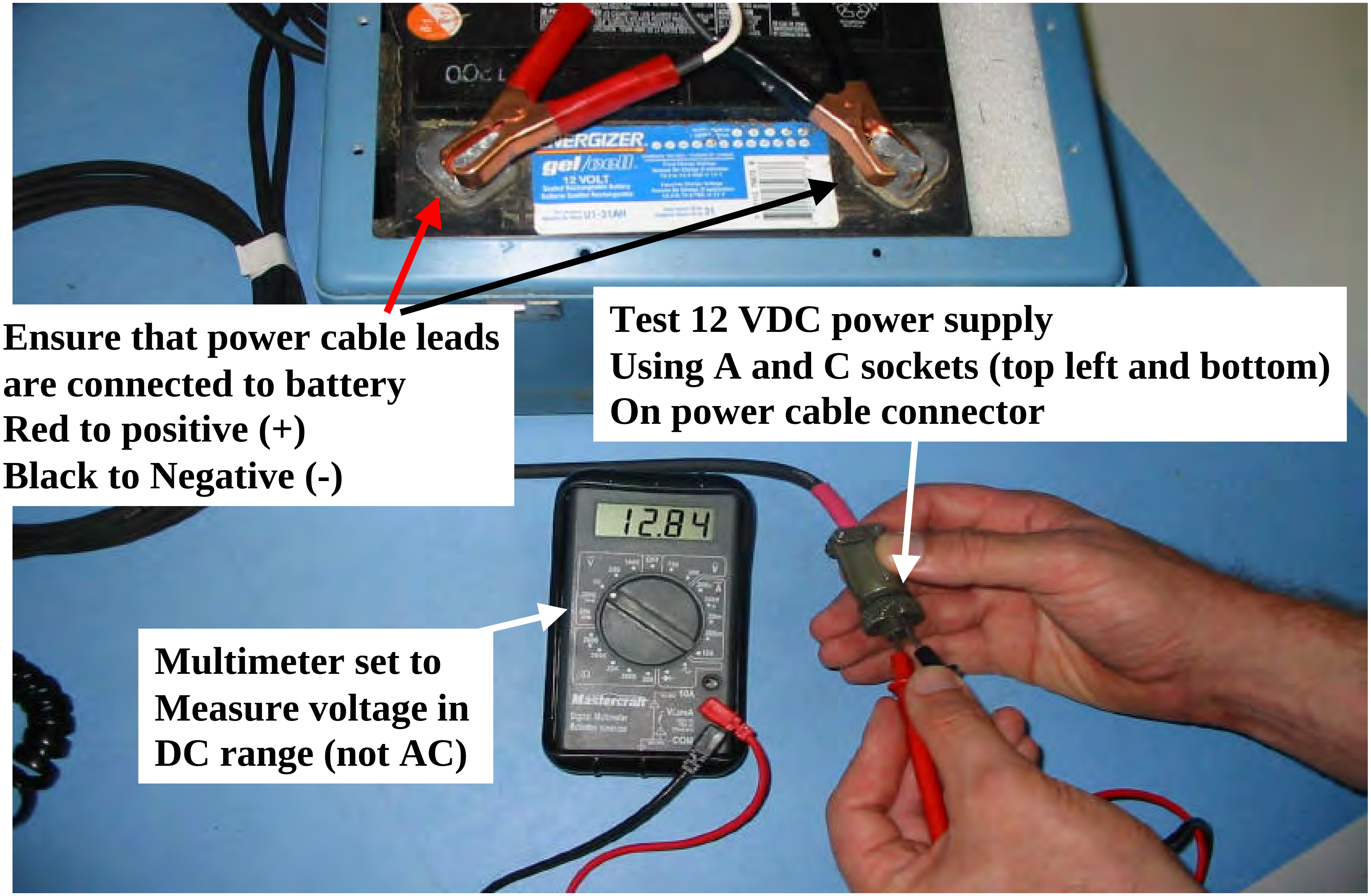
Pic.1 Computer Interface Units, old and new:
MPCI model 2522 (left) and MAGI model 2536 (right)



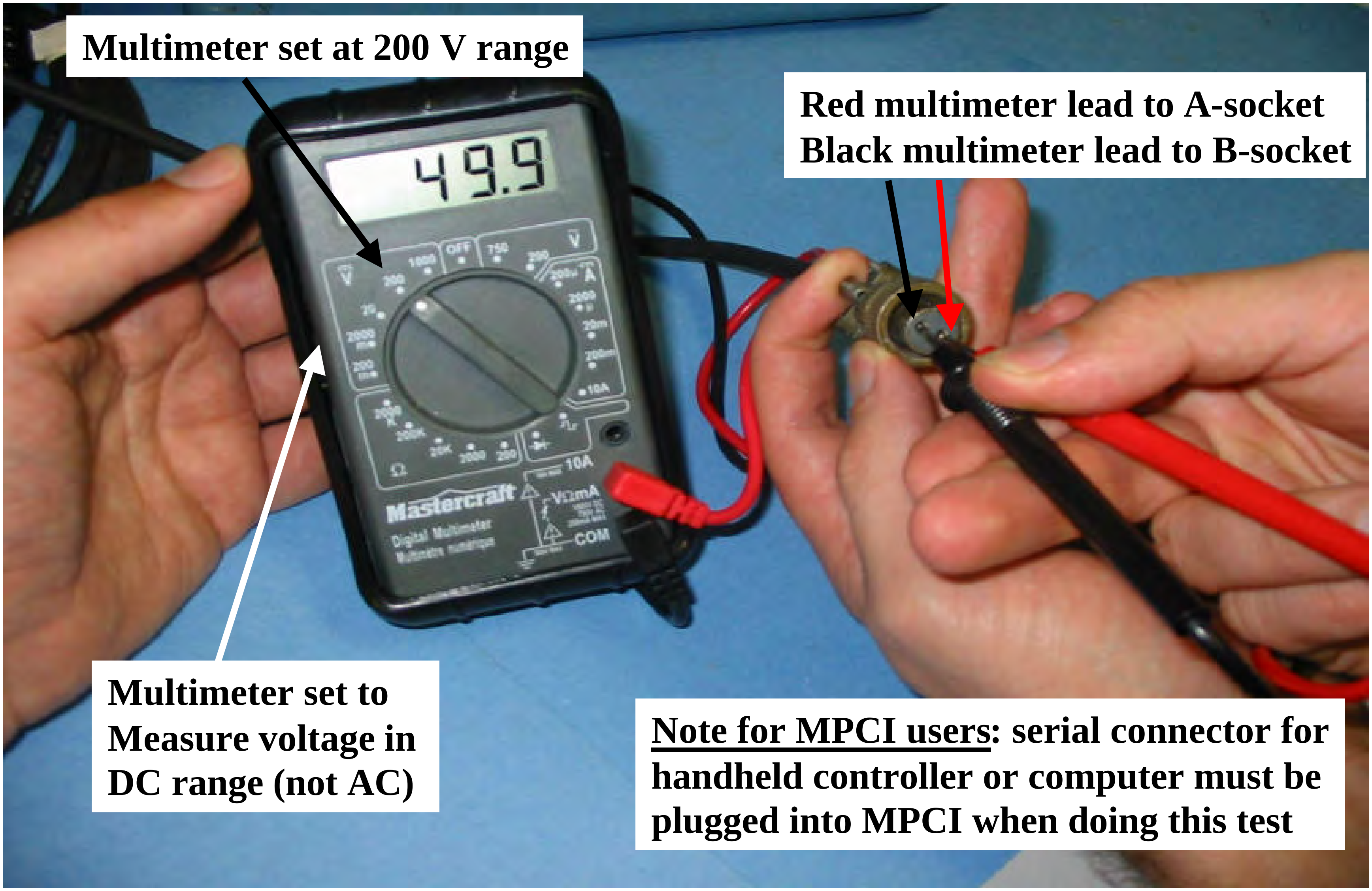
Pic.2 MPCI unit showing typical set-up configuration



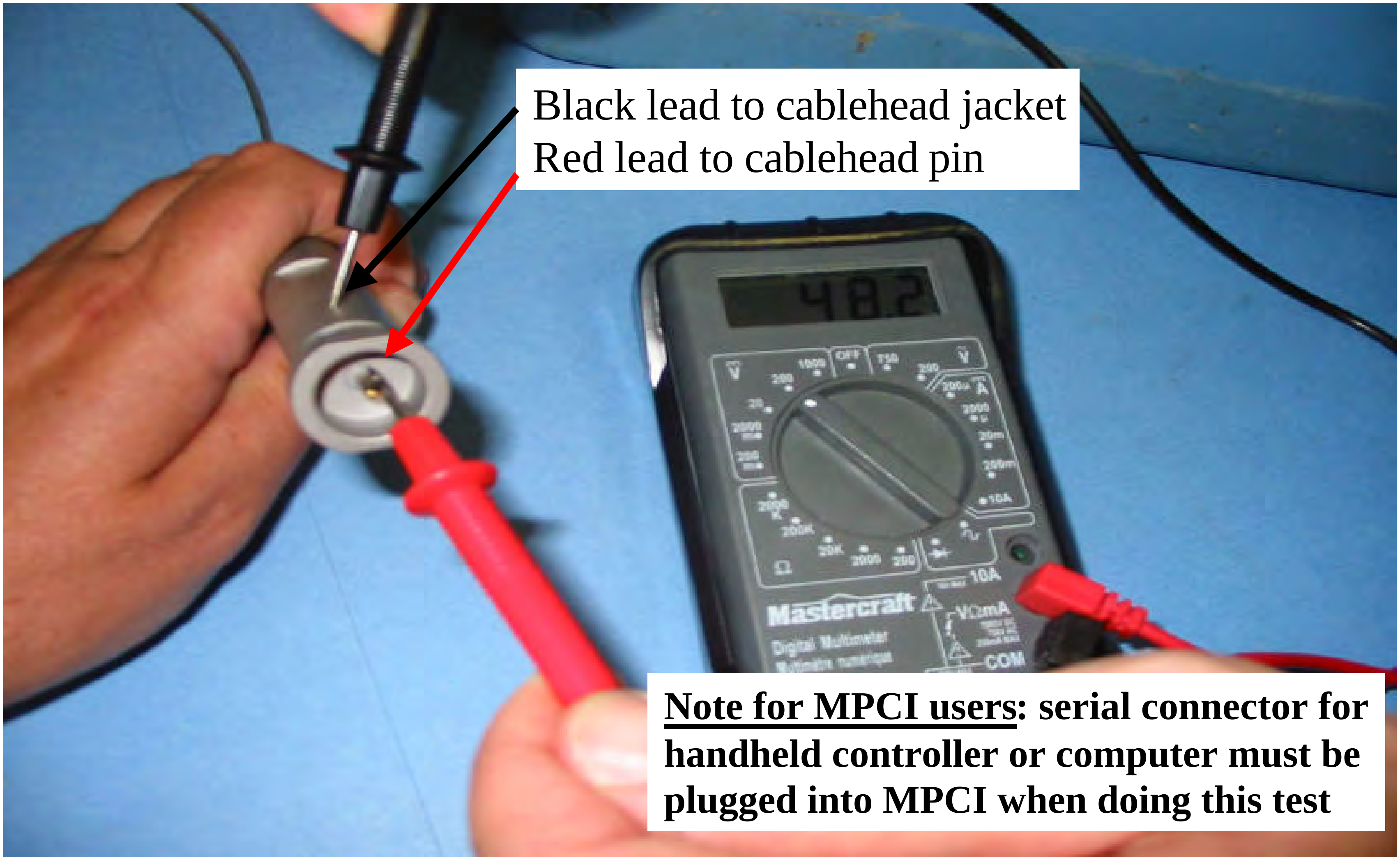
Pic.3 Testing 12 VDC Power Supply using Multimeter



Pic.4 Testing Power Cable Voltage
(should indicate greater than 12.00 V DC for good battery and cable)

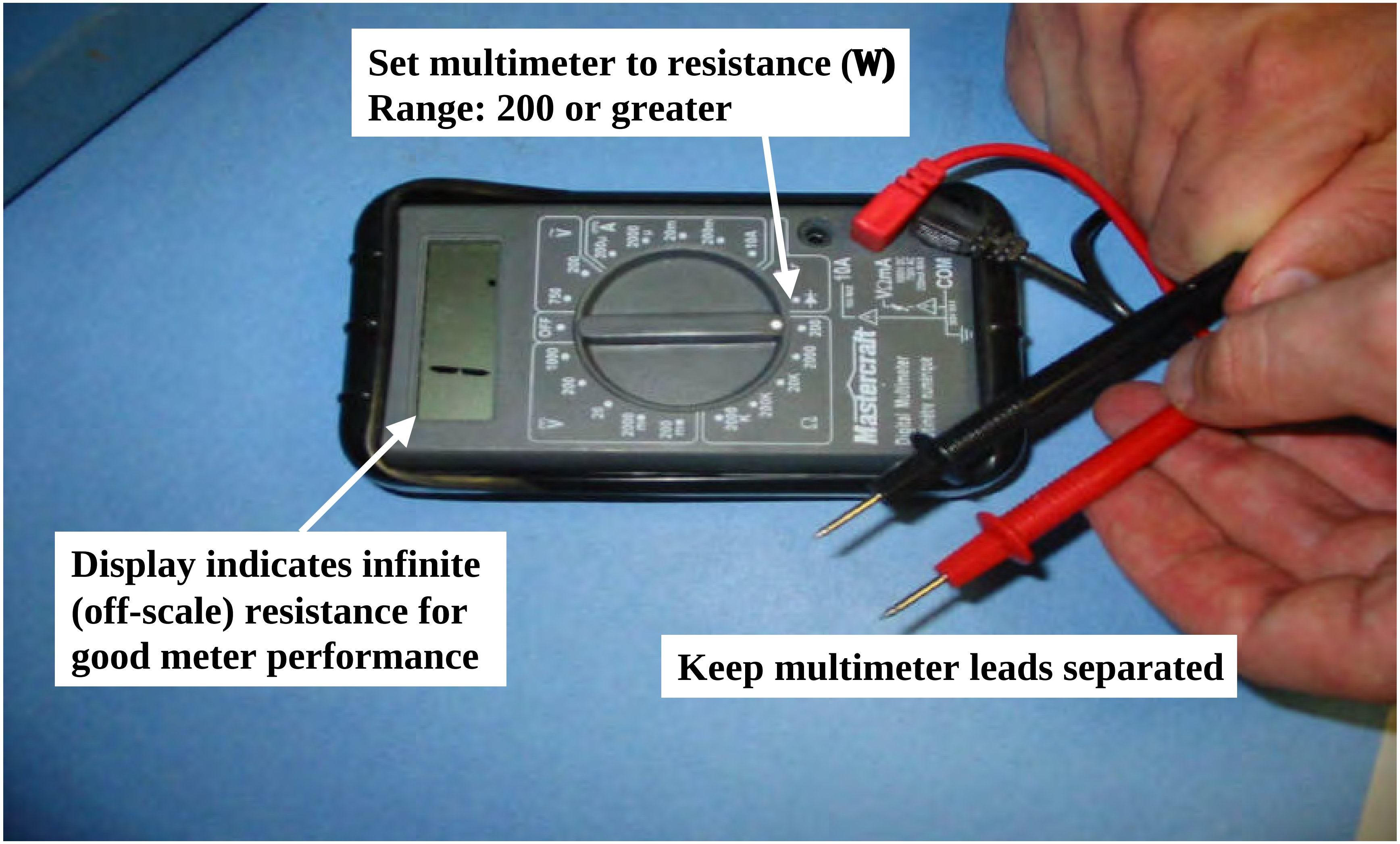


Pic.5 **Testing Power output from MPCI or MAGI using data cable (should be greater than 48 V)** ***Note: MPCI/MAGI must have power 'on' and be connected to power supply.***

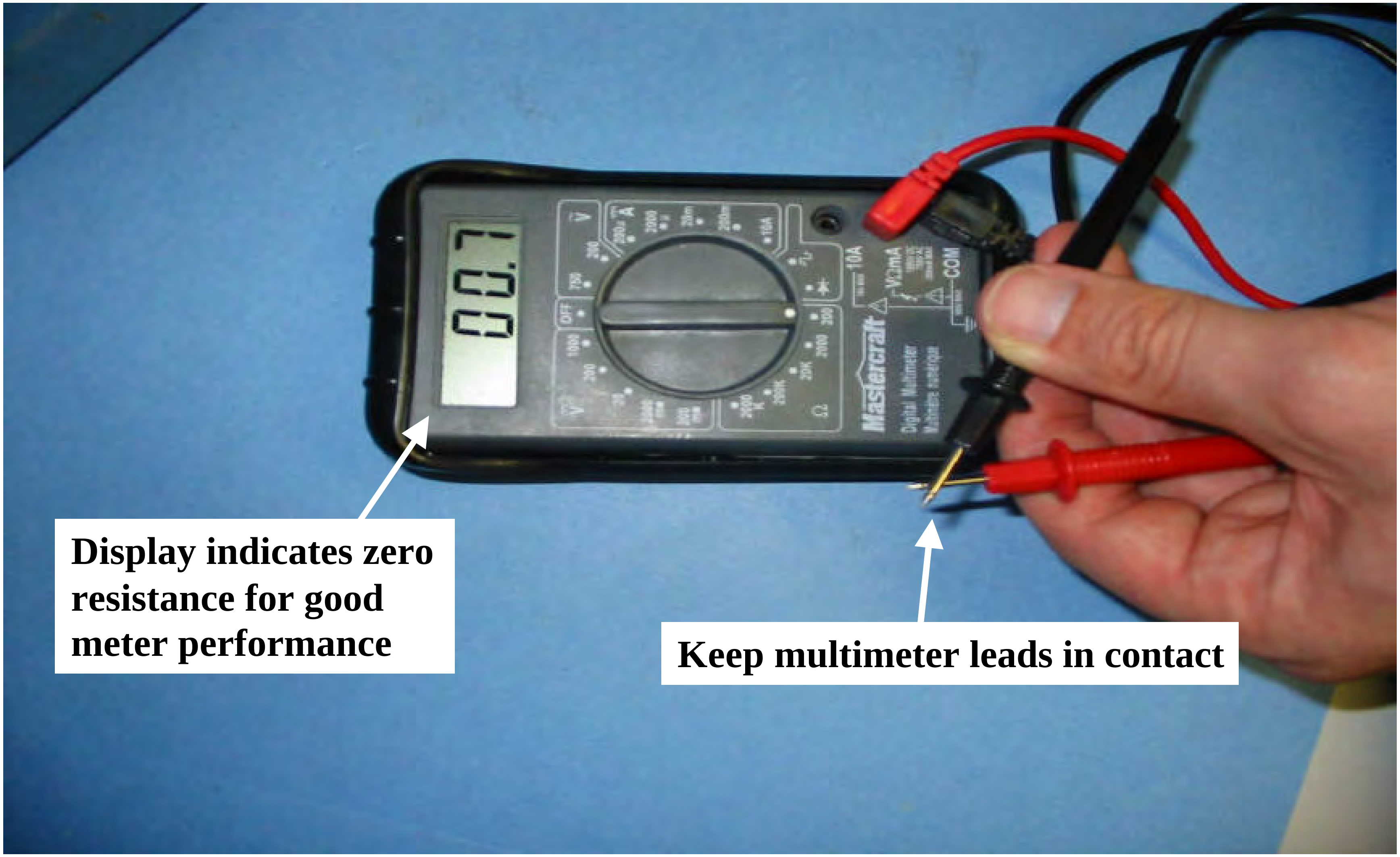


Pic.6 Checking power output at cablehead (should be greater than 48 V)

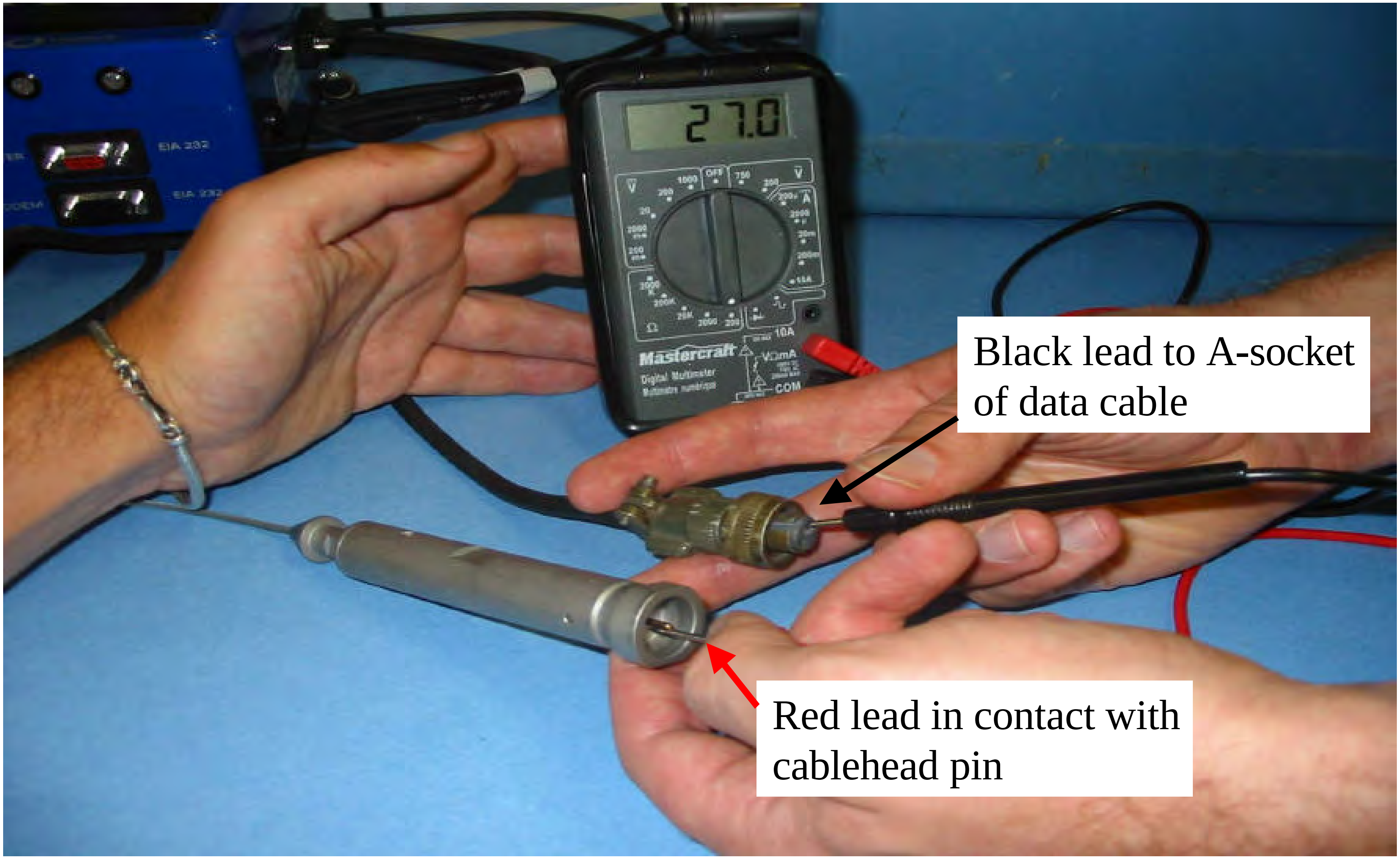
Note: MPCI/MAGI must have power 'on' and be connected to power supply.



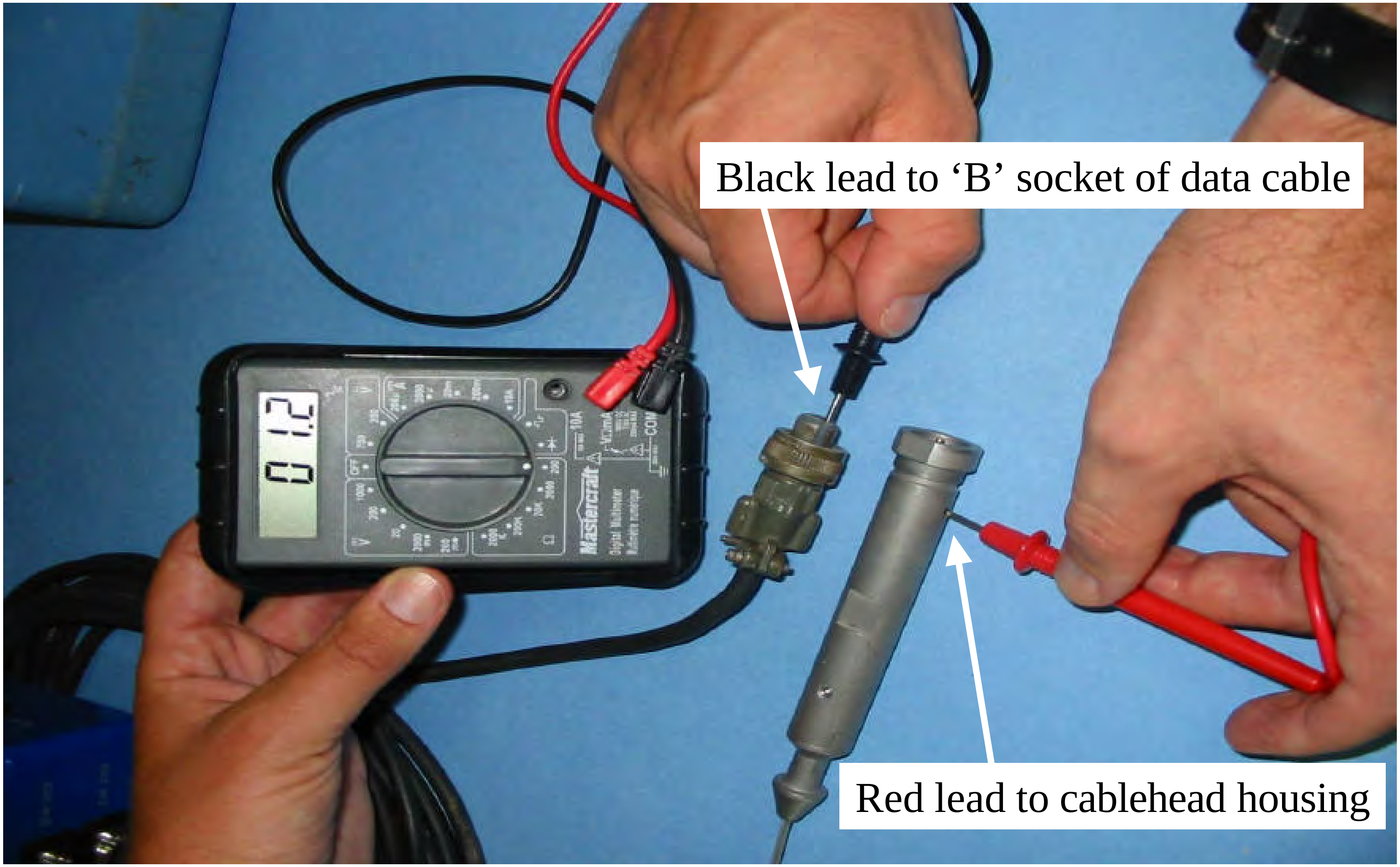
Pic.7 Test multimeter "open" resistence



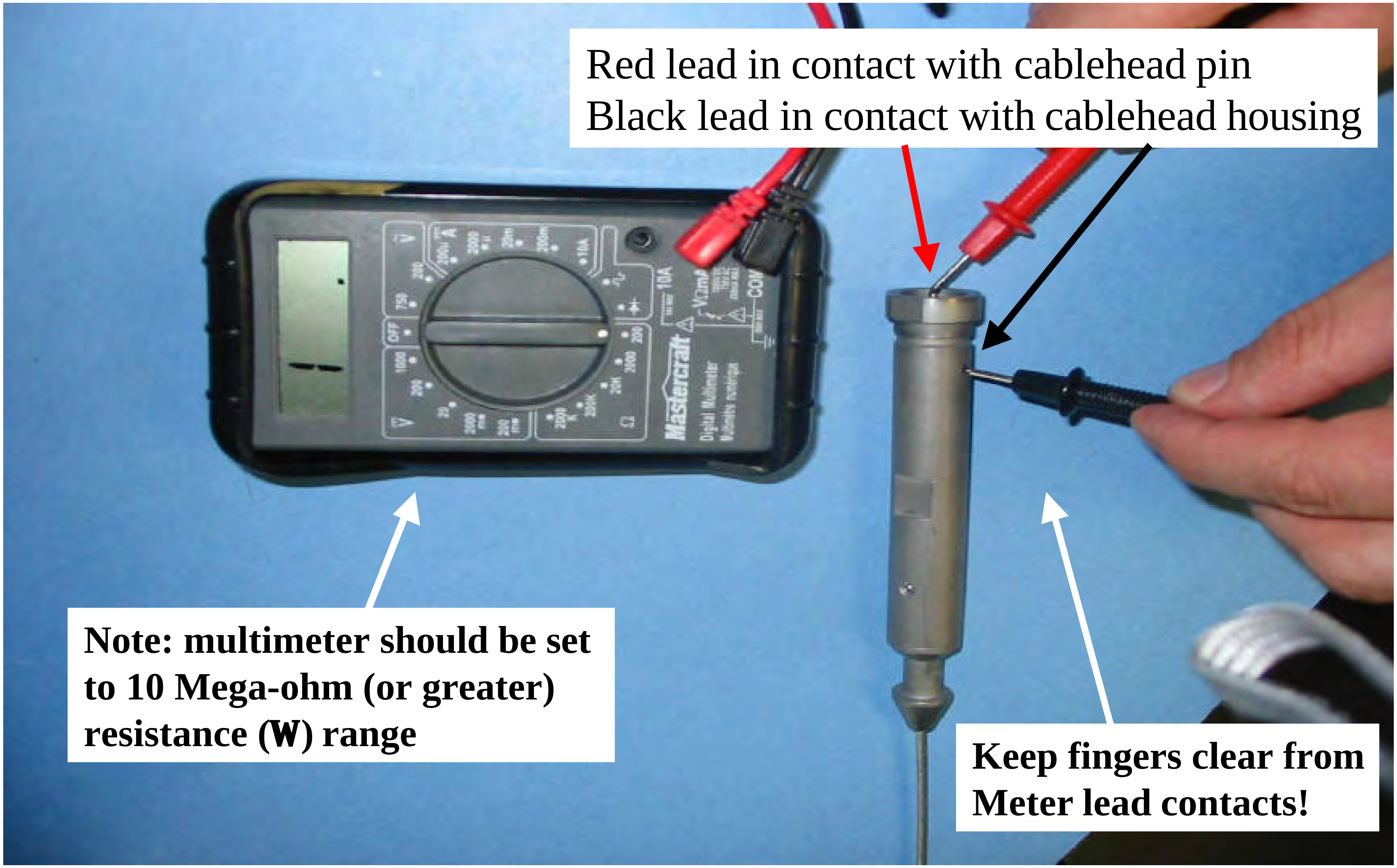
Pic.8 Test multimeter “closed” resistence



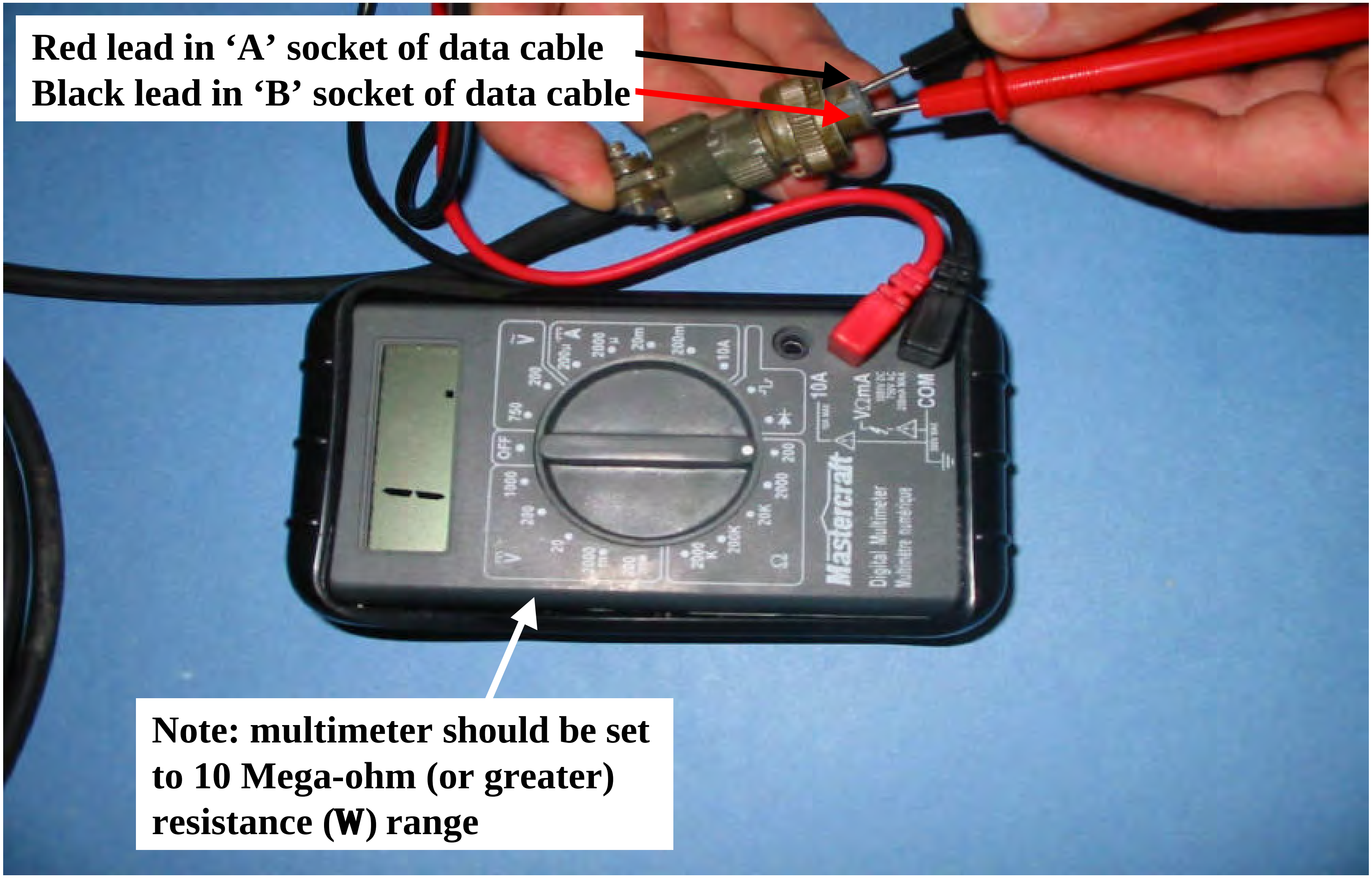
Pic.9 Test wireline ‘A-A’ resistance (approx. 27 W/1000 ft)



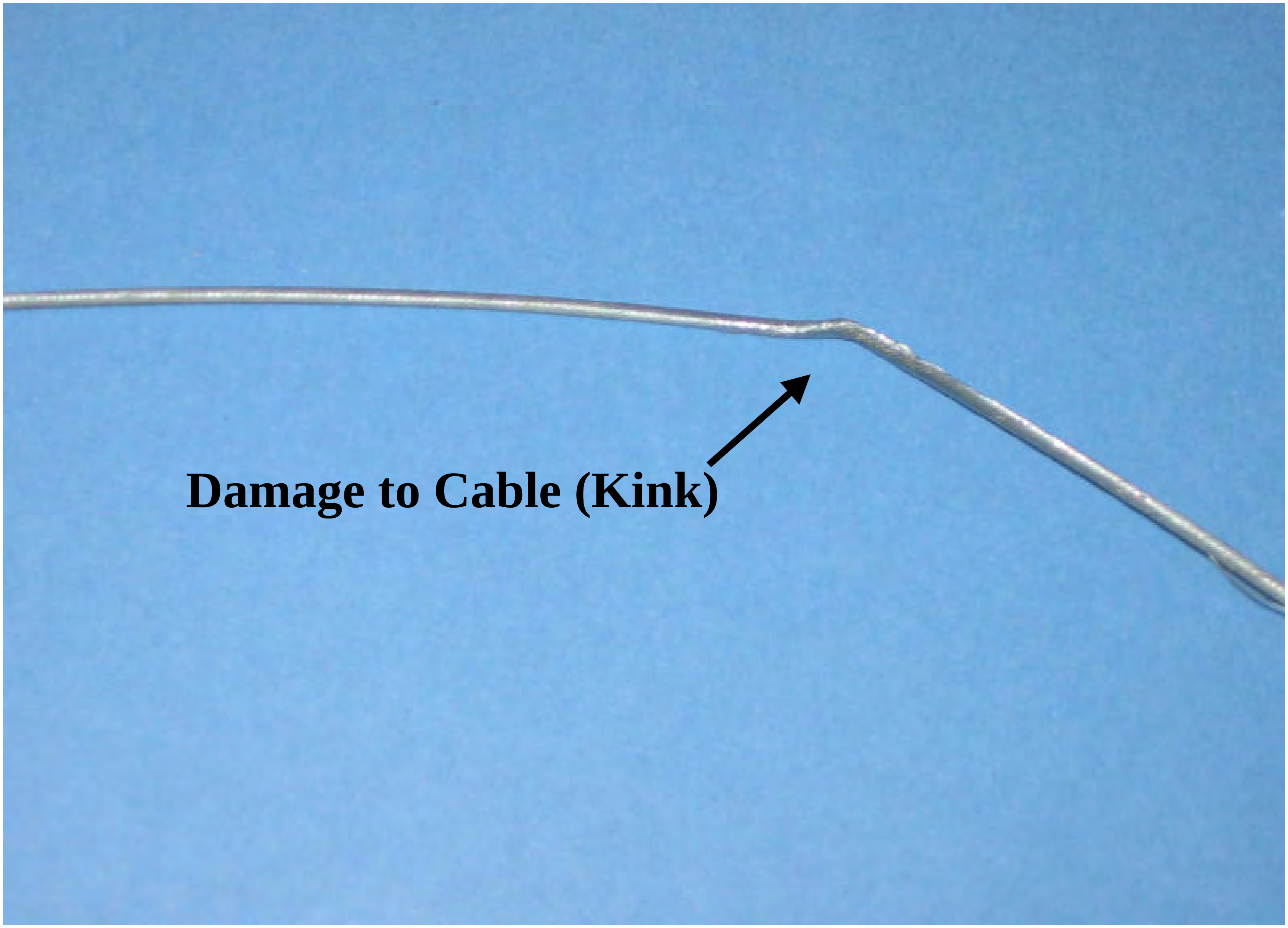
Pic.10 Test wireline ‘B-B’ resistance (should be less than ‘A-A’)



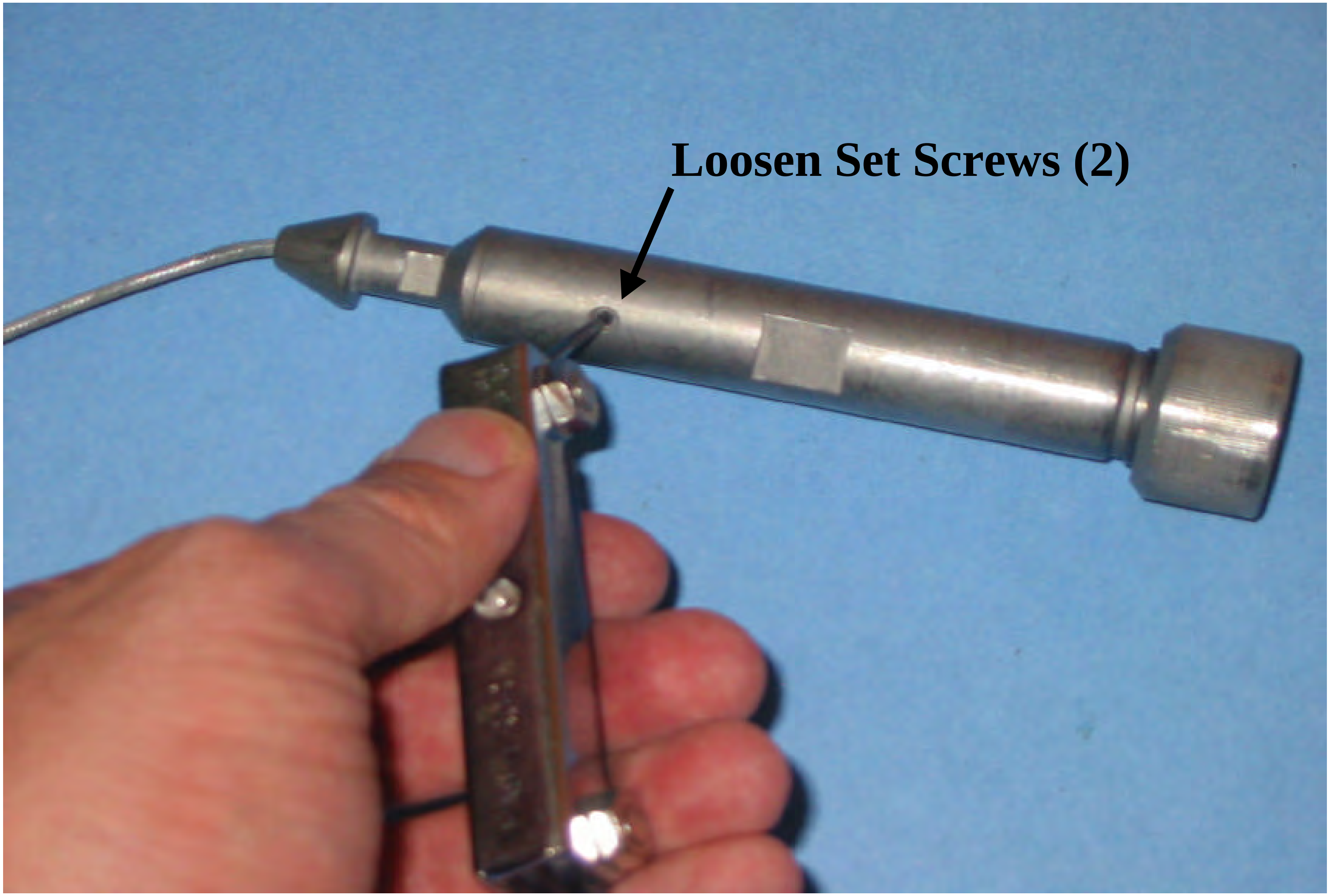
Pic.11 Test wireline 'A-B' resistance at cablehead (should be off-scale)



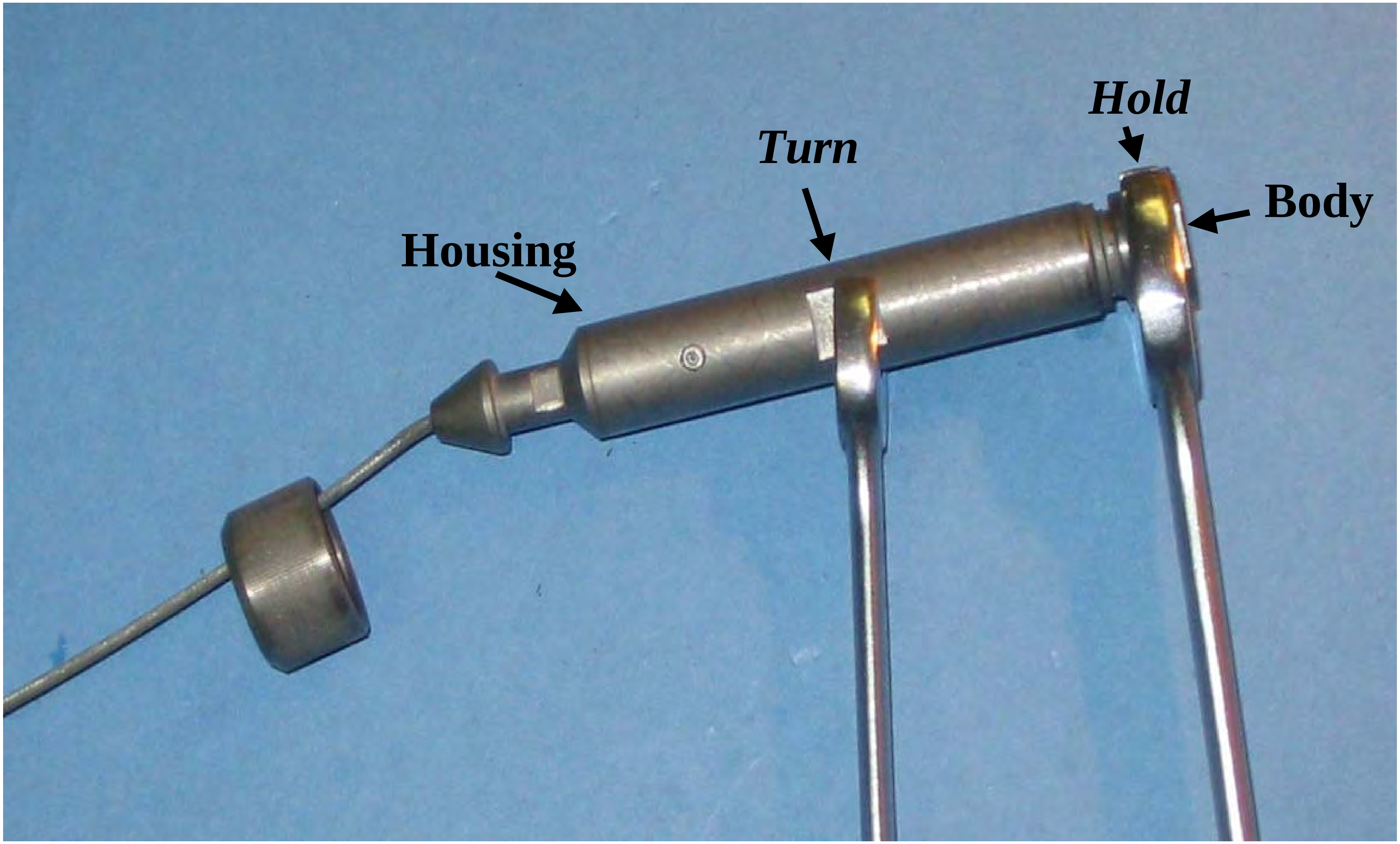
Pic.11 Test wireline ‘A-B’ resistance at data cable (should be off-scale)



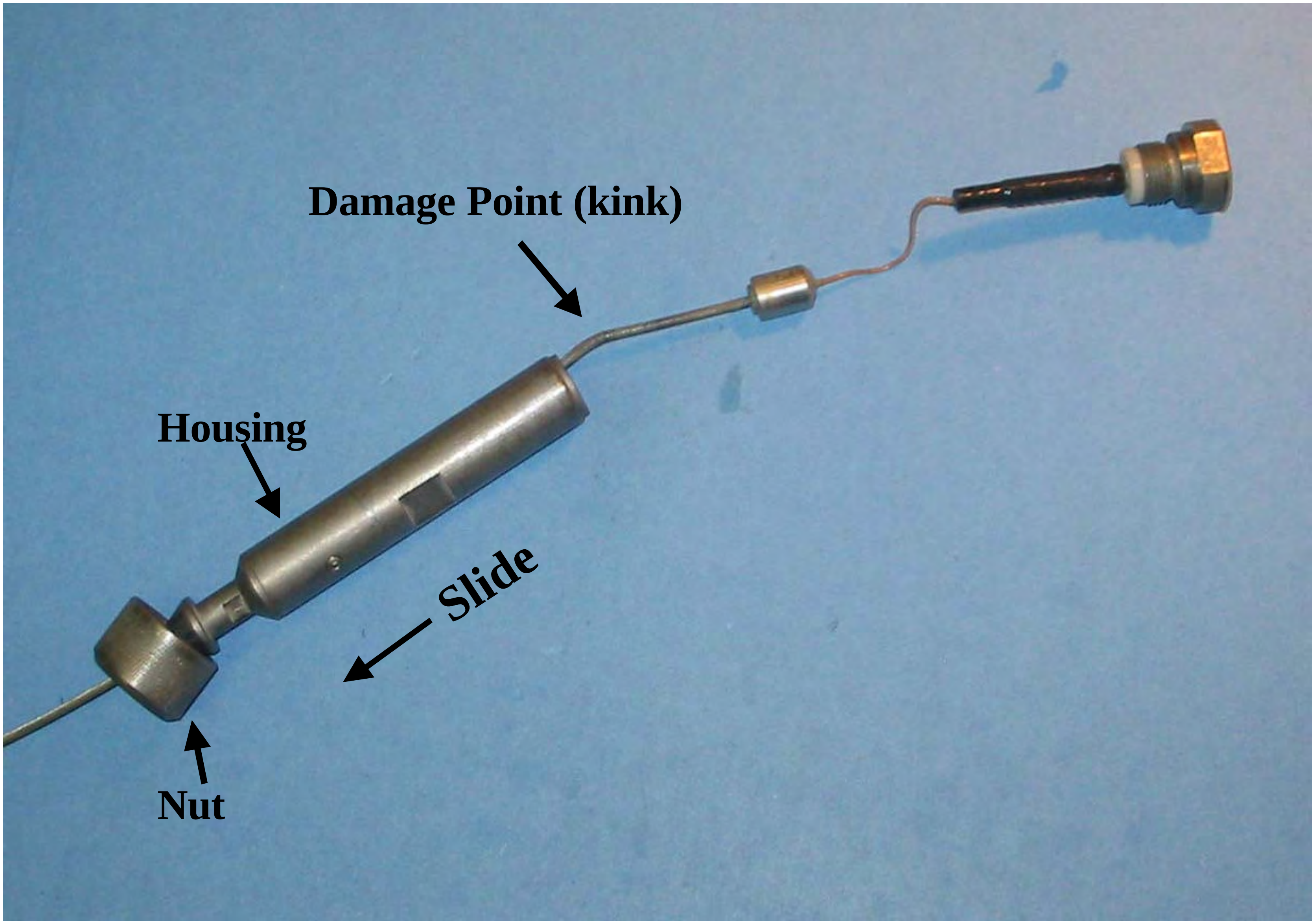
Pic.1 Identification of Cable Damage



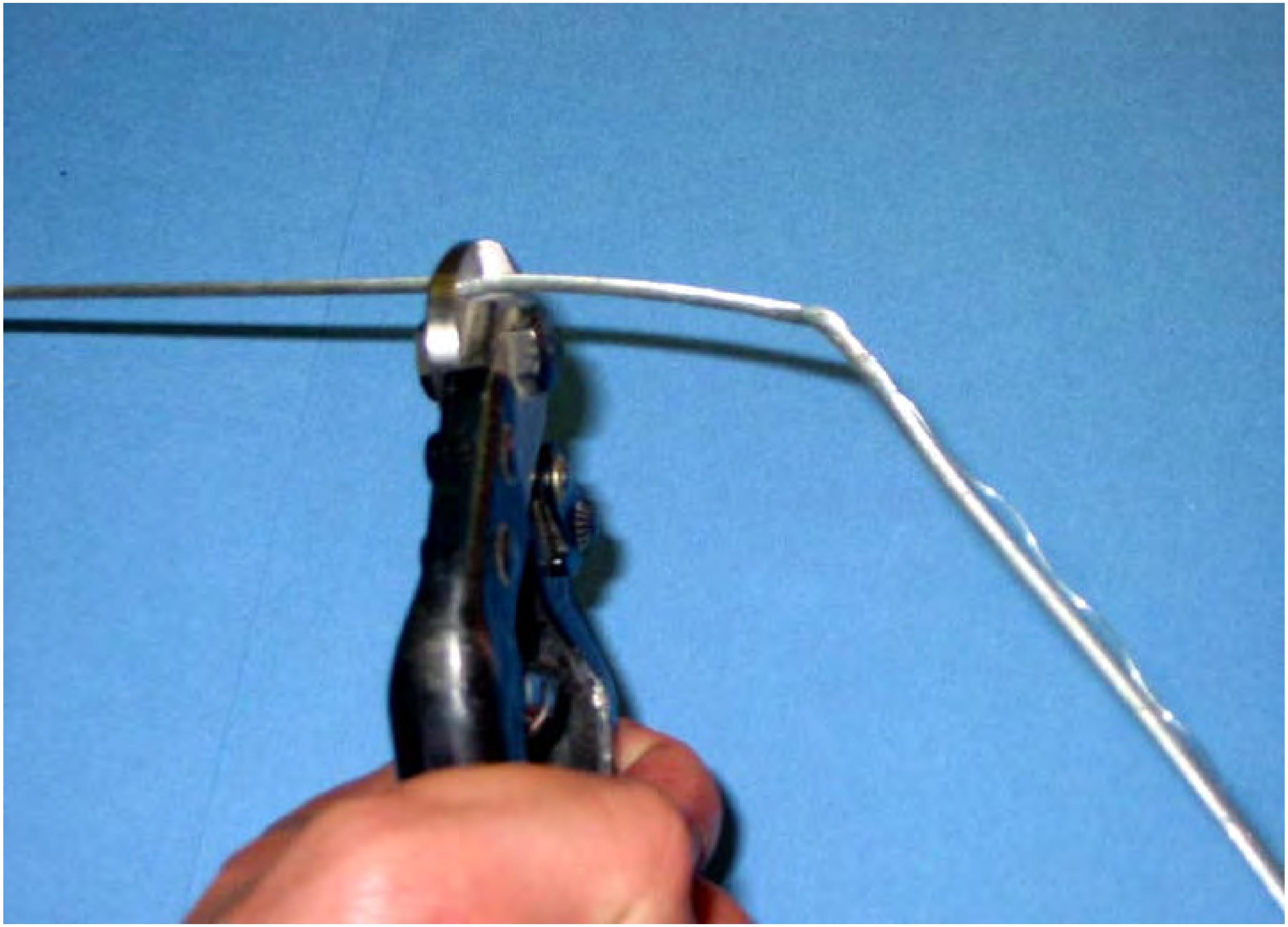
Pic.2 Cablehead Disassembly (1): Loosen set Screws



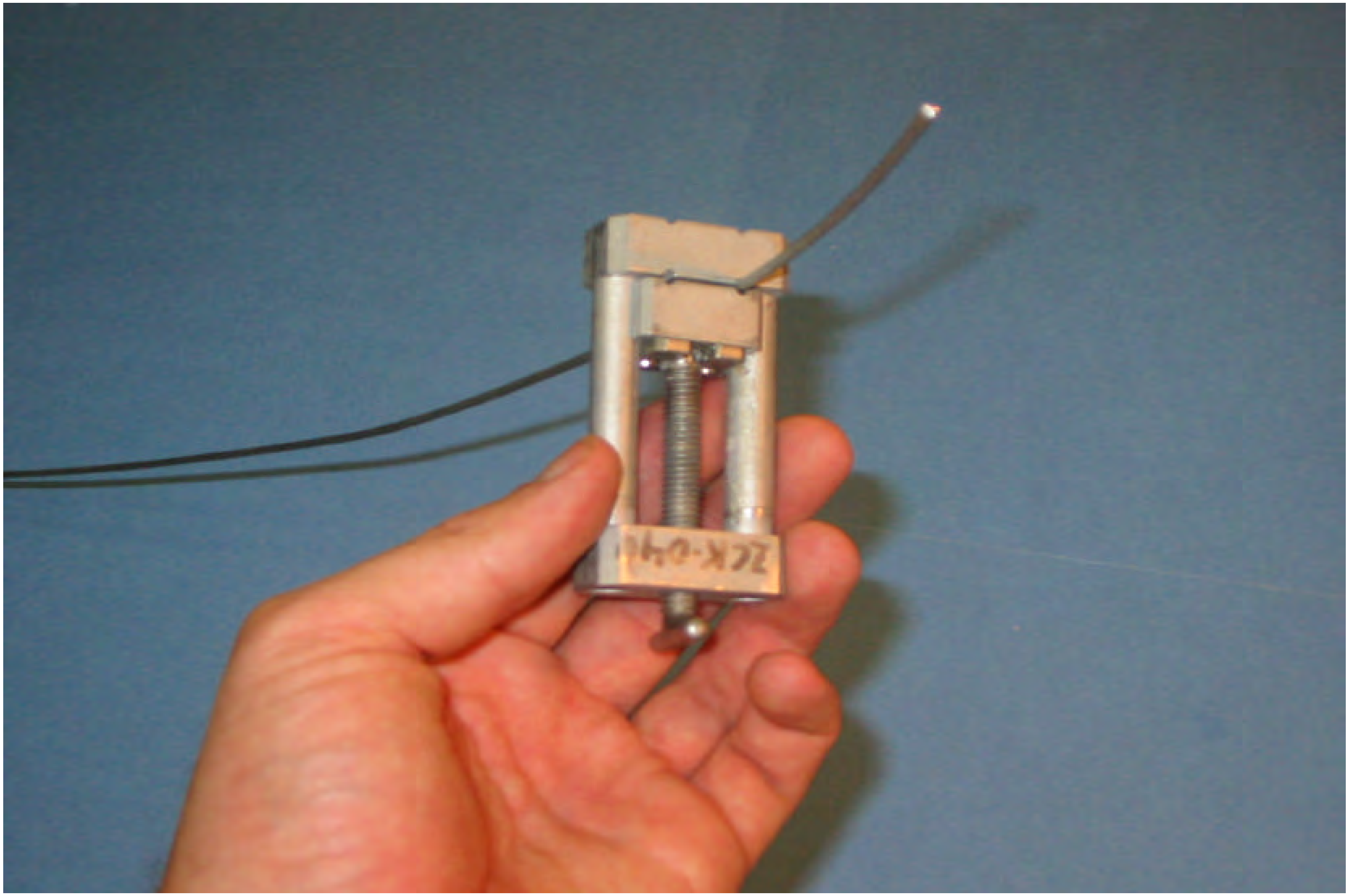
Pic.3 Cablehead Disassembly(2): Unscrew Housing From Body



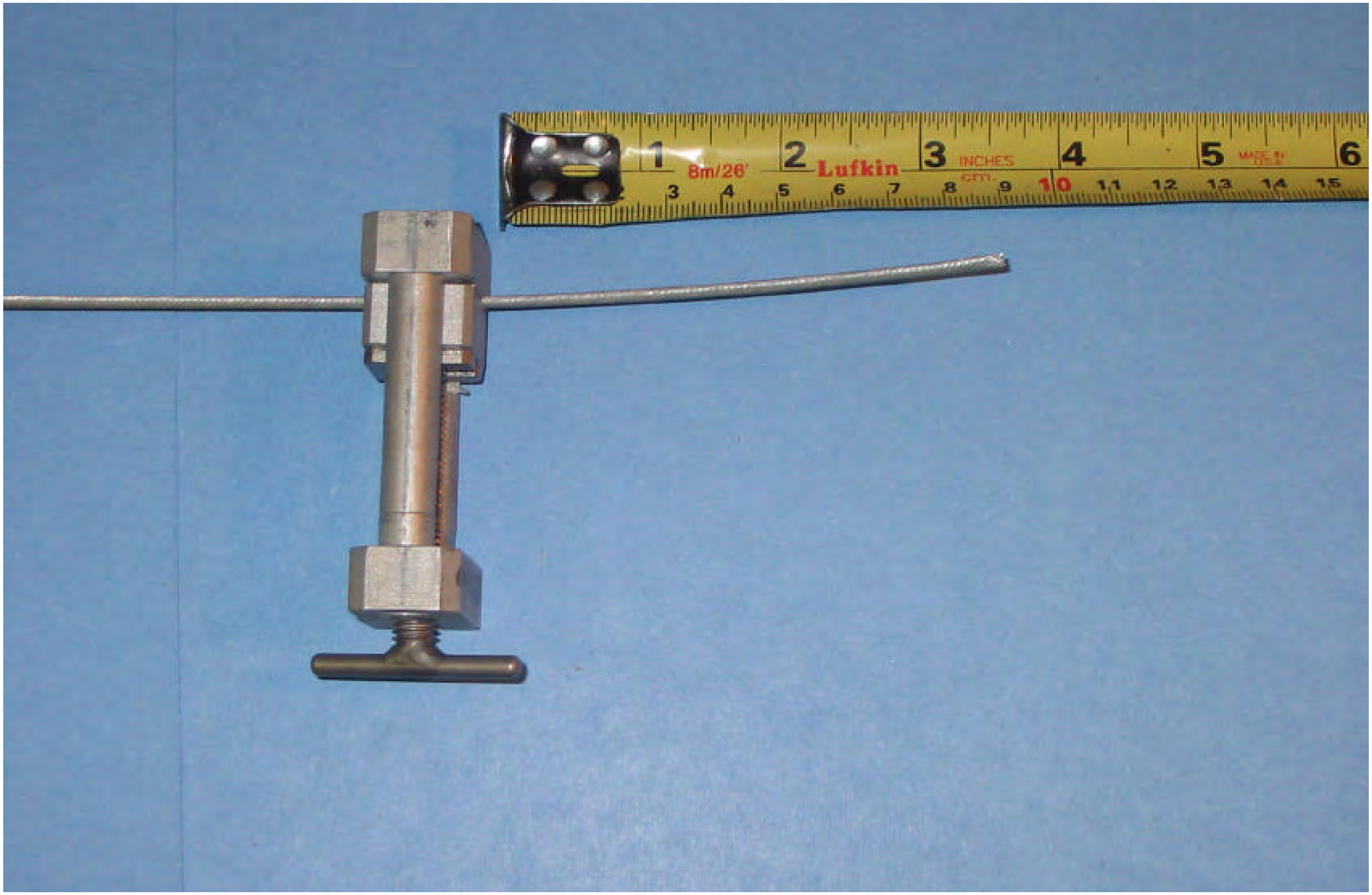
Pic.4 Cablehead Disassembly(3):
Slide Housing and Cablehead Nut Past Damage Point



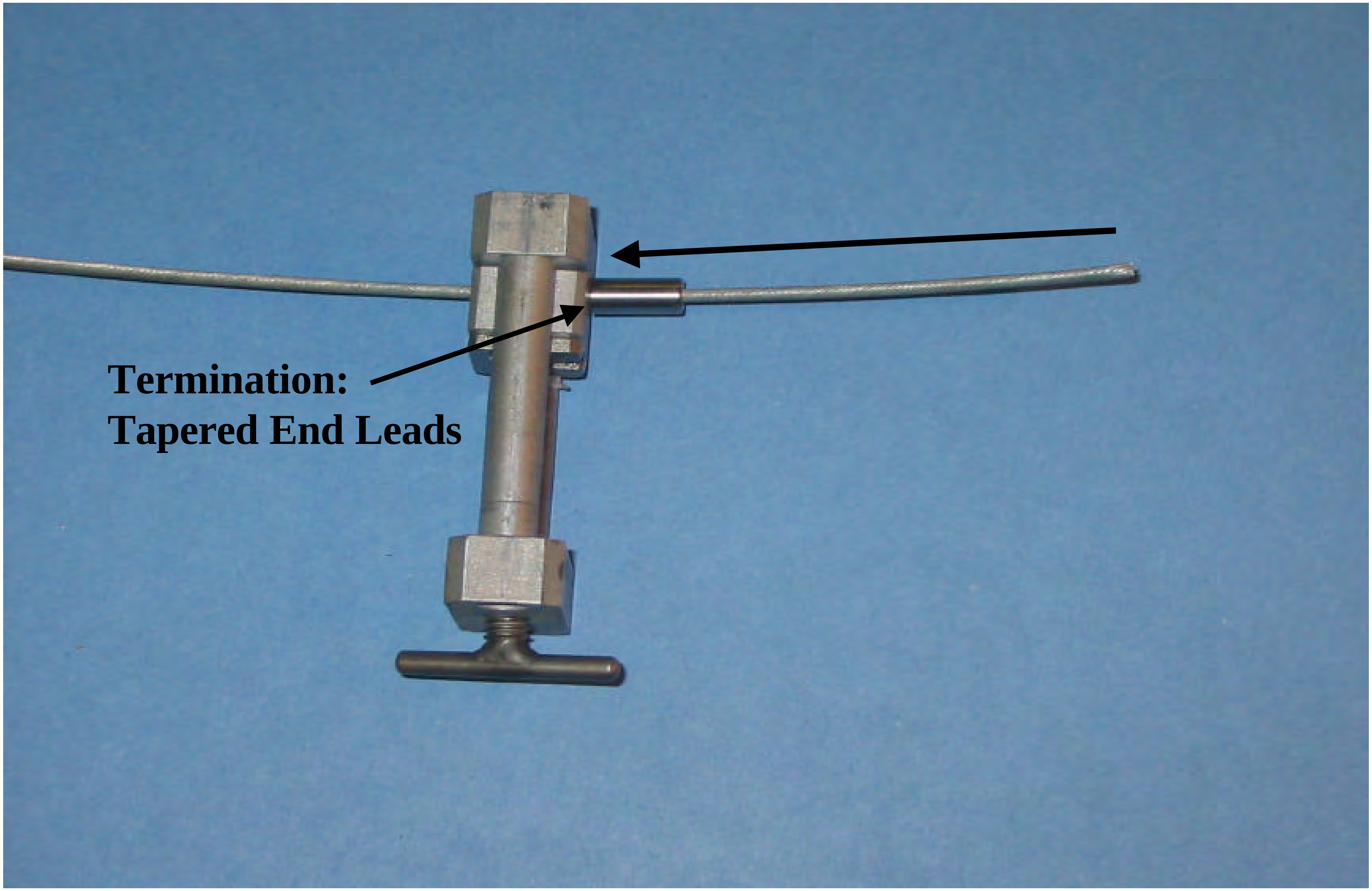
Pic.5 Cut Cable above Damage Point



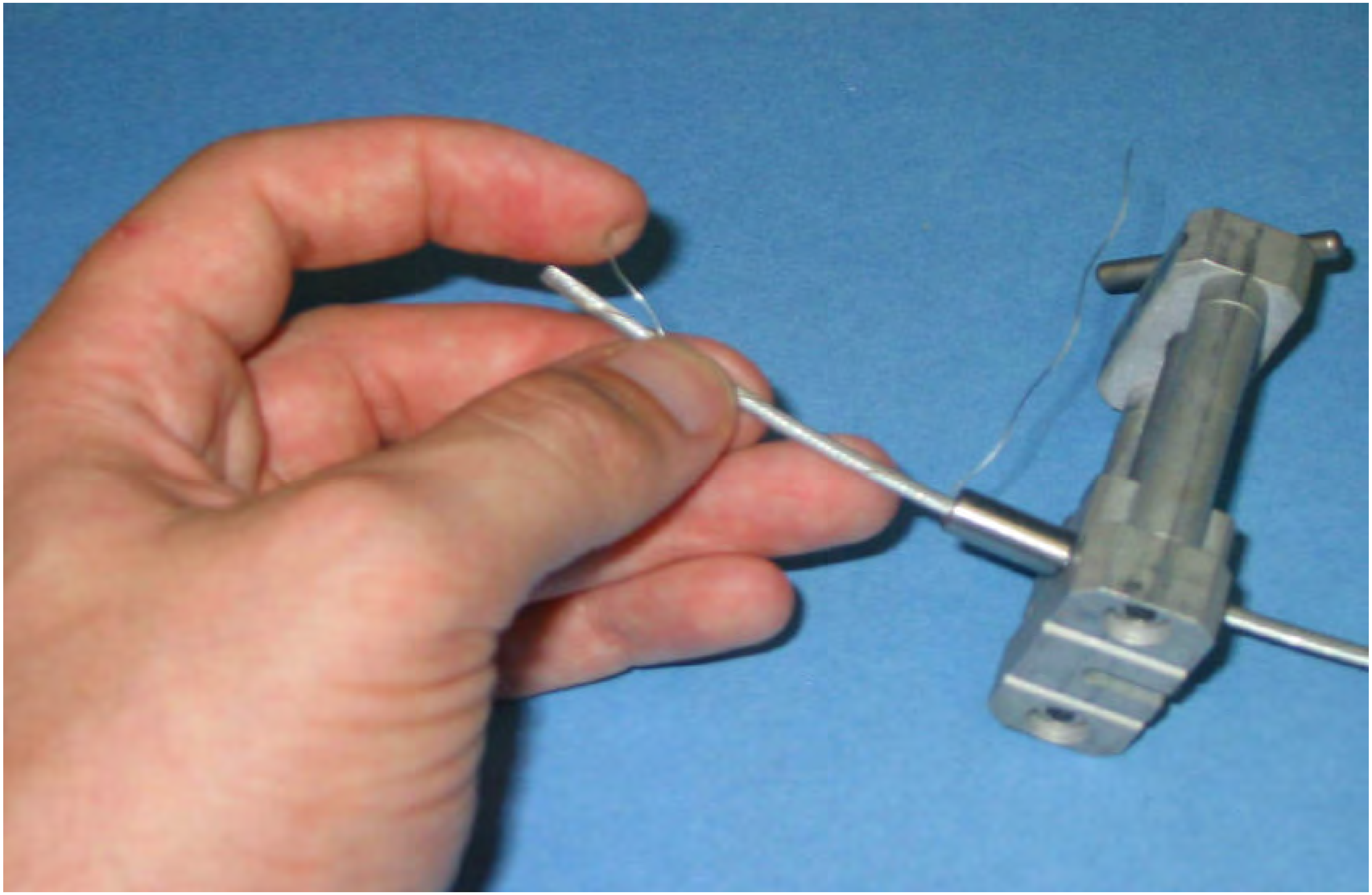
Pic.6a Clamp Cable in Termination Jig



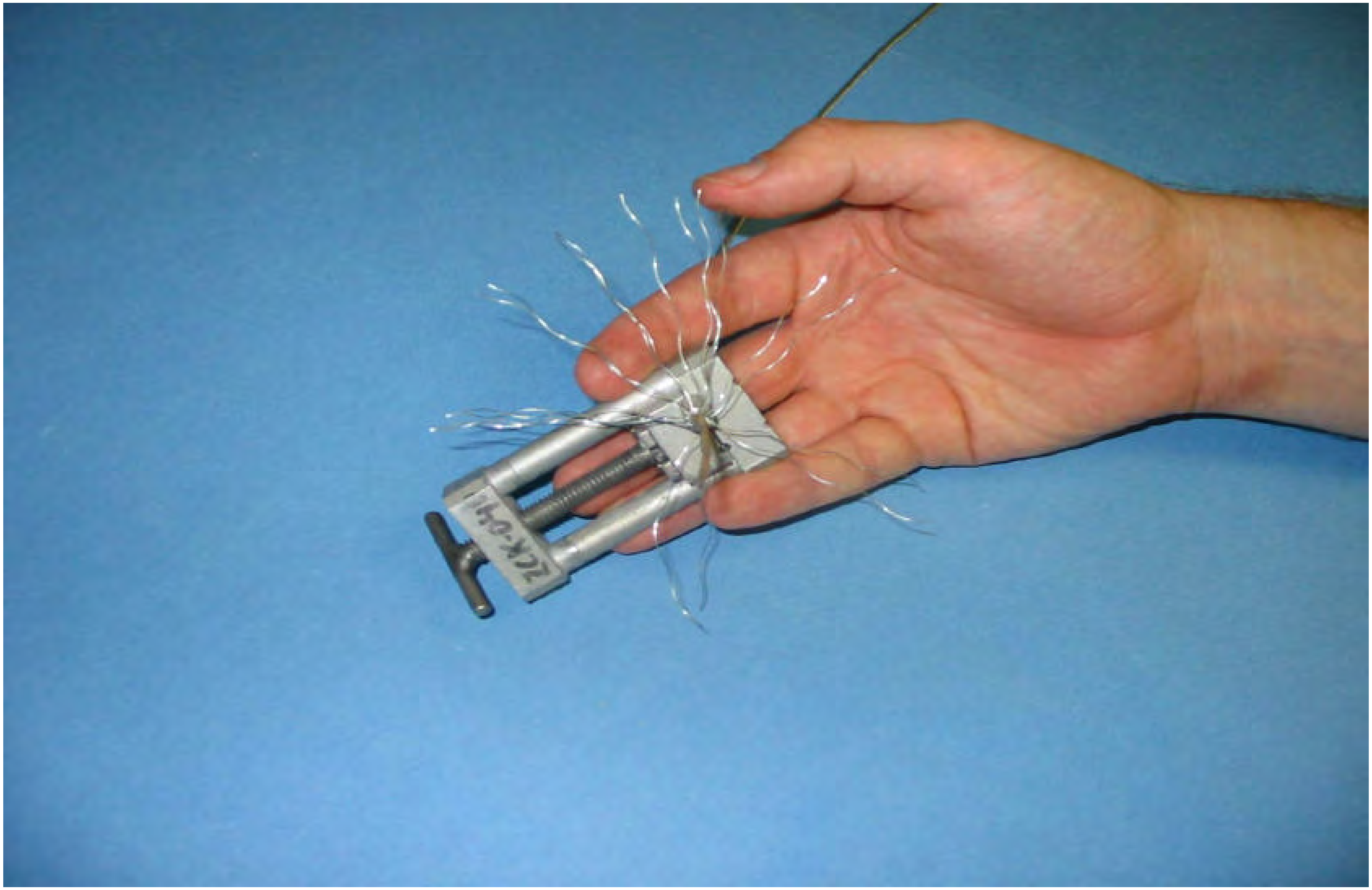
Pic.6b Leave 3.5 inches Cable Exposed



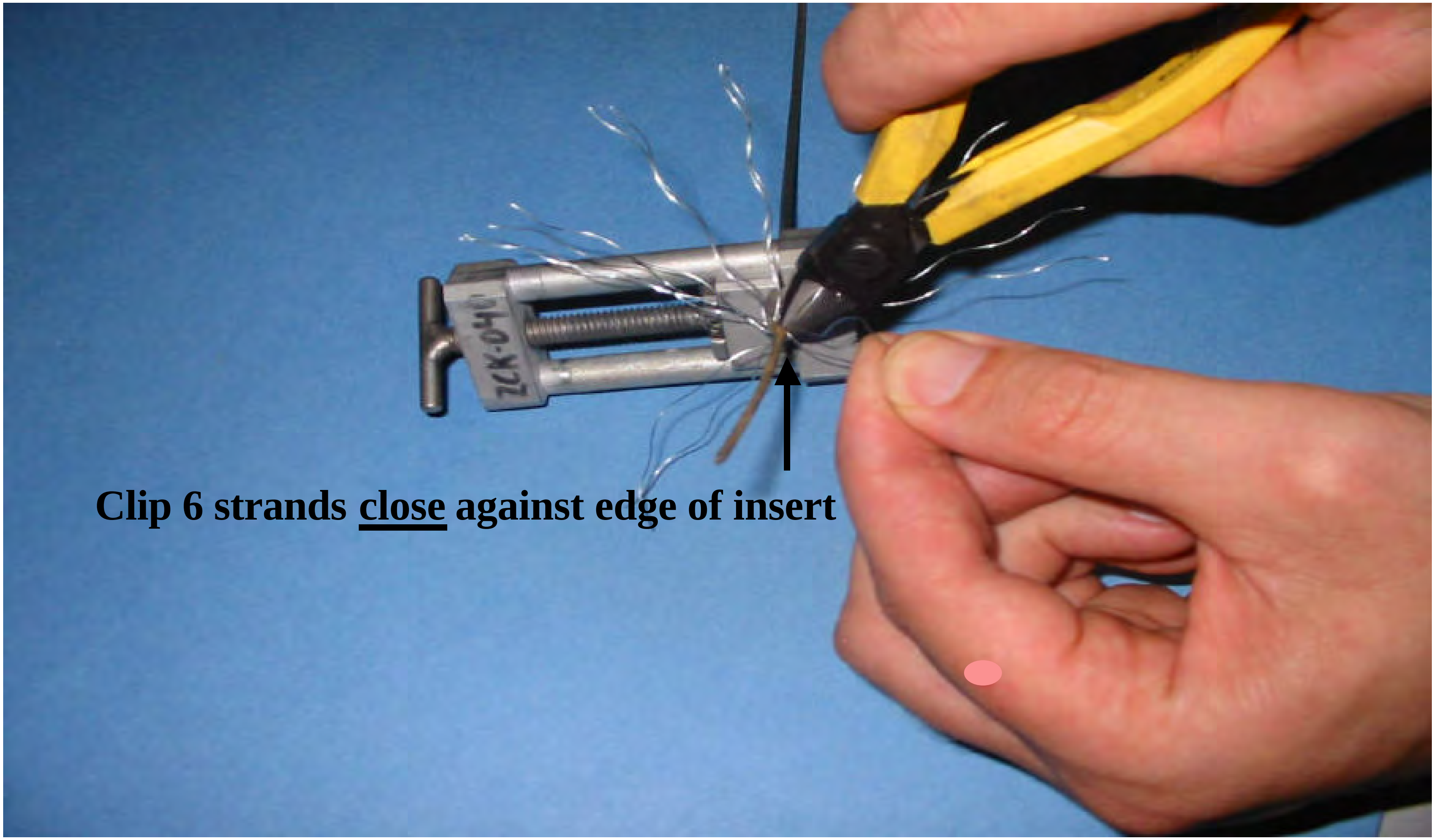
Pic.6c Slide Termination Insert Over Cable



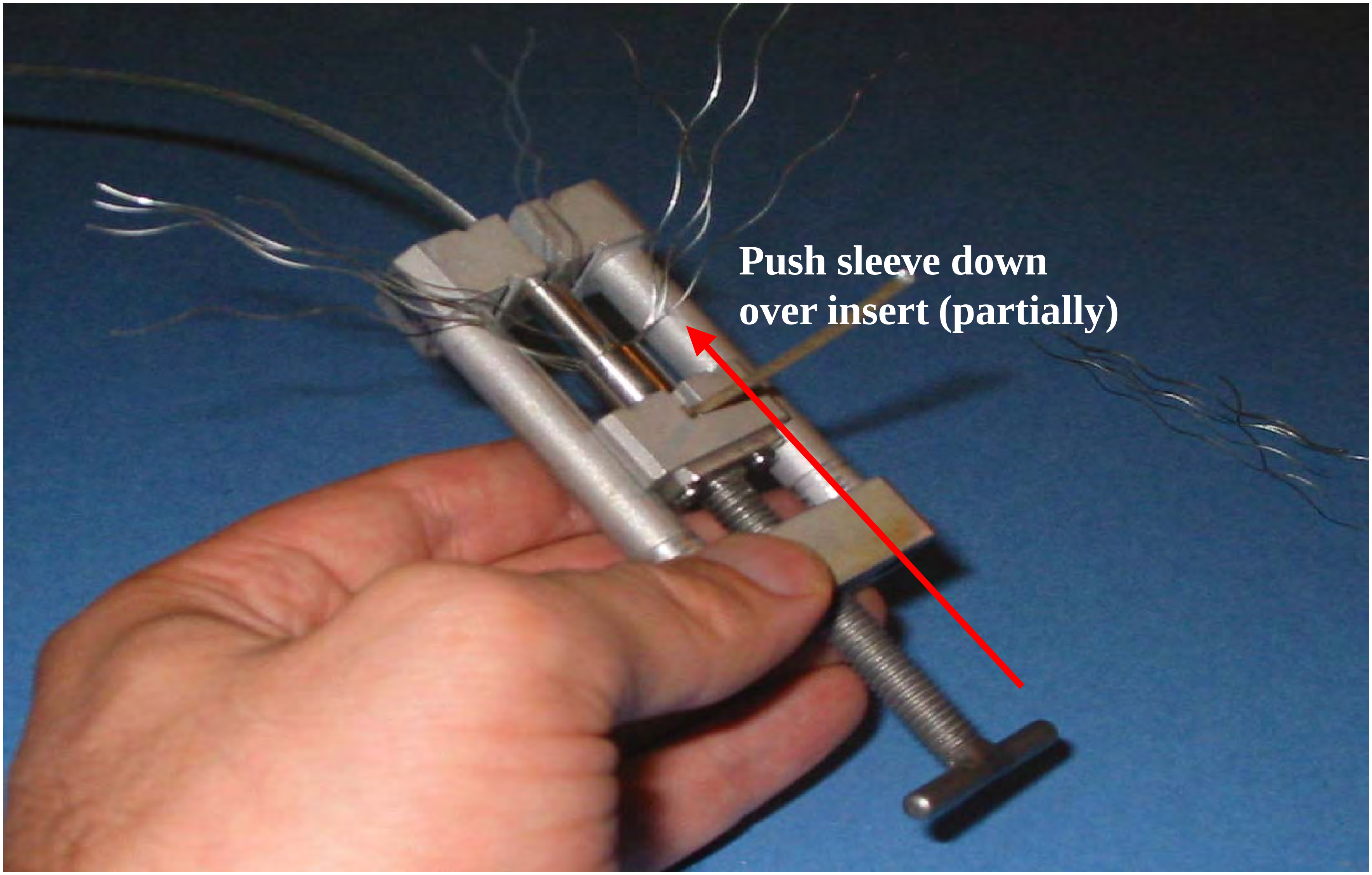
Pic.7a   Unwind Outer-layer Strands (start)



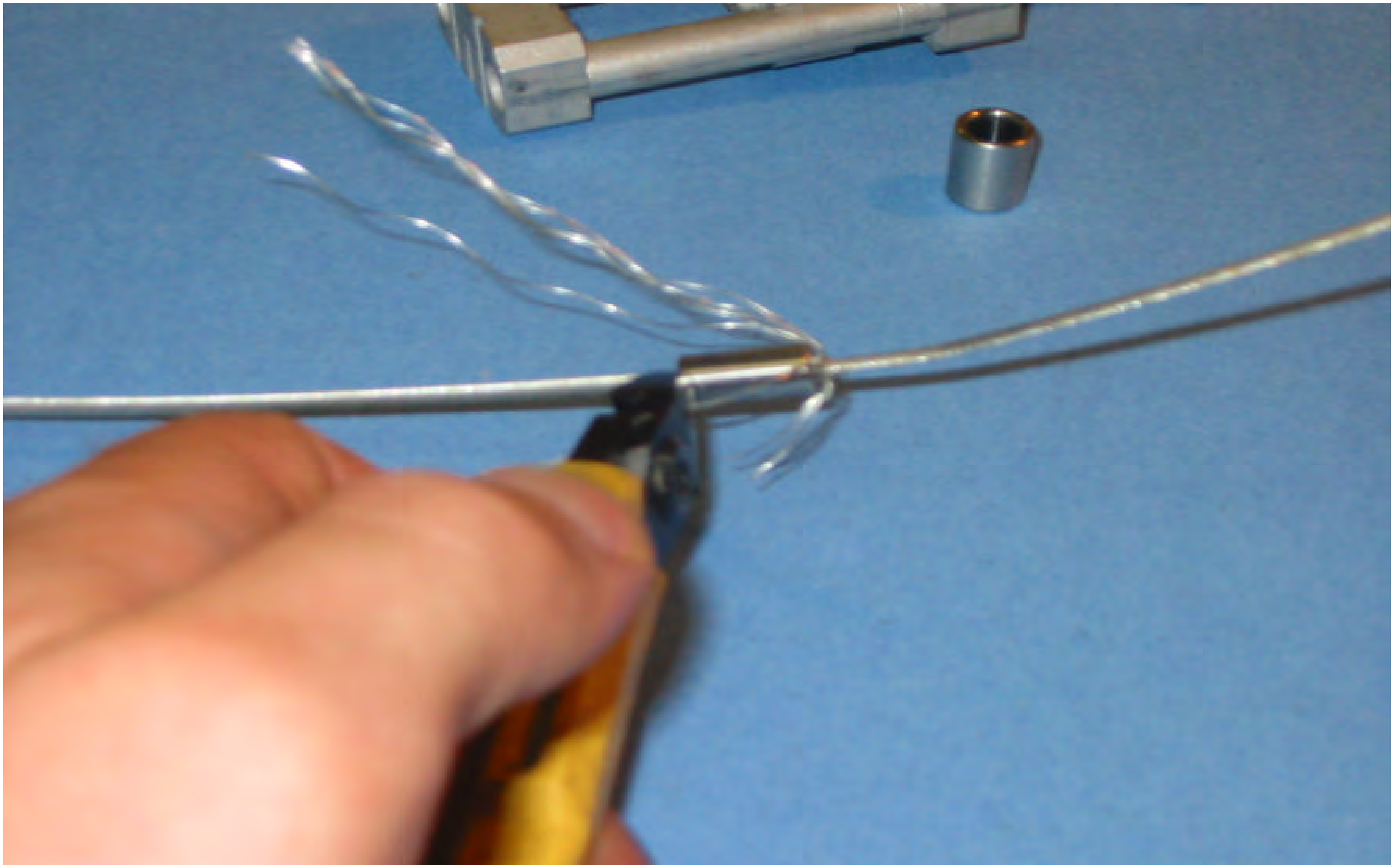
Pic.7b Unwind Outer Layer Strands (finish)



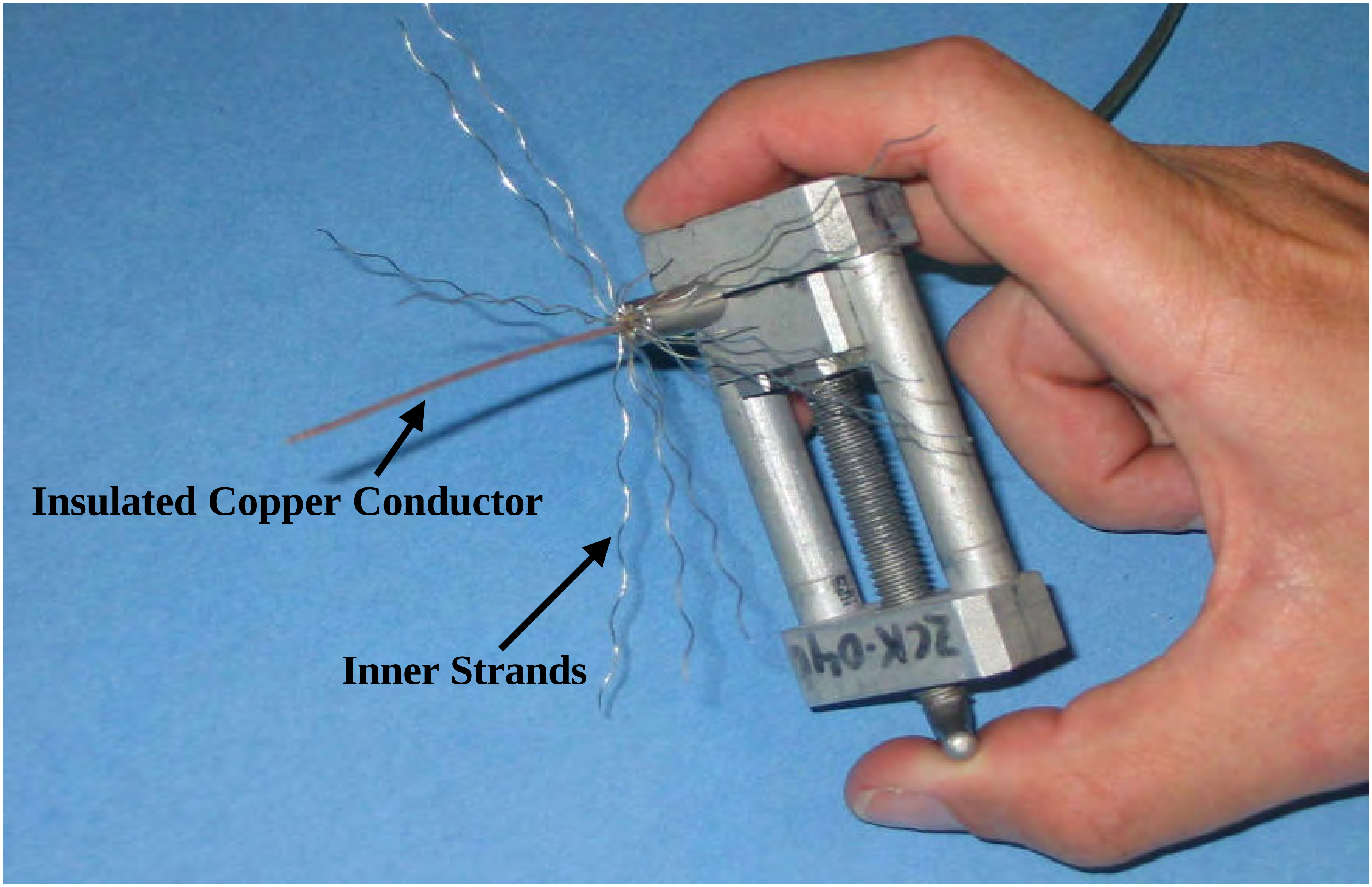
Pic.8 Clipping Outer Wire Strands (6 strands out of 18)



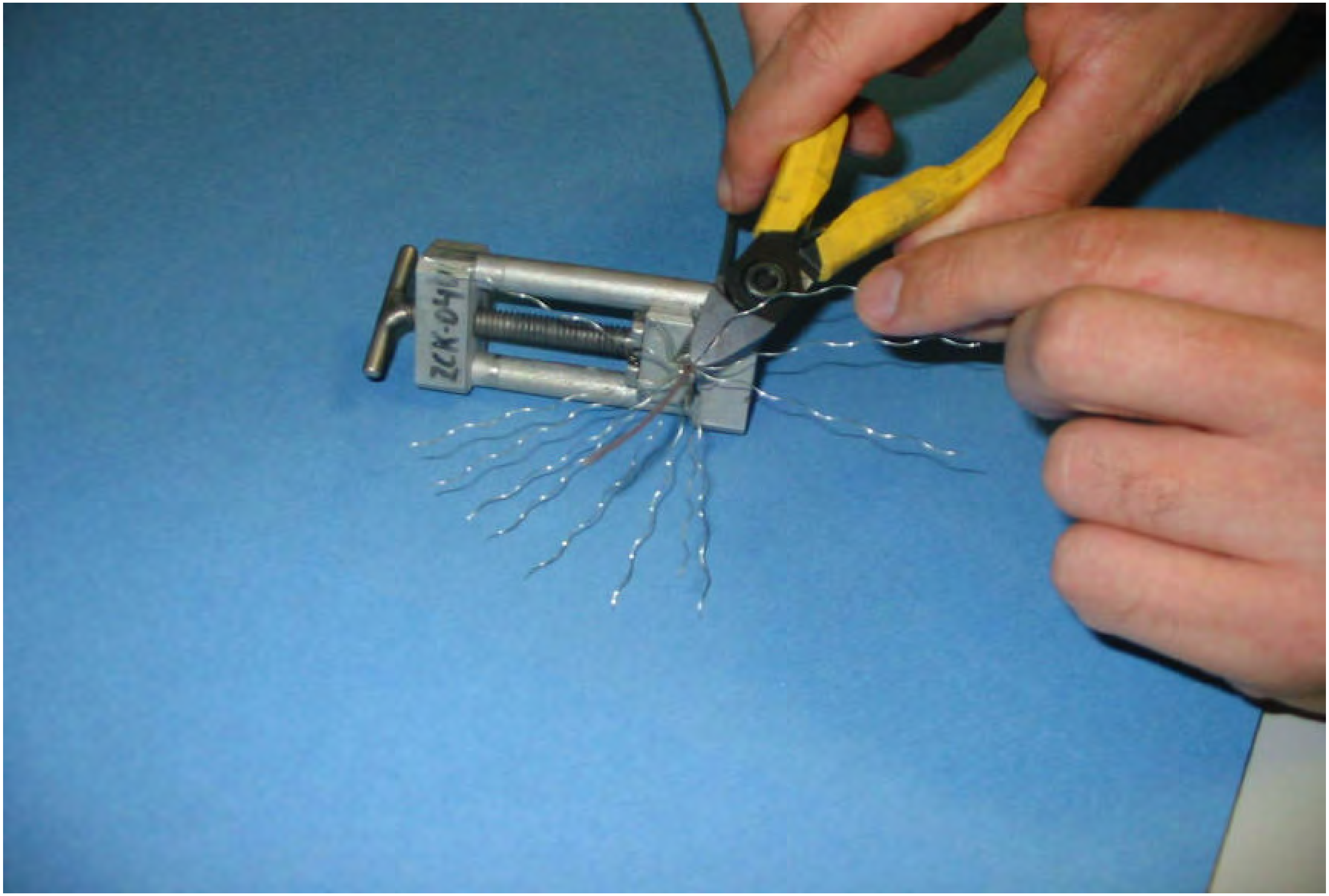
Pic.9 Partially Push Sleeve Down on Insert Using Jig (enough to bend strands down along insert)



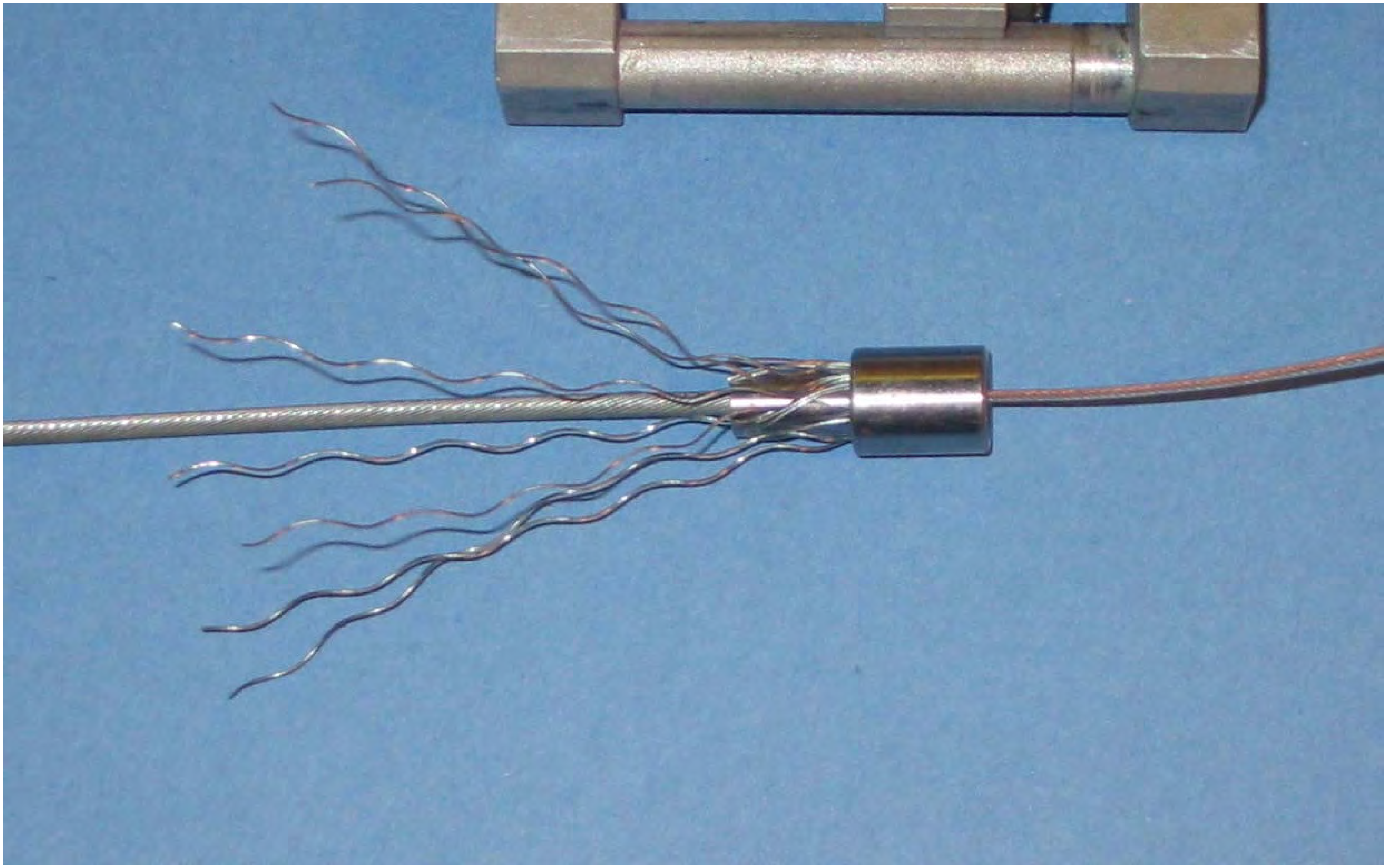
Pic.10 Trim Outer Wire Strands to Base of Insert.



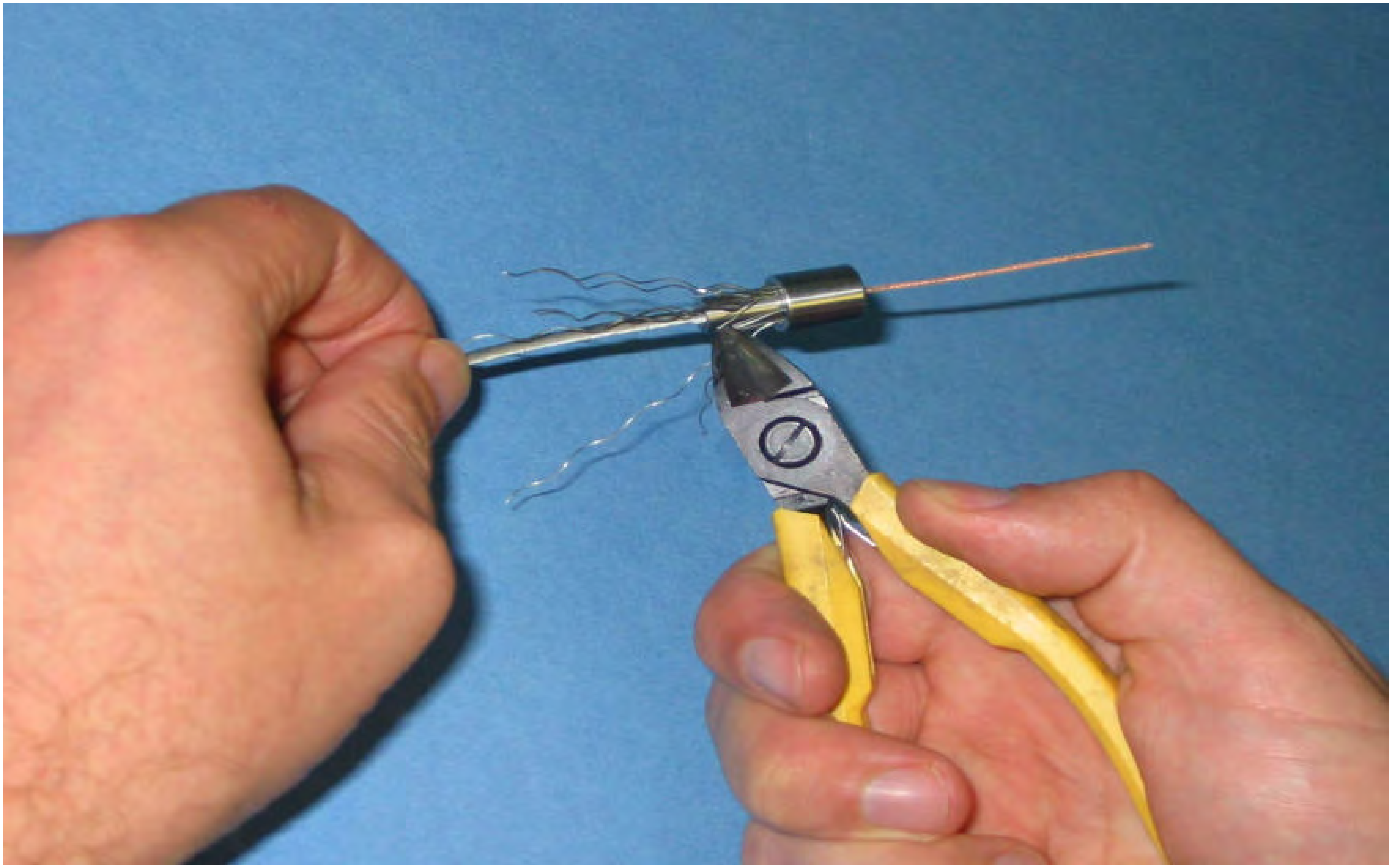
Pic.11 Unwind inner-layer strands of armor (exposing the insulated conductor wire)



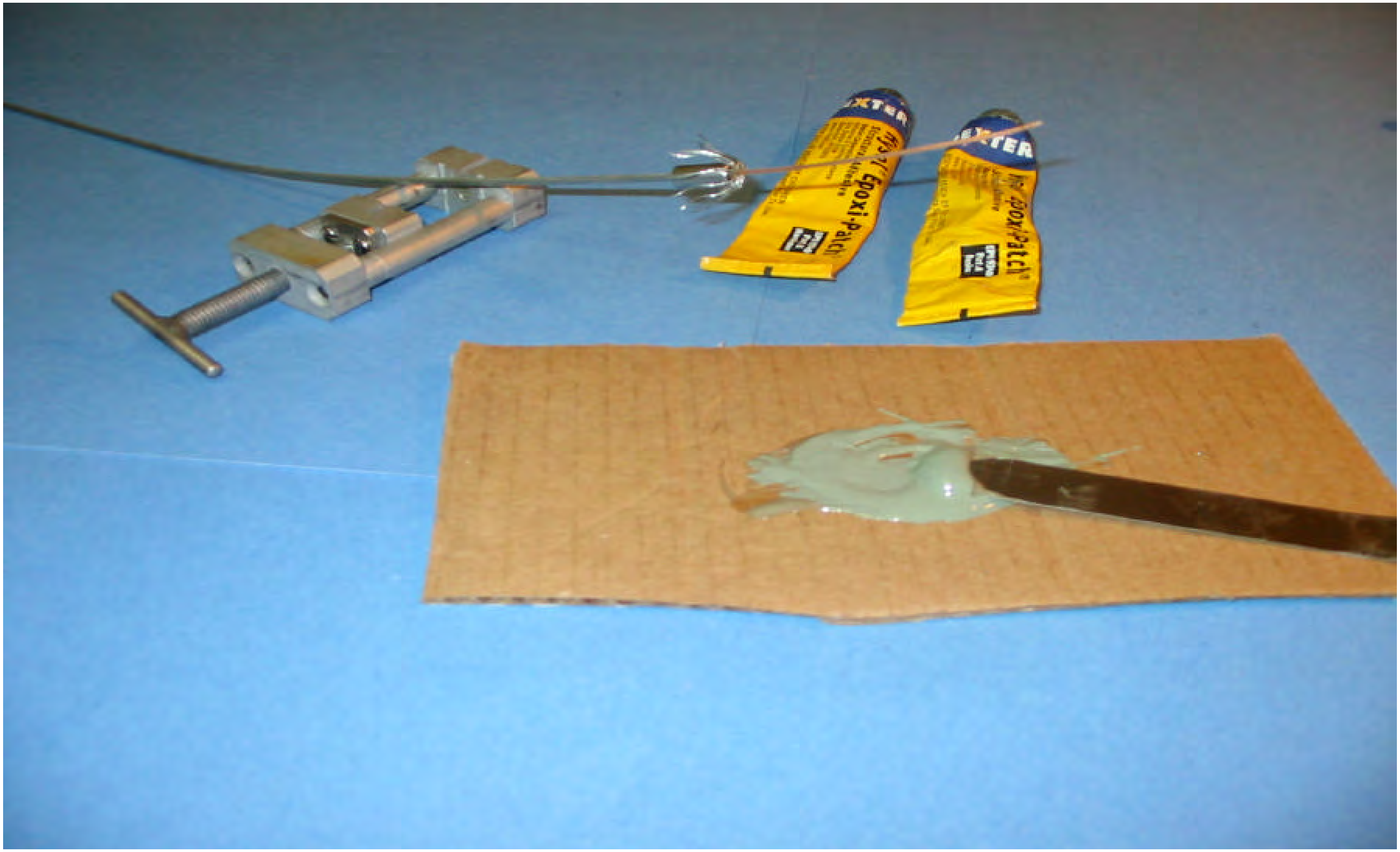
Pic.12 Clip 5 of the 12 inner armor strands close to the top of the insert



Pic.13 Bend down Remaining Inner Wire Strands
(Use jig and termination sleeve)

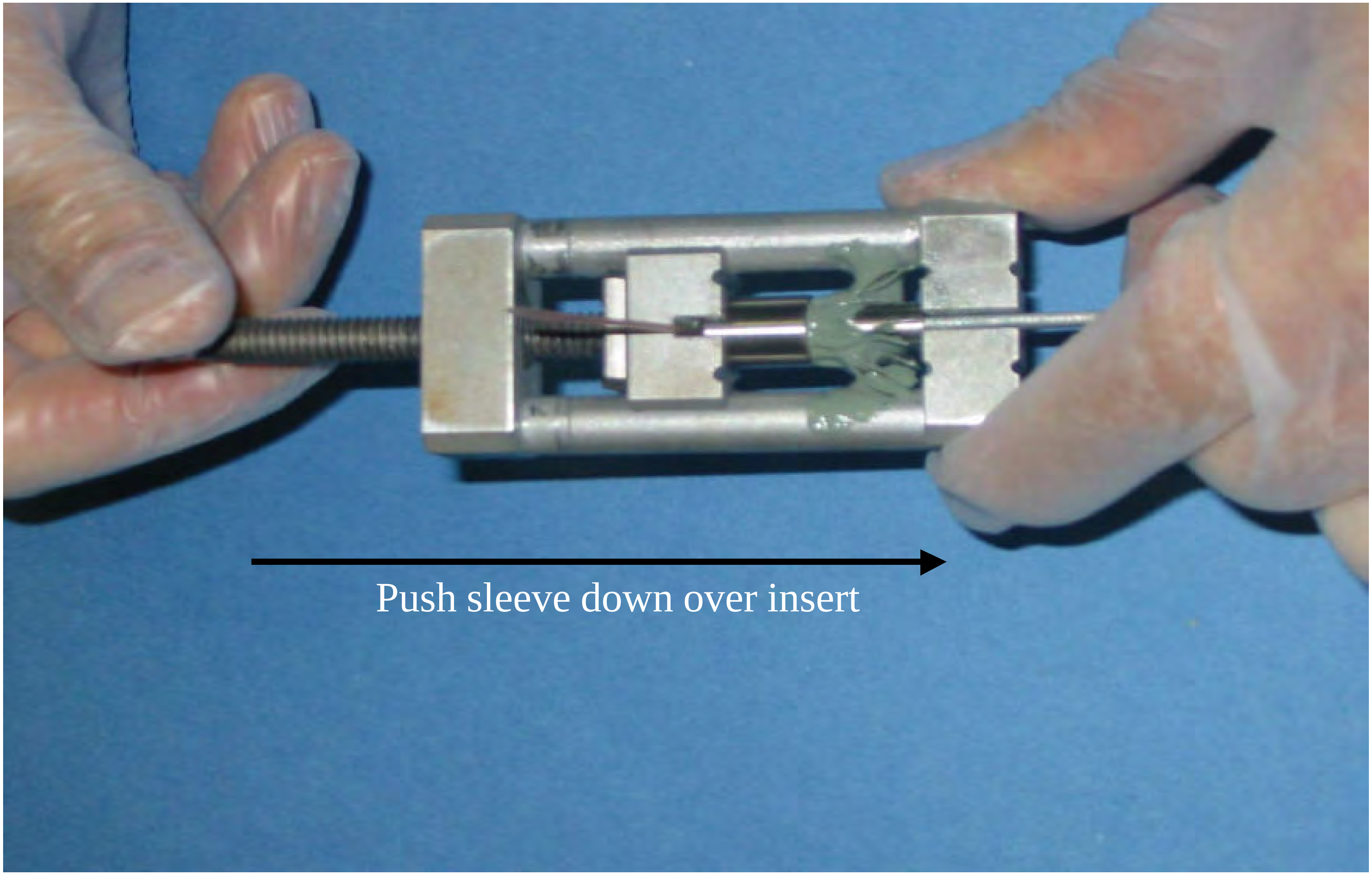


Pic.13 Trim Inner Wire Strands to Base of Insert

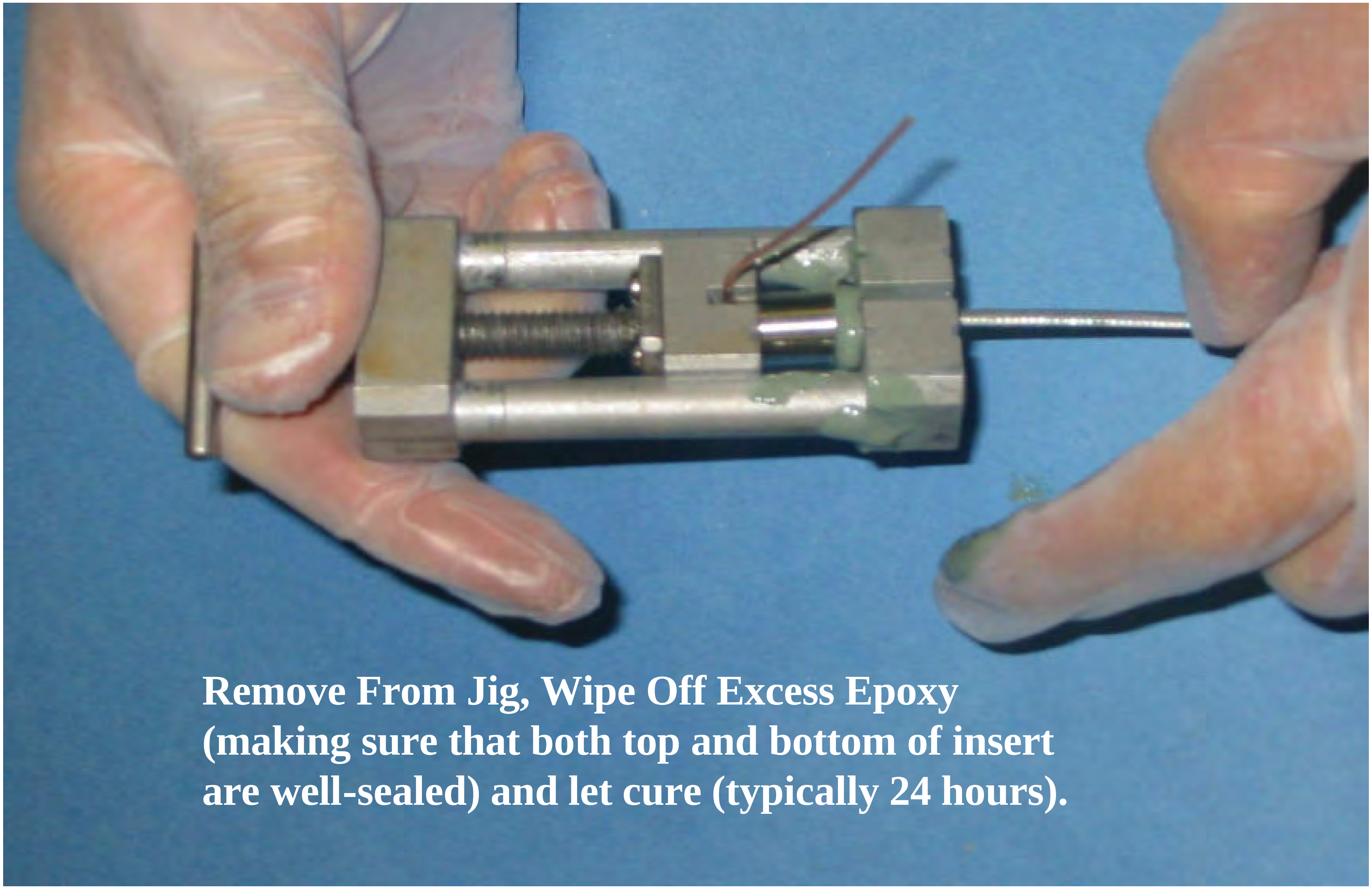


Pic.14 Mix epoxy

Pic.15 Apply epoxy. Cover the trimmed armor strands with epoxy

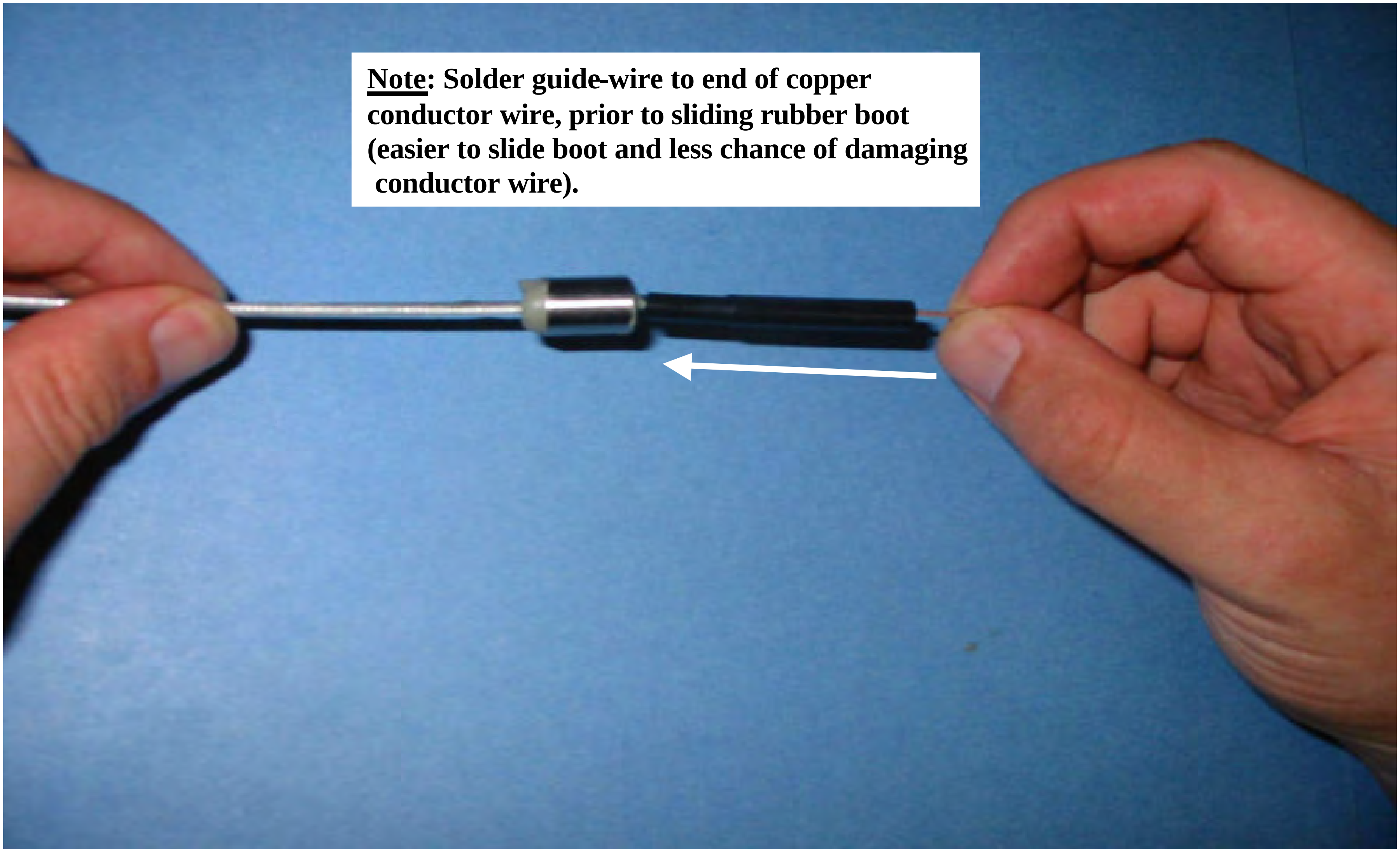


Pic.16 Using the termination jig, push the termination sleeve completely down over the insert

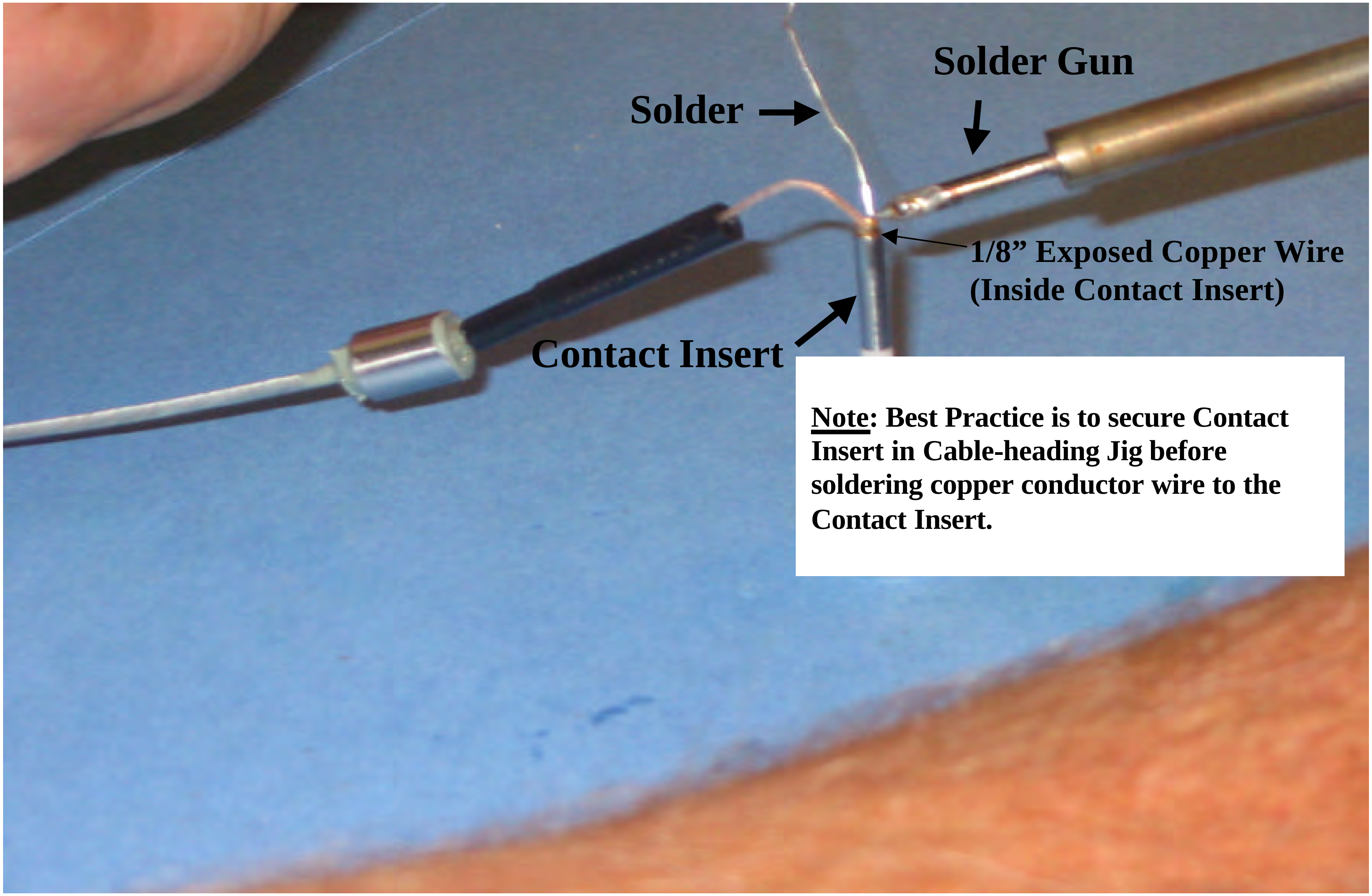


Pic.17 Termination Sleeve completely pushed down over insert

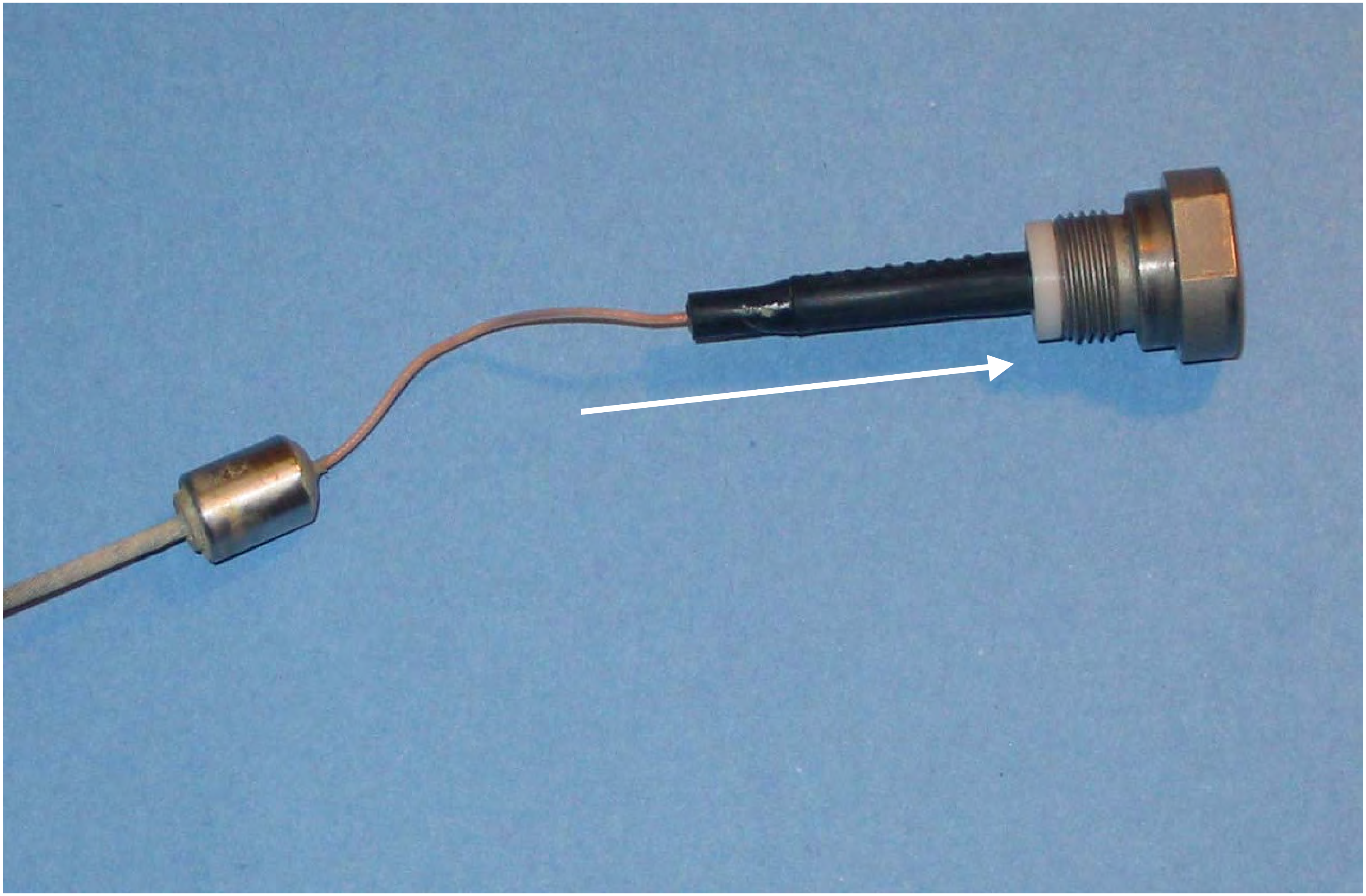
Pic.18 Apply silicon lubricant to the insulated conductor wire



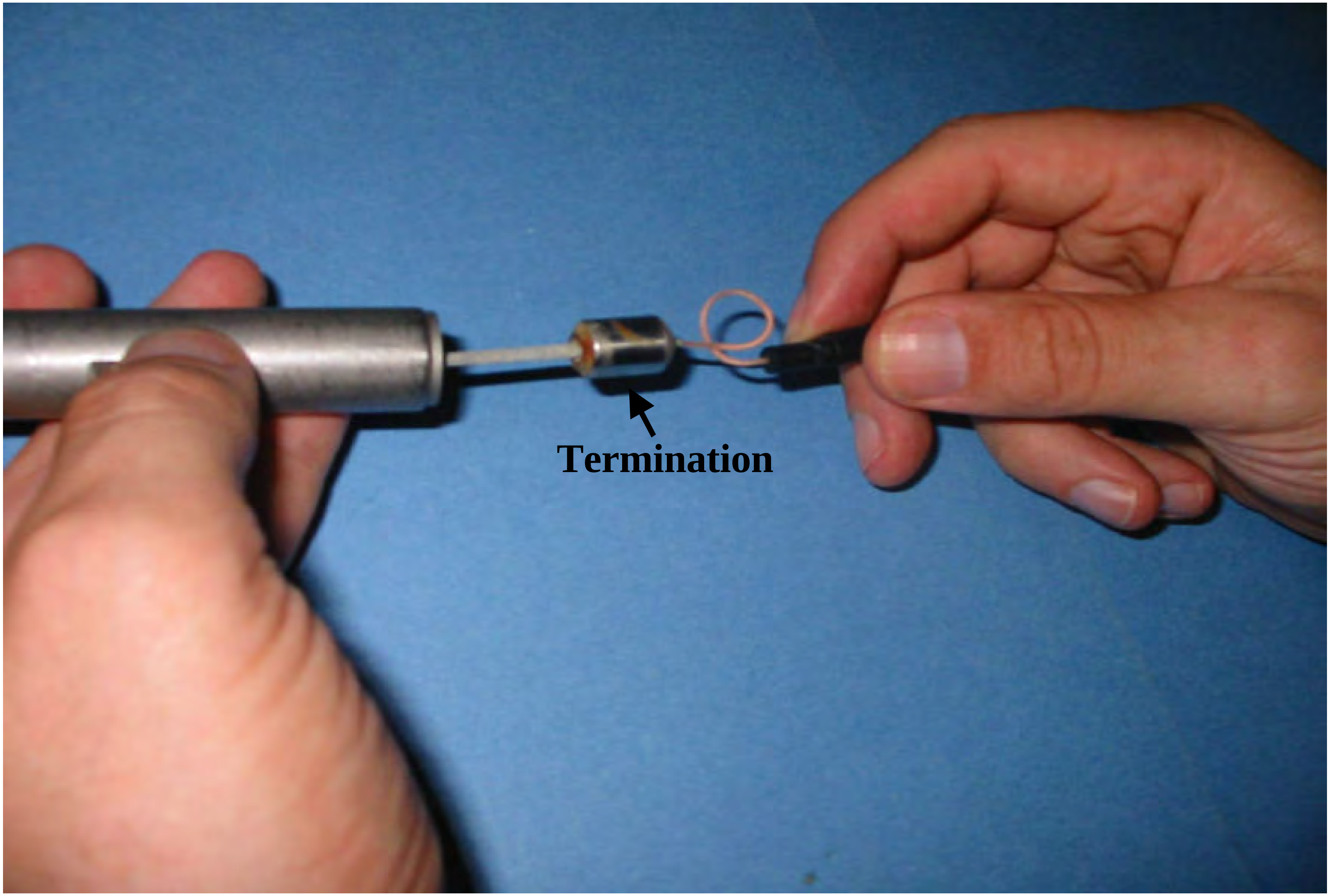
Pic.20 Slide the rubber boot towards the cablehead termination (final position)



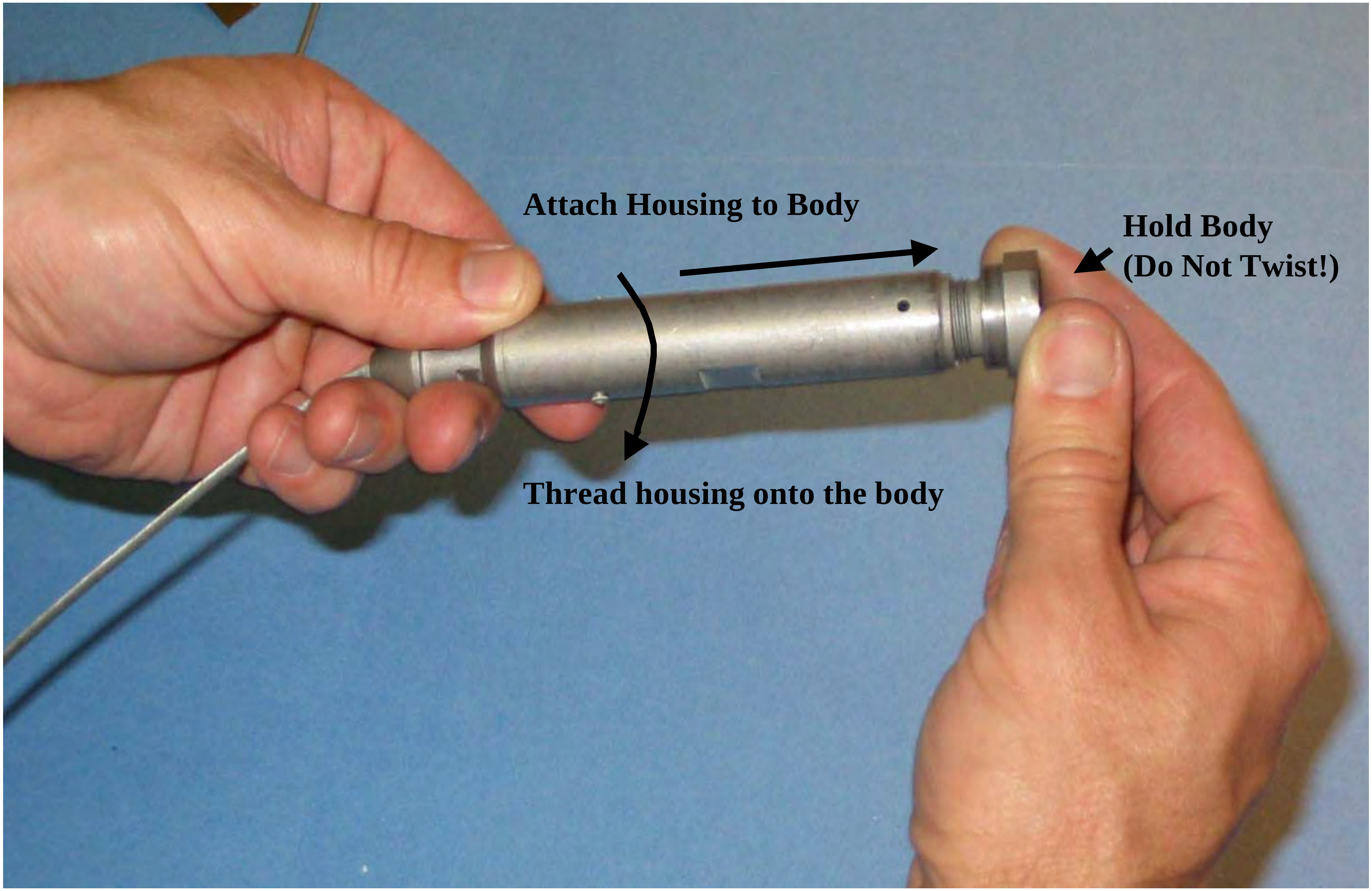
Pic.21 Solder 1/8 inch exposed copper wire (use wire strippers) into contact insert



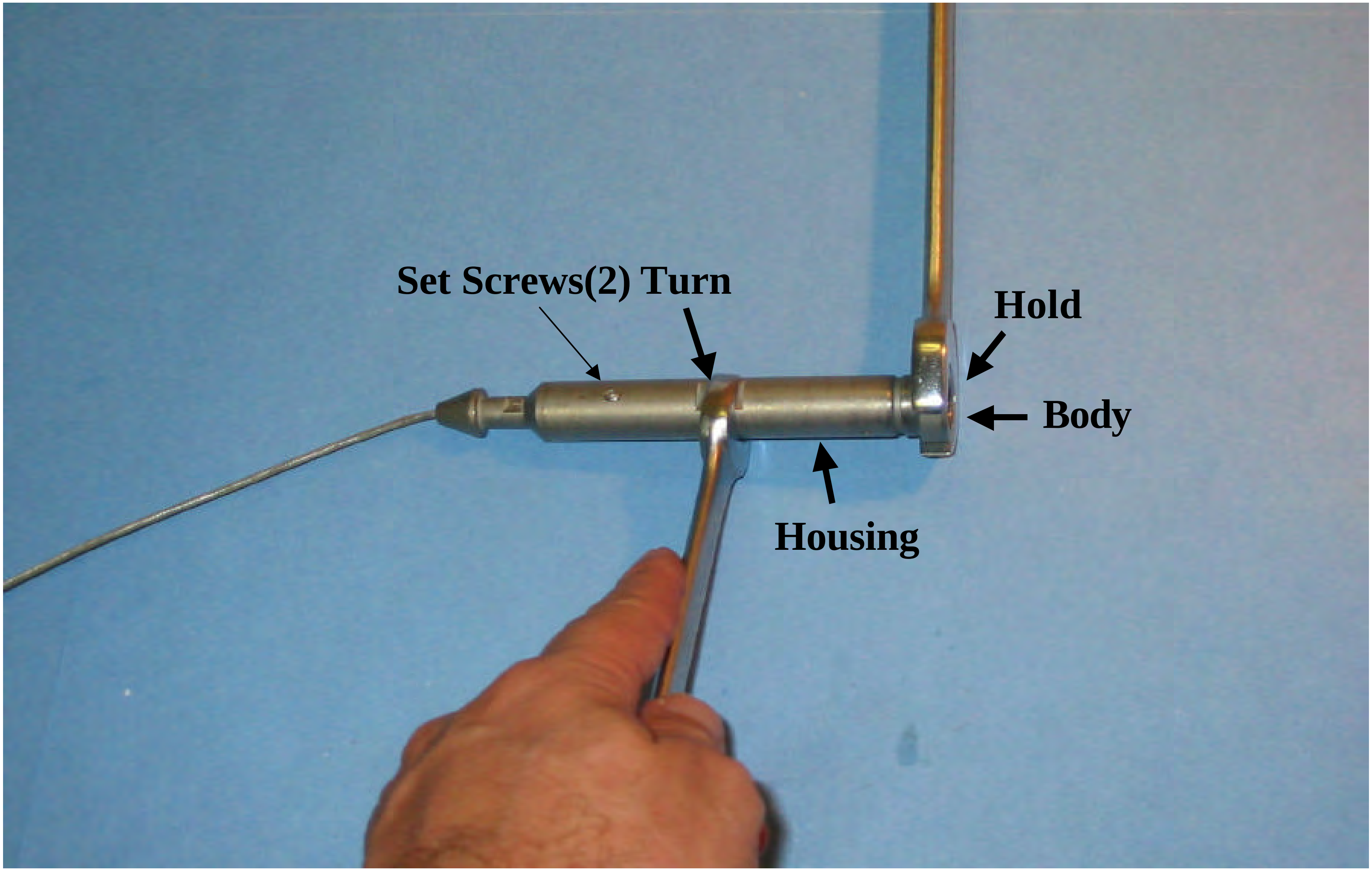
Pic.22 Slide the rubber boot down over the contact insert (when the solder has cooled)



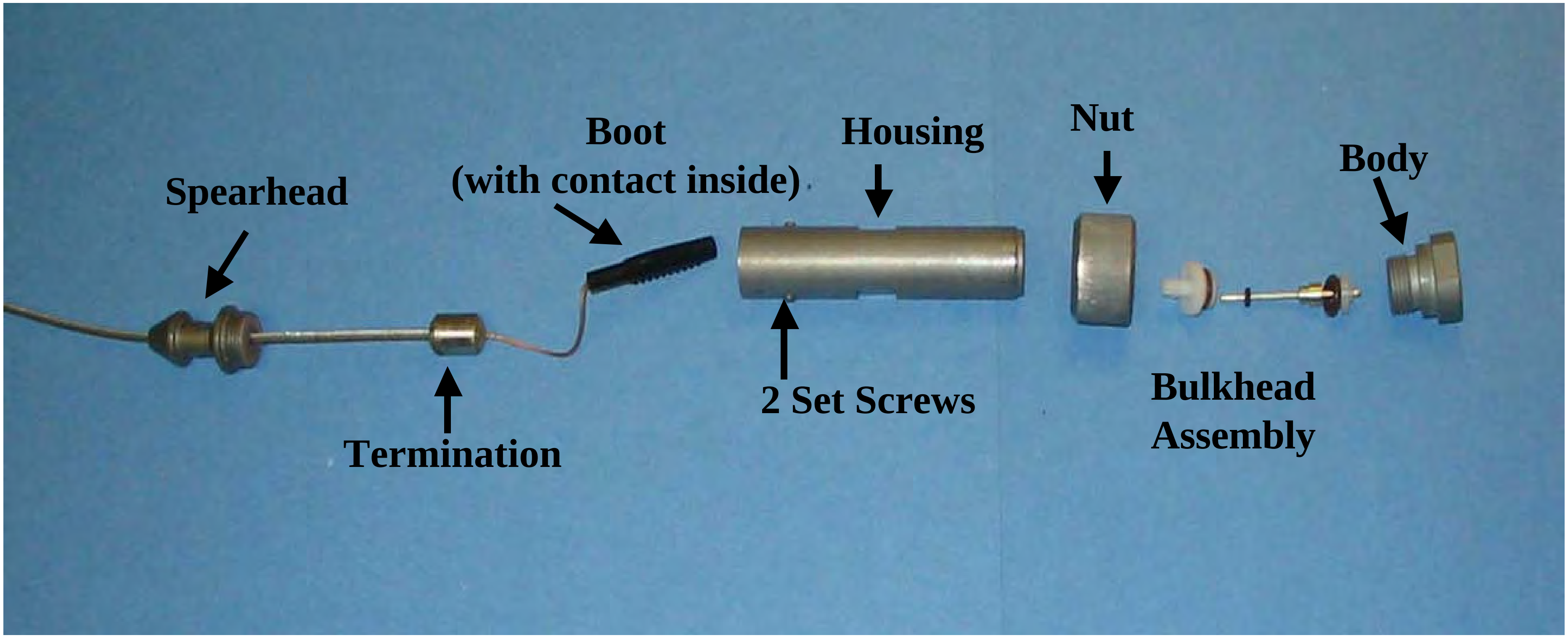
Pic.23 Create a loop in the conductor wire before sliding the cablehead housing down over the termination



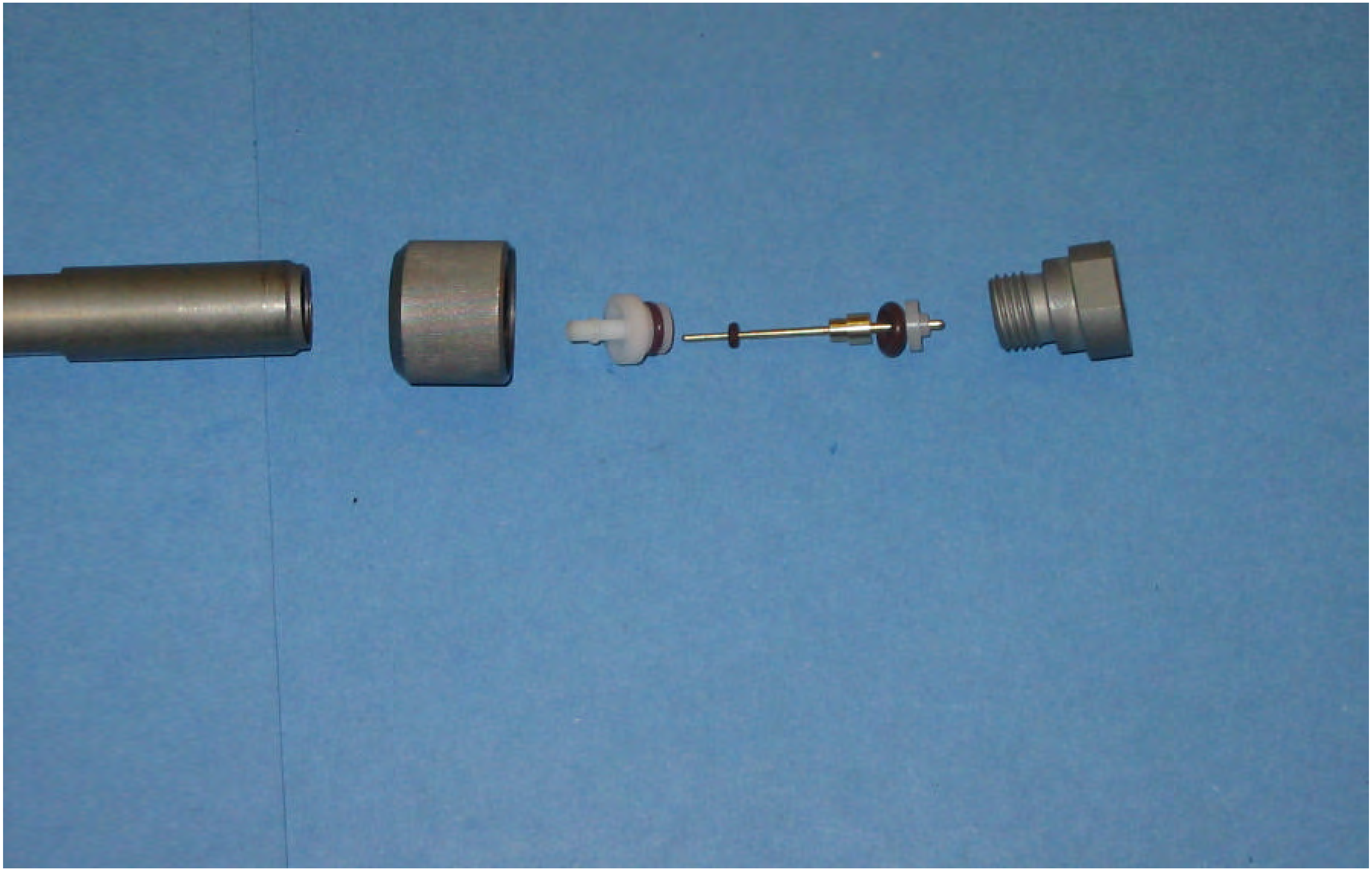
Pic.24 Thread the cablehead housing onto the body
(Do not twist the body! –this can damage the conductor wire)



Pic.25 Tighten the housing to the body
Tighten the set screws to complete re-assembly of the cablehead



Pic.26 Exploded view of cablehead assembly



Pic.27 Exploded view of bulkhead assembly

APPENDIX K

Field Monitoring Forms

Bioreactor Monitoring

Bioreactor Monitoring

Personnel:

Trench Sumps Water Levels ('BTOC)

Sump ID	Sump Depth (ft BTOC)	Sump Water Level (ft BTOC)	pH	Temp. (deg. C)	SpCond. (mS/cm)	ORP	DO (mg/L)	Trench Currently Being Used (√)	Notes
Date:		*Time:*							
B3-T1-1	**12.9**								
B3-T1-2	**12.4**								
B3-T1-3	**12.85**								
B3-T2-1	**9.67**								
B3-T2-2	**10.01**								
B3-T3-1	**9.96**								
B3-T3-2	**7.4**								
B3-T4-1	**6.32**								
B3-T5-1	**9.33**								
B3-T5-2	**7.98**								
B3-T6-1	**11.45**								
B3-T6-2	**12.34**								
B3-UIC									

B-3 Transfer System Monitoring

Flow Meters Readings

Meter	**Monday**		**Tuesday**		**Wednesday**		**Thursday**		**Friday**	
Date/Time:										
Rate (gpm) / Cumulative Total (gal)										
T-1										
T-2										
T-3										
T-4										
T-5										
T-6										
B-3 (Total)										
CS-MW16-LGR										
CS-MW16-CC										
B3-EXW01										

Bag Filter Pressure Reading (Pressure Drop (PB-1) - (PB-2)= *Note: If bag filter pressure drop is > or = 10 psi change fliter

PB-1 - PB-2 =	*PB-1 - PB-2 =*	*PB-1 - PB-2 =*	*PB-1 - PB-2 =*	*PB-1 - PB-2 =*

Notes:

Weekly Water Level Monitoring

Personnel	

Weekly Water Level Monitoring

Well Interval	Sampling Port Depth (ft BTOC)	Sample Date	Sample Time	Pressure at TOC (psi)	Pressure in MP (psi)	Zone Pressure (psi)
CS-WB05-LGR-01	99				*14.07*	
CS-WB05-LGR-02	182				*14.11*	
CS-WB05-LGR-03A	216				*14.14*	
CS-WB05-LGR-03B	262				*16.17*	
CS-WB05-LGR-04A	277				*22.70*	
CS-WB05-LGR-04B	329				*45.33*	
CS-WB05-BS-01	362				*59.67*	
CS-WB05-CC-01	432				*90.08*	
CS-WB05-CC-02	460				*102.24*	
CS-WB06-UGR-01	20				*14.04*	
CS-WB06-LGR-01	93				*14.07*	
CS-WB06-LGR-02	174				*14.11*	
CS-WB06-LGR-03A	207				*14.14*	
CS-WB06-LGR-03B	260				*21.60*	
CS-WB06-LGR-04	320				*47.66*	
CS-WB07-UGR-01	14				*14.05*	
CS-WB07-LGR-01	90				*14.10*	
CS-WB07-LGR-02	175				*14.14*	
CS-WB07-LGR-03A	208				*14.17*	
CS-WB07-LGR-03B	257				*15.58*	
CS-WB07-LGR-04	318				*42.13*	
CS-WB08-UGR-01	38				*14.03*	
CS-WB08-LGR-01	115				*14.08*	
CS-WB08-LGR-02	193				*14.12*	
CS-WB08-LGR-03A	228				*14.14*	
CS-WB08-LGR-03B	273				*18.87*	
CS-WB08-LGR-04	341				*48.45*	

Monthly Monitoring

Personnel

Quarterly Monitoring

MPMWs	Sampling Port Depth (ft BTOC)	Sample Date	Sample Time	Inside Pressure	Zone Pressure
CS-WB05-LGR-01	99				
CS-WB05-LGR-02	182				
CS-WB05-LGR03A	216				
CS-WB05-LGR03B	262				
CS-WB05-LGR04A	277				
CS-WB05-LGR04B	329				
CS-WB05-BS-01	362				
CS-WB05-CC-01	432				
CS-WB05-CC-02	460				
CS-WB06-UGR-01	20				
CS-WB06-LGR-01	93				
CS-WB06-LGR-02	174				
CS-WB06-LGR03A	207				
CS-WB06-LGR03B	260				
CS-WB06-LGR-04	320				
CS-WB07-UGR-01	14				
CS-WB07-LGR-01	90				
CS-WB07-LGR-02	175				
CS-WB07-LGR03A	208				
CS-WB07-LGR03B	257				
CS-WB07-LGR-04	318				
CS-WB08-UGR-01	38				
CS-WB08-LGR-01	115				
CS-WB08-LGR-02	193				
CS-WB08-LGR03A	228				
CS-WB08-LGR03B	273				
CS-WB08-LGR-04	341				

Monitroing Wells	Sample Date	Sample Time	pH	Temp	SpCond	ORP	DO
B3-MW01							
CS-D							
CS-MW16-LGR							
CS-MW16-CC							
CS-MW1-LGR							
B3-EXW01							

Quarter ___