B3-EXW05-LGR WELL INSTALLATION REPORT

Prepared for:

Camp Stanley Storage Activity
Boerne, Texas

December 2012

EXECUTIVE SUMMARY

This report documents the B3-EXW05-LGR well installation and construction activities conducted at Camp Stanley Storage Activity (CSSA) between May and November 2012. These activities were conducted in support of CSSA's groundwater investigation and treatability studies at Solid Waste Management Unit (SWMU) B-3. Parsons installed one new groundwater extraction well (EXW) to supplement the Bioreactor remediation system.

The borehole was drilled with a 7-$^{7}/_{8}$ inch diameter bit to its total depth of 380 feet below ground surface (bgs). The borehole was intended to penetrate several feet into the top of the underlying Bexar Shale (BS) to accommodate logging of the entire thickness of the Lower Glen Rose (LGR) Limestone. Geophysical logging was conducted that collected borehole video, spontaneous potential, resistivity, natural gamma, and a caliper data.

A pumping test was subsequently performed in the open borehole. An initial water level measurement was collected prior to pumping and multiple measurements were collected during the test. The pumping test sustained an average rate of 12.4 gpm for 4.36 hours with a net aquifer drawdown of 87 feet. The water level fully recovered within 75 minutes after the pumping was ceased. Based on these results, and to be consistent with the other EXW wells, a new 5-hp submersible pump was selected to be installed in the well upon its completion. This pump will be able to manage the higher flowrates expected to be produced when not under drought conditions, such as at the time of this pumping test.

B3-EXW05-LGR was designed as a telescoping well with 90 feet of surface casing. The well was reamed with a 12-inch bit to 90 feet bgs to facilitate the installation of the 8-inch diameter Schedule 80 PVC surface casing. The casing was fully cemented via tremie pipe using a bentonite-based CETCO grout (Volclay grout). The remainder of the drill cuttings that had accumulated in the 8-inch pilot hole were drilled out to 380 feet bgs.

Following casing installation, the well was developed by surging, jetting, and pumping. A total of 8,200 gallons of groundwater were purged from the well during the development process. Groundwater was purged at an average flowrate of 10 gpm until the discharge was free of visible sedimentation and water quality parameters were stable.

A groundwater sample was obtained for VOCs and total dissolved solids (TDS) analyses. In groundwater, *cis*-1,2-DCE was reported at 23.92 micrograms per liter (µg/L), TCE was reported at 43.16 µg/L, PCE was reported at 11.76 µg/L, and toluene was reported at 2.91 µg/L. A trace (F-flagged) detection of chloroform was also reported at 0.18 µg/L Concentrations of both TCE And PCE were in excess of the regulatory maximum contaminant level (MCL) of 5 µg/L. The TDS result was 309 milligrams per liter (mg/L).

The permanent 5-hp pump was installed on 2-inch galvanized steel column pipe, with a finished set depth of 368.4 feet bgs (top of pump). Upon completion of the pump installation, the well location was surveyed by a registered land surveyor.

Once the well was completed, additional construction activities commenced to incorporate B3-EXW05-LGR into the Bioreactor system. The wellhead surface completion included a 10 foot by 12 foot concrete pad with covered control stanchion to accommodate the electrical distribution, motor control, and SCADA RTU panels. Discharge plumbing was completed to regulate and measure flow produced from the well. Approximately 500 feet of new electrical distribution was extended to the wellhead to operate the pump and control equipment. Approximately 390 feet of 3 inch waterline was installed to convey B3-EXW05-LGR groundwater to the Bioreactor Building. SCADA equipment and programming to automate the groundwater production will be performed under a separate task order at a later date.

At the Bioreactor Building, an elevated service platform was constructed to facilitate filter change-out tasks performed by the system operators. Finally, an exterior closet was constructed over the discharge manifold system to provide operational security and freeze protection.

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ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per liter
bgs	Below ground surface
BS	Bexar Shale
BTOC	Below top of casing
°C	Degrees Celsius
cis-1,2-DCE	*cis*-1,2-dichloroethene
CSSA	Camp Stanley Storage Activity
DO	Dissolved oxygen
EE	Environmental Encyclopedia
EXW	Extraction well
GPI	GeoProjects International, Inc.
gpm	Gallons per minute
hp	Horsepower
IDM	Investigation-derived media
LGR	Lower Glen Rose
MCL	Maximum contaminant level
mg/kg	Milligrams per kilogram
mS/cm	Millisiemens per centimeter
mV	Millivolt
NSF	National Sanitation Foundation
NTU	Nephelometric turbidity units
ORP	Oxidation-reduction potential
PCE	Tetrachloroethene
PID	Photoionization Detector
PVC	Polyvinyl chloride
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
SWMU	Solid Waste Management Unit
TCE	Trichloroethylene
TCEQ	Texas Commission on Environmental Quality
TDS	Total dissolved solids
USEPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound

SECTION 1
INTRODUCTION

1.1 PURPOSE

This document provides a summary of well installation and commissioning activities at Camp Stanley Storage Activity (CSSA) between May and November 2012. These activities were conducted in support of CSSA's groundwater investigation and treatability studies at Solid Waste Management Unit (SWMU) B-3. Included are descriptions of the field methods and results associated with the well installation and associated construction activities.

1.2 OVERVIEW

This report summarizes work associated with installation of a new groundwater extraction well (B3-EXW05-LGR), and presents limited interpretation of data collected during installation, as well as preliminary analytical results from groundwater samples. Further analysis and detailed interpretation of the analytical data collected will be incorporated in update reports associated with the *Annual Performance Report for SWMU B-3 Remediation System* (CSSA **Environmental Encyclopedia, Volume 3.2: Investigation and Closure Reports**). The entire CSSA groundwater program has been overseen by the U.S. Environmental Protection Agency (USEPA) and Texas Commission on Environmental Quality (TCEQ) since October 1993.

A chronology of work conducted in association with the CSSA groundwater investigation is provided in **Volume 1.1** of the Environmental Encyclopedia (EE) online at *http://www.stanley.army.mil/*. Detailed reviews of the regulatory basis for investigation, historical groundwater monitoring, and previous monitoring well installation reports, as well as specific construction and logging methods, decontamination procedures, and investigation-derived media (IDM) management procedures are contained in **Volume 4.1** of the EE.

1.3 OBJECTIVES OF INVESTIGATION

The objective of the investigation was to provide sources of additional data for determining the extent of groundwater contamination in the aquifer at CSSA, and to support active treatability studies at SWMU B-3. The well installation efforts included the following specific objectives:

1. Install one 8-inch-diameter open borehole extraction well (EXW) with submersible pump into the Lower Glen Rose (LGR) segment of the Middle Trinity Aquifer beneath SWMU B-3.
2. Perform geophysical and/or video inspection surveys in the well.
3. Survey the new monitoring well location.
4. Manage IDM and construction debris.
5. Construct a wellhead surface completion and control stanchion at B3-EXW05-LGR.
6. Install a waterline conveyance between the well and the Bioreactor treatment system.

7. Install electrical service to the wellhead for control and operation of the submersible pump and monitoring equipment.
8. Prepare a well installation report.

1.4 REPORT ORGANIZATION

This report consists of three sections. **Section 1** presents an overview, including the project purpose, and objectives of the well installation work accomplished under contract. **Section 2** details the installation and equipping of one open-hole groundwater extraction well to be incorporated into the SWMU B-3 Bioreactor system. Narratives for this effort include well construction methods, geophysical logging activities, pumping tests, equipment installation, and sampling results. **Section 3** documents the construction activities that were completed to make the well an operational entity within the Bioreactor system. Supporting data and electronic data DVDs are included in the appendices.

SECTION 2
SWMU B-3 WELL INSTALLATION

2.1 DETERMINATION OF WELL LOCATIONS

One extraction well was installed on the east side of the SWMU B-3 Bioreactor as part of this drilling effort. Previous analytical samples collected east of the suspected source area have confirmed the migration of volatile organic compounds (VOCs) in that direction, and the new extraction well was placed in a location that best utilized the local groundwater gradient and CSSA's geologic substructure. The premise for this well location was two-fold:

- The USEPA requested that a new EXW be installed east of the Bioreactor based upon operational results presented during the January 24, 2012 Regulatory Meeting held at CSSA; and
- Complete the zone of groundwater capture surrounding the Bioreactor, and preclude any further LGR contamination from migrating south eastward towards water production wells CS-1 (active) and CS-13 (pending).

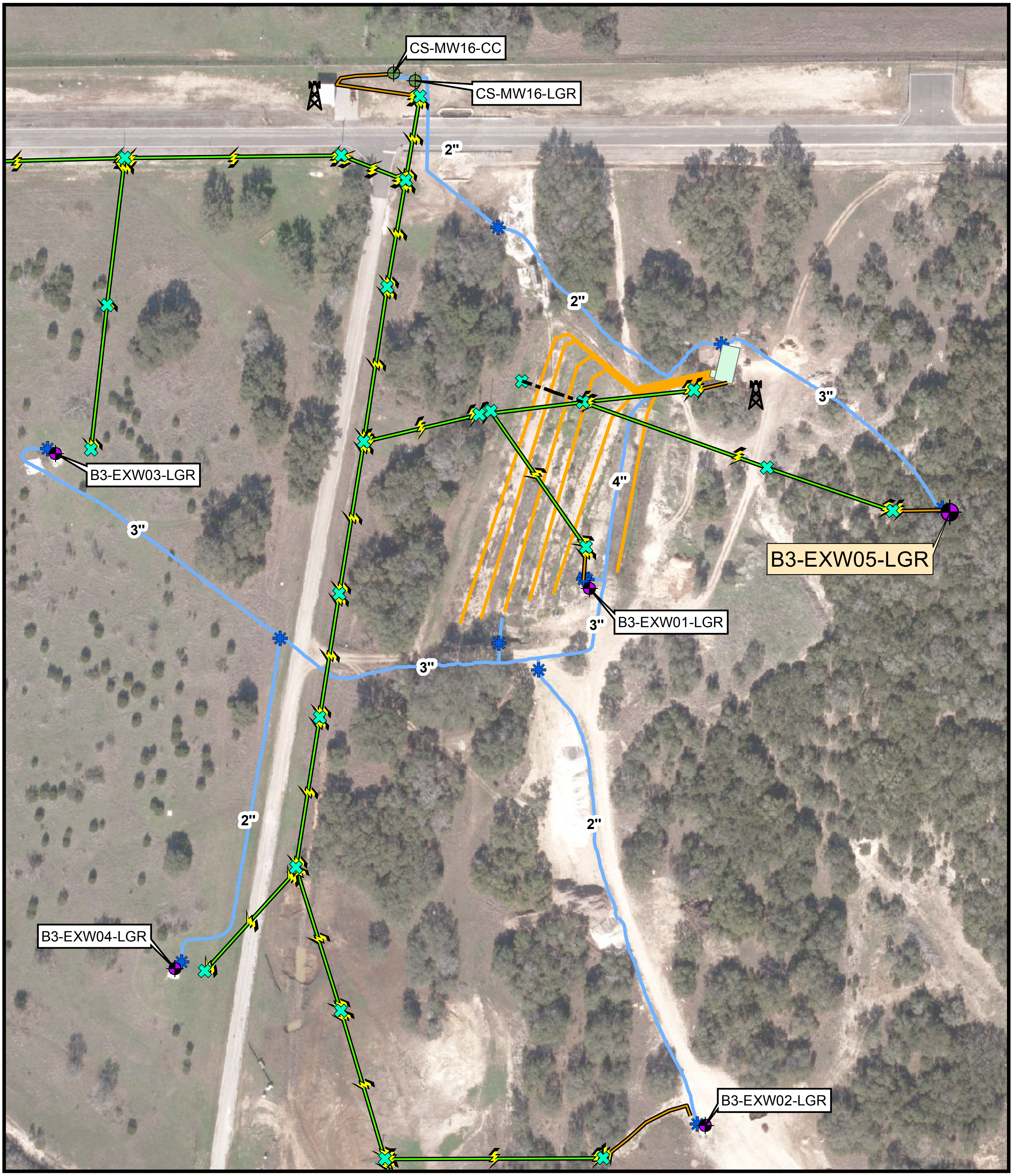
Figure 2.1 shows the location of this well and its relationship to the Bioreactor.

2.2 DRILLING AND GEOPHYSICAL LOGGING

Drilling for B3-EXW05-LGR began on May 21, 2012 and was completed on May 23, 2012. The State of Texas well report is included as **Appendix A**. Well installation began with establishment of a safety and quality assurance/quality control (QA/QC) exclusion zone created around the drilling rig and work area. A containment area consisting of 2 feet by 10 feet wood planks and heavy gauge plastic sheeting was constructed to surround the wellhead and the drilling table to capture drilling fluids and solid drill cuttings.

The subcontractor for drilling operations was GeoProjects International, Inc. (GPI) of Austin, TX. Non-chlorinated water used for fluid injection during drilling was obtained from CSSA water supply well CS-10. Drilling through the dry portions of the limestone formation requires small amounts of injected water for lubrication, cooling, and to assist in lifting the drill cuttings out of the hole.

The borehole was drilled with a 7-$^{7}/_{8}$ inch diameter tri-cone roller bit to its total depth of 380 feet bgs. Drilling depth was based on direct observations of cuttings and geophysical logs from previously drilled wells were used to estimate total depth of the new well. Continuous observation of cuttings was performed to provide indication of unusual or unexpected changes in rock characteristics. The borehole was intended to penetrate several feet into the top of the underlying Bexar Shale (BS) to accommodate logging of the entire thickness of the LGR. The drill cuttings and geophysical logging showed that the contact between the Upper Glen Rose (UGR) and LGR occurred at 48 feet below grade. The contact between the LGR and BS was determined to occur at373 feet bgs.



Aerial Photo Date: Jan. 2012

N W E S

0 50 100 200 Feet

- Monitoring Well
- Extraction Well
- Water Valve
- Effluent Water Line (3")
- Influent Water Line
- Utility Poles
- SCADA Antennae

Electrical

- Overhead Electrical
- Underground Electrical
- Support Line

Figure 2.1

Location of Extraction Well B3-EXW05-LGR Camp Stanley Storage Activity

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Photo 2.1 – Drilling B3-EXW05-LGR east of the SWMU B-3 Bioreactor (facing East)

A "TOTCO" single shot declination tool was used during drilling after every 50 feet of borehole advancement to check borehole plumbness. Borehole declination did not deviate more than 0.25 degrees from true vertical. A summary of results for the declination surveys is included in **Appendix B**.

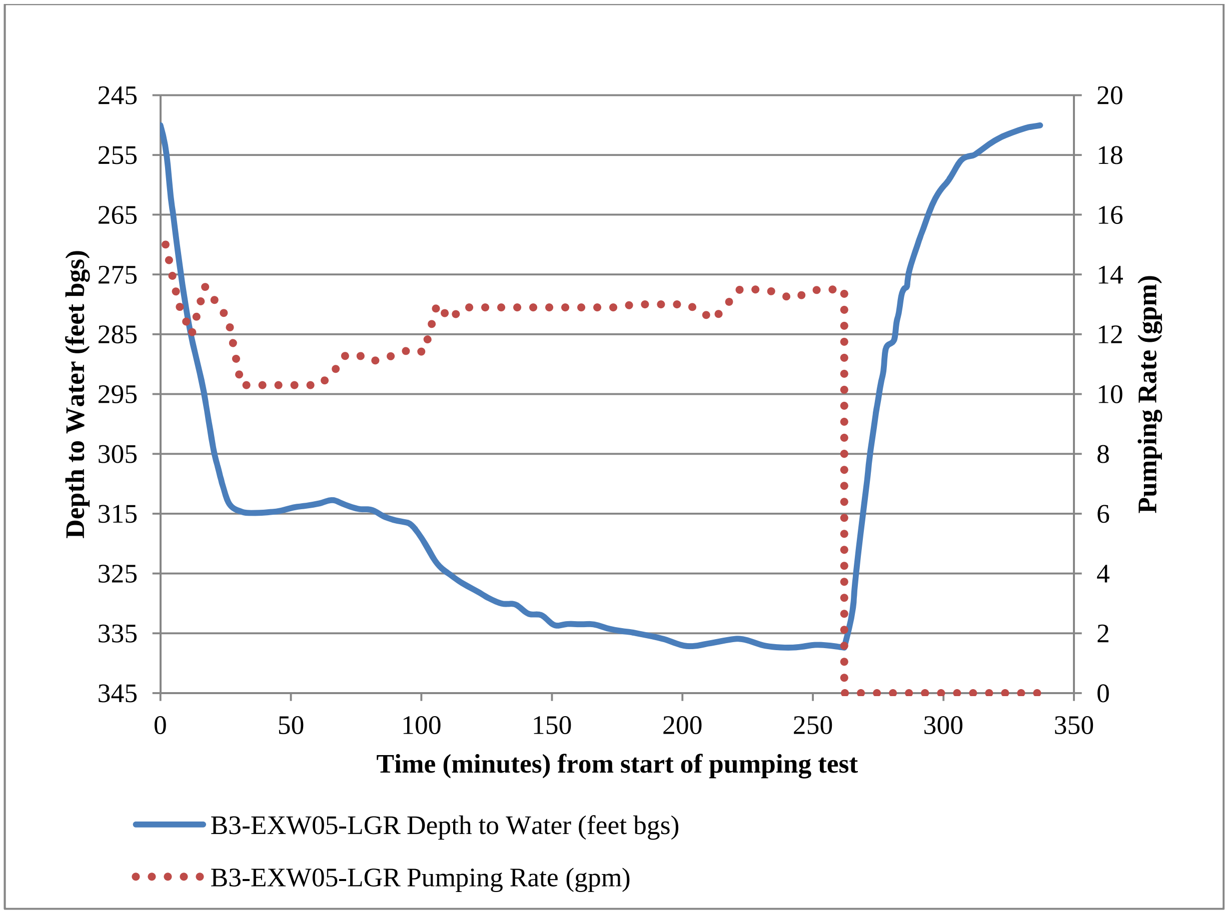
For safety purposes, the air (breathing space) was periodically screened by photoionization detector (PID) to monitor for the presence of VOCs. Water, soil, and cuttings generated during well construction were characterized by laboratory analysis prior to final disposition. IDM generated during drilling and development included both solids and liquids. All liquids generated during the well installation activities were introduced into the Bioreactor remediation system.

Geophysical logging was conducted May 25, 2012 by GeoCam, Inc of San Antonio, TX. GeoCam deployed tools that collected spontaneous potential, resistivity, natural gamma, and a caliper data. A separate borehole camera survey was also performed at the boring. An additional camera survey was completed in the borehole on June 8, 2012 because suspended solids in the water column severely deteriorated the visibility within the borehole. The geophysical log and DVD versions of both video surveys are included in **Appendix C**. The lithologic contacts between the UGR, LGR, and BS are shown on the geophysical log.

2.3 PUMPING TEST

A pumping test was performed in the 8-inch pilot hole drilled by GPI on May 24, 2012. Pumping tests provide data essential to understand the general hydraulic properties of the aquifer at that location, and ultimately aid in the decision making process for pump selection for the well. For the test, a submersible pump, capable of pumping up to 75 gallons per minute (gpm), was installed approximately 10 feet above the bottom of the borehole. An initial water level measurement was collected prior to pumping and multiple measurements were collected during the test. The pumping test at B3-EXW05-LGR was conducted on May 24, 2012 and included the sustained pumping of the well at an average rate of 12.4 gpm for 4.36 hours. Results of the pumping test are graphically depicted in **Figure 2.2**.

Figure 2.2 Pumping Test Data for B3-EXW05-LGR



2.4 WELL CONSTRUCTION

Extraction wells, unlike monitoring wells, are designed to remove large volumes of groundwater from the subsurface and not just the small quantities needed for analytical evaluation. Therefore, the well was designed in an "open borehole" fashion with the only installed well material consisting of Schedule 80 PVC surface casing to protect against the in-filling/collapse of less consolidated materials near the surface. The casing depth is also selected to preclude inadvertent "short-circuiting" of the Bioreactor by creating a pathway for the injected treatment water to drain directly into the aquifer. A summary of well construction details is provided in **Table 2.1** and **Appendix D**.

As previously described, the well was initially drilled to 380 feet bgs with a nominal 8-inch bit to the total depth of the well. Based upon geophysical results, video inspection, and visual observation of drill cuttings, B3-EXW05-LGR was designed as a telescoping well with 90 foot (bgs) surface casing. Subsequently, the well was reamed with a 12-inch bit to 90 feet bgs to facilitate the installation of the 8-inch diameter surface casing (May 29 through May 31, 2012). The surface casing was set in place by utilizing a stainless steel centralizer (50 feet bgs) and a shale trap to hold the CETCO grout (formerly Volclay grout) that was placed into the annular space with a tremie pipe. The bentonite-based grout was mixed per manufacturer recommendations of 24 gallons of water per 50 pound sack of the bulk material.

Table 2.1 Summary of Extraction Well Construction

Well ID	B3-EXW05-LGR
Easting (meters)	537,495.283
Northing (meters)	3,286,671.945
Casing Elevation (ft MSL)	1,279.23
Ground Elevation (ft MSL)	1275.28
Total Depth of Borehole (ft bgs) (8-inch diameter)	380
Well set depth/Open borehole depth (ft bgs)	380
Casing Cement	CETCO Grout (formerly Volclay Grout) 14 sacks (700 pounds)
Date drilled	5/21/2012 - 5/31/2012
Date constructed	5/31/2012
Casing (ft bgs)	90 ft Sch. 80 PVC (8-inch diameter cemented in 12 inch diameter boring)
Open Interval (ft bgs)	90-380 (8-inch open borehole)
Drilling Rig	Gardner-Denver 1500

2.5 WELL DEVELOPMENT

Following casing installation, the well was developed by surging, jetting, and pumping. The well development was initiated on June 1, 2012, and continued through June 4, 2012. A total of 8,200 gallons of groundwater were purged from the well during the entire development process. Groundwater was purged at an average flowrate of 10 gpm until the discharge was free of visible sedimentation and water quality parameters were stable. The final readings included a groundwater pumping level of 354.7 feet bgs, pH of 6.92, temperature of 24.85°C, conductivity of 0.540 millisiemens per second (mS/sec), turbidity of 3.15 nephelometric turbidity units (NTU), dissolved oxygen (DO) of 2.40 milligrams per liter (mg/L), and oxidation-reduction potential (ORP) of 129.4 millivolts (mV). A well development record is included as **Appendix E.**

2.6 SAMPLING RESULTS

After the completion of well development activities on June 4, 2012, a groundwater sample was obtained from B3-EXW05-LGR and analyzed for VOCs and total dissolved solids (TDS). In groundwater, *cis*-1,2-DCE was reported at 23.92 micrograms per liter (µg/L), TCE was reported at 43.16 µg/L, PCE was reported at 11.76 µg/L, and toluene was reported at 2.91 µg/L. A trace (F-flagged) detection of chloroform was also reported at 0.18 µg/L Concentrations of both TCE And PCE were in excess of the regulatory maximum contaminant level (MCL) of 5 µg/L. The TDS result was 309 milligrams per liter (mg/L).

One sample of the drill cuttings was collected on June 6, 2012 and analyzed for VOCs and metals. No VOCs were detected in the sample, and all inorganic (metals) results were below land use restriction criteria. Therefore, drill cuttings from B3-EXW05-LGR were re-purposed as base material for upcoming construction activities at the wellhead.

The analytical results of all samples collected are listed in **Appendix F**.

2.7 PUMP INSTALLATION

Based on pumping test results, a new 5-hp submersible pump (Grundfos model 40S50-15) was selected to meet this condition of service. This pump selection is consistent with the pump size in the other LGR EXWs at the Bioreactor. This pump will be able to manage the higher flowrates expected to be produced when not under drought conditions, such as at the time of this pumping test.

On June 19, 2012, a four-inch pump and cooling shroud was installed on 17.48 joints (21-foot each) of 2-inch galvanized steel column pipe, with a finished set depth of 368.4 feet bgs (bottom of pump). Check valves were installed just above the pump, and every seven pipe joints (~147 feet) above thereafter, for a total of three check valves (depths of 368, 221 and 74 ft bgs, respectively). The pump was wired with #8 AWG double-jacketed wire which is secured to the column pipe. GPI installed two, 1-inch diameter SDR21 PVC gauging tubes for water level and transducer access. Each gauging tube extends the entire length of the column pipe, and is perforated at the bottom 50 feet of the tubing length. The pump specifications for the well are listed in **Table 2.2**, and manufacturer information is supplied in **Appendix G**.

Upon completion of the pump installation, the well location was surveyed by a registered land surveyor (Ace Surveying, Inc.) on July 20, 2012. A copy of the land survey of the wellhead is included in **Appendix H**. Field notes for all the well installation activities are included in **Appendix I**.

Table 2.2 B3-EXW05-LGR Pump/Motor Specifications

Equipment	Description
Motor Manufacturer	**Franklin Electric**
Model	2343078602
Serial Number	11L14-24-009056
Power Requirement	3P 5KW 200V 20.5A
Service Factor	1.15
KVA Code	K
Pump Manufacturer	**Grundfos**
Model	40S50-15 (15 stages)
Code	11890015
Operating Range	24 -55 gpm
Wire Manufacturer	**Service Wire Co.**
Specification	#8 AWG THW (Cu) Submersible Pump Cable THW Heavy Duty Flat Black Jacketed 3 Conductors w/Ground 600 volt (UL) PFB8/3GG

SECTION 3
WELLHEAD COMPLETION AND CONSTRUCTION ACTIVITIES

3.1 GENERAL

To incorporate the new extraction well into the Bioreactor system, the existing water distribution and electrical utility was extended to the new well location. The connection of these infrastructure elements allows the well to be energized and operated in a "manual" mode only (e.g. not SCADA controlled). The construction activities were conducted between August and November 2012, and included the following:

- Construct a well pad foundation, subgrade conduit, and control stanchion with roof.
- Construct 425 feet of new 4,160-volt aerial primary power conveyance from the Bioreactor to B3-EXW05 wellhead.
- Construct 75 feet of new, 208-volt secondary power to the wellhead, including transformers, safety switch, and 100-amp distribution panel.
- Trench, install, and backfill 390 feet of 3-inch HDPE water pipe between the Bioreactor Tank Barn influent manifold and well B3-EXW05-LGR, including one isolation valve.
- Install wellhead plumbing with isolation valves and SCADA-compatible flowmeter, and make connection to the 3-inch HDPE waterline conveyance.
- Construct an elevated work platform at the filter housings to provide safe access for filter change-outs.
- Construct an exterior closet over the Bioreactor Building discharge manifold for weatherproofing and freeze protection.

The work was completed by J. Sanchez Contractors, Inc. (JSC), and their sub-tier contractors, Morlandt Electric (Morlandt) and Hillbig Plumbing (Hillbig). **Figure 3.1** depicts the location of the new electrical and plumbing components associated with this project.

3.2 WELLHEAD COMPLETION

JSC initiated the wellhead construction the week of August 20, 2012. The subcontractor graded and prepared the ground surface, ran sub-slab conduits, formed and installed a 10-foot by 12-foot reinforced concrete slab, constructed a covered control stanchion, and installed the necessary plumbing, metering, and control assemblies. The design for the wellhead is presented in **Figure 3.2**, which is consistent with the design implemented at existing wells EXW02, EXW03, and EXW04.

The ground surface was prepared with a flexible A2 base compacted to 95% proctor compaction. A 10-foot by 12-foot slab with 6 inches of thickness was formed around the extraction well. The slab was placed so that the well is offset from the southeast corner of pad by 3 feet in both directions. The Subcontractor precisely measured and installed two Schedule 80 PVC sub-slab conduits for the well pump motor and level transducer cabling. The motor lead conduit and the transducer conduit are 1.5 inches in diameter. The conduits originate at

Figure 3.1

Location of B3-EXW05-LGR Construction Activities Camp Stanley Storage Activity

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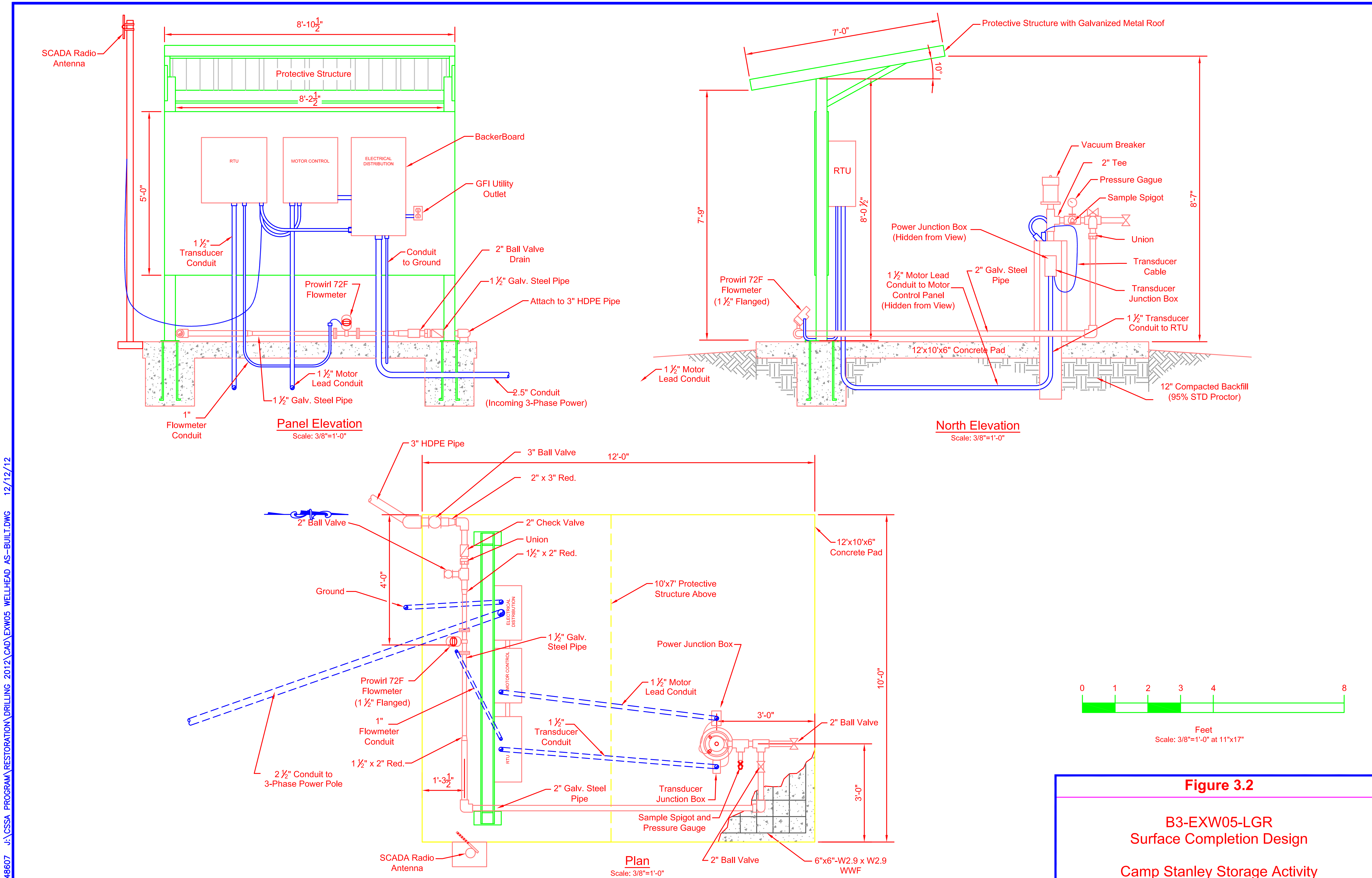


Figure 3.2

B3-EXW05-LGR
Surface Completion Design

Camp Stanley Storage Activity

the wellhead, and terminate at their respective control boxes mounted onto the stanchion wall. Waterproof junction boxes were placed at the wellhead for terminating electrical connections.

The Subcontractor installed a 7-foot by 9-foot fabricated steel stanchion with roof, identical to the current control stanchions assembled for wells EXW02, EXW03, and EXW04. The structure is set upon the concrete pad and anchored in place. The alignment of the stanchion is generally oriented north-south and the control equipment is installed on the east wall. JSC installed the electrical distribution and pump motor control panels on the stanchion and made the electrical connections between the well and the control panel.

At the wellhead, Hillbig made all the necessary 2-inch and 1.5-inch plumbing connections indicated on **Figure 3.2** using galvanized steel pipe. All plumbing from the wellhead was above-grade and affixed to the concrete slab using uni-strut mechanical restraints. The installation also included incorporating a 1.5-inch flanged flowmeter. The subcontractor installed an Endress-Hauser Shedding Vortex flowmeter model 72F40-SKOBA1NAB4AW (**Appendix G**), identical to meters already installed the other extraction wells. A 3-inch ball valve was installed to control the flow and isolate the system as necessary.

Photo 3.1 shows the completed EXW05-LGR wellhead and installed equipment.

Photo 3.1 – B3-EXW05-LGR Wellhead Completion (facing West)

3.3 WATER DISTRIBUTION TO BIOREACTOR BUILDING

JSC installed a 3-inch HDPE pipe from the B3-EXW05-LGR wellhead to the Bioreactor Building located 350 feet to the northwest (see **Figure 3.1**). The pipe trench traversed northwest to the Bioreactor Building, and then skirted the northern wall until it joined with the injection manifold at the northwest corner of the building. A trench with a minimum depth of 2 feet below grade, and a minimum width of 6 inches was excavated between the wellhead and the Bioreactor Building. The total length of the trench was approximately 390 feet to its connection to the inlet manifold. All HDPE connections were constructed with fusion welding. The pipe was placed on a bedding of sand, and backfilled with sand to minimum height of 4 inches above the pipe. The remainder of the trench was backfilled with excavated materials and compacted to match grade of surrounding surface.

The HDPE pipe was connected to the existing subgrade header located at the northwest corner of the building. When retrofitting the header, JSC installed a pipe tee with a threaded cap that will allow for future expansion of the header if another well is to be connected at a later date. JSC also installed a subgrade 3-inch isolation valve with concrete “cuff” on the new HDPE line, within 5 feet of the header system. At the wellhead, the 3-inch HDPE line was connected to the 2 inch galvanized discharge pipe from the wellhead, and can be isolated from the system via a 3-inch ball valve.

3.4 ELECTRICAL DISTRIBUTION CONNECTION

As a sub-tier contractor to JSC, Morlandt provided all the materials and services necessary to establish 120/208V three phase power to the extraction well. In general, the subcontractor extended the existing 4,160-volt primary power from the pole within the Bioreactor trench area to near the B3-EXW05-LGR wellhead (see **Figure 3.1**). The length of primary power service was approximately 425 feet, and required the installation of two new utility poles.

Specifically, the Subcontractor modified one existing pole within the Bioreactor Trench Area for the new aerial tap, and installed two new 45-foot Class 3 poles, including crossarms, braces, insulators, hardware, grounds, and downguy/anchor assemblies. Morlandt furnished and installed four, #2 ACSR aerial conductors approximately 425 feet between the existing pole and two new poles. The termination utility pole was set no closer than 75 feet to the well to provide ample room for future well service, as needed. At the termination utility pole, Morlandt installed three, re-conditioned 10 KVA transformers with 100 amp fused-open-cutouts, and 3KV lightning arrestors.

The utility pole located closest to the wellhead has been equipped with a riser, weatherhead, and 100-amp safety switch. The electrical subcontractor installed one run of four 3/0 electrical cable from transformers to the safety switch. A trench with a minimum depth of two feet was excavated from the utility pole to the wellhead to provide the 120/208 volt service. The service entrance conductors were installed in 2.5-inch diameter Schedule 80 PVC conduit, over a horizontal distance of approximately 75 feet to the wellhead stanchion. The Subcontractor installed one run of four 3/0 electrical cable from the safety switch on the pole to a service panel mounted at the control stanchion.

JSC then installed a 100-amp, 4-wire service panel and the motor control panel onto the stanchion. The Subcontractor included a triple-pole breaker for operating a 30-amp/200-volt motor and single-pole breakers for the 20-amp/120-volt Remote Telemetry Unit (RTU) panel, and a 15-amp/120-volt utility outlet (NEMA 3R enclosure). JSC and Parsons installed the necessary conduit and wiring to the motor control panel and successfully energized the well pump and pressure-tested for leaks.

3.5 ADDITIONAL CONSTRUCTION

3.5.1 Service Platform

The Bioreactor operators required a service platform to provide the necessary working height to exchange filter media with the Bioreactor Building. To this end, JSC constructed a steel platform at the dual filtration unit (see **Photo 3.2**). The working height of the platform is approximately 9 inches above the floor. The platform is painted with a high visibility epoxy paint (safety yellow) to prevent corrosion and enhance visibility. A non-skid textured surface was also applied to the work platform.

Photo 3.2 – Filtration Unit Service Platform

3.5.2 Exterior Manifold Closet

JSC installed an insulation system for the injection well manifold pipes located on the west side of the Bioreactor Building. This system included the construction of a small, metal clad insulated shed constructed on a footer foundation to allow natural ground warmth to keep the manifold lines above the freezing point. The shed is approximately seven feet by ten feet and fully accommodates the injection manifold system (**Photo 3.3**). The shed has been affixed to the exterior shell of the Bioreactor Building, and was constructed with identical materials used on the Bioreactor Building including a steel reinforced framing, galvanized steel walls, and interior insulation batting. Dual, standard 6-foot eight-inch exterior steel doors have been installed on the west side to provide access to the shed.

Photo 3.3 – Exterior Manifold Closet (facing East)

APPENDIX A
State of Texas Well Reports

STATE OF TEXAS WELL REPORT for Tracking #294843

Owner:	**U.S.Government**	Owner Well #:	**EXW-05**
Address:	**25800 Ralph Fair Road** **Boerne , TX 78015**	Grid #:	**68-20-1**
Well Location:	**25800 Ralph Fair Road** **Boerne , TX 78015**	Latitude:	**29° 42' 35" N**
Well County:	**Bexar**	Longitude:	**098° 36' 46" W**
Elevation:	**1263 ft.**	GPS Brand Used:	**Garmin**
Type of Work:	**New Well**	Proposed Use:	**Monitor**

Drilling Date:	Started: **5/21/2012** Completed: **6/19/2012**
Diameter of Hole:	Diameter: **12 3/4 in From Surface To 90 ft** Diameter: **7 7/8 in From 90 ft To 380 ft**
Drilling Method:	**Air Rotary**
Borehole Completion:	**Open Hole**
Annular Seal Data:	1st Interval: **From 0 ft to 2 ft with 1-Cement (#sacks and material)** 2nd Interval: **From 2 ft to 90 ft with 14 Bent. Grout (#sacks and material)** 3rd Interval: **No Data** Method Used: **Tremie** Cemented By: **Lee Gebbert** Distance to Septic Field or other Concentrated Contamination: **No Data** Distance to Property Line: **No Data** Method of Verification: **No Data** Approved by Variance: **No Data**
Surface Completion:	**Surface Sleeve Installed**

Water Level:	Static level: **No Data** Artesian flow: **No Data**
Packers:	**Rubber Shale Trap at 90-ft**
Plugging Info:	Casing or Cement/Bentonite left in well: **No Data**
Type Of Pump:	**Submersible** Depth to pump bowl: **368.4 ft**

Well Tests:	**Pump** Yield: **13.6 GPM with (No Data) ft drawdown after (No Data) hours**

Water Quality:	Type of Water: **Fresh** Depth of Strata: **No Data** Chemical Analysis Made: **No** Did the driller knowingly penetrate any strata which contained undesirable constituents: **No**
Certification Data:	The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.
Company Information:	**Geoprojects International, Inc.** **8834 Circle Drive** **Austin , TX 78736**
Driller License Number:	**58772**
Licensed Well Driller Signature:	**Lee Gebbert**
Registered Driller Apprentice Signature:	**No Data**
Apprentice Registration Number:	**No Data**
Comments:	**No Data**

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking number (Tracking #**294843**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

DESC. & COLOR OF FORMATION MATERIAL	CASING, BLANK PIPE & WELL SCREEN DATA
From (ft) To (ft) Description	Dia. New/Used Type Setting From/To
0 to 48 Upper Glen Rose Limestone Formation	**8 New SCH 40 PVC Casing set from +4 to 90**
48 to 372 Lower Glen Rose Limestone Formation	
372 to 380 Bexar Shale Formation	

APPENDIX B
Borehole Deviation Surveys

NOV MD Totco

CONTROLLED VERTICAL DRILLING

CHART ANGLE

1½ ☐ 7 ☒ 8 ☐ 90 ☐
3 ☐ 14 ☐ 16 ☐
21 ☐ 24 ☐

HOT WELL ☐
(USE ENCLOSED BACK-UP BLANK)

DRIFT RECORD

COMPANY Geoprojects Intl.
WELL B-3 EXW-05
DEPTH 150'
INCLINATION 1/16°
REMARKS
DRILLER Lee Gobbert
DATE 5-22-12

NOV MD Totco

CONTROLLED VERTICAL DRILLING

CHART ANGLE

1½ ☐ 7 ☒ 8 ☐ 90 ☐
3 ☐ 14 ☐ 16 ☐
21 ☐ 24 ☐

HOT WELL ☐
(USE ENCLOSED BACK-UP BLANK)

DRIFT RECORD

COMPANY Geoprojects Intl.
WELL B-3 EXW-05
DEPTH 100'
INCLINATION 1/4°
REMARKS
DRILLER Lee ~~Gobbert~~ Gobbert
DATE 5-22-12

NOV MD Totco

CONTROLLED VERTICAL DRILLING

CHART ANGLE

1½ ☐ 7 ☒ 8 ☐ 90 ☐
3 ☐ 14 ☐ 16 ☐
21 ☐ 24 ☐

HOT WELL ☐
(USE ENCLOSED BACK-UP BLANK)

DRIFT RECORD

COMPANY Geoprojects Intl.
WELL B-3 EXW-05
DEPTH 50'
INCLINATION 1/4°+
REMARKS
DRILLER Lee Gobbert
DATE 5-21-12

NOV MD Totco

CONTROLLED VERTICAL DRILLING

CHART ANGLE

1½ ☐ 7 ☒ 8 ☐ 90 ☐
3 ☐ 14 ☐ 16 ☐
21 ☐ 24 ☐

HOT WELL ☐
(USE ENCLOSED BACK-UP BLANK)

DRIFT RECORD

COMPANY Geoprojects Intl.
WELL B3-EXW-05
DEPTH 300'
INCLINATION 1/4°
REMARKS
DRILLER Lee Gobbert
DATE 5-22-12

NOV MD Totco

CONTROLLED VERTICAL DRILLING

CHART ANGLE

1½ ☐ 7 ☒ 8 ☐ 90 ☐
3 ☐ 14 ☐ 16 ☐
21 ☐ 24 ☐

HOT WELL ☐
(USE ENCLOSED BACK-UP BLANK)

DRIFT RECORD

COMPANY Geoprojects Intl.
WELL B-3 EXW 05
DEPTH 250'
INCLINATION 1/4°+
REMARKS
DRILLER Lee Gobbert
DATE 5-22-12

NOV MD Totco

CONTROLLED VERTICAL DRILLING

CHART ANGLE

1½ ☐ 7 ☒ 8 ☐ 90 ☐
3 ☐ 14 ☐ 16 ☐
21 ☐ 24 ☐

HOT WELL ☐
(USE ENCLOSED BACK-UP BLANK)

DRIFT RECORD

COMPANY Geoprojects Intl.
WELL B-3 EXW-05
DEPTH 200'
INCLINATION 1/16 +
REMARKS
DRILLER Lee Gobbert
DATE 5-22-12

NOV MD Totco

CONTROLLED VERTICAL DRILLING

CHART ANGLE

1½ ☐ 7 ☒ 8 ☐ 90 ☐
3 ☐ 14 ☐ 16 ☐
21 ☐ 24 ☐

HOT WELL ☐
(USE ENCLOSED BACK-UP BLANK)

DRIFT RECORD

COMPANY Geoprojects Intl.
WELL B3-EXW-05
DEPTH 350'
INCLINATION 1/16°
REMARKS
DRILLER Lee Gobbert
DATE 5-22-12

APPENDIX C
Geophysical Logs

GEO CAM

Water Well Logging & Video Recording Services

Geo Cam, Inc. 126 Palo Duro, San Antonio, TX 210-495-9121

Borehole: WELL B3-EXW-05

Logs: GAMMA, RESISTIVITY, CALIPER, SPR

Project: CAMP STANLEY WELL B3-EXW-05 Date: 05-25-12

Client: **GEO PROJECTS** County: BEXAR

Location: N 29* 42' 35.0" W 98* 36' 44.7" State: TX

BOREHOLE DATA

Drilling Contractor: GEO PROJECTS **Driller T.D. (ft) : 380'**

Elevation: 1253' GPS Logger T.D. (ft) : 375'2'

Depth Ref: G.L. Date Drilled: 05-24-12

BIT RECORD

RUN	BIT SIZE (in)	FROM (ft)	TO (ft)
1	7 7/8"	0	380
2			
3			

CASING RECORD

SIZE/WGT/THK	FROM (ft)	TO (ft)
NONE		

Drill Method: AIR ROTARY Weight: **Fluid Level (ft) : 246.3'**

Hole Medium: Mud Type: Time Since Circ:

Viscosity: Rm: at: Deg C

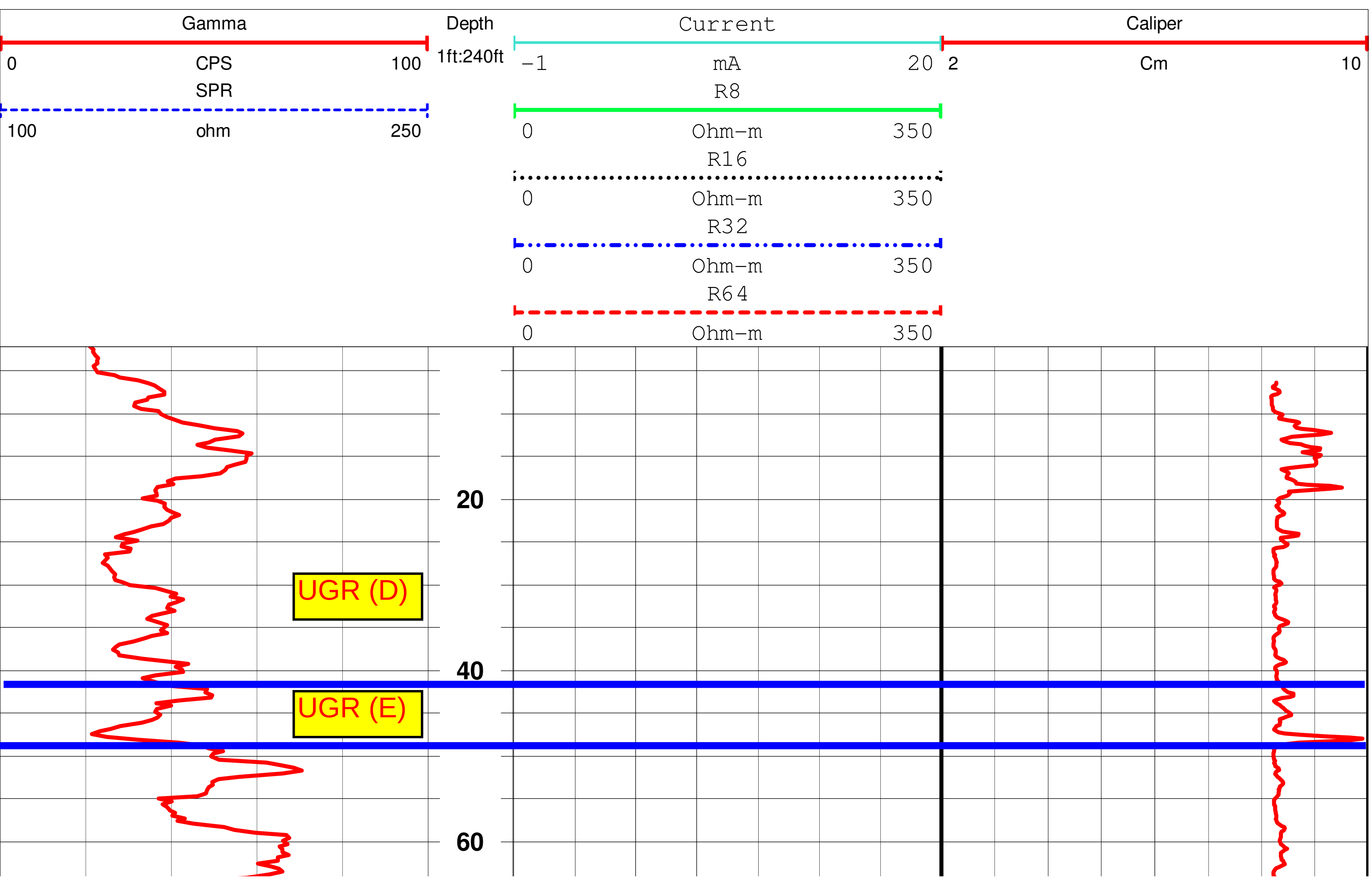
GENERAL DATA

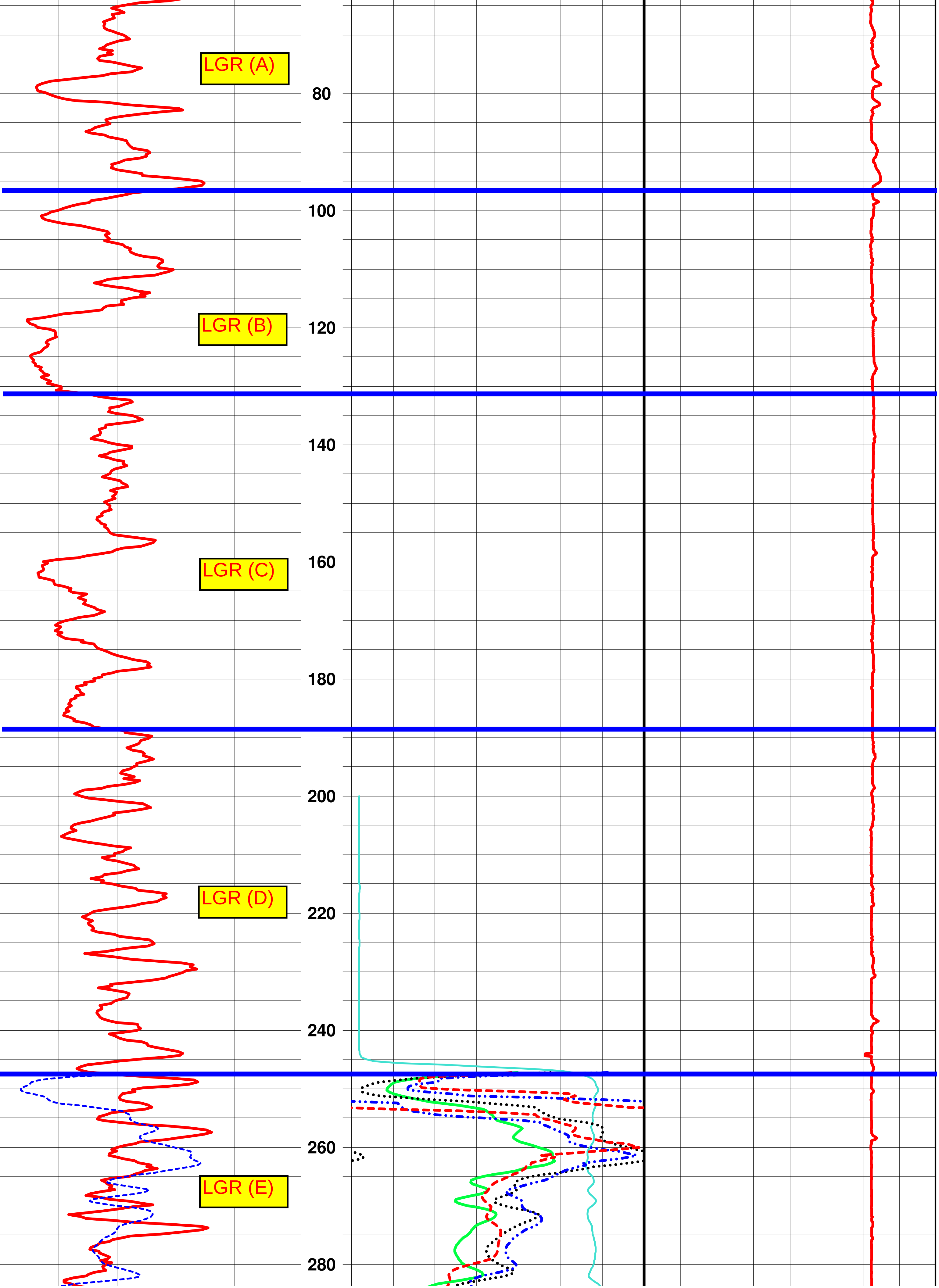
Logged by: Kelly O. Tuten Unit/Truck: 04

Witness:

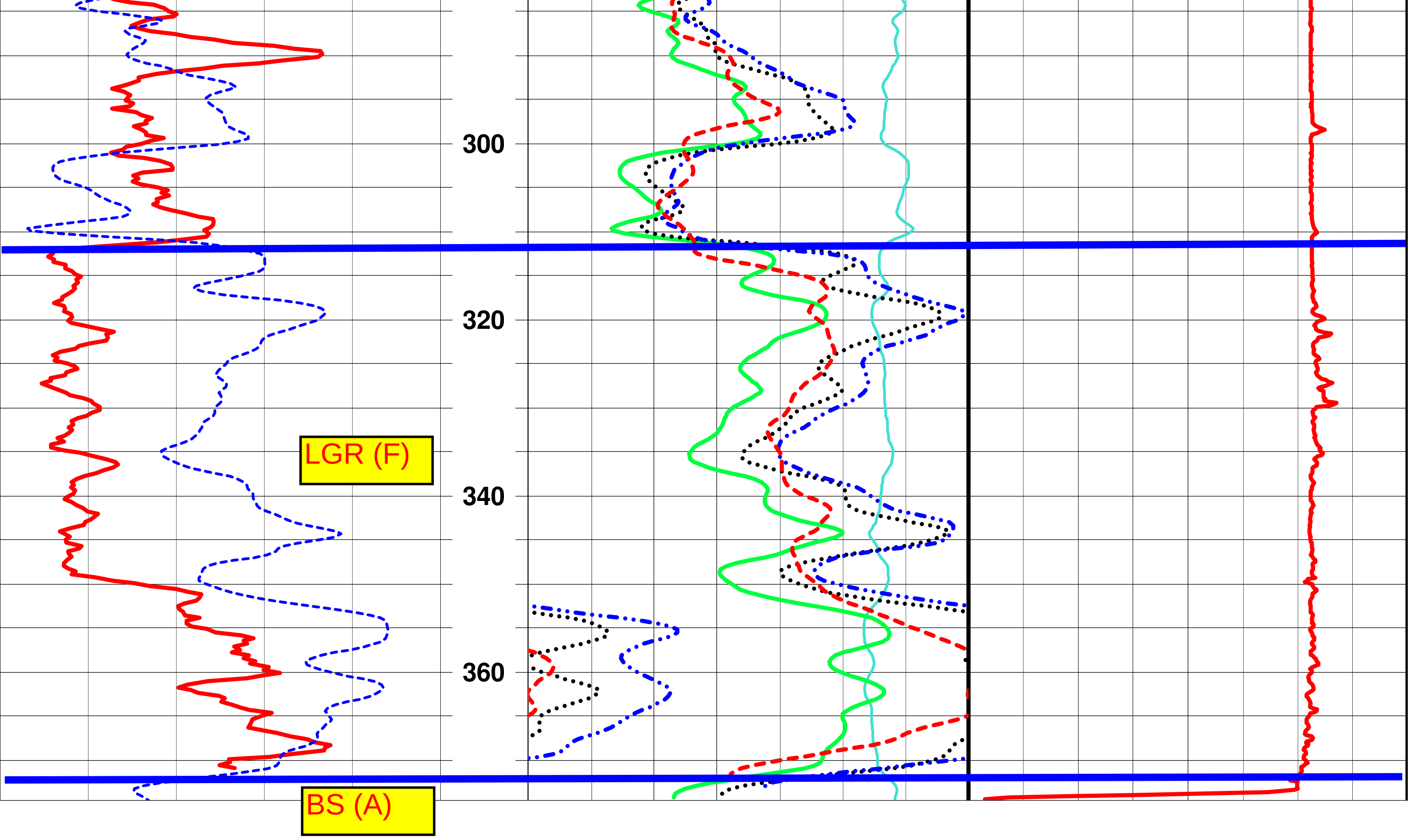
LOG TYPE	RUN NO	SPEED (ft/min)	FROM (ft)	TO (ft)	FT./ IN.
GAMMA	3	25	372	2	20
RESISTIVITY, SPR	2	25	374	247	20
CALIPER	1	25	375	6	20

Comments:





LGR (A)
80
100
LGR (B)
120
140
LGR (C)
160
180
200
LGR (D)
220
240
260
LGR (E)
280



300
320
340
360
LGR (F)
BS (A)

APPENDIX D
Well Completion Log

BOREHOLE LOG

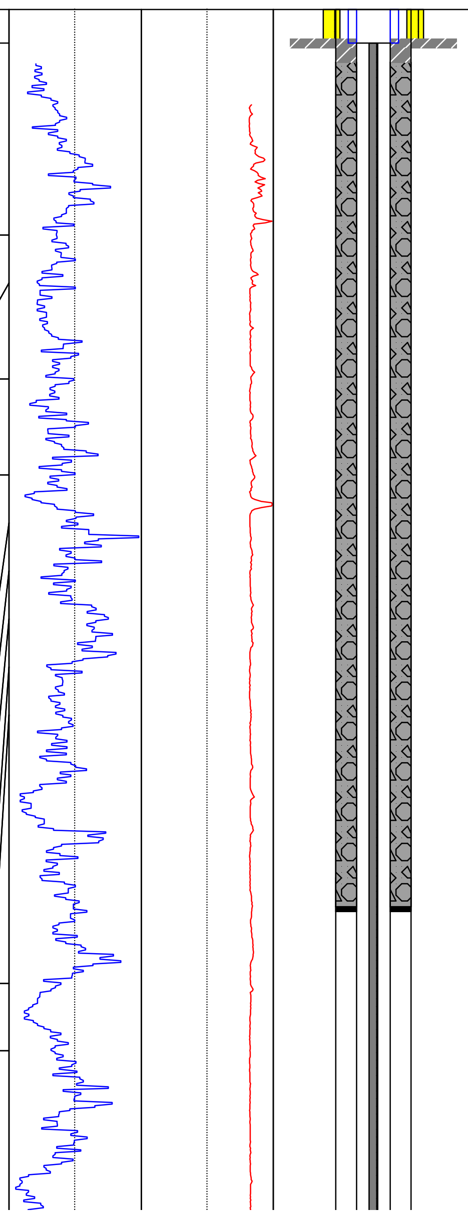
BOREHOLE NO.: **B3-EXW05-LGR**

TOTAL DEPTH: **380 feet**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT:	CSSA	DRILLING COMPANY:	GeoProjects Intl., Inc.
SITE LOCATION:	B-3	LEAD DRILLER:	Lee Gebbert
JOB NUMBER:	748607.01000	RIG TYPE:	Gardner-Denver
LOGGING GEOLOGIST:	Julie Bouch	METHOD OF DRILLING:	Air-Rotary
PROJECT MANAGER:	Scott Pearson	SAMPLING METHOD:	None
DATES DRILLED:	May 31, 2012	BORING DIAMETER	12" to 90'/8" to 380'

NOTES: Located east of SWMU B-3

Depth (ft. bgs)	TOTCO Test (degrees)	Lithology	Description Logged from Cuttings	Gamma	Caliper (Inches) 0 I--------I 10	Well Construction	Construction Material
0			Light brown weathered limestone, some clay				Cement 8" PVC Casing Grout
			Light brown weathered limestone, not as much clay				
			Light gray weathered limestone				
			Gray and some light brown weathered limestone				
-50	1/4+		Brown with some gray weathered limestone and clay, Upper Gen Rose and Lower Glen Rose Contact at 48'				
			Gray with some brown weathered limstone, little clay				
			Gray weathered limestone, little clay				
			Gray and brown weathered limestone, little clay, orbitulina				Grout
			Brown weathered limestone, little clay, orbitulina				Shale trap
			Gray weathered limestone				
-100	1/4		Brown limestone				Open Hole (90'-380')
			Light gray limestone				



-150 1/16

Light brown limestone

Light gray limestone

-200 1/16+

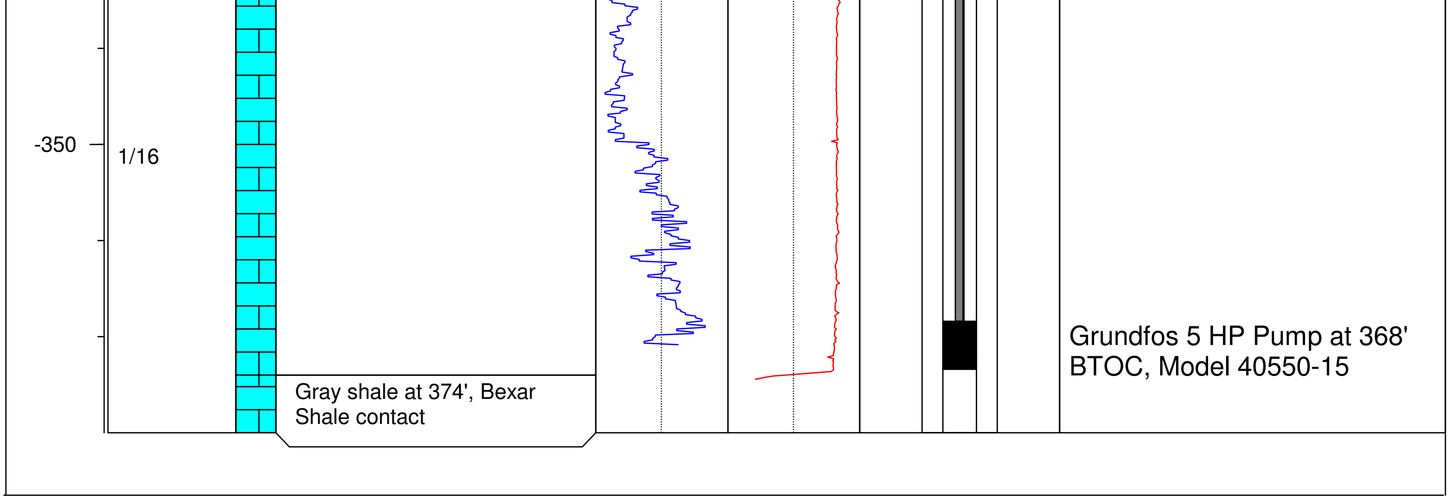
Light brown limestone interbedded with gray limestone

-250 1/4+

Gray clayey limestone, to hard gray limestone

-300 1/4+

Light brown limestone, water bearing zone


-350
1/16
Gray shale at 374', Bexar
Shale contact
Grundfos 5 HP Pump at 368'
BTOC, Model 40550-15

APPENDIX E
Well Development Record

Appendix E
B3-EXW05-LGR Well Development Record
Camp Stanley Storage Activity - Boerne, TX

Date	Time	Action	Pumping Rate *(gpm)*	Depth to Water *(ft BTOC)*	Interval Volume *(gallons)*	Culmulative Volume *(gallons)*	Temperature *(°C)*	Conductivity *(m S/cm)*	pH	Dissolved Oxygen *(mg/L)*	Oxidation-Reduction Potential *millivolts*	Turbidity *(NTU)*
5/31/2012	14:30	Jetting/Surging			1,450	1450						
6/1/2012	11:24	Start Pumping	11.6	265.6	0	1450	23.99	0.469	6.89	2.90	140.3	918
	11:30	Pumping	11.6	360.0	70	1520	23.83	0.385	6.91	3.14	147.7	15.2
	12:00	Pumping	11.6	N/A	348	1868	23.78	0.384	6.89	3.27	148.2	6.97
	12:30	Pumping	11.6	358.8	348	2216	23.96	0.384	6.78	2.31	148.3	8.08
	13:00	Pumping	11.6	358.7	348	2564	27.82	0.392	7.00	2.32	152.0	7.66
	13:30	Pumping	11.6	318.8	348	2912	24.86	0.382	6.68	1.41	148.1	6.38
	14:00	Pumping	11.6	355.2	348	3260	25.33	0.386	6.67	2.16	145.3	9.14
	14:30	Pumping	11.6	353.6	348	3608	24.79	0.381	6.61	2.97	142.7	17.2
	15:00	Pumping	11.6	354.3	348	3956	24.39	0.383	6.64	4.07	144.0	10.4
	15:30	Pumping	11.6	353.8	348	4304	24.54	0.376	6.76	5.40	142.8	53.3
6/4/2012	8:30	Start Pumping	10.0	274.8	0	4304	N/A	N/A	N/A	N/A	N/A	N/A
	10:00	Pumping	10.0	N/A	900	5204	N/A	N/A	N/A	N/A	N/A	N/A
	11:00	Pumping	10.0	301.6	600	5804	23.42	0.543	7.21	2.25	131.9	9.98
	11:30	Pumping	10.0	331.2	300	6104	24.04	0.545	7.09	1.52	129.7	20.6
	12:00	Pumping	10.0	338.8	300	6404	24.16	0.543	7.03	1.93	127.9	52
	12:30	Pumping	10.0	342.0	300	6704	24.28	0.541	7.00	1.98	128.2	8.46
	13:00	Pumping	10.0	354.2	300	7004	24.50	0.540	6.93	2.29	128.8	4.78
	13:30	Pumping	10.0	354.4	300	7304	25.06	0.541	7.00	3.06	129.4	5.26
	14:00	Pumping	10.0	354.5	300	7604	24.69	0.540	6.90	2.22	129.0	8.64
	14:30	Pumping	10.0	354.7	300	7904	25.63	0.543	6.95	2.35	128.8	4.94
	15:00	Pumping	10.0	354.7	300	8204	24.85	0.540	6.92	2.40	129.4	3.15

8,200 gallons purged

Notes:

gpm *gallons per minute*
BTOC *Below Top of Casing*
°C *Degrees Celsius*
mS/cm *milliSiemens per centimeter*
mg/L *milligrams per liter*
NTU *Nephelometric turbidity unit*

APPENDIX F
Laboratory Results

B3-EXW05-LGR Sampling Results

SAMPLE ID:		B3-EXW05		B3-EXW05-WC01	
DATE SAMPLED:		6/4/2012		6/6/2012	
LAB SAMPLE ID:		AY62944		AY63155	
MATRIX:		Groundwater		Soil	
	Units	Result	Flag	Result	Flag
Volatile Organics - SW8260B					
1,1,1,2-Tetrachloroethane	µg/L	0.090	U		
1,1,1-Trichloroethane	µg/L	0.030	U		
1,1,2,2-Tetrachloroethane	µg/L	0.070	U		
1,1,2-Trichloroethane	µg/L	0.060	U		
1,1-Dichloroethane	µg/L	0.070	U		
1,1-Dichloroethene	µg/L	0.12	U		
1,1-Dichloropropene	µg/L	0.10	U		
1,2,3-Trichlorobenzene	µg/L	0.24	U		
1,2,3-Trichloropropane	µg/L	0.17	U		
1,2,4-Trichlorobenzene	µg/L	0.16	U		
1,2,4-Trimethylbenzene	µg/L	0.040	U		
1,2-Dibromo-3-chloropropane	µg/L	0.76	U		
1,2-Dibromoethane (EDB)	µg/L	0.060	U		
1,2-Dichlorobenzene	µg/L	0.020	U		
1,2-Dichloroethane	µg/L	0.050	U		
1,2-Dichloropropane	µg/L	0.060	U		
1,3,5-Trimethylbenzene (Mesitylene)	µg/L	0.040	U		
1,3-Dichlorobenzene	µg/L	0.030	U		
1,3-Dichloropropane	µg/L	0.050	U		
1,4-Dichlorobenzene	µg/L	0.070	U		
1-Chlorohexane	µg/L	0.040	U		
2,2-Dichloropropane	µg/L	0.10	U		
2-Chlorotoluene	µg/L	0.040	U		
4-Chlorotoluene	µg/L	0.040	U		
Benzene	µg/L	0.070	U		
Bromobenzene	µg/L	0.060	U		
Bromochloromethane	µg/L	0.11	U		
Bromodichloromethane	µg/L	0.060	U		
Bromoform	µg/L	0.13	U		
Bromomethane	µg/L	0.080	U		
Carbon tetrachloride	µg/L	0.060	U		
Chlorobenzene	µg/L	0.040	U		
Chloroethane	µg/L	0.070	U		
Chloroform	µg/L	**0.18**	F		
Chloromethane	µg/L	0.16	U		
cis-1,2-Dichloroethene	µg/L	**23.92**			
cis-1,3-Dichloropropene	µg/L	0.030	U		
Dibromochloromethane	µg/L	0.060	U		
Dibromomethane	µg/L	0.060	U		
Dichlorodifluoromethane	µg/L	0.11	U		

B3-EXW05-LGR Sampling Results

SAMPLE ID:		B3-EXW05		B3-EXW05-WC01	
DATE SAMPLED:		6/4/2012		6/6/2012	
LAB SAMPLE ID:		AY62944		AY63155	
MATRIX:		Groundwater		Soil	
	Units	**Result**	**Flag**	**Result**	**Flag**
Ethylbenzene	µg/L	0.050	U		
Hexachlorobutadiene	µg/L	0.17	U		
Isopropylbenzene	µg/L	0.040	U		
m,p-Xylene	µg/L	0.070	U		
Methylene chloride	µg/L	0.35	U		
Naphthalene	µg/L	0.070	U		
n-Butylbenzene	µg/L	0.17	U		
n-Propylbenzene	µg/L	0.030	U		
o-Xylene	µg/L	0.060	U		
p-Cymene (p-Isopropyltoluene)	µg/L	0.050	U		
sec-Butylbenzene	µg/L	0.050	U		
Styrene	µg/L	0.080	U		
tert-Butylbenzene	µg/L	0.040	U		
Tetrachloroethene (PCE)	µg/L	**11.8**			
Toluene	µg/L	**2.91**			
trans-1,2-Dichloroethene	µg/L	0.080	U		
trans-1,3-Dichloropropene	µg/L	0.040	U		
Trichloroethene (TCE)	µg/L	**43.16**			
Trichlorofluoromethane	µg/L	0.070	U		
Vinyl chloride	µg/L	0.080	U		
Total Dissolved Solids - E160.1					
Total Dissolved Solids	mg/L	**309.0**			

B3-EXW05-LGR Sampling Results

SAMPLE ID:		B3-EXW05		B3-EXW05-WC01	
DATE SAMPLED:		6/4/2012		6/6/2012	
LAB SAMPLE ID:		AY62944		AY63155	
MATRIX:		Groundwater		Soil	
	Units	Result	Flag	Result	Flag
Volatile Organics - SW8260B					
1,1,1,2-Tetrachloroethane	mg/kg			0.00080	U
1,1,1-Trichloroethane	mg/kg			0.00090	U
1,1,2,2-Tetrachloroethane	mg/kg			0.00090	U
1,1,2-Trichloroethane	mg/kg			0.00090	U
1,1-Dichloroethane	mg/kg			0.0010	U
1,1-Dichloroethene	mg/kg			0.0011	U
1,1-Dichloropropene	mg/kg			0.0012	U
1,2,3-Trichlorobenzene	mg/kg			0.0010	U
1,2,3-Trichloropropane	mg/kg			0.0010	U
1,2,4-Trichlorobenzene	mg/kg			0.0010	U
1,2,4-Trimethylbenzene	mg/kg			0.0011	U
1,2-Dibromo-3-chloropropane	mg/kg			0.0020	U
1,2-Dibromoethane (EDB)	mg/kg			0.0013	U
1,2-Dichlorobenzene	mg/kg			0.0010	U
1,2-Dichloroethane	mg/kg			0.0010	U
1,2-Dichloropropane	mg/kg			0.00070	U
1,3,5-Trimethylbenzene (Mesitylene)	mg/kg			0.0011	U
1,3-Dichlorobenzene	mg/kg			0.0011	U
1,3-Dichloropropane	mg/kg			0.00070	U
1,4-Dichlorobenzene	mg/kg			0.00080	U
1-Chlorohexane	mg/kg			0.00090	U
2,2-Dichloropropane	mg/kg			0.0010	U
2-Chlorotoluene	mg/kg			0.0013	U
4-Chlorotoluene	mg/kg			0.0011	U
Benzene	mg/kg			0.00090	U
Bromobenzene	mg/kg			0.00090	U
Bromochloromethane	mg/kg			0.00080	U
Bromodichloromethane	mg/kg			0.00090	U
Bromoform	mg/kg			0.0011	U
Bromomethane	mg/kg			0.00070	U
Carbon tetrachloride	mg/kg			0.0010	U
Chlorobenzene	mg/kg			0.00070	U
Chloroethane	mg/kg			0.0015	U
Chloroform	mg/kg			0.00070	U
Chloromethane	mg/kg			0.0015	U
cis-1,2-Dichloroethene	mg/kg			0.00080	U
cis-1,3-Dichloropropene	mg/kg			0.00090	U
Dibromochloromethane	mg/kg			0.00090	U
Dibromomethane	mg/kg			0.0010	U

B3-EXW05-LGR Sampling Results

SAMPLE ID:		B3-EXW05		B3-EXW05-WC01	
DATE SAMPLED:		6/4/2012		6/6/2012	
LAB SAMPLE ID:		AY62944		AY63155	
MATRIX:		Groundwater		Soil	
	Units	Result	Flag	Result	Flag
Dichlorodifluoromethane	mg/kg			0.0018	U
Ethylbenzene	mg/kg			0.0010	U
Hexachlorobutadiene	mg/kg			0.0011	U
Isopropylbenzene	mg/kg			0.0010	U
m,p-Xylene	mg/kg			0.0018	U
Methylene chloride	mg/kg			0.0013	U
Naphthalene	mg/kg			0.0010	U
n-Butylbenzene	mg/kg			0.0010	U
n-Propylbenzene	mg/kg			0.0012	U
o-Xylene	mg/kg			0.00070	U
p-Cymene (p-Isopropyltoluene)	mg/kg			0.0012	U
sec-Butylbenzene	mg/kg			0.0011	U
Styrene	mg/kg			0.00090	U
tert-Butylbenzene	mg/kg			0.0012	U
Tetrachloroethene (PCE)	mg/kg			0.00080	U
Toluene	mg/kg			0.0010	U
trans-1,2-Dichloroethene	mg/kg			0.00080	U
trans-1,3-Dichloropropene	mg/kg			0.00090	U
Trichloroethene (TCE)	mg/kg			0.0012	U
Trichlorofluoromethane	mg/kg			0.0013	U
Vinyl chloride	mg/kg			0.0013	U
Metals - SW6010B/SW7471A					
Arsenic	mg/kg			**2.5**	F
Barium	mg/kg			**2.7**	
Cadmium	mg/kg			0.030	U
Chromium	mg/kg			**2.6**	F
Copper	mg/kg			**24.08**	
Lead	mg/kg			0.18	U
Mercury	mg/kg			0.010	U
Nickel	mg/kg			**4.96**	
Zinc	mg/kg			**32.6**	

QA NOTES AND DATA QUALIFIERS:

(NO CODE) - Confirmed identification.

U - Analyte was not detected above the indicated Method Detection Limit (MDL).

F - Analyte was positively identified, but the quantitation is an estimation above the MDL and below the Reporting Limit (RL).

Detections are bolded.

Laboratory Report

Parsons

Project #: 748607.01000 CSSA

ARF: 67961

Sample collected: June 4, 2012

APPL, Inc.

Summary Package
for
Project #: 748607.01000 CSSA

ARF 67961

TABLE OF CONTENTS

LABORATORY NAME: *APPL, Inc.*

CASE NARRATIVE

908 North Temperance Ave. ∇ Clovis, CA 93611 ∇ Phone 559-275-2175 ∇ Fax 559-275-4422

Case Narrative

ARF: 67961

Project: 748607.01000 CSSA

California State Certification Number: CA1312 (DW & WW)

NELAP Certification number: 05233CA (HW)

Texas Certificate Number: T104704242-10-3

Results in this report apply to the sample analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Sample Receipt Information:

The water sample was received June 5, 2012, at 1.5°C. The sample was assigned Analytical Request Form (ARF) number 67961. The sample number and requested analyses were compared to the chain of custody. The collection time was added to the COC, as instructed. No other exception was noted.

Sample Table

CLIENT ID	APPL ID	Matrix	Date Sampled	Date Received
B3-EXW05	AY62944	WATER	06/04/12	06/05/12

Volatile Organic Compounds

EPA Method 8260B

Sample Preparation:

The sample was purged according to EPA method 5030B. All holding times were met.

Sample Analysis Information:

The sample was analyzed according to EPA method 8260B using a Hewlett Packard Gas Chromatograph with a mass spectrometer detector. All holding times were met.

Quality Control/Assurance:

Spike Recovery:

A Laboratory Control Spike (LCS) was used for quality assurance. A second-source standard (SS) was used for the LCS. All LCS criteria were met.

There was no sample designated by the client for MS/MSD analysis.

Surrogates:

Surrogate recoveries are summarized on Form 2 & 8. All surrogate recoveries met acceptance criteria.

Method blanks:

No target compound was detected at or above its reporting limit in the method blank.

Calibration:

Initial and continuing calibrations were analyzed according to the method. All acceptance criteria were met.

Tuning:

The instrument was tuned using BFB. All method criteria were met.

Internal Standards:

The internal standard area counts were compared to the mid-point of the initial calibration according to method 8260. All acceptance criteria were met.

Summary:

No analytical exception was noted. All data generated are acceptable.

Total Dissolved Solids

EPA Method 160.1

Sample Preparation and Analysis Information:

The sample was prepared and analyzed according to the method. All holding times were met.

Quality Control/Assurance

Calibrations:

The balances are calibrated daily prior to use.

Blanks:

No target analyte was detected above the RL in the method blank.

Spikes:

Laboratory Control Spikes (LCS/LCSD) were used for quality assurance. All recoveries met acceptance criteria.

No sample was designated by the client for MS/MSD analysis.

Summary:

No analytical exception was noted. All data are acceptable.

CERTIFICATION

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness, for other than the conditions detailed above. These test results meet all requirements of NELAC. Release of the hard copy has been authorized by the Laboratory Manager or her designee, as verified by the following signature.

6-18-12

Sharon Dehmlow, Laboratory Director / Date

CHAIN OF CUSTODY
AND ARF

APPL - Analysis Request Form

67961

Client:	Parsons	Received by:	CM
Address:	8000 Centre Park Drive Ste 200 Austin, TX 78754	Date Received:	06/05/12 Time: 10:00
		Delivered by:	FED EX
Attn:	Tammy Chang	Shuttle Custody Seals (Y/N):	Y Time Zone: -5
Phone:	512-719-6092 Fax: 512-719-6099	Chest Temp(s):	1.5°C
Job:	748607.01000 CSSA	Color:	VOA/A-GRN
PO #:	748336.30000-00 (prime *G012)	Samples Chilled until Placed in Refrig/Freezer:	Y
Chain of Custody (Y/N):	Y # 060412APPFA	Project Manager:	Diane Anderson np
RAD Screen (Y/N):	Y pH (Y/N): N	QC Report Type:	DVP3/AFCEE/ERPIMS/TX
Turn Around Type:	7 DAYS	Due Date:	06/12/12

Comments:

pdf ARF to Tammy & Pam; send 1 DVP3 HC & CD to Tammy.
Data screening project: analyze samples ONCE; report deficiencies; do NOT re-analyze
Case Narrative. CSSA + AFCEE 3.1 QAPP. Only report MS/MSD when requested.
Use AFCEE forms with AFCEE flagging to report sample & QC data only.
APPL forms for everything else and APPL DVP3.
EDD: ERPIMS 4 Lab PC4 checked TXF to Pam.Ford@parsons.com
No collection time listed on COCs; Collection time taken from sample containers (15:10)
MAR 6-12-12

6-6 Sent ARF

Sample Distribution:
VOA: 1-$826AW
Wetlab: 1-$TDS

Charges:

Invoice To:
BOA 748336.30000 TO# 5
8000 Centre Park Drive Ste 200
Austin, TX 78754-5140
Attn: Ellen Felfe

Client ID	APPL ID	Sampled	Analyses Requested
1. B3-EXW05	AY62944W	06/04/12 15:10	$826AW, $TDS

Note: All times, excluding sample collection times, are Pacific Time Zone unless noted otherwise. Collection times are in: -5 UTC

APPL Sample Receipt Form

ARF# 67961

Sample	Container Type	Count	pH
AY62944	[3]PL 250mL	1	NA
	[13]VOAs - HCL	3	NA

Sample	Container Type	Count	pH

Renee Patterson

From: Bouch, Julie [Julie.Bouch@parsons.com]
Sent: Tuesday, June 05, 2012 1:16 PM
To: Chang, Tammy
Cc: Renee Patterson; Diane Anderson
Subject: RE: CSSA ARF 67961 receiving notes

I guess the sample time was not put on the COC. I collected it at 1510 and the COC was completed by someone else. Sorry.

It is a new well we are putting in. I do not know how to answer that question? Should I contact Scott?

Julie Di Bartolomeo Bouch
Geologist
Parsons
San Antonio, TX
210-376-0809

SAFETY - MAKE IT PERSONAL

-----Original Message-----
From: Chang, Tammy
Sent: Tue 6/5/2012 2:44 PM
To: Bouch, Julie
Cc: 'Renee Patterson'; 'Diane Anderson'
Subject: FW: CSSA ARF 67961 receiving notes

Julie?

From: Renee Patterson [mailto:rpatterson@applinc.com]
Sent: Tuesday, June 05, 2012 2:39 PM
To: Chang, Tammy
Cc: 'Diane Anderson'
Subject: CSSA ARF 67961 receiving notes
Importance: High

Tammy

There is no collection time listed on the COC. May we use the time listed on the container labels?

We noticed that there's a new project # on this COC. Is it correct? or does this mean we'll have a new task order under the BOA?

67961
1.5

Camp Stanley Storage Activity Chain Of Custody

COC ID:	060412APPFA	Relinquish_Date:	6/4/2012	Cooler ID:	A
Project Location:	CSSA	Relinquished_By:	EWR	LabCode:	APPF
Job Number:	748607.01000	Relinquish_Time:	4:30 PM	Carrier:	FedEx
Creation Date:	6/4/2012	Collection Team:	JDB	Airbill Carrier:	876436443789
Task Manager	Scott Pearson	Sample Data Type	Screening	TAT:	7 Day TAT

Sampler(s): Julie Burch

LOCID: **B3-EXW05** LOGDATE: 6/4/2012 MATRIX: WG TBLOT:
SBD: 0 LOGTIME: 1510 SACODE: N SMCODE: G ABLOT:
SED: 0 FLDSAMPID B3-EXW05_060412_N1510 EBLOT:
Containers: 4

Analysis Required:

E160.1	TOTAL DISSOLVED SOL	SW8260B	VOLATILE ORGANIC CO

Remarks: collection time per email. 6-5-12 rp

12

Relinquished by:	Date 6.4.12	Time 1630	Relinquished by:	Date	Time	Relinquished by:	Date	Time
Recieved by:	Date 6/5/12	Time 1000	Recieved by:	Date	Time	Recieved by:	Date	Time

COOLER RECEIPT FORM

1) Project: 748607.01000 CSSA Date Received: 06/05/12

2) Coolers: Number of Coolers: 1

3) **YES** NO Were coolers and samples screened for radioactivity?

4) **YES** NO Were custody seals on outside of cooler? How many? 2 Date on seal? 06/04/12

5) Name on seal? See Below

6) **YES** NO NA Were custody seals unbroken and intact at the time of arrival?

7) **YES** NO Did the cooler come with a shipping slip (air bill, etc.)? Carrier name: Fed Ex

8) Shipping slip numbers: 1) 8764 3644 3789 2) ______ 3) ______

9) YES **NO** NA Was the shipping slip scanned into the database?

10) YES **NO** NA If cooler belongs to APPL, has it been logged into the ice chest database?

11) Describe type of packing in cooler (bubble wrap, popcorn, type of ice, etc.): Wet ICE & Bubble Wrap

12) YES NO **NA** For hand delivered samples was sufficient ice present to start the cooling process?

13) **YES** NO Was a temperature blank included in the cooler?

14) Serial number of certified NIST thermometer used: A39267 Correction factor: -0

15) Cooler temp(s): 1) 1.5° 2) ______ 3) ______ 4) ______ 5) ______ 6) ______ 7) ______ 8) ______

Chain of custody:

16) **YES** NO Was a chain of custody received?

17) **YES** NO Were the custody papers signed in the appropriate places?

18) **YES** NO Was the project identifiable from custody papers?

19) YES **NO** Did the chain of custody include date and time of sampling?

20) **YES** NO Is location where sample was taken listed on the chain of custody?

Sample Labels:

21) **YES** NO Were container labels in good condition?

22) **YES** NO Was the client ID on the label?

23) **YES** NO Was the date of sampling on the label?

24) **YES** NO Was the time of sampling on the label?

25) **YES** NO Did all container labels agree with custody papers?

Sample Containers:

26) **YES** NO Were all containers sealed in separate bags?

27) **YES** NO Did all containers arrive unbroken?

28) YES **NO** Was there any leakage from samples?

29) YES **NO** Were any of the lids cracked or broken?

30) **YES** NO Were correct containers used for the tests indicated?

31) **YES** NO Was a sufficient amount of sample sent for tests indicated?

32) YES **NO** NA Were bubbles present in volatile samples? If yes, the following were received with air bubbles:

Larger than a pea: ______

Smaller than a pea: ______

Preservation & Hold time:

33) **YES** NO NA Was a sufficient amount of holding time remaining to analyze the samples?

34) YES NO **NA** Do the sample containers contain the same preservative as what is stated on the COC?

35) YES NO **NA** Was the pH taken of all non-VOA preserved samples and written on the sample container?

36) YES NO **NA** Was the pH of acid preserved non-VOA samples < 2 & sodium hydroxide preserved samples > 12?

37) YES NO **NA** Unpreserved VOA Vials received? ______

38) YES NO **NA** Are unpreserved VOA vials noted in the ADD TEST FIELD on the ARF? ______

Lab notified if pH was not adequate: ______

Deficiencies: No collection time listed on COCs; collection time taken from sample containers

Signature of personnel receiving samples: [signature] Second reviewer: [signature]

Signature of project manager notified: Renee Date and Time of notification: 6-5-12

Name of client notified: Tammy via email Date and Time of notification: 6-5-12

Information given to client: ______

______ by whom (Initials): ______

CUSTODY SEAL
APPL, Inc. (559) 275-2175
Initials [initials] Date 6/4/12

F:\Forms\Worksheet - CoolerReceipt.doc *Revision 18, August 24, 2011*

EPA METHOD 8260B
Volatile Organic Compounds

APPL, INC.

EPA METHOD 8260B
Volatile Organic Compounds
QC Summary

APPL, INC.

AFCEE
ORGANIC ANALYSES DATA SHEET 6
BLANK

Analytical Method: EPA 8260B
Lab Name: APPL, Inc
Concentration Units: ug/L
Initial Calibration ID: N120602

AAB #: 120605AN-167722
Contract #: *G012
Method Blank ID: 120605AN-BLK

Analyte	Method Blank	RL	Q
1,1,1,2-TETRACHLOROETHANE	< RL	0.5	U
1,1,1-TCA	< RL	0.8	U
1,1,2,2-TETRACHLOROETHANE	< RL	0.4	U
1,1,2-TCA	< RL	1.0	U
1,1-DCA	< RL	0.4	U
1,1-DCE	< RL	1.2	U
1,1-DICHLOROPROPENE	< RL	1.0	U
1,2,3-TRICHLOROBENZENE	< RL	0.3	U
1,2,3-TRICHLOROPROPANE	< RL	3.2	U
1,2,4-TRICHLOROBENZENE	< RL	0.4	U
1,2,4-TRIMETHYLBENZENE	< RL	1.3	U
1,2-DCA	< RL	0.6	U
1,2-DCB	< RL	0.3	U
1,2-DIBROMO-3-CHLOROPROPANE	< RL	2.6	U
1,2-DICHLOROPROPANE	< RL	0.4	U
1,2-EDB	< RL	0.6	U
1,3,5-TRIMETHYLBENZENE	< RL	0.5	U
1,3-DCB	< RL	1.2	U
1,3-DICHLOROPROPANE	< RL	0.4	U
1,4-DCB	< RL	0.3	U
1-CHLOROHEXANE	< RL	0.5	U
2,2-DICHLOROPROPANE	< RL	3.5	U
2-CHLOROTOLUENE	< RL	0.4	U
4-CHLOROTOLUENE	< RL	0.6	U
BENZENE	< RL	0.4	U
BROMOBENZENE	< RL	0.3	U
BROMOCHLOROMETHANE	< RL	0.4	U
BROMODICHLOROMETHANE	< RL	0.8	U
BROMOFORM	< RL	1.2	U
BROMOMETHANE	< RL	1.1	U
CARBON TETRACHLORIDE	< RL	2.1	U
CHLOROBENZENE	< RL	0.4	U
CHLOROETHANE	< RL	1.0	U
CHLOROFORM	< RL	0.3	U
CHLOROMETHANE	< RL	1.3	U
CIS-1,2-DCE	< RL	1.2	U
CIS-1,3-DICHLOROPROPENE	< RL	1.0	U
DIBROMOCHLOROMETHANE	< RL	0.5	U
DIBROMOMETHANE	< RL	2.4	U
DICHLORODIFLUOROMETHANE	< RL	1.0	U
ETHYLBENZENE	< RL	0.6	U

Comments: ARF: 67961, Sample: AY62944

AFCEE FORM O-6

AFCEE
ORGANIC ANALYSES DATA SHEET 6
BLANK

Analytical Method: EPA 8260B
Lab Name: APPL, Inc
Concentration Units: ug/L
Initial Calibration ID: N120602

AAB #: 120605AN-167722
Contract #: *G012
Method Blank ID: 120605AN-BLK

Analyte	Method Blank	RL	Q
HEXACHLOROBUTADIENE	< RL	1.1	U
ISOPROPYLBENZENE	< RL	0.5	U
M&P-XYLENE	< RL	0.5	U
METHYLENE CHLORIDE	< RL	1.0	U
N-BUTYLBENZENE	< RL	1.1	U
N-PROPYLBENZENE	< RL	0.4	U
NAPHTHALENE	< RL	0.4	U
O-XYLENE	< RL	1.1	U
P-ISOPROPYLTOLUENE	< RL	1.2	U
SEC-BUTYLBENZENE	< RL	1.3	U
STYRENE	< RL	0.4	U
TCE	< RL	1.0	U
TERT-BUTYLBENZENE	< RL	1.4	U
TETRACHLOROETHENE	< RL	1.4	U
TOLUENE	< RL	1.1	U
TRANS-1,2-DCE	< RL	0.6	U
TRANS-1,3-DICHLOROPROPENE	< RL	1.0	U
TRICHLOROFLUOROMETHANE	< RL	0.8	U
VINYL CHLORIDE	< RL	1.1	U

Surrogate	Recovery	Control Limits	Qualifier
SURROGATE: 1,2-DICHLOROETHAN	103	69-139	
SURROGATE: 4-BROMOFLUOROBE	89.3	75-125	
SURROGATE: DIBROMOFLUOROME	101	75-125	
SURROGATE: TOLUENE-D8 (S)	95.9	75-125	

Internal Std	Qualifier
1,4-DICHLOROBENZENE-D4 (IS)	
CHLOROBENZENE-D5 (IS)	
FLUOROBENZENE (IS)	

Comments: ARF: 67961, Sample: AY62944

Form 2 & 8

Surrogate Recovery

Lab Name: APPL, Inc.
Case No: 67961
Matrix: WATER

SDG No: 67961
Date Analyzed: 06/05/12
Instrument: Neo

APPL ID.	Client Sample No.	SURROGATE: 1,2-DICHLOROETHANE-D4 (S)			SURROGATE: 4-BROMOFLUOROBENZENE (S)		
		Limits	Result	Qualifier	Limits	Result	Qualifier
120605AN-LCS	Lab Control Spike	69-139	106		75-125	91.0	
120605AN-BLK	Blank	69-139	103		75-125	89.3	
AY62944	B3-EXW05	69-139	103		75-125	95.0	

Comments: Batch: #826AW-120605AN

Printed: 06/15/12 3:20:53 PM
Form 2 & 8, Surrogate Recovery Summary

Form 2 & 8

Surrogate Recovery

Lab Name: APPL, Inc.
SDG No: 67961
Case No: 67961
Date Analyzed: 06/05/12
Matrix: WATER
Instrument: Neo

APPL ID.	Client Sample No.	SURROGATE: DIBROMOFLUOROMETHANE (S)			SURROGATE: TOLUENE-D8 (S)		
		Limits	Result	Qualifier	Limits	Result	Qualifier
120605AN-LCS	Lab Control Spike	75-125	106		75-125	86.0	
120605AN-BLK	Blank	75-125	101		75-125	95.9	
AY62944	B3-EXW05	75-125	100		75-125	98.2	

Comments: Batch: #826AW-120605AN

AFCEE
ORGANIC ANALYSES DATA SHEET 7
LABORATORY CONTROL SAMPLE

Analytical Method: EPA 8260B

Lab Name: APPL, Inc

LCS ID: 120605AN LCS

Concentration Units: ug/L

AAB #: 120605AN-167722

Contract #: *G012

Initial Calibration ID: N120602

Analyte	Expected	Found	% R	Control Limits	Q
1,1,1,2-TETRACHLOROETHANE	10.00	8.94	89.4	72-125	
1,1,1-TCA	10.00	10.44	104	75-125	
1,1,2,2-TETRACHLOROETHANE	10.00	9.16	91.6	74-125	
1,1,2-TCA	10.00	11.13	111	75-127	
1,1-DCA	10.00	9.18	91.8	75-125	
1,1-DCE	10.00	9.60	96.0	75-125	
1,1-DICHLOROPROPENE	10.00	9.54	95.4	75-125	
1,2,3-TRICHLOROBENZENE	10.00	9.94	99.4	75-137	
1,2,3-TRICHLOROPROPANE	10.00	10.31	103	75-125	
1,2,4-TRICHLOROBENZENE	10.00	9.58	95.8	75-135	
1,2,4-TRIMETHYLBENZENE	10.00	9.98	99.8	75-125	
1,2-DCA	10.00	9.41	94.1	68-127	
1,2-DCB	10.00	10.12	101	75-125	
1,2-DIBROMO-3-CHLOROPROPANE	10.00	10.60	106	59-125	
1,2-DICHLOROPROPANE	10.00	11.10	111	70-125	
1,2-EDB	10.00	9.90	99.0	75-125	
1,3,5-TRIMETHYLBENZENE	10.00	9.15	91.5	72-125	
1,3-DCB	10.00	10.06	101	75-125	
1,3-DICHLOROPROPANE	10.00	10.25	103	75-125	
1,4-DCB	10.00	9.56	95.6	75-125	
1-CHLOROHEXANE	10.00	8.65	86.5	75-125	
2,2-DICHLOROPROPANE	10.00	10.33	103	75-125	
2-CHLOROTOLUENE	10.00	10.23	102	73-125	
4-CHLOROTOLUENE	10.00	9.83	98.3	74-125	
BENZENE	10.00	9.12	91.2	75-125	
BROMOBENZENE	10.00	9.49	94.9	75-125	
BROMOCHLOROMETHANE	10.00	10.53	105	73-125	
BROMODICHLOROMETHANE	10.00	11.01	110	75-125	
BROMOFORM	10.00	9.97	99.7	75-125	
BROMOMETHANE	10.00	8.63	86.3	72-125	
CARBON TETRACHLORIDE	10.00	9.23	92.3	62-125	
CHLOROBENZENE	10.00	9.43	94.3	75-125	
CHLOROETHANE	10.00	8.77	87.7	65-125	
CHLOROFORM	10.00	10.56	106	74-125	
CHLOROMETHANE	10.00	9.99	99.9	75-125	
CIS-1,2-DCE	10.00	8.88	88.8	75-125	
CIS-1,3-DICHLOROPROPENE	10.00	9.50	95.0	74-125	
DIBROMOCHLOROMETHANE	10.00	9.43	94.3	73-125	
DIBROMOMETHANE	10.00	9.63	96.3	69-127	
DICHLORODIFLUOROMETHANE	10.00	10.11	101	72-125	

Comments: ARF: 67961, QC Sample ID: AY62944

AFCEE
ORGANIC ANALYSES DATA SHEET 7
LABORATORY CONTROL SAMPLE

Analytical Method: EPA 8260B

AAB #: 120605AN-167722

Lab Name: APPL, Inc

Contract #: *G012

LCS ID: 120605AN LCS

Initial Calibration ID: N120602

Concentration Units: ug/L

Analyte	Expected	Found	% R	Control Limits	Q
ETHYLBENZENE	10.00	9.59	95.9	75-125	
HEXACHLOROBUTADIENE	10.00	9.29	92.9	75-125	
ISOPROPYLBENZENE	10.00	10.41	104	75-125	
M&P-XYLENE	20.00	17.98	89.9	75-125	
METHYLENE CHLORIDE	10.00	9.74	97.4	75-125	
N-BUTYLBENZENE	10.00	9.27	92.7	75-125	
N-PROPYLBENZENE	10.00	9.77	97.7	75-125	
NAPHTHALENE	10.00	11.30	113	75-125	
O-XYLENE	10.00	9.41	94.1	75-125	
P-ISOPROPYLTOLUENE	10.00	9.31	93.1	75-125	
SEC-BUTYLBENZENE	10.00	9.64	96.4	75-125	
STYRENE	10.00	9.08	90.8	75-125	
TCE	10.00	8.95	89.5	71-125	
TERT-BUTYLBENZENE	10.00	9.45	94.5	75-125	
TETRACHLOROETHENE	10.00	7.65	76.5	71-125	
TOLUENE	10.00	9.91	99.1	74-125	
TRANS-1,2-DCE	10.00	8.91	89.1	75-125	
TRANS-1,3-DICHLOROPROPENE	10.00	10.37	104	66-125	
TRICHLOROFLUOROMETHANE	10.00	11.09	111	67-125	
VINYL CHLORIDE	10.00	8.87	88.7	46-134	

Surrogate	Recovery	Control Limits	Qualifier
SURROGATE: 1,2-DICHLOROETHANE-	106	69-139	
SURROGATE: 4-BROMOFLUOROBENZE	91.0	75-125	
SURROGATE: DIBROMOFLUOROMETH	106	75-125	
SURROGATE: TOLUENE-D8 (S)	86.0	75-125	

Internal Std	Qualifier
1,4-DICHLOROBENZENE-D4 (IS)	
CHLOROBENZENE-D5 (IS)	
FLUOROBENZENE (IS)	

Comments: ARF: 67961, QC Sample ID: AY62944

EPA 8260B

Form 4

Blank Summary

Lab Name:	APPL, Inc.	SDG No:	67961
Case No:	67961	Date Analyzed:	06/05/12
Matrix:	WATER	Instrument:	Neo
Blank ID:	120605AN-BLK	Time Analyzed:	1309

APPL ID.	Client Sample No.	File ID.	Date Analyzed
120605AN-LCS	Lab Control Spike	0605N04	06/05/12 1115
120605AN-BLK	Blank	0605N07	06/05/12 1309
AY62944	B3-EXW05	0605N16	06/05/12 1908

Comments: Batch: #826AW-120605AN

Printed: 06/15/12 3:20:50 PM
Form 4, Blank Summary

Form 5
Tune Summary

Lab Name: APPL Inc.
Case No: 67961
Matrix: Water
ID: 25ug/mL BFB Std 05-09-12

SDG No: 67961
Date Analyzed: 06/05/12
Instrument: Neo
Time Analyzed: 8:54

	Client Sample No.	APPL ID.	File ID.	Date Analyzed
1		10ug/L Vol Std 06-05	0605N02W.D	06/05/12 10:00
2	Lab Control Spike	120605A LCS-1WN	0605N04W.D	06/05/12 11:15
3	Blank	120605A BLK-1WN	0605N07W.D	06/05/12 13:09
4	B3-EXW05	AY62944W01	0605N16W.D	06/05/12 19:08
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				

m/e		
50	14.95 - 40% of mass 95	24.3
75	30 - 60% of mass 95	51.0
95	100 - 100% of mass 95	100.0
96	5 - 9% of mass 95	7.3
173	0 - 2% of mass 174	0.6
174	50 - 100% of mass 95	70.5
175	5 - 9% of mass 174	7.3
176	95 - 101% of mass 174	97.4
177	5 - 9% of mass 176	6.4

8A
INTERNAL STANDARD AREA AND RT SUMMARY

Lab Name: APPL Inc. Contract: Review

Lab Code: ________ SDG No.: 67961

Lab File ID (Standard): 0602N08W.D Date Analyzed: 2 Jun 12 16:55

Instrument ID: Neo Time Analyzed: 2 Jun 12 16:55

GC Column: ________ ID: Heated Purge: (Y/N) ________

		Fluorobenzene (IS)		Chlorobenzene-D5 (IS)		1,4-Dichlorobenzene-D (IS)	
		AREA #	RT #	AREA #	RT #	AREA #	RT #
	12 HOUR STD	284864	13.31	179200	18.49	81408	22.68
	UPPER LIMIT	569728	13.81	358400	18.99	162816	23.18
	LOWER LIMIT	142432	12.81	89600	17.99	40704	22.18
	SAMPLE NO.						
01	10ug/L Vol Std 06-05-12	282843	13.26	175424	18.44	91624	22.64
02	120605A LCS-1WN	259200	13.26	179072	18.44	77208	22.64
03	120605A BLK-1WN	262656	13.27	181248	18.45	75168	22.65
04	AY62944W01	244672	13.28	163648	18.46	74392	22.65
05							
06							
07							
08							
09							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							

AREA UPPER LIMIT = +100% of internal standard area.
AREA LOWER LIMIT = -50% of internal standard area.
RT UPPER LIMIT = +0.50 minutes of internal standard RT
RT LOWER LIMIT = -0.50 minutes of internal standard RT

Column used to flag values outside QC limits with an asterisk.
* Values outside of QC limits.

EPA METHOD 8260B
Volatile Organic Compounds
Sample Data

APPL, INC.

AFCEE
ORGANIC ANALYSES DATA SHEET 2
RESULTS

Analytical Method: EPA 8260B   Preparatory Method: 5030B   AAB #: 120605AN-167722

Lab Name: APPL, Inc   Contract #: *G012

Field Sample ID: B3-EXW05   Lab Sample ID: AY62944   Matrix: Water

% Solids: NA   Initial Calibration ID: N120602

Date Received: 05-Jun-12   Date Prepared: 05-Jun-12   Date Analyzed: 05-Jun-12

Concentration Units: ug/L

Analyte	MDL	RL	Concentration	Dilution	Confirm	Qualifier
1,1,1,2-TETRACHLOROETHANE	0.09	0.5	0.09	1		U
1,1,1-TCA	0.03	0.8	0.03	1		U
1,1,2,2-TETRACHLOROETHANE	0.07	0.4	0.07	1		U
1,1,2-TCA	0.06	1.0	0.06	1		U
1,1-DCA	0.07	0.4	0.07	1		U
1,1-DCE	0.12	1.2	0.12	1		U
1,1-DICHLOROPROPENE	0.10	1.0	0.10	1		U
1,2,3-TRICHLOROBENZENE	0.24	0.3	0.24	1		U
1,2,3-TRICHLOROPROPANE	0.17	3.2	0.17	1		U
1,2,4-TRICHLOROBENZENE	0.16	0.4	0.16	1		U
1,2,4-TRIMETHYLBENZENE	0.04	1.3	0.04	1		U
1,2-DCA	0.05	0.6	0.05	1		U
1,2-DCB	0.02	0.3	0.02	1		U
1,2-DIBROMO-3-CHLOROPROPANE	0.76	2.6	0.76	1		U
1,2-DICHLOROPROPANE	0.06	0.4	0.06	1		U
1,2-EDB	0.06	0.6	0.06	1		U
1,3,5-TRIMETHYLBENZENE	0.04	0.5	0.04	1		U
1,3-DCB	0.03	1.2	0.03	1		U
1,3-DICHLOROPROPANE	0.05	0.4	0.05	1		U
1,4-DCB	0.07	0.3	0.07	1		U
1-CHLOROHEXANE	0.04	0.5	0.04	1		U
2,2-DICHLOROPROPANE	0.10	3.5	0.10	1		U
2-CHLOROTOLUENE	0.04	0.4	0.04	1		U
4-CHLOROTOLUENE	0.04	0.6	0.04	1		U
BENZENE	0.07	0.4	0.07	1		U
BROMOBENZENE	0.06	0.3	0.06	1		U
BROMOCHLOROMETHANE	0.11	0.4	0.11	1		U
BROMODICHLOROMETHANE	0.06	0.8	0.06	1		U
BROMOFORM	0.13	1.2	0.13	1		U
BROMOMETHANE	0.08	1.1	0.08	1		U
CARBON TETRACHLORIDE	0.06	2.1	0.06	1		U
CHLOROBENZENE	0.04	0.4	0.04	1		U
CHLOROETHANE	0.07	1.0	0.07	1		U
CHLOROFORM	0.06	0.3	0.18	1		F
CHLOROMETHANE	0.16	1.3	0.16	1		U

Comments:

ARF: 67961

AFCEE FORM O-2

AFCEE
ORGANIC ANALYSES DATA SHEET 2
RESULTS

Analytical Method: EPA 8260B   Preparatory Method: 5030B   AAB #: 120605AN-167722

Lab Name: APPL, Inc   Contract #: *G012

Field Sample ID: B3-EXW05   Lab Sample ID: AY62944   Matrix: Water

% Solids: NA   Initial Calibration ID: N120602

Date Received: 05-Jun-12   Date Prepared: 05-Jun-12   Date Analyzed: 05-Jun-12

Concentration Units: ug/L

Analyte	MDL	RL	Concentration	Dilution	Confirm	Qualifier
CIS-1,2-DCE .	0.07	1.2	23.92	1		
CIS-1,3-DICHLOROPROPENE	0.03	1.0	0.03	1		U
DIBROMOCHLOROMETHANE	0.06	0.5	0.06	1		U
DIBROMOMETHANE	0.06	2.4	0.06	1		U
DICHLORODIFLUOROMETHANE	0.11	1.0	0.11	1		U
ETHYLBENZENE	0.05	0.6	0.05	1		U
HEXACHLOROBUTADIENE	0.17	1.1	0.17	1		U
ISOPROPYLBENZENE	0.04	0.5	0.04	1		U
M&P-XYLENE	0.07	0.5	0.07	1		U
METHYLENE CHLORIDE	0.35	1.0	0.35	1		U
N-BUTYLBENZENE	0.17	1.1	0.17	1		U
N-PROPYLBENZENE	0.03	0.4	0.03	1		U
NAPHTHALENE	0.07	0.4	0.07	1		U
O-XYLENE	0.06	1.1	0.06	1		U
P-ISOPROPYLTOLUENE	0.05	1.2	0.05	1		U
SEC-BUTYLBENZENE	0.05	1.3	0.05	1		U
STYRENE	0.08	0.4	0.08	1		U
TCE	0.05	1.0	43.16	1		
TERT-BUTYLBENZENE	0.04	1.4	0.04	1		U
TETRACHLOROETHENE	0.06	1.4	11.76	1		
TOLUENE	0.06	1.1	2.91	1		
TRANS-1,2-DCE	0.08	0.6	0.08	1		U
TRANS-1,3-DICHLOROPROPENE	0.04	1.0	0.04	1		U
TRICHLOROFLUOROMETHANE	0.07	0.8	0.07	1		U
VINYL CHLORIDE	0.08	1.1	0.08	1		U

Surrogate	Recovery	Control Limits	Qualifier
SURROGATE: 1,2-DICHLOROETHANE-	103	69-139	
SURROGATE: 4-BROMOFLUOROBENZE	95.0	75-125	
SURROGATE: DIBROMOFLUOROMETH	100	75-125	
SURROGATE: TOLUENE-D8 (S)	98.2	75-125	

Internal Std	Qualifier
1,4-DICHLOROBENZENE-D4 (IS)	
CHLOROBENZENE-D5 (IS)	
FLUOROBENZENE (IS)	

Comments:

ARF: 67961

AFCEE FORM O-2

EPA METHOD 8260B
Volatile Organic Compounds
Calibration Data

APPL, INC.

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 6
Initial Calibration

Lab Name: APPL, Inc. SDG No: 67961
Case No: Initial Cal. Date: 06/02/12
Matrix: water Instrument: Neo Initials:

			0602N04W.D	0602N05W.D	0602N06W.D	0602N07W.D	0602N08W.D	0602N09W.D	0602N10W.D	0602N11W.D						
		Compound	0.3	0.5	1	5	10	40	100	200			Avg	%RSD		
1	I	Fluorobenzene (IS)														
2	TML	Dichlorodifluoromethane		0.1488	0.2331	0.2166	0.2424	0.2499	0.2415	0.2393			0.22	16	TML	1.000
3	TM**	Chloromethane	0.5145	0.4359	0.3892	0.3662	0.3780	0.3450	0.3535	0.3555			0.39	15	TM**	
4	TM*	Vinyl chloride	0.3483	0.2898	0.2940	0.3613	0.3111	0.3565	0.4005	0.3853			0.34	12	TM*	
5	TM	1,3-Butadiene													TM	
6	TML	Bromomethane	0.2422	0.3654	0.3976	0.3963	0.4899	0.6241	0.7450	0.7683			0.50	38	TML	0.999
7	TML	Chloroethane	1.553	1.310	0.8035	0.8457	0.7630	0.7792	0.7753	0.7164			0.94	33	TML	0.999
8	TM	Dichlorofluoromethane	0.3825	0.4661	0.3725	0.4551	0.4189	0.3681	0.3643	0.3434			0.40	11	TM	
9	TM	Trichlorofluoromethane	0.1284	0.1620	0.2022	0.1567	0.1335	0.1458	0.1516	0.1371			0.15	15	TM	
10	TM	Acrolein	0.0582	0.0474	0.0490	0.0491	0.0499	0.0529	0.0504	0.0500			0.05	6.5	TM	
11	TML	Acetone			0.1191	0.0466	0.0374	0.0324	0.0284	0.0271			0.05	73	TML	0.999
12	TML	Freon-113	0.2452	0.4585	0.5097	0.5231	0.4898	0.5491	0.5746	0.5108			0.48	21	TML	0.997
13	TM*	1,1-DCE			0.6833	0.7383	0.7359	0.7715	0.7696	0.7168			0.74	4.5	TM*	
14	TM	t-Butanol	0.0055	0.0082	0.0068	0.0062	0.0063	0.0063					0.01	14	TM	
15	TML	Methyl Acetate	1.562	1.182	0.8684	0.4647	0.4117	0.3898	0.3654	0.3642			0.70	65	TML	1.000
16	TML	Iodomethane	0.0461	0.0343	0.1290	0.2359	0.3323	0.3782	0.3951	0.3780			0.24	63	TML	0.999
17	TM	Acrylonitrile													TM	
18	TML	Methylene chloride	1.863	1.265	0.9767	0.7028	0.6301	0.5609	0.5440	0.5187			0.88	54	TML	1.000
19	TM	Carbon disulfide	0.4143	0.3099	0.4913	0.4653	0.4134	0.4354	0.4233	0.4013			0.42	13	TM	
20	TM	Methyl t-butyl ether (MtBE)	1.915	1.594	1.308	1.505	1.436	1.417	1.355	1.219			1.5	15	TM	
21		Hexane		0.3910	0.3416	0.3955	0.3587	0.4168	0.4208	0.3990			0.39	7.5		
22	TM	Trans-1,2-DCE	0.5712	0.5532	0.4479	0.4573	0.4368	0.4425	0.4374	0.4026			0.47	13	TM	
23	TM	Diisopropyl Ether	0.9645	0.9632	0.7899	0.9345	0.8853	0.8015	0.8249	0.7889			0.87	8.9	TM	
24	TM**	1,1-DCA		0.4613	0.4584	0.3670	0.3847	0.3306					0.40	14	TM**	
25	TM	Vinyl Acetate		0.7144	0.5924	0.6953	0.6792	0.6336	0.6757	0.6303			0.66	6.5	TM	
26	TM	Ethyl tert Butyl Ether	0.6292	0.4011	0.4968	0.6324	0.6477	0.5583	0.5547	0.5230			0.56	15	TM	
27	TML	MEK (2-Butanone)	0.2847	0.1821	0.1606	0.1171	0.1294	0.1235	0.1122	0.1052			0.15	39	TML	0.998
28	TM	Cis-1,2-DCE	0.2610	0.1996	0.2220	0.2258	0.2160	0.2094	0.1906	0.1735			0.21	12	TM	
29	TM	2,2-Dichloropropane	0.3225	0.2492	0.2517	0.2577	0.2698	0.2749	0.2804	0.2556			0.27	8.9	TM	
30	TM*	Chloroform	1.467	1.203	1.481	1.521	1.491	1.437	1.412	1.321			1.4	7.5	TM*	
31	TM	Bromochloromethane	0.2122	0.2370	0.2052	0.2164	0.2245	0.2102	0.2082	0.1976			0.21	5.7	TM	
32	S	Dibromofluoromethane(S)	0.9401	0.8519	0.8962	0.8778	0.8829	0.9062	0.8932	0.6888			0.87	8.8	S	
33	TM	2,2,4-Trimethylpentane	0.3142	0.2524	0.3551	0.3082	0.3125	0.3009	0.3126	0.2775			0.30	9.8	TM	
34	TM	1,1,1-TCA	0.8800	1.009	1.014	1.018	1.006	1.008	1.033	0.9379			0.99	5.3	TM	
35	TM	Cyclohexane	0.2357	0.1917	0.2032	0.1825	0.1798	0.1983	0.1998	0.1838			0.20	9.1	TM	

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 6
Initial Calibration

Lab Name: APPL, Inc. SDG No: 67961
Case No: Initial Cal. Date: 06/02/12
Matrix: water Instrument: Neo Initials:

		Compound	0.3	0.5	1	5	10	40	100	200			Avg	%RSD		
36	TM	1,1-Dichloropropene	0.8173	0.7950	0.8029	0.7359	0.7267	0.7681	0.7575	0.7032			0.76	5.3	TM	
37	S	1,2-DCA-D4(S)	0.9267	0.9135	0.8960	0.8694	0.8601	0.8859	0.8958	0.6669			0.86	9.6	S	
38	TM	Carbon Tetrachloride	0.1759	0.2125	0.2553	0.2036	0.2170	0.2257	0.2362	0.2124			0.22	11	TM	
39		Heptane	0.5608	0.5636	0.5431	0.5529	0.7061	0.5435					0.58	11		
40	TM	Tert Amyl Methyl Ether	2.322	1.914	1.738	1.805	1.686	1.631	1.551	1.524			1.8	15	TM	
41	TM	1,2-DCA	0.3570	0.3555	0.3274	0.2853	0.3248	0.2842	0.2799	0.2448			0.31	13	TM	
42	TM	Benzene	3.408	2.676	2.870	2.679	2.494	2.466	2.490	2.387			2.7	12	TM	
43	TM	TCE	0.7873	0.5362	0.6642	0.6642	0.6625	0.6737	0.6479	0.6074			0.66	11	TM	
44	TM	2-Pentanone	0.1125	0.1049	0.1151	0.1229	0.1190	0.1171	0.1146	0.1060			0.11	5.4	TM	
45	TM*	1,2-Dichloropropane	0.2874	0.2759	0.2631	0.2703	0.2516	0.2575	0.2530	0.2444			0.26	5.4	TM*	
46	TM	Bromodichloromethane	1.088	1.005	1.105	1.103	1.126	1.119	1.064	1.003			1.1	4.5	TM	
47	TM	Dibromomethane	0.1412	0.1518	0.1093	0.1353	0.1181	0.1017					0.13	15	TM	
48	TM	Methyl Cyclohexane	0.1468	0.1735	0.1886	0.1866	0.1678	0.1788	0.1802	0.1682			0.17	7.7	TM	
49	TM	2-Chloroethyl vinyl ether	0.0612	0.0550	0.0784	0.0745	0.0835	0.0831	0.0759	0.0761			0.07	14	TM	
50	TM	1-Bromo-2-chloroethane	0.8759	0.8562	0.8307	0.8931	0.8613	0.8433	0.8367	0.7788			0.85	4.1	TM	
51	TM	Cis-1,3-Dichloropropene	1.596	1.251	1.225	1.213	1.201	1.135	1.123	1.056			1.2	13	TM	
52	TM*	Toluene	1.156	0.8958	0.8926	0.9114	0.9279	0.8556	0.8406	0.8508			0.92	11	TM*	
53	TM	Trans-1,3-Dichloropropene	0.4188	0.2970	0.3126	0.3168	0.3330	0.3218	0.3172	0.3116			0.33	12	TM	
54	TM	1,1,2-TCA	0.3953	0.3646	0.4121	0.4430	0.4221	0.4335	0.4192	0.3913			0.41	6.2	TM	
55	I	Chlorobenzene-D5 (IS)														
56	S	Toluene-D8(S)	4.047	4.617	4.014	4.634	4.357	4.367	4.712	3.686			4.3	8.4	S	
57	TM	1,2-EDB	0.7357	0.5737	0.6122	0.7504	0.7045	0.6650	0.6660	0.6813			0.67	8.8	TM	
58	TM	Tetrachloroethene		0.2606	0.2645	0.2091	0.2054	0.2134	0.2239	0.2069			0.23	11	TM	
59	TM	1-Chlorohexane	0.5453	0.7128	0.5558	0.6181	0.5498	0.5546	0.5767	0.5423			0.58	10	TM	
60	TM	1,1,1,2-Tetrachloroethane	1.018	0.9969	0.8853	1.135	1.111	1.065	1.070	1.018			1.0	7.5	TM	
61	TM	m&p-Xylene	1.813	1.952	1.660	1.894	1.839	1.660	1.805	1.783			1.8	5.7	TM	
62	TM	o-Xylene	1.684	1.719	1.670	1.992	1.780	1.766	1.866	1.870			1.8	6.1	TM	
63	TM	Styrene	3.291	3.069	2.555	3.490	3.207	2.999	3.226	3.241			3.1	8.8	TM	
64	S	4-Bromofluorobenzene(S)	1.617	1.566	1.323	1.628	1.594	1.540	1.562	1.272			1.5	9.0	S	
65	TM	2-Hexanone	0.1747	0.2116	0.1446	0.2037	0.1672	0.1697	0.1809	0.1678			0.18	12	TM	
66	TML	1,3-Dichloropropane	0.4930	0.7119	0.4608	0.5069	0.4576	0.4341	0.4415	0.4335			0.49	19	TML	1.000
67	TM	Dibromochloromethane	0.9095	0.8828	0.9047	1.142	1.020	0.9365	0.9732	0.9778			0.97	8.6	TM	
68	TM**	Chlorobenzene	2.743	2.538	2.329	2.990	2.761	2.623	2.735	2.734			2.7	7.2	TM**	
69	TM*	Ethylbenzene	1.985	1.749	1.641	1.885	1.912	1.751	1.872	1.883			1.8	6.1	TM*	
70	TM**	Bromoform	0.5173	0.4620	0.4723	0.5235	0.5428	0.5055	0.5338.	0.5154			0.51	5.6	TM**	

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 6
Initial Calibration

Lab Name: APPL, Inc. SDG No: 67961

Case No: Initial Cal. Date: 06/02/12

Matrix: water Instrument: Neo Initials:

		Compound	0.3	0.5	1	5	10	40	100	200			Avg	%RSD		
71	I	1,4-Dichlorobenzene-D (IS)														
72	TM	MIBK (methyl isobutyl ketone)		0.6881	0.5831	0.5939	0.5665	0.4809	0.5408	0.5086			0.57	12	TM	
73	TM	Isopropylbenzene	3.932	3.073	3.170	3.610	3.437	3.333	3.486	3.367			3.4	7.8	TM	
74	TM**	1,1,2,2-Tetrachloroethane	0.7945	0.7223	0.5698	0.7711	0.6982	0.5850	0.6413	0.5859			0.67	13	TM**	
75	TML	1,2,3-Trichloropropane	0.3497	0.2668	0.2186	0.1772	0.1627	0.1541	0.1353	0.1398			0.20	37	TML	0.999
76	TML	t-1,4-Dichloro-2-Butene	0.4359	0.4433	0.2323	0.2047	0.2752	0.1989	0.2252	0.2017			0.28	37	TML	0.997
77	TM	Bromobenzene		0.9625	0.7344	0.7751	0.7987	0.7261	0.7004	0.7756			0.78	11	TM	
78	TM	n-Propylbenzene	5.143	5.031	5.516	5.274	5.774	4.844	5.117	5.160			5.2	5.6	TM	
79	TM	4-Ethyltoluene	8.705	8.210	7.657	8.126	7.816	7.206	7.752	7.856			7.9	5.6	TM	
80	TM	2-Chlorotoluene	3.383	3.131	2.800	3.074	2.987	2.766	2.903	2.816			3.0	7.0	TM	
81	TM	1,3,5-Trimethylbenzene	3.733	3.354	3.216	3.253	3.175	2.912	3.247	3.106			3.2	7.2	TM	
82	TM	4-Chlorotoluene	9.041	7.678	8.920	8.787	8.761	8.150	8.321	7.947			8.5	5.9	TM	
83	TM	Tert-Butylbenzene	9.653	8.060	8.638	8.527	8.300	7.881	8.120	8.131			8.4	6.6	TM	
84	TM	1,2,4-Trimethylbenzene	9.020	9.434	9.427	9.353	9.377	8.538	8.967	8.809			9.1	3.7	TM	
85	TM	Sec-Butylbenzene	11.5	11.6	11.4	12.0	11.8	10.8	11.7	11.5			12	3.0	TM	
86	TM	p-Isopropyltoluene	10.6	8.482	8.825	9.430	8.503	8.398	9.089	8.740			9.0	8.1	TM	
87	TML	Benzyl Chloride	5.331	4.807	4.004	3.744	3.621	3.099	3.175	3.120			3.9	21	TML	1.000
88	TM	1,3-DCB	5.075	4.131	4.007	4.771	4.839	4.250	4.316	4.286			4.5	8.6	TM	
89	TM	1,4-DCB	4.720	4.258	3.942	4.691	4.486	4.198	4.232	4.147			4.3	6.3	TM	
90	TM	n-Butylbenzene	4.588	3.613	4.385	4.099	3.944	3.947	3.764	3.953			4.0	7.9	TM	
91	TM	1,2-DCB	3.944	3.353	3.736	4.255	3.974	3.787	3.730	3.645			3.8	7.0	TM	
92	TM	Hexachloroethane	2.838	2.574	2.233	2.572	2.438	2.315	2.551	2.422			2.5	7.5	TM	
93	TML	1,2-Dibromo-3-chloropropane	1.293	0.5521	0.7238	0.3994	0.3807	0.2443	0.2653	0.2542			0.51	69	TML	0.999
94	TM	1,2,4-Trichlorobenzene	3.741	2.754	2.657	2.706	2.644	2.511	2.633	2.536			2.8	14	TM	
95	TML	Hexachlorobutadiene	0.6568	0.5174	0.1031	0.4200	0.3881	0.3675	0.3564	0.3569			0.40	40	TML	1.000
96	TM	Naphthalene	4.456	3.204	3.692	4.622	4.332	3.903	4.088	4.065			4.0	11	TM	
97	TM	1,2,3-Trichlorobenzene	1.049	0.8143	0.8305	0.8044	0.8750	0.6940	0.7491	0.7580			0.82	13	TM	
98	TM	Dibromochlorobenzene													TM	
99																
100																
101																
102																
103																
104																
105																

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Second Source Calibration

Lab Name: APPL, Inc. SDG No:
Case No: Date Analyzed: 4 Jun 12 11:16
Matrix: Instrument: Neo
Initial Cal. Date: 06/02/12
Data File: 0604N03W.D

		Compound	MEAN	CCRF	%D		%Drift	
1	I	Fluorobenzene (IS)	ISTD			I		
2	TML	Dichlorodifluoromethane	0.2197	0.2806	28	TML	15	
3	TM**	Chloromethane	0.3922	0.4264	8.7	TM**		
4	TM*	Vinyl chloride	0.3434	0.3449	0.45	TM*		
5	TM	1,3-Butadiene	0.0000	0.0000	0.00	TM		
6	TML	Bromomethane	0.5044	0.5143	2.0	TML	10.0	
7	TML	Chloroethane	0.9433	0.7892	16	TML	4.2	
8	TM	Dichlorofluoromethane	0.3964	0.4098	3.4	TM		
9	TM	Trichlorofluoromethane	0.1522	0.1727	13	TM		
10	TM	Acrolein	0.0509	0.0555	9.1	TM		
11	TML	Acetone	0.0485	0.0449	7.4	TML	19	
12	TML	Freon-113	0.4826	0.4655	3.6	TML	20	
13	TM*	1,1-DCE	0.7359	0.7535	2.4	TM*		
14	TM	t-Butanol	0.0066	0.0080	21	TM		*nt
15	TML	Methyl Acetate	0.7009	0.4211	40	TML	1.6	
16	TML	Iodomethane	0.2411	0.3027	26	TML	16	
17	TM	Acrylonitrile	0.0000	0.0728	0.00	TM		
18	TML	Methylene chloride	0.8827	0.6003	32	TML	2.2	
19	TM	Carbon disulfide	0.4193	0.4932	18	TM		
20	TM	Methyl t-butyl ether (MtBE)	1.468	1.483	0.97	TM		
21		Hexane	0.3891	0.3709	4.7			
22	TM	Trans-1,2-DCE	0.4686	0.4564	2.6	TM		
23	TM	Diisopropyl Ether	0.8691	0.8335	4.1	TM		
24	TM**	1,1-DCA	0.4004	0.4018	0.36	TM**		
25	TM	Vinyl Acetate	0.6601	0.7237	9.6	TM		
26	TM	Ethyl tert Butyl Ether	0.5554	0.5994	7.9	TM		
27	TML	MEK (2-Butanone)	0.1519	0.1328	13	TML	5.5	
28	TM	Cis-1,2-DCE	0.2122	0.2071	2.4	TM		
29	TM	2,2-Dichloropropane	0.2702	0.2973	10	TM		
30	TM*	Chloroform	1.417	1.487	4.9	TM*		
31	TM	Bromochloromethane	0.2139	0.2157	0.85	TM		
32	S	Dibromofluoromethane(S)	0.8671	0.6917	20	S		
33	TM	2,2,4-Trimethylpentane	0.3042	0.2845	6.5	TM		
34	TM	1,1,1-TCA	0.9883	1.034	4.7	TM		
35	TM	Cyclohexane	0.1969	0.1718	13	TM		
36	TM	1,1-Dichloropropene	0.7633	0.7522	1.5	TM		
37	S	1,2-DCA-D4(S)	0.8643	0.7181	17	S		
38	TM	Carbon Tetrachloride	0.2173	0.2127	2.1	TM		
39		Heptane	0.5783	0.5871	1.5			
40	TM	Tert Amyl Methyl Ether	1.771	1.736	2.0	TM		
		Average			9.2			

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Second Source Calibration

Lab Name: APPL, Inc.
Case No:
Matrix: 0

SDG No:
Date Analyzed: 4 Jun 12 11:16
Instrument: Neo
Cal. Date: 06/02/12
Data File: 0604N03W.D

		Compound	MEAN	CCRF	%D	%Drift	
41	TM	1,2-DCA	0.3074	0.2969	3.4	TM	
42	TM	Benzene	2.684	2.583	3.7	TM	
43	TM	TCE	0.6554	0.6680	1.9	TM	
44	TM	2-Pentanone	0.1140	0.1269	11	TM	
45	TM*	1,2-Dichloropropane	0.2629	0.3083	17	TM*	
46	TM	Bromodichloromethane	1.077	1.072	0.47	TM	
47	TM	Dibromomethane	0.1262	0.1042	17	TM	
48	TM	Methyl Cyclohexane	0.1738	0.1653	4.9	TM	
49	TM	2-Chloroethyl vinyl ether	0.0735	0.0800	8.9	TM	
50	TM	1-Bromo-2-chloroethane	0.8470	0.8762	3.4	TM	
51	TM	Cis-1,3-Dichloropropene	1.225	1.234	0.78	TM	
52	TM*	Toluene	0.9164	0.9194	0.33	TM*	
53	TM	Trans-1,3-Dichloropropene	0.3286	0.3412	3.8	TM	
54	TM	1,1,2-TCA	0.4101	0.4662	14	TM	
55	I	Chlorobenzene-D5 (IS)	ISTD			I	
56	S	Toluene-D8(S)	4.304	2.921	32	S	
57	TM	1,2-EDB	0.6736	0.6383	5.2	TM	
58	TM	Tetrachloroethene	0.2263	0.1853	18	TM	
59	TM	1-Chlorohexane	0.5819	0.5147	12	TM	
60	TM	1,1,1,2-Tetrachloroethane	1.037	0.9818	5.4	TM	
61	TM	m&p-Xylene	1.801	1.669	7.3	TM	
62	TM	o-Xylene	1.793	1.700	5.2	TM	
63	TM	Styrene	3.135	2.810	10	TM	
64	S	4-Bromofluorobenzene(S)	1.513	1.158	23	S	
65	TM	2-Hexanone	0.1775	0.1842	3.7	TM	
66	TML	1,3-Dichloropropane	0.4924	0.4820	2.1	TML	6.8
67	TM	Dibromochloromethane	0.9682	0.8896	8.1	TM	
68	TM**	Chlorobenzene	2.682	2.519	6.0	TM**	
69	TM*	Ethylbenzene	1.835	1.681	8.4	TM*	
70	TM**	Bromoform	0.5091	0.4421	13	TM**	
71	I	1,4-Dichlorobenzene-D (IS)	ISTD			I	
72	TM	MIBK (methyl isobutyl ketone)	0.5660	0.6307	11	TM	
73	TM	Isopropylbenzene	3.426	3.273	4.5	TM	
74	TM**	1,1,2,2-Tetrachloroethane	0.6710	0.6765	0.82	TM**	
75	TML	1,2,3-Trichloropropane	0.2005	0.1653	18	TML	8.1
76	TML	t-1,4-Dichloro-2-Butene	0.2771	0.2382	14	TML	2.7
77	TM	Bromobenzene	0.7818	0.7188	8.1	TM	
78	TM	n-Propylbenzene	5.232	4.894	6.5	TM	
79	TM	4-Ethyltoluene	7.916	7.522	5.0	TM	
80	TM	2-Chlorotoluene	2.982	2.916	2.2	TM	
		Average			8.4		

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Second Source Calibration

Lab Name: APPL, Inc.
Case No:
Matrix: 0

SDG No:
Date Analyzed: 4 Jun 12 11:16
Instrument: Neo
Cal. Date: 06/02/12
Data File: 0604N03W.D

		Compound	MEAN	CCRF	%D		%Drift
81	TM	1,3,5-Trimethylbenzene	3.249	3.096	4.7	TM	
82	TM	4-Chlorotoluene	8.451	8.042	4.8	TM	
83	TM	Tert-Butylbenzene	8.414	7.454	11	TM	
84	TM	1,2,4-Trimethylbenzene	9.116	8.612	5.5	TM	
85	TM	Sec-Butylbenzene	11.5	10.8	6.5	TM	
86	TM	p-Isopropyltoluene	9.008	8.193	9.0	TM	
87	TML	Benzyl Chloride	3.862	3.599	6.8	TML	9.0
88	TM	1,3-DCB	4.459	4.213	5.5	TM	
89	TM	1,4-DCB	4.334	3.961	8.6	TM	
90	TM	n-Butylbenzene	4.037	3.525	13	TM	
91	TM	1,2-DCB	3.803	3.468	8.8	TM	
92	TM	Hexachloroethane	2.493	2.299	7.8	TM	
93	TML	1,2-Dibromo-3-chloropropane	0.5141	0.2878	44	TML	6.6
94	TM	1,2,4-Trichlorobenzene	2.775	2.542	8.4	TM	
95	TML	Hexachlorobutadiene	0.3958	0.3489	12	TML	6.1
96	TM	Naphthalene	4.045	4.401	8.8	TM	
97	TM	1,2,3-Trichlorobenzene	0.8218	0.8509	3.5	TM	
98	TM	Dibromochlorobenzene	0.0000	0.0107	0.00	TM	
99							
100							
101							
102							
103							
104							
105							
106							
107							
108							
109							
110							
111							
112							
113							
114							
115							
116							
117							
118							
119							
120							
		Average			9.4		

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Continuing Calibration

Lab Name: APPL, Inc. SDG No:
Case No: Date Analyzed: 5 Jun 12 10:00
Matrix: Instrument: Neo
Initial Cal. Date: 06/02/12
Data File: 0605N02W.D

		Compound	MEAN	CCRF	%D		%Drift	
1	I	Fluorobenzene (IS)	ISTD			I		
2	TML	Dichlorodifluoromethane	0.2197	0.2695	23	TML	11	
3	TM**	Chloromethane	0.3922	0.3829	2.4	TM**		
4	TM*	Vinyl chloride	0.3434	0.3225	6.1	TM*		
5	TM	1,3-Butadiene	0.0000	0.0000	0.00	TM		
6	TML	Bromomethane	0.5036	0.4592	8.8	TML	17	
7	TML	Chloroethane	0.9433	0.7511	20	TML	9.5	
8	TM	Dichlorofluoromethane	0.3964	0.3795	4.3	TM		
9	TM	Trichlorofluoromethane	0.1522	0.1578	3.7	TM		
10	TM	Acrolein	0.0509	0.0552	8.5	TM		
11	TML	Acetone	0.0485	0.0475	2.1	TML	28	*nt
12	TML	Freon-113	0.4826	0.5742	19	TML	0.39	
13	TM*	1,1-DCE	0.7359	0.6775	7.9	TM*		
14	TM	t-Butanol	0.0066	0.0072	10	TM		
15	TML	Methyl Acetate	0.7009	0.4482	36	TML	9.1	
16	TML	Iodomethane	0.2411	0.2777	15	TML	22	*nt
17	TM	Acrylonitrile	0.0000	0.0735	0.00	TM		
18	TML	Methylene chloride	0.8827	0.6220	30	TML	1.9	
19	TM	Carbon disulfide	0.4193	0.3914	6.6	TM		
20	TM	Methyl t-butyl ether (MtBE)	1.469	1.516	3.2	TM		
21		Hexane	0.3891	0.4080	4.9			
22	TM	Trans-1,2-DCE	0.4686	0.4393	6.3	TM		
23	TM	Diisopropyl Ether	0.8691	0.9412	8.3	TM		
24	TM**	1,1-DCA	0.4004	0.3709	7.4	TM**		
25	TM	Vinyl Acetate	0.6601	0.7105	7.6	TM		
26	TM	Ethyl tert Butyl Ether	0.5554	0.6507	17	TM		
27	TML	MEK (2-Butanone)	0.1519	0.1296	15	TML	2.5	
28	TM	Cis-1,2-DCE	0.2122	0.2053	3.3	TM		
29	TM	2,2-Dichloropropane	0.2702	0.3033	12	TM		
30	TM*	Chloroform	1.417	1.504	6.2	TM*		
31	TM	Bromochloromethane	0.2139	0.2277	6.4	TM		
32	S	Dibromofluoromethane(S)	0.8671	0.6832	21	S		
33	TM	2,2,4-Trimethylpentane	0.3042	0.2919	4.0	TM		
34	TM	1,1,1-TCA	0.9883	1.056	6.8	TM		
35	TM	Cyclohexane	0.1969	0.2164	10.0	TM		
36	TM	1,1-Dichloropropene	0.7633	0.7433	2.6	TM		
37	S	1,2-DCA-D4(S)	0.8643	0.6767	22	S		
38	TM	Carbon Tetrachloride	0.2173	0.2312	6.4	TM		
39		Heptane	0.5783	0.5336	7.7			
40	TM	Tert Amyl Methyl Ether	1.771	1.851	4.5	TM		
		Average			9.9			

HW 6/6/12

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Continuing Calibration

Lab Name: APPL, Inc. SDG No:
Case No: Date Analyzed: 5 Jun 12 10:00
Matrix: 0 Instrument: Neo
Cal. Date: 06/02/12
Data File: 0605N02W.D

		Compound	MEAN	CCRF	%D		%Drift
41	TM	1,2-DCA	0.3074	0.3036	1.2	TM	
42	TM	Benzene	2.684	2.517	6.2	TM	
43	TM	TCE	0.6554	0.6195	5.5	TM	
44	TM	2-Pentanone	0.1140	0.1350	18	TM	
45	TM*	1,2-Dichloropropane	0.2629	0.2702	2.8	TM*	✓
46	TM	Bromodichloromethane	1.077	1.136	5.5	TM	
47	TM	Dibromomethane	0.1262	0.1102	13	TM	
48	TM	Methyl Cyclohexane	0.1738	0.1723	0.87	TM	
49	TM	2-Chloroethyl vinyl ether	0.0735	0.0702	4.4	TM	
50	TM	1-Bromo-2-chloroethane	0.8470	0.9150	8.0	TM	
51	TM	Cis-1,3-Dichloropropene	1.225	1.165	4.9	TM	
52	TM*	Toluene	0.9164	0.8452	7.8	TM*	✓
53	TM	Trans-1,3-Dichloropropene	0.3286	0.3494	6.3	TM	
54	TM	1,1,2-TCA	0.4101	0.4451	8.5	TM	
55	I	Chlorobenzene-D5 (IS)	ISTD			I	
56	S	Toluene-D8(S)	4.304	3.515	18	S	
57	TM	1,2-EDB	0.6736	0.6891	2.3	TM	
58	TM	Tetrachloroethene	0.2263	0.2107	6.9	TM	
59	TM	1-Chlorohexane	0.5819	0.6071	4.3	TM	
60	TM	1,1,1,2-Tetrachloroethane	1.037	1.045	0.72	TM	
61	TM	m&p-Xylene	1.801	1.756	2.5	TM	
62	TM	o-Xylene	1.793	1.808	0.80	TM	
63	TM	Styrene	3.135	3.124	0.36	TM	
64	S	4-Bromofluorobenzene(S)	1.513	1.285	15	S	
65	TM	2-Hexanone	0.1775	0.2037	15	TM	
66	TML	1,3-Dichloropropane	0.4924	0.4604	6.5	TML	1.8
67	TM	Dibromochloromethane	0.9682	1.047	8.2	TM	
68	TM**	Chlorobenzene	2.682	2.711	1.1	TM**	✓
69	TM*	Ethylbenzene	1.835	1.905	3.9	TM*	✓
70	TM**	Bromoform	0.5091	0.6104	20	TM**	✓
71	I	1,4-Dichlorobenzene-D (IS)	ISTD			I	
72	TM	MIBK (methyl isobutyl ketone)	0.5660	0.5933	4.8	TM	
73	TM	Isopropylbenzene	3.426	3.244	5.3	TM	
74	TM**	1,1,2,2-Tetrachloroethane	0.6710	0.6439	4.0	TM**	✓
75	TML	1,2,3-Trichloropropane	0.2005	0.1514	24	TML	1.9
76	TML	t-1,4-Dichloro-2-Butene	0.2771	0.1903	31	TML	21 *nt
77	TM	Bromobenzene	0.7818	0.6566	16	TM	
78	TM	n-Propylbenzene	5.232	4.516	14	TM	
79	TM	4-Ethyltoluene	7.916	7.209	8.9	TM	
80	TM	2-Chlorotoluene	2.982	2.616	12	TM	
		Average			8.4		

HW 6/5/12

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Continuing Calibration

Lab Name: APPL, Inc.
Case No:
Matrix: 0

SDG No:
Date Analyzed: 5 Jun 12 10:00
Instrument: Neo
Cal. Date: 06/02/12
Data File: 0605N02W.D

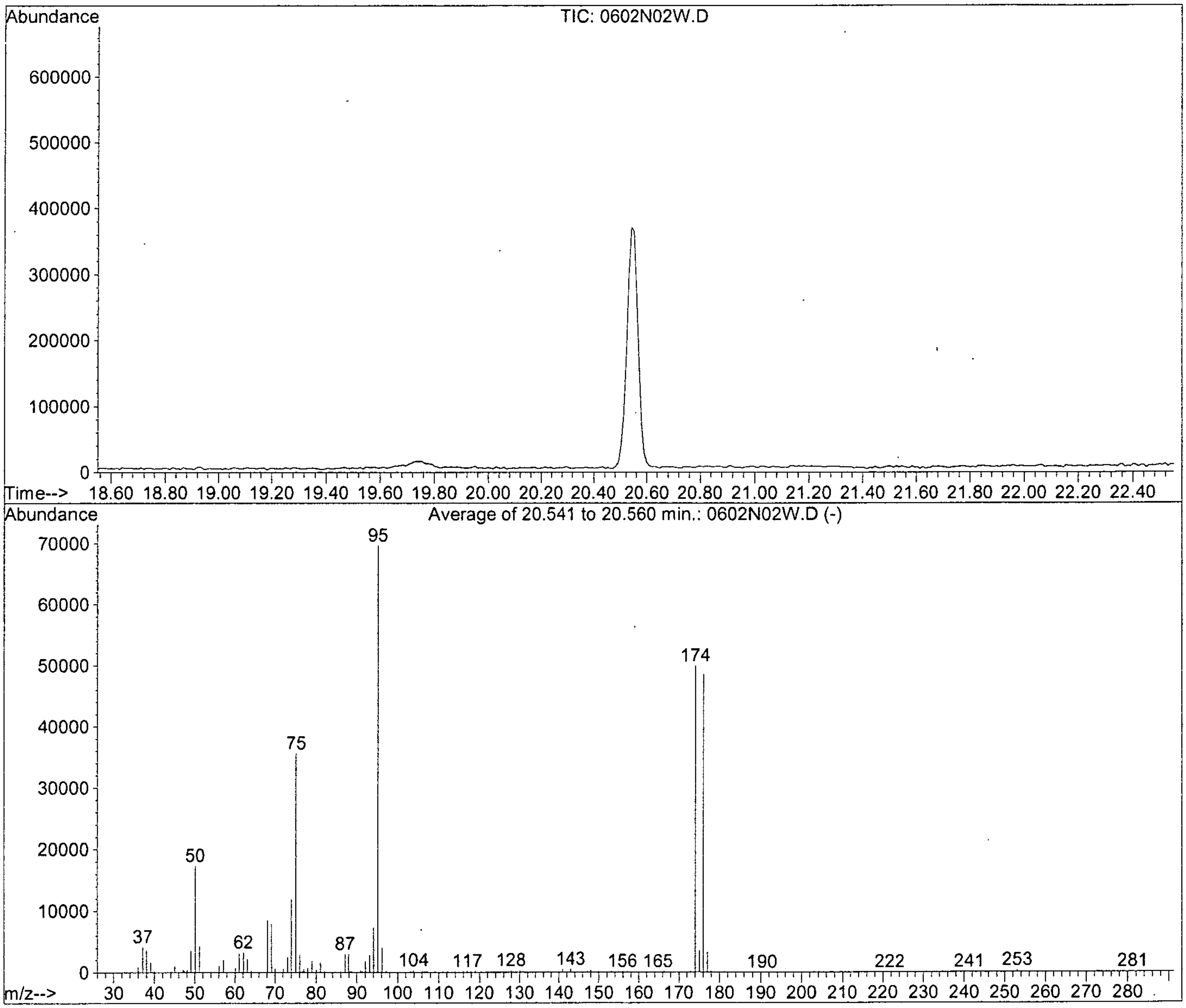
		Compound	MEAN	CCRF	%D		%Drift
81	TM	1,3,5-Trimethylbenzene	3.249	2.672	18	TM	
82	TM	4-Chlorotoluene	8.451	7.408	12	TM	
83	TM	Tert-Butylbenzene	8.414	7.027	16	TM	
84	TM	1,2,4-Trimethylbenzene	9.116	8.152	11	TM	
85	TM	Sec-Butylbenzene	11.5	10.4	9.4	TM	
86	TM	p-Isopropyltoluene	9.008	7.573	16	TM	
87	TML	Benzyl Chloride	3.862	3.624	6.2	TML	9.8
88	TM	1,3-DCB	4.459	3.912	12	TM	
89	TM	1,4-DCB	4.334	3.881	10	TM	
90	TM	n-Butylbenzene	4.037	3.414	15	TM	
91	TM	1,2-DCB	3.803	3.668	3.5	TM	
92	TM	Hexachloroethane	2.493	2.163	13	TM	
93	TML	1,2-Dibromo-3-chloropropane	0.5141	0.3068	40	TML	0.93
94	TM	1,2,4-Trichlorobenzene	2.773	2.580	6.9	TM	
95	TML	Hexachlorobutadiene	0.3958	0.3150	20	TML	16
96	TM	Naphthalene	4.045	4.300	6.3	TM	
97	TM	1,2,3-Trichlorobenzene	0.8218	0.7195	12	TM	
98	TM	Dibromochlorobenzene	0.0000	0.0091	0.00	TM	
99							
100							
101							
102							
103							
104							
105							
106							
107							
108							
109							
110							
111							
112							
113							
114							
115							
116							
117							
118							
119							
120							
		Average			12.6		

EPA METHOD 8260B
Volatile Organic Compounds
Raw Data

APPL, INC.

Data File : M:\NEO\DATA\N120602\0602N02W.D Vial: 1
Acq On : 2 Jun 12 13:06 Operator: SV,DG,RS
Sample : 25ug/mL BFB Std 05-09-12 Inst : Neo
Misc : 2uL Multiplr: 1.00

Method : M:\NEO\DATA\N120602\NALLW2.M (RTE Integrator)
Title : METHOD 8260B



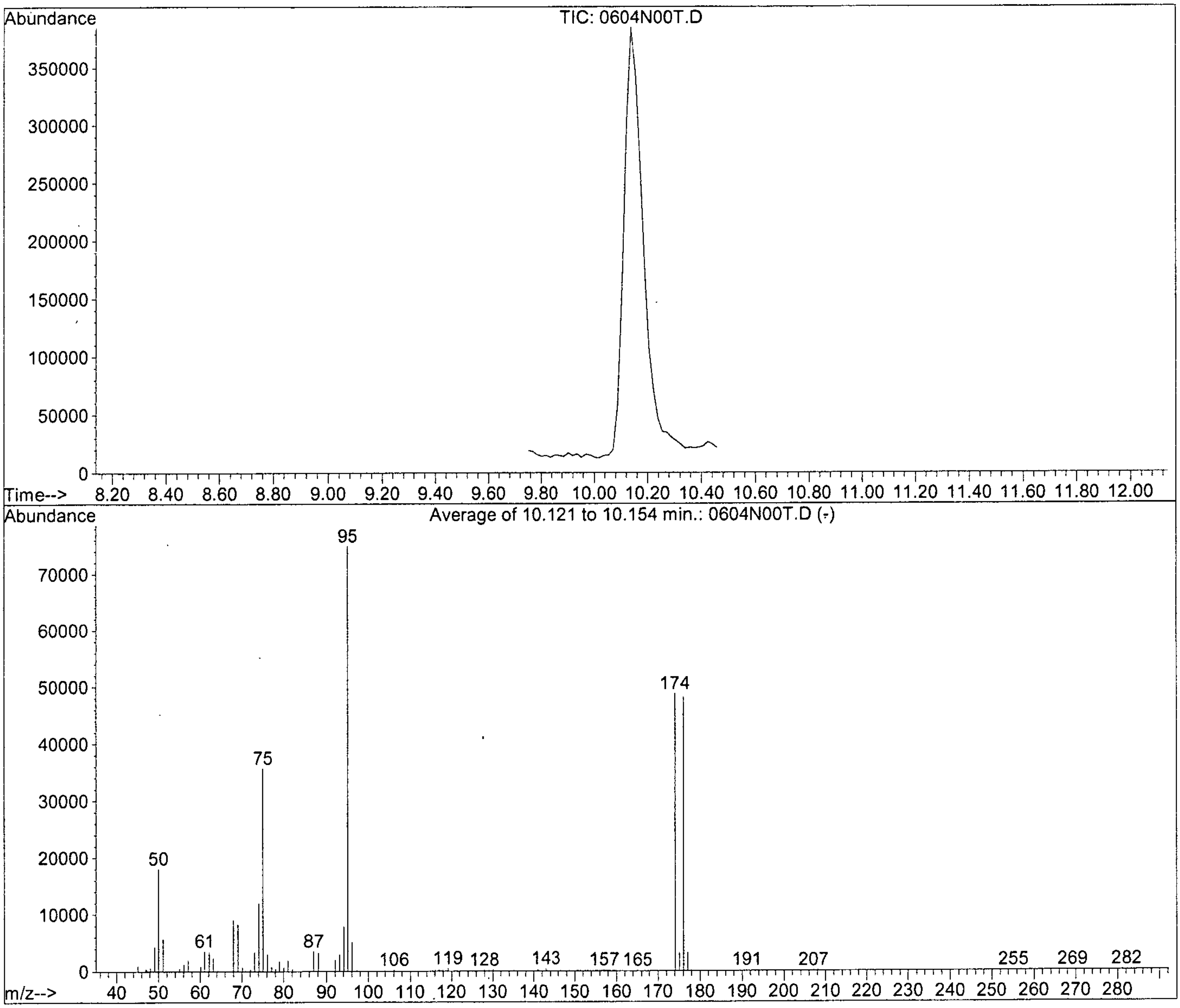
Spectrum Information: Average of 20.541 to 20.560 min.

Target Mass	Rel. to Mass	Lower Limit%	Upper Limit%	Rel. Abn%	Raw Abn	Result Pass/Fail
50	95	15	40	24.9	17360	PASS
75	95	30	60	51.1	35584	PASS
95	95	100	100	100.0	69632	PASS
96	95	5	9	5.8	4034	PASS
173	174	0.00	2	0.4	206	PASS
174	95	50	100	71.6	49880	PASS
175	174	5	9	7.1	3522	PASS
176	174	95	101	97.1	48435	PASS
177	176	5	9	6.7	3223	PASS

Data File : M:\NEO\DATA\N120602\0604N00T.D
Acq On : 4 Jun 12 9:19
Sample : 25ug/mL BFB Std 05-09-12
Misc : 2uL

Vial: 1
Operator: SV,DG,RS
Inst : Neo
Multiplr: 1.00

Method : M:\NEO\DATA\N120602\NALLW2.M (RTE Integrator)
Title : METHOD 8260B

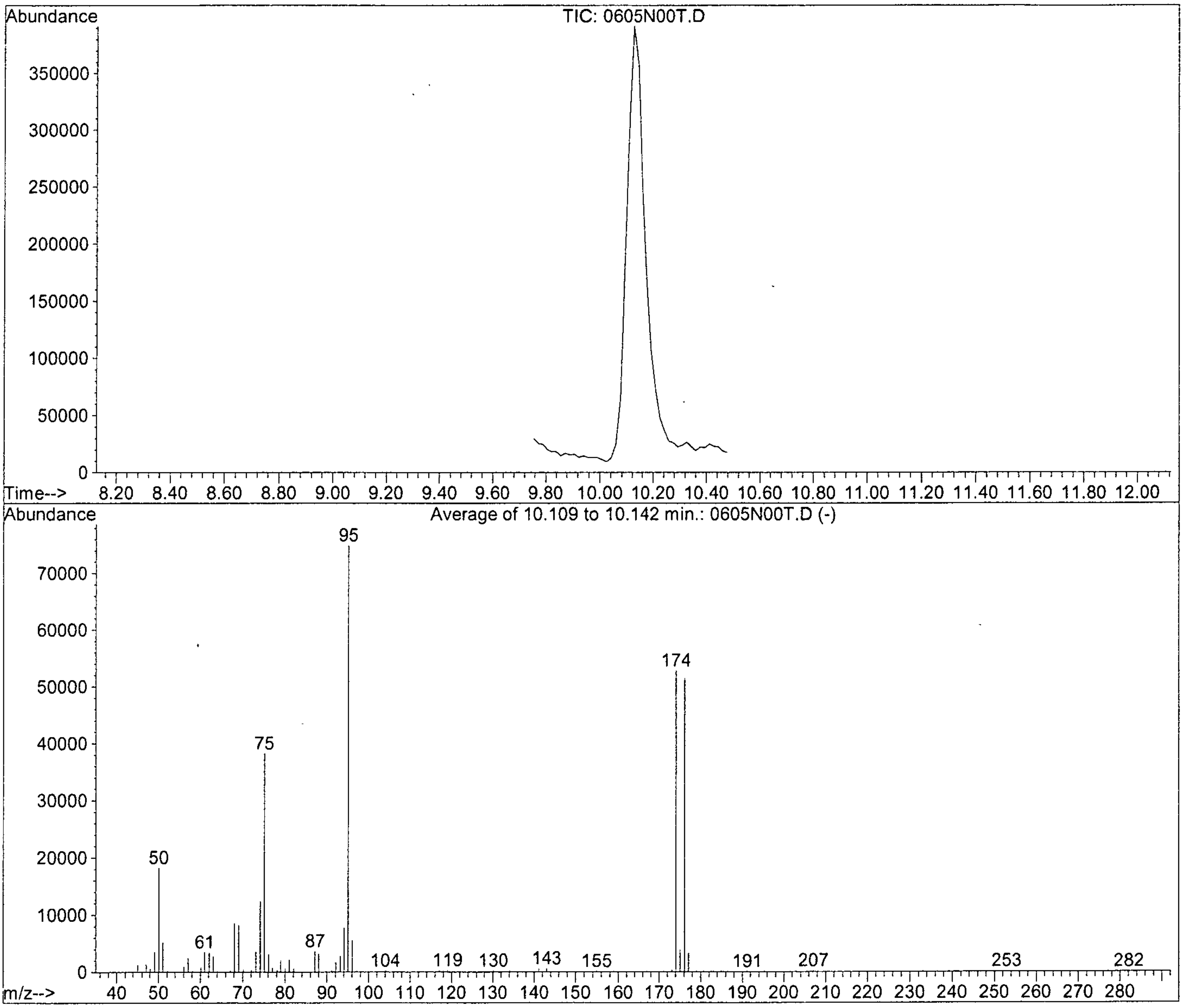


Spectrum Information: Average of 10.121 to 10.154 min.

Target Mass	Rel. to Mass	Lower Limit%	Upper Limit%	Rel. Abn%	Raw Abn	Result Pass/Fail
50	95	15	40	24.1	18037	PASS
75	95	30	60	47.7	35725	PASS
95	95	100	100	100.0	74939	PASS
96	95	5	9	6.8	5066	PASS
173	174	0.00	2	0.2	91	PASS
174	95	50	100	65.1	48755	PASS
175	174	5	9	6.5	3168	PASS
176	174	95	101	98.8	48179	PASS
177	176	5	9	6.6	3168	PASS

Data File : M:\NEO\DATA\N120602\0605N00T.D Vial: 1
Acq On : 5 Jun 12 8:54 Operator: SV,DG,RS
Sample : 25ug/mL BFB Std 05-09-12 Inst : Neo
Misc : 2uL Multiplr: 1.00

Method : M:\NEO\DATA\N120602\NALLW2.M (RTE Integrator)
Title : METHOD 8260B



Spectrum Information: Average of 10.109 to 10.142 min.

Target Mass	Rel. to Mass	Lower Limit%	Upper Limit%	Rel. Abn%	Raw Abn	Result Pass/Fail
50	95	15	40	24.3	18225	PASS
75	95	30	60	51.0	38212	PASS
95	95	100	100	100.0	74909	PASS
96	95	5	9	7.3	5431	PASS
173	174	0.00	2	0.6	331	PASS
174	95	50	100	70.5	52816	PASS
175	174	5	9	7.3	3845	PASS
176	174	95	101	97.4	51448	PASS
177	176	5	9	6.4	3295	PASS

0605N00T.D NALLW2.M Fri Jun 15 15:04:35 2012

Injection Log

Directory: M:\NEO\DATA\N120602\

Line	Vial	FileName	Multiplier	SampleName	Misc Info	Injected
1	1	0602N02W.D	1	25ug/mL BFB Std 05-09-12	2uL	2 Jun 12 13:06
2	1	0602N04W.D	1	0.3ug/L Vol Std 06-02-12	Water 10mL w/ IS:06-02-12	2 Jun 12 14:22
3	1	0602N05W.D	1	0.5ug/L Vol Std 06-02-12	Water 10mL w/ IS:06-02-12	2 Jun 12 15:00
4	1	0602N06W.D	1	1.0ug/L Vol Std 06-02-12	Water 10mL w/ IS:06-02-12	2 Jun 12 15:38
5	1	0602N07W.D	1	5.0ug/L Vol Std 06-02-12	Water 10mL w/ IS:06-02-12	2 Jun 12 16:17
6	1	0602N08W.D	1	10ug/L Vol Std 06-02-12	Water 10mL w/ IS:06-02-12	2 Jun 12 16:55
7	1	0602N09W.D	1	40ug/L Vol Std 06-02-12	Water 10mL w/ IS:06-02-12	2 Jun 12 17:33
8	1	0602N10W.D	1	100ug/L Vol Std 06-02-12	Water 10mL w/ IS:06-02-12	2 Jun 12 18:11
9	1	0602N11W.D	1	200ug/L Vol Std 06-02-12	Water 10mL w/ IS:06-02-12	2 Jun 12 18:49
10	1	0604N00T.D	1	25ug/mL BFB Std 05-09-12	2uL	4 Jun 12 9:19
11	1	0604N03W.D	1	10ug/L Vol Std 06-04-12 (SS)	Water 10mL w/ IS&S:06-02-	4 Jun 12 11:16
12	1	0605N02W.D	1	10ug/L Vol Std 06-05-12	Water 10mL w/ IS&S:06-02-	5 Jun 12 10:00
13	1	0605N04W.D	1	120605A LCS-1WN	Water 10mL w/ IS&S:06-02-	5 Jun 12 11:15
14	1	0605N07W.D	1	120605A BLK-1WN	Water 10mL w/ IS&S:06-02-	5 Jun 12 13:09
15	1	0605N16W.D	1	AY62944W01	Water 10mL w/ IS&S:06-02-	5 Jun 12 19:08

INORGANIC ANALYSIS

APPL, INC.

INORGANIC ANALYSIS
QC Summary

APPL, INC.

AFCEE
INORGANIC ANALYSES DATA SHEET 5
BLANK

Analytical Method: EPA 160.1
Lab Name: APPL, Inc
Concentration Units: mg/L
Initial Calibration ID: 120605A

AAB #: 120605A-167658
Contract #: *G012
Method Blank ID: 120605A-BLK

Analyte	Method Blank	RL	Q
TOTAL DISSOLVED SOLIDS EPA 160.1	< RL	10	U

Comments: ARF: 67961, Sample: AY62944

AFCEE FORM W-5

AFCEE
WET CHEM ANALYSES DATA SHEET 6
LABORATORY CONTROL SAMPLE

Analytical Method: EPA 160.1
Lab Name: APPL, Inc
LCS ID: 120605A LCS
Concentration Units: mg/L

AAB #: 120605A-167658
Contract #: *G012
Initial Calibration ID: 120605A

Analyte	Expected	Found	% R	Control Limits	Q
TOTAL DISSOLVED SOLIDS EPA 160.1	221.0	221.0	100	80-120	

Comments: ARF: 67961, Sample: AY62944

AFCEE FORM W-6

AFCEE
WET CHEM ANALYSES DATA SHEET 6
LABORATORY CONTROL SAMPLE DUPLICATE

Analytical Method: EPA 160.1
Lab Name: APPL, Inc
LCS ID: 120605A LCS
Concentration Units: mg/L

AAB #: 120605A-167658
Contract #: *G012
Initial Calibration ID: 120605A

Analyte	Expected	Found	% R	Control Limits	Q
TOTAL DISSOLVED SOLIDS EPA 160.1	221.0	227.0	103	80-120	

Comments: ARF: 67961, Sample: AY62944

AFCEE FORM W-6

INORGANIC ANALYSIS
Sample Data

APPL, INC.

AFCEE
WET CHEM ANALYSES DATA SHEET 2
RESULTS

Analytical Method: EPA 160.1

AAB #: 120605A-167658

Lab Name: APPL, Inc

Contract #: *G012

Field Sample ID: B3-EXW05

Lab Sample ID: AY62944

Matrix: Water

% Solids: NA

Initial Calibration ID: 120605A

Date Received: 05-Jun-12

Date Prepared: 05-Jun-12

Date Analyzed: 05-Jun-12

Concentration Units: mg/L

Analyte	MDL	RL	Concentration	Dilution	Qualifier
TOTAL DISSOLVED SOLIDS EPA 160.	4.4	10	309.0	1	

Comments: ARF: 67961

AFCEE FORM W-2

Laboratory Report

Parsons

CSSA

Project #: 748607.01000 CSSA

ARF: 67992

Sample collected: June 6, 2012

APPL, Inc.

Summary Package

for

Project #: 748607.01000 CSSA

ARF 67992

TABLE OF CONTENTS

LABORATORY NAME: <u>*APPL, Inc.*</u>

CASE NARRATIVE

APPL LABS
908 North Temperance Ave. ∇ Clovis, CA 93611 ∇ Phone 559-275-2175 ∇ Fax 559-275-4422

Case Narrative

ARF: 67992

Project: 748607.01000 CSSA

California State Certification Number: CA1312 (DW & WW)

NELAP Certification number: 05233CA (HW)

Texas Certificate Number: T104704242-10-3

Results in this report apply to the sample analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Sample Receipt Information:

The soil sample was received June 11, 2012, at 10.0°C. The sample was assigned Analytical Request Form (ARF) number 67992. The sample number and requested analyses were compared to the chain of custody and email communications. The client was notified of the temperature exceedance; the order to proceed was received on June 11. No other exception was noted.

Sample Table

CLIENT ID	APPL ID	Matrix	Date Sampled	Date Received
B3-EXW05-WC01	AY63155	SOIL	06/06/12	06/11/12

Percent moisture was determined using CLP 4.0.

Volatile Organic Compounds
EPA Method 8260B

Sample Preparation:

The soil sample was purged according to EPA method 5035. All holding times were met.

Sample Analysis Information:

The sample was analyzed according to EPA method 8260B using a Hewlett Packard Gas Chromatograph with a mass spectrometer detector. All holding times were met.

Quality Control/Assurance:

Spike Recovery:

A Laboratory Control Spike (LCS) was used for quality assurance. A second-source standard (SS) was used for the LCS. All LCS acceptance criteria were met.

No sample was designated by the client for MS/MSD analysis.

Surrogates:

Surrogate recoveries are summarized on the form 2 & 8. All surrogate recoveries met acceptance criteria.

Method blanks:

No target compound was detected above its reporting limit in the method blank.

Calibration:

Initial and continuing calibrations were analyzed according to the method. All calibration criteria were met.

Tuning:

The instrument was tuned using BFB. All method criteria were met.

Internal Standards:

The internal standard area counts were compared to the mid-point of the initial calibration according to method 8260. All acceptance criteria were met.

Summary:

No analytical exception was noted. All data generated are acceptable.

EPA Methods 6010B and 7471B

Metals

Digestion Information:

The soil sample was digested according to EPA methods 3050B and 7471B. All holding times were met.

Analysis Information:

Samples:

The sample was analyzed according to EPA method 6010B using a Perkin Elmer Optima 5300DV ICP and according to EPA method 7471B using a Perkin Elmer AAnalyst 300.

Calibrations:

Calibrations were performed according to the method for the initial calibration and the initial calibration verification. The initial calibration verification is prepared from a second source standard. All calibration acceptance criteria were met.

Blanks:

No target metal was detected above the reporting limit (RL) in the method blanks.

Spikes:

Laboratory Control Spikes (LCS), post-digestion spike (PDS) and dilution test (DT) were used for quality assurance. All LCS acceptance criteria were met.

Sample B3-EXW05-WC01 was selected by the laboratory for QC analysis. The DT was applicable to two analytes; copper and zinc exceeded the 10% deviation limit. The PDS was applicable to eight analytes. All PDS acceptance criteria were met.

Summary:

No other analytical exception is noted.

CERTIFICATION

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness, for other than the conditions detailed above. These test results meet all requirements of NELAC. Release of the hard copy has been authorized by the Laboratory Manager or her designee, as verified by the following signature.

6-15-12

Sharon Dehmlow, Laboratory Director / Date

CHAIN OF CUSTODY
AND ARF

APPL - Analysis Request Form 67992

Client:	Parsons	Received by:	TBV
Address:	8000 Centre Park Drive Ste 200 Austin, TX 78754	Date Received:	06/11/12 Time: 08:57
		Delivered by:	FED EX
Attn:	Tammy Chang	Shuttle Custody Seals (Y/N):	Y Time Zone: -5
Phone:	512-719-6092 Fax: 512-719-6099	Chest Temp(s):	10°C
Job:	748607.01000 CSSA	Color:	VOA,A-GRN
PO #:	748336.30000-00 (prime *G012)	Samples Chilled until Placed in Refrig/Freezer:	Y
Chain of Custody (Y/N):	Y # 060712APPFA	Project Manager:	Diane Anderson ᖘ
RAD Screen (Y/N):	Y pH (Y/N): N	QC Report Type:	DVP3/AFCEE/ERPIMS/TX
Turn Around Type:	7 DAYS	Due Date:	06/18/12

Comments:

pdf ARF to Tammy & Pam; send 1 DVP3 HC & CD to Tammy.
Data screening project: analyze samples ONCE; report deficiencies; do NOT re-analyze
Case Narrative. CSSA + AFCEE 3.1 QAPP. Only report MS/MSD when requested.
Use AFCEE forms with AFCEE flagging to report sample & QC data only.
APPL forms for everything else and APPL DVP3.
EDD: ERPIMS 4 Lab PC4 checked TXF to Pam.Ford@parsons.com
OK to proceed per email 12 noon 6-11-12.

6-12 Sent ARF

Sample Distribution:

VOA: 1-$826AF
Metals: 1-$HGAFBS, 1-$MTAFS(As,Ba,Cd,Cr,Cu,Ni,Pb,Zn)
Wetlab: 1-MOIST
Other: 1-_M3050GROSS, 1-_M7471GROSS

Charges:

Invoice To:

BOA 748336.30000 TO# 5
8000 Centre Park Drive Ste 200
Austin, TX 78754-5140
Attn: Ellen Felfe

Client ID	APPL ID	Sampled	Analyses Requested
1. B3-EXW05-WC01	AY63155S	06/06/12 12:00	$826AF, $HGAFBS, $MTAFS(As,Ba,Cd,Cr,Cu,Ni,Pb,Zn), MOIST

APPL Sample Receipt Form

ARF# **67992**

Sample	Container Type	Count	pH
AY63155	20 4oz Jar	2	NA

Sample	Container Type	Count	pH

Renee Patterson

From: de las Fuentes, Sandra [Sandra.delasFuentes@parsons.com]
Sent: Monday, June 11, 2012 11:53 AM
To: Renee Patterson
Cc: Chang, Tammy; Sharon Dehmlow; Diane Anderson
Subject: RE: CSSA Cooler
Attachments: 060712_APPL.PDF; 060712_APPL.PDF

Renee,

Please proceed with the 2 waste characterization samples on the attached COCs. We will resample the 3 definitive samples listed on the 3rd COC.

Thanks!

Sandra

From: Renee Patterson [mailto:rpatterson@applinc.com]
Sent: Monday, June 11, 2012 11:13 AM
To: de las Fuentes, Sandra
Cc: Chang, Tammy; 'Sharon Dehmlow'; 'Diane Anderson'
Subject: RE: CSSA Cooler

Sandra,

The CSSA cooler was received at 10°C -- 3 COCs attached. Please let us know if you'd like us to proceed.

Renée

From: de las Fuentes, Sandra [mailto:Sandra.delasFuentes@parsons.com]
Sent: Monday, June 11, 2012 7:14 AM
To: Renee Patterson
Cc: Chang, Tammy; Sharon Dehmlow; Diane Anderson
Subject: RE: ARNG: Puerto Rico and CSSA Coolers
Importance: High

Renee,

It doesn't look like any of the 4 coolers (3 for ARNG, only 2 have soils) and 1 for CSSA made it. The website shows no updates since Sat. morning ~ 7:30 AM when they arrived in Fresno. I don't know what the added hold up is, but was hoping you could help investigate...or possibly pick up.

3 –ARNG FedEx # is 899459960629
1 – CSSA FedEx # is 876436443790

10°c

Camp Stanley Storage Activity Chain Of Custody

COC ID:	060712APPFA	Relinquish_Date:	6/7/2012	Cooler ID:	A
Project Location:	CSSA	Relinquished_By:	SE	LabCode:	APPF
Job Number:	748607.01000	Relinquish_Time:	11:30 AM	Carrier:	FedEx
Creation Date:	6/7/2012	Collection Team:	JDB	Airbill Carrier:	876436443790
Task Manager	Scott Pearson	Sample Data Type	Screening	TAT:	7 Day TAT

Sampler(s): Julie Bach

LOCID: **B3-EXW05-WC01** LOGDATE: 6/6/2012 MATRIX: SD TBLOT:
SBD: 0 LOGTIME: 12:00 SACODE: N SMCODE: G ABLOT:
SED: 0 FLDSAMPID B3-EXW05-WC01_060612_N1200 EBLOT:
Remarks:

Containers: 2

Analysis Required:

SW6010B	ARSENIC	SW6010B	BARIUM
SW6010B	CADMIUM	SW6010B	CHROMIUM
SW6010B	COPPER	SW6010B	NICKEL
SW6010B	LEAD	SW6010B	ZINC
SW7471	MERCURY	SW8260B	VOLATILE ORGANIC CO

-12-

Relinquished by: [signature] Date 6.7.12 Time 1130
Recieved by: [signature] Date 6/11/12 Time 0857

Relinquished by:____ Date____ Time____
Recieved by:____ Date____ Time____

Relinquished by:____ Date____ Time____
Recieved by:____ Date____ Time____

COOLER RECEIPT FORM

1) Project: 748607.01000 CSSA Date Received: 6/8/12
2) Coolers: Number of Coolers: 1
3) (YES) NO Were coolers and samples screened for radioactivity?
4) (YES) NO Were custody seals on outside of cooler? How many? 1 Date on seal? 6/7/12
5) Name on seal? See label
6) (YES) NO NA Were custody seals unbroken and intact at the time of arrival?
7) (YES) NO Did the cooler come with a shipping slip (air bill, etc.)? Carrier name: Fed Ex
8) Shipping slip numbers: 1) 8764 3644 3790 2) ______ 3) ______
9) (YES) NO NA Was the shipping slip scanned into the database?
10) YES (NO) NA If cooler belongs to APPL, has it been logged into the ice chest database?
11) Describe type of packing in cooler (bubble wrap, popcorn, type of ice, etc.): bubble bag in wet ice
12) YES NO (NA) For hand delivered samples was sufficient ice present to start the cooling process?
13) (YES) NO Was a temperature blank included in the cooler?
14) Serial number of certified NIST thermometer used: A39267 Correction factor: -0-
15) Cooler temp(s): 1) 1.5°C 2) ______ 3) ______ 4) ______ 5) ______ 6) ______ 7) ______ 8) ______

Chain of custody:
16) (YES) NO Was a chain of custody received?
17) (YES) NO Were the custody papers signed in the appropriate places?
18) (YES) NO Was the project identifiable from custody papers?
19) (YES) NO Did the chain of custody include date and time of sampling?
20) (YES) NO Is location where sample was taken listed on the chain of custody?

Sample Labels:
21) (YES) NO Were container labels in good condition?
22) (YES) NO Was the client ID on the label?
23) (YES) NO Was the date of sampling on the label?
24) (YES) NO Was the time of sampling on the label?
25) (YES) NO Did all container labels agree with custody papers?

Sample Containers:
26) (YES) NO Were all containers sealed in separate bags?
27) (YES) NO Did all containers arrive unbroken?
28) YES (NO) Was there any leakage from samples?
29) YES (NO) Were any of the lids cracked or broken?
30) (YES) NO Were correct containers used for the tests indicated?
31) (YES) NO Was a sufficient amount of sample sent for tests indicated?
32) YES NO (NA) Were bubbles present in volatile samples? If yes, the following were received with air bubbles:
Larger than a pea: ______
Smaller than a pea: ______

Preservation & Hold time:
33) (YES) NO NA Was a sufficient amount of holding time remaining to analyze the samples?
34) YES NO (NA) Do the sample containers contain the same preservative as what is stated on the COC?
35) YES NO (NA) Was the pH taken of all non-VOA preserved samples and written on the sample container?
36) YES NO (NA) Was the pH of acid preserved non-VOA samples < 2 & sodium hydroxide preserved samples > 12?
37) YES NO (NA) Unpreserved VOA Vials received? ______
38) YES NO (NA) Are unpreserved VOA vials noted in the ADD TEST FIELD on the ARF? ______

CUSTODY SEAL APPL, Inc. (559) 275-2175 Initials [signature] Date 6/7/12

Lab notified if pH was not adequate: ______
Deficiencies: Received out of Temp - Ice all melted.

Signature of personnel receiving samples: Yang Zi Second reviewer: [signature]
Signature of project manager notified: Renee Date and Time of notification: 6-11-12
Name of client notified: Sandra + Tammy via email Date and Time of notification: 6-11-12
Information given to client: ______
______ by whom (Initials): ______

EPA METHOD 8260B
Volatile Organic Compounds

APPL, INC.

EPA METHOD 8260B
Volatile Organic Compounds
QC Summary

APPL, INC.

AFCEE
ORGANIC ANALYSES DATA SHEET 6
BLANK

Analytical Method: EPA 8260B

AAB #: 120611AS-167917

Lab Name: APPL, Inc

Contract #: *G012

Concentration Units: mg/kg

Method Blank ID: 120611AS-BLK

Initial Calibration ID: S120611

Analyte	Method Blank	RL	Q
1,1,1,2-TETRACHLOROETHANE	< RL	0.003	U
1,1,1-TCA	< RL	0.004	U
1,1,2,2-TETRACHLOROETHANE	< RL	0.002	U
1,1,2-TCA	< RL	0.005	U
1,1-DCA	< RL	0.002	U
1,1-DCE	< RL	0.006	U
1,1-DICHLOROPROPENE	< RL	0.005	U
1,2,3-TRICHLOROBENZENE	< RL	0.004	U
1,2,3-TRICHLOROPROPANE	< RL	0.020	U
1,2,4-TRICHLOROBENZENE	< RL	0.004	U
1,2,4-TRIMETHYLBENZENE	< RL	0.007	U
1,2-DCA	< RL	0.003	U
1,2-DCB	< RL	0.002	U
1,2-DIBROMO-3-CHLOROPROPANE	< RL	0.010	U
1,2-DICHLOROPROPANE	< RL	0.002	U
1,2-EDB	< RL	0.003	U
1,3,5-TRIMETHYLBENZENE	< RL	0.003	U
1,3-DCB	< RL	0.006	U
1,3-DICHLOROPROPANE	< RL	0.002	U
1,4-DCB	< RL	0.002	U
1-CHLOROHEXANE	< RL	0.003	U
2,2-DICHLOROPROPANE	< RL	0.020	U
2-CHLOROTOLUENE	< RL	0.002	U
4-CHLOROTOLUENE	< RL	0.003	U
BENZENE	< RL	0.002	U
BROMOBENZENE	< RL	0.002	U
BROMOCHLOROMETHANE	< RL	0.002	U
BROMODICHLOROMETHANE	< RL	0.004	U
BROMOFORM	< RL	0.006	U
BROMOMETHANE	< RL	0.005	U
CARBON TETRACHLORIDE	< RL	0.010	U
CHLOROBENZENE	< RL	0.002	U
CHLOROETHANE	< RL	0.005	U
CHLOROFORM	< RL	0.002	U
CHLOROMETHANE	< RL	0.007	U
CIS-1,2-DCE	< RL	0.006	U
CIS-1,3-DICHLOROPROPENE	< RL	0.005	U
DIBROMOCHLOROMETHANE	< RL	0.003	U
DIBROMOMETHANE	< RL	0.010	U
DICHLORODIFLUOROMETHANE	< RL	0.005	U
ETHYLBENZENE	< RL	0.003	U

Comments: ARF: 67992, Sample: AY63155

AFCEE
ORGANIC ANALYSES DATA SHEET 6
BLANK

Analytical Method: EPA 8260B
Lab Name: APPL, Inc
Concentration Units: mg/kg
Initial Calibration ID: S120611

AAB #: 120611AS-167917
Contract #: *G012
Method Blank ID: 120611AS-BLK

Analyte	Method Blank	RL	Q
HEXACHLOROBUTADIENE	< RL	0.005	U
ISOPROPYLBENZENE	< RL	0.008	U
M&P-XYLENE	< RL	0.007	U
METHYLENE CHLORIDE	< RL	0.005	U
N-BUTYLBENZENE	< RL	0.005	U
N-PROPYLBENZENE	< RL	0.002	U
NAPHTHALENE	< RL	0.020	U
O-XYLENE	< RL	0.005	U
P-ISOPROPYLTOLUENE	< RL	0.006	U
SEC-BUTYLBENZENE	< RL	0.007	U
STYRENE	< RL	0.002	U
TCE	< RL	0.010	U
TERT-BUTYLBENZENE	< RL	0.007	U
TETRACHLOROETHENE	< RL	0.007	U
TOLUENE	< RL	0.005	U
TRANS-1,2-DCE	< RL	0.003	U
TRANS-1,3-DICHLOROPROPENE	< RL	0.005	U
TRICHLOROFLUOROMETHANE	< RL	0.004	U
VINYL CHLORIDE	< RL	0.009	U

Surrogate	Recovery	Control Limits	Qualifier
SURROGATE: 1,2-DICHLOROETHAN	90.2	52-149	
SURROGATE: 4-BROMOFLUOROBE	92.8	65-135	
SURROGATE: DIBROMOFLUOROME	96.8	65-135	
SURROGATE: TOLUENE-D8 (S)	89.3	65-135	

Internal Std	Qualifier
1,4-DICHLOROBENZENE-D4 (IS)	
CHLOROBENZENE-D5 (IS)	
FLUOROBENZENE (IS)	

Comments: ARF: 67992, Sample: AY63155

Form 2 & 8

Surrogate Recovery

Lab Name: APPL, Inc. SDG No: 67992
Case No: 67992 Date Analyzed: 06/12/12
Matrix: SOIL Instrument: Sweetpea

APPL ID.	Client Sample No.	SURROGATE: 1,2-DICHLOROETHANE-D4 (S)			SURROGATE: 4-BROMOFLUOROBENZENE (S)		
		Limits	Result	Qualifier	Limits	Result	Qualifier
120611AS-LCS	Lab Control Spike	52-149	90.0		65-135	92.8	
120611AS-BLK	Blank	52-149	90.2		65-135	92.8	
AY63155	B3-EXW05-WC01	52-149	107		65-135	109	

Comments: Batch: #826AF-120611AS

Printed: 06/12/12 11:20:30 AM
Form 2 & 8, Surrogate Recovery Summary

Form 2 & 8

Surrogate Recovery

Lab Name: APPL, Inc.
Case No: 67992
Matrix: SOIL

SDG No: 67992
Date Analyzed: 06/12/12
Instrument: Sweetpea

APPL ID.	Client Sample No.	SURROGATE: DIBROMOFLUOROMETHANE (S)			SURROGATE: TOLUENE-D8 (S)		
		Limits	Result	Qualifier	Limits	Result	Qualifier
120611AS-LCS	Lab Control Spike	65-135	97.6		65-135	91.4	
120611AS-BLK	Blank	65-135	96.8		65-135	89.3	
AY63155	B3-EXW05-WC01	65-135	108		65-135	104	

Comments: Batch: #826AF-120611AS

Printed: 06/12/12 11:20:30 AM
Form 2 & 8, Surrogate Recovery Summary

AFCEE
ORGANIC ANALYSES DATA SHEET 7
LABORATORY CONTROL SAMPLE

Analytical Method: EPA 8260B
Lab Name: APPL, Inc
LCS ID: 120611AS LCS
Concentration Units: mg/kg

AAB #: 120611AS-167917
Contract #: *G012
Initial Calibration ID: S120611

Analyte	Expected	Found	% R	Control Limits	Q
1,1,1,2-TETRACHLOROETHANE	0.0500	0.0475	95.0	62-125	
1,1,1-TCA	0.0500	0.0494	98.8	65-135	
1,1,2,2-TETRACHLOROETHANE	0.0500	0.0471	94.2	64-135	
1,1,2-TCA	0.0500	0.0473	94.6	65-135	
1,1-DCA	0.0500	0.0492	98.4	62-135	
1,1-DCE	0.0500	0.0540	108	65-135	
1,1-DICHLOROPROPENE	0.0500	0.0493	98.6	65-135	
1,2,3-TRICHLOROBENZENE	0.0500	0.0430	86.0	65-147	
1,2,3-TRICHLOROPROPANE	0.050	0.048	96.0	65-135	
1,2,4-TRICHLOROBENZENE	0.0500	0.0430	86.0	65-145	
1,2,4-TRIMETHYLBENZENE	0.0500	0.0481	96.2	65-135	
1,2-DCA	0.0500	0.0496	99.2	58-137	
1,2-DCB	0.0500	0.0462	92.4	65-135	
1,2-DIBROMO-3-CHLOROPROPANE	0.050	0.043	86.0	49-135	
1,2-DICHLOROPROPANE	0.0500	0.0475	95.0	60-135	
1,2-EDB	0.0500	0.0473	94.6	65-135	
1,3,5-TRIMETHYLBENZENE	0.0500	0.0471	94.2	62-135	
1,3-DCB	0.0500	0.0460	92.0	65-135	
1,3-DICHLOROPROPANE	0.0500	0.0478	95.6	65-135	
1,4-DCB	0.0500	0.0450	90.0	65-135	
1-CHLOROHEXANE	0.0500	0.0483	96.6	65-135	
2,2-DICHLOROPROPANE	0.050	0.047	94.0	65-135	
2-CHLOROTOLUENE	0.0500	0.0454	90.8	63-135	
4-CHLOROTOLUENE	0.0500	0.0477	95.4	64-135	
BENZENE	0.0500	0.0497	99.4	65-135	
BROMOBENZENE	0.0500	0.0471	94.2	65-135	
BROMOCHLOROMETHANE	0.0500	0.0512	102	63-135	
BROMODICHLOROMETHANE	0.0500	0.0498	99.6	65-135	
BROMOFORM	0.0500	0.0463	92.6	65-135	
BROMOMETHANE	0.0500	0.0479	95.8	62-135	
CARBON TETRACHLORIDE	0.050	0.051	102	52-135	
CHLOROBENZENE	0.0500	0.0470	94.0	65-135	
CHLOROETHANE	0.0500	0.0576	115	55-135	
CHLOROFORM	0.0500	0.0494	98.8	64-135	
CHLOROMETHANE	0.0500	0.0475	95.0	65-135	
CIS-1,2-DCE	0.0500	0.0476	95.2	65-135	
CIS-1,3-DICHLOROPROPENE	0.0500	0.0453	90.6	64-135	
DIBROMOCHLOROMETHANE	0.0500	0.0469	93.8	63-135	
DIBROMOMETHANE	0.050	0.049	98.0	59-137	
DICHLORODIFLUOROMETHANE	0.0500	0.0533	107	65-135	

Comments: ARF: 67992, QC Sample ID: AY63154

AFCEE FORM O-7

AFCEE
ORGANIC ANALYSES DATA SHEET 7
LABORATORY CONTROL SAMPLE

Analytical Method: EPA 8260B
Lab Name: APPL, Inc
LCS ID: 120611AS LCS
Concentration Units: mg/kg

AAB #: 120611AS-167917
Contract #: *G012
Initial Calibration ID: S120611

Analyte	Expected	Found	% R	Control Limits	Q
ETHYLBENZENE	0.0500	0.0464	92.8	65-135	
HEXACHLOROBUTADIENE	0.0500	0.0481	96.2	65-135	
ISOPROPYLBENZENE	0.0500	0.0486	97.2	65-135	
M&P-XYLENE	0.1000	0.0954	95.4	65-135	
METHYLENE CHLORIDE	0.0500	0.0496	99.2	65-135	
N-BUTYLBENZENE	0.0500	0.0460	92.0	65-135	
N-PROPYLBENZENE	0.0500	0.0467	93.4	65-135	
NAPHTHALENE	0.0500	0.0456	91.2	65-135	
O-XYLENE	0.0500	0.0471	94.2	65-135	
P-ISOPROPYLTOLUENE	0.0500	0.0479	95.8	65-135	
SEC-BUTYLBENZENE	0.0500	0.0485	97.0	65-135	
STYRENE	0.0500	0.0483	96.6	65-135	
TCE	0.0500	0.0481	96.2	61-135	
TERT-BUTYLBENZENE	0.0500	0.0483	96.6	65-135	
TETRACHLOROETHENE	0.0500	0.0466	93.2	61-135	
TOLUENE	0.0500	0.0472	94.4	64-135	
TRANS-1,2-DCE	0.0500	0.0487	97.4	65-135	
TRANS-1,3-DICHLOROPROPENE	0.0500	0.0462	92.4	56-135	
TRICHLOROFLUOROMETHANE	0.0500	0.0560	112	57-135	
VINYL CHLORIDE	0.0500	0.0541	108	36-144	

Surrogate	Recovery	Control Limits	Qualifier
SURROGATE: 1,2-DICHLOROETHANE-	90.7	52-149	
SURROGATE: 4-BROMOFLUOROBENZ	90.9	65-135	
SURROGATE: DIBROMOFLUOROMETH	97.7	65-135	
SURROGATE: TOLUENE-D8 (S)	91.5	65-135	

Internal Std	Qualifier
1,4-DICHLOROBENZENE-D4 (IS)	
CHLOROBENZENE-D5 (IS)	
FLUOROBENZENE (IS)	

Comments: ARF: 67992, QC Sample ID: AY63154

EPA 8260B

Form 4

Blank Summary

Lab Name:	APPL, Inc.	SDG No:	67992
Case No:	67992	Date Analyzed:	06/12/12
Matrix:	SOIL	Instrument:	Sweetpea
Blank ID:	120611AS-BLK	Time Analyzed:	0206

APPL ID.	Client Sample No.	File ID.	Date Analyzed
120611AS-LCS	Lab Control Spike	0611S14	06/12/12 0020
120611AS-BLK	Blank	0611S17	06/12/12 0206
AY63155	B3-EXW05-WC01	0611S21	06/12/12 0426

Comments: Batch: #826AF-120611AS

Printed: 06/12/12 11:20:27 AM
Form 4, Blank Summary

Form 5
Tune Summary

Lab Name: APPL Inc.
Case No: 67992
Matrix: Soil
ID: 25ug/mL BFB Std 06-11-12

SDG No: 67992
Date Analyzed: 06/11/12
Instrument: Sweetpea
Time Analyzed: 22:35

	Client Sample No.	APPL ID.	File ID.	Date Analyzed
1		50ug/kg std 6-11-12	0611S12S.D	06/11/12 23:10
2	Lab Control Spike	120611A LCS-1SS(SS)	0611S14S.D	06/12/12 0:20
3	Blank	120611A BLK-1SS	0611S17S.D	06/12/12 2:06
4	B3-EXW05-WC01	AY63155S01 5.037	0611S21S.D	06/12/12 4:26
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				

m/e		
50	15 - 40% of mass 95	17.4
75	30 - 60% of mass 95	40.6
95	100 - 100% of mass 95	100.0
96	5 - 9% of mass 95	6.8
173	0 - 2% of mass 174	0.0
174	50 - 100% of mass 95	87.9
175	5 - 9% of mass 174	7.3
176	95 - 101% of mass 174	96.1
177	5 - 9% of mass 176	6.1

8A
INTERNAL STANDARD AREA AND RT SUMMARY

Lab Name: APPL Inc. Contract: Review

Lab Code: ________ SDG No.: 67992

Lab File ID (Standard): 0611S07S.D Date Analyzed: 06/11/12

Instrument ID: Sweetpea Time Analyzed: 20:15

GC Column: ________ ID: Heated Purge: (Y/N) ________

		Fluorobenzene (IS)		Chlorobenzene-D5 (IS)		1,4-Dichlorobenzene-D (IS)	
		AREA #	RT #	AREA #	RT #	AREA #	RT #
	12 HOUR STD	591697	9.65	393544	14.69	188044	18.77
	UPPER LIMIT	1183394	10.15	787088	15.19	376088	19.27
	LOWER LIMIT	295849	9.15	196772	14.19	94022	18.27
	SAMPLE NO.						
01	50ug/kg std 6-11-12	597453	9.65	383933	14.68	191655	18.76
02	120611A LCS-1SS(SS)	569772	9.64	378860	14.68	180264	18.76
03	120611A BLK-1SS	570383	9.65	381691	14.67	184029	18.76
04	AY63155S01 5.037	515712	9.64	341410	14.68	164137	18.76
05							
06							
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21							
22							

AREA UPPER LIMIT = +100% of internal standard area.
AREA LOWER LIMIT = -50% of internal standard area.
RT UPPER LIMIT = +0.50 minutes of internal standard RT
RT LOWER LIMIT = -0.50 minutes of internal standard RT

Column used to flag values outside QC limits with an asterisk.
* Values outside of QC limits.

EPA METHOD 8260B
Volatile Organic Compounds
Sample Data

APPL, INC.

AFCEE
ORGANIC ANALYSES DATA SHEET 2
RESULTS

Analytical Method: EPA 8260B   Preparatory Method: 5035   AAB #: 120611AS-167917

Lab Name: APPL, Inc   Contract #: *G012

Field Sample ID: B3-EXW05-WC01   Lab Sample ID: AY63155   Matrix: Soil

% Solids: 98   Initial Calibration ID: S120611

Date Received: 11-Jun-12   Date Prepared: 12-Jun-12   Date Analyzed: 12-Jun-12

Concentration Units: mg/kg

Analyte	MDL	RL	Concentration	Dilution	Confirm	Qualifier
1,1,1,2-TETRACHLOROETHANE	0.0008	0.003	0.0008	1		U
1,1,1-TCA	0.0009	0.004	0.0009	1		U
1,1,2,2-TETRACHLOROETHANE	0.0009	0.002	0.0009	1		U
1,1,2-TCA	0.0009	0.005	0.0009	1		U
1,1-DCA	0.0010	0.002	0.0010	1		U
1,1-DCE	0.0011	0.006	0.0011	1		U
1,1-DICHLOROPROPENE	0.0012	0.005	0.0012	1		U
1,2,3-TRICHLOROBENZENE	0.0010	0.004	0.0010	1		U
1,2,3-TRICHLOROPROPANE	0.001	0.020	0.001	1		U
1,2,4-TRICHLOROBENZENE	0.0010	0.004	0.0010	1		U
1,2,4-TRIMETHYLBENZENE	0.0011	0.007	0.0011	1		U
1,2-DCA	0.0010	0.003	0.0010	1		U
1,2-DCB	0.0010	0.002	0.0010	1		U
1,2-DIBROMO-3-CHLOROPROPANE	0.002	0.010	0.002	1		U
1,2-DICHLOROPROPANE	0.0007	0.002	0.0007	1		U
1,2-EDB	0.0013	0.003	0.0013	1		U
1,3,5-TRIMETHYLBENZENE	0.0011	0.003	0.0011	1		U
1,3-DCB	0.0011	0.006	0.0011	1		U
1,3-DICHLOROPROPANE	0.0007	0.002	0.0007	1		U
1,4-DCB	0.0008	0.002	0.0008	1		U
1-CHLOROHEXANE	0.0009	0.003	0.0009	1		U
2,2-DICHLOROPROPANE	0.001	0.020	0.001	1		U
2-CHLOROTOLUENE	0.0013	0.002	0.0013	1		U
4-CHLOROTOLUENE	0.0011	0.003	0.0011	1		U
BENZENE	0.0009	0.002	0.0009	1		U
BROMOBENZENE	0.0009	0.002	0.0009	1		U
BROMOCHLOROMETHANE	0.0008	0.002	0.0008	1		U
BROMODICHLOROMETHANE	0.0009	0.004	0.0009	1		U
BROMOFORM	0.0011	0.006	0.0011	1		U
BROMOMETHANE	0.0007	0.005	0.0007	1		U
CARBON TETRACHLORIDE	0.001	0.010	0.001	1		U
CHLOROBENZENE	0.0007	0.002	0.0007	1		U
CHLOROETHANE	0.0015	0.005	0.0015	1		U
CHLOROFORM	0.0007	0.002	0.0007	1		U
CHLOROMETHANE	0.0015	0.007	0.0015	1		U

Comments:

ARF: 67992

AFCEE FORM O-2

AFCEE
ORGANIC ANALYSES DATA SHEET 2
RESULTS

Analytical Method: EPA 8260B Preparatory Method: 5035 AAB #: 120611AS-167917

Lab Name: APPL, Inc Contract #: *G012

Field Sample ID: B3-EXW05-WC01 Lab Sample ID: AY63155 Matrix: Soil

% Solids: 98 Initial Calibration ID: S120611

Date Received: 11-Jun-12 Date Prepared: 12-Jun-12 Date Analyzed: 12-Jun-12

Concentration Units: mg/kg

Analyte	MDL	RL	Concentration	Dilution	Confirm	Qualifier
CIS-1,2-DCE	0.0008	0.006	0.0008	1		U
CIS-1,3-DICHLOROPROPENE	0.0009	0.005	0.0009	1		U
DIBROMOCHLOROMETHANE	0.0009	0.003	0.0009	1		U
DIBROMOMETHANE	0.001	0.010	0.001	1		U
DICHLORODIFLUOROMETHANE	0.0018	0.005	0.0018	1		U
ETHYLBENZENE	0.0010	0.003	0.0010	1		U
HEXACHLOROBUTADIENE	0.0011	0.005	0.0011	1		U
ISOPROPYLBENZENE	0.0010	0.008	0.0010	1		U
M&P-XYLENE	0.0018	0.007	0.0018	1		U
METHYLENE CHLORIDE	0.0013	0.005	0.0013	1		U
N-BUTYLBENZENE	0.0010	0.005	0.0010	1		U
N-PROPYLBENZENE	0.0012	0.002	0.0012	1		U
NAPHTHALENE	0.0010	0.020	0.0010	1		U
O-XYLENE	0.0007	0.005	0.0007	1		U
P-ISOPROPYLTOLUENE	0.0012	0.006	0.0012	1		U
SEC-BUTYLBENZENE	0.0011	0.007	0.0011	1		U
STYRENE	0.0009	0.002	0.0009	1		U
TCE	0.0012	0.010	0.0012	1		U
TERT-BUTYLBENZENE	0.0012	0.007	0.0012	1		U
TETRACHLOROETHENE	0.0008	0.007	0.0008	1		U
TOLUENE	0.0010	0.005	0.0010	1		U
TRANS-1,2-DCE	0.0008	0.003	0.0008	1		U
TRANS-1,3-DICHLOROPROPENE	0.0009	0.005	0.0009	1		U
TRICHLOROFLUOROMETHANE	0.0013	0.004	0.0013	1		U
VINYL CHLORIDE	0.0013	0.009	0.0013	1		U

Surrogate	Recovery	Control Limits	Qualifier
SURROGATE: 1,2-DICHLOROETHANE-	107	52-149	
SURROGATE: 4-BROMOFLUOROBENZ	109	65-135	
SURROGATE: DIBROMOFLUOROMETH	108	65-135	
SURROGATE: TOLUENE-D8 (S)	104	65-135	

Internal Std	Qualifier
1,4-DICHLOROBENZENE-D4 (IS)	
CHLOROBENZENE-D5 (IS)	
FLUOROBENZENE (IS)	

Comments:

ARF: 67992

AFCEE FORM O-2

EPA METHOD 8260B
Volatile Organic Compounds
Calibration Data

APPL, INC.

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 6
Initial Calibration

Lab Name: APPL, Inc. SDG No: 67992

Case No: ______ Initial Cal. Date: 06/11/12

Matrix: ______ Instrument: Sweetpea Initials: ______

			0611S03S D	0611S04S D	0611S05S.D	0611S06S.D	0611S07S D	0611S08S D	0611S09S.D							
		Compound	2	5	10	20	50	100	200				Avg	%RSD		
1	I	Fluorobenzene (IS)	ISTD													
2	TM	Dichlorodifluoromethane	0.3649	0.3259	0.3155	0.3044	0.3400	0.3191	0.3262				0.33	6.0	TM	
3	TML	Freon 114	0.0449	0.0468	0.0437	0.0300	0.0345	0.0404					0.04	16	TML	0.992
4	TM**	Chloromethane	0.2232	0.2382	0.2381	0.1842	0.2203	0.2053	0.2142				0.22	8.7	TM**	
5	TM*	Vinyl chloride	0.3427	0.2638	0.2301	0.2122	0.2480	0.2498	0.2548				0.26	16	TM*	
6	TML	Bromomethane		0.1399	0.1336	0.1424	0.1466	0.1844	0.1955				0.16	17	TML	0.997
7	TM	Chloroethane	0.0722	0.0616	0.0664	0.0493	0.0652	0.0615	0.0550				0.06	12	TM	
8	TM	Dichlorofluoromethane	0.4674	0.4564	0.4358	0.4024	0.3249	0.4532	0.4433				0.43	12	TM	
9	TM	Trichlorofluoromethane	0.2206	0.1984	0.2051	0.1857	0.2127	0.2102	0.2147				0.21	5.7	TM	
10	TM	Acrolein	0.0261	0.0249	0.0254	0.0257	0.0242	0.0233	0.0240				0.02	4.0	TM	
11	TML	Acetone		0.1382	0.0971	0.0673	0.0427	0.0504	0.0467				0.07	51	TML	0.995
12	TM	Freon-113	0.0468	0.0452	0.0370	0.0370	0.0291	0.0376	0.0379				0.04	15	TM	
13	TM*	1,1-DCE	0.1306	0.1170	0.1050	0.0874	0.0730	0.1039	0.1001				0.10	18	TM*	
14	TM	t-Butanol	0.0163	0.0159	0.0162	0.0176	0.0162	0.0158	0.0176				0.02	4.5	TM	
15	TM	Methyl Acetate													TM	
16	TMQ	Iodomethane	0.0193	0.0367	0.0461	0.0586	0.0444	0.0901	0.1156				0.06	57	TMQ	0.996
17	TMQ	Acrylonitrile	0.1060	0.0743	0.0600	0.0523	0.0460	0.0580					0.07	33	TMQ	0.999
18	TML	Methylene chloride	0.2986	0.1812	0.1054	0.0846	0.0618	0.0591					0.13	71	TML	0.998
19	TM	Carbon disulfide	0.0994	0.0966	0.0906	0.0818	0.0877	0.1116	0.1050				0.10	11	TM	
20	TM	Methyl t-butyl ether (MtBE)	0.5359	0.5187	0.4791	0.4172	0.3873	0.5483	0.5332				0.49	13	TM	
21	TML	Trans-1,2-DCE	0.1738	0.1528	0.1333	0.1230	0.1057	0.1480	0.1417				0.14	16	TML	0.995
22	TM	Diisopropyl Ether	1.070	1.007	1.006	0.9346	0.7288	1.037	1.005				0.97	12	TM	
23	TM**	1,1-DCA	0.4353	0.4026	0.4062	0.3736	0.2981	0.4186	0.4016				0.39	12	TM**	
24	TM	Vinyl Acetate	0.7353	0.6869	0.6893	0.6573	0.5454	0.7892	0.7473				0.69	11	TM	
25	TM	Ethyl tert Butyl Ether	0.6558	0.6640	0.6596	0.6311	0.5041	0.7203	0.7006				0.65	11	TM	
26	TMQ	MEK (2-Butanone)	0.2317	0.1950	0.1679	0.1514	0.1110	0.1528					0.17	25	TMQ	0.995
27	TM	Cis-1,2-DCE	0.2648	0.2236	0.2329	0.2171	0.1684	0.2321	0.2295				0.22	13	TM	
28	TM	2,2-Dichloropropane	0.3492	0.3132	0.3123	0.2836	0.2326	0.3071	0.3000				0.30	12	TM	
29	TM*	Chloroform	0.3861	0.4135	0.3844	0.3699	0.2956	0.4106	0.3931				0.38	11	TM*	
30	TM	Bromochloromethane	0.0734	0.0738	0.0871	0.0826	0.0665	0.0965	0.0942				0.08	14	TM	
31	S	Dibromofluoromethane(S)	0.2489	0.3022	0.2835	0.2916	0.3213	0.3189	0.3065				0.30	8.4	S	
32	TM	1,1,1-TCA	0.3063	0.2875	0.2679	0.2615	0.2072	0.2947	0.2889				0.27	12	TM	
33	TM	Cyclohexane	0.2270	0.2123	0.2143	0.1923	0.1626	0.2375	0.2279				0.21	12	TM	
34	TM	1,1-Dichloropropene	0.2280	0.2091	0.2033	0.1997	0.1613	0.2288	0.2206				0.21	11	TM	
35	TM	2,2,4-Trimethylpentane	0.4445	0.4887	0.4661	0.4184	0.3707	0.5155	0.4869				0.46	11	TM	

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 6
Initial Calibration

Lab Name: APPL, Inc. SDG No: 67992

Case No: Initial Cal. Date: 06/11/12

Matrix: Instrument: Sweetpea Initials:

		Compound	2	5	10	20	50	100	200				Avg	%RSD		
36	S	1,2-DCA-D4(S)	0.1886	0.2440	0.2177	0.2201	0.2546	0.2518	0.2393				0.23	10	S	
37	TM	Carbon Tetrachloride	0.2009	0.2180	0.2137	0.2164	0.1756	0.2488	0.2407				0.22	11	TM	
38	TM	Tert Amyl Methyl Ether	0.6172	0.5618	0.5816	0.5611	0.4147	0.6070	0.5934				0.56	12	TM	
39	TM	1,2-DCA	0.2241	0.1983	0.2161	0.2145	0.1586	0.2268	0.2196				0.21	11	TM	
40	TM	Benzene	0.8334	0.7976	0.7686	0.7246	0.5728	0.8265	0.7906				0.76	12	TM	
41	TM	TCE	0.2035	0.2003	0.2031	0.1807	0.1476	0.2034	0.1974				0.19	11	TM	
42	TM	2-Pentanone	0.1590	0.1527	0.1571	0.1608	0.1574	0.1484	0.1535				0.16	2.7	TM	
43	TM*	1,2-Dichloropropane	0.2678	0.2710	0.2414	0.2307	0.1846	0.2609	0.2530				0.24	12	TM*	
44	TM	Bromodichloromethane	0.2961	0.2898	0.3063	0.2911	0.2265	0.3289	0.3178				0.29	11	TM	
45	TM	Methyl Cyclohexane	0.2228	0.2227	0.2123	0.1924	0.1682	0.2407	0.2338				0.21	12	TM	
46	TM	Dibromomethane	0.1298	0.1192	0.1146	0.1140	0.0881	0.1296	0.1229				0.12	12	TM	
47	TM	2-Chloroethyl vinyl ether	0.2849	0.2906	0.2843	0.2835	0.2154	0.3122	0.2985				0.28	11	TM	
48	TM	1-Bromo-2-chloroethane	0.2849	0.2906	0.2843	0.2835	0.2154	0.3122	0.2985				0.28	11	TM	
49	TM	Cis-1,3-Dichloropropene	0.4285	0.3864	0.3662	0.3558	0.2562	0.3801	0.3623				0.36	15	TM	
50	TM*	Toluene	0.5878	0.5422	0.5081	0.4885	0.3889	0.5463	0.5265				0.51	12	TM*	
51	TM	Trans-1,3-Dichloropropene	0.2956	0.2849	0.3064	0.2750	0.2164	0.3003	0.3005				0.28	11	TM	
52	TM	1,1,2-TCA	0.1642	0.1654	0.1560	0.1603	0.1189	0.1730	0.1641				0.16	11	TM	
53	I	Chlorobenzene-D5 (IS)	ISTD													
54	S	Toluene-D8(S)	1.124	1.406	1.341	1.338	1.548	1.487	1.477				1.4	10	S	
55	TM	1,2-EDB	0.2807	0.2605	0.2549	0.2550	0.1939	0.2667	0.2707				0.25	11	TM	
56	TM	Tetrachloroethene	0.2795	0.2422	0.2438	0.2400	0.1862	0.2461	0.2407				0.24	11	TM	
57	TM	1-Chlorohexane	0.5383	0.5575	0.5470	0.5053	0.3972	0.5546	0.5490				0.52	11	TM	
58	TM	1,1,1,2-Tetrachloroethane	0.3857	0.3847	0.3685	0.3753	0.2725	0.3788	0.3876				0.36	11	TM	
59	TM	m&p-Xylene	0.6367	0.6351	0.6281	0.6044	0.4506	0.6063	0.6116				0.60	11	TM	
60	TM	o-Xylene	0.7166	0.6432	0.6272	0.6036	0.4590	0.6298	0.6484				0.62	13	TM	
61	TM	Styrene	1.085	1.049	1.081	1.064	0.7978	1.106	1.130				1.0	11	TM	
62	S	4-Bromofluorobenzene(S)	0.4722	0.5127	0.4911	0.4933	0.5079	0.4921	0.4984				0.50	2.7	S	
63	TM	2-Hexanone		0.2310	0.2007	0.2146	0.1486	0.1930	0.1982				0.20	14	TM	
64	TM	1,3-Dichloropropane	0.4341	0.4385	0.4506	0.4195	0.3315	0.4581	0.4493				0.43	10	TM	
65	TM	Dibromochloromethane	0.3725	0.3558	0.3604	0.3552	0.2632	0.3819	0.3737				0.35	11	TM	
66	TM**	Chlorobenzene	0.9987	0.9852	0.9478	0.9213	0.6856	0.9658	0.9412				0.92	12	TM**	
67	TM*	Ethylbenzene	1.577	1.648	1.604	1.536	1.169	1.612	1.615				1.5	11	TM*	
68	TM**	Bromoform	0.2242	0.2217	0.2185	0.2084	0.1625	0.2284	0.2341				0.21	11	TM**	
69	I	1,4-Dichlorobenzene-D (IS)	ISTD													
70	TM	MIBK (methyl isobutyl ketone)	0.7467	0.7304	0.6389	0.6023	0.4652	0.6234	0.6158				0.63	15	TM	

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 6
Initial Calibration

Lab Name: APPL, Inc. SDG No: 67992
Case No: Initial Cal. Date: 06/11/12
Matrix: Instrument: Sweetpea Initials:

		Compound	2	5	10	20	50	100	200				Avg	%RSD		
71	TM	Isopropylbenzene	3.356	3.307	3.188	3.028	2.411	3.281	3.277				3.1	11	TM	
72	TM**	1,1,2,2-Tetrachloroethane	0.7167	0.7547	0.7367	0.7121	0.5582	0.7703	0.7405				0.71	10 0	TM**	
73	TM	1,2,3-Trichloropropane	0.1451	0 1428	0.1565	0.1700	0.1248	0.1706	0.1678				0.15	11	TM	
74	TM	t-1,4-Dichloro-2-Butene	0.1974	0.1895	0.1638	0.1614	0.1233	0.1827	0.1796				0.17	14	TM	
75	TM	Bromobenzene	0.9289	0.8958	0.8226	0.7868	0.6343	0.8684	0.8622				0.83	12	TM	
76	TM	n-Propylbenzene	4.314	4.448	4.111	4.027	3.165	4.377	4.366				4.1	11	TM	
77	TM	4-Ethyltoluene	0.9251	0.9077	0.8733	0 8772	0.6804	0.9094	0.9592				0.88	10	TM	
78	TM	2-Chlorotoluene	2.791	2.771	2.801	2.582	1.984	2.800	2.761				2.6	11	TM	
79	TM	1,3,5-Trimethylbenzene	2.862	2.823	2.649	2.633	2.014	2.795	2.852				2.7	11	TM	
80	TM	4-Chlorotoluene	2.466	2.629	2.349	2.225	1.753	2.451	2.428				2.3	12	TM	
81	TM	Tert-Butylbenzene	2.976	3.013	2.919	2.839	2.173	3.017	3.047				2.9	11	TM	
82	TM	1,2,4-Trimethylbenzene	2.686	2.790	2.741	2.633	2.000	2.756	2.790				2.6	11	TM	
83	TM	Sec-Butylbenzene	4.178	4.059	3.924	3.861	3 063	4.195	4.173				3.9	10	TM	
84	TM	p-Isopropyltoluene	3.315	3.328	3.255	3.005	2.380	3.272	3.293				3.1	11	TM	
85	TM	Benzyl Chloride	1 159	1.039	1.106	1.036	1.060	1.023	1.042				1.1	4.6	TM	
86	TM	1,3-DCB	1.766	1.676	1.628	1.635	1.224	1.647	1.645				1.6	11	TM	
87	TM	1,4-DCB	1.826	1.685	1.559	1.511	1.186	1.601	1.622				1.6	13	TM	
88	TM	n-Butylbenzene	3.426	3.004	2.837	2.858	2.197	3.084	3.033				2.9	13	TM	
89	TM	1,2-DCB	1.643	1.541	1.489	1.413	1.085	1.495	1.502				1.5	12	TM	
90	TM	Hexachloroethane	0.8064	0.7672	0.7402	0.7312	0.7549	0.7416	0.7840				0.76	3.5	TM	
91	TM	1,2-Dibromo-3-chloropropane	0.0448	0.0356	0.0422	0.0379	0.0315	0.0434	0.0436				0.04	12	TM	
92	TM	1,2,4-Trichlorobenzene	1.070	1.015	0.9585	0.9312	0.7116	0.9843	0.9500				0.95	12	TM	
93	TM	Hexachlorobutadiene	0.6202	0.6983	0.6498	0.6208	0.4687	0.6441	0.6323				0.62	12	TM	
94	TM	Naphthalene	2.390	2.154	1.971	1.982	1.516	2.148	2.073				2.0	13	TM	
95	TM	1,2,3-Trichlorobenzene	1.090	0.9187	0.9424	0.9130	0.6645	0.9237	0.9053				0.91	14	TM	
96																
97																
98																
99																
100																
101																
102																
103																
104																
105																

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Second Source Calibration

Lab Name: APPL, Inc.
Case No:
Matrix:

SDG No: 67992
Date Analyzed: 06/12/12
Instrument: Sweetpea
Initial Cal. Date: 06/11/12
Data File: 0611S14S.D

		Compound	MEAN	CCRF	%D	%Drift	
1	I	Fluorobenzene (IS)	ISTD			I	
2	TM	Dichlorodifluoromethane	0.3280	0.3495	6.6	TM	
3	TML	Freon 114	0.0400	0.0458	14	TML	17
4	TM**	Chloromethane	0.2177	0.2068	5.0	TM**	
5	TM*	Vinyl chloride	0.2574	0.2785	8.2	TM*	
6	TML	Bromomethane	0.1571	0.1677	6.8	TML	4.3
7	TM	Chloroethane	0.0616	0.0709	15	TM	
8	TM	Dichlorofluoromethane	0.4262	0.4164	2.3	TM	
9	TM	Trichlorofluoromethane	0.2068	0.2317	12	TM	
10	TM	Acrolein	0.0248	0.0249	0.20	TM	
11	TML	Acetone	0.0737	0.0494	33	TML	6.8
12	TM	Freon-113	0.0387	0.0385	0.44	TM	
13	TM*	1,1-DCE	0.1024	0.1107	8.1	TM*	
14	TM	t-Butanol	0.0165	0.0187	13	TM	
15	TM	Methyl Acetate	0.0000	0.1322	0.00	TM	
16	TMQ	Iodomethane	0.0587	0.0937	60	TMQ	32 nt
17	TMQ	Acrylonitrile	0.0661	0.0566	14	TMQ	16
18	TML	Methylene chloride	0.1318	0.0638	52	TML	0.72
19	TM	Carbon disulfide	0.0961	0.1144	19	TM	
20	TM	Methyl t-butyl ether (MtBE)	0.4885	0.4741	3.0	TM	
21	TML	Trans-1,2-DCE	0.1398	0.1336	4.4	TML	2.6
22	TM	Diisopropyl Ether	0.9699	0.9279	4.3	TM	
23	TM**	1,1-DCA	0.3909	0.3847	1.6	TM**	
24	TM	Vinyl Acetate	0.6929	0.6815	1.6	TM	
25	TM	Ethyl tert Butyl Ether	0.6479	0.6384	1.5	TM	
26	TMQ	MEK (2-Butanone)	0.1683	0.1462	13	TMQ	12
27	TM	Cis-1,2-DCE	0.2241	0.2132	4.9	TM	
28	TM	2,2-Dichloropropane	0.2997	0.2817	6.0	TM	
29	TM*	Chloroform	0.3790	0.3747	1.1	TM*	
30	TM	Bromochloromethane	0.0820	0.0840	2.5	TM	
31	S	Dibromofluoromethane(S)	0.2961	0.2892	2.3	S	
32	TM	1,1,1-TCA	0.2734	0.2704	1.1	TM	
33	TM	Cyclohexane	0.2106	0.2148	2.0	TM	
34	TM	1,1-Dichloropropene	0.2073	0.2043	1.4	TM	
35	TM	2,2,4-Trimethylpentane	0.4558	0.4713	3.4	TM	
36	S	1,2-DCA-D4(S)	0.2309	0.2079	9.9	S	
37	TM	Carbon Tetrachloride	0.2163	0.2203	1.8	TM	
38	TM	Tert Amyl Methyl Ether	0.5624	0.5323	5.3	TM	
39	TM	1,2-DCA	0.2083	0.2066	0.84	TM	
40	TM	Benzene	0.7592	0.7548	0.57	TM	
		Average			8.8		

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Second Source Calibration

Lab Name: APPL, Inc.
Case No:
Matrix: 0

SDG No: 67992
Date Analyzed: 06/12/12
Instrument: Sweetpea
Cal. Date: 06/11/12
Data File: 0611S14S.D

		Compound	MEAN	CCRF	%D	%Drift	
41	TM	TCE	0.1909	0.1836	3.8	TM	
42	TM	2-Pentanone	0.1555	0.1556	0.04	TM	
43	TM*	1,2-Dichloropropane	0.2442	0.2318	5.1	TM*	
44	TM	Bromodichloromethane	0.2938	0.2929	0.32	TM	
45	TM	Methyl Cyclohexane	0.2133	0.2153	0.97	TM	
46	TM	Dibromomethane	0.1169	0.1148	1.8	TM	
47	TM	2-Chloroethyl vinyl ether	0.2813	0.2707	3.8	TM	
48	TM	1-Bromo-2-chloroethane	0.2813	0.2707	3.8	TM	
49	TM	Cis-1,3-Dichloropropene	0.3622	0.3285	9.3	TM	
50	TM*	Toluene	0.5126	0.4844	5.5	TM*	
51	TM	Trans-1,3-Dichloropropene	0.2828	0.2615	7.5	TM	
52	TM	1,1,2-TCA	0.1574	0.1488	5.5	TM	
53	I	Chlorobenzene-D5 (IS)	ISTD			I	
54	S	Toluene-D8(S)	1.389	1.269	8.6	S	
55	TM	1,2-EDB	0.2546	0.2410	5.3	TM	
56	TM	Tetrachloroethene	0.2398	0.2237	6.7	TM	
57	TM	1-Chlorohexane	0.5213	0.5037	3.4	TM	
58	TM	1,1,1,2-Tetrachloroethane	0.3647	0.3465	5.0	TM	
59	TM	m&p-Xylene	0.5961	0.5685	4.6	TM	
60	TM	o-Xylene	0.6183	0.5828	5.7	TM	
61	TM	Styrene	1.045	1.009	3.4	TM	
62	S	4-Bromofluorobenzene(S)	0.4954	0.4598	7.2	S	
63	TM	2-Hexanone	0.1977	0.2017	2.0	TM	
64	TM	1,3-Dichloropropane	0.4260	0.4072	4.4	TM	
65	TM	Dibromochloromethane	0.3518	0.3301	6.2	TM	
66	TM**	Chlorobenzene	0.9208	0.8652	6.0	TM**	
67	TM*	Ethylbenzene	1.537	1.427	7.1	TM*	
68	TM**	Bromoform	0.2140	0.1982	7.4	TM**	
69	I	1,4-Dichlorobenzene-D (IS)	ISTD			I	
70	TM	MIBK (methyl isobutyl ketone)	0.6318	0.6219	1.6	TM	
71	TM	Isopropylbenzene	3.121	3.031	2.9	TM	
72	TM**	1,1,2,2-Tetrachloroethane	0.7127	0.6717	5.8	TM**	
73	TM	1,2,3-Trichloropropane	0.1539	0.1485	3.6	TM	
74	TM	t-1,4-Dichloro-2-Butene	0.1711	0.1483	13	TM	
75	TM	Bromobenzene	0.8284	0.7803	5.8	TM	
76	TM	n-Propylbenzene	4.115	3.842	6.6	TM	
77	TM	4-Ethyltoluene	0.8761	0.8020	8.5	TM	
78	TM	2-Chlorotoluene	2.642	2.396	9.3	TM	
79	TM	1,3,5-Trimethylbenzene	2.661	2.509	5.7	TM	
80	TM	4-Chlorotoluene	2.329	2.222	4.6	TM	
		Average			5.2		

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Second Source Calibration

Lab Name: APPL, Inc.
Case No:
Matrix: 0

SDG No: 67992
Date Analyzed: 06/12/12
Instrument: Sweetpea
Cal. Date: 06/11/12
Data File: 0611S14S.D

		Compound	MEAN	CCRF	%D		%Drift
81	TM	Tert-Butylbenzene	2.855	2.758	3.4	TM	
82	TM	1,2,4-Trimethylbenzene	2.628	2.530	3.7	TM	
83	TM	Sec-Butylbenzene	3.922	3.805	3.0	TM	
84	TM	p-Isopropyltoluene	3.121	2.987	4.3	TM	
85	TM	Benzyl Chloride	1.067	0.8592	19	TM	
86	TM	1,3-DCB	1.603	1.474	8.0	TM	
87	TM	1,4-DCB	1.570	1.411	10	TM	
88	TM	n-Butylbenzene	2.920	2.684	8.1	TM	
89	TM	1,2-DCB	1.453	1.341	7.7	TM	
90	TM	Hexachloroethane	0.7608	0.7968	4.7	TM	
91	TM	1,2-Dibromo-3-chloropropane	0.0398	0.0346	13	TM	
92	TM	1,2,4-Trichlorobenzene	0.9457	0.8138	14	TM	
93	TM	Hexachlorobutadiene	0.6192	0.5959	3.8	TM	
94	TM	Naphthalene	2.034	1.854	8.8	TM	
95	TM	1,2,3-Trichlorobenzene	0.9083	0.7820	14	TM	
96							
97							
98							
99							
100							
101							
102							
103							
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113							
114							
115							
116							
117							
118							
119							
120							
		Average			8.4		

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Continuing Calibration

Lab Name: APPL, Inc.   SDG No: 67992
Case No: Date Analyzed: 06/11/12
Matrix: Instrument: Sweetpea
Initial Cal. Date: 06/11/12
Data File: 0611S12S.D

		Compound	MEAN	CCRF	%D	%Drift		
1	I	Fluorobenzene (IS)	ISTD			I		
2	TM	Dichlorodifluoromethane	0.3280	0.3344	1.9	TM		
3	TML	Freon 114	0.0400	0.0526	31	TML	35	nt
4	TM**	Chloromethane	0.2177	0.2104	3.3	TM**		
5	TM*	Vinyl chloride	0.2574	0.2746	6.7	TM*		
6	TML	Bromomethane	0.1571	0.1521	3.2	TML	12	
7	TM	Chloroethane	0.0616	0.0637	3.4	TM		
8	TM	Dichlorofluoromethane	0.4262	0.4415	3.6	TM		
9	TM	Trichlorofluoromethane	0.2068	0.2146	3.8	TM		
10	TM	Acrolein	0.0248	0.0209	16	TM		
11	TML	Acetone	0.0737	0.0488	34	TML	8.0	
12	TM	Freon-113	0.0387	0.0392	1.3	TM		
13	TM*	1,1-DCE	0.1024	0.1127	10	TM*		
14	TM	t-Butanol	0.0165	0.0143	13	TM		
15	TM	Methyl Acetate	0.0000	0.1470	0.00	TM		
16	TMQ	Iodomethane	0.0587	0.0728	24	TMQ	8.7	
17	TMQ	Acrylonitrile	0.0661	0.0627	5.1	TMQ	26	nt
18	TML	Methylene chloride	0.1318	0.0720	45	TML	15	
19	TM	Carbon disulfide	0.0961	0.1308	36	TM		nt
20	TM	Methyl t-butyl ether (MtBE)	0.4885	0.5439	11	TM		
21	TML	Trans-1,2-DCE	0.1398	0.1476	5.6	TML	7.2	
22	TM	Diisopropyl Ether	0.9699	1.039	7.2	TM		
23	TM**	1,1-DCA	0.3909	0.4206	7.6	TM**		
24	TM	Vinyl Acetate	0.6929	0.7776	12	TM		
25	TM	Ethyl tert Butyl Ether	0.6479	0.7106	9.7	TM		
26	TMQ	MEK (2-Butanone)	0.1683	0.1458	13	TMQ	12	
27	TM	Cis-1,2-DCE	0.2241	0.2326	3.8	TM		
28	TM	2,2-Dichloropropane	0.2997	0.3144	4.9	TM		
29	TM*	Chloroform	0.3790	0.4088	7.9	TM*		
30	TM	Bromochloromethane	0.0820	0.0970	18	TM		
31	S	Dibromofluoromethane(S)	0.2961	0.2832	4.4	S		
32	TM	1,1,1-TCA	0.2734	0.3066	12	TM		
33	TM	Cyclohexane	0.2106	0.2345	11	TM		
34	TM	1,1-Dichloropropene	0.2073	0.2276	9.8	TM		
35	TM	2,2,4-Trimethylpentane	0.4558	0.5044	11	TM		
36	S	1,2-DCA-D4(S)	0.2309	0.2133	7.6	S		
37	TM	Carbon Tetrachloride	0.2163	0.2443	13	TM		
38	TM	Tert Amyl Methyl Ether	0.5624	0.5810	3.3	TM		
39	TM	1,2-DCA	0.2083	0.2270	9.0	TM		
40	TM	Benzene	0.7592	0.8217	8.2	TM		
		Average			11.1			

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Continuing Calibration

Lab Name: APPL, Inc. SDG No: 67992
Case No: Date Analyzed: 06/11/12
Matrix: 0 Instrument: Sweetpea
Cal. Date: 06/11/12
Data File: 0611S12S.D

		Compound	MEAN	CCRF	%D		%Drift
41	TM	TCE	0.1909	0.2015	5.6	TM	
42	TM	2-Pentanone	0.1555	0.1340	14	TM	
43	TM*	1,2-Dichloropropane	0.2442	0.2557	4.7	TM*	
44	TM	Bromodichloromethane	0.2938	0.3081	4.9	TM	
45	TM	Methyl Cyclohexane	0.2133	0.2309	8.3	TM	
46	TM	Dibromomethane	0.1169	0.1239	6.0	TM	
47	TM	2-Chloroethyl vinyl ether	0.2813	0.3109	10	TM	
48	TM	1-Bromo-2-chloroethane	0.2813	0.3109	10	TM	
49	TM	Cis-1,3-Dichloropropene	0.3622	0.3816	5.3	TM	
50	TM*	Toluene	0.5126	0.5436	6.0	TM*	
51	TM	Trans-1,3-Dichloropropene	0.2828	0.2950	4.3	TM	
52	TM	1,1,2-TCA	0.1574	0.1692	7.5	TM	
53	I	Chlorobenzene-D5 (IS)	ISTD			I	
54	S	Toluene-D8(S)	1.389	1.277	8.1	S	
55	TM	1,2-EDB	0.2546	0.2867	13	TM	
56	TM	Tetrachloroethene	0.2398	0.2534	5.7	TM	
57	TM	1-Chlorohexane	0.5213	0.5790	11	TM	
58	TM	1,1,1,2-Tetrachloroethane	0.3647	0.4072	12	TM	
59	TM	m&p-Xylene	0.5961	0.6493	8.9	TM	
60	TM	o-Xylene	0.6183	0.6703	8.4	TM	
61	TM	Styrene	1.045	1.157	11	TM	
62	S	4-Bromofluorobenzene(S)	0.4954	0.4834	2.4	S	
63	TM	2-Hexanone	0.1977	0.1881	4.9	TM	
64	TM	1,3-Dichloropropane	0.4260	0.4724	11	TM	
65	TM	Dibromochloromethane	0.3518	0.3907	11	TM	
66	TM**	Chlorobenzene	0.9208	0.9998	8.6	TM**	
67	TM*	Ethylbenzene	1.537	1.695	10	TM*	
68	TM**	Bromoform	0.2140	0.2334	9.0	TM**	
69	I	1,4-Dichlorobenzene-D (IS)	ISTD			I	
70	TM	MIBK (methyl isobutyl ketone)	0.6318	0.5796	8.3	TM	
71	TM	Isopropylbenzene	3.121	3.193	2.3	TM	
72	TM**	1,1,2,2-Tetrachloroethane	0.7127	0.7455	4.6	TM**	
73	TM	1,2,3-Trichloropropane	0.1539	0.1667	8.3	TM	
74	TM	t-1,4-Dichloro-2-Butene	0.1711	0.1656	3.2	TM	
75	TM	Bromobenzene	0.8284	0.8744	5.5	TM	
76	TM	n-Propylbenzene	4.115	4.387	6.6	TM	
77	TM	4-Ethyltoluene	0.8761	0.9384	7.1	TM	
78	TM	2-Chlorotoluene	2.642	2.718	2.9	TM	
79	TM	1,3,5-Trimethylbenzene	2.661	2.843	6.8	TM	
80	TM	4-Chlorotoluene	2.329	2.457	5.5	TM	
		Average			7.4		

VOLATILE ORGANIC ANALYSIS BY
EPA METHOD 8260B

Form 7

Continuing Calibration

Lab Name: APPL, Inc.
Case No:
Matrix: 0

SDG No: 67992
Date Analyzed: 06/11/12
Instrument: Sweetpea
Cal. Date: 06/11/12
Data File: 0611S12S.D

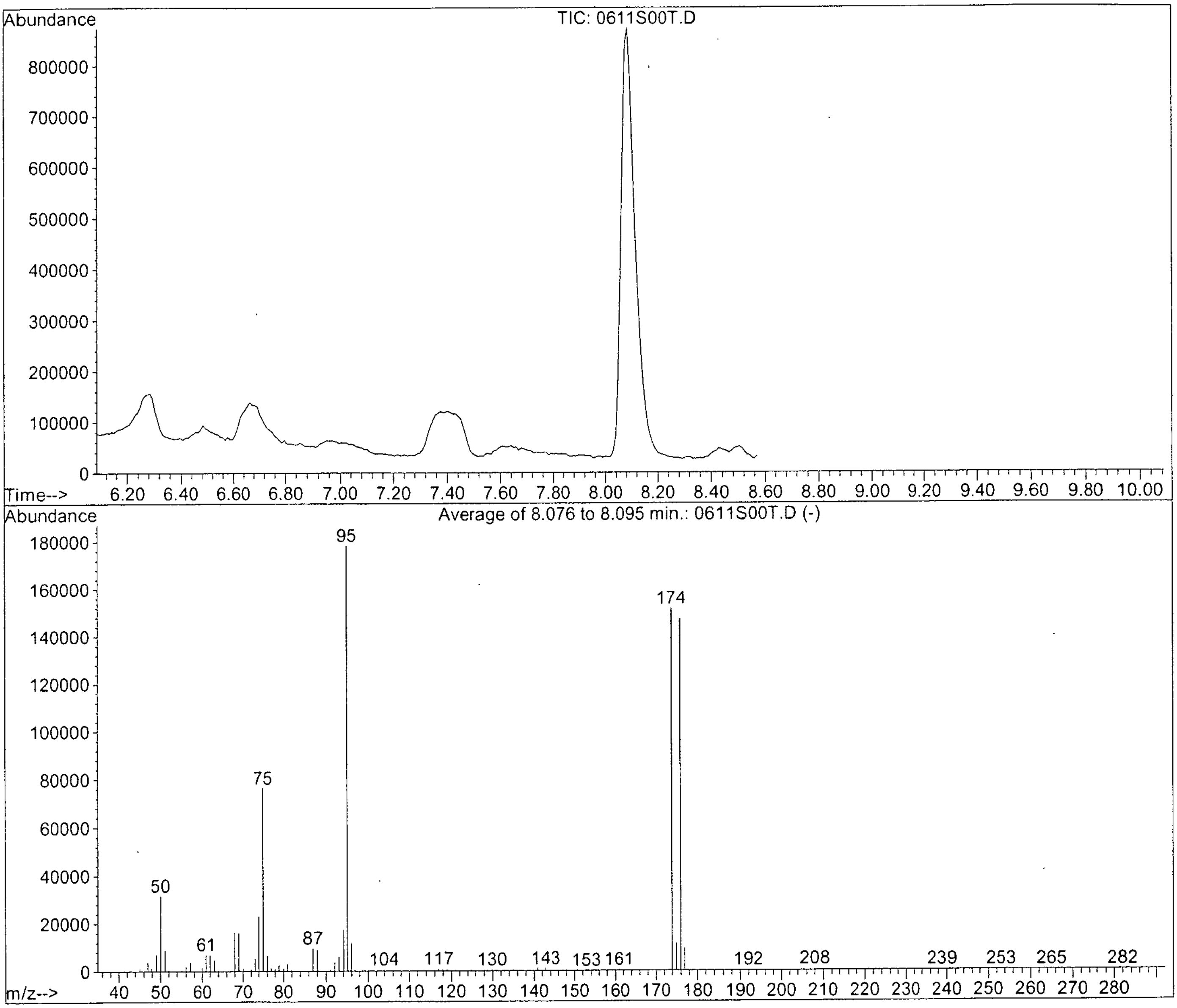
		Compound	MEAN	CCRF	%D		%Drift
81	TM	Tert-Butylbenzene	2.855	3.068	7.5	TM	
82	TM	1,2,4-Trimethylbenzene	2.628	2.804	6.7	TM	
83	TM	Sec-Butylbenzene	3.922	4.207	7.3	TM	
84	TM	p-Isopropyltoluene	3.121	3.348	7.2	TM	
85	TM	Benzyl Chloride	1.067	0.8705	18	TM	
86	TM	1,3-DCB	1.603	1.628	1.6	TM	
87	TM	1,4-DCB	1.570	1.520	3.2	TM	
88	TM	n-Butylbenzene	2.920	2.961	1.4	TM	
89	TM	1,2-DCB	1.453	1.452	0.05	TM	
90	TM	Hexachloroethane	0.7608	0.7269	4.5	TM	
91	TM	1,2-Dibromo-3-chloropropane	0.0398	0.0406	1.8	TM	
92	TM	1,2,4-Trichlorobenzene	0.9457	0.9010	4.7	TM	
93	TM	Hexachlorobutadiene	0.6192	0.6272	1.3	TM	
94	TM	Naphthalene	2.034	2.015	0.89	TM	
95	TM	1,2,3-Trichlorobenzene	0.9083	0.8754	3.6	TM	
96							
97							
98							
99							
100							
101							
102							
103							
104							
105							
106							
107							
108							
109							
110							
111							
112							
113							
114							
115							
116							
117							
118							
119							
120							
		Average			4.6		

EPA METHOD 8260B
Volatile Organic Compounds
Raw Data

APPL, INC.

```
Data File : M:\SWEETPEA\DATA\S120611\0611S00T.D          Vial: 1
Acq On    : 11 Jun 12  16:12                          Operator: DG,SV,RS
Sample    : 25ug/mL BFB Std 06-11-12                  Inst     : Sweetpea
Misc      :  2uL                                      Multiplr: 1.00

Method    : M:\SWEETPEA\DATA\S120611\SALLS2.M (RTE Integrator)
Title     : METHOD 8260B - SOILS
```



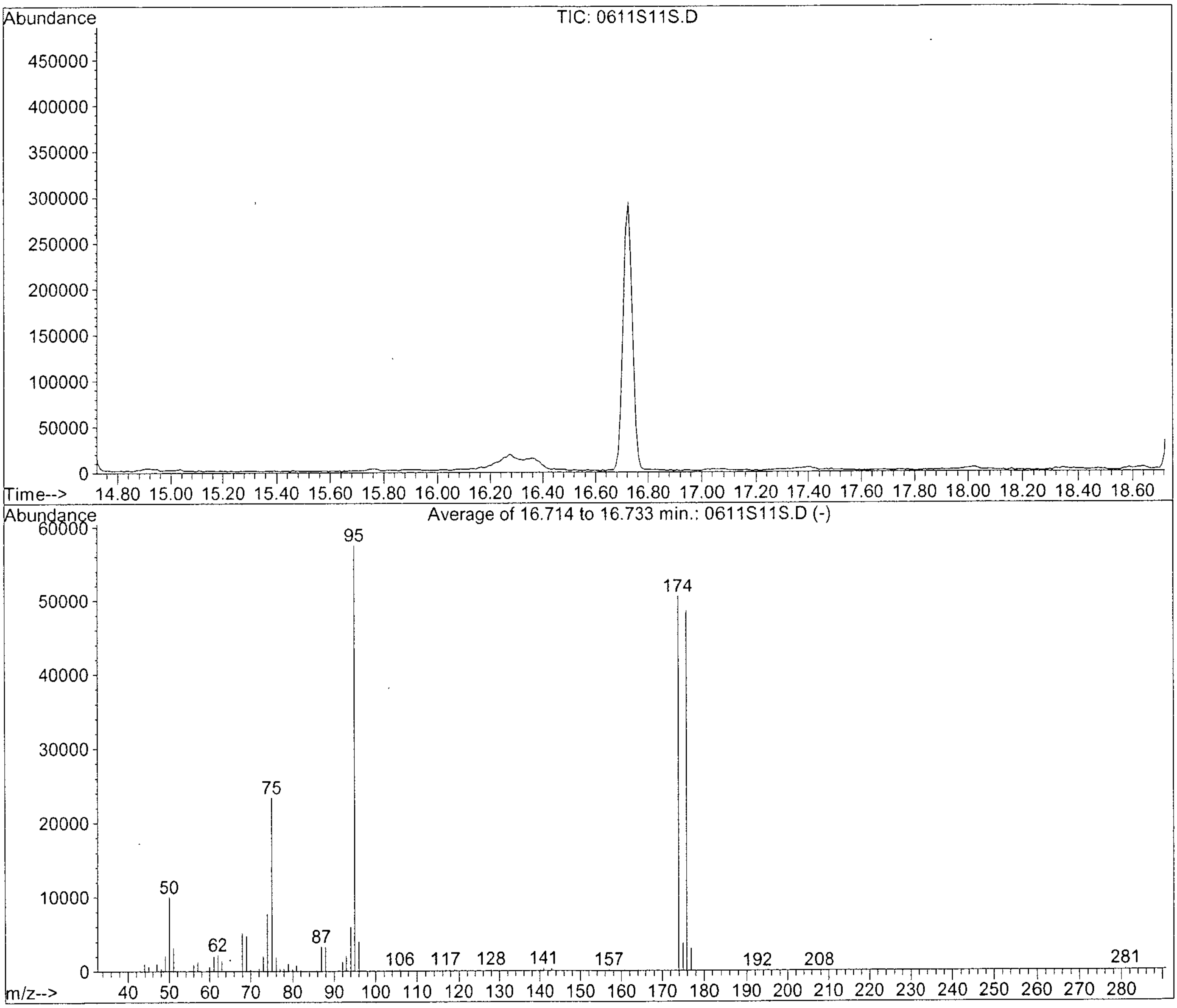
Spectrum Information: Average of 8.076 to 8.095 min.

Target Mass	Rel. to Mass	Lower Limit%	Upper Limit%	Rel. Abn%	Raw Abn	Result Pass/Fail
50	95	15	40	17.8	31651	PASS
75	95	30	60	42.8	76259	PASS
95	95	100	100	100.0	178155	PASS
96	95	5	9	6.8	12070	PASS
173	174	0.00	2	0.0	0	PASS
174	95	50	100	85.0	151488	PASS
175	174	5	9	7.5	11320	PASS
176	174	95	101	97.1	147051	PASS
177	176	5	9	6.3	9300	PASS

BFB

```
Data File : M:\SWEETPEA\DATA\S120611\0611S11S.D          Vial: 11
Acq On    : 11 Jun 12  22:35                          Operator: DG,SV,RS
Sample    : 25ug/mL BFB Std 06-11-12                  Inst     : Sweetpea
Misc      : Soil 5mL w/IS&S:05-21-12                  Multiplr: 1.00

Method    : M:\SWEETPEA\DATA\S120611\SALLS2.M (RTE Integrator)
Title     : METHOD 8260B - SOILS
```



Spectrum Information: Average of 16.714 to 16.733 min.

Target Mass	Rel. to Mass	Lower Limit%	Upper Limit%	Rel. Abn%	Raw Abn	Result Pass/Fail
50	95	15	40	17.4	9995	PASS
75	95	30	60	40.6	23363	PASS
95	95	100	100	100.0	57507	PASS
96	95	5	9	6.8	3938	PASS
173	174	0.00	2	0.0	0	PASS
174	95	50	100	87.9	50539	PASS
175	174	5	9	7.3	3699	PASS
176	174	95	101	96.1	48560	PASS
177	176	5	9	6.1	2949	PASS

Injection Log

Directory: M:\SWEETPEA\DATA\S120611\

Line	Vial	FileName	Multiplier	SampleName	Misc Info	Injected
1	1	0611S00T.D	1	25ug/mL BFB Std 06-11-12	2uL	11 Jun 12 16:12
2	3	0611S03S.D	1	2.0ug/kg Vol Std 06-11-12	Soil 5mL w/IS:05-21-12	11 Jun 12 17:53
3	4	0611S04S.D	1	5.0ug/kg Vol Std 06-11-12	Soil 5mL w/IS:05-21-12	11 Jun 12 18:28
4	5	0611S05S.D	1	10ug/kg Vol Std 06-11-12	Soil 5mL w/IS:05-21-12	11 Jun 12 19:04
5	6	0611S06S.D	1	20ug/kg Vol Std 06-11-12	Soil 5mL w/IS:05-21-12	11 Jun 12 19:39
6	7	0611S07S.D	1	50ug/kg Vol Std 06-11-12	Soil 5mL w/IS:05-21-12	11 Jun 12 20:15
7	8	0611S08S.D	1	100ug/kg Vol Std 06-11-12	Soil 5mL w/IS:05-21-12	11 Jun 12 20:50
8	9	0611S09S.D	1	200ug/kg Vol Std 06-11-12	Soil 5mL w/IS:05-21-12	11 Jun 12 21:25
9	11	0611S11S.D	1	25ug/mL BFB Std 06-11-12	2ul	11 Jun 12 22:35
10	12	0611S12S.D	1	50ug/kg std 6-11-12	Soil 5mL w/IS&S:05-21-12	11 Jun 12 23:10
11	14	0611S14S.D	1	120611A LCS-1SS(SS)	Soil 5mL w/IS&S:05-21-12	12 Jun 12 00:20
12	17	0611S17S.D	1	120611A BLK-1SS	Soil 5mL w/IS&S:05-21-12	12 Jun 12 2:06
13	21	0611S21S.D	0.992654	AY63155S01 5.037	Soil 5mL w/IS&S:05-21-12	12 Jun 12 4:26

METALS

APPL, INC.

METALS
QC Summary

APPL, INC.

AFCEE

INORGANIC ANALYSES DATA SHEET 5

BLANK

Analytical Method: EPA 6010B

Lab Name: APPL, Inc

Concentration Units: mg/kg

Initial Calibration ID: 120611A

AAB #: 120611A-167951

Contract #: *G012

Method Blank ID: 120611A-BLK

Analyte	Method Blank	RL	Q
ARSENIC (AS)	< RL	40.0	U
BARIUM (BA)	< RL	1.0	U
CADMIUM (CD)	< RL	0.50	U
CHROMIUM (CR)	< RL	20.0	U
COPPER (CU)	< RL	2.0	U
LEAD (PB)	< RL	10.0	U
NICKEL (NI)	< RL	2.0	U
ZINC (ZN)	< RL	5.0	U

Comments: ARF: 67992, Sample: AY63155

AFCEE
INORGANIC ANALYSES DATA SHEET 5
BLANK

Analytical Method: EPA 7471B
AAB #: 120611A-167918
Lab Name: APPL, Inc
Contract #: *G012
Concentration Units: mg/kg
Method Blank ID: 120611A-BLK
Initial Calibration ID: 120612A

Analyte	Method Blank	RL	Q
MERCURY (HG)	< RL	0.1	U

Comments: ARF: 67992, Sample: AY63155

AFCEE FORM W-5

AFCEE
INORGANIC ANALYSES DATA SHEET 6
LABORATORY CONTROL SAMPLE

Analytical Method: EPA 6010B
Lab Name: APPL, Inc
LCS ID: 120611A LCS
Concentration Units: mg/kg

AAB #: 120611A-167951
Contract #: *G012
Initial Calibration ID: 120611A

Analyte	Expected	Found	% R	Control Limits	Q
ARSENIC (AS)	25.0	24.3	97.2	75-125	
BARIUM (BA)	25.0	23.8	95.2	75-125	
CADMIUM (CD)	5.00	4.87	97.4	75-125	
CHROMIUM (CR)	25.0	24.9	99.6	75-125	
COPPER (CU)	25.00	26.10	104	75-125	
LEAD (PB)	25.00	25.65	103	75-125	
NICKEL (NI)	25.00	25.44	102	75-125	
ZINC (ZN)	50.0	51.8	104	75-125	

Comments: ARF: 67992, Sample: AY63155

AFCEE
INORGANIC ANALYSES DATA SHEET 6
LABORATORY CONTROL SAMPLE

Analytical Method: EPA 7471B

Lab Name: APPL, Inc

LCS ID: 120611A LCS

Concentration Units: mg/kg

AAB #: 120611A-167918

Contract #: *G012

Initial Calibration ID: 120612A

Analyte	Expected	Found	% R	Control Limits	Q
MERCURY (HG)	0.67	0.71	106	77-120	

Comments: ARF: 67992, Sample: AY63155

AFCEE FORM I-6

METALS
Sample Data

APPL, INC.

AFCEE
INORGANIC ANALYSES DATA SHEET 2
RESULTS

Analytical Method: EPA 6010B   Preparatory Method: 3050B   AAB #: 120611A-167951

Lab Name: APPL, Inc   Contract #: *G012

Field Sample ID: B3-EXW05-WC01   Lab Sample ID: AY63155   Matrix: Soil

% Solids: 98.0   Initial Calibration ID: 120611A

Date Received: 11-Jun-12   Date Prepared: 11-Jun-12   Date Analyzed: 11-Jun-12

Concentration Units: mg/kg

Analyte	MDL	RL	Concentration	Dilution	Qualifier
ARSENIC (AS)	0.2	40.0	2.5	1	F
BARIUM (BA)	0.1	1.0	2.7	1	
CADMIUM (CD)	0.03	0.50	0.03	1	U
CHROMIUM (CR)	0.1	20.0	2.6	1	F
COPPER (CU)	0.19	2.0	24.08	1	
LEAD (PB)	0.18	10.0	0.18	1	U
NICKEL (NI)	0.12	2.0	4.96	1	
ZINC (ZN)	0.6	5.0	32.6	1	

Comments: ARF: 67992

AFCEE
INORGANIC ANALYSES DATA SHEET 2
RESULTS

Analytical Method: EPA 7471B Preparatory Method: 7471B AAB #: 120611A-167918

Lab Name: APPL, Inc Contract #: *G012

Field Sample ID: B3-EXW05-WC01 Lab Sample ID: AY63155 Matrix: Soil

% Solids: 98.0 Initial Calibration ID: 120612A

Date Received: 11-Jun-12 Date Prepared: 11-Jun-12 Date Analyzed: 12-Jun-12

Concentration Units: mg/kg

Analyte	MDL	RL	Concentration	Dilution	Qualifier
MERCURY (HG)	0.01	0.1	0.01	1	U

Comments: ARF: 67992

METALS
Calibration Data

APPL, INC.

A.P.P.L. INC.

2A

INITIAL AND CONTINUING CALIBRATION VERIFICATION

Lab Name: A.P.P.L. INC. Contract: Parsons

ARF No: 67992 SDG: 67992

Initial Calibration Source: CPI

Continuing Calibration Source: Environmental Express

Analysis Date: 06/11/12 Concentration Units: ug/L

Analyte	Initial Calibration			Continuing Calibration						M
	True	Found 12:54	%R(1)	True CCV1	Found 13:18	%R(1)	True CCV1	Found 18:56	%R(1)	
Arsenic (As)	1000	998.1	99.8	1000	982.1	98.2	1000	973.6	97.4	P
Barium (Ba)	1000	986.1	98.6	1000	990.6	99.1	1000	975.3	97.5	P
Cadmium (Cd)	1000	1016	102	1000	1001	100	1000	993.7	99.4	P
Chromium (Cr)	1000	1025	103	1000	997.6	99.8	1000	976.6	97.7	P
Copper (Cu)	1000	1019	102	1000	992	99.2	1000	965.2	96.5	P
Nickel (Ni)	1000	1051	105	1000	1004	100	1000	991.2	99.1	P
Lead (Pb)	1000	1045	105	1000	1005	101	1000	996.9	99.7	P
Zinc (Zn)	1000	1071	107	1000	1014	101	1000	1008	101	P

(1) Control Limits: Metals 90-110 ILM02.0

A.P.P.L. INC.

2A

INITIAL AND CONTINUING CALIBRATION VERIFICATION

Lab Name: A.P.P.L. INC. Contract: Parsons

ARF No: 67992 SDG: 67992

Initial Calibration Source: CPI

Continuing Calibration Source: Environmental Express

Analysis Date: 06/11/12 Concentration Units: ug/L

Analyte	Initial Calibration			Continuing Calibration						M
	True	Found 12:54	%R(1)	True CCV2	Found 19:52	%R(1)	True CCV1	Found 20:49	%R(1)	
Arsenic (As)	1000	998.1	99.8	750	741.5	98.9	1000	995.7	99.6	P
Barium (Ba)	1000	986.1	98.6	750	740.9	98.8	1000	1000	100	P
Cadmium (Cd)	1000	1016	102	750	761.9	102	1000	1037	104	P
Chromium (Cr)	1000	1025	103	750	740.5	98.7	1000	998.4	99.8	P
Copper (Cu)	1000	1019	102	750	725.2	96.7	1000	960.5	96.0	P
Nickel (Ni)	1000	1051	105	750	758.3	101	1000	1024	102	P
Lead (Pb)	1000	1045	105	750	763.8	102	1000	1026	103	P
Zinc (Zn)	1000	1071	107	750	779.3	104	1000	1053	105	P

(1) Control Limits: Metals 90-110

ILM02.0

A.P.P.L. INC.
3
BLANKS

Lab Name: A.P.P.L. INC. Contract: Parsons

ARF No.: 67992 SDG: 67992

Preparation Blank Matrix (soil/water): soil

Preparation Blank Concentration Units (ug/L or mg/kg): mg/kg

Analysis Date: 06/11/12

Analyte	Initial Calibration Blank (ug/L)	C	Continuing Calibration Blank (ug/L) 1	C	2	C	3	C	Preparation Blank	C	M
	13:01		13:23		19:01		19:55		19:05		
Arsenic (As)	1.34	J	3.01	J	2.32	J	400.00	U	.14	J	P
Barium (Ba)	10.00	U	10.00	U	10.00	U	10.00	U	1.00	U	P
Cadmium (Cd)	5.00	U	5.00	U	5.00	U	5.00	U	.03	J	P
Chromium (Cr)	200.00	U	200.00	U	200.00	U	200.00	U	20.00	U	P
Copper (Cu)	2.24	J	2.14	J	20.00	U	20.00	U	1.07	J	P
Nickel (Ni)	20.00	U	20.00	U	20.00	U	20.00	U	2.00	U	P
Lead (Pb)	2.06	J	2.99	J	3.32	J	1.47	J	.49	J	P
Zinc (Zn)	50.00	U	50.00	U	50.00	U	50.00	U	5.00	U	P

A.P.P.L. INC.
3
BLANKS

Lab Name: A.P.P.L. INC. Contract: Parsons

ARF No.: 67992 SDG: 67992

Preparation Blank Matrix (soil/water): soil

Preparation Blank Concentration Units (ug/L or mg/kg): mg/kg

Analysis Date: 06/11/12

Analyte	Initial Calibration Blank (ug/L)	C	Continuing Calibration Blank (ug/L) 1	C	2	C	3	C	Preparation Blank	C	M
	13:01		20:54						19:05		
Arsenic (As)	1.34	J	400.00	U					.14	J	P
Barium (Ba)	10.00	U	10.00	U					1.00	U	P
Cadmium (Cd)	5.00	U	5.00	U					.03	J	P
Chromium (Cr)	200.00	U	200.00	U					20.00	U	P
Copper (Cu)	2.24	J	20.00	U					1.07	J	P
Nickel (Ni)	20.00	U	.95	J					2.00	U	P
Lead (Pb)	2.06	J	3.23	J					.49	J	P
Zinc (Zn)	50.00	U	50.00	U					5.00	U	P

ICP INTERFERENCE CHECK SAMPLE

Lab Name: A.P.P.L. INC. Contract: Parsons

ARF No.: 67992 SDG: 67992

ICP ID Number: Phoebe ICS Source: Environmental Express

Analysis Date: 06/11/12 Concentration Units: ug/L

Analyte	True		Initial Found		
	Sol A	Sol AB	Sol A 13:10	Sol AB 13:14	%R(1)
Aluminum (Al)	200000	200000	197000	196400	98.2
Arsenic (As)		500	2.323	472.9	94.6
Barium (Ba)		500	2.839	486.2	97.2
Calcium (Ca)	200000	200000	201500	201100	101
Cadmium (Cd)		1000	0.511	974.4	97.4
Chromium (Cr)		500	0.767	495.9	99.2
Copper (Cu)		500	ND	508.7	102
Iron (Fe)	200000	200000	186900	186400	93.2
Magnesium (Mg)	200000	200000	199300	199400	99.7
Nickel (Ni)		1000	ND	988.3	98.8
Lead (Pb)		1000	ND	1010	101
Zinc (Zn)		1000	7.558	1005	101

(1) Control Limits: Metals 80-120

A.P.P.L. INC.

9

ICP SERIAL DILUTION

CLIENT SAMPLE NO.

B3-EXW05-WC01

Lab Name: A.P.P.L. INC.

Contract: Parsons

ARF No.: 67992

SDG: 67992

Matrix: soil

Analysis Date: 06/11/12

Concentration Units: mg/kg

Analyte	Initial Sample Result (I)	C	Serial Dilution Result (S)	C	%D	Q	M
Copper (Cu)	23.6		20.9		11.4		M
Zinc (Zn)	31.93		36.48		14.2		M

Comments:

06/11/12 19:40 AY63155S02

06/11/12 20:20 AY63155S02-1/5

A.P.P.L. INC.

5B

POST DIGEST SPIKE SAMPLE RECOVERY

CLIENT SAMPLE NO.

B3-EXW05-WC01

Lab Name: A.P.P.L. INC. Contract: Parsons

ARF No.: 67992 SDG: 67992

Analysis Date: 06/11/12 Concentration Units: mg/kg

Analyte	Control Limit %R	Spiked Sample Result (SSR)	C	Sample Result (SR)	C	Spike Added (SA)	%R	Q	M
Arsenic (As)	75-125	49.56		2.437		49.020	96.1		
Barium (Ba)	75-125	45.35		2.677		49.020	87.0		
Cadmium (Cd)	75-125	8.57		ND		9.804	87.4		
Chromium (Cr)	75-125	46.54		2.521		49.020	89.8		
Copper (Cu)	75-125	69.42		23.6		49.020	93.5		
Nickel (Ni)	75-125	48.39		4.864		49.020	88.8		
Lead (Pb)	75-125	41.92		ND		49.020	85.5		
Zinc (Zn)	75-125	117.6		31.93		98.039	87.4		

Comments:

06/11/12 19:40 AY63155S02

06/11/12 20:04 AY63155S02-A

Parsons

Hg BY METHOD 7471B

ARF#67992

QCG 120611A-7471GROSS

ANALYSIS DATE: 06/12/12

R=0.99915

NAME	TRUE	RESULT	% RECOVERY
ICV	4.17ppb	4.518	108.3%
ICB	0ppb	0.060	
CCV-1	5.208ppb	5.044	96.9%
CCB-1	0ppb	0.034	
CCV-2	5.208ppb	5.239	100.6%
CCB-2	0ppb	0.016	

METALS
Raw Data

APPL, INC.

Metals Digestion Worksheet

Method Name 3050B Digestion (GROSS UP) **Prep Method** M3050GROSSa **Set** 120611A **Units** mL

Spikes			
Spiked ID 1	LCSW LOT#1036660-30924		
Spiked ID 2	LCSW LOT#1036661-30912		
Spiked ID 3			
Spiked ID 4			
Spiked By	LO	Date:	06/11/12 2:30:00 PM
Witnessed By	NM	Date:	06/11/12 2:30:00 PM

Starting Temp:	95 C
Ending Temp:	95 C
Temperature Type:	Mod Block
Sufficient Vol for Matrix QC:	YES
End Date/Time	06/11/12 17:00

	Sample	Sample Container	Spike Amount	Spike ID	Digested Amount	Final Volume	Start Date/Time	Comments
1	120611A Blk				1.00g	100mL	06/11/12 14:30	equip: Modblock1
2	120611A LCS		1mL	1+2	1.00g	100mL	06/11/12 14:30	equip: Modblock1
3	AY63154	AY63154S02			1.06g	100mL	06/11/12 14:30	equip: Modblock1
4	AY63155	AY63155S02			1.02g	100mL	06/11/12 14:30	equip: Modblock1
5	AY63155 MS	AY63155S02	2mL	1+2	1.02g	100mL	06/11/12 14:30	equip: Modblock1
6	AY63155 MSD	AY63155S02	2mL	1+2	1.02g	100mL	06/11/12 14:30	equip: Modblock1
7	AY63217	AY63217M01			1.00g	100mL	06/11/12 14:30	equip: Modblock1 NOT GROSS UP!!!!!!!!!!!

Solvent and Lot#
1:1 HNO3 NA
HNO3 J.T.B L08023 0210
H2O2 EMD NA
HCL BDH 4111110 0211

Sample COC Transfer	
Sample prep employee Initials	LO
Analyst's initials	EA
Date	6-11-12
Time	17:00
Moved to	Metals

Technician's Initials	
Scanned By	NM
Sample Preparation	NM
Digestion	NM
Bring up to volume	LO
Modified	06/11/12 3:36:07 PM

Reviewed By: EA **Date:** 6-11-12

Mercury Digestion Worksheet

Method Name 7471A Mercury Digestion (GROSS UP **Prep Method** M7471GRO **Set** 120611A **Units** mL

Spikes	
Spiked ID 1	Hg WORKING STANDARD prep 06-11-12
Spiked ID 2	Hg WORKING ICV prep 06-11-12
Spiked ID 3	
Spiked ID 4	
Spiked By	LO Date: 06/11/12 2:30:00 PM
Witnessed By	NM Date: 06/11/12 2:30:00 PM

Starting Temp:	95 C
Ending Temp:	95 C
Temp Type:	Modblock1
End Date/Time	06/11/12 3:15:00 PM

Mercury Calibration

Sample	Spike Amount	Spike ID	Final Volume
0 ppb		1	96 ml
0.2 ppb	0.4 ml	1	96 ml
0.5 ppb	1 ml	1	96 ml
1 ppb	2 ml	1	96 ml
2 ppb	4 ml	1	96 ml
5 ppb	10 ml	1	96 ml
5 ppb	10 ml	1	96 ml
10 ppb	20 ml	1	96 ml
ICV	8 ml	2	96 ml

Start Date/Time of Calibration 06/11/12 14:30

Sufficient Vol for Matrix QC: YES

	Sample	Sample Container	Spike Amount	Spike ID	Digested Amount	Final Volume	Start Date/Time	Comments
1	120611A Blk				0.60g	96mL	06/11/12 14:30	equip: Modblock1
2	120611A LCS		8mL	1	0.60g	96mL	06/11/12 14:30	equip: Modblock1
3	AY63154	AY63154S02			0.64g	96mL	06/11/12 14:30	equip: Modblock1
4	AY63155	AY63155S02			0.61g	96mL	06/11/12 14:30	equip: Modblock1
5	AY63155 MS	AY63155S02	8mL	1	0.61g	96mL	06/11/12 14:30	equip: Modblock1
6	AY63155 MSD	AY63155S02	8mL	1	0.61g	96mL	06/11/12 14:30	equip: Modblock1
7	AY63217	AY63217M01			0.60g	96mL	06/11/12 14:30	equip: Modblock1 NOT GROSS UP!!!!!!!!!!!!!

Solvent and Lot#
AQUAREGIA 06-06-12
KMnO4 05-30-12
DECOLORIZER 06-08-12

Sample COC Transfer	
Sample prep employee Initials	LO
Analyst's initials	EA
Date	6-11-12
Time	15:15
Moved to	Metals

Technician's Initials	
Scanned By	NM
Sample Preparation	NM
Digestion	NM
Bring up to volume	LO
Modified	06/11/12 3:44:42 PM

Reviewed By: EA **Date:** 6-11-12

6010 Injection Log

Directory: K:\ICAP PHOEBE\Backup Excel\

RunID	Injected		Sample Name	Misc Info	FileName	Multiplier
1	11 Jun 2012	12:38	CalBlk 120611EA I:PB O:EA		120611A6010	1.
2	11 Jun 2012	12:42	STD 1 120611EA I:PB O:EA		120611A6010	1.
3	11 Jun 2012	12:46	STD 2 120611EA I:PB O:EA		120611A6010	1.
4	11 Jun 2012	12:49	STD 3 120611EA I:PB O:EA		120611A6010	1.
5	11 Jun 2012	12:54	ICV 120611EA I:PB O:EA		120611A6010	1.
6	11 Jun 2012	13:01	ICB 120611EA I:PB O:EA		120611A6010	1.
8	11 Jun 2012	13:10	ICSA 120611EA I:PB O:EA		120611A6010	1.
9	11 Jun 2012	13:14	ICSAB 120611EA I:PB O:EA		120611A6010	1.
10	11 Jun 2012	13:18	CCV1 120611EA I:PB O:EA		120611A6010	1.
11	11 Jun 2012	13:23	CCB 120611EA I:PB O:EA		120611A6010	1.
81	11 Jun 2012	18:56	CCV1 120611EA I:PB O:EA		120611A6010	1.
82	11 Jun 2012	19:01	CCB 120611EA I:PB O:EA		120611A6010	1.
83	11 Jun 2012	19:05	120611A-3050G-BLK		120611A6010	1.
84	11 Jun 2012	19:09	120611A-3050G-LCS		120611A6010	1.
91	11 Jun 2012	19:40	AY63155S02		120611A6010	1.
93	11 Jun 2012	19:52	CCV2 120611EA I:PB O:EA		120611A6010	1.
94	11 Jun 2012	19:55	CCB 120611EA I:PB O:EA		120611A6010	1.
96	11 Jun 2012	20:04	AY63155S02-A		120611A6010	1.
99	11 Jun 2012	20:20	AY63155S02-1/5		120611A6010	5.
104	11 Jun 2012	20:49	CCV1 120611EA I:PB O:EA		120611A6010	1.
105	11 Jun 2012	20:54	CCB 120611EA I:PB O:EA		120611A6010	1.

Sample_ID	EL	Date	Time	Mean_SA	Units	Batch_ID	Wt	Dilu
Calib Blank	Hg	06/12/12	10:25:03		µg/L			
0.2083 06-11-12 LO	Hg	06/12/12	10:26:16		µg/L			
0.520833	Hg	06/12/12	10:27:29		µg/L			
1.041667	Hg	06/12/12	10:28:42		µg/L			
2.083333	Hg	06/12/12	10:30:44		µg/L			
5.208	Hg	06/12/12	10:32:47		µg/L			
10.417	Hg	06/12/12	10:34:50		µg/L			
ICV 06-11-12 LO	Hg	06/12/12	10:37:26	4.517739	µg/L			
ICB 06-11-12 LO	Hg	06/12/12	10:39:27	0.06046	µg/L			
CCV 06-11-12 LO	Hg	06/12/12	10:40:42	5.044275	µg/L			
CCB 06-11-12 LO	Hg	06/12/12	10:42:45	0.03418	µg/L			
120611A BLK	Hg	06/12/12	10:43:58	0.004042	mg/kg	120611A-7471GROSS	0.6	
120611A LCS	Hg	06/12/12	10:45:11	0.70633	mg/kg	120611A-7471GROSS	0.6	
~~AY63154S02~~	~~Hg~~	~~06/12/12~~	~~10:47:12~~	~~0.009348~~	~~mg/kg~~	~~120611A-7471GROSS~~	~~0.64~~	—
AY63155S02	Hg	06/12/12	10:48:25	0.005964	mg/kg	120611A-7471GROSS	0.61	
~~AY63155S02 MS~~	~~Hg~~	~~06/12/12~~	~~10:49:38~~	~~0.550319~~	~~mg/kg~~	~~120611A-7471GROSS~~	~~0.61~~	—
~~AY63155S02 MSD~~	~~Hg~~	~~06/12/12~~	~~10:51:40~~	~~0.533984~~	~~mg/kg~~	~~120611A-7471GROSS~~	~~0.61~~	—
~~AY63217M01 1/10~~	~~Hg~~	~~06/12/12~~	~~10:53:42~~	~~0.132534~~	~~mg/kg~~	~~120611A-7471GROSS~~	~~0.6~~	~~10~~
CCV 06-11-12 LO	Hg	06/12/12	10:54:56	5.239063	µg/L			
CCB 06-11-12 LO	Hg	06/12/12	10:56:58	0.015816	µg/L			

R=0.99915

APPENDIX G
Equipment Information

Franklin Electric 200 V, 3 Phase, 5 HP Motor

Grundfos Pump Model 40S50-15

Symcom 777 MotorSaver

Endress+Hauser Prowirl 72F Flowmeter

Home > Markets > Water Systems > Products > Motors and Controls > products > Product

Model: 234 307 8602

4-inch Motors - High Thrust

Related Links

- More High Thrust 4-inch Motors
- High Thrust 4-inch Motors Leads

Motor Specifications:

Horsepower:	5
Voltage:	200
Frequency:	60
Phase:	Three-Phase
RPM:	3450
Service Factor:	1.15
Rotation:	CCW Facing Shaft End
Poles:	2
Downward Thrust (lbs):	1500 LBS (6500 N)
Max. Ambient Temp.:	86°F / 30°C
Duty Rating:	Continuous at 0.25 ft/sec flow past motor

Construction Materials:

Construction:	Water Well
Length (inches):	23.2
Shipping Weight (lbs / kg):	56 / 25.4
Carton Size:	6 x 6 x 28
Stator Shell:	301 SS
Stator Ends:	Low Carbon Steel
Shaft Extension:	17-4 SS
Fasteners:	300 Series SS
Seal:	Nitrile Rubber Lip
Seal Cover:	Acetol
Slinger:	Nitrile Rubber
Lead in Motor:	YES
Lead Wire (or Cable):	XLPE*
Lead Potting:	Epoxy
Diaphragm:	Nitrile Rubber
Diaphragm Cover:	Gray Iron
Diaphragm Cup:	316 SS

Diaphragm Spring:	316 SS
Filter:	Delrin & Polyester

400 E. Spring St., Bluffton, IN 46714 U.S.A. Tel: 260.824.2900 Fax: 260.824.2909

SUBMERSIBLE MOTORS

Application • Installation • Maintenance

60 Hz, Single-Phase and Three-Phase Motors

FRANKLIN ELECTRIC

2011 AIM MANUAL

System Solutions

Franklin Electric

ATTENTION!
IMPORTANT INFORMATION FOR INSTALLERS OF THIS EQUIPMENT!

THIS EQUIPMENT IS INTENDED FOR INSTALLATION BY TECHNICALLY QUALIFIED PERSONNEL. FAILURE TO INSTALL IT IN COMPLIANCE WITH NATIONAL AND LOCAL ELECTRICAL CODES, AND WITHIN FRANKLIN ELECTRIC RECOMMENDATIONS, MAY RESULT IN ELECTRICAL SHOCK OR FIRE HAZARD, UNSATISFACTORY PERFORMANCE, AND EQUIPMENT FAILURE. FRANKLIN INSTALLATION INFORMATION IS AVAILABLE FROM PUMP MANUFACTURERS AND DISTRIBUTORS, AND DIRECTLY FROM FRANKLIN ELECTRIC. CALL FRANKLIN TOLL FREE 800-348-2420 FOR INFORMATION.

WARNING

SERIOUS OR FATAL ELECTRICAL SHOCK MAY RESULT FROM FAILURE TO CONNECT THE MOTOR, CONTROL ENCLOSURES, METAL PLUMBING, AND ALL OTHER METAL NEAR THE MOTOR OR CABLE, TO THE POWER SUPPLY GROUND TERMINAL USING WIRE NO SMALLER THAN MOTOR CABLE WIRES. TO REDUCE RISK OF ELECTRICAL SHOCK, DISCONNECT POWER BEFORE WORKING ON OR AROUND THE WATER SYSTEM. DO NOT USE MOTOR IN SWIMMING AREAS.

ATTENTION!
INFORMATIONS IMPORTANTES POUR L'INSTALLATEUR DE CET EQUIPEMENT.

CET EQUIPEMENT DOIT ETRE INTALLE PAR UN TECHNICIEN QUALIFIE. SI L'INSTALLATION N'EST PAS CONFORME AUX LOIS NATIONALES OU LOCALES AINSI QU'AUX RECOMMANDATIONS DE FRANKLIN ELECTRIC, UN CHOC ELECTRIQUE, LE FEU, UNE PERFORMANCE NON ACCEPTABLE, VOIRE MEME LE NON-FONCTIONNEMENT PEUVENT SURVENIR. UN GUIDE D'INSTALLATION DE FRANKLIN ELECTRIC EST DISPONIBLE CHEZ LES MANUFACTURIERS DE POMPES, LES DISTRIBUTEURS, OU DIRECTEMENT CHEZ FRANKLIN. POUR DE PLUS AMPLES RENSEIGNEMENTS, APPELEZ SANS FRAIS LE 800-348-2420.

AVERTISSEMENT

UN CHOC ELECTRIQUE SERIEUX OU MEME MORTEL EST POSSIBLE, SI L'ON NEGLIGE DE CONNECTER LE MOTEUR, LA PLOMBERIE METALLIQUE, BOITES DE CONTROLE ET TOUT METAL PROCHE DU MOTEUR A UN CABLE ALLANT VERS UNE ALIMENTATION D'ENERGIE AVEC BORNE DE MISE A LA TERRE UTILISANT AU MOINS LE MEME CALIBRE QUE LES FILS DU MOTEUR. POUR REDUIRE LE RISQUE DE CHOC ELECTRIQUE. COUPER LE COURANT AVANT DE TRAVAILLER PRES OU SUR LE SYSTEM D'EAU. NE PAS UTILISER CE MOTEUR DANS UNE ZONE DE BAIGNADE.

ATENCION!
INFORMACION PARA EL INSTALADOR DE ESTE EQUIPO.

PARA LA INSTALACION DE ESTE EQUIPO, SE REQUIERE DE PERSONAL TECNICO CALIFICADO. EL NO CUMPLIR CON LAS NORMAS ELECTRICAS NACIONALES Y LOCALES, ASI COMO CON LAS RECOMENDACIONES DE FRANKLIN ELECTRIC DURANTE SU INSTALACION, PUEDE OCASIONAR, UN CHOQUE ELECTRICO, PELIGRO DE UN INCENDIO, OPERACION DEFECTUOSA E INCLUSO LA DESCOMPOSTURA DEL EQUIPO. LOS MANUALES DE INSTALACION Y PUESTA EN MARCHA DE LOS EQUIPOS, ESTAN DISPONIBLES CON LOS DISTRIBUIDORES, FABRICANTES DE BOMBAS O DIRECTAMENTE CON FRANKLIN ELECTRIC. PUEDE LLAMAR GRATUITAMENTE PARA MAYOR INFORMACION AL TELEFONO 800-348-2420.

ADVERTENCIA

PUEDE OCURRIR UN CHOQUE ELECTRICO, SERIO O FATAL DEBIDO A UNA ERRONEA CONECCION DEL MOTOR, DE LOS TABLEROS ELECTRICOS, DE LA TUBERIA, DE CUALQUIER OTRA PARTE METALICA QUE ESTA CERCA DEL MOTOR O POR NO UTILIZAR UN CABLE PARA TIERRA DE CALIBRE IGUAL O MAYOR AL DE LA ALIMENTACION. PARA REDUCIR EL RIESGO DE CHOQUE ELECTRIC, DESCONECTAR LA ALIMENTACION ELECTRICA ANTES DE INICIAR A TRABAJAR EN EL SISTEMA HIDRAULICO. NO UTILIZAR ESTE MOTOR EN ALBERCAS O AREAS EN DONDE SE PRACTIQUE NATACION.

Commitment to Quality

Franklin Electric is committed to provide customers with defect free products through our program of continuous improvement. Quality shall, in every case, take precedence over quantity.

Franklin Electric

SUBMERSIBLE MOTORS

60 Hz, Single-Phase and Three-Phase

Application • Installation • Maintenance Manual

The submersible motor is a reliable, efficient and trouble-free means of powering a pump. Its needs for a long operational life are simple. They are:

1. A suitable operating environment
2. An adequate supply of electricity
3. An adequate flow of cooling water over the motor
4. An appropriate pump load

All considerations of application, installation, and maintenance of submersible motors relating to these four areas are presented in this manual. Franklin Electric's web page, www.franklin-electric.com, should be checked for the latest updates.

Contents

Application

All Motors

Single-Phase Motors

Three-Phase Motors

Installation

All Motors

Maintenance

All Motors

Single-Phase Motors and Controls

Electronic Products

Storage

Franklin Electric submersible motors are a water-lubricated design. The fill solution consists of a mixture of deionized water and Propylene Glycol (a non-toxic antifreeze). The solution will prevent damage from freezing in temperatures to -40 °F (-40 °C); motors should be stored in areas that do not go below this temperature. The solution will partially freeze below 27 °F (-3 °C), but no damage occurs. Repeated freezing and thawing should be avoided to prevent possible loss of fill solution.

There may be an interchange of fill solution with well water during operation. Care must be taken with motors removed from wells during freezing conditions to prevent damage.

When the storage temperature does not exceed 100 °F (37 °C), storage time should be limited to two years. Where temperatures reach 100° to 130 °F, storage time should be limited to one year.

Loss of a few drops of liquid will not damage the motor as an excess amount is provided, and the filter check valve will allow lost liquid to be replaced by filtered well water upon installation. If there is reason to believe there has been a considerable amount of leakage, consult the factory for checking procedures.

Frequency of Starts

The average number of starts per day over a period of months or years influences the life of a submersible pumping system. Excessive cycling affects the life of control components such as pressure switches, starters, relays and capacitors. Rapid cycling can also cause motor spline damage, bearing damage, and motor overheating. All these conditions can lead to reduced motor life.

The pump size, tank size and other controls should be selected to keep the starts per day as low as practical for longest life. The maximum number of starts per 24-hour period is shown in table 3.

Motors should run a minimum of one minute to dissipate heat build up from starting current. Six inch and larger motors should have a minimum of 15 minutes between starts or starting attempts.

Table 3 Number of Starts

MOTOR RATING		MAXIMUM STARTS PER 24 HR PERIOD	
HP	KW	SINGLE-PHASE	THREE-PHASE
Up to 0.75	Up to 0.55	300	300
1 thru 5.5	0.75 thru 4	100	300
7.5 thru 30	5.5 thru 22	50	100*
40 and over	30 and over	-	100

* Keeping starts per day within the recommended numbers provides the best system life. However, when used with a properly configured Reduced Voltage Starter (RVS) or Variable Frequency Drive (VFD), 7.5 thru 30 hp three-phase motors can be started up to 200 times per 24 hour period.

Mounting Position

Franklin submersible motors are designed primarily for operation in the vertical, shaft-up position.

During acceleration, the pump thrust increases as its output head increases. In cases where the pump head stays below its normal operating range during startup and full speed condition, the pump may create upward thrust. This creates upward thrust on the motor upthrust bearing. This is an acceptable operation for short periods at each start, but running continuously with upthrust will cause excessive wear on the upthrust bearing.

With certain additional restrictions as listed in this section and the Inline Booster Pump Systems sections of this manual, motors are also suitable for operation in positions from shaft-up to shaft-horizontal. As the mounting position becomes further from vertical and closer to horizontal, the probability of shortened thrust bearing life increases. For normal motor life expectancy with motor positions other than shaft-up, follow these recommendations:

1. Minimize the frequency of starts, preferably to fewer than **10** per 24-hour period. Six and eight inch motors should have a minimum of 20 minutes between starts or starting attempts
2. Do not use in systems which can run even for short periods at full speed without thrust toward the motor.

Transformer Capacity - Single-Phase or Three-Phase

Distribution transformers must be adequately sized to satisfy the kVA requirements of the submersible motor. When transformers are too small to supply the load, there is a reduction in voltage to the motor.

Table 4 references the motor horsepower rating, single-phase and three-phase, total effective kVA required, and the smallest transformer required for open or closed three-phase systems. Open systems require larger transformers since only two transformers are used.

Other loads would add directly to the kVA sizing requirements of the transformer bank.

Table 4 Transformer Capacity

MOTOR RATING		TOTAL EFFECTIVE KVA REQUIRED	SMALLEST KVA RATING-EACH TRANSFORMER	
HP	KW		OPEN WYE OR DELTA 2- TRANSFORMERS	CLOSED WYE OR DELTA 3- TRANSFORMERS
1.5	1.1	3	2	1
2	1.5	4	2	1.5
3	2.2	5	3	2
5	3.7	7.5	5	3
7.5	5.5	10	7.5	5
10	7.5	15	10	5
15	11	20	15	7.5
20	15	25	15	10
25	18.5	30	20	10
30	22	40	25	15
40	30	50	30	20
50	37	60	35	20
60	45	75	40	25
75	55	90	50	30
100	75	120	65	40
125	93	150	85	50
150	110	175	100	60
175	130	200	115	70
200	150	230	130	75

NOTE: Standard kVA ratings are shown. If power company experience and practice allows transformer loading higher than standard, higher loading values may be used to meet total effective kVA required, provided correct voltage and balance is maintained.

Effects of Torque

During starting of a submersible pump, the torque developed by the motor must be supported through the pump, delivery pipe or other supports. Most pumps rotate in the direction which causes unscrewing torque on right-handed threaded pipe or pump stages. All threaded joints, pumps and other parts of the pump support system must be capable of withstanding the maximum torque repeatedly without loosening or breaking. Unscrewing joints will break electrical cable and may cause loss of the pump-motor unit.

To safely withstand maximum unscrewing torques with a minimum safety factor of 1.5, tightening all threaded joints to at least 10 lb-ft per motor horsepower is recommended (table 4A). It may be necessary to tack or strap weld pipe joints on high horsepower pumps, especially at shallower settings.

Table 4A Torque Required (Examples)

MOTOR RATING		MINIMUM SAFE TORQUE-LOAD
HP	KW	
1 hp & Less	0.75 kW & Less	10 lb-ft
20 hp	15 kW	200 lb-ft
75 hp	55 kW	750 lb-ft
200 hp	150 kW	2000 lb-ft

Use of Engine Driven Generators - Single-Phase or Three-Phase

Table 5 lists minimum generator sizes based on typical 80 °C rise continuous duty generators, with 35% maximum voltage dip during starting, for Franklin's three-wire motors, single- or three-phase.

This is a general chart. The generator manufacturer should be consulted whenever possible, especially on larger sizes.

There are two types of generators available: externally and internally regulated. Most are externally regulated. They use an external voltage regulator that senses the output voltage. As the voltage dips at motor start-up, the regulator increases the output voltage of the generator.

Internally regulated (self-excited) generators have an extra winding in the generator stator. The extra winding senses the output current to automatically adjust the output voltage.

Generators must be sized to deliver at least 65% of the rated voltage during starting to ensure adequate starting torque. Besides sizing, generator frequency is important as the motor speed varies with the frequency (Hz). Due to pump affinity laws, a pump running at 1 to 2 Hz below motor nameplate frequency design will not meet its performance curve. Conversely, a pump running at 1 to 2 Hz above may trip overloads.

Generator Operation

Always start the generator before the motor is started and always stop the motor before the generator is shut down. The motor thrust bearing may be damaged if the generator is allowed to coast down with the motor running. This same condition occurs when the generator is allowed to run out of fuel.

Follow generator manufacturer's recommendations for de-rating at higher elevations or using natural gas.

Table 5 Engine Driven Generators

NOTE: This chart applies to 3-wire or 3-phase motors. For best starting of 2-wire motors, the minimum generator rating is 50% higher than shown.

MOTOR RATING		MINIMUM RATING OF GENERATOR			
		EXTERNALLY REGULATED		INTERNALLY REGULATED	
HP	KW	KW	KVA	KW	KVA
1/3	0.25	1.5	1.9	1.2	1.5
1/2	0.37	2	2.5	1.5	1.9
3/4	0.55	3	3.8	2	2.5
1	0.75	4	5.0	2.5	3.13
1.5	1.1	5	6.25	3	3.8
2	1.5	7.5	9.4	4	5
3	2.2	10	12.5	5	6.25
5	3.7	15	18.75	7.5	9.4
7.5	5.5	20	25.0	10	12.5
10	7.5	30	37.5	15	18.75
15	11	40	50	20	25
20	15	60	75	25	31
25	18.5	75	94	30	37.50
30	22	100	125	40	50
40	30	100	125	50	62.5
50	37	150	188	60	75
60	45	175	220	75	94
75	55	250	313	100	125
100	75	300	375	150	188
125	93	375	469	175	219
150	110	450	563	200	250
175	130	525	656	250	313
200	150	600	750	275	344

WARNING: To prevent accidental electrocution, automatic or manual transfer switches must be used any time a generator is used as standby or back up on power lines. Contact power company for use and approval.

Use of Check Valves

It is recommended that one or more check valves always be used in submersible pump installations. If the pump does not have a built-in check valve, a line check valve should be installed in the discharge line within 25 feet of the pump and below the draw down level of the water supply. For deeper settings, check valves should be installed per the manufacturer's recommendations. More than one check valve may be required, but more than the recommended number of check valves should not be used.

Swing type check valves are **not** acceptable and should never be used with submersible motors/pumps. Swing type check valves have a slower reaction time which can cause water hammer (see next page). Internal pump check valves or spring loaded check valves close quickly and help eliminate water hammer.

Check valves are used to hold pressure in the system when the pump stops. They also prevent backspin, water hammer and upthrust. Any of these can lead to early pump or motor failure.

NOTE: Only positive sealing check valves should be used in submersible installations. Although drilling the check valves or using drain-back check valves may prevent back spinning, they create upthrust and water hammer problems.

A. Backspin - With no check valve or a failed check valve, the water in the drop pipe and the water in the system can flow down the discharge pipe when the motor stops. This can cause the pump to rotate in a reverse direction. If the motor is started while it is backspinning, an excessive force is placed across the pump-motor assembly that can cause impeller damage, motor or pump shaft breakage, excessive bearing wear, etc.

B. Upthrust - With no check valve, a leaking check valve, or drilled check valve, the unit starts under a zero head condition. This causes an uplifting or upthrust on the impeller-shaft assembly in the pump. This upward movement carries across the pump-motor coupling and creates an upthrust condition in the motor. Repeated upthrust can cause premature failure of both the pump and the motor.

C. **Water Hammer -** If the lowest check valve is more than 30 feet above the standing (lowest static) water level, or a lower check valve leaks and the check valve above holds, a vacuum is created in the discharge piping. On the next pump start, water moving at very high velocity fills the void and strikes the closed check valve and the stationary water in the pipe above it, causing a hydraulic shock. This shock can split pipes, break joints and damage the pump and/or motor. Water hammer can often be heard or felt. When discovered, the system should be shut down and the pump installer contacted to correct the problem.

Wells – Large Diameter, Uncased, Top Feeding and Screened Sections

Franklin Electric submersible motors are designed to operate with a cooling flow of water over and around the full length of the motor.

If the pump installation does not provide the minimum flow shown in table 6, a flow inducer sleeve (flow sleeve) must be used. The conditions requiring a flow sleeve are:

- Well diameter is too large to meet table 6 flow requirements.
- Pump is in an open body of water.
- Pump is in a rock well or below the well casing.
- The well is “top-feeding” (a.k.a. cascading)
- Pump is set in or below screens or perforations.

Water Temperature and Flow

Franklin Electric’s standard submersible motors, except Hi-Temp designs (see note below), are designed to operate up to maximum service factor horsepower in water up to 86 °F (30 °C). A flow of 0.25 ft/s for 4" motors rated 3 hp and higher, and 0.5 ft/s for 6" and 8" motors is required for proper cooling. Table 6 shows minimum flow rates, in gpm, for various well diameters and motor sizes.

If a standard motor is operated in water over 86 °F (30 °C), water flow past the motor must be increased to maintain safe motor operating temperatures. See HOT WATER APPLICATIONS on page 7.

NOTE: Franklin Electric offers a line of Hi-Temp motors designed to operate in water at higher temperatures or lower flow conditions. Consult factory for details.

Table 6 Required Cooling Flow

MINIMUM GPM REQUIRED FOR MOTOR COOLING IN WATER UP TO 86 °F (30 °C).			
CASING OR SLEEVE ID INCHES (MM)	4" MOTOR (3-10 HP) 0.25 FT/S GPM (L/M)	6" MOTOR 0.50 FT/S GPM (L/M)	8" MOTOR 0.50 FT/S GPM (L/M)
4 (102)	1.2 (4.5)	-	-
5 (127)	7 (26.5)	-	-
6 (152)	13 (49)	9 (34)	-
7 (178)	20 (76)	25 (95)	-
8 (203)	30 (114)	45 (170)	10 (40)
10 (254)	50 (189)	90 (340)	55 (210)
12 (305)	80 (303)	140 (530)	110 (420)
14 (356)	110 (416)	200 (760)	170 (645)
16 (406)	150 (568)	280 (1060)	245 (930)

0.25 ft/s = 7.62 cm/sec 0.50 ft/s = 15.24 cm/sec
1 inch = 2.54 cm

Flow Inducer Sleeve

If the flow rate is less than specified, then a flow inducer sleeve must be used. A flow sleeve is always required in an open body of water. FIG. 1 shows a typical flow inducer sleeve construction.

EXAMPLE: A 6" motor and pump that delivers 60 gpm will be installed in a 10" well.

From table 6, 90 gpm would be required to maintain proper cooling. In this case adding an 8" or smaller flow sleeve provides the required cooling.

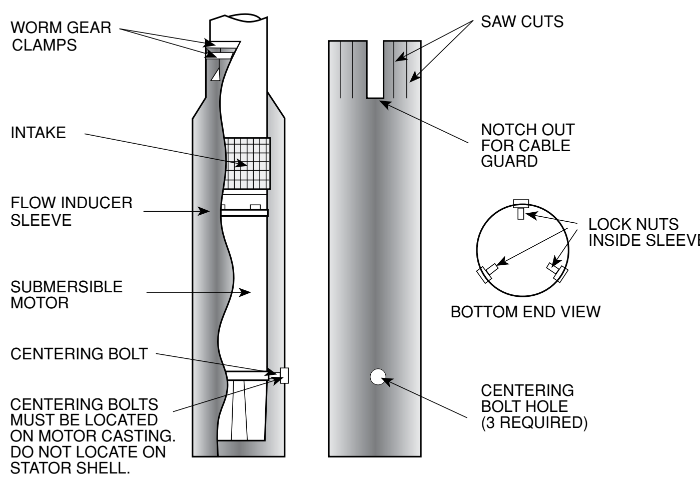


FIG. 1

Head Loss From Flow Past Motor

Table 7 lists the approximate head loss due to flow between an average length motor and smooth casing or flow inducer sleeve.

Table 7 Head Loss in Feet (Meters) at Various Flow Rates

MOTOR DIAMETER	4"	4"	4"	6"	6"	6"	8"	8"
CASING ID IN INCHES (MM)	4 (102)	5 (127)	6 (152)	6 (152)	7 (178)	8 (203)	8.1 (206)	10 (254)
Flow Rate in gpm (l/m)								
25 (95)	0.3 (.09)							
50 (189)	1.2 (.37)							
100 (378)	4.7 (1.4)	0.3 (.09)		1.7 (.52)				
150 (568)	10.2 (3.1)	0.6 (.18)	0.2 (.06)	3.7 (1.1)				
200 (757)		1.1 (.34)	0.4 (.12)	6.3 (1.9)	0.5 (.15)		6.8 (2.1)	
250 (946)		1.8 (.55)	0.7 (.21)	9.6 (2.9)	0.8 (.24)		10.4 (3.2)	
300 (1136)		2.5 (.75)	1.0 (.30)	13.6 (4.1)	1.2 (.37)	0.2 (.06)	14.6 (4.5)	
400 (1514)				23.7 (7.2)	2.0 (.61)	0.4 (.12)	24.6 (7.5)	
500 (1893)					3.1 (.94)	0.7 (.21)	37.3 (11.4)	0.6 (0.2)
600 (2271)					4.4 (1.3)	1.0 (.30)	52.2 (15.9)	0.8 (0.3)
800 (3028)								1.5 (0.5)
1000 (3785)								2.4 (0.7)

Hot Water Applications (Standard Motors)

Franklin Electric offers a line of Hi-Temp motors which are designed to operate in water with various temperatures up to 194 °F (90 °C) without increased flow. When a standard pump-motor operates in water hotter than 86 °F (30 °C), a flow rate of at least 3 ft/s is required. When selecting the motor to drive a pump in over 86 °F (30 °C) water, the motor horsepower must be de-rated per the following procedure.

1. Using table 7A, determine pump gpm required for different well or sleeve diameters. If necessary, add a flow sleeve to obtain at least 3 ft/s flow rate.

Table 7A Minimum gpm (l/m) Required for 3 ft/s (.91 m/sec) Flow Rate

CASING OR SLEEVE ID		4" HIGH THRUST MOTOR		6" MOTOR		8" MOTOR	
INCHES	(MM)	GPM	(L/M)	GPM	(L/M)	GPM	(L/M)
4	(102)	15	(57)				
5	(127)	80	(303)				
6	(152)	160	(606)	52	(197)		
7	(178)			150	(568)		
8	(203)			260	(984)	60	(227)
10	(254)			520	(1970)	330	(1250)
12	(305)					650	(2460)
14	(356)					1020	(3860)
16	(406)					1460	(5530)

Continued on next page

2. Determine pump horsepower required from the pump manufacturer's curve.

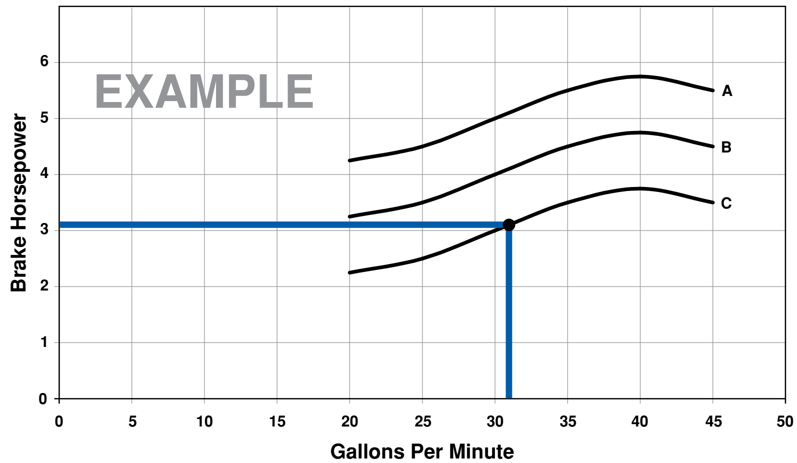


FIG. 2 MANUFACTURER'S PUMP CURVE

3. Multiply the pump horsepower required by the heat factor multiplier from table 8.

Table 8 Heat Factor Multiplier at 3 ft/s (.91 m/sec) Flow Rate

MAXIMUM WATER TEMPERATURE	1/3 - 5 HP .25 - 3.7 KW	7 1/2 - 30 HP 5.5 - 22 KW	OVER 30 HP OVER 22 KW
140 °F (60 °C)	1.25	1.62	2.00
131 °F (55 °C)	1.11	1.32	1.62
122 °F (50 °C)	1.00	1.14	1.32
113 °F (45 °C)	1.00	1.00	1.14
104 °F (40 °C)	1.00	1.00	1.00
95 °F (35 °C)	1.00	1.00	1.00

4. Select a rated hp motor on table 8A whose Service Factor Horsepower is at least the value calculated in Item 3.

Table 8A Service Factor Horsepower

HP	KW	SFHP	HP	KW	SFHP	HP	KW	SFHP	HP	KW	SFHP
1/3	0.25	0.58	3	2.2	3.45	25	18.5	28.75	100	75	115.00
1/2	0.37	0.80	5	3.7	5.75	30	22.0	34.50	125	93	143.75
3/4	0.55	1.12	7.5	5.5	8.62	40	30.0	46.00	150	110	172.50
1	0.75	1.40	10	7.5	11.50	50	37.0	57.50	175	130	201.25
1.5	1.10	1.95	15	11.0	17.25	60	45.0	69.00	200	150	230.00
2	1.50	2.50	20	15.0	23.00	75	55.0	86.25			

Hot Water Applications - Example

EXAMPLE: A 6" pump end requiring 39 hp input will pump 124 °F water in an 8" well at a delivery rate of 140 gpm. From table 7A, a 6" flow sleeve will be required to increase the flow rate to at least 3 ft/s.

Using table 8, the 1.62 heat factor multiplier is selected because the hp required is over 30 hp and water temperature is above 122 °F. Multiply 39 hp x 1.62 (multiplier), which equals 63.2 hp. This is the minimum rated service factor horsepower usable at 39 hp in 124 °F. Using table 8A, select a motor with a rated service factor horsepower above 63.2 hp. A 60 hp motor has a service factor horsepower of 69, so a 60 hp motor may be used.

Drawdown Seals

Allowable motor temperature is based on atmospheric pressure or higher surrounding the motor. "Drawdown seals," which seal the well to the pump above its intake to maximize delivery, are not recommended, since the suction created can be lower than atmospheric pressure.

Grounding Control Boxes and Panels

The National Electrical Code requires that the control box or panel-grounding terminal always be connected to supply ground. If the circuit has no grounding conductor and no metal conduit from the box to supply panel, use a wire at least as large as line conductors and connect as required by the National Electrical Code, from the grounding terminal to the electrical supply ground.

WARNING: Failure to ground the control frame can result in a serious or fatal electrical shock hazard.

Grounding Surge Arrestors

An above ground surge arrestor must be grounded, metal to metal, all the way to the lowest draw down water strata for the surge arrestor to be effective. GROUNDING THE ARRESTOR TO THE SUPPLY GROUND OR TO A DRIVEN GROUND ROD PROVIDES LITTLE OR NO SURGE PROTECTION FOR THE MOTOR.

Control Box, Pumptec Products and Panel Environment

Franklin Electric control boxes, Pumptec products and three-phase panels meet UL requirements for NEMA Type 3R enclosures. They are suitable for indoor and outdoor applications within temperatures of +14 °F (-10 °C) to 122 °F (50 °C). Operating control boxes below +14 °F can cause reduced starting torque and loss of overload protection when overloads are located in control boxes.

Control boxes, Pumptec products and three-phase panels should never be mounted in direct sunlight or high temperature locations. This will cause shortened capacitor life (where applicable) and unnecessary tripping of overload protectors. A ventilated enclosure painted white to reflect heat is recommended for an outdoor, high temperature location.

A damp well pit, or other humid location, accelerates component failure from corrosion.

Control boxes with voltage relays are designed for vertical upright mounting only. Mounting in other positions will affect the operation of the relay.

Equipment Grounding

WARNING: Serious or fatal electrical shock may result from failure to connect the motor, control enclosures, metal plumbing and all other metal near the motor or cable to the power supply ground terminal using wire no smaller than motor cable wires.

The primary purpose of grounding the metal drop pipe and/or metal well casing in an installation is safety. It is done to limit the voltage between nonelectrical (exposed metal) parts of the system and ground, thus minimizing dangerous shock hazards. Using wire at least the size of the motor cable wires provides adequate current-carrying capability for any ground fault that might occur. It also provides a low resistance path to ground, ensuring that the current to ground will be large enough to trip any overcurrent device designed to detect faults (such as a ground fault circuit interrupter, or GFCI).

Normally, the ground wire to the motor would provide the primary path back to the power supply ground for any ground fault. There are conditions, however, where the ground wire connection could become compromised. One such example would be the case where the water in the well is abnormally corrosive or aggressive. In this example, a grounded metal drop pipe or casing would then become the primary path to ground. However, the many installations that now use plastic drop pipes and/or casings require further steps to be taken for safety purposes, so that the water column itself does not become the conductive path to ground.

When an installation has abnormally corrosive water AND the drop pipe or casing is plastic, Franklin Electric recommends the use of a GFCI with a 10 mA set-point. In this case, the motor ground wire should be routed through the current-sensing device along with the motor power leads. Wired this way, the GFCI will trip only when a ground fault has occurred AND the motor ground wire is no longer functional.

3-Wire Control Boxes

Single-phase three-wire submersible motors require the use of control boxes. Operation of motors without control boxes or with incorrect boxes can result in motor failure and voids warranty.

Control boxes contain starting capacitors, a starting relay, and, in some sizes, overload protectors, running capacitors and contactors.

Ratings through 1 hp may use either a Franklin Electric solid state QD or a potential (voltage) type starting relay, while larger ratings use potential relays.

Potential (Voltage) Relays

Potential relays have normally closed contacts. When power is applied, both start and main motor windings are energized, and the motor starts. At this instant, the voltage across the start winding is relatively low and not enough to open the contacts of the relay.

As the motor accelerates, the increasing voltage across the start winding (and the relay coil) opens the relay contacts. This opens the starting circuit and the motor continues to run on the main winding alone, or the main plus run capacitor circuit. After the motor is started the relay contacts remain open.

CAUTION: The control box and motor are two pieces of one assembly. Be certain that the control box and motor hp and voltage match. Since a motor is designed to operate with a control box from the same manufacturer, we can promise warranty coverage only when a Franklin control box is used with a Franklin motor.

2-Wire Motor Solid State Controls

BIAC Switch Operation

When power is applied the bi-metal switch contacts are closed, so the triac is conducting and energizes the start winding. As rpm increases, the voltage in the sensor coil generates heat in the bi-metal strip, causing the bi-metal strip to bend and open the switch circuit. This removes the starting winding and the motor continues to run on the main winding alone.

Approximately 5 seconds after power is removed from the motor, the bi-metal strip cools sufficiently to return to its closed position and the motor is ready for the next start cycle.

Rapid Cycling

The BIAC starting switch will reset within approximately 5 seconds after the motor is stopped. If an attempt is made to restart the motor before the starting switch has reset, the motor may not start; however, there will be current in the main winding until the overload protector interrupts the circuit. The time for the protector to reset is longer than the reset of the starting switch. Therefore, the start switch will have closed and the motor will operate.

CAUTION: Restarting the motor within 5 seconds after power is removed may cause the motor overload to trip.

A waterlogged tank will cause fast cycling. When a waterlogged condition does occur, the user will be alerted to the problem during the off time (overload reset time) since the pressure will drop drastically. When the waterlogged tank condition is detected, the condition should be corrected to prevent nuisance tripping of the overload protector.

Bound Pump (Sandlocked)

When the motor is not free to turn, as with a sandlocked pump, the BIAC switch creates a “reverse impact torque” in the motor in either direction. When the sand is dislodged, the motor will start and operate in the correct direction.

QD Relays (Solid State)

There are two elements in the relay: a reed switch and a triac. The reed switch consists of two tiny rectangular blade-type contacts, which bend under magnetic flux. It is hermetically sealed in glass and is located within a coil, which conducts line current. When power is supplied to the control box, the main winding current passing through the coil immediately closes the reed switch contacts. This turns on the triac, which supplies voltage to the start winding, thus starting the motor.

Once the motor is started, the operation of the QD relay is an interaction between the triac, the reed switch and the motor windings. The solid state switch senses motor speed through the changing phase relationship between start winding current and line current. As the motor approaches running speed, the phase angle between the start current and the line current becomes nearly in phase. At this point, the reed switch contacts open, turning off the triac. This removes voltage from the start winding and the motor continues to run on the main winding only. With the reed switch contacts open and the triac turned off, the QD relay is ready for the next starting cycle.

2- or 3-Wire Cable, 60 Hz (Service Entrance to Motor - Maximum Length In Feet)

Table 11

60 °C

MOTOR RATING			60 °C INSULATION - AWG COPPER WIRE SIZE												
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000
115	1/2	.37	100	160	250	390	620	960	1190	1460	1780	2160	2630	3140	3770
230	1/2	.37	400	650	1020	1610	2510	3880	4810	5880	7170	8720			
	3/4	.55	300	480	760	1200	1870	2890	3580	4370	5330	6470	7870		
	1	.75	250	400	630	990	1540	2380	2960	3610	4410	5360	6520		
	1.5	1.1	190	310	480	770	1200	1870	2320	2850	3500	4280	5240		
	2	1.5	150	250	390	620	970	1530	1910	2360	2930	3620	4480		
	3	2.2	**120**	190	300	470	750	1190	1490	1850	2320	2890	3610		
	5	3.7	0	0	**180**	280	450	710	890	1110	1390	1740	2170	2680	
	7.5	5.5	0	0	0	**200**	310	490	610	750	930	1140	1410	1720	
	10	7.5	0	0	0	0	**250**	390	490	600	750	930	1160	1430	1760
	15	11	0	0	0	0	**170**	**270**	340	430	530	660	820	1020	1260

Table 11A

75 °C

MOTOR RATING			75 °C INSULATION - AWG COPPER WIRE SIZE												
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000
115	1/2	.37	100	160	250	390	620	960	1190	1460	1780	2160	2630	3140	3770
230	1/2	.37	400	650	1020	1610	2510	3880	4810	5880	7170	8720			
	3/4	.55	300	480	760	1200	1870	2890	3580	4370	5330	6470	7870	9380	
	1	.75	250	400	630	990	1540	2380	2960	3610	4410	5360	6520	7780	9350
	1.5	1.1	190	310	480	770	1200	1870	2320	2850	3500	4280	5240	6300	7620
	2	1.5	150	250	390	620	970	1530	1910	2360	2930	3620	4480	5470	6700
	3	2.2	**120**	190	300	470	750	1190	1490	1850	2320	2890	3610	4470	5550
	5	3.7	0	**110**	180	280	450	710	890	1110	1390	1740	2170	2680	3330
	7.5	5.5	0	0	**120**	200	310	490	610	750	930	1140	1410	1720	2100
	10	7.5	0	0	0	**160**	250	390	490	600	750	930	1160	1430	1760
	15	11	0	0	0	0	**170**	270	340	430	530	660	820	1020	1260

1 Foot = .3048 Meter

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors 60 °C or 75 °C in free air or water, not in magnetic enclosures, conduit or direct buried.

Lengths NOT in bold meet the NEC ampacity requirements for either individual conductors or jacketed 60 °C or 75 °C cable and can be in conduit or direct buried. Flat molded and web/ribbon cable are considered jacketed cable.

If any other cable is used, the NEC and local codes should be observed.

Cable lengths in tables 11 & 11A allow for a 5% voltage drop running at maximum nameplate amperes. If 3% voltage drop is desired, multiply table 11 and 11A lengths by 0.6 to get maximum cable length.

The portion of the total cable length, which is between the supply and single-phase control box with a line contactor, should not exceed 25% of total maximum allowable to ensure reliable contactor operation. Single-phase control boxes without line contactors may be connected at any point in the total cable length.

Tables 11 & 11A are based on copper wire. If aluminum wire is used, it must be two sizes larger than copper wire and oxidation inhibitors must be used on connections.

EXAMPLE: If tables 11 & 11A call for #12 copper wire, #10 aluminum wire would be required.

Contact Franklin Electric for 90 °C cable lengths. See pages 15, 49, and 50 for applications using 230 V motors on 208 V power systems.

Two or More Different Cable Sizes Can Be Used

Depending on the installation, any number of combinations of cable may be used.

For example, in a replacement/upgrade installation, the well already has 160 feet of buried #10 cable between the service entrance and the wellhead. A new 3 hp, 230-volt, single-phase motor is being installed to replace a smaller motor. The question is: Since there is already 160 feet of #10 AWG installed, what size cable is required in the well with a 3 hp, 230-volt, single-phase motor setting at 310 feet?

From tables 11 & 11A, a 3 hp motor can use up to 300 feet of #10 AWG cable.

The application has 160 feet of #10 AWG copper wire installed.

Using the formula below, 160 feet (actual) ÷ 300 feet (max allowable) is equal to 0.533. This means 53.3% (0.533 x 100) of the allowable voltage drop or loss, which is allowed between the service entrance and the motor, occurs in this wire. This leaves us 46.7% (1.00 - 0.533 = 0.467) of some other wire size to use in the remaining 310 feet “down hole” wire run.

The table shows #8 AWG copper wire is good for 470 feet. Using the formula again, 310 feet (used) ÷ 470 feet (allowed) = 0.660; adding this to the 0.533 determined earlier; 0.533 + 0.660 = 1.193. This combination is greater than 1.00, so the voltage drop will not meet US National Electrical Code recommendations.

Tables 11 & 11A show #6 AWG copper wire is good for 750 feet. Using the formula, 310 ÷ 750 = 0.413, and using these numbers, 0.533 + 0.413 = 0.946, we find this is less than 1.00 and will meet the NEC recommended voltage drop.

This works for two, three or more combinations of wire and it does not matter which size wire comes first in the installation.

Formula:

$$\frac{\text{Actual Length}}{\text{Max Allowed}} + \frac{\text{Actual Length}}{\text{Max Allowed}} = 1.00$$

EXAMPLE: 3 hp, 230-Volt, Single-Phase Motor

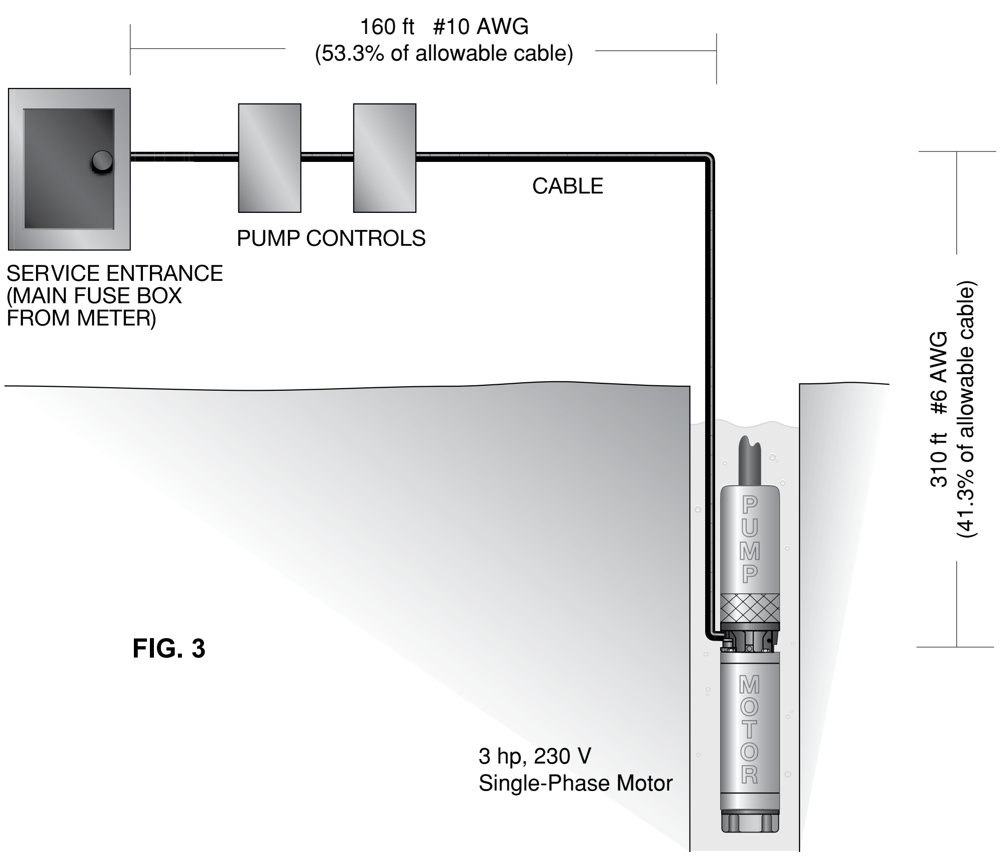


FIG. 3

Table 13 Single-Phase Motor Specifications (60 Hz) 3450 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		WINDING (1) RES. IN OHMS	EFFICIENCY %		POWER FACTOR %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	(2) AMPS	WATTS	(2) AMPS	WATTS	M=MAIN RES. S=START RES.	S.F.	F.L.	S.F.	F.L.		
4" 2-WIRE	244504	1/2	0.37	115	60	1.6	10.0	670	12.0	960	1.0-1.3	62	56	73	58	64.4	R
	244505	1/2	0.37	230	60	1.6	5.0	670	6.0	960	4.2-5.2	62	56	73	58	32.2	R
	244507	3/4	0.55	230	60	1.5	6.8	940	8.0	1310	3.0-3.6	64	59	74	62	40.7	N
	244508	1	0.75	230	60	1.4	8.2	1210	10.4	1600	2.2-2.7	65	62	74	63	48.7	N
	244309	1.5	1.1	230	60	1.3	10.6	1770	13.1	2280	1.5-2.1	64	63	83	76	66.2	M
4" 3-WIRE	214504	1/2	0.37	115	60	1.6	Y10.0 B10.0 R0	670	Y12.0 B12.0 R0	960	M1.0-1.3 S4.1-5.1	62	56	73	58	50.5	M
	214505	1/2	0.37	230	60	1.6	Y5.0 B5.0 R0	670	Y6.0 B6.0 R0	960	M4.2-5.2 S16.7-20.5	62	56	73	58	23	M
	214507	3/4	0.55	230	60	1.5	Y6.8 B6.8 R0	940	Y8.0 B8.0 R0	1310	M3.0-3.6 S10.7-13.1	64	59	74	62	34.2	M
	214508	1	0.75	230	60	1.4	Y8.2 B8.2 R0	1210	10.4 10.4 R0	1600	M2.2-2.7 S9.9-12.1	65	62	74	63	41.8	L
4" 3-WIRE W/CRC CB	214505	1/2	0.37	230	60	1.6	Y3.6 B3.7 R2.0	655	Y4.3 B4.0 R2.0	890	M4.2-5.2 S16.7-20.5	67	57	90	81	23	M
	214507	3/4	0.55	230	60	1.5	Y4.9 B5.0 R3.2	925	Y5.7 B5.2 R3.1	1220	M3.0-3.6 S10.7-13.1	69	60	92	84	34.2	M
	214508	1	0.75	230	60	1.4	Y6.0 B5.7 R3.4	1160	Y7.1 B6.2 R3.3	1490	M2.2-2.7 S9.9-12.1	70	64	92	86	41.8	L
4" 3-WIRE	214508 W/1- 1.5 CB	1	0.75	230	60	1.4	Y6.6 B6.6 R1.3	1130	Y8.0 B7.9 R1.3	1500	M2.2-2.7 S9.9-12.1	70	66	82	72	43	L
	224300	1.5	1.1	230	60	1.3	Y10.0 B9.9 R1.3	1620	Y11.5 B11.0 R1.3	2080	M1.7-2.1 S7.5-9.2	70	69	85	79	51.4	J
	224301	2	1.5	230	60	1.25	Y10.0 B9.3 R2.6	2025	Y13.2 B11.9 R2.6	2555	M1.8-2.3 S5.5-7.2	73	74	95	94	53.1	G
	224302 (3)	3	2.2	230	60	1.15	Y14.0 B11.2 R6.1	3000	Y17.0 B12.6 R6.0	3400	M1.1-1.4 S4.0-4.8	75	75	99	99	83.4	H
	224303 (4)	5	3.7	230	60	1.15	Y23.0 B15.9 R11.0	4830	Y27.5 B19.1 R10.8	5500	M.71-.82 S1.8-2.2	78	77	100	100	129	G
6"	226110 (5)	5	3.7	230	60	1.15	Y23.0 B14.3 R10.8	4910	Y27.5 B17.4 R10.5	5570	M.55-.68 S1.3-1.7	77	76	100	99	99	E
	226111	7.5	5.5	230	60	1.15	Y36.5 B34.4 R5.5	7300	Y42.1 B40.5 R5.4	8800	M.36-.50 S.88-1.1	73	74	91	90	165	F
	226112	10	7.5	230	60	1.15	Y44.0 B39.5 R9.3	9800	Y51.0 B47.5 R8.9	11300	M.27-.33 S.80-.99	76	77	96	96	204	E
	226113	15	11	230	60	1.15	Y62.0 B52.0 R17.5	13900	Y75.0 B62.5 R16.9	16200	M.17-.22 S.68-.93	79	80	97	98	303	E

(1) Main winding - yellow to black
Start winding - yellow to red

(2) Y = Yellow lead - line amps
B = Black lead - main winding amps
R = Red lead - start or auxiliary winding amps

(3) Control Boxes date coded 02C and older have **35 MFD** run capacitors. Current values should be Y14.0 @ FL and Y17.0 @ Max Load.
B12.2 B14.5
R4.7 R4.5

(4) Control Boxes date coded 01M and older have **60 MFD** run capacitors and the current values on a 4" motor will be Y23.0 @ FL - Y27.5 @ Max Load.
B19.1 B23.2
R8.0 R7.8

(5) Control Boxes date coded 01M and older have **60 MFD** run capacitors and the current values on a 6" motor will be Y23.0 @ FL -Y27.5 @ Max Load.
B18.2 B23.2
R8.0 R7.8

Performance is typical, not guaranteed, at specified voltages and specified capacitor values. Performance at voltage ratings not shown is similar, except amps vary inversely with voltage.

Table 14 Single-Phase Motor Fuse Sizing

TYPE	MOTOR MODEL PREFIX	RATING			CIRCUIT BREAKERS OR FUSE AMPS (MAXIMUM PER NEC)			CIRCUIT BREAKERS OR FUSE AMPS (TYPICAL SUBMERSIBLE)		
		HP	KW	VOLTS	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER
4" 2-WIRE	244504	1/2	0.37	115	35	20	30	30	15	30
	244505	1/2	0.37	230	20	10	15	15	8	15
	244507	3/4	0.55	230	25	15	20	20	10	20
	244508	1	0.75	230	30	20	25	25	11	25
	244309	1.5	1.1	230	35	20	30	35	15	30
4" 3-WIRE	214504	1/2	0.37	115	35	20	30	30	15	30
	214505	1/2	0.37	230	20	10	15	15	8	15
	214507	3/4	0.55	230	25	15	20	20	10	20
	214508	1	0.75	230	30	20	25	25	11	25
4" 3-WIRE W/CRC CB	214505	1/2	0.37	230	20	10	15	15	8	15
	214507	3/4	0.55	230	25	15	20	20	10	20
	214508	1	0.75	230	30	20	25	25	11	25
4" 3-WIRE	214508 W/ 1-1.5 CB	1	0.75	230	30	20	25	25	11	25
	224300	1.5	1.1	230	35	20	30	30	15	30
	224301	2	1.5	230	30	20	25	30	15	25
	224302	3	2.2	230	45	30	40	45	20	40
	224303	5	3.7	230	80	45	60	70	30	60
6"	226110	5	3.7	230	80	45	60	70	30	60
	226111	7.5	5.5	230	125	70	100	110	50	100
	226112	10	7.5	230	150	80	125	150	60	125
	226113	15	11	230	200	125	175	200	90	175

Auxiliary Running Capacitors

Added capacitors must be connected across “Red” and “Black” control box terminals, in parallel with any existing running capacitors. The additional capacitor(s) should be mounted in an auxiliary box. The values of additional running capacitors most likely to reduce noise are given below. The tabulation gives the **max.** S.F. amps normally in each lead with the added capacitor.

Although motor amps decrease when auxiliary run capacitance is added, the load on the motor does not. If a motor is overloaded with normal capacitance, it still will be overloaded with auxiliary run capacitance, even though motor amps may be within nameplate values.

Table 15 Auxiliary Capacitor Sizing

MOTOR RATING		NORMAL RUNNING CAPACITOR(S)	AUXILIARY RUNNING CAPACITORS FOR NOISE REDUCTION			MAXIMUM AMPS WITH RUN CAP		
HP	VOLTS	MFD	MFD	MIN. VOLTS	FRANKLIN PART	YELLOW	BLACK	RED
1/2	115	0	60(1)	370	TWO 155327101	8.4	7.0	4.0
1/2	230	0	15(1)	370	ONE 155328101	4.2	3.5	2.0
3/4		0	20(1)	370	ONE 155328103	5.8	5.0	2.5
1		0	25(1)	370	ONE EA. 155328101 155328102	7.1	5.6	3.4
1.5		10	20	370	ONE 155328103	9.3	7.5	4.4
2		20	10	370	ONE 155328102	11.2	9.2	3.8
3		45	NONE	370		17.0	12.6	6.0
5		80	NONE	370		27.5	19.1	10.8
7.5		45	45	370	ONE EA. 155327101 155328101	37.0	32.0	11.3
10		70	30	370	ONE 155327101	49.0	42.0	13.0
15		135	NONE			75.0	62.5	16.9

(1) Do not add running capacitors to 1/3 through 1 hp control boxes, which use solid state switches or QD relays. Adding capacitors will cause switch failure. If the control box is converted to use a voltage relay, the specified running capacitance can be added.

Buck-Boost Transformers

When the available power supply voltage is not within the proper range, a buck-boost transformer is often used to adjust voltage to match the motor. The most common usage on submersible motors is boosting a 208 volt supply to use a standard 230 volt single-phase submersible motor and control. While tables to give a wide range of voltage boost or buck are published by transformer manufacturers, the following table shows Franklin’s recommendations. The table, based on boosting the voltage 10%, shows the minimum rated transformer kVA needed and the common standard transformer kVA.

Table 15A Buck-Boost Transformer Sizing

MOTOR HP	1/3	1/2	3/4	1	1.5	2	3	5	7.5	10	15
LOAD KVA	1.02	1.36	1.84	2.21	2.65	3.04	3.91	6.33	9.66	11.70	16.60
MINIMUM XFMR KVA	0.11	0.14	0.19	0.22	0.27	0.31	0.40	0.64	0.97	1.20	1.70
STANDARD XFMR KVA	0.25	0.25	0.25	0.25	0.50	0.50	0.50	0.75	1.00	1.50	2.00

Buck-Boost transformers are power transformers, not control transformers. They may also be used to lower voltage when the available power supply voltage is too high.

Table 16 Three-Phase 60 °C Cable, 60 Hz (Service Entrance to Motor) Maximum Length in Feet

60 °C

MOTOR RATING			60 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
200 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	710	1140	1800	2840	4420													
	3/4	0.55	510	810	1280	2030	3160													
	1	0.75	430	690	1080	1710	2670	4140	5140											
	1.5	1.1	310	500	790	1260	1960	3050	3780											
	2	1.5	240	390	610	970	1520	2360	2940	3610	4430	5420								
	3	2.2	180	290	470	740	1160	1810	2250	2760	3390	4130								
	5	3.7	**110**	170	280	440	690	1080	1350	1660	2040	2490	3050	3670	4440	5030				
	7.5	5.5	0	0	200	310	490	770	960	1180	1450	1770	2170	2600	3150	3560				
	10	7.5	0	0	0	**230**	370	570	720	880	1090	1330	1640	1970	2390	2720	3100	3480	3800	4420
	15	11	0	0	0	**160**	**250**	390	490	600	740	910	1110	1340	1630	1850	2100	2350	2570	2980
	20	15	0	0	0	0	**190**	**300**	380	460	570	700	860	1050	1270	1440	1650	1850	2020	2360
	25	18.5	0	0	0	0	0	**240**	**300**	**370**	460	570	700	840	1030	1170	1330	1500	1640	1900
	30	22	0	0	0	0	0	0	**250**	**310**	**380**	470	580	700	850	970	1110	1250	1360	1590
230 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	930	1490	2350	3700	5760	8910												
	3/4	0.55	670	1080	1700	2580	4190	6490	8060	9860										
	1	0.75	560	910	1430	2260	3520	5460	6780	8290										
	1.5	1.1	420	670	1060	1670	2610	4050	5030	6160	7530	9170								
	2	1.5	320	510	810	1280	2010	3130	3890	4770	5860	7170	8780							
	3	2.2	240	390	620	990	1540	2400	2980	3660	4480	5470	6690	8020	9680					
	5	3.7	**140**	230	370	590	920	1430	1790	2190	2690	3290	4030	4850	5870	6650	7560	8460	9220	
	7.5	5.5	0	**160**	260	420	650	1020	1270	1560	1920	2340	2870	3440	4160	4710	5340	5970	6500	7510
	10	7.5	0	0	**190**	310	490	760	950	1170	1440	1760	2160	2610	3160	3590	4100	4600	5020	5840
	15	11	0	0	0	**210**	330	520	650	800	980	1200	1470	1780	2150	2440	2780	3110	3400	3940
	20	15	0	0	0	0	**250**	400	500	610	760	930	1140	1380	1680	1910	2180	2450	2680	3120
	25	18.5	0	0	0	0	0	**320**	400	500	610	750	920	1120	1360	1540	1760	1980	2160	2520
	30	22	0	0	0	0	0	**260**	**330**	**410**	510	620	760	930	1130	1280	1470	1650	1800	2110
380 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	2690	4290	6730															
	3/4	0.55	2000	3190	5010	7860														
	1	0.75	1620	2580	4060	6390	9980													
	1.5	1.1	1230	1970	3100	4890	7630													
	2	1.5	870	1390	2180	3450	5400	8380												
	3	2.2	680	1090	1710	2690	4200	6500	8020	9830										
	5	3.7	400	640	1010	1590	2490	3870	4780	5870	7230	8830								
	7.5	5.5	270	440	690	1090	1710	2640	3260	4000	4930	6010	7290	8780						
	10	7.5	**200**	**320**	510	800	1250	1930	2380	2910	3570	4330	5230	6260	7390	8280	9340			
	15	11	0	0	**370**	590	920	1430	1770	2170	2690	3290	4000	4840	5770	6520	7430	8250	8990	
	20	15	0	0	0	**440**	700	1090	1350	1670	2060	2530	3090	3760	4500	5110	5840	6510	7120	8190
	25	18.5	0	0	0	**360**	570	880	1100	1350	1670	2050	2510	3040	3640	4130	4720	5250	5740	6590
	30	22	0	0	0	0	**470**	730	910	1120	1380	1700	2080	2520	3020	3430	3920	4360	4770	5490
	40	30	0	0	0	0	0	**530**	660	820	1010	1240	1520	1840	2200	2500	2850	3170	3470	3990
	50	37	0	0	0	0	0	0	**540**	**660**	820	1000	1220	1480	1770	2010	2290	2550	2780	3190
	60	45	0	0	0	0	0	0	0	**560**	**690**	850	1030	1250	1500	1700	1940	2150	2350	2700
	75	55	0	0	0	0	0	0	0	0	**570**	**700**	**860**	1050	1270	1440	1660	1850	2030	2350
	100	75	0	0	0	0	0	0	0	0	0	**510**	**630**	**760**	910	1030	1180	1310	1430	1650
	125	93	0	0	0	0	0	0	0	0	0	0	0	**620**	**740**	**840**	**950**	1060	1160	1330
	150	110	0	0	0	0	0	0	0	0	0	0	0	0	**620**	**700**	**790**	**880**	**960**	1090
	175	130	0	0	0	0	0	0	0	0	0	0	0	0	0	**650**	**750**	**840**	**920**	1070
	200	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**630**	**700**	**760**	**880**

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See page 11 for additional details.

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Table 17 Three-Phase 60 °C Cable (Continued)

60 °C

MOTOR RATING			60 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
460 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	3770	6020	9460															
	3/4	0.55	2730	4350	6850															
	1	0.75	2300	3670	5770	9070														
	1.5	1.1	1700	2710	4270	6730														
	2	1.5	1300	2070	3270	5150	8050													
	3	2.2	1000	1600	2520	3970	6200													
	5	3.7	590	950	1500	2360	3700	5750												
	7.5	5.5	420	680	1070	1690	2640	4100	5100	6260	7680									
	10	7.5	310	500	790	1250	1960	3050	3800	4680	5750	7050								
	15	11	0	**340**	540	850	1340	2090	2600	3200	3930	4810	5900	7110						
	20	15	0	0	**410**	650	1030	1610	2000	2470	3040	3730	4580	5530						
	25	18.5	0	0	0	**530**	830	1300	1620	1990	2450	3010	3700	4470	5430					
	30	22	0	0	0	**430**	680	1070	1330	1640	2030	2490	3060	3700	4500	5130	5860			
	40	30	0	0	0	0	**500**	790	980	1210	1490	1830	2250	2710	3290	3730	4250			
	50	37	0	0	0	0	0	**640**	800	980	1210	1480	1810	2190	2650	3010	3420	3830	4180	4850
	60	45	0	0	0	0	0	**540**	**670**	**830**	1020	1250	1540	1850	2240	2540	2890	3240	3540	4100
	75	55	0	0	0	0	0	0	0	**680**	**840**	1030	1260	1520	1850	2100	2400	2700	2950	3440
	100	75	0	0	0	0	0	0	0	0	**620**	**760**	**940**	1130	1380	1560	1790	2010	2190	2550
	125	93	0	0	0	0	0	0	0	0	0	0	**740**	**890**	**1000**	1220	1390	1560	1700	1960
	150	110	0	0	0	0	0	0	0	0	0	0	0	**760**	**920**	**1050**	**1190**	1340	1460	1690
	175	130	0	0	0	0	0	0	0	0	0	0	0	0	**810**	**930**	**1060**	**1190**	1300	1510
	200	150	0	0	0	0	0	0	0	0	0	0	0	0	0	**810**	**920**	**1030**	**1130**	1310
575 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	5900	9410																
	3/4	0.55	4270	6810																
	1	0.75	3630	5800	9120															
	1.5	1.1	2620	4180	6580															
	2	1.5	2030	3250	5110	8060														
	3	2.2	1580	2530	3980	6270														
	5	3.7	920	1480	2330	3680	5750													
	7.5	5.5	660	1060	1680	2650	4150													
	10	7.5	490	780	1240	1950	3060	4770	5940											
	15	11	**330**	530	850	1340	2090	3260	4060											
	20	15	0	**410**	650	1030	1610	2520	3140	3860	4760	5830								
	25	18.5	0	0	**520**	830	1300	2030	2530	3110	3840	4710								
	30	22	0	0	**430**	680	1070	1670	2080	2560	3160	3880	4770	5780	7030	8000				
	40	30	0	0	0	**500**	790	1240	1540	1900	2330	2860	3510	4230	5140	5830				
	50	37	0	0	0	0	**640**	1000	1250	1540	1890	2310	2840	3420	4140	4700	5340	5990	6530	7580
	60	45	0	0	0	0	0	**850**	1060	1300	1600	1960	2400	2890	3500	3970	4520	5070	5530	6410
	75	55	0	0	0	0	0	**690**	**860**	**1060**	1310	1600	1970	2380	2890	3290	3750	5220	4610	5370
	100	75	0	0	0	0	0	0	0	**790**	**970**	**1190**	1460	1770	2150	2440	2790	3140	3430	3990
	125	93	0	0	0	0	0	0	0	0	**770**	**950**	**1160**	1400	1690	1920	2180	2440	2650	3070
	150	110	0	0	0	0	0	0	0	0	0	**800**	**990**	**1190**	1440	1630	1860	2080	2270	2640
	175	130	0	0	0	0	0	0	0	0	0	0	**870**	**1050**	**1270**	**1450**	1650	1860	2030	2360
	200	150	0	0	0	0	0	0	0	0	0	0	0	**920**	**1110**	**1260**	**1440**	1620	1760	2050

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See 11 for additional details.

Continued on next page

Table 18 Three-Phase 60 °C Cable (Continued)

60 °C

MOTOR RATING			60 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
200 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	160	250	420	660	1030	1620	2020	2490	3060	3730	4570	5500	6660	7540				
	7.5	5.5	110	180	300	460	730	1150	1440	1770	2170	2650	3250	3900	4720	5340				
	10	7.5	**80**	130	210	340	550	850	1080	1320	1630	1990	2460	2950	3580	4080	4650	5220	5700	6630
	15	11	0	0	**140**	240	370	580	730	900	1110	1360	1660	2010	2440	2770	3150	3520	3850	4470
	20	15	0	0	0	**170**	280	450	570	690	850	1050	1290	1570	1900	2160	2470	2770	3030	3540
	25	18.5	0	0	0	**140**	**220**	360	450	550	690	850	1050	1260	1540	1750	1990	2250	2460	2850
	30	22	0	0	0	0	**180**	294	370	460	570	700	870	1050	1270	1450	1660	1870	2040	2380
230 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	210	340	550	880	1380	2140	2680	3280	4030	4930	6040	7270	8800	9970				
	7.5	5.5	150	240	390	630	970	1530	1900	2340	2880	3510	4300	5160	6240	7060	8010	8950	9750	
	10	7.5	**110**	180	280	460	730	1140	1420	1750	2160	2640	3240	3910	4740	5380	6150	6900	7530	8760
	15	11	0	0	**190**	310	490	780	970	1200	1470	1800	2200	2670	3220	3660	4170	4660	5100	5910
	20	15	0	0	**140**	230	370	600	750	910	1140	1390	1710	2070	2520	2860	3270	3670	4020	4680
	25	18.5	0	0	0	**190**	300	480	600	750	910	1120	1380	1680	2040	2310	2640	2970	3240	3780
	30	22	0	0	0	**150**	**240**	390	490	610	760	930	1140	1390	1690	1920	2200	2470	2700	3160
380 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	600	960	1510	2380	3730	5800	7170	8800										
	7.5	5.5	400	660	1030	1630	2560	3960	4890	6000	7390	9010								
	10	7.5	300	480	760	1200	1870	2890	3570	4360	5350	6490	7840	9390						
	15	11	210	340	550	880	1380	2140	2650	3250	4030	4930	6000	7260	8650	9780				
	20	15	**160**	260	410	660	1050	1630	2020	2500	3090	3790	4630	5640	6750	7660	4260	9760		
	25	18.5	0	**210**	330	540	850	1320	1650	2020	2500	3070	3760	4560	5460	6190	7080	7870	8610	9880
	30	22	0	0	**270**	430	700	1090	1360	1680	2070	2550	3120	3780	4530	5140	5880	6540	7150	8230
	40	30	0	0	0	**320**	510	790	990	1230	1510	1860	2280	2760	3300	3750	4270	4750	5200	5980
	50	37	0	0	0	**250**	**400**	630	810	990	1230	1500	1830	2220	2650	3010	3430	3820	4170	4780
	60	45	0	0	0	0	**340**	540	660	840	1030	1270	1540	1870	2250	2550	2910	3220	3520	4050
	75	55	0	0	0	0	0	**450**	550	690	855	1050	1290	1570	1900	2160	2490	2770	3040	3520
	100	75	0	0	0	0	0	0	**420**	**520**	640	760	940	1140	1360	1540	1770	1960	2140	2470
	125	93	0	0	0	0	0	0	0	**400**	**490**	**600**	730	930	1110	1260	1420	1590	1740	1990
	150	110	0	0	0	0	0	0	0	0	**420**	**510**	**620**	750	930	1050	1180	1320	1440	1630
	175	130	0	0	0	0	0	0	0	0	**360**	**440**	**540**	660	780	970	1120	1260	1380	1600
	200	150	0	0	0	0	0	0	0	0	0	0	**480**	**580**	**690**	790	940	1050	1140	1320
460 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	880	1420	2250	3540	5550	8620												
	7.5	5.5	630	1020	1600	2530	3960	6150	7650	9390										
	10	7.5	460	750	1180	1870	2940	4570	5700	7020	8620									
	15	11	310	510	810	1270	2010	3130	3900	4800	5890	7210	8850							
	20	15	**230**	380	610	970	1540	2410	3000	3700	4560	5590	6870	8290						
	25	18.5	**190**	310	490	790	1240	1950	2430	2980	3670	4510	5550	6700	8140					
	30	22	0	**250**	410	640	1020	1600	1990	2460	3040	3730	4590	5550	6750	7690	8790			
	40	30	0	0	**300**	480	750	1180	1470	1810	2230	2740	3370	4060	4930	5590	6370			
	50	37	0	0	0	**370**	590	960	1200	1470	1810	2220	2710	3280	3970	4510	5130	5740	6270	7270
	60	45	0	0	0	**320**	**500**	810	1000	1240	1530	1870	2310	2770	3360	3810	4330	4860	5310	6150
	75	55	0	0	0	0	**420**	660	810	1020	1260	1540	1890	2280	2770	3150	3600	4050	4420	5160
	100	75	0	0	0	0	0	**500**	**610**	760	930	1140	1410	1690	2070	2340	2680	3010	3280	3820
	125	93	0	0	0	0	0	0	**470**	**590**	**730**	880	1110	1330	1500	1830	2080	2340	2550	2940
	150	110	0	0	0	0	0	0	0	**510**	**630**	**770**	950	1140	1380	1570	1790	2000	2180	2530
	175	130	0	0	0	0	0	0	0	0	**550**	**680**	**830**	1000	1220	1390	1580	1780	1950	2270
	200	150	0	0	0	0	0	0	0	0	0	**590**	**730**	**880**	1070	1210	1380	1550	1690	1970
575 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	1380	2220	3490	5520	8620													
	7.5	5.5	990	1590	2520	3970	6220													
	10	7.5	730	1170	1860	2920	4590	7150	8910											
	15	11	490	790	1270	2010	3130	4890	6090											
	20	15	370	610	970	1540	2410	3780	4710	5790	7140	8740								
	25	18.5	**300**	490	780	1240	1950	3040	3790	4660	5760	7060								
	30	22	**240**	400	645	1020	1600	2500	3120	3840	4740	5820	7150	8670						
	40	30	0	**300**	480	750	1180	1860	2310	2850	3490	4290	5260	6340	7710	8740				
	50	37	0	0	**380**	590	960	1500	1870	2310	2830	3460	4260	5130	6210	7050	8010	8980	9790	
	60	45	0	0	0	**500**	**790**	1270	1590	1950	2400	2940	3600	4330	5250	5950	6780	7600	8290	9610
	75	55	0	0	0	**420**	**660**	1030	1290	1590	1960	2400	2950	3570	4330	4930	5620	6330	6910	8050
	100	75	0	0	0	0	**400**	**780**	960	1180	1450	1780	2190	2650	3220	3660	4180	4710	5140	5980
	125	93	0	0	0	0	0	**600**	**740**	920	1150	1420	1740	2100	2530	2880	3270	3660	3970	4600
	150	110	0	0	0	0	0	0	**650**	**800**	**990**	1210	1480	1780	2160	2450	2790	3120	3410	3950
	175	130	0	0	0	0	0	0	0	**700**	**860**	1060	1300	1570	1910	2170	2480	2780	3040	3540
	200	150	0	0	0	0	0	0	0	0	**760**	**930**	1140	1370	1670	1890	2160	2420	2640	3070

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See page 11 for additional details.

Table 19 Three-Phase 75 °C Cable, 60 Hz (Service Entrance to Motor) Maximum Length in Feet

75 °C

MOTOR RATING			75 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
200 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	710	1140	1800	2840	4420													
	3/4	0.55	510	810	1280	2030	3160													
	1	0.75	430	690	1080	1710	2670	4140	5140											
	1.5	1.1	310	500	790	1260	1960	3050	3780											
	2	1.5	240	390	610	970	1520	2360	2940	3610	4430	5420								
	3	2.2	180	290	470	740	1160	1810	2250	2760	3390	4130								
	5	3.7	**110**	170	280	440	690	1080	1350	1660	2040	2490	3050	3670	4440	5030				
	7.5	5.5	0	0	200	310	490	770	960	1180	1450	1770	2170	2600	3150	3560				
	10	7.5	0	0	**150**	230	370	570	720	880	1090	1330	1640	1970	2390	2720	3100	3480	3800	4420
	15	11	0	0	0	**160**	250	390	490	600	740	910	1110	1340	1630	1850	2100	2350	2570	2980
	20	15	0	0	0	0	**190**	300	380	460	570	700	860	1050	1270	1440	1650	1850	2020	2360
	25	18.5	0	0	0	0	0	**240**	300	370	460	570	700	840	1030	1170	1330	1500	1640	1900
	30	22	0	0	0	0	0	**200**	**250**	310	380	470	580	700	850	970	1110	1250	1360	1590
230 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	930	1490	2350	3700	5760	8910												
	3/4	0.55	670	1080	1700	2580	4190	6490	8060	9860										
	1	0.75	560	910	1430	2260	3520	5460	6780	8290										
	1.5	1.1	420	670	1060	1670	2610	4050	5030	6160	7530	9170								
	2	1.5	320	510	810	1280	2010	3130	3890	4770	5860	7170	8780							
	3	2.2	240	390	620	990	1540	2400	2980	3660	4480	5470	6690	8020	9680					
	5	3.7	**140**	230	370	590	920	1430	1790	2190	2690	3290	4030	4850	5870	6650	7560	8460	9220	
	7.5	5.5	0	**160**	260	420	650	1020	1270	1560	1920	2340	2870	3440	4160	4710	5340	5970	6500	7510
	10	7.5	0	0	**190**	310	490	760	950	1170	1440	1760	2160	2610	3160	3590	4100	4600	5020	5840
	15	11	0	0	0	**210**	330	520	650	800	980	1200	1470	1780	2150	2440	2780	3110	3400	3940
	20	15	0	0	0	**160**	**250**	400	500	610	760	930	1140	1380	1680	1910	2180	2450	2680	3120
	25	18.5	0	0	0	0	**200**	320	400	500	610	750	920	1120	1360	1540	1760	1980	2160	2520
	30	22	0	0	0	0	0	**260**	330	410	510	620	760	930	1130	1280	1470	1650	1800	2110
380 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	2690	4290	6730															
	3/4	0.55	2000	3190	5010	7860														
	1	0.75	1620	2580	4060	6390	9980													
	1.5	1.1	1230	1970	3100	4890	7630													
	2	1.5	870	1390	2180	3450	5400	8380												
	3	2.2	680	1090	1710	2690	4200	6500	8020	9830										
	5	3.7	400	640	1010	1590	2490	3870	4780	5870	7230	8830								
	7.5	5.5	270	440	690	1090	1710	2640	3260	4000	4930	6010	7290	8780						
	10	7.5	**200**	320	510	800	1250	1930	2380	2910	3570	4330	5230	6260	7390	8280	9340			
	15	11	0	0	370	590	920	1430	1770	2170	2690	3290	4000	4840	5770	6520	7430	8250	8990	
	20	15	0	0	**280**	440	700	1090	1350	1670	2060	2530	3090	3760	4500	5110	2840	6510	7120	8190
	25	18.5	0	0	0	**360**	570	880	1100	1350	1670	2050	2510	3040	3640	4130	4720	5250	5740	6590
	30	22	0	0	0	**290**	470	730	910	1120	1380	1700	2080	2520	3020	3430	3920	4360	4770	5490
	40	30	0	0	0	0	0	**530**	660	820	1010	1240	1520	1840	2200	2500	2850	3170	3470	3990
	50	37	0	0	0	0	0	**440**	**540**	660	820	1000	1220	1480	1770	2010	2290	2550	2780	3190
	60	45	0	0	0	0	0	**370**	**460**	**560**	690	850	1030	1250	1500	1700	1940	2150	2350	2700
	75	55	0	0	0	0	0	0	0	**460**	**570**	700	860	1050	1270	1440	1660	1850	2030	2350
	100	75	0	0	0	0	0	0	0	0	**420**	**510**	**630**	760	910	1030	1180	1310	1430	1650
	125	93	0	0	0	0	0	0	0	0	0	0	**510**	**620**	**740**	840	950	1060	1160	1330
	150	110	0	0	0	0	0	0	0	0	0	0	0	**520**	**620**	**700**	**790**	880	960	1090
	175	130	0	0	0	0	0	0	0	0	0	0	0	0	**560**	**650**	**750**	**840**	920	1070
	200	150	0	0	0	0	0	0	0	0	0	0	0	0	0	**550**	**630**	**700**	**760**	880

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See page 11 for additional details.

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Table 20 Three-Phase 75 °C Cable (Continued)

75 °C

MOTOR RATING			75 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
460 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	3770	6020	9460															
	3/4	0.55	2730	4350	6850															
	1	0.75	2300	3670	5770	9070														
	1.5	1.1	1700	2710	4270	6730														
	2	1.5	1300	2070	3270	5150	8050													
	3	2.2	1000	1600	2520	3970	6200													
	5	3.7	590	950	1500	2360	3700	5750												
	7.5	5.5	420	680	1070	1690	2640	4100	5100	6260	7680									
	10	7.5	310	500	790	1250	1960	3050	3800	4680	5750	7050								
	15	11	0	**340**	540	850	1340	2090	2600	3200	3930	4810	5900	7110						
	20	15	0	0	410	650	1030	1610	2000	2470	3040	3730	4580	5530						
	25	18.5	0	0	**330**	530	830	1300	1620	1990	2450	3010	3700	4470	5430					
	30	22	0	0	**270**	430	680	1070	1330	1640	2030	2490	3060	3700	4500	5130	5860			
	40	30	0	0	0	**320**	**500**	790	980	1210	1490	1830	2250	2710	3290	3730	4250			
	50	37	0	0	0	0	**410**	640	800	980	1210	1480	1810	2190	2650	3010	3420	3830	4180	4850
	60	45	0	0	0	0	0	**540**	**670**	830	1020	1250	1540	1850	2240	2540	2890	3240	3540	4100
	75	55	0	0	0	0	0	**440**	**550**	**680**	840	1030	1260	1520	1850	2100	2400	2700	2950	3440
	100	75	0	0	0	0	0	0	0	**500**	**620**	**760**	940	1130	1380	1560	1790	2010	2190	2550
	125	93	0	0	0	0	0	0	0	0	0	**600**	**740**	**890**	1000	1220	1390	1560	1700	1960
	150	110	0	0	0	0	0	0	0	0	0	0	**630**	**760**	**920**	1050	1190	1340	1460	1690
	175	130	0	0	0	0	0	0	0	0	0	0	0	**670**	**810**	**930**	1060	1190	1300	1510
	200	150	0	0	0	0	0	0	0	0	0	0	0	**590**	**710**	**810**	**920**	1030	1130	1310
575 V 60 Hz Three-Phase 3 - Lead	1/2	0.37	5900	9410																
	3/4	0.55	4270	6810																
	1	0.75	3630	5800	9120															
	1.5	1.1	2620	4180	6580															
	2	1.5	2030	3250	5110	8060														
	3	2.2	1580	2530	3980	6270														
	5	3.7	920	1480	2330	3680	5750													
	7.5	5.5	660	1060	1680	2650	4150													
	10	7.5	490	780	1240	1950	3060	4770	5940											
	15	11	**330**	530	850	1340	2090	3260	4060											
	20	15	0	**410**	650	1030	1610	2520	3140	3860	4760	5830								
	25	18.5	0	0	520	830	1300	2030	2530	3110	3840	4710								
	30	22	0	0	**430**	680	1070	1670	2080	2560	3160	3880	4770	5780	7030	8000				
	40	30	0	0	0	**500**	790	1240	1540	1900	2330	2860	3510	4230	5140	5830				
	50	37	0	0	0	**410**	**640**	1000	1250	1540	1890	2310	2840	3420	4140	4700	5340	5990	6530	7580
	60	45	0	0	0	0	**540**	850	1060	1300	1600	1960	2400	2890	3500	3970	4520	5070	5530	6410
	75	55	0	0	0	0	0	**690**	860	1060	1310	1600	1970	2380	2890	3290	3750	5220	4610	5370
	100	75	0	0	0	0	0	0	**640**	**790**	970	1190	1460	1770	2150	2440	2790	3140	3430	3990
	125	93	0	0	0	0	0	0	0	**630**	**770**	**950**	1160	1400	1690	1920	2180	2440	2650	3070
	150	110	0	0	0	0	0	0	0	0	**660**	**800**	**990**	1190	1440	1630	1860	2080	2270	2640
	175	130	0	0	0	0	0	0	0	0	0	**700**	**870**	**1050**	1270	1450	1650	1860	2030	2360
	200	150	0	0	0	0	0	0	0	0	0	0	**760**	**920**	**1110**	1260	1440	1620	1760	2050

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See page 11 for additional details.

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Table 21 Three-Phase 75 °C Cable (Continued)

75 °C

MOTOR RATING			75 °C INSULATION - AWG COPPER WIRE SIZE													MCM COPPER WIRE SIZE				
VOLTS	HP	KW	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
200 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	160	250	420	660	1030	1620	2020	2490	3060	3730	4570	5500	6660	7540				
	7.5	5.5	110	180	300	460	730	1150	1440	1770	2170	2650	3250	3900	4720	5340				
	10	7.5	**80**	130	210	340	550	850	1080	1320	1630	1990	2460	2950	3580	4080	4650	5220	5700	6630
	15	11	0	0	140	240	370	580	730	900	1110	1360	1660	2010	2440	2770	3150	3520	3850	4470
	20	15	0	0	**120**	170	280	450	570	690	850	1050	1290	1570	1900	2160	2470	2770	3030	3540
	25	18.5	0	0	0	**140**	220	360	450	550	690	850	1050	1260	1540	1750	1990	2250	2460	2850
	30	22	0	0	0	**120**	**180**	294	370	460	570	700	870	1050	1270	1450	1660	1870	2040	2380
230 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	210	340	550	880	1380	2140	2680	3280	4030	4930	6040	7270	8800	9970				
	7.5	5.5	150	240	390	630	970	1530	1900	2340	2880	3510	4300	5160	6240	7060	8010	8950	9750	
	10	7.5	**110**	180	280	460	730	1140	1420	1750	2160	2640	3240	3910	4740	5380	6150	6900	7530	8760
	15	11	0	**130**	190	310	490	780	970	1200	1470	1800	2200	2670	3220	3660	4170	4660	5100	5910
	20	15	0	0	**140**	230	370	600	750	910	1140	1390	1710	2070	2520	2860	3270	3670	4020	4680
	25	18.5	0	0	**120**	190	300	480	600	750	910	1120	1380	1680	2040	2310	2640	2970	3240	3780
	30	22	0	0	0	**150**	240	390	490	610	760	930	1140	1390	1690	1920	2200	2470	2700	3160
380 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	600	960	1510	2380	3730	5800	7170	8800										
	7.5	5.5	400	660	1030	1630	2560	3960	4890	6000	7390	9010								
	10	7.5	300	480	760	1200	1870	2890	3570	4360	5350	6490	7840	9390						
	15	11	210	340	550	880	1380	2140	2650	3250	4030	4930	6000	7260	8650	9780				
	20	15	**160**	260	410	660	1050	1630	2020	2500	3090	3790	4630	5640	6750	7660	4260	9760		
	25	18.5	0	**210**	330	540	850	1320	1650	2020	2500	3070	3760	4560	5460	6190	7080	7870	8610	9880
	30	22	0	0	**270**	430	700	1090	1360	1680	2070	2550	3120	3780	4530	5140	5880	6540	7150	8230
	40	30	0	0	**210**	320	510	790	990	1230	1510	1860	2280	2760	3300	3750	4270	4750	5200	5980
	50	37	0	0	0	**250**	400	630	810	990	1230	1500	1830	2220	2650	3010	3430	3820	4170	4780
	60	45	0	0	0	0	**340**	540	660	840	1030	1270	1540	1870	2250	2550	2910	3220	3520	4050
	75	55	0	0	0	0	**290**	450	550	690	855	1050	1290	1570	1900	2160	2490	2770	3040	3520
	100	75	0	0	0	0	0	**340**	**420**	520	640	760	940	1140	1360	1540	1770	1960	2140	2470
	125	93	0	0	0	0	0	0	**340**	**400**	**490**	600	730	930	1110	1260	1420	1590	1740	1990
	150	110	0	0	0	0	0	0	0	**350**	**420**	**510**	620	750	930	1050	1180	1320	1440	1630
	175	130	0	0	0	0	0	0	0	0	**360**	**440**	**540**	660	780	970	1120	1260	1380	1600
	200	150	0	0	0	0	0	0	0	0	0	**410**	**480**	**580**	690	790	940	1050	1140	1320
460 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	880	1420	2250	3540	5550	8620												
	7.5	5.5	630	1020	1600	2530	3960	6150	7650	9390										
	10	7.5	460	750	1180	1870	2940	4570	5700	7020	8620									
	15	11	310	510	810	1270	2010	3130	3900	4800	5890	7210	8850							
	20	15	230	380	610	970	1540	2410	3000	3700	4560	5590	6870	8290						
	25	18.5	**190**	310	490	790	1240	1950	2430	2980	3670	4510	5550	6700	8140					
	30	22	0	**250**	410	640	1020	1600	1990	2460	3040	3730	4590	5550	6750	7690	8790			
	40	30	0	0	**300**	480	750	1180	1470	1810	2230	2740	3370	4060	4930	5590	6370			
	50	37	0	0	**250**	370	590	960	1200	1470	1810	2220	2710	3280	3970	4510	5130	5740	6270	7270
	60	45	0	0	0	**320**	500	810	1000	1240	1530	1870	2310	2770	3360	3810	4330	4860	5310	6150
	75	55	0	0	0	0	**420**	660	810	1020	1260	1540	1890	2280	2770	3150	3600	4050	4420	5160
	100	75	0	0	0	0	**310**	**500**	610	760	930	1140	1410	1690	2070	2340	2680	3010	3280	3820
	125	93	0	0	0	0	0	**390**	**470**	**590**	730	880	1110	1330	1500	1830	2080	2340	2550	2940
	150	110	0	0	0	0	0	0	**420**	**510**	**630**	770	950	1140	1380	1570	1790	2000	2180	2530
	175	130	0	0	0	0	0	0	0	**450**	**550**	**680**	830	1000	1220	1390	1580	1780	1950	2270
	200	150	0	0	0	0	0	0	0	0	**480**	**590**	**730**	880	1070	1210	1380	1550	1690	1970
575 V 60 Hz Three-Phase 6 - Lead Y-D	5	3.7	1380	2220	3490	5520	8620													
	7.5	5.5	990	1590	2520	3970	6220													
	10	7.5	730	1170	1860	2920	4590	7150	8910											
	15	11	490	790	1270	2010	3130	4890	6090											
	20	15	370	610	970	1540	2410	3780	4710	5790	7140	8740								
	25	18.5	**300**	490	780	1240	1950	3040	3790	4660	5760	7060								
	30	22	**240**	400	645	1020	1600	2500	3120	3840	4740	5820	7150	8670						
	40	30	0	**300**	480	750	1180	1860	2310	2850	3490	4290	5260	6340	7710	8740				
	50	37	0	0	**380**	590	960	1500	1870	2310	2830	3460	4260	5130	6210	7050	8010	8980	9790	
	60	45	0	0	**330**	500	790	1270	1590	1950	2400	2940	3600	4330	5250	5950	6780	7600	8290	9610
	75	55	0	0	0	**420**	660	1030	1290	1590	1960	2400	2950	3570	4330	4930	5620	6330	6910	8050
	100	75	0	0	0	0	**400**	780	960	1180	1450	1780	2190	2650	3220	3660	4180	4710	5140	5980
	125	93	0	0	0	0	0	**600**	740	920	1150	1420	1740	2100	2530	2880	3270	3660	3970	4600
	150	110	0	0	0	0	0	**520**	**650**	800	990	1210	1480	1780	2160	2450	2790	3120	3410	3950
	175	130	0	0	0	0	0	0	**570**	**700**	860	1060	1300	1570	1910	2170	2480	2780	3040	3540
	200	150	0	0	0	0	0	0	**500**	**610**	**760**	930	1140	1370	1670	1890	2160	2420	2640	3070

Lengths in **BOLD** only meet the US National Electrical Code ampacity requirements for individual conductors in free air or water. Lengths NOT in bold meet NEC ampacity requirements for either individual conductors or jacketed cable. See page 11 for additional details.

Table 22 Three-Phase Motor Specifications (60 Hz) 3450 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		LINE TO LINE RESISTANCE OHMS	EFFICIENCY %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	AMPS	WATTS	AMPS	WATTS		S.F.	F.L.		
4"	234501	1/2	0.37	200	60	1.6	2.8	585	3.4	860	6.6-8.4	70	64	17.5	N
	234511			230	60	1.6	2.4	585	2.9	860	9.5-10.9	70	64	15.2	N
	234541			380	60	1.6	1.4	585	2.1	860	23.2-28.6	70	64	9.2	N
	234521			460	60	1.6	1.2	585	1.5	860	38.4-44.1	70	64	7.6	N
	234531			575	60	1.6	1.0	585	1.2	860	58.0-71.0	70	64	6.1	N
	234502	3/4	0.55	200	60	1.5	3.6	810	4.4	1150	4.6-5.9	73	69	24.6	N
	234512			230	60	1.5	3.1	810	3.8	1150	6.8-7.8	73	69	21.4	N
	234542			380	60	1.5	1.9	810	2.5	1150	16.6-20.3	73	69	13	N
	234522			460	60	1.5	1.6	810	1.9	1150	27.2-30.9	73	69	10.7	N
	234532			575	60	1.5	1.3	810	1.6	1150	41.5-50.7	73	69	8.6	N
	234503	1	0.75	200	60	1.4	4.5	1070	5.4	1440	3.8-4.5	72	70	30.9	M
	234513			230	60	1.4	3.9	1070	4.7	1440	4.9-5.6	72	70	26.9	M
	234543			380	60	1.4	2.3	1070	2.8	1440	12.2-14.9	72	70	16.3	M
	234523			460	60	1.4	2	1070	2.4	1440	19.9-23.0	72	70	13.5	M
	234533			575	60	1.4	1.6	1070	1.9	1440	30.1-36.7	72	70	10.8	M
	234504	1.5	1.1	200	60	1.3	5.8	1460	6.8	1890	2.5-3.0	76	76	38.2	K
	234514			230	60	1.3	5	1460	5.9	1890	3.2-4.0	76	76	33.2	K
	234544			380	60	1.3	3	1460	3.6	1890	8.5-10.4	76	76	20.1	K
	234524			460	60	1.3	2.5	1460	3.1	1890	13.0-16.0	76	76	16.6	K
	234534			575	60	1.3	2	1460	2.4	1890	20.3-25.0	76	76	13.3	K
	234305	2	1.5	200	60	1.25	7.7	1960	9.3	2430	1.8-2.4	76	76	50.3	K
	234315			230	60	1.25	6.7	1960	8.1	2430	2.3-3.0	76	76	45.0	K
	234345			380	60	1.25	4.1	1960	4.9	2430	6.6-8.2	76	76	26.6	K
	234325			460	60	1.25	3.4	1960	4.1	2430	9.2-12.0	76	76	22.5	K
	234335			575	60	1.25	2.7	1960	3.2	2430	14.6-18.7	76	76	17.8	K
	234306	3	2.2	200	60	1.15	10.9	2920	12.5	3360	1.3-1.7	77	77	69.5	K
	234316			230	60	1.15	9.5	2920	10.9	3360	1.8-2.2	77	77	60.3	K
	234346			380	60	1.15	5.8	2920	6.6	3360	4.7-6.0	77	77	37.5	K
	234326			460	60	1.15	4.8	2920	5.5	3360	7.2-8.8	77	77	31.0	K
	234336			575	60	1.15	3.8	2920	4.4	3360	11.4-13.9	77	77	25.1	K
	234307	5	3.7	200	60	1.15	18.3	4800	20.5	5500	.68-.83	78	78	116	K
	234317			230	60	1.15	15.9	4800	17.8	5500	.91-1.1	78	78	102	K
	234347			380	60	1.15	9.6	4800	10.8	5500	2.6-3.2	78	78	60.2	K
	234327			460	60	1.15	8.0	4800	8.9	5500	3.6-4.4	78	78	53.7	K
	234337			575	60	1.15	6.4	4800	7.1	5500	5.6-6.9	78	78	41.8	K
	234308	7.5	5.5	200	60	1.15	26.5	7150	30.5	8200	.43-.53	78	78	177	K
	234318			230	60	1.15	23.0	7150	26.4	8200	.60-.73	78	78	152	K
	234348			380	60	1.15	13.9	7150	16.0	8200	1.6-2.0	78	78	92.7	K
	234328			460	60	1.15	11.5	7150	13.2	8200	2.3-2.8	78	78	83.8	K
	234338			575	60	1.15	9.2	7150	10.6	8200	3.6-4.5	78	78	64.6	K
	234549	10	7.5	380	60	1.15	19.3	10000	21.0	11400	1.2-1.6	75	75	140	L
	234595			460	60	1.15	15.9	10000	17.3	11400	1.8-2.3	75	75	116.0	L
	234598			575	60	1.15	12.5	10000	13.6	11400	2.8-3.5	75	75	92.8	L

Table 23 Three-Phase Motor Fuse Sizing

TYPE	MOTOR MODEL PREFIX	RATING			CIRCUIT BREAKERS OR FUSE AMPS (MAXIMUM PER NEC)			CIRCUIT BREAKERS OR FUSE AMPS (TYPICAL SUBMERSIBLE)		
		HP	KW	VOLTS	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER
4"	234501	1/2	0.37	200	10	5	8	10	4	15
	234511			230	8	4.5	6	8	4	15
	234541			380	5	2.5	4	5	2	15
	234521			460	4	2.25	3	4	2	15
	234531			575	3	1.8	3	3	1.4	15
	234502	3/4	0.55	200	15	7	10	12	5	15
	234512			230	10	5.6	8	10	5	15
	234542			380	6	3.5	5	6	3	15
	234522			460	5	2.8	4	5	3	15
	234532			575	4	2.5	4	4	1.8	15
	234503	1	0.75	200	15	8	15	15	6	15
	234513			230	15	7	10	12	6	15
	234543			380	8	4.5	8	8	4	15
	234523			460	6	3.5	5	6	3	15
	234533			575	5	2.8	4	5	2.5	15
	234504	1.5	1.1	200	20	12	15	20	8	15
	234514			230	15	9	15	15	8	15
	234544			380	10	5.6	8	10	4	15
	234524			460	8	4.5	8	8	4	15
	234534			575	6	3.5	5	6	3	15
	234305	2	1.5	200	25	15	20	25	11	20
	234315			230	25	12	20	25	10	20
	234345			380	15	8	15	15	6	15
	234325			460	15	6	10	11	5	15
	234335			575	10	5	8	10	4	15
	234306	3	2.2	200	35	20	30	35	15	30
	234316			230	30	17.5	25	30	12	25
	234346			380	20	12	15	20	8	15
	234326			460	15	9	15	15	6	15
	234336			575	15	7	10	11	5	15
	234307	5	3.7	200	60	35	50	60	25	50
	234317			230	50	30	40	45	20	40
	234347			380	30	17.5	25	30	12	25
	234327			460	25	15	20	25	10	20
	234337			575	20	12	20	20	8	20
	234308	7.5	5.5	200	90	50	70	80	35	70
	234318			230	80	45	60	70	30	60
	234348			380	45	25	40	40	20	40
	234328			460	40	25	30	35	15	30
	234338			575	30	17.5	25	30	12	25
	234349	10	7.5	380	70	40	60	60	25	60
	234329			460	60	30	45	50	25	45
	234339			575	45	25	35	40	20	35
	234549			380	70	35	60	60	25	60
	234595			460	60	30	45	50	25	45
	234598			575	45	25	35	40	20	35

Table 24 Three-Phase Motor Specifications (60 Hz) 3450 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		LINE TO LINE RESISTANCE OHMS	EFFICIENCY %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	AMPS	WATTS	AMPS	WATTS		S.F.	F.L.		
6" STD.	236650	5	3.7	200	60	1.15	17.5	4700	20.0	5400	.77-.93	79	79	99	H
	236600			230	60	1.15	15	4700	17.6	5400	1.0-1.2	79	79	86	H
	236660			380	60	1.15	9.1	4700	10.7	5400	2.6-3.2	79	79	52	H
	236610			460	60	1.15	7.5	4700	8.8	5400	3.9-4.8	79	79	43	H
	236620			575	60	1.15	6	4700	7.1	5400	6.3-7.7	79	79	34	H
	236651	7.5	5.5	200	60	1.15	25.1	7000	28.3	8000	.43-.53	80	80	150	H
	236601			230	60	1.15	21.8	7000	24.6	8000	.64-.78	80	80	130	H
	236661			380	60	1.15	13.4	7000	15	8000	1.6-2.1	80	80	79	H
	236611			460	60	1.15	10.9	7000	12.3	8000	2.4-2.9	80	80	65	H
	236621			575	60	1.15	8.7	7000	9.8	8000	3.7-4.6	80	80	52	H
	236652	10	7.5	200	60	1.15	32.7	9400	37	10800	.37-.45	79	79	198	H
	236602			230	60	1.15	28.4	9400	32.2	10800	.47-.57	79	79	172	H
	236662			380	60	1.15	17.6	9400	19.6	10800	1.2-1.5	79	79	104	H
	236612			460	60	1.15	14.2	9400	16.1	10800	1.9-2.4	79	79	86	H
	236622			575	60	1.15	11.4	9400	12.9	10800	3.0-3.7	79	79	69	H
	236653	15	11	200	60	1.15	47.8	13700	54.4	15800	.24-.29	81	81	306	H
	236603			230	60	1.15	41.6	13700	47.4	15800	.28-.35	81	81	266	H
	236663			380	60	1.15	25.8	13700	28.9	15800	.77-.95	81	81	161	H
	236613			460	60	1.15	20.8	13700	23.7	15800	1.1-1.4	81	81	133	H
	236623			575	60	1.15	16.6	13700	19	15800	1.8-2.3	81	81	106	H
	236654	20	15	200	60	1.15	61.9	18100	69.7	20900	.16-.20	82	82	416	J
	236604			230	60	1.15	53.8	18100	60.6	20900	.22-.26	82	82	362	J
	236664			380	60	1.15	33	18100	37.3	20900	.55-.68	82	82	219	J
	236614			460	60	1.15	26.9	18100	30.3	20900	.8-1.0	82	82	181	J
	236624			575	60	1.15	21.5	18100	24.2	20900	1.3-1.6	82	82	145	J
	236655	25	18.5	200	60	1.15	77.1	22500	86.3	25700	.12-.15	83	83	552	J
	236605			230	60	1.15	67	22500	75	25700	.15-.19	83	83	480	J
	236665			380	60	1.15	41	22500	46	25700	.46-.56	83	83	291	J
	236615			460	60	1.15	33.5	22500	37.5	25700	.63-.77	83	83	240	J
	236625			575	60	1.15	26.8	22500	30	25700	1.0-1.3	83	83	192	J
	236656	30	22	200	60	1.15	90.9	26900	104	31100	.09-.11	83	83	653	J
	236606			230	60	1.15	79	26900	90.4	31100	.14-.17	83	83	568	J
	236666			380	60	1.15	48.8	26900	55.4	31100	.35-.43	83	83	317	J
	236616			460	60	1.15	39.5	26900	45.2	31100	.52-.64	83	83	284	J
	236626			575	60	1.15	31.6	26900	36.2	31100	.78-.95	83	83	227	J
	236667	40	30	380	60	1.15	66.5	35600	74.6	42400	.26-.33	83	83	481	J
	236617			460	60	1.15	54.9	35600	61.6	42400	.34-.42	83	83	397	J
	236627			575	60	1.15	42.8	35600	49.6	42400	.52-.64	83	83	318	H
	236668	50	37	380	60	1.15	83.5	45100	95	52200	.21-.25	82	83	501	H
	236618			460	60	1.15	67.7	45100	77	52200	.25-.32	82	83	414	H
	236628			575	60	1.15	54.2	45100	61.6	52200	.40-.49	82	83	331	H
	276668			380	60	1.15	82.4	45100	94.5	52200	.21 - .25	82	83	501	H
	276618			460	60	1.15	68.1	45100	78.1	52200	.25 - .32	82	83	414	H
	276628			575	60	1.15	54.5	45100	62.5	52200	.40 - .49	82	83	331	H
	236669	60	45	380	60	1.15	98.7	53500	111	61700	.15-.18	84	84	627	H
	236619			460	60	1.15	80.5	53500	91	61700	.22-.27	84	84	518	H
	236629			575	60	1.15	64.4	53500	72.8	61700	.35-.39	84	84	414	H
	276669			380	60	1.15	98.1	53500	111.8	61700	.15 - .18	84	84	627	H
	276619			460	60	1.15	81.0	53500	92.3	61700	.22 - .27	84	84	518	H
	276629			575	60	1.15	64.8	53500	73.9	61700	.35 - .39	84	84	414	H

Model numbers above are for three-lead motors. Six-lead motors with different model numbers have the same running performance, but when Wye connected for starting have locked rotor amps 33% of the values shown. Six-lead individual phase resistance = table X 1.5.

Table 25 6" Three-Phase Motor Specifications (60 Hz) 3450 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		LINE TO LINE RESISTANCE OHMS	EFFICIENCY %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	AMPS	WATTS	AMPS	WATTS		S.F.	F.L.		
6" HI-TEMP 90 °C	276650	5	3.7	200	60	1.15	17.2	5200	19.8	5800	.53 - .65	73	72	124	K
	276600			230	60	1.15	15.0	5200	17.2	5800	.68 - .84	73	72	108	K
	276660			380	60	1.15	9.1	5200	10.4	5800	2.0 - 2.4	73	72	66.0	K
	276610			460	60	1.15	7.5	5200	8.6	5800	2.8 - 3.4	73	72	54.0	K
	276620			575	60	1.15	6.0	5200	6.9	5800	4.7 - 5.7	73	72	43.0	K
	276651	7.5	5.5	200	60	1.15	24.8	7400	28.3	8400	.30 - .37	77	76	193	K
	276601			230	60	1.15	21.6	7400	24.6	8400	.41 - .50	77	76	168	K
	276661			380	60	1.15	13.1	7400	14.9	8400	1.1 - 1.4	77	76	102	K
	276611			460	60	1.15	10.8	7400	12.3	8400	1.7 - 2.0	77	76	84.0	K
	276621			575	60	1.15	8.6	7400	9.9	8400	2.6 - 3.2	77	76	67.0	K
	276652	10	7.5	200	60	1.15	32.0	9400	36.3	10700	.21 - .26	80	79	274	L
	276602			230	60	1.15	27.8	9400	31.6	10700	.28 - .35	80	79	238	L
	276662			380	60	1.15	16.8	9400	19.2	10700	.80 - .98	80	79	144	L
	276612			460	60	1.15	13.9	9400	15.8	10700	1.2 - 1.4	80	79	119	L
	276622			575	60	1.15	11.1	9400	12.7	10700	1.8 - 2.2	80	79	95.0	L
	276653	15	11	200	60	1.15	48.5	14000	54.5	15900	.15 - .19	81	80	407	L
	276603			230	60	1.15	42.2	14000	47.4	15900	.19 - .24	81	80	354	L
	276663			380	60	1.15	25.5	14000	28.7	15900	.52 - .65	81	80	214	L
	276613			460	60	1.15	21.1	14000	23.7	15900	.78 - .96	81	80	177	L
	276623			575	60	1.15	16.9	14000	19.0	15900	1.2 - 1.4	81	80	142	L
	276654	20	15	200	60	1.15	64.9	18600	73.6	21300	.10 - .12	80	80	481	K
	276604			230	60	1.15	56.4	18600	64.0	21300	.14 - .18	80	80	418	K
	276664			380	60	1.15	34.1	18600	38.8	21300	.41 - .51	80	80	253	K
	276614			460	60	1.15	28.2	18600	32.0	21300	.58 - .72	80	80	209	K
	276624			575	60	1.15	22.6	18600	25.6	21300	.93 - 1.15	80	80	167	K
	276655	25	18.5	200	60	1.15	80.0	22600	90.6	25800	.09 - .11	83	82	665	L
	276605			230	60	1.15	69.6	22600	78.8	25800	.11 - .14	83	82	578	L
	276665			380	60	1.15	42.1	22600	47.7	25800	.27 - .34	83	82	350	L
	276615			460	60	1.15	34.8	22600	39.4	25800	.41 - .51	83	82	289	L
	276625			575	60	1.15	27.8	22600	31.6	25800	.70 - .86	83	82	231	L
	276656	30	22	200	60	1.15	95.0	28000	108.6	31900	.07 - .09	81	80	736	K
	276606			230	60	1.15	82.6	28000	94.4	31900	.09 - .12	81	80	640	K
	276666			380	60	1.15	50.0	28000	57.2	31900	.23 - .29	81	80	387	K
	276616			460	60	1.15	41.3	28000	47.2	31900	.34 - .42	81	80	320	K
	276626			575	60	1.15	33.0	28000	37.8	31900	.52 - .65	81	80	256	K
	276667	40	30	380	60	1.15	67.2	35900	76.0	42400	.18 - .23	84	83	545	L
	276617			460	60	1.15	55.4	35900	62.8	42400	.23 - .29	84	83	450	L
	276627			575	60	1.15	45.2	35900	50.2	42400	.34 - .43	84	83	360	L

Model numbers above are for three-lead motors. Six-lead motors with different model numbers have the same running performance, but when Wye connected for starting have locked rotor amps 33% of the values shown. Six-lead individual phase resistance = table X 1.5.

Table 26 Three-Phase Motor Fuse Sizing

TYPE	MOTOR MODEL PREFIX		RATING			CIRCUIT BREAKERS OR FUSE AMPS (MAXIMUM PER NEC)			CIRCUIT BREAKERS OR FUSE AMPS (TYPICAL SUBMERSIBLE)		
			HP	KW	VOLTS	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER
6" STD. & HI-TEMP	236650	276650	5	3.7	200	60	35	45	50	25	45
	236600	276600			230	45	30	40	45	20	40
	236660	276660			380	30	17.5	25	30	12	25
	236610	276610			460	25	15	20	25	10	20
	236620	276620			575	20	12	15	20	8	15
	236651	276651	7.5	5.5	200	80	45	70	80	35	70
	236601	276601			230	70	40	60	70	30	60
	236661	276661			380	45	25	35	40	20	35
	236611	276611			460	35	20	30	35	15	30
	236621	276621			575	30	17.5	25	25	11	25
	236652	276652	10	7.5	200	100	60	90	100	45	90
	236602	276602			230	90	50	80	90	40	80
	236662	276662			380	60	35	45	50	25	45
	236612	276612			460	45	25	40	45	20	40
	236622	276622			575	35	20	30	35	15	30
	236653	276653	15	11	200	150	90	125	150	60	125
	236603	276603			230	150	80	110	125	60	110
	236663	276663			380	80	50	70	80	35	70
	236613	276613			460	70	40	60	60	30	60
	236623	276623			575	60	30	45	50	25	45
	236654	276654	20	15	200	200	110	175	175	80	175
	236604	276604			230	175	100	150	175	70	150
	236664	276664			380	100	60	90	100	45	90
	236614	276614			460	90	50	70	80	35	70
	236624	276624			575	70	40	60	70	30	60
	236655	276655	25	18.5	200	250	150	200	225	100	200
	236605	276605			230	225	125	175	200	90	175
	236665	276665			380	125	80	110	125	50	110
	236615	276615			460	110	60	90	100	45	90
	236625	276625			575	90	50	70	80	35	70
	236656	276656	30	22	200	300	175	250	300	125	250
	236606	276606			230	250	150	225	250	100	200
	236666	276666			380	150	90	125	150	60	125
	236616	276616			460	125	70	110	125	50	100
	236626	276626			575	100	60	90	100	40	80
	236667	276667	40	30	380	200	125	175	200	90	175
	236617	276617			460	175	100	150	175	70	150
	236627	276627			575	150	80	110	125	60	110
	236668	276668	50	37	380	250	150	225	250	110	225
	236618	276618			460	225	125	175	200	90	175
	236628	276628			575	175	100	150	175	70	150
	236669	276669	60	45	380	300	175	250	300	125	250
	236619	276619			460	250	150	225	250	100	225
	236629	276629			575	200	125	175	200	80	175

Table 27 Three-Phase Motor Specifications (60 Hz) 3525 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		LINE TO LINE RESISTANCE OHMS	EFFICIENCY %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	AMPS	KILOWATTS	AMPS	KILOWATTS		S.F.	F.L.		
8" STD.	239660			380	60	1.15	64	35	72	40	.16-.20	86	86	479	J
	239600	40	30	460	60	1.15	53	35	60	40	.24-.30	86	86	396	J
	239610			575	60	1.15	42	35	48	40	.39-.49	86	86	317	J
	239661			380	60	1.15	79	43	88	49	.12-.16	87	87	656	K
	239601	50	37	460	60	1.15	64	43	73	49	.18-.22	87	87	542	K
	239611			575	60	1.15	51	43	59	49	.28-.34	87	87	434	K
	239662			380	60	1.15	92	52	104	60	.09-.11	88	87	797	K
	239602	60	45	460	60	1.15	76	52	86	60	.14-.17	88	87	658	K
	239612			575	60	1.15	61	52	69	60	.22-.28	88	87	526	K
	239663			380	60	1.15	114	64	130	73.5	.06-.09	88	88	1046	L
	239603	75	55	460	60	1.15	94	64	107	73.5	.10-.13	88	88	864	L
	239613			575	60	1.15	76	64	86	73.5	.16-.21	88	88	691	L
	239664			380	60	1.15	153	85	172	97.5	.05-.06	89	89	1466	L
	239604	100	75	460	60	1.15	126	85	142	97.5	.07-.09	89	89	1211	L
	239614			575	60	1.15	101	85	114	97.5	.11-.13	89	89	969	L
	239165			380	60	1.15	202	109	228	125	.03-.04	87	86	1596	K
	239105	125	93	460	60	1.15	167	109	188	125	.05-.07	87	86	1318	K
	239115			575	60	1.15	134	109	151	125	.08-.11	87	86	1054	K
	239166			380	60	1.15	235	128	266	146	.02-.03	88	87	1961	K
	239106	150	110	460	60	1.15	194	128	219	146	.04-.05	88	87	1620	K
	239116			575	60	1.15	155	128	176	146	.06-.08	88	87	1296	K
	239167			380	60	1.15	265	150	302	173	.02-.04	88	88	1991	J
	239107	175	130	460	60	1.15	219	150	249	173	.04-.05	88	88	1645	J
	239117			575	60	1.15	175	150	200	173	.06-.08	88	88	1316	J
	239168			380	60	1.15	298	169	342	194	.02-.03	88	88	2270	J
	239108	200	150	460	60	1.15	246	169	282	194	.03-.05	88	88	1875	J
	239118			575	60	1.15	197	169	226	194	.05-.07	88	88	1500	J

Table 27A 8" Three-Phase Motor Specifications (60 Hz) 3525 rpm

TYPE	MOTOR MODEL PREFIX	RATING					FULL LOAD		MAXIMUM LOAD		LINE TO LINE RESISTANCE OHMS	EFFICIENCY %		LOCKED ROTOR AMPS	KVA CODE
		HP	KW	VOLTS	HZ	S.F.	AMPS	KILOWATTS	AMPS	KILOWATTS		S.F.	F.L.		
8" HI-TEMP	279160			380	60	1.15	69.6	38	78.7	43	.11 - .14	79	78	616	M
	279100	40	30	460	60	1.15	57.5	38	65.0	43	.16 - .19	79	78	509	M
	279110			575	60	1.15	46.0	38	52.0	43	.25 - .31	79	78	407	M
	279161			380	60	1.15	84.3	47	95.4	53	.07 - .09	81	80	832	M
	279101	50	37	460	60	1.15	69.6	47	78.8	53	.11 - .14	81	80	687	M
	279111			575	60	1.15	55.7	47	63.0	53	.18 - .22	81	80	550	M
	279162			380	60	1.15	98.4	55	112	62	.06 - .07	83	82	1081	N
	279102	60	45	460	60	1.15	81.3	55	92.1	62	.09 - .11	83	82	893	N
	279112			575	60	1.15	65.0	55	73.7	62	.13 - .16	83	82	715	N
	279163			380	60	1.15	125	68	141	77	.05 - .06	83	82	1175	L
	279103	75	56	460	60	1.15	100	68	114	77	.07 - .09	83	82	922	L
	279113			575	60	1.15	80	68	92	77	.11 - .14	83	82	738	L
	279164			380	60	1.15	159	88	181	100	.04 - .05	86	85	1508	M
	279104	100	75	460	60	1.15	131	88	149	100	.05 - .07	86	85	1246	M
	279114			575	60	1.15	105	88	119	100	.08 - .10	86	85	997	M
	279165			380	60	1.15	195	109	223	125	.03 - .04	86	85	1793	L
	279105	125	93	460	60	1.15	161	109	184	125	.04 - .06	86	85	1481	L
	279115			575	60	1.15	129	109	148	125	.07 - .09	86	85	1185	L
	279166			380	60	1.15	235	133	269	151	.02 - .03	85	84	2012	K
	279106	150	110	460	60	1.15	194	133	222	151	.03 - .05	85	84	1662	K
	279116			575	60	1.15	155	133	178	151	.05 - .07	85	84	1330	K

Model numbers above are for three-lead motors. Six-lead motors with different model numbers have the same running performance, but when Wye connected for starting have locked rotor amps 33% of the values shown. Six-lead individual phase resistance = table X 1.5.

Table 28 Three-Phase Motor Fuse Sizing

TYPE	MOTOR MODEL PREFIX	RATING			CIRCUIT BREAKERS OR FUSE AMPS (MAXIMUM PER NEC)			CIRCUIT BREAKERS OR FUSE AMPS (TYPICAL SUBMERSIBLE)		
		HP	KW	VOLTS	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER
8" STD.	239660	40	30	380	200	125	175	200	80	175
	239600			460	175	100	150	175	70	150
	239610			575	150	80	110	125	60	110
	239661	50	37	380	250	150	200	225	100	200
	239601			460	200	125	175	200	80	175
	239611			575	175	90	150	150	70	150
	239662	60	45	380	300	175	250	300	125	250
	239602			460	250	150	200	225	100	200
	239612			575	200	110	175	175	80	175
	239663	75	55	380	350	200	300	350	150	300
	239603			460	300	175	250	300	125	250
	239613			575	250	150	200	225	100	200
	239664	100	75	380	500	275	400	450	200	400
	239604			460	400	225	350	400	175	350
	239614			575	350	200	300	300	125	300
	239165	125	93	380	700	400	600	600	250	600
	239105			460	500	300	450	500	225	450
	239115			575	450	250	350	400	175	350
	239166	150	110	380	800	450	600	700	300	600
	239106			460	600	350	500	600	250	500
	239116			575	500	300	400	450	200	400
	239167	175	130	380	800	500	700	800	350	700
	239107			460	700	400	600	700	300	600
	239117			575	600	350	450	600	225	450
	239168	200	150	380	1000	600	800	1000	400	800
	239108			460	800	450	700	800	350	700
	239118			575	600	350	500	600	250	500

Table 28A 8" Three-Phase Motor Fuse Sizing

TYPE	MOTOR MODEL PREFIX	RATING			CIRCUIT BREAKERS OR FUSE AMPS (MAXIMUM PER NEC)			CIRCUIT BREAKERS OR FUSE AMPS (TYPICAL SUBMERSIBLE)		
		HP	KW	VOLTS	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER	STANDARD FUSE	DUAL ELEMENT TIME DELAY FUSE	CIRCUIT BREAKER
8" HI-TEMP	279160	40	30	380	225	125	175	200	90	175
	279100			460	175	110	150	175	70	150
	279110			575	150	90	125	125	60	125
	279161	50	37	380	250	150	225	225	110	225
	279101			460	200	125	175	200	90	175
	279111			575	175	100	150	150	70	150
	279162	60	45	380	300	175	250	300	125	250
	279102			460	275	150	225	250	100	225
	279112			575	200	125	175	175	80	175
	279163	75	56	380	400	200	350	350	150	350
	279103			460	300	175	275	300	125	275
	279113			575	275	150	225	225	100	225
	279164	100	75	380	500	300	450	450	200	450
	279104			460	400	250	350	400	175	350
	279114			575	350	200	300	300	125	300
	279165	125	93	380	700	400	600	600	250	600
	279105			460	500	300	450	500	225	450
	279115			575	450	250	350	400	175	350
	279166	150	110	380	800	450	600	700	300	600
	279106			460	600	350	500	600	250	500
	279116			575	500	300	400	450	200	400

Overload Protection of Three-Phase Submersible Motors **Class 10 Protection Required**

The characteristics of submersible motors are different than standard motors and special overload protection is required.

If the motor is locked, the overload protection must trip within 10 seconds to protect the motor windings. Subtrol/SubMonitor, a Franklin-approved adjustable overload relay, or a Franklin-approved fixed heater must be used.

Fixed heater overloads must be the ambient-compensated quick-trip type to maintain protection at high and low air temperatures.

All heaters and amp settings shown are based on total line amps. When determining amperage settings or making heater selections for a six-lead motor with a Wye-Delta starter, divide motor amps by 1.732.

Pages 29, 30 and 31 list the correct selection and settings for some manufacturers. Approval for other manufacturers' types not listed may be requested by calling Franklin's Submersible Service Hotline at 800-348-2420.

Refer to notes on page 30.

Table 29 - 60 Hz 4" Motors

HP	KW	VOLTS	NEMA STARTER SIZE	HEATERS FOR OVERLOAD RELAYS		ADJUSTABLE RELAYS (NOTE 3)	
				FURNAS (NOTE 1)	G.E. (NOTE 2)	SET	MAX.
1/2	0.37	200	00	K31	L380A	3.2	3.4
		230	00	K28	L343A	2.7	2.9
		380	00	K22	L211A	1.7	1.8
		460	00	-	L174A	1.4	1.5
		575	00	-	-	1.2	1.3
3/4	0.55	200	00	K34	L510A	4.1	4.4
		230	00	K32	L420A	3.5	3.8
		380	00	K27	L282A	2.3	2.5
		460	00	K23	L211A	1.8	1.9
		575	00	K21	L193A	1.5	1.6
1	0.75	200	00	K37	L618A	5.0	5.4
		230	00	K36	L561A	4.4	4.7
		380	00	K28	L310A	2.6	2.8
		460	00	K26	L282A	2.2	2.4
		575	00	K23	L211A	1.8	1.9
1.5	1.1	200	00	K42	L750A	6.3	6.8
		230	00	K39	L680A	5.5	5.9
		380	00	K32	L420A	3.3	3.6
		460	00	K29	L343A	2.8	3.0
		575	00	K26	L282A	2.2	2.4
2	1.5	200	0	K50	L111B	8.6	9.3
		230	0	K49	L910A	7.5	8.1
		380	0	K36	L561A	4.6	4.9
		460	00	K33	L463A	3.8	4.1
		575	00	K29	L380A	3.0	3.2
3	2.2	200	0	K55	L147B	11.6	12.5
		230	0	K52	L122B	10.1	10.9
		380	0	K41	L750A	6.1	6.6
		460	0	K37	L618A	5.1	5.5
		575	0	K34	L510A	4.1	4.4
5	3.7	200	1	K62	L241B	19.1	20.5
		230	1	K61	L199B	16.6	17.8
		380	0	K52	L122B	10.0	10.8
		460	0	K49	L100B	8.3	8.9
		575	0	K42	L825A	6.6	7.1
7.5	5.5	200	1	K68	L332B	28.4	30.5
		230	1	K67	L293B	24.6	26.4
		380	1	K58	L181B	14.9	16.0
		460	1	K55	L147B	12.3	13.2
		575	1	K52	L122B	9.9	10.6
10	7.5	380	1	K62	L241B	19.5	21.0
		460	1	K60	L199B	16.1	17.3
		575	1	K56	L165B	12.9	13.6

Table 30 - 60 Hz 6" Standard & Hi-Temp Motors

HP	KW	VOLTS	NEMA STARTER SIZE	HEATERS FOR OVERLOAD RELAYS		ADJUSTABLE RELAYS (NOTE 3)	
				FURNAS (NOTE 1)	G.E. (NOTE 2)	SET	MAX.
5	3.7	200	1	K61	L220B	17.6	19.1
		230	1	K61	L199B	15.4	16.6
		380	0	K52	L122B	9.4	10.1
		460	0	K49	L100B	7.7	8.3
		575	0	K42	L825A	6.1	6.6
7.5	5.5	200	1	K67	L322B	26.3	28.3
		230	1	K64	L293B	22.9	24.6
		380	1	K57	L165B	13.9	14.9
		460	1	K54	L147B	11.4	12.3
		575	1	K52	L111B	9.1	9.8
10	7.5	200	2(1)	K72	L426B	34.4	37.0
		230	2(1)	K70	L390B	29.9	32.2
		380	1	K61	L220B	18.1	19.5
		460	1	K58	L181B	15.0	16.1
		575	1	K55	L147B	12.0	12.9
15	11	200	3(1)	K76	L650B	50.7	54.5
		230	2	K75	L520B	44.1	47.4
		380	2(1)	K68	L322B	26.7	28.7
		460	2(1)	K64	L265B	22.0	23.7
		575	2(1)	K61	L220B	17.7	19.0
20	15	200	3	K78	L787B	64.8	69.7
		230	3(1)	K77	L710B	56.4	60.6
		380	2	K72	L426B	34.1	36.7
		460	2	K69	L352B	28.2	30.3
		575	2	K64	L393B	22.7	24.4
25	18.5	200	3	K86	L107C	80.3	86.3
		230	3	K83	L866B	69.8	75.0
		380	2	K74	L520B	42.2	45.4
		460	2	K72	L426B	34.9	37.5
		575	2	K69	L352B	27.9	30.0
30	22	200	4(1)	K88	L126C	96.7	104.0
		230	3	K87	L107C	84.1	90.4
		380	3(1)	K76	L650B	50.9	54.7
		460	3(1)	K74	L520B	42.0	45.2
		575	3(1)	K72	L390B	33.7	36.2
40	30	380	3	K83	L866B	69.8	75.0
		460	3	K77	L710B	57.7	62.0
		575	3	K74	L593B	46.1	49.6
50	37	380	3	K87	L107C	86.7	93.2
		460	3	K83	L950B	71.6	77.0
		575	3	K77	L710B	57.3	61.6
60	45	380	4(1)	K89	L126C	102.5	110.2
		460	4(1)	K87	L107C	84.6	91.0
		575	4(1)	K78	L866B	67.7	72.8

Footnotes for Tables 29, 30, and 31

NOTE 1: Furnas intermediate sizes between NEMA starter sizes apply where (1) is shown in tables, size 1.75 replacing 2, 2.5 replacing 3, 3.5 replacing 4, and 4.5 replacing 5. Heaters were selected from Catalog 294, table 332 and table 632 (starter size 00, size B). Size 4 starters are heater type 4 (JG). Starters using these heater tables include classes 14, 17 and 18 (inNOVA), classes 36 and 37 (reduced voltage), and classes 87, 88 and 89 (pump and motor control centers). Overload relay adjustments should be set no higher than 100% unless necessary to stop nuisance tripping with measured amps in all lines below nameplate maximum. Heater selections for class 16 starters (Magnetic Definite Purpose) will be furnished upon request.

NOTE 2: General Electric heaters are type CR123 usable only on type CR124 overload relays and were selected from Catalog GEP-126OJ, page 184. Adjustment should be set no higher than 100%, unless necessary to stop nuisance tripping with measured amps in all lines below nameplate maximum.

NOTE 3: Adjustable overload relay amp settings apply to approved types listed. Relay adjustment should be set at the specified SET amps. Only if tripping occurs with amps in all lines measured to be within nameplate maximum amps should the setting be increased, not to exceed the MAX value shown.

NOTE 4: Heaters shown for ratings requiring NEMA size 5 or 6 starters are all used with current transformers per manufacturer standards. Adjustable relays may or may not use current transformers depending on design.

Table 31 - 60 Hz 8" Motors

MOTOR MODEL PREFIX	HP	KW	VOLTS	NEMA STARTER SIZE	HEATERS FOR OVERLOAD RELAYS		ADJUSTABLE RELAYS (NOTE 3)	
					FURNAS (NOTE 1)	G.E. (NOTE 2)	SET	MAX.
239660	40	30	380	3	K78	L866B	68	73
239600			460	3	K77	L710B	56	60
239610			575	3	K73	L520B	45	48
239661	50	37	380	3	K86	L107C	81	87
239601			460	3	K78	L866B	68	73
239611			575	3	K77	L710B	56	60
239662	60	45	380	4(1)	K89	L126C	101	108
239602			460	4(1)	K86	L107C	83	89
239612			575	4(1)	K78	L787B	64	69
239663	75	55	380	4	K92	L142C	121	130
239603			460	4(1)	K89	L126C	100	107
239613			575	4(1)	K85	L950C	79	85
239664	100	75	380	5(1)	K28	L100B	168	181
239604			460	4	K92	L155C	134	144
239614			575	4	K90	L142C	108	116
239165	125	93	380	5	K32	L135B	207	223
239105			460	5(1)	K29	L111B	176	189
239115			575	5(1)	K26	L825A	140	150
239166	150	110	380	5	-	L147B	248	267
239106			460	5(1)	K32	L122B	206	221
239116			575	5(1)	K28	L100B	165	177
239167	175	130	380	6	K26	-	270	290
239107			460	5	K33	L147B	233	250
239117			575	5	K31	L111B	186	200
239168	200	150	380	6	K27	-	316	340
239108			460	5	K33	L165B	266	286
239118			575	5	K32	L135B	213	229

Table 31A - 60 Hz 8" Hi-Temp 75°C Motors

MOTOR MODEL PREFIX	HP	KW	VOLTS	NEMA STARTER SIZE	HEATERS FOR OVERLOAD RELAYS		ADJUSTABLE RELAYS (NOTE 3)	
					FURNAS (NOTE 1)	G.E. (NOTE 2)	SET	MAX.
279160	40	30	380	3	K83	L866B	73	79
279100			460	3	K77	L710B	60	65
279110			575	3	K74	L593B	48	52
279161	50	37	380	3	K87	L107C	89	95
279101			460	3	K83	L866B	73	79
279111			575	3	K77	L710B	59	63
279162	60	45	380	4(1)	K89	L126C	104	112
279102			460	4(1)	K87	L107C	86	92
279112			575	4(1)	K78	L866B	69	74
279163	75	56	380	4	K92	L155C	131	141
279103			460	4(1)	K89	L126C	106	114
279113			575	4(1)	K87	L950C	86	92
279164	100	75	380	5(1)	K28	L100B	168	181
279104			460	5(1)	K26	L825A	139	149
279114			575	4	K90	L142C	111	119
279165	125	93	380	5	K32	L135B	207	223
279105			460	5(1)	K29	L111B	171	184
279115			575	5(1)	K26	L825A	138	148
279166	150	110	380	5	-	L147B	250	269
279106			460	5(1)	K32	L122B	206	222
279116			575	5(1)	K28	L100B	166	178

Note: Other relay types from these and other manufacturers may or may not provide acceptable protection, and they should not be used without approval of Franklin Electric.

Some approved types may only be available for part of the listed motor ratings. When relays are used with current transformers, relay setting is the specified amps divided by the transformer ratio.

Recommended Adjustable Overload Relays

Advance Controls: MDR3 Overload

AEG Series: B17S, B27S, B27-2

ABB Type: RVH 40, RVH65, RVP160, T25DU, T25CT, TA25DU

AGUT: MT03, R1K1, R1L0, R1L3, TE set Class 5

Allen Bradley: Bulletin 193, SMP-Class 10 only

Automatic Switch Types: DQ, LR1-D, LR1-F, LR2 Class 10

Benshaw: RSD6 (Class 10) Soft Start

Bharita C-H: MC 305 ANA 3

Clipsal: 6CTR, 6MTR

Cutler-Hammer: C316F, C316P, C316S, C310-set at 6 sec max, Advantage Class10

Fanal Types: K7 or K7D through K400

Franklin Electric: Subtrol-Plus, SubMonitor

Fuji Types: TR-OQ, TR-OQH, TR-2NQ, TR- 3NQ, TR-4NQ, TR-6NQ, RCa 3737-ICQ & ICQH

Furnas Types: US15 48AG & 48BG, 958L, ESP100-Class 10 only, 3RB10-Class 10

General Electric: CR4G, CR7G, RT*1, RT*2, RTF3, RT*4, CR324X-Class 10 only

Kasuga: RU Set Operating Time Code = 10 & time setting 6 sec max

Klockner-Moeller Types: ZOO, Z1, Z4, PKZM1, PKZM3 & PKZ2

Lovato: RC9, RC22, RC80, RF9, RF25 & RF95

Matsushita: FKT-15N, 15GN, 15E, 15GE, FT-15N, FHT-15N

Mitsubishi: ET, TH-K12ABKP, TH-K20KF, TH-K20KP, TH-K20TAKF, TH-K60KF, TH-K60TAKF

Omron: K2CM Set Operating Timing Code = 10 & time setting 6 sec max, SE-KP24E time setting 6 sec max

Riken: PM1, PM3

Samwha: EOCRS Set for Class 5, EOCR-ST, EOCR-SE, EOCR-AT time setting 6 sec max

Siemens Types: 3UA50, -52, -54, -55, -58, -59, -60, -61, -62, -66, -68, -70, 3VUI3, 3VE, 3UB (Class 5)

Sprecher and Schuh Types: CT, CT1, CTA 1, CT3K, CT3-12 thru CT3-42, KTA3, CEF1 & CET3 set at 6 sec max, CEP 7 Class 10, CT4, 6, & 7, CT3, KT7

Square D/Telemecanique: Class 9065 Types: TD, TE, TF, TG, TJ, TK, TR, TJE &TJF (Class 10), LR1-D, LR1-F, LR2 Class 10, Types 18A, 32A, SS-Class 10, SR-Class 10 and 63-A-LB Series. Integral 18,32,63, GV2-L, GV2-M, GV2-P, GV3-M (1.6-10 amp only) LR9D, SF Class 10, ST Class 10, LT6 (Class 5 or 10), LRD (Class 10), Motor Logic (Class10)

Toshiba Type: 2E RC820, set at 8 sec max.

WEG: RW2

Westinghouse Types: FT13, FT23, FT33, FT43, K7D, K27D, K67D, Advantage (Class 10), MOR, IQ500 (Class 5)

Westmaster: OLWROO and OLWTOO suffix D thru P

SUBMERSIBLE PUMP
Installation Check List

1. Motor Inspection

- [ ] A. Verify that the model, hp or kW, voltage, phase and hertz on the motor nameplate match the installation requirements.
- [ ] B. Check that the motor lead assembly is not damaged.
- [ ] C. Measure insulation resistance using a 500 or 1000 volt DC megohmmeter from each lead wire to the motor frame. Resistance should be at least 200 megohms without drop cable.
- [ ] D. Keep a record of motor model number, hp or kW, voltage, and serial number (S/N). (S/N is stamped in shell above the nameplate. A typical example, S/N 07A18 01-0123)

2. Pump Inspection

- [ ] A. Check that the pump rating matches the motor.
- [ ] B. Check for pump damage and verify that the pump shaft turns freely.

3. Pump/Motor Assembly

- [ ] A. If not yet assembled, check that pump and motor mounting faces are free from dirt, debris and uneven paint thickness.
- [ ] B. Pumps and motors over 5 hp should be assembled in the vertical position to prevent stress on pump brackets and shafts. Assemble the pump and motor together so their mounting faces are in contact and then tighten assembly bolts or nuts evenly to manufacturer specifications.
- [ ] C. If accessible, check that the pump shaft turns freely.
- [ ] D. Assemble the pump lead guard over the motor leads. Do not cut or pinch lead wires during assembly or installation.

4. Power Supply and Controls

- [ ] A. Verify that the power supply voltage, Hertz, and kVA capacity match motor requirements.
- [ ] B. Verify control box hp and voltage matches motor (3-wire only).
- [ ] C. Check that the electrical installation and controls meet all safety regulations and match the motor requirements, including fuse or circuit breaker size and motor overload protection. Connect all metal plumbing and electrical enclosures to the power supply ground to prevent shock hazard. Comply with national and local codes.

5. Lightning and Surge Protection

- [ ] A. Use properly rated surge (lightning) arrestors on all submersible pump installations. Motors 5 hp and smaller, which are marked “Equipped with Lightning Arrestors”, contain internal arrestors.
- [ ] B. Ground all above ground arrestors with copper wire directly to the motor frame, or to metal drop pipe or casing which reaches below the well pumping level. Connecting to a ground rod does not provide good surge protection.

6. Electrical Drop Cable

- [ ] A. Use submersible cable sized in accordance with local regulations and the cable charts. See pages 11 and 16-21. Ground motor per national and local codes.
- [ ] B. Include a ground wire to the motor and surge protection, connected to the power supply ground if required by codes. Always ground any pump operated outside a drilled well.

7. Motor Cooling

- [ ] A. Ensure at all times that the installation provides adequate motor cooling; see page 6 for details.

8. Pump/Motor Installation

- ☐ A. Splice motor leads to supply cable using electrical grade solder or compression connectors, and carefully insulate each splice with watertight tape or adhesive-lined shrink tubing, as shown in motor or pump installation data.
- ☐ B. Support the cable to the delivery pipe every 10 feet (3 meters) with straps or tape strong enough to prevent sagging. Use padding between cable and any metal straps.
- ☐ C. A check valve in the delivery pipe is recommended. More than one check valve may be required, depending on valve rating and pump setting; see page 5 for details.
- ☐ D. Assemble all pipe joints as tightly as practical, to prevent unscrewing from motor torque. Torque should be at least 10 pound feet per hp (2 meter-KG per kW).
- ☐ E. Set the pump far enough below the lowest pumping level to assure the pump inlet will always have at least the Net Positive Suction Head (NPSH) specified by the pump manufacturer. Pump should be at least 10 feet (3 meters) from the bottom of the well to allow for sediment build up.
- ☐ F. Check insulation resistance as pump/motor assembly is lowered into the well. Resistance may drop gradually as more cable enters the water, but any sudden drop indicates possible cable, splice or motor lead damage; see page 45.

9. After Installation

- ☐ A. Check all electrical and water line connections and parts before starting the pump.
- ☐ B. Start the pump and check motor amps and pump delivery. If normal, continue to run the pump until delivery is clear. If three-phase pump delivery is low, it may be running backward. Rotation may be reversed (with power off) by interchanging any two motor lead connections to the power supply.
- ☐ C. Check three-phase motors for current balance within 5% of average, using motor manufacturer instructions Imbalance over 5% will cause higher motor temperatures and may cause overload trip, vibration, and reduced life.
- ☐ D. Verify that starting, running and stopping cause no significant vibration or hydraulic shocks.
- ☐ E. After at least 15 minutes running time, verify that pump output, electrical input, pumping level, and other characteristics are stable and as specified.

Date ______________________ Filled In By ____

Notes ____

____

____

____

____

____

Franklin Electric

SUBMERSIBLE MOTOR INSTALLATION RECORD
Form 2207 - Page 1

RMA Number ____________

KEY DEALER # ____________

DISTRIBUTOR	INSTALLER	END USER
Name: ____________	Name: ____________	Name: ____________
City: ____________	City: ____________	City: ____________
State: ________ Zip: ________	State: ________ Zip: ________	State: ________ Zip: ________

Well ID or GPS: ________ ________ ____________ Water Temperature: ________ ☐ °F ☐ °C

Application/Water Use (e.g. potable water, irrigation, municipal, fountain, etc.): ____________

Date Installed (mm/yy): ________ Date Failed (mm/yy): ________ Motor Position Shaft-Up: ☐ Yes ☐ No

Operating Cycle: ON Time Per Start _____ ☐ Hrs. ☐ Mins. Time OFF Between Stop & Restart _____ ☐ Hrs. ☐ Mins.

MOTOR

Model: ____________ Serial Number: ____________ Date Code (if updated): ________

MOTOR OVERLOAD

System Typical Operating Current: ________ Amps @ ________ Volts

Overload: ☐ FE SubMonitor Input Amps ______ D3 Attached ☐ Yes ☐ No Fault Settings Attached ☐ Yes ☐ No

☐ Other Manufacturer Model: ____________ Dial Set at: ________ or Heater# ________

NEMA Class: ☐ 10 ☐ 20 ☐ 30 Ambient Compensated: ☐ Yes ☐ No

Power to Motor by: ☐ Full Volt Starter ☐ VFD ☐ Soft Starter VFD or Soft Starter Mfr. & Model: ____________

PUMP

Manufacturer: ____________

Model: ____________

Stages: ____________

Design Rating: ______ gpm @ ______ ft TDH

Horsepower Required by Pump End: ________

Actual Pump Delivery: ______ gpm @ ______ psi

What Controls When System Runs & Stops:

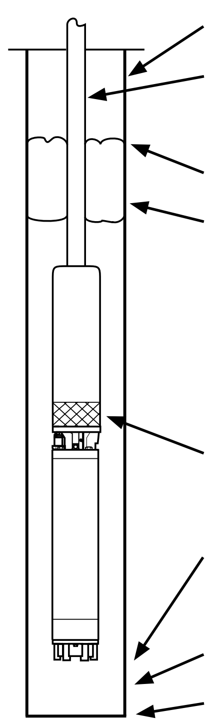
____

(e.g. pressure, level, flow, manual on/off, timer, time clock etc.)

YOUR NAME / DATE

____________ / ________

WELL DATA (All measurements from well head down.)



Casing Diameter ____________ in

Drop Pipe Diameter ____________ in

Number of Sticks of Drop Pipe ________

Static Water Level ____________ ft

Drawdown (pumping) Water Level ________ ft

Spring Assist Check Valves:
(Measured from Well Head Down)

#1 _____ #2 _____ #3 _____ #4 _____ ft

☐ Solid ☐ Drilled Poppet ☐ Break-Off Plug

Pump Inlet Setting ____________ ft

Flow Sleeve ☐ No ☐ Yes, Dia. ________ in

Case Ends ____________ ft

☐ Well Screen ☐ Perforated Casing

#1 from ____ to ____ ft & #2 from ____ to ____ ft

Well Depth ____________ ft

Franklin Electric

SUBMERSIBLE MOTOR INSTALLATION RECORD
Form 2207 - Page 2

RMA Number

______

TRANSFORMERS

Number of Transformers: ☐ Two ☐ Three   Transformers Supply Motor Only: ☐ Yes ☐ No ☐ Unsure

Transformer #1: __________ kVA   Transformer #2: __________ kVA   Transformer #3: __________ kVA

POWER CABLES & GROUND WIRE

1 **Service Entrance to Pump Control Panel:**

Length: __________ ft. & Gauge: __________ AWG/MCM

Material: ☐ Copper ☐ Aluminum   Construction: ☐ Jacketed ☐ Individual Conductors ☐ Web ☐ Twisted

Temperature Rating of Cable: ☐ 60C ☐ 75C ☐ 90C ☐ 125C or Insulation Type: ______________ (e.g. THHN)

2 **Pump Control Panel to Motor:**

Length: __________ ft. & Gauge: __________ AWG/MCM

Material: ☐ Copper ☐ Aluminum   Construction: ☐ Jacketed ☐ Individual Conductors ☐ Web ☐ Twisted

Temperature Rating of Cable: ☐ 60C ☐ 75C ☐ 90C ☐ 125C or Insulation Type: ______________ (e.g. THHN)

3 **Ground Wire Size:** From Control Panel to Motor: __________ AWG/MCM

Control Grounded to (mark all that apply):

☐ Well Head ☐ Metal Casing ☐ Motor ☐ Driven Rod ☐ Power Supply

INCOMING VOLTAGE

No Load   L1-L2 ______ L2-L3 ______ L1-L3 ______

Full Load   L1-L2 ______ L2-L3 ______ L1-L3 ______

RUNNING AMPS & CURRENT BALANCE

Full Load   L1 ________ L2 ________ L3 ________

% Unbalance: ______

CONTROL PANEL

1 **Pump Panel Manufacturer/Fabricator:** ______________________________

2 **Short Circuit Protection - Fuses or Circuit Breaker**

Option #1 - Fuse

Manufacturer: ________________ Model: ________________ Rating: ____________ Amps

Type: ☐ Time-Delay ☐ Standard

Option #2 - Circuit Breaker

Manufacturer: ________________ Model: ________________ Rating: ____________ Amps Setting: __________

3 **Starter - Full Voltage, Reduced Voltage, Soft-Starter or VFD (Variable Frequency Drive)**

Option #1 - Full Voltage

Manufacturer: ________________ Model: ________________ Size: ____________ Contacts: ☐ NEMA ☐ IEC

Option #2 - Reduced Voltage

Manufacturer: ________________ Model: ________________ Ramp Time to Full Voltage: ____________ sec.

Option #3 - Soft-Starter or VFD

Manufacturer: ________________ Model: ________________ Max. Continuous Amp Output Rating: __________

Min. Setting: ____________ Hz & GPM: ____________   Max. Setting: ____________ Hz & GPM: ____________

Start Ramp Time to 30 Hz: ________ sec.   Stop Mode: ☐ Power Off Coast ☐ 30-0 Hz Ramp ________ sec.

Special Output Filter Purchased: ☐ Yes ☐ No

Output Filter Manufacturer: ________________ Model: ________________ % Reactance: __________

4 **Surge Arrestor:** ☐ No ☐ Yes, Manufacturer: ________________ Model: ________________

Franklin Electric

SUBMERSIBLE MOTOR
Booster Installation Record

RMA Number

Date ______ /______/________ Filled In By ____________________________________

INSTALLATION

Owner/User ____ Telephone (______) __________________

Address ____City ______________ State ______ Zip __________

Installation Site, If Different ____

Contact ____ Telephone (______) __________________

System Application____

____

____

System Manufactured By___________________________Model _______________ Serial No. ______________

System Supplied By______________________________ City ________________ State ______ Zip __________

Is this a "HERO" system (10.0 - 10.5 PH)? ☐ Yes ☐ No

MOTOR

Model No. ______________ Serial No. ______________ Date Code ______

Horsepower ______ Voltage ______ ☐ Single-Phase ☐ Three-Phase Diameter ______ in.

Slinger Removed? ☐ Yes ☐ No Check Valve Plug Removed? ☐ Yes ☐ No

Motor Fill Solution ☐ Standard ☐ DI Water Model No. ____________ Serial No. ____________ Date Code ______

PUMP

Manufacturer ______________ Model ______________ Serial No. ______________

Stages ______ Diameter ________ Flow Rate Of ________ gpm At ______TDH

Booster Case Internal Diameter ________ Material ______________

CONTROLS AND PROTECTIVE DEVICES

SubMonitor? ☐ Yes ☐ No If Yes, Warranty Registration No.____________________________________

If Yes, Overload Set? ☐ Yes ☐ No ______ Set At ____________________

Underload Sets? ☐ Yes ☐ No ______ Set At ____________________

VFD or Reduced Voltage Starter? ☐ Yes ☐ No If Yes, Type ________________________________

Mfr. ______________Setting ________% Full Voltage In ________sec

Pump Panel? ☐ Yes ☐ No If Yes, Mfr. ____________________________Size ______________________

Magnetic Starter/Contactor Mfr. __________________________ Model _________________Size__________

Heaters Mfr. ____________________ No. ___________ If Adjustable Set At ______________________

Fuses Mfr. ___________________ Size __________ Type ____________________________________

Lightning/Surge Arrestor Mfr. _______________________ Model _____________________________

Controls Are Grounded to ________________ with No. ________Wire

Inlet Pressure Control ☐ Yes ☐ No If Yes, Mfr.________ Model _______ Setting _____ psi Delay ____ sec

Inlet Flow Control ☐ Yes ☐ No If Yes, Mfr.________ Model _______ Setting _____ gpm Delay ____ sec

Outlet Pressure Control ☐ Yes ☐ No If Yes, Mfr.________ Model _______ Setting _____ psi Delay ____ sec

Outlet Flow Control ☐ Yes ☐ No If Yes, Mfr.________ Model _______ Setting _____ gpm Delay ____ sec

Water Temperature Control ☐ Yes ☐ No If Yes, Mfr.________ Model ______________________ Delay ____ sec

Set At ________ °F or ______ °C Located ______________________________

Franklin Electric

SUBMERSIBLE MOTOR

Booster Installation Record

INSULATION CHECK

Initial Megs: Motor & Lead Only — Black (T1/U1)_________ Yellow (T2/V1)________ Red (T3/W1)_________

Installed Megs: Motor, Lead, & Cable — Black (T1/U1)_________ Yellow (T2/V1)________ Red (T3/W1)_________

VOLTAGE TO MOTOR

Non-Operating: — B-Y (T1/U1 - T2/V1)_____ Y-R (T2/V1 - T3/W1)_____ R-B (T3/W1 - T1/U1)_____

At Rated Flow of __________gpm — B-Y (T1/U1 - T2/V1)_____ Y-R (T2/V1 - T3/W1)_____ R-B (T3/W1 - T1/U1)_____

At Open Flow ____________gpm — B-Y (T1/U1 - T2/V1)_____ Y-R (T2/V1 - T3/W1)_____ R-B (T3/W1 - T1/U1)_____

AMPS TO MOTOR

At Rated Flow of __________gpm — Black (T1/U1)_________ Yellow (T2/V1)________ Red (T3/W1)_________

At Open Flow ____________gpm — Black (T1/U1)_________ Yellow (T2/V1)________ Red (T3/W1)_________

At Shut Off* — Black (T1/U1)_________ Yellow (T2/V1)________ Red (T3/W1)_________

*Do **NOT** run at Shut Off more than two (2) minutes.

Inlet Pressure __________psi Outlet Pressure __________psi Water Temperature _______ °F or _______ °C

If you have any questions or problems, call the Franklin Electric Toll-Free Hot Line: 1-800-348-2420

Comments: ____

____

____

____

PLEASE SKETCH THE SYSTEM

Franklin Electric

SubMonitor Three-Phase Protection

Applications

SubMonitor is designed to protect 3-phase pumps/motors with service factor amp ratings (SFA) from 5 to 350 A (approx. 3 to 200 hp). Current, voltage, and motor temperature are monitored using all three legs and allows the user to set up the SubMonitor quickly and easily.

Protects Against

- Under/Overload
- Under/Overvoltage
- Current Unbalance
- Overheated Motor
  (if equipped with Subtrol Heat Sensor)
- False Start (Chattering)
- Phase Reversal

Power Factor Correction

In some installations, power supply limitations make it necessary or desirable to increase the power factor of a submersible motor. The table lists the capacitive kVAR required to increase the power factor of large Franklin three-phase submersible motors to the approximate values shown at maximum input loading.

Capacitors must be connected on the line side of the overload relay, or overload protection will be lost.

Table 32 kVAR Required 60 Hz

MOTOR		KVAR REQUIRED FOR PF OF:		
HP	KW	0.90	0.95	1.00
5	3.7	1.2	2.1	4.0
7.5	5.5	1.7	3.1	6.0
10	7.5	1.5	3.3	7.0
15	11	2.2	4.7	10.0
20	15	1.7	5.0	12.0
25	18.5	2.1	6.2	15.0
30	22	2.5	7.4	18.0
40	30	4.5	11.0	24.0
50	37	7.1	15.0	32.0
60	45	8.4	18.0	38.0
75	55	6.3	18.0	43.0
100	75	11.0	27.0	60.0
125	93	17.0	36.0	77.0
150	110	20.0	42.0	90.0
175	130	9.6	36.0	93.0
200	150	16.0	46.0	110.0

Values listed are total required (not per phase).

Three-Phase Starter Diagrams

Three-phase combination magnetic starters have two distinct circuits: a power circuit and a control circuit.

The power circuit consists of a circuit breaker or fused line switch, contacts, and overload heaters connecting incoming power lines L1, L2, L3 and the three-phase motor.

The control circuit consists of the magnetic coil, overload contacts and a control device such as a pressure switch. When the control device contacts are closed, current flows through the magnetic contactor coil, the contacts close, and power is applied to the motor. Hand-Off-Auto switches, start timers, level controls and other control devices may also be in series in the control circuit.

Line Voltage Control

This is the most common type of control encountered. Since the coil is connected directly across the power lines L1 and L2, the coil must match the line voltage.

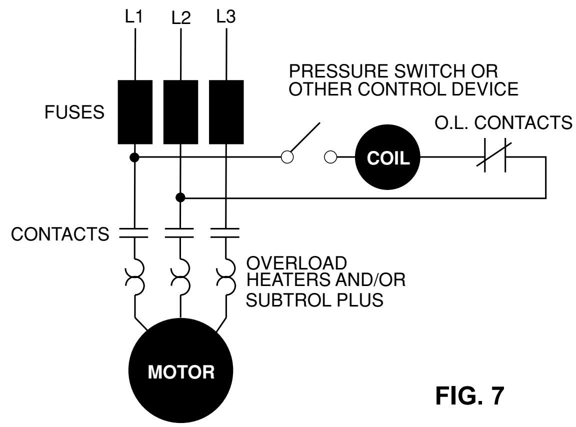


FIG. 7

Low Voltage Transformer Control

This control is used when it is desirable to operate push buttons or other control devices at some voltage lower than the motor voltage. The transformer primary must match the line voltage and the coil voltage must match the secondary voltage of the transformer.

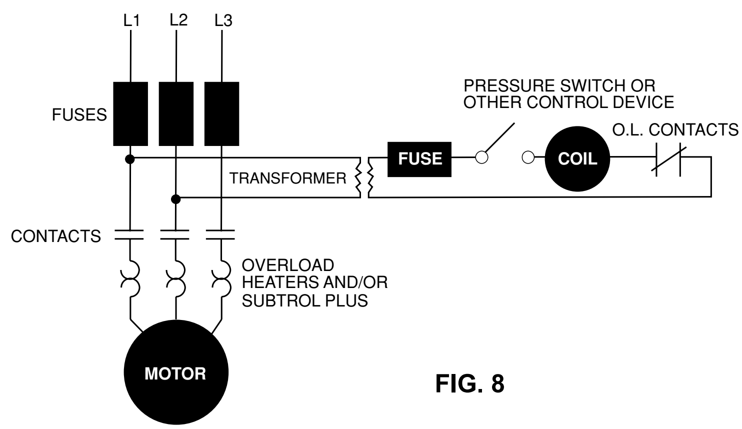


FIG. 8

External Voltage Controls

Control of a power circuit by a lower circuit voltage can also be obtained by connecting to a separate control voltage source. The coil rating must match the control voltage source, such as 115 or 24 volts.

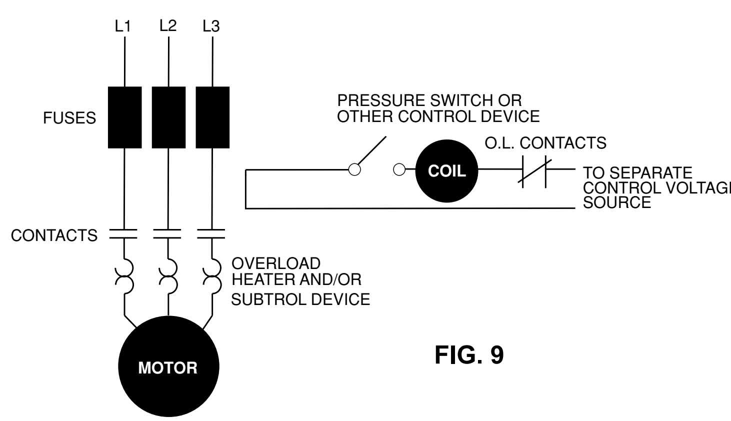


FIG. 9

Three-Phase Power Unbalance

A full three-phase supply is recommended for all three-phase motors, consisting of three individual transformers or one three-phase transformer. So-called "open" delta or Wye connections using only two transformers can be used, but are more likely to cause problems, such as poor performance, overload tripping or early motor failure due to current unbalance.

Transformer rating should be no smaller than listed in table 4 for supply power to the motor alone.

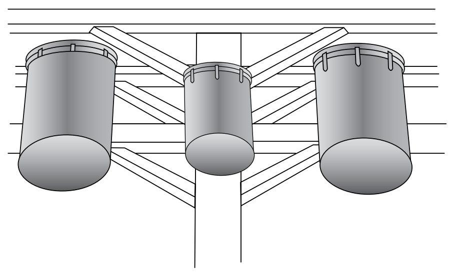


FIG. 10
FULL THREE-PHASE

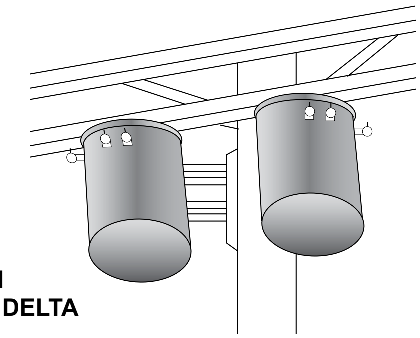


FIG. 11
OPEN DELTA

Checking and Correcting Rotation and Current Unbalance

1. Establish correct motor rotation by running the motor in both directions. Normal rotation is CCW viewing the shaft end. Rotation can be changed by interchanging any two of the three motor leads. The rotation that gives the most water flow is typically the correct rotation.
2. After correct rotation has been established, check the current in each of the three motor leads and calculate the current unbalance as explained in 3 below.

   If the current unbalance is 2% or less, leave the leads as connected.

   If the current unbalance is more than 2%, current readings should be checked on each leg using each of three possible hook-ups. Roll the motor leads across the starter in the same direction to prevent motor reversal.
3. To calculate percent of current unbalance:
   - A. Add the three line amps values together.
   - B. Divide the sum by three, yielding average current.
   - C. Pick the amp value which is furthest from the average current (either high or low).
   - D. Determine the difference between this amp value (furthest from average) and the average.
   - E. Divide the difference by the average. Multiply the result by 100 to determine percent of unbalance.
4. Current unbalance should not exceed 5% at max amp load or 10% at rated input load. If the unbalance cannot be corrected by rolling leads, the source of the unbalance must be located and corrected. If, on the three possible hookups, the leg farthest from the average stays on the same power lead, most of the unbalance is coming from the "power side" of the system. If the reading farthest from average moves with the same motor lead, the primary source of unbalance is on the "motor side" of the starter. In this instance, consider a damaged cable, leaking splice, poor connection, or faulty motor winding.

Phase designation of leads for CCW rotation viewing shaft end.

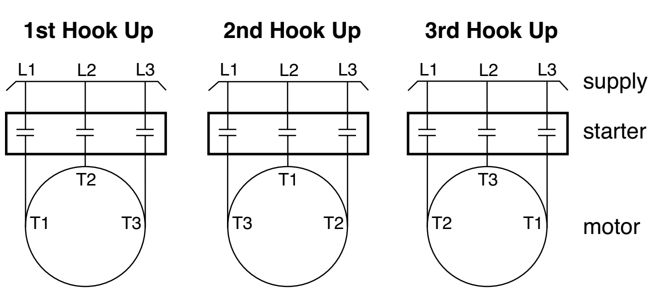
To reverse rotation, interchange any two leads.

Phase 1 or "A" - Black, T1, or U1

Phase 2 or "B" - Yellow, T2, or V1

Phase 3 or "C" - Red, T3, or W1

NOTICE: Phase 1, 2 and 3 may not be L1, L2 and L3.



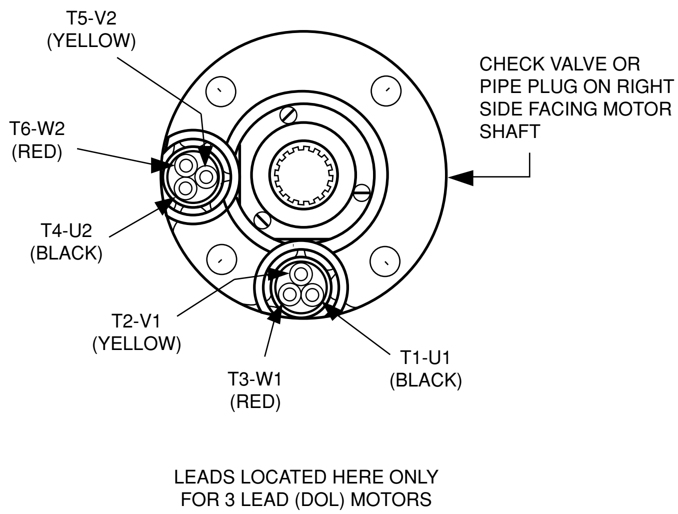
EXAMPLE:

T1 = 51 amps	T3 = 50 amps	T2 = 50 amps
T2 = 46 amps	T1 = 49 amps	T3 = 48 amps
+ T3 = 53 amps	+ T2 = 51 amps	+ T1 = 52 amps
Total = 150 amps	Total = 150 amps	Total = 150 amps
$\frac{150}{3}$ = 50 amps	$\frac{150}{3}$ = 50 amps	$\frac{150}{3}$ = 50 amps
50 - 46 = 4 amps	50 - 49 = 1 amp	50 - 48 = 2 amps
$\frac{4}{50}$ = 0.08 or 8%	$\frac{1}{50}$ = 0.02 or 2%	$\frac{2}{50}$ = 0.04 or 4%

Three-Phase Motor Lead Identification

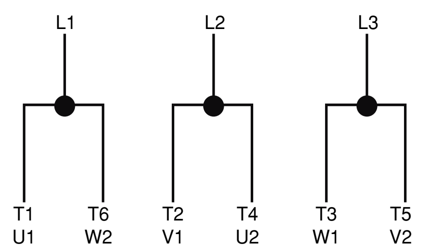
Line Connections — Six-Lead Motors

WARNING: When installing 6-lead motors extra care must be used to ensure lead identification at the surface. Leads must be marked and connected per diagram. Motor leads are not connected red to red, yellow to yellow, etc.

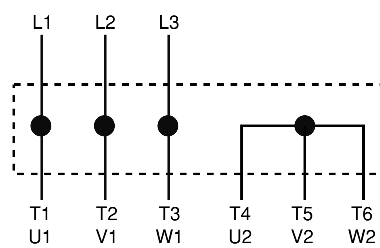


90° Lead Spacing

Connections for across-the-line starting, running, and any reduced voltage starting except WYE-DELTA type starters.



WYE-DELTA starters connect the motor as shown below during starting, then change to the running connection shown at the left.



Each motor lead is numbered with two markers, one near each end. To reverse rotation, interchange any two line connections.

Phase Converters

There are a number of different types of phase converters available. Each generates three-phase power from a single-phase power line.

In all phase converters, the voltage balance is critical to current balance. Although some phase converters may be well balanced at one point on the system-operating curve, submersible pumping systems often operate at differing points on the curve as water levels and operating pressures fluctuate. Other converters may be well balanced at varying loads, but their output may vary widely with fluctuations in the input voltage.

The following guidelines have been established for submersible installations to be warrantable when used with a phase converter.

1. Limit pump loading to rated horsepower. Do not load into motor service factor.
2. Maintain at least 3 ft/s flow past the motor. Use a flow sleeve when necessary.
3. Use time delay fuses or circuit breakers in pump panel. Standard fuses or circuit breakers do not provide secondary motor protection.
4. SubMonitor may be used with electro mechanical type phase converters, however special connections are required. Consult SubMonitor Manual for connections of receiver and lightning arrestor.
5. SubMonitor will not work with electronic solid state phase converters.
6. Current unbalance must not exceed 10%.

Reduced Voltage Starters

All Franklin three-phase submersible motors are suitable for full-voltage starting. Under this condition the motor speed goes from zero to full speed within a half second or less. The motor current goes from zero to locked rotor amps, then drops to running amps at full speed. This may dim lights, cause momentary voltage dips to other electrical equipment, and shock power distribution transformers.

In some cases the power companies may require reduced-voltage starters to limit this voltage dip. There are also times when reduced-voltage starters may be desirable to reduce motor starting torque thus reducing the stress on shafts, couplings, and discharge piping. Reduced-voltage starters also slow the rapid acceleration of the water on start-up to help control upthrust and water hammer.

Reduced-voltage starters may not be required if the maximum recommended cable length is used. With maximum recommended cable length there is a 5% voltage drop in the cable at running amps, resulting in about 20% reduction in starting current and about 36% reduction in starting torque compared to having rated voltage at the motor. This may be enough reduction in starting current so that reduced-voltage starters are not required.

Three-Lead Motors: Autotransformer or solid-state reduced-voltage starters may be used for soft-starting standard three-phase motors.

When autotransformer starters are used, the motor should be supplied with at least 55% of rated voltage to ensure adequate starting torque. Most autotransformer starters have 65% and 80% taps. Setting the taps on these starters depends on the percentage of the maximum allowable cable length used in the system. If the cable length is less than 50% of the maximum allowable, either the 65% or the 80% taps may be used. When the cable length is more than 50% of allowable, the 80% tap should be used.

Six-Lead Motors: Wye-Delta starters are used with six-lead Wye-Delta motors. All Franklin 6" and 8" three-phase motors are available in six-lead Wye-Delta construction. Consult the factory for details and availability. Part winding starters are not compatible with Franklin Electric submersible motors and should not be used.

Wye-Delta starters of the open-transition type, which momentarily interrupt power during the starting cycle, are not recommended. Closed-transition starters have no interruption of power during the start cycle and can be used with satisfactory results.

Reduced-voltage starters have adjustable settings for acceleration ramp time, typically preset at 30 seconds. They must be adjusted so the motor is at full voltage within THREE SECONDS MAXIMUM to prevent excessive radial and thrust bearing wear.

If Subtrol-Plus or SubMonitor is used the acceleration time must be set to TWO SECONDS MAXIMUM due to the 3 second reaction time of the Subtrol-Plus or SubMonitor.

Solid-state starters AKA soft starts may not be compatible with Subtrol-Plus/SubMonitor. However, in some cases a bypass contactor has been used. Consult the factory for details.

During shutdown, Franklin Electric's recommendation is for the power to be removed, allowing the pump/motor to coast down. Stopping the motor by ramping down the voltage is possible, but should be limited to three (3) seconds maximum.

Inline Booster Pump Systems

Franklin Electric offers three different types of motors for non-vertical applications.

1. The **Booster** motors are specifically designed for booster applications. They are the **"Best Choice" for sealed Reverse Osmosis applications.** These motors are the result of two years of focused development and bring additional value and durability to booster module systems. These motors are only available to OEMs or Distributors who have demonstrated capability in Booster Module systems design and operation and adhere to Franklin's Application Manual requirements.

2. The **Hi-Temp** motors have many of the internal design features of the Booster motor. It's additional length allows for higher temperature handling and the Sand Fighter sealing system provides greater abrasion resistance. One or both of these conditions are often experienced in open atmosphere applications such as lakes, ponds, etc.

3. The **Standard Vertical Water Well** (40-125 hp) motors can be adapted to non-vertical applications when applied per the below guidelines. However, they will be more sensitive to application variances than the other two designs.

All of the above motors must be applied per the guidelines listed below. In addition, for all applications where the motor is applied in a sealed system, a Submersible Motor Booster Installation Record (Form 3655) or its equivalent must be completed at startup and received by Franklin Electric within 60 days. A sealed system is one where the motor and pump intake are mounted in a sleeve and the water feeding the pump intake is not open to the atmosphere.

Continued on next page

Inline Booster Pump Systems (continued)

Design And Operational Requirements

1. **Non-Vertical Operation:** Vertical Shaft-up (0°) to Horizontal (90°) operation is acceptable as long as the pump transmits "down-thrust" to the motor within 3 seconds after start-up and continuously during operation. However, it is best practice to provide a positive slope whenever it is possible, even if it is only a few degrees.

2. **Motor, Sleeve, and Pump Support System:** The booster sleeve ID must be sized according to the motor cooling and pump NPSHR requirements. The support system must support the motor's weight, prevent motor rotation and keep the motor and pump aligned. The support system must also allow for thermal axial expansion of the motor without creating binding forces.

3. **Motor Support Points:** A minimum of two support points are required on the motor. One in the motor/pump flange connection area and one in the bottom end of the motor area. The motor castings, not the shell area, are recommended as support points. If the support is a full length support and/or has bands in the shell area, they must not restrict heat transfer or deform the shell.

4. **Motor Support Material and Design:** The support system shall not create any areas of cavitation or other areas of reduced flow less than the minimum rate required by this manual. They should also be designed to minimize turbulence and vibration and provide stable alignment. The support materials and locations must not inhibit the heat transfer away from the motor.

5. **Motor and Pump Alignment:** The maximum allowable misalignment between the motor, pump, and pump discharge is 0.025 inch per 12 inches of length (2 mm per 1000 mm of length). This must be measured in both directions along the assembly using the motor/pump flange connection as the starting point. The booster sleeve and support system must be rigid enough to maintain this alignment during assembly, shipping, operation and maintenance.

6. The best motor lubrication and heat resistance is obtained with the factory based propylene glycol fill solution. Only when an application MUST HAVE deionized (DI) water should the factory fill solution be replaced. When a deionized water fill is required, the motor must be derated as indicated on the below chart. The exchange of the motor fill solution to DI water must be done by an approved Franklin service shop or representative using a vacuum fill system per Franklin's Motor Service Manual instruction. The motor shell then must be permanently stamped with a D closely behind the Serial Number.

   The maximum pressure that can be applied to the motor internal components during the removal of the factory fill solution is 7 psi (0.5 bar.)

Derating Factor for Motors That Must Have Their Factory Fill Replaced With Deionized Water 8" Encapsulated Motor

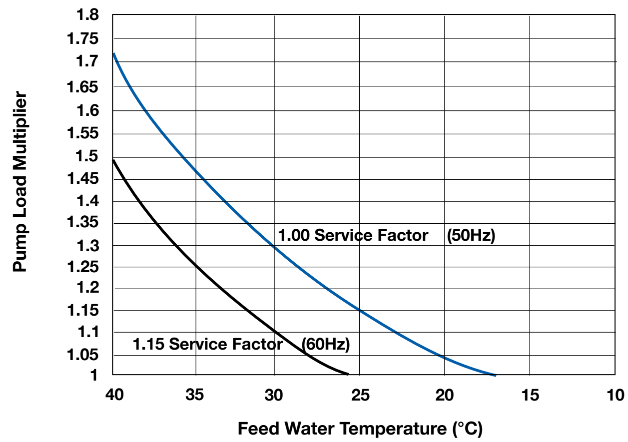


FIG. 12

First: Determine maximum Feed Water Temperature that will be experienced in this application. If the feed water exceeds the maximum ambient of the motor, both the DI water derating and a hot water application derating must be applied.

Second: Determine the Pump Load Multiplier from the appropriate Service Factor curve. (Typical 1.15 Service Factor is for 60 Hz ratings &1.00 Service Factor for 50 Hz ratings).

Third: Multiply the Pump Load Requirement times the pump load multiplier number indicated on the vertical axis to determine the Minimum Motor Nameplate Rating.

Fourth: Select a motor with a nameplate equal or higher than the above calculated value.

7. **Motor Alterations - Sand Slinger & Check Valve Plug:** On 6" and 8" motors, the rubber sand slinger located on the shaft must be removed. If a pipe plug is covering the check valve, it must be removed. The special Booster motor already has these modifications.

8. **Frequency of Starts:** Fewer than 10 starts per 24-hour period are recommended. Allow at least 20 minutes between shutdown and start-up of the motor.

Continued on next page

Inline Booster Pump Systems (continued)

9. **Controls-Soft Starters and VFDs:** Reduced voltage starters and variable speed drives (inverter drives) may be used with Franklin three-phase submersible motors to reduce starting current, upthrust, and mechanical stress during start-up. The guidelines for their use with submersible motors are different than with normal air cooled motor applications. Refer to the Franklin Electric Application, Installation and Maintenance (AIM) Manual Reduced Voltage Starters section or Variable Speed Submersible Pump Operation, Inverter Drives sections for specific details including required filtering.

10. **Motor Overload Protection:** Submersible motors require properly sized ambient compensated Class 10 quick-trip overloads per Franklin's AIM Manual guidelines to protect the motor. Class 20 or higher overloads are NOT acceptable. Franklin's SubMonitor is strongly recommended for all large submersibles since it is capable of sensing motor heat without any additional wiring to the motor. Applications using Soft Starters with a SubMonitor require a start-up bypass - consult the factory for details. SubMonitor can not be used in applications using a VFD control.

11. **Motor Surge Protection:** Properly sized, grounded and dedicated motor surge arrestors must be installed in the supply line of the booster module as close to the motor as possible. This is required on all systems including those using soft-starters and variable speed drives (inverter drives).

12. **Wiring:** Franklin's lead assemblies are only sized for submerged operation in water to the motor nameplate maximum ambient temperature and may overheat and cause failure or serious injury if operated in air. Any wiring not submerged must meet applicable national and local wiring codes and Franklin Cable Chart tables 16-21. (Notice: wire size, wire rating and insulation temperature rating must be known when determining its suitability to operate in air or conduit. Typically, for a given size and rating, as the insulation temperature rating increases its ability to operate in air or conduit also increases.)

13. **Check Valves:** Spring-loaded check valves must be used on start-up to minimize motor upthrusting, water hammer, or in multiple booster (parallel) applications to prevent reverse flow.

14. **Pressure Relief Valves:** A pressure relief valve is required and must be selected to ensure that, as the pump approaches shut-off, it never reaches the point that the motor will not have adequate cooling flow past it.

15. **System Purge (Can Flooding):** An air bleeder valve must be installed on the booster sleeve so that flooding may be accomplished prior to booster start-up. Once flooding is complete, the booster should be started and brought up to operating pressure as quickly as possible to minimize the duration of an upthrust condition. At no time should air be allowed to gather in the booster sleeve because this will prevent proper cooling of the motor and permanently damage it.

16. **System Flush – Must Not Spin Pump:** Applications may utilize a low flow flushing operation. Flow through the booster sleeve must not spin the pump impellers and the motor shaft. If spinning takes place, the bearing system will be permanently damaged and the motor life shortened. Consult the booster pump manufacturer for maximum flow rate through the pump when the motor is not energized.

Table 38 Franklin Cable chart (See 12. Wiring)

CABLE TEMP. RATING (°C)	MOTOR NAMEPLATE RATED AMPS FULL LOAD	#10 AWG		#8 AWG		#6 AWG		#4 AWG		#2 AWG	
		IN AIR	IN CONDUIT	IN AIR	IN CONDUIT	IN AIR	IN CONDUIT	IN AIR	IN CONDUIT	IN AIR	IN CONDUIT
75	3-LEAD (DOL)	40A	28A	56A	40A	76A	52A	100A	68A	136A	92A
	6-LEAD (Y-Δ)	69A	48A	97A	69A	132A	90A	173A	118A	236A	159A
90	3-LEAD (DOL)	44A	32A	64A	44A	84A	60A	112A	76A	152A	104A
	6-LEAD (Y-Δ)	76A	55A	111A	76A	145A	104A	194A	132A	263A	180A
125	3-LEAD (DOL)	66A	46A	77A	53A	109A	75A	153A	105A	195A	134A
	6-LEAD (Y-Δ)	114A	80A	133A	91A	188A	130A	265A	181A	337A	232A

Based on 30 °C maximum ambient with cable length of 100 feet or less.

Continued on next page

Inline Booster Pump Systems (continued)

17. **Open Atmosphere Booster Pump Systems:** When an open booster is placed in a lake, tank, etc. that is open to atmospheric pressure, the water level must provide sufficient head pressure to allow the pump to operate above its NPSHR requirement at all times and all seasons. Adequate inlet pressure must be provided prior to booster start-up.

Four Continuous Monitoring System Requirements for Sealed Booster Systems.

1. **Water Temperature:** Feed water on each booster must be continuously monitored and not allowed to exceed the motor nameplate maximum ambient temperature at any time. IF THE INLET TEMPERATURE EXCEEDS THE MOTOR NAMEPLATE MAXIMUM AMBIENT TEMPERATURE, THE SYSTEM MUST SHUTDOWN IMMEDIATELY TO PREVENT PERMANENT MOTOR DAMAGE. If feed water temperatures are expected to be above the allowable temperature, the motor must be derated. See Franklin's AIM Manual Hot Water Applications section for derating guidelines. (The high temperature feed water derating is in addition to the exchange to DI water derating if the motor factory fill solution was exchanged to DI water.)

2. **Inlet Pressure:** The inlet pressure on each booster module must be continuously monitored. It must always be positive and higher than the NPSHR (Net Positive Suction Head Requirement) of the pump. A minimum of 20 PSIG (1.38 Bar) is required at all times, except for 10 seconds or less when the motor is starting and the system is coming up to pressure. Even during these 10 seconds the pressure must remain positive and be higher than the NPSHR (Net Positive Suction Head Requirement) of the pump.

   PSIG is the actual value displayed on a pressure gauge in the system piping. PSIG is the pressure above the atmospheric conditions. If at any time these pressure requirements are not being met, the motor must be de-energized immediately to prevent permanent damage to the motor. Once the motor is damaged, it is usually not immediately noticeable, but progresses and results in a premature motor failure weeks or months after the damage occurred.

   Motors that will be exposed to pressure in excess of 500 psi (34.47 Bar) must undergo special high pressure testing. Consult factory for details and availability.

3. **Discharge Flow:** The flow rate for each pump must not be allowed to drop below the motor minimum cooling flow requirement. IF THE MOTOR MINIMUM COOLING FLOW REQUIREMENT IS NOT BEING MET FOR MORE THAN 10 SECONDS, THE SYSTEM MUST BE SHUT DOWN IMMEDIATELY TO PREVENT PERMANENT MOTOR DAMAGE.

4. **Discharge Pressure:** The discharge pressure must be monitored to ensure that a downthrust load toward the motor is present within 3 seconds after start-up and continuously during operation. IF THE MOTOR DISCHARGE PRESSURE IS NOT ADEQUATE TO MEET THIS REQUIREMENT, THE SYSTEM MUST BE SHUT DOWN IMMEDIATELY TO PREVENT PERMANENT MOTOR DAMAGE.

Variable Frequency Drive Submersible Motor Requirements

Franklin Electric's three-phase, encapsulated submersible motors can be used with variable frequency drives (VFD) when applied within the guidelines below.

All three-phase, encapsulated submersible motors must have the VFD sized based on the motor's nameplate maximum amps, not horsepower. The continuous rated amps of the VFD must be equal to or greater than the motor's nameplate maximum amps or warranty will be void.

Franklin Electric's single-phase, 2- and 3-wire, encapsulated submersible motors can only be used with the appropriate Franklin constant pressure controller.

Franklin Electric's submersible motor Application Installation Maintenance (AIM) manual should be checked for the latest guidelines and can be found online at www.franklin-electric.com.

WARNING: There is a potential shock hazard from contact with and/or touching the insulated cables connected to the variable frequency drive output anytime the motor has energy applied.

Output Filter Requirement Test:

NOTICE: An incoming power supply or line-side filter for the drive does not replace the need for additional output filters.

An output filter is required if the answer is yes to one or both of the items below:
#1 - Is the VFD's pulse width modulation (PWM) voltage rise-time (dV/dt) more than 500 Volts per micro-second (500 V/μ-second)?

#2 - Is the motor nameplate voltage more than 379 Volts and is the cable from drive-to-motor more than 50 ft (15.2 m)?

NOTICE:
More than 99% of the drives applied on water well submersible motors will require the purchase of additional output filtering based on question #1.

Output filters can be expensive. However, when needed, it is required for the motor to be considered for warranty. Make sure this item is not overlooked when quoting a job.

PWM dV/dt value can be defined as: the rate at which voltage is changing with time or how fast the voltage is accelerating. This information can be supplied by the drive manufacturer or the manufacturer's drive specification sheet. The dV/dt value cannot be measured with typical field equipment, even when using a true-RMS voltage/amperage multi-meter.

Franklin Electric has a line of VFDs that are specifically designed for Franklin application systems. These VFDs are used in the MonoDrive and SubDrive constant pressure systems. Franklin drive systems have the required additional output filtering installed; however, the SubDrive HPX does not.

Types of Output Filters:

A resistor-inductor-capacitor (RLC) filter has both a high pass filter & a low pass filter section and are considered the best practice, but a high pass reactor filter is also acceptable.

Filters should be recommended by the drive manufacturer; for the correct recommendations provide them with answers to all five of the items below.

REQUIRED ITEMS FOR PROPER VFD FILTER SIZING:
(1) VFD model (2) Carrier frequency setting (3) Motor nameplate voltage (4) Motor nameplate max amps (5) Cable length from the drive output terminals to the motor

Input Current & Motor Overload Protection:

- Motor input current should be set at the system's typical operating current when running at nameplate rated voltage and frequency (Hz).
- Motor overload protection should be set to trip at 115% of the system's typical operating current.
- Motor overload protection must trip equal to or faster than NEMA Class 10 motor overload curve requirements.

Motor Maximum Load Limits:

- The system must never operate in excess of the motor nameplate maximum amps.
- On 50 Hz motors, nameplate amps are maximum amps as these motors have a 1.0 service factor.

Variable Frequency Drive Submersible Motor Requirements

Motor Operating Hertz, Cooling Requirements & Underload Settings:

- Standard practice for large VFD installations is to limit the operation to 60 Hz max. Operating at greater than 60 Hz requires special system design considerations.
- The motor must never operate below 30 Hz. This is the minimum speed required to provide correct bearing lubrication.
- The motor's operating speed must always operate so the minimum water flow requirements of 0.5 ft/sec for 6-inch & 8-inch motors and 0.25 ft/sec for 4-inch motors is supplied.
- The motor underload protection is normally set to trip at 80% of the system's typical operating current. However, the underload trip point must be selected so that minimum flow requirements are always met.

Starting & Stopping Ramp Settings:

- The motor must reach or pass the 30 Hz operating speed within 1 second of the motor being energized. If this does not occur, the motor bearings will be damaged and the motor life reduced.
- The best stopping method is to turn power off followed by a natural coast to stop.
- A controlled stop from 30 Hz to 0 Hz is allowed if the time does not exceed 1 second.

Drive Carrier Frequency:

- The carrier frequency is set in the field. The drive typically has a selectable range between 2k and 12k Hz. The higher the carrier wave frequency setting, the greater the voltage spikes; the lower the carrier wave frequency setting, the rougher/poorer the shape of the power curve.
- The carrier frequency should be set within the range of 4k to 5k Hz for encapsulated submersible motors.

Application Function Setting:

- If the VFD has a setting of centrifugal pump or propeller fan it should be used.
- Centrifugal pumps and fans have similar load characteristics.

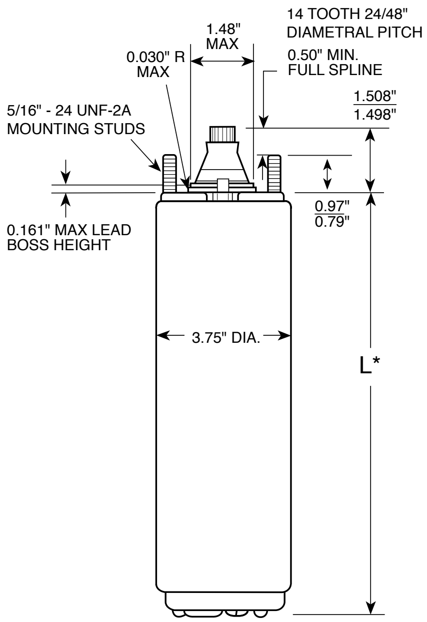
VFD Frequency of Starts:

- Keeping the starts per day within the recommended numbers shown in the frequency of starts section of the AIM manual provides the best system life. However, since in-rush current is typically reduced when used with a properly configured VFD, large 3-phase submersible motors can be started more frequently. In all cases a minimum of 7 minutes must be allowed between a power off and the next restart attempt or consecutive restart attempts.

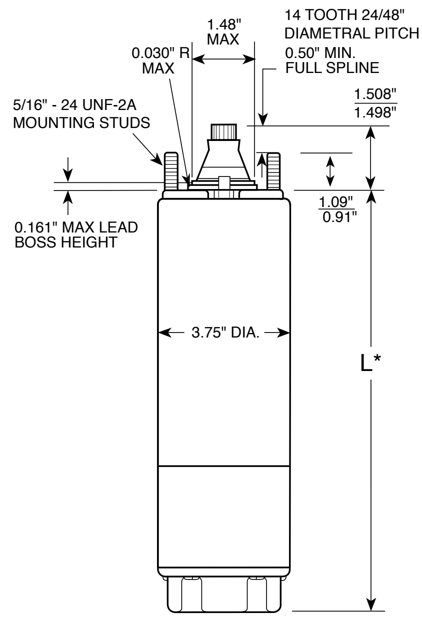
NEMA MG1 Above Ground Motor Standard Comments:

- Franklin Electric encapsulated submersible motors are not declared inverter duty motors by NEMA MG1 standards. The reason is NEMA MG1 standard part 31 does not include a section covering encapsulated winding designs.
- Franklin submersible motors can be used with VFDs without problems or warranty concerns providing Franklin's Application Installation Maintenance (AIM) manual guidelines are followed. See Franklin's on-line AIM manual for the latest guidelines.

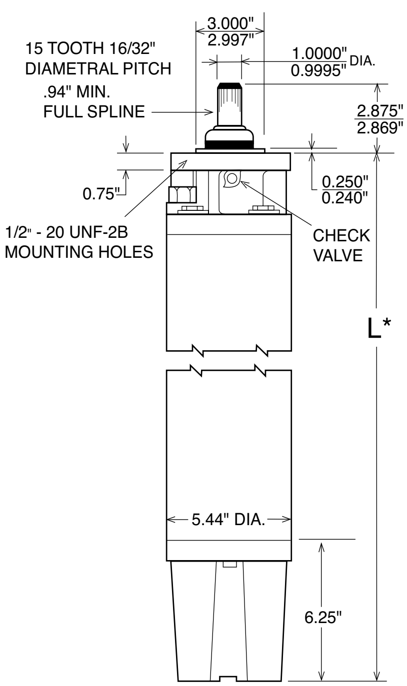
4" Super Stainless — Dimensions
(Standard Water Well)



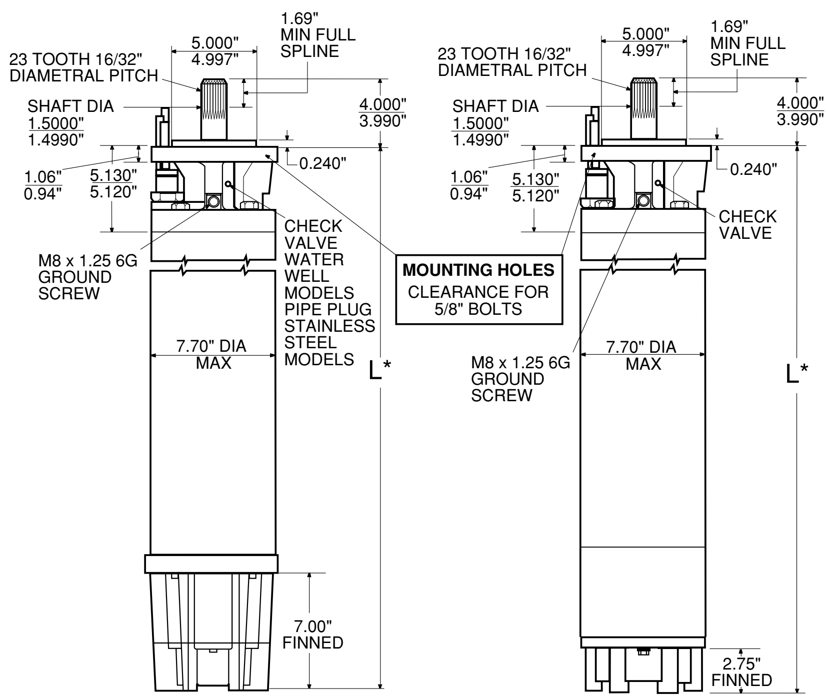
4" High Thrust — Dimensions
(Standard Water Well)



6" — Dimensions
(Standard Water Well)



8" — Dimensions
(Standard Water Well)



40 to 100 hp

125 to 200 hp

*** Motor lengths and shipping weights are available on Franklin Electric's web site (www.franklin-electric.com) or by calling Franklin's submersible hotline (800-348-2420).**

Tightening Motor Lead Connector Jam Nut

4" Motors with Jam Nut:
15 to 20 ft-lb (20 to 27 Nm)

4" Motors with 2 Screw Clamp Plate:
35 to 45 in-lb (4.0 to 5.1 Nm)

6" Motors:
40 to 50 ft-lb (54 to 68 Nm)

8" Motors with 1-3/16" to 1-5/8" Jam Nut:
50 to 60 ft-lb (68 to 81 Nm)

8" Motors with 4 Screw Clamp Plate:
Apply increasing torque to the screws equally in a criss-cross pattern until 80 to 90 in-lb (9.0 to 10.2 Nm) is reached.

Jam nut tightening torques recommended for field assembly are shown. Rubber compression set within the first few hours after assembly may reduce the jam nut torque. This is a normal condition which does not indicate reduced seal effectiveness. Retightening is not required, but is permissible and recommended if original torque was questionable.

A motor lead assembly should not be reused. A new lead assembly should be used whenever one is removed from the motor, because rubber set and possible damage from removal may prevent proper resealing of the old lead.

All motors returned for warranty consideration must have the lead returned with the motor.

Pump to Motor Coupling

Assemble coupling with non-toxic FDA approved waterproof grease such as Mobile FM102, Texaco CYGNUS2661, or approved equivalent. This prevents abrasives from entering the spline area and prolongs spline life.

Pump to Motor Assembly

After assembling the motor to the pump, torque mounting fasteners to the following:

4" Pump and Motor: 10 lb-ft (14 Nm)

6" Pump and Motor: 50 lb-ft (68 Nm)

8" Pump and Motor: 120 lb-ft (163 Nm)

Shaft Height and Free End Play

Table 42

MOTOR	NORMAL SHAFT HEIGHT		DIMENSION SHAFT HEIGHT		FREE END PLAY	
					MIN.	MAX.
4"	1 1/2"	38.1 mm	1.508" / 1.498"	38.30 / 38.05 mm	0.010" 0.25 mm	0.045" 1.14 mm
6"	2 7/8"	73.0 mm	2.875" / 2.869"	73.02 / 72.88 mm	0.030" 0.76 mm	0.050" 1.27 mm
8" TYPE 1	4"	101.6 mm	4.000" / 3.990"	101.60 / 101.35 mm	0.008" 0.20 mm	0.032" 0.81 mm
8" TYPE 2.1	4"	101.6 mm	4.000" 3.990"	101.60 101.35 mm	0.030" 0.76 mm	0.080" 2.03 mm

If the height, measured from the pump-mounting surface of the motor, is low and/or end play exceeds the limit, the motor thrust bearing is possibly damaged, and should be replaced.

Submersible Leads and Cables

A common question is why motor leads are smaller than specified in Franklin's cable charts.

The leads are considered a part of the motor and actually are a connection between the large supply wire and the motor winding. The motor leads are short and there is virtually no voltage drop across the lead.

In addition, the lead assemblies **operate under water**, while at least part of the supply cable must **operate in air.** Lead assemblies running under water operate cooler.

CAUTION: Lead assemblies on submersible motors are suitable only for use in water and may overheat and cause failure if operated in air.

System Troubleshooting

Motor Does Not Start

POSSIBLE CAUSE	CHECKING PROCEDURES	CORRECTIVE ACTION
A. No power or incorrect voltage.	Check voltage at line terminals. The voltage must be ± 10% of rated voltage.	Contact power company if voltage is incorrect.
B. Fuses blown or circuit breakers tripped.	Check fuses for recommended size and check for loose, dirty or corroded connections in fuse receptacle. Check for tripped circuit breakers.	Replace with proper fuse or reset circuit breakers.
C. Defective pressure switch.	Check voltage at contact points. Improper contact of switch points can cause voltage less than line voltage.	Replace pressure switch or clean points.
D. Control box malfunction.	For detailed procedure, see pages 48-56.	Repair or replace.
E. Defective wiring.	Check for loose or corroded connections or defective wiring	Correct faulty wiring or connections.
F. Bound pump.	Check for misalignment between pump and motor or a sand bound pump. Amp readings will be 3 to 6 times higher than normal until the overload trips	Pull pump and correct problem. Run new installation until the water clears
G. Defective cable or motor.	For detailed procedure, see pages 46 & 47.	Repair or replace.

Motor Starts Too Often

A. Pressure switch.	Check setting on pressure switch and examine for defects.	Reset limit or replace switch.
B. Check valve - stuck open.	Damaged or defective check valve will not hold pressure.	Replace if defective.
C. Waterlogged tank.	Check air charge	Clean or replace.
D. Leak in system.	Check system for leaks.	Replace damaged pipes or repair leaks.

System Troubleshooting

Motor Runs Continuously

POSSIBLE CAUSE	CHECKING PROCEDURES	CORRECTIVE ACTION
A. Pressure switch.	Check switch for welded contacts. Check switch adjustments.	Clean contacts, replace switch, or adjust setting.
B. Low water level in well.	Pump may exceed well capacity. Shut off pump, wait for well to recover. Check static and drawdown level from well head.	Throttle pump output or reset pump to lower level. Do not lower if sand may clog pump.
C. Leak in system.	Check system for leaks.	Replace damaged pipes or repair leaks.
D. Worn pump.	Symptoms of worn pump are similar to those of drop pipe leak or low water level in well. Reduce pressure switch setting, if pump shuts off worn parts may be the fault.	Pull pump and replace worn parts.
E. Loose coupling or broken motor shaft.	Check for loose coupling or damaged shaft.	Replace worn or damaged parts.
F. Pump screen blocked.	Check for clogged intake screen.	Clean screen and reset pump depth.
G. Check valve stuck closed.	Check operation of check valve.	Replace if defective.
H. Control box malfunction.	See pages 47-55 for single-phase.	Repair or replace.

Motor Runs But Overload Protector Trips

A. Incorrect voltage.	Using voltmeter, check the line terminals. Voltage must be within ± 10% of rated voltage.	Contact power company if voltage is incorrect.
B. Overheated protectors.	Direct sunlight or other heat source can raise control box temperature causing protectors to trip. The box must not be hot to touch.	Shade box, provide ventilation or move box away from source.
C. Defective control box.	For detailed procedures, see pages 47-55.	Repair or replace.
D. Defective motor or cable.	For detailed procedures, see pages 45 & 46.	Repair or replace.
E. Worn pump or motor.	Check running current, see tables 13, 22, 24 & 27.	Replace pump and/or motor.

Table 45 Preliminary Tests - All Sizes Single- and Three-Phase

TEST	PROCEDURE	WHAT IT MEANS
Insulation Resistance	1. Open master breaker and disconnect all leads from control box or pressure switch (QD type control, remove lid) to avoid electric shock hazard and damage to the meter. 2. Use a megohmmeter or set the scale lever to R X 100K on an ohmmeter. Zero the meter. 3. Connect one meter lead to any one of the motor leads and the other lead to the metal drop pipe. If the drop pipe is plastic, connect the meter lead to ground.	1. If the ohms value is normal (table 46), the motor is not grounded and the cable insulation is not damaged. 2. If the ohms value is below normal, either the windings are grounded or the cable insulation is damaged. Check the cable at the well seal as the insulation is sometimes damaged by being pinched.
Winding Resistance	1. Open master breaker and disconnect all leads from control box or pressure switch (QD type control, remove lid) to avoid electric shock hazard and damage to the meter. 2. Set the scale lever to R X 1 for values under 10 ohms. For values over 10 ohms, set the scale lever to R X 10. “zero” the ohmmeter. 3. On 3-wire motors measure the resistance of yellow to black (main winding) and yellow to red (start winding). On 2-wire motors: measure the resistance from line-to-line. Three-phase motors: measure the resistance line-to-line for all three combinations.	1. If all ohms values are normal (tables 13, 22, 24 & 27), the motor windings are neither shorted nor open, and the cable colors are correct 2. If any one value is less than normal, the motor is shorted. 3. If any one ohm value is greater than normal, the winding or the cable is open, or there is a poor cable joint or connection. 4. If some ohms values are greater than normal and some less on single-phase motors, the leads are mixed. See page 46 to verify cable colors.

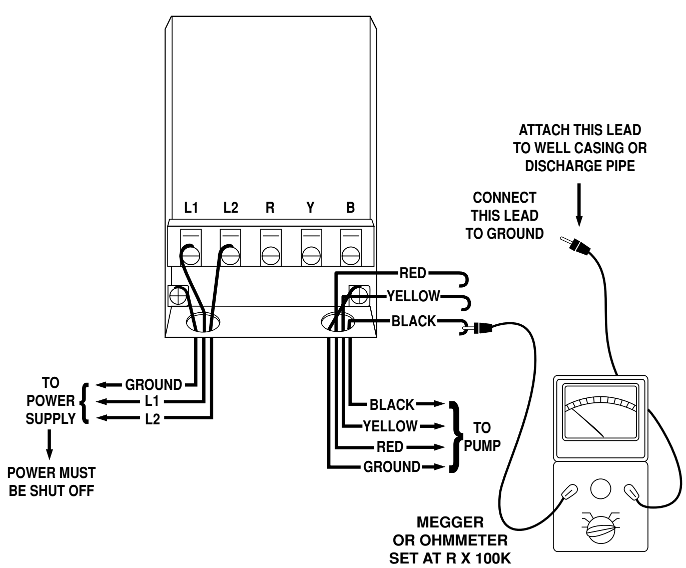


FIG. 13

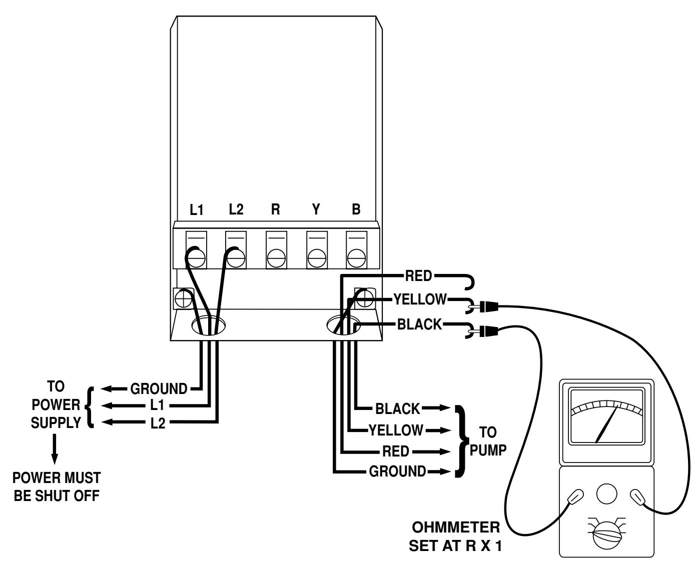


FIG. 14

Insulation Resistance Readings

Table 46 Normal ohm and Megohm Values Between All Leads and Ground

CONDITION OF MOTOR AND LEADS	OHMS VALUE	MEGOHM VALUE
A new motor (without drop cable).	200,000,000 (or more)	200.0 (or more)
A used motor which can be reinstalled in well.	10,000,000 (or more)	10.0 (or more)
MOTOR IN WELL. READINGS ARE FOR DROP CABLE PLUS MOTOR.		
New motor.	2,000,000 (or more)	2.0 (or more)
Motor in good condition.	500,000 - 2,000,000	0.50 - 2.0
Insulation damage, locate and repair.	Less than 500,000	Less than .50

Insulation resistance varies very little with rating. Motors of all hp, voltage, and phase rating have similar values of insulation resistance.

The table above is based on readings taken with a megohm meter with a 500 VDC output. Readings may vary using a lower voltage ohmmeter, consult Franklin Electric if readings are in question.

Resistance of Drop Cable (ohms)

The values below are for copper conductors. If aluminum conductor drop cable is used, the resistance will be higher. To determine the actual resistance of the aluminum drop cable, divide the ohm readings from this chart by 0.61. This chart shows total resistance of cable from control to motor and back.

Winding Resistance Measuring

The winding resistance measured at the motor should fall within the values in tables 13, 22, 24 & 27. When measured through the drop cable, the resistance of the drop cable must be subtracted from the ohmmeter readings to get the winding resistance of the motor. See table below.

Table 46A DC Resistance in ohms per 100 ft of Wire (Two conductors) @ 50 °F

AWG OR MCM WIRE SIZE (COPPER)	14	12	10	8	6	4	3	2
OHMS	0.544	0.338	0.214	0.135	0.082	0.052	0.041	0.032

1	1/0	2/0	3/0	4/0	250	300	350	400	500	600	700
0.026	0.021	0.017	0.013	0.010	0.0088	0.0073	0.0063	0.0056	0.0044	0.0037	0.0032

Identification Of Cables When Color Code Is Unknown (Single-Phase 3-Wire Units)

If the colors on the individual drop cables cannot be found with an ohmmeter, measure:

Cable 1 to Cable 2
Cable 2 to Cable 3
Cable 3 to Cable 1

Find the highest resistance reading.

The lead not used in the highest reading is the yellow lead.

Use the yellow lead and each of the other two leads to get two readings:

Highest is the red lead.
Lowest is the black lead.

EXAMPLE:
The ohmmeter readings were:

Cable 1 to Cable 2 - 6 ohms
Cable 2 to Cable 3 - 2 ohms
Cable 3 to Cable 1 - 4 ohms

The lead not used in the highest reading (6 ohms) was

Cable 3—Yellow

From the yellow lead, the highest reading (4 ohms) was

To Cable 1—Red

From the yellow lead, the lowest reading (2 ohms) was

To Cable 2—Black

Single-Phase Control Boxes

Checking and Repairing Procedures (Power On)

WARNING: Power must be on for these tests. Do not touch any live parts.

A. VOLTAGE MEASUREMENTS

Step 1. Motor Off

1. Measure voltage at L1 and L2 of pressure switch or line contactor.
2. Voltage Reading: Should be ± 10% of motor rating.

Step 2. Motor Running

1. Measure voltage at load side of pressure switch or line contactor with pump running.
2. Voltage Reading: Should remain the same except for slight dip on starting. Excessive voltage drop can be caused by loose connections, bad contacts, ground faults, or inadequate power supply.
3. Relay chatter is caused by low voltage or ground faults.

B. CURRENT (AMP) MEASUREMENTS

1. Measure current on all motor leads.
2. Amp Reading: Current in red lead should momentarily be high, then drop within one second to values in table 13. This verifies relay or solid state relay operation. Current in black and yellow leads should not exceed values in table 13.
3. Relay or switch failures will cause red lead current to remain high and overload tripping.
4. Open run capacitor(s) will cause amps to be higher than normal in the black and yellow motor leads and lower than normal in the red motor lead.
5. A bound pump will cause locked rotor amps and overloading tripping.
6. Low amps may be caused by pump running at shutoff, worn pump, or stripped splines.
7. Failed start capacitor or open switch/relay are indicated if the red lead current is not momentarily high at starting.

CAUTION: The tests in this manual for components such as capacitors, relays, and QD switches should be regarded as indicative and not as conclusive. For example, a capacitor may test good (not open, not shorted) but may have lost some of its capacitance and may no longer be able to perform its function.

Ohmmeter Tests

QD, Solid State Control Box (Power Off)

A. START CAPACITOR AND RUN CAPACITOR IF APPLICABLE (CRC)

1. Meter Setting: R x 1,000.
2. Connections: Capacitor terminals.
3. Correct meter reading: Pointer should swing toward zero, then back to infinity.

B. Q.D. (BLUE) RELAY

Step 1. Triac Test

1. Meter setting: R x 1,000.
2. Connections: Cap and B terminal.
3. Correct meter reading: Infinity for all models.

Step 2. Coil Test

1. Meter Setting: R x 1.
2. Connections: L1 and B.
3. Correct meter reading: Zero ohms for all models.

C. POTENTIAL (VOLTAGE) RELAY

Step 1. Coil Test

1. Meter setting: R x 1,000.
2. Connections: #2 & #5.
3. Correct meter readings:

   For 115 Volt Boxes:
   0.7-1.8 (700 to 1,800 ohms).

   For 230 Volt Boxes:
   4.5-7.0 (4,500 to 7,000 ohms).

Step 2. Contact Test

1. Meter setting: R x 1.
2. Connections: #1 & #2.
3. Correct meter reading: Zero for all models.

Ohmmeter Tests

Integral Horsepower Control Box (Power Off)

A. OVERLOADS (Push Reset Buttons to make sure contacts are closed.)

1. Meter Setting: R x 1.
2. Connections: Overload terminals.
3. Correct meter reading: Less than 0.5 ohms.

B. CAPACITOR (Disconnect leads from one side of each capacitor before checking.)

1. Meter Setting: R x 1,000.
2. Connections: Capacitor terminals.
3. Correct meter reading: Pointer should swing toward zero, then drift back to infinity, except for capacitors with resistors which will drift back to 15,000 ohms.

C. POTENTIAL (VOLTAGE) RELAY

Step 1. Coil Test

1. Meter setting: R x 1,000.
2. Connections: #2 & #5.
3. Correct meter readings: 4.5-7.0 (4,500 to 7,000 ohms) for all models.

Step 2. Contact Test

1. Meter Setting: R x 1.
2. Connections: #1 & #2.
3. Correct meter reading: Zero ohms for all models.

D. CONTACTOR

Step 1. Coil

1. Meter setting: R x 100
2. Connections: Coil terminals
3. Correct meter reading:
   1.8-14.0 (180 to 1,400 ohms)

Step 2. Contacts

1. Meter Setting: R X 1
2. Connections: L1 & T1 or L2 & T2
3. Manually close contacts
4. Correct meter reading: Zero ohms

CAUTION: The tests in this manual for components such as capacitors, relays, and QD switches should be regarded as indicative and not as conclusive. For example, a capacitor may test good (not open, not shorted) but may have lost some of its capacitance and may no longer be able to perform its function.

Table 49 QD Control Box Parts 60 Hz

HP	VOLTS	CONTROL BOX MODEL NUMBER	QD (BLUE) RELAY	START CAPACITOR	MFD	VOLTS	RUN CAPACITOR	MFD	VOLTS
1/3	115	280 102 4915	223 415 905	275 464 125	159-191	110			
	230	280 103 4915	223 415 901	275 464 126	43-53	220			
1/2	115	280 104 4915	223 415 906	275 464 201	250-300	125			
	230	280 105 4915	223 415 902	275 464 105	59-71	220			
	230	282 405 5015 (CRC)	223 415 912	275 464 126	43-53	220	156 362 101	15	370
3/4	230	280 107 4915	223 415 903	275 464 118	86-103	220			
	230	282 407 5015 (CRC)	223 415 913	275 464 105	59-71	220	156 362 102	23	370
1	230	280 108 4915	223 415 904	275 464 113	105-126	220			
	230	282 408 5015 (CRC)	223 415 914	275 464 118	86-103	220	156 362 102	23	370

Table 49A QD Capacitor Replacement Kits

CAPACITOR NUMBER	KIT
275 464 105	305 207 905
275 464 113	305 207 913
275 464 118	305 207 918
275 464 125	305 207 925
275 464 126	305 207 926
275 464 201	305 207 951
156 362 101	305 203 907
156 362 102	305 203 908

Table 49B Overload Kits 60 Hz

HP	VOLTS	KIT (1)
1/3	115	305 100 901
1/3	230	305 100 902
1/2	115	305 100 903
1/2	230	305 100 904
3/4	230	305 100 905
1	230	305 100 906

(1) For Control Boxes with model numbers that end with 4915.

Table 49C QD Relay Replacement Kits

QD RELAY NUMBER	KIT
223 415 901	305 101 901
223 415 902	305 101 902
223 415 903	305 101 903
223 415 904	305 101 904
223 415 905	305 101 905
223 415 906	305 101 906
223 415 912 (CRC)	305 105 901
223 415 913 (CRC)	305 105 902
223 415 914 (CRC)	305 105 903

FOOTNOTES:

(1) Control boxes supplied with QD Relays are designed to operate on 230-volt systems. For 208-volt systems or where line voltage is between 200 volts and 210 volts use the next larger cable size, or use a boost transformer to raise the voltage.

(2) Voltage relays kits for 115-volts (305 102 901) and 230-volts (305 102 902) will replace current, voltage or QD Relays, and solid state switches.

Table 50 Integral Horsepower Control Box Parts 60 Hz

MOTOR SIZE	MOTOR RATING HP	CONTROL BOX (1) MODEL NO.	CAPACITORS PART NO. (2)	CAPACITORS MFD.	CAPACITORS VOLTS	CAPACITORS QTY.	OVERLOAD (2) PART NO.	RELAY (3) PART NO.	CONTACTOR (2) PART NO.
4"	1 - 1.5 STANDARD	282 300 8110 (See Note 5)	275 464 113 S 155 328 102 R	105-126 10	220 370	1 1	275 411 107	155 031 102	
		282 300 8110 (See Note 5)	275 464 113 S 155 328 101 R	105-126 15	220 370	1 1	275 411 114 S 275 411 113 M	155 031 102	
		282 300 8610	275 464 113 S 155 328 101 R	105-126 15	220 370	1 1	None (See Note 4)	155 031 102	
4"	2 STANDARD	282 301 8110	275 464 113 S 155 328 103 R	105-126 20	220 370	1 1	275 411 117 S 275 411 113 M	155 031 102	
4"	2 DELUXE	282 301 8310	275 464 113 S 155 328 103 R	105-126 20	220 370	1 1	275 411 117 S 275 411 113 M	155 031 102	155 325 102 L
4"	3 STANDARD	282 302 8110	275 463 123 S 155 327 109 R	208-250 45	220 370	1 1	275 411 118 S 275 411 115 M	155 031 102	
4"	3 DELUXE	282 302 8310	275 463 123 S 155 327 109 R	208-250 45	220 370	1 1	275 411 118 S 275 411 115 M	155 031 102	155 325 102 L
4" & 6"	5 STANDARD	282 113 8110	275 468 119 S 155 327 114 R	270-324 40	330 370	1 2	275 411 119 S 275 406 102 M	155 031 601	
4" & 6"	5 DELUXE	282 113 9310	275 468 119 S 155 327 114 R	270-324 40	330 370	1 2	275 411 119 S 275 406 102 M	155 031 601	155 326 101 L
6"	7.5 STANDARD	282 201 9210	275 468 119 S 275 468 118 S 155 327 109 R	270-324 216-259 45	330 330 370	1 1 1	275 411 102 S 275 406 122 M	155 031 601	
6"	7.5 DELUXE	282 201 9310	275 468 119 S 275 468 118 S 155 327 109 R	270-324 216-259 45	330 330 370	1 1 1	275 411 102 S 275 406 121 M	155 031 601	155 326 102 L
6"	10 STANDARD	282 202 9210	275 468 119 S 275468 120 S 155 327 102 R	270-324 350-420 35	330 330 370	1 1 2	275 406 103 S 155 409 101 M	155 031 601	
6"	10 STANDARD	282 202 9230	275 463 120 S 275 468 118 S 275 468 119 S 155 327 102 R	130-154 216-259 270-324 35	330 330 330 370	1 1 1 2	275 406 103 S 155 409 101 M	155 031 601	
6"	10 DELUXE	282 202 9310	275 468 119 S 275468 120 S 155 327 102 R	270-324 350-420 35	330 330 370	1 1 2	275 406 103 S 155 409 101 M	155 031 601	155 326 102 L
6"	10 DELUXE	282 202 9330	275 463 120 S 275 468 118 S 275 468 119 S 155 327 102 R	130-154 216-259 270-324 35	330 330 330 370	1 1 1 2	275 406 103 S 155 409 101 M	155 031 601	155 326 102 L
6"	15 DELUXE	282 203 9310	275 468 120 S 155 327 109 R	350-420 45	330 370	2 3	275 406 103 S 155 409 102 M	155 031 601	155 429 101 L
6"	15 DELUXE	282 203 9330	275 463 122 S 275 468 119 S 155 327 109 R	161-193 270-324 45	330 330 370	1 2 3	275 406 103 S 155 409 102 M	155 031 601	155 429 101 L
6"	15 X-LARGE	282 203 9621	275 468 120 S 155 327 109 R	350-420 45	330 370	2 3	275 406 103 S 155 409 102 M	155 031 601 2 required	155 429 101 L

FOOTNOTES:

(1) Lightning arrestors 150 814 902 are suitable for all control boxes.

(2) S = Start, M = Main, L = Line, R = Run
Deluxe = Control box with line contactor.

(3) For 208-volt systems or where line voltage is between 200 volts and 210 volts, a low voltage relay is required. On 3 hp and smaller control boxes use relay part 155 031 103 in place of 155 031 102 and use the next larger cable size than specified in the 230-volt table. On 5 hp and larger use relay 155 031 602 in place of 155 031 601 and next larger wire. Boost transformers per page 15 are an alternative to special relays and cable.

(4) Control box model 282 300 8610 is designed for use with motors having internal overload protectors. If used with a 1.5 hp motor manufactured prior to date code 06H18, Overload/Capacitor Kit 305 388 901 is required.

(5) Control box model 282 300 8110 with date code 11C19 (March 2011) and newer contain 15 MFD run capacitor and both start and run overloads. This box is designed for use with any Franklin 1.5 hp motor.

Table 51 Integral hp Capacitor Replacement Kits

CAPACITOR NUMBER	KIT
275 463 120	305 206 920
275 463 122	305 206 922
275 463 123	305 206 923
275 464 113	305 207 913
275 468 118	305 208 918
275 468 119	305 208 919
275 468 120	305 208 920
155 327 101	305 203 901
155 327 102	305 203 902
155 327 109	305 203 909
155 327 114	305 203 914
155 328 101	305 204 901
155 328 102	305 204 902
155 328 103	305 204 903

Table 51A Integral hp Overload Replacement Kits

OVERLOAD NUMBER	KIT
275 406 102	305 214 902
275 406 103	305 214 903
275 406 121	305 214 921
275 406 122	305 214 922
275 411 102	305 215 902
275 411 107	305 215 907
275 411 108	305 215 908
275 411 113	305 215 913
275 411 114	305 215 914
275 411 115	305 215 915
275 411 117	305 215 917
275 411 118	305 215 918
275 411 119	305 215 919

Table 51B Integral hp Voltage Relay Replacement Kits

RELAY NUMBER	KIT
155 031 102	305 213 902
155 031 103	305 213 903
155 031 601	305 213 961
155 031 602	305 213 962

Table 51C Integral hp Contactor Replacement Kits

CONTACTOR	KIT
155 325 102	305 226 902
155 326 101	305 347 903
155 326 102	305 347 902
155 429 101	305 347 901

FOOTNOTES:

(1) The following kit number changes were made for number consistency purposes only. Parts in the kit did not change.

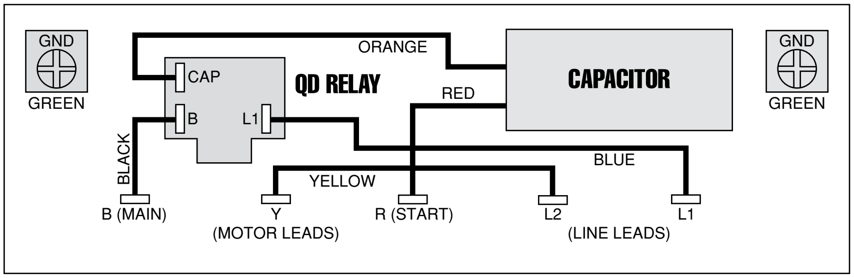
305 206 922 was 305 206 912

305 206 923 was 305 206 911

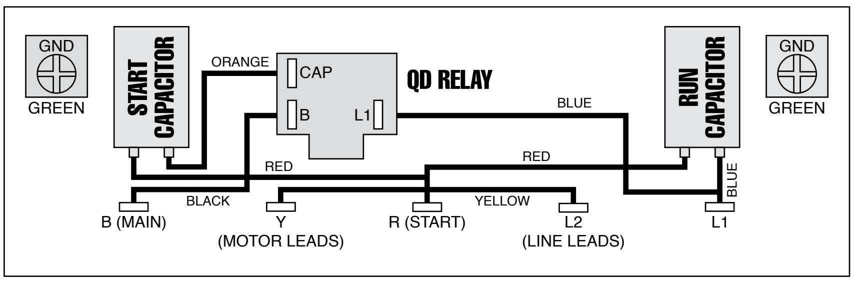
305 213 962 was 305 213 904

305 226 902 was 305 226 901

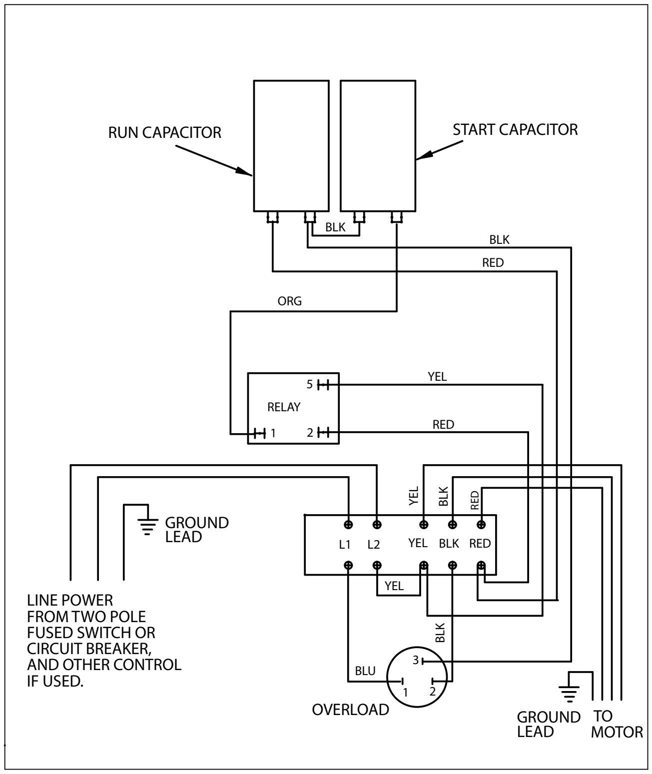
Control Box Wiring Diagrams



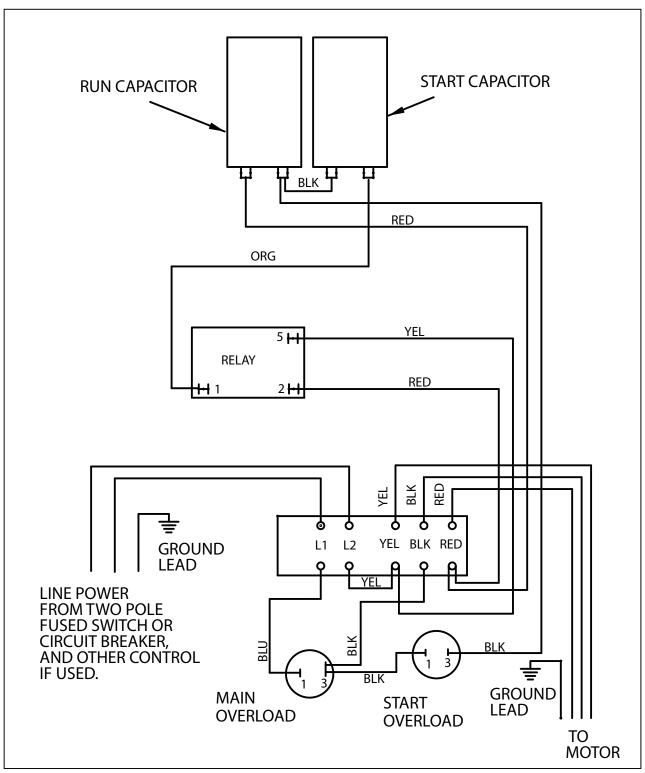
1/3 - 1 hp QD RELAY
280 10_ 4915
Sixth digit depends on hp



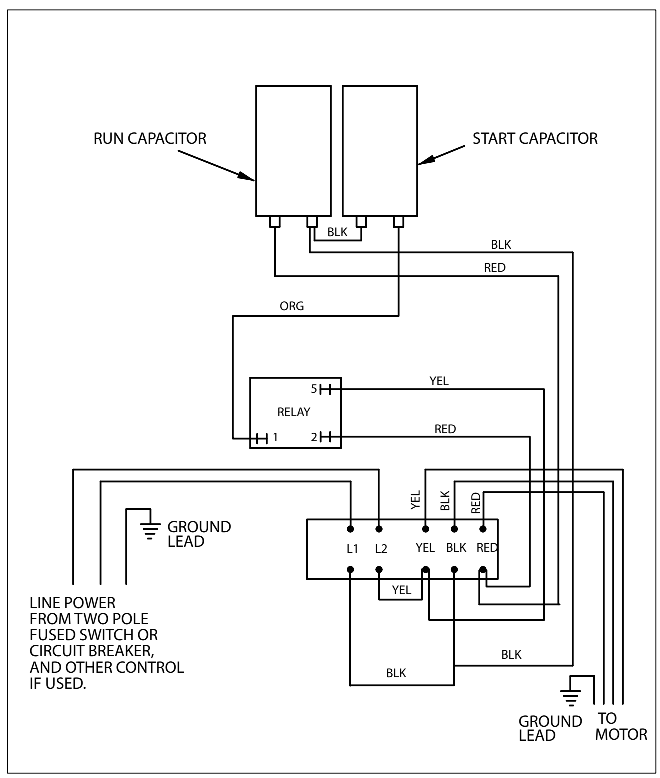
1/2 - 1 hp CRC QD RELAY
282 40_ 5015
Sixth digit depends on hp



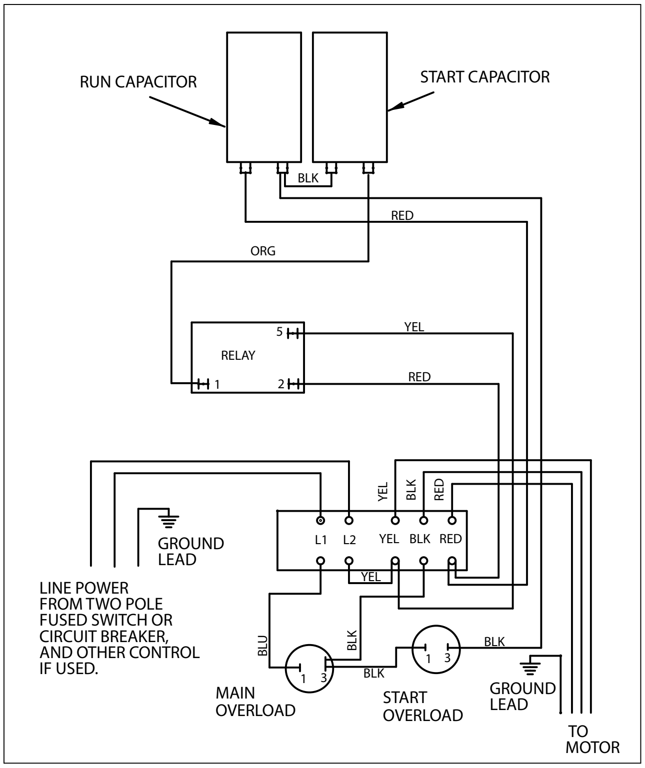
1 - 1.5 hp
282 300 8110
(Date Codes 11C19 & Older)



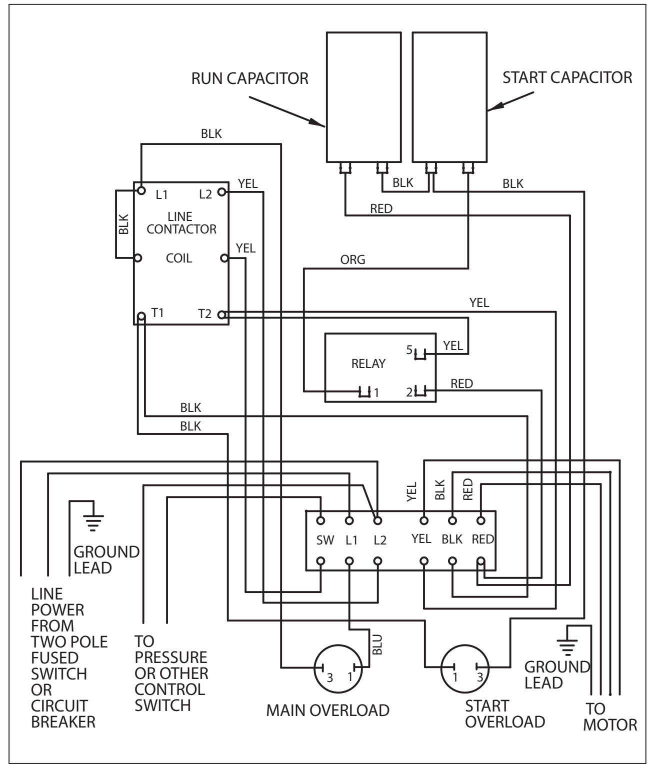
1 - 1.5 hp
282 300 8110
(Date Codes 11C19 & Newer)



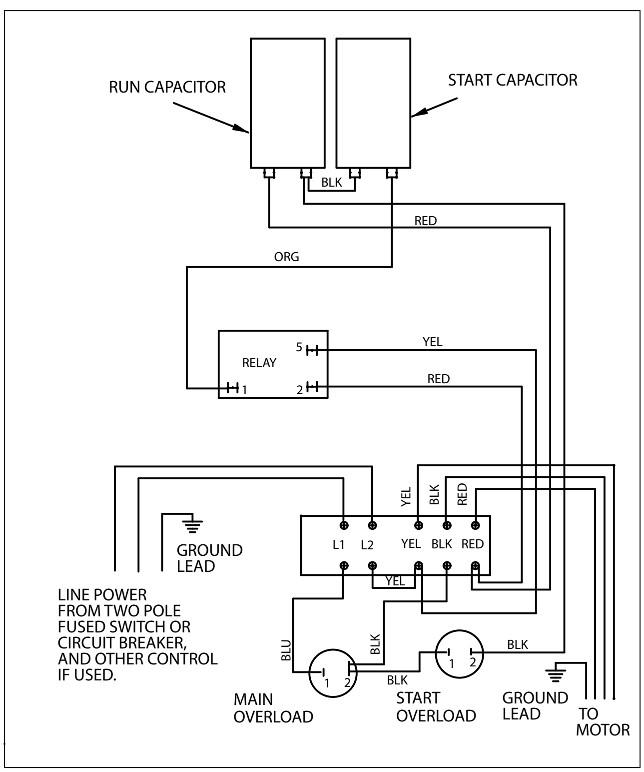
1 - 1.5 hp
282 300 8610



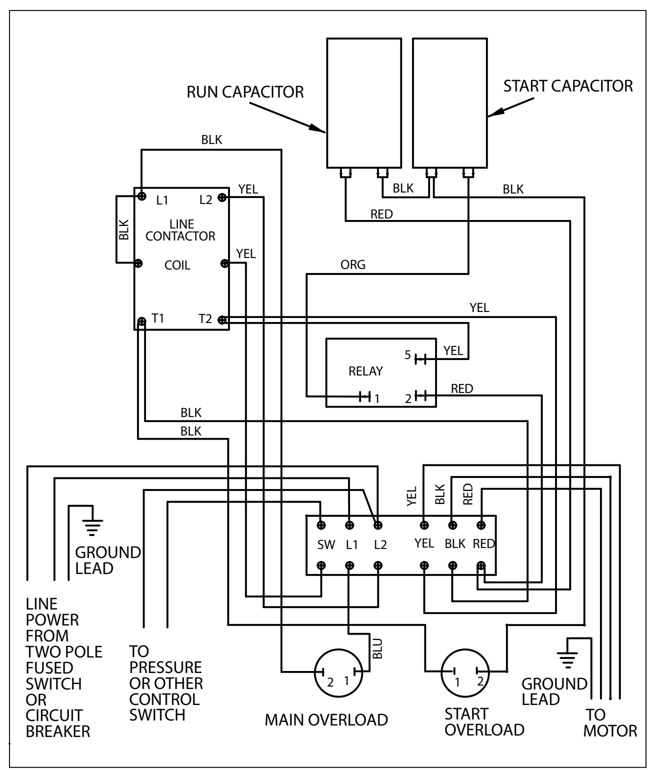
2 hp STANDARD
282 301 8110



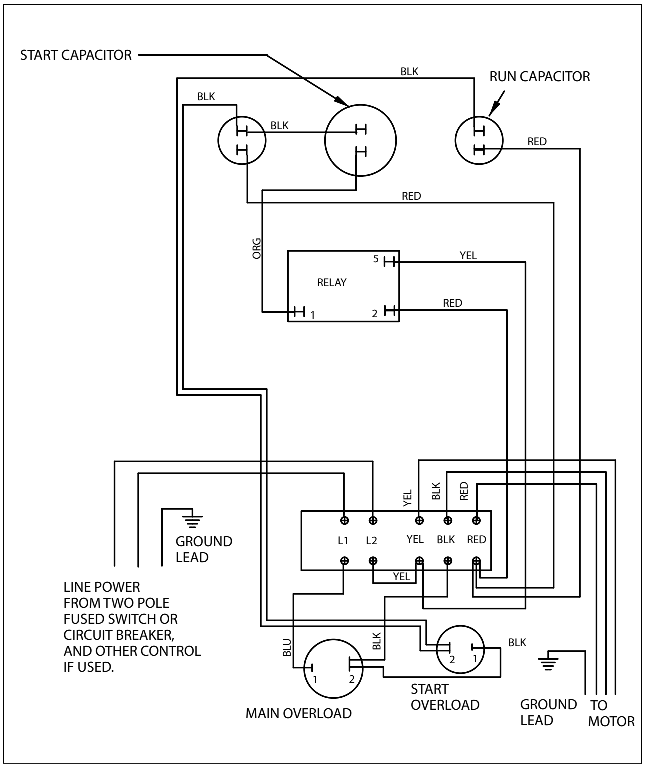
2 hp DELUXE
282 301 8310



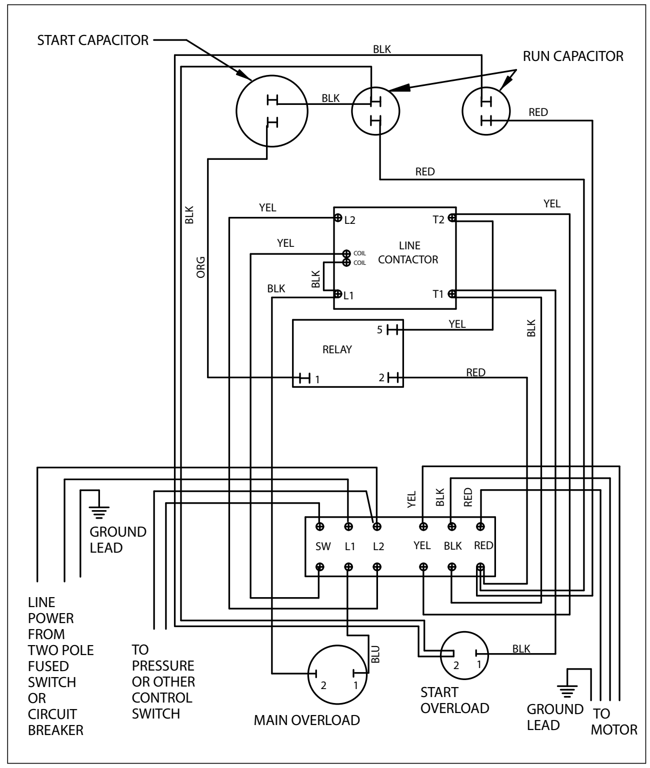
3 hp STANDARD
282 302 8110



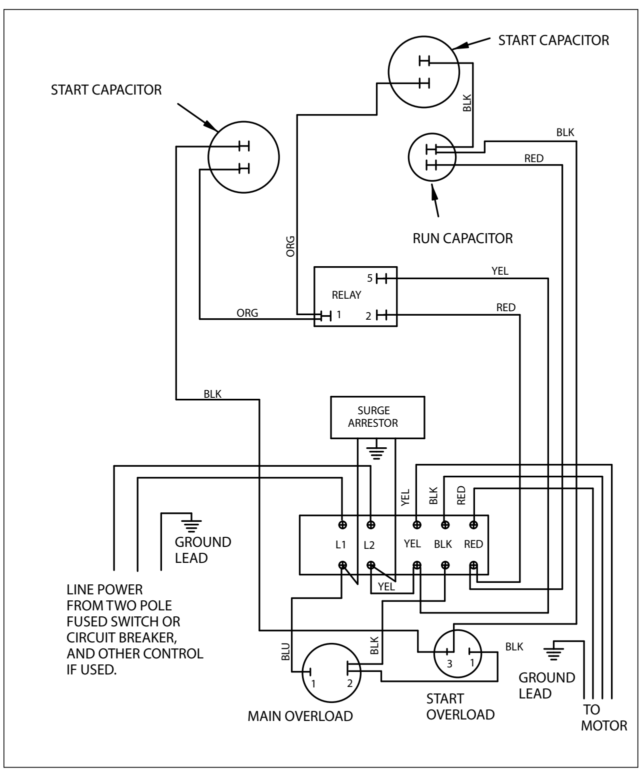
3 hp DELUXE
282 302 8310



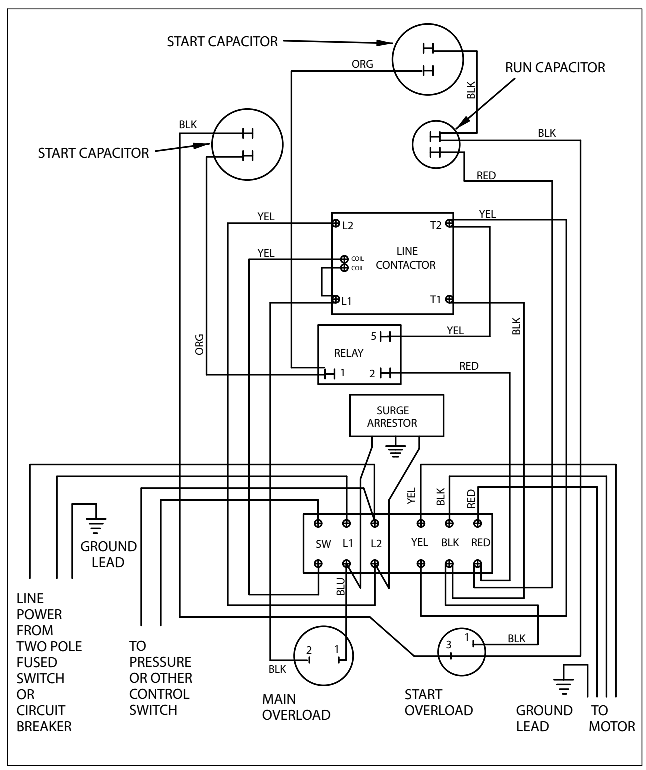
5 hp STANDARD
282 113 8110



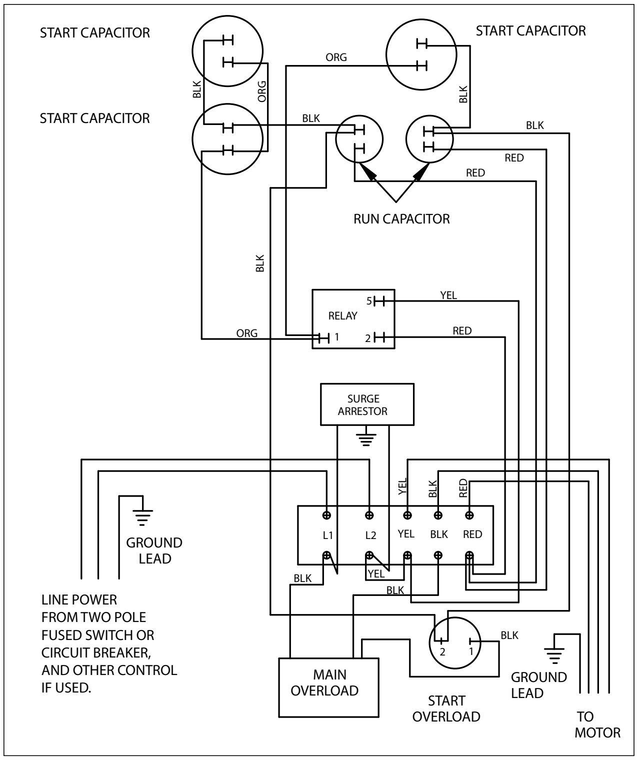
5 hp DELUXE
282 113 8310 or 282 113 9310



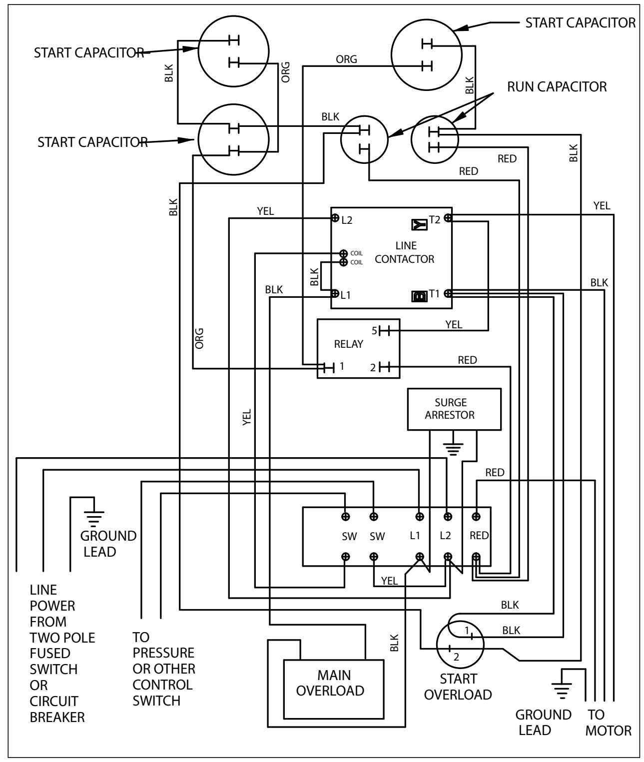
7.5 hp STANDARD
282 201 9210



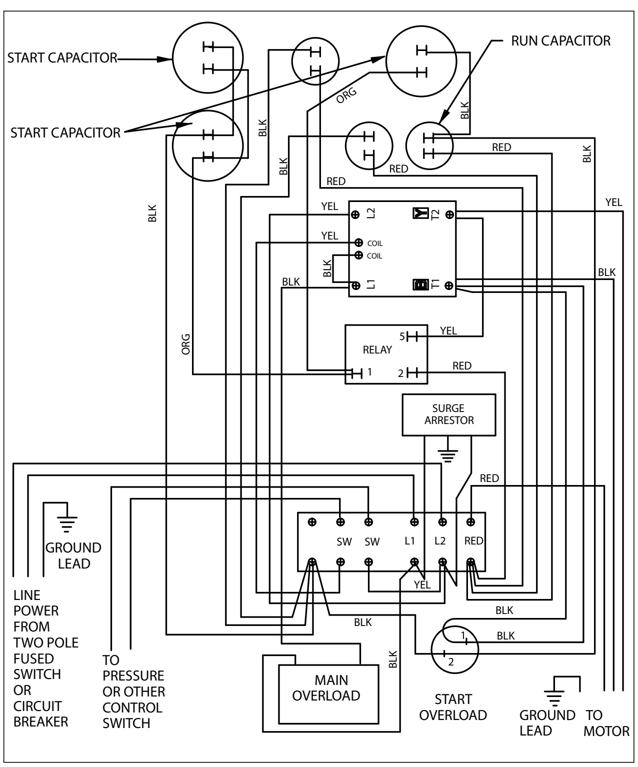
7.5 hp DELUXE
282 201 9310



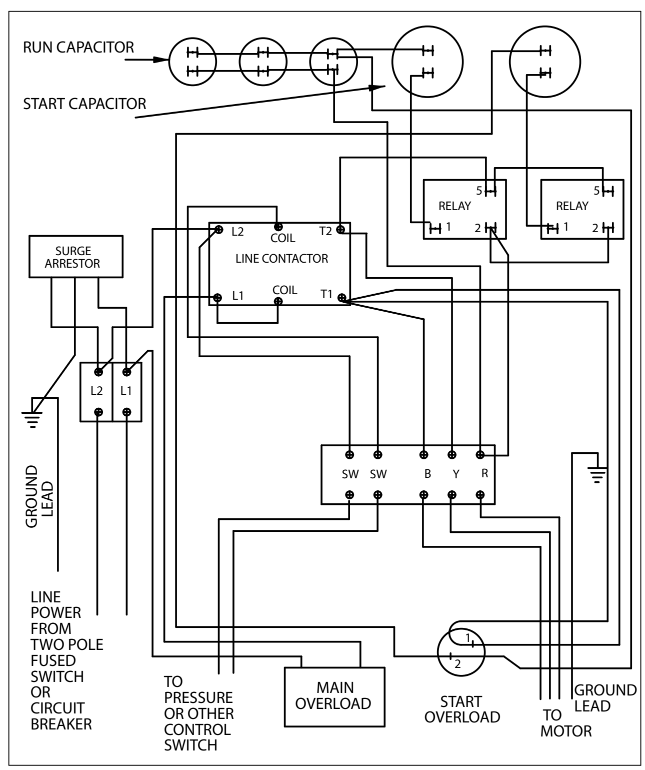
10 hp STANDARD
282 202 9210 or 282 202 9230



10 hp DELUXE
282 202 9230 or 282 202 9330



15 hp DELUXE
282 203 9310 or 282 203 9330



15 hp X-LARGE
282 203 9621

Pumptec-Plus

Pumptec-Plus is a pump/motor protection device designed to work on any 230 V single-phase induction motor (PSC, CSCR, CSIR, and split phase) ranging in size from 1/2 to 5 horsepower. Pumptec-Plus uses a micro-computer to continuously monitor motor power and line voltage to provide protection against dry well, water logged tank, high and low voltage and mud or sand clogging.

Pumptec-Plus – Troubleshooting During Installation

SYMPTOM	POSSIBLE CAUSE	SOLUTION
Unit Appears Dead (No Lights)	No Power to Unit	Check wiring. Power supply voltage should be applied to L1 and L2 terminals of the Pumptec-Plus. In some installations the pressure switch or other control devices is wired to the input of the Pumptec-Plus. Make sure this switch is closed.
Flashing Yellow Light	Unit Needs to Be Calibrated	Pumptec-Plus is calibrated at the factory so that it will overload on most pump systems when the unit is first installed. This overload condition is a reminder that the Pumptec-Plus unit requires calibration before use. See step 7 of the installation instructions.
	Miscalibrated	Pumptec-Plus should be calibrated on a full recovery well with the maximum water flow. Flow restrictors are not recommended.
Flashing Yellow Light During Calibration	2-Wire Motor	Step C of the calibration instructions indicate that a flashing green light condition will occur 2 to 3 seconds after taking the SNAPSHOT of the motor load. On some two-wire motors the yellow light will flash instead of the green light. Press and release the reset button. The green should start flashing.
Flashing Red and Yellow Lights	Power Interruption	During the installation of Pumptec-Plus power may be switched on and off several times. If power is cycled more than four times within a minute Pumptec-Plus will trip on rapid cycle. Press and release the reset button to restart the unit.
	Float Switch	A bobbing float switch may cause the unit to detect a rapid cycle condition on any motor or an overload condition on two-wire motors. Try to reduce water splashing or use a different switch.
Flashing Red Light	High Line Voltage	The line voltage is over 253 volts. Check line voltage. Report high line voltage to the power company.
	Unloaded Generator	If you are using a generator the line voltage may become too high when the generator unloads. Pumptec-Plus will not allow the motor to turn on again until the line voltage returns to normal. Overvoltage trips will also occur if line frequency drops too far below 60 Hz.
Solid Red Light	Low Line Voltage	The line voltage is below 207 volts. Check line voltage.
	Loose Connections	Check for loose connections which may cause voltage drops.
	Loaded Generator	If you are using a generator the line voltage may become too low when the generator loads. Pumptec-Plus will trip on undervoltage if the generator voltage drops below 207 volts for more than 2.5 seconds. Undervoltage trips will also occur if the line frequency rises too far above 60 Hz.

Pumptec-Plus

Pumptec-Plus - Troubleshooting After Installation

SYMPTOM	POSSIBLE CAUSE	SOLUTION
Solid Yellow Light	Dry Well	Wait for the automatic restart timer to time out. During the time out period the well should recover and fill with water. If the automatic reset timer is set to the manual position, then the reset button must be pressed to reactivate the unit.
	Blocked Intake	Clear or replace pump intake screen.
	Blocked Discharge	Remove blockage in plumbing.
	Check Valve Stuck	Replace check valve.
	Broken Shaft	Replace broken parts.
	Severe Rapid Cycling	Machine gun rapid cycling can cause an underload condition. See flashing red and yellow lights section below.
	Worn Pump	Replace worn pump parts and recalibrate.
Yellow Flashing Light	Stalled Motor	Repair or replace motor. Pump may be sand or mud locked.
	Float Switch	A bobbing float switch can cause two-wire motors to stall. Arrange plumbing to avoid splashing water. Replace float switch.
	Ground Fault	Check insulation resistance on motor and control box cable.
Solid Red Light	Low Line Voltage	The line voltage is below 207 volts. Pumptec-Plus will try to restart the motor every two minutes until line voltage is normal.
	Loose Connections	Check for excessive voltage drops in the system electrical connections (i.e. circuit breakers, fuse clips, pressure switch, and Pumptec-Plus L1 and L2 terminals). Repair connections.
Flashing Red Light	High Line Voltage	The line voltage is over 253 volts. Check line voltage. Report high line voltage to the power company.
Flashing Red and Yellow Lights	Rapid Cycle	The most common cause for the rapid cycle condition is a waterlogged tank. Check for a ruptured bladder in the water tank. Check the air volume control or snifter valve for proper operation. Check setting on the pressure switch and examine for defects.
	Leaky Well System	Replace damaged pipes or repair leaks.
	Stuck Check Valve	Failed valve will not hold pressure. Replace valve.
	Float Switch	Press and release the reset button to restart the unit. A bobbing float switch may cause the unit to detect a rapid cycle condition on any motor or an overload condition on 2-wire motors. Try to reduce water splashing or use a different switch.

QD Pumptec and Pumptec

QD Pumptec and Pumptec are load sensing devices that monitor the load on submersible pumps/motors. If the load drops below a preset level for a minimum of 4 seconds the QD Pumptec or the Pumptec will shut off the motor.

The QD Pumptec is designed and calibrated expressly for use on Franklin Electric 230 V 3-wire motors (1/3 to 1 hp.) The QD Pumptec must be installed in QD relay boxes.

The Pumptec is designed for use on Franklin Electric 2- and 3-wire motors (1/3 to 1.5 hp) 115 and 230 V. The Pumptec is not designed for jet pumps.

QD Pumptec & Pumptec – Troubleshooting

SYMPTOM	CHECKS OR SOLUTION
If the QD Pumptec or Pumptec trips in about 4 seconds with some water delivery.	A. Is the voltage less than 90% of nameplate rating? B. Are the pump and motor correctly matched? C. Is the **QD Pumptec** or **Pumptec** wired correctly? For the **Pumptec** check the wiring diagram and pay special attention to the positioning of the power lead (230 V or 115 V). D. For **QD Pumptec** is your system 230 V 60 Hz or 220 V 50 Hz?
If the QD Pumptec or Pumptec trips in about 4 seconds with no water delivery.	A. The pump may be airlocked. If there ia a check valve on top of the pump, put another section of pipe between the pump and the check valve. B. The pump may be out of water. C. Check the valve settings. The pump may be dead-heading. D. Pump or motor shaft may be broken. E. Motor overload may be tripped. Check the motor current (amperage).
If the QD Pumptec or Pumptec will not timeout and reset.	A. Check switch position on side of circuit board on **Pumptec**. **QD Pumptec** check timer position on top/front of unit. Make sure the switch is not between settings. B. If the reset time switch is set to manual reset (position 0), **QD Pumptec** and **Pumptec** will not reset (turn power off for 5 sec. then back on to reset).
If your pump/motor will not run at all.	A. Check voltage. B. Check wiring. C. Remove the **QD Pumptec** from the control box. Reconnect wires in box to original state. If motor does not run the problem is not **QD Pumptec**. Bypass **Pumptec** by connecting L2 and motor lead with jumper. Motor should run. If not, the problem is not **Pumptec**. D. On **Pumptec** only check that **Pumptec** is installed between the control switch and the motor.
If your QD Pumptec or Pumptec will not trip when the pump breaks suction.	A. Be sure you have a Franklin motor. B. Check wiring connections. On **Pumptec** is lead power (230 V or 115 V) connected to correct terminal? Is motor lead connected to correct terminal? C. Check for ground fault in the motor and excessive friction in the pump. D. The well may be "gulping" enough water to keep **QD Pumptec** or **Pumptec** from tripping. It may be necessary to adjust the **QD Pumptec** or the **Pumptec** for these extreme applications. Call the Franklin Electric Service Hotline at 800-348-2420 for information. E. On **Pumptec** applications does the control box have a run capacitor? If so, **Pumptec** will not trip. (Except for Franklin 1.5 hp motors).
If your QD Pumptec or Pumptec chatters when running.	A. Check for low voltage. B. Check for waterlogged tank. Rapid cycling for any reason can cause the **QD Pumptec** or the **Pumptec** relay to chatter. C. On **Pumptec** make sure the L2 and motor wires are installed correctly. If they are reversed, the unit can chatter.

SubDrive2W, 75, 100, 150, 300, MonoDrive, & MonoDrive XT

The Franklin Electric SubDrive/MonoDrive Constant Pressure controller is a variable-speed drive that delivers water at a constant pressure.

WARNING: Serious or fatal electrical shock may result from failure to connect the motor, SubDrive/MonoDrive Controller, metal plumbing and all other metal near the motor or cable to the power supply ground terminal using wire no smaller than motor cable wires. To reduce the risk of electrical shock, disconnect power before working on or around the water system. Capacitors inside the SubDrive/MonoDrive Controller can still hold a lethal voltage even after power has been removed. Allow 10 minutes for dangerous internal voltage to discharge. Do not use motor in swimming areas.

SubDrive2W, 75, 100, 150, 300, MonoDrive, & MonoDrive XT

SubDrive/MonoDrive Troubleshooting

Should an application or system problem occur, built-in diagnostics will protect the system. The “FAULT” light or digital display on the front of the SubDrive/MonoDrive Controller will flash a given number of times or display a number indicating the nature of the fault. In some cases, the system will shut itself off until corrective action is taken. Fault codes and their corrective actions are listed below. See SubDrive/MonoDrive Installation Manual for installation data.

NUMBER OF FLASHES OR DIGITAL DISPLAY	FAULT	POSSIBLE CAUSE	CORRECTIVE ACTION
1	MOTOR UNDERLOAD	- Overpumped well - Broken shaft or coupling - Blocked screen, worn pump - Air/gas locked pump - SubDrive not set properly for pump end	- Frequency near maximum with less than 65% of expected load, 42% if DIP #3 is “on” - System is drawing down to pump inlet (out of water) - High static, light loading pump - reset DIP switch #3 to “on” for less sensitivity if not out of water - Check pump rotation (SubDrive only) reconnect if necessary for proper rotation - Air/gas locked pump - if possible, set deeper in well to reduce - Verify DIP switches are set properly
2	UNDERVOLTAGE	- Low line voltage - Misconnected input leads	- Line voltage low, less than approximately 150 VAC (normal operating range = 190 to 260 VAC) - Check incoming power connections and correct or tighten if necessary - Correct incoming voltage - check circuit breaker or fuses, contact power company
3	LOCKED PUMP	- Motor and/or pump misalignment - Dragging motor and/or pump - Abrasives in pump	- Amperage above SFL at 10 Hz - Remove and repair or replace as required
4 (MonoDrive & MonoDriveXT only)	INCORRECTLY WIRED	- MonoDrive only - Wrong resistance values on main and start	- Wrong resistance on DC test at start - Check wiring, check motor size and DIP switch setting, adjust or repair as needed
5	OPEN CIRCUIT	- Loose connection - Defective motor or drop cable - Wrong motor	- Open reading on DC test at start. - Check drop cable and motor resistance, tighten output connections, repair or replace as necessary, use “dry” motor to check drive functions, if drive will not run and exhibits underload fault replace drive
6	SHORT CIRCUIT	- When fault is indicated immediately after power-up, short circuit due to loose connection, defective cable, splice or motor	- Amperage exceeded 50 amps on DC test at start or max amps during running - Incorrect output wiring, phase to phase short, phase to ground short in wiring or motor - If fault is present after resetting and removing motor leads, replace drive
	OVER CURRENT	- When fault is indicated while motor is running, over current due to loose debris trapped in pump	- Check pump
7	OVERHEATED DRIVE	- High ambient temperature - Direct sunlight - Obstruction of airflow	- Drive heat sink has exceeded max rated temperature, needs to drop below 85 °C to restart - Fan blocked or inoperable, ambient above 125 °F, direct sunlight, air flow blocked - Replace fan or relocate drive as necessary
8 (SubDrive300 only)	OVER PRESSURE	- Improper pre-charge - Valve closing too fast - Pressure setting too close to relief valve rating	- Reset the pre-charge pressure to 70% of sensor setting. Reduce pressure setting well below relief valve rating. Use next size larger pressure tank. - Verify valve operation is within manufacturer’s specifications. - Reduce system pressure setting to a value less than pressure relief rating.
RAPID	INTERNAL FAULT	- A fault was found internal to drive	- Unit may require replacement. Contact your supplier.
9 (SubDrive2W only)	OVER RANGE (Values outside normal operating range)	- Wrong hp/voltage - Internal fault	- Verify motor hp and voltage - Unit may require replacement. Contact your supplier.

SubMonitor

SubMonitor Troubleshooting

FAULT MESSAGE	PROBLEM/CONDITION	POSSIBLE CAUSE
SF Amps Set Too High	SF Amps setting above 359 Amps.	Motor SF Amps not entered.
Phase Reversal	Reversed incoming voltage phase sequence.	Incoming power problem.
Underload	Normal line current.	Wrong SF Max Amps setting.
	Low line current.	Over pumping well. Clogged pump intake. Closed valve. Loose pump impeller. Broken shaft or coupling. Phase loss.
Overload	Normal line current.	Wrong SF Max Amps setting.
	High line current.	High or low line voltage. Ground fault. Pump or motor dragging. Motor stalled or bound pump.
Overheat	Motor temperature sensor has detected excess motor temperature.	High or low line voltage. Motor is overloaded. Excessive current unbalance. Poor motor cooling. High water temperature. Excessive electrical noise (VFD in close proximity).
Unbalance	Current difference between any two legs exceeds programmed setting.	Phase loss. Unbalanced power supply. Open Delta transformer.
Overvoltage	Line voltage exceeds programmed setting.	Unstable power supply.
Undervoltage	Line voltage below programmed setting.	Poor connection in motor power circuit. Unstable or weak power supply.
False Starts	Power has been interrupted too many times in a 10 second period.	Chattering contacts. Loose connections in motor power circuit. Arcing contacts.

Continued on next page

Subtrol-Plus (Obsolete - See SubMonitor)

Subtrol-Plus - Troubleshooting After Installation

SYMPTOM	POSSIBLE CAUSE OR SOLUTION
Subtrol-Plus Dead	When the Subtrol-Plus reset button is depressed and released, all indicator lights should flash. If line voltage is correct at the Subtrol-Plus L1, L2, L3 terminals and the reset button does not cause lights to flash, Subtrol-Plus receiver is malfunctioning.
Green Off Time Light Flashes	The green light will flash and not allow operation unless both sensor coils are plugged into the receiver. If both are properly connected and it still flashes, the sensor coil or the receiver is faulty. An ohmmeter check between the two center terminals of each sensor coil connected should read less than 1 ohm, or coil is faulty. If both coils check good, receiver is faulty.
Green Off Time Light On	The green light is on and the Subtrol-Plus requires the specified off time before the pump can be restarted after having been turned off. If the green light is on except as described, the receiver is faulty. Note that a power interruption when the motor is running will initiate the delay function.
Overheat Light On	This is a normal protective function which turns off the pump when the motor reaches maximum safe temperatures. Check that amps are within the nameplate maximum on all three lines, and that the motor has proper water flow past it. If overheat trip occurs without apparent motor overheating, it may be the result of an arcing connection somewhere in the circuit or extreme noise interference on the power lines. Check with the power company or Franklin Electric. A true motor overheat trip will require at least five minutes for a motor started cold. If trips do not conform to this characteristic, suspect arcing connections, power line noise, ground fault, or SCR variable speed control equipment.
Overload Light On	This is a normal protective function, protecting against an overload or locked pump. Check the amps in all lines through a complete pumping cycle, and monitor whether low or unbalanced voltage may be causing high amps at particular times. If overload trip occurs without high amps, it may be caused by a faulty rating insert, receiver, or sensor coil. Recheck that the insert rating matches the motor. If it is correct, carefully remove it from the receiver by alternately lifting sides with a knife blade or thin screwdriver, and make sure it has no pins bent over. If the insert is correct and its pins are okay, replace receiver and/or sensor coils.
Underload Light On	This is a normal protective function. A. Make sure the rating insert is correct for the motor. B. Adjusting the underload setting as described to allow the desired range of operating conditions. Note that a DECREASE in underload setting is required to allow loading without trip. C. Check for drop in amps and delivery just before trip, indicating pump breaking suction, and for unbalanced line current. D. With the power turned off, recheck motor lead resistance to ground. A grounded lead can cause underload trip.

Subtrol-Plus (Obsolete - See SubMonitor)

Subtrol-Plus - Troubleshooting After Installation (Continued)

SYMPTOM	POSSIBLE CAUSE OR SOLUTION
Tripped Light On	Whenever the pump is off as a result of Subtrol-Plus protective function, the red tripped light is on. A steady light indicates the Subtrol-Plus will automatically allow the pump to restart as described, and a flashing light indicates repeated trips, requiring manual reset before the pump can be restarted. Any other red light operation indicates a faulty receiver. One-half voltage on 460 V will cause tripped light on.
Control Circuit Fuse Blows	With power turned off, check for a shorted contactor coil or a grounded control circuit lead. The coil resistance should be at least 10 ohms and the circuit resistance to panel frame over 1 megohm. A standard or delay-type 2 amp fuse should be used.
Contactor Will Not Close	If proper voltage is at the control coil terminals when controls are operated to turn the pump on, but the contactor does not close, turn off power and replace the coil. If there is no voltage at the coil, trace the control circuit to determine if the fault is in the Subtrol-Plus receiver, fuse, wiring, or panel operating switches. This tracing can be done by first connecting a voltmeter at the coil terminals, and then moving the meter connections step by step along each circuit to the power source, to determine at which component the voltage is lost. With the Subtrol-Plus receiver powered up, with all leads disconnected from the control terminals and with an ohmmeter set at RX10, measure the resistance between the control terminals. It should measure 100 to 400 ohms. Depress and hold in the reset button. The resistance between the control terminals should measure close to infinity.
Contactor Hums or Chatters	Check that coil voltage is within 10% of rated voltage. If voltage is correct and matches line voltage, turn off power and remove the contactor magnetic assembly and check for wear, corrosion, and dirt. If voltage is erratic or lower than line voltage, trace the control circuit for faults similar to the previous item, but looking for a major drop in voltage rather than its complete loss.
Contactor Opens When Start Switch is Released	Check that the small interlocks switch on the side of the contactor closes when the contactor closes. If the switch or circuit is open, the contactor will not stay closed when the selector switch is in HAND position.
Contactor Closes But Motor Doesn't Run	Turn off power. Check the contactor contacts for dirt, corrosion, and proper closing when the contactor is closed by hand.
Signal Circuit Terminals Do Not Energize	With the Subtrol-Plus receiver powered up and all leads disconnected from the signal terminals, with an 0hmmeter set at RX10, measure the resistance between the signal terminals. Resistance should measure close to infinite. Depress and hold in the reset button. The resistance between the signal terminals should measure 100 to 400 ohms.

Abbreviations

A	Amp or amperage
AWG	American Wire Gauge
BJT	Bipolar Junction Transistor
°C	Degree Celsius
CB	Control Box
CRC	Capacitor Run Control
DI	Deionized
Dv/dt	Rise Time of the Voltage
EFF	Efficiency
°F	Degree Fahrenheit
FDA	Federal Drug Administration
FL	Full Load
ft	Foot
ft-lb	Foot Pound
ft/s	Feet per Second
GFCI	Ground Fault Circuit Interrupter
gpm	Gallon per Minute
HERO	High Efficiency Reverse Osmosis
hp	Horsepower
Hz	Hertz
ID	Inside Diameter
IGBT	Insulated Gate Bipolar Transistor
in	Inch
kVA	Kilovolt Amp
kVAR	Kilovolt Amp Rating
kW	Kilowatt (1000 watts)
L1, L2, L3	Line One, Line Two, Line Three
lb-ft	Pound Feet
L/min	Liter per Minute
mA	Milliamp
max	Maximum
MCM	Thousand Circular Mils
mm	Millimeter
MOV	Metal Oxide Varister
NEC	National Electrical Code
NEMA	National Electrical Manufacturer Association
Nm	Newton Meter
NPSH	Net Positive Suction Head
OD	Outside Diameter
OL	Overload
PF	Power Factor
psi	Pounds per Square Inch
PWM	Pulse Width Modulation
QD	Quick Disconnect
R	Resistance
RMA	Return Material Authorization
RMS	Root Mean Squared
rpm	Revolutions per Minute
SF	Service Factor
SFhp	Service Factor Horsepower
S/N	Serial Number
TDH	Total Dynamic Head
UNF	Fine Thread
V	Voltage
VAC	Voltage Alternating Current
VDC	Voltage Direct Current
VFD	Variable Frequency Drive
W	Watts
XFMR	Transformer
Y-D	Wye-Delta
Ω	ohms

TOLL FREE HELP FROM A FRIEND

800-348-2420 • 260-827-5102 (fax)

Phone Franklin's toll free SERVICE HOTLINE for answers to your pump and motor installation questions. When you call, a Franklin expert will offer assistance in troubleshooting and provide immediate answers to your system application questions. Technical support is also available online. Visit our website at:

www.franklin-electric.com

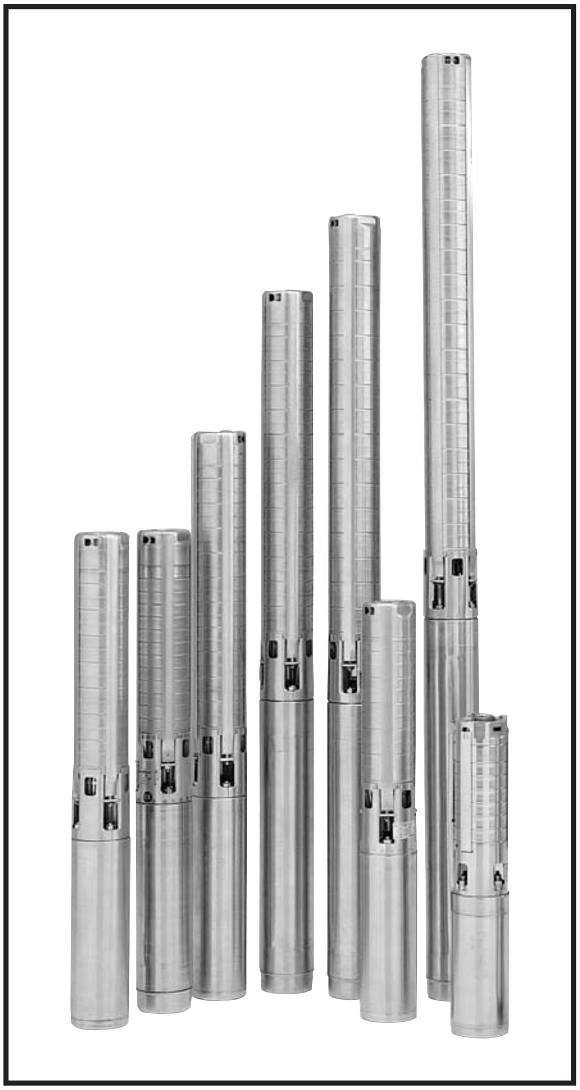
Franklin Electric

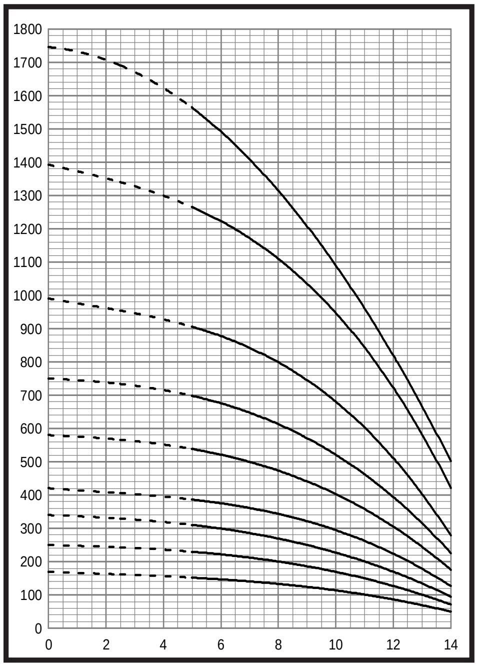
The Company You Trust Deep Down

M1311 07.11

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

(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			

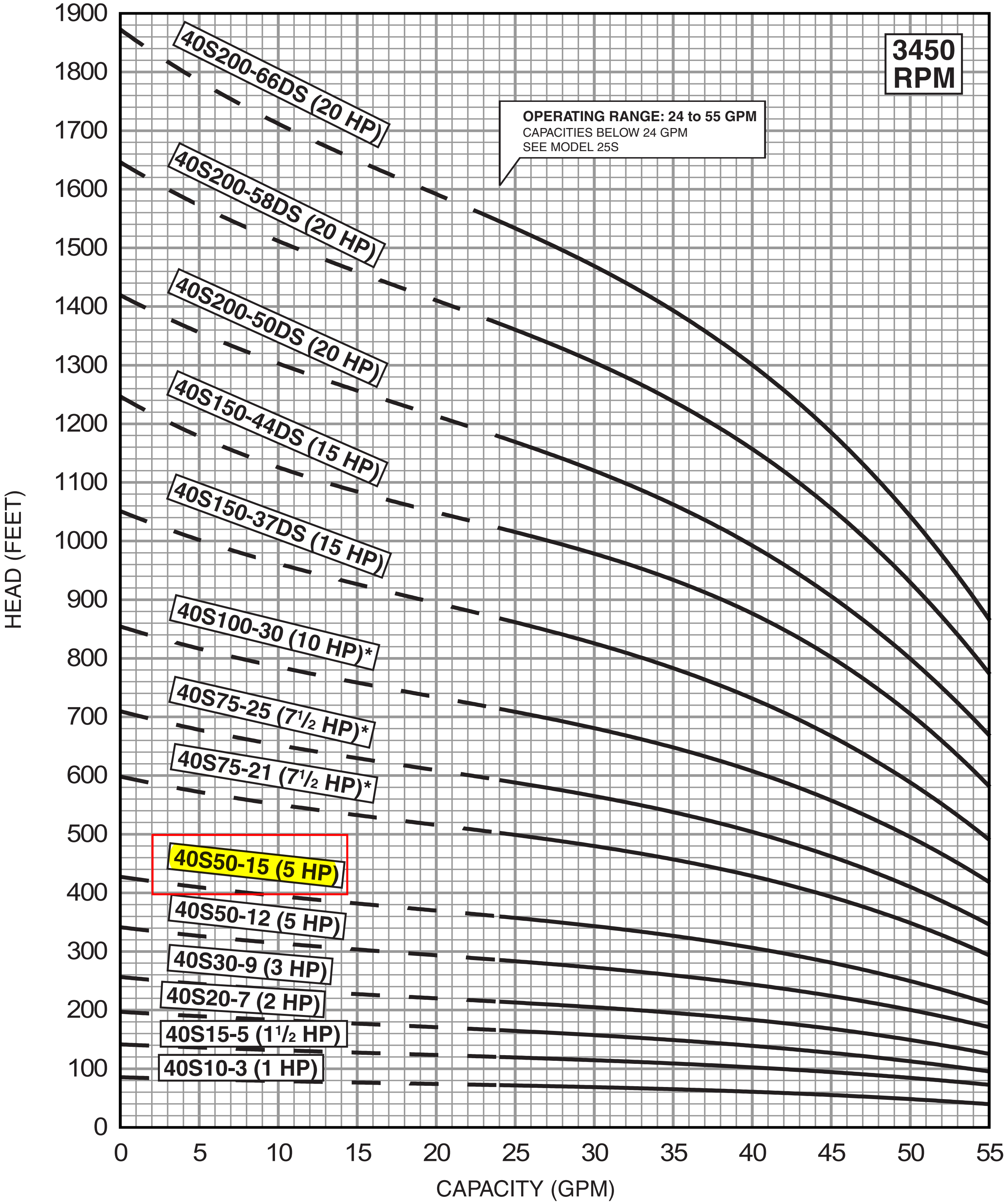
*** 6" Motor**

See 40S performance curves for higher head models.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

PERFORMANCE CURVES 40 GPM MODEL 40S

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.

MODEL 40S 40 GPM TECHNICAL DATA

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.

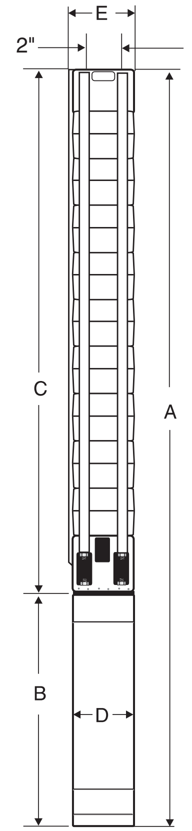


Fig. A

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

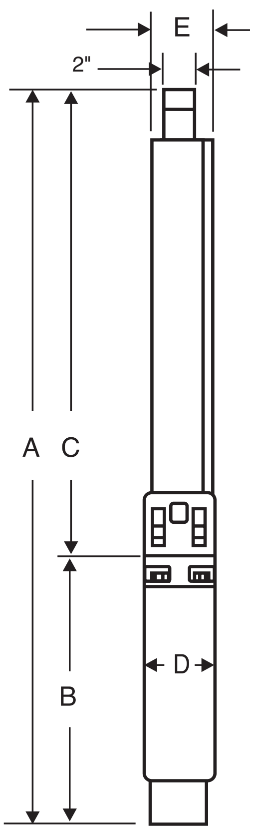


Fig. B

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

CONTROL BOX SA-SPM5

Enclosure
NEMA Type 3R rated suitable for outdoor mounting provided with mounting holes, progressive knockouts, and hinged door. 18 gauge steel construction with a gray colored epoxy coating provides great mechanical properties and corrosion protection.

Product Range
Provided in 115 VAC, 60 Hz, Single-phase for 1/3 HP and 1/2 HP motors.

Provided in 230 VAC, 60 Hz, single-phase for 1/3 HP, to 5 HP motors.

Internal wiring
Internal wire is 14 AWG, THHN, 105 degrees C, 600 VAC rated insulation.

Voltage relay
UL Recognized General Electric™ voltage relay.

Start capacitor
User friendly quick disconnect brackets for UL Recognized Mallory™ start capacitor.

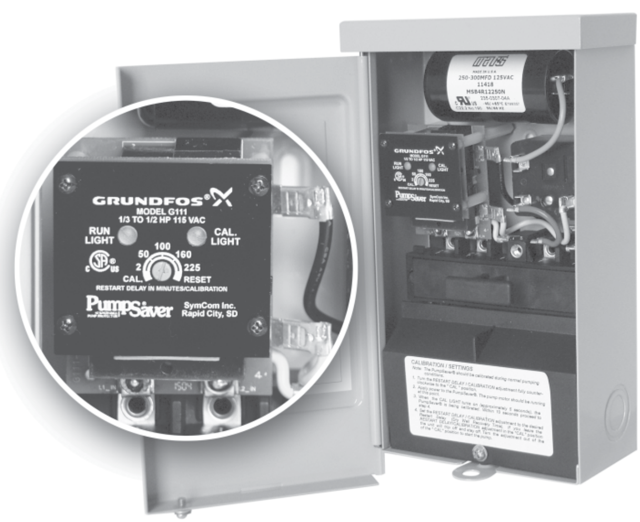
Pull handle disconnect
The pull handle disconnect is available to break voltage between line/service voltage and the starting components and motor leads.

G111 & G231 PumpSaver

The **Model G111** fits inside 1/3 and 1/2 Hp 115V control boxes.
Model G231 fits inside 1/3, 1/2, 3/4, and 1 Hp 230V control boxes. The PumpSaver Model G111/231 is a current monitor designed to protect single phase pumps from dry well, dead head, jammed impeller, and over & under voltage conditions. Typical applications include residential waterwells, commercial water wells, irrigation wells, and golf course systems.

Features and benefits:

- Restart delay can be set up to 225 minutes or placed in manual reset mode.
- Can be calibrated to specific pump/motor combinations and various conditions.
- “Run Light” conveniently shows that the unit is functional.
- Fits in existing Grundfos control box – saving enclosure costs.
- Quick easy installation.



Made for pumps by pump experts

Simple set-up a priority
Simple installation and set-up was a major priority for the MP 204 designers. Mounting is done by means of four screws or by sliding the unit onto a mounting rail, and the entire set-up can be completed in just two minutes. The simple menu is used to set four parameters: rated motor amps, nominal voltage, trip class, and no. of motor phases. After just 120 seconds of setting, the unit is ready to go.

Electronic pump protection made simple
Submersible motors are made to be very strong indeed. But that does not mean they cannot benefit from extra protection that prolongs their lifetime and safeguards them against external threats. That is why we created the new MP 204 motor protection unit. Made especially for pump motors by pump specialists, it was designed to bring you protection that is as simple to use as it is efficient. Our engineers crammed it full of all the protection features you need – but kept it easy to install, set, and use.

Protect your motors against external threats
The MP 204 protects pump motors against undervoltage, overvoltage and other variations in power supply. So even if your external power supply is not entirely steady, your SP pump will remain as reliable as ever. Very importantly, the extra protection also reduces wear, thereby prolonging the motor's lifespan. Reduced power consumption is a strong indication that the pump is about to run dry, so the MP 204 will immediately stop the pump if the well goes dry.

Access more functions with the R 100 remote control

R 100 remote

The R 100 remote control from Grundfos gives you access to even more options. For example, you can adjust factory settings, carry out service and troubleshooting, and get read-outs of data stored in the MP 204 unit.

Technical data – MP 204

• Enclosure class:	NEMA 1 (IP 20)
• Ambient temperature:	-4°F to 140°F (-20°C to 60°C)
• Relative humidity:	99%
• Voltage range:	80-610VAC
• Current range:	3-999A
• Frequency:	47 – 63 Hz
• IEC trip class:	1 – 45
• Special Grundfos trip class:	0.1 – 30 s
• Voltage variations:	-25/+15% of nominal voltage
• Approvals:	EN 60947, EN 60355, UL/CSA 508
• Marking:	SE, cUL, C-tick

* For currents above 120A, external transformers required

Monitoring parameters

- Insulation resistance before start-up
- Temperature (Tempcon, PT sensor and PTC/thermal switch)
- Overload / underload
- Overvoltage / undervoltage
- Phase sequence
- Phase missing
- Power factor (cos φ)
- Power consumption
- Harmonic distortion
- Current asymmetry
- Run and start capacitor (single-phase)
- Operating hours and number of starts

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

GRUNDFOS Single Phase Lightning Arrestor
(Optional accessory for surge protection in single phase submersible motors.)

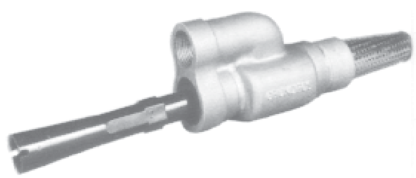
Part No. 825017

GRUNDFOS Three Phase Lightning Arrestor

All Ratings
Part No. 825045

Parallel Pipe Ejector/Foot Valve

EJECTOR	FOR USE WITH	HP	NOM. DEPTH	MIN. WELL DIA.	PRESSURE CONNECT	SUCTION CONNECT	ORDER NO.
5050	JS-5	1/2	50'	4"	1"	11/4"	465118
5100	JS-5	1/2	100'	4"	1"	11/4"	465119
7050	JS-7	3/4	50'	4"	1"	11/4"	465120
7100	JS-7	3/4	100'	4"	1"	11/4"	465121
10050	JS-10	1	50'	4"	1"	11/4"	465136
10100	JS-10	1	100'	4"	1"	11/4"	465137



GRUNDFOS Three Inch Stainless Steel Well Seal

Part No.	Part Name
1B5102	Well Seal

PART 1: INTRODUCTION

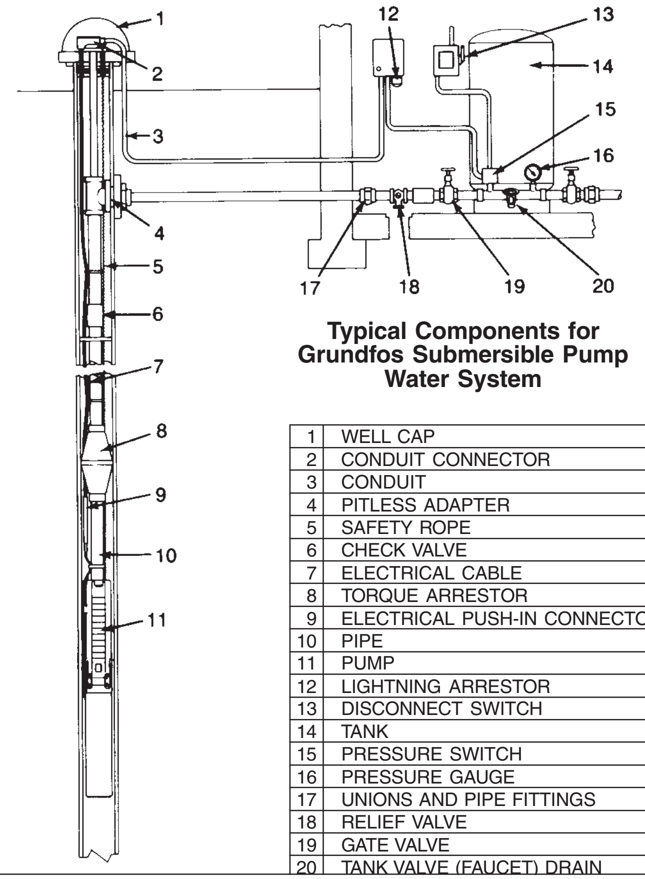
General

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.



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).

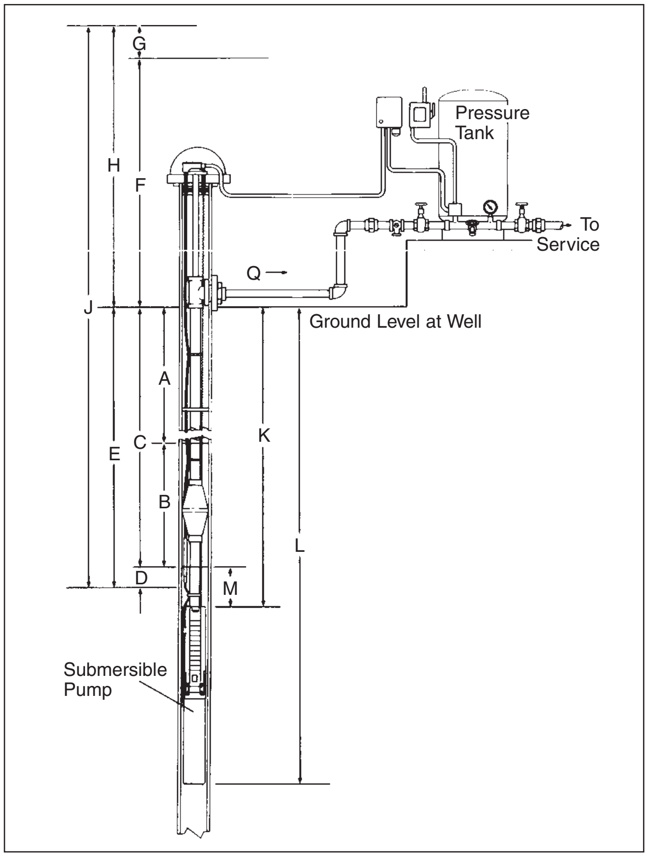


FIGURE 8-B
Figure 8-B illustrates a schematic layout of a CLOSED goundwater pumping system using a submersible pump and pressure tank set for automatic operation. A pressure switch controls the cycling of the pump.

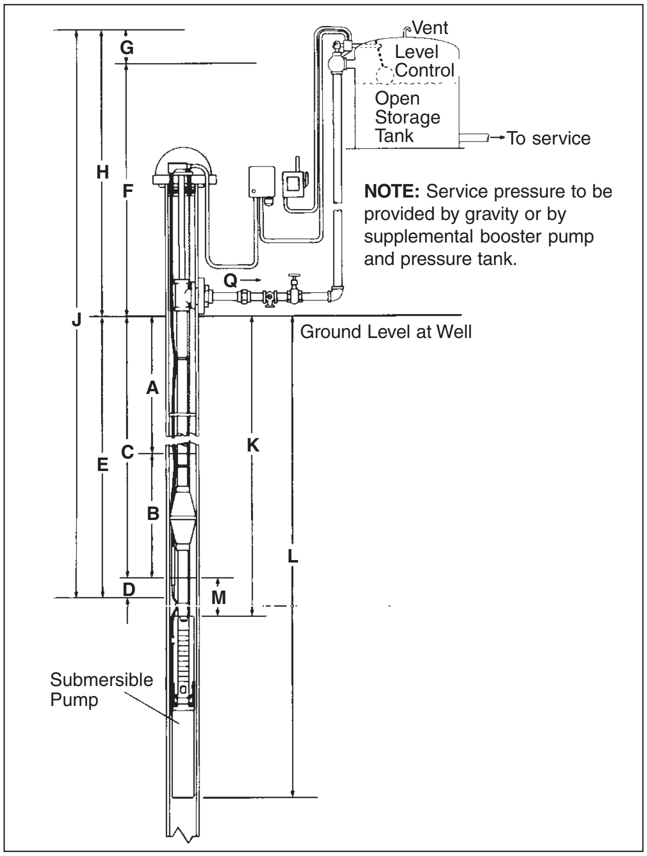


FIGURE 8-C
Figure 8-C illustrates a schematic layout of an OPEN groundwater pumping system using a submersible pump and an elevated storage tank set for automatic operation. A level control on the storage tank controls the cycling of the pump.

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.

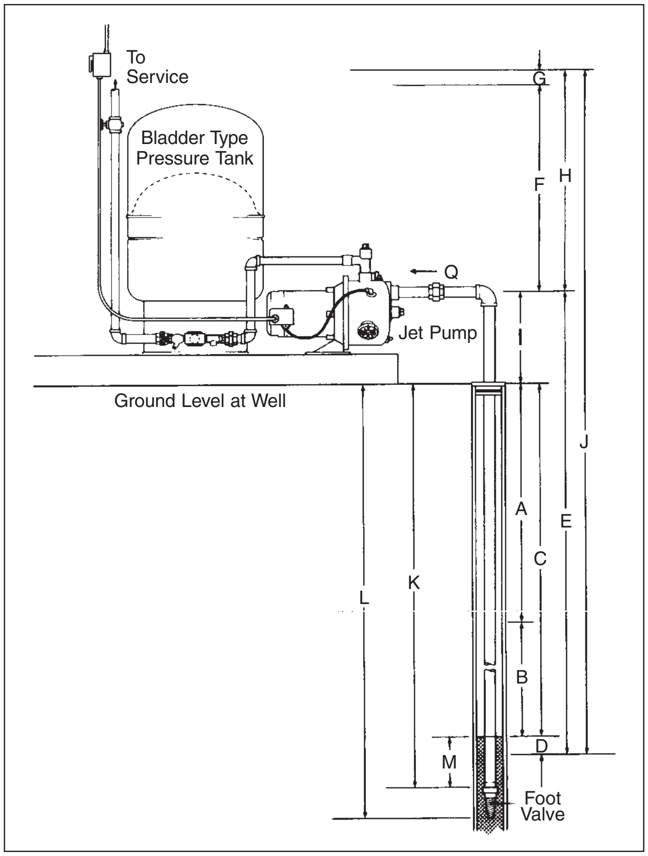


FIGURE 8-D
Figure 8-D illustrates a schematic layout of a SHALLOW WELL groundwater pumping system using a shallow well JET PUMP designed for setting to 25 feet. The pressure tank is set for automatic operation with a pressure switch controlling the cycling of the pump.

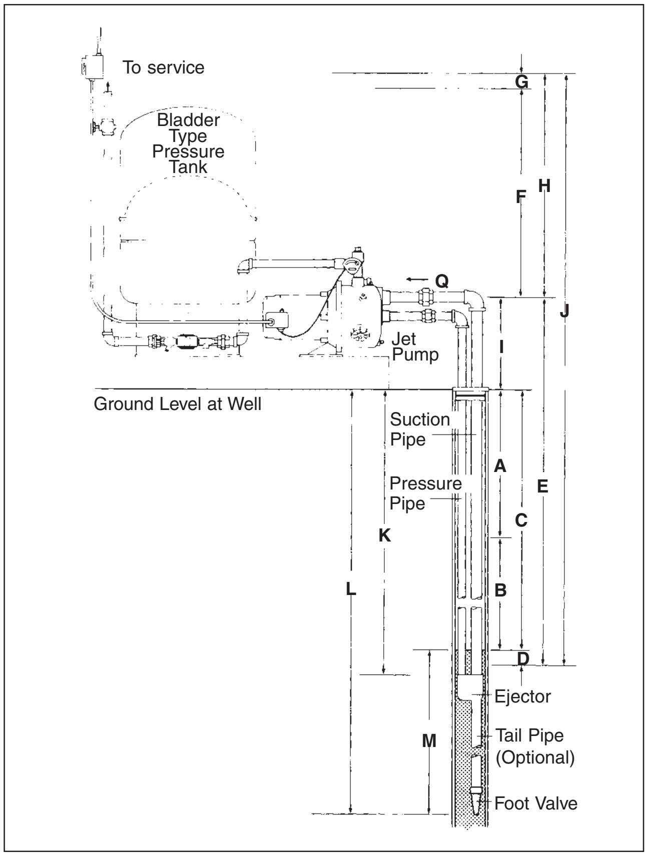


FIGURE 8-E
Figure 8-E illustrates a schematic layout of an DEEP WELL groundwater pumping system using a deep well JET PUMP designed for settings to 100 feet. The pressure tank is set for automatic operation with a pressure switch controlling the cycling of the pump.

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.

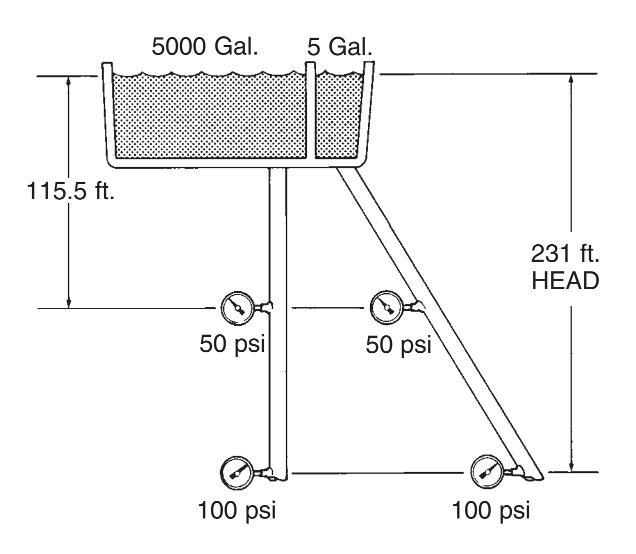


FIGURE 8-F

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).

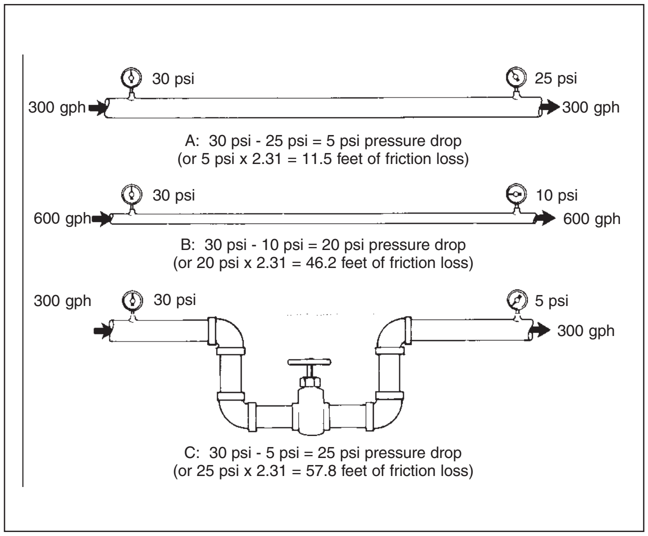


FIGURE 8-G

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.

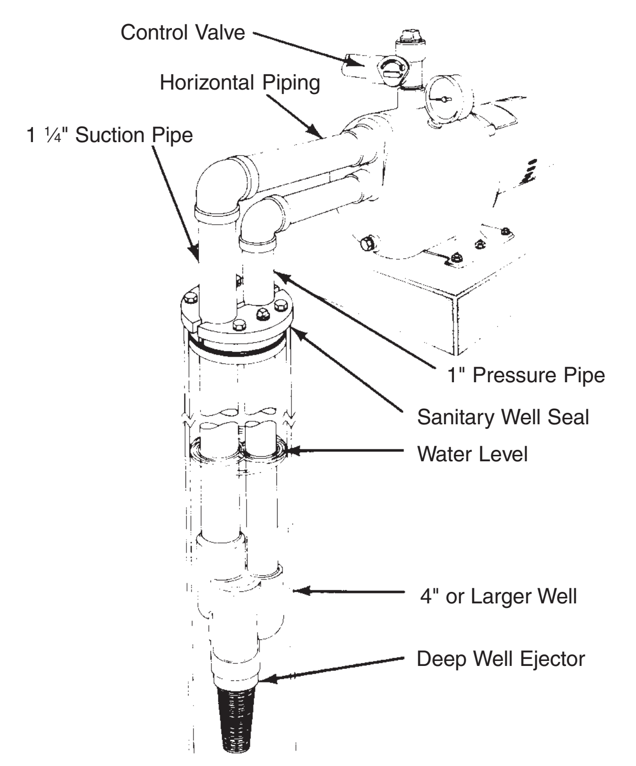


FIGURE 8-H
Figure 8-H illustrates a convertible jet pump set for deep well use (to 100 feet).

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.

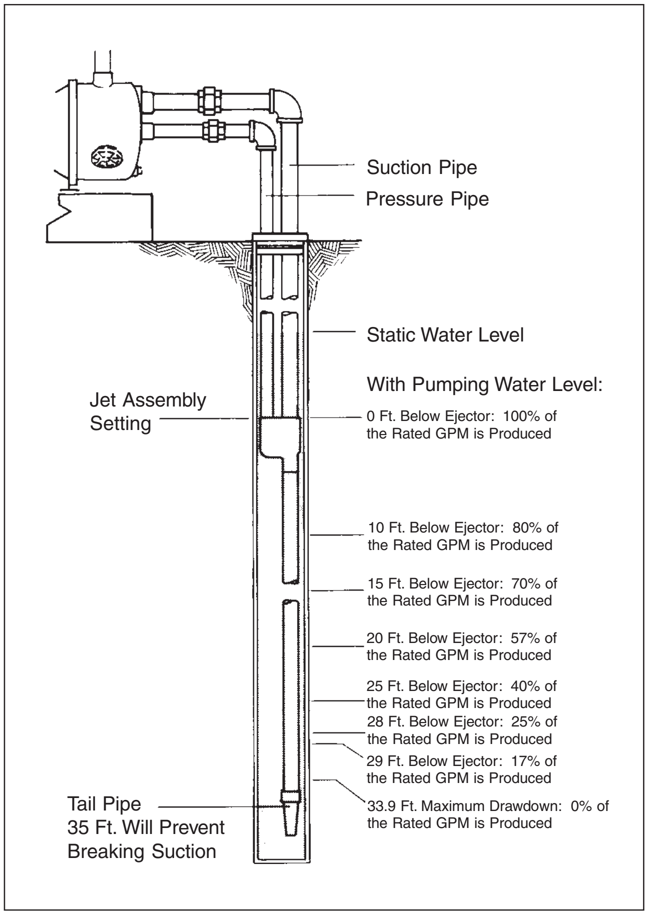


FIGURE 8-I
Figure 8-I illustrates the use of a tail pipe on a deep well convertible jet pump to compensate for weak well conditions.

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.

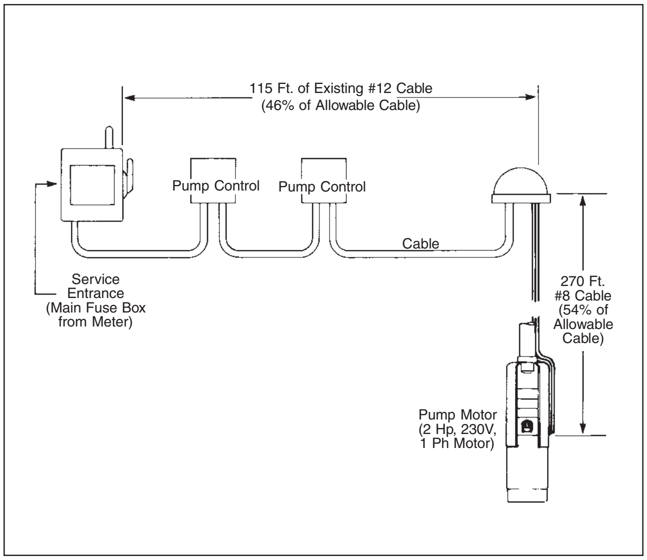


FIGURE 8-Q(1)
Example of Mixed Cable Installation

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.

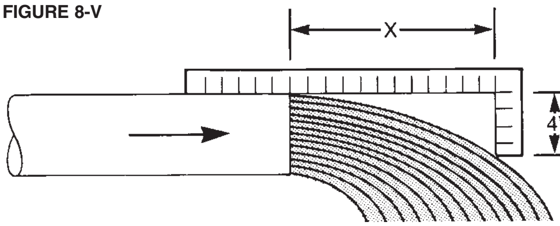
Notes:
1. If aluminum conductor is used, multiply lengths by 0.5 Maximum allowable length of aluminum is considerably shorter than copper wire of same size.
2. The portion of the total cable which is between the service entrance and a 3ø motor starter should not exceed 25% of the total maximum length 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:

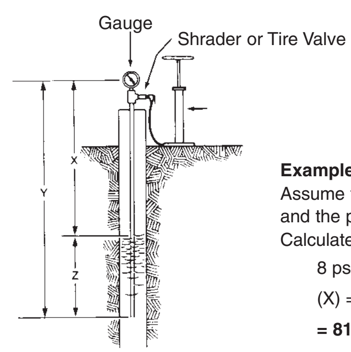
X = Distance to water level (in feet). This figure to be determined.

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:

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

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

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

FORMULAS

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

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

Cost in Cents per Acre-Inch

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

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 – EQUIVALENT LENGTH OF PIPE (IN FEET)						
		1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"
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 FROM ↓ / CONVERT TO →	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 FROM ↓ / CONVERT TO →	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 FROM ↓ / CONVERT TO →	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.

BE > THINK > INNOVATE >

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

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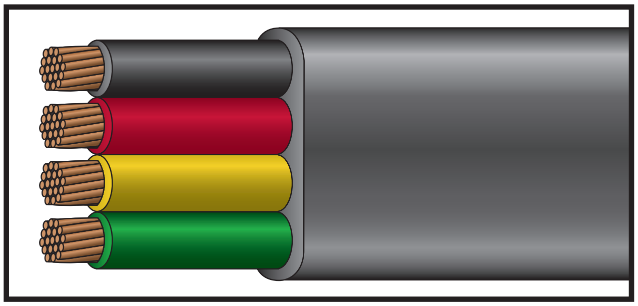

Submersible Pump Cable
TYPE THW-Heavy Duty FLAT BLACK JACKETED with Ground 75°C/600V

Description & Features:
UL listed Type THW heavy duty flat submersible pump cable is a multi-purpose cable with parallel, individually insulated, color coded conductors, green ground insulated conductor and an overall jacket. Construction provides flexible copper stranding insulated with Type THW (PVC) compound. A tough PVC jacket, with a non-penetrating web, is easily stripped to facilitate installation yet provide optimum flexibility, mechanical protection and crush resistance.

- UL listed as Type THW Submersible Pump Cable
- Acid, alkali, oil and grease resistant
- Weather, ozone and sunlight resistant jacket
- Abrasion and crush resistant
- Sequential footage marks

Applications:
- For use within the well casing to supply power to the submersible pump
- Designed for use where extra mechanical protection and flexibility during installation and operation are required

Construction:
Conductors: Flexible stranded soft annealed copper
Insulation: Thermoplastic polyvinyl chloride (PVC)
Color coding: black, red, yellow, green (ground)
Assembly: The insulated conductors, including the grounding conductor, are configured flat and parallel without fillers
Jacket: Black thermoplastic polyvinyl chloride (PVC) applied directly over the conductors with a non-penetrating web
Temperature: 75°C **Voltage:** 600

Specifications & Standards:
UL Standard 83; RoHS Compliant

THREE CONDUCTORS WITH GREEN INSULATED GROUNDING CONDUCTORS

Part Number	Conductor Size, AWG		Dimensions (Inches)			Standard Packaging	Ampacity NEC§	Weight (Lbs./Mft.)
	Power	Ground	Insulation	Jacket	O.D.			
PFB14/3GG	14/3 (7 str)	14 (7 str)	.045	.045	.261 x .763	500' & 1000'	15	145
PFB12/3GG	12/3 (19 str)	12 (19 str)	.045	.045	.280 x .840	500' & 1000'	20	189
PFB10/3GG	10/3 (19 str)	10 (19 str)	.045	.045	.305 x .940	500' & 1000'	30	255
PFB8/3GG	8/3 (19 str)	10 (19 str)	.060	.045	.364 x 1.120	500' & 1000'	50	374
PFB6/3GG	6/3 (19 str)	8 (19 str)	.060	.045	.414 x 1.336	500' & 1000'	65	522
PFB4/3GG	4/3 (19 str)	8 (19 str)	.060	.045	.465 x 1.489	500' & 1000'	85	714
PFB2/3GG	2/3 (19 str)	6 (19 str)	.060	.045	.535 x 1.749	500' & 1000'	115	1,036
PFB1/03GG	1/03 (19 str)	6 (7 str)	.080	.060	.660 x 1.990	Bulk	150	1,613
PFB2/03GG	2/03 (19 str)	6 (7 str)	.080	.060	.700 x 2.120	Bulk	175	1,932
PFB3/03GG	3/03 (19 str)	4 (7 str)	.080	.060	734 x 2.314	Bulk	200	2,135
PFB4/03GG	4/03 (19 str)	4 (7 str)	.080	.060	.800 x 2.490	Bulk	230	2,871
PFB250/3GG	250/3 (37 str)	4 (7 str)	.095	.080	.925 x 2.807	Bulk	235	3,518
PFB350/3GG	350/3 (37 str)	3 (7 str)	.095	.080	1.031 x 3.153	Bulk	310	4,689
PFB500/3GG	500/3 (37 str)	2 (7 str)	.095	.080	1.163 x 3.590	Bulk	380	6,410

TWO CONDUCTORS WITH GREEN INSULATED GROUNDING CONDUCTORS

PFB14/2GG	14/2 (7 str)	14 (7 str)	.045	.045	.261 x .592	500' & 1000'	15	112
PFB12/2GG	12/2 (19 str)	12 (19 str)	.045	.045	.280 x .654	500' & 1000'	20	152
PFB10/2GG	10/2 (19 str)	10 (19 str)	.045	.045	.305 x .729	500' & 1000'	30	210
PFB8/2GG	8/2 (19 str)	10 (19 str)	.060	.045	.364 x .828	500' & 1000'	50	276

§ Per Table 310-16 of the NEC
All values are nominal; all weights are exclusive of packaging. All diameters and weights are subject to normal manufacturing tolerances.
* Direct Burial rated in sizes 12 through 500 KCMIL, upon request
All sales are subject to Standard Terms & Conditions of Sale.

7/2/12

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INSTALLATION INSTRUCTIONS

Revision A2
Rapid City, SD, USA, 01/2010

MODEL 777-P2
777-575-P2
ELECTRONIC OVERLOAD RELAY

II_777-P2_A2

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DANGER!

HAZARDOUS VOLTAGES MAY BE PRESENT DURING INSTALLATION.
Electrical shock can cause death or serious injury.
Installation should be done by qualified personnel following all national, state and local electrical codes.

BE SURE POWER IS DISCONNECTED PRIOR TO INSTALLATION!
FOLLOW NATIONAL, STATE AND LOCAL CODES.
READ THESE INSTRUCTIONS ENTIRELY BEFORE INSTALLATION.

WARNING!

Hazardous Voltage. Failure to follow these instructions can result in death, serious injury, or equipment damage.

Power must be disconnected prior to attaching and/or using the battery cable.

Damage to the device or serious injury may occur if the battery programming feature is used while power is applied. Always follow proper safety procedures for removing and securing the power source before connecting the battery cable.

The battery cable cannot be used when power is applied to the device. To program the device when it is powered, the user must utilize a network programming option.

The 777-P2 is an electronic overload relay that is fully programmable for customized protection. The 777-P2 is designed to protect 3-phase systems with operating voltages of 200-480VAC (500-600VAC for the Model 777-575-P2). The output relay is a Form C contact, which can control a contactor or other device within the output relay contact rating.

The 777-P2 can be safely programmed prior to installation by supplying power with a 9V battery. See Figure 4 in the PROGRAMMING section. DO NOT connect the battery to the unit when line voltage is present. The 777-P2 **cannot** be tested for proper operation or communications using a 9V battery. For testing purposes, 3-phase power must be used with a minimum voltage of 200VAC (500VAC for the Model 777-575-P2). Follow all safety warnings when dealing with hazardous voltages.

CONNECTIONS

1. Disconnect power and verify line and control power are off.
2. Using the four corner tabs or the DIN rail mount, install the 777-P2 directly above or below the contactor. To mount on a DIN rail, hook the top clips first then apply downward pressure until the lower clips snap onto the rail.
3. a) For amperages from 20-90 amps, insert the motor conductors through the holes marked A, B, and C. Ensure the motor phase conductors correspond with the round hole designations, i.e. the A phase conductor should go through the round hole marked “A”. See Figure 1 for a typical wiring diagram.

   b) For amperages less than 20 amps, loop the motor conductors according to Table 1. Figure 2 shows an example of the looping required for current ranging from 12-20 amps (MULT=2).

c) For amperages greater than 90 amps, external CTs (current transformers) are required. SymCom recommends using CTs with terminal connections for easier installation. All CT secondaries must make five passes through the round holes on the MotorSaver®Plus. See Figure 3 for a typical wiring diagram using external CTs.

NOTE: Pay close attention to the wiring diagrams to eliminate any errors when communicating power factor information over a network. The L2 phase conductor must pass through the B current measurement hole for proper operation.

4. Connect the 3-phase power from the line side of the contactor to L1, L2, and L3 terminals using 12-18 AWG copper wire. These should be tightened to 7 in.-lbs., max.

5. Connect the control circuit wires to the appropriate terminals. The relay is designed for fail-safe operation; the NO (normally open) contact should be in series with the coil on the contactor for motor control (see Figure 1). For alarm circuits, the NC (normally closed) contact is in series with the alarm circuitry.

Recommended Full Load Amps	OC Range (Amps)	UC Range (Amps)	# of Passes through each Window	MULT (CT Ratio)
2-2.5	2-10	0, 1-9.8	10	10
2.5-3	2.2-11.1	0, 1.1-10.8	9	9
3-3.5	2.5-12.5	0, 1.2-12.2	8	8
3.5-4	2.8-14.3	0, 1.4-14	7	7
4-5	3.3-16.7	0, 1.6-16.3	6	6
5-6	4-20.1	0, 2-19.6	5	5
6-8	5-25.1	0, 2.5-24.5	4	4
8-12	6.6-33.5	0, 3.3-32.6	3	3
12-20	10-50.3	0, 5-49	2	2
20-90	20-100	0, 10-98	1	1
80-110	80-140	0, 40-140	5	100 (100:5)
110-160	120-210	0, 60-210	5	150 (150:5)
160-220	160-280	0, 80-280	5	200 (200:5)
220-320	240-420	0, 120-420	5	300 (300:5)
320-420	320-560	0, 160-560	5	400 (400:5)
400-520	400-700	0, 200-700	5	500 (500:5)
480-600	480-840	0, 240-840	5	600 (600:5)
540-700	560-980	0, 280-980	5	700 (700:5)
560-800	640-992/FFF	0, 320-992/FFF	5	800 (800:5)

Table 1: Wiring Configuration Based on Motor Full Load Amps

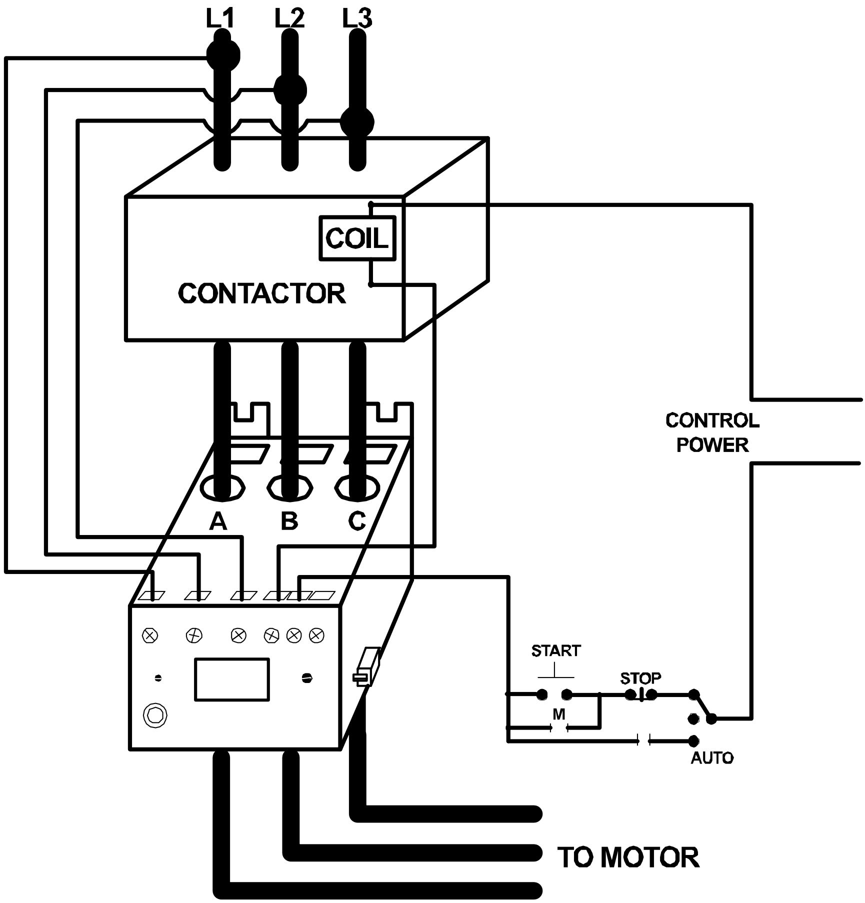


Figure 1: Typical Wiring Diagram

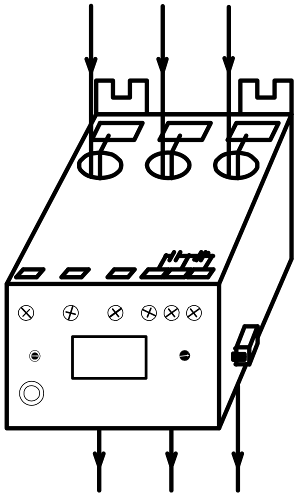


Figure 2: Looping Example for 12-20A, MULT = 2

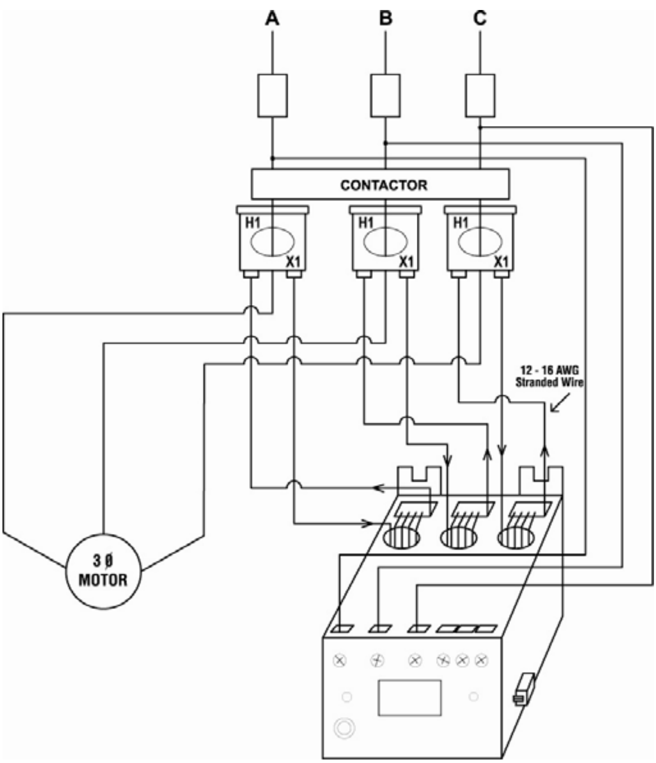


Figure 3: Typical Wiring Using External CTs[1]

[1] All CTs must face the same direction, and all CT secondaries must be wired identically, i.e. all X1 terminals enter the main (round) window and return to H1 terminal after exiting the loop conductor window (rectangle). Every CT secondary must make 5 passes through the corresponding main conductor window. SymCom recommends using CTs with terminals to simplify installation.

PROGRAMMING

To program prior to installation, connect the 9V battery cable to the pins on the left side of the unit (when looking at the display), and then attach a standard 9V battery to the cable. See Figure 4. The 9V battery cable is keyed for proper installation. If the cable is connected improperly, the 777-P2 will not power the display. DO NOT connect the battery when line voltage is present. The 777-P2 **cannot** be tested for proper operation or communications using a 9V battery. For testing purposes, 3-phase power must be used with a minimum voltage of 200VAC (500VAC for the Model 777-575-P2). Follow all safety warnings when dealing with hazardous voltages.

1. Rotate the MODE SELECT switch to the parameter to be programmed. It is recommended that LV be programmed first.
2. Press and hold the RESET/PROGRAM button.
3. While holding the RESET/PROGRAM button, rotate the DISPLAY/PROGRAM knob until the proper setting for the parameter that is being programmed is displayed.
4. Release the RESET/PROGRAM button. This stores the new parameter in the nonvolatile memory. If the number changes back to what is was before programming, then the tamper guard is on and will need to be unlocked before programming can be completed (see Tamper Guard).
5. Move clockwise through the positions to complete the process. Continue steps 1-4 until all parameters are programmed.

Figure 4: Proper Position of the Battery Cable

PROGRAMMABLE PARAMETERS

The following settings MUST be programmed by the user in order to provide proper protection for the application. Settings vary by situation and application and should be selected and tested for each unique installation. All parameters are actual values except for the VUB and CUB settings; these are programmed as percentages. The range each parameter can be programmed is found in the electrical specifications table. See Programming Examples for sample setup instructions. Failure to program all setpoints could result in nuisance tripping or prevent the device from protecting the motor. Always use the proper CTs for the motor full load amperage (FLA).

LV/HV - Low Voltage/High Voltage. The recommended settings for LV (low voltage) and HV (high voltage) according to the NEMA MG1 standard are ±10% of the motor's nameplate voltage. Generally, the motor manufacturer should be contacted to verify these limits. High and low voltage trips are based on average voltage measured. Never set LV higher than HV.

Example: Nameplate voltage = 230 V
LV **=** 90% x 230=207 V
HV = 110% x 230 = 253 V

VUB - Voltage Unbalance. The NEMA MG1 standard says a motor should not be operated above a 1% voltage unbalance without derating the motor. Most utility supplied power sources have a difficult time sustaining a 1% VUB. The motor manufacturer should be consulted for an exact VUB setting. Setting VUB to 999 will disable voltage unbalance protection, but will not disable voltage single-phase protection. Voltage unbalance is calculated as follows:

%Voltage Unbalance = [(Maximum deviation from the average)/Average] x 100%

Example: Measured line-line voltages = 203, 210, and 212. The average = (203+210+212)/3 = 208.3. The maximum deviation from the average is the greatest difference between the average voltage (208.3) and any one voltage reading: 212-208.3 = 3.7, 210-208.3 = 1.7 and 208.3-203 = 5.3. The maximum deviation from the average is 5.3, thus voltage unbalance = 5.3/208.3 x 100= 2.5%.

MULT - MULT (multiplier) setting is found in Table 1. The MULT setting is determined by the number of passes of the motor leads or the size of external CTs and the full load amps of the motor the unit will be monitoring. MULT sets the trip point range for undercurrent, overcurrent and ground fault current faults. Set MULT first, then set UC, OC and GF.

OC - Overcurrent. Is typically set to the service factor amperage (SFA) of the motor or 100-135% of motor full-load amps (FLA), which are determined by the motor manufacturer. The value must be higher than UC. If any one leg exceeds the OC setting, the 777-P2 will trip according to the Trip Class (TC) settings.

NOTE: When using external CTs, do not set OC greater than the thermal rating of the CTs

UC - Undercurrent. Is most commonly set to 80% of the full-load amperage (FLA) of the motor. This is usually adequate for protection of loss of load for many pumps and motors, including submersibles. If the motor is drawing less than full load amperage, then the UC may be set lower than 80% of FLA for adequate protection. Centrifugal/booster pumps may have to be set to something higher than 80% of FLA for adequate protection. UC can be set to 0 if UC protection is not desired. The 777-P2 examines average current to determine if an undercurrent trip condition exists. The value must be lower than OC

CUB - Current Unbalance. SymCom recommends contacting the motor manufacturer for a specific setting. Current unbalance is calculated the same way voltage unbalance is calculated (see formula above). Setting CUB to 999 will disable current unbalance and current single-phase protection.

TC - Trip Class. Determines how quickly the 777-P2 will trip when an overcurrent (overload) condition is detected. TC is a dual-function setting—both a thermal trip class (NEMA standard) and a linear trip delay (in seconds) can be set.

While the standard trip classes are 5, 10, 15, 20, and 30, TC can be set from 2–60, with or without jam protection. The trip class setpoint is the time in seconds that the device will take to trip when any phase current is greater than or equal to 600% of the OC setpoint. These additional "non-standard" trip classes allow the unit to follow a trip curve in-between the "standard" trip class curves shown in Figure 5.

Trip classes 2–60 can be set from approximately the 7 o'clock to 10 o'clock position with the DISPLAY/PROGRAM knob. Trip classes J02–J60, which include jam protection, can be set from approximately the 10 o'clock to 1 o'clock position. This additional jam protection feature, when enabled, is initiated 1 minute after the motor starts and provides a 2-second trip delay for motors exceeding 400% of the OC setting.

The linear overcurrent trip delay can be set from approximately the 1 o'clock to 5 o'clock position from 0–60 seconds (L00–L60) or to "oFF." If TC is set to L00, the 777-P2 will trip off within 1 second after motor current reaches the OC setpoint. If both trip class and linear trip delay settings are programmed, the 777-P2 will follow the faster trip time. For example, TC is set to J15 and L20, and the amperage is 200% of the OC setting. Following the trip class 15 curve, the 777-P2 will trip off in approximately 100 seconds. Thus the 777-P2 will follow the linear trip delay setting, because it is faster, and will trip off in 20 seconds.

The motor manufacturer should be contacted for an exact TC setting. Table 3 describes the trip classes, and Figure 5 shows the trip class curves.

RD1 - Restart Delay One. Rapid-cycle timer, in seconds (default). The purpose of this timer is to provide protection against short cycling and to allow adequate cool down time between motor starts. This timer is initiated when power is first applied to the unit. If no voltage fault conditions exists, the output relay will energize (the NO will close and the NC will open) as soon as RD1 timer expires. In most cases, this is set to 20-30 seconds. This should provide adequate protection for successive power outages or short cycling caused by other motor controls. This timer is also initiated when motor current goes to zero. Setting RD1 to zero will turn off this feature and ensure that when an alarm circuit is used, an alarm will sound only when there is a fault or power to the unit is lost.

RD2 - Restart Delay Two. Referred to as a motor cool-down timer, in minutes (default). RD2 is used to restart the motor after a trip due to a current unbalance, current single-phasing, or an overcurrent condition. A setting of 5-10 minutes will give most motors adequate time to cool down after an overcurrent condition. The motor manufacturer should be contacted for an exact value.

RD3 - Restart Delay Three. This timer, in minutes (default), only initiates after an undercurrent trip and is referred to as a dry-well recovery timer in pumping applications. This is set according to the time it takes for the well to recharge after pumping dry. This setting varies widely by application and there is no typical setting. RD3 can be set from 2-500 minutes or to A to enable the automatic Dry-Well Recovery Calculator.

The Automatic Dry-Well Recovery Calculator allows the 777-P2 to automatically select a restart delay based on the run time of the last run cycle before tripping on an undercurrent fault. Table 2 shows the next restart delay vs. run time. In general, a longer run time produces a shorter restart delay. This feature allows the 777-P2 to optimize running and rest times automatically.

Run Time	Next Restart Delay (minutes)	Starts/Hr
> 1Hr	6	10
30 min.- 59.99 min.	15	4
15 min.- 29.99 min.	30	2
< 15 min.	60	1

TABLE 2: Automatic Dry-Well Recovery Timer

#RU/ADDR - Restart Attempts (undercurrent)/Address. The #RU/ADDR is a dual-function setting. #RU settings are displayed and selected by turning the DISPLAY/PROGRAM dial from approximately the 7 o'clock to 12 o'clock position. ADDR settings are displayed and selected by turning the DISPLAY/PROGRAM dial from approximately the 12 o'clock to 5 o'clock position.

#RU is the number of restarts the 777-P2 will attempt after an undercurrent fault before the unit locks out and requires a manual reset. #RU can be set to 0, 1, 2, 3, 4, or A. This counter is cleared one minute after restarting if the 777-P2 does not trip again on undercurrent.

If #RU is set to "0", the 777-P2 will require manual resetting after all undercurrent faults.
If #RU is set to "A", the 777-P2 will always automatically restart after undercurrent faults, once the RD3 timer expires.

ADDR is the RS-485 address of the 777-P2 and is only used when communicating with any external communication device. The address can be set from A01–A99.

#RF/COM - Restart Attempts (other faults)/ Communications Settings. The #RF settings are displayed and selected by turning the DISPLAY/PROGRAM dial from approximately the 7 o'clock to 12 o'clock position. COM settings are displayed and selected by turning the DISPLAY/PROGRAM dial from approximately the 12 o'clock to 5 o'clock position.

#RF is the number of restarts the 777-P2 will attempt after current unbalance or current single-phase faults before the unit locks out and requires a manual reset. This counter will be cleared one minute after start-up if the unit does not trip again for the same fault condition. Available settings are 0, 1, 2, 3, 4 and A, or to include overcurrent faults, #RF can be set to oc1, oc2, oc3, oc4 or ocA.

If #RF is set to "0", the 777-P2 will require manual resetting after all current unbalance, current single-phase and overcurrent faults.
If #RF is set to "A", the 777-P2 will always restart automatically after current unbalance and current single-phase faults, once the RD2 timer expires. Overcurrent faults will require a manual reset.
If #RF is set to "ocA", the 777-P2 will always restart automatically after current unbalance, current single-phase and overcurrent faults, once the RD2 timer expires.

COM determines the baud rate, even/odd parity, and stop bit. COM can bet set to C00-C07. C00 and C04 are duplicates provided for backward compatibility.

- C00 = 9600 baud, No parity, and 1 stop bit
- C01 = 9600 baud, Odd parity, and 1 stop bit
- C02 = 9600 baud, No parity, and 1 stop bit
- C03 = 9600 baud, Even parity, and 1 stop bit
- C04 = 19200 baud, No parity, and 1 stop bit
- C05 = 19200 baud, Odd parity, and 1 stop bit
- C06 = 19200 baud, No parity, and 1 stop bit
- C07 = 19200 baud, Even parity, and 1 stop bit

UCTD - Undercurrent Trip Delay. The length of time, in seconds (default), the unit will allow the motor to run in an undercurrent situation before de-energizing its relay. Typically, UCTD is set to 2-4 seconds to allow for motor to reach full load.

GF - Ground Fault. The maximum allowable current that can flow to ground before the 777-P2 de-energizes its relay. This is a residual, class II ground fault system and should not be used for personnel safety. A typical setting for GF is 10-20% of motor FLA (in amps). GF may be set to oFF if this feature is not desired. The GF test procedure in this installation instruction manual must be conducted before the device is brought online.

OPERATION

The relay operation of the Model 777-P2 is designed to be fail-safe. This means when the voltage is within the programmed limits, the relay will energize—the NO contact will close and the NC contact will open. When the unit loses power or senses a fault condition, the relay will de-energize and contacts will return to their original state. Once the unit has been installed and programmed, the unit is ready to operate. Turn MODE SELECT to the RUN position. The display will show “run” alternating with a number (the number displayed will be the number corresponding to where the DISPLAY/PROGRAM knob is pointed). It will do this for the restart delay time programmed into RD1. Once the timer expires, the relay will energize—the NO contact will close and the NC contact will open. If something other than this is displayed, see the troubleshooting section for more information. If MODE SELECT is taken out of RUN, the 777-P2’s relay will de-energize.

Trip Class	Application Description
5	Small fractional horsepower motors where acceleration times are almost instantaneous or where extremely quick trip times are required
10	(Fast Trip) Hermetic refrigerant motors, compressors, submersible pumps and general-purpose motors that reach rated speed in less than 4 seconds
15	Specialized applications
20	(Standard Trip) Most NEMA-rated general-purpose motors will be protected by this setting
30	(Slow Trip) Motors with long acceleration times (>10 seconds) or high inertia loads
J Prefix (Jam Protection)	Programming any of the trip classes with the J prefix will enable jam protection. This additional protection is enabled 1 minute after the motor starts and provides a 2 second trip time for motors exceeding 400% of the OC setting
Non-Standard Trip Classes	Trip time in seconds when any phase current is 600% of OC. Time is approximately 90% of the TC setting

Table 3: Trip Class Descriptions

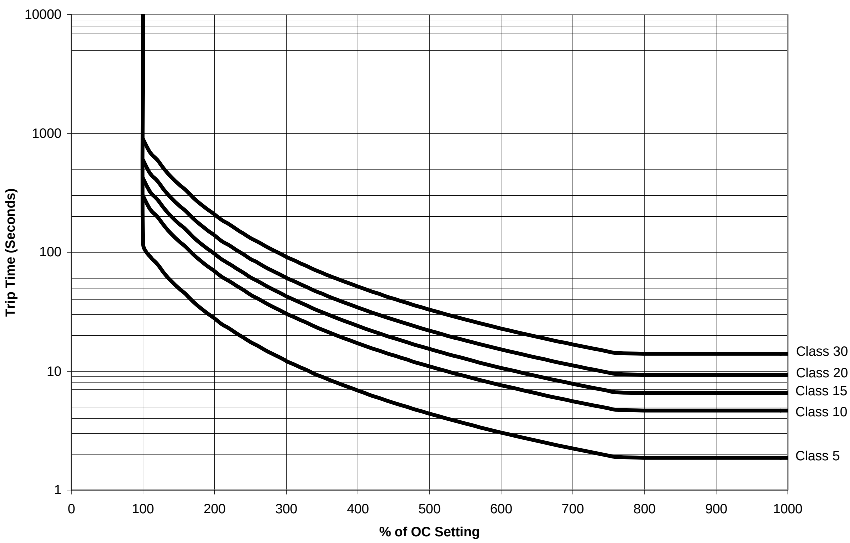


Figure 5: Overload Trip Curves

PROGRAMMING EXAMPLES

NOTE: Since no network communications are connected in these examples there are no setting changes needed for ADDR or COM

Example #1

Motor to be protected: 3-phase, 460 Volt, 25 hp air compressor with a full load amperage rating of 34A and a service factor of 1.1 or max amps at 37.4. Use the following calculations and reasoning to determine the appropriate settings for this application.

LV-	460 x 0.90 = 414
HV-	460 x 1.10 = 506
VUB-	Manufacturer suggests 3
MULT-	MULT=1 from Table 1
OC-	Service Factor Amperage = 37.4
UC-	FLA x 0.80 = 34A x 0.80 = 27.2
CUB-	Manufacturer suggests 5
TC-	From Table 3, general purpose motor = 20 Linear Trip = Off
RD1-	Since this compressor takes about 10 seconds to bleed off excess pressure after a shutdown, setting RD1 = 15 will allow the compressor to unload before being restarted.
RD2-	Because the motor may be hot from running in an unbalance or single-phase condition, a motor cool-down time of 10 minutes should be appropriate, RD2 = 10.
RD3/#RU-	Because an undercurrent would signal a serious problem in this application (a broken shaft or belt), #RU should be set to 0 for a manual reset. Therefore, RD3 does not have any function and no timer setting is needed.
#RF-	Because an overcurrent (overload) fault signals a serious problem in this application (e.g., worn bearings), "oc" should not be included in the #RF setting so that a manual reset after an overcurrent fault is required. A #RF=1 will give the system 1 chance to recover from a current unbalance or current single-phasing problem before manual reset is required.
UCTD-	Setting UCTD = 5 will allow the compressor to reach normal operation and not allow the motor to run too long in a failure mode.
GF-	A ground fault setting of 15% of full load amps may likely indicate that the motor should be evaluated for repair or replacement. Therefore, GF = 34A x 0.15 = 5.1.

Example #2

Motor to be protected: 3-phase, 230 Volt, 5 hp submersible pump with a full load amperage of 15.9A and a service factor of 1.15 or max amps at 18.3. Use the following calculations and reasoning to determine the appropriate settings for this application.

LV-	230 x 0.90 = 207
HV-	230 x 1.10 = 253
VUB-	Manufacturer suggests 3
MULT-	MULT=2 from Table 1
OC-	Service Factor Amperage = 18.3
UC-	FLA x 0.80 = 15.9 x 0.80 = 12.7
CUB-	Manufacturer suggests 5
TC-	From Table 3, for this (and most) submersible pump, TC = 10 (fast trip) Linear Trip = Off
RD1-	To protect the pump from rapid cycling, RD1 = 60
RD2-	Since the motor is small and submerged in water, the motor will generally cool down quickly. RD2=5

RD3- The well history shows that it will fully recover in 2 hours. RD3 = 120

#RU- In this application, we know that the well will eventually recharge itself, #RU = A (Automatic).

#RF- This well is known for sand to jam the impeller, therefore “oc” should be included so that the pump will attempt to automatically restart after an overloaded condition. History shows that 2 or 3 starts and stops usually clears the sand out of the impeller. #RF= oc2 or oc3.

UCTD- This well may become air locked on startup, but will usually re-prime itself in 5 seconds or less. UCTD = 10

GF- Because this type of fault indicates the impending failure of the motor and it may take several days to get a new pump and schedule for a driller to remove and replace the pump, GF setting of 10% of full load amperage will give the well owner enough time to prepare for pump replacement. GF = 15.9A x 0.10 = 1.59 (use a setting of 1.6 amps).

SYSTEM DISPLAY

On power up, the 777-P2 will show the current software revision. For example if the software revision is 33.04, the 777-P2 will show 033 followed by 004.

The output display can show one of the following parameters when MODE SELECT is in RUN: L1-L2, L2-L3, and L3-L1 line voltage; %VUB; A, B, and C phase current; %CUB; measured GF current. The display is used for programming the operating parameters of the device and also identifies what caused the unit to de-energize its relay or what is keeping the unit from energizing its relay, and under normal operating conditions, what the last fault was. The last fault can be displayed by pressing and holding the RESET/PROGRAM button while MODE SELECT is in RUN. When the unit trips off or is holding the motor off, the current fault condition will be shown in the display without pressing the button (CAUTION: pressing the reset button at this time will reset the unit). Table 4 lists the fault codes the unit could display.

Displayed Message	Meaning
oc	Tripped on overcurrent
SP	Tripped on current single-phasing or unit won’t start because the voltage is single-phased
ub	Tripped on current unbalance or unit won’t start because the voltage is unbalanced
uc	Tripped on undercurrent
CF	Tripped on contactor failure (due to faulty contacts or connections on the load side)
GrF	Tripped on ground fault
HI	A high voltage condition exists (won’t allow motor to start)
Lo	A low voltage condition exists (won’t allow motor to start)
rP	Incoming phases have been reversed, the motor may run backwards if started
oFF	A stop command was issued from a remote source
HPr	Tripped on high power
LPr	Tripped on low power
CLo	Tripped on low control voltage
clr	No previous faults
Pro	Shown when programming using the battery in the RUN position
FFF	Displayed value is greater than 999 (can be due to incorrect MULT setting)

Table 4: Fault Codes

TROUBLESHOOTING

The 777-P2 will display a fault code alternating with a number or with “run” when it has tripped. If the unit is showing a fault code alternating with “run,” it is timing down the restart delay. If the fault code is alternating with a number (voltage reading or zero), the unit will not allow the motor to start because there is a problem with the incoming voltage. If the display is showing just a fault code, the unit is in a manual reset mode. This could be because the number of restarts (#RF, #RU) has expired or is not allowed. If the display reads “oFF,” a stop command was issued through the communications network or a remote monitor.

PROBLEM	SOLUTION
The unit will not start. Display alternates “rP” with the DISPLAY/PROGRAM parameter value.	The voltage inputs are reverse-phased. If this is the initial start-up, swap any two of the leads connected to L1, L2, or L3 on the 777-P2 to correct the problem. If the overload relay has been previously running, the power system has been reverse-phased. Check the phase sequence of the incoming power lines. **Note**: L1 must be tapped from conductor Phase A, L2 from B, and L3 from C for correct power factor measurements on remote communications.
The unit will not start. Display alternates “SP”, “ub”, “HI”, or “Lo” with the DISPLAY/ PROGRAM parameter value.	The incoming voltage is not within the limits programmed in the VUB, HV, and LV settings. Turn the DISPLAY / PROGRAM knob to read each incoming line voltage value. Correct the incoming power problem and check programmed limits by turning the MODE SELECT knob. Compare incoming values for HV, LV, and VUB to setpoints to verify they are correct.
Display alternates “SP”, “ub”, or “oc” with “run.”	The overload relay has tripped on the fault shown on the display and is timing down RD2 before restarting. No further action is required.
Display alternates “uc” with “run.”	The overload relay has tripped on undercurrent and is counting down RD3 before restarting. If undercurrent is not a normal condition for this installation, check for broken shafts, broken belts, etc.
Display is showing a solid “SP”, “ub”, or “oc.”	The unit has tripped on the fault shown and a manual reset is required because of the programmed setting in #RF. Check the system for problems that would produce the single-phase, overcurrent or current unbalance fault, such as a jam.
Display is showing a solid “uc.”	The unit has tripped on undercurrent and a manual reset is required because of the setting in #RU. Check the system for problems that would produce a loss of load such as a broken belt or a lack of liquid to pump.
Display is showing a solid “CF.”	The unit has tripped on current single-phasing, but was not single-phased by the incoming voltage. Check for damaged contacts or loose or corroded wiring connections.
Display is showing a solid “GrF.”	A ground fault current greater than the programmed GF value has been detected. Check the motor for insulation breakdown. A manual reset is required to clear this message. Press the RESET button to perform a manual reset.
Display alternates “LPr”[2] with “RUN”	The overload relay has tripped on low power (LPr) and is timing down RD3 before restarting. If LPr is not a normal condition for this installation, check for loss of liquid, closed valves, broken belts, etc.

PROBLEM	SOLUTION
Display is showing a solid “LPr” [2]	The unit has tripped on low power and a manual reset is required because of the setting in #RU. Check the system for problems that would produce a loss of load like a broken belt or a pump is out of liquid. Press the RESET button to perform a manual reset.
Display alternates “HPr” [2] with “RUN”	The unit has tripped on high power and is timing down RD2. Check for a high power condition.
Display is showing solid “HPr”[2]	The unit has tripped on high power and requires a manual reset because of the setting in #RF. Press the RESET button to perform a manual reset.
Display alternates “CLo” [2] with “RUN”	The overload relay has tripped on low control voltage (CLo) and is timing down RD2 before restarting.
Display is showing solid “CLo”[2]	The unit has tripped on low control voltage and a manual reset is required because of the setting in #RF. Verify system voltage is correct. Press the RESET button to perform a manual reset.

[2] LPr, HPr, and CLo are enabled only from a network master via a communications module.

CLEARING LAST FAULT

The last fault stored can be cleared on the 777-P2 by following these steps:

1. Rotate the MODE SELECT switch to GF.
2. Press and hold the RESET/PROGRAM button. Adjust the DISPLAY/PROGRAM knob until “cLr” appears on the display. Release the RESET/PROGRAM button.

To verify the last fault was cleared, place the MODE SELECT switch in the RUN position. Then press and hold the RESET/PROGRAM button; “cLr” should be on the display.

TAMPER GUARD

The 777-P2 setpoints can be locked to protect against unauthorized program changes.

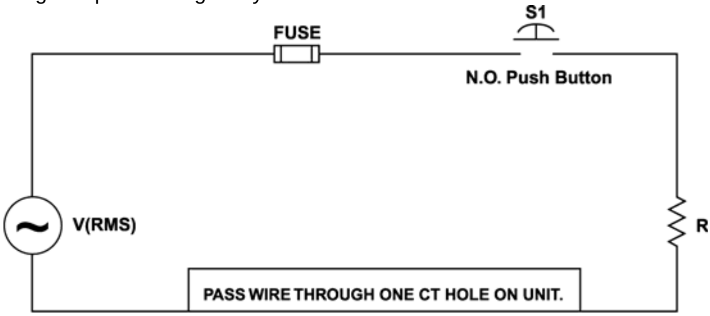
1. Rotate the MODE SELECT switch to GF.
2. Press and hold the RESET button. Adjust the DISPLAY/PROGRAM knob until “Loc” appears on the display.
3. Release the RESET button.
4. Turn MODE SELECT switch to RUN.

The program is now locked, but all settings can be viewed. The unit can be unlocked by following the same steps except adjust the DISPLAY/PROGRAM knob to “unL” in step 2.

GROUND FAULT TESTING PROCEDURE

A ground fault test must be performed before installing the 777-P2 as required by UL1053 and NEC, ANSI/NFPA 70.

1. Disconnect power.
2. Hook up the three line voltages to L1, L2, and L3 as required by the installation instructions.
3. Program the desired parameters into the unit. For test purposes, set MULT to 1 and GF to the minimum allowed setting.
4. Construct the circuit, using an AC power supply. This circuit simulates a ground fault condition by generating a current in one of the phases. Alternate test circuits may be used. The only requirement is the current through the current transformer must be between 115% and 150% of the GF setting and pass through only one CT window.



5. The values of V and R will be determined by the current required to generate a GF trip condition: I = Vrms/R, where I = 115% of GF setting.
6. Place the unit in the RUN position, apply 3-phase power and allow the NO contact to close.
7. Energize the test circuit by pushing and holding the test pushbutton until the unit trips (within 8.5 seconds). The display should show “GrF” and the NO contacts should be open. Release the NO pushbutton.
8. The results of the test are to be recorded on the test form provided below. The form should be kept by those in charge of the building’s electrical installation in order to be available to the authority having jurisdiction.
9. Confirm programmed parameters and proceed with installation instructions.

GROUND FAULT TEST RESULTS*

Date	Performed by	Results	Location

*A copy of this form should be retained by the building’s electrical foreman.

777-P2 SPECIFICATIONS

Functional Specifications	
Programmable Operating Points	
LV- Low Voltage Threshold	170–524V (450–649)*
HV- High Voltage Threshold	172–528V (451–660V)*
VUB- Voltage Unbalance Threshold	2-25% or 999 (disable)
MULT- # of Conductors or CT Ratio (XXX:5)	1–10, 100, 150, 200, 300, 400, 500, 600, 700, 800
OC- Overcurrent Threshold **	(20–100A) ÷ MULT or 80–140% of CT Primary
UC- Undercurrent Threshold **	(0, 10–98A) ÷ MULT or 40–140% of CT Primary
CUB- Current Unbalance Threshold	2–50% or 999 (disable)
TC- Overcurrent Trip Class[3]	2-60, J2-J60, L00-L60, oFF
RD1- Rapid Cycle Timer	0-999 seconds
RD2- Restart Delay After All Faults Except Undercurrent (motor cool-down timer)	2–500 minutes
RD3- Restart Delay After Undercurrent (dry-well recovery timer)	2–500 minutes, A (Automatic)
#RU- Number of Restarts After Undercurrent	0, 1, 2, 3, 4, A (Automatic)
ADDR- RS485 Address	A01–A99
#RF-Number of Restarts After All Faults Except Undercurrent[4]	0, 1, oc1, 2, oc2, 3, oc3, 4, oc4, A, ocA (Automatic)
COM- Communication setting	C00-C07
UCTD- Undercurrent Trip Delay	2–999 seconds
GF- Ground Fault Current Threshold**	(3-20A) ÷ MULT or 12-40% of CT Primary or oFF
Trip Times	
Ground Fault Trip Time	Trip time
101%-200% of Setpoint	8 seconds ±1 second
201%-300% of Setpoint	4 seconds ±1 second
301%-400% of Setpoint	3 seconds ±1 second
401% or Greater	2 seconds ±1 second
Current Unbalance Trip Times	
% Over Setpoint	Trip time
0%	30 seconds
1%	15 seconds
2%	10 seconds
3%	7.5 seconds
4%	6 seconds
5%	5 seconds
6%	4 seconds
11%	3 seconds
15%	2 seconds
Input Characteristics	
Input Voltage (3-phase)	200–480VAC (Model 777-P2) 500–600VAC (Model 777-575-P2)
Frequency	50/60 Hz
Motor Full Load Amp Range	
3-phase, (looped conductors required)	1–20A
3-phase (direct)	20–90A
3-phase (external CTs required)	80–800A

[3] If a “J” is included in the trip class (TC) setting, jam protection is enabled.
[4] If "oc" is displayed in the #RF setting, overcurrent will be included as an automatic restart after RD2 expires. Otherwise, a manual reset is required after an OC fault.

Output Characteristics	
Output Contact Rating SPDT (Form C)	Pilot duty rating: 480VA @ 240VAC, B300 General purpose: 10A @ 240VAC
Expected Life	
Mechanical	1 x 10^6 operations
Electrical	1 x 10^5 operations at rated load
General Characteristics	
Environmental	
Temperature Range	Ambient Operating: -20° to 70°C (-4° to 158°F) Ambient Storage: -40° to 80°C (-40° to 176°F)
Pollution Degree	3
Class of Protection	IP20 (Finger Safe)
Relative Humidity	10-95%, non-condensing per IEC 68-2-3
Accuracy at 25°C (77°F)	
Voltage	±1%
Current	±3% (<100A direct)
Timing	±0.5 second
Ground Fault	±15% (< 100A)
Repeatability	
Voltage	±0.5% of nominal voltage
Current	±1% (<100A direct)
Maximum Input Power	10 W
Safety Marks	
UL	UL508, UL1053
CE	IEC 60947-1, IEC 60947-5-1
Standards Passed	
Electrostatic Discharge (ESD)	IEC 61000-4-2, Level 3, 6kV contact, 8kV air
Radio Frequency Immunity (RFI), Conducted	IEC 61000-4-6, Level 3 10V
Radio Frequency Immunity (RFI), Radiated	IEC 61000-4-3, Level 3 10V/m
Fast Transient Burst	IEC 61000-4-4, Level 3, 3.5 kV input power
Surge	
IEC	61000-4-5 Level 3, 2kV line-to-line; Level 4, 4kV line-to-ground
ANSI/IEEE	C62.41 Surge and Ring Wave Compliance to a level of 6kV line-to-line
Hi-potential Test	Meets UL508 (2 x rated V +1000V for 1 minute)
Vibration	IEC 68-2-6, 10-55Hz, 1mm peak-to-peak, 2 hours, 3 axis
Shock	IEC 68-2-27, 30g, 3 axis, 11ms duration, half-sine pulse
Mechanical	
Dimensions	3.0" H x 3.6" W x 5.1" D
Terminal Torque	7 in.-lbs.
Enclosure Material	Polycarbonate
Weight	1.2 lbs
Maximum Conductor Size Through 777-P2	0.65" with insulation

NOTE: The 777-P2 can be programmed prior to installation by connecting a 9V battery. Disconnect power prior to using the battery cable and follow all safety warnings.
*575 Volt Model
** Do not program the unit above the thermal rating for the CTs.

For warranty information, please see **Terms and Conditions** at
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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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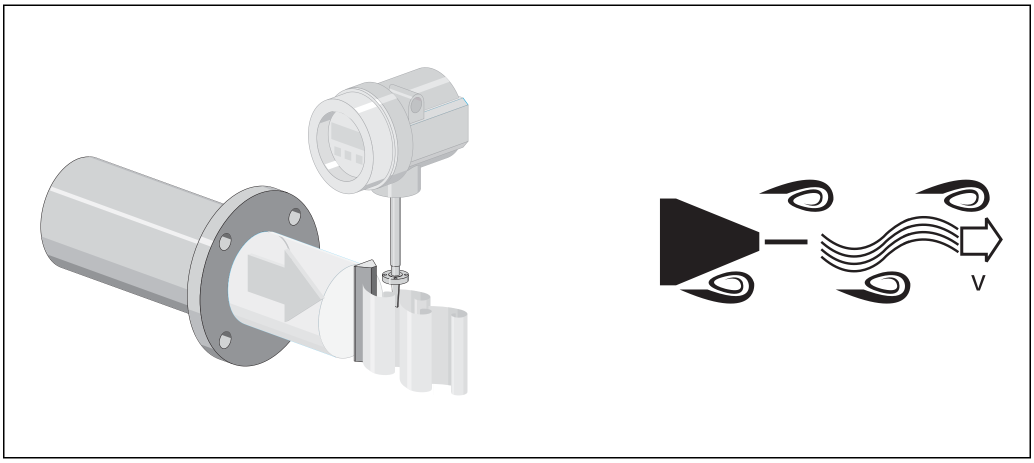
Table of contents

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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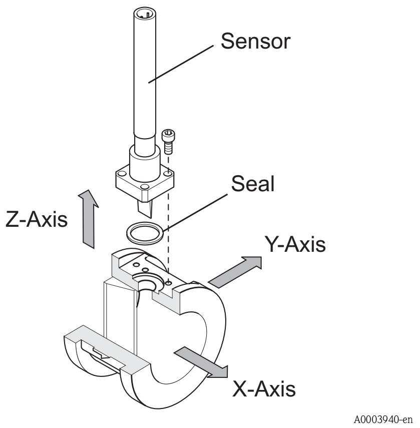
- Within the application limits of the device, the K-factor only depends on the geometry of the device. It is independent of the fluid velocity and the fluid properties viscosity and density. In this way, the K-factor is also independent of the type of matter that is to be measured, regardless of whether 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

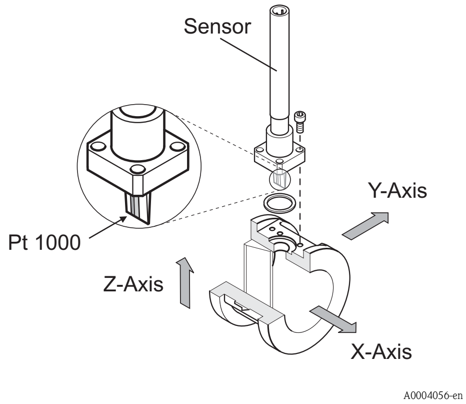
The sensor of a vortex flowmeter has a major influence on the performance, robustness and reliability of the whole measuring system.

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.

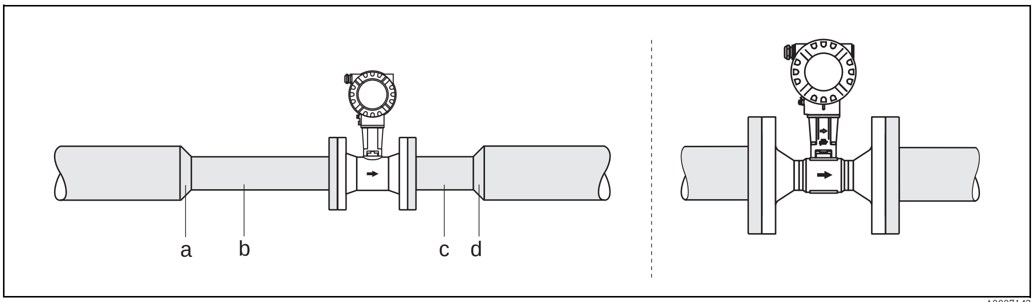
Thus, the Prowirl product line offers calibration for life if the measuring device is used in non-abrasive and non-corrosive fluids.

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.

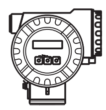
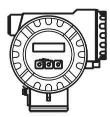
Diagnostic functions (Prowirl 73)

Extensive diagnostic options, such as retracing fluid and ambient temperatures, extreme flows etc., are also optionally available for the measuring device.

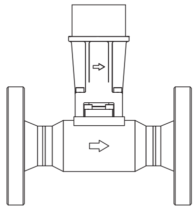
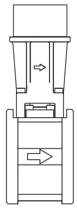
Measuring system

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:

$$Re = \frac{4 \cdot Q\,[m^3/s] \cdot \rho\,[kg/m^3]}{\pi \cdot di\,[m] \cdot \mu\,[Pa{\cdot}s]}$$

A0003794-en

Re = Reynolds number; Q = flow; di = internal diameter; m = dynamic viscosity, r = density

$$DN\ 15...25 \rightarrow v_{min.}{}^{*} = \frac{6}{\sqrt{\rho\,[kg/m^3]}}\,[m/s] \qquad DN\ 40...300 \rightarrow v_{min.}{}^{*} = \frac{7}{\sqrt{\rho\,[kg/m^3]}}\,[m/s]$$

A0003239-en

** 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:

$$\rho\ [\text{kg/m}^3] = \frac{\rho_N\ [\text{kg/Nm}^3] \cdot P\ [\text{bar abs}] \cdot 273.15\ [\text{K}]}{T\ [\text{K}] \cdot 1.013\ [\text{bar abs}]} \qquad \rho_N\ [\text{kg/Nm}^3] = \frac{\rho\ [\text{kg/m}^3] \cdot T\ [\text{K}] \cdot 1.013\ [\text{bar abs}]}{P\ [\text{bar abs}] \cdot 273.15\ [\text{K}]}$$

A0003946-en

The following formulae can be used to calculate the volume [Q] or corrected volume [Q_N] in the case of ideal gases:

$$Q\ [\text{m}^3/\text{h}] = \frac{Q_N\ [\text{Nm}^3/\text{h}] \cdot T\ [\text{K}] \cdot 1.013\ [\text{bar abs}]}{P\ [\text{bar abs}] \cdot 273.15\ [\text{K}]} \qquad Q_N\ [\text{Nm}^3/\text{h}] = \frac{Q\ [\text{m}^3/\text{h}] \cdot P\ [\text{bar abs}] \cdot 273.15\ [\text{K}]}{T\ [\text{K}] \cdot 1.013\ [\text{bar abs}]}$$

A0003941-en

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

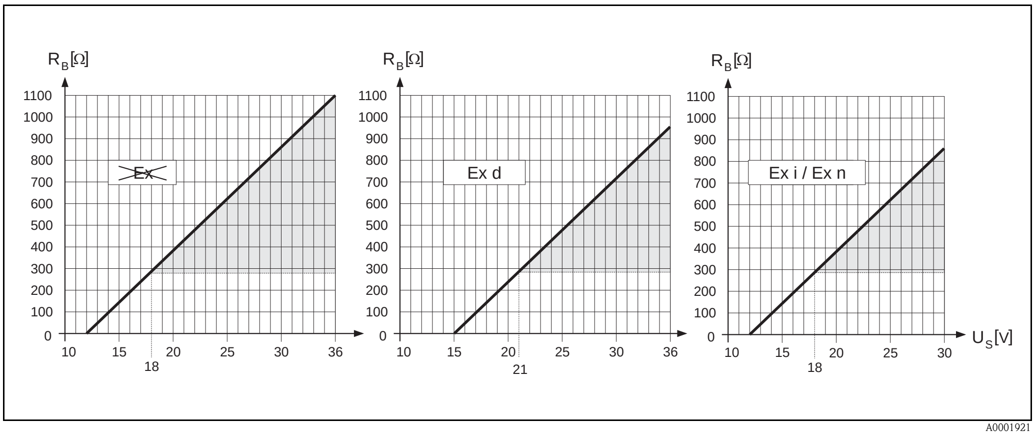
FOUNDATION Fieldbus interface:

- 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

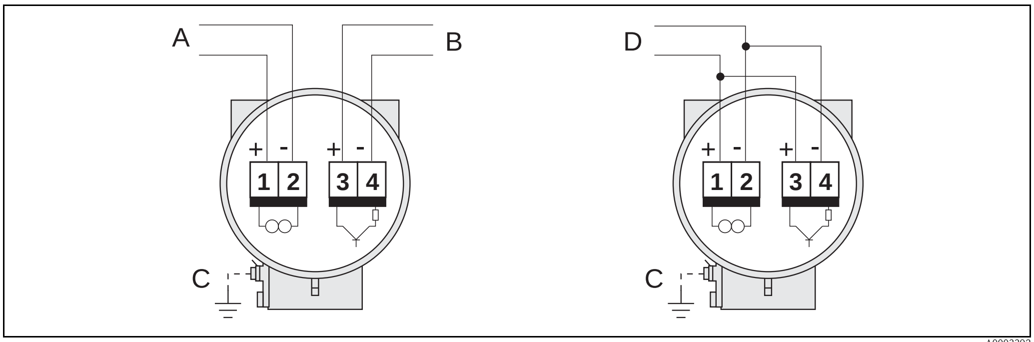
Switch points for low flow cut off can be selected as required.

Galvanic isolation

All electrical connections are galvanically isolated from one another.

Power supply

Electrical connection



A0003392

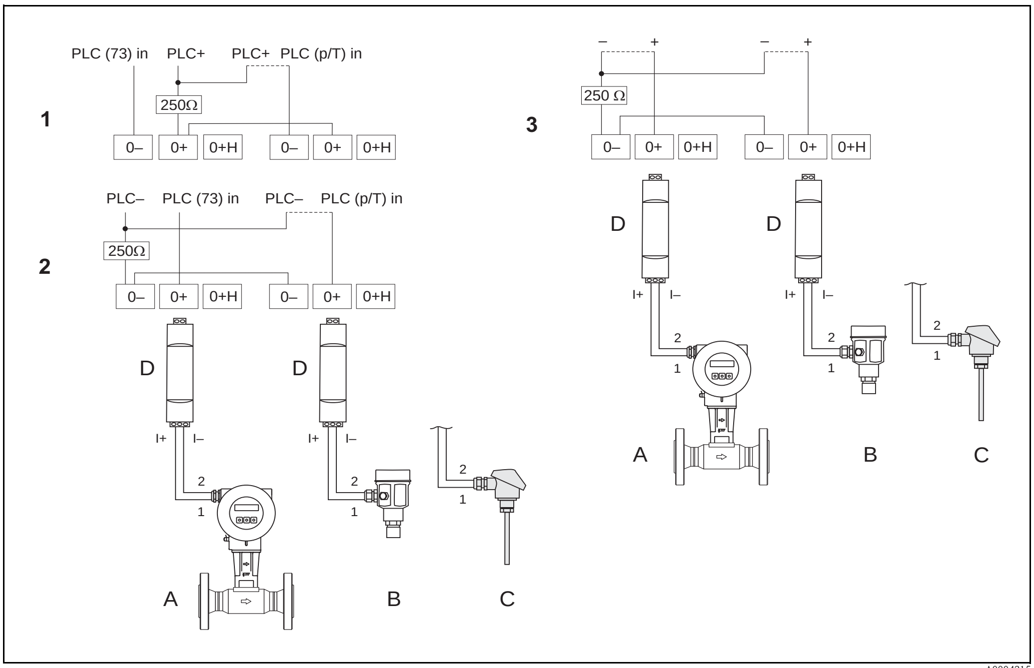
A – HART: power supply, current output
– PROFIBUS PA: 1 = PA+, 2 = PA–
– FOUNDATION Fieldbus: 1 = FF+, 2 = FF–

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

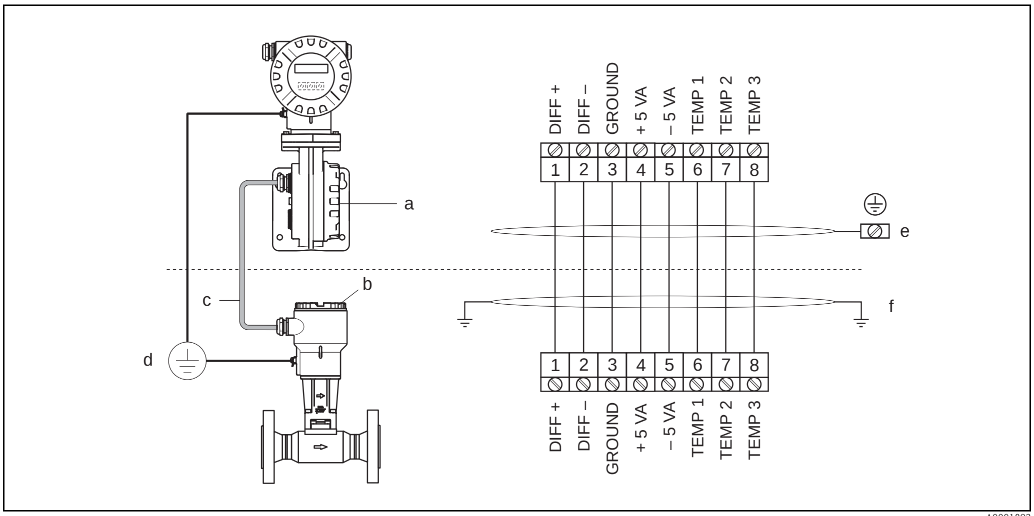
1 Connection diagram for PLC with common "plus"
Dotted line = alternative wiring when only the signal of the Prowirl 73 is fed to the PLC.

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

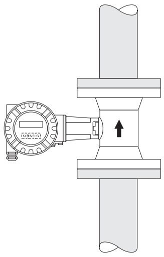
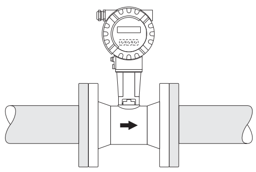
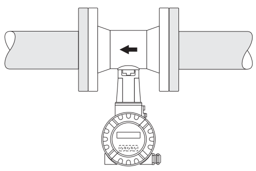
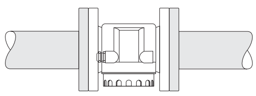
Current output (additional error, in reference to the span of 16 mA):
- Zero point (4 mA):
  Average Tk: 0.05%/10K, max. 0.6% over the entire temperature range –40 to +80 °C
- Span (20 mA):
  Average Tk: 0.05%/10K, max. 0.6% over the entire temperature range –40 to +80 °C

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:

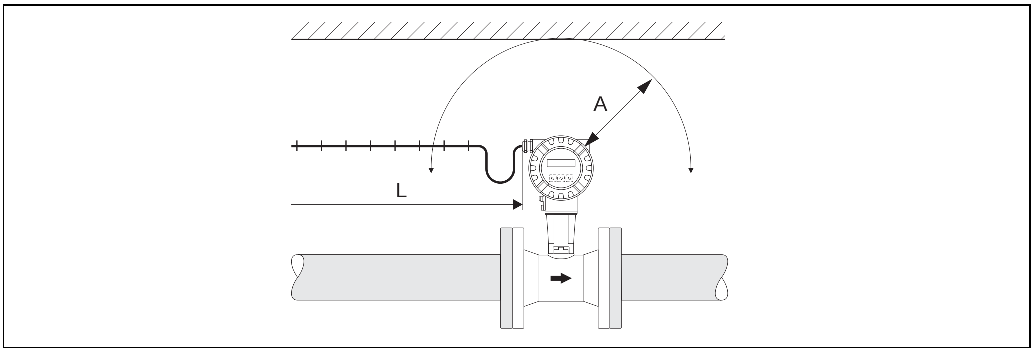
③ Select orientation C or D for hot fluids (e.g. steam or fluid temperature (TM) ≥200 °C

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



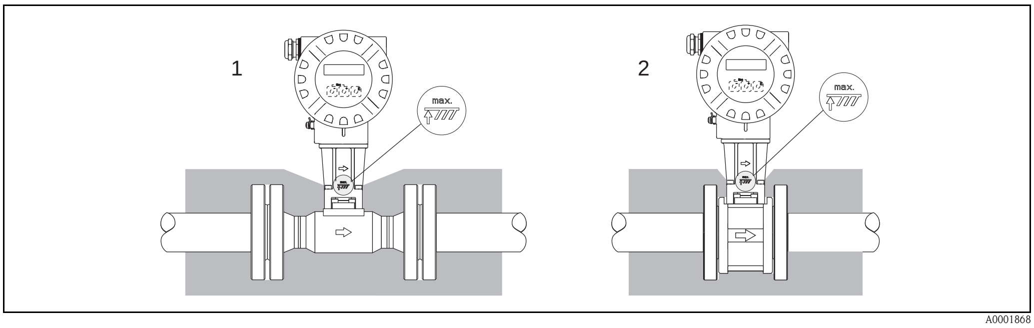
A0001870

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

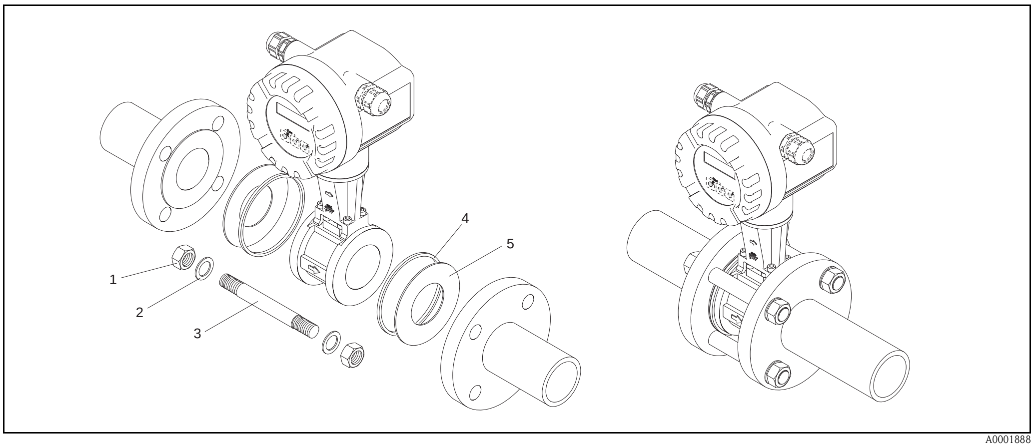
When insulating, please ensure that a sufficiently large area of the housing support is exposed.
The uncovered part serves as a radiator and protects the electronics from overheating (or undercooling).
The maximum insulation height permitted is illustrated in the diagrams. These apply equally to both the compact version and the sensor in the remote version.



1 = Flanged version
2 = Wafer version

Wafer version mounting set

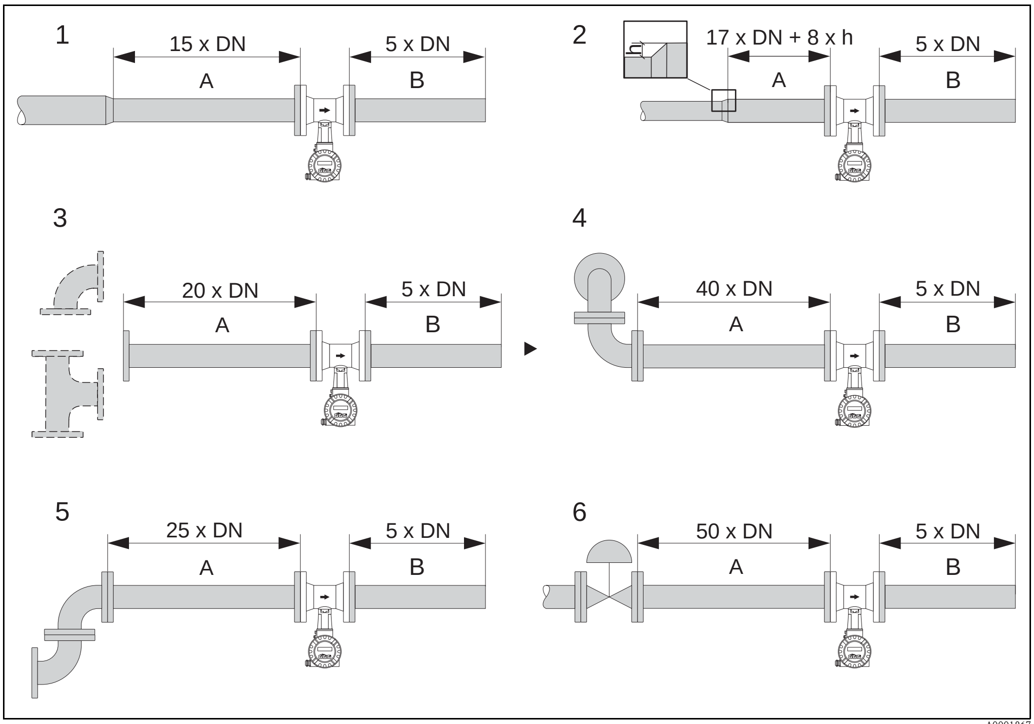
The centering rings supplied are used to mount and center the wafer-style devices. A mounting set consisting of tie rods, seals, nuts and washers can be ordered separately.



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.



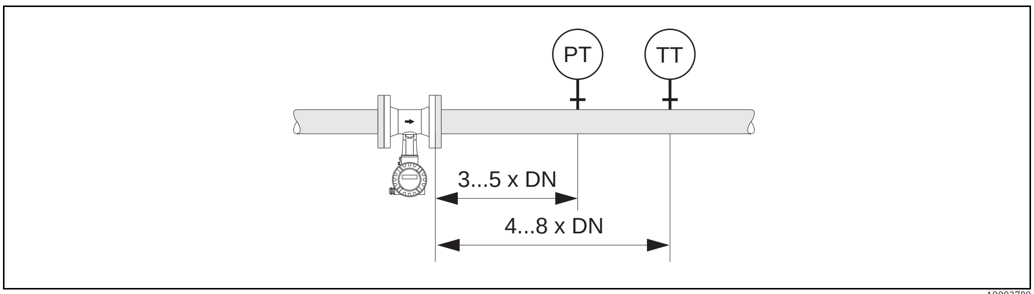
Minimum inlet and outlet runs with various flow obstructions

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

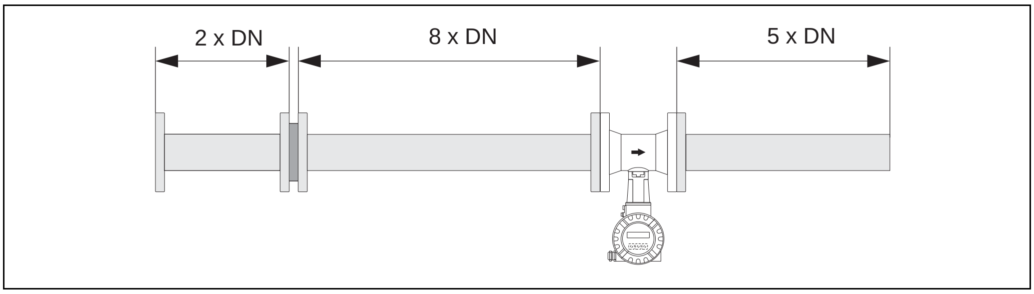
If pressure and temperature measuring points are installed after the device, please ensure there is a large enough distance between the device and the measuring point so there are no negative effects on vortex formation in the sensor.



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.



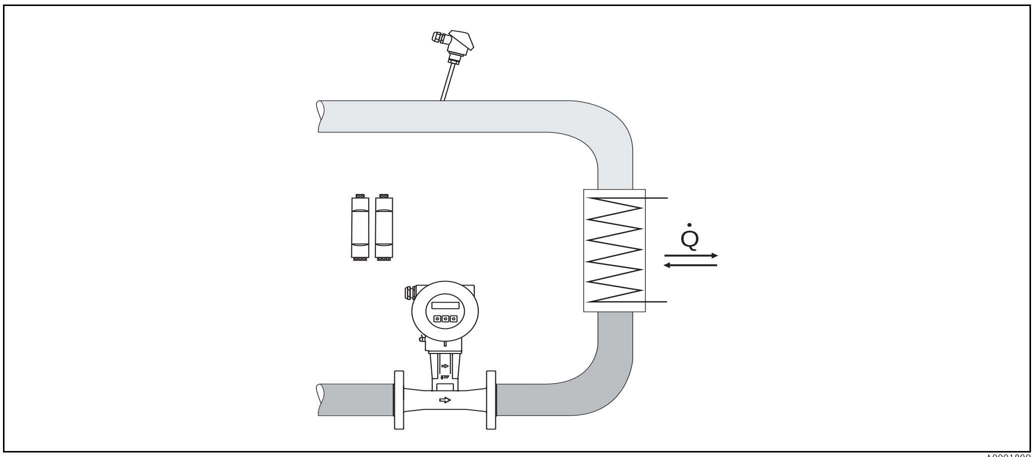
The pressure loss for flow conditioners is calculated as follows:
Δp [mbar] = 0.0085 · ρ [kg/m³] · v^2 [m/s]

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.



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

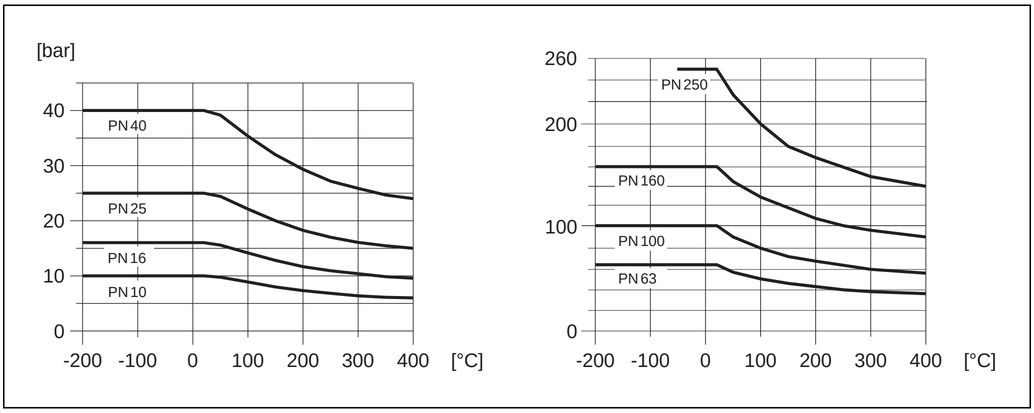
Stainless steel	–200 to +400 °C
Special version for high fluid temperatures (on request)	–200 to +450 °C –200 to +440 °C, Ex version

Medium pressure

Prowirl 72

Pressure-temperature curve to EN (DIN), stainless steel

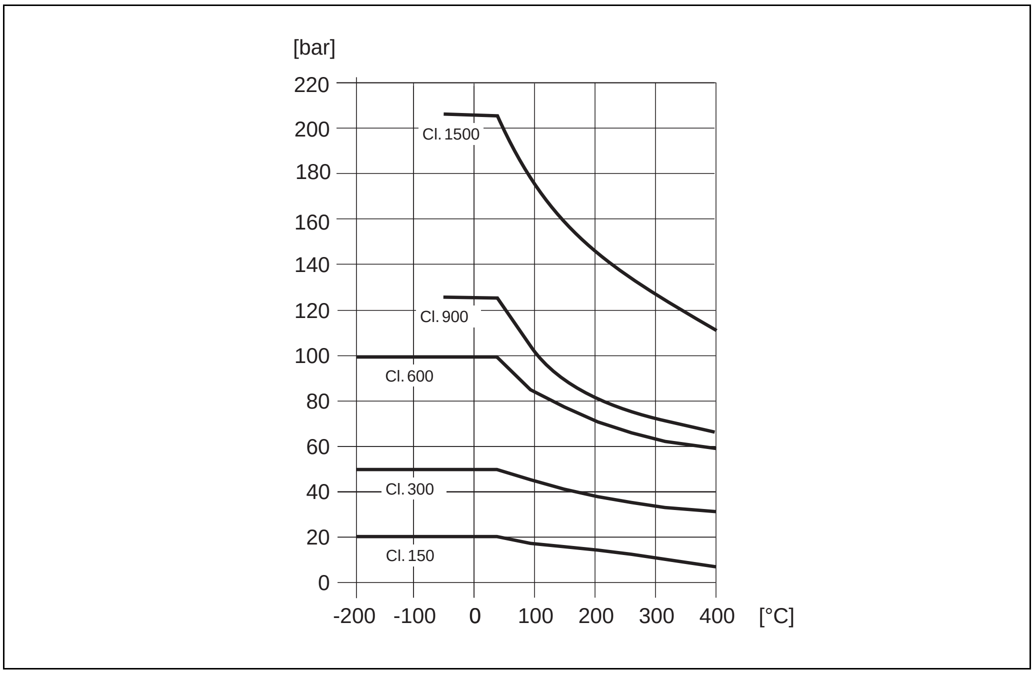
PN 10 to 40 → Prowirl 72W and 72F
PN 63 to 250 → Prowirl 72F



A0003238-en

Pressure-temperature curve to ANSI B16.5, stainless steel

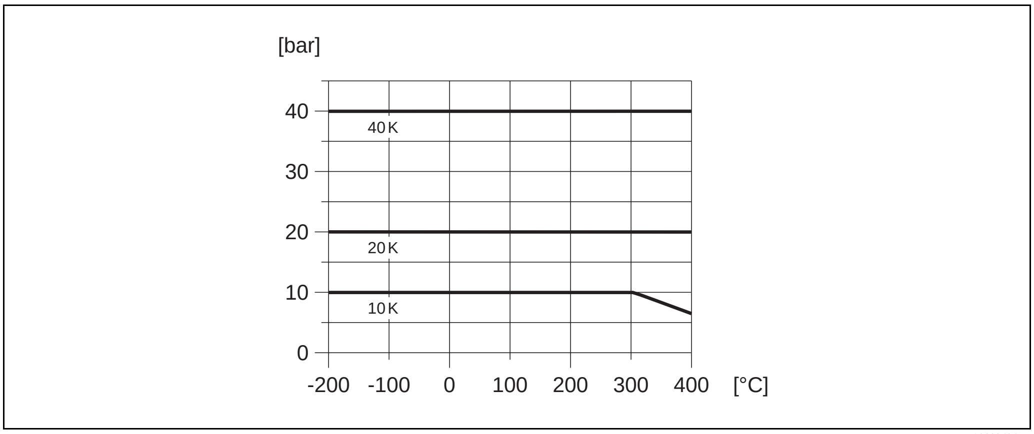
Class 150 to 300 → Prowirl 72W and 72F
Class 600 to 1500 → Prowirl 72F



A0003402-en

Pressure-temperature curve to JIS B2220, stainless steel:

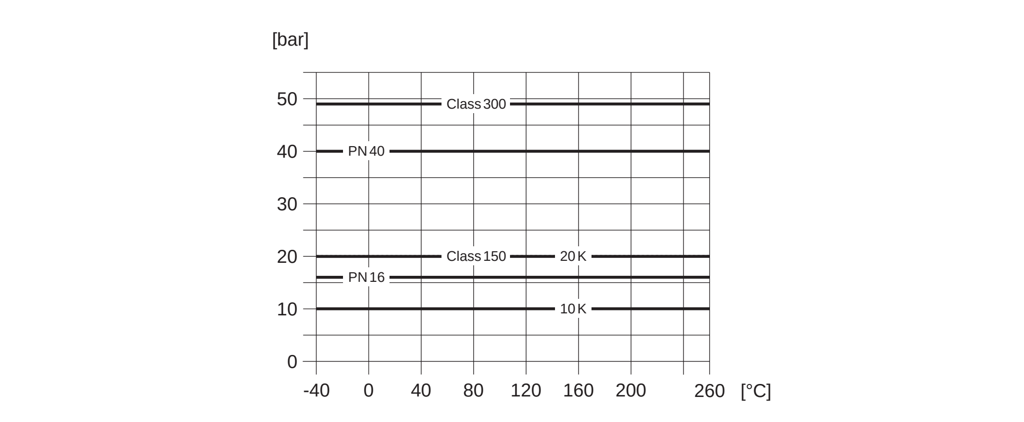
10 to 20K → Prowirl 72W and 72F
40K → Prowirl 72F



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

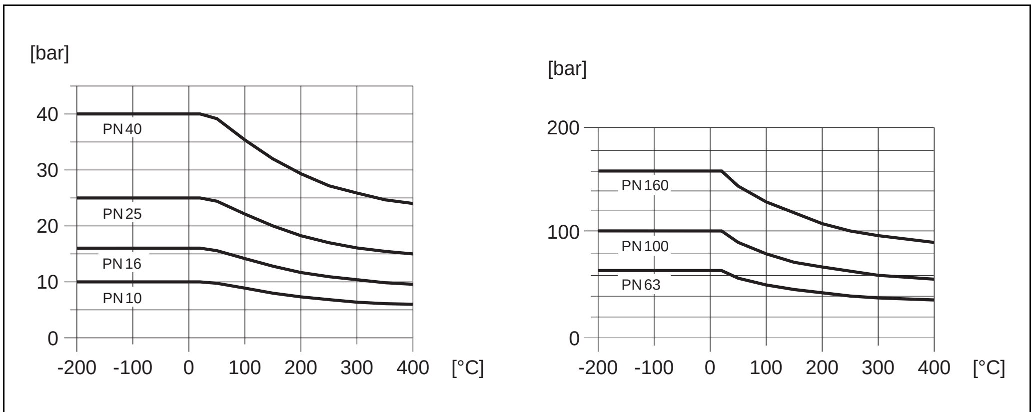


A0003395-en

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)

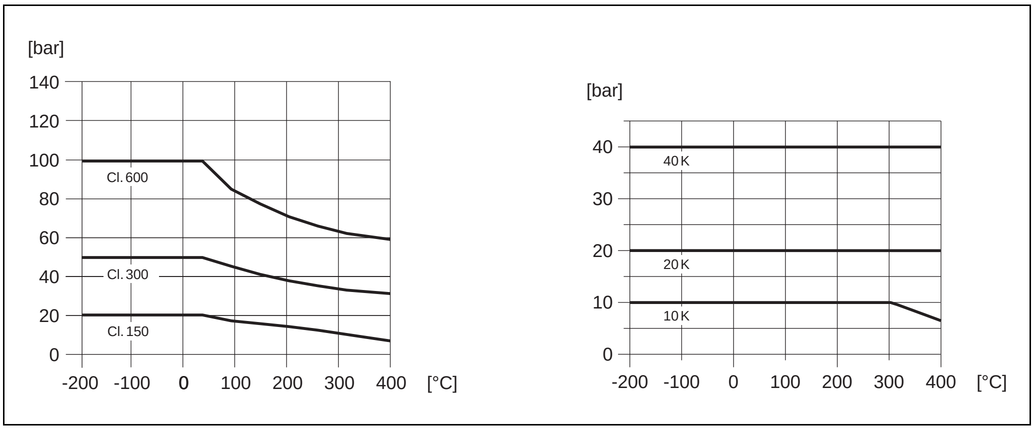


A0007085-en

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

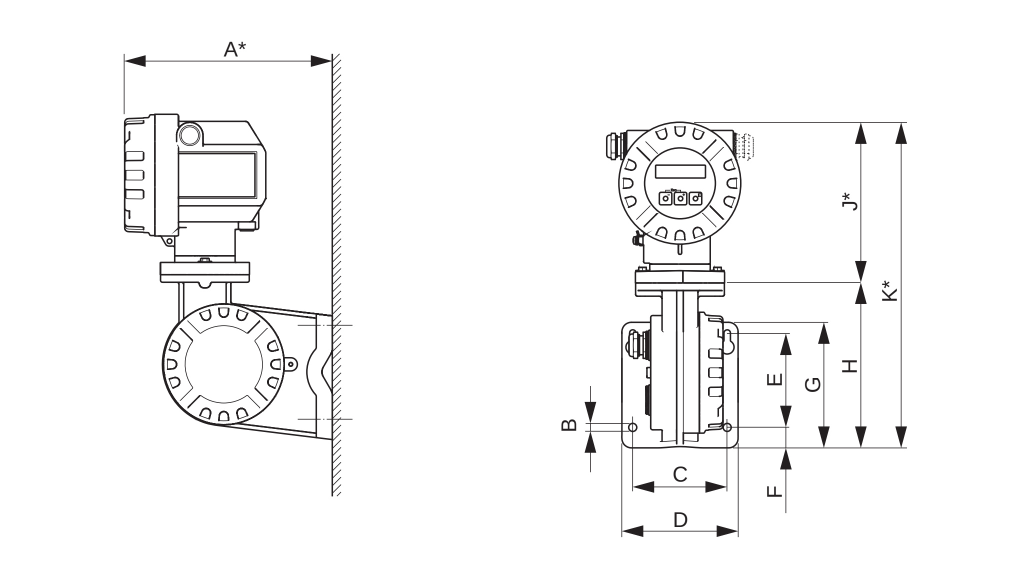
Pressure loss

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



A0003594

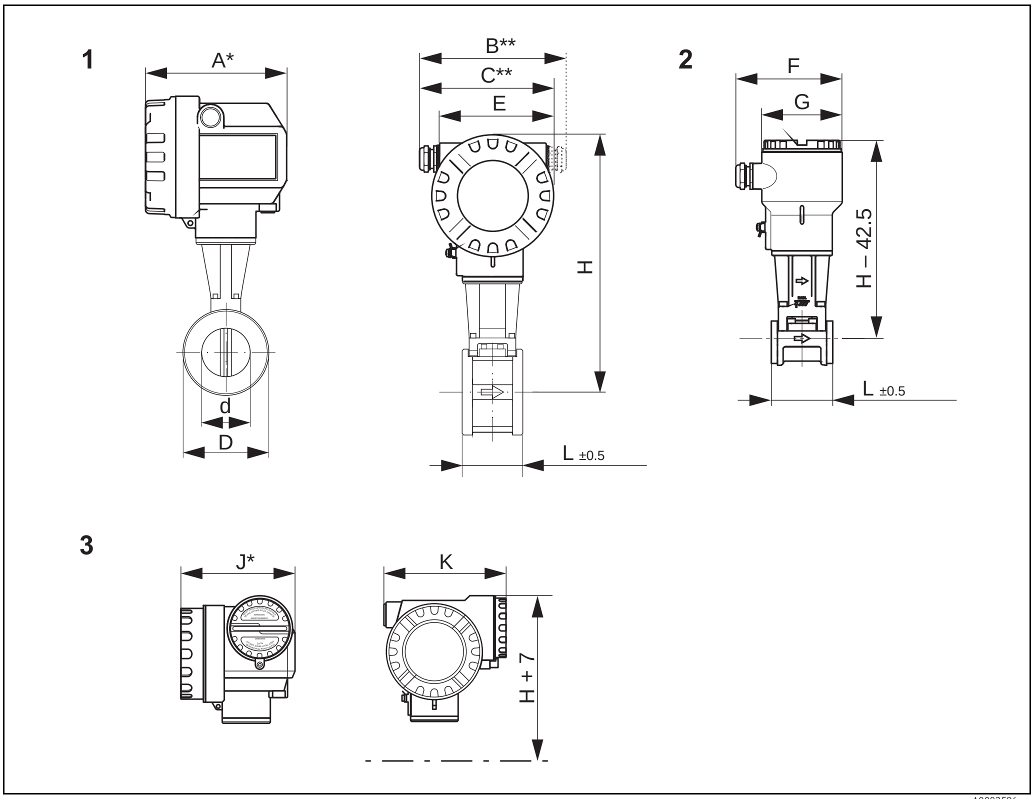
A	B	C	D	E	F	G	H	J	K
[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
232	∅ 8.6 (M8)	100	123	100	23	144	170	170	340

* 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).

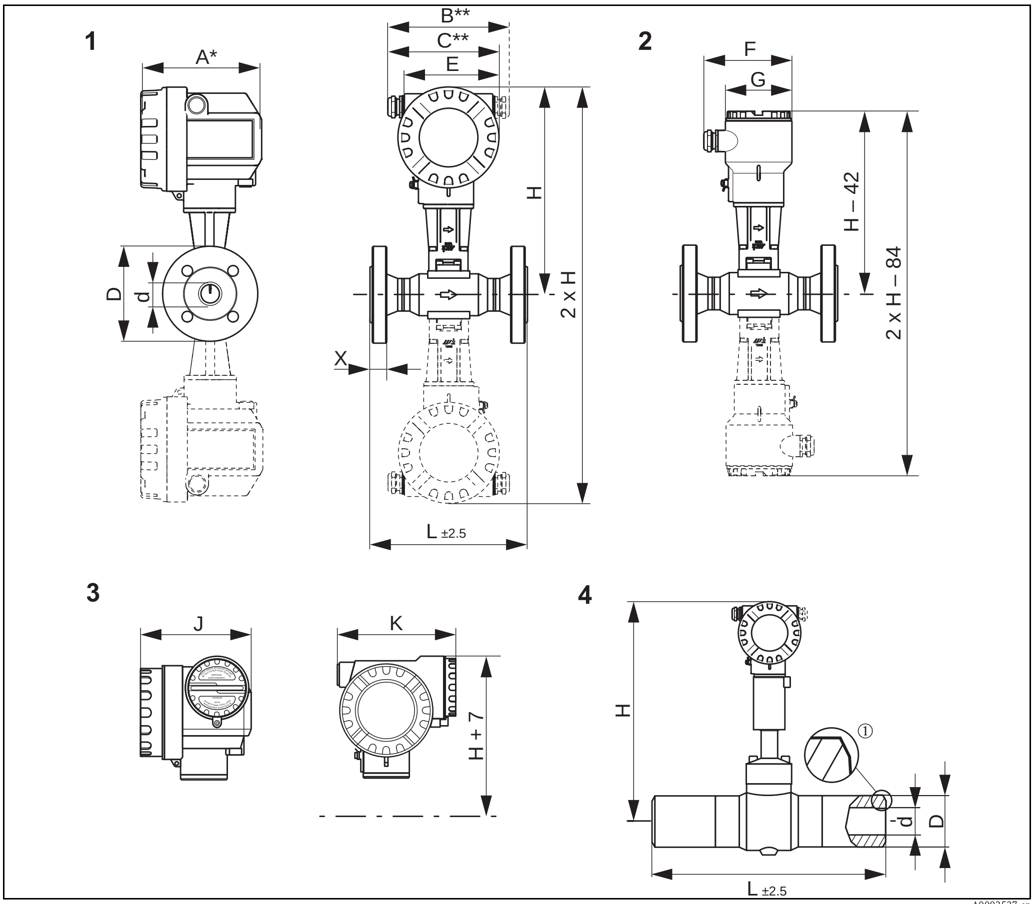
DN		d	D	H[1]	L	Weight[2]
DIN/JIS	ANSI	mm	mm	mm	mm	kg
15	½"	16.5	45.0	247	65	3.0
25	1"	27.6	64.0	257	65	3.2
40	1½"	42.0	82.0	265	65	3.8
50	2"	53.5	92.0	272	65	4.1
80	3"	80.3	127.0	286	65	5.5
100 (DIN)	–	104.8	157.2	299	65	6.5
100 (JIS)	4"	102.3	157.2	299	65	6.5
150	6"	156.8	215.9	325	65	9.0

[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	D	H[3)]	L	X	Weight[4)]
		mm	mm	mm	mm	mm	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

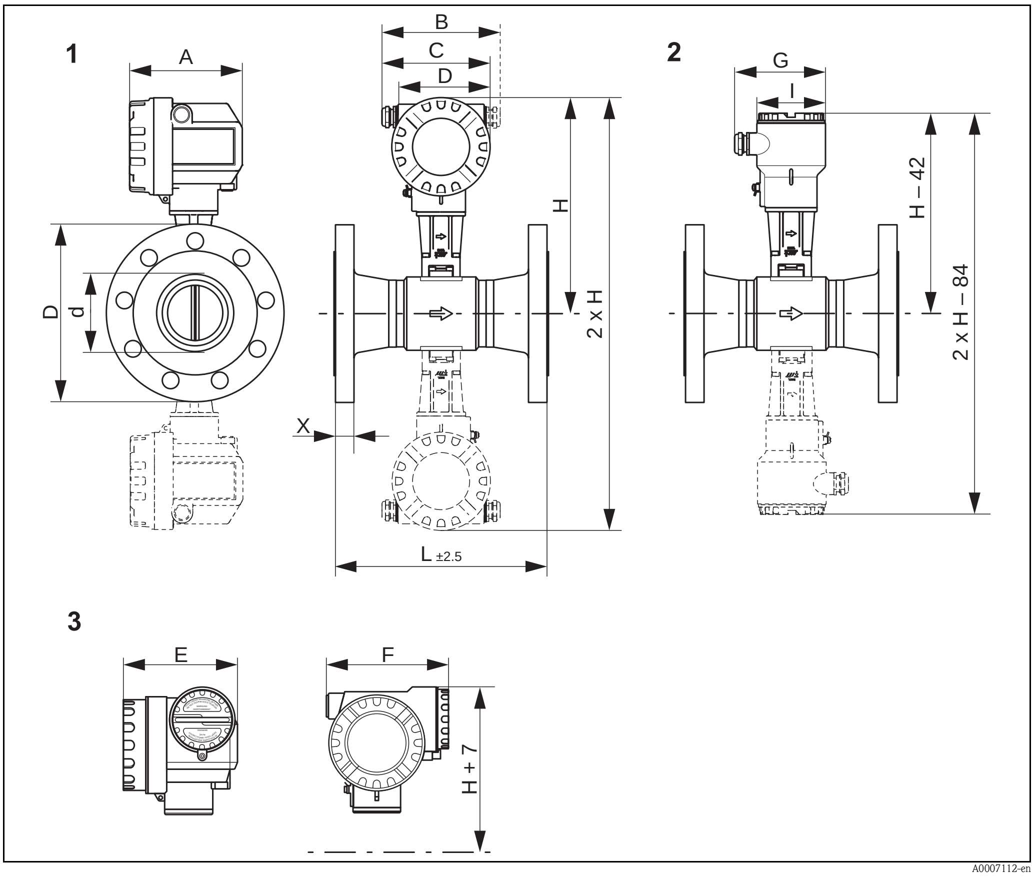
Flanged versions (standard devices) to JIS B2220 Prowirl 72F, 73F								
DN	Pressure rating		d [mm]	D [mm]	H[2)] [mm]	L [mm]	X [mm]	Weight[3)] [kg]
300[4)]	Schedule 40	10K	304.8	445	398	450	51	119
	Schedule 40	20K	304.8	480	398	450	51	134

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.

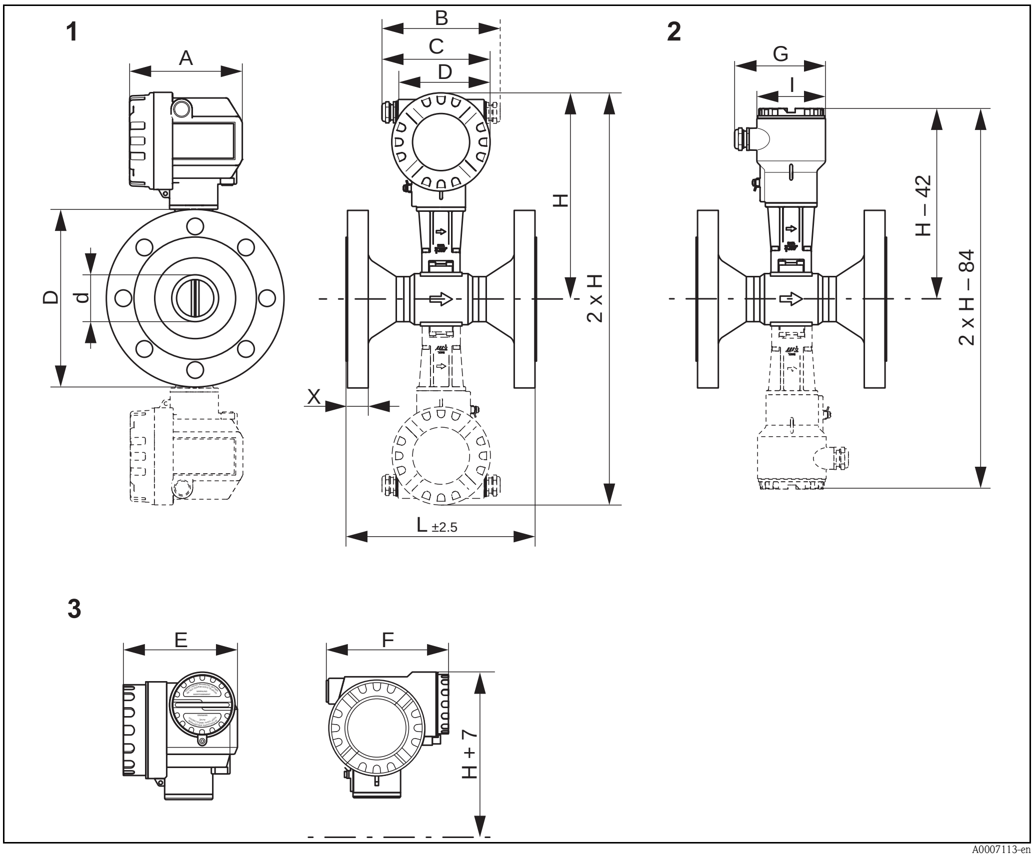
Flanged versions (R Style) to JIS B2220 Prowirl 72F, 73F										
DN	Inner diameter	Pressure rating		d [mm]	D [mm]	H[1)] [mm]	L [mm]	X [mm]	Weight[2)] [kg]
25[3)]	15	Sched. 40	20K	22.0	125	248	200	18.5	7
		Sched. 80	20K	22.0	125	248	200	18.5	7
40[3)]	25	Sched. 40	20K	30.0	140	255	200	18.5	8
		Sched. 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 diameter	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

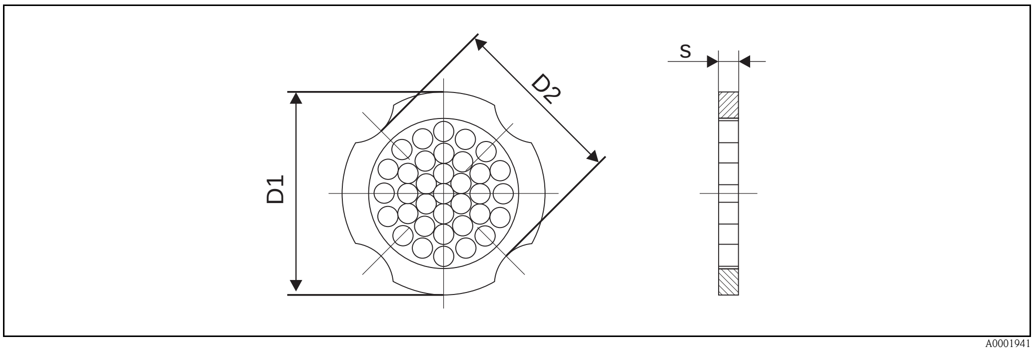
DN	Inner diameter	Pressure rating		d [mm]	D [mm]	H[1)] [mm]	L [mm]	X [mm]	Weight[2)] [kg]
40[3)]	15	Sched. 40	20K	22	140	248	200	20.5	8
		Sched. 80	20K	22	140	248	200	20.5	8
50[3)]	25	Sched. 40	10K	30	155	255	200	20.5	9
		Sched. 40	20K	30	155	255	200	21.0	11
		Sched. 80	10K	30	155	255	200	20.5	9
		Sched. 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^{TM} 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
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Endress+Hauser
People for Process Automation

TI070D/06/en/11.08
71081835
FM+SGML 6.0 ProMoDo

APPENDIX H
Registered Land Survey

Registered Land Survey of New Wells at Camp Stanley Storage Activity - Boerne, TX
EXW05-LGR (SWMU B-3), CS-13, and TSW Wells (AOC-65)

Point Num.	Northing	Easting	Elevation	Description
2000	3283615.904	535713.942	1218.16	TSW006_NG
2001	3283615.794	535713.87	1218.28	TSW006_CONC
2002	3283615.305	535713.208	1218.45	TSW006_COV
2003	3283615.344	535713.23	1217.95	TSW006_PVC
2004	3283623.267	535680.462	1210.37	TSW007_NG
2005	3283623.125	535680.359	1210.49	TSW007_CONC
2006	3283622.546	535679.79	1210.58	TSW007_COV
2007	3283622.527	535679.732	1210.27	TSW007_COV
2008	3283650.232	535680.482	1213.40	TSW04_NG
2009	3283650.075	535680.343	1213.47	TSW04_CONC
2010	3283649.624	535679.781	1213.50	TSW04_COV
2011	3283649.597	535679.802	1213.10	TSW04_PVC
2012	3283675.002	535680.392	1215.97	TSW03_NG
2013	3283674.85	535680.282	1215.91	TSW03_CONC
2014	3283674.227	535679.674	1216.01	TSW03_COV
2015	3283674.248	535679.703	1215.51	TSW03_PVC
2016	3283696.019	535680.077	1217.81	TSW02_NG
2017	3283695.873	535679.969	1217.86	TSW02_CONC
2018	3283695.314	535679.415	1218.00	TSW02_COV
2019	3283695.364	535679.417	1217.55	TSW02_PVC
2020	3283708.727	535680.611	1219.07	TSW01_NG
2021	3283708.631	535680.482	1219.15	TSW01_CONC
2022	3283708.093	535679.902	1219.26	TSW01_COV
2023	3283708.128	535679.94	1218.83	TSW01_PVC
2024	3283717.295	535732.823	1218.35	TSW05_NG
2025	3283717.087	535732.65	1218.45	TSW05_CONC
2026	3283716.538	535732.091	1218.54	TSW05_COV
2027	3283716.576	535732.137	1218.19	TSW05_PVC
2028	**3286671.945**	**537495.283**	**1279.23**	**B3EXW05_CASING**
2029	**3286671.942**	**537495.215**	**1279.46**	**B3EXW05_A**
2030	**3286672.013**	**537495.272**	**1279.58**	**B3EXW05_B**
2031	**3286671.915**	**537495.615**	**1275.28**	**B3EXW05_NG**
2032	3284340.274	538456.824	1192.92	CS13_CASING
2033	3284340.246	538456.787	1193.26	CS13_A
2034	3284340.317	538456.805	1193.24	CS13_B
2035	3284340.689	538456.66	1188.88	CS13_NG

Monitoring well northing and eastings based on NAD 83, UTM 14N from CSSA Site Benchmarks.
Elevation datum based on CSSA Site Benchmarks converted to feet MSL.

Ace Surveying, Inc.

P. O. BOX 597
DEVINE, TEXAS 78016
830-334-7264
830-665-5796 FAX
acesurveying@sbcglobal.net

APPENDIX I
Drilling Logbook

5.21.12 Mobilization Day for B3EXW-05

0800 J. Bouch onsite, getting paperwork together for H&S Tailgate and job prep.
Talked to Lee Will be onsite about 1100

1030 R. Bell onsite

1100 L. Gebbert ; K Graham onsite

1130 Lunch

1230 back onsite
Lee had moved to new location
H&S Tailgate: Mobilization, job set up, scope

1340 Started drilling @ EXW05
Slightly moist @ 19'

1400 Called Cheryl to touch base w/her about getting water

1415 offsite to go fill up @ CS-10

1600 Rig @ 60', running TOTCO Test was 1/4+

1630 To B-3 for readings, back to 606

1700 GPI offsite - rig @ 80'

1730 J. Bouch offsite

J. B...
5/21/12

5.22.12 B3EXWD5

0730 GPI onsite to warm up rig
0800 J. Bonch onsite
Health and Safety Tailgate: Working in the heat, drink water.
Helping out w/ tracer test
0900 Lee @ 140', ran TOTCO @ 100' — 1/4
1040 Rig @ 180', ran TOTCO @ 150' — 1/16 (almost a bullseye)
J. Bonch to AOC-65 to drop some equipment
b/c other work Lee will call if there is an issue.
1400 200' 1/16 +
1500 250' 1/4 +
1600 300' ~~1/16~~ 1/4
1630 320' — done for the day.
1645 GPI offsite

5.22.12

5.23.12 B3EXW05

0730 GPI onsite

0745 J.Bunch onsite

H&S Tailgate: Pinch points

0900 rig @ 340'

Plan today is to TD and install pump for pump test tom

1130 350' - 1/16

380' - TD, Bexar Shale is about 374'-378'

Set pump @ 373', pumping to clean out the well

1425 pumping ≈ 10-12 gpm.

1700 GPI, J.Bunch offsite

5.23.12

5.24.12 B3EXW05

0730 GPI onsite

H.S Tailgate: Heat Exhaustion, drink plenty of water

pump test. Will take readings every 5 min. 1st hour

weather: Overcast / 70°

0900	Time	Initial DTW	255.03 (5 ft Stickup)
0910	STARTED TEST		
0911			~~258.7~~
0912		15 GPM	258.7
0913			262.95
0914			266.89
0915			270.3
0916			273.85
0917		13 GPM	277.19
0918			280.4
0919			283.32
0920			286.02
0921			288.51
0922		12 GPM	290.65
0923			292.7
0924			294.51
0925			296.18
0926			298.15
0927		13 GPM	300.68
0928			303.2
0929			305.74
0930			308.4

0931		310.51
0936	12.5 6pm	318.05
0941	10.3 6pm	319.66
0946	10.3 6pm	319.89
0951	10.3 6pm	319.78
0956	'' ''	319.52
1001	'' ''	318.96
1006	'' ''	318.67
1011	'' ''	318.28
1016	10.7 6pm	317.74
1021	11.3 6pm	318.56
1026	'' ''	319.22
1031	11.1 6pm	319.39
1036	11.19 6pm	320.54
1041		321.22
1046	11.5 6pm	321.84
1051	11.4 6pm	324.74
1056	13 6pm	328.34
1101	12.5 6pm	330.2
1106	12.9 6pm	331.72
1111	12.9 6pm	332.98
1116	12.9 6pm	334.18
1121	·2 9 6pm	335.06
1126	12.9 6pm	335.2
1131	12.9 6pm	336.74
1136	12.9 6pm	336.99
1141		338.65

	1146	12.9 GPm	338.46
	1151	12.9 GPm	338.51
	1156		338.52
	1201	12.9 GPm	339.15
	1206	12.9 GPm	339.6
	1214	13.6 GPm	339.89
	1222	13.0	340.88
	1232	13.0	342.16
	1242	12.5	341.56
	1252	13.5	340.95
	1302	13.5	342.12
	1312	13.2	342.4
	1322	13.5	341.94
4	1332	13.5	342.4
2			
24	4:20:36	4500 Gallons Dumped into bio feild	
4	Recovery		
24			
2	13:35		336.7
72	1336		332.15
98	1336.5		330.05
18	1337		328.15
06	1337.5		326.1
2	1338		324.05
74	1338.5		322.3
99	1339		320.5
65	1339.5		318.9

1340	317.1
1340.5	315.4
1341	313.3
1341.5	311.47
1342	309.49
1342.5	307.95
1343	306.43
1343.5	305.27
1344	303.47
1345	300.83
1346	298.2
1347	296.09
1348	292.3
1341	291.00
1342	288.08
1343	286.03
1344	283.27
1345	282.34
1346	281.98
1347	279.18
1352	272.6
1357	267.15
1402	264.2
1407	260.8
1412	259.95
1417	258.36
1422	257.05

1427 256.16

1432 258.44

1437 255.06

1:11:77 Total Recovery time

- Pump Test Complete, GPI pulling pump

1515 To Communications to ask them to mark Bldg 90 for new wells

1530 Back to work

- Tracking sheet, scan, upload, plan for GeoCam

OTHER WORK

5.25.12

0900 GPI onsite

H&S Tailgate: Working w/moving parts

weather: hot, clear, 70-95°

1000 GeoCam onsite to log B3EXW05

Water level was ≈ 245', well is very silty.

0-10'	light brown weathered limestone, ver
10-20'	same
20-25'	same not as clayey
25-30'	light gray weathered limestone
30-35'	same
35-40'	gray / light brown (more gray)
40-45'	Same
45-50'	same - more brown (more clay)
50-55'	more gray (less clay)
55-60'	gray (less clay)
60-65'	gray / brown weathered limeston orbitolina, less clay
65-70'	same, more brown
70-75'	same, more gray
75-80'	same, gray UGR/LGR contact

1345 GeoCam / GPI offsite

1400 J. Bonch back to 60U

5.25.12

5.29.12

1100 GPI onsite

H.S Tailgate: Reaming, wear PPE

Weather: hot, clear, 70-95°

Talked to Scott, looked at video and log, going to ream to 86' w/a 4" Stick up (case to 86')

1345 Re Sample UIC / back to office pack and ship

1630 Back to rig, Lee at 46'. Reaming 12 3/4".

80-90' gray weathered limestone, same

90-100' same (95-100' some brown)

100-110' brown/gray weathered limestone (105-110' more gray)

110-120' gray weathered limestone See well log

1700 Shutting down for the night. Rig @ 52'

Back @ 0600

5.29.12

p/cloudy AM 70°
Sunny PM 90°
H&S Tailgate: Setting casing

5.30.12 B3EXW05

0730 GPI onsite

1130 Reached TD of ~~89~~ 90' for reaming.

Set casing @ 90', used 14 bags of volclay (24 gallons of H_2O) Shale (double shale trap) 8/14" apiece at 90'. Centralizer (8x12") is @ 50' from the surface down. 4' stick in the end.

Finished cleaning out hole (8" hole to depth)

1630 GPI offsite

[signature] 5.30.12

5.31.12

0700 GPI onsite
H2S Tailgate
weather:
1230 - Finished cleaning out the hole, started laying down drill pipe
1330 setting pump. Set pump @ 373'
1430 started pumping and surging, the water was very silty, pumped 1450 gallons, dumped 2200 gallons TOTAL (plus 4500 from pump test)
- will take readings tomorrow
1700 GPI offsite

[signature] 5.31.12

6.1.12

0700 GPI onsite

H2S Tailgate:

weather:

Initial DTW 245.62'

Water has cleared up | pumping @ 11.6 gpm

1124 Turbidity: 9.10

23.99 : T

specific cond: ~~0.478~~ 0.469 (me)

2.90 ~~3.13~~ (me) DO

6.89 pH

148.3 ORP

1130 Turbitity: 15.2

T: 23.83

μC: 0.385

DO: 3.14

pH: 6.91

ORP: 147.7

3X the well volume is ≈300 gallons — pumping @ 11.6 gpm | will let the well pump for ~~360~~ about 1/2 hour then will take a reading. WL is @ 360'

1200 Turbitity: 6.97

T: 23.78

Specific Cond: 0.384

DO: 3.27

pH: 6.89

ORP: 148.2

1230 358.8 WL

Turbitity: 8.08

Temperture: 23.96

specific Cond: 0.384

DO: 2.31

pH: 6.78

ORP: 148.3

1300 358.7 WL

Turbitity: 7.66

Temperture: 27.82

specific Cond: 0.372

DO: 2.32

RH: 7.00

ORP: 152.0

1330 318.8 WL — dumped 2900 gallons

Tribitity 6.38

Temp. 24.86

Specific Cond. 0.382

DO 1.41

PH 6.68

ORP 148.1

1400 355.2 WL

Tribitity 9.14

Temp 25.33

Specific Cond 0.386

DO. 2.16
ph 6.67
ORD 145.3
1430 353.55 WL
Tribitity 17.2
Temp 24.79
Specific Cond 0.381
DO 2.97
ph 6.61
ORD 142.7
1500 354.25 WL
Tribitity 10 ~~5~~
Temp 24.39
~~Spec~~ Specific Cond 0.383
~~DO~~ 4.07
~~ORD~~ ph 6.64
ORD 144.0
1530 353.81 WL
Tribitity 53.3
Temp 24.54
Specific Cond 0.376
DO 5.40
ph 6.76
ORD 142.8

6.4.12 EXW05

GPI onsite

weather: overcast 75° / 92 and sunny

H+S Tailgate: Electricity

0830 R. Bell Started up the pump. 274.84'

1000 dumped 2100 gallons into B-3

11:00 30.60 WL

Tribitity 9.98

Temp 23.42

Specific 0.543

DO ~~2.75~~

ph 7.21

ORP 131.9

pumping @ 10 gpm

1130 31.22 WL

Tribitity 20.6

Temp 24.04

Specif. Cond 0.545

DO 1.52

ph 7.09

ORP 129.7

10 GPM

1200 ~~Tb~~ 338.8 WL

Tribitiy 52.0

Temp 24.16

Specific Cond 0.543

DO 1.93

PH 7.03

ORD 127.9
10 GPM
1230 342.0 WL
Tribitity 8.46
Temp 24.28
specific Cond 0.541
DO ~~2.00~~ 1.98
ph 7.00
ORD 128.2
10. GPM
1300 354.2 WL
Turbitity: 4.78
Temp: 24.50
specific cond: 0.540
DO: 2.29
pH: 6.93
ORP: 128.8
10 gpm
1330 354.4 WL
Turbitity: 5.26
Temp: 25.06
specific cond: 0.541
DO: 3.06
ORP: 129.4
pH: 7.00
10 gpm

1400 354.5 WL
Turbitity 8.64
Temp: 24.69
Specific Cond: 0.540
DO: 2.22
ORP 129.0
pH 6.90
10 gpm
Water is clear
1430 354.70 WL
Trbitity 4.94
Temp 25.63
Specific Cond, 0.543
DO 2.35
ORP 128.8
ph 6.95
10 gpm
1500 354.7 WL
Turbitity 3.15
Temp 24.85
Specific Cond 0.540
DO 2.40
ORP 129.4
pH 6.92
10 gpm
Water clear

1510 Collected sample @ 1510 for VOCs
and TDS
- Dumped 2500 gallons.
J. Bonch back to 60K
- guys are pulling pump.
- all offsite @ 1630

4.4.12

6.18.12

GPI onsite

H&S Tailgate: Working w/overhead hazards

weather: wet /cloudy /95°

- Concrete truck was supposed to come, called off due to rain Sunday night
- Geoprojects painted CS-13, got pump ready to be installed at B3EXWD5
- Set steel sleave on B3EXWD5.

1700 GPI offsite

Motor: 5HP 200 Volt 3Ø
6 Hz
Date Code: 11L14
2343078602
S/n 11L14-24-009056
3389149904 18.3 AMP-
20.5 AMP Ma
Pump = 40550-15 (4")
Grundfos 11890015

6.18.12

6.19.12

GPI onsite

H.S Tailgate : Working w/ Concrete

weather: Sunny 95°

GPI installed pump @ B3EXW05 @ 368.40 BTOC

Concrete truck onsite. Poured pads at new wells at AOC-65

Out to finish up B3EXW05, set up to pump @ MW21GR in the morning

GPI offsite

6.19.12

6.20.12

GPI onsite

H&S Tailgate: purging wells

weather: rain 80° / overcast 95°

0900 GPI offsite to get a 3" pump for MW2LGR - casing is 3"

- Purging @ CSMW-2LGR, pump and line were covered w/ calc

1430 J Bohch, L Gebbert back to MW9BS to pull pump and bail silt at the bottom

Some bentonitey material on the bottom of the drop tube

- Water is milky w/ what looks to be calcite crystals. Lee does not think it is silted up thinks it is just a build up of the formation

- Bailed it dry ≈ 90 gallons.

- CS MW2LGR pumping since about 1430 @ about 8 gpm. Pumping for 5 minutes shuts off after about 5 min.

Will take readings tomorrow to see if pH has changed

1830 GPI offsite

6.20.12