FLOWSERVE

USER INSTRUCTIONS

Byron Jackson Single Mechanical Seal Submersible

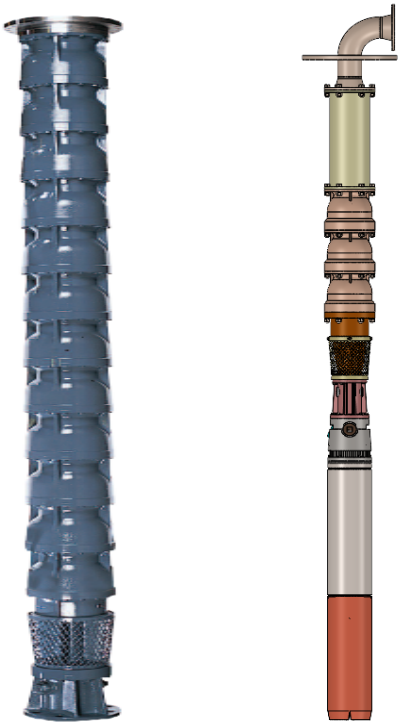
(Cavern and Single Sealed Type Standard Units)

Installation
Operation
Maintenance

PUIOM001019_EN (formerly LM035137)

Original Instructions

⚠ ***These instructions must be read prior to installing, operating, and maintaining this equipment.***



Experience In Motion

Copyright

Document Version

Initial Release, 31-Jan-2023

CONTENTS

1 General Information

1.1 Scope of manual

⚠ These instructions must be kept close to the product's operating location or directly with the product.

⚠ *These instructions must be read prior to installing, operating, using, or maintaining the equipment in any region worldwide. The equipment must not be put into service until all safe operating conditions noted in the instructions have been met. Failure to comply with the information provided in the User Instructions is considered to be misuse. Personal injury, product damage, delay in operation, or product failure caused by misuse are not covered by the Flowserve warranty.*

Flowserve products are designed, developed, and manufactured with state-of-the-art technologies in modern facilities. The unit is produced with great care and commitment to continuous quality control, utilizing sophisticated quality techniques, and safety requirements.

Flowserve is committed to continuous quality improvement and being at service for any further information about the product in its installation and operation or about its support products, repair and diagnostic services.

BJ Oil Submersibles

Byron Jackson Single Mechanical Seal Cavern Submersible Pumps and Motors (oil filled)

These instructions are intended to familiarize the reader with the product and its permitted use. Operating the product in compliance with these instructions is important to help ensure reliability in service and avoid risks. These instructions may not take into account all local regulations; ensure such regulations are observed by all, including those installing the product. Always coordinate repair activities with operations personnel and follow all plant safety requirements and applicable safety and health legislation.

Supplementary user instructions determined from the contract requirements for inclusion into User Instructions for buy-out equipment such as instrumentation, controller, sealant system, mounting component etc., are included in Annex (insert reference).

1.2 Disclaimer

Information in this User Instruction is believed to be complete and reliable. With all Flowserve's efforts to provide comprehensive information and instructions, sound engineering and safety practices should always be used. Please consult with a qualified engineer for further information.

Flowserve manufactures products to applicable International Quality Management System Standards as certified and audited by external Quality Assurance organizations. Genuine parts and accessories have been designed, tested, and incorporated into the products to help ensure continued product quality and performance in use. As Flowserve cannot test parts and accessories sourced from other vendors the incorrect incorporation of such parts and accessories may adversely affect the performance and safety features of the product. The failure to properly select, install, or

use authorized Flowserve parts and accessories is considered to be misuse. Damage or failure caused by misuse is not covered by Flowserve's warranty. In addition, any modification of Flowserve products or removal of original components may impair the safety of these products in use.

1.3 Symbol explanation

Information: *This symbol indicates a recommendation and important information when handling the equipment.*


This symbol is used in safety instructions to remind personnel not to rub non-metallic surfaces with a dry cloth; ensure the cloth is damp. It is used in safety instructions where non-compliance in the hazardous area would cause the risk of an explosion.

Note: *This sign is not a safety symbol but indicates an important instruction in the assembly process. Safety symbols are explained in section 2.2*

1.4 Certification instruction

It is a legal requirement that machinery and equipment put into service within certain regions of the world shall conform to the Marking Directives applicable to Flowserve products (i.e. Machinery Directive, Low Voltage Directive, Electromagnetic Compatibility (EMC) Directive, Pressure Equipment Directive (PED), Equipment for Potentially Explosive Atmospheres (ATEX), etc.).

Note: Certificates defined in the Contract requirements are provided with these instructions where applicable. Examples of the certificates can be found in the Annex of this document. If required, copies of other certificates sent separately to the Purchaser should be obtained from the Purchaser for retention with this User Instruction.

1.5 Units

Both US Customary and Metric unit systems may be utilized in this document.

2 Safety Information

2.1 Intended use


The product/system must not be operated beyond the parameters specified for the application. If there is any doubt as to the suitability of the product/system for the application intended, contact Flowserve for advice, citing the serial number.

- *Installing, operating, or maintaining the product/system in any way that is not covered in this User Instruction could cause death, serious personal injury, or damage to the equipment. This includes any modification to the product/system or use of the parts not provided by Flowserve.*
- *Only operate the product/system when it has successfully passed all inspection acceptance criteria*
- *Do not operate the product/system in a partially assembled condition.*

- *If the conditions of service on the customer's purchase order change (i.e. pumping fluid, temperature, or duty conditions) it is requested that the user seeks written agreement from Flowserve that the equipment is suitable for the revised conditions of service before start up.*
- *Observe equipment labels, such as arrows designating the direction of rotation, warning signs, etc., and keep them in a legible condition. Replace any damaged and/or illegible labels immediately.*
- *Catastrophic or fatal electric shock may result from failure to connect motor controller, metal plumbing, and all other metal near the motor or cable to the power supply ground terminal, using a wire size and connector complying with local regulations. To reduce the risk of electrical shock, disconnect power before working on or around the pumping system.*
- *Do not install this pumping system in areas used for swimming.*

2.2 Safety symbols and description

This User Instruction contains specific safety markings where non-observance of an instruction would cause a hazard. The specific safety markings are:

Table 2.2.a Definition of safety symbols and markings

Symbol	Description
DANGER	**DANGER** This symbol indicates a hazardous situation which, if not avoided, will result in death or serious injury
WARNING	**WARNING** This symbol indicates a hazardous situation which, if not avoided, could result in death or serious injury
CAUTION	**CAUTION** This symbol indicates a hazardous situation which, if not avoided, could result in minor or moderate injury
SAFETY INSTRUCTIONS	**Safety Instruction** This symbol indicates specific safety-related instruction or procedures
NOTICE	**NOTICE** This symbol is used to address practices not related to physical injury
	This is the safety alert symbol. It is used to alert you to potential physical injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

Table 2.2.b: Additional symbols

Symbol	Description
	**ELECTRICAL HAZARD** This symbol indicates electrical safety instructions where non-compliance would affect personal safety and could result in loss of life
	**TOXIC HAZARD** This symbol indicates "hazardous substances and toxic fluid" safety instructions where non-compliance would affect personal safety and would damage the equipment or property
	**ATEX EXPLOSION PROTECTION** This symbol indicates explosive atmosphere marking according to ATEX. It is used in safety instructions where non-compliance in the hazardous area would cause the risk of an explosion

2.3 General hazard sources

2.3.1 Mechanical Hazards

a) Lifting limits and guidelines

Note: The load values mentioned in this section are Flowserve recommendations only. All lifting must be done in compliance with site safety protocol, local regulations, and related industry standards.

Many precision parts have sharp corners which require appropriate personal protective equipment during handling. Prior to any attempt to lift an item, employees must first determine the approximate weight and stability of the load.

- *Large, unstable, or awkward loads should always be handled with the assistance of additional personnel or appropriate mechanical means.*
- *Loads more than 23kg (50 lb.) should only be lifted by appropriate mechanical means and in accordance with current local legislation or with the assistance of additional personnel.*
- *Lifting items less than 23kg (50 lb.) may be prohibited without assistance if the lift is repetitive and/or awkward (i.e., away from the body, above the shoulders or below the knees) thus placing excessive stress on the personnel.*
- *Repetitive lifting of any kind should be evaluated and documented as part of a risk assessment under the end-user's safety program.*

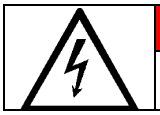
b) Handling in hazardous locations

⚠WARNING If the area to handle, install, operate, remove, or maintain the equipment is designated a hazardous location, refer to applicable safety procedures for safe handling of tools, equipment, and test instruments before proceeding with installation.

2.3.2 Electrical hazards

Protective measures against shock-hazard voltages must be taken according to applicable local and national regulations and the local electricity power company requirements.

In most jurisdictions, the ground conductor must be connected directly to the motor on new systems. This also applies when the unit is installed in an inaccessible well. The surface discharge plate must also be bonded/grounded.



⚠ DANGER

NEVER DO MAINTENANCE WORK WHEN THE UNIT IS CONNECTED TO POWER

2.3.3 Insulation Resistance Testing (Megohm Test)

⚠ DANGER

NEVER CONDUCT THIS TEST IN AN AREA THAT HAS BEEN DESIGNATED AS A HAZARDOUS LOCATION

ONLY CONDUCT THIS TEST ON OTHERWISE NON-ENERGIZED EQUIPMENT

2.3.4 Safety data sheets

Safety data sheets are available upon request. Typically, the only supplied material requiring an SDS are the oil in the motor.

2.4 Responsibility of the owner/operator of the equipment

- *Complete a risk assessment of the site where the product/system will be in operation, by observing the working conditions.*
- *Create site specific work instructions for the operation of the product*
- *Ensure that the personnel have read and understand all applicable instructions*
- *Provide regular training to the necessary personnel in regular intervals*
- *Provide the required personal protective equipment*

2.5 Qualified personnel

All personnel involved in the operation, installation and maintenance of the unit must be proven qualified to carry out the work involved. If the personnel in question do not already possess the

necessary knowledge and skill, appropriate training and instruction must be provided. If required, the operator may commission the manufacturer / supplier to provide applicable training.

Always co-ordinate repair activities with operations, and health and safety personnel. Follow all plant safety requirements and applicable safety and health laws and regulations.

⚠ DANGER

All work on the electrical system may only be performed by qualified electricians!
All work on the hydraulic connections may only be performed by qualified fitters.

2.6 Industrial health and safety measures

Follow industry safety standards including the use of appropriate equipment in required areas.

2.7 Potential explosive areas

Unless specifically noted, the submersible pump and motor supplied for this application are not suitable for ATEX or Hazardous locations. Surface electrical equipment may be suitable for ATEX or Hazardous locations only if specifically called out in the manual and on the equipment nameplate. This equipment includes cable, controllers, switches, enclosures, etc. The installation tools and equipment also may not be suitable for ATEX or Hazardous locations unless specially called in their respective manuals and on the equipment nameplate. If equipment for ATEX or Hazardous locations is required, please confirm all equipment is suitable for these locations before installing.


For equipment located in hazardous or explosive areas, measures are required to:

- *Avoid excess temperature*
- *Prevent build-up of explosive mixtures*
- *Prevent the generation of sparks*
- *Prevent leakages*
- *Maintain the pump to avoid hazard*

All instructions for equipment installed in potentially explosive atmospheres must be followed to help ensure explosion protection. For ATEX, both electrical and non-electrical equipment must meet the requirements of the European Explosion Protection Directive 2014/34/EU. Always observe the regional legal Ex requirements, e.g. Ex electrical items outside the EU may be required certified to other than ATEX e.g. IECEx, UL.


Use equipment only in the zone for which it is appropriate. Always check that all equipment is suitably rated and/or certified for the classification of the specific atmosphere in which they are to be installed.

The following statements are presented as general guidelines.

- *The end user/operator is responsible for ensuring the equipment supplied by Flowserve is in compliance with the local regulatory requirements and the end user/operator's safety program.*
- *In most applications, the motor and flat cable motor lead are considered to be in a non-hazardous environment since oxygen will not be present while it is operating. Care must be taken during operating the equipment to ensure an upset condition does not change this non-hazardous condition*
- *The cable as it exits the surface discharge plate may enter a hazardous or potentially hazardous environment and thus may require special precautions or certified equipment according to the local regulatory requirements*
- *Care should be taken during installation to ensure installation procedures do not cause potentially hazardous events. These steps may include use of non-sparking tools, means to control inadvertent release of explosive materials, appropriate Personal Protective Equipment, etc. The end user/operator/installer is responsible to ensure appropriate tools and materials are used and these precautions are followed*

2.8 Protective equipment

During transportation, installation and removal of the pumping unit, all personal must wear

- *Helmet*
- *Safety tools*
- *Protective gloves*
- *Other Personal Protective Equipment as prescribed by local regulatory requirements*

 Make sure that hazardous substances or toxic fluids are disposed of safely and that the correct personal protective equipment is used. The safety specifications must be in accordance with the current regulations at all times.

3 Product Description

3.1 General product description

The Flowserve BJOIL submersible motor and pumping unit is a combination of

- *a vertical pump bowl assembly*
- *an oil filled electric submersible motor*
- *power cable with motor lead extension assembly extending from the motor to the power supply*
- *disconnect pothead (also known as penetrator) typically used only in cavern applications*
- *oil reservoir and oil line tubing*

designed for sustained operation submerged in liquids. The motor is positioned directly below the pump bowl assembly. The rotating element of the pump bowl assembly is driven from the bottom where its shaft is connected to the motor shaft by a coupling. Power is supplied to the motor through a submarine power cable and motor lead extension assembly which is fastened to the riser or column

pipe and extends to the starting equipment. Motor and pump bowl assembly are connected to the riser/column pipe. The riser/column pipe is threaded or flanged and coupled in lengths and the entire unit is coupled to a wellhead assembly.

Each pumping unit has been individually manufactured according to the special requirements of the customer. The technical data is given in Chapter 12.

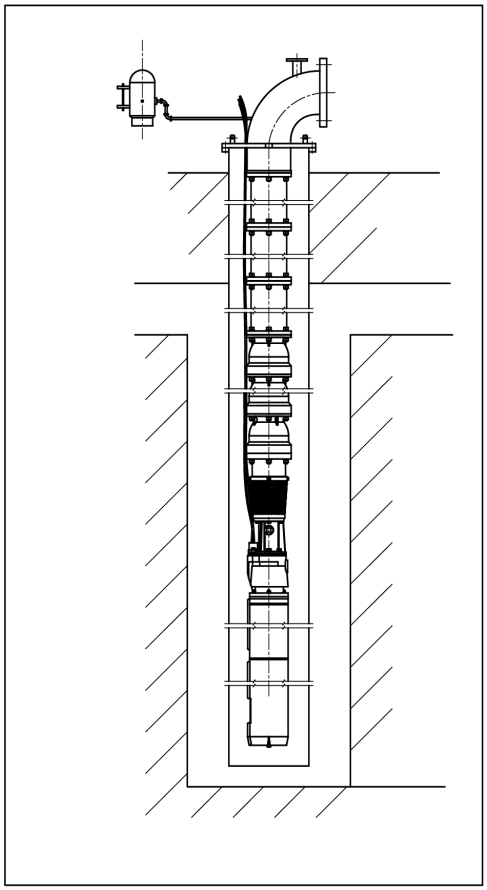


Figure 3.1: View of the entire single mechanical sealed submersible system (cavern configuration)

3.2 Design

A pumping unit consists of

- *Motor*
- *Pump bowl assembly*
- *Non-return valve (if recommended)*
- *Power cable assembly including power cable (round or flat) and motor lead extension (MLE)*
- *Discharge tubing/column/riser*

- *Disconnect pothead/penetrator (typically cavern installations only)*
- *Oil line tubing*
- *Oil reservoir*
- *Cable banding or brackets to fasten the motor power cable and oil onto the riser pipe*
- *Surface plate/discharge assembly*

NOTE: Not all components or sub-assemblies of a pumping unit are necessarily supplied by Flowserve or part of this delivery. These user instructions apply only to the components or sub-assemblies supplied by Flowserve in this delivery, see Chapter 12

- *Motor*

The electric motor is an oil-filled three-phase AC squirrel-cage motor with an insulated winding, which is operating in motor oil and is designed especially for direct drive of submersible pumps. The motor filling-oil cools the winding and bearings as well as lubricates the thrust and radial bearings.
All BJOIL motors are ingress protection code IP68.

- *Pump Bowl assembly*

The bowl(s) contain passageways to transfer the liquid between the outside diameter of the preceding impeller and through the eye of the subsequent impeller. The pump bowl assembly consists of impeller(S) mounted on the shaft within the bowls
The submersible-motor-pump is connected to the lower end of a riser/column pipe and submerged in the pumped medium. The power supply is through power cables fastened to the riser pipes with cable clips.

- *Non-return valve*

A non- return valve is used to prevent the flow back to the pump from the piping system which in turn prevents the rotation of pump in reverse direction. This valve is mounted in the discharge casing and operates using spring force or via a flapper valve. In most applications, the non-return valves should be located 100 feet above the pump and 3/5ths of the distance between the first valve and the surface plate.

- *Power Cable and MLE*

The submersible power cable is constructed to operate in a submersed and wet environment and supply power to the motor. The cable is spliced to the motor lead extension (MLE) with liquid proof materials and is affixed to the riser piping up to the surface and connected to either a junction box or the controller or to the disconnect penetrator. Proper sizing of the cable is required to ensure adequate voltage is supplied to the motor and to ensure the cable does not overheat. The installing Electrician has final responsibility of the correct cable sizing according to relevant local regulations.

Please note that power cables installed in liquid pressurized gases (propane, butane, ethane, etc.) will often experience a phenomenon called explosive gas decompression when the cable is surfaced after being in operation. Generally, Flowserve cables consist of insulated conductors which are held together with a jacket. The jacket material is intended for the purpose of physical protection to prevent damage to the insulated conductors and to hold them together during installation. The jacket material is not designed to be impervious to the liquified gases and thus the liquid permeates the cable jacket during service. When the cable is surfaced and is exposed to local atmospheric pressure, the liquid will expand to gaseous form and cause explosive gas decompression (EGD) of the jacket material. This EGD can cause blisters, fissures, etc. on the cable jacket but does not harm the underlying insulation of the cable nor does it affect the function of the jacket to physically protect the insulation and hold the cable together. There are means to mitigate these factors with special cable constructions that can add cost, weight, and dimensionally larger construction. If these are required, please consult your Flowserve representative.

- *Riser pipe*

Riser pipe is also called discharge tubing or column pipe. It can be constructed in numerous forms such as threaded or flanged steel piping. Riser pipe is assembled to the non-return valve or top pump bowl and the entire submersible pump/motor assembly is suspended from this riser pipe.

- *Disconnect pothead/penetrator (typically cavern installations only)*

The penetrator provides a liquid and gas tight seal at the surface plate to allow the electrical connections to be made in a liquid and gas tight manner. The penetrator may be configured to allow the power cable to connect to it or it may be affixed to the power cable assembly.

- *Oil line tubing*

The oil line tubing connects the oil reservoir to the motor. The oil line should be full of oil when connecting to the motor and should remain full of oil during the entire installation in order to ensure positive pressure is maintained on the mechanical seal.

- *Oil reservoir*

The oil reservoir is used to ensure a positive pressure on the motor seal to prevent pumped liquids from entering the motor. The oil reservoir may have various monitoring instruments to measure reservoir oil level, pressure, and temperature. In cold locations, the oil reservoir and oil line tubing at the surface may need to be protected by using heaters or heat tracing to ensure the oil viscosity is not too low.

- *Cable and oil line banding or bracket*

The cable and oil line bands or brackets are used to mount the power cable and oil line from the motor to the riser/discharge pipe up to the surface.

- *Surface plate/discharge assembly*

The surface plate and discharge assembly are used to support the entire riser and pump/motor assembly with power cable and oil line from the pump location to the surface where it connects to surface piping. The connection to the surface plate may be threaded or flanged. The surface plate will also serve as the mounting point for the disconnect pothead/penetrator (if applicable). The surface plate is usually constructed to allow sealing of the caisson to prevent any liquids or gases from escaping the well caisson.

3.3 Scope of delivery

Delivered materials will be per contract with components specified on a packing list. Job specific details including arrangement drawings, data sheets or other accessories shall be specified and supplied per contract. An IOM shall be provided with equipment. Other information is available from Flowserve upon request.

3.4 Connections

3.4.1 Electrical connections


Electrical connections must be made by a qualified Electrician in accordance with applicable local, national and international regulations.

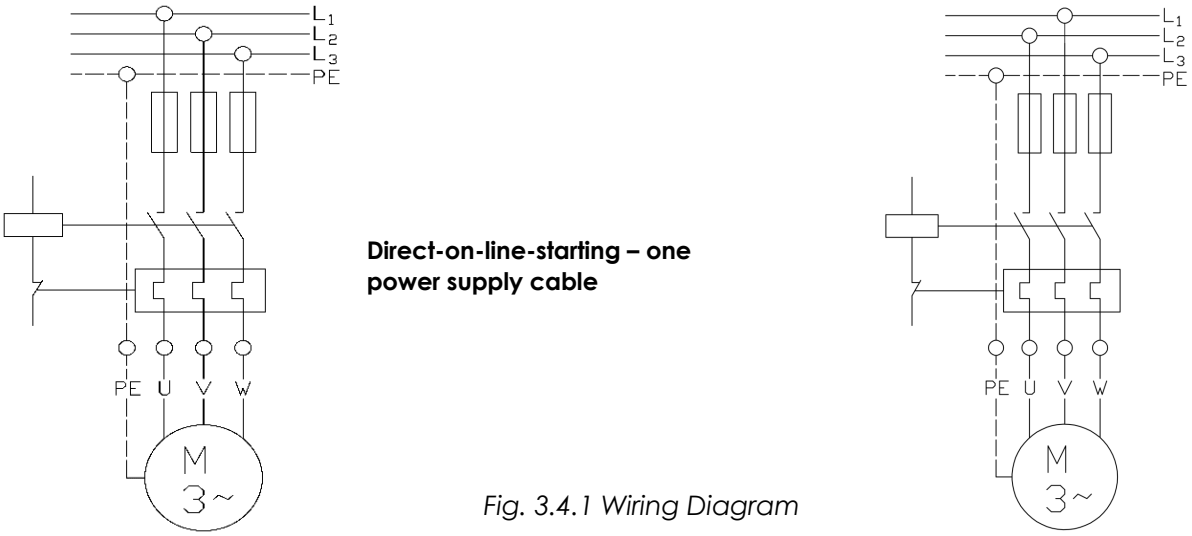

It is important to be aware of the EUROPEAN DIRECTIVE on potentially explosive areas where compliance with IEC60079-14 is an additional requirement for making electrical connections. This submersible motor is not certified for use in locations where ATEX is applicable.


It is important to be aware of the EUROPEAN DIRECTIVE on electromagnetic compatibility when wiring up and installing equipment on site. Attention must be paid to ensure that the techniques used during wiring/installation do not increase electromagnetic emissions nor decrease the electromagnetic immunity of the equipment, wiring or any connected devices. If in any doubt, contact Flowserve for advice.


The motor must be connected in accordance with the requirements in this manual and the local governing electrical codes. The nameplate should be checked to ensure the power supply is appropriate.

BJOIL submersible systems may not have marking of phases with color or other identification. Most BJOIL pumps are intended to rotate in the counter clockwise direction when looking from above the vertical oriented pump/motor. If required by the user, phase rotation can be identified by use of a phase rotation meter and the appropriate connection of these phases as the unit is being installed. In all cases, the phase rotation can be reversed by swapping two phases of the three-phase cable at the surface. The start up section also provides instructions for determining if your pump is rotating in the correction direction when operating downhole.

Clockwise rotation **Counter-Clockwise rotation**



Direct-on-line-starting – one power supply cable

Fig. 3.4.1 Wiring Diagram

3.4.2 Mechanical connections

Pump to motor connection—It is important to ensure the integrity of the connection between the pump and motor. Ensure the faces of the pump and motor flanges are clean with no burrs or debris. Do not use a gasket between the pump and motor.

Pump to riser/column pipe connection—If the connection to the pump is threaded, then a thread locking compound appropriate for the application is recommended to prevent potential unthreading.

Oil line connections—The oil line connections are critical to the operation of the submersible motor and should be liquid tight. Check all connections for tightness during installation and routine maintenance.

3.4.3 Auxiliary connections

If a disconnect pothead /penetrator is used, ensure the electrical connections, the sealing connections to the MLE, and the sealing connection to the surface plated are clean and free from debris.

3.5 Controls

3.5.1 General remarks

Installation of lightning arrestors is recommended to protect the control panel, motor cables and the motor. Any failure due to lightning is not covered by warranty.

The Byron Jackson submersible motor is designed for across the line start, thus eliminating the need for reduced voltage starting equipment. The high reactance motor is designed for operating submersible centrifugal pump loads and thus limits the starting current required. Reduced voltage starting using soft starters, autotransformers, variable speed drives, star delta starters (if motor is provided with 6 leads), etc. require additional care to ensure the motor is not subjected to additional problems. Please ensure compliance with the following when setting up the starter:

Overload settings and breakers must be sized appropriately and properly set to protect the motor.

The starter must allow the motor to accelerate the pump with sufficient torque to allow it to reach full speed as quickly as possible. The motor must be up to full speed in 3 seconds. Failure to do so will cause overheating of the motor and/or thrust bearing wear.

The motor voltage must reach full voltage within 3 seconds. Operation at reduced voltage for longer than a few seconds will prevent the motor from accelerating to full speed and will cause the motor to overheat and fail.

Reduced starter voltages should not be set at lower than 80% voltage. Lower settings should be reviewed with Flowserve representative.

3.5.2 Motor Electrical Requirements

The Byron Jackson submersible motor is designed for across-the-line starting, eliminating the need for reduced voltage starting equipment. Maximum current inrush when the motor is connected across the line at full voltage will be limited to about 400-700 % of the rated load current. See your motor data sheet for exact starting current values.

Because starting the motor at full voltage results in high starting torque, the motor accelerates to operating speed very rapidly (within 0.8 seconds, typically), and current consumption correspondingly drops to normal values. The rated power requirements of the motor are stated on the pump nameplate located on the wellhead.

Allowed combinations of voltage and frequency variations during operation are classified according to IEC 60034 as being either Zone A or Zone B (Figure 3.5.2.a) or according to NEMA (see Figure 3.5.2.b). Your BJOIL motor complies with both requirements

IEC 60034 Requirements

The motor is capable of providing its rated torque continuously within Zone A but need not comply fully with its performance at rated voltage and frequency (see rated point in Figure 3.5.2a) and may exhibit some deviations. Temperature rise may be higher than at rated voltage and frequency. For conditions at the extreme boundaries of Zone A, the temperatures may exceed the specified limits of temperature rise and temperature by approximately 10 °C (18°F).

Operation outside Zone A (within Zone B) may exhibit greater deviation from its performance at rated voltage and frequency than in Zone A. Temperature rise may be higher than at rated voltage and

frequency and most likely will be higher than in Zone A. Extended operation at the perimeter of Zone B is not recommended.

Low voltage is a serious problem since the motor current is increased, resulting in additional motor heating. However, the motor is designed to operate continuously at 110 % of rated current, so that some reduction in voltage can be tolerated if it is not also accompanied by an overload of the motor.

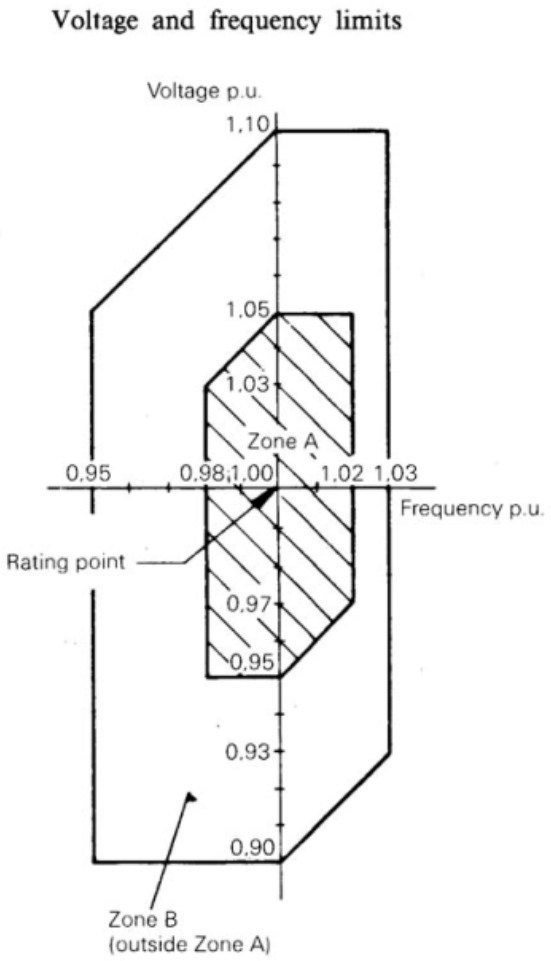


Figure 3.5.2a Voltage and frequency limits acc. IEC 60034

NEMA MG1 Requirements

Rated or full load current refers to the amperage drawn by the motor at nameplate output, frequency and voltage at the motor terminals. The maximum allowable current (except momentarily at start-up) is 110 % of the rated value or as specified by the service factor on the nameplate.

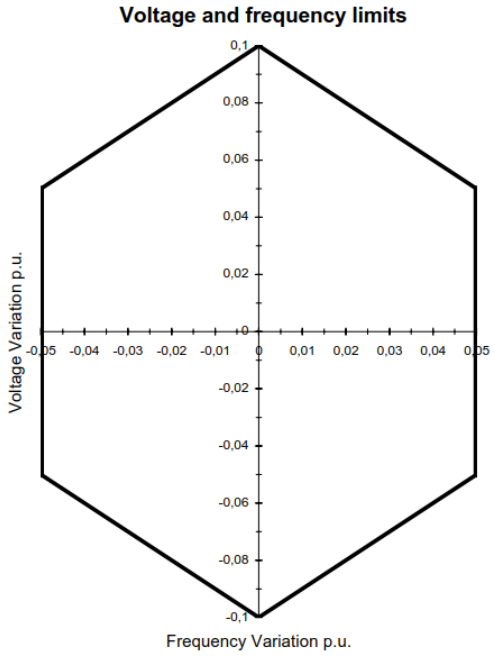


Figure 3.5.2b Voltage and frequency limits acc. NEMA MG1

Other Electrical Supply Requirements

The voltage on all three phases should be evenly balanced as closely as can be read on the usually available commercial voltmeter, because the current unbalance will be in the order of 6 to 10 times the voltage unbalance. Running the motor with the unbalanced voltage will lead to increased temperature and decreased motor lifetime, and therefore must be avoided.

Poor voltage regulation of an engine-driven generator, if the power is derived from such a source, can be very disadvantageous to the motor. Thus, Flowserve assumes no responsibility for pumping units operated on such equipment unless agreed upon in writing.

Use of phase converters to obtain three phase power requires Flowserve approval prior to order to ensure a warranty is valid. Flowserve will void all warranties for applications that do not meet the requirements for clean three phase power without approval prior to purchase.

3.5.3 Inverters

Inverters are referred to by several different names including Variable Speed Drive (VSD), Variable Frequency Drive (VFD), Adjustable Speed Drive (ASD), or Adjustable Frequency Drive (AFD)), Variable Voltage Variable Frequency controllers (VVVF). Inverters are controllers with the ability to vary the speed of the submersible pumping unit. The ability to change speed provides more flexibility for

operating the pump at a variety of conditions. With this ability, extra care must be taken to ensure proper system configuration and operational controls.

1) *Accurate and calibrated quick trip overload settings should be set to trip if any phase exceeds the safety factor full load current.*
2) *A constant ratio of V/Hz must be maintained during operation. In some cases, an increased V/Hz ratio may be employed to aid in starting but this is usually not necessary with centrifugal pumps. This is often called Voltage Boost. Voltage boost during starting is permitted in order to ensure a rapid acceleration time to minimum speed in the required time.*
3) *Direct Torque Control or other similar operating schemes are not permitted as they can cause fatiguing of shafts and shaft failure and are not necessary for applications driving centrifugal pumps.*
4) *When operating under normal service conditions where the inverter input nominal voltage does not exceed the motor rated voltage, can operate at the following withstand voltage at the motor terminals:*

V_{peak} = 3.1 * V_{rated} *for motors rated 600 V or less*

V_{peak} = 2.3 * V_{rated} *for motors rated more than 600 V*

Rise time shall be ≥ 1 µs

Note—When the input voltage to the inverter exceeds the motor rated voltage, care must be taken to ensure the maximum peak voltage (V_{peak})is not exceeded when applied to the motor by the inverter

5) *Minimum operating frequency should be 30 Hz for short periods, but for normal operation, it should be above 35 Hz. This is for protection of all bearings and because most submersible applications require a certain speed to lift water to the surface. If no fluid is lifted to the surface, there will not be any cooling flow over the motor and then the motor will overheat and fail. Operation should ensure adequate flow is passing the motor and the pump is operating at or above its minimum continuous stable flow rate.*
6) *Maximum operating frequency is nameplate frequency.*
7) *Motor should be ramped up to at least 30 Hz within 3 sec*
8) *Dynamic braking options on the inverter should be disabled. Actively attempting to brake the motor could cause shaft breakage, voltage spikes, overheating, and other motor issues*
9) *The inverter switching frequency should be as per the inverter manufacturer's recommendations for non-dynamic loads such as pumps.*
10) *Most modern inverters use high speed/high power switching devices called IGBT's which can present rapidly peaking high voltage spikes that can stress the motor insulation windings. These peaks can be exacerbated by long cables typically used in submersible applications. The drives must be supplied with an output filter to protect the motor insulation.*
11) *Grounding should be in compliance with the drive manufacturer's recommendations plus local regulatory requirements.*
12) *Care must be taken to ensure adequate flow velocity past the motor as changing speeds could drastically drop the velocity.*

3.6 Accessories

If your submersible motor is provided with temperature monitoring, the PT100 probes should be connected to a temperature monitor. The instrument leads will require an additional instrument cable to the surface. The temperature limits should be set at 158°F (70°C) or below to maintain a safety margin for the insulation winding temperature limits. Records should be maintained of temperature and any rise in temperature should be investigated to understand the cause for the rise.

3.7 Tools, equipment, and fixtures

In addition to the common millwright tools used in working with heavy precision equipment, the following tools and equipment are necessary for the pump installation.

Lifting equipment—Lifting equipment must be of sufficient strength and configuration to lift the entire unit with riser safely and of sufficient height to provide clearance when installing the riser sections. The lifting arrangement should ensure no damage is done to the pump equipment.

⚠WARNING *All weights provided in this manual are for reference only. The installer should confirm weights of the actual equipment being used by referring to the pump and motor data sheet and GA drawings. For piping, refer to your supplier to confirm the weights.*

Table 3.7a Weight of the column

Column	Weight per foot in lbs		Weight per meter in kg	
Size	Empty	Full	Empty	Full
2-1/2	5.8	7.9	8.7	11.9
3	7.6	10.8	11.4	16.2
4	10.9	16.4	16.4	24.6
5	14.8	23.5	22.2	35.3
6	19.2	31.7	28.8	47.6
8	25.0	47.2	37.5	70.8
10	32.0	66.6	48.0	99.9
12	45.0	93.9	67.5	141.0

Table 3.7b Weight of the Bowl assembly

Bowl Assembly	Weight in lbs		Weight in kg	
Size	1st stage	Per additional stage	1st stage	Per additional stage
8MQ	80	15	36	7
10MQ	175	37	79	17
11MQ	290	70	132	32
12MQ	440	125	200	57
13MQ	625	175	284	79
15MQ	850	265	386	120
10LQ	520	115	236	53
11LQ	630	140	287	64
13LQ	755	175	343	80
14LQ	840	205	382	93
15LQ	930	220	423	100
15LQ	1175	275	534	125
18LQ	1565	360	712	164

Table 3.7c Weight of the power cable

Cable	Size	Weight	
Volt rating		Per foot in lbs	Per meter in kg
600	#8 AWG	0.30	0.45
	#4 AWG	0.77	1.16
	#2 AWG	1.10	1.65
	300 MCM	4.40	6.60
	500 MCM	6.80	10.2
5000	#6 AWG	0.90	1.35
	#2 AWG	1.20	1.80
	#1/0 AWG	2.20	3.30
	#4/0 AWG	3.40	5.10

Refer to cable data sheet for metric cables and other sizes

Table 3.7d Weight of the Motor

Motor	*Rated Power*		*Weight*	
Nominal Motor Size	*HP (60 Hz)*	*kW (50 Hz)*	*Lbs*	*Kg*
8" 2 pole cavern	*30*	*18.6*	*440*	*200*
	50	*31*	*530*	*241*
10" 4 pole cavern	*75*	*46.6*	*1010*	*458*
	100	*62*	*1080*	*490*
10" 2 pole cavern	*75*	*46.6*	*1050*	*477*
	100	*62*	*1230*	*560*
12" 2 pole cavern	*150*	*93.2*	*850*	*386*
	200	*124*	*1020*	*464*
	250	*155*	*1275*	*580*
14" 4 pole single seal cavern	*125*	*77.7*	*2580*	*1170*
	150	*93.2*	*2580*	*1288*
	200	*124*	*3140*	*1424*
	250	*155*	*3273*	*1485*
	300	*186*	*3273*	*1485*
17" 4 pole cavern	*All sizes*		*Consult factory*	
17" 2 pole cavern	*400*	*248*	*3825*	*1739*
21" 4 pole cavern	*600*	*373*	*Consult factory*	
	800	*497*		
	1000	*622*		
	1250	*777*		
	1500	*932*		
	1750	*1088*		

For all motors with heat exchangers or special flange requirements on the lower end of the motor, consult GA drawing or factory

Motor U-plate—Provides support at well head (see Figure 3.7)

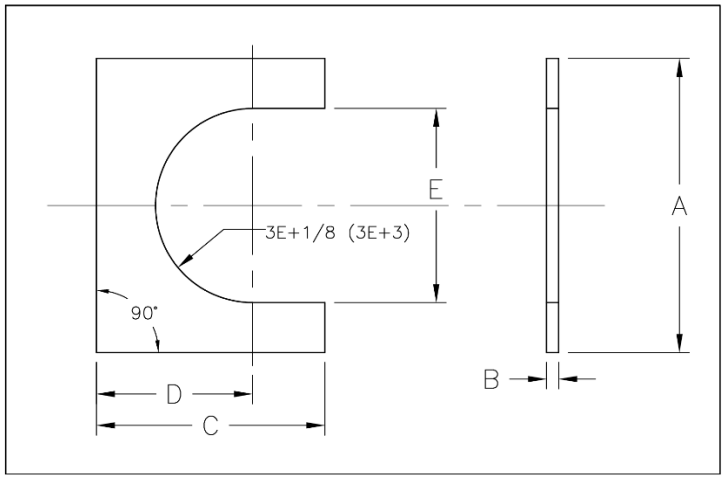


Figure 3.7a Motor U-Plate Chart

Table 3.7e Dimensions of the Motor

Nominal Motor Size	Dimensions, Inches (cm)				
	A	B	C	D	E
8"	15.0 (38.1)	.500/.375 (1.27/0.95)	10 (25.4)	10 (25.4)	5.875/5.750 (14.93/14.61)
10"	16.0 (40.6)	.500/.375 (1.27/0.95)	12 (30.5)	10 (25.4)	7.250/7.125 (18.42/18.10)
12" 4 pole	18.0 (45.7)	.625/.500 (1.59/1.27)	14 (35.6)	10 (25.4)	7.625/7.500 (19.37/19.05)
12" 2 pole	18.0 (45.7)	.625/.500 (1.59/1.27)	14 (35.6)	10 (25.4)	8.750/8.6250 (22.22/21.91)
14"	20 (50.8)	.625/.500 (1.59/1.27)	14 (35.6)	10 (25.4)	9.875/9.750 (25.09/24.77)
17"	22 (55.8)	.625/.500 (1.59/1.27)	16 (40.6)	10 (25.4)	10.375/10.25 (26.35/26.04)
21"	36 (91.4)	.625/.500 (1.59/1.27)	29 (73.7)	21 (53.3)	16.875/16.750 (42.89/42.57)

Pipe handling equipment—Lifting equipment sized to support riser/column pipe. This equipment is dependent on the specifics of the installation and can include slips, elevators, clamps, u-plate(s), etc. If the riser/column pipe is threaded, tools required to join the pipes such as tongs (manual or power), etc will also be needed. It is recommended to work with a pump installer experienced in submersible cavern installations to ensure all the appropriate equipment and procedures are available.

Cable bands or bracket installations tools—Banding tools or other tools as appropriate for the proper support of the cable and oil line.

Sheaves for cable and oil line—Appropriately sized sheaves should be used to aid in guiding the cable and oil line into the casing without excessive bending that could damage the cable or oil line.

Insulation resistance tester—Megohmmeter rated at 500 VDC or 1000 VDC to check the motor and cable insulation resistance.

⚠WARNING *Use of an insulation resistance tester has the potential to ignite an explosion if used in a hazardous location. In the event these instructions direct the use of the insulation resistance tester equipment, do not use it in a hazardous location.*

Kelvin bridge or other suitable meter—Resistance meter intended to confirm continuity of motor windings and cable connections.

Oil pump—Suitable means to pressure test oil connections to motor at 50 PSIG (345 kPa). A small, portable air actuated oil pump has proven to be the best choice for this type of installation

Oil Line pressure monitoring equipment—During install, integrity of the oil line and motor pressure barriers (such as the mechanical face seal and the sealing O-rings) must be ensured. One of the simplest means to do this is to connect a pressure gauge and valve at the surface end of the oil line (see Fig., 3.7b). After the oil pump pressurizes the line, the valve can be closed, and the pump disconnected at the quick disconnect.

Do not exceed the maximum allowable motor pressure. The pressure gauge is used to monitor and ensure no pressure is lost during the installation period. See Fig. 3.7b

Centralizers—Or other means for preventing cable damage during installation in tight wells or wells deviating from vertical

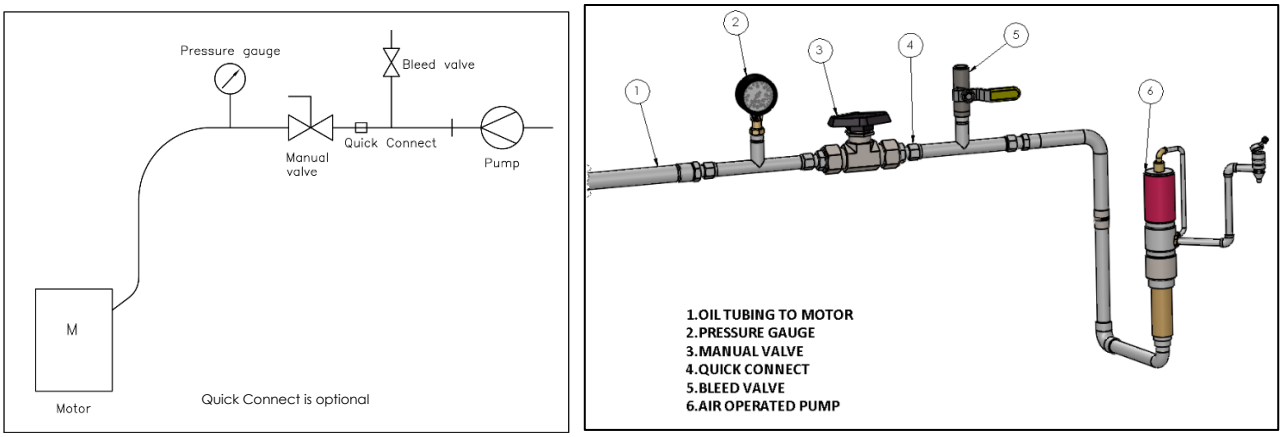


Fig. 3.7b Oil Line Filling and Pressure Monitoring (During Install)

4 Packaging, Transportation and Storage

4.1 Receipt and Unpacking

Submersible pumps are subjected to a thorough inspection before leaving the factory and are supplied with operating instructions for fitting, starting, care etc, that conform to international safety regulations.

During all aspects of handling, transportation and installation, the unit must be protected from mechanical shock to prevent damage to the components.

Immediately after receipt of the equipment, check the delivery/shipping documents for completeness of the shipment and verify there has been no damage in transportation. Any shortage and/or damage must be reported immediately to Flowserve.

Check any crates, boxes and wrappings for any accessories or spare parts that may be packed separately with the equipment or attached to side walls of the box or equipment.

Each product has a unique serial number. Check that this number corresponds with that advised and always quote this number in correspondence as when ordering spare parts or further accessories.

Handling and lifting

⚠	**⚠ CAUTION**
	Take special care when handling the pump unit. Make certain that it does not impact against walls, steel structures or floors etc.

Under no circumstances must the power cables be used for lifting or moving the motor.

⚠	**⚠ CAUTION**
	Do not lift heavy equipment overhead of personnel.

A safe distance must be kept when lifting and moving the equipment.

Use approved and suitable lifting equipment only.

The height of the lifting equipment should be such that the pump and motor are able to be lifted in vertical position.

Do not attempt to lift the pump or motor using eyebolts on pump/motor components as this could damage sealing and machined fit surfaces.

Do not remove the protection cover from the pump discharge until installation in the well as it prevents contamination of the pump.

In general, care is to be taken when removing crating, coverings, and strapping in order not to damage any auxiliary equipment and/or the paint finish.

If a pump and motor is shipped assembled, then care must be taken not to lift the unit from the packaging in such a way to allow the unit to "bend". This will likely cause damage to the interconnector.

Note: Parts and accessories may be placed inside shipping containers or attached to skids in individual packages. Inspect all containers, crates and skids for attached parts before discarding.

4.2 Transportation

⚠ *A crane must be used for all pump sets weighing more than 23 kg (50 lb). Fully trained personnel must carry out lifting, in accordance with local regulations.*

Slings, ropes and other lifting gear should be positioned where they cannot slip and where a balanced lift is obtained. The angle between sling or ropes used for lifting must not exceed 60˚.

⚠	**⚠ CAUTION**
	Pumps and motors often have integral lifting lugs or eye bolts. These are intended for use in only lifting the individual piece of equipment.

⚠	**⚠ CAUTION**
	Do not use eye bolts or cast-in lifting lugs to lift pump, motor and assemblies.

⚠	**⚠ CAUTION**
	Care must be taken to lift components or assemblies above the center of gravity to prevent the unit from flipping

4.3 Storage

4.3.1 General remarks

⚠	**⚠ CAUTION** *Store the pump and motor vertically and secured properly to prevent their tipping over in a clean, dry location away from vibration. Leave piping connection covers in place to keep dirt and other foreign material out of pump casing*

⚠	**⚠ CAUTION** *Submersible pump units need special storage conditions.*

All motors should be stored in a filled condition as supplied from the factory with bladder bag attached.

Depending on the pump metallurgy, it may be coated with a rust-preventative to prevent excessive corrosion during storage only.

The leads of the power cables must be protected from moisture and sunlight. Ensure that the power cables are not bent during storage.

Requirements for the storage area

a) The storage area must be well ventilated.
b) Air humidity should be in a range of 40 to 60%.
c) Temperatures: +50 to -25 °C (+122 to -13 °F) for units
d) The motor, pump, and cable should not be stored where they are exposed to direct sunlight
e) Ideally, the pump, motor, and cable should be stored indoors to prevent potential contamination from windblown debris and rain.

4.3.2 Storing for up to (1) one month

No other special arrangements are required.

4.3.3 Storing between (1) one and 24 months

For storage between one and 24 months, it is recommended that the pump shaft of the unit be turned at intervals of approximately 8 weeks.

4.3.4 Storing for over 24 months

For long term storage over 24 months, it is recommended to rotate the pump shaft at 8-week intervals, rotate the motor at 6-month intervals and check the motor insulation resistance at least yearly. Record the date and insulation resistance reading value. If insulation resistance deteriorates over this period, then it is recommended the motor be replaced or serviced if possible.

4.3.5 Inspection before storage

a) Inspect the preservative coating/painted surfaces on the various parts. Touch up the areas, If necessary. Most cavern pumps and motors will not be painted so a preservative coating of Houghton Rust-Veto 4221 – P/N 801849-90 (or equivalent) should be applied to prevent excessive corrosion
b) Inspect all covers over pump openings and piping connections. If found damaged, remove the covers and inspect interiors of the opening for any deposits of foreign materials or water.
c) Exercise caution with pumps exposed to weather. Containers are not leak proof. Parts may be coated with a residual amount of protective coating, which will wash away if exposed to elements.

5 Installation

Note: The installation should be conducted and supervised by people trained in the installation of Byron Jackson Cavern Pump systems. These trained personnel are key to ensuring a successful installation and reliable operation.

5.1 Inspection and preparation

5.1.1 Inspection prior to installation

Prior to the scheduled installation date, conduct an inspection of the equipment and the facility where it is to be installed. If any deterioration of equipment is noticed, is recommended the equipment be repaired or replaced to ensure reliable system operation

5.1.2 Motor Continuity and Insulation Resistance Testing

These tests will be conducted on a number of different steps during installation or storage inspection of the motor, cable, or other electrical components. Only qualified personnel should conduct this test and interpret the results.

The motor continuity test is performed to verify the electrical continuity of the motor and cable. The motor continuity test will be performed using a Kelvin bridge or other suitable meter to read low resistances. Leads are connected to terminals on two phases and then compared with each other.

R_{AB} *= Resistance as measured from terminal phase A to terminal phase B, measured*

R_{BC} *= Resistance as measured from terminal phase B to terminal phase C, measured*

R_{CA} *= Resistance as measured from terminal phase C to terminal phase A, measured*

R_{PP} *= Average resistance as caclulated from the terminal resistance measurements*

$$R_{PP} = \frac{R_{AC} + R_{BC} + R_{CA}}{3}$$

Each ot the terminal resistance measurements should be within +/- 5% of the average resistance. A larger discrepancy is an indicator of potentiall issues with the electrical connection in the motor

and/or the cable. A competetent person should investigate the cause of the imbalance in the resistances before proceeding with the installation.

⚠WARNING *Use of an insulation resistance tester has the potential to ignite an explosion if used in a hazardous location. In the event these instructions direct the use of the insulation resistance tester equipment, do not use it in a hazardous location.*

For conducting the insulation resistance test, use a megohmmeter rated for 500 VDC or 1000 VDC

Attach insulation resistance tester return lead to a suitable ground path for the test. This may be the motor housing, metal well casing, or cable armor or ground wire (if so constructed). Set the voltage test level at 500 VDC or 1000 VDC

Attach other lead to device to be tested (motor, cable, other) at the copper terminal or wire conductor.

Start test and after 60 seconds have elapsed record the insulation resistance value in MΩ.

Disengage power from the insulation resistance tester and ensure any residual voltage is discharged through a shorting lead for at least 4 minutes or 4X the length of time energized

⚠	**⚠ CAUTION** *Failure to discharge the motor lead can result in inadvertent discharge resulting in injury or ignition if in a hazardous location*

If possible, record the temperature of the motor and/or the environment. Insulation resistance varies with temperature, so consideration of ambient temperature is required when comparing readings in different environments or times.

Logging of readings for future reference and comparison can be a useful method to evaluate the change in insulation condition over time

5.2 Installation

⚠	**⚠ CAUTION** *A final job safety plan should be completed by the customer's designated responsible person before each job that involves exposure of workers to hazards arising from work at a worksite. This job safety plan is specific to the job to be performed whether a new install or basic troubleshooting.*

The safety plan and all requirements should be communicated to all involved with the installation/removal/maintenance of equipment.

5.2.1 General advice for installation

The following criteria must be considered to determine the installation configuration, position and depth:

The required minimum velocity past the motor is 1 ft/s (0.3 m/s). For applications requiring lower flow velocities, Flowserve should be contacted for application review and approval to operate at the lower velocity. Generally, Flowserve will require a flow shroud to ensure velocity is above the minimum required.

Note: Contact your Flowserve representative if you require assistance determining the flow velocity in your application.

⚠	**⚠ CAUTION**
	In most cavern applications the caisson will be installed into a sump in the floor of the cavern so flow across the motor will be facilitated by design to assist heat transfer. If this is not possible a flow shroud should be provided to induce the flow of water/ product across the motor.

⚠	**⚠ CAUTION**
	Pump units can only be operated with a completely filled and submersed motor

If there is insufficient flow velocity in your application and/or the flow will be coming from above the pump, then a flow inducing shroud (see Fig. 5.2.1) will be required. The non-closed end of the shroud should be fixed to the center of the motor in the shroud without causing deformation of the motor or pump housing. Failure to install a shroud when required can cause premature failure and voids the warranty.

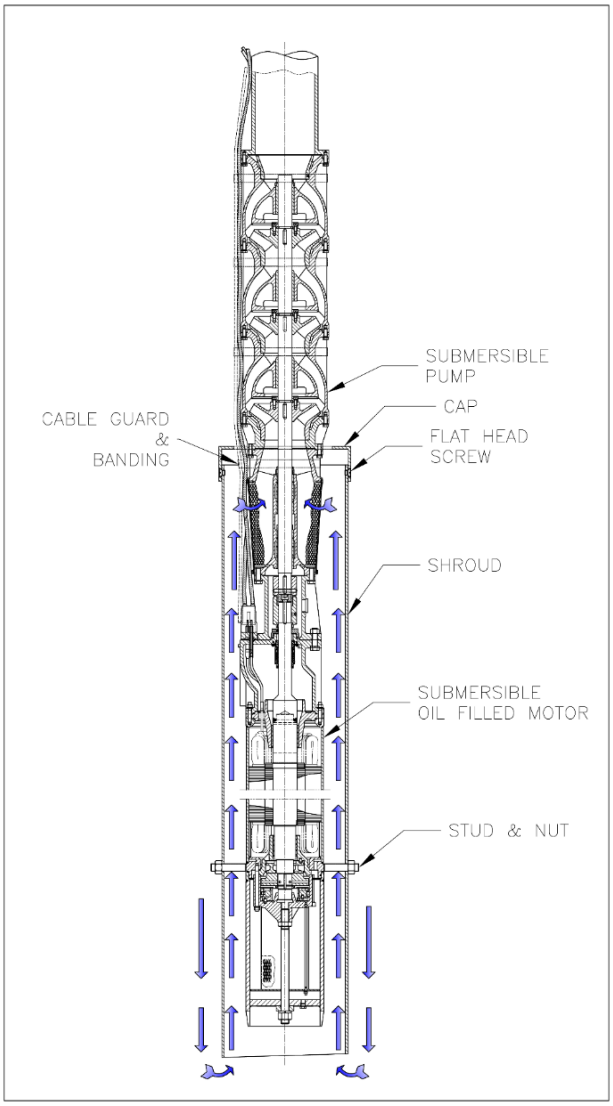


Figure 5.2.1 Pump and Motor Installed with Flow Shroud

- *Your motor is designed to operate in applications with fluid temperatures as specified in the data sheet. Please contact your Flowserve representative if the application temperature differs from the data sheet for recommendations. Adjustments may be required if the temperature is significantly different than the original design conditions shown on the data sheet*
- *The submersible motor has a single mechanical seal that must be pressurized internal to the motor at a greater pressure than the external environment. Ensure the oil pressure line is filled and pressurized so that a positive oil pressure in the motor can be maintained. This requirement applies during both installation and operation. See section (5.2.12) to determine how to calculate motor differential pressure.*
- *The oil tank location must be above the surface plate and the oil line must have a continually upward slope to ensure no gas is trapped in the line.*

- *The pump must have sufficient depth in the well to ensure adequate submergence and NPSH available*
- *The dynamic fluid level should be above the pump intake, cable splice, motor, and meet pump NPSH requirements. (See pump characteristic curve.)*
- *Flow rate. (See pump characteristic curve).*

⚠	**⚠ CAUTION**
	Under no circumstances must the power cables be used for lifting or moving the motor

5.2.2 Checks before installation

⚠	**⚠ CAUTION**
	A safety protocol must consider safe electrical work procedures that identify how to properly isolate the electrical and pressure equipment as well as provide guidance to select the proper PPE and any other protective equipment to be used during work associated with the installation, operation, and maintenance of equipment. Utilizing surface equipment with lockable enclosures and performing associated lock-out-tag-out (LOTO procedures is an example of good practice for minimizing incidental contact with the electrical system

The following checks should be made before starting actual installation.

a) Verify that the wellhead foundation is poured and cured, if made of concrete. The total load on the wellhead foundation will consist of the motor, pump bowl assembly, riser/column pipe (full of water), wellhead assembly and power cable.
b) Verify that open discharge run-off, ditch, containment, etc. for water removal and testing the unit is provided for.
c) Verify that a log of the installation recording depth, casing variations, standing liquid level, rated capacity, pumping level, etc., is at the installation site.
d) Ensure that the well caisson diameter is large enough down to the installation depth so that the pumping unit can be fitted without difficulties.
e) Check all pump connections (bolts, nuts etc.) for any shipping and handling related problems.

In case of uncertainty, contact Flowserve or the nearest factory representative before starting up the unit.

f) Before installation, the insulation resistance of the motor must be measured and documented.
g) When lowering the unit, ensure the power cable and oil line are neither squeezed nor scratched. Ensure protection of the power cables and oil line at the entry point into the casing. The cable and oil line are fed into the well shaft using sheaves or other suitable devices that do not cause excessive bending of the cable or oil line.

⚠	**⚠ CAUTION**
	Due to the potential hazards of the pump and motor being dropped uncontrolled during the installation, the areas between the cable and oil line reels and the well casing should be cordoned off and personnel should not be working in this area.

h) During lowering, the unit must always hang freely and centered in the casing and must not become wedged in the well shaft. Adjustment of the rig positioning may be required as more load is added to the rig. Always ensure that the load can be rotated freely.
i) Attach band or clamp every 10ft (3m) or as least one per column section to secure cable and oil tube to pipe to eliminate cable sag.

⚠	**⚠ CAUTION**
	When pump units are installed in narrow wells or inclined installations, the risers/ column pipes, whether steel pipes or hose lines, will need to be centralized to prevent them from touching the wall of the casing which could cause damage to any cables and oil lines fastened to them.

5.2.3 Installing the motor

a) Remove motor crating sides and ends and protective wrapping.
b) Remove the motor terminal shipping cap (6562) and verify that motor terminal gland plate (4120) and power terminals (8393) are clean and undamaged.
c) Verify the continuity of motor windings as described in Paragraph 5.1.2. Use an insulation resistance meter to check insulation resistance as described in Paragraph 5.1.2. Measured resistance should be 100 megohms or more. Ground the terminals to dissipate any accumulated charge. Replace the motor terminal shipping cap with gasket/ o-ring.

⚠	**⚠ CAUTION**
	Failure to dissipate any accumulated charge could present as an ignition source and result in an explosion.

d) Inspect all motor exterior joints, fasteners, plugs, and fittings for tightness and absence of oil leakage.
e) Attach lifting lines to holes in shipping cap using shackles on the shaft shipping cap or use a lifting line securely wrapped around cast lugs of cast shipping cap (whichever is the case) and carefully lift the motor to a vertical position. Avoid letting the motor drag or roll when picked up. A two point pick up of the motor at the motor shipping cap and the joint at the bottom of the stator above the lower case is required.

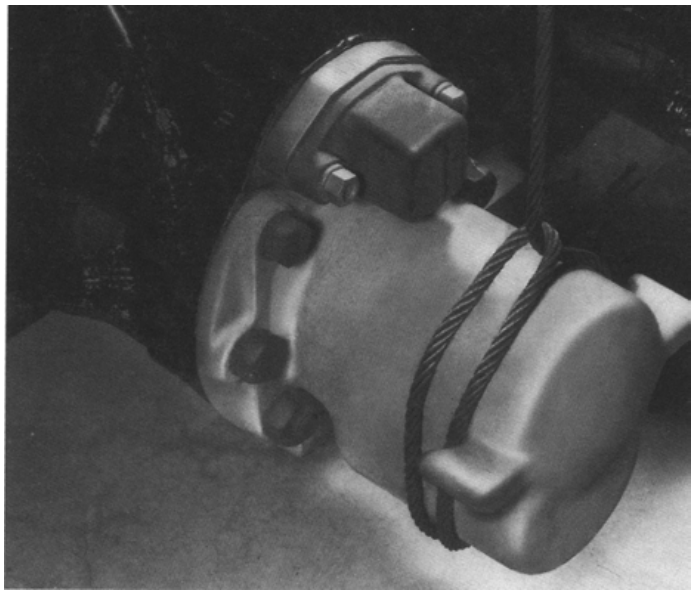


Figure 5.2.3 Lifting line under lifting lugs

f) Remove banding from motor that holds the shipping bag PVC protection pipe in place. Remove bag from PVC protection pipe.

g) While holding the shipping bag to prevent damage, lower motor into the well casing opening, insert motor U-plate in slots below motor top flange, then lower motor to rest on the U-plate and remove the lifting lines. Other retaining methods may be used. Check with factory if alternative retaining method is preferred.
NOTE: It is advisable to wrap a cloth or other protection around the motor so that parts and tools cannot fall into the casing. Remove the protective cloth before lowering the pump in the casing.

h) Remove the shaft shipping cap and shipping cap gasket (if any) and set the fasteners aside for later use.

NOTICE Care should be taken in the next step to not damage the shaft or coupling including the keyway as these are considered critical fits to ensure reliable vibration free operation.

i) Rotate motor shaft with strap wrench to verify smooth, free rotation, then position the shaft so that the keyway is aligned directly toward or directly away from the power terminal shipping cap. This establishes correct alignment of motor shaft for installation of the pump bowl assembly and coupling.

j) Motor is now ready to receive the pump bowl assembly as described in the next section.

5.2.4 Install coupling

NOTE: The coupling configuration between motor and pump bowl assembly depends on the type of motor and pump bowl assembly delivered. Flowserve manufactures two coupling variants for the Byron Jackson Single Mechanical Seal Motor:

Coupling Variant A: One-piece coupling (most common for cavern units). This type is used on all 2 pole motors/pumps and some 4 pole motors/pumps. The coupling pins may be held in place by external retaining rings, internal retaining rings, or screws with washers.

Coupling Variant B: Two-piece Motor half and Pump half coupling (less common for cavern units). This type is used on some but not all 4 pole motors/pumps.

Coupling Variant A: One-piece coupling. Figure 5.2.4a or 5.2.4b.

Note: Some one-piece coupling designs will have the coupling partly recessed in the motor top case. Access to some coupling components may be gained through the access ports in the motor top case.

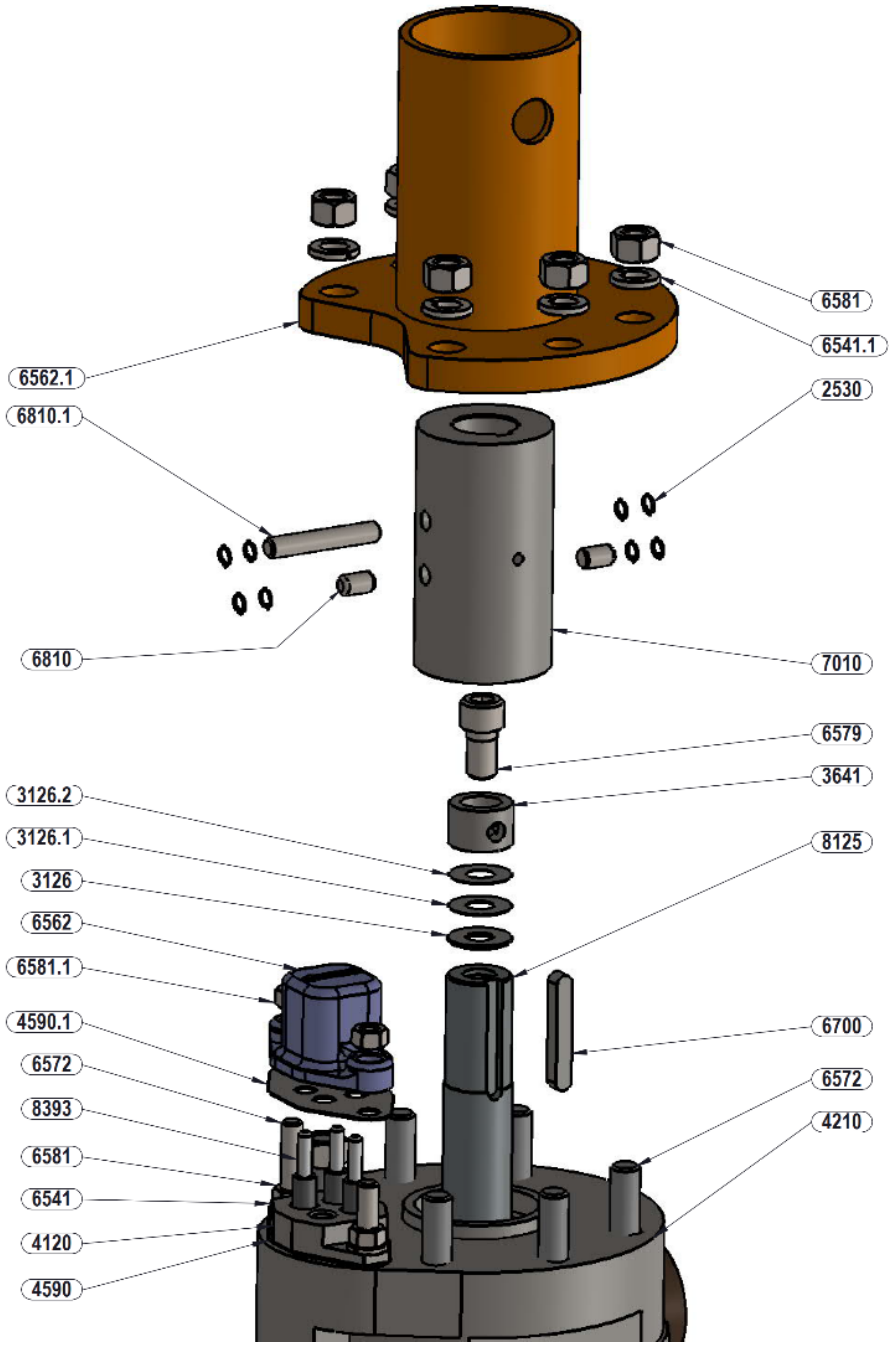


Figure 5.2.4a One Piece Coupling With Internal Retaining Rings

Coupling Variant A

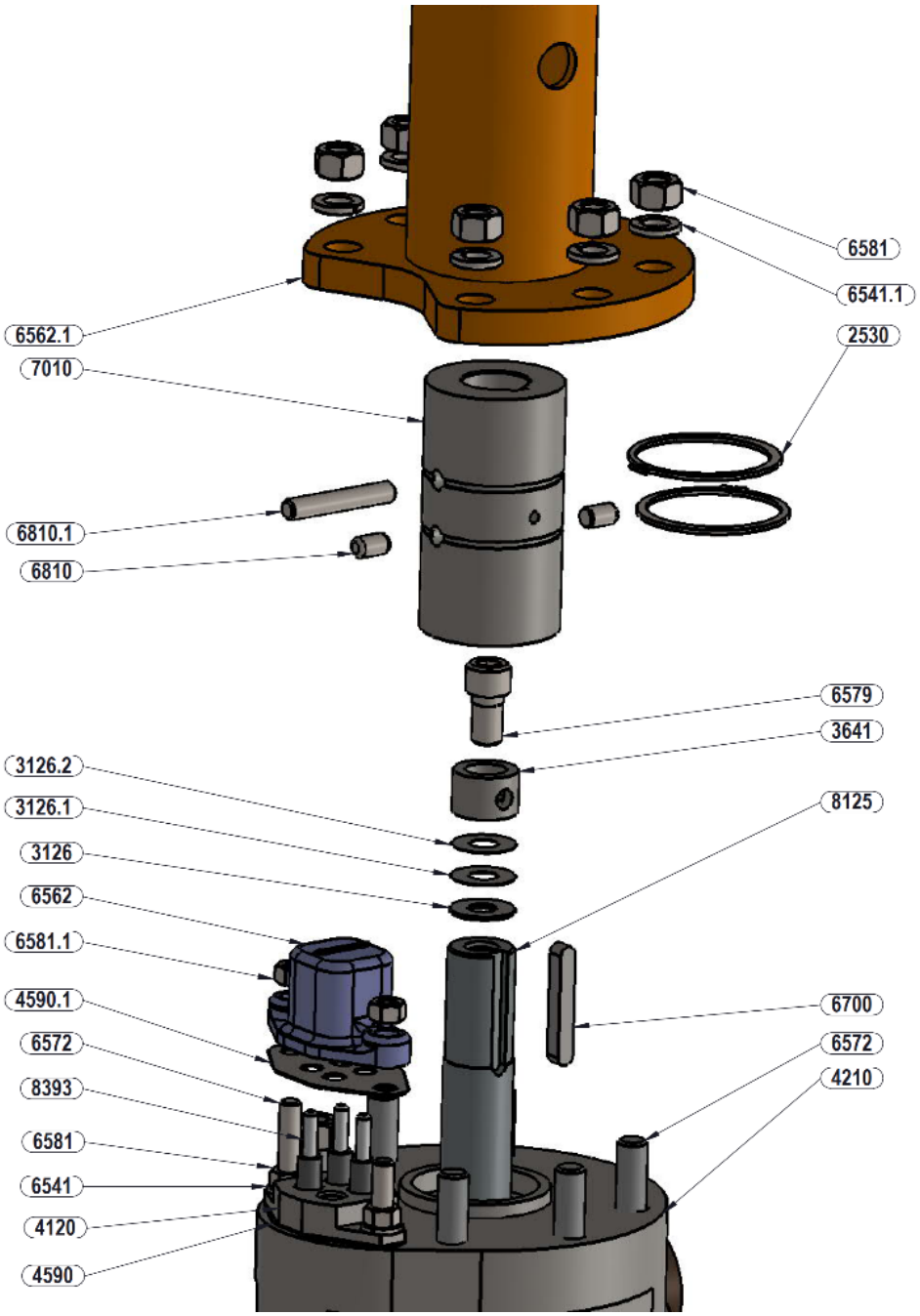


Figure 5.2.4b One Piece Coupling with External Retaining Rings

Coupling Variant A

a) If the coupling (7010) is on the pump, remove the coupling from the pump by removing the retaining rings (2530) internal) or external or screws and washers (not shown) and the dowel pin (6810.1) from the pump.
b) For types of couplings with retaining rings, replace all retaining rings at each install.
c) Clean the coupling (7010) and motor shaft (8125) and apply a light coat of oil to both.
d) Identify the thrust button (3641), thrust button screw (6579) and shaft adjusting shims (3126, 3126.1, 3261.2) as required. These pieces are factory installed. Some models may not have a thrust button and instead have a hole drilled through the end of the motor shaft.
e) The number of shims (3126, 3126.1, 3126.2) will vary and are factory selected to obtain the exact shaft extension required.
f) Insert key (6700), round end down, in the keyway.
g) Slip coupling (7010) on motor shaft with keyways aligned.

⚠	**⚠ CAUTION**
	Do not force the coupling. If the coupling will not seat properly, again verify that shaft and coupling mating surfaces are clean

h) Tighten the thrust button socket head screw (6579).
i) For designs using a thrust button: Install the coupling pins (6810) into the coupling (7010) holes and the thrust button (3641). The thrust button may need to be rotated to align holes. Internal or external retaining rings (2530) to hold the coupling pins (6810) in the coupling. Visually ensure the retaining ring is properly seated in the retaining ring groove.
j) For designs not using a thrust button (not shown):
Install the dowel pin into the coupling holes and the motor shaft. Install the retaining ring(s) (2530) to hold the dowel pin in place.
k) Rotate the motor shaft (8125) and coupling (7010) until the pin holes on the coupling are pointed 90 ° from the power terminal shipping cap (6562). This aligns pin holes in coupling to allow pump coupling pin (6810.1) to be installed later.
l) Clean the motor flange face of any dirt or foreign matter.
m) Cover the coupling (7010) and shaft (8125) with a clean cloth. The coupling and motor are now ready to receive the pump bowl assembly.

Coupling Variant B: Two-piece Motor and Pump half coupling.

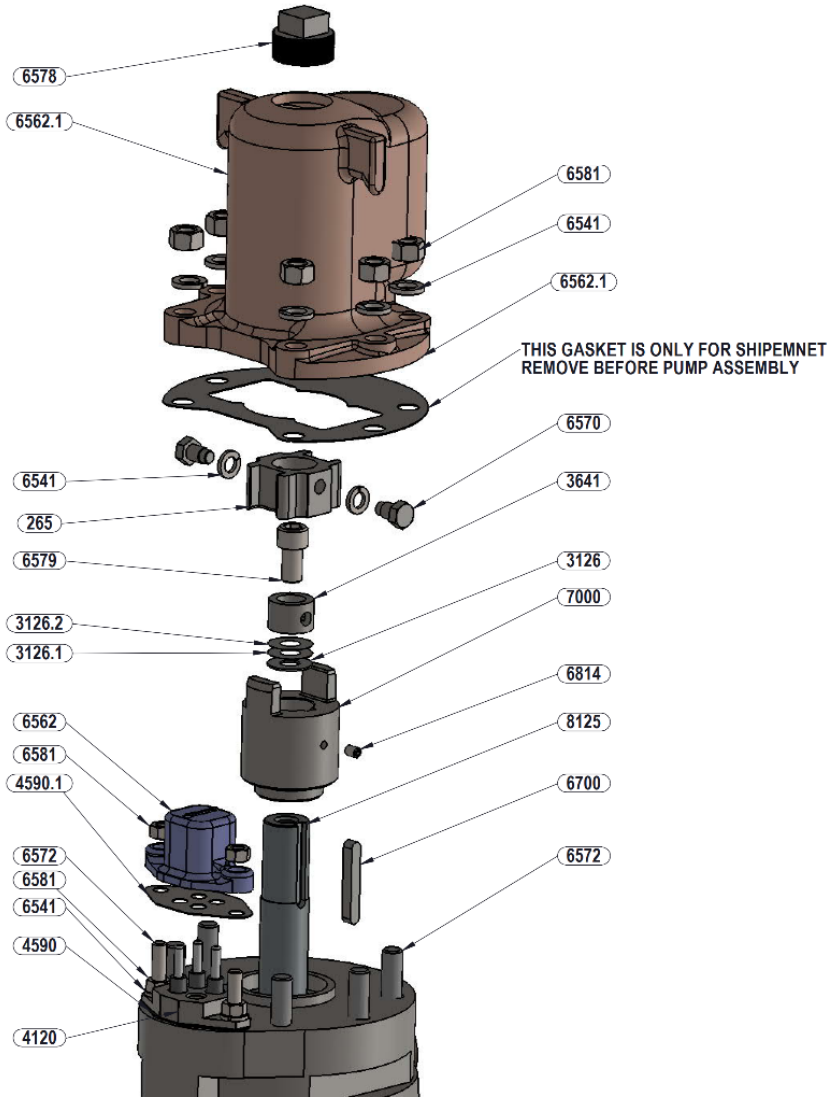


Figure 5.2.4c Motor Parts for Two Piece Coupling

a) Pump half coupling (Fig 5.2.7.c) is usually factory mounted but adjustment may be required.
b) Clean motor half coupling (7000) and motor shaft (8125), and apply a light coating of oil to both.
c) Slip motor half coupling (7000) on motor shaft with keyways aligned.

NOTE Do not attempt to force the coupling. If the coupling will not fit freely: - remove the coupling - verify that the shaft is free of dirt and foreign matter - reinstall the coupling.

d) Insert key (6700), round end down, in the keyway.

e) Install socket head set screw (6814) through its hole in the coupling (7000) to engage the coupling to the shaft. Use wrench provided to lightly tighten set screw (6814).
f) Identify the thrust button (3641), alignment jig (265), screws (6570) with washers (6541), thrust button screw (6579) and shims (3126, 3126.1, 3126.2). These parts usually come attached to the shaft but may be shipped in a loose assembly in the shipping cap.
g) The number of shims (3126, 3126.1, 3126.2) will vary and are factory selected to obtain the correct shaft extension required.
h) Install alignment jig assembly on motor half coupling (7000).
i) Install thrust button screw (6579) and use wrench provided to tighten thrust button screw (6579).
j) Loosen set screw (6814) in motor half coupling (7000) and slide motor half coupling (7000) up to butt against alignment jig (265). Use wrench provided to fully retighten set screw (6814).
k) Rotate the motor shaft (8125) and coupling (7000) and alignment jig (265) until the pin holes on the alignment jig are pointed 90 ° from the power terminal shipping cap. This aligns pin holes in thrust button (3641) with adapter bracket (1140) to allow pump coupling lock screws (6570) and washers (6541) to be installed later.
l) Remove alignment jig (265) and hold for storage in motor shipping cap (6562).
m) Clean the motor flange face of any dirt or foreign matter.
n) Cover the coupling (7000) and shaft (8125) with a clean cloth. The motor is now ready to receive the pump bowl assembly.

5.2.5 Lifting pump bowl assembly

NOTE Not all components or subassemblies of a pumping unit are necessarily supplied by Flowserve as part of this delivery. These user instructions apply only to the components or subassemblies supplied by Flowserve in this delivery.

a) Remove any crating, wrapping, covers, or shaft restraints from the pump bowl assembly. Remove cable guard if attached.
b) Check pump shaft and motor shaft extension to ascertain enough pump shaft lift in the following steps:

- *The pump bowl assembly may include a one-piece strainer body/intake (6531) or two piece strainer body (6531) and adapter (1340). Check pump shaft and fit of strainer body (6531) and adapter (1340, if included) for possible damage and make sure these items are clean. Rotate pump shaft to align coupling pin hole in shaft with coupling access holes in strainer body or adapter.*
- *The method to lift the pump depends on the design of the pump. Be careful to ensure the lower pump flange does not drag on the ground or get damaged during this operation.*
  1. If the top bowl has a threaded flange, thread in a piece of column pipe, usually a short piece (pup joint) with a column pipe coupling. If the joint first being used will be a part of the permanent installation, apply a thread locking compound such as Loctite. The pump can then be lifted using elevators.
  2. If the top bowl has a flanged connection, install the o-ring or gasket and then install the flanged column pipe on the bowl. Ensure all fasteners have been properly torqued. The pump can then be lifted using elevators.

- *Raise the pump bowl assembly into position over the motor. To ease the installation of the pump to the motor, it is critical that the pump hangs plumb and centered directly over the motor shaft.*

5.2.6 Checking pump and motor shaft extension to confirm impeller lift

Flowserve manufactures two pump variants for the Byron Jackson Oil Filled Motor:

- *Impeller Variant A: Closed impeller (this will be the most common variant)*
- *Impeller Variant B: Open impeller (rarely used)*

Steps for verifying impeller lift are described by the following.

- *Impeller Variant A: Closed impeller*
  1. Refer to Figs. 5.2.7.a, b, c. Scale from the face of the one piece strainer body/intake (6531) or the two piece strainer body (6531)/ adapter bracket (1340) to the end of the pump shaft (2110) with the shaft in the fully down position. Record the dimension.
  2. Adapter brackets are typically used on 4 pole motors and are less common on cavern pumps. Remove adapter bracket (1140) from bowl assembly if this is present.
  3. Scale from the face of the motor top case (4210) to the top face of the shaft adjusting button (3641).
  4. The distance recorded in step 1 should be 1/8" to 1/4" (3.175 mm to 6.350 mm) less than that measured in step 3
  5. Install adapter bracket (1340) (if included) on motor top case (4210), using fasteners for motor shipping cap (6572, 6541, 6581).

- *Impeller Variant B: Open impeller (contact factory for designs without adapter bracket)*
  1. Remove adapter bracket (1340) from bowl assembly if it is present.
  2. Install adapter bracket (1340) on motor top case (4210), using fasteners from motor shipping cap (6572, 6541, 6581).
  3. Remove the pump half coupling (7411) or one-piece coupling (7010).
  4. Provide four pieces of shim stock, each (2" x 2" x 0.020" (50.8 mm x 50.8 mm x 0.508 mm) thick and place each shim 90 degrees apart on the face of the one piece strainer body/intake (6531) or two piece strainer body/ adapter bracket (6531/1340).
  5. Lower the pump bowl assembly to rest on the shims.
  6. Put a feeler gauge through the opening in the motor top case or adapter bracket (1340) and check the gap from shaft adjusting button (3641) to pump shaft (2110).
  7. If gap, step 6, is less than 0.0381 mm (0.015") or more than 0.4572 mm (0.018"), the shims beneath the shaft button (3641) must be changed.
  8. Reinstall the pump half coupling (7411) or one-piece coupling (7010) on pump.
  9. Remove shim stock from between motor top case and adapter bracket

Note: The impeller lift on variant B can be measured by using depth micrometers if the installer has these available.

5.2.7 Installing pump on motor

In reference to section 5.2.4, Flowserve manufactures two coupling variants for the Byron Jackson Single Mechanical Seal Motor:

Coupling Variant A: One-piece coupling. This type is used on all 2 pole motors/pumps and some 4 pole motors/pumps. (most common for cavern units)

Coupling Variant B: Two-piece Motor half and pump half coupling. This type is used on some but not all 4 pole motors/pumps. (less common)

Coupling Variant A: One-piece coupling See Figures 5.2.7a and 5.2.7b

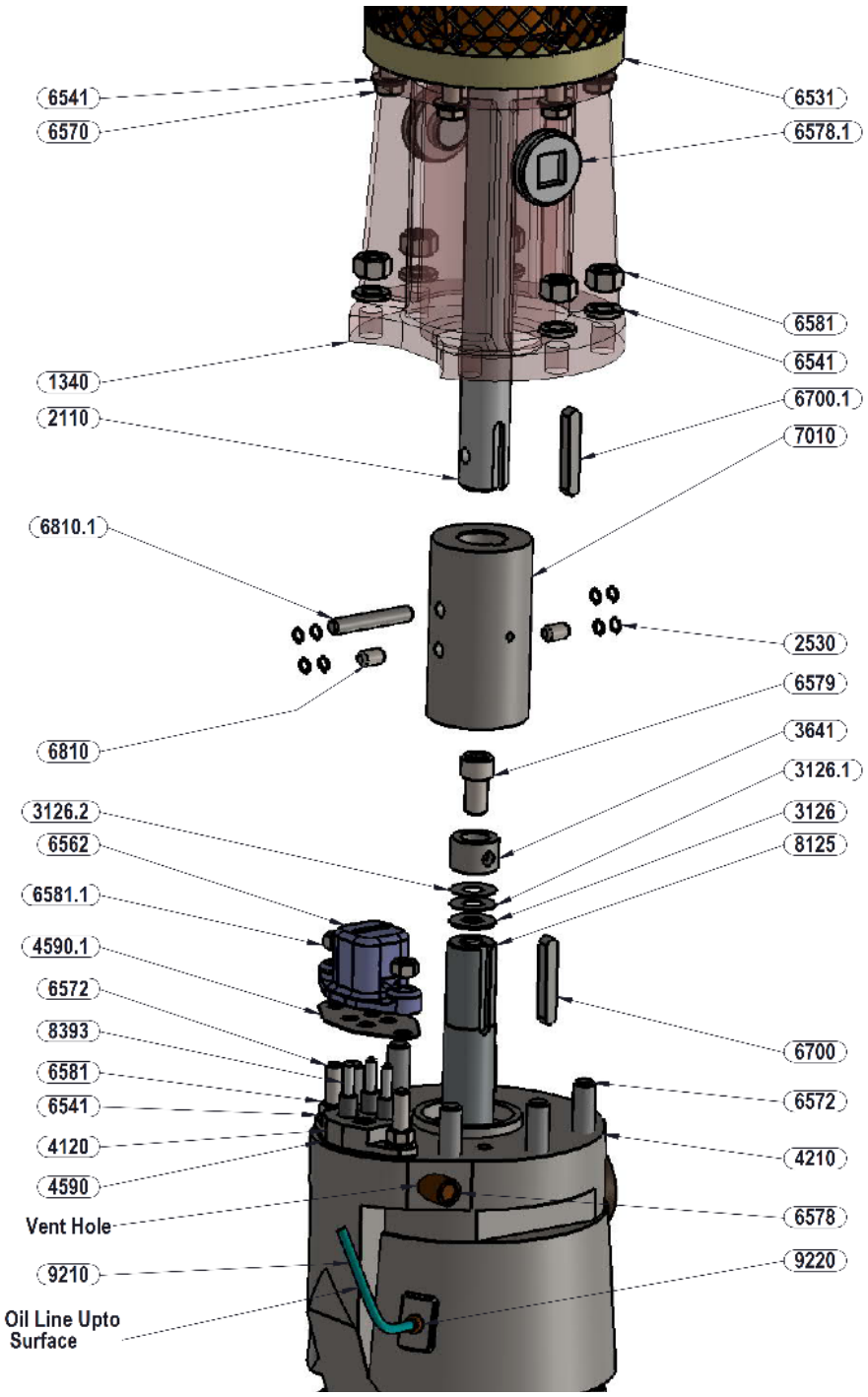


Figure 5.2.7a Coupling Variant A: One-piece Coupling Pump and Motor Connection with Internal Retaining Rings

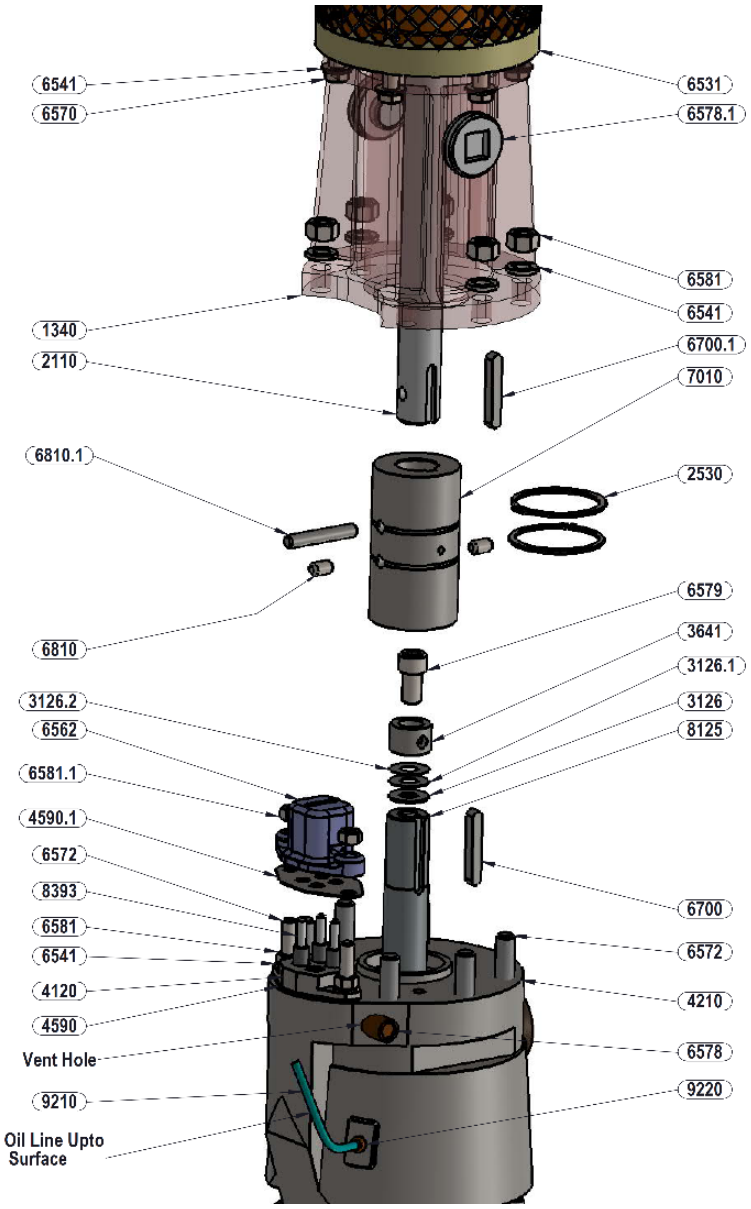


Figure 5.2.7b Coupling Variant A: One-piece Coupling Pump and Motor Connection with External Retaining Ring

a) Insert coupling key (6700) in the pump shaft (2110) and lubricate pump shaft if desired to ease assembly into coupling. Rotate bowl assembly as necessary to align coupling key with coupling keyway and slowly lower pump until pump shaft has entered coupling and strainer body (6531)/ adapter (1340) is flush with fit on motor. Note that most standard pump shafts will be lifted 1/4" (6.3 mm) as bowl assembly is mated to motor.

b) Locate coupling pin hole in coupling by looking into access holes in strainer body/adapter (1340), then insert coupling pin (6810.1) into the coupling hole and install bolts (not shown) or

retaining ring(s) (2530) into coupling to hold pin in position. Bolts on one-piece couplings should be installed with a thread locking compound that does not require heat for removal Continue to step d) below

Coupling Variant B: Two-piece coupling.

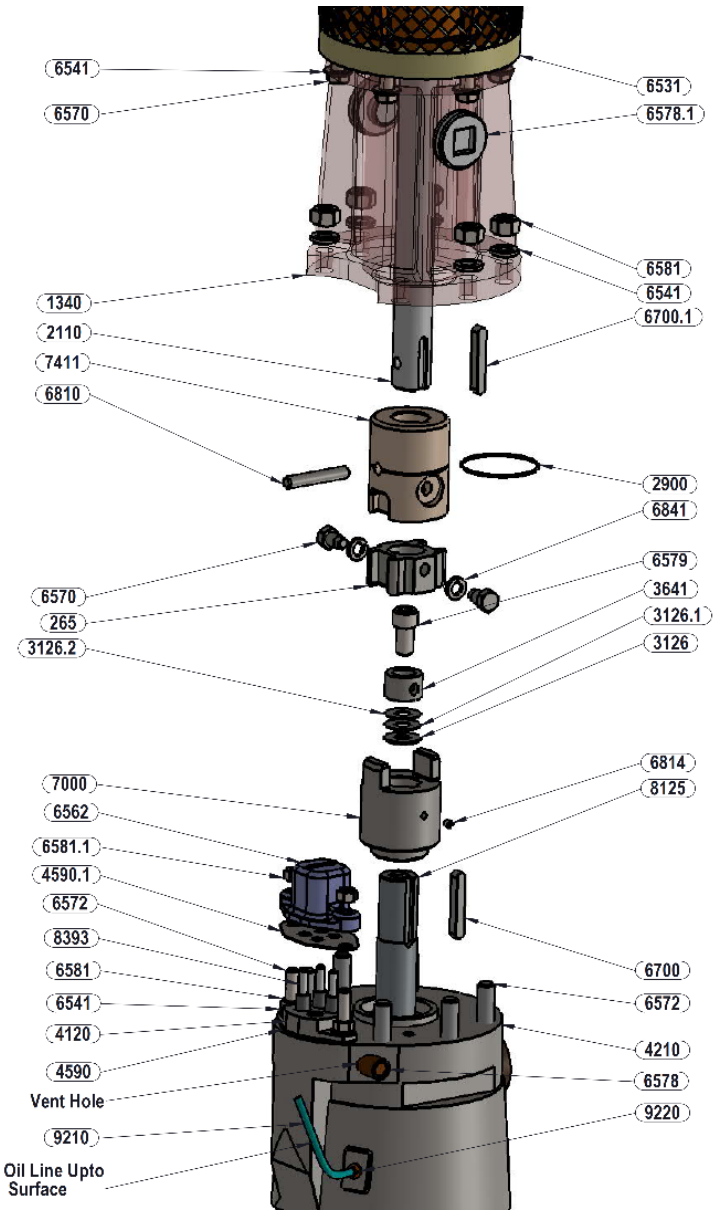


Figure 5.2.7c Coupling Variant B: Two-piece Coupling Pump and Motor Connection

a) Rotate the bowl assembly to line up bolt holes of strainer (6531) with those of the adapter (1340) then lower until flanges butt metal to metal.
b) Remove the adapter bracket pipe plugs (6578) to observe through the ports, the alignment of the pump half coupling (7411) alignment with the motor half coupling (7000).
c) Install the half coupling lock screws (6570) and washers (6541) and apply torque to the half coupling screws (6570) to the values in Table 5.27. After tightening, confirm that half coupling screws (6570) are seated firmly and lock washers (6541) are compressed,
Continue with step d) below

Table 5.2.7 Half Coupling Screw Torque Requirements

Unit size (inches)	*Torque (ft-lbs)*	*Torque (Nm)*
8	*20*	*27*
10	*30*	*41*
12	*40*	*54*
14	*40*	*54*
17	*50*	*68*
18	*50*	*68*

d) With pump lowered into final position on motor, install and tighten the pump-to-motor retaining lock washers (6541) and stud nuts (6581) which were previously used to retain the shaft shipping cap.
e) Carefully release the tension on the lifting device. If it appears that the pump is too heavy to be stabilized by the motor on the slip plate, use guide ropes as necessary.
f) Lift the oil expansion bag and affix to the pump temporarily so that oil can drain in motor.
g) Remove the vent screw or plug (6578) in the top case vent hole to allow any oil in the expansion bag to flow in the motor and vent air from the motor.
h) Reinstall and tighten vent screw or plug (6578). Do not allow air to enter motor.

5.2.8 Installing power cable to motor

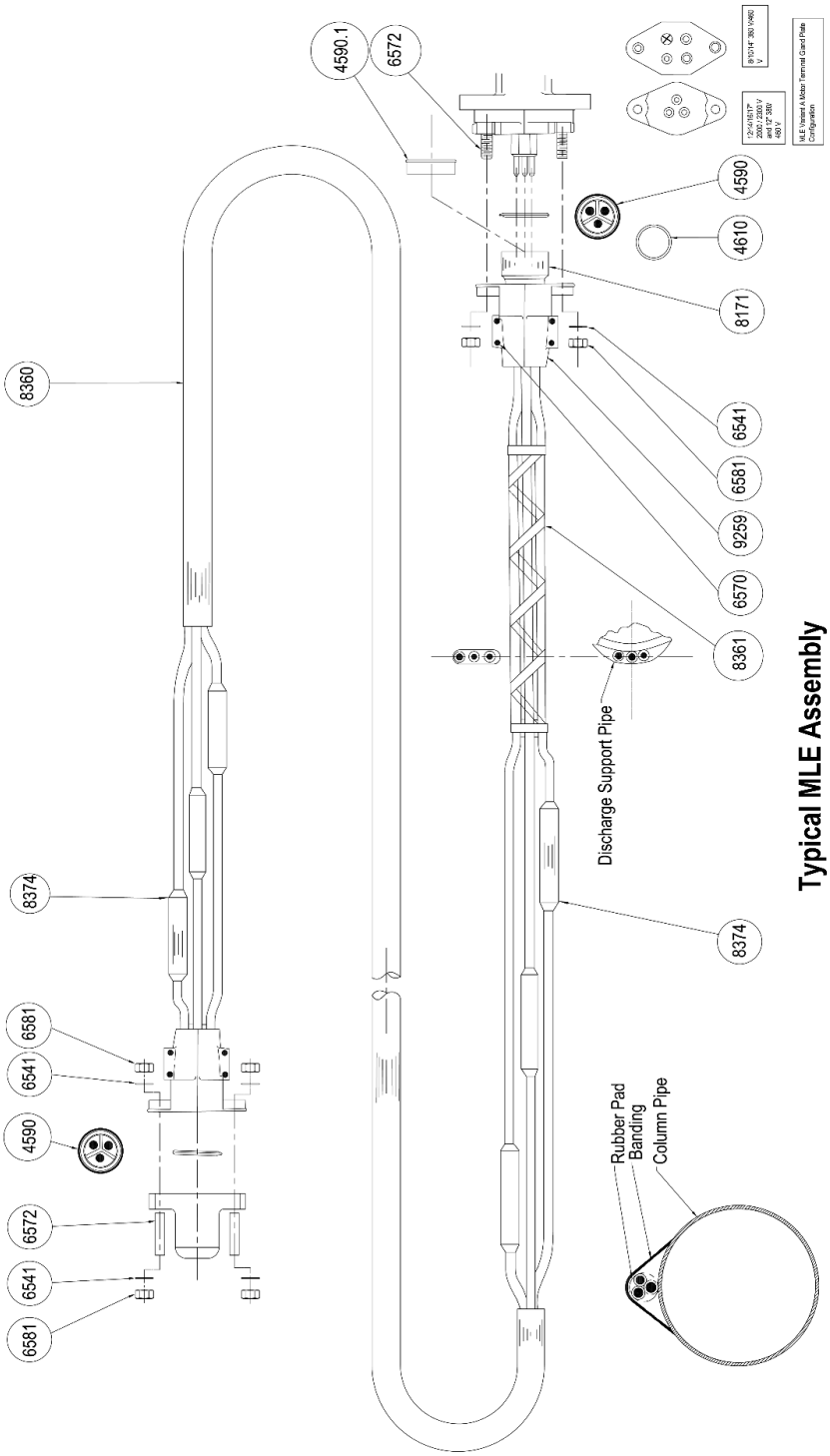


Figure 5.2.8a Typical MLE and Power Cable Assembly

Use a fly line or large diameter sheave to support the power cable and bring the cable looping up off the cable reel stand so that the motor lead extension body is suspended over the motor terminals. See Figure (5.2.8a) Do not strain cable or bend sharper than a diameter of 14 times the power cable outer diameter.

Remove and store motor lead extension (MLE) shipping cap or cover plate and the motor terminal shipping cap (6562). These parts can be stored in the motor shipping cap (6562) and should be retained for future removal of equipment. Check that motor terminal gland plate (4120), terminals (8393), and the MLE and its connectors are clean and dry.

In the following, three variants of the Motor Lead Extension are described:

Variant A Motor Lead Extension for voltages usually of 2300 V and less (slip on metal clamp with molded plug with flanged bolted connection). See Fig. 5.2.8b

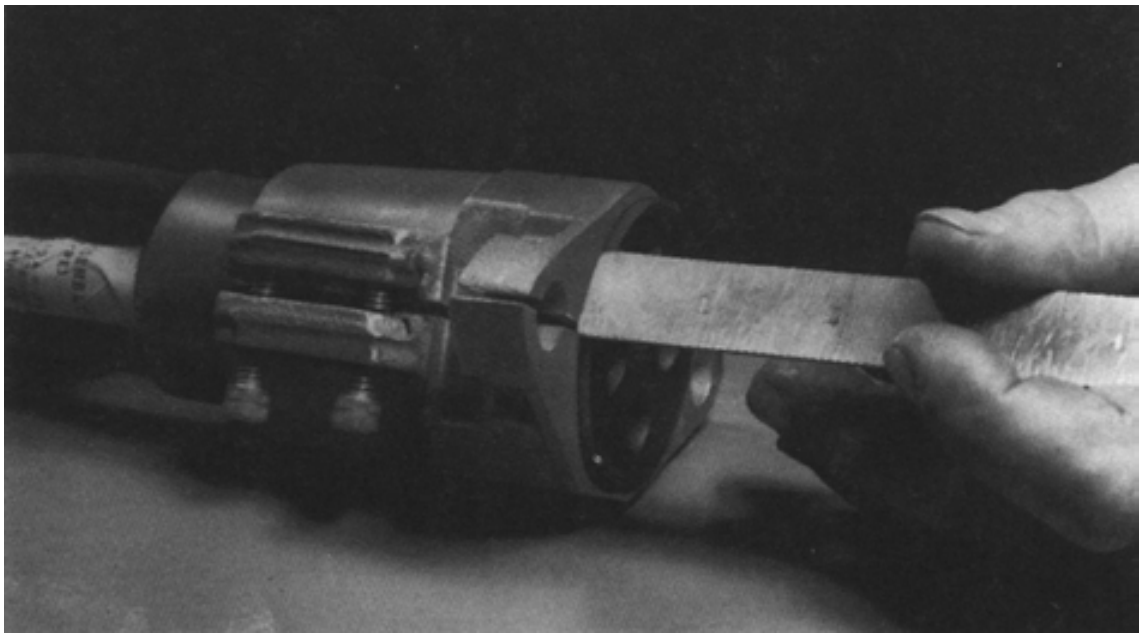


Figure 5.2.8b Variant A- Slip on Metal Clamp with Molded Motor Lead Extension Plug

Variant B- Motor Lead Extension for voltages usually of 3300 V and greater (metal housing molded to plug with flanged/bolted connection). See Fig. 5.2.8c

Figure 5.2.8c Variant B- Metal Housing Motor Lead Extension with Flanged Connection

Variant C- Motor Lead Extension for voltages usually of 3300 V and greater (metal housing molded to plug with threaded ring connection). See Fig. 5.2.8d

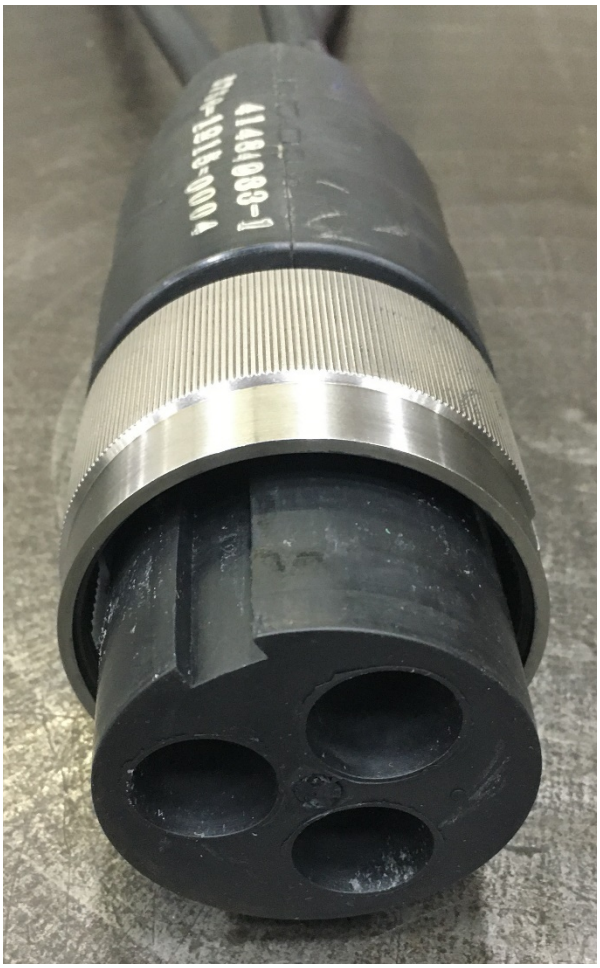


Figure 5.2.8d Variant C- Metal Housing Motor Lead Extension with Threaded Connection

Determine which type of Motor Lead Extension is for your application and proceed to the appropriate section to continue.

MLE Variant A- Installation of the molded MLE type seen in Fig. 5.2.8b.

1. Use the power cable installation wheel to unreel a sufficient length of power cable to pass the bowl assembly. Elevate the power cable to the approximate height of the pump bowl assembly and fasten the cable plug to the motor.

⚠	**⚠ CAUTION**
	Do not kink or stretch the power cable

2. Install flat gasket (4590) over power terminals (8393). See Fig 5.2.8e

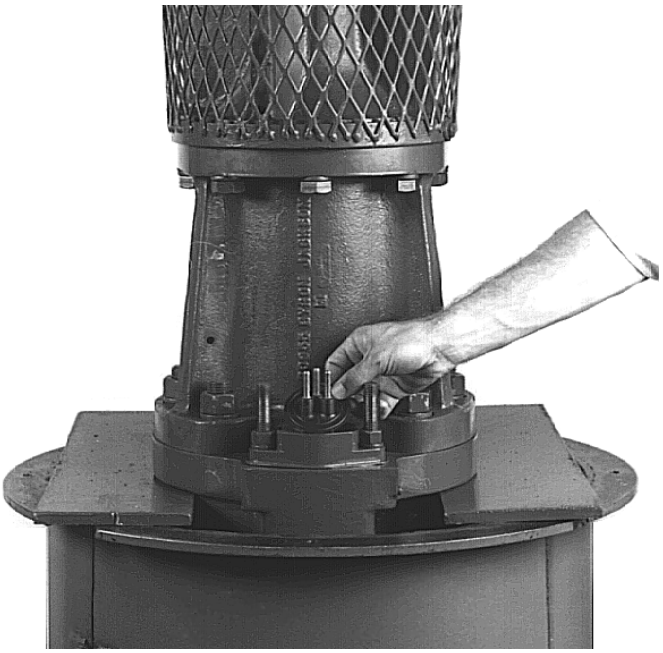


Figure 5.2.8e Installing power terminal gasket (flat-faced type shown)

3. Remove the MLE shipping cap (4590.1) from the MLE (8171).

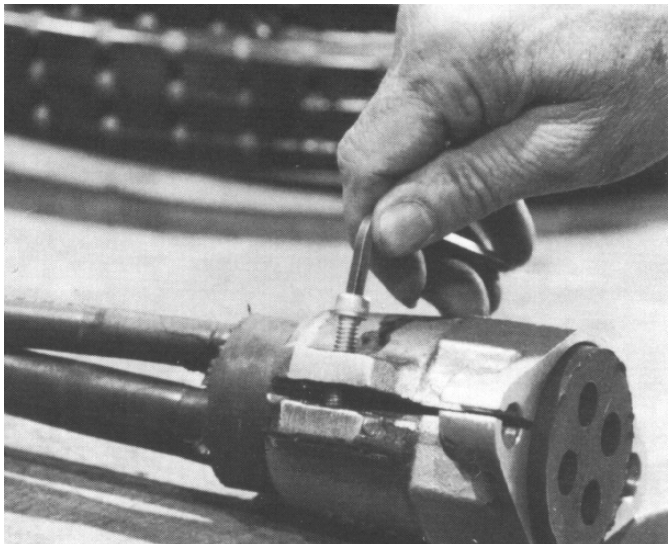


Figure 5.2.8f Preparing molded plug clamp

4. Slide the MLE clamp (180) down over the molded plug (9259) as far as possible. Then check gap from bottom face of clamp (9259) to bottom face of molded MLE plug (8171). This gap should be minimum 1/32" (0.8 mm) and maximum 3/32" (2.4 mm). See Figure 5.2.8f.

5. Slide the metal clamp (9259) up the flat cable and off the MLE plug (8171) loosening the clamping screws (6570), if necessary.

⚠	**⚠ CAUTION**
	Do not distort the clamp

6. Align plug connectors with the motor power terminals and push the MLE plug (8171)) down on to the motor power terminals (8393) to mate with the gland plate (6541) and gasket(s) (4590). See Figure 5.2.8g.

7. Slide metal clamp (9259) down over MLE molded plug (8171) and gland plate studs (6572)

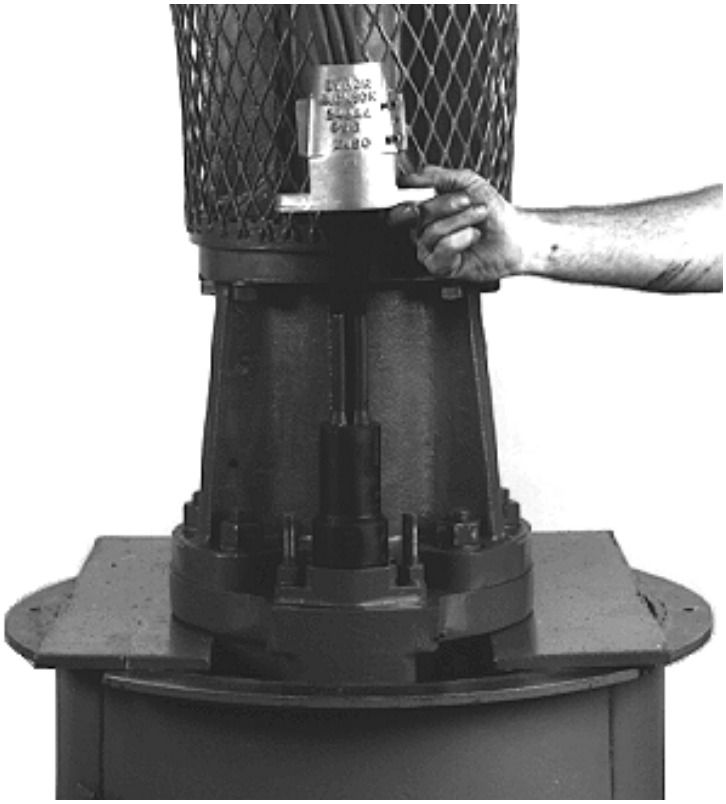


Figure 5.2.8g Molded Plug installed and slide clamp to fit over molded plug

8. See Figure 5.2.8h
   Install washers (6541) and nuts (6581). Tighten the nuts (6541) alternatively and evenly to bring the clamp (9259 firmly metal to metal against the gland plate (4120) .

9. Back off the nuts (6581) two or three turns each and tighten clamping screws (6570).

10. Retighten the nuts 6581) to achieve metal-to-metal fit of clamp (9259) to gland plate (6541).

Continue with " Installing Oil Tube and Set Up for Running in Hole", Section 5.2.9.

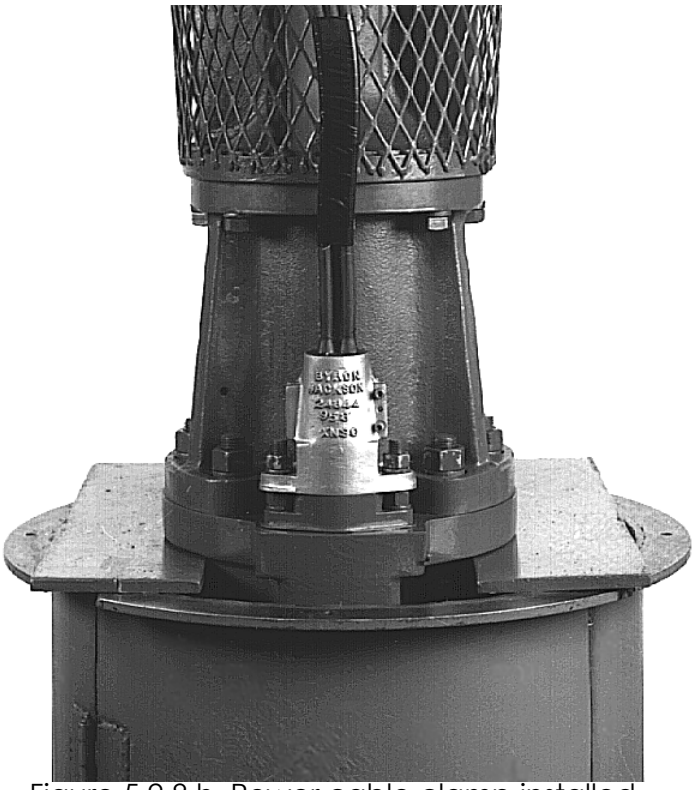


Figure 5.2.8.h Power cable clamp installed

MLE Variant B. Installation of the cable plug type for voltages usually of 3300 V and greater (metal housing molded to plug with flanged/bolted connection). See Fig. 5.2.8.c

Refer to Figure 5.2.8i

1. Remove the power terminal shipping cap nuts (6581), washers (6541) and power terminal shipping cap (6562) at the motor.
2. Remove the MLE shipping cap from the MLE (8171).

Figure 5.2.8i Metal housing power terminal connector with bolted connection (3300 V-cable or higher)

3. Refer to Figure 5.2.8.j. Place new O-Ring (4610) into groove of the terminal gland plate (6541) at the motor top case.

Figure 5.2.8.j O-ring for metal housing power terminal connector at motor gland plate (3300 V or higher)

4. Align the MLE connector (8171) with the motor power terminals (8393) and push down to mate with the gland plate (651) and O-Ring (4610).

   Slight side-to-side movement will aid this engagement.

   Do not use nuts to force the MLE connector (8171) down

5. Install the lock washers (6541) and tighten nuts (6581) at gland plate studs (6572). Note: Connectors will have either 2 studs or 4 studs to attach
6. Tighten the nuts (6581) alternately and evenly to bring the MLE connector (8171) firmly metal to metal against the gland plate (6581).

Continue with " **Installing Oil Tube and Set Up for Running In Hole**", Section 5.2.9.

MLE Variant C. Motor lead extension for voltages usually of 3300 V and greater (metal housing power terminal connector with threaded ring connection) Fig 5.2.8.d

NOTE Key and keyway must be engaged prior to terminal engagement to prevent damage. The gland nut must be tightened by hand and repeated until sufficient seal is accomplished. Do not use a wrench to tighten the gland nut. Failure to fully engage the plug and receptacle will result in electrical failure.

1. See Fig. 5.2.8k Align keyway in MLE connector with key in the motor terminal receptacle. Apply a downward force to engage the cable connector and motor terminal receptacle.

Figure. 5.2.8k MLE with keyway

2. See Fig. 5.2.8.m Engage the threaded gland nut and tighten by hand. A slight side to side movement may be required to allow further engagement. Retighten the gland nut. Repeat until visual inspection though the inspection window of the gland nut confirms the rubber seal is properly compressed and a seal has been achieved.

Fig. 5.2.8.m Inspection window with fully tightened MLE gland nut

3. After the connection is complete, water should be liberally poured over the connector area and the insulation resistance of the connection checked with a megohm meter.

Continue with " Installing Oil Tube and Set Up for Running In Hole"

5.2.9 Installing Oil Tube and Set Up for Running In Hole

⚠	**⚠ CAUTION**
	Due to the potential hazards of the pump and motor being dropped uncontrolled during the installation, the areas between the cable and oil line reels and the well casing should be cordoned off and personnel should not be working in this area

The oil tube should be of one single continual length and sized appropriately per Flowserve's recommendation, coiled on a reel with the surface end protruding out of one of the reel flanges and protected from kinking and damage during shipment. The oil tubing reel should be placed in close proximity of the power cable reel (see Fig. 5.2.9a. As with the power cable, the oil line must be supported at the same height as the power cable using a sheave of sufficient diameter to eliminate the possibility of kinking the oil tube during installation. An additional mobile crane may be required to hold the sheeve in position during the installation of the cavern equipment. Note: Both the cable reel and oil tubing reel must be manned by personnel during the unreeling process to keep the reels from unspooling and damaging the cable or oil tubing. Power cable and oil tubing should unreel from the top of the reels so proper orientation of both reels is required.

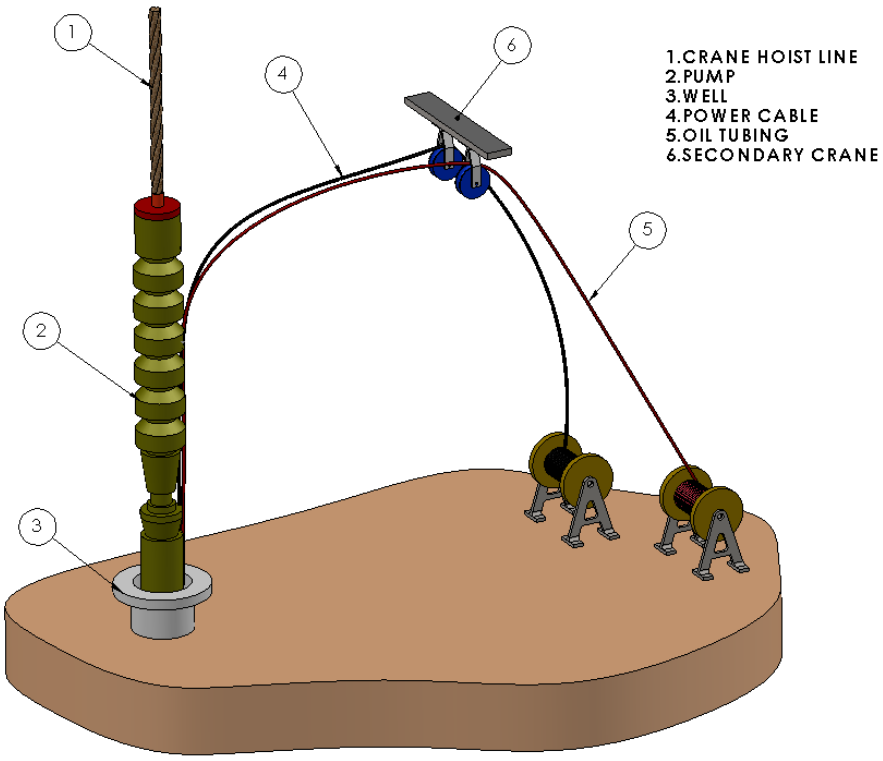


Figure 5.2.9a Cable and oil line feeding into casing

1. Note: Oil tubing supplied by Flowserve will be pre-filled at the factory. Ensure the oil line is full of oil by connecting the motor end of the oil line to the oil pump. Remove the cap on the surface end of the tube. Fill the oil line until oil flows out the other end. Make sure to collect any oil overflow into a container. Cap the oil line surface end until ready for next steps.
2. At the surface end of the oil line remove the plug and install a valve. Close the valve as quickly as is possible to reduce oil loss from the tubing. Next, install a pressure gauge, another valve and the fittings required to attach to the mobile oil pump. See picture/drawing for reference.
3. With oil tube fitting located close to the motor, remove the motor connection (where the expansion bag was installed). See Fig. 5.2.9b Remove the plug on the oil line and install on to the motor. Some oil loss is expected during this process. Take appropriate precautions to limit the leakage and contain it.

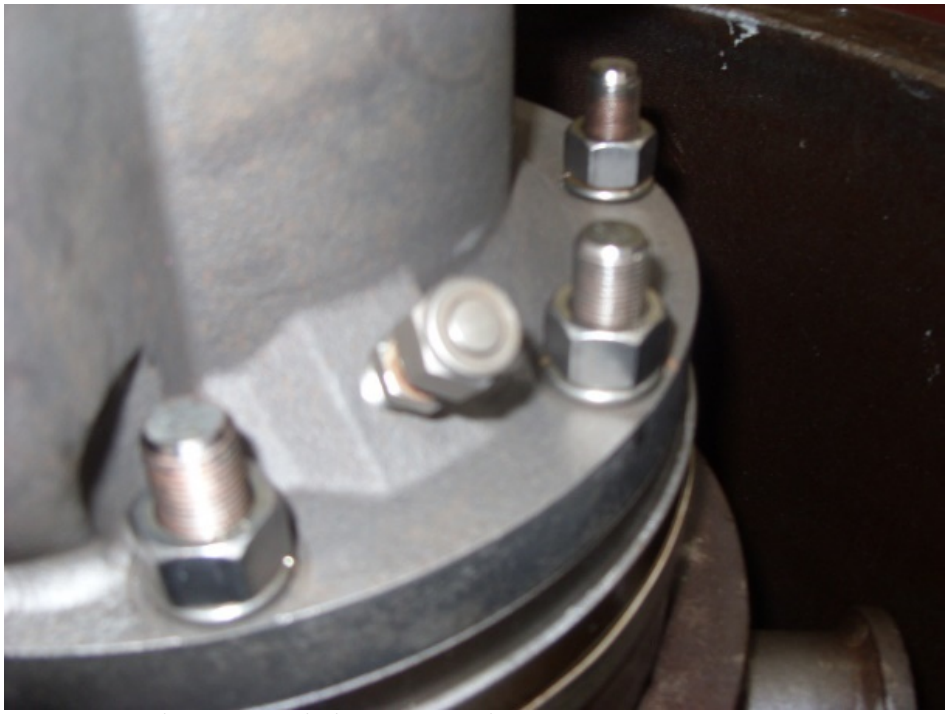


Fig. 5.2.9b Oil Line connection port to the motor

4. Loosen or remove the motor vent screw and start the oil filling pump to let the oil flow until no air bubbles are present at the motor vent. Once clear oil is flowing from the vent and all air has been removed from the motor, reinstall the vent screw on to the motor, pressurize the motor to 50psig. Close the valve and stop the oil pump.

Fig. 5.2.9.c Motor Vent Screw Location in Top Case

5. Check the motor and oil tubing for any oil leaks. Once pressure is stabilized (there may be some air bubbles in the oil line reel) and no leaks are found, hold the pressure for 20 minutes. Note: in very warm conditions the pressure may increase over time. After a successful pressure test open the valve closest to the oil pump very slowly to reduce the pressure in the motor/oil tubing to between 10 to 15psig and close the valve again. Remove the oil pump from the valve. The motor and oil tubing will be kept pressurized during the entire installation. Check the pressure gauge occasionally to verify the system pressure is maintained.

   Since the oil line is suspended above the well from a hanging sheave, any air that has been trapped in the oil tubing will migrate upwards during installation. Keeping the oil line pressurized ensures that the motor internal motor pressure will be greater than the cavern pressure at all times during the installation process. Continuous monitoring of pressure will ensure integrity is not compromised during the installation process.

⚠	**⚠ CAUTION**
	It is recommended that at least 15 psig (1.0 bar) positive pressure be maintained on oil line at surface throughout installation process in order to ensure the motor mechanical seal is at a higher pressure than its surrounding environment. See Oil Tank Pressure Setting Calculation Worksheet for assistance in determining net positive pressure at various setting depths

Safety Note: The area between where the power cable reel and oil tubing reels are located, and the well head should be sectioned off with caution tape. Personnel should avoid being in the area between the reels and the cavern well head unless absolutely necessary.

Fasten the Power Cable to the Cable Guard and Pump

1. Attach ground wire (if provided) to rib of motor adapter (1140) using terminal lug, lock washer and cap screw.
2. If the surface end of the power cable consists of another plug assembly, remove the shipping cap. Using surface end of the power cable, check insulation resistance of the power cable and motor for ground and continuity. The insulation resistance reading should be 10 MΩ or more.
3. When megger test is completed, replace the shipping cap if applicable or install a plastic bag over the surface end of the power cable for protection from the weather.

Notes:

Inspect cable guards, particularly their inner surfaces, for sharp edges that could damage the cable insulation

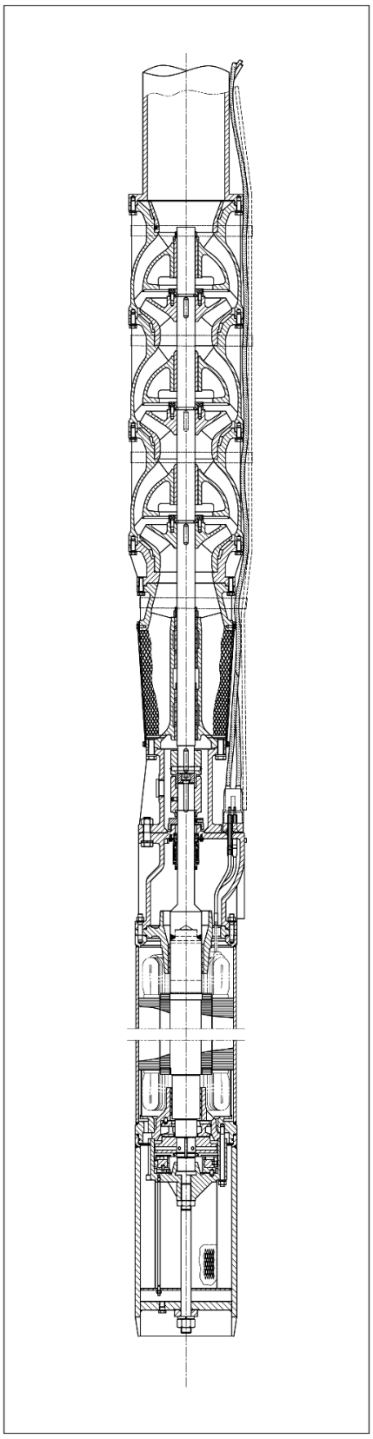
When installing the motor lead extension (AKA flat cable), verify any sharp edges of the guard cannot damage the cable insulation.

Avoid strain on the MLE plug assembly. Do not use force to suspend the cable until at least 4 bands have been placed over the cable and column pipe to hold it in place.

Use "BAND-IT" or equivalent stainless steel or Monel bands to fasten the cable assembly to the pump and discharge column (riser pipes). Refer to the BAND-It manual for installation instructions.

Procedure:

1. Elevate the cable alongside the bowl assembly without stretching or straining the cable plug assembly
2. Use tape to fasten the inner cable guard to the bowl assembly. The inner guard should overlap the housing of the cable plug clamp/ housing (between plug and motor adapter) to protect the cable from damage due to vibrational rubbing against the motor adapter/strainer body/pump.
3. Lay the motor lead extension into the inner cable guard and tape in place. The oil line may be placed inside the inner cable guard if room allows. Otherwise, the oil line should be placed next to the inner cable guard to facilitate banding both the MLE and oil in place.



MLE with outer Guard in Place (oil line not shown)

4. Install outer guard. The bottom edge should start at the mid-point on the MLE clamp or housing, and the top edge should extend above the inner guard by several inches.
5. Clamp the cable guard and MLE assembly to the bowl assembly with bands. For bowl assemblies 6 feet (2 m) or less in length set a band at the adapter flange, at top and bottom of the suction strainer, at the top case flange and at the approximate center. For longer bowl assemblies, use the same procedure except space the intermediate bands no more than 3 feet (1 m) apart.
6. Oil line should be arranged to prevent damage while installing down hole. Usually this is accomplished by running the oil line tubing next to the cable. Care should be taken to ensure the oil line tubing is not damaged or crimped as it enters the hole. Use of rubber pads to grip and protect the oil line tubing while it is banded to the column pipe is recommended.

⚠	**⚠ CAUTION**
	It is recommended that at least 15 psig (1.0 bar) positive pressure be maintained on oil line at surface throughout installation process in order to ensure the motor mechanical seal is at a higher pressure than its surrounding environment. See Oil Tank Pressure Setting Calculation Worksheet for assistance in determining net positive pressure at various setting depths

7. Slightly lift the pumping unit and remove the U-plate

5.2.10 INSTALLING THE RISER PIPES

NOTE Not all components or subassemblies of a pumping unit are necessarily supplied by Flowserve or part of this delivery. These user instructions apply only to the components or subassemblies supplied by Flowserve in this delivery.

⚠	**⚠ CAUTION**
	Do not stretch the power cable and the splices.

During the installation, observe the following precautions:

- *Support the pumping unit weight with riser pipe elevator.*
- *Keep the riser pipe centered in the well casing.*
- *While lowering the riser pipe, hold the power cable and oil tubing flat against the riser pipe and keep it from dragging across the sharp edges of the well casing or flange.*
- *Avoid loss of power cable length by ensuring cable is suspended vertically tight against the riser pipe and does not wrap around the riser pipe.*
- *Prevent rotation of the riser pipe so that the power cable does not spiral wrap around it.*
- *If used or out of round riser pipe is utilized, it is recommended to weld a steel strap across each coupling to prevent unthreading during start up or running.*

NOTE: Instructions are for threaded riser/column pipe. If using flanged column pipe, refer to supplier for specific instructions.

1. Raise power cable installation sheave to 1.5 times the riser pipe length to facilitate power cable alignment to riser pipe and well casing.

2. Arrange the random lengths of riser pipe with their coupling ends facing one direction. At 5.0 feet (1.5 m) in from each pipe end, draw a chalk mark to set the banding location.
3. Install the check valve. Ensure that the flow direction is upward.

If the riser pipes are threaded:

- *Clean the mating pipe threads of the riser pipe as shown in Figure 5.2.10a.*

Fig 5.2.10a Cleaning threaded column pipe threads

- *Apply thread locking fluid, e. g. Loctite 242 or DELO 5249/5349 or equivalent, to the threads as shown in Figure 5.2.10b, applying to the first joint only.*

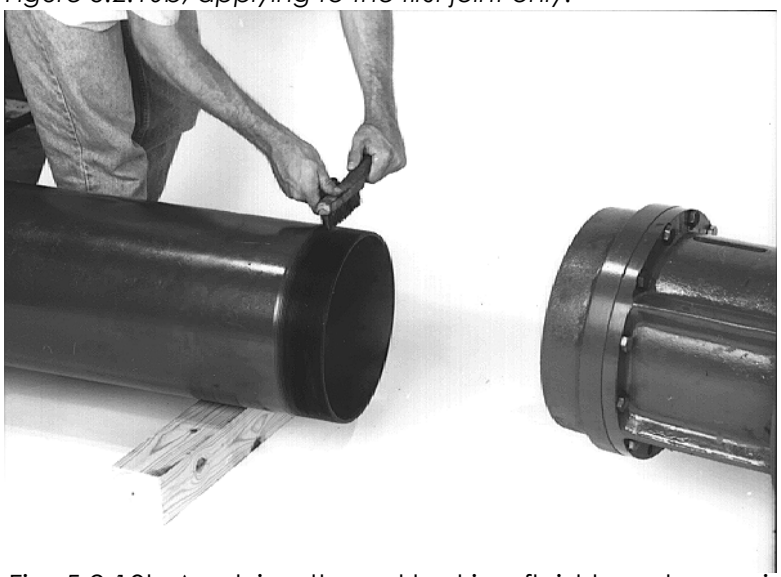


Fig. 5.2.10b Applying thread locking fluid to column pipe threads

- *Install the pipe using chain tongs and apply torque according to Table 5.2.10*

Table 5.2.10 Torque required for threaded column assembly

Pipe Size (inches)	*Torque (ft-lbs)*	*Torque (Nm)*
2-1/2	*500*	*620*
3	*700*	*950*
4	*900*	*1220*
5	*1050*	*1425*
6	*1200*	*1625*
8	*1600*	*2170*
10	*2000*	*2710*
12	*3000*	*4070*

4. When the motor first enters the fluid, use the surface end of the power cable to megger the power cable and motor for ground and continuity. The reading should be 10 MΩ or more.

If one or more vertical riser pipe check valves are to be used on an installation, each valve will take the place of a riser pipe coupling. Each valve should have a bleed-back self-draining feature or a break-off drain plug to prevent having to pull the pipe full of liquid.

Check Valve Installation

The recommended installation is as follows:

- *One check valve:*
- *Locate the check valve approximately 75 feet (23 m) above the pump bowl assembly.*
- *Two valves:*
- *Locate the first valve 100 feet (3 m) above the pump bowl assembly.*
- *Locate the second valve at 3/5 of the distance between first valve and the surface support plate.*

Fasten the power cable to the riser pipe

Use "BAND-IT" or equal stainless steel or Monel bands and buckles to fasten the cable and oil line tubing to the riser pipe. Pull each steel band tight enough to fasten the cable guard onto the riser pipe, but do not over tension it.

Bands should be used every 10 feet (6 m) and care should be taken to not stress the cable and oil line tubing as they cross the column couplings or flanges. Rubber pads may be installed to cushion the bands and prevent damage to the cable and tubing.

5.2.11 Surface Plate and Disconnect Pothead Installation

Reference Fig. 5.2.11 Penetrator, Oil Line, Oil Tank, Surface Plate Arrangement

- *Once you are near the desired depth, the wellhead surface plate is ready to be installed.*
- *When there is only a single wrap of oil tubing on the reel, open the valve and remove the pressure gauge and valve. If desired, the oil line tubing can be cut to a shorter length. Next, install the tubing cap into the fitting. At this point, the head pressure of the oil in the oil tubing should be sufficient to maintain the required pressure inside the motor. Any gas leakage through the tube is a sign the oil line is damaged, or a fitting is not connected properly.*

For wellhead surface plates that have disconnect pothead penetrators

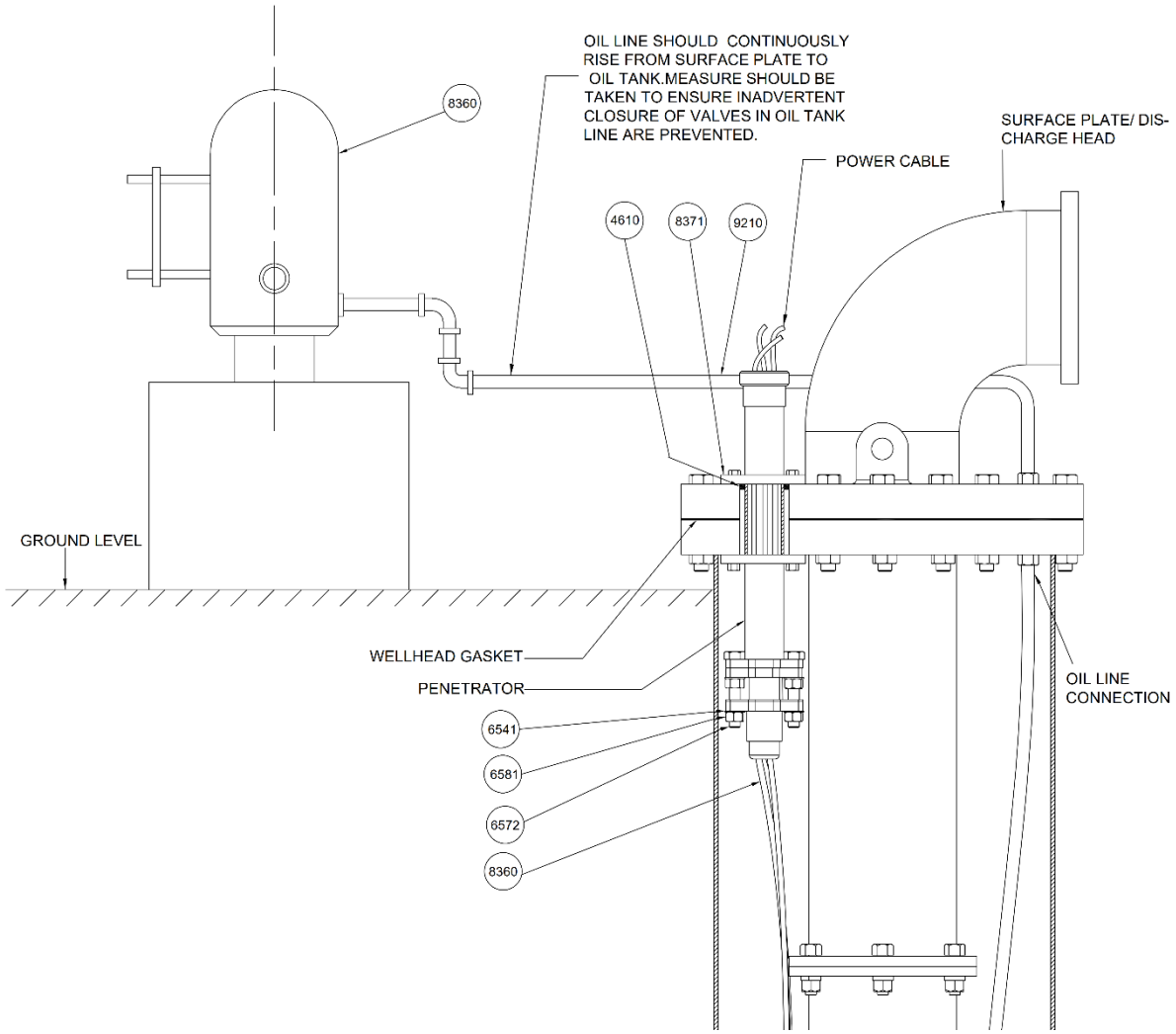


Figure 5.2.11 Penetrator, Oil Line, Oil Tank, Surface Plate Arrangement

- *If the MLE Plug assembly (8171) is not spliced to the power cable (8360), a splice (8374) will need to be completed before conducting next steps. Cut MLE (8171) to length. It is recommended to shorten the MLE leads as much as possible before splicing. If a replacement MLE is needed in the future, Flowserve will supply one in a standard length and any cable length that is lost due to the splice can be made up with the longer, standard length, replacement MLE.*
- *Install disconnect pothead penetrator into the surface plate at this time. This IOM will refer to the most common design for disconnect pothead penetrators.*
  Refer to job specific detail drawings for how this is done if it is of a non-standard design.
- *A series of o-rings or packing gaskets (4610) are installed over the top side of the disconnect pothead to seal to the surface discharge plate. If using packing gaskets, ensure they are staggered so that seams are not lined up in the packing area.*
- *A packing ring and packing gland plate (8371) are typically installed to compress the o-rings or packing gaskets.*
- *The surface discharge plate is now ready to be installed on the top column pipe (riser) piece*
- **Note:** *Tape or wire the well head gasket to the flange of the surface plate and take care not to damage it during the surface plate installation. This step will hold the gasket out of the way during the next steps*
- *Install wellhead surface plate to column pipe. Wellhead surface plates come in many different configurations but are usually threaded to the column pipe with a pipe coupling or bolted to the column pipe with a flange connection. If using a flange, ensure the gasket or o-ring is installed to seal the joint.*
- **Note:** *Installation of the flat cable plug to the pothead disconnect penetrator is performed the same as installing to the motor. See section 5.2.8 for details on this connection.*
- *Remove the pothead penetrator terminal shipping cap and place the cap with the other caps for storage. Remove protective caps from the MLE plug (8360). Check that penetrator terminals and the MLE plug (8171) and its connectors are clean and dry. Align MLE (8171) with disconnect pothead penetrator terminals and plug the MLE into position over the terminals. A slight wriggling motion may be required due to the tight fit. Push MLE plug all the way to the gland plate, then install and tighten the retaining lock washers (6541) and nuts (6581). Do not use bolts to force MLE plug (8171) on penetrator terminals. Install additional banding, if required, to secure cable and oil tube.*
- *Install oil line below surface plate. The oil line may need to be cut to length and a new tube fitting installed. In some cases, the oil line and cable may be wrapped around the column pipe to take up any slack.*
- *Remove any materials holding the wellhead casing gasket and install the well casing flange gasket that was attached to the surface plate. Lower the well casing surface plate and mount in place.*
- *Another oil line is needed to connect the surface plate oil line connection to the oil tank. To prevent possible gas locks, the oil line must be routed continually upward on a positive slope from the surface plate to the oil tank connection with no level areas or dips in the oil line.*

⚠	**⚠ CAUTION**
	Flowserve does not recommend installing a valve in the oil line due to the risk of a closed valve causing the motor seal failure. If a valve is installed, ensure proper procedures and labeling are used to prevent closure of the valve while the unit is installed and operating.

- *For initial startup of the motor, ensure the oil level in the tank is approximately halfway up the level sight gage. The oil tank pressure should be set at the value determined in the Oil Tank Pressure Setting Calculation Worksheet below (Table 5.2.12. The pressure relief valve should be set to ensure the motor maximum allowable pressure is not exceeded.*
- *Conduct insulation resistance test to confirm the motor, cable, and disconnect pothead penetrator are connected properly and sealed. The insulation resistance value should be 10 MΩ or better.*

5.2.12 Oil Tank Pressure Setting

Maintaining appropriate oil tank pressure is key to successful operation of the submersible motor which ensures there is no contamination of the motor oil. Too low oil pressure can cause ingress of contaminating fluid resulting in electrical failure and/or bearing failure. Too high pressure can cause mechanical failure of the motor pressure barrier causing mechanical failure

Calculations are provided here for both types of arrangements with the following exceptions:

1. When fluid temperatures are expected to be below 60°F (15.6°C)
2. When oil line length at surface is more than 10 ft (3 m) and is not heat traced
3. When the application setting depth elevation of submersible pump is greater than 700 feet (213 m) from the oil pressure tank elevation
4. When the motor size is larger than 17"
5. Any other conditions where the minimum pressure of the motor cannot be maintained above 25 PSI (1.7 bar)
6. Any other conditions where the maximum pressure of the motor can be exceeded (see chart below)

In the case where one or more of these applications apply, consult your Flowserve representative for oil tank pressure setting recommendations and other applications engineering advice. In all cases where the user is uncertain of these calculations, consult your Flowserve representative for applications engineering assistance.

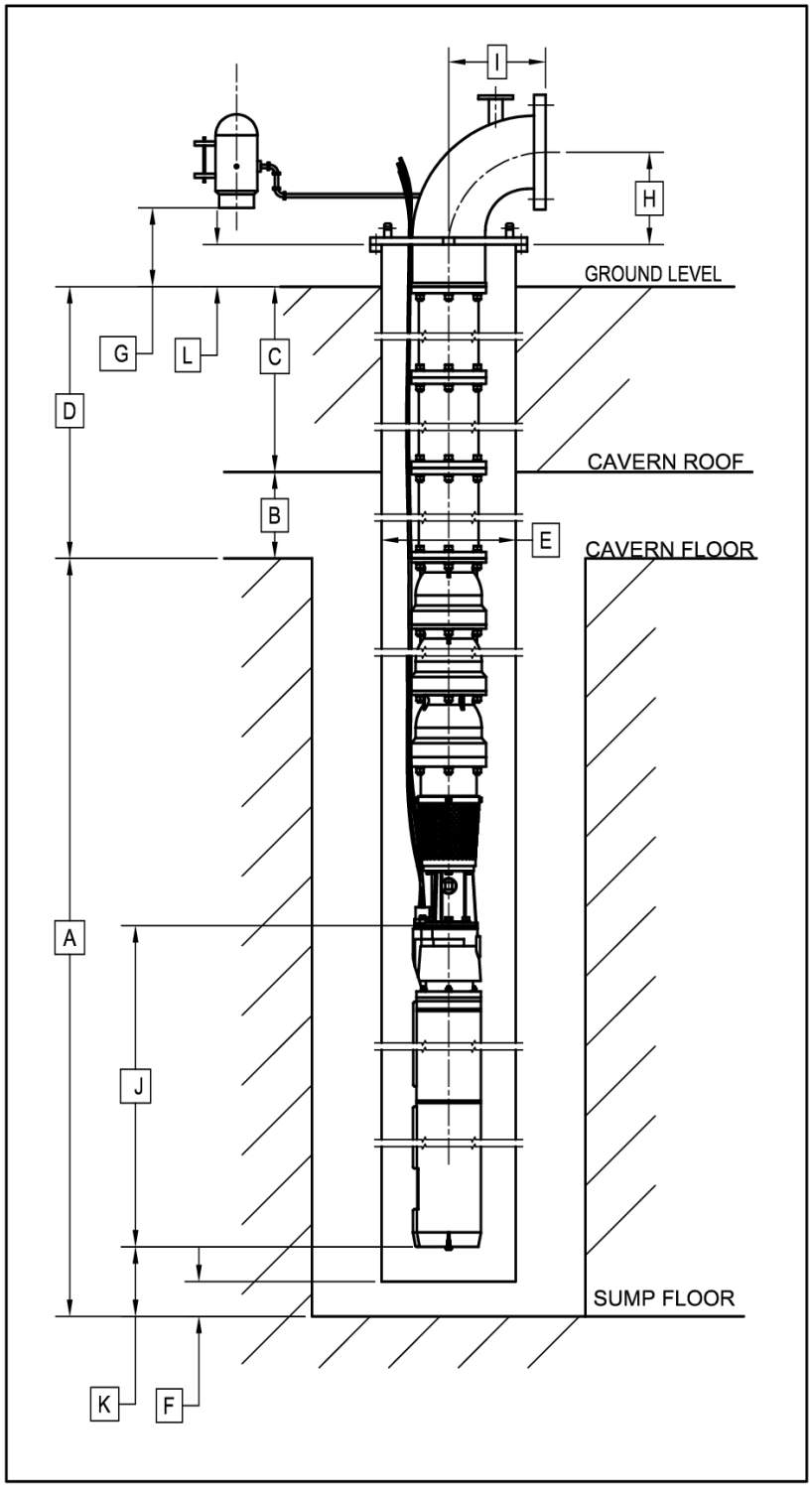


Fig 5.2.12. Typical General Arrangement Drawing of Cavern

Table 5.2.12a Oil Tank Pressure Setting Calculation Datasheet for Vertically Oriented applications such as caverns and vertical wells

Inputs	US Units	Metric Units	
Submersible Motor Length (top flange to bottom) J	ft	m	See specific GA Drawing or use chart below if no GA drawing is provided
Submersible Motor Maximum Design Pressure Pm	PSI	bar	See specific GA Drawing or use chart below if no GA drawing is provided
Depth of cavern or well A+D	ft	m	Note 1
Distance from bottom of sump to bottom of motor K	ft	m	Note 2
Distance from oil tank bottom to surface G	ft	m	
Cavern vapor pressure Pc	PSI	bar	Note 3
Maximum allowable working pressure of oil tank Pt	PSI	bar	Note 4
Motor oil Specific Gravity SG			Note 5

Note 1: Depth of cavern should be from surface level to bottom of sump. Depth of well should be to bottom of motor

Note 2: For caverns, this distance is typically the same as the distance from the caisson bottom to the sump bottom, typically 1 ft in North America. For installations in wells without sumps, assume this value is 0.

Note 3: For water applications, vapor pressure can be considered 0 psi (0 bar)

Note 4: MAWP for the oil tank is typically the setting of the pressure relief valve (often 150 PSI in North America)

Note 5: Byron Jackson 100 SSU oil SG = 0.88, 300 SSU oil SG = .84

Table 5.2.12.b Oil Tank Pressure Setting Calculation Worksheet for Vertically Oriented applications such as caverns and vertical wells

Outputs	*US units*	*Metric units*	
Distance from oil tank to motor *SD = Setting Depth*	*ft*	*m*	*A + D + G – K – J*
Internal Motor pressure without tank pressure *Pmc*	*PSI*	*bar*	*SD x SG / 2.31 US units* *SD x SG/10.2 metric units*
Internal Motor Differential Pressure without Oil Tank Pressure *Pdmc*	*PSI*	*bar*	*Pmc-Pc*
Tank Oil Pressure *Pt*	*PSI*	*bar*	*Adjust Pt so that Pd falls between Pd minimum and Pd maximum*
Internal Motor Differential Pressure with Oil Tank Pressure *Pd*	*PSI*	*bar*	*Pdmc + Pt*
Pd minimum *Same for all motors unless Applications Engineering provides a different number*	*50 PSI*	*3.45 bar*	*Confirm the calculated Pd is greater than or equal to Pd minimum*
Pd maximum *See Table XX*	*PSI*	*bar*	*Confirm the calculated Pd is less than or equal to Pd maximum*

Table 5.2.12c Standard Cavern Motor Lengths

Motor Frame and Horsepower (standard motors only)	*Motor Length (J)*		*Motor Maximum Design Pressure*	
	feet	*meters*	*PSI*	*Bar*
8", 30 HP, 460 V, 2-pole	*6.1*	*1.86*	*150*	*10.3*
8", 50 HP, 460 V, 2-pole	*6.9*	*2.10*	*150*	*10.3*
10", 75 Hp, 460 V, 2-pole	*5.1*	*1.55*	*150*	*10.3*
10", 100 Hp, 460 V, 2-pole	*5.8*	*1.77*	*150*	*10.3*
12", 150 Hp, 460 V, 2-pole (motors built before S/N 12- *-1)*	*5.4*	*1.65*	*200*	*13.8*
12", 200 or 250 Hp, 460 V or 2300 V, 2-pole (motors built starting with S/N 12-5466-1)	*6.7*	*2.04*	*320*	*22.1*
12", 200 Hp, 460 V, 2-pole (motors built before S/N 12-5466-1)	*6.1*	*1.86*	*150*	*10.3*
16", 400HP, 2300V, 2-pole (Old style - pre 1987)	*7.5*	*2.29*	*320*	*22.1*
17", 400HP, 2300V, 2-pole (New style - 1987 and later)	*7.5*	*2.29*	*320*	*22.1*

Confirm all lengths since some motors may have customer engineered lengths for a specific application. These custom length motors include motors with heat exchangers. For motors not listed, please check with your Flowserve representative to confirm Lengths and Maximum Design Pressure.

5.2.13 Connecting Discharge Piping and Electrical Equipment

This section provides general guidelines. These directions may need to be adjusted for location specific requirements.

Connect the system piping to pump discharge flange. Be certain pipe and pump flanges and cavities are clean before connecting piping. Flange faces must meet parallel and flush; do not force into alignment. Use pipe of ample size having a minimum of bends and fittings.

The pumping unit is now ready for connection to the power supply.

⚠	**⚠ CAUTION** *Work in this area involves electrical hazards and may also pose explosive hazards if working in locations with flammable vapors. Refer to section 2 for details regarding these hazards*

Connect terminal box to main power supply

NOTE Starting equipment for the pump/motor system is typically furnished by the customer.

1. Ensure that the rating of the equipment that is used conforms to the local code and regulatory requirements for high reactance squirrel cage motors. Make certain that the controller main contacts are in good condition and are working properly. Also confirm the overload relays are for the correct full load current.
2. To ensure that the controller is operated safely, verify that the controller housing is properly grounded to a ground rod and electrically bonded to the surface plate assembly.
3. Check the no-load voltage at the starter between all three phases. The voltage values must be equal and must be approximately 3-10% higher than the motor nameplate voltage rating.
4. Perform insulation resistance test.
5. Insulation resistance must be at least 10 MΩ.
6. Perform electrical continuity test.
7. Install the cable in the controller junction box with appropriate cable glands and seals as required for the local application and local regulations.
8. Ensure that the starter cannot be activated accidentally.

The pumping unit is now ready to be started.

6 Commissioning

6.1 Safety instructions

NOTE Before commissioning, operation or shutdown of the pumping unit, read Chapter 2 "Safety Information"

⚠	**⚠ CAUTION**
	These operations must be carried out by fully qualified personnel. Turn off power supply for safety while any work on the electrical equipment is being conducted

⚠	**⚠ DANGER**
	If the area was designated a hazardous location, refer to applicable safety procedures for safe handling of tools, equipment, and test instruments. The pumping unit may only be operated: • *By trained and certified or qualified personnel,* • *In a completely assembled condition* • *Completely filled and immersed in liquid.* • *With proper oil tank pressure as outlined above*

6.2 General notes

Due to the slender design of the submersible motors, unequal current values can be measured in the individual phases. This is especially true for two-pole motors. These differences can be reinforced by voltage differences between the phases already present from the line side.

This effect of unbalance supply voltage may often be reduced to a minimum by transposing all of the phase connections. Remember that transposing just two phases will cause the unit to operate in reverse rotation.

6.3 Connection to starter/controller

⚠	**⚠ CAUTION**
	The work conducted here can present electrical hazards and risks. Refer to the starter/controller IOM for specific details. Instructions here are offered as general guidelines and should neither take precedence over starter/controller instructions nor local regulations.

Prior to connecting the cable to the panel, the cable and motor insulation resistance should be checked and be at least 10 MΩ.

Connection to the starter/controller should be handled by a qualified electrician and by following the directions in the manual for the starter/control panel. Local electrical codes and regulations should be followed.

6.4 Electrical Requirements

The Byron Jackson submersible motor is designed for across the line starting, eliminating the need for reduced voltage starting equipment. Because starting the motor at full voltage results in high starting torque, the motor accelerates to operating speed very rapidly (within 0.8 seconds, typically), and current consumption correspondingly drops to normal range. The rated power requirements of the motor are stated on the pump nameplate located on the surface plate. The motor will operate satisfactorily (although not necessarily at guaranteed performance levels) at rated load provided:

- *The frequency is not more than 5% above or below rated frequency.*
- *Voltage is not more than 10% above or below rated voltage.*

Low voltage is a serious problem since the operating motor current is increased, resulting in additional motor heating. However, the motor is designed to operate continuously at 110% of rated current, so some reduction in voltage can be tolerated so long as it is not also accompanied by an overload of the motor. To maximize motor life, voltage should be maintained as close to motor rated voltage as possible.

Some models are also capable of being operated on a variable frequency drive. Rated or full load current refers to the amperage drawn by the motor at nameplate horsepower output, frequency

and voltage at the motor terminals. The maximum allowable current (except momentarily at start-up) is 110% of the rated value. See section 3.5 for more details about the electrical controls.

The voltage on all three phases should be evenly balanced as closely as possible since the current unbalance can be on the order of magnitude of 6 to 10 times the voltage unbalance. Running the motor with unbalanced voltage will lead to increased temperature and decreased motor life, and therefore must be avoided.

If the power is derived from an engine-driven generator, poor voltage regulation is possible and can be very detrimental to the motor. For this reason, Flowserve assumes no responsibility for units operated on such equipment unless otherwise agreed upon in writing.

6.5 Starting the pump

6.5.1 Pre-starting checks

Before starting the Pump, the following checks should be made.

1. Check that all piping connections are in place and tight.
2. Check all bolting connections for tightness
3. Confirm all electrical connections are good.
4. Check oil tank pressure
5. Check that oil level in reservoir is approximately one-half of the way up the level sight gage and that reservoir is pressurized as outlined in section 5.2.12
6. Prior to connection to starter, measure insulation resistance (leads-to-ground) with power turned off and motor turned off to ascertain that no short circuits are present.

⚠	**⚠ CAUTION** *Do not attempt to start the pumping unit with an insulation resistance reading of less than 10 MΩ*

⚠	**⚠ CAUTION** *Never attempt to run the pumping unit with an unbalanced voltage between two leads. An imbalance between two leads can cause 6-10 times that amount of imbalance in an amperage and the resultant temperature increase means a decrease in motor life. Any voltage imbalance more than 1% requires the motor be derated as specified in NEMA MG1.*

⚠	**⚠ CAUTION** *An improperly sized engine driven generator can be very detrimental. Ensure proper sizing is achieved by consulting with the generator supplier. The generator supplier should select the generator based on the operating characteristics of a submersible motor which may not match the operating characteristics of a similarly sized surface motor.*

6.5.2 First-time start-up of the pump

1. Ensure all downstream equipment is ready to receive fluid.
2. Confirm incoming voltage is correct. Do not attempt to start the motor if the voltage is less than 95% of nameplate.
3. For motor pumping units working with inverters (also known as Variable speed drive (VSD), Variable Frequency Drive (VFD), Adjustable Speed Drive (ASD), or Adjustable Frequency Drive (AFD)), care must be taken to ensure proper set up and limits are established

    a. A constant ratio of V/Hz must be maintained (7.67 for 460 V, 60 Hz and 380 V, 50 Hz motors)
    b. Motor should be ramped up to at least 30 Hz within 3 sec
    c. Dynamic braking options on the inverter should be disabled
    d. Refer to section 3.5 for details about controls

Operational Limits

- *NOTE: Never let the submersible motor pump run dry.*
- *Starting, including for test purposes, is never allowed if the pump is not submerged.*
- *For the minimum setting depth in the product, refer to the Section 12 "Technical Data" or check with your Flowserve representative. The motor lead extension (MLE) including the splice should always be submerged in liquid.*

⚠	**⚠ CAUTION**
	Operation with a flow rate that is above rated flows can cause motor overload and cavitation in the pump. Low flow rates can cause shortened service life of the pump, overheating of the pump and motor, instability, cavitation, and vibration.

- *The duty point for which the pump unit has been designed can be found in Section 12 "Technical Data"*
- *To avoid overheating the motor, a pump must never be operated for more than 1 minute against a closed discharge valve.*
    a) Depending on your pump type, as the empty piping is being filled, the ammeter may show a higher current than in the data sheet even after the starting current has decayed during the initial start. This higher current may be due to high flow in the pump. If this condition continues after all piping is full, then the control valve may need to be adjusted to a flow rate that will not overload the motor.
    b) In cavern installations, the dewatering phase may require choking the flow back to limit current and prevent overloading the motor.
    c) Excessive flow can cause motor overload and, in certain applications, excessive production of sand from the well. These conditions could cause premature wear on a submersible pump and motor unit.
- *After the unit has operated for a period, it is possible that a minimal readjustment of the control valve and motor controller may be required, due to changing operating conditions, for example by the drawdown of the fluid level.*

⚠	**⚠ CAUTION** Motor protection settings that do not follow these guidelines could cause unsafe conditions or premature failure of submersible equipment. Please note, data sheet may have been supplied with quote or may be shipped with equipment. If required, consult your Flowserve representative for setting these limitations.

Table 6.4.1 Control Settings

Control setting	*Minimum*	*Maximum*
Flow rate	*See data sheet minimum continuous flow*	*See data sheet maximum flow on curve*
Voltage	*See data sheet*	*See data sheet*
Voltage Imbalance		*See 5.2.4*
Current	*Typically set 10% below minimum load current*	*Typically set at no more than full load current X SF. Prefer setting at 10% over normal operating current. Remember that during a cavern dewatering phase, flow control may be required to limit current without going below the pump minimum continuous stable flow point.*
Current Imbalance		*10%*
Starts/hour		*See 7.1.4 Recommend minimum possible*

1. Partially close the pump discharge valve.
2. Start the motor and record the current after the starting current has dropped

⚠	**⚠ CAUTION** *Do not run the Pump for more than 1 minute with discharge valve closed*

When the direction of rotation is incorrect, the pump will have no production or extremely reduced production.

⚠	**⚠ CAUTION** The unit must not be operated for longer than three minutes in the reverse direction. In the case of operating in the wrong direction • *press STOP and de-energize the equipment* • *turn off all power and confirm power is not being delivered to the cable junction box or terminals* • *exchange the motor power cable leads from two phases with one another in the control panel.* • *Mark the leads so that they can always be placed correctly any time they are removed.*

3. Restart the motor as in part 2 above.
4. After verifying proper rotation, open the discharge valve to the desired flow rate without exceeding the motor full load current

⚠	**⚠ CAUTION** *If a circuit breaker or overload control trips, always correct the issue causing the trip prior to restart. Wait at least 10 minutes before restarting*

During first-time start-up, take notice of the following:

a) When motor is started, it should attain full speed within 3 seconds. If after this period the line current is still high (over twice normal value), the pumping unit is not attaining the full speed and the unit should be shut down and action should be taken to correct this issue.

⚠	**⚠ CAUTION** *In the event the pumping unit does not attain the full speed, stop the pumping unit and do not attempt to restart it until the trouble is found and corrected.*

During normal operation, the current must not exceed the motor name plate value.

5. Measure the line voltage between phases while the pumping unit is pumping. The readings obtained should not be more than 10 % above or below the rated motor voltage.
6. In case of malfunction, stop the pumping unit and refer to Section 9 "Trouble shooting Guide".

7 Operation

7.1 Normal Operation

7.1.1 Normal start-up of the pump

⚠	**⚠ CAUTION**
	If maintenance has been performed, follow Section 6.5.2 "First-time start-up of the pump".

1. Verify that the control panel door is closed.
2. Verify that balanced three-phase voltage is supplied

⚠	**⚠ CAUTION**
	Never attempt to run the pumping unit with an unbalanced voltage between two leads.

3. Start the pumping unit.
4. Verify that the pump motor comes up to speed within 3 seconds as indicated by normal readings of current, voltage, head and flow.
5. If one of the following conditions occurs

   a) current exceeds the rated value of the amperage or

   b) voltage varies +/-10 % from the rated value or

   c) head and flow are abnormal

   then stop the pumping unit and refer to Chapter 9 "Trouble shoot Guide"

Submersible pumps serve to transport fluid under the operating conditions described in the following:

7.1.2 Normal operating conditions

a) No sand or abrasives. If sand and other abrasives are present, they can damage the pump and motor components and steps may be required to eliminate or reduce the abrasives in the fluid
b) Fluid velocity along motor surface must be maintained at 1 ft/sec (0.3 m/sec) or more
c) No impurities that could lead to deposits and blockages within the pump or to deposits on the motor surface
d) Maximum 1-minute operation against closed discharge control valve.
e) Operation within prescribed voltage tolerances, Section 3.5 Controls
f) Permissible operational range: unless otherwise stated, 50 to 120 % of the best efficiency point (BEP)
g) Correctly selected and adjusted motor protection
h) Observation of the maximum permissible number of starts per hour as specified in Section 7.1.4

⚠	**⚠ CAUTION** *At higher ambient temperatures and/or lower flow velocities on the external motor surfaces, or if there is risk of clogging, special measures for heat dissipation are required. This must be checked with the manufacturer for the suitability of the unit for its planned application*

- *Fluid level*

An application should always be provided with a means for determining the static fluid level, and pumping level if possible.

- *Sand and abrasives*

If the application produces sand or abrasives, this will affect the life of the pump and will also increase thrust as the pump is worn.

⚠	**⚠ CAUTION** *Continued sand pumping will result in increased pump wear which in turn will show up as increased efficiency loss. Too great a wear will ruin the pump beyond the repair stage and possibly have serious effects on the motor.*

Some installations will always produce a small amount of sand at start-up. Therefore, it may be necessary to bypass or trap out this first flow at each start-up, particularly if a closed piping system is used.

7.1.3 Motor operation

- *Always check the motor insulation resistance (megger) before resetting a tripped controller.*
- *Wait 10 minutes before restarting the motor. See section 7.1.4 for requirements for starting the pump and motor.*
- *Breaking suction due to inadequate fluid level at the pump suction can cause pump and motor damage and thus renders warranty void.*
- *Inadequate power supply can cause damage to the motor which renders warranty void.*
- *A time delay must be installed when any type of automatic system is used to prevent starting of the motor while it is spinning backwards due to riser pipe drain back through the pump. Even if a check valve is supplied, the timer delay may be necessary in case the check valve is prevented from fully functioning (for example due to debris or corrosion)*
- *A pumping unit should not be run at closed valve for more than 1 minute as all the energy supplied is then dissipated as heat. This condition can raise the water temperature to boiling and create an overheating problem for the motor.*
- *After the pumping unit has operated for a longer period of time, a minimal readjustment of the motor controller may be required due to changed operating conditions, e. g. lowering of the water level.*

If the pumping unit has shut-off and the reason cannot be traced to a positive external source:

a) Ensure power to the motor is turned off.

⚠	**⚠ CAUTION**
	Ensure power is safely disconnected and de-energized. Only qualified electrical personnel should conduct next steps.

b) Disconnect the motor from the main power supply.
c) Disconnect the power cable leads from the starter
d) Measure the insulation resistance of the power cable leads to the ground (the well casing). A low insulation resistance reading is an indicator of a damaged motor or cable.

⚠	**⚠ CAUTION**
	Never reset a breaker or replace a blown fuse and start a motor without first measuring the insulation resistance of the unit

7.1.4 Number of starts

- *The motor is capable of 2 consecutive starts from an initial cold start*
- *The motor is capable of 1 consecutive start from an initial hot start*
- *The allowable number of starts per hour is 6.*
- *Excessive starting of a submersible pumping unit can result in a shorter life and damage to the equipment. To protect the motor against non-permitted restart, use a timer relay or program the controller accordingly.*

7.2 Shut-down

- *To minimize water hammer the control valve must be closed before the unit will be switched off. After the valve has been closed the unit must be switched off within 1 minute.*
- *To stop the pump, follow the user instructions for the control panel.*
- *The pump should be started at least monthly and operated for at least 10 minutes to ensure free rotation of the pump and prevent sanding that might lock up the pump.*

⚠	**⚠ CAUTION**
	For prolonged shutdowns and especially when ambient temperatures are likely to drop below freezing point, the piping system must be drained or otherwise protected.

8 Maintenance

8.1 Schedule

Submersible pump units normally run without needing maintenance.

If a pump unit is installed but in standby in the installation for a lengthy period of time, perform a 10-minute test run every month, so that potential malfunctions can be recognized in time.

⚠	**⚠ CAUTION**
	The pump unit must be completely submersed in pumping medium for this test run

8.2 Monitoring requirements

As the units are normally used at very great depths, it is recommended that the following checks are performed and recorded at regular intervals, in order to recognize malfunctions in a timely manner:

- *Motor current*
- *System voltage*
- *Oil Level in oil reservoir*
- *Amount of oil added to reservoir*
- *Dielectric value of any oil added to motor*
- *Head/Pressure at surface*
- *Flow*
- *Operating hours*
- *Insulation resistance test*
- *Temperature (only if temperature sensors PT100 [RTD] exist)*
- *Time and date of readings*

Oil level and Motor current plus Head/Pressure or Flow are the most important parameters to be monitored. By tracking these parameters over time, the operator is able to ascertain if there is a deterioration in the equipment or other changes in the process that may need to be corrected. The best way to do this is to plot the parameters on a graph vs. time and analyze the data for sudden unexplained changes which can often be indicative of a change in the equipment condition.

For Troubleshooting, see Section 9.

8.3 Special tools

Standard mechanics tools are used for installing the pump and motor. An insulation resistance meter can be purchased or borrowed from your local electrical supplier or your pump installation contractor.

8.4 Required replacement parts for maintenance

The only component that may need replacement during the operating life of your equipment is the motor oil. It is recommended to source your oil from Flowserve or an authorized representative. Due to the critical functions that the motor oil provides, it is not possible for Flowserve to qualify and approve oils from other suppliers. The oil should have a dielectric breakdown voltage level of at least

25 kV when poured into the reservoir. This dielectric breakdown level can be checked by those familiar with checking transformer oils.

⚠	**⚠ CAUTION**
	Do not perform oil breakdown voltage test in hazardous or ATEX locations

Depending on the type of MLE supplied, Flowserve may recommend replacement every time the equipment is removed from service. Specifically, the MLE in section A of 5.2.8 is a type of MLE requiring replacement if removed from service. The replacement of the MLE is recommended as a more economical choice based on the cost of the MLE and the risk and cost of failure and the installation and removal costs incurred plus lost production if the used MLE fails.

8.5 Disassembly and Reassembly

The structural design of a submersible pump unit makes assembly and disassembly possible using simple tools. It is recommended when the unit is removed from service that the unit is inspected by Flowserve technicians and is overhauled at a Flowserve authorized service center.

When taking the unit out of service and before starting removal work, reviewing the IOM once again is strongly recommended.

For additional product information or for purchasing replacement parts, the following information is required:

- *Serial number of the unit from the nameplate (also printed on the stator housing)*
- *Description of the unit type according to the nameplate (size, power, voltage, speed)*

For questions regarding replacement parts:

- *item number from the sectional drawing part description and number as shown in the parts list*
- *quantity of parts required*

For technical support and trouble shooting:

- *short description of the problem and/or the effects*
- *description of the faulty part(s) as shown in the parts list*

Please refer all questions directly to the main factory or to a factory representative.

8.6 Spare parts stocking recommendation

At a minimum, motor oil should be stocked and used to maintain the motor as needed. Since the motor uses a mechanical seal, some oil leakage is expected.

Please note, the motor oil has a shelf life and improper storage

Other spares can be provided as subcomponents (shaft, impellers, wear rings, bearings, gaskets, etc.), subassemblies (stator, rotor) or complete assemblies (pump, motor)

Spare parts are most economically purchased at the same time as purchasing the new equipment. While Flowserve may stock many spare parts, please consider that often there are special castings, fabrications, etc. that may have long lead times. If a pump is considered for a critical function, Flowserve encourages operators to consider the need for spares analytically and make appropriate plans.

8.7 Oil storage recommendation

Lubricant inventory levels should be set so that lubricants are used within 12 months. Set inventory levels to stay within targets. If limits are reached, verify quality of product with professional oil analysis.

- *Make sure of the appropriate environment for storing lubricants.*
- *Estimating quarterly, semiannual or annual volume usage requirements will be helpful.*
- *Usage and storage methods should be "first in, first out" in your inventory system.*
- *Storage life limits varies for various lubricants in various storage environments.*
- *Labeling requirements, including blending and packaging date, delivery date, and the date*
- *the lubricant was put into service by opening the container.*
- *Testing the condition of expired lubricants or those that have been compromised in storage.*
- *Testing should include confirmation of dielectric strength of at least 25 kV.*
- *Oil should be stored in a protected area; out of sun, rain, snow; away from extremes in heat and cold.*
- *Best practice is to store all lubricants indoors in a cool, clean and dry environment in the original sealed container.*
- *To get the best performance, make sure there is an accurate inventory rotation program. This also provides guidelines for determining age of the product*

9 Trouble Shooting

Potential issues with pump production are often caused by factors external to the pump and motor unit itself. The following guide is intended to cover many common factors, both internal and external. An experienced pump installer, operator, or factory representative may need to be consulted to determine the root cause of any issue not outlined below.

Pump is operating but no water or limited water is produced

The control valve or other valving is closed or partially closed	Open the valve
Motor is operating in the wrong direction	Exchange two phases of the power cable
The water level in the well is too shallow	Increase installation depth. Close the valve to decrease flow and prevent the water level from dropping as quickly.
Incorrectly selected pump	Replace with appropriately sized pump
Leakage in the riser tubing or discharge piping	Repair/replace as needed
The intake strainer if blocked with debris	Remove pump and clean the strainer
Pump or check valve passages are blocked	Remove pump and correct the issue
Motor is turning at a slower speed	Ensure proper voltage is being applied during operation
Pump shaft or coupling is damaged/broken	Remove pump and repair/replace
Pump is worn out	Repair/replace as needed

Pump discharge pressure is low

The water level in the well is too shallow	Increase the installation depth. Close the valve to decrease flow and prevent the water level from dropping as quickly.
Pressure switch is malfunctioning or incorrectly set	Verify pressure switch functionality
Leakage in the riser tubing or discharge piping	Repair/replace as needed
Pump is worn out	Repair/replace as needed
Pump or check valve passages are blocked	Remove pump and correct the issue

Pump flow rate is low

Motor is turning the incorrect direction	Exchange two phases of the power cable as directed in section 6.5.2
Flow line or intake is plugged	Correct as needed. This may require pulling the pump
Inadequate NPSH is available	Lower pump to be deeper in the caisson or choke control valve to a lower flow rate where NPSHR of the pump is less than the NPSHA.

Voltage varies more than +/-10% from nameplate

Power supply does not meet requirements	Adjust transformer taps to obtain correct voltage Adjust inverter controller to output correct voltage

Motor Current is high or varies rapidly

Supply voltage is too low	Adjust transformer taps to obtain correct voltage Adjust inverter controller to output correct voltage
Pump is being operated on location of curve that causes overload (usually high flow rates)	Choke control valve to reduce load on motor. If using inverter, reduce speed to reduce load
Current is varying rapidly due to mechanical issues	Often a sign of mechanical issues in pump. May require pump/motor to be pulled and inspected.
Current is varying rapidly due to inadequate NPSH available.	Lower the pump deeper in the caisson or choke control valve to a lower flow rate where NPSHR of the pump is less than the NPSHA.

Motor Temperature is high

Motor is overloaded	Shut the unit down and troubleshoot to find the cause
Pump or Motor is Locked	Remove pump and correct the issue Repair/replace as needed
Control settings are set incorrectly	Verify and correct as needed
Motor is operating on two phases	Check controls, fusing, and cable connections

Frequent Starts and Stops

Settings for level controls are too close to one another	Modify to ensure starting/stopping is limited as required
Pump is oversized for application	Change pump to one with smaller flow rate or close valve to reduce flow rate (while ensuring adequate flow past motor for cooling).

Pump Operates Noisily and/or Vibration

Pump or piping is partially or completely blocked	Diagnose and correct
Excessive air or gas in water	Pump intake is too high. Install pump more deeply in the caisson.
Pump or Motor bearings are damaged	Remove and repair/replace pump/motor
Incorrectly selected pump	Replace with appropriately sized pump
Piping flanges/joints are not installed properly	Diagnose and correct
Pump is operating outside it's flow range limits	Adjust control valve to ensure flow rate is within the pump's operating design range

Pump Does not Operate

No power being supplied	Correct electrical issues with controller and/or power supply
Fuses are blown or breaker is tripped	Diagnose the cause for the trip. Ensure motor has good insulation resistance. Replace fuses/ reset breaker only after cause is found and corrected
The control has tripped due to low water level	Confirm the water level and do not start pump until water level is raised. Consider moving pump intake deeper to ensure adequate water supply.
Motor or cable has short circuited	Check insulation resistance and pull unit if too low.

Note: In the event the pump or motor needs to be repaired, spare parts should be ordered from Flowserve. Use of non-Flowserve parts could result in numerous operational risks and non-compliance with safety and performance requirements all of which could void warranty.

10 Decommissioning and Recommissioning

10.1 Decommissioning

If a unit is pulled from service, Flowserve recommends the following:

- *The unit should be removed from service in the reverse order of installation*
- *The pump should be inspected for wear, corrosion, and freedom of rotation. If there are any questions about the pump condition, it should be disassembled, inspected, and repaired as needed*
- *The motor should be inspected for external corrosion.*
- *The shaft should be rotated, and the rotor should spin freely once you are able to break it free and begin the rotation.*
- *Remove motor half-coupling (7000) or motor one-piece coupling (7010).*
- *Place coupling and components in motor shipping cap (6562.1) and reinstall on motor top case*
- *Reinstall motor terminal cap (6562) with its power terminal gasket (4590.1) or o-ring and bolt cap securely in place.*
- *Elevate motor over a sump or drum to drain oil and water from motor.*
- *Drain the motor before laying it horizontal. Oil samples should be retained for analysis if the motor condition is questionable.*
- *Remove lower casing drain plug from bottom of motor, then remove vent plug (6578) at top of motor and allow motor to fully drain.*
- *Replace drain and vent plug.*
- *An insulation resistance measurement should be taken to confirm the motor is in good electrical condition.*
- *If the motor is to be stored for future use, fresh motor oil should be installed.*

Note: These steps are needed to ensure that any water or product in the motor does not contaminate the electrical components which are not water proof and the rotating elements which may corrode when exposed to water.

10.2 Recommissioning

Recommissioning should follow the instructions outlined in Section 5.

11 Returns and Disposal

11.1 Returns

Contact your nearest Flowserve office or representative for instructions to return a piece of equipment.

11.2 Disposal and recycling

Motor oil should be disposed of according to the local rules and regulations similar to any other oils such as those used in transformer. No PCB's are used in Byron Jackson motor oils supplied by Flowserve. Other components can be recycled according to the normal recycling processes used for metal components.

Make sure that hazardous substances are disposed of safely and that the correct personal protective equipment is used. The safety specifications must be in accordance with the current regulations at all times.

12 Technical Data

Refer to the order specific document supplied

13 ANNEXES

Annex A: Declaration of Conformity

Annex B: Parts and Accessories List

Annex C: Technical Terms, Acronyms, and Abbreviations

Annex D: Additional Sources of Information

Annex E: Supplementary User Instructions

(Byron Jackson Single Mechanical Seal Submersible) User Instruction

Flowserve factory contacts:

Flowserve Taneytown:
5310 Taneytown Pike
Taneytown, MD 21787
Telephone: +1 (410) 756-2602

FLOWSERVE REGIONAL SALES OFFICES:

USA and Canada
Flowserve Corporation
5215 North O'Connor Blvd.,
Suite 2300
Irving, Texas 75039-5421, USA
Telephone +1 972 443 6500
Fax +1 972 443 6800

Europe, Middle East, Africa
Flowserve Worthington S.r.l.
Via Rossini 90/92
20033 Desio (Milan), Italy
Telephone +39 0362 6121
Fax +39 0362 303 396

Latin America and Caribbean
Flowserve Corporation
6840 Wynnwood Lane
Houston, Texas 77008, USA
Telephone +1 713 803 4434
Fax +1 713 803 4497

Asia Pacific
Flowserve Pte. Ltd
10 Tuas Loop
Singapore 637345
Telephone +65 6771 0600
Fax +65 6862 2329

Local Flowserve representative:

To find your local Flowserve representative use the Sales Support Locator System found at www.flowserve.com