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# SURFACE PUMPING SYSTEM (SPS™) USER INSTRUCTIONS—INSTALLATION, OPERATION, AND MAINTENANCE

## 1 Introduction

GE Oil & Gas strives to improve performance and exceed customer expectations and has adopted the ISO 9001 quality assurance standard. The most recent revision (2008) continues to emphasize on process management and a structured approach to continuous improvement, an interpretation we have actively embraced. Increasing attention is being paid to the alignment of quality systems with those of health and safety, and environmental management. These issues are related by similarly structured international standards, which allow the development of integrated systems and focus delivering quantifiable results that add value to our clients and our businesses.

Depending on the final destination, GE Oil & Gas Surface Pumping Systems are required to conform to applicable regulatory standards including:

- Machinery Directive
- Pressure Equipment Directive
- Low Voltage Directive
- Electromagnetic Compatibility (EMC) Directive.

Important safety aspects referenced in the Essential Safety Requirements are outlined in the directives listed above. Where applicable, this document includes information relevant to these European Directives.



**Table 1: General Specifications**

Shipping Weight:	
Unit Dimensions:	
Model and Type:	
Voltage:	
Amperage:	

**Table 1: General Specifications (cont'd.)**

Function:	
Year of Construction:	

**Table 2: Manufacturing and Contact Information**

Manufactured by:	Contact for Service:
GE Oil & Gas ESP, Inc. 5500 SE 59th Street Oklahoma City, OK 73135	GE Oil & Gas 5500 SE 59th Street Oklahoma City, OK 73135 +1 405 671 2228 +1 800 723 3771

## 2 General Safety

### 2.1 SPS™ General Safety Instructions



#### • CAUTION

- Do not attempt to install, operate, commission, decommission, or maintain this equipment until you have been trained on specific activities (i.e., commissioning, maintenance, etc.) and have read and understood all of the product safety information and directions contained in this manual.
- During any type of preventive or corrective maintenance, the unit should be locked out for safety. Safety should always come first and is non-negotiable.

### 2.1.1 Safety Alert Symbols



The safety alert symbol indicates a potential personal injury exists. These are located where moving parts, pinch points and/or electricity could be a potential danger.

### 2.1.2 Signal Words

Listed below are the signal words used throughout this manual, their descriptions and associated symbols.

When the words **DANGER**, **WARNING**, and **CAUTION** are used in this manual they will be followed by important safety information to which all personnel must adhere.

- The word “**DANGER**” preceded by the safety alert symbol indicates an imminently hazardous situation exists which, if not avoided, will result in death or serious injury to personnel.



- The word “**WARNING**” preceded by the safety alert symbol indicates a potentially hazardous situation exists which, if not avoided, could result in death or serious injury to personnel.



- The word “**CAUTION**” preceded by the safety alert symbol indicates a potentially hazardous situation exists, which if not avoided, may result in minor or moderate injury.



- The word “**CAUTION**” without the safety alert symbol indicates a potentially hazardous situation exists which, if not avoided, may result in equipment and or property damage.

**Important Notice:** There are several components that make up a Surface Pumping System. These components may vary by unit. The instructions contained in this manual are not intended to cover all details or variations in the equipment types, nor may it provide for every possible contingency concerning the installation, operation, or maintenance of this equipment. Please refer to the motor, drive, cooler, and seal support system manuals for further information and precautions concerning these components. Should additional information be required, please contact your GE Oil & Gas representative.

The contents of this manual should not become a part of, or modify, any prior or existing agreement, commitment, or relationship. The sales contract contains the entire obligation of GE Oil & Gas and its affiliates. The warranty contained in the contract between the parties is the sole warranty of GE Oil & Gas and any statements contained herein do not create new warranties or modify the existing warranty.

### • **WARNING**

- ***Any electrical or mechanical modifications to this equipment without written consent of GE Oil & Gas will void all warranties and may void any safety certifications that were issued with this equipment. Unauthorized modifications may also result in a safety hazard, equipment damage and/or personal injury.***
- ***Misuse of this equipment could result in injury and equipment damage. Under no circumstance will GE Oil & Gas be responsible or liable for either indirect or consequential damage or injury that may result from misuse of this equipment.***

## 2.2 Manual Purpose and Scope

This manual provides information on how to safely operate a Surface Pumping System (SPS™). Refer to the motor, drive, seal and any other specific component manual for further information and precautions. This manual includes a section of general safety instructions that describes the warning labels and symbols used throughout the manual. Read the manual completely before installing, operating, or performing maintenance on this equipment. This manual and the accompanying drawings should be considered a permanent part of the equipment and should be readily available for reference and review.

GE Oil & Gas reserves the right, without prior notice, to update information, make product changes, or to discontinue any product or service identified in this publication. SPS™ Surface Pumping Systems is a trademark of GE Oil & Gas ESP, Inc. All other product or trade references in this manual are registered trademarks of their respective owners.

### • **NOTE**

*Neither GE Oil & Gas ESP, Inc. nor any GE affiliate is liable for direct, indirect, special, or consequential damages resulting from the use of the information contained within this manual.*

### 2.2.1 Special Symbols

To identify special hazards, other symbols may appear in conjunction with DANGER, WARNING, and CAUTION signal words. These symbols indicate areas that require special and/or strict adherence to the procedures to prevent serious injury to personnel or death.

### 2.2.2 The Electrical Hazard Symbol

[Figure 1: Electrical Hazard, page 10](#) is a symbol which indicates a hazard of injury from electrical shock or burn. It is comprised of an equilateral triangle enclosing a lightning bolt.



**Figure 1: Electrical Hazard**

### 2.2.3 Earth Grounds

[Figure 2: Earth Grounds, page 10](#) is an example of the symbols for grounding points.



**Figure 2: Earth Grounds**

## 2.2.4 Equipment Warning Labels



There are some components in the SPS such as the thrust chamber that could be operating at temperatures above 70°C (158°F). As a way to reduce the chance of touching the hot surface, warning labels are attached to the equipment which remind the operators to wait until surfaces are cool before servicing the system.



Even though some SPS systems are designed with “low noise” equipment (e.g., motor, oil coolers, seal systems, etc.) and their assembly and installation procedures include alignment tasks to reduce vibration and noise levels, there is still some level of noise associated with the normal operation of the system. therefore it is always recommended to use hearing protection while the system is running in order to minimize noise hazards.



**Important Note:** A Lock-out tag must be employed prior to any service. Failure of the main control could allow and unexpected start under various scenarios including reenergize after power interruption. The use of Lock-out tags and E-stops will eliminate the potential of the operations control system failing under service mode. E-stops as well as control system guidelines are provided according to what is included in the scope of supply of the SPS system. Site Risk assessments must be completed prior to operation.



Entanglement and trapping hazards are present at the motor coupling area. A protective coupling guard has been designed to prevent access to these dangerous moving parts while the SPS system is running. Do not remove the coupling guard until the lock-out/tag-out procedures have been accomplished.



Do not attempt to install, operate, or perform maintenance to this equipment until you have read and understood all of the product labels ) and user directions contained in this manual. Labels attached to the equipment are there to provide useful information or to indicate an imminently hazardous situation that may result in serious injury, severe property and equipment damage, or death if the instructions are not followed.

## 3 Principles and Features

### 3.1 Principles of Operation

SPS™ pumps (see [Figure 3: SPS™ Pump Installation, page 13](#)) are versatile, low-maintenance, high-pressure pumping systems that provide an alternative to many multistage split-case (SC) centrifugal, positive displacement (PD) and vertical-turbine pump models. SPS™ pumps feature a quiet, low-vibration, environmentally friendly design adaptable for changing conditions. They can include an API 682 mechanical seal and API 610 flush/quench options if required. Multiple units can be combined in tandem for higher capacities and flexible operation. This energy-efficient pump is available with short delivery times and is well-suited to many surface industrial and mining applications, as well as traditional oilfield applications such as water and CO<sup>2</sup> injection.

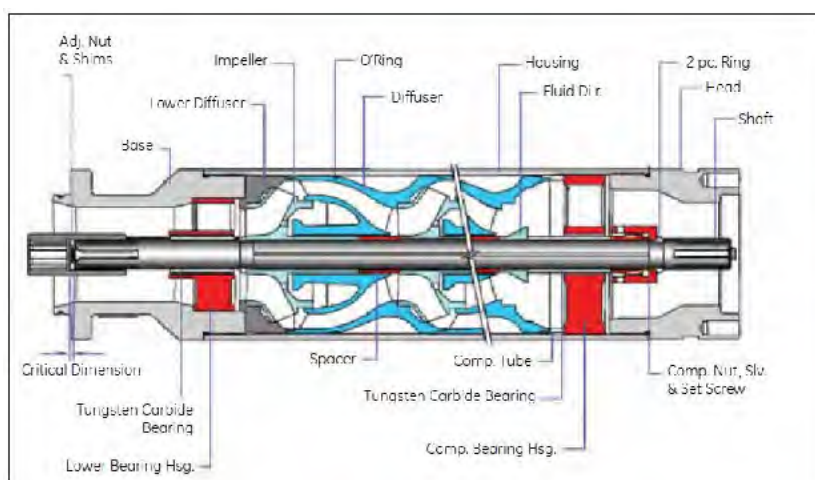


**Figure 3: SPS™ Pump Installation**

### 3.2 Exclusive Features

#### 3.2.1 Pump

Each pump is sized based on the customer's design specifications and operating parameters. The SPS™ pumping element ([Figure 4: SPS™ Pump Cutaway, page 13](#)) is a multistage centrifugal pump consisting of a rotating impeller on a keyed shaft and a stationary diffuser that can be stacked to meet performance requirements. Corrosion-resistant impellers and diffusers are cast from a high-nickel iron with destructive-resistant properties. GE Oil & Gas has a variety of coatings available to offer additional resistance if necessary. All pumps come standard with a 316 stainless steel head and base.



**Figure 4: SPS™ Pump Cutaway**

### 3.2.2 Motor

Motors ([Figure 5: SPS™ Electric Motor and Engine Drive, page 14](#)) are chosen based on customer's design specifications. Site conditions determine how the pump will be powered (i.e., electric drive—NEMA, electric drive—IEC, engine drive—gas, engine drive—diesel, etc.).



**Figure 5: SPS™ Electric Motor and Engine Drive**

### 3.2.3 Drives

The system's power requirements and customer preference determine what size and type of drive will be used, if one is required (i.e., GE Vector Plus™, Apollo Intelligent Control™, medium voltage Toshiba, ABB, or Siemens VSD). [Figure 6: GE Vector Plus™ VSD, page 15](#) is an illustration of a typical GE Vector® VSD



**Figure 6: GE Vector Plus™ VSD**

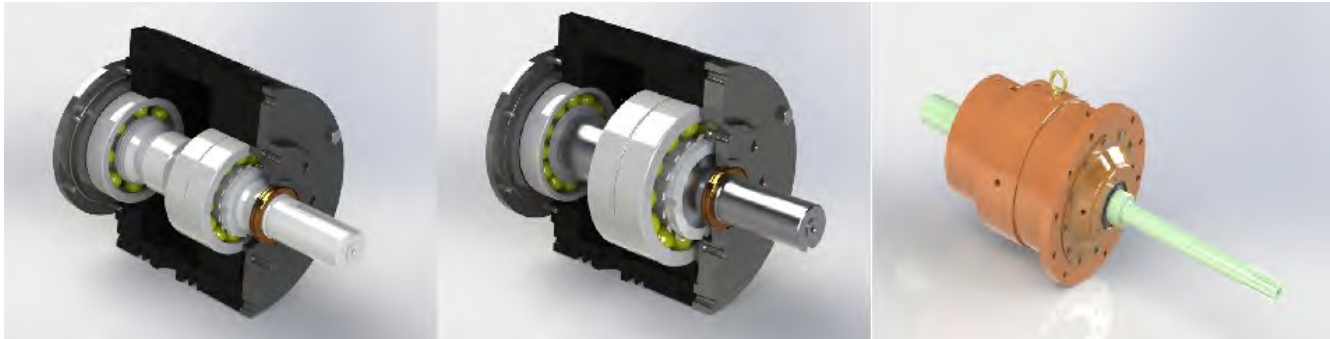
### **3.2.4 Seals/Seal Support Systems**

The type of seal employed depends on design specifications, operating parameters and customer preference. Several different seals can be used (i.e., component, single-balanced mechanical, cartridge, double-balanced mechanical, double cartridge, and tandem).

The seal support system used depends on the design specifications and seal type used. There are a variety of API 682 seal flush plans available with or without a seal reservoir/pot (e.g., single-balanced mechanical—no flush, standard flush system, tandem—API Plan 52 seal support system, double-balanced mechanical—API Plan 53 seal support system, etc.).

### **3.2.5 Thrust Chamber**

The type of Thrust Chamber (TC) selected depends on the amount of thrust generated by the pump for the given application. Currently there are three TC options available: a Standard-Duty (SDTC), a Heavy-Duty (HDTC), and an Extreme-Duty (XDTC) ([Figure 7: SPS™ Thrust Chambers \(SDTC, HDTC, and XDTC Left to Right Respectively\), page 16](#)). GE Oil & Gas also has forced lubrication cooler systems available to use in conjunction with the HDTC and XDTC options. These are powered by a small horsepower Total Enclosed Fan Cooled (TEFC) motor.

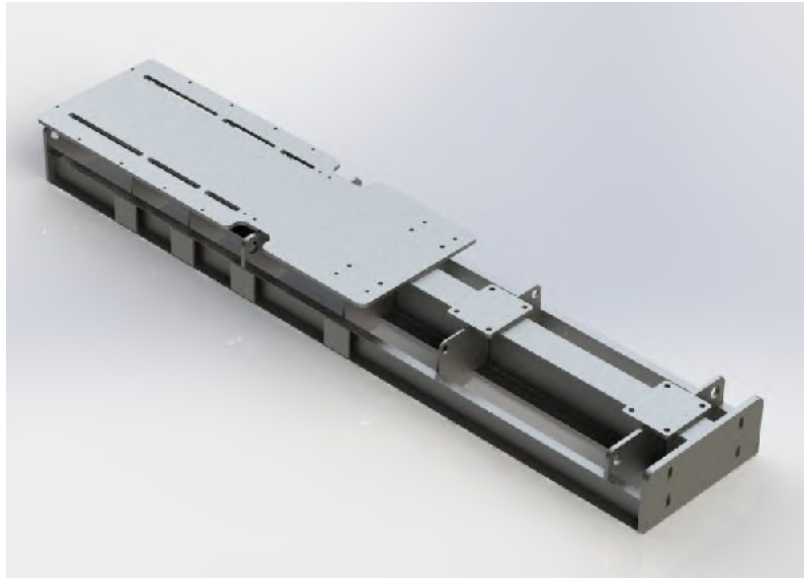


**Figure 7: SPS™ Thrust Chambers (SDTC, HDTC, and XDTC Left to Right Respectively)**

### 3.2.6 SPS™ System Frames

Larger GE Oil & Gas SPS™ units incorporate the patented FM75, FM350, FM1000, FM1500, or FM2000 Easily Modified Frames™ (EMF™). All are modular in construction and both facilitate system modifications should operating conditions change. These frames feature a rigid base frame for low vibration and ease of installation. They incorporate integral lifting lugs throughout and a machined motor adapter plate ([Figure 8: FM1000 Easily Modified Frame \(EMF™\), page 17](#)), which together with the frame motor plate are pre-drilled for virtually all available motor options. FM1000, FM1500, and FM2000 frame features include:

- Motors: 75 hp to 1,000 hp NEMA (50 kW to 750 kW IEC) motors can be mounted to the FM1000 EMF™ design without having to cut metal or weld anything and without adjusting the pipe work.
- Each adapter plate has all possible motor mounting holes pre-drilled for the particular shaft height. The adapter plates have machined surfaces.
- If a replacement motor has a different shaft height the motor adapter plate can be swapped out. The pump center-line stays the same so suction and discharge levels do not change.
- Frame end plates facilitate the addition of future extension sections if required.
- EMF™ is a heavy-duty rigid design.

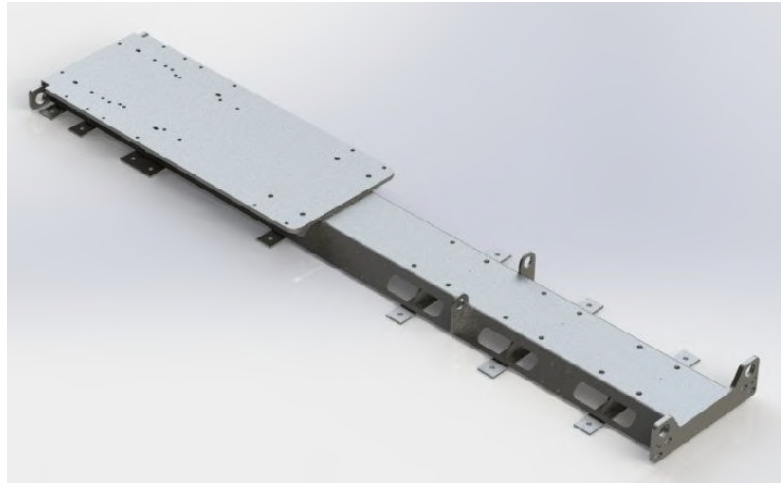


**Figure 8: FM1000 Easily Modified Frame (EMF™)**

GE Oil & Gas also provides FM75 ([Figure 9: FM75 Frame Design, page 17](#)) or FM350 ([Figure 10: FM350 Frame Design, page 18](#)) frames for SPS™ systems that employ small motors. The FM75 is a C-channel frame made for C-faced motor applications from 20 hp up to 75 hp. The design allows for ease of alignment for motor and pump coupling. The 150 frame design is designed for foot mounted motors up to 350 hp. The bent foot frame design allows for a smaller footprint and reduces fabrication cost.



**Figure 9: FM75 Frame Design**



**Figure 10: FM350 Frame Design**

#### 4 SPS™ Unit Handling and Transport Procedures

##### **W** • WARNING

***Perform all necessary safety precautions before beginning any work on or around the SPS™ unit. Failure to follow all safety precautions can lead to damage to the equipment, personal injury or death.***

##### **N** • NOTE

***At GE Oil & Gas safety is non-negotiable. Follow all safety procedures and precautions. Before working on or around an SPS™ pump, it is imperative to read and follow all warnings, cautions, notes, and instructions included in this document.***

**⚠ CAUTION**

**Important Notice:** Lifting equipment must be sized appropriately for the equipment being lifted and inspected prior to use. A site Job Safety Analysis (JSA) should be performed to make sure the proper sized equipment is being used.



Check the load before lifting. Make sure the total weight of the load and its center of gravity is secure, especially when lifting separate components.

#### **4.1 Lifting an SPS™ Unit**

There are two recommended methods to lift an SPS™ unit when loading or unloading for transport, :

- Lifting the SPS™ unit using a forklift (see [Section 4.1.1 Lifting the SPS™ Unit Using a Forklift, page 19](#)).
- Lifting the SPS™ unit using a crane (see [Section 4.1.2 Lifting the SPS™ Unit Using a Crane, page 21](#)).

##### **4.1.1 Lifting the SPS™ Unit Using a Forklift**

Make sure the forklift is rated for the given load at a distance from the mast. Since SPS™ units have the load located along the longitudinal axis of the frame, the center-line of the motor is the center-line of the load.

Each SPS™ unit has the center of gravity (C.O.G.) marked on the unit. This is the unit balance point and is determined by the manufacturer. If there is packing material or other loose items on the frame, the center of gravity will change depending on the weight of the items. When lifting with a forklift the forks must straddle the center of gravity (see [Figure 11: Lifting an SPS™ Unit with a Forklift, page 20](#)).



**Figure 11: Lifting an SPS™ Unit with a Forklift**



**NOTE**

A sticker ([Figure 12: Center of Gravity Sticker, page 20](#)) located on the SPS™ frame indicates the approximate center of gravity (C.O.G.). For units with a pump extension, the C.O.G. sticker is located in the same area on the extension frame.



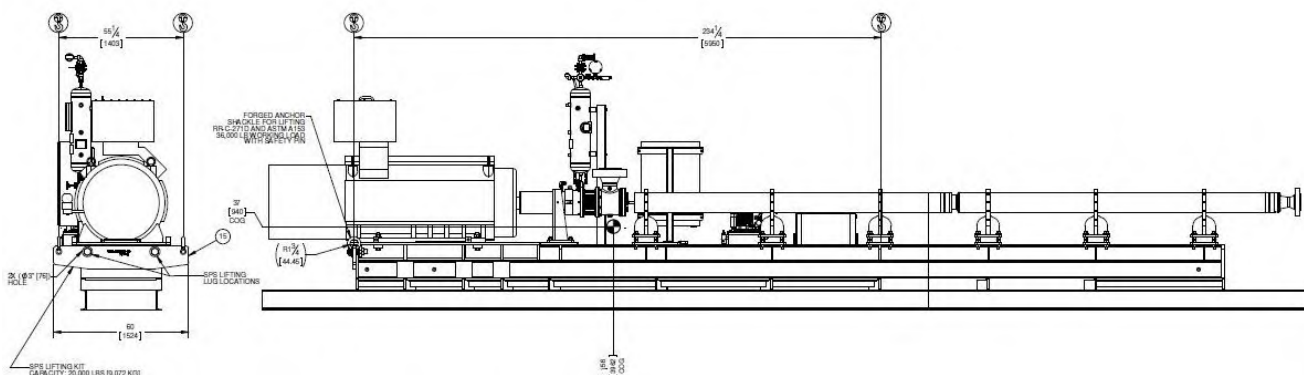
**Figure 12: Center of Gravity Sticker**

### 4.1.2 Lifting the SPS™ Unit Using a Crane

Before lifting an SPS™ unit determine the center of gravity and locate lifting lugs. Take steps not to interfere with pump and motor alignment. Use recommended lifting locations.

#### **N** • NOTE

For specific configurations where the motor weight affects the COG and standard lifting points a four-point spreader bar is recommended for lifting or moving the SPS™ equipment when using a crane refer to the general arrangement drawing of your unit for specific lifting points. SPS™ lifting kits ([Figure 13: Lifting an SPS™ Using a Lifting Kit](#), page 21) can be provided. Each kit is specific to a specific unit. For more information, contact GE Oil & Gas customer service department (phone +1 405 671 2228).



**Figure 13: Lifting an SPS™ Using a Lifting Kit**

### 4.2 Preparation of Skid Supports for Transportation

The recommended spacing of supports is 4 to 8 ft and should not exceed 10 ft.

#### **N** • NOTE

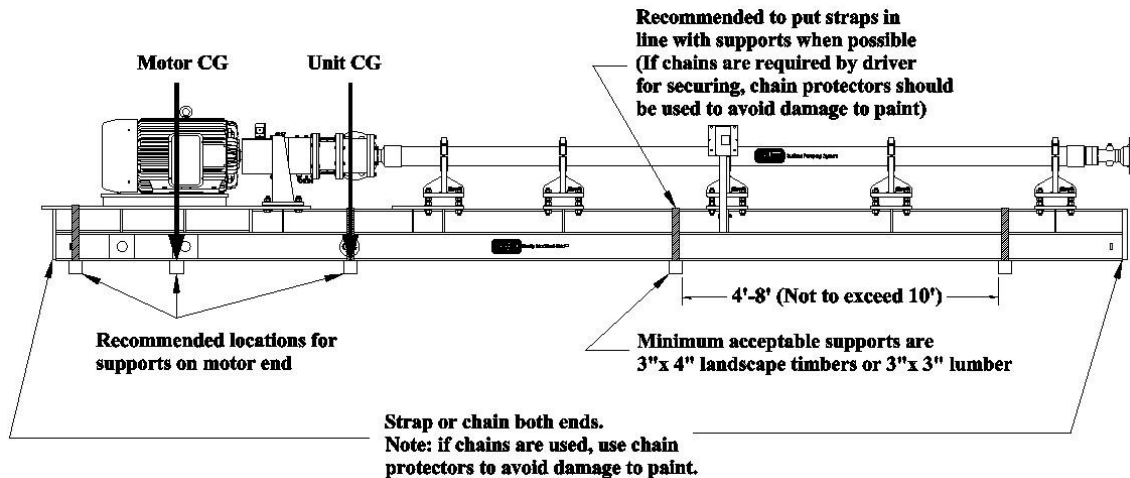
Minimum acceptable supports are 3" x 4" landscape timbers or 3" x 3" lumber. Make sure the height of every support used is the same.

It is recommended the frame be supported under or near the center of gravity of the motor and the whole unit as well as the back end of the motor plate. This will help distribute the weight evenly.

#### **C** • CAUTION

Equipment must be secured to a flat surface when transporting or damage to the equipment may result.

- Do NOT prop or over hang equipment.
- Do NOT strap or chain on the pump body, supports, or brackets.
- Do NOT lift by the motor eyebolts or strap across the motor.
- Make sure straps and chains clear motors, junction boxes, and coolers (see [Figure 14: Recommended Strap/Support Locations, page 22](#)).



**Figure 14: Recommended Strap/Support Locations**

### 4.3 Securing the SPS™ Unit

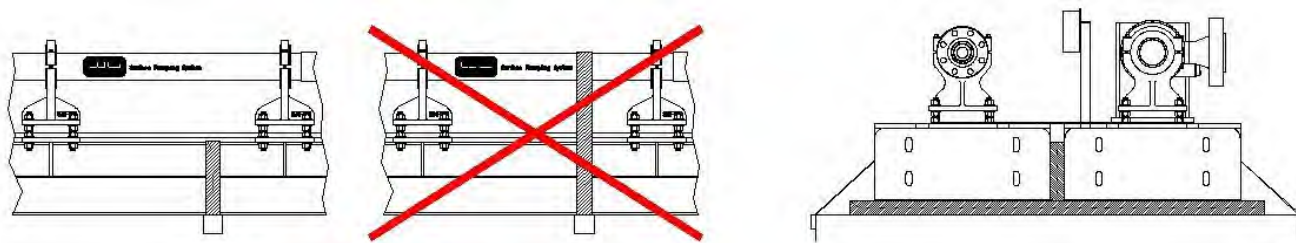
**N • NOTE**

*This instruction only applies to transporting SPS™ units.*

After the SPS™ unit is loaded onto the supports, attention should be made to any significant gaps (1/8 in. or greater) between the unit and the supports. These gaps should be shimmed solidly. Secure the SPS™ units directly in line with the supports or as close as possible. Straps should be routed over the top of the frame and under any tubing, if present, to avoid possible damage to the tubing. If it is not feasible to run straps under tubing, wood blocks can be used as shims under the tubing to prevent deflection. Check for loose supports after strapping. If there are any loose supports, unstrap the frame in that area, shim the frame solidly to the support and re-strap.

**C • CAUTION**

**Do not run straps over the top of the pump as this will cause deformation to the pump (see [Figure 15: Correct Use of Straps, page 23](#)).**



**Figure 15: Correct Use of Straps**

When securing multiple units side-by-side it is recommended to butt the units solidly with 3" x 3" blocks in between to prevent straps from coming loose in transit (see [Figure 15: Correct Use of Straps, page 23](#))

**Disclaimer:** The purpose of this instruction is to provide guidelines for securing and transporting SPS™ units to avoid damage to the units. It is ultimately the driver's responsibility to make sure each unit is secured in a manner safe for transportation.

#### 4.4 Unloading Equipment

Care should be taken when unloading the equipment. If the shipment is not delivered in good condition or according to the bill-of-lading, detailed notes about the condition of the shipment should be made on the receipt and freight bill. Promptly contact the transportation company and mention any claims regarding the shipment. Retain all documentation related to your claim.

#### **N** • NOTE

*Each SPS™ unit is shipped from the factory in a manner suitable for protection during short-term storage (0 to 90 days). If prolonged storage (over 90 days) of the equipment is required, please follow the long-term storage procedures found in [Section 8: Storage Procedures, page 48](#) of this manual, or contact your nearest GE Oil & Gas field service representative for any questions regarding your unit.*

### 5 Installation and Commissioning

#### **CAUTION**

**Important Notice:** Lifting equipment must be sized appropriately for the equipment being lifted and inspected prior to use. A site Job Safety Analysis (JSA) should be performed to make sure the proper sized equipment is being used.

**⚠ CAUTION**

Check the load before lifting. Make sure the total weight of the load and its center of gravity is secure, especially when lifting separate components.

### 5.1 Unit Location



**• WARNING**

***Perform all necessary safety precautions before beginning any work on or around the SPS™ unit. Failure to follow all safety precautions can lead to damage to the equipment, personal injury or death.***



**• NOTE**

*For complete installation and commissioning instructions refer to GE Oil & Gas ESP, Inc. Form F-480 SPS Installation and Commissioning Manual.*

**⚠ CAUTION**

**Important Notice:** If any risk of fire or explosion applies to the operation of the SPS, recommendations and warnings will be included according to the specific ATEX Risk Analysis (if applicable).

#### 5.1.1 Net Positive Suction Head (NPSH) Optimization

To optimize the suction conditions the unit should be placed as close to the product supply source as possible to prevent friction loss. Each unit has certain NPSH requirements which need to be met in order to have adequate product supply for the pump upon start up and during operation, refer to the pump specifications for the detailed NPSHr value. This will reduce the likelihood of cavitation. A charge pump will be required if adequate NPSHr is not obtainable.

#### 5.1.2 Unit Clearances

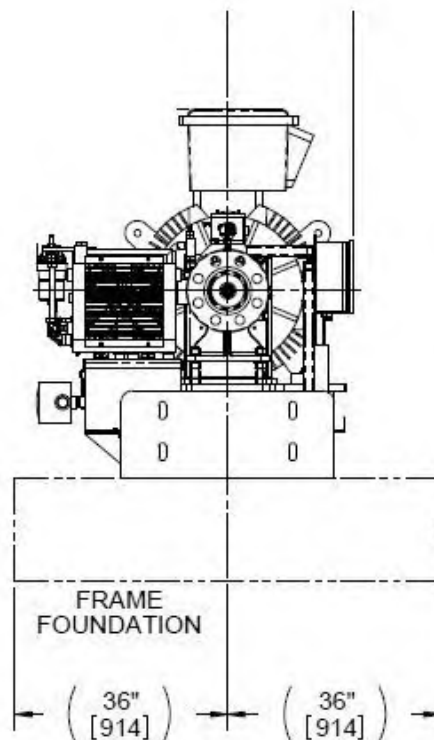
Floor and head space allocated to the equipment must be sufficient for inspection and maintenance. Allow for crane or hoist service as required (generally 3 ft around the unit should be open for maintenance activities).

### 5.1.3 Foundation Recommendations

A flat level concrete slab 18 in. thick is recommended for mounting the unit (see [Figure 16: Suggested Foundation/Pad Specifications \(Reference Only\), page 25](#)). Support pillars are acceptable with no more than 4 ft between supports. For additional rigidity the frame can be grouted to the foundation but this is not required. Contact your closest GE Oil & Gas service center for grouting procedures.



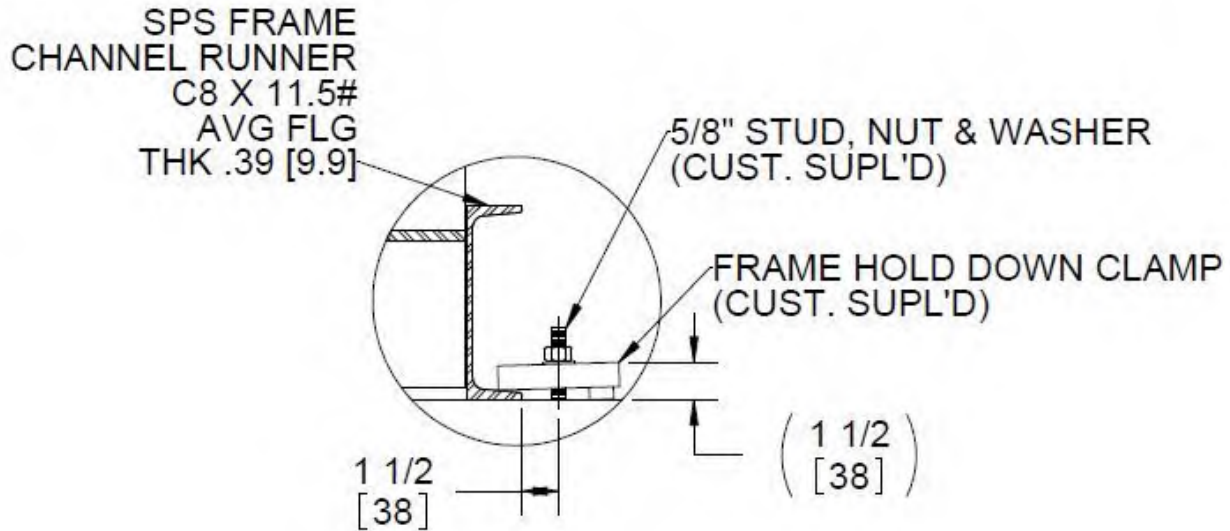
*Do not use general dimensions for foundation design. Refer to your product drawings for specific foundation requirements. Customers should consult API RP 686 or a civil engineer for foundation design.*



**Figure 16: Suggested Foundation/Pad Specifications (Reference Only)**

### 5.1.4 Foundation Bolts

If foundation bolts are used, place them at cross member locations and take care not to distort the base when tightening (see [Figure 17: Suggested Frame Clamp \(FM1000 Frame Example\)](#), [page 26](#) for a reference). The base must remain level to maintain pump alignment, refer to the suggested frame clamp down detail provided in the general arrangement drawing of your unit.



**Figure 17: Suggested Frame Clamp (FM1000 Frame Example)**

## 5.2 Piping Guidelines

### 5.2.1 Piping Installation Standards

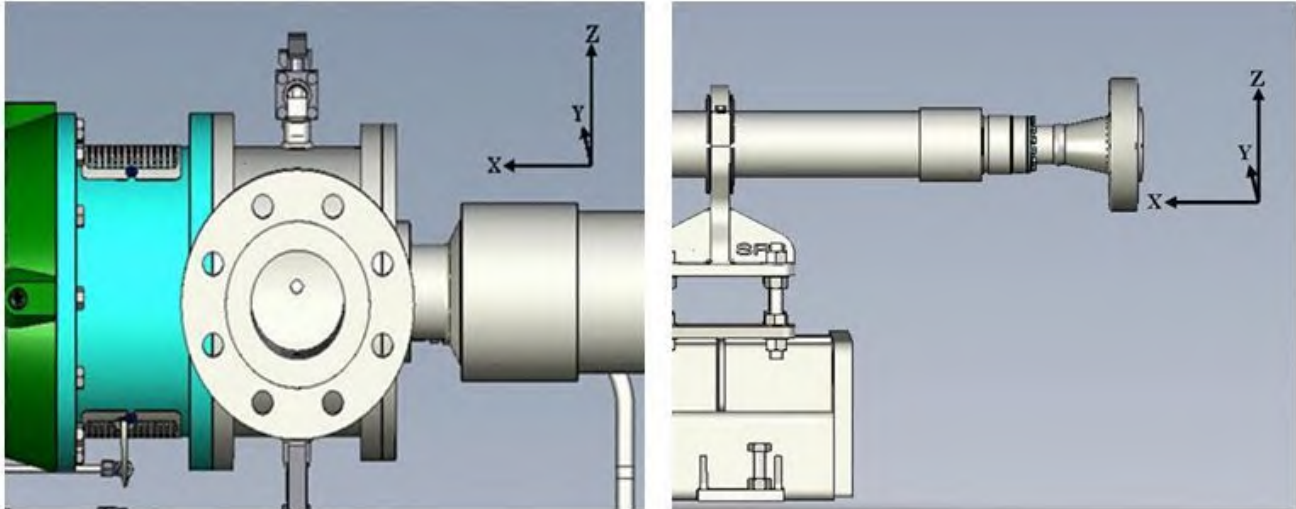
Piping should be installed in accordance with NORSOK Standard L-CR-004 Rev 1 and API RP 686.

### 5.2.2 Pipe Loads

Refer to API 610 Annex F, [Table 3: Maximum Allowable Nozzle Loads in Ft-Lb, page 27](#), and [Figure 18: Right Hand Rule Cartesian Coordinate System, page 28](#) for allowable piping loads.

**Table 3: Maximum Allowable Nozzle Loads in Ft-Lb**

Flange Size (Inches)	≤ 2"	3"	4"	6"	8"	10"	12"	14"
Each Top Nozzle								
FX	160	240	320	560	850	1200	1500	1600
FY	130	200	260	460	700	1000	1200	1300
FZ	200	300	400	700	1100	1500	1800	2000
Each Side Nozzle								
FX	160	240	320	560	850	1200	1500	1600
FY	200	300	400	700	1100	1500	1800	2000
FZ	130	200	260	460	700	1000	1200	1300
Each End Nozzle								
FX	200	300	400	700	1100	1500	1800	2000
FY	160	240	320	560	850	1200	1500	1600
FZ	130	200	260	460	700	1000	1200	1300
Each Nozzle								
MX	340	700	980	1700	2600	3700	4500	4700
MY	170	350	500	870	1300	1800	2200	2300
MZ	260	530	740	1300	1900	2800	3400	3500



**Figure 18: Right Hand Rule Cartesian Coordinate System**

### 5.2.3 Piping Length

Use the minimum length of piping according to design specifications to keep friction loss to a minimum.

### 5.2.4 Piping Clearances

Make sure piping is arranged to allow the proper clearance and accessibility for easy operation, inspection and maintenance.

### 5.2.5 Strainer Specifications

Install an in-line strainer according to specified design conditions (100 micron strainer recommended). After the strainer, allow a space equal to ten times the pipe diameter so the product/liquid can stabilize before entering the suction of the pump.

### 5.2.6 Piping Layout

Provide a simple piping layout that is neat and economical and allows for easy support and adequate flexibility.

### 5.2.7 Connections to the SPS™ Unit

Piping connected to equipment should be designed so any forces or movements caused by thermal expansion, dead and operating loads do not exceed the API or specified limits required

by the manufacturer. Piping connections should not be forced together and are required to remain within the API standard nozzle loads or as specified by manufacturer.

### **5.2.8 Flexible Suction Connections**

Flexible suction connections can be used to ease expansion and contraction of piping which could exert damaging forces on the unit's suction chamber. Flexible connections should meet all design and pressure specifications.

### **5.2.9 Flexible Discharge Hose**

A flexible discharge hose can be used, but it must be capable of handling not only the duty point pressure but the pump's dead head pressure at maximum temperature allowing for expansion without creating a misalignment force.

### **5.2.10 Suction-End Isolation Block**

An isolating block should be installed before the suction-end of the pump so the process fluid can be shutoff from the pump for maintenance purposes. Refer to [Figure 19: Valve/Piping Diagram, page 30](#).

### **5.2.11 Discharge-End Isolation Block**

A block needs to be installed in the discharge line to isolate the pump from other units or downstream process equipment for maintenance purposes. Refer to [Figure 19: Valve/Piping Diagram, page 30](#).

### **5.2.12 Discharge Bypass Valve**

A bypass valve can be installed in the discharge line, which should be piped back to the suction tank and sized to bypass the minimum operating flow. This is for the protection of the pump in case a valve is closed or process change occurs during operation. Redirecting the fluid back to the holding tank will prevent the pump from operating in a dead head situation. Refer to [Figure 19: Valve/Piping Diagram, page 30](#).

### **5.2.13 Use of a Choke**

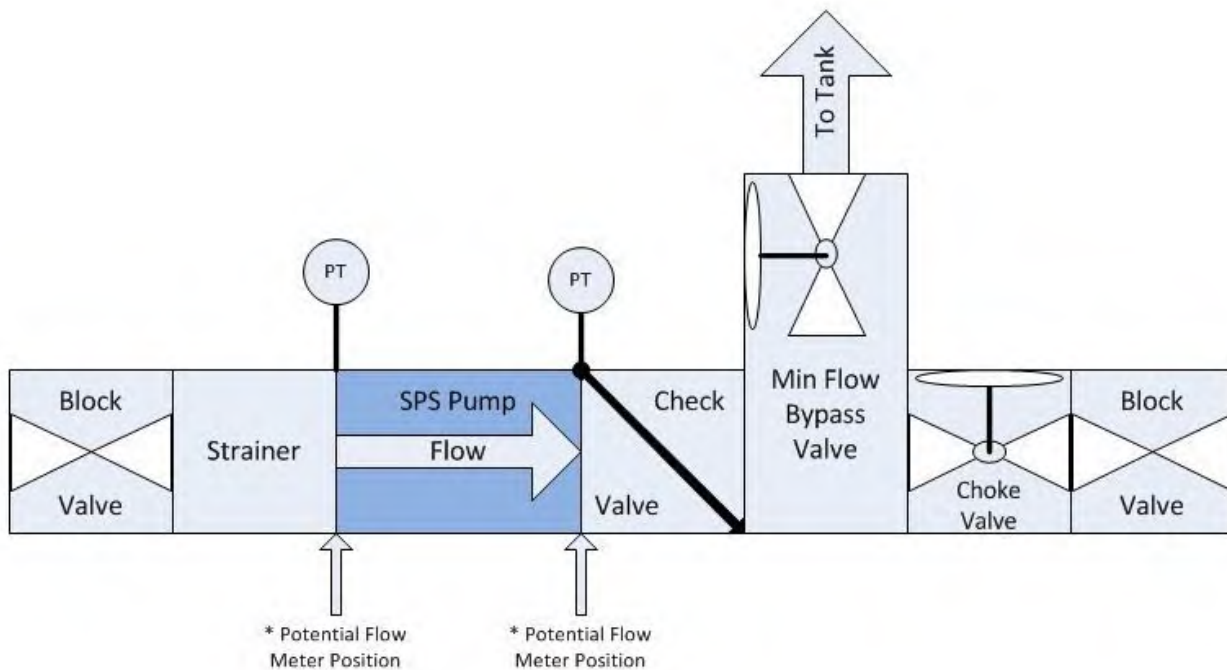
A choke should be installed in the discharge piping. A choke allows the pump to operate against pressure on startup until the line is fully charged. An automated choke is recommended as it prevents the pump from operating in upthrust. The choke should be located after the bypass valve in the discharge line. Refer to [Figure 19: Valve/Piping Diagram, page 30](#).

### **5.2.14 Use of a Discharge Line Check Valve**

A check valve should be installed in the discharge line for applications where back flow is likely to occur once the pump stops operating. This will prevent the equipment from back-spinning. Refer to [Figure 19: Valve/Piping Diagram, page 30](#).

**C** • CAUTION

- Failure to install a discharge line check valve may allow the equipment to backspin and cause damage to the pump and motor.
- Do not pipe a plant from these incomplete instructions. Failure to follow these guidelines will reduce pump efficiency and increase pump maintenance cost. These guidelines apply to all SPS™ styles of liquid flow centrifugal oilfield pumps. Refer to the Norsok and API RP 686 piping standards as close as possible for best results.



**Figure 19: Valve/Piping Diagram**

## 6 Operation and Startup

### • WARNING

***Perform all necessary safety precautions before beginning any work on or around the SPS™ unit. Failure to follow all safety precautions can lead to damage to the equipment, personal injury or death.***

### • CAUTION

**Coolant lines and thrust chamber can be hot after operation. Adhere to warning labels.**



There are some components in the SPS such as the thrust chamber that could be operating at temperatures above 70°C (158°F). As a way to reduce the chance of touching the hot surface, warning labels are attached to the equipment which remind the operators to wait until surfaces are cool before servicing the system.



Even though some SPS systems are designed with “low noise” equipment (e.g., motor, oil coolers, seal systems, etc.) and their assembly and installation procedures include alignment tasks to reduce vibration and noise levels, there is still some level of noise associated with the normal operation of the system. therefore it is always recommended to use hearing protection while the system is running in order to minimize noise hazards.



**Important Note:** A Lock-out tag must be employed prior to any service. Failure of the main control could allow and unexpected start under various scenarios including reenergize after power interruption. The use of Lock-out tags and E-stops will eliminate the potential of the operations control system failing under service mode. E-stops as well as control system guidelines are provided according to what is included in the scope of supply of the SPS system. Site Risk assessments must be completed prior to operation.



Entanglement and trapping hazards are present at the motor coupling area. A protective coupling guard has been designed to prevent access to these dangerous moving parts while the SPS system is running. Do not remove the coupling guard until the lock-out/tag-out procedures have been accomplished.

## 6.1 Critical Installation/Operating Instructions

### 6.1.1 Duty Conditions

This SPS™ has been designed to meet the specifications of your purchase order. The reliability of the SPS™ depends upon the operator using the product in the intended manner, in accordance with safety and the statutes of this manual. The limit values specified in the data sheet must never be exceeded under any circumstance. If a user plans to change, or anticipates a change in, the conditions of service (e.g., fluid, temperature, duty, etc.) it is required the user seek written agreement from GE Oil & Gas prior to start up.



***This product must not be operated beyond the parameters specified for the application. Operation beyond the safety parameters can lead to equipment damage, personal injury, or death. If there is doubt as to the suitability of the product for the application intended, contact GE Oil & Gas for advice.***

### 6.1.2 Unauthorized Alterations and Spare Parts

Modifications or alterations of the equipment supplied are only permitted after consultation with the manufacturer and to the extent permitted by the manufacturer. Use of original spare parts and accessories authorized by the manufacturer leads to safer operation. The use of other parts may create an unsafe condition and can invalidate any warranty or liability of the manufacturer.

### 6.1.3 Personnel Qualification and Training

The operator is responsible for ensuring all maintenance, inspection, and installation work be performed by authorized, qualified specialist personnel who are thoroughly familiar with this manual and fully and appropriately trained on the operation, maintenance, repair, inspection, and installation of the particular GE Oil & Gas SPS™. If required the operator may commission the manufacturer/supplier to provide applicable training.



***Always coordinate repair activity with operations and health and safety personnel following all plant safety requirements, applicable safety and health laws, and regulations. Failure to follow all applicable requirements, regulations, and laws may lead to equipment injury, personal injury, or death.***

### 6.1.4 Scope of Compliance

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

### 6.1.5 Pump Performance and Protection

This equipment has a specific performance window and operational limits. It is the end users responsibility to understand these limits and to make sure proper measures including sensors are installed to monitor key functions and to shut down the equipment in the event those limits are exceeded. In the event pumps are installed in parallel or in series each pump must be operated within its own specific performance and operational limits.

### 6.1.6 Pump Operating Range

Multistage centrifugal pumps have an operating range specific to the model of pump: refer to the pump performance curve for your pump. [Figure 20: Sample Pump Curve, page 34](#) is an example of a pump curve, it is imperative to make sure the pump is running within the operating range at all times. Operation of the pump outside the operating range can drastically reduce the life of the pump due to high thrust loads, increased vibration, cavitation and high pressure



**Figure 20: Sample Pump Curve**

### 6.1.7 Low Flow/No Flow Operation

When a pump operates near the shutoff with almost no flow, almost all the motor power is transformed into thermal energy which is absorbed by the pumped fluid. In this condition, there is risk of the pump casing taking on high surface temperatures within a very short time, due to a rapid temperature buildup inside the pump. This causes excessive stresses on the pump and pumps materials and may result in premature pump failure, the pump seizing, or even bursting, which could lead to injury or death of persons standing in the immediate area or property damage.



***Pump operation at shutoff or near shutoff conditions outside of the pump operational limits could lead to equipment damage, personal injury or death of persons standing in the immediate area.***



Never exceed the maximum allowable working pressure (MAWP) limit at the stated design temperature marked on your equipment.

### 6.1.8 Maximum Flow Operation

When a pump operates with little resistance in the discharge line, the pump will operate at a condition of maximum flow or end of curve performance. Maximum horsepower is required to operate at this point.



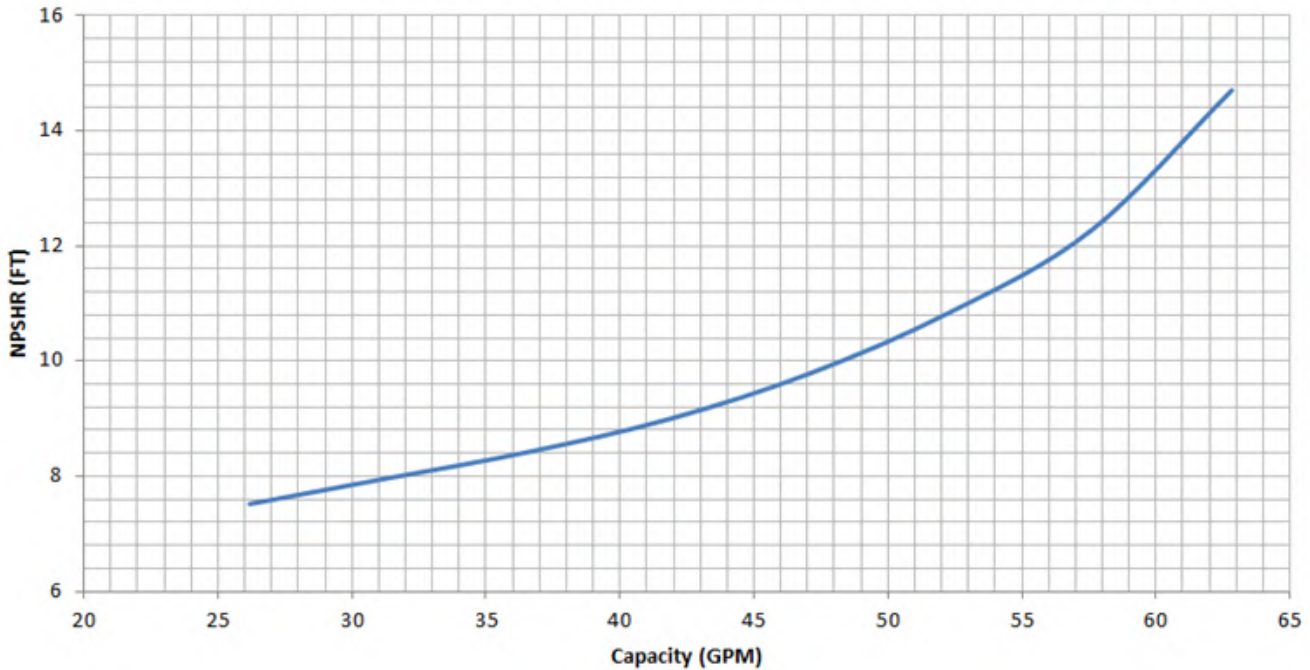
***Operating a pump with little resistance in the discharge line will cause motor overload and may result in equipment damage, personal injury, or death.***

### 6.1.9 Net Positive Suction Head (NPSH)

To avoid cavitation conditions, the NPSHa must have additional margin to avoid cavitation and be greater than or equal to the net positive suction head required (NPSHr). Refer to the NPSHr curve for your particular pump. [Figure 21: NPSHr Curve, page 36](#) is an example of an NPSHr curve.



***Operating a SPS™ without the pump being fully flooded with fluid or with Inlet valves fully open may cause the system to cavitate leading to equipment damage, personal injury, or death.***



**Figure 21: NPSHr Curve**

### 6.1.10 Piping Loads

Piping should always be supported to neutralize any forces, moments, piping weights, thermal expansions, etc., which could create pump/motor misalignment or deflections and overloading of pump flanges. There should not be any tensions, deformations, or misalignment of the piping when loosening the bolts holding the flanges together. Refer to [Section 5.2 Piping Guidelines](#), page 26.

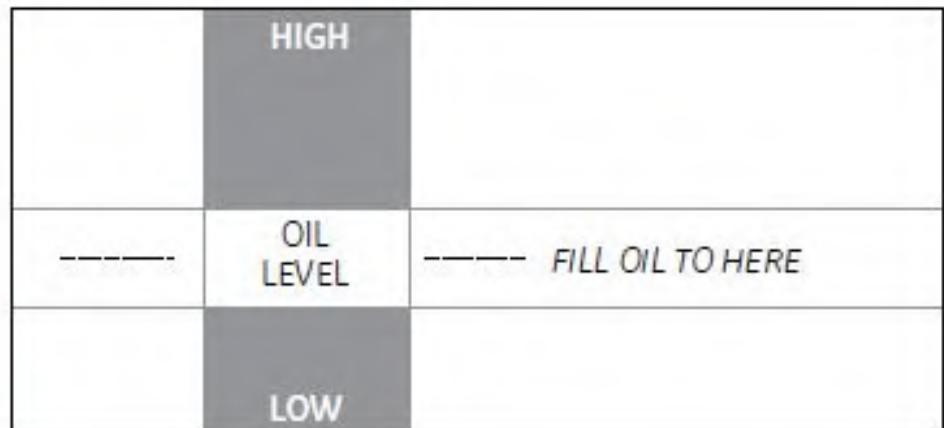
## 6.2 Thrust Chamber Lubrication



**Important Notice:** Make sure to read the Material Safety Data Sheets (MSDS) of the fluids used for lubrication before attempting to work with them. always consult with your supervisor if you have any questions.

For SDTC's, change the full synthetic ISO Grade 68 oil in the thrust chamber after the first hour of operation and every 2,200 hours of operation or once a year thereafter.

1. With the unit in a cold condition, oil should be filled to half way up the “Oil Level Zone” (approximately 46 to 48 ounces) on the sight glass as shown in [Figure 22: Oil Level Zone, page 37](#).



**Figure 22: Oil Level Zone**

2. Use approved full-synthetic ISO Grade 68 oil only (see [Table 4: Recommended Oil Chart: Thrust Chamber, page 38](#)).
3. Check the oil level after the unit has been running for 30 minutes.
4. The oil level should have stabilized and should not exceed the high mark in the oil level zone in a stopped condition. When operating correctly, there should be a reasonable splashing of oil against the sight glass.

**C** • CAUTION

**Under-filling or overfilling the thrust chamber oil will result in elevated run temperatures, which can lead to reduced service life. Under filling will also result in insufficient lubrication and reduced service life.**

**N** • NOTE

- *When the unit is running in a cold condition and the oil level is at the top of the zone line, the oil level will exceed the oil level zone line until normal operating temperatures are reached.*
- *Mineral oils of the same viscosity can be substituted under certain conditions (contact GE Oil & Gas Engineering Department for approval).*

**Table 4: Recommended Oil Chart: Thrust Chamber**

Manufacturer	Oil Description
Shell	Morlina S4 B68 (manufacturer preferred)
Texaco	Code 2053 Pinnacle 68
Chevron	Hypr Syn (68)
Mobil/Exxon	Mobil SHC 626 (ISO 68)
Conoco	Syncon Synthetic R&O (ISO 68)

**N • NOTE**

The frequency of oil change for approved (non-synthetic) mineral oils is every 1,000 hours for SDTC's only. For HDTC's and XDTC's the oil change interval is noted in [Table 5: Recommended Lubrication Intervals, page 43](#).

**6.3 Motor to Thrust Chamber Coupling**



**Important Note:** A Lock-out tag must be employed prior to any service. Failure of the main control could allow and unexpected start under various scenarios including reenergize after power interruption. The use of Lock-out tags and E-stops will eliminate the potential of the operations control system failing under service mode. E-stops as well as control system guidelines are provided according to what is included in the scope of supply of the SPS system. Site Risk assessments must be completed prior to operation.



Entanglement and trapping hazards are present at the motor coupling area. A protective coupling guard has been designed to prevent access to these dangerous moving parts while the SPS system is running. Do not remove the coupling guard until the lock-out/tag-out procedures have been accomplished.

**⚠ CAUTION**

**Important Notice:** When installing, servicing, or removing the SPS system it is possible operators may need to step on the skid. It is recommended to use caution when surfaces are wet because they can become slippery, especially when there are mixed fluids like grease, oil, and water.

**Follow the coupling manufacturer's recommendations.**

## 6.4 SPS Start-Up

**W • WARNING**

***Before starting an SPS™ unit, consult the motor manufacturer's instructions and follow all their recommendations related to starting the motor. Failure to wear proper personal protection and follow motor manufacturer's directions may result in equipment damage, personal injury or death.***

**N • NOTE**

- *The motor startup procedure is only a summary of the commissioning manual. For the complete instructions for motor startup refer to the SPS Form F-481.*
- *Generally, noise from SPS™ units is directly related to motor design and size. Noise levels are typically in the 80 dBA to 95 dBA range. When required, SPS™ units are designed for low noise emissions (below 85 dBA). These quieter units employ low noise motors, low noise auxiliary systems (e.g., oil coolers, seal systems, etc.), and noise mitigation covers (i.e., sound enclosures).*

**⚠ CAUTION**

**Important Notice:** If any risk of fire or explosion applies to the operation of the SPS, recommendations and warnings will be included according to the specific ATEX Risk Analysis (if applicable).

1. For a standard duty thrust chamber prior to motor startup:
  - a. Before rotating the thrust chamber remove the two oil ring stem and stem adapters.

- b. Before starting the motor, remove the sight glass on the thrust chamber and use a flashlight to make sure the oil rings are correctly located in their respective grooves on the bearing shaft.
- c. Install short bolts and washers located in the junction box. Retain the shipping stems for future shipment—stems are to be refitted for shipping only (see [Figure 23: Thrust Chamber with Oil Ring Stems, page 40](#)).



**Figure 23: Thrust Chamber with Oil Ring Stems**

2. Open the suction line valve and bleed off all the air inside the lines by filling the pump with fluid and then opening the bleeder valve on top of the pump case at the discharge-end of the unit.
3. Close the valve as soon as the air flowing through the bleeder valve has stopped.
4. If the SPS™ unit is not equipped with a bleeder valve, a bleeder valve must be installed.
5. Set the discharge line valve open at 30% initially, then adjust as necessary.
6. If applicable, unlock the power supply to motor and start the charge pump.

**CAUTION**

**Important Notice:** The SPS system is tested prior to delivery to the user to make sure the connections do not leak under pressure. In addition, the assembly and test procedures include specific torque ratings when installing flanges and hoses, and instructions for properly marking up tube fitting connections. However, prior to startup it is recommended to perform pre-commissioning and commissioning reviews in order to verify there are no leaks in the SPS system or customer piping and connections.

7. Jog the motor to check rotation. Correct rotation of the SPS™ pump is clockwise when standing behind the motor or at the Non-Drive End (NDE).

**C** • CAUTION

**Do not run sleeve bearing equipped motors at slow speeds for more than 2 seconds, doing so will cause damage to the motor.**

8. Correct the motor phase rotation if required.
9. Connect an ammeter to motor leads and start the unit to check motor amps for correct motor full load amps.
10. Check both suction and discharge pressure to confirm unit is operating properly.
11. Measure and record a full set of vibration readings using GE Oil & Gas Form F-486.
12. Monitor all instruments, including motor temperatures and thrust chamber temperature using a multimeter attached to a thermocouple. Record all parameters on GE Oil & Gas Forms F-481, F-482, F-483 and F-485 only after the temperature has stabilized.

**N** • NOTE

*SPS™ systems perform at or below the vibration amplitude of 0.156 in./sec (3.96 mm/sec) in 1x frequency as per API RP 11S8.*

13. Inspect the pump carefully during the first hour of operation. Make sure to check for leaks at all connections and excessive vibration.
14. Complete and retain a copy of the commissioning report.

## 7 Maintenance

**W** • WARNING

**Failure to perform all necessary safety precautions before beginning work may cause damage to equipment, personal injury, or death.**



Even though some SPS systems are designed with “low noise” equipment (e.g., motor, oil coolers, seal systems, etc.) and their assembly and installation procedures include alignment tasks to reduce vibration and noise levels, there is

still some level of noise associated with the normal operation of the system. therefore it is always recommended to use hearing protection while the system is running in order to minimize noise hazards.



**Important Note:** A Lock-out tag must be employed prior to any service. Failure of the main control could allow and unexpected start under various scenarios including reenergize after power interruption. The use of Lock-out tags and E-stops will eliminate the potential of the operations control system failing under service mode. E-stops as well as control system guidelines are provided according to what is included in the scope of supply of the SPS system. Site Risk assessments must be completed prior to operation.



Entanglement and trapping hazards are present at the motor coupling area. A protective coupling guard has been designed to prevent access to these dangerous moving parts while the SPS system is running. Do not remove the coupling guard until the lock-out/tag-out procedures have been accomplished.



**Important Notice:** When installing, servicing, or removing the SPS system it is possible operators may need to step on the skid. It is recommended to use caution when surfaces are wet because they can become slippery, especially when there are mixed fluids like grease, oil, and water.



**Important Notice:** Lifting equipment must be sized appropriately for the equipment being lifted and inspected prior to use. A site Job Safety Analysis (JSA) should be performed to make sure the proper sized equipment is being used.

## 7.1 Preventive and Corrective Maintenance



There are some components in the SPS such as the thrust chamber that could be operating at temperatures above 70°C (158°F). As a way to reduce the chance of touching the hot surface, warning labels are attached to the equipment which remind the operators to wait until surfaces are cool before servicing the system.



**Important Notice:** Make sure to read the MSDS of the fluids used for lubrication before attempting to work with them. always consult with your supervisor if you have any questions.



• **CAUTION**

**Coolant lines and thrust chamber can be hot and cause burns.**

Lubrication requirements for the motor, coupling, and thrust chamber are shown in [Table 5: Recommended Lubrication Intervals, page 43](#).

**Table 5: Recommended Lubrication Intervals**

Part	Lubrication Intervals	Recommended Oil
Main Motor—Anti Friction Bearing	Replenish motor grease every 3 months or every 2,000 hours of operation or as recommended by the motor manufacturer's OEM.	Refer to the motor manufacture's recommended grease (usually found on nameplate).
Main Motor—Sleeve Bearing	Replenish motor oil as recommended by the motor manufacturer's OEM.	Refer to the motor manufacture's recommended oil (usually found on nameplate).
Lube Oil Motor—Anti—Friction Bearing	Sealed bearing—no maintenance required	

**Table 5: Recommended Lubrication Intervals (cont'd.)**

Part	Lubrication Intervals	Recommended Oil
Coupling—Grid Type (Lubricated)	Replenish coupling grease as needed or as required every 12 months or every 8,760 hours of operation if required. (Refer to coupling Manual).	Requires Shell Alvania CG grease or Falk LTG grease.
Coupling—Spacer Type (Metal Flex)	No maintenance required	
Thrust Chamber-Standard Duty	Change every 3 months or every 2,200 hours of operation (slinger rings) Analysis every 3 months, replace at least once a year (oil injection)	Requires Shell Morlina S4 B68 synthetic oil or equivalent.
Thrust Chamber-Heavy Duty	Analysis every 3 months, replace at least once a year	Requires Shell Morlina S4 B68 synthetic oil or equivalent.
Thrust Chamber-Extreme Duty	Analysis every 3 months, replace at least once a year	Requires Shell Morlina S4 B68 synthetic oil or equivalent.
Thrust Chamber Cooler Filter (if equipped)	Replace every 6 months	

## 7.2 Recommended Maintenance Schedules

SPS™ units are designed for years of trouble-free operation. There are no V-belts or packings to service. Routine maintenance consists of a quarterly lubricant change and component checks. To help keep your SPS™ unit operating properly, [Table 6: Recommended/Minimum Maintenance Schedule, page 45](#) lists the 15 recommended maintenance tasks that should be performed regularly.

### NOTE

- *The SPS™ unit should be running while performing tasks one through three.*
- *The SPS™ unit should be shut down and lock out/tag out procedures completed for the remaining tasks.*

**Table 6: Recommended/Minimum Maintenance Schedule**

Task	Task Description	Daily	Monthly	Quarterly	Semiannual	Annually
1	While the SPS™ unit is operating, listen and feel for changes in sound and vibration level.			X		
2	Perform vibration and alignment checks.			X		
3	Verify the shutdown setting has not been changed and instruments are functioning.			X		
4	Inspect suction and discharge connections for leaks.			X		
5	Inspect the thrust chamber for leaks.			X		
6	Inspect the mechanical seal for leaks.			X		
7	If the SPS™ unit is equipped with a thrust chamber cooling system, inspect the cooling system for leaks and clean the radiator.			X		
8	If the SPS™ unit is equipped with a thrust chamber cooling system, replace the oil in the oil cooling system.					X

**Table 6: Recommended/Minimum Maintenance Schedule (cont'd.)**

Task	Task Description	Daily	Monthly	Quarterly	Semiannual	Annually
9	Standard Duty Thrust Chamber (slinger rings)—Check the thrust chamber and thrust chamber cooling system oil levels.			X <sup>1</sup>		
10	Standard Duty Thrust Chamber (oil injection)—Check the thrust chamber and thrust chamber cooling system oil levels and perform oil cooling system oil analysis.			X		
11	Heavy Duty and Extreme Duty Thrust Chambers—Check the thrust chamber and thrust chamber cooling system oil levels and perform oil cooling system oil analysis.			X		
12	If the SPS™ unit is equipped with electric motor bearings lubricated with oil, change the oil.	Follow manufacturers recommendations.				
13	Inspect the frame for damage due to external forces.			X		

**Table 6: Recommended/Minimum Maintenance Schedule (cont'd.)**

Task	Task Description	Daily	Monthly	Quarterly	Semiannual	Annually
14	Inspect the SPS™ unit for cleanliness especially the electric motor fins, thrust chamber, and mechanical seal.			X		
15	If the electric motor bearings are lubricated with grease, lubricate the bearings in accordance to the specified motor manufacture recommendations.	Follow Manufacturers Recommendations				
16	If the SPS™ unit runs on intermittent duty and the unit does not have a thrust chamber cooling system, change the thrust chamber oil.			X		
17	Change the thrust chamber oil regardless of accessories.				X	
18	If the SPS™ unit is equipped with a lubricated coupling, inspect the coupling for the grease leaks.			X		
<sup>1</sup> Or 2,200 hours, whichever occurs first.						

### 7.3 Recommissioning Procedures

The following recommissioning procedures should be performed before any idle SPS™ unit is placed back into service.

1. Purge the system.
2. Re-plumb Heavy-Duty Thrust Chamber (HDTC) and Standard (STD) INJ.
3. Reset thrust chamber oil levels. Refer to [Section 6.2 Thrust Chamber Lubrication](#) [Thrust Chamber Lubrication, page 36](#) for more information.
4. If applicable, remove heater blankets.
5. Follow standard start up procedures. Refer to [Section 6.4 SPS Start-Up](#) [SPS Start-Up, page 39](#) for more information.

### 7.4 SPS™ Installation and Service Report



*A field service report should be started before any work is done on an SPS™ unit. This will help maintain a good service record and act as a reminder for commissioning and maintenance steps performed on the unit.*

## 8 Storage Procedures

### 8.1 New Pump Storage Procedures



***Failure to perform all necessary safety precautions before beginning work may cause damage to equipment, personal injury or death.***

#### 8.1.1 Short-Term Storage Procedures (0 to 90 Days)

1. Partial fill with 75%/25% glycol/water mixture standard from factory.
2. Energize space heaters.

3. On units equipped with a standard thrust chamber (SDTC), remove the shipping stems and install short bolts and washers located in the junction box. Retain the shipping stems for future shipment.



• **CAUTION**

**Do not throw the shipping stems away. If the unit has to be transported to another location, these stems will have to be reinstalled before shipping. Shipping the unit without the shipping stems will damage the equipment.**

4. Rotate the pump/motor monthly (10 revolutions) making sure the pump spins freely.
5. Make sure proper oil levels are maintained in the thrust chamber. Refer to [Section 6.2 Thrust Chamber Lubrication](#) for more information.
6. Follow motor manufacturer's requirements related to short-term storage.
7. Protect the system from freezing.

### 8.1.2 Long-Term Storage Procedures (Over 90 Days)

In addition to all short-term procedures the following steps should be completed when storing an SPS™ unit for more than 90 days.

1. Fill thrust chamber with proper specified oil levels. Refer to [Section 6.2 Thrust Chamber Lubrication](#) for more information.
  - a. For standard-duty thrust chamber (SDTC):
    - i. Fill oil level no lower than the middle of the ball bearings and no higher than the bottom of the inner race on the 7315 ball bearings.
    - ii. Remove the sight glass and spray the inside of the thrust chamber with Morlina S4 B68 oil.
    - iii. Replace sight glass taking care not to damage gasket.
    - iv. Oil leaks may result if overfilled.
  - b. For heavy-duty thrust chamber (HDTC) and Oil Injected SDTC:
    - i. Remove oil return line from the bottom of the thrust chamber and plug (typically 1-1/4" NPT).
    - ii. Fill oil level no lower than the middle of the ball bearings and no higher than the bottom of the inner race on the 7315 ball bearing. Refer to [Section 6.2 Thrust Chamber Lubrication](#) for more information.
    - iii. Remove the sight glass and spray the inside of the thrust chamber with Morlina S4 B68.
    - iv. Replace sight glass taking care not to damage the gasket.
    - v. Oil leaks may result if overfilled.

- vi. If applicable to your installation, energize the immersion heater for thrust chamber reservoir. If an immersion heater is not available, install a heater blanket around the thrust chamber reservoir.
- c. For extreme-duty thrust chamber (XDTC) maintain oil fill from factory.
  - i. Energize the immersion heater for thrust chamber reservoir. If an immersion heater is not available, install a heater blanket around the thrust chamber reservoir.
  - ii. Follow lube system manufacturer's requirements for long-term storage.
  - iii. Protect the system from freezing.

## 8.2 Commissioning



*The commissioning procedure is only a summary, for the complete instructions for commissioning refer to SPS Form F-480.*

1. Purge the thrust chamber oil system.
2. Re-plumb the HDTC and SDTC spray mister system if equipped.
3. Reset thrust chamber oil levels. Refer to [Section 6.2 Thrust Chamber Lubrication](#) [Thrust Chamber Lubrication, page 36](#) for more information.
4. If present, remove heater blankets.
5. Follow standard startup procedures. Refer to [Section 6.4 SPS Start-Up](#) [SPS Start-Up, page 39](#) for more information.

## 8.3 Decommissioning

### 8.3.1 Short-Term (0 to 14 Days)

1. Pump must remain flooded with glycol or rust inhibitor.
2. Do not allow air to enter the system.
3. Lock out power supply to motor.
4. Protect the system from freezing.



**Important Note:** A Lock-out tag must be employed prior to any service. Failure of the main control could allow an unexpected start under various scenarios including reenergize after power interruption. The use of Lock-out tags and E-stops will eliminate the potential of the operations control system failing under service mode. E-stops as well as control system guidelines are provided according to what is included in the scope of supply of the SPS system. Site Risk assessments must be completed prior to operation.

### 8.3.2 Long-Term (14 to 90 Days)

1. Isolate pump from the process and purge the system.
2. Flush and fill with 75% glycol.
3. Rotate pump and motor weekly (10 revolutions) making sure pump spins freely.
4. Maintain the proper thrust chamber lube levels. Refer to [Section 6.2 Thrust Chamber Lubrication](#) for more information.
5. Lock out power supply to motor.
6. Follow manufacturer's recommended long-term storage procedures for the motor.
7. Protect the system from freezing.



**Important Note:** A Lock-out tag must be employed prior to any service. Failure of the main control could allow an unexpected start under various scenarios including reenergize after power interruption. The use of Lock-out tags and E-stops will eliminate the potential of the operations control system failing under service mode. E-stops as well as control system guidelines are provided according to what is included in the scope of supply of the SPS system. Site Risk assessments must be completed prior to operation.

### 8.3.3 Long-Term (Over 90 Days)

1. Follow all decommissioning procedures in [Section 8.3.1 Short-Term \(0 to 14 Days\) Short-Term \(0 to 14 Days\), page 50](#) and [Section 8.3.2 Long-Term \(14 to 90 Days\)Long-Term \(14 to 90 Days\), page 51](#).
2. Follow manufacturer's recommended long-term storage procedures for the motor.
3. Protect the system from freezing.

### 8.4 Recommissioning

1. Purge system.
2. Re-plumb thrust chamber and STD INJ, if applicable.
3. Reset thrust chamber oil levels. Refer to [Section 6.2 Thrust Chamber LubricationThrust Chamber Lubrication, page 36](#) for more information.
4. If applicable to your installation, remove heater blankets.
5. Follow standard startup procedures. Refer to [Section 6.4 SPS Start-UpSPS Start-Up, page 39](#) for more information.

## 9 Troubleshooting



**Important Note:** A Lock-out tag must be employed prior to any service. Failure of the main control could allow and unexpected start under various scenarios including reenergize after power interruption. The use of Lock-out tags and E-stops will eliminate the potential of the operations control system failing under service mode. E-stops as well as control system guidelines are provided according to what is included in the scope of supply of the SPS system. Site Risk assessments must be completed prior to operation.



**Important Notice:** Make sure to read the MSDS of the fluids used for lubrication before attempting to work with them. always consult with your supervisor if you have any questions.

## 9.1 Basics of Troubleshooting

### 9.1.1 General Troubleshooting

Much of the work performed by technicians involves the maintenance and repair of equipment and systems. Technicians must have a good knowledge of what is commonly referred to as troubleshooting to make sure the equipment and systems operate at their peak performance.

Troubleshooting is the ability to determine the root cause of the problem and finding the solution to correct it. Troubleshooting covers a wide range of problems from the standard oil changes, finding a short circuit or tracing a defect in a complex SPS™ system. The same basic principles are used in all cases. Troubleshooting requires a technician with a thorough knowledge of electrical, hydraulic, and mechanical theory combined with a systematic and methodical approach to find and correct a problem.

### 9.1.2 Basics of Troubleshooting

The following general principles and tips will help with the troubleshooting process:

- Think before acting.
- Thoroughly study the symptoms of the problem and ask the following questions:
  - Were there warning signs preceding the trouble?
  - Were there any previous repairs or maintenance performed?
  - Is the unit or component still operational and is it safe to continue operation before further testing?
- Answers to these questions can be obtained by the following:
  - Question the owner or operator of the equipment.
  - Take the time to think the problem through.
  - Look for additional symptoms.
  - Consult troubleshooting tables in this section.
  - Check the simple things first.
  - Refer to the repair and maintenance records.
  - Always use calibrated instruments.

### 9.1.3 Find and Correct the Problem

The source of a problem cannot always be traced back to a single component alone but to the relationship of that component and its interaction with other components of the system. Make sure all symptoms have been checked to prevent unnecessary work. There could be an easy solution to the problem that will prevent a major tear down.

Use the troubleshooting tables provided in this manual to help diagnose problems that may occur. Remember there are many variations and solutions that can occur. It is suggested a strict preventive and corrective maintenance schedule is followed and recorded to help with the diagnosis of possible problems.

After the symptoms of the problem have been thoroughly investigated, make sure to correct the cause of the problem to prevent repeated failures.

## 9.2 Troubleshooting: Symptoms, Categorized by Component

[Table 7: Pump Symptoms, page 54](#) through [Table 13: Motor Coupling Symptoms, page 55](#) outline possible symptoms to investigate. The possible causes are coded and listed in [Table 14: Causes, Comments and Remedies, page 56](#).

**Table 7: Pump Symptoms**

Pump Symptoms	Possible Causes
Vibration	C, PP, S, DD, GG, F, U
Noise	C, PP, DD
Change in performance (pressure, flow rate)	PP, C, DD, E, V, JJ, P
High housing temperature (too hot to touch)	D, DD
Locked rotor	L, HH, DD
Leak	CC, J, F, EE, Q

**Table 8: Thrust Chamber Symptoms**

Thrust Chamber Symptoms	Possible Causes
Over temperature (measured by thrust chamber thermocouple, more than a 110° F rise over ambient temperature)	NN, X, Y, Z, AA, B
Vibration	B, Also refer to pump section
Noise	B, A, AA, X, Y, Z
Locked rotor	AA, Also refer to pump section
Leak	BB, CC, KK, II, AA
Oil discolored	W, Z, A, AA

**Table 9: Motor Symptoms**

Motor Symptoms	Possible Causes
Vibration	OO, S, U, Q
Windings over temperature (if equipped with temperature detector), motor running above nameplate amperage	FF, DD, PP
Vibration	B, N, T

**Table 10: Suction Chamber/Intake Symptoms**

Suction Chamber/Intake Symptoms	Possible Causes
Leak	R, CC, F
Noise	K, Also refer to pump section
Vibration	Refer to pump and thrust chamber sections

**Table 11: Frame Symptoms**

Frame Symptom	Possible Causes
Vibration	Refer to pump and thrust chamber sections

**Table 12: Instrumentation Symptoms**

Instrumentation Symptoms	Possible Causes
Shutdown on high discharge pressure	E, LL, MM, K
Shutdown on low discharge pressure	E, M, V, O, P, QQ
Shutdown on high suction pressure	E, MM, LL
Shutdown on low suction pressure	E, O, V, M, P, QQ
Shutdown on high vibration	qq, Refer to motor, thrust chamber, and pump sections
NOTE: Also verify all settings on switches are correct.	

**Table 13: Motor Coupling Symptoms**

Motor Coupling Symptoms	Possible Causes
Leak	CC, J, G, Q
Noise	S, Q, H, I

### 9.3 Troubleshooting: Causes, Comments, and Remedies

Table 14: Causes, Comments and Remedies

Code letter	Cause	Comment	Remedy
A	Bearing cages melted.	Typically black plastic particles will be found in the lubricant. Check also for items 1, 3, and 6 under thrust chamber section.	Replace thrust chamber.
B	Bearings are worn.	Refers to rolling element bearings in the motor and thrust chamber.	Replace thrust chamber or service motor (depending on where the problem is).
C	Cavitations.	Typically identified by noise near the pump base. Impeller vanes are processing a mixture of gas/liquid.	Increase suction pressure until the problem goes away.
D	Choke/Discharge valve closed.	This can destroy a pump quickly.	Set the valve properly.
E	Choke/Discharge valve not properly set.		Set the valve properly.
F	Corrosion.	This can occur in the pump head/base, the pump housing, the pump stages, and the intake parts.	Replace corroded components if possible.
G	Coupling grease plug missing.	Check for coupling wear	Install grease plug.
H	Coupling is worn.	Typically wear can be seen in the coupling gears and steel grid (if it is a flexible type coupling).	Replace coupling.
I	Coupling lacks grease.	Also check for wear.	Replace coupling if worn, otherwise re-grease coupling.
J	Flange gasket failure.	If it is a motor coupling leak, check also for coupling wear.	Replace gasket.

**Table 14: Causes, Comments and Remedies (cont'd.)**

Code letter	Cause	Comment	Remedy
K	Foreign objects stuck in flow path.		Clear flow path.
L	Frozen pump.		Heat up the pump until it is able to turn.
M	Insufficient discharge line back-pressure.		To be decided by customer, typically a valve can be adjusted.
N	Insufficient motor bearing grease.		Re-grease, if symptom still exists have motor serviced.
O	Insufficient suction line pressure.		Increase suction line pressure.
P	Leak in pipe work.		Fix leaks.
Q	Loose screws or bolts.		Tighten applicable screws, bolts.
R	Mechanical seal failure.		Replace seal.
S	Misalignment.	Will see high (greater than 1X amplitude) 2X vibration, 2 critical points are between the pump base and intake, and between the motor and thrust chamber.	Check motor for soft foot condition, check alignment, make adjustments as necessary.
T	Motor bearing grease needs changing.		Re-grease, if symptom still exists have motor serviced.
U	Motor rotor unbalance.	Motor 1X vibration on the bearing housings in the radial direction more than 0.2 in./sec peak.	Have motor serviced
V	No flow to pump.	Check for pump vibration and for mechanical seal leaks after the problem is fixed.	Verify proper flow to pump.
W	Oil is emulsified.		Change oil.

**Table 14: Causes, Comments and Remedies (cont'd.)**

Code letter	Cause	Comment	Remedy
X	Oil level too high.	Check for foreign particles in existing oil. Change thrust chamber if necessary.	Fill thrust chamber at proper oil level. Refer to <a href="#">Section 6.2 Thrust Chamber LubricationThrust Chamber Lubrication, page 36</a> for more information.
Y	Oil level too low.	Check for noise and for foreign particles in existing oil. Change thrust chamber, if necessary.	Refer to <a href="#">Section 6.2 Thrust Chamber LubricationThrust Chamber Lubrication, page 36</a> for more information.
Z	Oil needs to be changed.		Refer to <a href="#">Section 6.2 Thrust Chamber LubricationThrust Chamber Lubrication, page 36</a> for more information.
AA	Oil-ring stems not properly set.	Check for foreign particles in existing oil. Change thrust chamber if necessary.	Set stems properly.
BB	Oil seal failure.		Replace oil seal.
CC	O-ring failure.		Replace O-ring.
DD	Plugged pump.		Consult factory.
EE	Pump housing over pressure.	Pump discharge pressure equals housing pressure (see technical catalog for housing pressure limit).	Lower pump discharge pressure immediately, consult factory.
FF	Pump is not operating at proper point.		Make adjustments (speed, valve) to get the pump operating properly.

**Table 14: Causes, Comments and Remedies (cont'd.)**

Code letter	Cause	Comment	Remedy
GG	Resonance.	Vibration will be maximum at a certain speed (can check, if equipped with variable speed drive).	Consult factory.
HH	Rusted pump.	Occurs when pump has been idle for more than several months.	Consult factory.
II	Sight glass not tight.	Also check oil level.	Tighten sight glass.
JJ	Speed change.	Applicable to units run on variable speed drives.	Determine why speed was changed.
KK	Thrust chamber ball valve not closed.		Close valve.
LL	Too much discharge line back-pressure.		See remedy for "m".
MM	Too much suction line pressure.		See remedy for "m".
NN	Too much thrust.		See "ff".
OO	Unbalanced phase voltages.	Determine if the problem is in the supply line or in the motor.	Correcting a problem in the motor requires motor to be serviced.
PP	Worn pump.	increasing vibration trend (primarily in 1X) with reduction in performance	Consult factory.
QQ	Time delay relay on control panel not properly set.	Unit may not start due to low suction and discharge pressure, and high vibration at the start. Time delay relay is needed to bypass the switches at the startup.	Set time delay relay properly.



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