JET Manual 23 Fracturing Pump Units, SPF/SPS-343

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1.0 Introduction

This JET manual is to familiarize you with the theory and operational procedures of this unit. Both one-on-one training and classroom instruction are required to provide the information you need to properly and safely operate this piece of equipment. This and several other trailer/skid units have many similarities, so you can apply what you learn to those units as well.

The SPF/SPS-343 fracturing pumper may be float- or trailer-mounted (SPF: stimulation pumping float) or on a skid (SPS: stimulation pumping skid) configuration. It is designed and used for high-horsepower fracturing applications. The single triplex pump delivers fracturing fluids to the well at high pressures and rates.

The unit can be delivered with any of the Schlumberger OPI-type fluid ends, depending on the rate and pressure requirements in the user’s market. These fluid ends can be readily changed if needed to get required pressures and rates.

The unit may be equipped with a remote control panel (operable up to 125 ft away), touch screen daisy chain cable control, or wireless touch screen control. From this panel/touch screens, brake, start/stop, throttle control, gear selection, pump instant idle, and emergency shutdown can be performed.

Pump pressures and rates, along with various warning indicators are displayed on both panel designs. The touch screen panels, upon request, will also display the readings for all major components like temperature and pressure.

1.1 Learning objectives

Upon completion of this training, you should be able to understand the following:

- safety requirements for Department of Transportation (DOT), Service Quality and unit operation limits
- proper pre- and posttrip requirements per Schlumberger’s STC-3039G Drivers Trip Report for both chassis and auxiliary systems
- the differences between a trailer-mounted and a skid-mounted unit and what purposes they are designed for
- the differences between the MTU/DDC Detroit diesel and the 3512B Caterpillar 2250 brake horsepower engines
- the proper pre- and posttrip process per DOT and service quality requirements
- panel application differences between the remote control and touch screen panels, (wired and wireless configurations)
- deck engine starting procedures and warmup applications
- awareness of all displays and warning devices such as fluid-end pressure and pump rate modules, lock-up clutch light, and major component sensor warning lights
- proper transmission shift procedures
- recognition of transmission proper lockup operation
- proper prime-up procedures according to Safety Standard 5.12 and 5.12.1
- proper pressure test procedures according to Safety Standard 5.13.2
• recognition of loss of prime
• recognition of pump cavitation
• fluid end sizes for the GD 2250 and the SPT-TWS-2250 power-ends
• pressure and rate limitation of all fluid-ends per plunger diameters
• pump curves for proper pressure and rate requirements per job design
• configuration of suction and discharge hoses corresponding to nipple and clamp design per Well Services Safety Standard 5
• rate and pressure for all suction and discharge hoses and their application in the low pressure treating process per Well Services Safety Standard 5
• rate and pressure limitation for respective treating pipe diameters per Well Services Safety Standard 5.
2.0 Safety

Wellsite processes are very dangerous and require attention at all times.

Personal protective equipment (PPE) as described in Standard 5 of the Safety and Loss Prevention Manual is required while on location.

Parking brakes must be set and wheels must be chocked when trailer-mounted units are spotted on location. Fire extinguishers must be placed on the ground at the front of the unit before starting the job.

The potential for slips, trips, and falls are present climbing on and off the unit, near hoses and treating lines on the ground, and at the wellhead.

NO ONE can place a pump in gear or start prime up or pressure testing, without direct instructions from the service supervisor.

Prime-up and pressure tests are very dangerous and must only be performed by properly trained personnel when directed by the supervisor.

Only properly trained persons are allowed in the high-pressure treating area. Minimize time in high-pressure areas to as little as necessary to perform the duties required; stay out of these areas at all other times. Persons in this area must wear a working radio at all times. Be aware of rotating parts such as drive lines, drive belts, and plungers in motion. These are all hazardous pinch points.

Warning: Be sure the unit is stopped and locked out before performing any service.

Before servicing valves, seats, or plunger packing, the unit must be

- brought to idle
- placed in neutral
- brake set, engine shut down
- treating line discharge valves closed
- treating pressure bled off the unit.

Never use suction hoses on the discharge side of the blender going to the triplex pump. These hoses will not meet the minimum burst requirements for the discharge hoses. Suction hoses have a single knobbed nipple and single clamps on each end. These hoses are referred to as hard hoses.

Be aware of hot fluids and gases from exhaust, cooling, lubrication, and hydraulic systems. Touching a pipe or a hose, or approaching failures of these systems, may cause either chemical and heat burns or both.

Dangers in relation to fluid-end disassembly can be chemical burns, impact from hammers, slips, trips or falls, injury to the eyes, or cuts from sharp areas on valve covers and threads.

Filling packing lubrication systems may also expose the operator to hazards from slips, trips, and falls. The packing lubrication reservoir may be pressurized and must be bled before removing the fill cap for filling.
2.1 Location safety

**Note:**
Personal safety is described in Well Services Safety Standard 5, sections 5.8 through 5.8.2.3

The PPE minimum requirements are

- fire-retardant uniforms: long-sleeved NOMEX™, with sleeves rolled down (Dale coveralls must NOT be worn by Well Services personnel because they lose fire retardant properties after exposure to certain chemicals, OFS QHSE S003).
- hard hat
- safety glasses with side shields
- steel-toed boots
- hearing protection
- appropriate additional PPE, depending on the types of fluids or chemicals in use.

Review all the information in Well Services Safety Standard 5, sections 5.8 to 5.8.1.3, to understand your personal responsibility for your own safety.

Additional personal restrictions include

- no finger rings
- no contact lens
- no wrist chains
- no ungroomed facial hair (when breathing apparatus (SCBA) is required, facial hair must be groomed to ensure a proper fit).

2.2 Pressure pumping safety

**Note:**
Fracturing involves pressures up to 20,000 psi. These pressures must never be taken for granted. Safety standards must be closely followed when dealing with the 343 fracturing pump, the hoses, and high-pressure components. The parameters of high-pressure pumping, treating iron components, and both suction and discharge hoses from the blender can be found in Standard 5 of the Well Services Field Safety Handbook in 5.9 to 5.13.4.

Review Safety Standard 5 sections 5.5.4, 5.6.4, 5.7.1.1, 5.7.1.3, 5.7.4 to 5.8.1.3, 5.10, and 5.11 in the Well Services Field Safety Handbook to understand your personal responsibility for the safe operation of the SPF-343 fracturing pump.

<table>
<thead>
<tr>
<th>Safety Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5.4</td>
<td>Responsibilities of all employees</td>
</tr>
<tr>
<td>5.6.4</td>
<td>( \text{H}_2\text{S} ) (Hydrogen Sulfide Gas)</td>
</tr>
<tr>
<td>5.7.1.1</td>
<td>Fluid ends</td>
</tr>
<tr>
<td>5.7.1.3</td>
<td>High-pressure hammer valves</td>
</tr>
<tr>
<td>5.7.4</td>
<td>Unit safety equipment</td>
</tr>
<tr>
<td>5.8.1.3</td>
<td>Additional personal safety requirements</td>
</tr>
<tr>
<td>5.10</td>
<td>Suction and discharge hoses for fluid supply</td>
</tr>
<tr>
<td>5.11</td>
<td>High-pressure rig up</td>
</tr>
</tbody>
</table>
2.3 Personal and operational safety

You, more than anyone else are responsible for your personal safety. Complete understanding of all the items listed above are required before operating the SPF/SPS-343 fracturing pump.

Safety training requirements are:

- one-on-one training from a certified SPF/SPS-343 fracturing pump operator
- personal review of all location requirements listed above for this manual as listed in Well Services Safety Standard 5
- personal proper rigup of the SPF/SPS-343 fracturing pump on location
- a thorough understanding of the purpose and operation of the overpressure shutdown
- operation of the SPF/SPS-343 fracturing pump with a certified operator in your presence at all times for not less than five jobs.
The Caterpillar unit of the SPF/SPS 343 fracturing pump is shown in Figs. 3-1 through 3-4. The Detroit Diesel version is shown in Figs. 3-5 through 3-8.
Figures 3-9 through 3-12 show the Caterpillar skid unit.

Figure 3-9. SPS-343 Caterpillar Skid Unit, Side View

Figure 3-10. SPS-343 Caterpillar Skid Unit, Front View

Figure 3-11. SPS-343 Caterpillar Skid Unit, Side View 2
### 3.1 Applications for the unit

This unit has numerous applications, including well stimulation processes: fracturing, acidizing, coiled tubing, and carbon dioxide (CO₂) services, or in industrial service applications.

It can operate with pressures from 0 to 15,000 psi (0 to 103.4 MPa). It can also perform special services that include special fluid ends and treating pipe at pressures up to 20,000 psi (137.9 MPa).

The fracturing pump can pump at rates from 0 to 28.3 bbl/min (0 to 4.5 m³/min).

### 3.2 Unit specifications

The SPF/SPS 343 fracturing pump has the specifications listed in Table 3-1.

#### Table 3-1. Unit Specifications

<table>
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<th>Deck Trailer</th>
<th>Skid</th>
</tr>
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<tr>
<td>Single drop with air-bag suspension</td>
<td>NA</td>
</tr>
<tr>
<td>Engine:</td>
<td></td>
</tr>
<tr>
<td>MTU/DDC 4000 SCCC or Caterpillar 3512 B</td>
<td>Caterpillar 3512 B</td>
</tr>
<tr>
<td>12 cylinder, 2250 brake horsepower</td>
<td>Same</td>
</tr>
<tr>
<td>Transmission: Allison S9800M with 8th gear locked out</td>
<td>Same</td>
</tr>
<tr>
<td>Triplex pump: GD 2250 or SPM TWS 2250 power end</td>
<td>Same</td>
</tr>
<tr>
<td>OPI type fluid ends: 3.75 in, 4.5 in, 5 in, 5.5 in, 6.5 in, and 6.75 in</td>
<td>Same</td>
</tr>
<tr>
<td>Rated hhp: 2,000 hhp (1492 kw)</td>
<td>Same</td>
</tr>
<tr>
<td>Length: 42 ft, 7 in (13.0 m)- bare trailer 26 ft (7.92 m)</td>
<td>26 ft (7.92 m)</td>
</tr>
<tr>
<td>Width: 8 ft, 6 in (2.599 m)</td>
<td>8 ft (2.44 m)</td>
</tr>
<tr>
<td>Height: 12 ft, 9 in (3.98 m) 12 ft (3.7 m)</td>
<td>12 ft (3.7 m)</td>
</tr>
<tr>
<td>Weight: 82,000 lbm (37,196 kg) 40,100 lbm (22,679 kg)</td>
<td>40,100 lbm (22,697kg)</td>
</tr>
<tr>
<td>24-V battery provides the control system power. 12-VDC is provided to control the system by center tapping the battery bank.</td>
<td>Same</td>
</tr>
</tbody>
</table>
4.0 Electrical Power System

The main components in the electrical system are

- batteries
- main electrical junction box
- main control console
- main/daisy control cable
- 24-V power supply converter
- gauge panel, including mechanical, fluid-filled switch gauges
- cable and loom
- pressure transducer
- emergency shutdown system.

4.1 Control panels

There are two types of control panels for the SPF/SPS 343 fracturing pump:

- universal operator’s remote control console (UORCC)
- touch screen operator’s remote control console (FPC).

Both the UORCC and the FPC allow the operator to operate and control the SPF/SPS fracturing pump and the truck/pony motor.

The FPC differs from the UORCC only in that it has touch screen monitors and controls that allow the operator to control the unit simply by touching the labeled item, i.e., the sixth gear of the transmission can be selected simply by touching the sixth gear button on the transmission control area of the panel. The throttle is controlled by a touch point slide bar and can be either increased or decreased by sliding your finger up or down. In addition, this panel can monitor and control from one to eight pumps.

4.2 Emergency kill switch

The emergency kill switch is a two-position toggle switch, which immediately shuts off the fuel and air supply to the deck engine, resulting in system shutdown. To activate this switch, the red switch guard (which prevents accidental shutdown) must be lifted and the switch moved up. Emergency shutdown will work even if the master power switch is off.

Note:
To reset after an emergency shutdown, you must manually open the air intake shutoff flapper valves and cycle the main J-box power switch and the ORCC main power switch for at least 15 sec.

4.3 Master power switch

The master power switch is a two-position toggle switch. This switch is the power switch for the operator’s remote control console. Activating this switch also turns the power on/off to certain auxiliary devices; it does not affect operation of the emergency kill system.

4.4 Deck start/run kill switch

The deck start/run kill switch is a three-position toggle switch, center off. When it is up, it establishes contact momentarily, allowing the engine to crank. When it is down, the engine is
stopped. This switch starts and stops the deck engine.

4.5 Deck rpm control switch
The deck rpm control switch is a rotary control knob used to control the speed of the deck engine. Turning the knob clockwise will increase engine speed.

A reset-start switch is an integral part of the throttle control assembly. This switch returns the engine to idle speed and resets the throttle control if an overpressure or neutral tripped condition occurs. This process prevents the hazard of immediately returning to full throttle speed once the overpressure or neutral tripped condition has been corrected.

The throttle control must be turned counterclockwise to the idle position to reset and then clockwise to accelerate the engine and resume pumping conditions.

4.6 Gear selector switch
The gear selector shift is a rotary, eight-position switch used to select the deck transmission gearing. The actuator’s knob must be pushed in to allow gear selection. Pushing the knob automatically activates the down shift enable (lock-up inhibit) solenoid. This solenoid causes the transmission to go into the converter phase, reducing shock load on the transmission when the shift occurs.

Note: Tech Alert 2000-03, Shifting of gears: Power shifting the transmission should be avoided. Take the transmission out of lock-up (decrease engine speed) before shifting gears.

4.7 Pump brake switch
The pump brake is a two-position toggle switch with the off (downward) position locked and maintained. The switch lever must be lifted and moved upward to on to engage the pump brake. This switch is only active while the gear selector is in neutral. In addition, starting the deck engine is not possible with the pump switch on.

Note: When the pump brake is turned on, the pump packing lubrication system is automatically turned off.

4.8 Instant neutral/line test switch
This is a three-position, center off, toggle switch. The upward instant neutral position establishes contact momentarily; the other two switch positions maintain contact. Moving this switch upward into the instant neutral position moves the deck transmission immediately to neutral, brings the deck engine’s speed to idle, and illuminates the neutral tripped light.

The neutral tripped light remains illuminated until the neutral tripped condition is reset. To reset a neutral tripped condition, the reset/start switch must be activated with the deck rpm control by rotating the knob counterclockwise all the way to idle. This action will turn off the neutral tripped light and allow the transmission to return to the selected gear.

Note: When the pump brake is turned on, the pump packing lubrication system is automatically turned off.

To reset an overpressure shutdown condition, the reset button on the pressure module must
be pressed and the deck rpm control moved to the reset/start position.

Moving the switch downward to the line position activates the downshift enable (lockup inhibit) solenoid. Since the line test position of the switch is maintained, it is a continuous signal and places the transmission into the converter phase. This position is used during prejob testing for leaks in the treating line.

To accomplish the line test, the operator places the switch in the line test position, selects the fifth gear position and allows the transmission to stall, moves the gearshift selector to neutral position, and rapidly moves from neutral to first repeatedly until line test pressure is achieved. If line test pressure cannot be reached, it may be necessary to raise the deck engine throttle in increments of 100 rpm until the line test pressure can be reached.

4.9 Lamp test switch
The lamp test switch is a two-position toggle switch. The upward on position establishes contact momentarily. Moving this switch to on powers all warning/indication lights on the remote panel.

4.10 Discharge pressure module
This discharge pressure module provides a digital display in pounds per square inch for pump discharge pressure and provides overpressure shutdown protection. The user configures the discharge module. The overpressure trip point can be selected by using this module. This module also allows the user to calibrate the fluid end pressure transducer. For more information, please see the ERAD literature.

4.11 Pump rate/engine speed module
The pump rate/engine tachometer module digitally displays the pump rate and the deck engine speed. The pump rate/engine tachometer module of the pump rate and the fluid end K factor and the rpm calibration factor can be stored directly in the modules memory. The fluid end K factor is variable depending on the particular unit’s fluid end/pump calibration.

See Table 4-1 for pump K factors. For more information, see the ERAD literature.

<table>
<thead>
<tr>
<th>Fluid End Size</th>
<th>Max Pressure psi (Mpa)</th>
<th>ERAD Pump K-Factor</th>
<th>Pump Rate</th>
<th>Engine Tach</th>
<th>ERAD Test Value (60HZ) FracCAT K Factor (mbbl/pulse)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 3/4 JOPI</td>
<td>6,500 (44.8)</td>
<td>591.8</td>
<td>6.08</td>
<td>23</td>
<td>1.68947</td>
</tr>
<tr>
<td>6 1/2 UOPI</td>
<td>7,000 (48.3)</td>
<td>638.2</td>
<td>5.64</td>
<td>23</td>
<td>1.56664</td>
</tr>
<tr>
<td>5 1/2 IOPI</td>
<td>10,000 (69.0)</td>
<td>891.3</td>
<td>4.04</td>
<td>23</td>
<td>1.12168</td>
</tr>
<tr>
<td>5.0 HOPI</td>
<td>12,000 (82.7)</td>
<td>1078.5</td>
<td>3.34</td>
<td>23</td>
<td>0.92701</td>
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<tr>
<td>4 1/2 EOPI</td>
<td>15,000 (103.4)</td>
<td>1331.5</td>
<td>2.7</td>
<td>23</td>
<td>0.75088</td>
</tr>
<tr>
<td>3 3/4 FOPI</td>
<td>20,000 (137.9)</td>
<td>1917.3</td>
<td>1.88</td>
<td>23</td>
<td>0.52144</td>
</tr>
</tbody>
</table>
4.12 Deck engine warning light

Note:
The red deck engine warning light indicates that something is abnormal with the deck engine or some of its subcomponents. The set points for each of these conditions are determined by the electronic control module (ECM).

The set points for each warning condition are as follows:

- deck engine warning light: low oil pressure less than 7 psi @ 600 rpm, or less than 26 psi @ 1,900 rpm
- high jacket water coolant: temperature greater than 216 degF (102 degC)
- high engine coolant: temperature greater than 216 degF (102 degC)
- low voltage less than 20 V
- low jacket water coolant: temperature less than 149 degF (65 degC), with average engine load greater than 20% for the last 10 minutes
- over speed: speed greater than 2,242 rpm (this speed will also shut down the engine)
- air inlet (filter) restriction: greater than 28 in H2O
- high exhaust temperature: temperature greater than 1,393 degF (756 degC)
- high differential pressure: pressure across oil filters greater than 15 psi
- high differential pressure: pressure across fuel filters greater than 10 psi
- high crankcase pressure: pressure greater than 8 in of H2O

Note:
The light operates via pressure/temperature transducers that supply information to the ECM. A 1-A circuit breaker shields the ECM from electrical damage. The ECM can only source 250 mA for this light.

4.13 Deck transmission/pump warning lights

Note:
The red deck transmission/pump warning light indicates low oil pressure or high temperature of the transmission/pump. These lights are also illuminated if the transmission filters go into bypass mode, indicating filter restriction.

These lights operate via pressure/temperature switches on the gauges themselves, plumbed directly into the transmission and pump. These switches do not have adjustable set points.

The set points for these conditions are as follows:

- transmission
  - transmission oil pressure: 30 psi
  - high oil temperature: 230 degF
  - filter differential pressure: 35 psi
• pump
  o low pump oil pressure: <30 psi
  o high pump oil temperature: >151 degF.

**Note:**
The transmission oil pressure to varies according to the engine type used.

### 4.14 Neutral trip warning light

The red neutral trip warning light indicates that the deck transmission has been set to neutral because of a fault condition. This light will be illuminated if pump discharge overpressure is sensed by the discharge module, the emergency kill/remote kill is initiated by the discharge module, or the operator manually selects instant neutral on the instant neutral toggle switch.

To turn this light off in case of an instant neutral condition, the deck engine speed control knob must be turned counterclockwise past the reset/start position. To turn this light off in case of overpressure, emergency kill, or remote kill conditions, the reset button on the ERAD must be pressed and the reset/start of the deck rpm control must be set.

### 4.15 Converter lock-up indicator light

The amber converter lock-up light indicates when the deck transmission has shifted into the lock-up mode. This occurs at approximately 1400 rpm. If the light is off, the transmission is operating in the converter mode. On the touch screen panel, the indicator light is for lock-up and for the converter phase.

**Warning:**
It is very important not to operate the transmission under load for more than 30 sec in the converter phase because damage to the transmission will result.

### 4.16 Line test indication light

The line test indication light is an amber light that indicates that the instant neutral/line test is set to the line test position. The deck transmission is operating in continuous converter mode for the line test.

### 4.17 Panel illumination lights

Two panel illumination lights are on the face of the operator’s remote control console.

### 4.18 FracCAT cable connector

The FracCAT* fracturing computer-aided treatment system cable connector is a 4-pin, Jupiter connector to the job recording. The connector is located on the bottom of the operator’s remote control panel next to the remote control cable. This connector is used for pump rate recording and remote kill.

### 4.19 Remote control cable connector

The remote cable connector is a 37-pin connector to a mating connector on the 125-ft (38.1-m) remote control cable provided with the unit. The connector is located on the left side of the main junction box towards the bottom.

Daisy-chain remote control cable control connections are located on the right side of the main junction box about the middle of the right side, and are used with the touch screen control panel.
4.20 Main junction box

The main junction box houses the central wiring junction point for relays for logic switching functions. The inside of the main junction box also contains the following:

- The engine hour meter shows the total hours the engine has run.
- The engine warning light will illuminate only when there is a problem with the engine. A qualified technician can use the CAT ET to aid in deck engine diagnostics.
- The pump stroke counter provides a running total of pump strokes for pump life to assist in recording and determining packing life.

4.21 Fuel cutoff switch

The fuel cutoff switch shuts off fuel to the engine. This switch may be used as a kill switch. It is located on the main junction box about midway on the street side of the unit.

4.22 Main power supply disconnect

The externally supplied +24-VDC power supply operate the engine electronics. These require 24 V, while the operator controls require only 12 V. The 12 VDC is provided to the control system by a power converter insulator module.

The main power supply disconnect is located on the left side of the main junction box, about 3/4 of the way to the top. It is a two-position, rotating switch, labeled on/off, and it must be in the on position for the SPF/SPS fracturing pump to operate.

The remote cable connector is a 37-pin connector to a mating connector on the 125-ft (38.1-m) remote control cable provided with the unit. The connector is located on the left side of the main junction box towards the bottom.

Daisy-chain remote control cable control connections are located on the middle right side of the main junction box, and are used with the touch screen control panel.

4.23 Gauge panel

The gauge panel contains mechanical, fluid-filled indication gauges to provide physical readings of important system parameters.

Table 4-2 shows the ranges for the gauges in the gauge panel.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck engine oil pressure</td>
<td>0 to 200 psig</td>
</tr>
<tr>
<td>Deck engine coolant temp</td>
<td>0 to 240 degF</td>
</tr>
<tr>
<td>Transmission oil pressure</td>
<td>0 to 400 psig</td>
</tr>
<tr>
<td>Transmission oil temp</td>
<td>0 to 300 degF</td>
</tr>
<tr>
<td>Pump oil pressure</td>
<td>0 to 200 psig</td>
</tr>
<tr>
<td>Pump oil temp</td>
<td>0 to 240 degF</td>
</tr>
<tr>
<td>Deck air system</td>
<td>0 to 300 psig</td>
</tr>
<tr>
<td>Voltmeter</td>
<td>0 to 24 V</td>
</tr>
</tbody>
</table>

4.24 Unit master gauge panel

The master gauge panel is located on the street side of the unit, directly in line with the separation of the engine and transmission. Figures 4-1 and 4-2 illustrate different versions of the panel. This panel contains from 6 to 8 m of analog mechanical gauges and sends a signal to the main control panel or touch screen panel when parameters are outside normal operating ranges. These signals will cause either a warning light to illuminate or a warning signal to display on the touch screen panel.
4.25 FPC touch screen operator’s remote control console

This panel provides for operation and control of the SPF/SPS fracturing pump. From this console, the operator can control the truck/pony motor and the SPF/SPS 343 pumping unit.

Fracturing pump control, phase I, can control up to eight fracturing pump units from a central control station through a digital network. The network can be cabled or wireless and is controlled from a touch screen panel.

The FPC uses a controller area network (CAN) to communicate commands and sensor data between the control station and the pump units. Commands are transmitted from the control station to the appropriate pump when a control button on the touch screen is pressed. For example, when pump number 1 is selected and the engine start button is pressed, a start command is sent to the master DCU for pump 1. The master DCU will then activate the appropriate circuity.

The master DCU operates from its own inputs, and the slave DCU and interface board accumulate sensor data for a pump. Periodically, the master DCU sends the data to the control station for display to the user and other processing. The FPC must know what equipment is installed on each pump unit (e.g., engine, transmission). This information is stored on the master DCU when the unit is first constructed. If some component is changed, for example, fluid end size, it is possible to reconfigure the unit through the FPC application.
All pump controls and a complete monitor of all component parameters are available in this system simply by selecting the appropriate pump on the screen.

Tables 4-3 to 4-5 displays normal operating parameters for these components. Numbers well above or below these ranges should be considered abnormal and should turn on a warning light on the UORCC or display on the touch screen panel.

**Table 4-3. Engine Normal Operating Parameter**

<table>
<thead>
<tr>
<th>Engine type</th>
<th>Engine temp (degF)</th>
<th>Engine oil pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16V-149 Detroit</td>
<td>185</td>
<td>80</td>
</tr>
<tr>
<td>4000 Detroit</td>
<td>190</td>
<td>100</td>
</tr>
<tr>
<td>CAT 3512</td>
<td>190</td>
<td>70</td>
</tr>
<tr>
<td>CAT 3412</td>
<td>190</td>
<td>85</td>
</tr>
<tr>
<td>Cummins QSK 50</td>
<td>220</td>
<td>70</td>
</tr>
</tbody>
</table>

**Table 4-4. Allison Transmission Operating Parameter**

<table>
<thead>
<tr>
<th>Transmission temperature (degF)</th>
<th>Transmission oil pressure (psi)</th>
<th>Transmission lock-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>190</td>
<td>250</td>
<td>225</td>
</tr>
</tbody>
</table>

**Table 4-5. Power End Operating Parameter**

<table>
<thead>
<tr>
<th>Power End Type</th>
<th>Power End Temp (degF)</th>
<th>Power End Press (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GD1800</td>
<td>120</td>
<td>70</td>
</tr>
<tr>
<td>SPM2000</td>
<td>135</td>
<td>150</td>
</tr>
<tr>
<td>OPI 1800</td>
<td>95</td>
<td>135</td>
</tr>
<tr>
<td>HD2000</td>
<td>110</td>
<td>100</td>
</tr>
</tbody>
</table>
5.0 Major Components

The fracturing pump has the following major components. Table 5-1 shows the operational parameters of a fracturing pump with a fluid end:

- engine: Caterpillar 3512B SCAC DITA 173-2949 or MTU/DDC 4000 Detroit Diesel
- transmission: Allison S9800M with single-stage, lock-up clutch with eighth gear and reverse locked out
- power end: eight-in stroke with 23,7000 lbs (107,501 kg) rod load GD 2250 or SPM TWS 2250
- fluid end: Gardner Denver/SPM OPI type
- packing lubrication system
- suction manifold
- suction stabilizer
- pneumatic systems
- hydraulic systems

5.1 Engine

The fracturing pump has an engine oil cooler. There are three different coolers: the YTS (shown in Figs. 5-1 through 5-4), IEA (shown in Figs. 5-5 through 5-10), and Detroit Diesel coolers (shown in Fig. 5-11).
Figure 5-8. IEA Radiator Fan

Figure 5-9. IEA Hydraulic Motor Section

Figure 5-10. IEA Motor Detail

Figure 5-11. Detroit Diesel Hart Radiator
### 5.1.1 Engine lubrication system

The Caterpillar diesel engine has the fluid and part requirements shown in Tables 5-1 and 5-2.

**Table 5-1. Caterpillar Engine Filter Assembly Part Numbers**

<table>
<thead>
<tr>
<th>Part</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil filter</td>
<td>2P-4005</td>
<td></td>
</tr>
<tr>
<td>Engine fuel filter</td>
<td>CAT #1R-0755 Parker #73/1000 FG-30</td>
<td>CAT #134-6307 Parker #RK11868</td>
</tr>
<tr>
<td>Air filters</td>
<td>CAT #8N-6309</td>
<td></td>
</tr>
</tbody>
</table>

**Table 5-2. Caterpillar Engine 3512 B**

<table>
<thead>
<tr>
<th>System</th>
<th>T&gt; 20 degF (–7 degC)</th>
<th>20 degF (–7 degC) &lt;T&gt;</th>
<th>T, –20 degF (–29 degC)</th>
<th>Tank Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine coolant JW and AC circuit</td>
<td>Always min 3% inhibitor</td>
<td>Approximately 50/50 antifreeze and water</td>
<td>60/40 antifreeze and water, OK to –60 degF</td>
<td></td>
</tr>
<tr>
<td><strong>Engine oil</strong></td>
<td>(EMA LRG–1)</td>
<td>SAE 5W30</td>
<td>SAE 0W20</td>
<td>58 galUS (220 L)</td>
</tr>
<tr>
<td></td>
<td>API CH-4</td>
<td>SAE 5W40</td>
<td>SAE 0W30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>API CG-4</td>
<td>SAE 15W40</td>
<td>SAE 0W40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>API CF-4</td>
<td>SAE 10W30</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>#2 Diesel</td>
<td></td>
<td></td>
<td>2X150</td>
</tr>
</tbody>
</table>

The Detroit Diesel engine has the fluid requirements shown in Tables 5-3 and 5-4.

**Table 5-3. Detroit Diesel Engine Filter Part Numbers**

<table>
<thead>
<tr>
<th>System</th>
<th>Strainer</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine oil</td>
<td>N/A</td>
<td>23540000 (4 each)</td>
<td>Serviceable</td>
</tr>
<tr>
<td>Fuel</td>
<td>Parker Hannifin Corp. P/N Separator: 73/1000 FG-30 Water/Fuel: 73/1000 MA-10</td>
<td>Detroit Diesel: 23518529 (two each)</td>
<td></td>
</tr>
<tr>
<td>Air filters</td>
<td></td>
<td>Donaldson P 181015 (4 each)</td>
<td></td>
</tr>
</tbody>
</table>
Table 5-4. Detroit Diesel MTU/DDC 4000 SCCC T123-7K73 Engine

<table>
<thead>
<tr>
<th>System</th>
<th>T&gt; 20 degF (–7 degC)</th>
<th>20 degF (–7 degC) &lt;T&gt;</th>
<th>T, –20 degF (–29 degC)</th>
<th>Tank Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine coolant JW and AC circuit</td>
<td>Always min 3% inhibitor</td>
<td>Approximately 50/50 antifreeze and water</td>
<td>60/40 antifreeze and water, OK to –60 degF</td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>#2 Diesel</td>
<td></td>
<td></td>
<td>2X150</td>
</tr>
</tbody>
</table>

### 5.2 Transmission

**Note:**
The service requirements, other than fluid level checks, are the responsibility of the maintenance department. Should you require additional information, it can be found in the Allison transmission 9000 series service manual or the SPF/SPS fracturing pump parts manual.

The transmission is an Allison S9800M with single-stage, lock-up clutch with eighth gear and reverse locked out Figs. 5-12 through 5-17 show the transmission. The fluid fill capacity is approximately 25 to 30 galUS and the fluid level can be viewed in the sight glass on the street side of the main transmission case just above the oil pan. Fluid must be visible in the sight glass with the engine shut off.

If the maintenance bulletin has been performed, an additional sight glass has been installed at the transmissions output shaft end on the curb side of the unit. This sight glass is adjacent to the transmission fill pipe. Fluid must be visible in this sight glass between the indication lines with the unit running.
5.2.1 Transmission lubrication and cooling system

The fluid specification for the transmission is C-4 TCS-228 or 15x40 motor oil as specified in Service Technical letter 13-TR-90 Revision D.

5.3 Power end

The power end has an 8-in stroke with 237,000 lbm (107,501 kg) rod load GD 2250 or SPM TWS 2250. The maximum main shaft revolution is 330 rpm.

The plunger to the pony rod is a two-piece clamp with an Allen head cap screw. The required Allen wrench/socket is 3/8 in. Cap screws must be tightened with clamp halves equally spaced.

Note: Plunger to pony rod: Check that both surfaces of the plunger and the pony rod are not damaged, to ensure proper mating when the clamps are tightened.

CAUTION: Never place hands or fingers in plunger/pony rod area while parts are in motion. This is a pinch point.

The fluid level of the power end, shown in Figs. 5-18 and 5-19, must be kept between the indicator lines on the sight glass at all times. This indicator will be either on the face of the power end opposite the plunger end or on the tank reservoir under the power end itself. The approximate fill capacity of the power end is 55 galUS. Fig. 5-20 shows the lubrication guide.

The radiator surfaces on the power end oil cooler must be clean at all times.

The fluid specification for the power end is EPSOW 90 and it holds approximately 55 galUS of fluid.

The maximum temperature is 180 degF [82 degC].
Figure 5-18. Power End

Figure 5-19. Hydraulic Filter Regulator
Figure 5-20. Power End Lubrication

- Triplex power end
  - Set at 150 degF
  - Drain
- Gearbox
- Case
  - Set at 100 psi
- Cooler
  - Set at 140 degF
- AMOT valve
  - Bypass at 50 psig
- Filter
  - Set at 160 psi
- Transmission
  - PTO Drive
- Vent
- Fill
- Lubrication tank
  - Drain (T)
- Strainer

Set at 30 psig
Figure 5-21. Lines GP-Hydraulic
Top view
1. radiator
2. right side fuel tank
3. left side fuel tank
4. triplex pump

Left side view
1. radiator
2. muffler
3. transmission
4. stabilizer
5. dive shaft guard
6. triplex pump
7. gauge panel
8. chassis rail

Figure 5-22. Power End Lubrication Tank

Figure 5-23. Power End Lubrication Tank Case Drain
Figure 5-29. Power End Lubrication Diagram
5.4 Fluid end

Table 5-5 shows the fluid end model, size, and operations parameters.

<table>
<thead>
<tr>
<th>Model Size</th>
<th>Maximum Pressure (psi)</th>
<th>Maximum Rate (bbl/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOPI 3.75 in</td>
<td>20,000</td>
<td>8.7</td>
</tr>
<tr>
<td>EOI 4.5 in</td>
<td>15,000</td>
<td>12.6</td>
</tr>
<tr>
<td>HOI 5 in</td>
<td>12,000</td>
<td>15.5</td>
</tr>
<tr>
<td>IOI 5.5 in</td>
<td>10,000</td>
<td>18.8</td>
</tr>
<tr>
<td>UOI 6.5 in</td>
<td>7,000</td>
<td>26.3</td>
</tr>
<tr>
<td>JOI 6.75 in</td>
<td>6,500</td>
<td>28.3</td>
</tr>
</tbody>
</table>

The following equations will provide the pump rate:

$$\text{pump rate}_{\text{bbl/min}} = \frac{(\text{bbl/rev})_{\text{mainshaft}} \times \text{rpm}_{\text{mainshaft}}}{\text{rpm}_{\text{mainshaft}} = \frac{\text{Engine}}{(\text{power end ratio} \times \text{transmission ratio})}}$$

The following equation provides the hydraulic horsepower

$$\text{Hydraulic horse power} = \frac{\text{pressure(psi)} \times \text{rate(bbl/min)}}{40.8}$$

Some important points about the fluid end are in the following sections.

5.4.1 Fluid end suction burst disc valves

Burst disc valves are installed in the suction seats of the triplex pump as safety backups, to rupture at pressures significantly above normal pump operating pressures. These valves help prevent unsafe conditions, treating line failures, and major component failures.

Inadequate blender pressure and loss of prime can contribute to ruptures to the burst disc valve; therefore, it is important to recognize when one of these valves have burst. A noticeable pulsation will exist in the blender discharge hose going to the triplex pump when a disc is ruptured. There may also be a hissing sound in the suction manifold, caused by the fracturing fluids being squeezed through the ruptured disc. Table 5-6 shows the burst disc ratings.

Note:

All Schlumberger positive displacements must have burst disc valves installed in the suction manifold according to the parameters in Table 5-6.

<table>
<thead>
<tr>
<th>Maximum Pump Pressure Ratings</th>
<th>Burst Disc Pressure Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>44,850 Kpa [6,500 psi]</td>
<td>69,000 Kpa [10,000 psi]</td>
</tr>
<tr>
<td>69,000 Kpa [10,000 psi]</td>
<td>103,500 Kpa [15,000 psi]</td>
</tr>
<tr>
<td>103,500 Kpa [15,000 psi]</td>
<td>155,250 Kpa [22,500 psi]</td>
</tr>
</tbody>
</table>

5.4.2 Fluid end triplex pump packing

Packing the triplex pump jet module requires considerable knowledge of the unit. Details of the fluid end are shown in Figs. 5-24 and 5-25.

Two types of packing can be used on the fluid end:

- standard Chevron (adjustable)
- header ring (nonadjustable—do not overtighten).

Familiarize yourself with each component and their position in the packing arrangement before attempting to pack a pump.
Figure 5-24. Fluid End Cross-Section

1. fluid end
2. retainer valve cover
3. retainer valve cover
4. cover discharge
5. cover gauge 2 in
6. cover gauge 2 in
7. o-ring
8. ring back up
9. ring retainer
10. O-ring
11. ring back up
12. spring valve
13. spring valve
14. retainer suction
15. nut packing
16. adapter valve cover
17. bolt cover puller
18. plunger
19. clamps
Figure 5-25. Fluid End
Lightly lubricate packing arrangement; see Fig. 5-26 for a diagram of the points to lubricate. In all types of packing, the lip side of the packing is to be installed towards the fluid source (towards the inside of the fluid end).

When header ring packing is installed, be sure to label the fluid end as “HEADER RING PACKING: DO NOT OVERTIGHTEN.”

**Warning:**

Never place hands or fingers in the packing nut area while parts are in motion. This is a pinch point use proper tool.
Figure 5-26. Fluid End Lubrication
5.5 Packing lubrication system

Two types of packing lubrication systems are

- reservoir/pump arrangement
- reservoir/pressurized (air-over-oil).

The pressurized packing lubrication system, Fig. 5-27, is turned on when the pump brake is turned off. This is accomplished by a normally closed set of contacts (in the brake off position) of the brake toggle switch that energize a solenoid control valve, allowing regulated air to start the packing lubrication system.

The reservoir-pressurized system is pressurized between 15 and 60 psi. The lubrication system air regulator sets this pressure. A flow control valve on each of the three packing lube lines can be regulated on the individual lines should it become necessary. For the most part, these valves will remain all the way open unless a packing leak occurs on one plunger. Then it may become necessary to restrict flow on that plunger.

![Figure 5-27 Pressurized Packing Lubrication System](image-url)
The reservoir/ pump arrangement has a packing lubrication oil pump powered by air pressure with a calibrated flow divider block; see Fig. 5-28. The pump is regulated by a lubrication system air regulator and can be set anywhere between 30 and 120 psi. The higher the pressure setting is, the faster the pump will operate.

If one of the calibrated ports becomes blocked, the entire packing lubrication system will shut down.

**Note:**
Pay close attention to the operation because this system or packing failure will occur very quickly after the system stops.

### 5.6 Suction manifold

All SPF/SPS 343 suction manifolds must be labeled either “For CO₂ Service” or “Not For CO₂ Service”.

The suction stabilizer MUST NOT be used when pumping CO₂ or N₂.

The CO₂ manifold must not use one-piece caps, as these will not meet the pressure requirements for CO₂ service.

All fluid end rates of less than 10 bbl/min will require one 4-in discharge hose.

All fluid end rates in excess of 10 bbl/min will require two 4-in discharge hoses or one larger-diameter hose such as a 5- or 6-in hose.

---

*Figure 5-28. Pump Packing Lubrication System*
There must be a positive cutoff valve at each end of the discharge hose on the suction manifold. The butterfly valves on the missile and the back of the fracturing pump manifold meet this requirement. All discharge hoses will have a double knobbled nipple with 2 clamps rotated at 90 degrees on each end. This rotation prevents distorting the nipple when tightening the clamps.

The butterfly valves must be removed when pumping CO\textsubscript{2} or nitrogen because butterfly valves do not meet the pressure requirements for CO\textsubscript{2} service.

### 5.7 Suction stabilizer

The SPF/SPS-343 stimulation pumper is equipped with a flow stabilizer, sometimes called a suction stabilizer, to reduce pulsation in the fluid end and discharge lines. The stabilizer is installed in the end of the suction manifold piping. The internal cartridge must be charged with nitrogen or air pressure with 30 to 60 psi, (approximately half the blender pressure).

**Warning:**
Do not attempt to remove the cartridge from the case until the pressure from both the system and cartridge have been relieved from the system.

The suction stabilizer provides a more positive suction pressure at the base of the suction valve in the triplex pump, thus preventing cavitations. This positive pressure is accomplished by placing a charged pressure, approximately half the blender pressure, on the backside of a bladder inside a closed cavity connected to the suction manifold. This pressure dampens the surges in fluid flow. It also provides a more positive filling of the pump crossbore area in which the plunger is being driven on the pump discharge stroke.

The suction stabilizer must be charged to between 30 and 60 psi, depending on anticipated blender pressure. Nitrogen is preferred, but if it is not available, air pressure can be used. If the chamber cannot be charged, the fitting is either plugged or the bladder is blown and must be serviced.

The suction stabilizer must be bled as in Step 13 of the prime-up procedure in 7.11 until all air is expelled. Pulsation dampeners must be unhooked for CO\textsubscript{2} service and the components must be labeled as “Not For CO\textsubscript{2} Service”.

**Warning:**
The suction stabilizer must NOT be used when pumping CO\textsubscript{2} or N\textsubscript{2}.

The procedure to charge the suction stabilizer follows:

**STEP 01** Shut the pump down, close suction supply valve, and relieve blender pressure.

**STEP 02** Open the stabilizer bleed valve at the suction manifold. Remove the loading valve protector and the cap from the loading valve stem.

**STEP 03** Loosen the loading valve stem no more than two turns. Charge with nitrogen if possible, or with air pressure to approximately half the blender pressure, and close the suction manifold bleeder valve.

**STEP 04** Tighten the nut on the loading valve snug, but do not overtighten.
**STEP 05**  Replace the valve stem cap and loading valve protector.

**STEP 06**  With blender pressure on the line, open the suction stabilizer bleed valve until clean fluid is passed and all air is removed; then close the bleed valve.

### 5.8 Suction and discharge hose requirements

All hoses for suction (hard) and discharge (soft) must meet the performance specifications as shown in the Schlumberger Treating Manual Version B, section 6: Hoses and Fittings, InTouch ID # 3013931. Use only approved nipples and clamps as shown in the Treating Equipment Manual.

The following lists some guidelines for the hoses:

- **Suction hose requirements for each 4-in hose is 8 bbl/min.**
- **Discharge hose requirement for each 4-in hose is 10 bbl/min.**
- **Suction hoses must never be used on the discharge side, and discharge hoses must never be used on the suction side of the system.**
- **Both suction and discharge hoses must have a positive cutoff on each end.**
- **The suction hose requirement for each 8-in hose is 35 bbl/min as per 5.10.3.**
- **Hose covers must be placed on all discharge hoses when pumping flammable fluids.**
- **There must be a positive cutoff valve between the suction hose and the fluid source.**
- **There must be a positive cutoff valve on both ends of the discharge hose.**
5.9 Pneumatic systems

Figures 5-30 and 5-31 detail the air piping. Table 5-7 provides the legend.

Figure 5-30. Air Piping System
Figure 5-31. Air Piping System Detail
### Table 5-7. Sections and Details of Air Piping Graphic

<table>
<thead>
<tr>
<th>Section A-A</th>
<th>Detail C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Left side chassis rail</td>
<td>1- Right side chassis rail</td>
</tr>
<tr>
<td>2- Chassis crossmember</td>
<td>2- Chassis crossmember</td>
</tr>
<tr>
<td>3- Right side chassis rail</td>
<td>3- Driveshaft</td>
</tr>
<tr>
<td>4- To dryer</td>
<td>4- Left side chassis rail</td>
</tr>
<tr>
<td>5- Brake caliper</td>
<td>5- Brake caliper</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section B-B</th>
<th>Detail H</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Gage</td>
<td>1- Chassis crossmember</td>
</tr>
</tbody>
</table>

If the deck engine air system fails for any reason, it may be necessary to charge the system with truck air, air from another unit, or rig air to complete the job. The system must then be repaired before the next job.

The system air regulator/lubricator and all tanks must be properly maintained and drained at all times. Water in the system during winter months can freeze, causing the system to shut down. It may therefore be necessary to service these systems in cold climates and winter months with an air system additive to prevent winter freezing. Check with the maintenance department for service instructions of these systems.
5.10 Hydraulic systems

The hydraulic systems are illustrated in Figs. 5-32 through 5-37.
Figure 5-35. Cooling System
Figure 5-36. Cooling System Details
Figure 5-37. Fan Drive Hydraulic Circuit

Major Components

- Pump
- Spin-on filter
- Pressure gauge
- Local panel
- Loop flushing valve
- Motor
- Check valve
- Radiator
- Reservoir 30 gal US
- Filter

Figure 5-37. Fan Drive Hydraulic Circuit
5.11 Other major components

Other major components are

- radiator: Caterpillar or Masabi
- trailer: Liddell/Atoka
- drive shaft: Spicer 1950/Aisco
- air filter: Caterpillar 3512 Donaldson Ebb
  MTU 4000 SCCc
- skid: process manufacturing two-piece skid.
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Before any job, the pretrip inspection must be conducted according to STEM 1 requirements (STC-3039G). You can find a driver’s trip report at InTouch Content ID# 3017061.

The auxiliary check report from the last trip should also be reviewed before this trip; see Fig. 6-1.

![Image](https://via.placeholder.com/150)

Figure 6-1. Auxiliary Post-Trip Driver’s Report

All fluid levels and possible leaks should be inspected.

All suction and discharge hoses must be properly hooked up according to Safety Standard 5, section 5.10.

### 6.1 Unit spotting and rigup

Fracturing pump placements at the missile/low pressure should be hooked up as follows:

**STEP 01** Spot units on location with enough space between pumps to allow for fluid end services and pump maintenance if required.

**STEP 02** Set the brakes and place chock blocks between the dual tires. Turn off all engines that do not need to be running.

**STEP 03** Remove the fire extinguisher and place it at the front of the unit.

**STEP 04** Larger fracturing pump plunger diameters must be placed on opposite sides of the missile and as close to the blender as possible, thereby ending up with small pumps at the missile’s far end. This positioning allows a greater amount of fluid to go to the high rate pumps.

**STEP 05** Ensure that a positive shutoff valve is between the suction hose and the fluid source.

On well stimulation jobs, a positive shutoff valve must be on both ends of the discharge hose connecting the blender to the triplex pump suction. The positive shutoff valves on any unit, such as blender, pump truck suction manifold, or missiles, must meet the requirements for these valves, set out in the Treating Equipment Manual, Version B InTouch Content ID# 3013931.

When transferring liquids from one tank to another circulating tank, use the fill line on the receiving tank to discharge fluid. If no fill line is available on the tank to which you are transferring fluid, circulation should be done on top of the tank. This hose must be equipped with a T or elbow on the end. Fasten the T or elbow to the end of the hose where it enters the tank so it can be secured. If the hose cannot be fastened, use a length of treating iron
connected to the hose where it goes down into the tank.

Make the discharge hose(s) from the blender to the pumps as short as possible, to improve the flow of fluids to the pumps. If the flow of fluids to the pump is restricted, the pumps will be starved, resulting in pump cavitations and causing excessive movement to the treating line, potential damage to the pumps, and possible line failure.

6.2 High pressure hookup

Review of Location Standard 5 is required (Standard Five 5.11.4 through 5.11.4.3). It includes the following:

- pump to wellhead rigup
- pump discharge to the ground
- pump to main treating line or manifold trailer (missile)
- main treating line rigup
- wellhead connections.

Review Figs. 5-56 through 5-68 in Standard 5 to obtain a complete understanding of this process.

Warning lights and signals must be tested before pumping operations.

The overpressure shutdown system must be tested before pumping operations.

Flow rate and pressure specifications for treating equipment are listed in Table 6-1.

6.3 Startup procedure

The unit should be started up according to this procedure.

**STEP 01** Be sure all fluid levels are at their proper level and that the packing lubrication system is full.

**STEP 02** With the truck engine running, engage hydraulic start system and allow warming up (approximately 10 minutes).

**STEP 03** Uncoil remote control cable to FracCAT.

**STEP 04** Remove control panel (see Fig. 6-2) from its storage place in FracCAT and hook it up.
**STEP 05** Ask the service supervisor for authorization to start the equipment.

**Warning:** Always verify with the service supervisor that it is safe to proceed with starting up equipment. Conditions such as a gassy well or personnel working on equipment can cause hazards to personnel and equipment.

**Note:**
Ensure that the pump brake is off and that the gear selector is in the neutral position.

**STEP 06** Engage the start switch with the fuel switch on, and allow the engine to turn until it starts; then release the start switch.

**STEP 07** Monitor all warning lights and signals.

**STEP 08** Throttle the engine to approximately 900 rpm.

**STEP 09** Take note of all warning lights and either have someone read the major component gauge panel or do it yourself.

**STEP 10** Allow engine, transmission, power end, and hydraulic systems to warm up to at least 130 degF [54 degC] before pumping operations. At this point, you can partially increase the throttle.

**STEP 11** Begin pumping operations.

**STEP 12** Upon completion of the job, return the engine to idle speed and place the transmission in neutral.

**STEP 13** Flush and drain the triplex pump.

**STEP 14** Allow temperatures to cool down in major components, turn off the fuel, and restore control console and cable to their respective storage areas.
6.4 Cold weather startup and shutdown procedures

Follow these procedures to start up and shut down in cold weather.

**STEP 01** Before starting the equipment, fire the Webasto coolant heater, open the coolant circulation, and allow the deck engine cooling system to warm. Then start the unit.

**STEP 02** Turn off the Webasto coolant heater and close the coolant circulation valves.

**STEP 03** Operate the unit according to service supervisor’s instructions.

6.5 SPF and SPS 343 skid units with pony motors

Start the units with pony motors, shown in Figs. 6-5 and 6-6, according to this procedure.

**STEP 01** Start the pony motor, engage the hydraulic start system, and allow it to warm up for approximately 10 minutes.

**STEP 02** If a Webasto coolant heater is present, fire the Webasto coolant heater and allow it to warm engine cooling system.

**STEP 03** Uncoil remote control cable to FracCAT.

**STEP 04** Remove control panel from its storage spot, place in FracCAT, and hook up.

**STEP 05** Engage the start switch and allow the engine to rotate until it starts; then release the start switch.

**STEP 06** Throttle the engine to approximately 900 rpm.

**STEP 07** Allow transmission, power end, and hydraulic systems to warm up.

Figure 6-4. Pony Motor, Side View

Figure 6-5. Pony Motor on Unit

6.6 Proper shift procedures for SPF 343 fracturing pump

Shift the fracturing pump according to these guidelines. The gearshift selector switch is an eight-position rotary type and must be pushed in to shift.

- Pushing the selector switch in automatically activates the down shift enable. The switch may then be rotated clockwise or counterclockwise to the planned gear position.
- With the transmission warmed up, to shift the transmission up, push in the control
switch and rotate the control clockwise to the desired gear.

- When the desired gear is reached, accelerate the engine until the lock-up light comes on and the required pump rate is reached.
- If the lock-up light does not come on, the switch must be pushed in, the throttle must be reduced to 1,400 rpm, and the switch must be rotated counterclockwise to the next lower gear.
- Accelerate the engine to the desired pump rate. Continue to repeat this process until the desired pump rate is reached.
- Continue to repeat this process until lock-up can be achieved.

### 6.7 Transmission lock-up

**Note:** Operators need to recognize transmission lock-up and the need to reduce the throttle for shifting.

The transmission must not be run in the converter, under load, for extended times because excessive temperature will cause in the clutch assemblies in the transmission to fail.

A lock-up light is provided to prevent these failures and if lock-up cannot be obtained, a lower gear must be selected.

When the lock-up light is on, the transmission is in lock-up.

Soft failures are usually a result of overheating. Clutch failures are considered to be soft failures and are usually cheaper to repair than hard failures. Clutch failures are usually contributed to pumping out of lock-up, causing the clutches to slip and overheat.

Hard failures are usually caused by lack of lubrication or high shock load, and consist of failures to the planetary, housings, shafts, and main drive components.

**Note:**

Because of the high failure rate and cost of failure in these transmissions, the new procedure for shifting the transmission is to reduce the throttle to 1,400 rpm before shifting.

This procedure will automatically cause the transmission to go into the converter phase and create a torque reduction at the engine, thus reducing the shock load to the transmission.

Cavitation is best described as air entrapped in the fracturing fluids which under-blender pressures implode, reach the fluid end crossbore cavity, and then explode on the suction stroke of the triplex pump. This action prevents the fluid end chamber from being completely filled. As the plunger is driven in on the discharge stroke, the air is compressed into the equivalent fluid area volume until this area is displaced. When the rising fluid level has completely displaced the air, a very violent shock occurs in each chamber and on each stroke until all air is displaced.

The result of cavitation is the failure of transmissions, fluid ends, and power ends. Cavitation has also contributed to some line failures, which are not only costly but may also be very dangerous.

Cavitations and hard shifts (shifts in the lock-up mode) are usually the cause of hard transmission, power end, and fluid end failures; therefore it is very important that all suction and
discharge hose arrangements meet Standard 5 and that a blender pressure of a minimum of 80 psi is maintained at all time.

Keep in mind that this pump may be turning at 320 rpm and has 3 plungers. This could equate to 320 X 3 = 960 spikes in the system, and these spikes can be felt all the way through the power train until all air has passed through the system.

6.8 Overpressure shutdown test

The overpressure system is designed to prevent unsafe situations and overpressure conditions to the equipment and or components at the wellsite.

Operation of the overpressure shutdown systems is as follows.

**STEP 01** Determine maximum pressure according to the customer’s requirements.

**STEP 02** Preset the OPS to the required pressure on the universal control panel with the ERAD panel by using the left/right and up/down arrow keys to maximum treating pressure according to the job design.

**STEP 03** To test the system, with the transmission in neutral, raise the engine speed to 1,000 rpm, and then press the Test button at the lower left of the ERAD panel. This action will elevate the pressure reading to the preset reading, and once it is reached the engine will return to idle speed.

Caution:
If the neutral trip indicator light does not trip as indicated in the previous steps, do not operate this unit until the fault is corrected. This overpressure trip system is the only protection provided during a screenout or overpressure condition.

6.9 Instant neutral/line test system

The test system is a toggle switch on the operations console or a touch point on the touch screen of the eight-pump panel control system. In the line test/instant neutral position, the system allows the transmission to be run only in the converter phase.

An amber line test light or highlighted point on the touch screen is illuminated at the control panel/console to indicate this condition.

Move the instant neutral/line test switch to the instant neutral up position. The neutral tripped indicator light turns on and the engine returns to low idle.

Move the instant neutral/line test switch to the off (center) position and move the rpm control counterclockwise to the reset position. The neutral tripped indicator light turns off. On the touch screen, this is simply a touch point labeled “instant neutral.”

On the touch screen panel, this test is accomplished using the throttle slide button to raise the engine speed to 1,000 rpm to test the system. With the transmission in neutral, press the test button on the control panel. The pressure reading will be elevated to the preset reading; once this reading is reached the engine will return to idle speed.

6.10 Priming triplex pump

Prime the triplex pump according to Standard Five 5.12 and 5.12.1 as follows.

**STEP 01** Start the engine of the pumping unit and allow it to warm up.
**STEP 02** Ensure the overpressure shutdown system functions properly by manually tripping it.

**STEP 03** Set the overpressure shutdown to 1000 psi.

**STEP 04** Ensure the wellhead valves are closed.

**STEP 05** Ensure that the valves on the main line bleed/return are open.

**STEP 06** Take the bleedline choke out of the bleed/return line. This choke is to be replaced after priming up and before the pressure test.

**STEP 07** Ensure the isolation line from the pump to the main treating line is opened.

**STEP 08** Open the 4-in discharge hose valves to the pump. If more than one is used, ensure that they are all open.

**STEP 09** The blender discharge pressure must be kept at a minimum pressure of 80 psi.

**STEP 10** Ensure that fluid flows freely from the blender through the pump and out the return/bleed line.

**STEP 11** Run the engine at idle speed and select the highest gear.

**Caution:**
Do not move the throttle!

**STEP 12** If the pump will not rotate, check whether it is sanded up or if a valve is closed on the discharge side.

**STEP 13** Allow the pump to rotate at idle speed for approximately 1 min to remove air from the line.

**STEP 14** Bleed the pulsation dampener.

**STEP 15** Slowly increase the speed of the pump while in the highest gear, and do not exceed 1000 psi or 3 bbl for 3 3/4-in pumps, 5 bbl for 4 1/2-in and 5-in pumps, or 8 bbl for all pumps with a larger diameter.

**STEP 16** Continue pumping for 2 min or until a steady stream of fluid is obtained.

**STEP 17** Ensure that the pump is primed by monitoring the blender discharge pressure and suction hose pulsation. The pressure must not change. If the pressure changes, continue to prime the pump.

**STEP 18** When the pump is primed, move the throttle to the idle position and return the pump transmission to neutral position. Maintain blender pressure.

**STEP 19** If the pumping unit has a pump or power end brake system, engage the brake. For other type of units, stop the engine.

**STEP 20** Close the pump isolation valve. This valve is connected to the main treating line with a lateral, and is located between the pump and the main treating line.

Prime each pump using Steps 1 through 20 above, until all pumps are primed.

**6.11 Pressure testing**

Before pressure testing the pump and treating line according to Safety Standard 5.13.2, review Safety Standard 5.12 through 5.13.2.1 and perform the following procedure.
STEP 01  Pretest the overpressure shutdown.

STEP 02  Set the overpressure shutdown to the required maximum predetermined pressure.

STEP 03  If a leak occurs during any stage of the procedure, shut all pumps down, bleed off the line, and repair the leaks.

STEP 04  Ensure that the customer wellhead master valve is closed.

STEP 05  Open the Schlumberger master valve on the wellhead after all pumps are primed. Ensure that all valves in the discharge line are open from the pumps to the well.

STEP 06  Move all personnel to a safe area. All persons performing the pressure test must use radio communications.

STEP 07  Ensure that the pump overpressure shutdowns are functioning properly by manual actuation. The overpressure shutdowns on all pumps must be set at the required test pressure.

STEP 08  Apply a low pressure test to the line (approximately 25% to 50% of final pressure).

STEP 09  Inspect for any leaks. If no leaks are found, slowly increase the pressure in the line to the final pressure test.

6.12 Pressure testing
Pressure test newer model pumps such as the SPF/SPS-343 by this procedure.

STEP 01  Activate the line test switch on the pump panel (this switch inhibits the transmission from achieving lock-up).

STEP 02  Maintain the engine speed at idle speed.

STEP 03  While maintaining the engine speed at idle speed, shift the transmission to the highest gear and allow the pump to stall until the pump stops. This action should result in a pressure reading between 2,500 psi and 4500 psi, depending on fluid end size.

STEP 04  Shift to neutral after the correct pressure has been attained. If a higher pressure is required, rapidly move in and out of first gear with engine speed at idle until the desired test pressure is achieved. If the desired pressure cannot be obtained, increase the throttle in increments of 100 rpm while in neutral and repeat steps 4 and 5 until the desired test pressure is achieved.

Note:
Hold your thumb over the instant neutral switch during the test. It may be necessary to activate the switch quickly if the desired test pressure is exceeded.
STEP 05  If the pressure drops or visible leaks occur, do the following:

1. Stop all pumps.

2. Release the pressure using the bleed line located between the check valve and the wellhead.

3. The individual responsible for line bleedoff must notify the job supervisor that the valves are open, and both must agree that the pressure on the line is completely bled off before repairs can be started.

4. Have the Schlumberger supervisor advise the repair crew when the pressure is at 0, so that they can repair any leaks.

5. After the repairs are completed, the pumps must be primed up again.

STEP 06  If the pressure does not change and no leaks are visible, the stabilized test pressure must remain on the line and be recorded for a minimum of 1 min.

After initially applying the test pressure to the treating lines and shutting down the pumps, it is possible that a decrease in pressure may occur without visible leaks. If this situation occurs, the job supervisor can return the pressure to the test pressure. The line test is acceptable when the pressure stabilizes at the required test pressure for more than 1 minute. When the line test is complete, decrease the line pressure until it is equal to the wellhead pressure and open the wellhead master valve.

### 6.13 Pumping the job

Variables among locations, rates, fluid end sizes, pressures, and types of fluids being used make it impossible to properly describe complete processes for job pumping and completion.

Operate the pumping as required by the service supervisor for the individual well requirements. A constant pressure and rate must be maintained at all times for proper safety and service quality requirements.

From this point on until the end of the well treatment, it is your responsibility to follow the instructions of the service supervisor. If anything unusual occurs, such as warning lights on the control panel that indicates equipment problems, notify the service supervisor immediately.

**Note:**

When shifting gears during pumping operations, it is advisable to reduce engine speed below transmission lock-up (approximately 1400 rpm) before actually shifting.
6.14 Flushing and draining the triplex pump

Note:
While the engine cools down, check with the service supervisor to determine whether the pump is to be drained before shutdown.

Perform the following steps if the pump is to be drained:

**STEP 01** Open the suction stabilizer bleed valve.

**STEP 02** Adjust the deck rpm control to low idle (approximately 700 rpm).

**STEP 03** Move the gear selector to the fifth gear.

**STEP 04** Adjust the deck engine speed control to increase engine speed until the barrel meter reads 50% of the fluid end’s maximum output.

**STEP 05** Continue spinning out the pump until no fluid comes out the discharge arm. This process normally takes less than 1 min.

**STEP 06** In extremely cold climates, it may be necessary to remove the suction manifold side caps and manually trip the suction valves in the pump to be absolutely sure the pump is drained.

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**Note:**
When getting online, you should be able to get the transmission into lock-up within a maximum of 30 sec. If you have chosen a gear that is too high, you may be unable to get into lock-up. Make sure that you do not try to pump in the converter mode for more than 20 to 30 sec before trying a lower gear. Failure to do so may cause damage to the transmission.

The approximate rates per gear with the respective fluid end are shown in Table 7-2.

**Note:**
All rates are approximate and transmission must be in lock-up to achieve these rates.

<table>
<thead>
<tr>
<th>Fluid End Gear</th>
<th>Gear 1</th>
<th>Gear 2</th>
<th>Gear 3</th>
<th>Gear 4</th>
<th>Gear 5</th>
<th>Gear 6</th>
<th>Gear 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOPI</td>
<td>2.1</td>
<td>2.75</td>
<td>3.5</td>
<td>4.25</td>
<td>5.5</td>
<td>6.1</td>
<td>8.7</td>
</tr>
<tr>
<td>EOPI</td>
<td>3</td>
<td>4.25</td>
<td>5.25</td>
<td>6.25</td>
<td>8</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>HOPI</td>
<td>3.75</td>
<td>5</td>
<td>6.3</td>
<td>8</td>
<td>12</td>
<td>12.6</td>
<td>15.5</td>
</tr>
<tr>
<td>IOPI</td>
<td>4.5</td>
<td>6.25</td>
<td>9</td>
<td>10.5</td>
<td>14.75</td>
<td>18</td>
<td>26.3</td>
</tr>
<tr>
<td>UOPI</td>
<td>6.25</td>
<td>9</td>
<td>11</td>
<td>14.75</td>
<td>18</td>
<td>20</td>
<td>28.3</td>
</tr>
</tbody>
</table>

Table 6-2. Approximate Rate per Gear

Upon completing the job, return the engine to idle speed and place the transmission to neutral and set the pump brake.
6.15 Shutdown procedure

When the treatment is complete and the pump is drained perform the following steps:

**STEP 01** Adjust the engine speed to idle (around 700 rpm).

**STEP 02** Place the gear selector in the neutral.

**STEP 03** Increase engine speed to approximately 1000 rpm for 5 to 10 min; this allows temperatures to cool down and stabilize in the major components. This cooldown enables the following:

- The lubricating oil carries the heat away from the turbo chargers, preventing bearing failure.
- The engine coolant distributes heat evenly through the cooling system, preventing heat shock cracks in the cylinder head exhaust valve port areas.

**STEP 04** Stop the engine.

**STEP 05** Turn off the fuel and restore control console and cable to their respective storage areas.

**STEP 06** Lock and secure both the remote control cable spool and control panel storage box. Repair/replacement cost of these items is very expensive; therefore, if these items become uncoiled or lost it is possible that this unit will not be used on the next job.

**STEP 07** Turn off the main power switch on the main junction box.

**STEP 08** Rig down both the high-pressure and low-pressure systems.

**STEP 09** Place all low-and high-pressure components in their respective places and secure.

**STEP 10** Replace fire extinguisher in its rack and secure.

**STEP 11** Replace chock blocks in their respective place and secure.

**STEP 12** Perform the posttrip inspection according to the DOT chassis and the Schlumberger Auxiliary Check Sheet (see Fig. 6-2)

**STEP 13** When applicable, turn off all work lights.
All Schlumberger employees must be familiar with the relevant safety regulations and precautions because of the many hazards involved in the oilfield industry. The following are the minimum documents you should review before attempting to carry out any of the procedures described in this document.

- Well Services Safety Standard 5, InTouch Content ID# 3038407
- STEM 1 DOT & Auxiliary Check (STC-3039G) Drivers Trip Report, InTouch Content ID# 3017061
- JET Manual 1, treating Equipment, InTouch Content ID# 4127821
- JET Manual 2, Triplex Pumps, InTouch Content ID# 4127825
- JET Manual 4, Basic Oilfield Equipment, InTouch Content ID# 4127828
- JET Manual 5, Low-Pressure Equipment, InTouch Content ID# 4127829
- Treating Equipment Manual, InTouch Content ID# 3013931.
1. Match the SPF and SPS with their respective unit types.
   ___ A. SPS  1. trailer
   ___ B. SPF  2. skid

2. Choose three types of control panels.
   ___ A. main junction box
   ___ B. pump power end control panel
   ___ C. touch screen daisy chain cable/wireless control panel (FPC)
   ___ D. power pump control panel
   ___ E. universal operators remote control console (UORCC)
   ___ F. daisy chain gauge control panel
   ___ G. touch screen 37-pin cable control panel.

3. Select the two engine types used on the SPF/SPS pump.
   ___ A. Cummins
   ___ B. Solar
   ___ C. Caterpillar
   ___ D. Perkins
   ___ E. Detroit Diesel

4. Which of the following best describes the power description of the SPS/SPF fracturing pump?
   A. 2,250 bhp
   B. 1,900 hp
   C. 2,300 engine hp

5. Select the two control panels for the SPF/SPS fracturing pump.
   A. touch screen panel
   B. main pump junction box
   C. main junction control box
   D. universal pump control panel

6. Place an X beside each function for the main control panel.
   ___ A. starts the deck engine
   ___ B. stops the deck engine
   ___ C. turns on the packing liberation system
   ___ D. controls engine oil pressure
   ___ E. displays engine exhaust temperature
   ___ F. displays pressure and rate from the fracturing pump
   ___ G. accelerates and decelerates the deck engine
   ___ H. shifts the deck transmission
   ___ I. monitors or displays major component
   ___ J. operating parameters
   ___ K. creates instant neutral
   ___ L. creates overpressure shutdown
7. In cold climates it may be necessary to do which of the following?
   A. Remove the side covers and manually trip the suction valves.
   B. Spin the pump out twice.
   C. Remove the hose of the suction manifold and open the valve.
   D. Use truck air pressure to blow out the manifold.
   E. Wash out the pump in the wash bay back at the district.

8. How many gears are usable in the deck transmission?
   A. four
   B. six
   C. seven
   D. five
   E. eight
   F. reverse

9. Place an X beside five reasons that we place burst disc valves in the suction seat of the triplex pump.
   ___ A. to prevent overspeed on the deck engine
   ___ B. to prevent power end failures
   ___ C. to protect the overpressure shutdown system
   ___ D. to prevent the fluid end from overheating
   ___ E. to prevent the suction manifold from overfilling when blender pressure exceeds 100 psi
   ___ F. to protect the treating line string from failure from extreme overpressure
   ___ H. to prevent overpressure to the well
   ___ I. to prevent unsafe conditions
   ___ J. to prevent fluid end failures
   ___ K. to prevent transmission failures

10. Transmission lockup clutch engagement can be indicated by which two of the following?
    A. The green light on the touch screen panel is illuminated.
    B. The red light on the touch screen panel is illuminated.
    C. Fourth gear can be reached in the transmission.
    D. The gauge reads 40 psi on the universal remote control panel.
    E. The amber light on the universal remote control panel is illuminated.
    F. Transmission temperature reaches 180 degF.