

# 1. Startup Sequence

## 1.1. Initial Startup

Turn on the Control Cab Power Switch and the Auxiliary Engine Power Switch underneath the cab.

Turn on the Control Power Switch on the console inside the cab.

Insert the key into the key switch on the console. Press and hold the Reset Before Starting button. Turn and hold the key switch to Start. Wait for the engine to start up. Release key switch. Release Reset Before Starting button.

Lift knob on the Auxiliary Engine portion of the console to increase the engine's RPM. Increase the RPMs to 2200.

On the HMI press the Unit Test & Diagnostics button. If the alarm horn is sounding, press either the alarm silence button on the HMI or the alarm silence button on the console. Press the Ack All button on the screen to clear the alarms.

Press the Turbine Systems Test button at the bottom of the HMI screen.

Press the Fuel Pump Run button on the HMI. Go outside and turn the valve to the right of the Fuel pump open. Fuel will cycle through the fuel pump removing the air bubbles. After the air bubble noises stop, close the valve, and press the Fuel Pump Stop button on the HMI.

Place one hand on the knob on the front of the console. Press the Start button on the HMI. Quickly turn the knob clockwise until the Turbine's RPMs on the HMI screen start increasing. Start turning the knob counterclockwise until the Turbine's RPMs start to level out. Start turning the knob to increase the Turbine's RPMs at a moderate rate.

Once the Turbine's RPM reach 3500, press the Fuel Shutoff Open button on the HMI. If another person is present have him stand by Parker valve to the far right of the Fuel Pump. Once the Turbine's RPM reach 4000, open the valve. If another person is not present, leave the cab and turn on the valve for a few minutes. Close the valve.

If the Turbine goes closer to 17000 RPMs, turn the knob on the front of the console counterclockwise until the RPMs are close to 16000 RPMs.

Once the Turbine reaches 16000 RPMs, press the Full button on the HMI. The Turbine should reach 17000 or more RPMs.

Once the Turbine has reached 17000 RPMs, the Turbine is ready to have the pumps turned on. Go to Pump Startup.

## 1.2. Normal Startup

Turn on the Control Cab Power Switch and the Auxiliary Engine Power Switch underneath the cab.

Turn on the Control Power Switch on the console inside the cab.

Insert the key into the key switch on the console. Press and hold the Reset Before Starting button. Turn and hold the key switch to Start. Wait for the engine to start up. Release key switch. Release Reset Before Starting button.

Lift knob on the Auxiliary Engine portion of the console to increase the engine's RPM. Increase the RPMs to 2200.

On the HMI press the Unit Test button. If the alarm horn is sounding, press either the alarm silence button on the HMI or the alarm silence button on the console. Press the Ack All button on the screen to clear the alarms.

Press the Turbine Systems button at the bottom of the HMI screen.

Place one hand on the knob on the front of the console. Press the Start button on the HMI. Quickly turn the knob clockwise until the Turbine's RPMs on the HMI screen start increasing. Start turning the knob counterclockwise until the Turbine's RPMs start to level out. Start turning the knob to increase the Turbine's RPMs at a moderate rate.

Once the Turbine's RPM reach 3500, press the Fuel Shutoff Open button on the HMI.

If the Turbine goes closer to 17000 RPMs, turn the knob on the front of the console counterclockwise until the RPMs are close to 16000 RPMs.

Once the Turbine reaches 16000 RPMs, press the Full button on the HMI. The Turbine should reach 17000 or more RPMs.

Once the Turbine has reached 17000 RPMs, the Turbine is ready to have the pumps turned on. Go to Pump Startup.

### 1.3. Pump Startup

Once the Nitrogen truck is attached to the Turbine, press the Nitrogen System button at the bottom of the HMI.

Check the Auto Manual Selector Switch on the Quintiplex Control portion of the console. Change the switch to whichever method is preferred. If the switch is in auto position, go to the Auto Startup subsection. If the switch is in manual position, go to the Manual Startup position.

#### 1.1.1. Auto Startup

Press the Setpoints button at the bottom of the HMI.

Check the Staging State on the HMI. Choose whichever method is preferred. If Staging is on, set the Discharge Rate, the Total Volume, and Over Pressure Trip Setpoints for each of the stages by pressing the values and press the close button. If Staging is off, press the close button and set the Discharge Rate, the Total, and Over Pressure Trip setpoints in the Setpoints section of the Nitrogen Systems page on the HMI.

Press the Pump Start button on the HMI. It should change for Pump to Pump Requested to Pumping.

If Staging is on, press the Stage Advance button on the screen to proceed to the next stage.

If the Quintiplex pump not turning alarm is present, press the Alarm Silence button. Then press the Ack All button on the screen. Turn up the setpoint and press the Pump Start button again.

#### 1.1.2. Manual Startup

Use the potentiometer knob on the Quintiplex Control portion of the console to control the Discharge rate setpoint. Press the Total and Over Pressure Trip values on the screen to set their setpoints respectively.

Press the Pump Start button on the HMI. It should change from Pump to Pump Requested to Pumping.

If the Quintiplex pump not turning alarm is present, press the Alarm Silence button. Then press the Ack All button on the screen. Turn up the setpoint and press the Pump Start button again.

For information about the Pumps and Filters, press the Differential pressure lights below the Pump Start and Stop button. The Pump Info popup should appear.

## 2. Shutdown Sequence

### 2.1. Full Shutdown

Press the Turbine Systems button at the bottom of the screen. Press the Idol button on the screen. The Turbine will ramp down to 16,000 RPMs. The Pumps will stop.

Press the Fuel Shutoff Close Button. The Turbine will start to ramp down.

Turn the knob on the front of the console counterclockwise until the valve is completely closed.

Press the Stop button on the screen. The alarm will sound. Press the alarm silence and Ack All buttons.

Once the Turbine reaches 0 RPM, press the Engine RPM knob down to slow the engine down to slow speed.

Turn the key to off.

### 2.2. Partial Shutdown

Turn down the Tri-Pump

Press the Nitrogen Systems button at the bottom of the screen. Then press the Stop button on the screen.

Open bypass valve.

Close Discharge valve.

Close off C-Pump.

### 3. Pump Info

#### 3.1. Pump Specs

Model No.:	5-SLSCBGRO
Fluid Used:	Liquid N <sub>2</sub>
Flow:	215 GPM
Net Positive Suction Pressure Required:	60 PSIG
Max Working Pressure:	10,000 PSIG
Max RPM:	1000
Gearbox Ratio:	2.38: 1
No. of Cylinders:	5
Cylinder Size:	2.70in Bore x 2.25in Stroke
Volume Efficiency:	85%
Mechanical Efficiency:	90%
Horsepower:	1638.8

#### 3.2. Lube Oil Specs

Lube Oil Specs:	15W50
Lube Oil Pressure Min:	60 PSI
Lube Oil Pressure Max:	110 PSI
Lube Oil Temperature Min:	60 °F
Lube Oil Temperature Max:	120 °F

#### 3.3. Special Info

This pump is a right-hand drive with Gearbox rotated to Twelve o'clock position with companion flange pointing away from the drive.

## 4. Valves

### 4.1. Prime Valve Actuator



This valve actuator opens and closes a valve with the intake coming from the Pump and the outtake going to the intake of the Turbine Exhaust Heat Exchanger and to the atmosphere near the diesel tank. The button will control the valve if the system has power. It does not matter if the Valve Control is in Automatic or Manual.



### 4.2. Diverter Valve Actuator



This valve actuator opens a valve with the intake coming from the Pump and the outtake going to the intake of the Turbine Exhaust Heat Exchanger and the intake of the Turbine Intake Heat Exchanger. The physical button will control the valve if the Valve Control Selector Switch is set to Manual mode. If the Valve Control Selector Switch is set to Auto mode, the PLC will control

the valve. If the Manual Override button is pressed, the plus and minus adjust buttons for the Diverter Valve on the Turbine Systems screen.



### 4.3. Temper 1 Cold Valve Actuator



This valve actuator opens and closes a valve with the intake coming from the Pump and the outtake going to one of the intakes of a cross fittings. The button will control the valve if the Valve Control Selector Switch is set to Manual mode. If the Valve Control Selector Switch is set to Auto mode, the PLC will control the valve. If the Manual Override button is pressed, the plus and minus adjust buttons for the Temper Valve #1 on the Nitrogen Systems screen.



### 4.4. Temper 2 Hot Valve Actuator



This valve actuator opens and closes a valve with the intake coming from the Pump and the intake of the Temper #1 Cold Valve Actuator and the outtake going to the outtake of the Turbine Exhaust Heat Exchanger. The button will control the valve if the Valve Control Selector Switch is set to Manual mode. If the Valve Control Selector Switch is set to Auto mode, the PLC will control the valve. If the Manual Override button is pressed, the plus and minus adjust buttons for the Temper Valve #2 on the Nitrogen Systems screen.



#### 4.5. HE Valve Actuator



This valve actuator opens and closes a valve with the intake coming from the Booster Pump and the outtake going to the atmosphere on the side of the Turbine. This valve is controlled by the Omega PID controller on the door side of the console in the cab.



This valve is controlled by the Omega PID controller on the door side of the console in the cab.

#### 4.6. Bottom Fill Valve



This valve opens and closes based on the Bottom Fill Valve lever on the console inside the cab. The one side of the valve goes to the N2 tank and the other side goes to the Fill Valves, Valve V4, and Valve V2. The valve when open will either have the liquid Nitrogen travel from the Fill Valves to the N2 Tank or have the liquid Nitrogen travel from the N2 Tank to the Nitrogen Pump and Booster Pump.



#### 4.7. Pressure Build Valve



This valve opens and closes based on the Pressure Build Valve lever on the console inside the cab. The one side of the valve goes to the N2 tank and the other side goes to the Heat Exchanger on the side of the N2 Tank.





#### 4.8. VH2



This valve opens and closes based on the unmarked lever on the console inside the cab. The intake of the valve comes from the N2 tank and the Pump and the outtake of the valve goes to the atmosphere. This valve seems to be a bleed valve for the line between the check valve for the N2 Tank and the Pump.



#### 4.9. Discharge Valve Actuator



This valve actuator opens and closes the discharge valve. The discharge valve is controlled through the Discharge Valve Selector Switch on the console in the cab. The two lights indicate whether the valve is opened or closed. NOTE: The Valve is pinned opened physically.



#### 4.10. N2 Pump Relief Valve

The valve is a relief valve. The intake is coming from the Pump and the outtake is going to the atmosphere. At 12,000 PSI, this valve should open.



#### 4.11. V2

This valve allows liquid Nitrogen to travel from the Fill Valves or the N2 Tank to the check valve to the Pump. If the Bottom Fill Valve is opened and the Fill Valves are closed, the liquid Nitrogen will travel from the N2 Tank. If the Bottom Fill Valve is closed and the Fill Valves are opened, the liquid Nitrogen will travel from the Fill Valves. The outtake of the valve also goes to same line as the outtake of the Booster pump.



#### 4.12. V3

This valve allows liquid Nitrogen to travel from the N2 Tank to the intake of the Booster Pump or from Valve V4 to the N2 Tank. This valve allows liquid Nitrogen to be loaded into the Booster Pump directly from the N2 Tank without having a Truck attached to the Fill Valves.



#### 4.13. V4

This valve allows liquid Nitrogen to travel from the Fill Valves or the N2 Tank to the intake of the Booster Pump or N2 Tank. If Valve V3 is opened, the Bottom Fill Valve is closed, and the Fill Valves are opened, then the liquid Nitrogen will travel from the Fill Valves through this valve and into the N2 Tank. If the Fill Valves are opened, Valve V3 is closed, and the Bottom Fill Valve is closed, then the liquid Nitrogen will travel from the Fill Valves to the Booster Pump allowing the system to bypass the N2 Tank and go straight into the Booster Pump.



#### 4.14. Road Relief Valve



This valve allows Nitrogen to travel from the check valve from the heat exchangers on the side of the N2 Tank to another check valve toward the atmosphere dump.

#### 4.15. Manual Vent Valve



This valve is used to manual vent Nitrogen to the atmosphere from the heat exchangers on the N2 Tank.

#### 4.16. Pressure Buildup Relief Valve



This valve is a safety relief valve. This valve will open when the pressure in the tank reaches 45 PSI. This valve is not part of the pump system but of the pressure build system for the tank.