Model 290 HPHT Consistometer
Instruction Manual

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Instrument No. 101443590

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Fann Instrument Company

Model 290 HPHT Consistometer Instruction Manual

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1 Introduction

The Model 290 High-Pressure High-Temperature (HPHT) Consistometer is used to evaluate the consistency or pumpability of cement slurries. Operators can determine the maximum available pumping time of cement slurry before it reaches a non-pumpable consistency before setting.

The Model 290 HPHT Consistometer measures the thickening time of cement slurries under simulated downhole pressure and temperature conditions. Its maximum operating conditions are 400°F (204°C) and 30,000 psi (207 MPa).

The thickening time of cement slurry is a good indicator of how long the slurry will remain pumpable. Thickening time is the time required for stirred cement slurry to reach a consistency of 100 Bearden units (Bc). The Bearden unit of consistency (Bc) is a dimensionless quantity from 0-100 units. The Bc number corresponds to the torque required to deflect an electrical potentiometer.

The Model 290 HPHT Consistometer is designed for conformance with relevant standards and practices as published by API Subcommittee 10 on Well Cements.

1.1 Document Conventions

The following icons are used in this manual.

NOTE. Notes emphasize additional information that may be useful to the reader.

CAUTION. Describes a situation or practice that requires operator awareness or action in order to avoid undesirable consequences.

MANDATORY ACTION. Gives directions that, if not observed, could result in loss of data or in damage to equipment.

WARNING! Describes an unsafe condition or practice that if not corrected, could result in personal injury or threat to health.

ELECTRICITY WARNING! Alerts the operator that there is risk of electric shock.

HOT SURFACE! Alerts the operator that there is a hot surface and that there is risk of getting burned if the surface is touched.

2 Safety

Follow the instructions provided to avoid personal injuries or equipment damage.

Always wear appropriate personal protective equipment (PPE) when operating or maintaining the Model 290.

Two front casters with attached locks support the consistometer. When the instrument is not going to be moved, its casters should be locked to keep the instrument from moving unexpectedly. If the instrument needs to be moved, at least two people who have experience moving heavy machines should move it.

2.1 Safe Pressurization

The Model 290 HPHT Consistometer has pressurized air, water, and hydraulic lines that present a hazard if not depressurized before maintenance or disassembly.

The hydraulic diaphragm pump and the pressure relief valve require compressed air. This air is generally pressured to 100 psi (689 kPa). Before working on any of these devices or connected air lines, shut off the compressed air supply to the machine, and carefully relieve air pressure from the machine.

The high-pressure lines may be pressurized up to 30,000 psi (207 MPa). Use the pressure-down or drain switch on the front panel or the manual pressure relief valve located inside the lower cabinet door, to release the pressure. To confirm that the all pressure is released, check the pressure gauge located inside the lower cabinet door.

2.2 Safe Heating

The chamber has an internal electric heating element that can exceed 400°F (204°C). Before opening the pressure chamber, use the cooling system to lower the temperature to at least 120°F (49°C). The machine uses domestic water as coolant. Shut off the domestic water supply before servicing. In some labs, a recirculating chiller is used for cooling.

The software will begin a cool down cycle when the test ends. Use the temperature display in the software to measure the temperature. The coolant return line can be very hot [212°F (100°C)] at the beginning of a cool down cycle.

NEVER operate the heater when the chamber is empty. The heater element will quickly overheat and fail. To prevent smoke and possible fire, always fill the chamber and pressurize before heating.

2.3 Safe Electrical Operation

Disconnect the power cable and turn off the uninterruptible power supply (UPS) before attempting any electrical or mechanical maintenance. Be aware that after the power switch is turned off, the electrical terminals inside the panel will remain electrically energized.

The UPS is also a source of lethal current. Unplug the outputs of the UPS before servicing the consistometer.

Refer to the electrical schematic before performing maintenance or troubleshooting.

Always disconnect the power cable before attempting any repair.

2.4 Ergonomic Considerations

The Model 290 HPHT Consistometer is a tall, heavy machine that must be handled carefully when moving it. The casters allow the machine to be rolled easily in the lab, but since the machine is tall, it is somewhat top-heavy. The center of gravity is forward of the machine's center. Operators should roll the machine slowly and should watch for debris on the floor. If the machine must go on an incline or decline, more than one person should help guide it.

The pressure chamber has a heavy lid that must be removed to load samples. A counterbalanced lift helps raise and lower the lid so that the operator does not have to lift the full weight.

2.5 Environmental Considerations

This machine tests cement slurries containing additives, using white mineral oil as a pressurizing fluid. The operator must be aware of proper handling and disposal practices for these materials.

The hydraulic diaphragm pump is lubricated by an oil mist in the pressurizing air source. The lubricating oil and the mineral oil will be discharged into the air exhaust. The air exhaust should be routed to a trap to capture the oil (local regulations may require this setup.) If a rupture disk fails, this exhaust will also route the hot mineral oil to the trap.

3 Features and Specifications

The Model 290 High-Pressure, High-Temperature Consistometer measures the consistency of cement slurries at temperatures up to 400°F (204°C) and pressures up to 30,000 psi (207 MPa). The instrument has built-in safety features for safe operating at high temperatures and pressures. A flat panel, high-resolution touch screen makes it easy to use and view real-time temperature, pressure and consistency data. The unit's control system software runs the instrument and generates reports and graphs. See Figure 3-1 and Figure 3-2.

The consistometer consists of a pressure chamber that holds the slurry cup sample, a heater, cooling coil, and various operating components and subsystems described in this section. This section also describes the functions of the HPHT Consistometer's control panel.

The HPHT Consistometer must be connected to air, electrical power, coolant, and drain lines that meet the specifications listed in Table 3-1. For detailed installation instructions, see Section 4. A picture of those connections is shown in Figure 4-1.

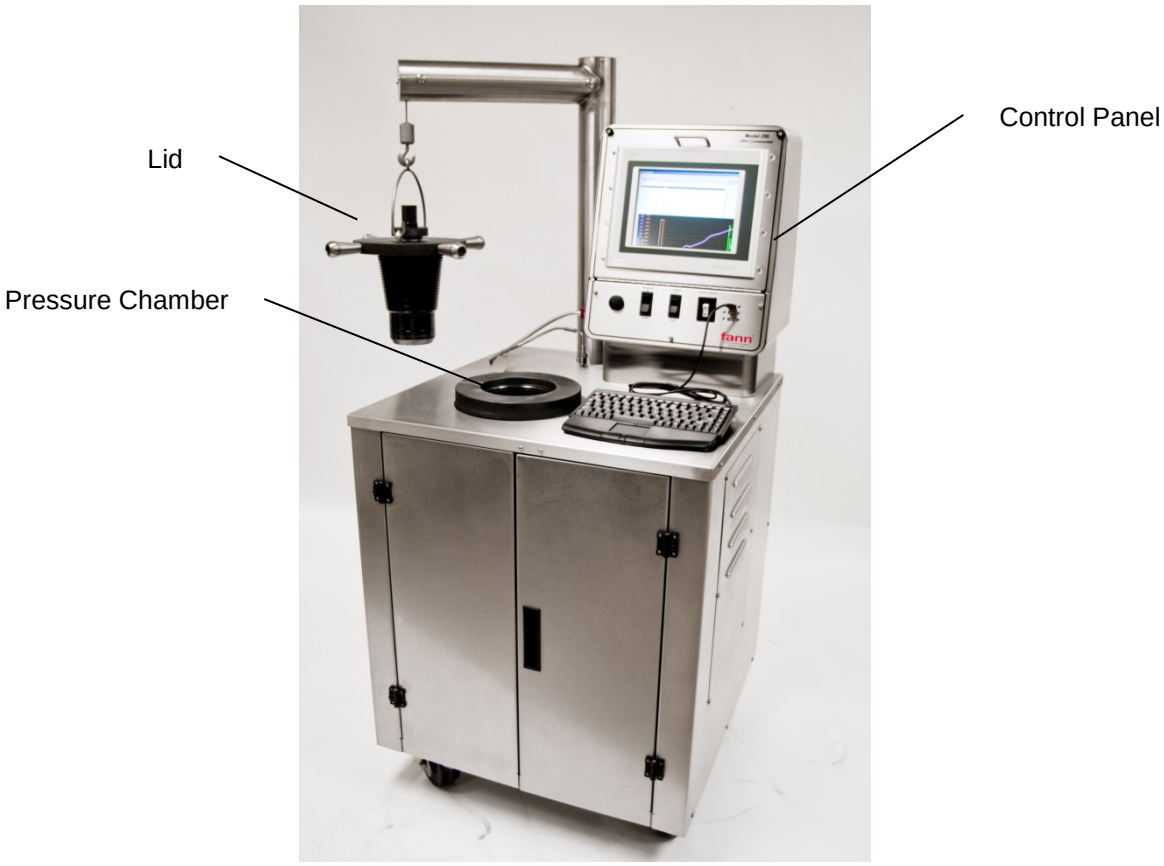


Figure 3-1 High-Pressure High-Temperature Consistometer

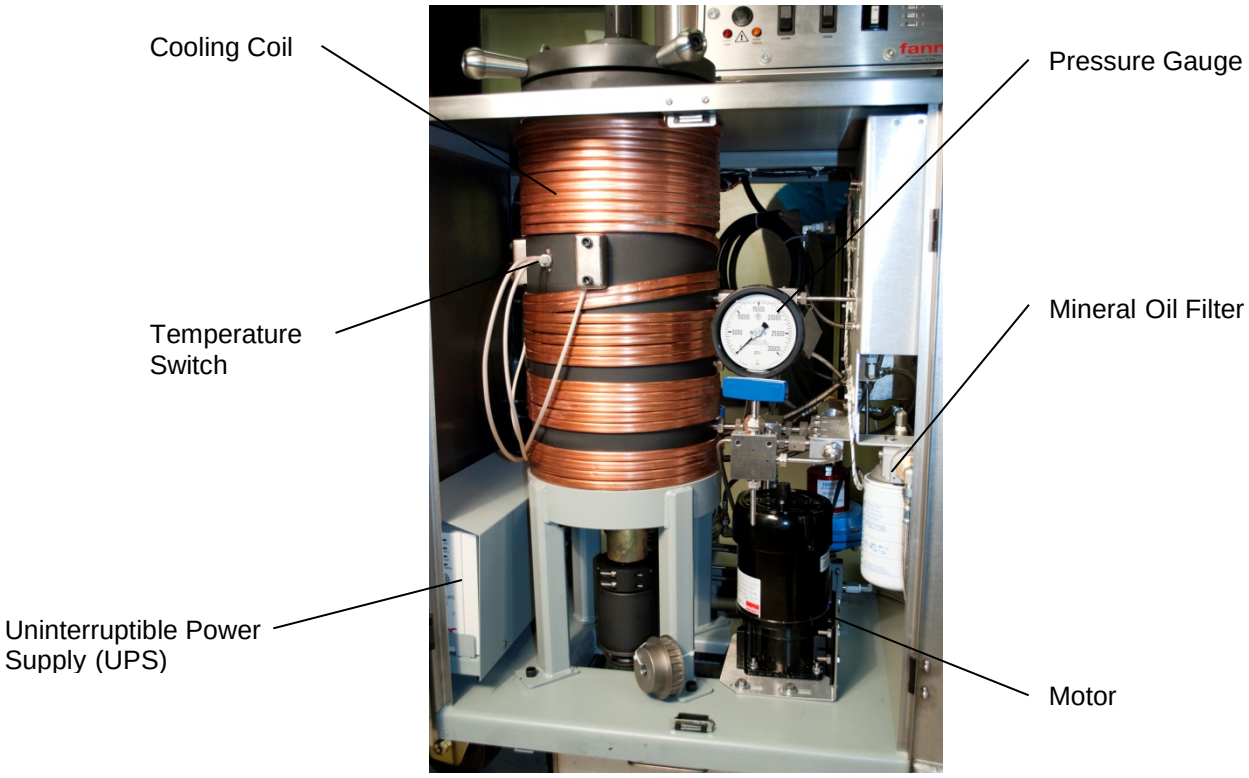


Figure 3-2 Inside Front Panel

Table 3-1 Model 290 HPHT Consistometer Specifications*

Category		Specification
Maximum Temperature		400º F (204º C)
Maximum Pressure		30,000 psi (207 MPa)
Stirring Speed		150 rpm ± 15 rpm
Heating Rate		7º F (13.9º C) per minute maximum
Cup Volume		500 ml
Dimensions	Width	28.5 in (72.4 cm)
	Depth	28.5 in (72.4 cm)
	Height	63.5 in. (161.3 cm)
Weight		990 lb (449 kg)
Voltage and Current		230 Volts AC, single-phase, 50/60 Hz, 30 A (plug not provided)
Compressed Air		100 psi minimum (689 kPa), filtered thru 50 micron, 3/8-inch female NPT
Air Exhaust		1/4- inch female NPT. Connect to muffler or drain. Air will contain oil and should be routed to an oil recovery trap.
Coolant		4 psi minimum (27.6 kPa), 1/4-inch female NPT
Coolant Drain		212º F (100º C), 1/4-inch female NPT. May contain steam at beginning of cool down

*Temperature/Pressure/Motor Speed/Timing Performance specifications compliant with API spec 10A and API RP 10B-2/ISO 10426-2.

3.1 Mechanical

3.1.1 Pressure Chamber

The pressure chamber contains the heater, slurry cup, and potentiometer. Pressure is sealed by a reusable metal seal ring located in the threaded lid. A thermocouple that extends through the lid and into the slurry cup measures the slurry temperature.

3.1.2 Heater

A multi-loop tubular ceramic heater that is rated 3,000 watts at 230 VAC is contained in an Incoloy® sheath. Metallic seals on the heater sheath provide a positive seal.

3.1.3 Pump

An air-driven hydraulic diaphragm pump provides up to 30,000 psi (207 MPa) hydraulic pressure. A built-in oil mist lubricator keeps the pump lubricated.

3.1.4 Cooling Coil

The external surface of the pressure chamber is wrapped with copper tubing that acts as a cooling coil. This cooling coil reduces the cool-down time after the test ends, minimizing the wait time between tests. It also allows testing at sub-ambient temperatures when used with a chiller. An over-temperature thermostat automatically turns off the heater if the external chamber surface rises above 350°F (177°C).

3.1.5 Packing Operation and Cooling

A chevron-style, nitrile-filled, glass and Dacron® polyester reinforced packing seals pressure in the chamber. A well-sealed chamber permits the slurry cup drive shaft to operate properly. A thermostatically controlled cooling jacket surrounds the packing for operation at high temperature

3.1.6 Lid Counterbalance

The pressure chamber lid weighs approximately 70 pounds (26.1 kg). A counterbalance offsets the lid's weight, allowing it to be moved away from the pressure chamber.

3.1.7 Lid Counterbalance Rotation Stop

An adjustable mechanical stop at the base of the mast prevents the lid from freely swinging into the control panel or adjacent instruments.

3.1.8 Rupture Disk

The HPHT Consistometer uses a rupture disk that is designed to rupture when pressures above maximum allowable working pressures are exceeded. The exact point above the working pressure at which this safety device operates is determined by the temperature and manufacturing tolerance of the rupture disc, Pressure is released through the exhaust fitting on the rear of the machine.

3.1.9 Shear Pin

A shear pin in the drive disk and drive bar of the slurry cup prevents damage to the paddle by shearing when the cement sets.

3.2 Control System

The control system (cRio) provides data acquisition, instrument control, reporting, and remote data viewing via standard Ethernet network.

Data is stored in the cRio's internal flash memory, which can store a limited number of tests.

3.2.1 Control Panel

An LCD touch screen, control switches and indicator lights are located on the front panel.

The two, 3-position rocker switches – Pressure Up/Down and Chamber Fill/Drain, are the manual controls operating the high pressure pump and the pressure relief valve and provide for filling and draining the chamber of oil.

The Motor/Heater switch provides the operator a quick way to shut off all power to the heater and motor. This control is also a circuit breaker. If the circuit breaker trips, the motor or heater may require service.

The HIGH TEMP and HIGH PRESS indicator lights come on to warn operators that the chamber temperature is greater than 120^{o}F (49^{o}C) and the pressure is greater than 250 psi (1724 kPa).

The three USB ports are available for transferring data or connecting a keyboard and mouse.

Figure 3-3 Control Panel

3.2.2 Built-in Safety Features

The HPHT Consistometer generates high pressures and temperatures during testing. Safety features including rupture disk, over-temp switch and software controls ensure safe operation.

3.2.3 Electrical Fuses

The HPHT Consistometer uses separate fuses for the heater and the main electrical systems.

3.3 Software

You can operate the instrument by using the LCD touch screen or the keyboard and mouse (included).

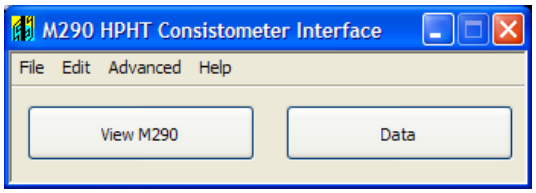
The system stores test data internally on the cRio's flash memory. It may alternately be configured to store data on the computer's hard drive or externally on USB storage devices or network file shares

The cRio has limited storage capacity and may fill quickly. It is recommended to move test results to user supplied storage devices, such as USB memory devices or network file services to avoid exceeding the storage capacity.

To launch the program, you click on the icon, wait for the HPHT Consistometer interface, and then click **ViewMODEL 290**. The main screen will appear.

The main screen and its functions are described in the following sections.

Model 290 Icon on Windows desktop



Model 290 Consistometer Interface

Main Screen Display at Start-Up

3.3.1 Sensor Display

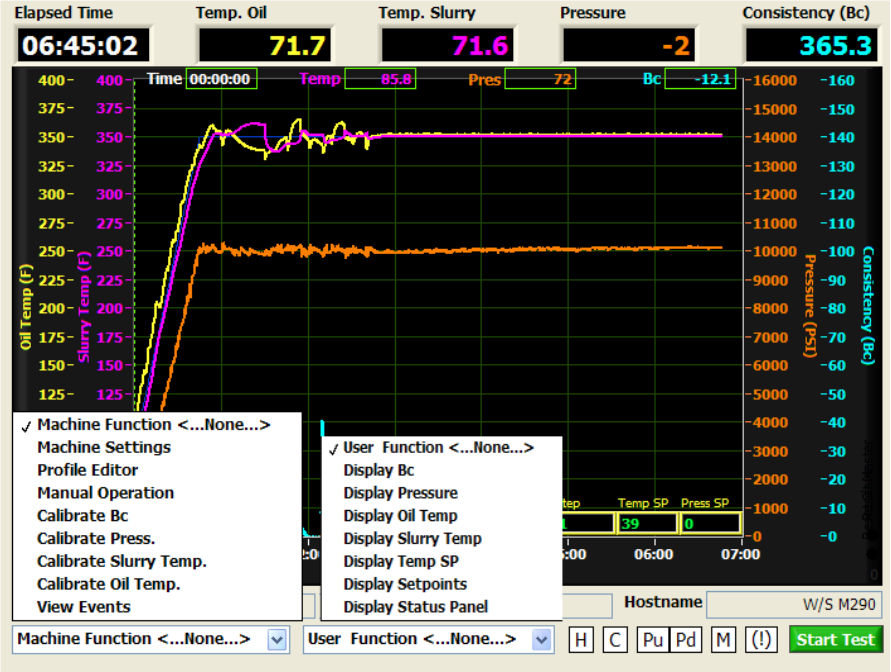
The sensor display shows these sensor readings in real-time when the test is running:

- Elapsed Time
- Oil Temperature
- Slurry Temperature
- Pressure
- Consistency (Bc)

3.3.2 Machine Function Menu

The options within this drop-down menu are as follows:

- Machine Setting - To configure controller settings, such as PID settings for temperature control, pressure dead band, machine units, cooling, and test headers.
- Profile Editor -To set up steps that define the test profile such as time, temperature set point, pressure set point and optional cooling on each step.
- Manual Operation - To manually turn on/off the motor, heater, siren, and to increase or decrease pressure.
- Calibrate Bc- A pop-up menu that guides user through calibrating the consistency values using known weights.
- Calibrate Pressure -To calibrate the pressure readings.
- Calibrate Slurry Temperature - To calibrate the slurry or sample temperature readings.
- Calibrate Oil Temperature - To calibrate the oil temperature readings.
- View Events - To view the user-specified events table during current test. Events are configured during the process of starting a test. Events will be discussed in detail in the operations section.



Machine and User Function Menus

3.3.3 User Function Menu

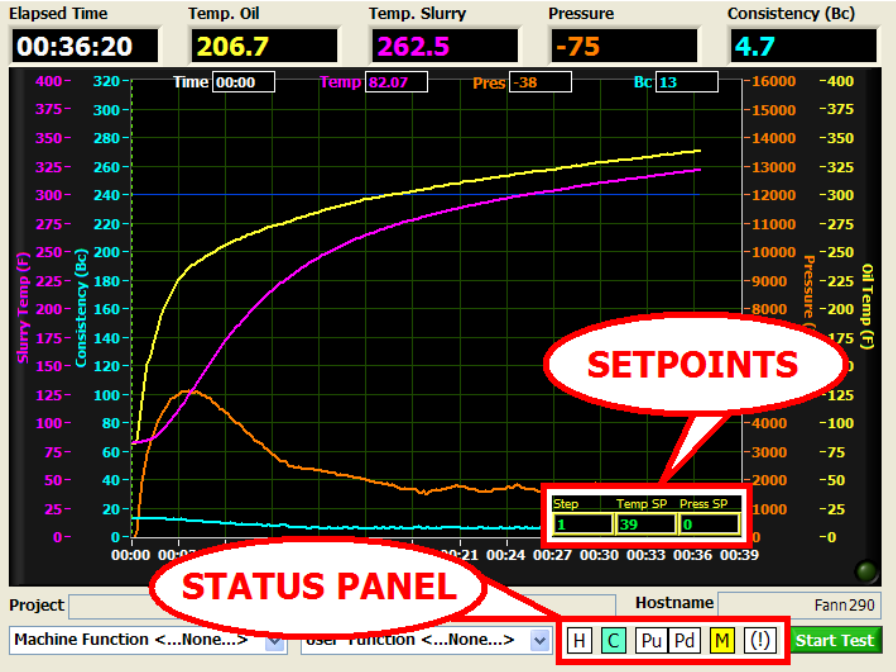
Within this drop-down menu are several options that allow the user to choose how the real-time graphs are displayed and to display the set points and status panel. The graph only shows real-time data during a test. The graph display is stationary when a test ends.

Use these commands to toggle the display of chart plots for Bc, Pressure, Oil Temperature, Slurry Temperature, and Temperature Set Point:

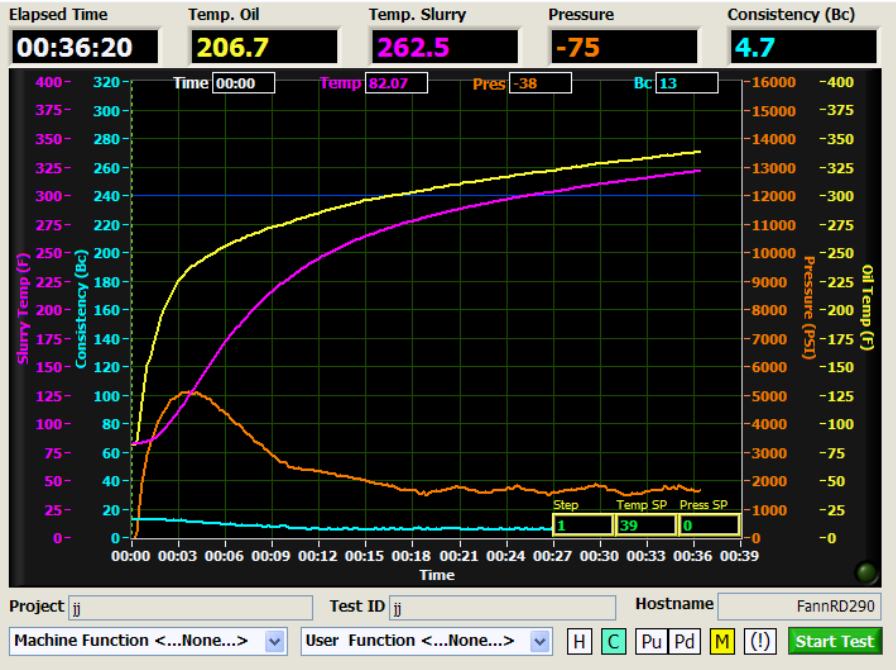
- Display Bc
- Display Pressure
- Display Oil Temp
- Display Slurry Temp
- Display Temp SP

Use these commands as outlined below:

- Display Setpoints – To hide or show the profile setpoints.
- Display Status Panel - To hide or show the Status Panel. The Status Panel shows the status of the Heater (H), Cooling (C), Pump (Pu), Pressure Down Valve (Pd), Motor (M), and User Configured Events [(!)]. The indicators change color to indicate the control hardware is activating that device.



Set Points and Status Panel



Real-time Graph

3.3.4 Start Test

The Start Test button is located on the bottom right side of the main screen. This button initiates the Start Wizard for quick test launch.

4 Installation

The Model 290 weighs approximately 1000 lb (450 kg) and is top-heavy. If the consistometer is being installed in a laboratory with engineered wood flooring (usually found in portable buildings and trailers houses) or in other structures not built on concrete floors, reinforce the floor where the machine will be operated and serviced. Please keep the Model 290 on the reinforced flooring. The weight of the machine makes it very difficult to roll over small bumps. Unprotected and unreinforced flooring will fail quickly under the weight of the machine.

4.1 Secure Placement and Safe Moving

The two front casters supporting the consistometer have locks. When the consistometer is stationary, please lock the casters to prevent the machine from moving unexpectedly. The floor must be level and flat for safe operation of the machine. To avoid personal injury, the consistometer should be moved by two persons experienced in moving heavy machines. Sharp sheet metal edges on the instrument present hazards as well. Proper Personal Protective Equipment (PPE) should be worn to prevent injury.

4.2 Best Location

4.2.1 Air Exhaust

When placing the consistometer, you should choose a location suitable for the air exhaust of the consistometer. This exhaust is the escape route for the high temperature oil if a rupture disc fails. The entire 1.5 gallon (5.7 liters) contents of the oil reservoir and chamber will escape through this exhaust. Routing this exhaust out of the lab is highly recommended for a clean, safe work environment. Simply placing the machine under a fume hood is not a good alternative to venting the machine out of the lab.

The air exhaust will contain oil. If the reservoir is overfilled with oil, the oil will escape through the air exhaust port. If the port is unconnected, the oil mist may get on the floor behind the machine causing the work area to be slippery and unsafe. The oil will damage some plastics over time.

While the recommended mineral oil is relatively safe for skin contact, breathing the oil vapors can be dangerous. This oil vapor will also likely contain traces of the chemical additives used in your cements.

Multiple machines may be connected to a single oil recovery system outside the lab. Be sure to observe all applicable rules and laws regarding safe handling and disposal of waste mineral oil.

4.2.2 Power Connection

The Model 290 comes with a 10-ft (3.05-m) power cord. A power cord plug is not included because diverse types of electrical outlets exist worldwide. You should either wire the HPHT Consistometer directly to an electrical disconnect or attach a plug that inserts into an electrical outlet.

A safe and appropriate electrical supply must meet the following requirements:

- 230 V
- Single-phase AC
- 30 A
- 50/60 Hz

The frequency of the electric power source, 50 or 60 Hz, determines the rotating speed of the electric motor for the slurry cup. To achieve the API required slurry cup speed of 150 ±15 RPM, the correct pulley must be installed on the motor output shaft. Those pulley requirements are as follows:

- 50HZ power – 24 Tooth
- 60HZ power – 20 Tooth

4.3 Hydraulic and Pneumatic Connections

Four hydraulic and pneumatic ports are located on the back of the HPHT Consistometer: 1) coolant supply; 2) coolant drain; 3) air supply; 4) air exhaust. See Figure 4-1.

Using flexible lines to connect the hydraulic and pneumatic services is recommended. Flexible lines make it easier to move the instrument without disrupting services.

The specifications for the hydraulic and pneumatic ports are listed in Table 3-1.

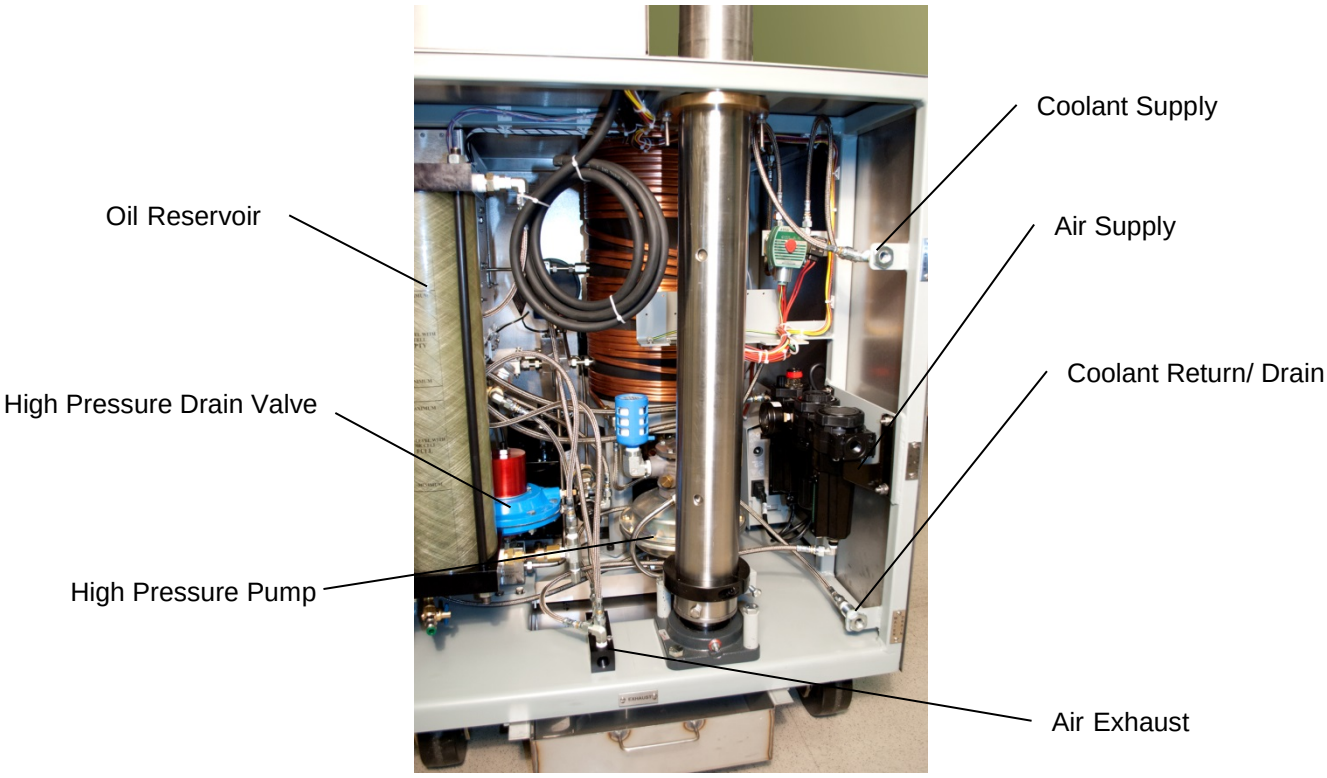


Figure 4-1 Inside Back Panel

4.4 Keyboard, Printer, and Network

The keyboard with integral touchpad is connected to any available USB connector on the front of the Model 290 HPHT Consistometer. User supplied accessories, such as a printer, may also be connected to an available USB connection. The Model 290 HPHT Consistometer may be connected to a local area network (LAN) through the rear-mounted RJ-45 connector.

4.5 User and System Configuration

The machine's PID gains settings directly affect the instrument's performance. System configurations are set and tested before the instrument is shipped.

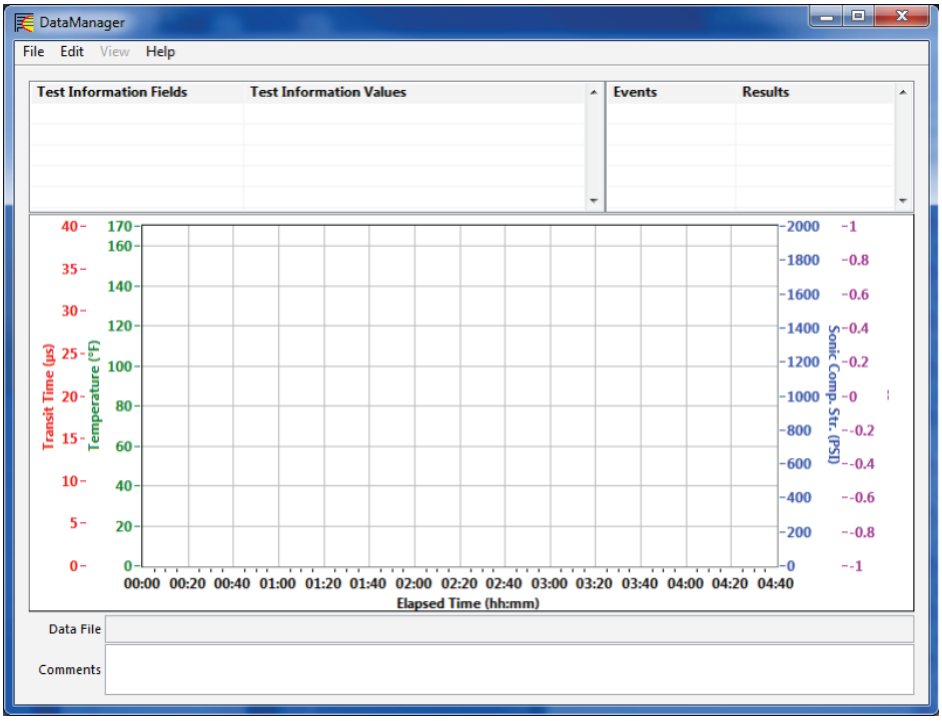
Consult Fann Instrument Company before changing parameters in Machine Setting and Pressure Setting sections.

Making changes to the Machine Setting and Pressure Setting commands will directly affect the performance of your HPHT Consistometer.

4.6 Data Manager

You must use Data Manager to view the data. Data Manager is included in the system.

In Data Manager, you can customize how the test data looks. For instance, you can change the report title, or subtitle, and change the scale values for graphs. To change scale values on the graph, double-click on the scale and input your minimum and maximum values.



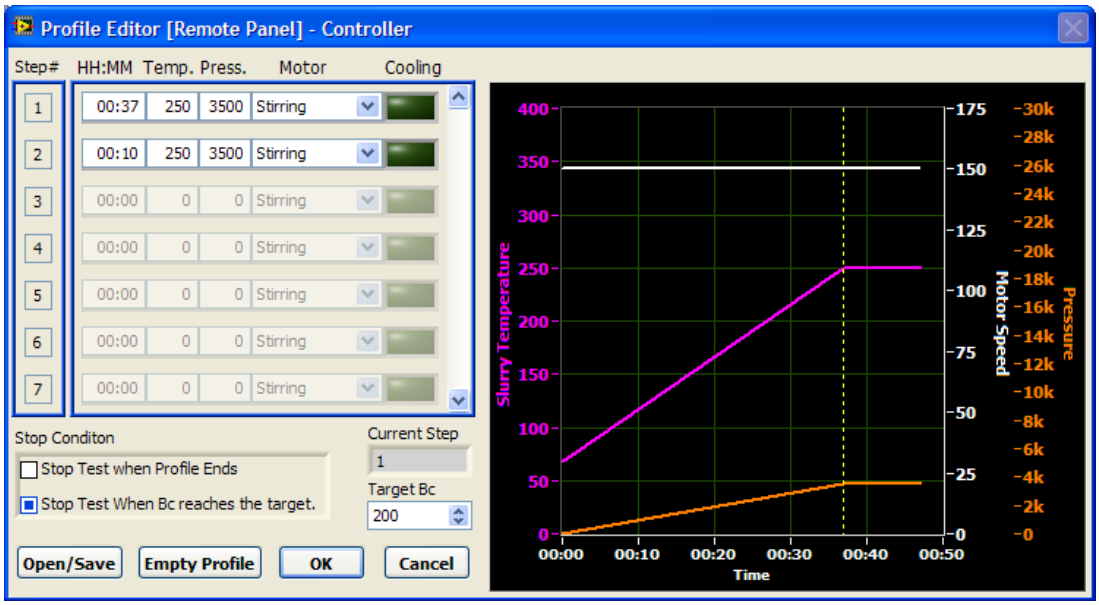
Data Manager Screen

4.7 Profile Editor Tips

The purpose of this section is to explain the requirements for the Profile Editor and to identify the preferred profile.

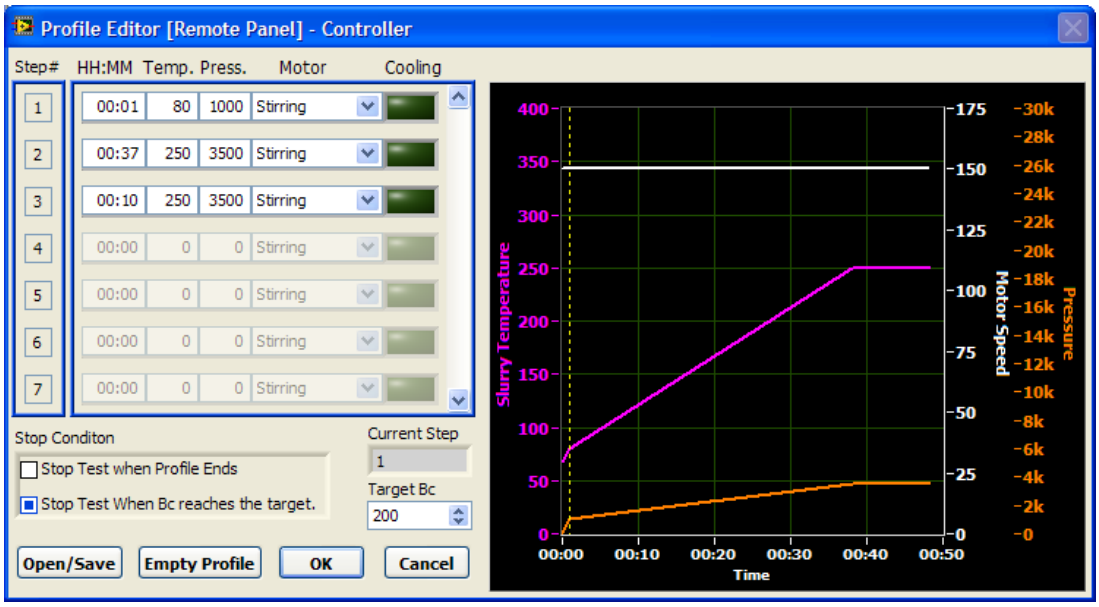
When entering a profile, you are not required to enter an initial step to set initial conditions, but you can do so. The calculation of the temperature ramp begins from the current slurry temperature.

The following screen capture is the preferred profile. Notice that it does not contain an initial step.



Profile without an Initial Step

The following screen capture is an example of a profile that uses an initial step.



Profile with an Initial Step

Do NOT end profiles with a ramp. Always include a step that indicates temperature hold.

5 Local Area Network (LAN) Setup

The Fann Model 290 is the industry's first HPHT Consistometer that uses embedded network controls. This unique architecture consists of the Model 290 Integrated Control Panel, and the Model 290 HPHT Consistometer Controls Hardware. The integrated control panel communicates with the controls hardware via an internal Ethernet connection. The Model 290 is designed to use Dynamic Host Configuration Protocol (DHCP) and automatically configures itself at boot time to operate as either a standalone consistometer, independent of a computer network, or as network nodes on your existing TCP/IP Ethernet network. See Figure 5-1.

Static or fixed IP addresses are not recommended, but you may use it if your existing network requires it. The Model 290 will use two addresses – one for the integrated control panel and one for the controls hardware (cRio). Both addresses must be in the same network.

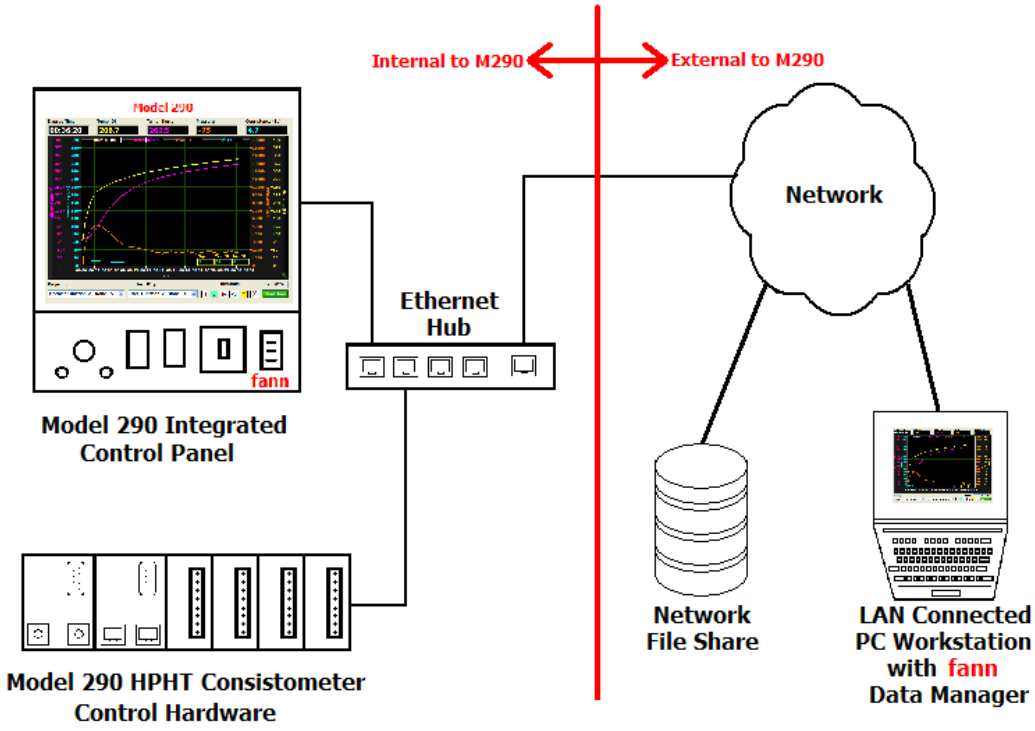


Figure 5-1 Fann Model 290 Controls Architecture

The simplest configuration uses your network's Dynamic Host Configuration Protocol (DHCP) to automatically receive Internet Protocol (IP) addresses. This is the factory default configuration, and it will allow your consistometer to operate without a network as well. If your network does not support DHCP, or if your network requires a static IP address, you may use the static IP address provided by your network administrator. If no network connection is available, the machine will be configured as "standalone" automatically at boot time.

A manual hardware configuration process identifies the address assigned to the controls hardware, and configures the Model 290 Integrated Control Panel to connect to the HPHT Consistometer Controls Hardware in *that* machine. During the hardware discovery process, other equipment may be found on your network, such as other Fann laboratory test equipment and possibly other non Fann Instrument company hardware.

It is very important that the person configuring the hardware take care to verify that the serial number on the front panel of the consistometer exactly matches the serial number of the controls hardware found. Failure to do so may result in interrupting tests and data collection on other machines.

5.1 Configuring for Network Supporting DHCP

To configure your Model 290 for use on a network supporting Dynamic Host Configuration Protocol (DHCP), or to configure for use without a network (standalone), perform the steps in this section to restore your network setting to the default factory configuration.

Normally, you would not need to follow these instructions to configure your Fann Model 290. It should automatically configure itself at boot time. The Model 290 Controls Software searches for the serial number of the Consistometer Controls Hardware upon initialization. If the Controls Software cannot find the Controls Hardware, it will automatically launch the Hardware Configuration screen.

If you have completely powered off the hardware using the UPS unit on/off switch, and powered the unit on, and the control panel still will not communicate with the controls hardware, then follow these instructions to verify your settings.

It is required that these machines receive two IP addresses in the same subnet. Check with your network administrator to ensure that both IP addresses assigned to these machines are in the same subnet. If these settings do not establish connection

to the embedded controls hardware, contact Fann Instrument Company or your authorized reseller for assistance.

Follow these steps to restore to your network setting to the default fault factory setting whether or not your instrument is on a network.

1. From the Windows Control Panel, configure your Network TCP/IP settings for DHCP.

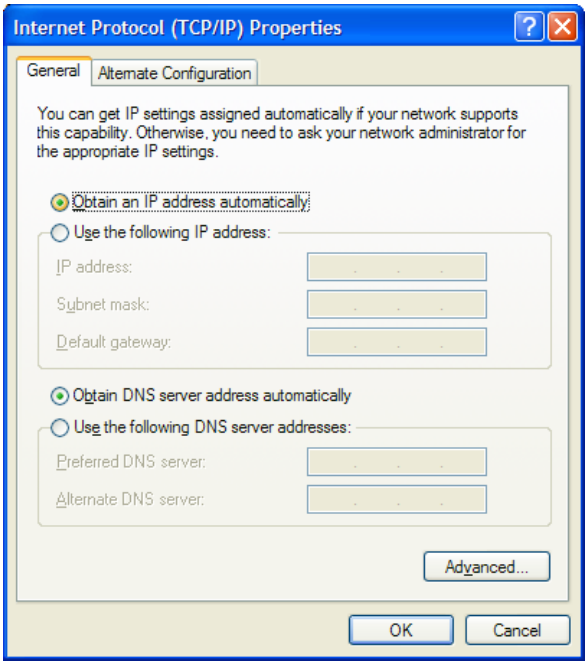
   a. Click **Start**, **Settings**, **Control Panel**.

   b. In the **Control Panel**, open the **Network Connections**.

   c. Double click **Local Area Connection** and select **Properties**.

   d. Scroll down to **Internet Protocol TCP/IP**. Double click to open.

   e. Select **Obtain an IP address automatically** and also **select Obtain DNS Server addresses automatically**.



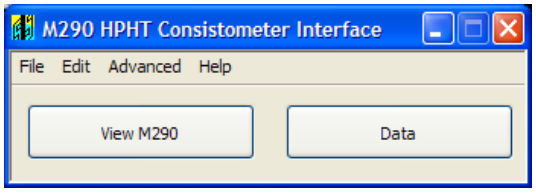
2. Unless you are configuring for no network, make sure the Ethernet cable is plugged into the Ethernet jack on the rear of the Model 290 control panel. If you are configuring for no network, be sure the cable is NOT plugged in.

3. Click on the Windows **START** button, and select the options to shut down the computer. Wait until Windows has completely shut down.

4. Press the power button on the front of the UPS unit located in the lower left front of the consistometer chassis to power the unit off. Ensure the lights on the UPS have all turned off for about 30 seconds before pressing the button again to power on. The display may go blank momentarily during the boot process; this is normal.

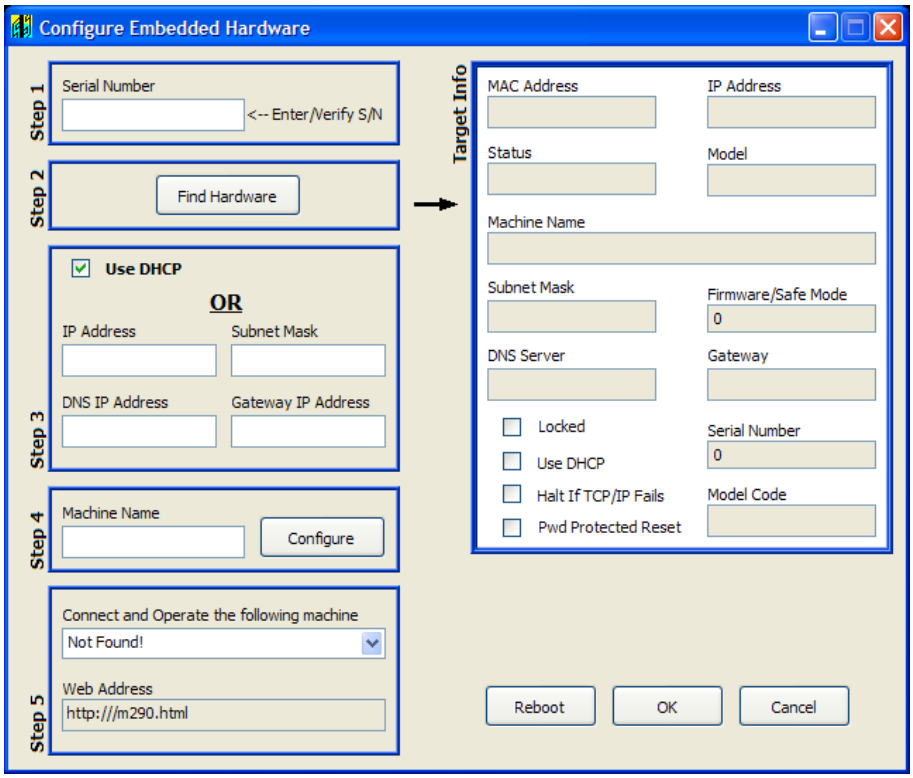
5. After Windows has fully booted, double click the Model 290 icon on the Windows Desktop to open the Model 290 HPHT Consistometer Interface.

The Model 290 Controls Software searches for the serial number of the Consistometer Controls Hardware upon initialization. If the Controls Hardware is found, a window will open showing two buttons: 1) **View MODEL 290**; 2) **Data**.



If the Model 290 Controls Software is unable to communicate with the Controls Hardware, the Hardware Configuration will open automatically.

6. Click **Edit**, then **Config HW** to open the **Configure Embedded Hardware** screen. You will see six boxes with blue borders labeled as **Target Info** and **Steps 1**, **2**, **3**, **4**, and **5**.



Step 1

Enter the serial number that matches the serial number on the label below the Model 290 Integrated Control Panel.

The serial number is located on a sticker below the consitometer's monitor.

Step 2

Click on **Find Hardware** in the **Step 2** box. You will see a pop-up dialog box that reads "Performing Operation – Please Wait." The fields in the **Target Info** box will populate.

Network connection is optional. If the IP address has this format, 169.254.XXX.XX, then the instrument is not connected to a network. For network connection, the Ethernet cable must be plugged into the machine. If it is connected, contact your IT personnel for assistance.

Step 3

Make sure the **Use DHCP** in the **Step 3** box is selected.

Step 4

The **Machine Name** (of the embedded controls hardware) field located in the **Step 4** box should be automatically populated.

It is recommended that you do not change the machine name, but if required, you may type in a new machine name. If you change the machine name, then click Configure to **Configure** and reboot the Model 290 embedded controls software.

The machine name should not be an IP address. Use the machine serial number or an actual name.

Wait for the software to configure the controller. You will see a pop-up dialog box that reads, “Performing Operation – Please Wait.”

Step 5

This step is **VERY IMPORTANT.** In the **Step 5** box, the **Web Address** field will be populated with a Uniform Resource Locator (URL).

- Verify that it contains the IP address displayed in the IP address field in the above **Target Info** box.
- Click **OK**. The screen will close and return to the interface window.

Restart the application to complete the initialization of the hardware.

5.2 Configuring for Network Using Static IP Address

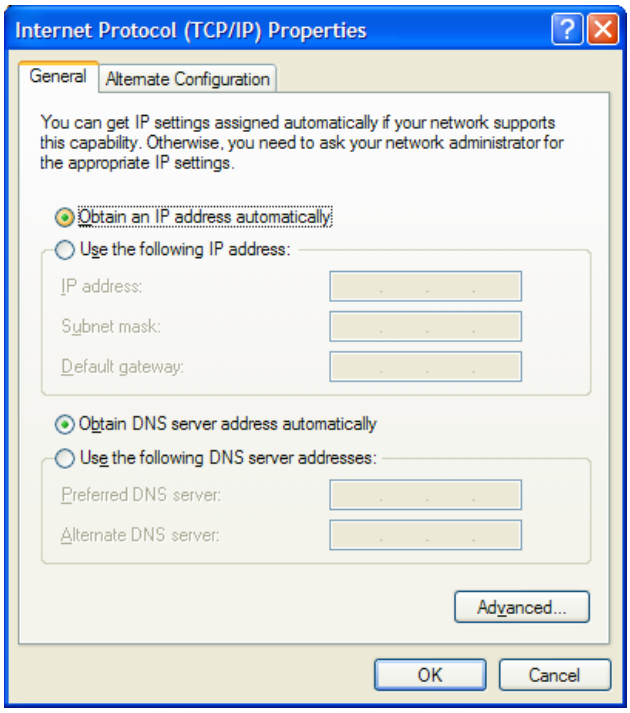
To use your Model 290 on a network using static IP address, obtain the following information from your network administrator for each Model 290 being configured:

- IP Addresses (2)
- Subnet Mask
- DNS Server IP Address
- Default Gateway IP Address

IP addresses must be unique, located in the same network subnet, and must not already exist on your network. One IP address will be used for the embedded controls hardware. The second IP address will be used for the Model 290 Integrated Control Panel.

Make sure that your network cable is disconnected before proceeding. It will get connected after configuration.

1. Make sure that the Ethernet cable is NOT plugged into the Ethernet jack on the rear of the Model 290 control panel.
2. From the Windows Control Panel, configure your Network TCP/IP settings for DHCP.
   a. Click **Start**, **Settings**, **Control Panel**.
   b. In the **Control Panel**, open the **Network Connections**.
   c. Double click **Local Area Connection** and select **Properties**.
   d. Scroll down to **Internet Protocol TCP/IP**. Double click to open
   e. Select **Obtain an IP address automatically** and also select **Obtain DNS Server addresses automatically**.

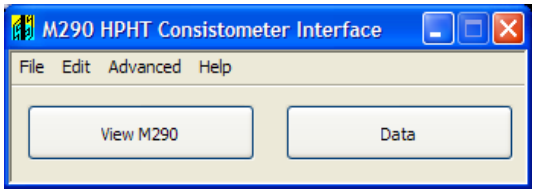


3. Click on the Windows **START** button, and select the options to shut down the computer. Wait until Windows has completely shut down.

4. Press the power button on the front of the UPS unit located in the lower left front of the consistometer chassis to power the unit off. Make sure that the lights on the UPS have all turned off for about 30 seconds before pressing the button again to power on. The display may go blank momentarily during the boot process; this is normal.

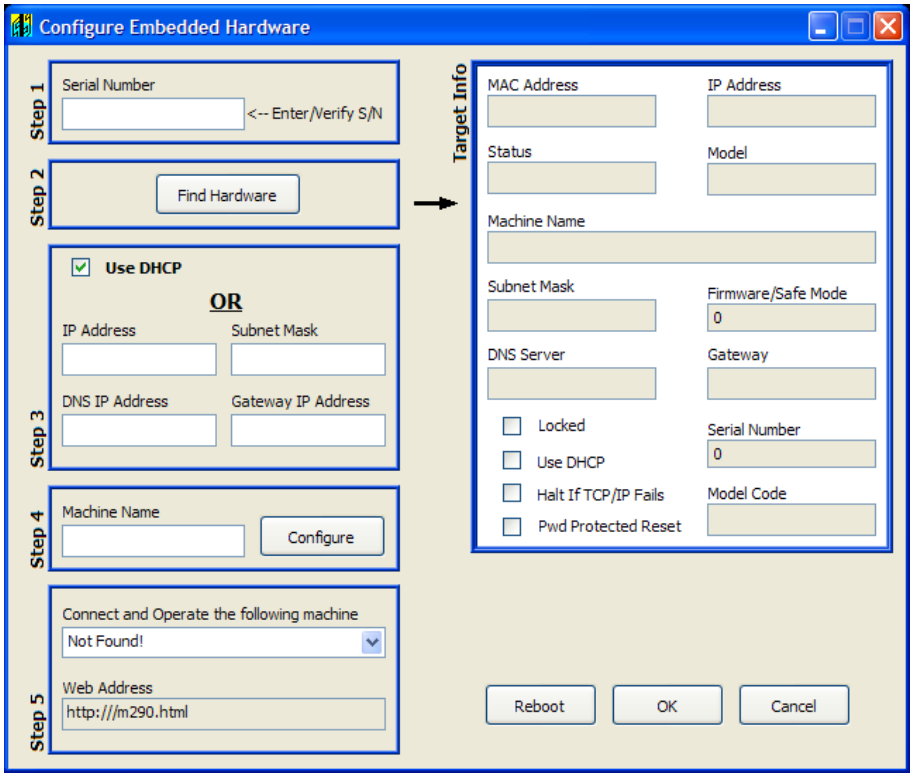
5. After Windows has fully booted, double click the Model 290 icon on the Windows Desktop to open the M290 HPHT Consistometer Interface.

The Model 290 Controls Software searches for the serial number of the Consistometer Controls Hardware upon initialization. If the Controls Hardware is found, a window will open showing two buttons: 1) **View MODEL 290**; 2) **Data**.



If the Model 290 Controls Software is unable to communicate with the Controls Hardware, the Hardware Configuration will open automatically

6. Click **Edit**, then **Config HW** to open the **Configure Embedded Hardware** screen. You will see six boxes with blue borders labeled as **Target Information** and **Steps 1**, **2**, **3**, **4**, and **5**.



Step 1

Enter the serial number that matches the serial number on the label below Model 290 Integrated Control Panel.

The serial number is located on a sticker below the consitometer's monitor.

Step 2

Click on **Find Hardware** in the **Step 2** box. You will see a pop-up dialog box that reads, “Performing Operation – Please Wait.” The fields in the **Target Info** box will populate.

Step 3

Enter the IP Address, Subnet Mask, Domain Name System (DNS) IP Address, and Gateway IP Address provided by your network administrator for the embedded controls hardware in the available fields in the **Step 3** box.

Step 4

The **Machine Name** (of the embedded controls hardware) field should be automatically populated in the **Step 4** box. It is recommended that you do not change the machine name, but if required, you may type in a new machine name.

If you type a new machine name, then click **Configure** to configure and reboot the Model 290 embedded controls software.

The machine name should not be an IP address. Use the machine serial number or an actual name.

Wait for the software to configure the controller. You will see a pop-up dialog box that reads, “Performing Operation – Please Wait.”

Step 5

In the **Step 5** box, the **Web Address** field will be populated with a Uniform Resource Locator (URL) containing the IP address displayed in the IP address field in the **Target Info** box. If it does not, use the drop- down menu in the field **Connect and Operate the following machine** to select your machine name.

Click **OK**. The screen will close and return to the interface window.

Make sure that your Ethernet cable is plugged into the Ethernet jack on the rear of the Model 290 control panel.

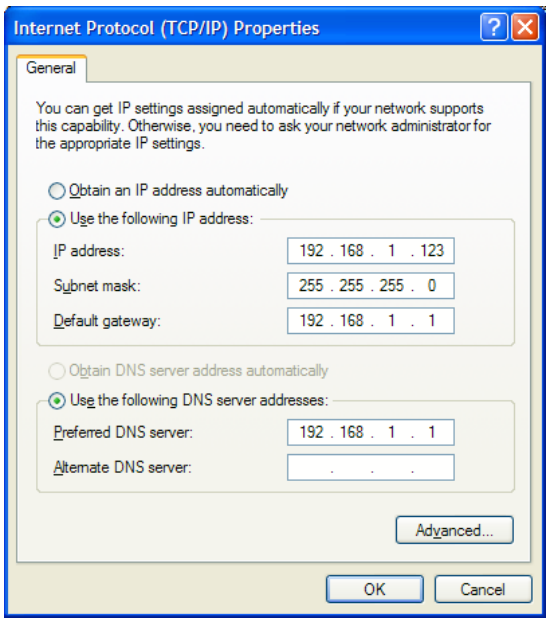
From the Windows Control Panel, configure your Network TCP/IP settings for manually configured IP addresses.

a. Click **Start**, **Settings**, **Control Panel**.

b. In the **Control Panel**, open the **Network Connections**.

c. Double click **Local Area Connection** and select **Properties**.

d. Scroll down to **Internet Protocol TCP/IP**. Double click to open.



e. Select the option **Use the following IP address**.

f. Using the information provided by your network administrator for the Model 290 Integrated Control Panel, enter the IP address, Subnet mask, Default gateway, and DNS server address (es).

g. Click **OK**.

On the Model 290 HPHT Consistometer Interface, click **View MODEL 290**.

5.3 Remote Data Viewing

This section outlines the steps required to automatically view test results from computers other than the Model 290 computer. Viewing the data remotely requires that the data be automatically transferred to a network location and that the viewing computer has the necessary software. These requirements will be also addressed in this section.

You may need to obtain network permissions to perform some of these steps. Please contact your IT department for assistance.

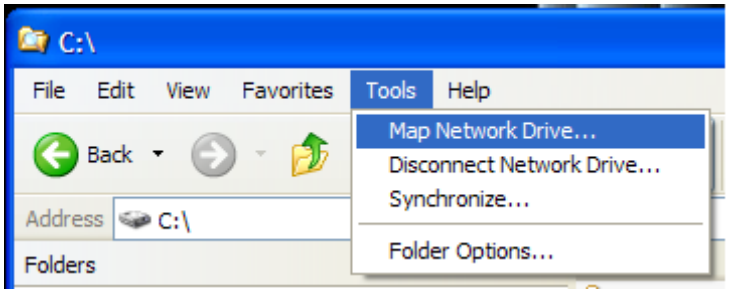
5.3.1 Model 290 Computer Configuration

These steps explain how to configure the Model 290 computer and software to save the test files to a network location.

Decide where you will archive your Model 290 data files. This network location should be easily reached by both the Model 290 systems and anyone who needs remote access to the data.

On the Model 290 computer, open **Windows Explorer**. Right-click on the **Start** button and select **Explore**.

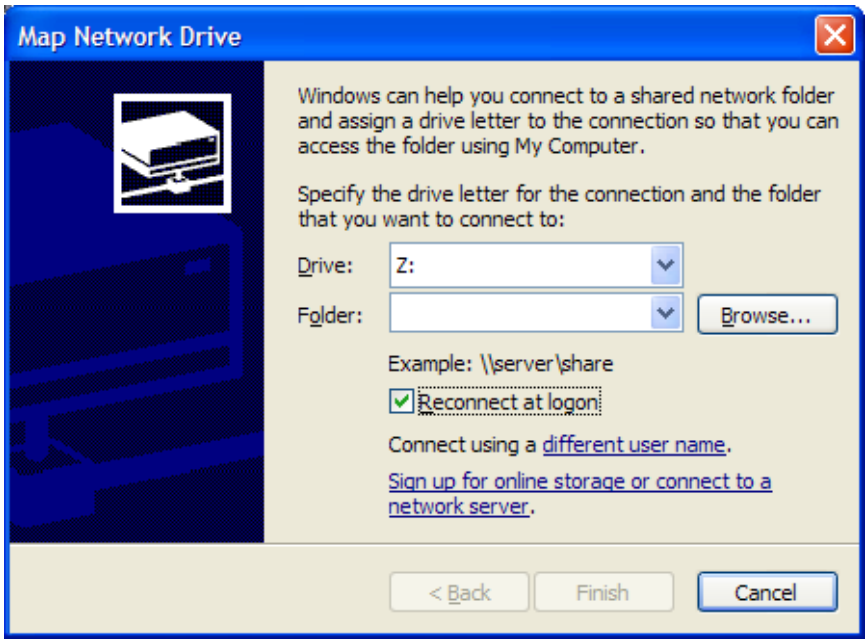
Select **Map Network Drive** from the **Tools** menu.



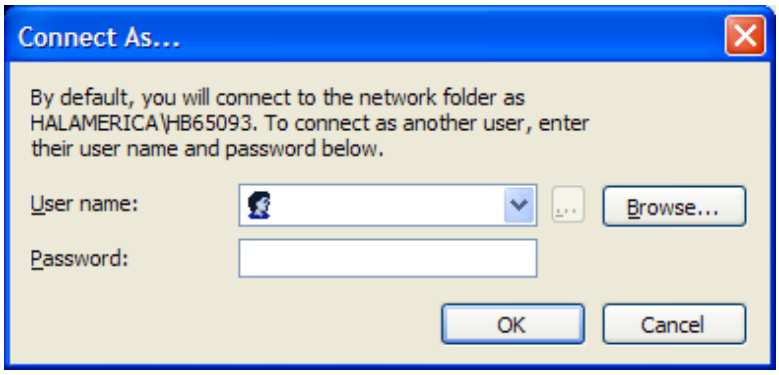
Select the drive (**Drive:**).

Enter the full path to the network directory in the folder (**Folder:**) where the files will be saved.

Make sure that **Reconnect at logon** is checked.



If permissions to this directory requires a user logon other than the one used for the system, click on a different user name to set up those options.



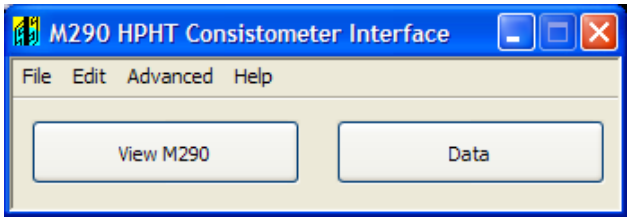
After entering the user name and password, click **OK** to close the window.

It is recommended that your lab create a generic user name and password for the instrument. A dedicated user name and password will not expire or change unless you change it.

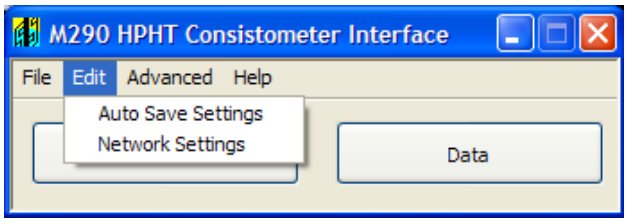
Select **Finish** to complete setting up the mapped drive.

5.3.2 Model 290 Software Configuration

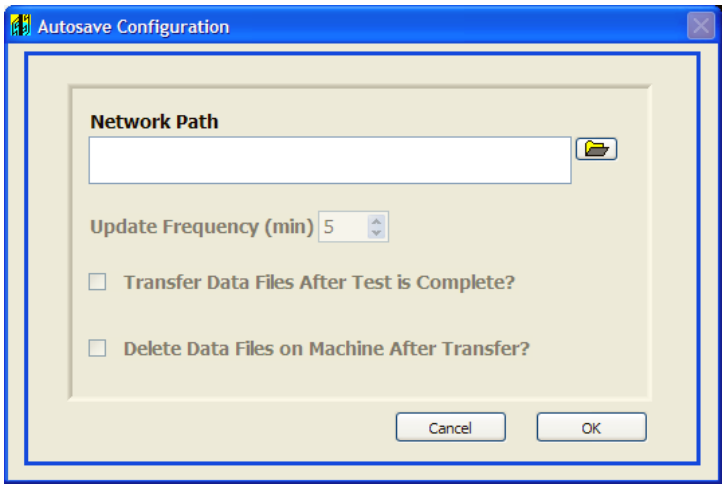
Open the Model 290 software and wait for initialization to complete.



From the **Edit** menu, select **Auto Save Settings**.



Click on the folder icon to browse to the mapped drive and any subdirectory for the data files.



Select **Transfer Data Files After Test Is Complete?**

Verify that the network transfer of data files was successful. You have the option to setup auto-deletion. However, it is recommended that you verify that data files were successfully transferred before choosing auto-deletion. To setup auto-deletion, select **Delete Data Files on Machine After Transfer?**

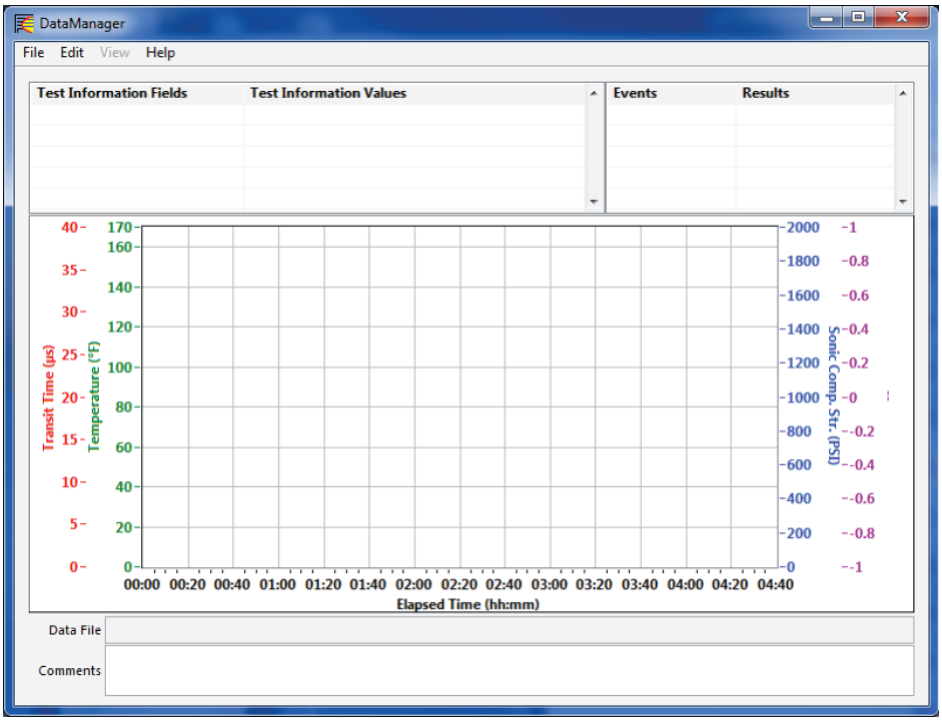
5.3.3 Remote Computer Configuration

These steps show how to configure the remote computer for viewing the test data.

If necessary, follow the same procedures for mapping the network drive as described for the Model 290 computer. This step may not be required if the user already has access to the network folder.

Download and install the Data Manager software from the Fann website.

After installation, open Data Manager. Select the **Help** menu and choose **Check for Updates** to get the latest version.



From the **File** menu, select **Open** and choose the file to view.

The normal file extension for data files is *.tdms*. The file extension for tests that are in progress is *.tdmp*. Knowing these file extensions helps you find files if the exact file name is unknown.

6 Operation

This section contains procedures for designing and entering a test schedule (profile), starting a test, and completing a test. Non-routine procedures are also included in this section – calibrating pressure, temperature, and consistency, and making changes during a test.

Calibrate according to your laboratory requirements. It is not necessary to calibrate before every test. However, Consistency (Bc) calibration needs to be performed anytime the potentiometer is adjusted or repaired.

Before running a test, you must plan a test schedule and set the events to log if you need them.

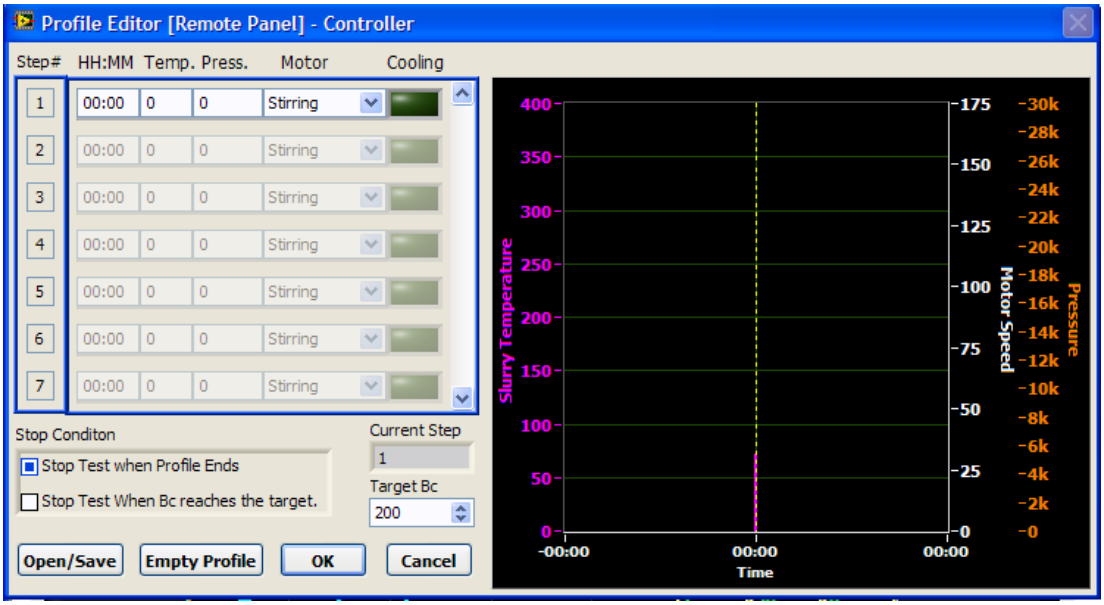
6.1 Test Schedule

If you want to run a test using a previously defined test schedule, then you can proceed with calibrating the consistometer or running a test. Otherwise, follow the instructions in this section to plan a test schedule.

When the HPHT Consistometer runs a test, it progresses through a sequence of user-specified pressures, slurry temperatures, and coolant and motor states that are planned to occur at specific times during the test. This sequence of parameters makes up the test schedule. A schedule can contain up to 99 steps.

6.1.1 Creating a New Schedule

1. From **Machine Function** menu, choose **Profile Editor**.



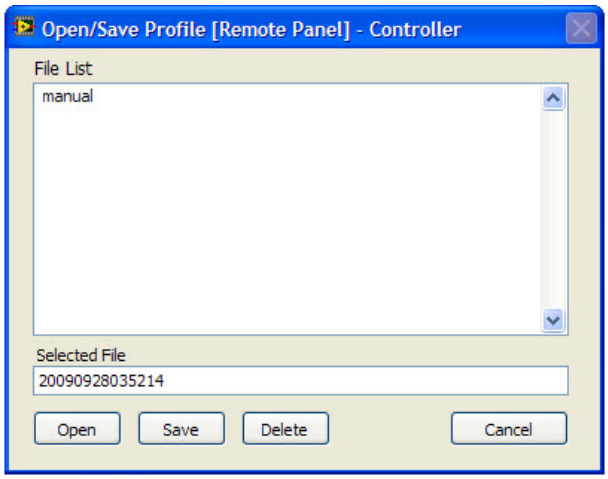
Profile Editor Screen

2. For each step number (**Step#**), enter values in each field - **HH:MM** (time in hours and minutes), **Temp** (temperature), **Press** (pressure), **Motor** (rotation), and **Cooling**. If no data is entered these fields will default to HH:MM: 00:01, Temp: 32, Press: 100, Motor: Stirring, Cooling: Off.

There are three possible motor states: Stirring (turning at 150 revolutions per minute); Not Stirring; and H Squeeze (hesitation squeeze).

If the set point entered is different than the current status of the chamber at the time the step begins, a Ramp will be generated automatically by the software. The Ramp will control the increase/decrease of the temperature and/or pressure over the time entered in the step.

3. Press the **Open/Save** button (on the Profile Editor screen) to save all step data. In the **Open/Save Profile** screen, you have the option to name the test profile. By default the file name will be a series of numbers. You may erase this name and type a more useful name for the profile.



Open/Save Profile Dialog

6.1.2 Editing an existing Schedule

You can edit an existing schedule name or description. You can also edit, add new steps, or delete existing steps in a schedule.

To edit the schedule name and description:

1. On the **Machine Function** menu, select **Profile Editor**.

2. From **Profile Editor**, click **Open/Save** button.

3. In the **Open/Save Profile** dialog box, select the profile you want to edit. Press the **Open** button located on the **Open/Save Profile** screen panel. The profile is displayed in the **Profile Editor**.

4. Make the desired changes, and click the **Open/Save** button to save your changes. By default, the system will choose a unique numerical name. You may use this name, type in a new name for your schedule, or overwrite an existing schedule.

5. Click **Save**.

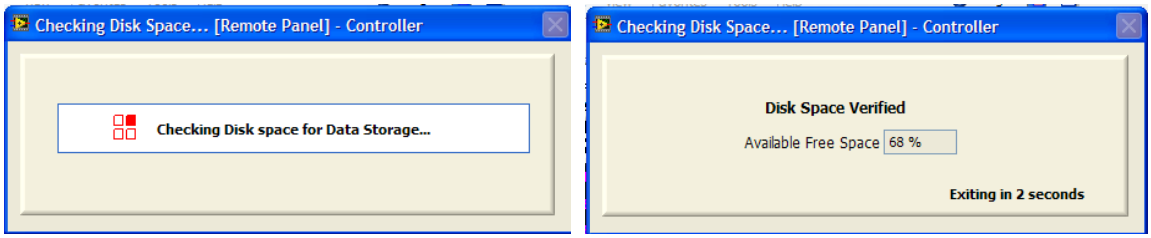
6. At **Profile Editor**, click **OK** to write the schedule displayed in the editor to the active schedule or press **Cancel** to abort the changes made.

To edit an existing schedule step:

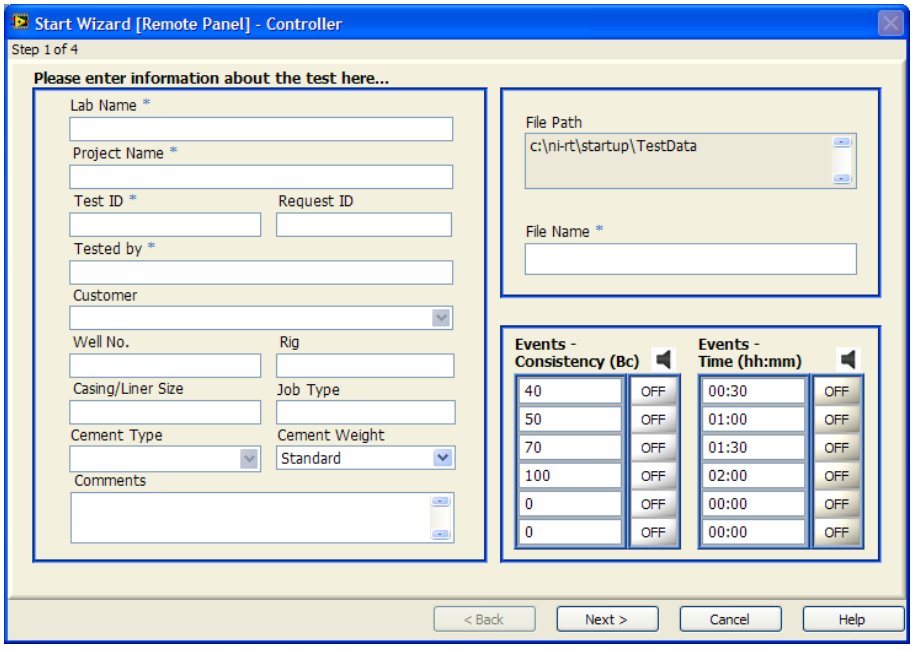
1. Highlight desired schedule to edit.
2. Make the appropriate changes in these steps.
3. Press the **OK** button to save your changes.

6.2 Test Start-up

1. Choose the **Start Test** button from the main screen (Figure 3-5). Wait for the system to check data storage space on the controller, and then to display the percentage of available storage space on the controller (cRio).



2. When the **Start Wizard** screen appears, fill out the text fields accordingly.



Start Wizard, Step 1 of 4

3. Type a file name for the test in the **File Name*** field. This file will reside on the controller until transferred by using data button on the main menu.

4. Press the **Next >** button when required text fields are complete or set your events as discussed in Section 6.3 and then press the **Next >** button.

6.3 User-specified Events

The HPHT Control System software allows the operator to log events when certain conditions are met while a test is running. The event panel is on the bottom right side of the screen.

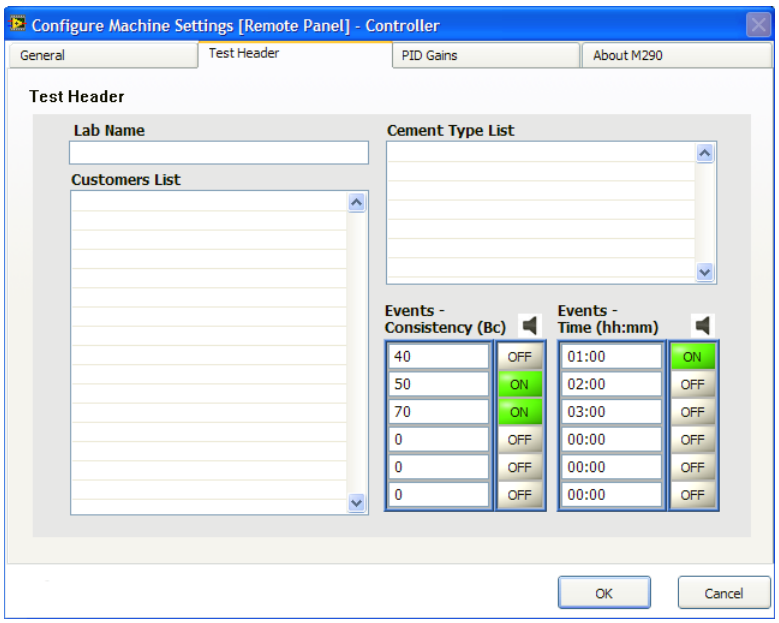
Event recording is configured in the **Start Wizard** screen, step 2 of 4. Event defaults can be set on the Machine Settings screen.

The two event (alarm) types are consistency-triggered (also called Bc-triggered) and time-triggered events. Six events of each type can be logged per test.

The Bc events are recorded when predefined consistency values are reached during test. The software marks and records the times when those Bc values are reached.

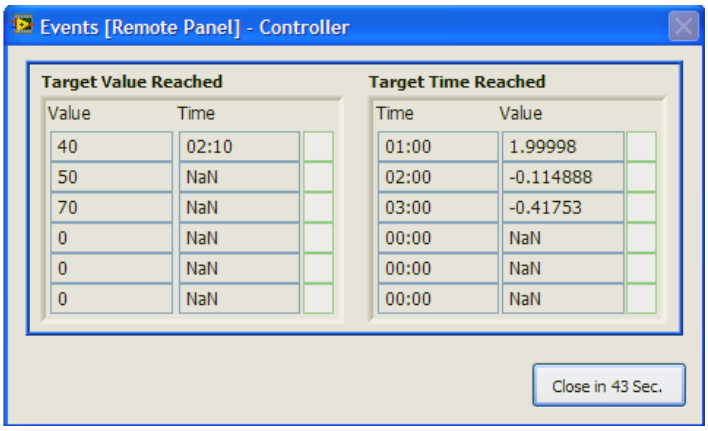
The time-triggered events are recorded when the elapsed times match the value set by the operator. The software records the Bc values at these times.

In the following example, the system will record a time stamped report entry when the consistency reaches 50 and 70 Bc. Similarly, report entries will be generated recording the current Bc value of the slurry at one (1) hour into the test.



Events Example

During a test, a pop-up dialog box will open, and the alarm buzzer will sound to alert the operator. The operator may acknowledge the event by clicking **Close** on the events pop-up dialog box. The dialog box will close automatically after one minute.



Events Pop-up Screen

During a test, the status indicator [**(!)**] located on the status panel will light up to indicate that an event (alarm) has occurred. The operator may acknowledge the events by clicking **View Events** on the **Machine Function** menu. Once the events are viewed by the operator, the indicator will return to normal.

6.4 Slurry Cup Assembly

Refer to Figure 6-1, which shows the slurry cup parts.

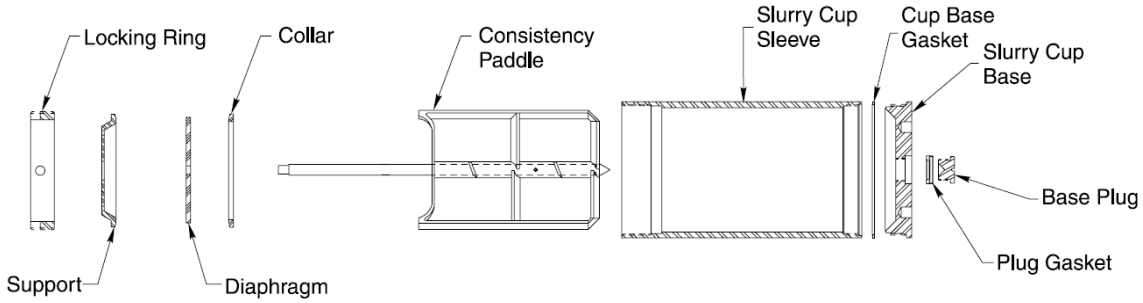


Figure 6-1 Slurry Cup Parts

Have the cup assembled and ready. According to API Specification 10, after the slurry sample is mixed, you have only 5 minutes before the test can begin.

1. Coat the threads of the slurry cup sleeve with high-temperature magneto grease (P/N 100001841). (Use grease that does not contain chemicals that might interfere with the thickening time of your test sample. Some grease contains sugar which will slow down the setting of the cement sample.)

DO NOT coat the paddle or the inside of the slurry cup with grease. If the sample becomes contaminated with grease, the test may be give inaccurate results.

2. Coat the locking ring threads, base threads, and base plug threads thoroughly with high-temperature grease. Also lightly grease the base that will come into contact with the cement slurry and place grease inside the base plug pivot point

3. Place slurry cup sleeve right side up on the cup stand.

The top of the sleeve has more threads than the bottom.

4. Place the collar in the slurry cup first, pressing it down until it settles on the ridge inside the slurry cup.

The collar has a slight bevel. The flat portion will face towards the bottom of the slurry cup sleeve (short threads), and the bevel will face towards the top (long threads) of the slurry cup sleeve.

5. Install a new diaphragm and install the diaphragm support with the concave side facing down.

6. Install the greased locking ring with its notches toward the top of the slurry cup sleeve. Screw the locking ring down, then turn the cup assembly upside down and fit the slots into the locking ring over the nuts on the cup stand. Continue tightening the locking ring until figure tight

7. Insert the paddle into the cup. The paddle must be right-side up relative to the cup; the paddle's shaft must pass through the diaphragm and the top of the cup.

8. Pour the mixed cement slurry into the cup. Tap the cup firmly to release trapped air.

9. Screw the greased base onto the slurry cup. Place the plate wrench with its slots over the bolts in the slurry cup base and tighten the base. If slurry is forced out of the hole in the base, the cup is full. If slurry is not forced out of the hole in the base, add a little more slurry through that hole..

10. Screw in the base plug and tighten it with a wrench.

11. Clean the cement from the outside of the cup. Contaminants in the chamber oil will adversely affect the hydraulic components of the machine.

12. Turn the slurry cup over. Install the drive disk and bar at the optimum position and tighten it with an Allen wrench.

6.5 Slurry Cup Installation

1. Confirm that the heater protector sleeve is installed in the chamber. Failure to use a heater protector sleeve can result in a failed heater even after one test.

DO NOT operate the system without the heater protector.

2. Use the slurry cup bail to lower the slurry cup into the chamber with the drive disk and bar end facing the top of the chamber.

3. Ensure that the pins on the bottom of the slurry cup engage the holes on the chamber turntable.

4. Without beginning the schedule (profile), start the stirring motor as soon as possible to prevent the cement slurry from setting. Press the **Motor** button to the ON position to start the stirring motor.

5. Use the slurry cup bail to lower the potentiometer onto the top of the slurry cup. The potentiometer should fit over the paddle shaft and rest on the heater protector sleeve.

6. Ensure that the potentiometer is supported on the heater protector sleeve, not on the paddle shaft. Verify this by reaching into the chamber and gently moving the top portion of the potentiometer up and down. If the top portion moves freely, the potentiometer is resting correctly on the sleeve. If the top portion does not move freely, the potentiometer is resting on the slurry cup diaphragm support, and the potentiometer must be adjusted. See Section 8.4 for those instructions.

7. Swing the chamber lid over gently and screw it onto the chamber. Turn the lid until it stops and back it off a quarter of a turn. It is normal for the lid to feel loose prior to applying pressure. Once pressure is applied, the mandrel will seal the lid.

8. Insert the slurry thermocouple into the lid. Screw the thermocouple nut, but do not tighten the nut.

6.6 Chamber Fill/Drain

Before the test begins, the chamber must be filled with oil, and air must be forced out of the chamber.

Perform the following procedure to fill the chamber with oil:

1. Press the **Chamber Fill/Drain** switch (Figure 3-3) to the *chamber fill* position.
2. Ensure the weep hole is facing away from you toward the back of the unit.
3. Hold a rag over the weep hole in the thermocouple nut, and have a wrench ready to tighten the nut. Oil will fill the chamber, forcing air out at the weep hole in the thermocouple nut. When oil begins to squirt out of the weep hole, the air is completely expelled from the chamber.
4. Tighten the thermocouple nut.
5. The switch must be in the chamber fill position for the duration of the test.

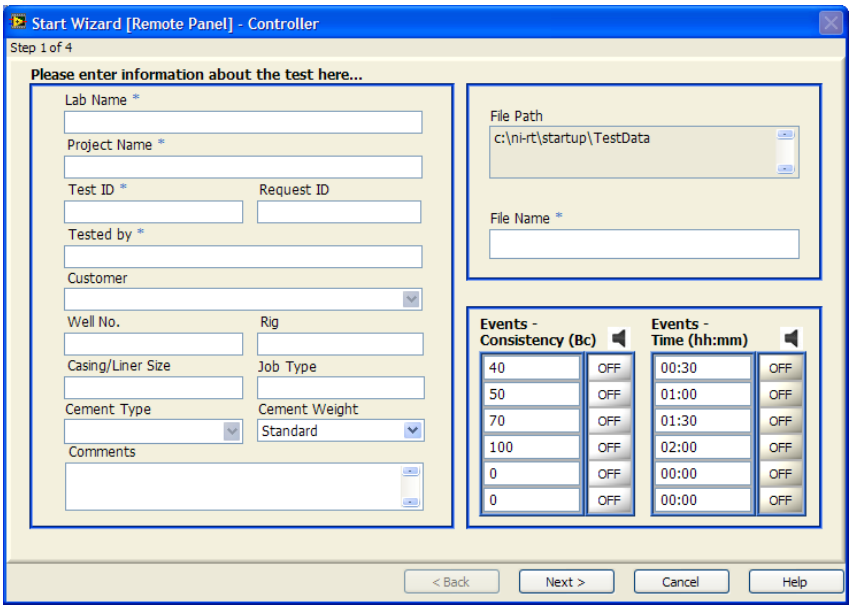
6.7 Initial Conditions

1. Before beginning the test, bring the pressure up to the initial pressure specified in the schedule at set point 1.
2. Repeatedly press the **Pressure Up/Down** switch (Figure 3-3) to the *pressure up* position. Release the switch when the desired pressure is reached.
3. If the initial level is exceeded, lower the pressure to compensate by briefly pressing the switch to the *pressure down* position, then release. Repeat if necessary.

6.8 Start Wizard

Start Wizard, Step 1

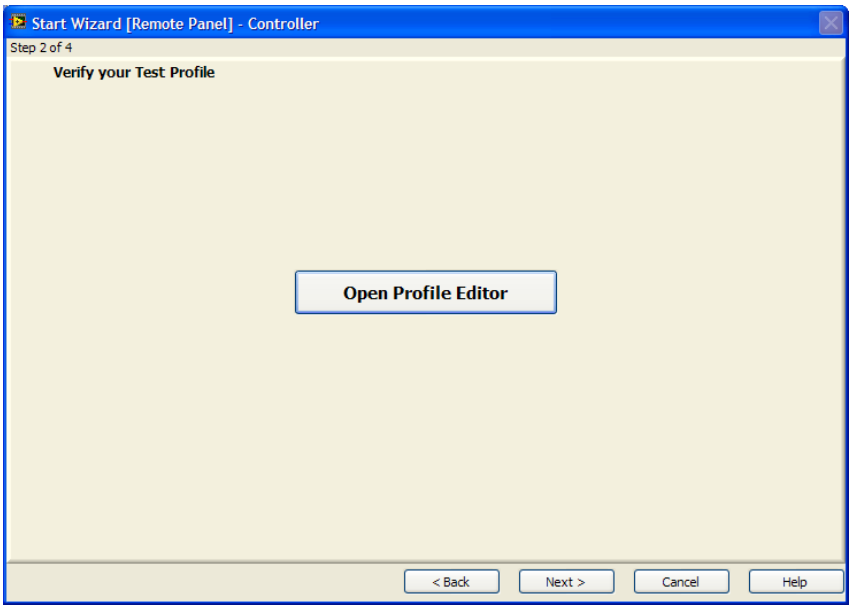
Click **Next >**.



Start Wizard, Step 1 of 4

Start Wizard, Step 2

When the next start wizard screen appears, click **Open Profile Editor**.



Start Wizard, Step 2 of 4

If you select **OK** before saving your profile, the instrument will use the profile, but it will not be saved.

You may choose a saved profile and make edits to it. If you want to save the edits, you must choose **Open/Save** option.

The **Profile Editor** screen will appear.

Select a saved test profile by pressing the **Open/Save** option and selecting a profile.

At this step, you may use the profile that appears. You may also choose to edit and save the existing profile, or choose another profile.

Profile Editor Screen

Once the profile is selected, it should appear on the profile editor screen.

Select how you want the test to end:

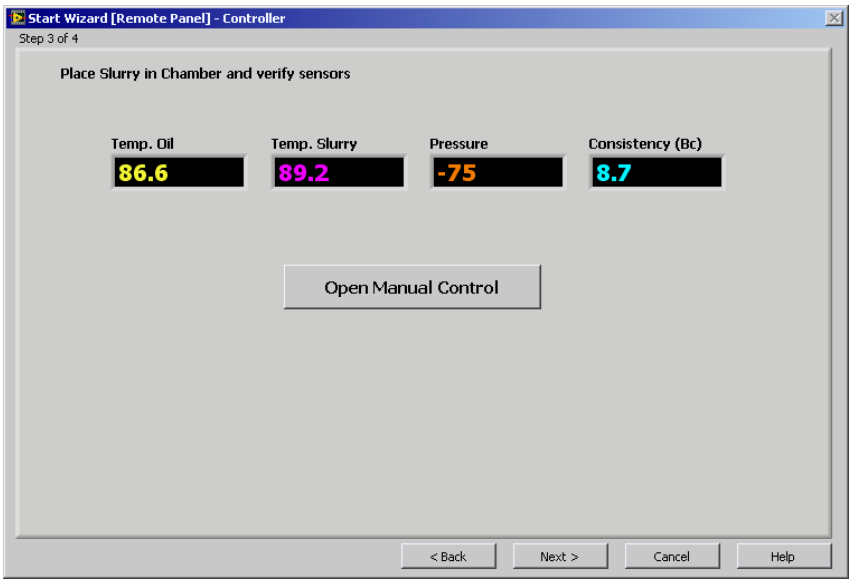
- Stop after profile steps are complete.
- Remain in a dwell state until the Bc value is met.

Click **OK** on the **Profile Editor** screen.

The **Start Wizard** screen, step 2 of 4, will appear again. Click **Next** >.

Start Wizard, Step 3

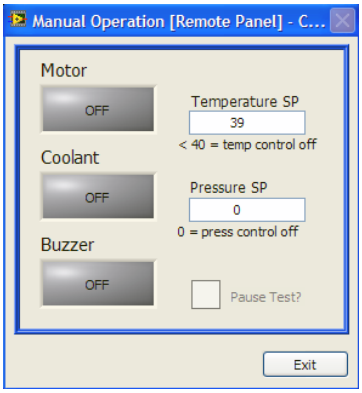
The next start wizard screen will appear. Verify that all sensors are reading the data correctly before you start the test.



Start Wizard, Step 3 of 4

Press the **Open Manual Control** button on the panel to access the manual controls.

A screen showing the various controls will appear. Make sure that everything is working as planned.



Manual Controls on Manual Operation Screen

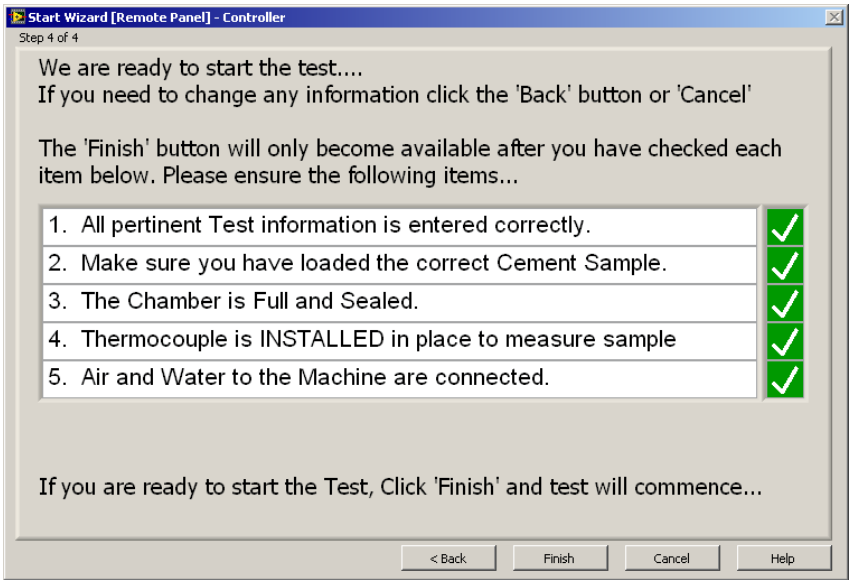
Click **Exit** to return to the start wizard screen**.** Click **Next>**.

Start Wizard, Step 4

The next start wizard screen will appear; it is a check list.

Press the appropriate box to show that action has been completed.

The **Next >** button will become **Finish**. Press the **Finish** button and the test will begin.



Start Wizard Check List

During the test, you can modify test parameters. The changes will not stop the test. See Sections 6.14 and 6.15..

6.9 Test Shutdown

The test can end either automatically (Bc or time alarms) or manually. To end the test manually, select the **Stop Test** button. (On the main screen, the **Start Test** button will become red and read as **Stop Test** when the test is in progress.)

When a test is stopped, the consistometer immediately goes into the default shutdown mode. The state of the motor, cooling and pressure during the shutdown mode can be set in the Machine Settings screen.

The motor continues to turn. Cooling water is turned on to cool down the chamber, and the chamber pressure naturally drops as the chamber cools. This prevents the cement slurry from boiling out of the slurry cup and into the chamber.

When the temperature decreases to 120° F (48.9°C), shutdown is complete. The motor will stop, pressure is no longer maintained at 1,000 psi (6.89 MPa), and the cooling water is turned off. The unit then cools to room temperature, and consequently, the pressure drops.

With no pressure control, the unit cools and the pressure drops unregulated. If the temperature is still above the boiling point and the pressure drops too quickly, the cement will boil out of the slurry cup, and the instrument will require major cleanup.

It is critical to prevent boiling by maintaining manual pressure control while the temperature is higher than 212°F (100°C).

Perform the following steps after shutdown is complete:

1. Push and hold the **Pressure Down** position until all pressure is released from the chamber.
2. Push the **Chamber Fill/Drain** switch to the *drain* position.
3. The sound of air bubbling through the oil in the reservoir indicates all oil has been evacuated from the chamber.
4. Push the **Chamber Fill/Drain** switch to the center (OFF) position.
5. Follow the directions in Section 6.10 for removing the lid and the slurry sample cup.

After a test ends, always select the **Stop Test** option on the Test Schedule screen to exit that test before starting another test. Never attempt to run another test without exiting the current test screen.

6.10 Disassembly and Cleanup

After a test is shut down, the lid assembly has to be removed so that the slurry cup and the potentiometer can be removed for cleaning. This section describes these procedures in detail.

Before removing the lid assembly, ensure that all pressure has been released from the chamber before removing the lid. Check the pressure display on both the screen display and the pressure gauge to verify that all pressure is released.

6.10.1 Remove the Lid Assembly

1. Hold a rag over the weep hole in the thermocouple nut to absorb spray, and gently loosen the slurry thermocouple gland nut. Remove the thermocouple and place it in its holder.

2. Unscrew the lid and swing it out of the way.

3. Clean the bottom of the lid. Contaminated oil on the bottom of the lid can affect the next test.

6.10.2 Remove the Slurry Cup

1. Use the slurry cup bail to remove the potentiometer from the chamber. Place it in a solvent (e.g., 140 Solvent) or in mineral oil, and agitate the potentiometer to loosen any contaminants.

2. Use the slurry cup bail to remove the slurry cup from the chamber.

3. Loosen the drive collar set screw with an Allen wrench and remove the drive collar.

4. Place the slurry cup upside down in the slurry cup stand. The slots in the locking ring will be fitted over the screws in the stand.

5. Loosen and remove the base plug with a wrench.

6. Loosen and remove the base from the slurry cup with a flat plate wrench.
7. Loosen the locking ring by turning the cup on the stand.
8. If the cement sample is still in a liquid phase, pour it into an appropriate waste container.
9. Turn the cup over and place it on the stand. Unscrew and remove the locking ring. Remove the diaphragm support, the diaphragm, and the collar.
10. Remove the paddle and cement sample.

6.10.3 Clean the Slurry Cup and Potentiometer

Cleanup is very important. Thorough cleanup extends the life of your consistometer components and keeps its test results reliable.

1. After disassembling the slurry cup, thoroughly wash all its parts in soapy water. Use mineral oil solvent and a soft brush to remove stubborn particles.
2. Clean the potentiometer with mineral oil solvent to rinse contaminants from it.

Do not scrub the potentiometer. The potentiometer can be easily damaged.

6.10.4 Inspect the Chamber

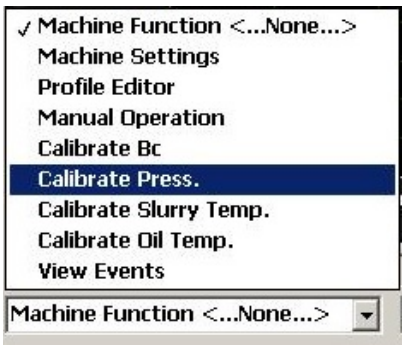
1. After the test ends, inspect the chamber. If it is contaminated with water or cement, clean the chamber, using a vacuum.
2. To maintain accuracy in the test results, keep the chamber oil clean.

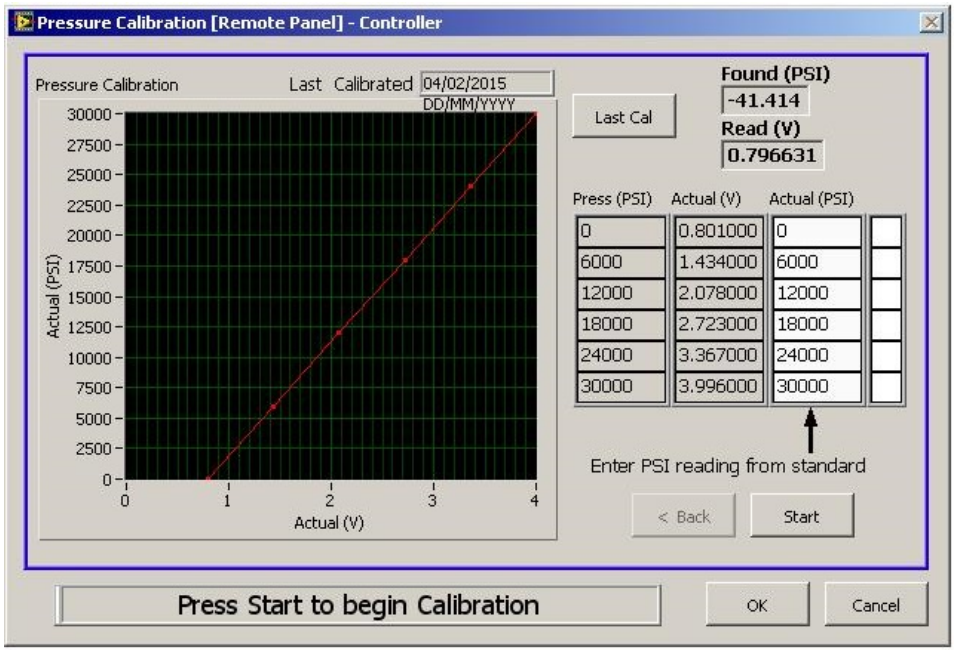
6.11 Presssure Calibration

NOTE: When calibrating pressure only use the calibrated gauge for pressure readings. Ignore any pressure reading that are on the software screen.

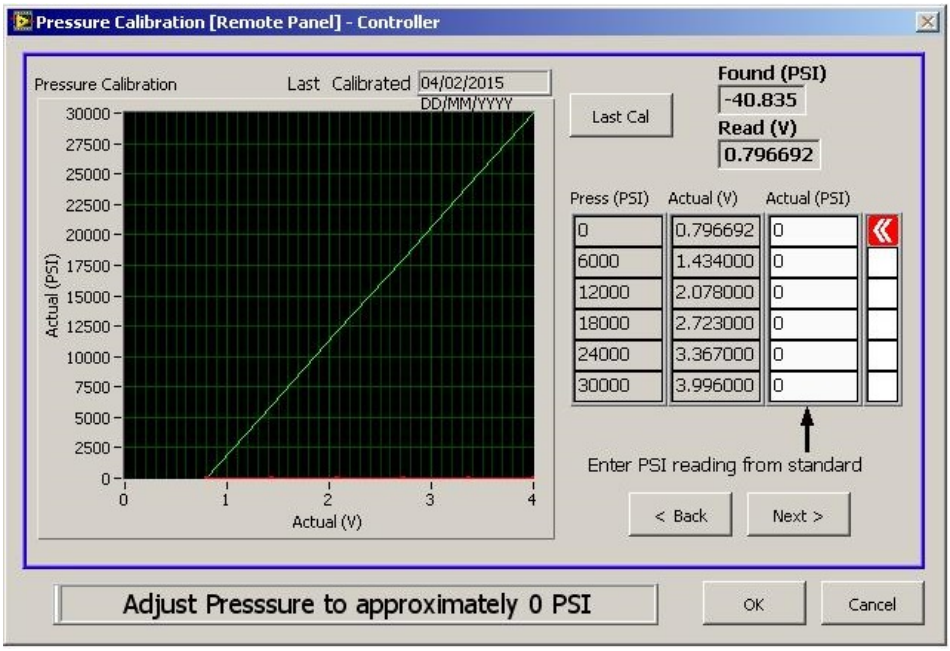
1. Connect a calibrated pressure gauge to the system.

2. On the main screen, select Main Function and choose Calibrate Press from the drop-down menu. Next, you will see the Pressure Calibration screen.





Pressure Calibration Screen



Pressure Calibration Screen

3. Press **Start**. The Start button will change to **Next >.**

4. Press **Next >.** This will record the Zero reading. Ensure that the lid is open and there is no pressure in the chamber for an accurate reading. The arrow will move to next calibration point.

5. Close the lid to the chamber. Screw the lid onto the chamber. It is not necessary to place the cup inside the chamber to calibrate pressure if enough oil is in the reservoir. Do not completely tighten thermocouple nut.

6. Rotate the mandrel with the weep hole pointed away from personnel and nearby equipment. Oil may spray from the weep hole. Place a lab towel over the weep hole near the top of the lid mandrel to prevent oil from squirting across the room.

7. Push the **Chamber Fill/Drain** switch to the fill position.

8. Purge the chamber of air until oil squirts from the weep hole in the top of the lid mandrel.

9. Tighten the thermocouple nut.

10. Using the **Pressure Up/Down** button on the front panel, pressure the system to approximately 6000 psi using the calibrated master gauge.

11. Once the Read (V) value is stable, view the actual pressure (psi) on the calibrated pressure gauge and record that value in the Actual (PSI) box. Click **Next >**.

12. Repeat steps 2-11 for 12000, 18000, 24000 and 30000 readings. Record the readings from the calibrated master gauge in their respective boxes.

13. Press **OK** to save the calibration.

Anytime during the calibration, you may advance to the next step by pressing the **Next >** button, or to the previous step by pressing the **< Back** button. If you press the **LastCal** button, the system reloads the last saved calibration and returns to the starting point.

To exit a calibration without saving, press Cancel. The system will use the last calibration data already saved.

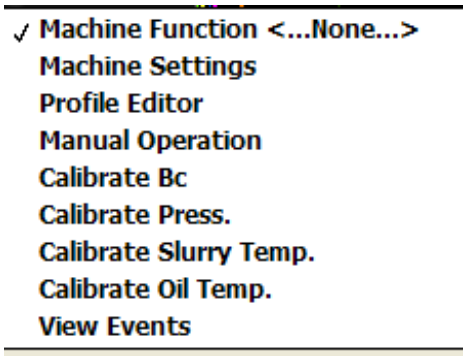
6.12 Temperature Calibration

It is not necessary to calibrate the slurry and oil temperatures before each use. Perform these calibrations according to your laboratory schedule or guidelines.

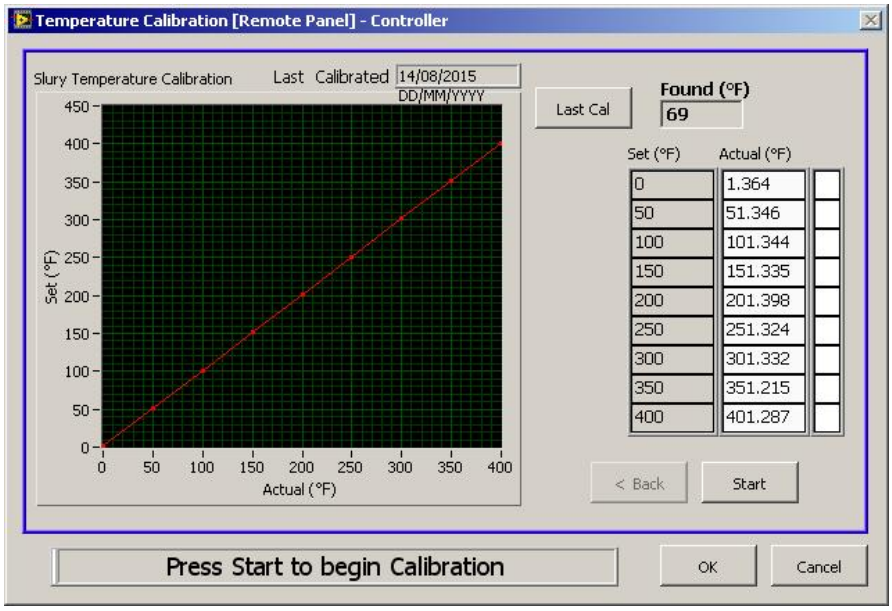
To perform this procedure, you will need a temperature calibrator.

1. Connect the temperature calibrator. For Slurry Temperature Calibration connect the calibrator to the J-Type connector on the left side of the unit. For Oil Temperature Calibration connect the calibrator to the J-type connector on the right side of the chamber. The operational thermocouples will have to be disconnected prior to connection the calibrator.

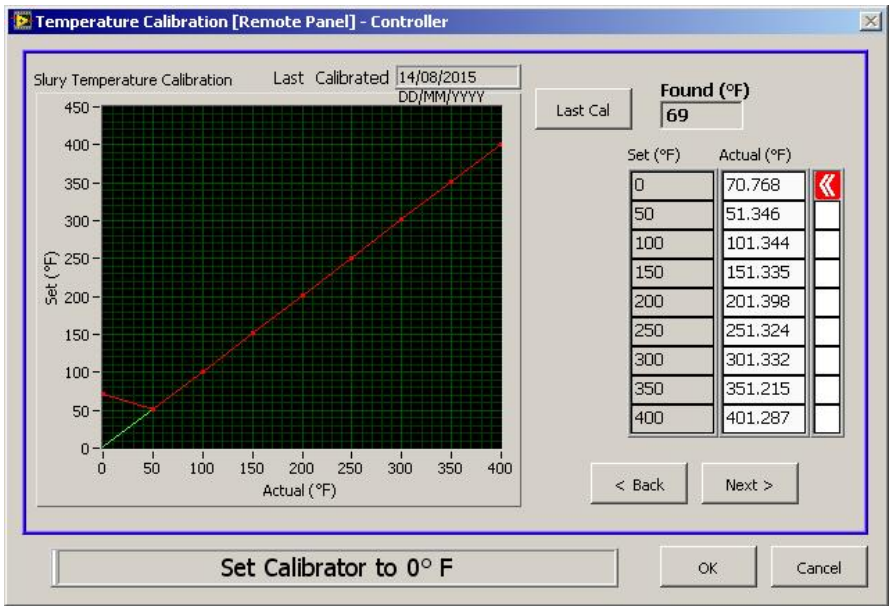
2. On the Main Screen, select **Main Function** and choose **Calibrate Slurry Temp** or **Calibrate Oil Temp** from the drop- down menu.



3. The **Temperature Calibration** screen will display. Press **Star**t. The **Start** button will change to **Next >** and a red box with white << will appear at the first data point in the calibration table.



Slurry Temperature Calibration Screens



Slurry Temperature Calibration Screens

4. Set the temperature calibrator to output the temperature in the **Set (^{o}F)** field.

5. Record the actual temperature in the **Actual (^{o}F)** field. This completes the first calibration point.

6. Press **Next >**.

7. Repeat steps until all temperature points have been calibrated. The calibration is complete when **Next >** changes back to **Start**.

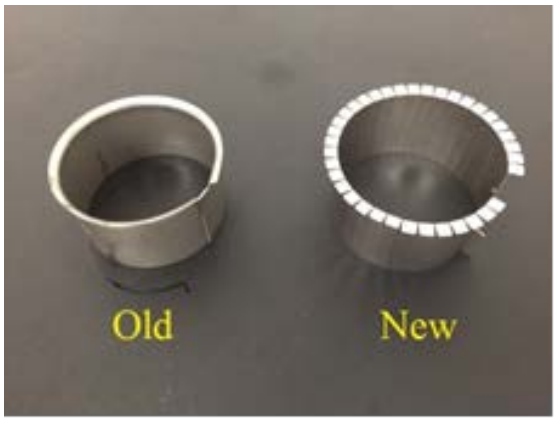
8. Press **OK** to save the calibration.

6.13 Consistency Calibration

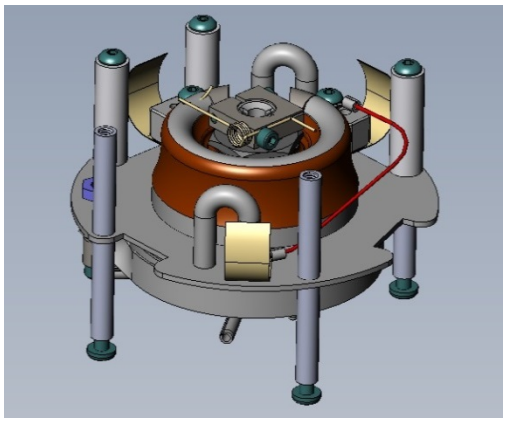
It is not necessary to calibrate before each use. However, the consistency calibration needs to be performed anytime the potentiometer is adjusted or repaired. Otherwise, perform calibrations according to your laboratory schedule or guidelines.

6.13.1 Potentiometer Upgrade

In order to properly perform this procedure the heater protector sleeve must be installed and the latest revision of the potentiometer (pictured below) installed. If your unit does not have these installed, place an order for the potentiometer upgrade kit (P/N 102159400).



Heater Protector



Upgraded Potentiometer

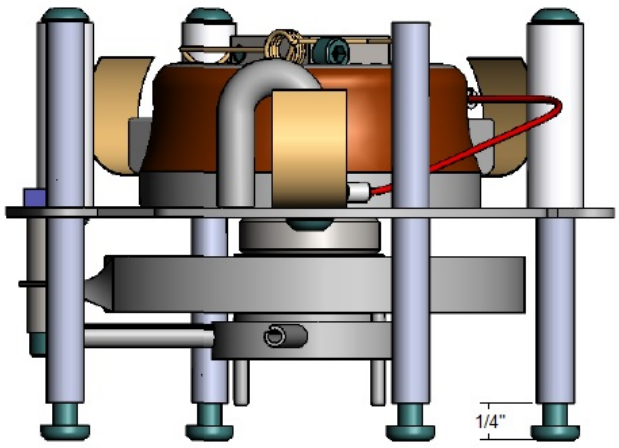
6.13.2 Consistency Calibration Procedure

Potentiometer Setup:

1. Ensure that the new Heater Protector is properly installed.

2. Place the potentiometer on a level surface and level the potentiometer using the leveling screws.

3. The leveling screws should protrude ¼ inch maximum from the bottom of the standoff



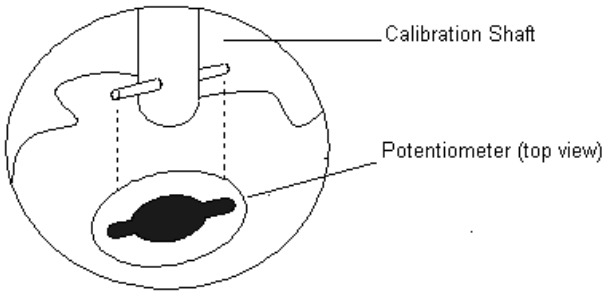
Proper Leveling Screw Height

4. Using the slurry cup bail, place the potentiometer in to the Model 290 consistometer chamber ensuring that all contact springs make contact with the contact pins. The potentiometer should sit firmly and level on the heater protector

6.13.3 Potentiometer Calibration Kit Set Up

1. Place the calibrator base into the slurry chamber. The base fits into the chamber bore only if it is right-side up (bevel facing downward toward the bottom of the Model 290 consistometer chamber). Make sure that the calibrator base is sitting flush and level with the Model 290 Consistometer chamber top.

2. Insert the calibration shaft into the potentiometer. Align the crossbar located on the bottom of the calibration shaft with the slot located on the top of the potentiometer.

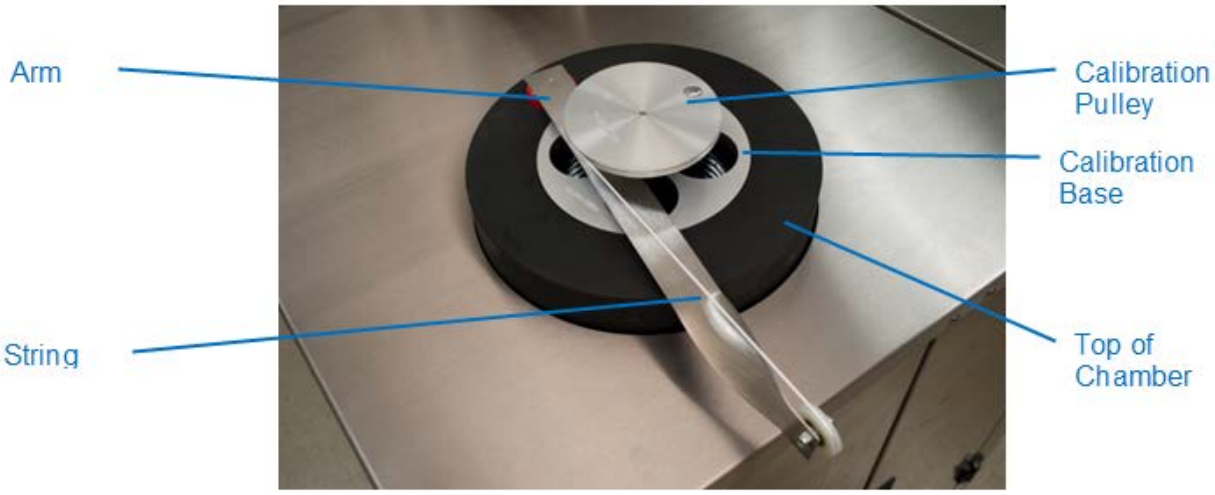


Inserting Calibration Shaft into Potentiometer

3. Raise the shaft slightly off the potentiometer, so that the crossbar fits into the slot of the potentiometer, but does not press down on it (The potentiometer will experience increased drag if it is bearing the full weight of the calibration apparatus). Tighten the Allen screw on the stop nut above the calibration base.

4. Place the calibration arm on the chamber and secure it with the magnet. Be certain that the calibration arm is not pressing down on the calibration base.

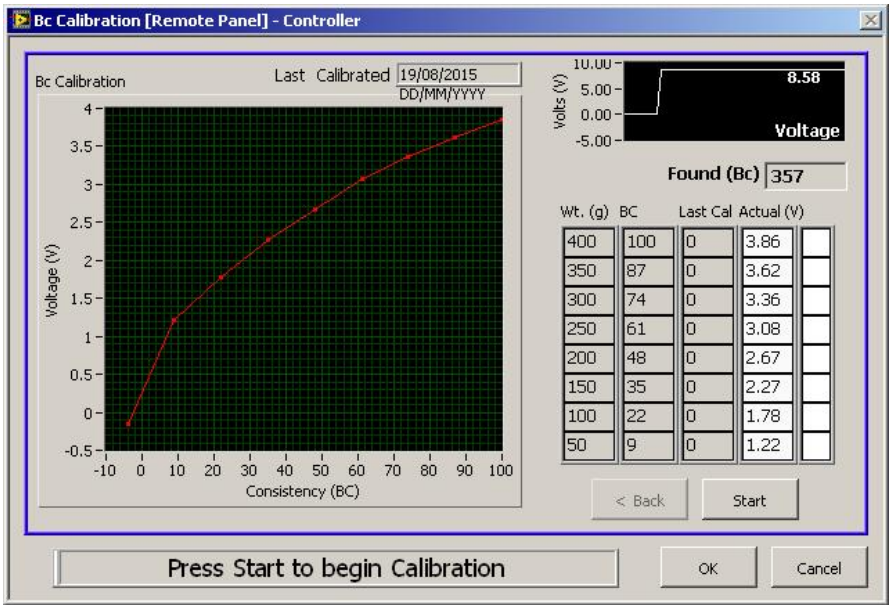
5. Wind the string counterclockwise in the groove of the calibration pulley. Leave enough string to be allowed to ride smoothly in the pulley located on the calibration arm. Give the wheel a small turn clockwise until it meets resistance.



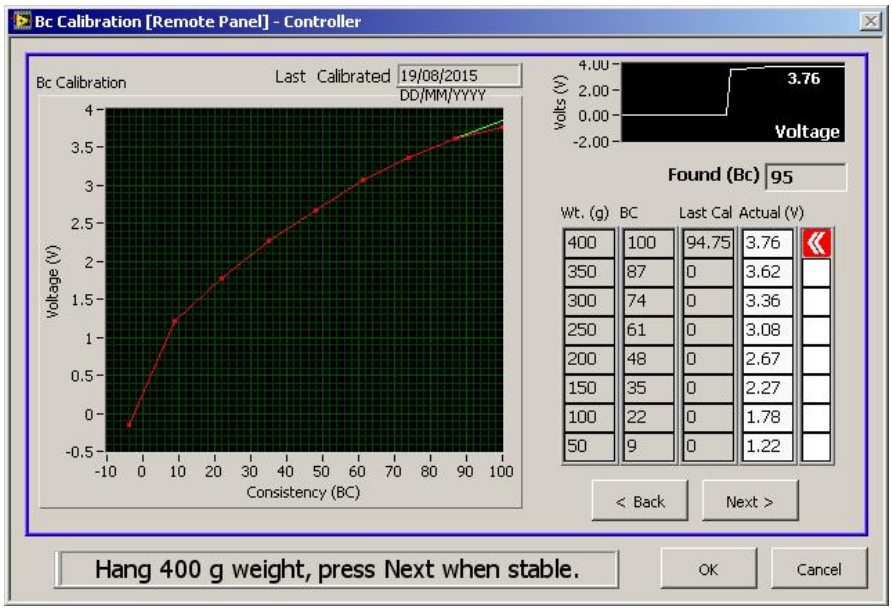
Assembled Calibration Kit

6.13.4 Start Calibration

1. To open the Bc calibration routine, select Machine Function and choose Calibrate Bc. The Calibrate Bc window will appear.



Consistency Calibration Screen

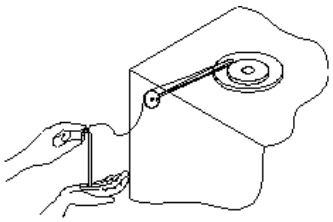


Consistency Calibration Screen

2. Press the Start button to begin the calibration routine. The Start button will change to **Next >** and a red box with white << will appear next to the 400 gram / 100 Bc row.

3. Hang 400 grams of weight on the string. (350 grams of weights plus the 50 gram weight holder)

4. When attaching a weight, support the weight on the palm of your hand, so that your hand does not pull down on the calibration string.



Attaching the Weight for Calibration

Hanging Weight

1. Gently lower your hand away from the weight until the string becomes taut and the weight lifts away from your hand.

2. Verify that the calibration string can move freely and is running over the calibration pulley.

3. Minimize the swing of the hanging weight; a swinging weight unwinds the string and makes the weight appear larger than it is.

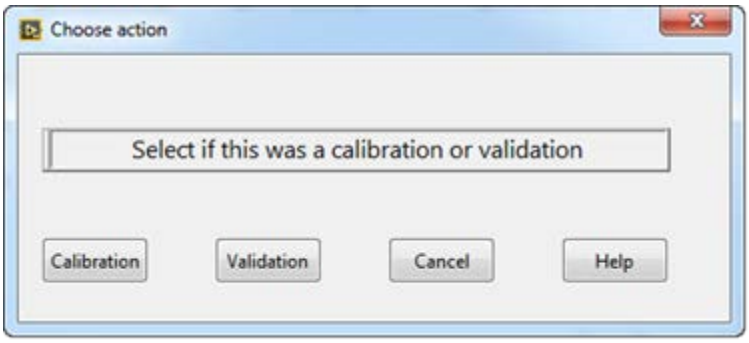
4. Once the Current Voltage value is stable, the Actual (V) field will populate with that value. Press Next > to show the next calibration weight.

5. As indicated in the Weight column, hang 350 grams by removing appropriate weight. Wait until the Current Voltage value becomes stable and the Actual (V) field populates with the value. Click Next> to go to the next calibration point.

6. Repeat the process by decreasing the weight on the string until the calibration is complete for 350, 300, 250, 200, 250, 100, and 50 grams total weight.

7. Once complete, click **OK**.

8. A screen will ask if this was a Calibration or a Validation. Click the appropriate button.



9. Calibration – changes the system to the calibration values that were just entered.
Validation - No changes will be made to the calibration values. This is a "calibration check".

6.14 Pressure Tolerance

During the test, you can modify the pressure tolerance. This change will not stop the test.

You can adjust the pressure tolerance to control how closely the pressure pump and relief valve follow the scheduled pressure.

The control margin is the amount (psi) that the actual pressure is allowed to deviate from the scheduled pressure before the pump or relief valve attempts to correct the problem. If the pressure is above or below the control margin, the pump or relief valve restores the pressure to the scheduled pressure or within the margin.

The default control margin is 200 psi (1.38 MPa). The maximum control margin is 500 psi (3.45 MPa).

Do not set the control margin too low (tight tolerance). If the pump and relief valve must readjust almost constantly to maintain the scheduled pressure, the pump and relief valve can wear out quickly.

You can specify the pressure tolerance by entering the value in the machine settings tab.

To change the pressure tolerance, enter the new value in the **Deadband** field located on the machine settings tab. This option is located in the pull-down menu of the machine function command.

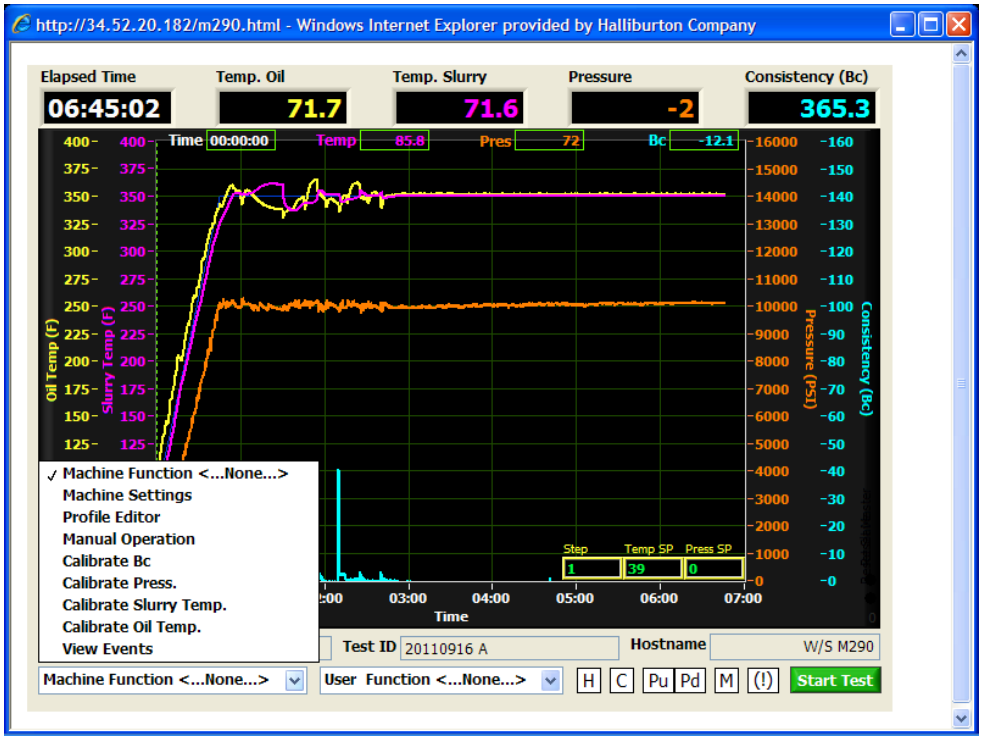
6.15 Heat Control

During the test, you can modify the heat control. This change will not stop the test.

You can specify how closely the heat controller tracks and controls the heater to keep the sample temperature within the value specified in the test schedule. The wider the margin, the more aggressive the heater control function works to keep the sample temperature closer to that specified by the test schedule. These parameters are located in the machine function panel on the PID gains tab. For detailed instructions on fine-tuning the temperature controller, refer to Section 8.19.1.

6.16 Machine Settings

The purpose of the **Machine Settings** function is to configure controller settings. This menu is found within the **Machine Functions** menu.

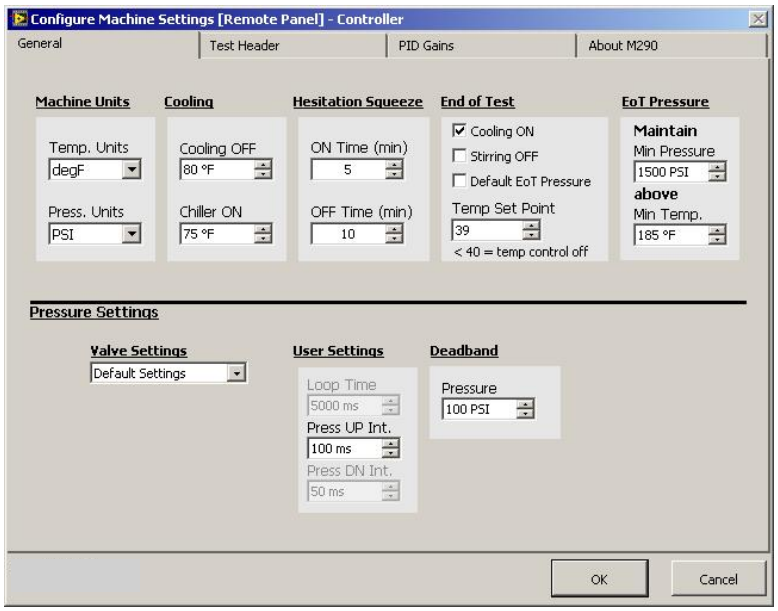


This section describes each tab within the Machine Settings function:

- General
- Test Header
- PID Gains
- About MODEL 290

General

This section describes the controls on this tab. Refer to the following screen capture.



Machine Units

These controls (temperature and pressure units) are disabled until this function is added.

Safety

This setting maintains the minimum pressure (Min Pressure) until the minimum temperature (Min Temp.) is reached.

Cooling

- Cooling Off – sets the point where cooling after the test will shut off
- Cooling On – sets the test temperature where cooling will turn on

Hesitation Squeeze

- On Time – stirring for set time (minutes); motor on
- Off Time – not stirring for set time (minutes); motor off

End of Test

The following settings control what happens when the test ends. The first three controls are options that can be selected (“checked”) or ignored (“unchecked”). The visible text changes depending on the option selected.

Auto Cool After Test	Checked – auto cool after test Unchecked – cooling OFF
Stirring Off	Checked – auto stir after test Unchecked – stirring OFF
Pressure Control Off	Checked – maintain last pressure Unchecked – pressure control OFF
Temp Set Point	Default is 39°F; if less than 40°F, then temperature control is OFF.

Pressure Settings

There are three pressure settings.

Valve Settings	The options are **Default Settings** or **User Defined Settings**.
User Settings	This setting is enabled when it is selected in the valve settings.
Deadband	This is the pressure range around the setpoint where the pump up/down is disabled.

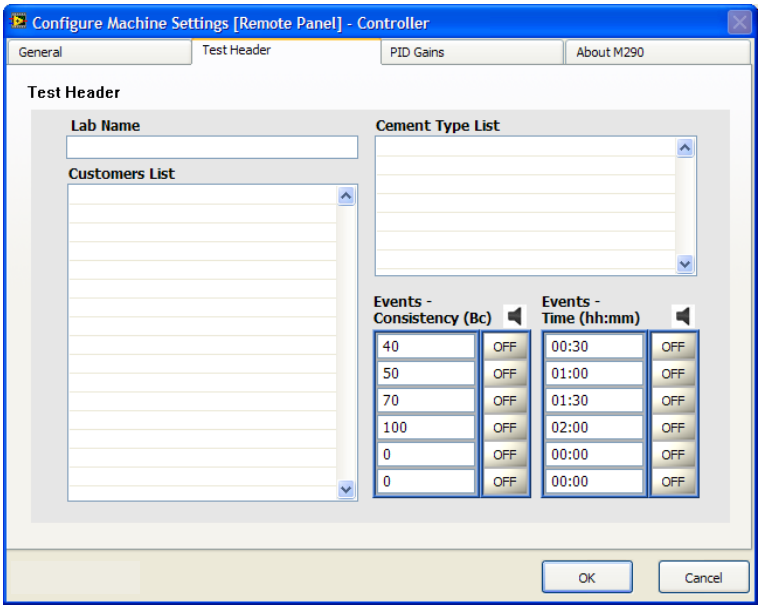
6.16.1 Test Header

The user records information in these options:

- Lab Name
- Customer List
- Cement Type List

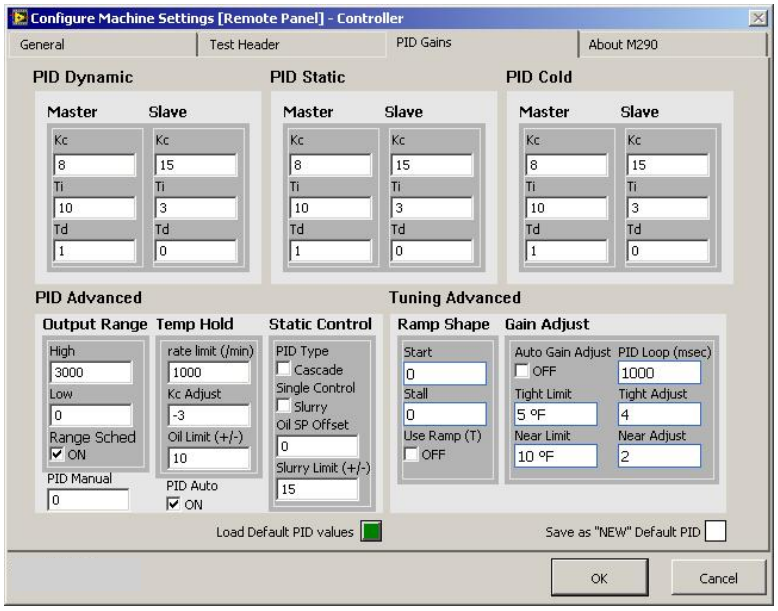
These options are currently available for use. Any information that you add to these lists will be available when you start a test.

Specific instructions for completing these fields are provided in the instruction manual (Section 6.3 User-specified Events).



6.16.2 PID Gains

The PID Gains functions are explained in this section. Refer to the following screen capture.



Cascade PID System

The basic control follows a cascade PID system:

- Master
- Slave

Master is the PID control output developed with SP = Temp SP, PV = Slurry Temp.

Slave is the PID control output developed with SP = Master Output, PV = Oil Temp.

There are three sets of values based on the settings for motor on/off and cold tests:

- PID Dynamic
- PID Static
- PID Cold

PID Advanced

The PID Advanced settings are Output Range, Temp Hold, and Static Control.

Output Range

This setting limits the available output range for different supply voltages.

- High – upper limit; 4000 maximum
- Low – lower limit; -300 default
- Range Sched – set to ON when the high setting is less than 4000

Example Settings

Supply Voltage	High	Low	Range Scheduling
208V	4000	-300	Off
230V	3000	-300	On
240V	3000	-300	On

Temp Hold

These settings only apply when the current temperature setpoint is the same as the end setpoint of the prior step.

- Rate limit – to set a maximum rate of changefor the heater control
- Kc Adjust – to reduce the gain based oupon motor status
- Oil Limit (+/-) – for limiting range of oil setpoint when temperature setpoint is static

Static Control

This setting applies only when the motor is OFF.

- PID Type – to select either Cascade (default) or Single PID
- Single Control – to select Slurry or Oil for process variable when in Single PID
- Oil SP Offset – to deviate from profile temperature when using Single and Oil
- Slurry Limit (+/-) – to set maximum slurry deviation before overriding Oil setpoint

PID Auto

The default is ON; the off setting is for debug and engineering.

PID Manual

This value is the setting for a specific output for heater control.

Tuning Advanced

The Tuning Advanced settings are Ramp Shape and Gain Adjust.

These controls are only for Fann engineering development's use.

Ramp Shape

This control is used to modify temperature ramp shape when Use Ramp = T.

- Start – number of points when ramp starts to replace with start point value
- Stall – replaces last 2x stop points with a ramp of one-half the slope
- Use Ramp
    - T = ramp is calculated at 1 minute intervals
    - F = ramp is calculated dynamically based on time

Gain Adjust

This control is used to modify gain based upon how close PV is to SP.

- Auto Gain Adjust – feature active when ON
- Tight Limit – the ± temperature range for maximum gain reduction
- Tight Adjust – the amount to reduce gain within Tight Limit
- Near Limit – the ± temperature range for lesser gain reduction; this value must be greater than the Tight Limit
- Near Adjust – the amount to reduce gain when it is within Near Limit
- PID Loop (msec) – this control sets the PID Loop rate ; the default is 4000

Load Default PID settings

Press this button (lower left corner) to restore settings to default values.

About MODEL 290

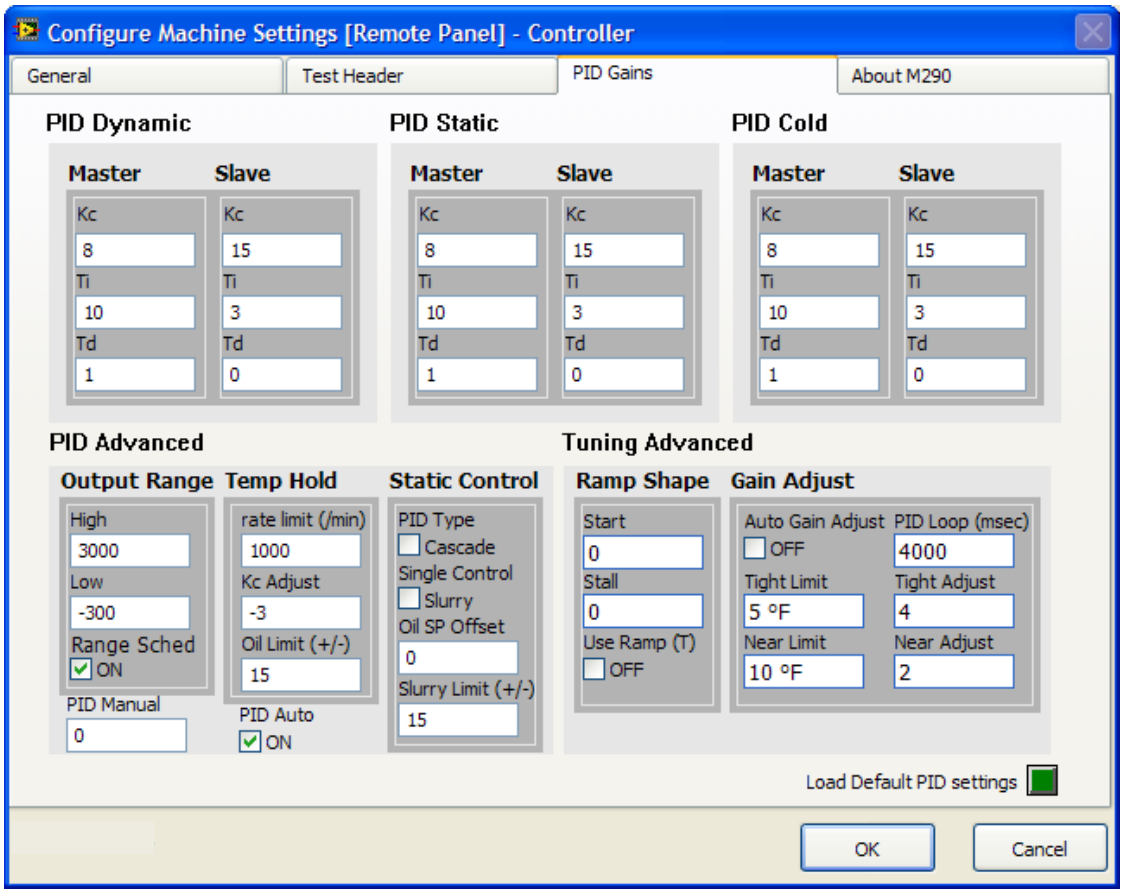
This section lists the copyright information.

6.17 Tuning Guide

This section explains the function of the tuning controls and provides a guide for making adjustments when required. The Model 290 software has many controls that are available to the user. However, most of these controls will not require modification or should not be modified by the user.

The controls that the user may need to adjust are discussed in order from most likely to least likely to require adjusting.

Refer to the following screen capture that highlights the PID Gains tab.



The software version displayed in the lower left corner is not important to this discussion. If the PID Gains tab matches the one shown, then this information is relevant.

6.17.1 PID Dynamic/Static/Cold

These three identical sets of controls allow different settings based upon Profile settings. If cooling is ON, then **PID Cold** values are used. If motor is set to stirring, then **PID Dynamic** values are used. Otherwise, the **PID Static** values are used.

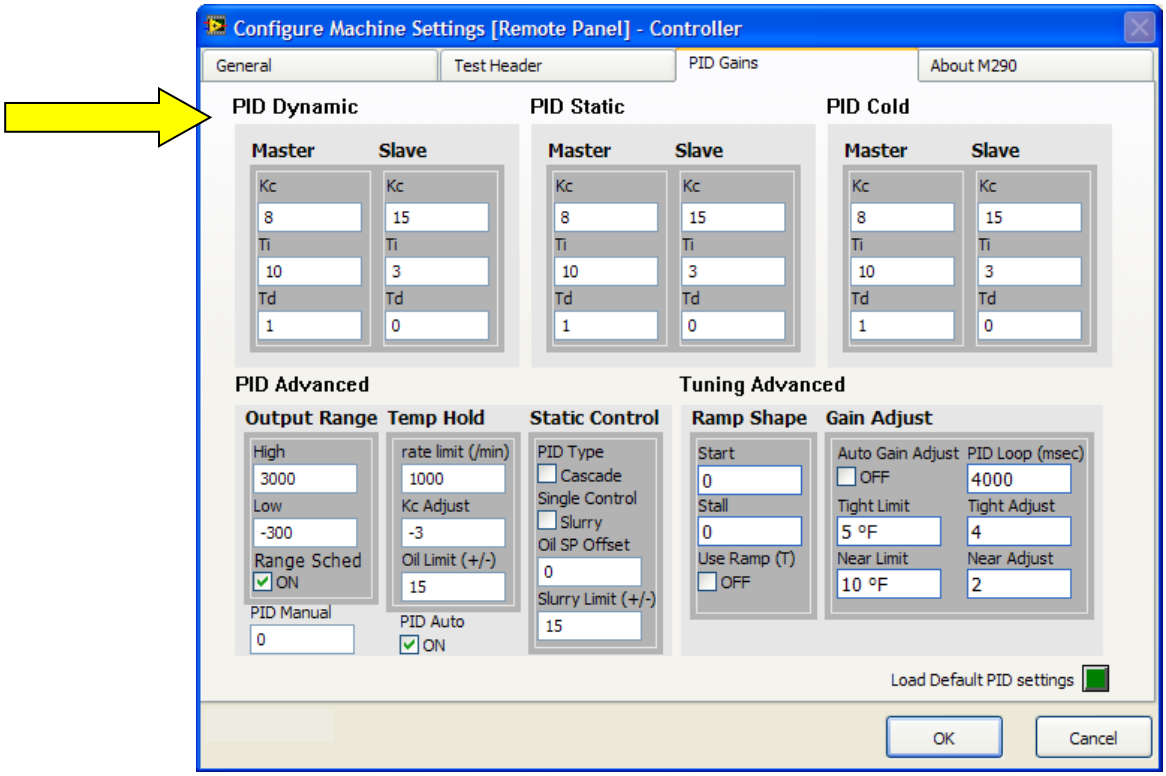
As previously mentioned, the default temperature control uses a cascade PID control – **Master** and **Slave**. The *Slave* is tuned to provide the desired response for heating the oil and the *Master* is tuned to provide control of the slurry temperature. Typically, the *Slave* values should NOT require any modifications.

6.17.2 PID Dynamic - Master

During product development, the value for Kc was set near the maximum useable value. Increasing this number above 8, the default value, may result in the slurry temperature

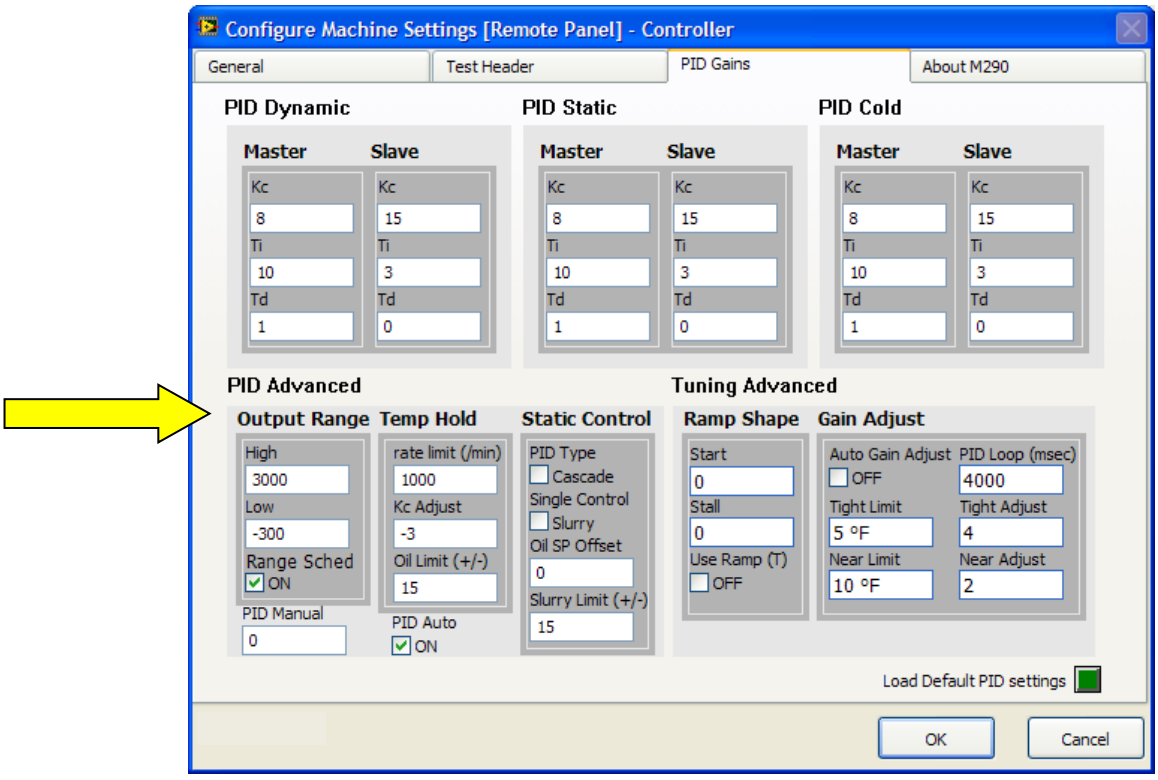
overshooting the target and oscillating during temperature stabilization. To determine whether or not the Kc value needs adjusting, observe the ramping portion of a test profile. If the slurry temperature overshoots the target temperature and oscillates while settling to the target, the Kc value may be too large.

Before modifying **Ti** or **Td** values, contact Fann about your temperature control concerns.



6.17.3 **PID Advanced**

The PID Advanced control settings are Output Range, Temp Hold, and Static Control.



6.17.4 PID Advanced – Output Range

The **Output Range** controls allow the software to use similar control settings across several supply voltages. Refer to the table shown for recommended settings.

The supply voltage is directly related to the power output of the heater. There is approximately 30% more power for a system operating at 240V than a system with 208V.

Recommended Settings

Supply Voltage	High	Low	Range Sched
208	4000	-300	OFF
215-220	TBD	-300	TBD
230	3000	-300	ON
240	3000	-300	ON

Problems related to overall system heating may be related to these settings. For example, if the system heating is too fast (i.e., overheating and cooling during the ramping portion), then *High* value may need to be decreased. If the oil and/or slurry heating lags behind the desired ramp, then this value may need to be increased.

The maximum High setting is 4000; do **not** exceed this value.

The *Low* setting provides a range that allows the heater to be OFF when maintaining lower temperatures. If your system continues to heat when holding temperature, this value may need to be decreased. The recommended increment or decrement to this number is 100.

At this time, a system operating at 215-220VAC has not been tested. If your system operates at this voltage, the recommendation is to initially use the settings for 208V. If the heating is too fast, then changing the settings to those for 230V is suggested. If the heating is too slow, increase the *High* setting in increments of 250 until desired response is achieved.

6.17.5 PID Advanced – Temp Hold

The settings in this group are applied after the temperature setpoint has not changed for 10 minutes.

Rate limit (/min)

This value sets the maximum rate of change for the heater control. Modifying this value is not recommended.

Kc Adjust

This value modifies the dynamic and static gain (**Kc**) after the temperature setpoint has not changed for 10 minutes. The default value -3 is the reduction required to reduce oscillations caused by the excessive gain. This value should not be set to greater than zero.

Oil Limit (+/-)

This value is the limiting range of oil setpoint temperature. This setting can be valuable for tests involving shutdowns or using the Hesitation Squeeze function.

This can help compensate for the delta (often false) between measured and average slurry temperature when stirring is OFF. A rapid change in the slurry temperature immediately after stirring resumes is an indication of the false temperature.

6.17.6 PID Advanced – Static Control

These controls are only used when the profile step has **Motor** set to **Stirring Off**.

PID Type

The choices are **Cascade** (default) or **Single PID** temperature control.

Single Control

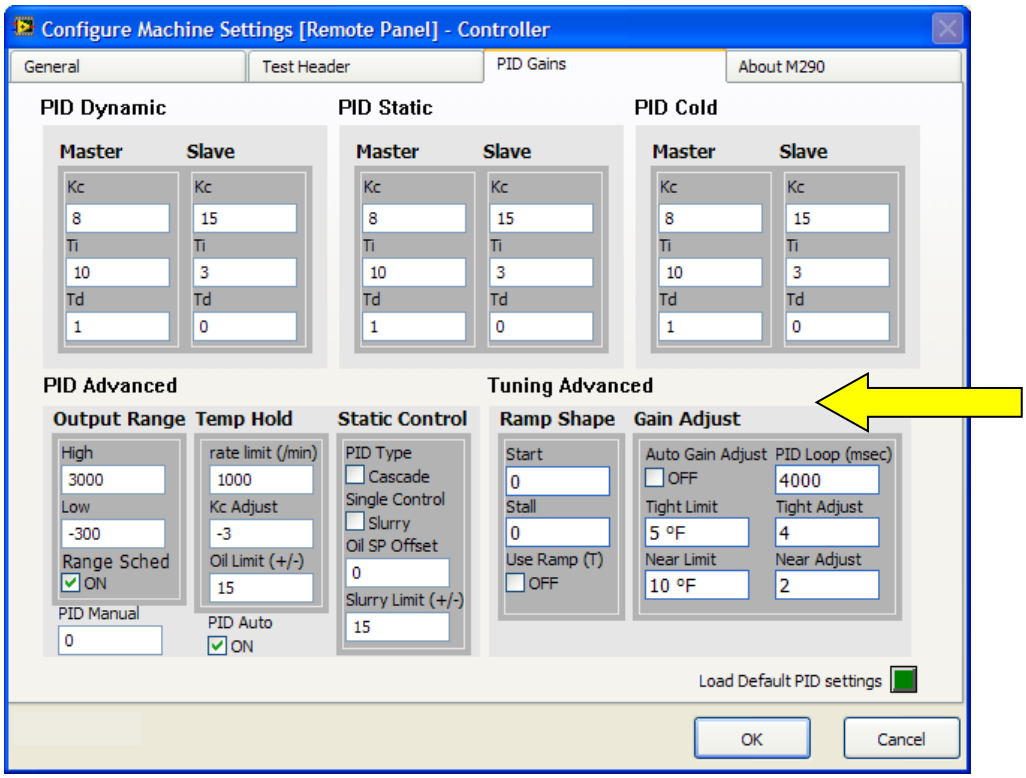
User can select Slurry (default) or Oil for control when in Single PID.

These two controls were developed to allow testing of using a Single PID with control by oil temperature. This process was developed for testing involving long shutdowns and/or hesitation squeeze cycles. If Single PID is selected, then setting Single Control to Oil is also recommended.

6.17.7 **Tuning Advanced**

These controls are least likely to require adjustment. If adjustments are necessary, contact your Fann representative.

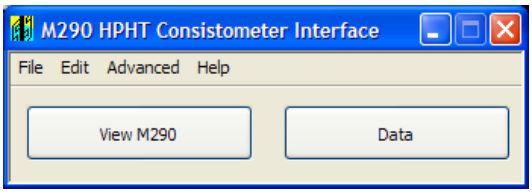
These controls are only for Fann engineering development's use.



7 Test Analysis

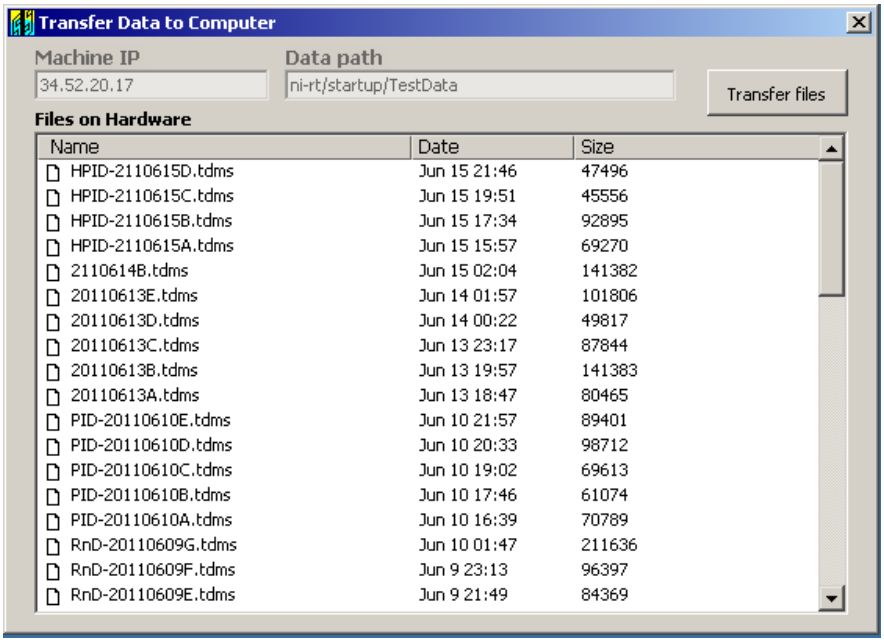
All test data results are stored in an internal hard drive on the instrument. You can retrieve these test results for printing or sending to a designated folder on a server or a USB drive.

7.1 View a Test Report



Interface Screen

To view a test report, minimize the test screen and locate the Interface Screen. Press the **Data** button to display the main data transfer screen as shown below.

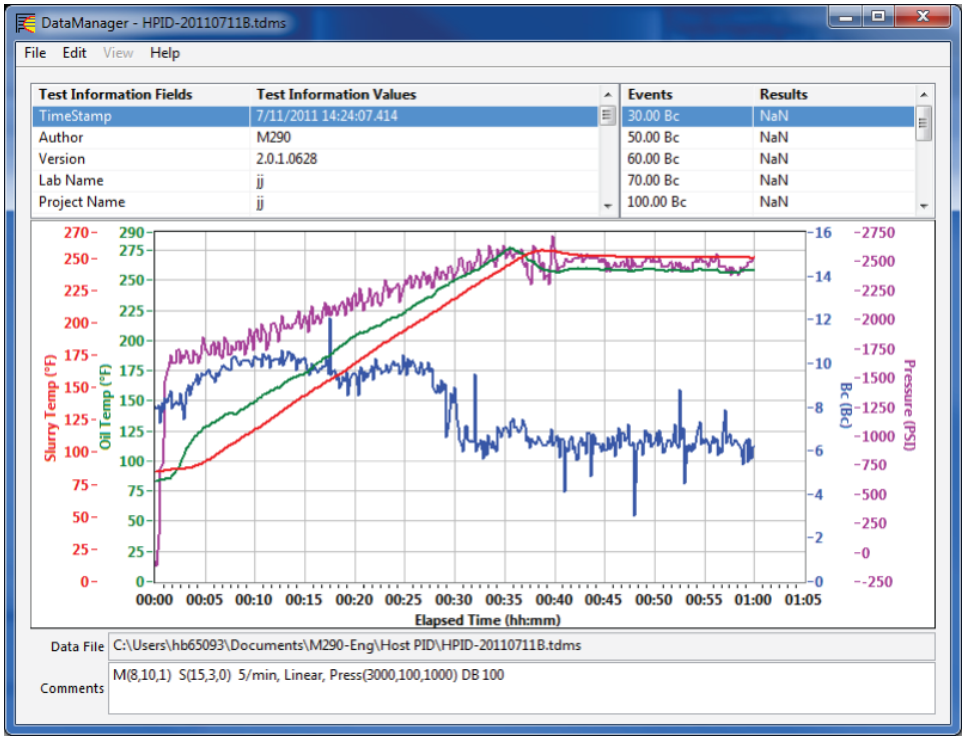


Transfer Data Screen

This screen shows the test data files stored on the controller (cRio). To view the files, select them, and press the **Transfer Files** button. A window will appear asking where to save files; select the destination. You may open the files located in the chosen destination with Data Manager software.

7.2 View and Print Test Data Graph

To view the test data graph, select the **File** drop-down menu, and click on open. A dialog box opens. Locate your file and double click it. The file will open on your screen. See below.



Data Viewer Screen

7.3 View and Print Test Data Detail Report

A test data detail report contains all data collected for a particular test. To view and print this report, press on **File**. A drop-down menu appears. Select **Print** to display the print screen. A screen similar to below is displayed.

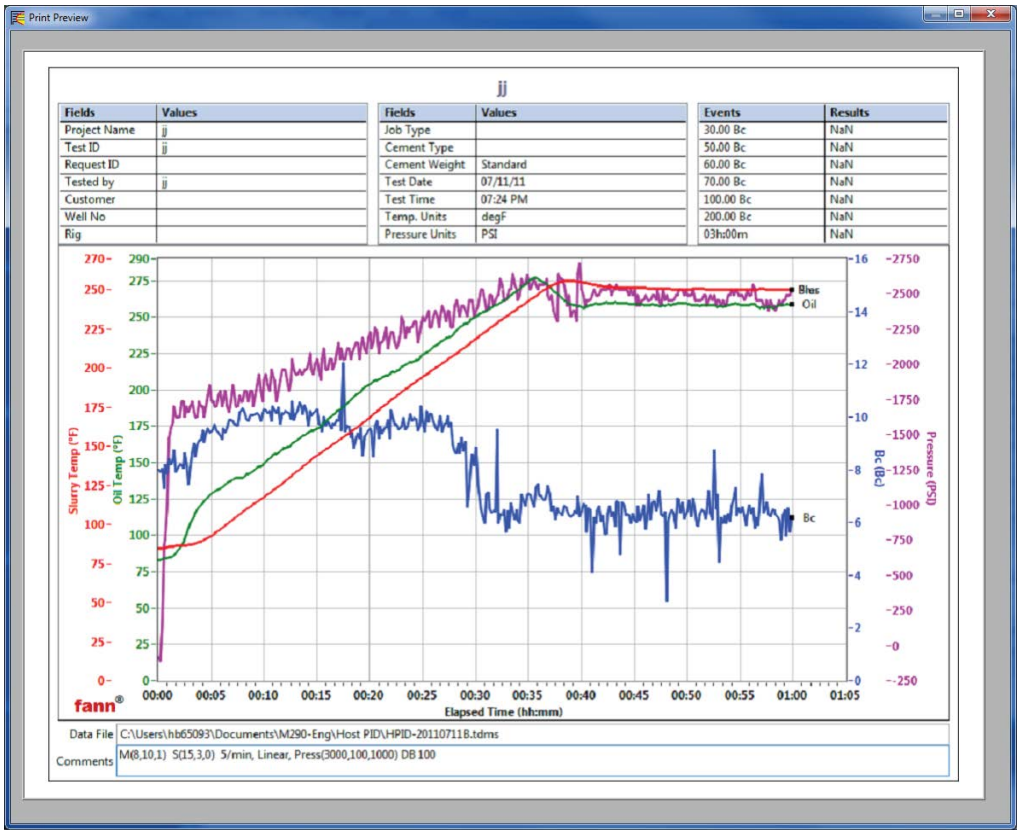


Figure 7-1 Detail Report Screen

7.4 View and Print Test Data Summary Report

The test data detail report contains the test header data, test schedule, and event (alarm) information for a particular test. To view and print, press the **Print** button from the File drop-down menu.

8 Troubleshooting and Maintenance

Section 8.1 discusses general troubleshooting for the hardware controls and the processor unit.

Section 8.2 provides easy-to-read tables that outline common problems along with possible solutions. These troubleshooting tips address the system, temperature, pressure, and the hydraulic pump.

Section 8.3 provides specific maintenance instructions for various parts.

If assistance is needed, contact Fann Instrument Company.

Only qualified personnel specifically trained in the construction and repair of the HPHT Consistometer should attempt electronic or hydraulic repairs.

8.1 Hardware Controls

When Manual Operation is selected from the Machine Function menu, it displays the Manual Operation Control panel

In the manual mode, you can turn on or off the motor, heater, or buzzer, and increase or decrease pressure. These buttons also act as system status indicators. For example, when the heater is on, the motor button lights up to indicate that the motor is currently running.

The function of each manual button is explained as follows:

Do not check the hardware controls while you are running a test.

- **Coolant -** Press the coolant button to turn the coolant on. You should hear a clicking sound and water circulating. Press the coolant button again to turn it off.
- **Temperature -**Type a temperature value and press **Enter** to turn on the heater. The oil temperature reading should gradually increase. To turn the heater off, type the number zero (0) and press **Enter**.

- **Pressure –** To adjust the pressure, enter in a pressure value and press **Enter**. The pump will make a sound as it pumps or releases pressure in the chamber. To turn the pressure, off, type the number zero (0) and press **Enter**.

- **Motor -** Press the motor button to turn on the motor. Press it again to turn the motor off.

- **Buzzer -**Press the buzzer button to turn the siren on. Press the button again to turn the siren off.

8.2 Troubleshooting Tips

Table 8-1 General System Problems

Problem or Symptom	Possible Cause	Corrective Action
The system does not power up.	The power fuses are blown.	Check/replace the power fuses located inside the electronics enclosure.
	The power switch has malfunction or failed.	Check/replace the power switch.
	The power source has been disconnected or turned off.	Check/repair power wiring.
	The backup battery has malfunctioned or failed.	Check the backup battery switch.
	The power supply has malfunctioned or failed.	Check the power supply switch.

Table 8-2 Temperature Problems

Problem or Symptom	Possible Cause	Corrective Action
The system will not heat up, but the heater light is on.	The heater wiring is faulty.	Check/repair the heater wiring.
	The heater malfunctioned or failed.	Check/replace the heater; see section 8.8.
	The heater fuse is faulty.	Check/replace the heater fuse.
	The heater's control electronics have malfunctioned or failed.	Check the heater solid-state relay (SSR2), the heater safety solid-state relay (SSR3), and the heater circuit wiring.
The heater light is not on, but the heater is working.	The heater wiring is faulty.	Check/repair the heater wiring.
	The heater's control electronics have malfunctioned or failed.	Check the heater solid-state relay (SSR2), the heater safety solid-state relay (SSR3), and the heater circuit wiring.
The system cooling will not come on, but the coolant light is on.	The coolant supply's control solenoid valve has malfunctioned or failed.	Clean, repair, or replace the coolant supply's control solenoid valve.
	The coolant supply's solenoid valve wiring is faulty.	Check/repair the coolant supply's solenoid valve wiring.
	The coolant supply plumbing lines are obstructed.	Check/clear the coolant supply plumbing lines.
	The coolant source has been disconnected or turned off.	Check the coolant source.
	The coolant supply's control electronics have malfunctioned or failed.	Check the chamber coolant switch, the coolant-supply OAC5 relay, and coolant-supply circuit wiring.
The coolant light is not on, but the cooling system is working.	The coolant supply's solenoid valve wiring is faulty.	Check/repair the coolant supply's solenoid valve wiring.
The system coolant will not	The coolant supply's control	Clean, repair, or replace the

Problem or Symptom	Possible Cause	Corrective Action
shut off.	solenoid valve has malfunctioned or failed.	coolant supply's control solenoid valve.
	The coolant supply's control electronics have malfunctioned or failed.	Check the chamber coolant switch, the coolant-supply OAC5 relay, and the coolant-supply circuit wiring.
The control system is controlling temperature poorly.	The temperature schedule contains an error or is unreasonable.	Check/correct the temperature schedule.
	The temperature fine-tuning parameters are incorrect.	Fine tune the temperature.
The control system does not control temperature.	The control system has malfunctioned or failed.	Contact a Fann representative.
The temperature reading is >1000°F (>538°C).	Possible open circuit in thermocouple.	Look for and repair the broken wire or loose connection.
The temperature reading is about room temperature even though the chamber is hot.	Possible short circuit in thermocouple.	Look for and repair the short in the thermocouple line.

Table 8-3 Pressure Problems

Problem or Symptom	Possible Cause	Corrective Action
The system will not pressure up, but the pump is working.	The oil reservoir is low.	Check/fill the oil reservoir.
	An internal component of the pump has malfunctioned or failed.	Clean/repair the pump.
	The high-pressure plumbing lines are obstructed.	Check/clear the high-pressure plumbing lines.
	A high pressure check valve has failed or is contaminated.	Check/clean or replace the faulty check valve.
	The high-pressure relief valve's control solenoid valve has malfunctioned or failed.	Clean, repair, or replace high pressure relief valve's control solenoid valve.
	The high-pressure relief valve's control electronics have malfunctioned or failed.	Check the pressure-down OAC5 relay, the Pressure Control-Down switch, the Pressure Release switch, and the pressure-down circuit wiring
	The rupture disc pressure limit was exceeded.	Replace the rupture disc.
	The pressure system plumbing has a leak.	Check, repair, or replace pressure system plumbing.
	The oil supply plumbing lines are obstructed.	Check/clear the oil supply plumbing lines.
The system will not pressure up, and the pump is not working.	The pressure release valve is open.	Close the pressure release valve.
	The pump's control solenoid valve has malfunctioned.	Clean, repair, or replace the pump's control solenoid valve.
	The pump's control electronics have malfunctioned or failed.	Check the pressure-up OAC5 relay, pressure control-up switch, pressure release switch, and pressure-up circuit

Problem or Symptom	Possible Cause	Corrective Action
		wiring.
	The air source has been disconnected or turned off.	Check the air source.
The system will not hold pressure.	The pressure system plumbing has a leak.	Check, repair, or replace the pressure system plumbing.
The pump runs continuously.	The pump's control solenoid valve has malfunctioned or failed.	Clean, repair, or replace the pump's control solenoid valve.
	The pump's control electronics have malfunctioned or failed.	Check the pressure-up OAC5 relay, the pressure control-up switch, the pressure release switch, and the pressure-up circuit wiring.
	The dead band tolerance is too tight.	Set the tolerance to 300 psi, under the Machine Settings screen.
The system pressure cannot be relieved.	The high-pressure relief valve has malfunctioned or failed.	Clean/repair the high-pressure relief valve.
	The high-pressure relief valve's control solenoid valve has malfunctioned or failed.	Clean, repair, or replace the high-pressure relief valve's control solenoid valve.
	The high-pressure relief valve's control electronics have malfunctioned or failed.	Check the pressure-down OAC5 relay, the pressure control-down switch, the pressure release switch, and the pressure-down circuit wiring.
	The high-pressure plumbing lines are obstructed.	Check/clear the high pressure plumbing lines.
The pressure gauge won't zero.	The pressure gauge is faulty.	Test the pressure gauge.
The pressure won't zero on the control system LCD display.	The pressure transducer is overstrained.	Re-calibrate and check the transducer. Replace it, if necessary.
The control system controls pressure poorly.	The pressure schedule contains an error or is unreasonable.	Check/correct the pressure schedule.
	The pressure fine-tuning parameters are incorrect.	Fine-tune pressure.
The control system does not control pressure.	The control system has malfunctioned or failed.	Contact a Fann representative.

Table 8-4 Hydraulic Pump Problems

Problem or Symptom	Possible Cause	Corrective Action
The pump is running, but not delivering.	Reservoir fluid supply is low.	Add fluid as required.
	Fluid supply line to pump inlet check valve is clogged.	Remove and clean line.
	Foreign matter is lodged in pump inlet and outlet check valves.	Remove and clean check valves. Replace o-rings on poppet valves.
Pump is not running.	Air shuttle valve is sticking.	Remove and clean air valve and housing assembly and its shuttle valve components. Adjust air lubricator.
	Connecting rod is improperly adjusted or bent.	Readjust rod and nut. Straighten or replace rod.
Pump fails to reach desired air pressure.	Air supply is set too low.	Increase input air pressure.
Pressure drop or pump fails to build up pressure.	Leakage or blockage at inlet or outlet check valves. Damaged or worn o-rings.	Remove and clean check valves. Look for foreign matter lodged in seating areas. Replace damaged or worn o-rings.
	Fluid found in lower housing damaged seals in sealing groove of fluid body.	Replace o-rings, packing retainers, and back-up rings
	Damaged o-ring, in outer groove of air piston, or scratched or scored cylinder. Either or both allow air pressure to escape exhaust port.	Replace o-ring. Inspect cylinder for scores or scratches. If so marred, replace cylinder.
Hydraulic fluid in exhaust air.	Damaged seals in fluid body or fluid piston scored.	Replace o-ring and retainers. Inspect fluid piston for score marks; polish as required. Replace pistons and fluid body if in-service-wear allowance exceeded.
Air leak in cover of air valve and housing assembly.	Cover loose, cracked, or damaged gasket.	Tighten cover bolts or replace gasket.
Air is in system.	Air leak in suction line from reservoir to pump or at pump inlet check valve. Reservoir fluid level below reservoir suction outlet.	Tighten line fittings; use Teflon tape to seal fittings. Check reservoir fluid level; refill as required.

8.3 Pre-Maintenance Safety Precautions

Perform the following safety procedures before performing in-depth maintenance on the HPHT Consistometer. You can be injured, or the equipment can be damaged if you fail to use these safety precautions.

1. Turn off and disconnect the power supply.
2. Turn off the air, water, and coolant supply, and relieve pressure in the hoses.
3. Relieve the chamber pressure.
4. Allow the unit to cool to room temperature.

8.4 Drive Disk and Bar (Slurry Cup)

Perform this procedure on any new slurry cup to adjust it. The objective is to position the drive disk and bar as low on the paddle shaft as possible to prevent the potentiometer from resting on the paddle shaft and to prevent the drive collar from rubbing the slurry cup.

Refer to Figure 8-1.

1. Assemble the slurry cup without the drive disk and bar, but with the paddle.
2. Use the slurry cup bail to lower the slurry cup into the chamber with the paddle shaft pointing up. Ensure that the pins on the bottom of the slurry cup engage the holes on the chamber turntable.
3. Use the slurry cup bail to lower the potentiometer onto the top of the slurry cup and paddle shaft.
4. Reach down into the chamber and gently move the top portion of the potentiometer up and down to ensure that the potentiometer is supported on the heater protector sleeve. If the top of the potentiometer moves freely, the potentiometer is resting correctly on the sleeve. If the top does not move freely, the potentiometer is resting on the slurry cup diaphragm support, and the potentiometer must be adjusted.
5. Estimate the distance of the potentiometer's position relative to the paddle shaft when the potentiometer is properly seated on the sleeve.
6. Remove the potentiometer and the slurry cup.

7. Place the potentiometer on the shaft at the same position determined in step 4.

8. Determine where the drive disk and bar should be set on the paddle shaft. The potentiometer's drive collar must engage the drive disk and bar, and there must be enough clearance to prevent the potentiometer from resting on the paddle shaft.

9. Tighten the drive disk at this location. You might want to mark the location with a small groove.

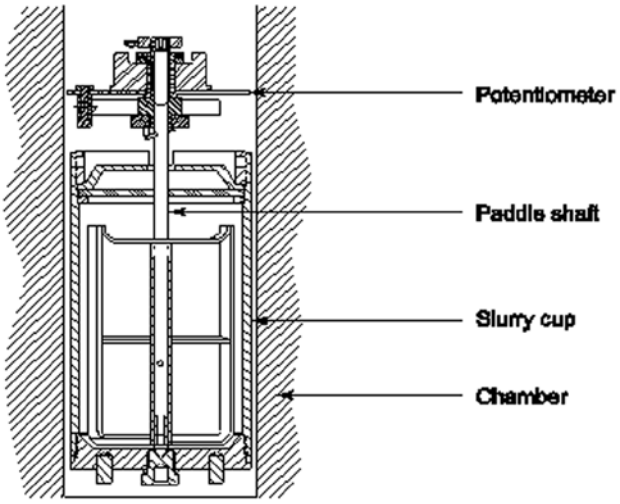


Figure 8-1 Potentiometer and Slurry Cup in Chamber

8.5 Electric Motor

Perform the safety steps previously mentioned in Section 8.3.

To start, remove the old motor as follows:

1. Loosen the four cap screws on the motor mount assembly, and slide the assembly toward the shaft as far as possible.
2. Slide the belt off the shaft or motor pulley.
3. Remove the motor and mount assembly from the cabinet.
4. Separate the motor from the mount assembly
5. Install the new motor on the mount assembly. If the old pulley is worn, replace it with the correct pulley for the electrical system frequency (50 or 60 Hz). Refer to section 8.6 for more information.

Next, install the new motor as follows:

1. Install the assembly in the cabinet and place the drive belt around the pulleys. Slide the motor mount away from the shaft until the sides of the belt appear straight. It is not necessary to force the motor mount to make the belt tight against the pulleys. Over-tightening the belt can lead to premature bearing failure.

2. Tighten the motor mount bolts to the frame.

3. Ensure the pulleys are adjusted so the belt is level. To adjust the shaft pulley, loosen the set screw on it and move the pulley up or down on the shaft.

4. Make the proper connections between the motor and instrument wiring. The motor shaft should rotate counterclockwise when viewed from above.

Reinstallation of the motor is easier if the pulley is installed on the new motor in approximately the same position as it was on the old motor.

8.6 Motor Pulley

The Model 290 HPHT Consistometer can operate on either 50 or 60 Hz electrical power. Before it is shipped, the consistometer is configured for the electrical power at the destination.

When the equipment is moved from one country to another, it may be necessary to convert it to operate on another electrical power frequency that makes the slurry cup rotate at correct 150 rpm. This requires changing the pulley on the main motor. Pulleys for both 50 and 60 Hz are provided with each instrument. The unused pulley should be attached to the frame for safekeeping.

Perform the following steps to remove the motor pulley:

14. Perform the safety procedures previously mentioned.
15. Remove the drive belt as described in the next section
16. Note and/or mark the location of the pulley on the motor drive shaft.
17. Loosen the set screws that hold the pulley to the motor drive shaft, and remove the pulley. Retain the square key in the motor drive shaft.
18. Select the correct motor pulley for the frequency of the electrical power system as follows:
    - 50 Hertz – 24 teeth
    - 60 Hertz – 20 teeth

The pressure chamber drive pulley has 22 teeth.

19. If necessary, install set screws in the pulley. Ensure the square key is in the motor drive shaft. Push the pulley onto the motor drive shaft to the same position as the pulley that was removed.
20. Securely tighten the set screws.
21. Install the drive belt and adjust the tension. Refer to Section 8.7, which describes removing and replacing the drive belt.
22. Secure the unused pulley to the frame.

8.7 Drive Belt

If the drive chain breaks or wears out, you can replace it.

Begin by performing the safety steps described in the safety precaution section, and then proceed as follows:

1. Loosen the four cap screws on the motor mount assembly and slide the assembly towards the shaft as far as possible.
2. Slide the old belt off the shaft and motor pulley.
3. Slide the new belt on the shaft and motor pulley. Ensure that the belt is level between the two pulleys.
4. Slide the motor mount away from the shaft until the sides of the belt appear straight. It is not necessary to force the motor mount to make the belt tight against the pulleys. Over-tightening the belt can lead to premature bearing failure.
5. Tighten the four motor mount cap screws to the frame.

8.8 Heater

If the heater needs replacement, obtain the heater replacement tool kit (P/N 100072380), and follow the correct procedure for replacing the heater.

Start by removing the heater from the consistometer:

1. Perform the safety procedures described in Section 8.3.
2. Remove the electric contact pins from the inside of the chamber.

3. Remove the wires from the heater terminals.
4. Remove the nuts that secure the heater in the chamber from the bottom of the heater.
5. Install a J-Bolt puller (Figure 8-2) on an element loop nearest an element end that goes through the chamber. Tighten the J-Bolt nut until the heater starts moving.

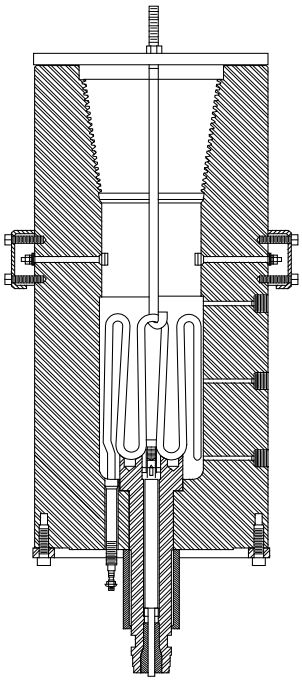


Figure 8-2 J-Bolt Puller Arrangement

6. Place the J-Bolt puller on the loop nearest the other element end that goes through the chamber. Tighten the J-Bolt nut until the opposite end of the heater starts moving. Continue pulling on alternate end loops until the heater is removed. If the heater is lodged too tightly to pull out with the J-Bolt puller, perform steps 7 to 10. If the heater comes out, proceed to step 11.
7. Loosen the motor and remove the belt, the bearing assembly, and the split collar nut that connects the bearing assembly to the packing gland.
8. Place a jack support plate and spacer below the heater element ends and over the opening in the HPHT Consistometer from below the chamber.
9. Place the jack and heater-jack adapter between the spacer and heater element as shown in Figure 8-3.
10. Unscrew the jack bolt out of the jack body with a wrench until one end of the heater starts to move. Simultaneously placing tension on the top with the J-Bolt puller can help when pulling the heater. Then, place the jack on the other heater end, reposition the J-Bolt puller, and unscrew the bolt until the heater starts to move. Continue using the jack (and/or J-Bolt puller) by jacking (or pulling) alternate ends of the heater element until the heater is removed. The long

heater-jack adapter may be needed when the heater is jacked out of the chamber.

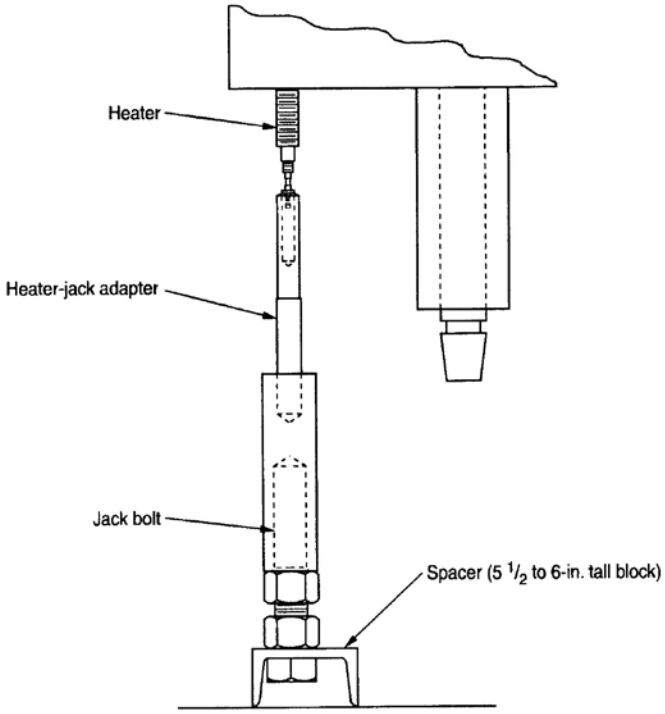


Figure 8-3 Jack Arrangement for Heater Removal

11. Ensure that the brass heater seals are removed when the heater is removed. If the brass heater seals are not removed, screw the seal removal tool into the brass seal about three turns (Figure 8-4), and pull the slide up quickly. Bump the handle to remove the seal rings.

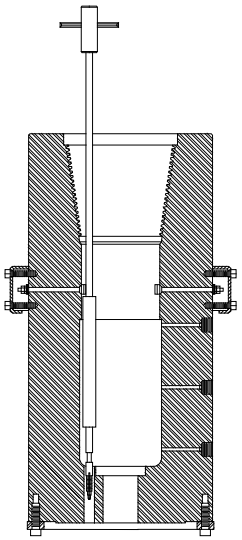


Figure 8-4 How to use Seal Removal Tool

Use about four or five turns to screw in the removal tool. Using more than four or five turns could cause the tool to thread and lodge in the chamber.

Next, reinstall the heater as follows:

1. Clean the inside of the pressure chamber thoroughly, giving special care to the holes into which the heater and electrical contacts fit.

2. Spread the heater element loops slightly so that the heater fits snugly against the inside of the chamber wall.

3. Insert the brass seal ring into the chamber with its taper (narrow end) at the top.

4. Insert the heater into the chamber. If it is difficult to get the heater ends through the chamber, place the installation tool over the shoulder on the heater seal sleeve, and tap the tool on alternate heater posts to drive the heater into position. See Figure 8-5.

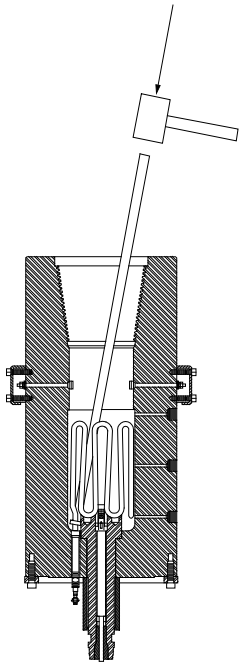


Figure 8-5 How to use the Installation Tool

Ensure that the heater is correctly aligned before tapping it into place. If the heater is incorrectly aligned, you may damage the heater or the threads.

5. Install the heater nuts and tighten them until the heater is firmly seated.

6. Replace the heater wires, electrical contact pins, and contact pin guards.

7. Replace the split nut collar-bearing assembly, and belt. Verify that the packing shaft is engaged properly. Position the motor and tighten the motor-mount bolts.

8. If oil leaks from the bottom of the heater posts after the chamber is pressurized, retighten the heater-holding nuts.

If the sleeve cannot be installed in the chamber, reposition the heater. Using the prying tool with the fluted side against the heater tube, reposition the heater elements inside the chamber until the sleeve is installed.

8.9 Sprague Pump

This section contains excerpts from the Sprague S-216-J Pump Handbook.

8.9.1 Routine Maintenance

For every 10 hours of use:

- Check the oil level of the driving air lubricator. Refill using SAE 10W oil.
- Check the oil-drip rate. If necessary, use the adjustment knob to bring this rate to two drops per minute.
- Check the pump and fittings for leaking. Repair these parts as needed.
- Shut off the inlet air pressure, and check the driving air pressure gauge for a zero (0) reading.

For every 50 hours of use:

- Check the air filter for clogging. Clean the filter if required.
- Calibrate the driving air pressure gauge against the master gauge.

8.9.2 Disassembly

If the pump needs in-depth repairs, remove and completely disassemble it. A rebuilt kit is available for order, p/n 100033823.

Use these tools to disassemble and reassemble the pump:

- O-ring removal tool
- Retainer ring pliers
- Ratchet wrench with 7/16-inch diameter × 3-inch extension hex socket
- 7/16-inch wrench
- 11/16-inch wrench
- 3/4-inch wrench
- 15-inch adjustable wrench
- A bench vise to hold the pump

Cushion the vise jaws with soft aluminum plates to avoid scratching the pump fluid body.

Perform the following steps to disassemble the pump:

1. Position the pump in the vise with the tube turned toward the front of the pump.
2. Unscrew the four cap screws to remove the air valve cover and its gasket.
3. Remove the tube assembly by removing the two fittings from the two 90° elbows on the upper and lower housing. Do not remove the elbows. Apply the air hose and air pressure to the lower 90° elbow to raise the air piston and the shuttle to the upper position.
4. Use a 7/16-inch wrench to remove the self-locking nut from the connecting rod. Remove the flat washer.
5. Use the 7/16-inch socket on the ratchet wrench to remove the 12 cap screws and nuts that attach the upper housing to the lower housing. Lift and remove the upper housing assembly.

Perform the following steps if the shuttle assembly in the upper housing requires removal and disassembly:

1. Use the 11/16-inch wrench to remove the four sets of detent bolts, springs, and pins from the air-valve body.

2. From the inside of the upper housing, push upward on the shuttle stop to remove the shuttle assembly.

3. Use retainer ring pliers to remove one of the two snap rings in order to release the guide, spring, and stop from the shuttle.

4. Remove the cylinder and its O-ring from the lower housing.

5. Remove the rod, the air piston, and the fluid piston from the fluid body.

6. Disassemble the shifting nut, lock washer, plain nut, and connecting rod from the air piston.

7. Unscrew the air piston from the fluid piston. Remove the O-ring from the air piston.

Perform the following steps to disassemble the fluid body:

1. Use the O-ring removal tool to carefully remove the two Teflon® retainers and O-ring from the seal groove in the fluid body. Discard the old retainers and the O-ring.

2. Use the adjustable wrench to remove the inlet check valve assembly from the fluid body port. Remove the O-ring or gasket from the port. Note the sequence of parts removal and the position of the poppet relative to the check valve body. Wipe all surplus fluid from the inside of the port.

3. Use the adjustable wrench to remove the outlet check valve assembly from the fluid body port. Remove the O-ring and seat from the port. Note the sequence of parts removal and the position of the poppet relative to the check valve body. Wipe all surplus fluid from inside the port.

4. Check for leakage at the gasket junction between the lower body housing and the fluid body.

Do not remove the lower housing from the fluid body unless there is evidence of leakage at the gasket.

8.9.3 Cleaning and Inspection

1. Wash all metal parts in a solvent. Dry the parts thoroughly with air or with a lint-free cloth. Remove hardened sediment with a soft bristle brush.

Do not scrape pump parts with a metal tool.

2. Using a light source and a magnifying glass, visually inspect parts for cracks, pitting, scratches, corrosion, or galling.
3. Inspect all threaded parts for chipped, crossed, or stripped threads.
4. Inspect and measure the free (relaxed) length of springs. The recommended free lengths for the various springs are
    - detent springs, 7/8 inch
    - check-valve springs, 3/4 inch
    - check-valve springs, 11/16 inch
    - shuttle spring, 15/16 inch
5. Roll the springs over a flat surface to check for any wobbling.
6. Check the tube assembly for kinks, breaks, or defective tube flares.
7. Check the outside diameter of the fluid piston and the inside diameter of the fluid body to determine the wear clearance between the two parts. Check the diameters at several points up and down the bore of the body, and check the circumference of the piston.
8. Check for smooth movement of the shuttle assembly within the air-valve body. Examine the contacting surfaces of the shuttle and the bore of the body for dirt, scratches, or galling.
9. Check the rings on the shuttle for wear, particularly at the diagonal splice tips. Check the general condition of the O-rings. Inspect the detent pins for wear.
10. Inspect the seating surfaces of the inlet and outlet check valves in the fluid body for nicks, burrs, or excessive wear.
11. Inspect the valve bodies, poppet valves, springs, and seat for nicks, burrs, excessive wear, or rust.

8.9.4 Repair

1. Polish the metal parts to remove minor scratches. Use wet or dry 600-grit sandpaper.

2. Inspect the fluid piston and fluid body. If you find any evidence of galling, replace both the piston and the body. Polish the piston carefully, using 600-grit sandpaper to remove minor scratches or nicks. Polish the fluid body bore, using a very fine polishing stone to remove minor imperfections.

3. Recheck for wear clearances between the fluid body and the piston.

4. If imperfections cannot be easily removed, replace the piston and body as a matched set. The replacement piston body set also includes the lower housing and gasket.

5. Polish minor imperfections on the air valve and upper housing assembly. Keep the polishing and honing to a minimum to prevent an increase in water clearance. If the imperfections cannot be easily removed, replace the entire air valve and upper housing assembly.

6. Place all repaired parts in a solvent for cleaning.

7. Replace all metal parts that do not pass inspection, or that are damaged or worn beyond simple repair.

8. For a complete pump overhaul, replace all O-rings, packing retainers, springs, and detent pins. Overhaul and seal kits from Teledyne Sprague Engineering contain all the parts needed for pump overhaul and service.

8.9.5 Reassembly

Before reassembling the pump, thoroughly wash the metallic parts in a solvent, and then dry them. Lubricate O-rings and threads with petroleum jelly, hydraulic oil, petrolatum (per Federal Specification VV-P-236), or with lubricant compatible with seal compounds.

Follow these steps to reassemble the pump:

1. Position the fluid body and lower housing in a vise that has soft aluminum plates in its vise jaws to cushion their grip against the fluid body.

2. Reassemble and install the inlet and outlet check valves into the fluid body. Do not over torque the valve bodies, and avoid crossing any threads when installing the check valve bodies.

3. Remove the fluid body from the vise.

4. Position the fluid piston in the vise with aluminum plates in the vise jaws. Screw the air piston fully onto the fluid piston. With the 7/16-inch wrench, screw the nut firmly onto the threaded end of the fluid piston. Install the O-ring into the groove in the air piston.

5. Screw the shifting nut over the length of the threads on the connecting rod, with the beveled end of the nut toward the center of the rod.

6. Insert the lock washer under the shifting nut, holding the washer next to the underside of the shifting nut. Screw the end of the connecting rod into the threaded end of the fluid piston until the rod bottoms solidly. Torque the shifting nut tightly against the plain nut to secure the connecting rod.

7. Place the fluid body and lower housing assembly in the vise.

8. Install the new backup ring, O-ring, and packing retainer in the sealing groove in the bore of the fluid body.

9. Lubricate the bore and seals of the fluid body and fluid piston.

10. Insert the assembled fluid piston and air piston assembly carefully into the bore of the fluid body to avoid scratching any surfaces.

11. Press down and rotate the piston until it bottoms on the top side of the fluid body.

12. Lubricate the inside wall of the cylinder and the O-ring in the groove of the air piston with petroleum jelly. Press the cylinder into position between the air piston and the lower housing. Position the second O-ring around the outside of the cylinder and in contact with the flange of the lower housing.

13. Screw a nut onto the first several threads of the connecting rod.

14. Gripping the connecting rod and the underside of the nut, pull the rod up so that the air piston and the fluid piston are in the “up” position. Remove the nut from the rod.

15. Reassemble the shuttle assembly and install the long end first into the air valve and upper body assembly. Press the shuttle down evenly and slowly. Move the shuttle up and down several times to assure smooth movement.

16. Install the air valve and the upper housing assembly onto the fluid body and lower housing assembly. Verify that the two elbow fittings for the tube-assembly are aligned with each other for later assembly.

17. Install and loosely tighten the cap screws and nuts around the housing flanges.

Uneven tightening causes binding between the cylinder and the air piston. To achieve evenness, tighten each set of opposite screws and nuts, moving back-and-forth between the two, until they are sufficiently, but loosely tightened. For example, loosely tighten the screws and nuts in the opposing 12 o'clock and 6 o'clock positions evenly before proceeding to those in the 3 o'clock and 9 o'clock positions. Continue in this manner until all cap screws and nuts are tightened.

18. Install the four sets of detent pins, springs, O-ring packings, and bolts into the four threaded ports in the valve body. Detent pins should engage in the lower groove of the shuttle.

19. Apply air pressure alternately several times to the elbow fittings in the upper and lower housings to verify smooth shuttle motion. Stop the movement with the shuttle in the top position.

20. Install the flat washer, and screw the self-locking nut on the upper threaded end of the connecting rod. If no lower threads of the connecting rod show above the shifting nut, install the self-locking nut with at least one upper thread of connecting rod exposed beyond the self-locking nut.

21. If one or two lower threads of the connecting rod are exposed beyond the shifting nut, install the self-locking nut with the same number of connecting rod upper threads exposed beyond the lock nut.

22. Check for a smooth up-and-down movement of the shuttle. Using compressed air (about 10 psi), inject air into the elbow in the lower housing to raise the shuttle to the "up" position. Push down on the shuttle. Repeat this up-and-down movement several times to determine smoothness of movement. If the movement is not smooth, the air piston is binding against the cylinder wall. Binding is caused by uneven tightening of the twelve screws and nuts at the housing flange.

23. Retighten the screws evenly. See previous NOTE.

24. Install a new gasket, cover, and four screws to close the air valve portion of the pump.

25. Reinstall the tube assembly to the elbows in the upper and lower housings.

26. Perform a final movement check by injecting air pressure into the inlet port. Movement of the assembled shuttle, air piston, and fluid piston should be smooth and regular.

8.10 High-Pressure Relief Valve

You must remove this valve from the consistometer, and then disassemble and clean it. Then you will be able to inspect it for repair or replacement. Those steps are outlined below. Reassembly and reinstallation instructions are also included.

Repair the high-pressure relief valve only if it is faulty. Regular maintenance is not required and only increases the risk of damage. If maintenance is necessary, obtain the high-pressure relief valve repair kit to perform repairs on the high-pressure relief valve.

8.10.1 Remove High-Pressure Relief Valve

1. Remove the left side panel, and locate the high-pressure relief valve shown in Figure 8-6.

2. Disconnect the high-pressure 1/4-inch stainless steel line from the high-pressure relief valve.

3. Disconnect the low-pressure 1/4-inch braided or plastic lines from the high-pressure relief valve and from the center port on the high-pressure relief valve's solenoid valve. Press the plastic rings on the tube fittings and gently pull out the plastic tubing.

4. Remove the two 1/4-inch mounting screws that secure the high-pressure relief valve, and remove the high-pressure relief valve together with its solenoid valve.

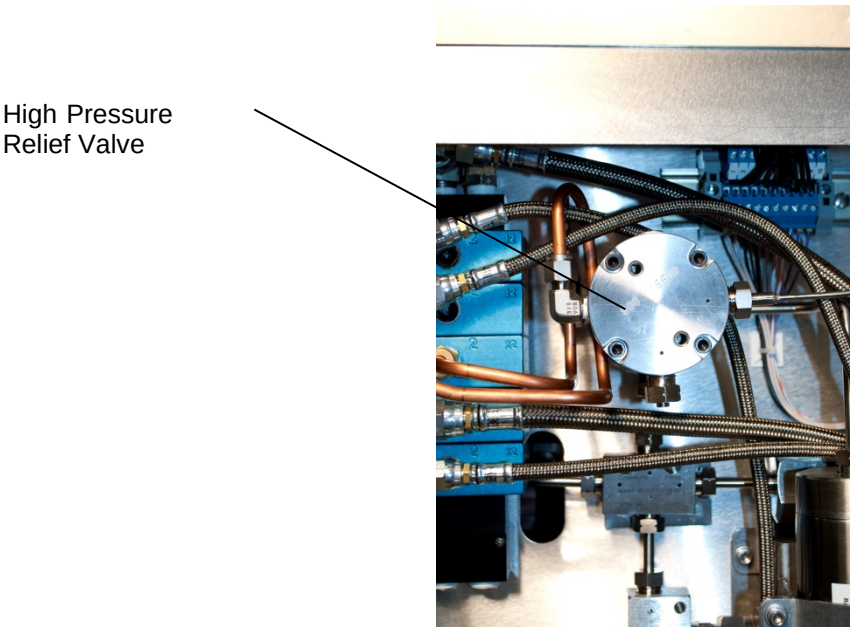


Figure 8-6 Location of High-Pressure Relief Valve

Before disassembling the valve, tag or mark the caps as *Tank* or *Pressure*. Note the orientation of the caps, including the fittings, relative to each other.

If the caps are not reassembled exactly as they were disassembled, the high-pressure relief valve cannot be reinstalled into the unit.

8.10.2 Disassembling High-Pressure Relief Valve

Refer to Figure 8-7, Figure 8-8, and Figure 8-9.

1. Remove the eight socket-head screws (10-32NF), four on each end, from the caps. Refer to Figure 8-7.

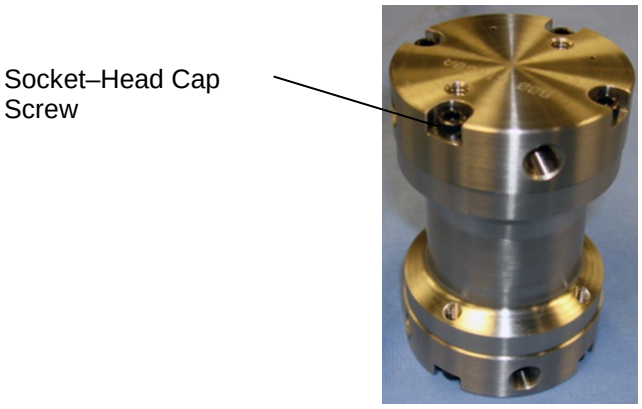
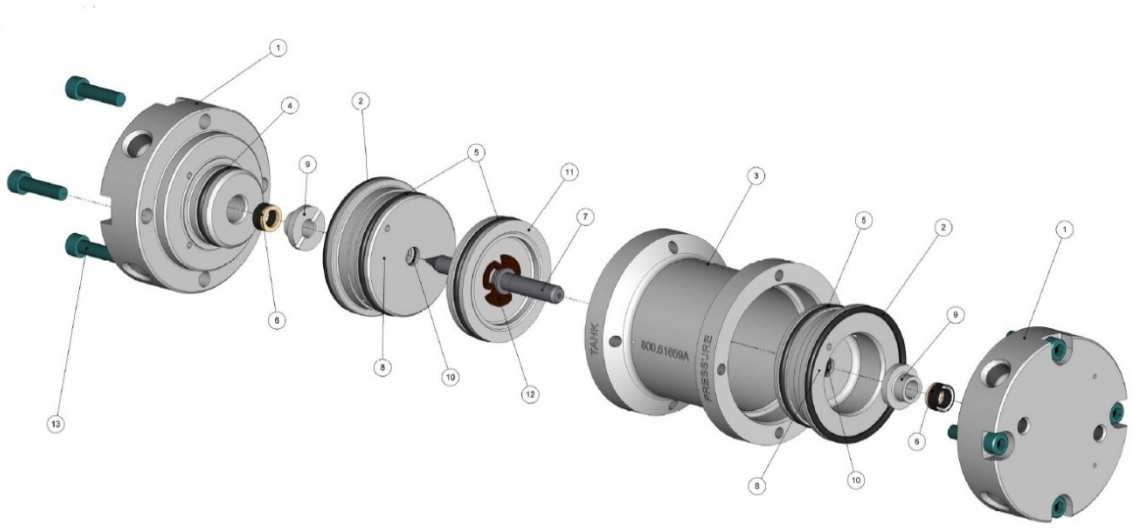


Figure 8-7 High Pressure Relief Valve

2. Use a flat-bladed screwdriver to carefully pry the caps off each end.
3. Use your fingers to remove the seal glands from the caps.

The seals and seal glands may or may not come off with the caps.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	100072418	CAP	2
2	100012943	O-RING	2
3	100072417	SLEEVE	1
4	100001933	O-RING	2
5	100001927	O-RING	3
6	100012997	SEAL	2
7	100013733	STEM	1
8	100072419	RETAINER, SEAL	2
9	100013732	GLAND	2
10	100001941	O-RING	2
11	100072416	PISTON	1
12	100028057	RETAINING RING	1
13	100028192	SCREW	8

Figure 8-8 High-Pressure Relief Valve Schematic

For the Model 290, the valve stem, piston valve, and retaining ring are a single assembly and cannot be individually replaced or repaired.

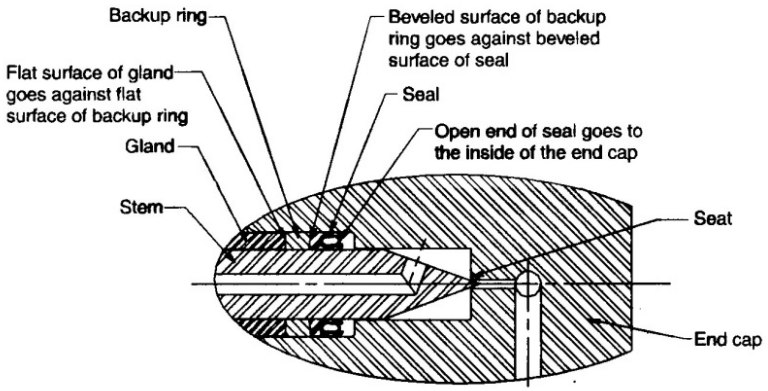


Figure 8-9 High-Pressure Relief Valve, Detail

Do not use any tools on the seal glands. Using tools on the seal glands could damage the seal glands.

4. Ensure that the seals and seal glands came off with the caps. If the seals and seal glands do not come off with the caps, using your fingers carefully remove each seal, including its seal backup ring, from the valve stem.

If the seals are not damaged, they can be reused.

The seals are very delicate and can be easily damaged. Exercise care when handling any seals.

5. If the seals need replacement, use a small screwdriver to remove the seals from the caps.

6. Remove the seals from the valve stem if they did not separate from the valve stem.

Do not use tools on the seal glands. Using tools on the seal glands could damage the seal glands

Do not remove the seals from the caps unless they need to be replaced. Removing the seals from the caps destroys them.

7. Remove the two O-rings, one on each end, from inside the valve sleeve.

8. Place the valve with the valve stem pointing down onto blocks or onto an open vise as shown in Figure 8-10. Provide enough width and depth clearance to allow the seal retainer and valve stem to be removed downward from the sleeve.

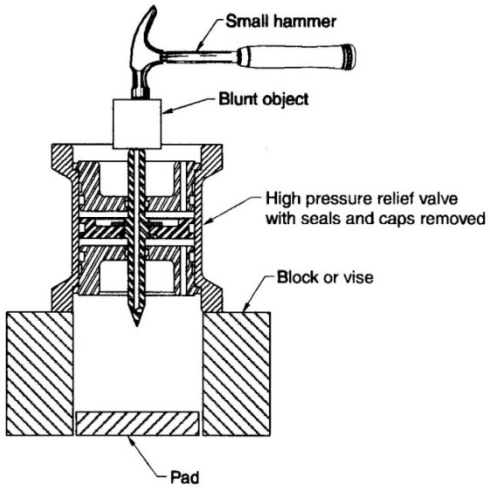


Figure 8-10 Valve Mounted on Blocks

9. Place a soft pad under the valve to cushion the fall of the seal retainer and valve stem.

The pointed end of the valve stem is a sealing surface and must be protected from damage.

10. Place a blunt object on the flat end of the valve stem to protect it from damage. Use a small hammer to tap the blunt object lightly and force the valve stem and seal retainer out of the sleeve.

Do not strike the valve stem directly with the hammer.

11. Remove the seal retainer from the valve stem.

12. Rotate the valve on the blocks or open vise. Using the blunt object and small hammer, lightly tap the remaining seal retainer out of the sleeve.

13. Remove the O-rings from the outside of the caps and piston and from the inside and outside of the seal retainers.

8.10.3 Clean and Replace High-Pressure Relief Valve

1. Wash the components of the high-pressure control valve with soapy water or a solvent, or wipe them with a clean cloth.
2. Dry the components thoroughly with a clean cloth and/or low-pressure filtered air.
3. Inspect the components for damage and excessive wear. Replace damaged or excessively worn components.
4. Inspect the point of the valve stem for deformation, and replace the valve stem if it is excessively deformed.
5. Inspect the valve seat (the small-diameter hole in the center of the inside face of the cap) for deformation. Replace the cap acting as the valve seat if the seat is deformed excessively, or if it leaks before disassembly.
6. Inspect the O-rings for damage, especially cuts, flattening, hardness, and excessive wear. Replace damaged O-rings.

The caps are interchangeable. Only the cap on the end with the valve-stem point is used as the valve seat. If this cap needs to be replaced, you can replace it with the cap on the other end without affecting the valve's performance.

If the caps are switched, the fittings must also be switched. Re-label the caps accurately as *Tank* and *Pressure*. If the caps are improperly labeled or if fittings are improperly installed, the valve cannot be reassembled.

8.10.4 Reassemble High-Pressure Relief Valve

1. Coat the O-rings with a thin film of grease and install them on the outside of the caps and piston. Coat the inside and outside of the seal retainers with grease as well. Avoid damaging the O-rings.

2. Place the seal retainer on the end of the valve sleeve marked *Tank*. Place a blunt object in the center of the outside surface of the seal retainer to protect it from damage. Use a small hammer to tap the blunt object lightly to force the seal retainer into the sleeve. Firmly seat the seal retainer.

Do not strike the seal retainer directly with the hammer. Direct hammering damages the valve stem.

3. Place the valve sleeve with the end marked *Tank* facing down on blocks or an open vise. Provide enough width and depth clearance for the valve stem to be installed in the sleeve from underneath, but to prevent the seal retainer from being removed.

4. Insert the valve stem (valve-stem point first) and piston into the sleeve and the center hole of the seal retainer.

5. Place a blunt object on the flat end of the valve stem to protect it from damage. Use a small hammer to tap the blunt object lightly and to force the valve stem into the sleeve and seal retainer until the piston is approximately 0.25 inches (6.35 mm) down in the sleeve.

Do not strike the valve stem directly with the hammer. Direct hammering damages the valve stem.

6. Place the remaining seal retainers on the end of the valve sleeve marked *Pressure*, and slip it down over the flat end of the valve stem. Place a blunt object in the center of the seal retainer's outside surface to protect it from damage. Use a small hammer to tap the blunt object lightly and force the seal retainer into the sleeve. Firmly seat the seal retainer.

Do not strike the seal retainer directly with the hammer. Direct hammering damages the seal retainer.

The blunt object used in this step must have a clearance hole in the center for the flat end of the valve stem.

7. Coat the seals, including the seal backup rings, with a thin film of grease and carefully install the seals in the caps. Seat the seals lightly. Each seal consists of a seal and a seal backup ring. The seal is open on one end and beveled on the other. The backup ring is flat on one side and beveled on the other. The seal must be inserted into the cap first with the open end facing the cap and the beveled end facing outward. The seal backup ring must be inserted into the cap after the seal, with the beveled side facing the cap and seal and the flat side facing outward.

Do not use tools on the delicate seals. Using tools on the seals damages them.

Improperly installing the seal and seal backup ring causes the high-pressure relief valve to fail!

8. Install the seal glands into the caps.

Do not use tools on the delicate seal glands. Using tools on the seal glands damages them.

9. Coat the remaining two O-rings with a thin film of grease. Install the O-rings, one on each end, into the valve sleeve and against the seal retainers.

10. Place the cap marked *Tank* onto the end of the valve marked *Tank*, and press it firmly into the valve until it is seated.

11. Place the cap marked *Pressure* onto the end of the valve marked *Pressure*, and press it firmly into the valve until it is seated.

Be sure the caps are accurately labeled before installing them.

12. Position the caps and fittings relative to each other as they were before disassembly. Align the four holes in each cap with the four threaded holes in each end of the sleeve.

13. Insert the eight socket-head screws, four on each end, into the caps and tighten them.

8.10.5 Reinstall High-Pressure Relief Valve

1. Place the high-pressure relief valve with its solenoid valve onto the mounting bracket inside the unit. Put the high-pressure relief valve where it was before removal. Insert the two 1/4-inch (6.35 mm) mounting screws and tighten.

2. Reconnect the low-pressure flexible lines to the high-pressure relief valve and to the center port on the high-pressure relief valve's solenoid valve.

3. Reconnect the high-pressure 1/4-inch (6.35 mm) stainless steel line to the high-pressure relief valve. Ensure that the gland nut is tight.

8.11 Rupture Disk

The rupture disk needs replacement only if the disk's pressure rating has been exceeded and the disk is ruptured. The rupture disk is contained in a safety head in the lower part of the consistometer. The safety head is pictured in Figure 8-11.

Figure 8-11Safety Head and Surrounding Parts

Perform the following steps to replace a ruptured disk:

1. Remove the flexible exhaust line from the safety head fitting. See Figure 8-11.
2. While holding the backup on the safety head body, loosen and remove the safety head.
3. Use a small screwdriver or a small, probing instrument to remove the failed rupture disk from inside the safety head.
4. Insert a new rupture disk into the safety head.

If replacing the rupture disk on the Model 290 Consistometer, only use Fann approved parts to ensure compatibility and operational safety. Fann rupture disk P/N 1000723846 is the only approved rupture disk for this consistometer.

Using a rupture disk with a rating less than 32,000 psi will lower the operating pressure of the unit.

5. While holding the backup on the safety head body, reinstall the safety head fitting.

6. Reinstall the flexible exhaust line onto the safety-head fitting.

8.12 Chamber and Reservoir

It is very important to keep the chamber and the reservoir clean and filled with oil that does not contain impurities.

Routine Maintenance	
Add oil	When oil level is low, add oil directly to the pressure chamber.
	Use Kaydol mineral oil. PN 100072408 (5 gallon) or PN 100013145 (55 gallon).
Change oil	Change every 6 to 12 months or when oil is dirty or contaminated.
	Chamber requires 4 quarts of Kaydol mineral oil.
	The reservoir holds approximately 2 ½ gallons.
Replace oil filter	Replace every 6 to 12 months. Replace more often if oil drained from reservoir is dirty.
	Use a Gresen hydraulic 1551 filter element (PN 100024683), or 10 µm filter with 7 - 8.5 kg/gm (100 to 125 psi) pressure rating.
Inspect reservoir	If the oil is dirty, remove and clean the oil reservoir.
Inspect chamber	If the chamber contains cement residue or dirty oil, vacuum the chamber and wipe it clean.

Cement residue and other impurities can affect a test results (inaccurate data). The chamber must be kept clean to allow the HPHT Consistometer to work properly.

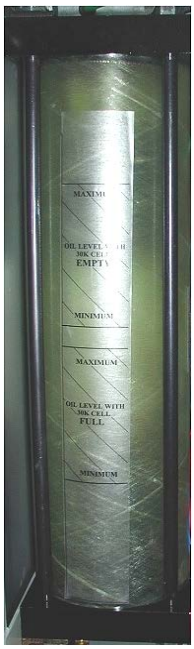


Figure 8-12 Oil Reservoir

8.13 Shaft Packing

As the shaft packing wears out, cement and packing particles begin to travel through the packing cartridge. Change the packing if oil leaks beside the shaft.

After changing the shaft packing, perform the maintenance described in Section 8.12 for changing the oil.

To disassemble the shaft packing:

1. Loosen the four screws on the motor mount and slide it toward the shaft. The belt will loosen so that it can be removed from the pulley.
2. Disconnect the vent line from the bearing housing.
3. Use vise grips to loosen the upper nut. The 1/4-inch shaft should come out with the housing. If it does not, remove it carefully. If the shaft is stuck in the bearing housing, place the shaft in a vise and pull gently on the housing.

Use care when removing the shaft. The shaft breaks easily if it is bent.

4. Unscrew and remove the packing backup ring.
5. Lift the turntable from the test chamber.
6. Insert a rod about 3/8-inch (9.5-mm) diameter into the top of the packing gland body. Tap lightly until the packing and the upper packing gland ring fall out.

Be sure the caps are accurately labeled before installing them.

7. Clean the upper packing ring.

To clean the bearing housing:

1. Mark the pulley's position along the bearing shaft so it can later be reinstalled in the same place.
2. Loosen and remove the pulley.
3. Mark the bottom and body of the housing for later realignment.

During reassembly of the housing, each hole in the bottom must be in the same position relative to the body.

4. Remove the bolts, and then carefully and evenly pry off the bottom.
5. Turn the bearing housing over and place it on blocks. Drive the bearing shaft, with the bearings and bearing spacer, out of the bearing housing.
6. Remove the bearing retaining ring, and remove the bearings and bearing spacer.
7. Thoroughly wash the bearing shaft, bearings, and bearing spacer with clean solvent.
8. Pack the thrust bearing and the radial bearing with grease. Place the thrust bearing onto the bearing shaft.
9. Place the bearing spacer onto the bearing shaft and fill it with grease.
10. Place the radial bearing onto the bearing shaft and reinstall the retaining ring.
11. Turn the bearing housing over. Coat the exposed end of the thrust bearing with a generous amount of grease, and reinstall it into the bearing housing.

12. Tap lightly and evenly around the outer race of the radial bearing to fully seat both bearings into the bearing housing.
13. Replace the bottom cover. The bolt holes should be in the same position to the housing as before disassembly.
14. Ensure that the O-ring is properly installed on the cover. Do not damage the O-ring when replacing the bottom cover. Tighten the bolts evenly, ensuring that the gap around the edge is uniform as the bolts are tightened.
15. Replace the pulley.
16. Place the 1/4-inch (6.35 mm) diameter shaft into the hex socket of the bearing shaft. The round end of the shaft should point up.

To reinstall the shaft and packing:

1. Grease the first piece of the packing and set it onto the packing tool.
2. Set the upper packing ring on the top packing.

A packing tool can be made with an old or used backup ring. Grind off the threads, and use silver solder to solder the ring to a small rod. If necessary, a small handle can be welded onto the other end of the tool.

3. Use the packing tool to insert the upper packing ring and the first piece of packing into the lower packing gland body. Tap the tool lightly until the packing is solidly in place.
4. Grease the second piece of packing, set it on the tool, and tap it into place. Repeat this procedure for the third piece of packing.
5. Replace the backup ring by screwing it in with a screwdriver until it is flush. Tighten it with an additional one-quarter turn.

Be careful not to over tighten the backup ring.

After the 1/4-inch shaft is inserted, you should be able to grasp it firmly at the hex and turn it manually. If the backup ring will not go in completely, the packing is incorrectly placed. Tap the packing again. If the backup ring still will not go in all the way, remove and reinsert the packing.

6. With the 1/4-inch (6.35 mm) diameter shaft in place, lift the bearing housing straight up onto the packing gland nut. Do not rotate the packing shaft until the head of the shaft is through the packing. Screw the gland nut onto the housing and tighten it with chain vise grips.

Do not hammer the vise grips. Hammering the vise grips can cause overtightening.

7. Reconnect the vent line to the bearing housing.
8. Place the drive belt on the pulley. Slide the motor mount over until the belt applies slight pressure. Tighten down the motor mount.
9. Ensure that the belt is level between the drive shaft and the electric motor pulley. If the belt is not level, adjust it by loosening the set screw on the shaft pulley and sliding the pulley up or down until the belt is level.
10. Replace the turntable. Turn on the drive motor momentarily to ensure that the support is engaged with the shaft.

8.14 Lid Assembly

The lid assembly must be maintained to assure a proper seal and pressure control.

8.14.1 Release a Jammed Lid

Occasionally, at the completion of a test, the lid assembly will not open because the mandrel assembly is jammed. If it is impossible to turn the mandrel assembly by hand after the pressure is released, the mandrel is probably pressure-locked.

Perform the following steps to release the jammed lid:

1. Push the **Chamber Fill/Drain** switch to the *fill* position. Refill the chamber with oil.
2. Use the **Pressure Up/Down** switch to increase the pressure to a value that is slightly greater than the value for the last test. For example, if the last test pressure was 5500 psi, then increase the pressure to 6000 psi.
3. After pressure has increased, loosen the retainer lid seal nut approximately one full turn.
4. Push **Pressure Up/Down** switch to the *down* position and hold until all pressure is released from the chamber.
5. Push the **Chamber Fill/Drain** switch to the *drain* position. Drain the oil from the chamber.

6. Recheck the lid. The lid should no longer be jammed.

8.14.2 Disassemble the Lid

Perform the following steps to disassemble and reassemble the lid if the lid needs repair or if parts need replacement:

1. Release the pressure and remove the slurry thermocouple. Unscrew the retainer lid seal nut.
2. Remove the thrust washer.
3. Remove the mandrel and the high-pressure seal ring from the bottom of the lid assembly.
4. Remove the high-pressure ring from the mandrel.
5. Replace the high-pressure ring if it is damaged or worn.

Protect the inner and outer seal areas at the bottom of the ring from damage or indentation from accidental blows. Undamaged seals are critical for obtaining and holding a good seal at high pressures.

6. Inspect the mandrel and file it if necessary. Replace the mandrel if it cannot be repaired.

File only the surface of the cylindrical outer diameter of the mandrel, not the mandrel's conical seal surface. Filing the conical seal surface can damage the seal.

8.14.3 Reassemble the Lid

1. Replace the high-pressure ring on the mandrel.
2. Replace the mandrel.
3. Replace the thrust washer.
4. Replace the ring retainer lid seal nut.
5. Replace the slurry thermocouple.

After assembly, there should be a minimum 1/16-inch (1.6 mm) gap between the high-pressure ring and the lid. Replace the low-pressure O-ring if the chamber does not pressure up, or if the top of the pressure chamber lid is leaking.

8.15 Counterbalance

After initial installation, the counterbalance requires minimal maintenance. Adjust the counterbalance only if its cable is worn or if it is not the correct length to allow the lid assembly to clear the top of the chamber.

8.15.1 Disassemble the Counterbalance

1. Remove the front swivel arm cap by unscrewing the self-tapping screws.
2. Remove the back swivel arm cap by unscrewing the self-tapping screws.
3. Unhook the swivel assembly from the lid assembly.
4. Remove both short sheaves by loosening the hex socket head screws on the collars.
5. Grasp the cable at the top of the vertical post and lift the balancing weight partially out of the vertical post.
6. Slide a pin into the post under the balancing weight to support it so that the cable set screws can be accessed. (The balance weight weighs approximately 70 lb.)

8.15.2 Retrieve a Separated Counterbalance

If the counterbalance separates from the cable, follow these steps to retrieve it:

1. Loosen the swivel post, pivot head, and top guide sleeve.
2. Lift out the swivel post, pivot head, and top guide sleeve.
3. Lift the swivel post and tilt it slightly, allowing the weight to fall out.

8.15.3 Reassemble the Counterbalance

1. Attach the end of the cable to the balancing weight.
2. Grasp the cable at the top of the vertical post and lift the balancing weight partially out of the vertical post.
3. Slide the pin from under the balancing weight and lower the balancing weight to the bottom of the chamber.
4. Install the short sheaves in their positions and secure them on the collars with hex socket head screws.
5. Hook the swivel assembly onto the lid assembly.
6. Replace the front swivel arm cap and secure it with its self-tapping screws.
7. Replace the back swivel arm cap and secure it with its self-tapping screws.

8.16 Potentiometer

Inspect the calibration spring for corrosion, and inspect the resistance wire on the core winding for pitting and corrosion. This core winding should have a resistance of 450 to 500 ohm. See Figure 8-13 for a detailed drawing of the potentiometer parts.

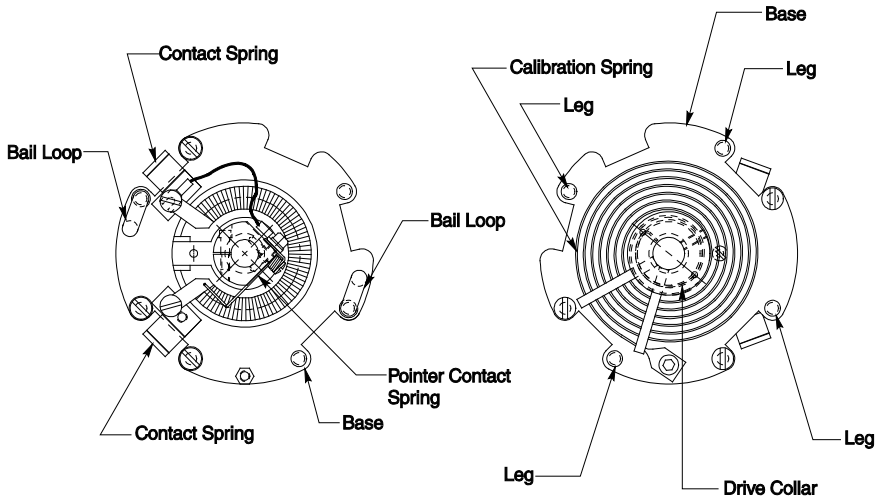


Figure 8-13 Potentiometer Parts

8.16.1 Lengthen the Legs

Perform the following steps to lengthen the legs if the potentiometer rests on the slurry cup diaphragm support and not on the heater protector sleeve:

1. Screw four number 8 screws into the legs of the potentiometer to lengthen the legs by the thickness of the screw head.
2. Assemble the slurry cup without the drive disk and bar, but with the paddle.
3. Lower the slurry cup into the chamber using the slurry cup bail.
4. Use the slurry cup bail to lower the potentiometer onto the top of the cup and paddle shaft.
5. Reach down into the chamber and gently move the top portion of the potentiometer up and down to verify that the potentiometer is supported on the heater protector sleeve. If the top portion moves freely, then the potentiometer is resting correctly on the sleeve. If the top portion does not move freely up and down, the potentiometer's legs need further lengthening.

Perform steps 6 and 7 only if the potentiometer's legs require more lengthening.

6. Use the slurry cup bail to remove the potentiometer from the chamber.
7. Loosen the screws in the legs slightly to attain more length. Repeat Steps 4 and 5.

8.16.2 Replace the Rheostat

Perform the following steps if the rheostat needs replacement:

1. Remove the contact bar and contact spring from both end terminals on the rheostat. Remove one terminal of the wire to the contact spring pointer.
2. Remove the pointer collar and the pointer contact spring from the center shaft.
3. Loosen and remove the locking nut and remove the old rheostat.
4. Replace the old rheostat with a new rheostat. Reinstall the locking nut.
5. Reinstall the pointer collar and the pointer contact spring onto the center shaft
6. Reinstall the contact bar and the contact spring onto both end terminals of the rheostat. Reinstall the wire to the contact spring pointer on only one terminal.

7. Fully rotate the drive collar by hand to ensure that the pointer contact spring travels the full distance around the rheostat without passing either terminal. Ensure that the wire between the contact spring pointer and the rheostat end terminal does not restrict the rotation of the pointer collar with the pointer contact spring. Lengthen the legs of the potentiometer.

8.16.3 Replace the Pointer Contact Spring

Perform the following steps if the pointer contact spring needs replacement:

1. Remove the two screws that hold the pointer contact spring and the wire from the rheostat end terminal onto the pointer collar.
2. Remove the old pointer contact spring and replace it with a new pointer contact spring.
3. Reinstall the two screws.
4. Fully rotate the drive collar by hand to ensure that the wire between the contact spring pointer and the rheostat end terminal does not restrict the rotation of the pointer collar with the pointer contact spring.

8.16.4 Replace the Calibration Spring

Perform the following steps if the calibration spring needs replacement:

1. Remove the drive collar from the center shaft.
2. Remove the jam nut from the end of the shoulder screw. While holding the end of the calibration spring, remove the shoulder screw and spacers.
3. Remove the old calibration spring and replace it with a new calibration spring.
4. Reinstall the shoulder screws and spacers to secure the end of the calibration spring. Ensure that the end of the calibration spring is tangent to the center shaft, and tighten the shoulder screw.
5. Reinstall the jam nut onto the end of the shoulder screw.
6. Reinstall the drive collar.
7. Fully rotate the drive collar by hand to ensure that the pointer contact spring travels the full distance around the rheostat without passing either end terminal. If the pointer contact spring goes past either end terminal, adjust the position of the drive collar.

8.17 Fuses

Before replacing fuses, perform the steps previously mentioned in Section 8.3.

Unplug the HPHT Consistometer power cord before attempting to replace fuses. Failure to unplug the power cord could result in personal injury or damage to the HPHT Consistometer.

Do not replace the fuses with fuses of a higher rating. Replacing old fuses with fuses of different ratings could cause personal injury or damage to the HPHT Consistometer.

The general electrical system is protected by two 2-A fuses located inside the electronics enclosure. The chamber heater is protected by two 20-A fuses located inside the electronics enclosure.

8.18 Shear Pins

When the shear pin breaks, install a replacement shear pin.

Do not substitute an ordinary sewing pin for a replacement shear pin. A sewing pin will not allow the pin to shear before the cement paddle is damaged.

Align the holes in the drive disk and bar, and insert the pin through the holes. Bend the excess length of the pin against the drive bar, as shown in Figure 8-14.

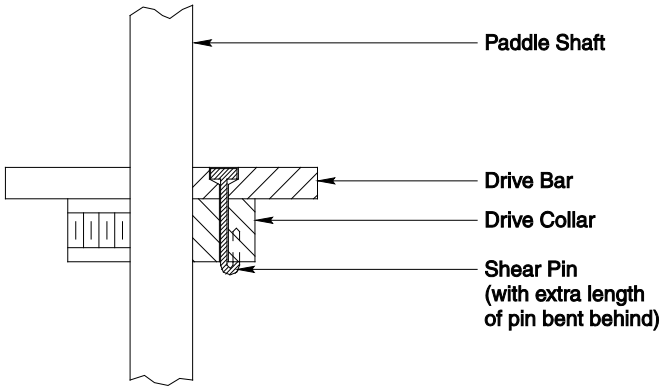


Figure 8-14 Shear Pin inserted through Drive Disk and Bar

8.19 Fine-tune HPHT Process Control

Before your HPHT Consistometer is shipped, a Fann technician made fine-tuning adjustments to the temperature and pressure controls.

Fann Instrument Company engineers have optimized these settings. Only make changes to these controls under the advice of factory engineers. If these controls are set incorrectly, it will affect the machine's ability to control temperature and pressure.

If the instrument needs fine-tuning adjustment after several tests have been conducted, follow the instructions in this section to modify these tuning parameters.

8.19.1 Temperature Controller

When the HPHT Consistometer runs a test, it progresses through a sequence of user-specified slurry temperatures that occur at designated times during the test. This sequence of temperatures forms the temperature schedule of the test.

Temperature fine-tuning affects the way that the HPHT Consistometer attempts to follow, or track, the scheduled slurry temperature.

To change the heat controller value, go to the Machine Settings>PID screen. Enter values for P, I, and D in the fields.

If the slurry temperature overshoots the schedule temperature, decrease the P number. This is a very critical process. Usually, adjusting the *Master P* value is enough. If the slurry temperature undershoots the schedule temperature, increase the number.

Fine-tuning temperature should be done only when it is at least 15 minutes into the test. Also, you should make only a small adjustment value at a time (the recommended value is 7.5 for *Master P* value). Then, wait at least 5 minutes for the temperature to respond before making another adjustment.

8.19.2 Pressure Controller

You should fine-tune the pressure when the pump and relief valve make frequent and occasionally conflicting adjustments to maintain the scheduled pressure.

Because pressure control varies from machine to machine, this option allows fine-tuning of an individual HPHT Consistometer for optimum control.

Pressure fine-tuning must be performed while a test is running.

9 Accessories

An optional accessories kit is available for separate purchase.

Table 9-1 Accessories Kit, P/N 101443608

Item No.	Part No.	Quantity	Description
0001	101623634	1	PNEUMATIC VACUUM WAND ASSEMBLY
0002	100071979	1	SLURRY CUP ASSEMBLY
0003	100072504	5	PIN, SHEAR, SLURRY CUP
0004	210219	3	FUSE 2 AMP
0005	100010309	5	GASKET, CUP BASE
0006	100001372	1	BAG, VINYL, 12 IN X 15 IN X 0.006 THK, PRESTITE ZIPPER
0007	100002026	5	O-RING, 90 DURO, 3 7/8 X 3 3/4 X 1/16
0008	101443607	1	MANUAL MODEL 290 HPHT CONSISTOMETER
0010	100013735	2	DIAPHRAGM, NEOPRENE, SLURRY CUP, FLAT
0011	100072678	1	CALIBRATOR ASSEMBLY, ISOLATED CERAMIC POTENTIOMETER
0012	100071980	1	TOOL KIT
0013	205553	1	UPS (UNINTERUPTED POWER) 350 VA 230V AC
0014	101730954	5	O-RING, 028 VITON 1 3/8 x 1 1/2 DURO 75
0015	101843357	5	REPLACEMENT ELEMENT, FOR IN-LINE FILTER, 30K PSI OPERATING PRESSURE, 17-4 MATERIAL, 1/4 HIGH PRESSURE FEMALE CONNECTIONS, 40 MICRON STAINLESS STEEL ELEMENT, VITON® O-RING, TEFLON BACK-UP RING
0016	102005503	5	O-RING KIT, VITON® 016V & TEFLON O-RINGS
0018	102126448	1	SPARES, MANIFOLD, 3 O-RINGS, 2 SCREWS
0019	102220929	1	NITRILE SQUARE-CUT O-RING, 5-IN. ID x 1/16-IN. WIDE

10 Parts List

Table 10-1 HPHT Consistometer, Model 290, P/N 101443590

Item No.	Part No.	Quantity	Description
0001	101709739	1	BRAIDED STAINLESS STEEL HOSES
0005	100072525	1	LID ASSEMBLY
0007	101465338	1	MOTOR ASSEMBLY
0008	101465342	1	DRAIN VALVE ASSEMBLY
0009	101465343	1	PUMP ASSEMBLY
0010	101469807	1	FRAME & PANEL ASSEMBLY
0019	100053485	1	FRAME INSTALLATION
0020	101936775	1	ELECTRICAL ENCLOSURE INSTALLATION
0035	398332	1	VISUAL RESERVIOR KIT
0044	101432351	1	HYDRAULIC / PNEUMATIC PANEL ASSEMBLY
0048	100071985	1	CHAMBER ASSEMBLY
0108	102278347	1	POTENTIOMETER ASSEMBLY
0110	101443608	1	ACCESSORIES KIT

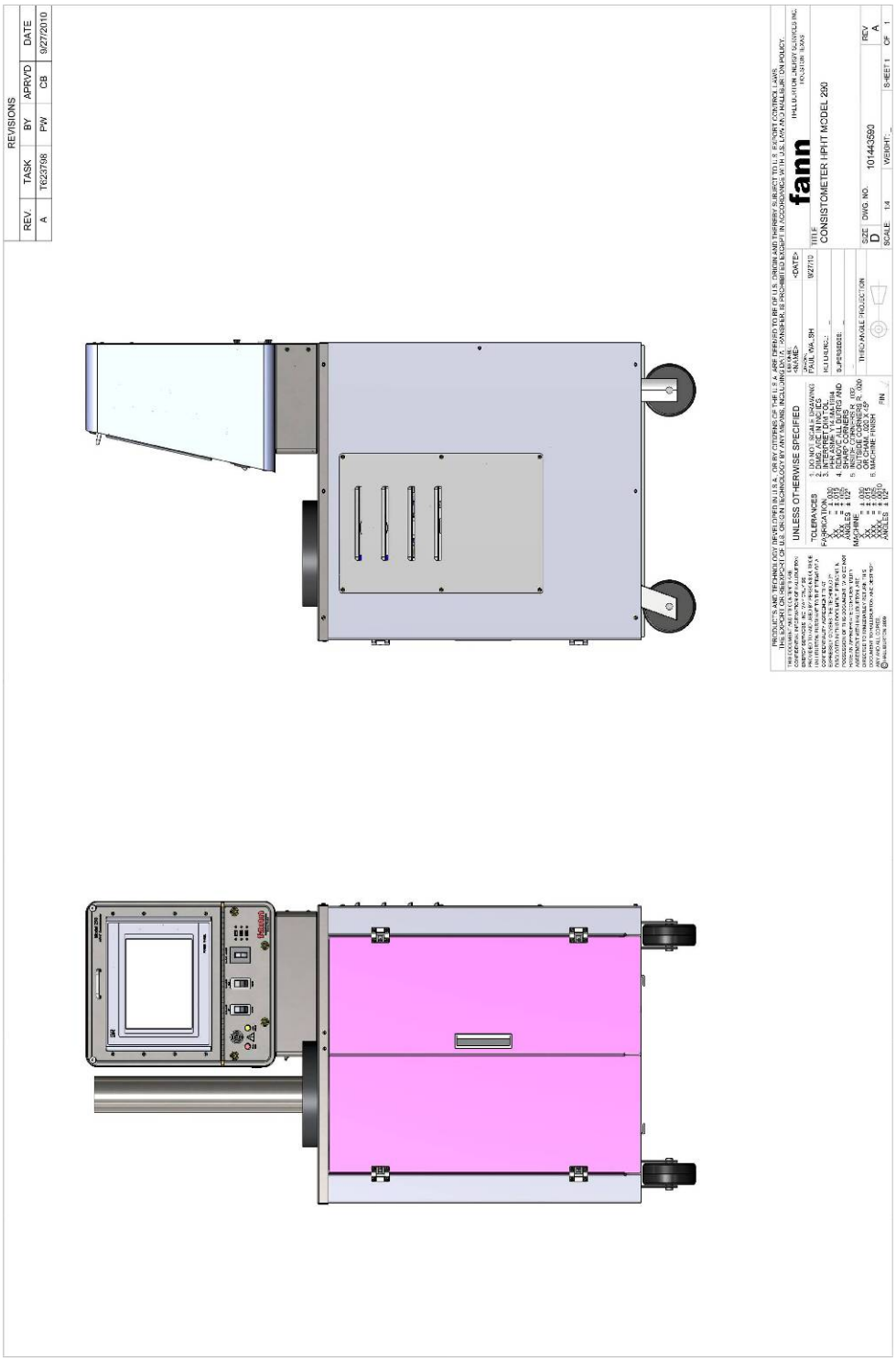


Figure 10-1 HPHT Consistometer, Model 290

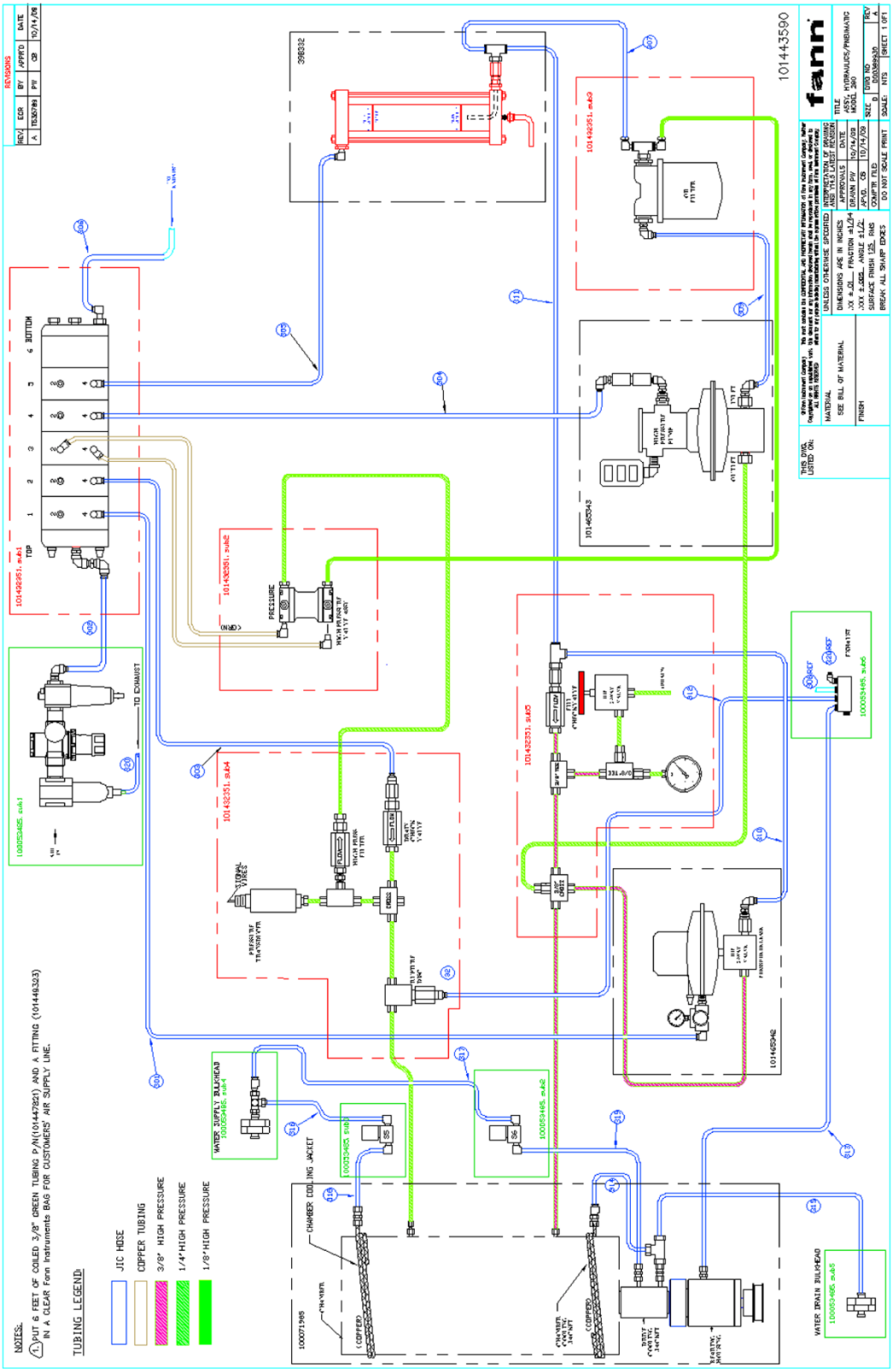


Figure 10-2 Hydraulic and Pneumatic Assembly

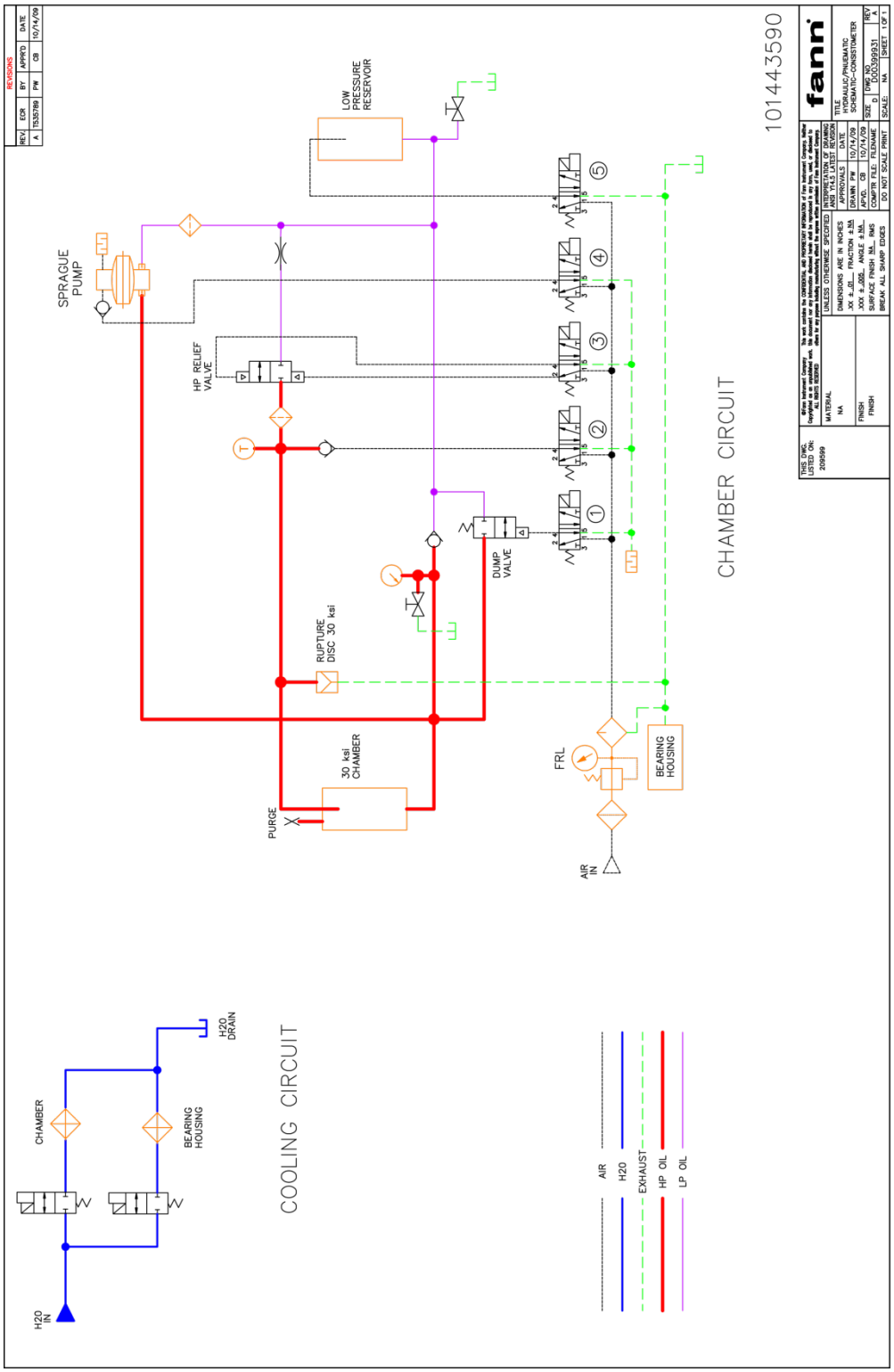


Figure 10-3 Model 290 Schematic

Table 10-2 Lid Counterbalance Assembly, P/N 100072525

Item No.	Part No.	Quantity	Description
0001	100072530	1	PIVOT HEAD
0002	100028324	2	HEX CAP SCREW, 3/8-24 NF X 3/4, PL
0003	100072531	1	BALANCING WEIGHT
0004	100028830	4	HEX SOCKET SCREW, #10-32 NF X 1/4, CUP PORT
0005	100028129	36	NEOPRENE RUBBER SHEET, 1/4, 50-55 DURO
0006	207764	4	HEX SOCKET SET SCREW, 10-32 X 3/8, HSSS BOPL, CUP POINT
0007	100072639	1	COUNTERBALANCE CABLE & SWIVEL ASSEMBLY
0008	100072526	1	SWIVEL POST, WELDED ASSEMBLY, COUNTERBALANCE LID
0011	100028731	4	OVAL HEAD MACHINE SCREW, #8-32 NC X 3/8
0012	100072535	2	SHORT PULLEY SHAFT
0013	100023446	4	COLLAR SET, 5/8 ID X 1 1/8 OD X 1/2 LG
0014	100029262	2	SHEAVE, 1 GR, 0.625 BORE X 2.75 OD X 2.18 PITCH DIA
0015	100072527	4	WASHER, RETAINING, PIN, SWIVEL POST
0016	100072534	2	SWIVEL ARM CAP
0018	100021835	1	BALL BEARING, FLANGE BLOCK
0019	213468	2	1/4-20 X 3/4, SCREW, HHCS
0020	100072559	1	BEARING, POST, COUNTERBALANCE
0021	101535909	1	SWIVEL STOP RETROFIT KIT
0025	100002256	4	WASHER, LOCK, 1/2, STEEL
0026	100028492	2	HEX CAP SCREW, 1/2-13 NC X 2
0027	100026525	4	HEX NUT, 1/2-13 NC
0028	100033559	4	FLAT WASHER, 1/2, 1 OD, STEEL, SAE STANDARD

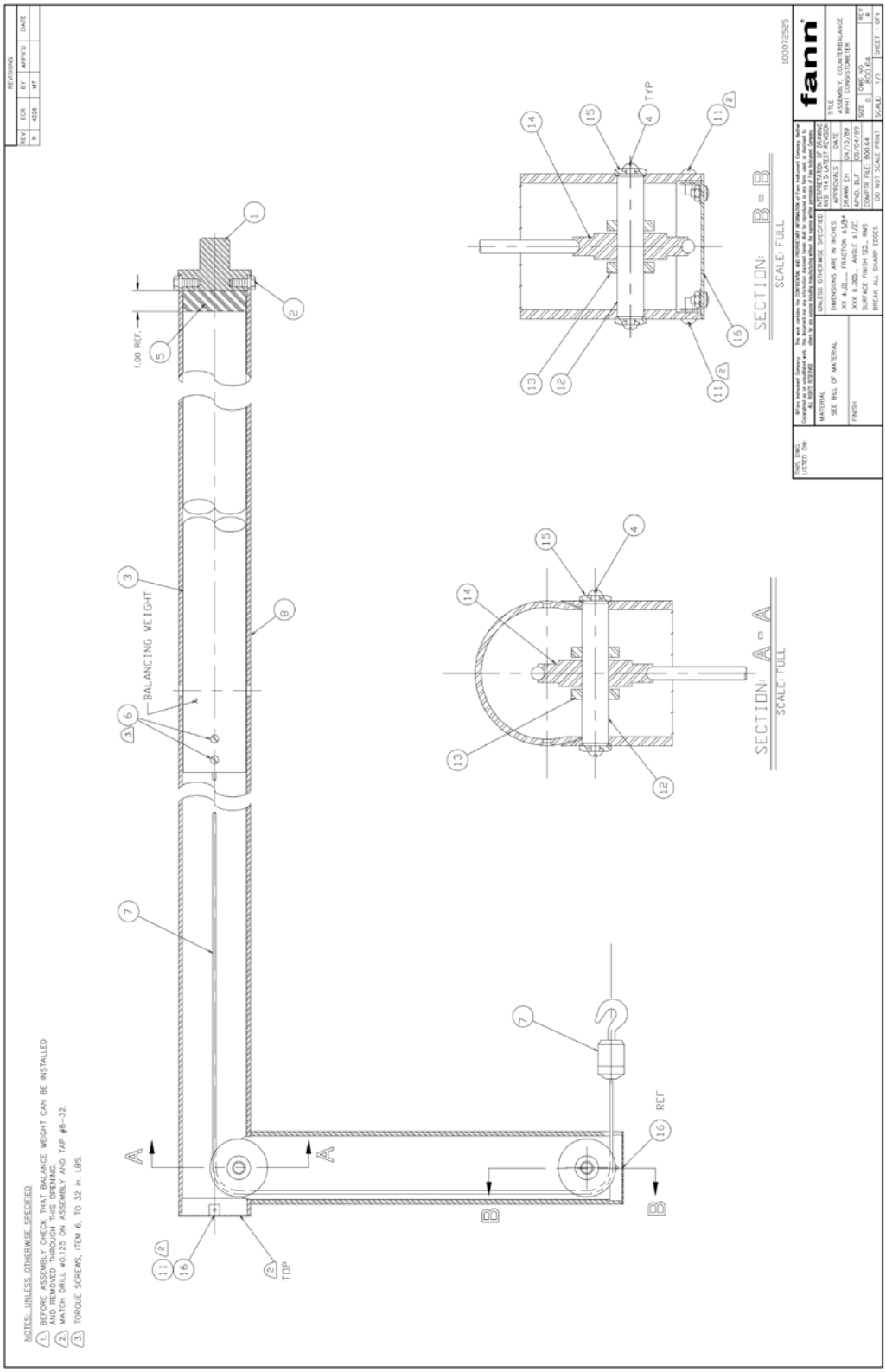


Figure 10-4 Counterbalance Assembly

Table 10-3 Motor Assembly, P/N 101465338

Item No.	Part No.	Quantity	Description
0001	100027802	1	ELECTRIC GEAR MOTOR, 1/6 HP
0002	378046	1	BRACKET MOTOR MOUNT
0003	207898	2	SCREW, 1/4-20 X 1, FHMS
0004	100028423	6	HEX CAP SCREW, 1/4-20 NC X 3/4, PL
0005	100029920	8	WASHER, LOCK, 1/4, STEEL
0006	207626	8	HEX NUT 1/4-20
0007	204331	2	BUTT SPLICE
0008	100071986	1	SYNCH PULLEY, 20 TOOTH, 3/8 PITCH, 1/2 BELT, 5/8 BORE
0009	100071989	1	SYNCH PULLEY, 24 TOOTH, 3/8 PITCH, 1/2 BELT, 5/8 BORE
0010	100027787	1	NEOPRENE TIMING BELT
0011	100031551	5.5	WIRE, 12 GA, STRANDED, WHITE/BLACK, TEFLON
0012	205713	1	ANGLE CONNECTOR

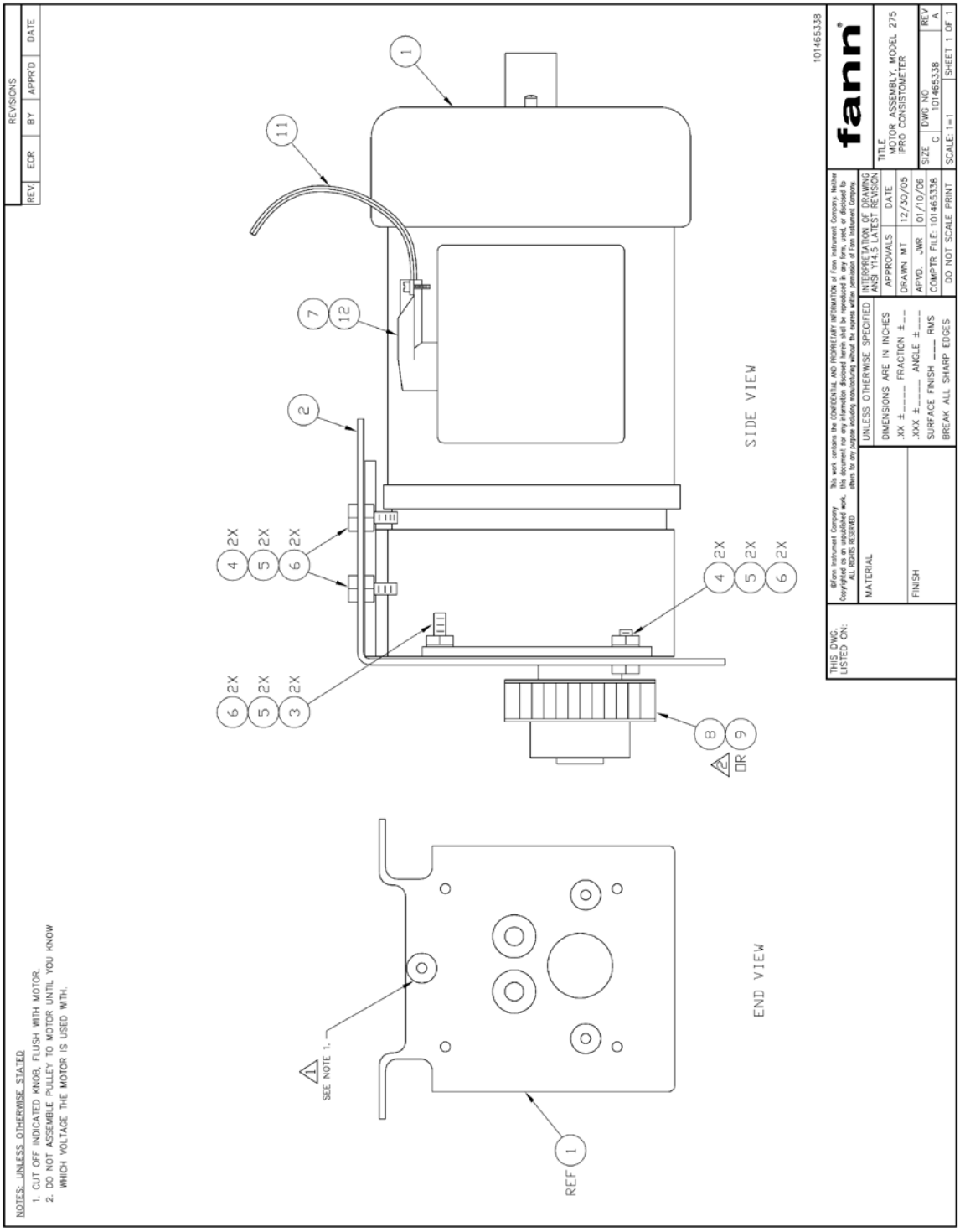


Figure 10-5 Motor Assembly

Table 10-4 Drain Valve Assembly, P/N 101465342

Item No.	Part No.	Quantity	Description
0001	101605352	1	AIR OP VALVE, NORMALLY CLOSED, 3/8, 60 KPSI
0002	204898	1	REGULATOR, 2-125 PSI, AIR, 1/4 NPT
0003	208602	1	GAUGE, 160 PSI, 1.5 IN. DIAL, 1/8 MNPT, BOTTOM CONNECTION
0004	100032885	1	EXHAUST MUFFLER, PNEUMATIC, 1/4
0007	205583	1	NIPPLE, 1/4 NPT, HEX, STAINLESS STEEL
0008	207835	2	SCREW, 10-32 X 2, BHMS, STAINLESS STEEL
0009	207633	2	REGULAR HEX NUT, 10-32, STAINLESS STEEL
0010	208704	2	SPLIT WASHER, STAINLESS STEEL
0011	101709591	2	ELBOW, 1/4 MNPT x 1/4 JIC, 90 DEG
0012	101605357	1	ADAPTER, 3/8 HP MALE X 1/4 NPT, FEM

If your instrument has been upgraded to the Model 290 HPHT Consistometer, please verify the valve size – 1/4 inches or 3/8 inches, and order the correct tubing size. For 1/4-inch tubing, the P/N is 206159. For 3/8-inch tubing, the P/N is 101605352.

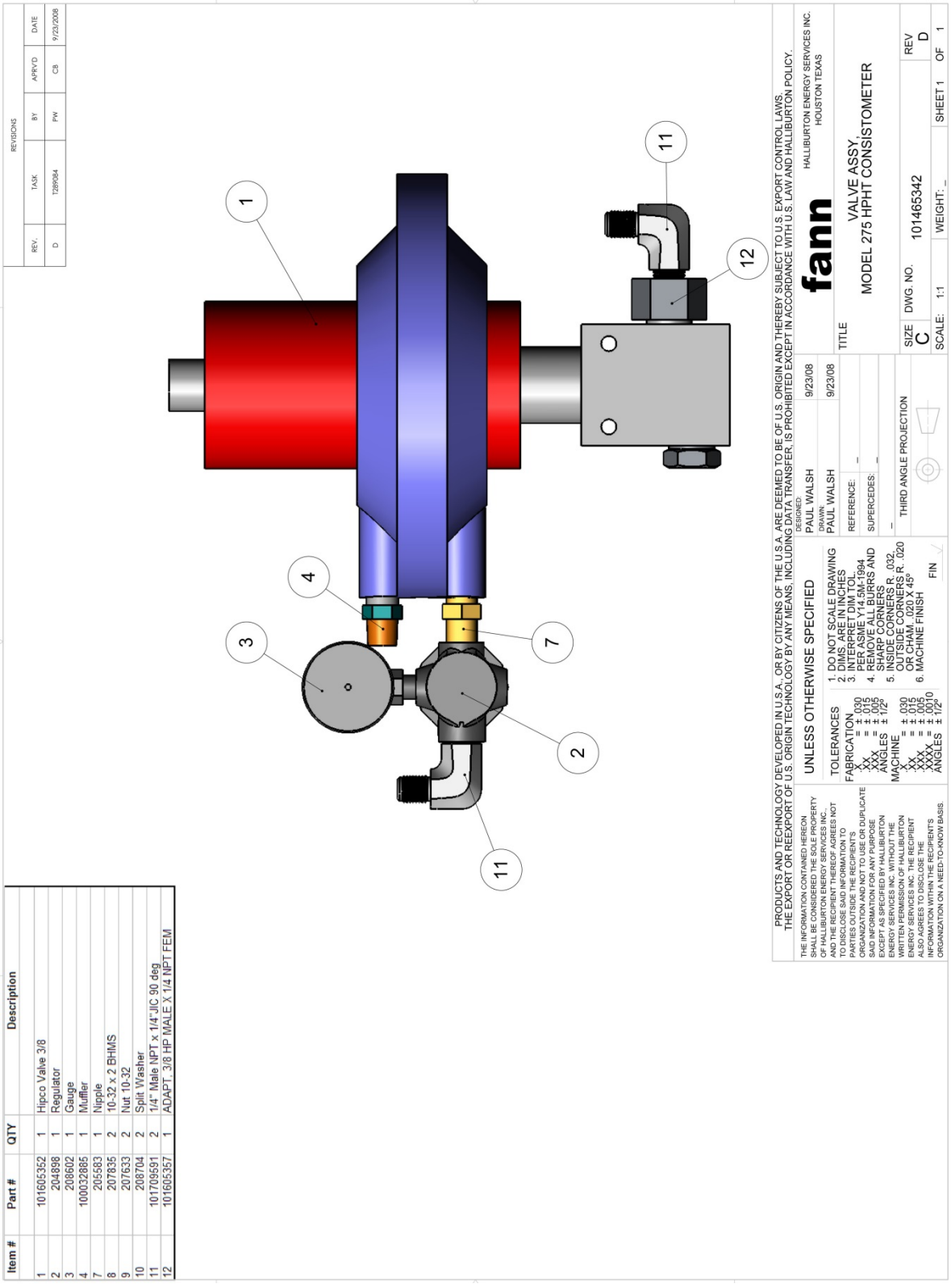


Figure 10-6 Two-Way Valve Assembly

Table 10-5 Pump Assembly, P/N 101465343

Item No.	Part No.	Quantity	Description
0001	100012990	1	AIR OPERATED PUMP, 300-30,000 PSI MAXIMUM
0002	369797	1	AIR EXHAUST MUFFLER, 1/2 MNPT, 3 CFM MAX
0005	100026124	1	REDUCING BUSHING, 1/2 MALE PIPE THREAD X 1/4 FPT
0006	396061	1	STREET ELBOW, 1/2 NPT
0007	100001646	1	AUTOCLAVE COLLAR,1/4 TUBE, 60,000 PSI
0008	101709592	1	ELBOW, 1/4 MNPT x 3/8, JIC, 90 DEG
0009	100001771	1	AUTOCLAVE GLAND
0011	203376	2	SCREW, 5/16-18 X 3/4, HHCS
0012	206202	2	LOCK SPLIT WASHER, 5/16 IN.
0026	101709591	1	ELBOW, 1/4 MNPT x 1/4 JIC, 90 DEG
0077	208607	1	STREET ELBOW, 1/4 SS-4-SE, SWAGELOK, 4-4-SE PARKER
0091	101710380	1	ELBOW, 1/4 MNPT x 1/4 MNPT, 90 DEG, BRASS
0094	101709773	1	CHECK VALVE, 1/4 FNPT, BRASS, 250 PSI, 180 F, SS POPPET

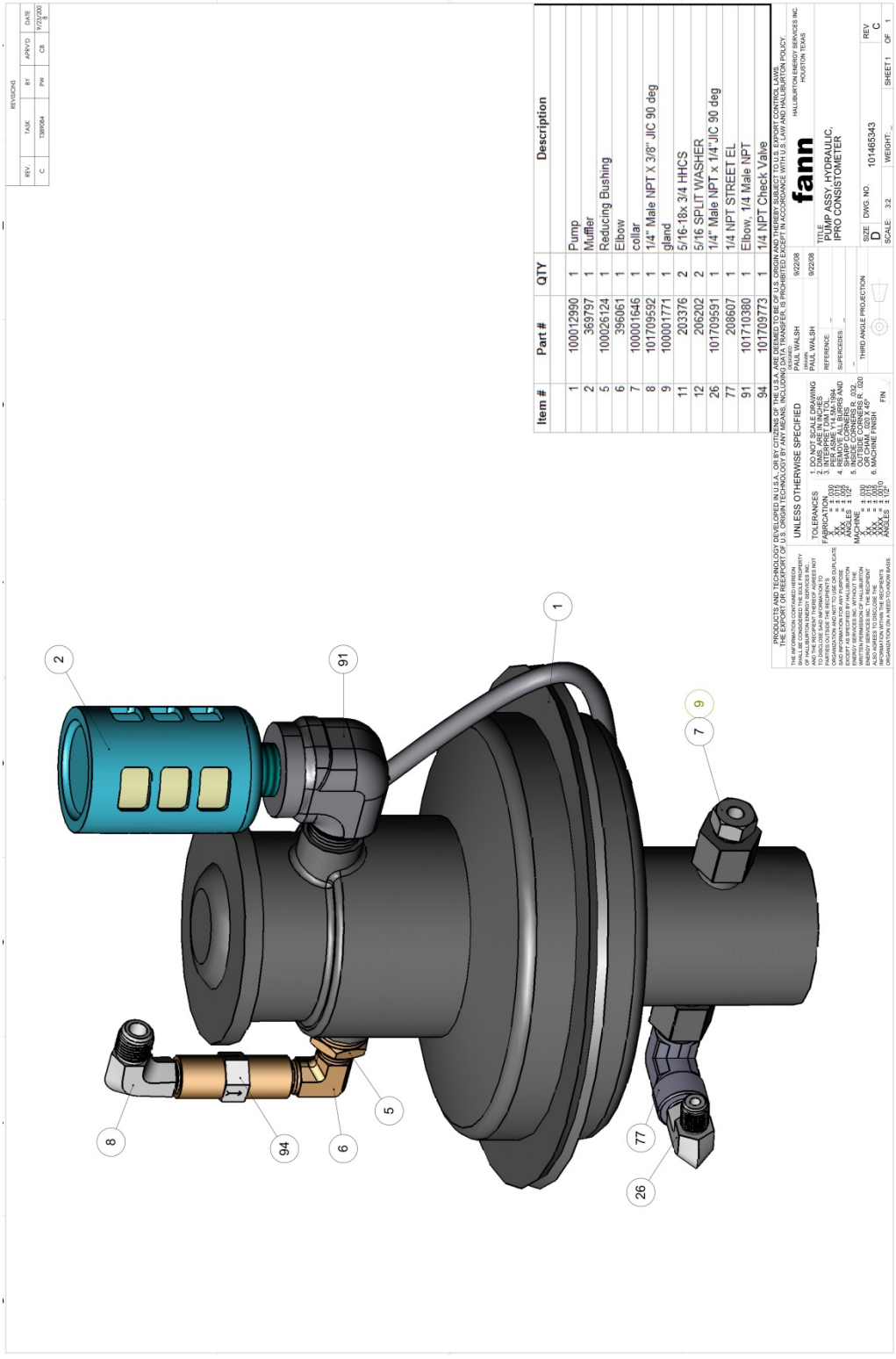


Figure 10-7 Hydraulic Pump Assembly

Table 10-6 Frame & Panel Assembly, P/N 101469807

Item No.	Part No.	Quantity	Description
0001	100071984	1	FRAME WELDMENT
0002	100071974	1	RIGHT SIDE PANEL
0003	100071975	1	LEFT SIDE PANEL
0004	100071976	1	TOP PANEL
0005	207610	20	SCREW, 8-32 X 1/2, BHMS, STAINLESS STEEL
0006	401199	1	DOOR LATCH PLATE
0007	401005	4	ADUSTABLE FRICTION HINGE
0008	401006	1	LARGE SNAP-IN POCKET PULL
0009	401202	1	RIGHT DOOR
0010	401200	1	LEFT DOOR
0011	401072	2	STEEL MAGNETIC CATCH STRIKE
0012	401215	2	MAGNETIC CATCH LATCH
0013	401217	2	MOUNTING LATCH BRACKET
0014	207605	26	SCREW, 10-32 X 1/2, BHMS, STAINLESS STEEL
0015	101438899	1	RIGHT SIDE COVER PANEL
0016	207487	12	SCREW, 6-32 X 1/4 , BHMS, STAINLESS STEEL

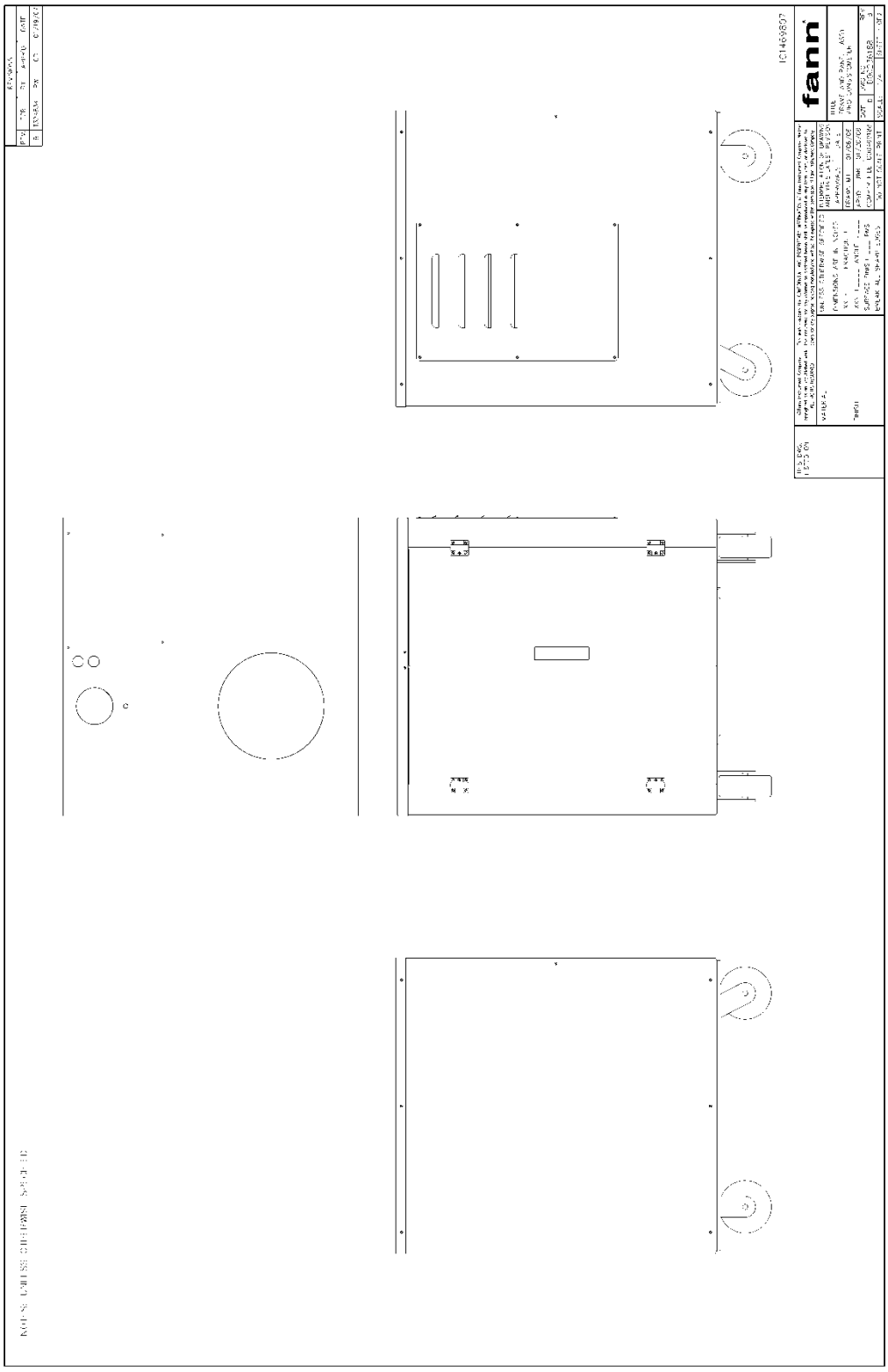


Figure 10-8 Frame & Panel Assembly, Front View

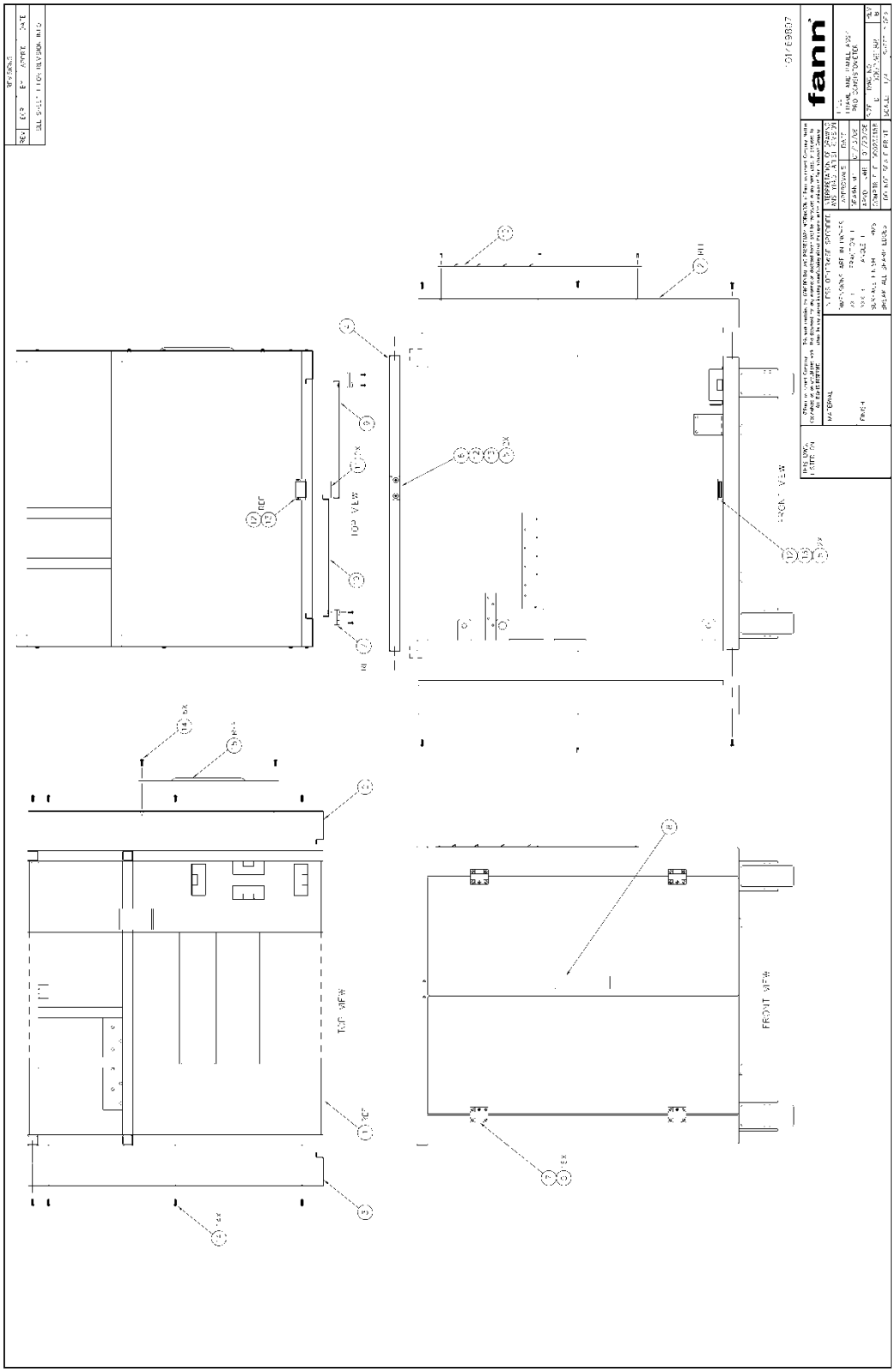


Figure 10-9 Frame & Panel Assembly, Back View

Table 10-7 Installation Frame, P/N 100053485

Item No.	Part No.	Quantity	Description
0001	100071978	1	DRIP PAN
0008	100072033	1	MODIFIED BULKHEAD FOR THERMOCOUPLE HOLDER
0009	100071982	1	PORT LABEL, SET OF 4 LABELS
0010	207473	4	RIVET POP AL 1/8 LG 3/16 GRIP
0011	100071983	1	NAME PLATE
0013	207605	14	SCREW, 10-32 X ½, BHMS, STAINLESS STEEL
0016	100028426	12	HEX CAP SCREW, 1/4-20 NC X 1/2, STAINLESS STEEL
0017	203484	2	SCREW, 6-32 X 1-3/4, BHMS, STAINLESS STEEL
0018	207489	20	SCREW, 6-32 X 1/2, BHMS, STAINLESS STEEL
0020	101709777	1	AIR FILTER, REGULATOR, LUBRICATOR 3/8 NPT PORTS WITH GAUGE
0021	100015027	1	ADAPTER HOSE, 070202-6-6C, ELBOW, 9/16-18 JIC MALE X 3/8-18 NPT MALE, STEEL
0022	100022333	1	SOLENOID VALVE, 2 WAY, SUBMINIATURE, BRASS BODY, 1/8 NPT, 220V, 50/60 HZ, 0.19 FLOW FACTOR
0023	101709596	1	ADAPTER, 1/8 MNPT x 1/4 JIC
0024	101709597	2	ELBOW, 1/8 MNPT x 1/4 JIC 90 DEG
0025	101711792	1	SOLENOID VALVE, 2 WAY NC, 1/4 NPT, SUBMINIATURE, BRASS BODY, 240/60, 220/50, 0.50 FLOW FACTOR
0026	101709595	4	ADAPTER, 1/4 MNPT x 1/4 JIC
0027	101709591	3	ELBOW, 1/4 MNPT x 1/4 JIC, 90 DEG
0028	101463360	2	BULKHEAD, 1/4 FEMALE NPT TO 1/4 FEMALE NPT, BRASS
0029	101709709	1	TEE,1/4 MNPT X 1/4 JIC RUN X 1/4 JIC, BRANCH
0030	101709772	1	MANIFOLD, 4 OUTLET, 3/8 FNPT INLET X 1/4 FNPT OUTLET
0031	101463533	1	PLUG, 3/8 NPT, HEX COUNTERSUNK, BRASS

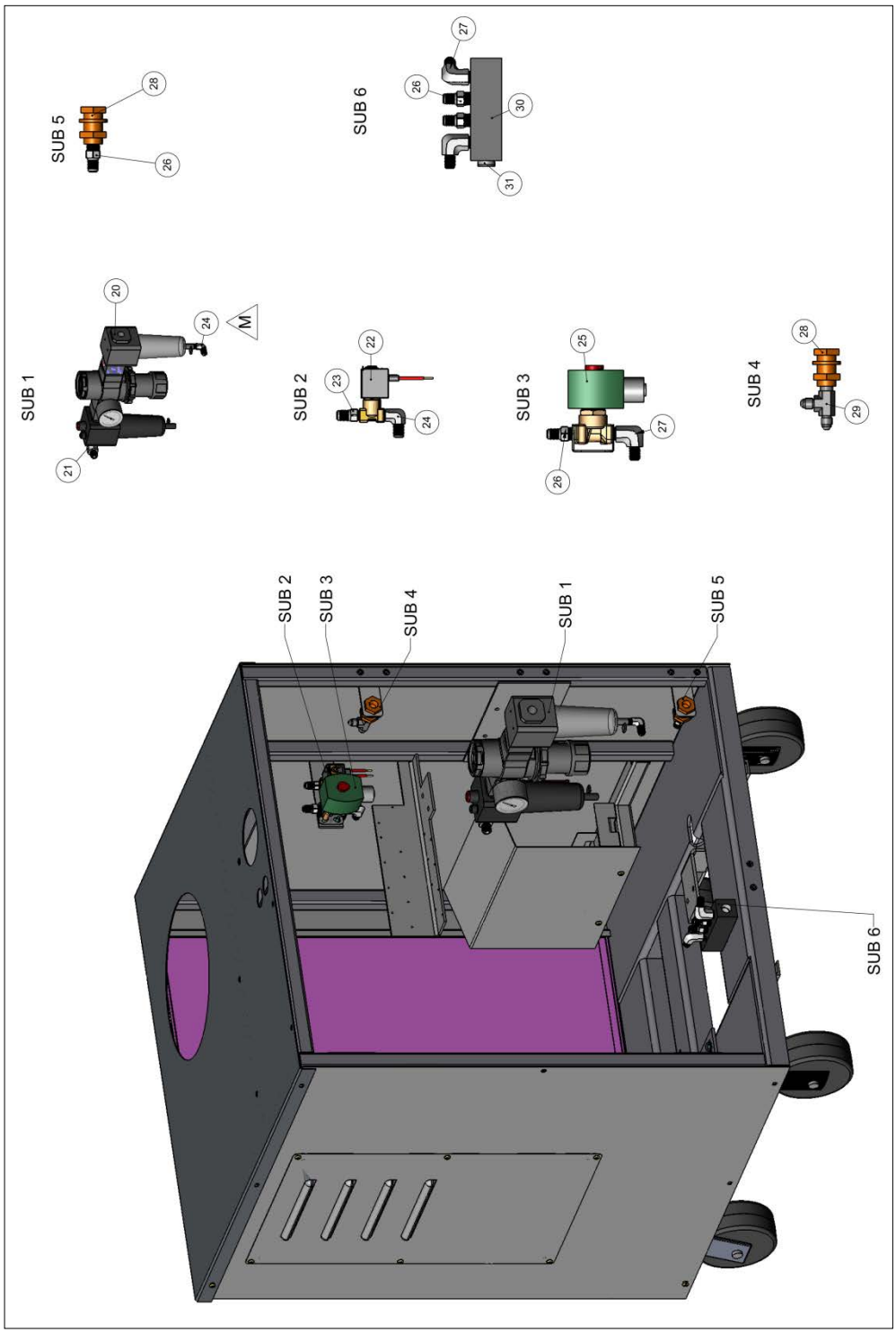


Figure 10-10 Installation Frame

Table 10-8 Electrical Enclosure Installation, P/N 101936775

Item No.	Part No.	Quantity	Description
0001	101866735	1	ELECTRONICS CHASSIS
0003	101791314	1	COMPUTER ASSEMBLY
0004	101761371	1	POWER SUPPLY, 24V, 5 AMP, LED DISPLAY, DIN RAIL MOUNT
0005	101773541	1	POWER SUPPLY, 5V, 2A, 10 WATTS, DIN RAIL MOUNTED
0006	101536091	1	ETHERNET SWITCH, 5 TP-RJ45 PORTS, 10/100 MBPS, 18.5 - 30.2 VDC INPUT
0007	208438	1	PLUG INTL ELECT CODE TYPE
0008	101391619	5	END CLAMP, UNIVERSAL, FOR 35 MM X 7.5 MM MOUNTING RAIL, E/NS 35 N
0009	101483688	13	FEED-THROUGH TERMINAL BLOCKS WITH SPRING-CAGE CONNECTION, CROSS SECTION: 0.2 - 2.5 MM, WIDTH: 5.2 MM, GRAY
0010	101634351	10	SPRING CAGE GROUND TERMINAL BLOCK, AWG 24 TO 14, YELLOW GREEN
0011	101580642	1	USB 1.1 AND 2.0 HUB 4 PORT WITH 1 METER USB CABLE
0012	101497194	1	PANEL MOUNT ALARM, 5 TO 30 VDC, 2900 Hz, 1.055 DIA
0013	205142	1	ROCKER SWITCH, SPDT, FULL SIZE, MOMEN
0014	362023	1	ROCKER SWITCH, DPDT, FULL-SIZE, ON-OFF-ON
0015	101673479	1	CIRCUIT BREAKER, DPST, 250 VAC, 50/60 HZ, 20 A
0016	101481464	3	USB CABLE ASSEMBLY EXTENSION, PANEL MOUNT, USB TYPE A MALE TO TYPE A FEMALE CABLE.
0017	101805377	1	cRIO-9073 CONTROLLER AND 8 SLOT CHASSIS
0019	101462045	1	ANALOG INPUT MODULE NI cRIO9211
0020	101471631	1	NI 9477, 32-CH 5 V TO 60 V, 8 US, SINKING DO MODULE
0021	101462057	1	DIGITAL OUTPUT AND RELAY MODULE NI cRIO-9472
0022	101462058	1	ANALOG INPUT MODULE NI cRIO-9215
0023	101777282	1	37 PIN DIRECT PLUG-ON SCREW TERMINAL PANEL, WITH DB- 37 FEMALE CONNECTOR
0024	204402	1	VARISTOR(MOV) 250V/200 JOULE
0025	100116653	2	TERMINAL, DISCONNECT, FEMALE, 0.250 TAB, 22-18 GA, NYLON INSULATED
0028	203856	60	FERRULE INSUL 22 AWG WIRE
0030	206250	5	WIRE 22AWG PVC STRANDED BLACK PVC INSULATION BLACK STRANDED 22 AWG 7/30 300 V 80 DEG C
0031	208517	2	WIRE 22 AWG PVC STRANDED RED
0032	206249	5	WIRE 22AWG STRANDED PVC INSULATION WHITE STRANDED 22 AWG 7/30
0033	101461967	3	PLUG
0034	101462041	3	FEED THRU
0035	101461990	3	PLUG
0036	101787314	2	FAN, 80MM X 38 MM, 230V, AC, 5W
0037	101260820	8	SCREW, MACHINE, PAN HEAD, PHILLIPS, 8-32 UNC x 2.00, STAINLESS STEEL, 18-8
0038	101631188	8	NUT, JAM, ELASTIC INSERT, 8-32 NC, STAINLESS STEEL
0039	101787316	1	DAISY CHAIN FAN CORD, 24 IN, 45 DEG, 2, C45, UL LISTED, CSA CERTIFIED, BLUNT CUT
0040	101785133	2	LANYARD, 18 INCHES LENGTH, EYE/EYE, 3/64 DIA STAINLESS STEEL WIRE ROPE, NYLON-COATED
0041	101787315	1	BACK PANEL FILTER

Item No.	Part No.	Quantity	Description
0044	208047	1	RESISTOR 10K OHM 1/4W
0045	203540	1	CABLE POWER RT ANGLE 110V 3 COND
0046	101635103	4	3M VHB FOAM TAPE, ADHESIVE BOTH SIDES, 4950, 0.045 IN THK x 1 IN WIDE, WHITE
0047	101443937	2	PANEL THERMOCOUPLE JACK, ROUND HOLE, RMJ MINIATURE
0048	101260869	2	SCREW, MACHINE, PAN HEAD, PHILLIPS, 10-32 UNF x 0.75, STAINLESS STEEL, 18-8
0050	100033128	2	RAIL, MOUNTING, 35MM, X 1 METER, DIN,46277, SYMMETRICAL
0051	207757	4	10-32 X 1/4 BHMS STAINLESS STEEL
0052	101259083	6	SCREW, MACHINE, FLAT HEAD, PHILLIPS, 4-40 UNC x 0.25, STAINLESS STEEL, 18-8
0053	203862	1	CONNECTOR RJ45 F X F 8-COND
0054	101779157	2	GUARD, FAN, 80 MM
0056	101255670	2	SCREW, PHILLIPS, PAN HEAD (METRIC) - M2.5 x 6 - 18-8 SS
0058	101260865	8	SCREW, MACHINE, PAN HEAD, PHILLIPS, 10-32 UNF x 0.50, STAINLESS STEEL, 18-8
0059	101787318	10	SPEED NUT, NUMBER 10-32, G-STYLE CLIP ON
0060	101483689	9	PLUG-IN BRIDGE FOR CROSS-CONNECTIONS IN THE TERMINAL CENTER, 2-POS., RED 12-28AWG
0061	101792239	3	FEED-THROUGH TERMINAL BLOCKS WITH SPRING CAGE DISCONNECT, WIDTH 5.2, COLOR GRAY
0062	101792240	3	COMPONENT PLUG, FOR FEED-THROUGH TERMINAL BLOCKS WITH SPRING CAGE DISCONNECT, WIDTH 5.2, COLOR GRAY
0064	101267977	9	WASHER, LOCK, REGULAR SPRING (US) - NO. 10 - 18-8 SS
0065	207871	9	FLAT WASHER 10 STAINLESS STEEL
0066	204980	1	RESISTOR 200 OHM 1/4W
0069	101483695	5	WIRE, HOOK UP, 14AWG, STRANDED, PVC, 600V, UL 1015 DARK GREEN
0070	206257	5	WIRE 14 AWG PVC STRANDED RED
0071	100027804	1	RESISTOR, 100000 OHM, 1 WATT
0072	101795759	1	CABLE ASSEMBLY, DC POWER TO INTFC PCB, FEMALE TO PIG TAIL
0073	101431869	2	CABLE, CAT5, SHIELDED, 2 FT, RJ45
0074	206242	5	WIRE 22 AWG TEFLON STRANDED BLUE
0075	101256658	2	NUT, HEX MACHINE SCREW (US) - NO. 4 -40 - GRADE 8 ZINC-PLATED STL
0076	101262156	6	SCREW, THREADED, BUTTON HEAD SCS (US) - NO. 4 -40 UNC x 0.25 - 18-8 SS
0078	101462159	3	COVER, 2.2MM X 48.5 MM
0079	205547	1	CABLE CAT5 RJ45-RJ45 1 FT LG
0080	101443938	2	MINIATURE CONNECTOR, TYPE J MALE, SMPW-J-M
0081	101828650	1	SWITCH, PC-MNT, PUSHBUTTON, 1A@120VAC OR 28VDC, SPST, ON-MOM
0082	101736420	1	FEMALE CONNECTOR, 4 POLE, 5MM PIN SPACING, 12 A
0083	101736419	1	MALE CONNECTOR, 4 POLE, 5MM PIN SPACING, 12 A
0084	101834824	1	INDICATOR, LED PANEL MOUNT, 10MM MOUNTING HOLE, 6V, RED

Item No.	Part No.	Quantity	Description
0085	101834825	1	INDICATOR, LED PANEL MOUNT, 10MM MOUNTING HOLE, 6V, YELLOW
0086	101359254	3	END COVER, FOR USE WITH ST 2.5 TWIN TYPE SPRING CAGE TERMINAL BLOCK, D-ST 2.5
0089	101895504	2	DISCONNECT, RT ANGLE FEMALE, NYLON INSUALTED; 22-18AWG, RED
0090	100109222	2	MOUNT, CABLE TIE, ADHESIVE BACKED
0091	204299	3	TERMINAL FEMALE Q.C 0.25X0.032 1
0092	208485	40 in.	WIRE THERMOCOUPLE DUPLEX TYPE
0093	101906656	4	WASHER 0.810 x 0.565 x 0.050 304 SS
0100	100027782	1	TRANSFORMER, 115/230 VAC, 50/60 HZ PRIMARY, 24 VAC, 1 AMP SECONDARY
0101	100012686	3	RELAY - SOLID STATE - 240V AC - 45A - 3-32 CONTROL VOLTAGE - 25-65 HZ
0102	100028659	2	SCREW, FLAT HEAD, MACHINE, #6-32 NC X 1/2, STAINLESS STEEL
0103	207607	2	SCREW, 10-32 X 3/8 BHMS STAINLESS STEEL
0104	210219	2	FUSE 2 AMP SLOW-BLOW MDL-2
0105	100033128	9	RAIL, MOUNTING, 35MM, X 1 METER, DIN,46277, SYMMETRICAL
0106	100008175	34	BLOCK, MODULAR TERMINAL, SINGLE CONNECTOR, FEED THROUGH, GRAY, TYPE 9700A/6 S35
0107	100032909	1	PLATE, 6MM, END, TYPE 9701/6, SINGLE
0108	205166	2	CLAMP END 35MM DIN RAIL
0109	209612	1	CABLE ASSEMBLY
0111	100032084	1	LABEL, DANGER HIGH VOLTAGE, 4 MIL VINYL, 2 1/2 IN X 1 3/4 IN, 5 PER PACKAGE
0112	206229	2	WIRE 22 AWG PVC STRANDED GREEN
0113	208517	2	WIRE 22 AWG PVC STRANDED RED
0114	100021087	2	BOARD, MOUNTING, FOR I/O MODULES, 4 POSITION
0115	100001447	7	MODULE, 110V 3 AMP OUTPUT, SOLID STATE
0116	100021088	1	MODULE, 220V INPUT, SOLID STATE
0117	206251	8	WIRE 12 AWG PVC STRANDED 600V BROWN
0118	206248	1	WIRE 12 AWG PVC STRANDED 600V GREEN
0119	206245	8	WIRE 12 AWG PVC STRANDED 600V WHITE
0120	206250	10	WIRE 22AWG PVC STRANDED BLACK PVC INSULATION BLACK STRANDED 22 AWG 7/30 300 V 80 DEG C
0121	100027015	5	RESISTOR, 20000 OHM, 5 WATT,
0122	100027783	1	RESISTOR, 500 OHM, 5 WATT
0123	100013072	4	WIRE, THERMOCOUPLE, 3W2P6, 20 GA, POLYVINYL OVER POLYVINYL, I/C
0124	315093	1	POWER CABLE ASSY
0125	203856	48	FERRULE INSUL 22 AWG WIRE
0126	203857	17	FERRULE INSUL 18 AWG WIRE
0127	203858	7	FERRULE INSUL 12 AWG WIRE
0128	204294	50	TIE WRAP 1/16 IN. TO 2 IN. DIAMETER
0129	205296	20	TIE WRAP ADHESIVE PAD
0130	100033126	1	STRIP, RAPID MARKING, #1-100, MARKED, SIZE 9705/A/6/10B
0131	209620	1	PCB ASSEMBLY HPHT POT POWER
0132	207771	4	6-32 X 3/16 BHMS STAINLESS STEEL
0134	204128	2	FUSE US 20 AMP 1/4 X 1-1/4

Item No.	Part No.	Quantity	Description
0137	208518	7	WIRE 22 AWG PVC STRANDED ORANGE
0138	208520	7	WIRE 22 AWG PVC STRANDED VIOLET
0139	353294	1	KEYBOARD SM W/TOUCH PAD BLACK USB
0140	100072616	1	CONNECTOR, JACK, TYPE JX THERMOCOUPLE
0141	101581263	1	BUSHING, NEOPRENE, THERMOCOUPLE
0142	206235	4	WIRE 18 AWG PVC STRANDED WHITE
0143	100032227	1	CONNECTOR, CROSS, 9703/6M
0144	100021750	2	BLOCK, MODULAR TERMINAL, GROUND, 6 MM WIDE, POLYAMIDE
0145	208659	8	WASHER INTERNAL TOOTH 6 STAINLESS STEEL
0146	100072391	1	PANEL MOUNT, SINGLE CIRCUIT, THERMOCOUPLE, JX CALIBRATION
0147	203870	1	PLUG POWER CORD IEC320M STRAIGHT
0148	101673480	4	FUSE HOLDER, 1/4 X 1-1/4, 300 V, 30 A, SCREW TERMNIAL, 130 C
0149	100027016	1	CONNECTOR, CORD, STRAIGHT FLEX, STRAIN RELIEF, WATER TIGHT, NYLON, 0.35 IN TO 0.63 IN, CORD DIA
0150	208521	4	WIRE 18 AWG PVC STRANDED BROWN
0151	208529	3	WIRE 18 AWG PVC STRANDED WHITE
0152	206249	30	WIRE 22AWG STRANDED PVC INSULATION WHITE
0153	207487	6	6-32 X 1/4 BHMS STAINLESS STEEL
0154	207842	8	6-32 X 1/4 THMS STAINLESS STEEL
0155	203461	8	6-32 X 1 LG RHMS STAINLESS STEEL
0156	101260865	2	SCREW, MACHINE, PAN HEAD, PHILLIPS, 10-32 UNF x 0.50, STAINLESS STEEL, 18-8
0157	208549	7	WIRE 22 AWG TEFLON STRANDED WHITE
0158	206219	4	WIRE 20 AWG PVC STRANDED BLACK
0159	206217	4	WIRE 20 AWG PVC STRANDED RED
0160	206225	4	WIRE 20 AWG PVC STRANDED YELLOW/ WHITE
0161	208704	2	WASHER SPLIT 10 STAINLESS STEEL
0163	101939760	8	TERMINAL FORK
0164	101939224	2	STANDOFF, ALUMINUM 3/8 HEX MALE/FEMALE, 1-1/2IN LENGTH, 10-32 THREAD
0165	349301	2	TERMINAL FEMALE Q.C, 0.25X0.032 12-10GA, NYLON FULLY INSULATED FEMALE DISCONNECT WIRE RANG 12/10 AWG TAB SIZE 0.250 X 0.032, 25 PER PACKAGE
0166	101895500	18	TERMINAL, BLOCK FORK, 22 to 18 AWG, 0.145 IN. , ETP COPPER (TERMINAL), TIN, 6, RED
0168	101987730	21	GROMMET EDGE .062-.099 PANEL THK, SLOTTED,ADHESIVE BACKED
0170	204288	2	DISCONNECT FEMALE, 0.110 TAB 22
0171	204344	2	DISCONNECT FEMALE .250 TAB 22
0172	365255	1	TERMINAL RING 10-12 AWG 10
0173	102104257	1	POWER CABLE ASSEMBLY
0174	102106881	4	4-40 KEPS LOCK NUT STAINLESS STEEL
0175	102107359	27	GROMMET EDGE .099-.144 PANEL THK, SOLID,ADHESIVE BACKED
0176	100032007	6	TERMINAL, FEMALE, SLIP ON, FULLY INSULATED, FOR #18-22 GA WIRE

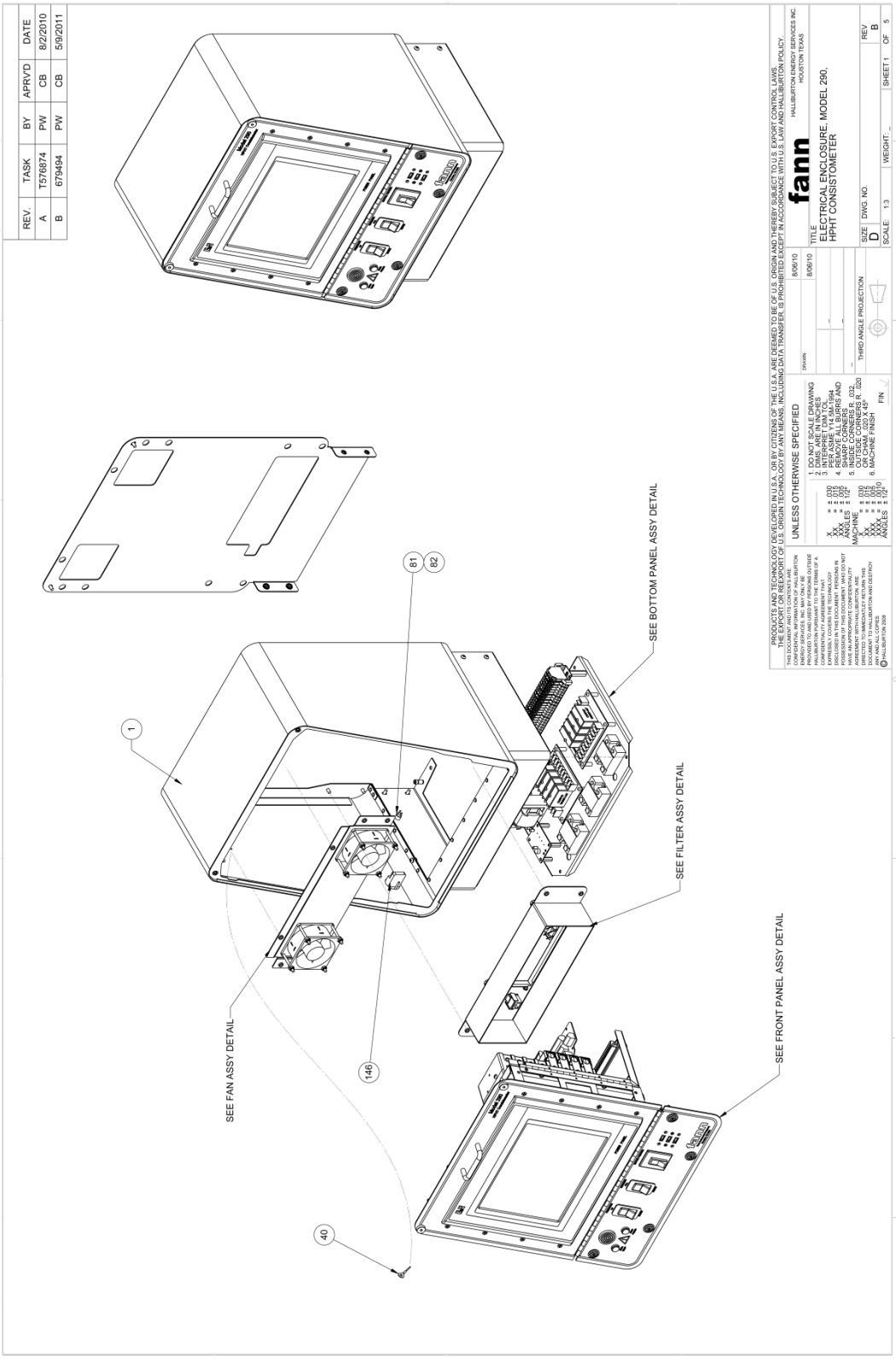


Figure 10-11 Electrical Enclosure, 1/5

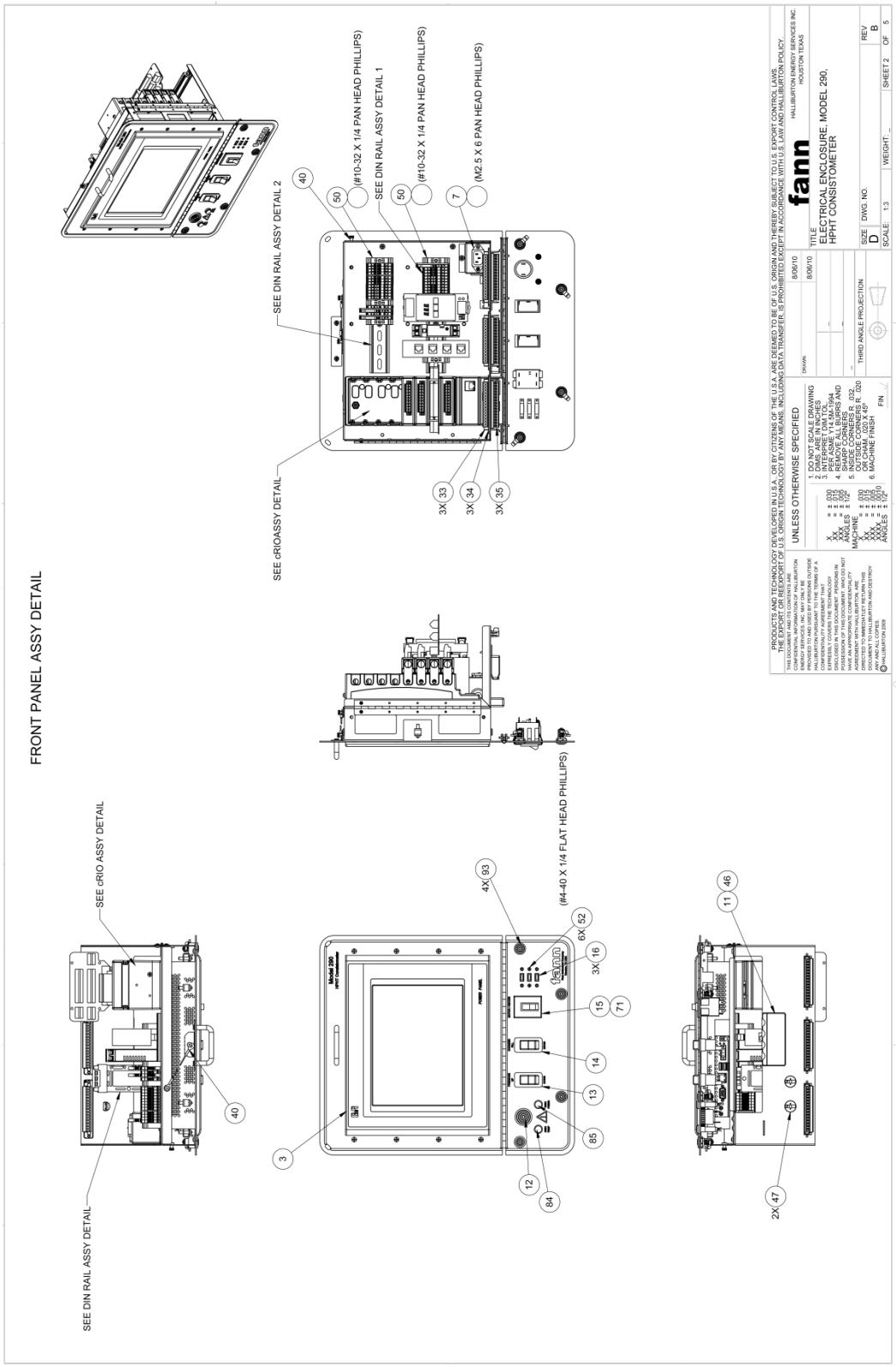


Figure 10-12 Electrical Enclosure, 2/5

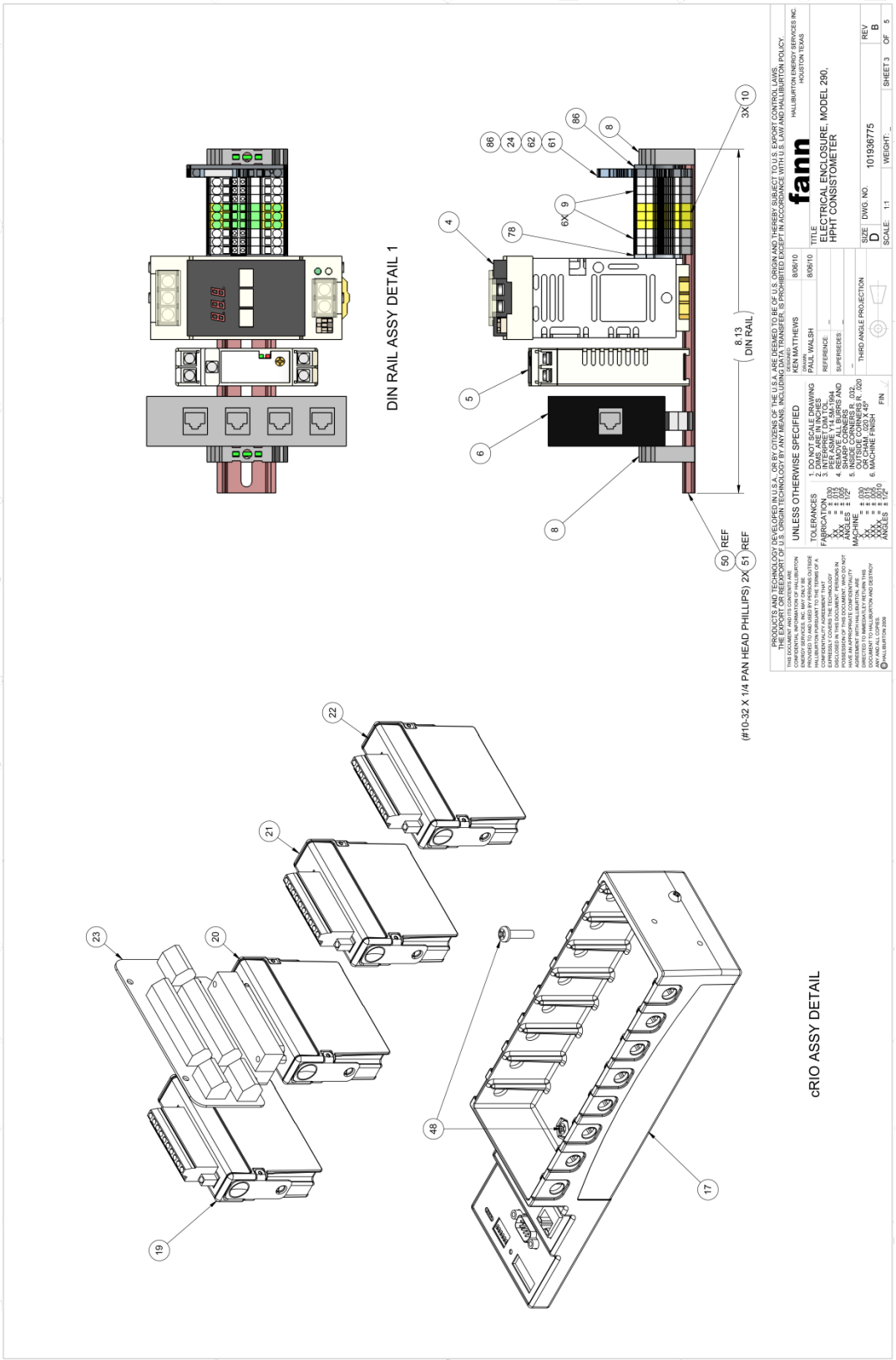


Figure 10-13 Electrical Enclosure, 3/5

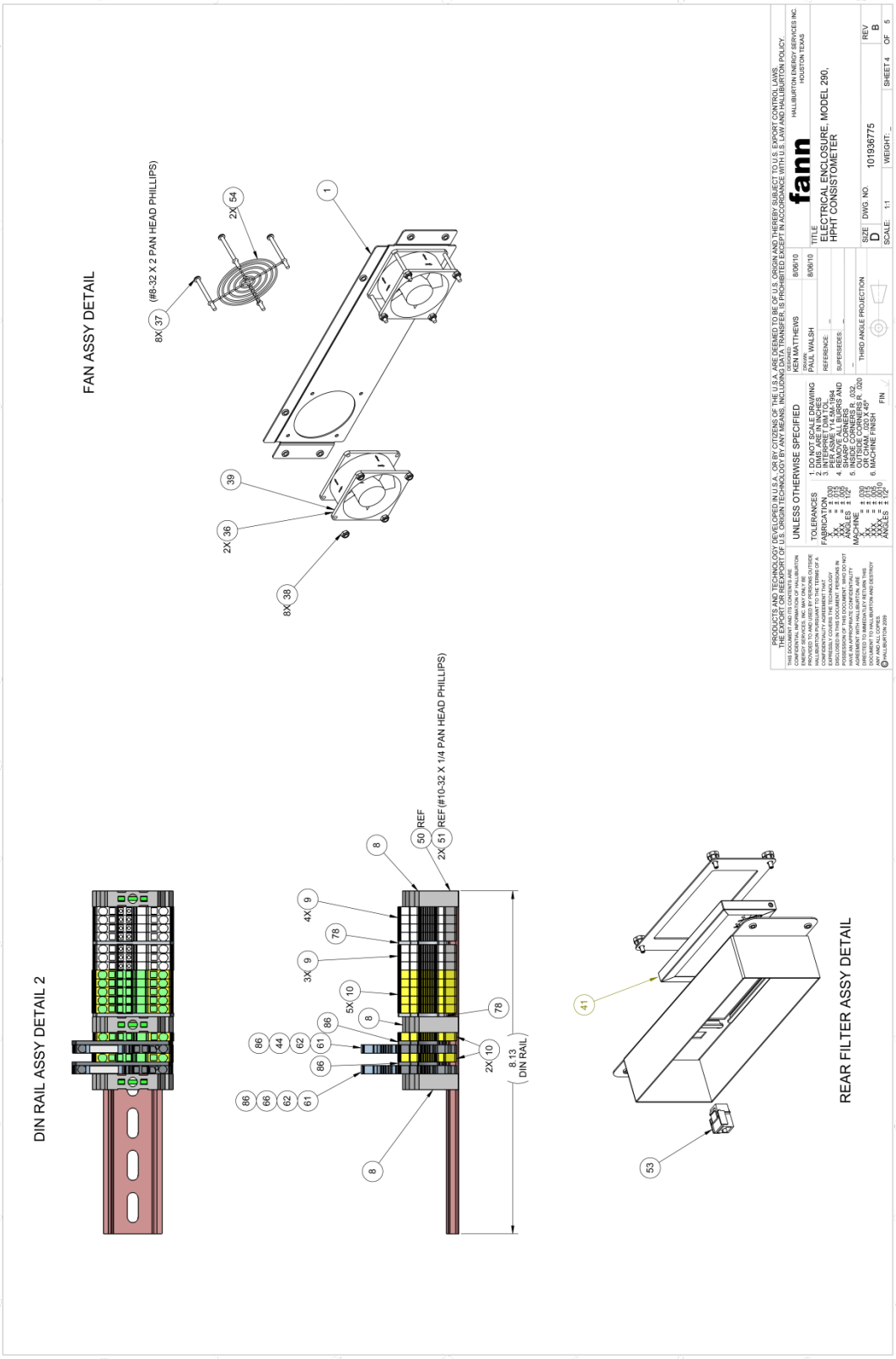


Figure 10-14 Electrical Enclosure, 4/5

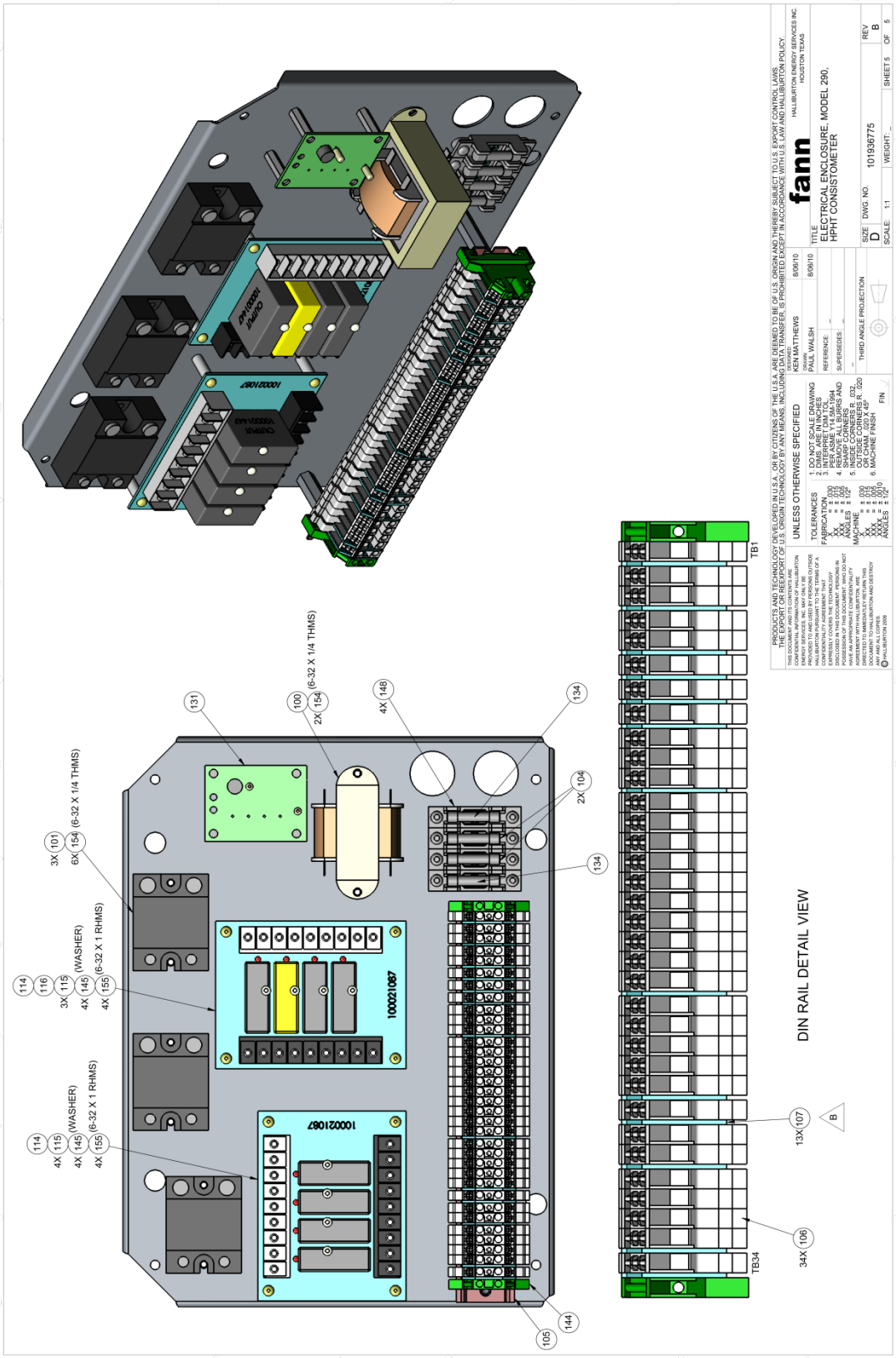


Figure 10-15 Electrical Enclosure, 5/5

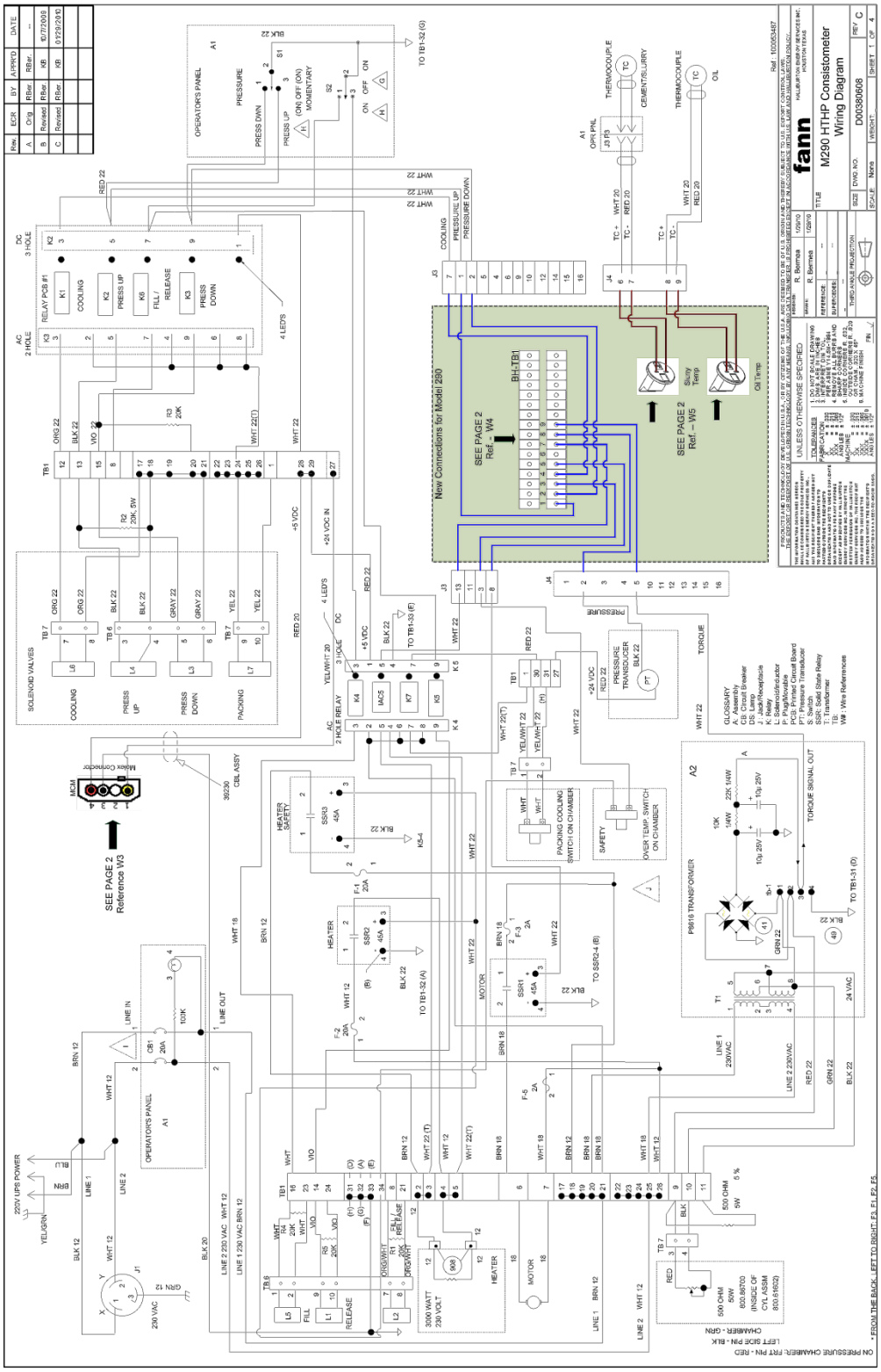


Figure 10-16 Electrical Wire Diagram Kit, 1/4

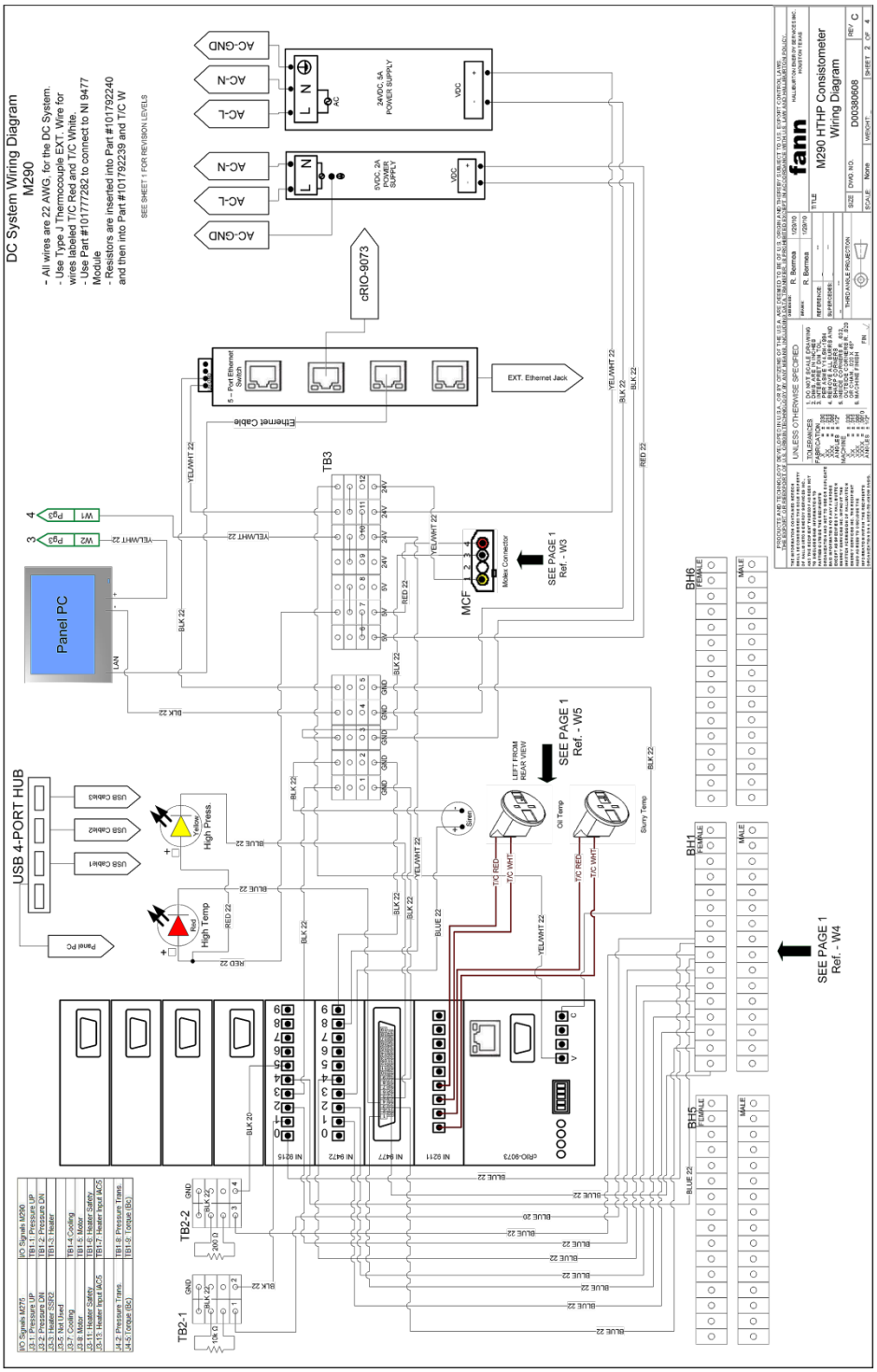


Figure 10-17 Electrical Wire Diagram Kit, 2/4

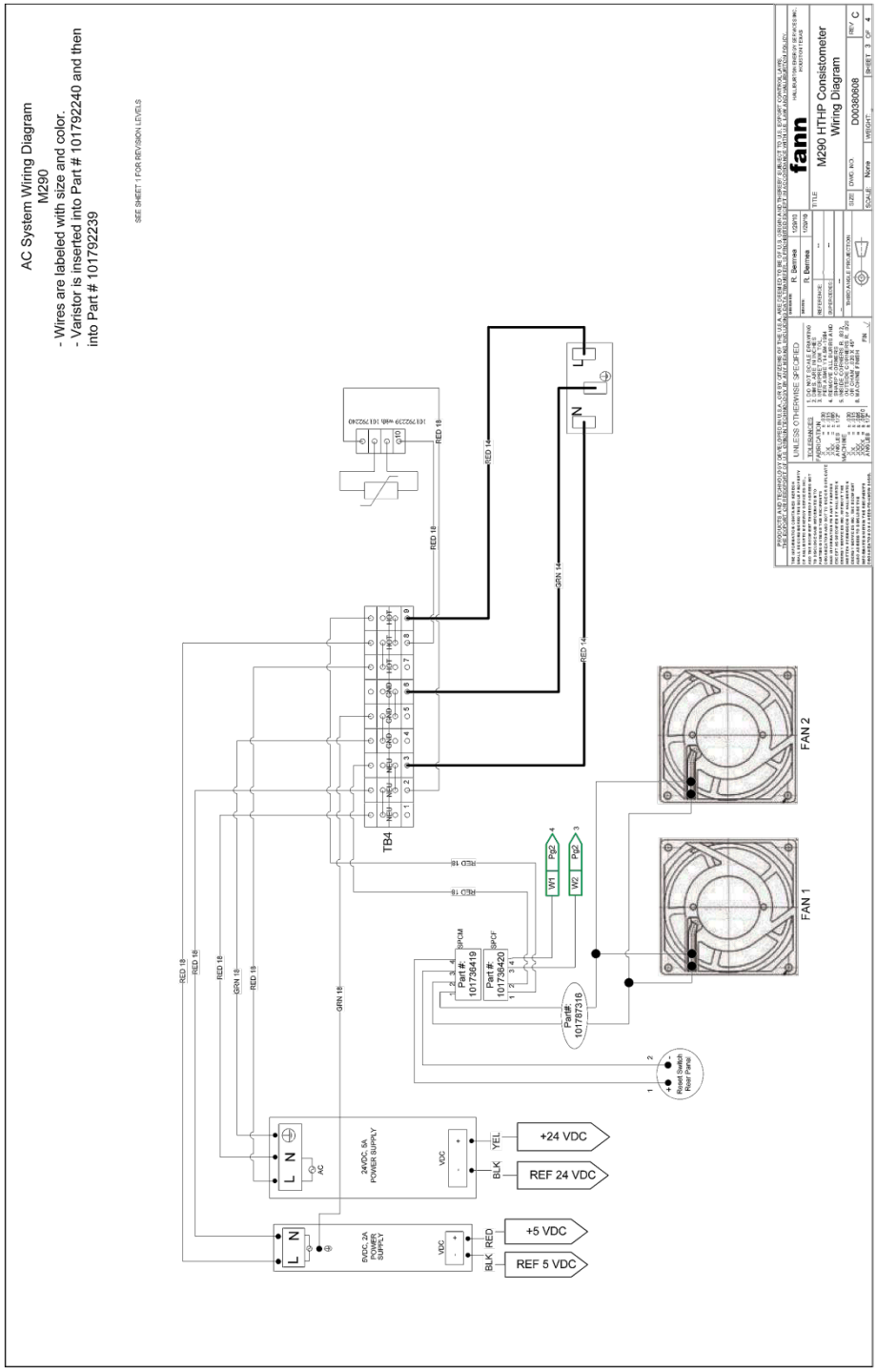


Figure 10-18 Electrical Wire Diagram Kit, 3/4

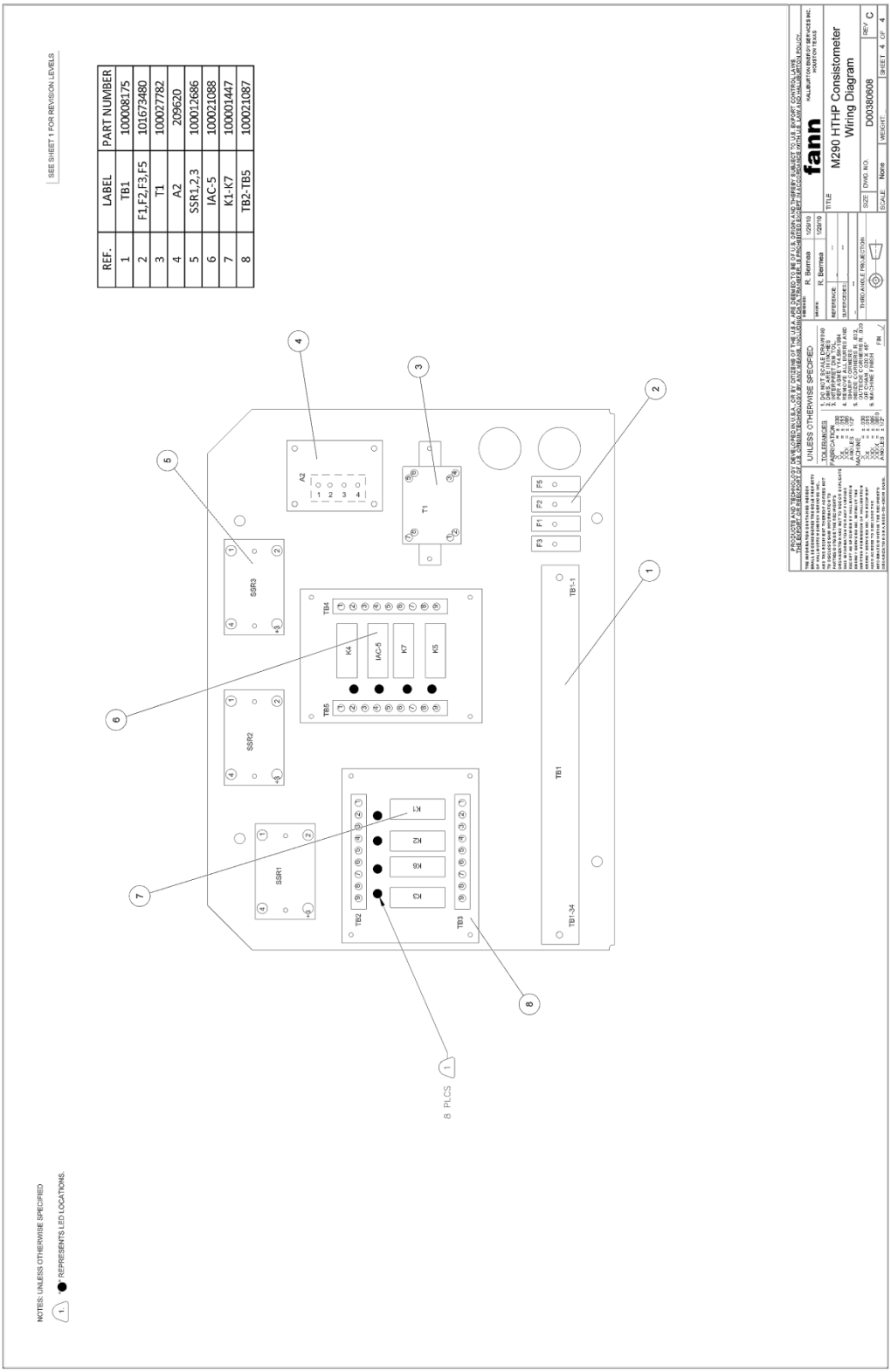


Figure 10-19 Electrical Wire Diagram Kit, 4/4

Table 10-9 Visual Reservoir Kit, P/N 398332

Item No.	Part No.	Quantity	Description
0001	101709708	1	TEE, 1/4 FNPT X 1/4 FNPT RUN X 1/4 MNPT BRANCH
0002	100024753	1	CONNECTOR, 1/4 FPT X 1/4 OD TUBE
0003	396290	1	UNION 1/4 TUBE X 1/2 MPT BRASS 1/4 BORE THRU
0004	207377	10	TUBING, SOFT COPPER 1/4 X 0 .032
0005	396057	1	RESERVOIR AIR-OIL 1.5 GAL FIBERGLASS
0006	100016510	1	BUSHING, HEXAGON, 1/2 X 3/8, STEEL, PIPE
0007	100028507	4	SCREW, HEX CAP, 5/8-11 NC X 1
0008	100031014	4	NUT, HEX, 5/8-11 UNC-2B, ASTM-A194, GRADE 7, CADMIUM PLATED
0009	100029924	4	WASHER, LOCK, 5/8, STEEL
0011	101465729	2	RESERVOIR BRACKET
0012	398334	1	SCALE INDICATOR POSITION
0014	204097	2	BUSHING REDUCING 3/8 MNPT X 1/4 FNPT
0015	204095	1	BUSHING REDUCING 1/4 MPPT X 1/8 FNPT
0016	100000593	1	VALVE, PLUG, 1/8 MNPT, BRASS, 3000 PSI, 250 F, BUNA N SEALS
0017	100016378	1	ELBOW, 90 DEG, STREET, 1/8
0018	100033231	1	CONNECTOR, PLASTIC TUBING, BRASS, 1/4 TUBE X 1/8 FPT STRAIGHT
0019	101709591	2	ELBOW 1/4 MNPT x 1/4 JIC 90 DEG
0020	101709595	1	ADAPTER, 1/4 MNPT x 1/4 JIC

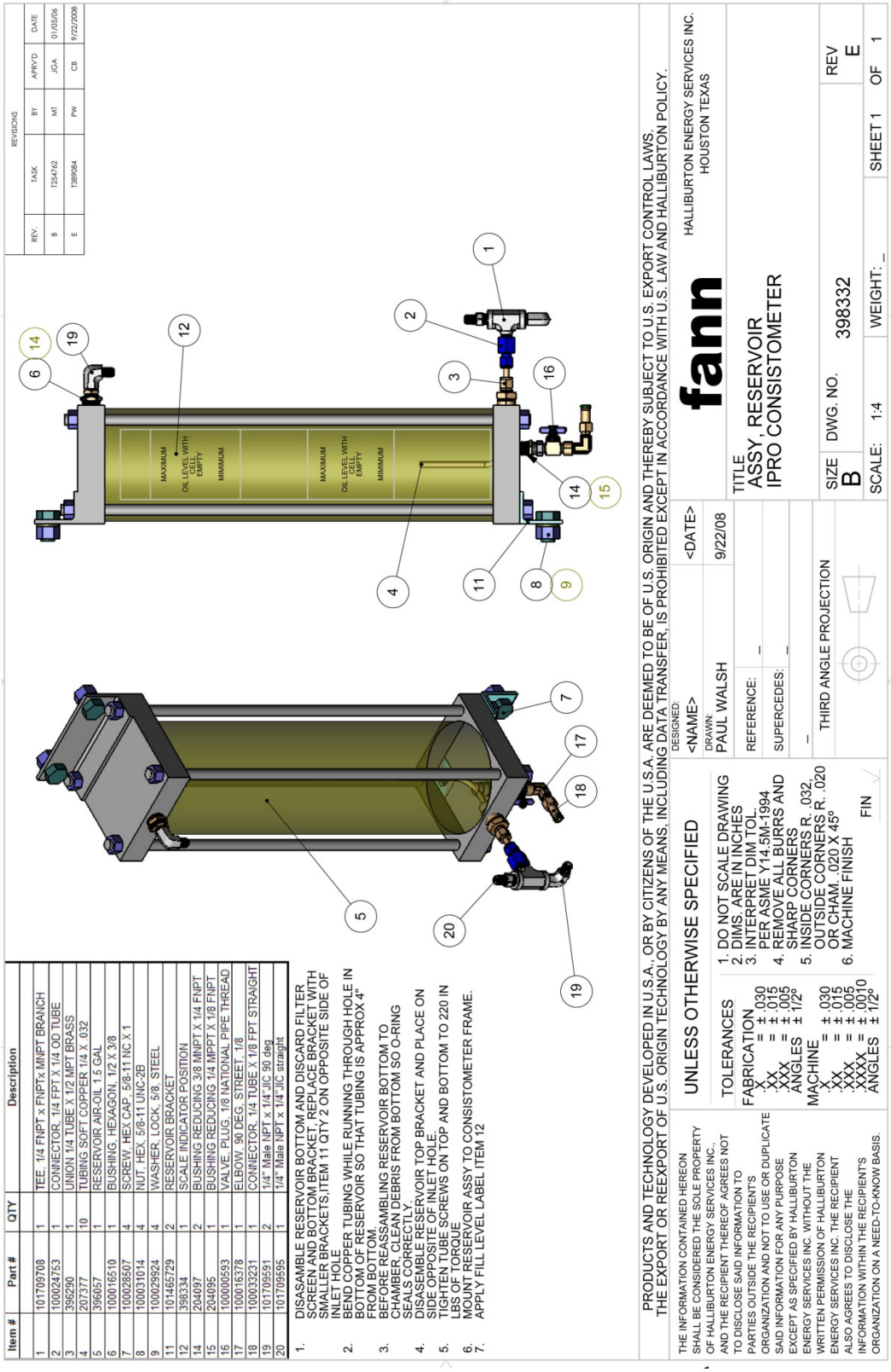


Figure 10-20 Visual Reservoir Kit

Table 10-10 Hydraulic/Pneumatic Panel Assembly, P/N 101432351

Item No.	Part No.	Quantity	Description
0001	101633891	1	PANEL, MOUNT HIGH PRESSURE COMPONENTS
0002	100028608	2	SCREW, BIND HEAD, #8-32 NC X 1/2, STAINLESS STEEL
0003	101260651	4	SCREW, MACHINE, PAN HEAD, PHILLIPS, 6-32 UNC x 1.75, STAINLESS STEEL, 18-8
0005	207819	4	WASHER SPLIT 6 STAINLESS STEEL
0006	100026587	4	HEX NUT, 6-32 NC, STAINLESS STEEL
0007	100028427	4	SCREW, HEX CAP, 1/4-20 NC X 3/4, STAINLESS STEEL, 316
0008	207753	4	WASHER SPLIT 1/4 STAINLESS STEEL
0009	100030959	6	SCREW, BIND HEAD, #8-32 NC X 1 1/2, STAINLESS STEEL
0010	207947	8	WASHER SPLIT 8 STAINLESS STEEL
0011	207631	8	NUT 8-32 HEX REGULAR STAINLESS STEEL
0012	101427603	20	TERMINAL BLOCK AWG 30-12
0013	101433640	2	END COVER TERM BLOCK GRAY
0014	101391619	4	CLAMP, END, UNIVERSAL, FOR 35 MM X 7.5 MM MOUNTING RAIL, E/NS 35 N
0015	100033128	1	RAIL, MOUNTING, 35MM, X 1 METER, DIN,46277, SYMMETRICAL
0016	205379	2	GROMMET EDGE .062-.099 THK SLD
0017	101833840	1	TUBING ASSY CAPILLARY
0018	101713459	1	TUBING SET, 3/8 IN AND 1/4 IN HIGH PRESSURE 60 KSI
0019	207377	30	TUBING SOFT COPPER 1/4 X 0.032
0021	101711344	5	VALVE, 4-WAY, 2-POSITION, SINGLE, 1/4 NPT PORTS
0022	101711348	1	MANIFOLD, VALVE, 6 STATION, L20, 3/8 NPT PORTS
0023	101711349	1	BLANK, VALVE MANIFOLD L20
0025	101432908	5	COIL SOLENOID 230V FOR VALVE NEMA 4X, 18 IN. LEADS
0026	101709802	2	MUFFLER, EXHAUST, 3/8 NPT
0027	100015027	1	ADAPTER, HOSE, 070202-6-6C, ELBOW, 9/16-18 JIC MALE X 3/8-18 NPT MALE, STEEL
0028	207698	1	ELBOW STREET 3/8 NPT
0029	100027497	4	PLUG, PIPE, 1/4 18 NPTF, STEEL COUNTERSUNK HEX, HEADLESS
0030	101463533	2	PLUG, 3/8 NPT, HEX COUNTERSUNK, BRASS
0031	204097	1	BUSHING REDUCING 3/8 MNPT X 1/4 FNPT
0032	101709591	8	ELBOW 1/4 MNPT x 1/4 JIC 90 DEG
0033	204085	2	CONNECTOR MALE 1/4 TUBE X 1/4 MNPT BRASS
0034	101709592	1	ELBOW 1/4 MNPT x 3/8 JIC 90 DEG
0035	101713232	1	BLOCKING DISC, VALVE MANIFOLD L20
0036	100032370	1	FITTING, TUBE, B-200-2-4, ELBOW, 90 DEG, BRASS, 1/8 TUBE X 1/4MALE PIPE THREAD, SWAGELOK
0041	100072420	1	VALVE ASSEMBLY, 30 KSI, ON/OFF, AIR OPERATED
0042	100002103	2	PLUG, PIPE, 1/8, SOCKET HEAD, ALLEN
0043	100031412	3	PLUG, AP40, F250C, AUTOCLAVE
0044	100001771	7	GLAND, AUTOCLAVE, ANGLE 40, 60000 POUNDS PER SQ IN, FOR 1/4 TUBE, F250C FEMALE THREAD
0045	204052	2	ELBOW MALE 1/4 TUBE X 1/8 NPT
0046	100012838	1	ADAPTER, 15M44B8, F250C, MALE TO 1/4 FEMALE NPT
0047	101709708	1	TEE 1/4 FNPT X 1/4 FNPT RUN X 1/4 MNPT BRANCH
0051	100024683	1	FILTER, OIL, 10 MICRON, 3/4 NPT, WITH ELEMENT & GAUGE
0052	100048575	2	BUSHING, HEXAGON, 3/4 X 1/4, BRASS

Item No.	Part No.	Quantity	Description
0054	101709595	1	ADAPTER 1/4 MNPT x 1/4 JIC
0061	100033092	1	CROSS, CX4444-PM, 60 KPSI @RT, WITH F250C FEMALE
0062	100001646	5	AUTOCLAVE COLLAR, ACL40, 1/4 TUBE, 60,000 PSI, STAINLESS STEEL
0063	101392264	1	60K MALE TO MALE 1/4 HIGH PRESSURE CONNECTOR
0064	101709594	1	ADAPTER 3/8 MNPT x 1/4 JIC
0065	100072640	1	SAFETY HEAD ASSEMBLY, TEE, 1/4 60000 PSI, RUPTURE DISC
0066	100072346	1	RUPTURE DISC, INCONEL
0067	100022028	1	PRESSURE TRANSDUCER, 30,000 PSI, 4-20 MA
0068	101671154	1	TEE, 1/4 HP, 600000 PSI RATING WITH SPECIAL MOUNTING HOLES
0069	100072110	1	VALVE, CHECK, AUTOCLAVE, CKO 4400, O-RING, 60,000 PSI
0070	101843356	1	IN-LINE FILTER, 30K PSI OPERATING PRESSURE
0071	101847671	1	IN-LINE FILTER BRACKET
0072	102162992	1	IN LINE FILTER, 30K PSI
0083	100013114	1	AUTOCLAVE ANGLE VALVE
0084	101605355	2	ADAPTER, 3/8 HP FEM X 1/4 TUBE MALE
0085	386832	1	PRESSURE GAUGE, 0-30,000 PSI
0086	101630172	2	TEE, HIGH PRESSURE, 3/8 IN TUBING. 60-23HF6 WITH TWO 7/32 MOUNTING HOLES
0088	204066	1	TEE STREET 1/4 BRASS
0090	101605357	1	ADAPTER, 3/8 HP MALE X 1/4 NPT FEM
0091	101605354	1	AUTOCLAVE CHECK VALVE
0092	101605353	1	CROSS, 3/8, 60,000 PSI, WITH TWO 7/32 MOUNTING HOLES
0093	100031720	1	AUTOCLAVE ADAPTER
0094	101563871	2	ZACK MARKER STRIPS, 1-10, ZB 5 SIZE, VERTICALLY LABELED FOR 5.2 MM TERMINALS

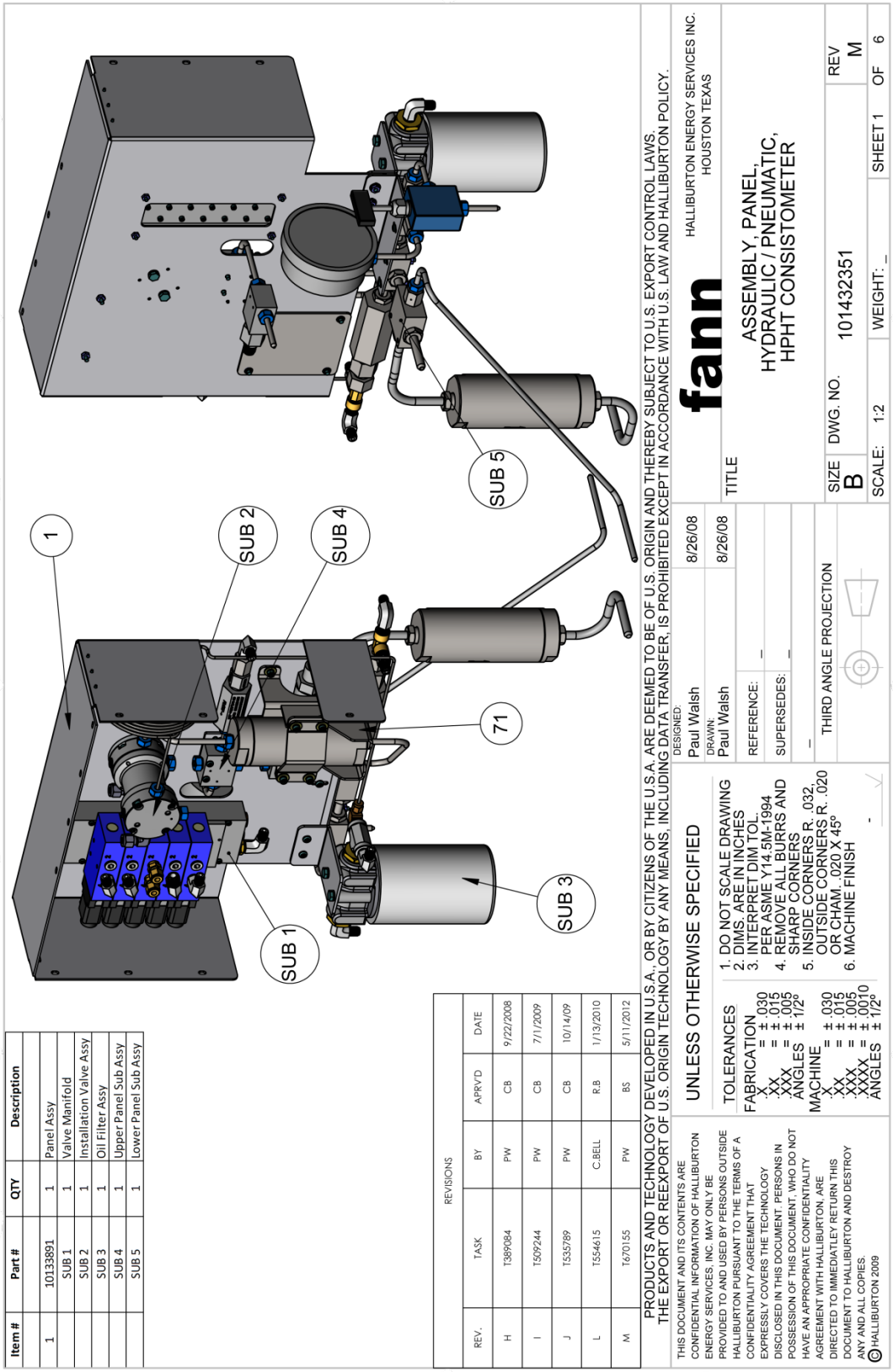
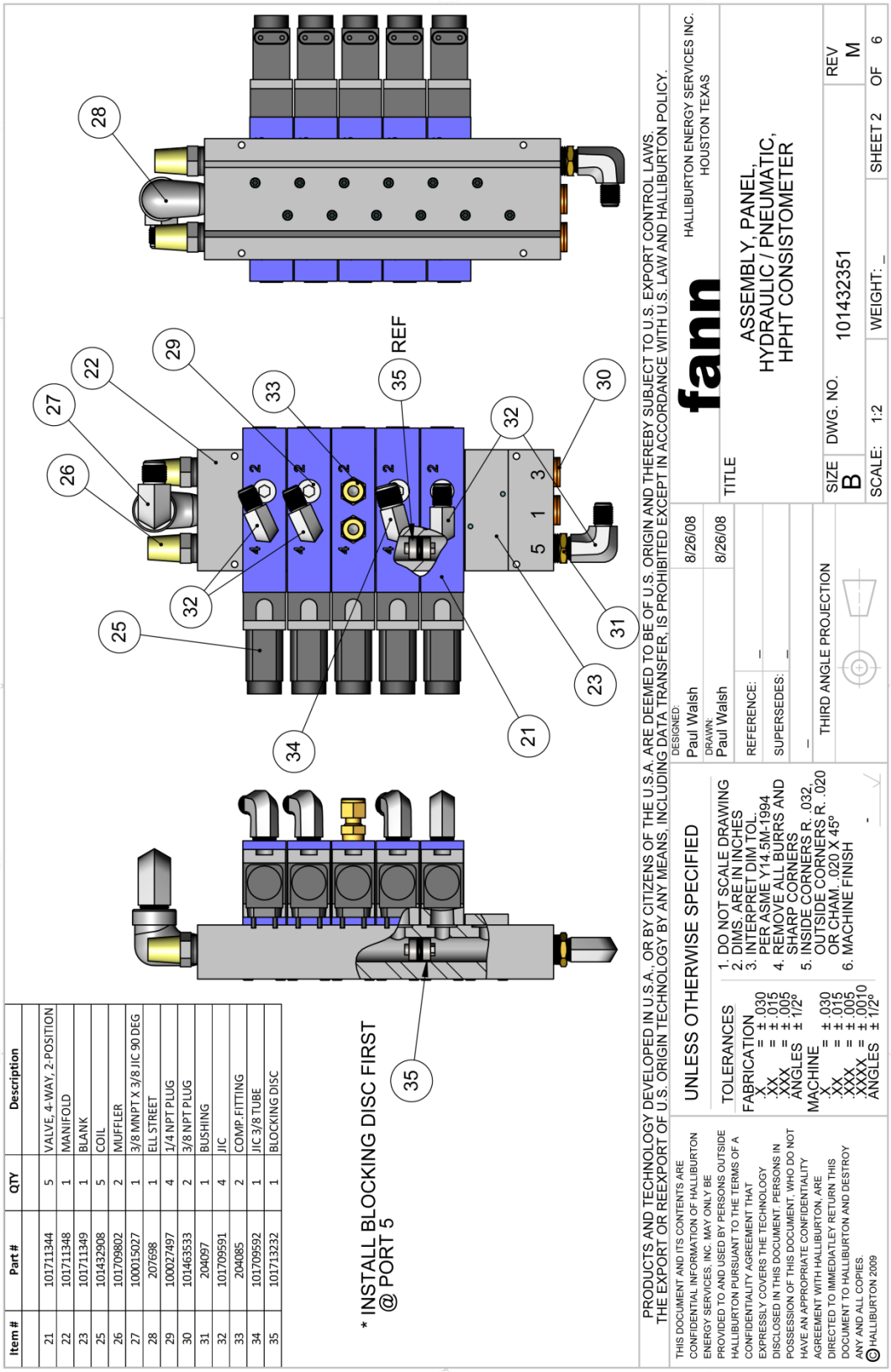
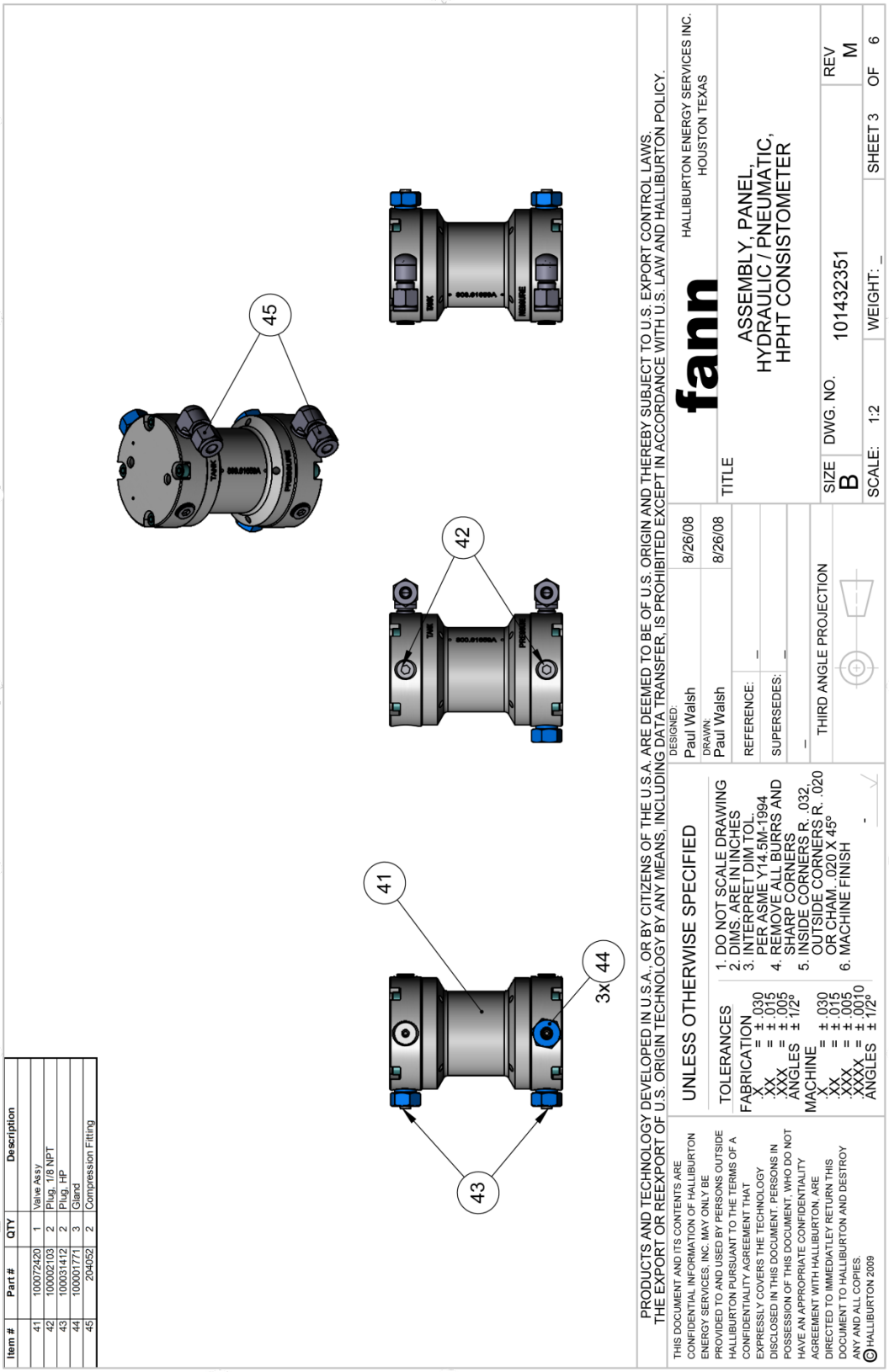


Figure 10-21 Hydraulic/Pneumatic Panel Assembly, 1/6



Item #	Part #	QTY	Description
21	101711344	5	VALVE, 4-WAY, 2-POSITION
22	101711348	1	MANIFOLD
23	101711349	1	BLANK
25	101432908	5	COIL
26	101709802	2	MUFFLER
27	100015027	1	3/8 MNPT X 3/8 JIC 90 DEG
28	207698	1	ELL STREET
29	100027497	4	1/4 NPT PLUG
30	101463533	2	3/8 NPT PLUG
31	204097	1	BUSHING
32	101709591	4	JIC
33	204085	2	COMP.-FITTING
34	101709592	1	JIC 3/8 TUBE
35	101713232	1	BLOCKING DISC

Figure 10-22 Hydraulic/Pneumatic Panel Assembly, 2/6



Item #	Part #	QTY	Description
41	100072420	1	Valve Assy
42	100002103	2	Plug, 1/8 NPT
43	100031412	2	Plug, HP
44	100001771	3	Gland
45	204052	2	Compression Fitting

Figure 10-23 Hydraulic/Pneumatic Panel Assembly, 3/6

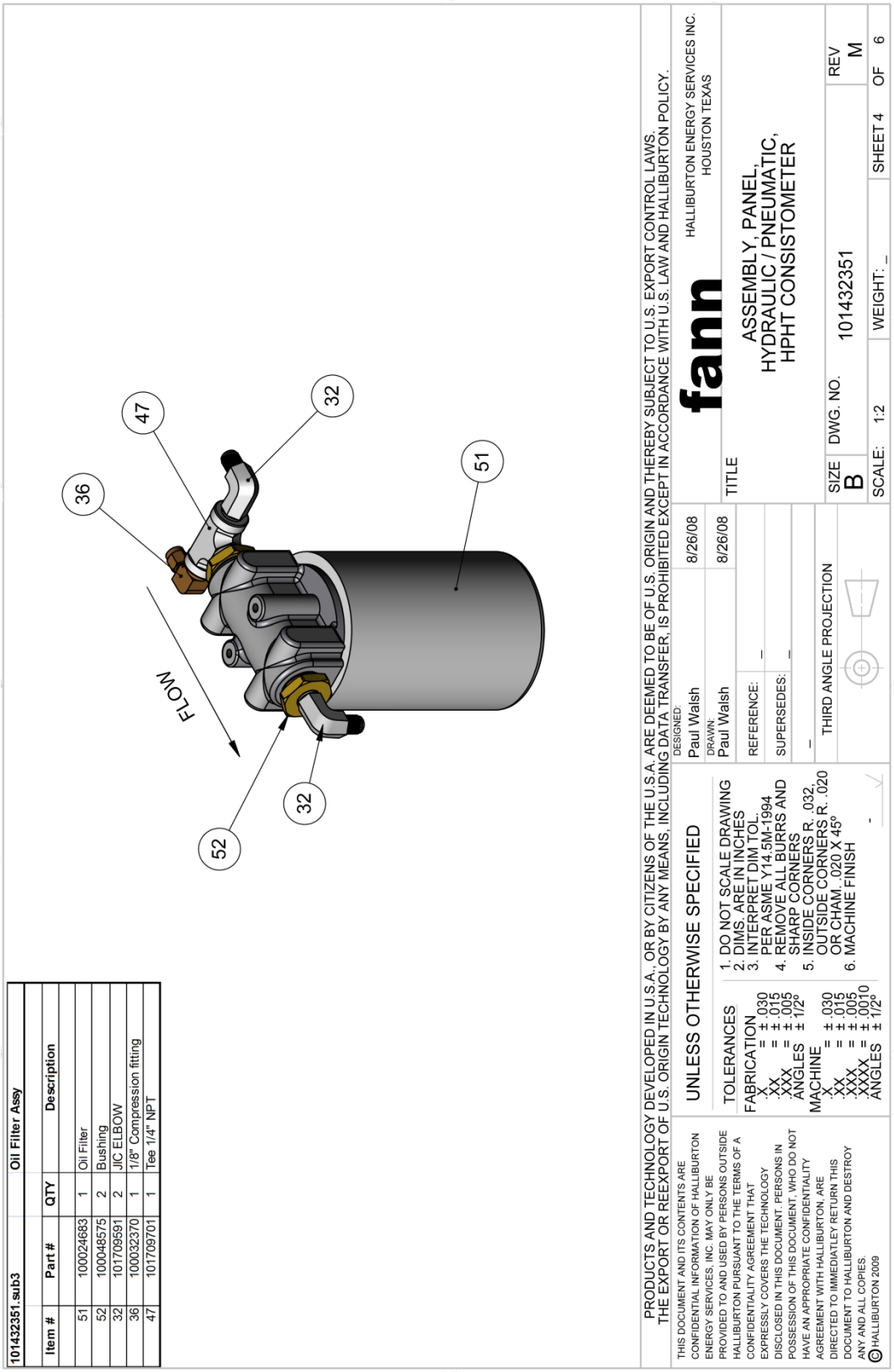


Figure 10-24 Hydraulic/Pneumatic Panel Assembly, 4/6

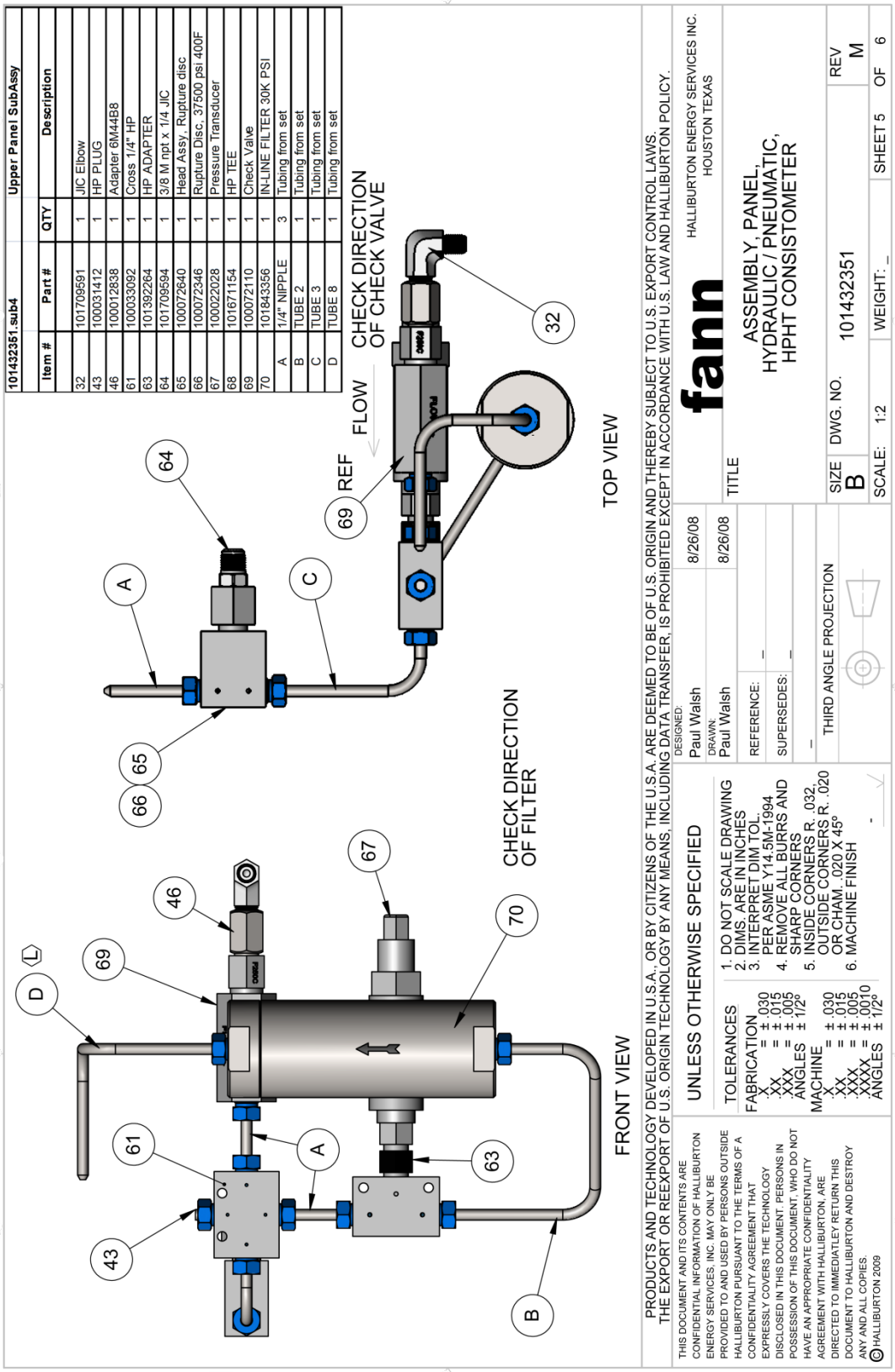


Figure 10-25 Hydraulic/Pneumatic Panel Assembly, 5/6

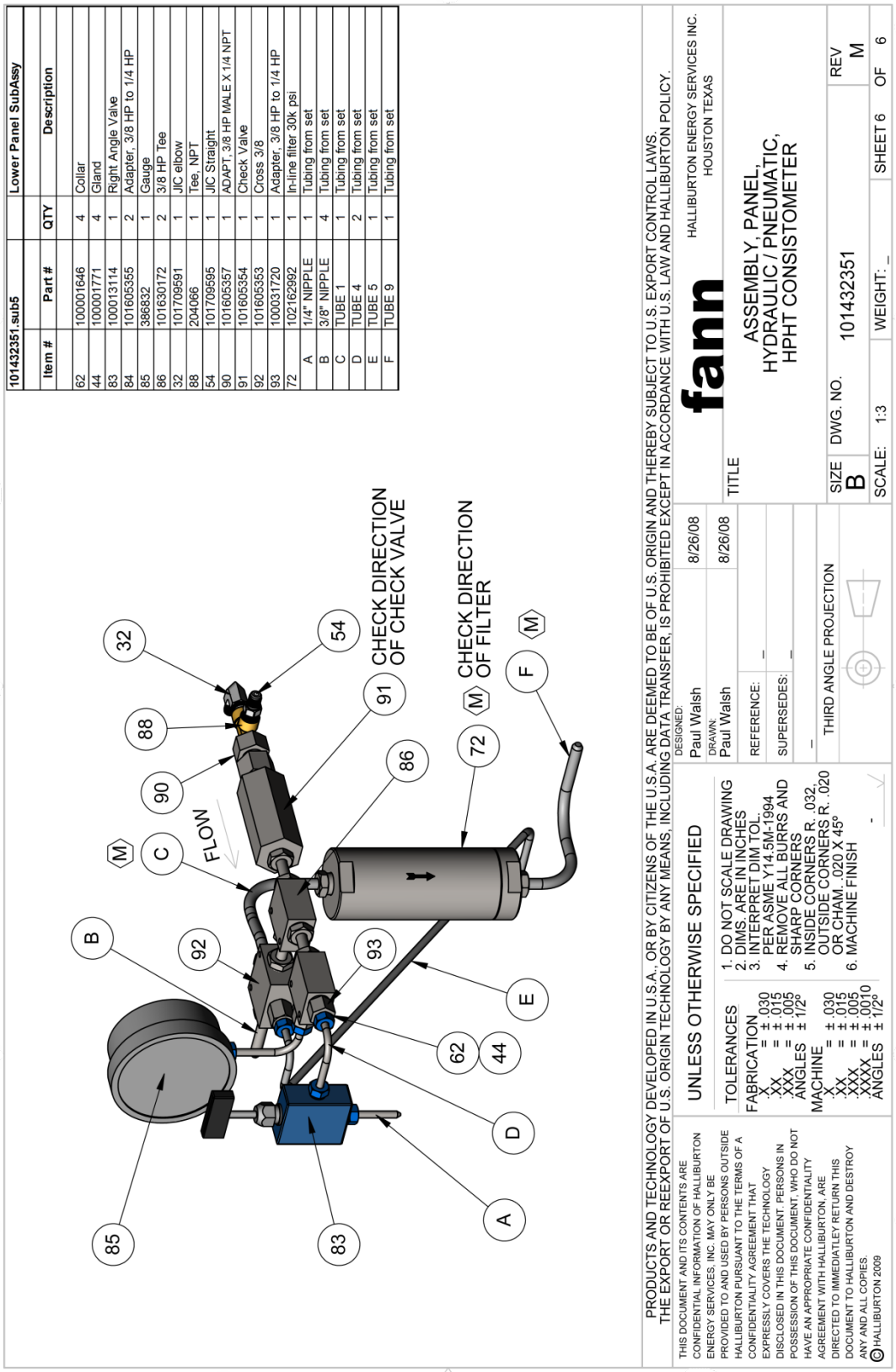


Figure 10-26 Hydraulic/Pneumatic Panel Assembly, 6/6

Table 10-11 Chamber Assembly, P/N 100071985

Item No.	Part No.	Quantity	Description
0001	100072507	1	PRESSURE CYLINDER, PACKING, CARTRIDGE TYPE
0002	100071987	1	CHAMBER SUPPORT
0003	100002169	6	SCREW, HEX SOCKET, 3/8-16 NC X 1 1/4
0004	206206	6	WASHER FLAT 3/8 STAINLESS STEEL
0005	100004329	1	BODY, PACKING, CARTRIDGE
0006	100072358	1	PACKING GLAND RING
0007	100001896	1	CHEVRON PACKING
0008	100004326	1	BACK-UP PACKING GLAND RING
0009	100004327	1	SHAFT, PACKING GLAND
0010	100072360	1	TURN TABLE BASE
0011	100002201	1	COMPRESSION SPRING, 0.360 OD X 0.032 WIRE DIA X 0.750 LG
0012	100004328	1	DRIVE SHAFT, TURN TABLE
0013	204641	1	PIN ROLL 1/8 X 11/16
0014	100001994	4	O-RING, 90 DURO, 1 7/8 X 1 5/8 X 1/8
0015	100072359	1	JACKET, COOLING, PACKING
0016	100072357	1	PACKING GLAND NUT
0017	100072356	1	BEARING BODY, HOUSING
0018	100072354	1	BEARING SHAFT
0019	100010314	1	CUP BEARING
0020	100010313	1	CONE BEARING
0021	100072355	1	BEARING SPACER
0022	100010311	1	BALL BEARING, 0.984 ID X 2.440 OD X 0.669 THK
0023	100028051	1	EXTERNAL RETAINING RING
0024	100072353	1	RETAINER BEARING
0025	100002000	1	O-RING, 90 DURO, 2 5/8 X 2 3/8 X 1/8
0026	100029177	1	SEAL 1.628 OD X 0.875 ID X 0.25 L
0027	100028029	1	INTERNAL RETAINING RING
0028	100028198	6	HEX SOCKET SCREW, 1/4-28 NF X 3/4
0030	100009972	1	HEATING UNIT ASSEMBLY, 230V AC, 3000W
0031	100009405	2	SEALING RING, HEATING UNIT
0032	100026512	2	HEX NUT, 1/2-20
0033	100072431	1	HEATER, TOP PROTECTOR
0034	101792881	2	MODIFIED CONTACT PIN, CHAMBER ASSY
0036	100072493	2	GUARD, THERMOCOUPLE CONTACT PIN
0037	208663	4	5SCREW, /16-24 X 1-1/4, SHCS
0038	100072495	1	LOCK TYPE LID
0039	100072362	1	MANDREL, 1 1/2, METAL SEAL
0040	100072515	1	RING, METAL SEAL
0041	100002026	1	O-RING, 90 DURO, 3 7/8 X 3 3/4 X 1/16
0042	100072497	1	THRUST WASHER, LOCK TYPE LID
0043	100072496	1	SEAL NUT, LOCK TYPE LID
0044	100028806	2	HEX SOCKET SCREW, SET, 1/4-20 NC X 3/4, CUP PORT
0045	101730954	1	O-RING, 028 VITON 1 3/8 x 1 1/2 DURO 75
0047	203385	1	SCREW, 1/4-20 X 1/2 HHMS
0048	100072474	4	HANDLE
0049	100072473	2	BOLT, EYE, ROD END BEARING, PRESSURE CYLINDER LID,
0050	100072475	1	BAIL
0051	205377	1	KEY 3/16 X 3/16 X 0.75 CF 1018
0052	101488430	1	COOLING COIL

Item No.	Part No.	Quantity	Description
0053	101730956	1	PULLEY SYNCH, 22 TOOTH, 3/8 PITCH, 1/2 BELT
0054	101730957	1	BUSHING TAPER 1008, 3/4 BORE
0062	100004334	1	THERMOCOUPLE, CEMENT SLURRY CUP
0066	203404	6	SCREW,10-32 X 1-1/2 BHMS STAINLESS
0067	100028451	4	HEX CAP SCREW, 3/8-16 NC X 1/2, PL
0068	100029921	4	LOCK WASHER, 3/8, STAINLESS STEEL
0069	204601	4	REGULAR HEX NUT, 3/8-16 STAINLESS
0071	214456	1	THERMOCOUPLE OIL TAPERED SEAT
0072	101476559	4	FEMALE QUICK-SLIDE TERMINAL, NICKEL PLATED ALLOY
0073	101004231	1	SNAP DISC THERMOSTAT
0074	208660	4	SCREW, 6-32 X 1/4 PHMS
0076	204290	16	FIBERGLASS SLEEVING,SIZE 6, CLASS R ,GRADE A, 125 FT PER PACKAGE
0077	208531	16	WIRE 16 AWG TEFLON STRANDED WHITE
0078	102188343	1	TEMPERATURE CONTROL SWITCH, 350F, 15A/120V
0081	101709679	4	ADAPTER 1/4 FNPT X 3/8 COMPRESSION
0082	100031720	1	ADAPTER, AUTOCLAVE, 60M64B3, F375C MALE X F250C FEMALE, 60,000 PSI
0083	101605356	1	GLAND, 3/8, 60,000 PSI
0084	100072513	1	COLLAR, FOR 3/8 OD THREAD TUBING
0085	101709591	2	ELBOW 1/4 MNPT x 1/4 JIC 90 DEG
0086	101709595	1	ADAPTER 1/4 MNPT x 1/4 JIC
0087	101709709	1	TEE,1/4 MNPT X 1/4 JIC RUN X 1/4 JIC BRANCH
0088	101709596	1	ADAPTER 1/8 MNPT x 1/4 JIC
0089	101586615	2	COVER, TERMINAL, CERAMIC, SET, NO. 10-32 CAP

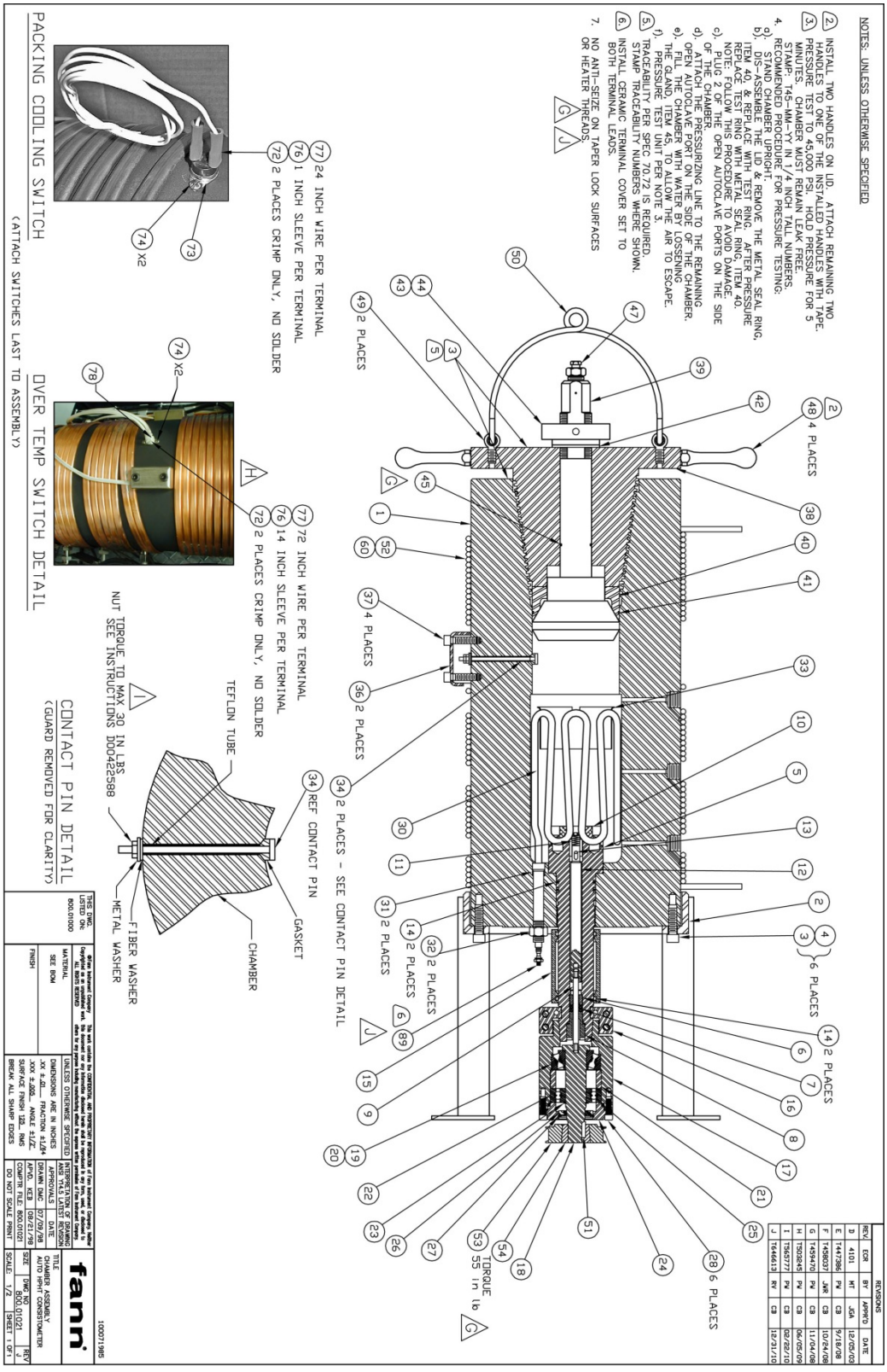


Figure 10-27 Chamber Assembly

Table 10-12 Potentiometer Assembly, P/N 102278347

Item No.	Part No.	Quantity	Description
0001	100072674	1	BASE, CERAMIC
0002	100072675	1	RHEOSTAT HOLDER, CERAMIC
0003	100072677	1	RHEOSTAT, 500 OHM
0004	100027792	1	NUT, POTENTIOMETER, HEX, 5/8, 24 UNEF, 3/32 IN. THICK, 3/4 IN. ACROSS FLATS, STNLS
0005	100072676	1	SHAFT, CERAMIC POTENTIOMETER, AUTOMATIC CONSISTOMETER
0006	100072656	1	COLLAR POINTER POTENTIOMETER
0007	100004342	1	COLLAR, DRIVE, CERAMIC POTENTIOMETER
0008	100004343	1	SPRING, CALIBRATION, CERAMIC POTENTIOMETER
0009	203413	1	6-32 X 3/8 AHSS STAINLESS STEEL
0010	100012982	2	PIN, ROLL, 5/32 X 1 3/8, STAINLESS STEEL
0011	100021315	2	PIN, ROLL, 3/32 X 9/16, 0.022 WALL, STAINLESS STEEL
0012	203469	1	6-32 X 3/4 SOC HD CAP STAINLESS STEEL
0013	100004339	1	POINTER CONTACT SPRING
0014	100002170	1	SCREW, HEX SOCKET, #6-32 NC X 1/4, STAINLESS STEEL
0015	100002184	1	SCREW, BIND HEAD, #6-32 NC X 5/16, BRASS, NICKEL PLATED
0016	101409261	4	WIRE, HOOK-UP, 22 AWG(19/34) TEFLON INSULATED,0.044 O.D. 200 DEG C RATED 250V MIL-W-16878E, INSULATION THK 0.006, SOLD IN 100 FT SPOOLS
0017	101409270	1	TERMINAL, RING, HIGH TEMP (900 DEG), NO. 8-10 STUD, WIRE 22-18 GA 100
0018	207759	10	8-32 X 1/4 BHMS STAINLESS STEEL
0019	208672	7	WASHER INTERNAL TOOTH 8 STAINLESS STEEL
0020	100072666	2	BAR, CONTACT, SPRING, POTENTIOMETER, CERAMIC
0021	100072665	3	CONTACT, SPRING, POTENTIOMETER, CERAMIC
0022	100001398	1	STANDOFF, 3/16 HEX, 0.187 LG, 4-40 FEMALE/FEMALE, STAINLESS STEEL
0023	207664	1	4-40 X 1/4 BHMS STAINLESS STEEL
0024	100072662	2	BAIL, LOOP, POTENTIOMETER, CERAMIC, SPECIAL
0025	100072668	3	INSULATOR, POTENTIOMETER, CERAMIC, SPECIAL
0026	100002073	4	STANDOFF, 1/4 IN ROUND, 1 1/4 IN LG, 8-32 NC, MALE/FEMALE, STAINLESS STEEL
0027	100002072	5	STANDOFF, 1/4 IN ROUND, 1 1/4 IN LG, 8-32 NC, FEMALE/FEMALE, STAINLESS STEEL
0028	207631	1	NUT 8-32 HEX REGULAR STAINLESS STEEL
0029	101545811	1	SCREW SHOULDER HEX SOCKET, 0.75 LONG, 0.19 ID, STAINLESS STEEL
0030	100029055	6	SCREW, BIND HEAD, #8-32 NC X 1/4, STAINLESS STEEL
0031	100002074	1	SPACER, 0.192 IN ID X 5/16 IN ROUND X 5/16 IN LG, STAINLESS STEEL
0032	101409263	1	TERMINAL, RING, HIGH TEMP (900 DEG), NO. 4-6 STUD, WIRE 22-18 GA
0033	101545812	1	SPACER, 5/16 DIAMETER, 7/16 LONG 0.19 ID OF STAINLESS STEEL
0034	102161282	4	8-32 X 1/2 PHMS PHILLIPS W/THREAD LOCK
0035	100002297		SCREW HEX SOC 4-40NC X 3/

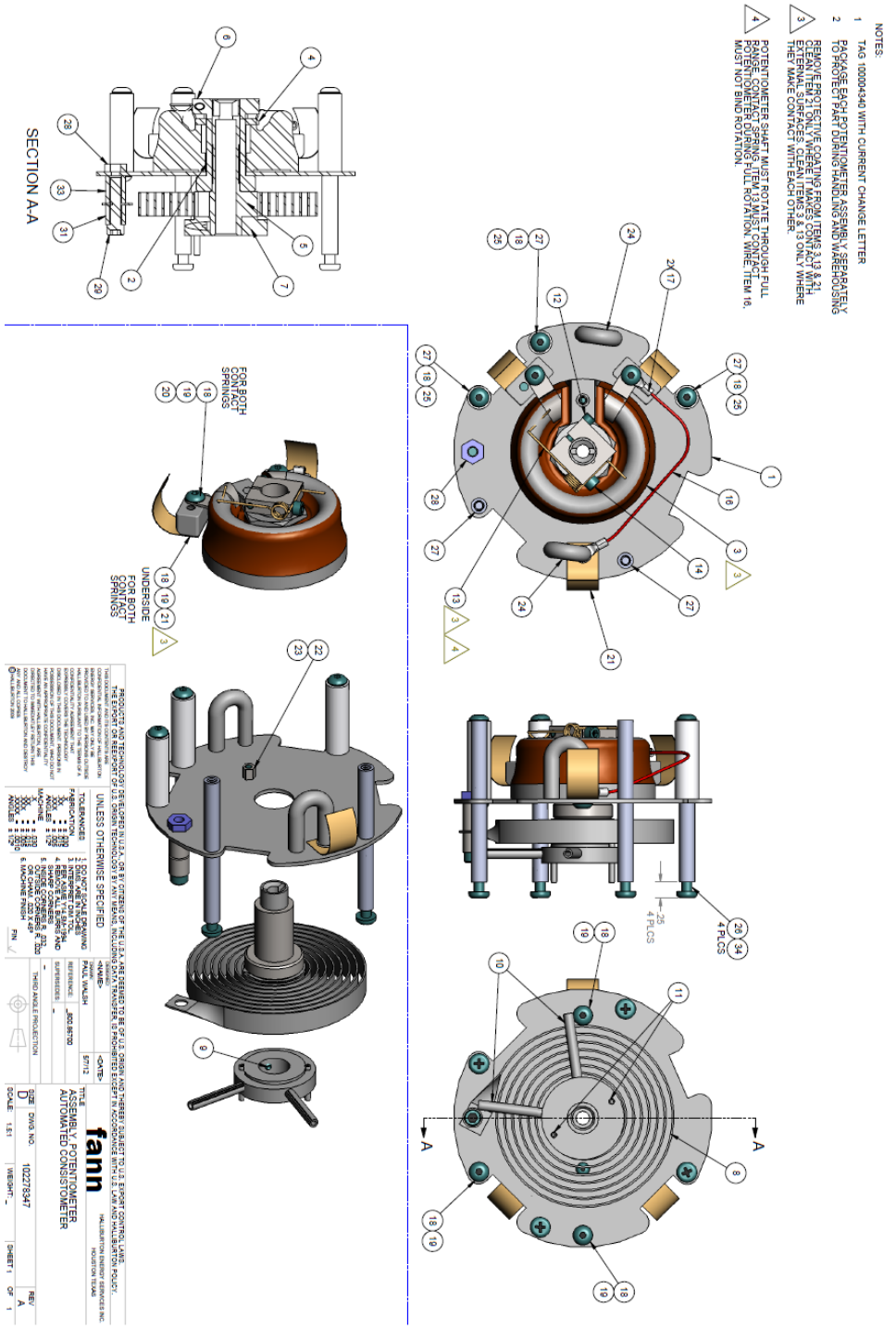


Figure 10-28 Potentiometer Assembly

Table 10-13 Slurry Cup Assembly Parts Included, P/N 100071979

Item No.	Part No.	Quantity	Description
0001	100004335	1	PLUG, BASE
0002	100010310	1	GASKET, CUP PLUG
0003	100007921	1	BASE
0004	100010309	1	GASKET, CUP BASE
0005	100007920	1	SLEEVE
0006	100004333	1	SHAFT
0007	100004313	1	PADDLE
0008	100021371	1	PIN, ROLL, 1/16 x 1/2, STAINLESS STEEL
0009	100007922	1	COLLAR, DIAPHRAGM
0010	100013735	1	DIAPHRAGM, NEOPRENE
0011	100007917	1	SUPPORT, DIAPHRAGM
0012	100007916	1	RING, LOCK
0013	100007918	1	DISC, DRIVE
0014	207764	1	SET SCREW, 10-32 x 3/8 HSSS BOPL HEX SOCKET
0015	100007919	1	BAR, DRIVE
0016	100072504	1	PIN, SHEAR
0017	100002475	2	PIN, ROLL, 1/4 x 1/2, T420 STAINLESS STEEL

Table 10-14 One Year Spare Parts Kit, P/N 220713

Item No.	Part No.	Quantity	Description
0010	100010309	10	GASKET, CUP BASE, HIGH PRESSURE-HIGH TEMPERATURE CONSISTOMETER
0020	100010310	10	GASKET, CUP PLUG, HIGH PRESSURE-HIGH TEMPERATURE CONSISTOMETER
0030	100013735	50	DIAPHRAGM, SLURRY CUP, FLAT, HP-HT CONSISTOMETER
0040	100004335	1	PLUG, BASE, SLURRY CUP, CONSISTOMETER
0050	100007921	1	BASE, SLURRY CUP, CONSISTOMETER
0060	100004333	6	SHAFT, SLURRY CUP, HP-HT CONSISTOMETER
0070	100004313	2	PADDLE, SLURRY CUP, HPHT CONSISTOMETER
0080	100008167	4	SCREW, SET, 6-32 NC X 1/4, CUP PORT, HEX SOCKET
0090	100007918	1	DISC, DRIVE, SLURRY CUP, HP-HT CONSISTOMETER
0100	100007919	1	BAR, DRIVE, SLURRY CUP, HP-HT CONSISTOMETER
0110	100002475	2	PIN, ROLL, 1/4 X 1/2
0120	100072504	50	PIN, SHEAR, SLURRY CUP, HP-HT CONSISTOMETER
0130	100001841	1	GREASE, MAGNETO
0140	100072665	2	CONTACT, SPRING, POTENTIOMETER, CERAMIC, SPEC, CONSISTOMETER
0150	100004343	1	SPRING, CALIBRATION, CERAMIC POTENTIOMETER, AUTOMATIC CONSISTOMETER
0170	100004339	4	POINTER, CONTACT, SPRING, POTENTIOMETER, CERAMIC
0180	100001896	2	PACKING, CHEVRON, 1/4 X 5/8, 3 RINGSET, NITRILE FILLED

			WITH SYNTHETIC GLASS& DACRON/POLYESTER, FOR HIGH TEMPERATURE & HCL SERVICE
0200	100004327	2	SHAFT, PACKING, PACKING GLAND CONSISTOMETER
0210	100029177	1	SEAL 1.628 OD X 0.875 ID X 0.25 L
0240	100004334	1	THERMOCOUPLE, CEMENT SLURRY CUP, 50 KSI, CONSISTOMETER 1/8 in DIAMETER SHEATH.
0250	214456	1	THERMOCOUPLE OIL TAPERED SEAT
0270	100072346	1	DISC, RUPTURE,
0300	204139	1	FUSE 2 AMP 250V 1/4 X 1-1/4 NORMAL 10/BOX
0310	100021315	4	PIN, ROLL, 3/32 X 9/16, 0.022 WALL
0320	100007915	1	KIT, REPAIR, VALVE ASSEMBLY, 30 KSI, ON/OFF, AIR OPERATED
0330	101843357	5	REPLACEMENT ELEMENT, FOR IN-LINE FILTER, 30K PSI OPERATING PRESSURE, 17-4 MATERIAL, 1/4 HIGH PRESSURE FEMALE CONNECTIONS, 40 MICRON STAINLESS STEEL ELEMENT, VITON O-RING, TEFLON BACK-UP RING
0340	102005503	5	KIT O-RING FOR HP FILTER 3B P8430, CONTAINS O-RING VITON 016V, O-RING TEFLON 016TBU
0350	102126448	3	SPARES, MANIFOLD
0351	102220929	2	NITRILE SQUARE-CUT O-RING, 5 INCH ID X 1/16 INCH WIDE
0360	101787315	1	FILTER, BACK PANEL, MODEL 290
0370	100024328	1	ELEMENT, FILTER, 10-MICRON, FOR 70.22561, SPEC
0380	204128	2	FUSE US 20 AMP 1/4 X 1-1/4 LITTLE FUSE P/N 314020 20 AMP
0390	204127	8	FUSE 5 AMP 125 V-FAST ACTING

11 Warranty and Returns

11.1 Warranty

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11.2 Returns

For your protection, items being returned must be carefully packed to prevent damage in shipment and insured against possible damage or loss. Fann will not be responsible for damage resulting from careless or insufficient packing.

Before returning items for any reason, authorization must be obtained from Fann Instrument Company. When applying for authorization, please include information regarding the reason the items are to be returned.

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