HTHP Consistometer Model 640 & 640CC

Instruction Manual

Manual No. D01206676 Revision A

Instrument No. 102538936 (Model 640)
102546634 (Model 640CC)

fann®
Fann Instrument Company

HTHP Consistometer, Single & Dual Cell Instruction Manual

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1 Introduction

Cements are a critical element in the drilling, completion, workover, and abandonment of wells. For each application, cement slurry is designed with specific properties and is given additives that provide predictable slurry density, volume, viscosity, compressive strength, fluid loss, gas migration, and thickening time. Slurry thickening time, or the time a slurry remains pumpable in a well, is one of the most critical properties in designing cement slurry. A predictable thickening time is desired, while maintaining the other specific properties of the cement slurry. The thickening time can be measured in a laboratory by testing a sample of the cement slurry in a pressurized consistometer. The elapsed time between initial application of pressure and temperature on the slurry sample and occurrence of a predetermined value of consistency (usually 100 Bearden Units, Bc) is the thickening time for the sample at the particular specification test schedule. The typical test schedules are listed in API Specification 10 on oilwell cements.

The Model 640 & 640CC Pressurized Consistometers are able to test cement slurries at temperatures up to 600 F/316 C and pressures as high as 40,000 psig/276 MPa.

1.1 Document Conventions

The following icons are used as necessary in this instruction 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.

EXPLOSION RISK! Alerts the operator that there is risk of explosion.

2 Safety

Safe laboratory practices and procedures should be observed while operating and maintaining the Model 640 & 640 CC. Follow the instructions provided to avoid personal injuries or damage to the equipment.

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

2.1 Safe Pressurization

This 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. 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.

2.2 Safe Heating

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.

NEVER operate the heater on an empty chamber. 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 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.

Refer to the electrical schematic before performing any maintenance or troubleshooting.

Always disconnect the power cable before attempting any repair.

3 Instrument Overview

The consistometer Slurry Cup Assembly uses a rotating, cylindrical slurry cup and a stationary paddle assembly enclosed in a pressure vessel. Pressure is applied to the vessel using mineral oil and an air driven hydraulic pump. A tubular heater surrounding the slurry cup supplies heat to the pressure chamber. A centerline thermocouple is provided for determining the temperature of the cement slurry. The slurry cup is rotated through the use of an electric motor and a magnetic drive unit. The rotational speed of the slurry cup is variable between 25 and 250 rpm to allow the user to study slurries at speeds other than the API prescribed speed of 150 rpm. The consistency of the cement slurry is measured through a potentiometer mechanism commonly referred to as a “pot mech”. The potentiometer is coupled with a torsion spring to resist the rotating force of the paddle. The rotational force is proportional to the consistency of the cement slurry and is measured through the potentiometer resistor as the spring deflects under load. The consistency is displayed on the plot generated by the data acquisition system. The consistency values are recorded in Bearden Units of consistency (Bc). Bearden units are defined in API Specification 10. The consistometer is equipped with one or two devices for post-test cooling of the instrument. The first is an external-cooling coil attached to the pressure vessel. After completion of the test, cooling water may be circulated through this coil to cool the pressure vessel. The instrument is optionally equipped with an oil reservoir cooling coil as well.

These pressurized consistometers are equipped with a state-of-the-art temperature controller and data acquisition system that provides unparalleled ease of use for the operator. The parameters of interest may be displayed in either English or SI units. Temperature control and data acquisition is programmed through the use of a touch screen monitor. A separate PC and keyboard/mouse are not required but may be connected through a network cable. A plot showing temperature and consistency (pressure is optional) may be plotted on any compatible ink jet printer. The plots may also be transferred automatically to a network or USB drive for use on a user supplied computer.

4 Specifications

Table 4-1 Model 640 & 640 CC Specifications

Category	Specification
Electrical	
Input Voltage	230 VAC (±10%)
Input Power	5500W (single), 11000W (dual)
Current	24A (single), 48A (dual)
Input Frequency	50-60Hz
Mechanical	
Height	70in (175cm)
Width (single)	33in (83cm)
Width (dual)	51in (129 cm)
Depth	29in (72cm)
Weight (single)	1100lb (500 kg)
Weight (dual)	2050lb (930 kg)
Environmental	
Operating Temperature	(32º to 105º F) 0-40º C
Operating Humidity	0-95% noncondensing
Heater	
Heater Power	5000W
Heater Type	Internal tubular with MgO insulation
Heater Control	Solid state relay
Drive Unit	
Drive Motor	1/8 Hp (93W), 180 VDC
Drive Speed	25-250 rpm (variable)
Utilities – Water and Air	
Compressed Air	maximum: 150 psig (10.2 bar) minimum: 80 psig (5.4 bar)
Cooling Water Pressure	100 psig (6.8 bar)
Utility Inlets	¼ inch female NPT

5 Installation

Upon uncrating the instrument, verify that the instrument and any spare parts on the packing have been received and are undamaged. Notify Fann if anything is missing or damaged. The instrument's center of gravity is located near the front of the instrument due to the weight of the pressure vessels.

Be very careful when rolling or transporting the instrument that it does not tip over toward the front.

It is ideal to leave room behind the instrument so that qualified personnel may have service access. If this is not possible, try to make the unit easy to disconnect and move for service.

Once the instrument has been moved to its desired location, air, water, and electrical connections can be made. The air inlet, water inlet, and water drain connections are each ¼ inch female NPT connections and are located on the lower right rear of the instrument. A number of ¼ inch male NPT to 8mm tube fittings are included for international locations. The air and water inlet connections may be made with either metal or plastic tubing. It is recommended that the water drain lines be made from metal, since this line may carry very hot water and steam from time to time. Electrical connections are made using the twist lock receptacle on the rear of the instrument. A 50 A female plug is supplied with each dual consistometer and a 30 A female plug is included with each single consistometer. Please observe the following precautions when making the wiring connections.

- A qualified installer should do the wiring in accordance with local electrical codes.
- The instrument should be securely connected to a separate earth ground. The ground wire must be larger in diameter than the supply conductors. An 8-gauge minimum ground wire is recommended for a dual consistometer and a 10-gauge minimum ground wire is recommended for a single consistometer.
- An 8BC or larger fire extinguisher to fight electrical and oil fires should be placed within 50 feet of the consistometer.

Exposed metal surfaces on the seal shaft, sealing nut, and cylinder are coated to prevent rust. The coating should be removed with a hydrocarbon-based solvent before operation of the instrument.

Certain components are supported during shipment with wooden blocks, foam padding, and plastic ties to prevent damage. Open the front doors and remove all the packing materials that would interfere with the operation of the instrument before powering the instrument.

Some components such as touch screen LCD monitors (if applicable) and computer control modules are be removed from the instrument prior to shipment and may be in a separate container to prevent damage. These devices must be reinstalled before operating the instrument. Locate the box containing the touch screen monitors and remove them from their shipping containers.

While standing at the rear of the instrument, align the four mounting holes in the black monitor housing with the four holes in the front panel. With the monitor screen facing the front of the instrument, secure the monitor to the front panel with the four screws provided. Connect the 15-pin video and USB cables from the monitor to the back of the control box. You must also connect the power cord from the monitor to an A/C outlet on the back of the instrument.

If the instrument is equipped with auxiliary standalone temperature controllers, they must be removed from their shipping containers and installed into the sleeves in the front panel. Simply slide the controllers into the sleeves and snap them into place. In order to protect the internal mechanisms of the pressure gauges, the needles are fixed in place with a screw and a small metal bracket. This bracket must be removed prior to using the instrument.

On 640 and 640CC consistometers, the counterweight in each swivel arm has been locked in place prior to shipment to prevent the weight from damaging the swivel arm. Prior to removing the plug from the pressure vessel, loosen the bolt holding the counterweight in place until the counterweight is free to move. The control box should be connected to the instrument by connecting the 5-pin power cord to the back of the instrument frame as well as the supplied USB cable.

The instrument will not operate without this USB cable connected from the computer to the machine.

Before operating the instrument, check the bottom of the consistometer for loose screws or bolts that may have loosened and/or fallen out during shipment. This is particularly true for overseas shipments.

There are two power connectors on the back of the electrical box. An uninterruptible power supply (UPS) may be connected between these power

connectors to maintain consistometer operation during short power outages or interruptions. If an UPS is not used, a jumper cord must be connected between these two connectors or the unit will not power up. An appropriate jumper cord was included with the consistometer accessories. If a printer is included with the instrument, it may be connected to the rear of the consistometer. Connect the USB connector on the printer cable to any USB input on the control box. The printer must also be connected to an A/C power outlet. One is supplied on the back of the instrument for this. Refer to the printer documentation for power requirements. A USB flash drive may also be connected to the control box in lieu of a printer. Test data may be uploaded to the USB drive and then transferred to a PC for archival storage. Refer to section 9.2 for more information on printer and USB drive. An optional keyboard may be connected to the control box at this time. Before attempting to operate the instrument, it is recommended that the operators read the remainder of this manual to become familiar with the consistometer operation.

Some instruments, especially in overseas locations, have printer power connectors located on the rear on the electrical box. Check to see if yours does.

6 Touchscreen Software

Touch screens were created to provide users with an easy to use interface. This allows the user to input and view data without a keyboard or mouse. The touch surface is able to detect contact and send position information back to the processor. Using the touch screen has the same result of using a mouse to point and click. One mouse click is accomplished by one touch of the screen. A double-click is achieved with two quick touches. With this standard method of input, no special software is required to utilize the screen.

6.1 Using the Touchscreen

Most any object may be used on the touch-screens. Experimentation will quickly show which objects will activate the screen and which will not.

It is important to note the touch surface does NOT use pressure to detect input. A light touch is all that is needed.

In addition sharp instruments (such as pencils, pens, screwdrivers, etc.) should not be used as they may damage the touch surface. A pen-like touch stylus has been included in your accessories to use if desired.

The purpose of the touch screen is to provide the user with a single interface to the instrument. Temperature control, motor control, instrument setup, and current test data are accessed through the touch screen. This eliminates the need to individually program controllers or other off-site PC software to begin running a test. Additionally, the touch screen allows the user to access current information at the instrument during a test. Each instrument is complete and requires no additional software or hardware to function.

The main menu is starting point for the instrument. From here users may start new tests, set up test parameters, setup instrument parameters, or view an old test. Also located on the main menu is the current reading for temperature, consistency, and pressure (if so equipped). As noted in the instructions on the screen, all the user need do is touch a button to begin.

6.2 View Test

Pressing this button opens the test viewer software and allows you to select any test file available.

6.3 Instrument Setup

This button takes the user to the Instrument Setup Screen. From this screen the user may calibrate temperature, consistency, gel strength (optional) and pressure (optional). Additionally, the user can ARCHIVE all tests on the consistometer to the USB memory stick or network location. This function will copy all tests in current C:/FANN data folder and paste them into the selected folder, networked drive, or USB. An AUTO EXPORT function allows the user to select a folder or network storage where any test will be automatically copied to after the test is stopped.

6.4 Calibrate Temperature/Calibrate Pressure

This button allows the user to select the calibration routines. When this screen appears, connect a temperature calibrator to the thermocouple input on the instrument. Enter a lower-limit temperature value on the calibrator. Touch the Enter Low Value parameter box and then enter the correct temperature value for the Low Data Point using the touchpad at the right. The raw value is the signal read directly off the I/O hardware and it should change as the calibration signal changes. When the low data point has been entered, press the SAVE LOW VALUE button. The user can now enter the high data point on the calibrator and then again on the touchscreen as before. The raw value should be different for the low and high data points or there will be a computation error. After the high data point has been established, press the SAVE HIGH VALUE button. The user can now vary the calibration signal and see how the calibrated signal compares with that of the calibration device in the VERIFY NEW CALIBRATION box. If the signals compare favorably, press the Accept button to save the calibration. The calibration values will be stored in a configuration file and take effect upon exiting the Instrument Setup menu.

6.5 Sample Rate

This menu allows the user to select a sampling rate for the Data Acquisition program. Rate is given in number of seconds between samples. To save data space and achieve acceptable test resolution, a sample rate of 30 or 60 seconds is recommended.

6.6 Units

These menus allow the user to select English or SI units for the Data Acquisition program. Additional units may be available as an option.

6.7 Archive Data

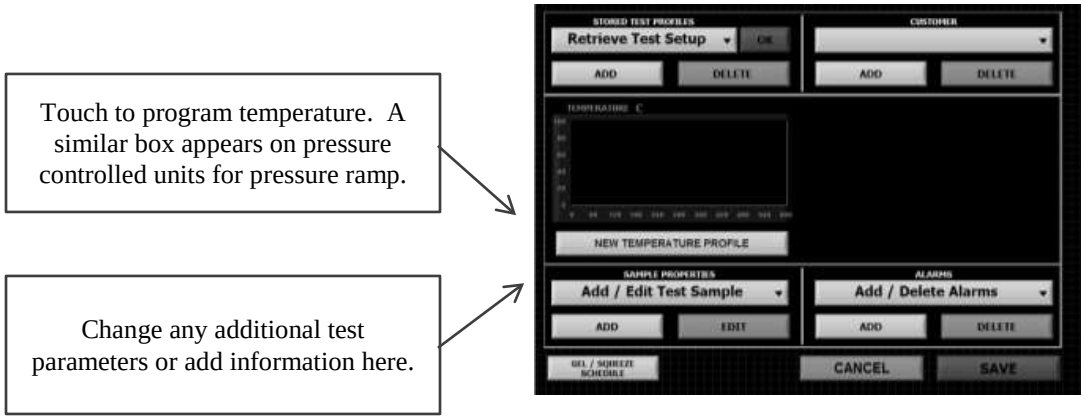
This button allows the user to copy all the test files stored in the consistometer to an archive computer for permanent storage. The tests may be saved to the USB memory stick or to a local/network folder. Note that the program will ask for the storage location and the user may browse to any available drive or folder. Once the files are copied from the consistometer to the memory stick, the files remain on the consistometer and will still be accessible from the instrument. To permanently delete these files, the user must go to their stored location and delete them manually. The default location for Fann test files is C:/FANN/Tests. This folder also stores the actual test parameters so any test deleted cannot be run again without reprogramming TEST SETUP.

6.8 Edit Instrument

This button should only be used when instructed to by Fann.

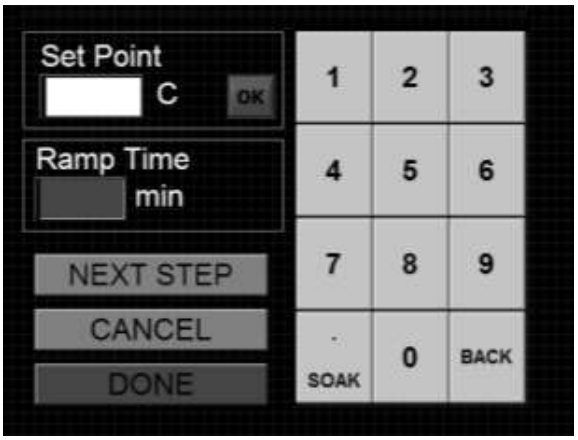
7 Test Setup

From this menu the user can enter or reset a temperature ramp and soak schedule. The user can also configure the hesitation squeeze and gel strength parameters on equipped instruments. This section explains how to use the software to view and print the test results.



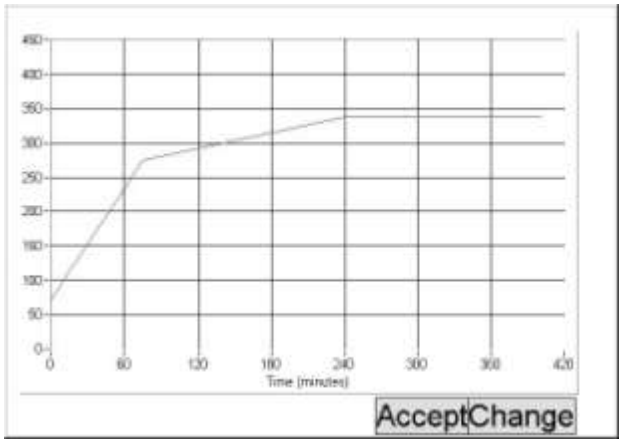
7.1 Temperature Control (Pressure When Available)

The Program Temperature screen is shown below:



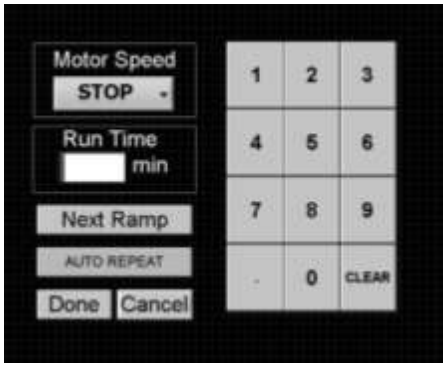
Enter desired set point values by touching the SET POINT parameter box and entering the values on the keypad. Time to set point is selected by touching the TIME parameter box and entering a time in minutes on the touch pad. The final segment should always be a SOAK segment where the temperature equals the final test temperature and the time equals SOAK. This guarantees the instrument will maintain final temperature for the remainder of a test. After a profile has been entered, press the SAVE button. At this point a graph of the desired temperature

ramp is displayed for confirmation. Press: ACCEPT to save ramp or CANCEL to exit without saving.



7.2 Hesitation Squeeze

On units equipped with the hesitation squeeze option it may be accessed using the button labeled Hesitation Squeeze. Pressing this button will bring up the following screen.



This allows a very random schedule to be programmed using user selected timing intervals.

Select Motor Speed = Bc, select the empty box under Run Time and enter the hesitation start time in minutes using the touch pad a right. The Start Time is the elapsed time from the beginning of the test to the first hesitation squeeze start.

Select Next Ramp to enter first stop. The screen will re-initialize and you can select STOP for motor speed and enter desired amount of time for STOP segment in Run Time box. Selecting Next Ramp again will allow you to enter run time after first STOP segment. If you wish to repeat the schedule for the remainder of the test simply select AUTO REPEAT after 3 segments have been entered (Bc-STOP-Bc). An infinite number of sequences can be input.

Select SAVE to save or Cancel to exit without new schedule. A preview of the schedule will be shown for approval.

7.3 Optional Parameters and Profile Saving

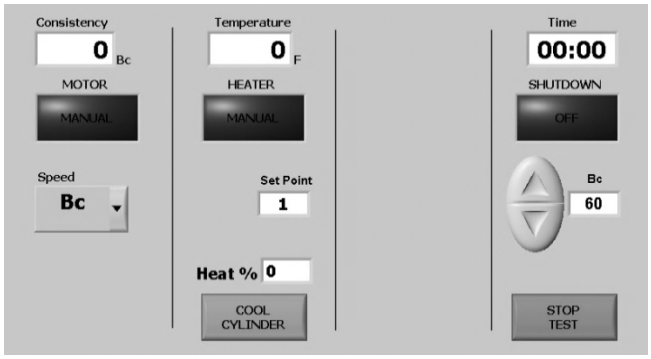
Many optional parameters can be saved in your test profile from the Test Setup screen. These include names for Well, Cement, District, etc. and can be input by simply touching on the ADD/EDIT boxes and entering data using the pop-up keypad. Additionally, repeat customers can be saved in the Customer menu by pressing NEW next to the Customer menu and inputting a customer name. The customer can then be selected from the drop-down Customer menu box. The entire profile of any test can be easily saved and recalled by selecting SAVE PROFILE after the profile has been completely configured. To recall a saved profile simply select it from the SAVED PROFILES drop-down menu and press OK. Customers and profiles can be deleted from memory by pressing the RED DELETE BUTTON next to either Customer or Profiles. Be sure to have the profile you would like to delete selected at the time you press the DELETE button. Test parameters can be deleted or changed by selecting the parameter and touching the EDIT button.

8 Start Test

Once your instrument is properly configured and a test has been entered in the TEST SETUP section. You may begin testing by selecting the START TEST button from the main menu.

8.1 Live Testing Screen

Once a test has begun, a real-time display of current values will be presented. The user may view a live chart at any time by pressing the LIVE CHART tab button located at the top of the screen. Printing can be done at any time by selecting the ADVANCED CHART & PRINTING OPTIONS button (Please note that a printer must be connected to the instrument before trying to print.). This button will also enable the user to view detailed test information and streaming numerical data. The user can also create custom header and footer segments of the printed plot. Pressing the EXIT button returns the user to the RUN TIME MENU shown below.



Temperature control may be toggled between AUTO and MANUAL. AUTO is recommended. Note that establishing a set point significantly different from the current temperature may cause large overshoots in temperature set point. If manual temperature control is required, it is recommended that it be increased slowly in 2-5 degree increments.

The instrument is equipped with an automatic consistency shutdown alarm. Use the up/down arrows to select the consistency value at which the alarm should occur. If the Auto Shutdown feature is ON, the instrument will automatically stop the test when the indicated alarm value is reached. In addition to stopping the test, automatic shutdown will also turn the heater and motor off and the cooling water on. Note that the Auto Shutdown Alarm is in addition to the alarm values entered in TEST SETUP that are printed with each plot.

9 Stopping a Test

To stop the current test, the user must press the STOP TEST button on the RUN-TIME MENU screen. Once the test has been stopped, no further data will be logged and no further temperature or pressure control will be provided. The software will save the current test in a file on the instrument's local hard disk. The default location is C: /FANN/Tests. If auto-shutdown is enabled, the test will be stopped when the Consistency Alarm value has been reached. This action has the same effect as the user pressing the STOP TEST button; however it also turns the motor and heater off and the cooling water on. Note that there is a 5-10 second delay from the time a consistency alarm is triggered until automatic shutdown occurs. This is to prevent noise or spikes in the consistency signal from triggering automatic shutdown prematurely.

9.1 Software Upgrades

From time to time, Fann makes software upgrades available that provide increased functionality or problem fixes. Generally, the only file that needs to be upgraded is CementLab.exe. It is located in the C:\Program Files\FANN folder. If it is necessary to install an updated CementLab.exe file, it may be copied from the USB memory stick. It may also be copied over a network if the instrument is connected to one. To copy the file from a memory stick, put the new file on the memory stick, rename the old CementLab.exe file to "Old.exe" and copy the new file into the proper folder using Windows Explorer, which is accessible from the start menu or My Computer icon. The memory stick will generally be the D: drive. Should the new CementLab.exe program not work properly, simply delete it and restore Old.exe to the original.

9.2 Using the USB Memory and Printer

The instrument is equipped with a Universal Serial Bus (USB) port that allows the use of a USB memory stick for mobile storage. The memory stick is a flash disk that can be connected to the USB port on the instrument control box and used as an external disk drive. Simply insert the memory stick into the USB port and the memory stick will become the D: drive. Software upgrades may be installed using the memory stick and tests may be archived to the memory stick and transferred to a PC for permanent storage.

10 Front Panel Controls

All the functions of the consistometer are controlled from the front panel. It is very important for the user to have a thorough understanding of each control and its effect on the operation of the consistometer.

The front panel controls can be roughly divided into four different sections: the hydraulic pressure controls, the pneumatic controls, the cooling water controls, and the electrical/electronic controls. This chapter will discuss each section in detail.

10.1 Hydraulic Pressure Controls

This section consists of the following controls: the PRESSURE gauge, the PRESSURE RELEASE valve, and the FILL/DRAIN switch. Components that make up this section are used to control the flow of oil used to pressurize the cylinder and to display the cylinder pressure.

The pressure gauge displays pressure in both English and SI units.

The pressure gauge displays pressure in both English and SI units.

The PRESSURE gauge is used to display the pressure inside the pressure vessel.

The PRESSURE RELEASE valve is used to release pressure from the pressurized cylinder. The PRESSURE RELEASE valve must also be fully opened to remove oil from the cylinder. If it is necessary to fill only one pressure vessel of a dual consistometer, the PRESSURE RELEASE valve on the unfilled side must be closed or oil may back up into the cylinder through the oil return lines.

The FILL/DRAIN switch is used to control the flow of oil into the pressure vessel. When the switch is set to FILL and there is air pressure on the instrument, oil will begin to flow into the cylinder. Ensure that the lid is closed and thermocouple fitting is loose to allow air to escape while filling.

When the switch is set to DRAIN, the PRESSURE RELEASE valve is open, and air is exhausted from the instrument, the cylinder will be emptied of oil. Under DRAIN conditions, the cylinder must be closed. When the selector is in the OFF position, the instrument is idle and cannot be run.

If only one cylinder is to be drained of oil, the AIR EXHAUST must be active. During the draining process the other side of the instrument cannot pump until AIR SUPPLY is turned back on after fully draining the non-active cell.

10.2 Pneumatic Controls

The pneumatic section consists of the AIR PRESSURE gauge, the air pressure REGULATOR, the PUMP AIR PRESSURE gauge, and the AIR SUPPLY / AIR EXHAUST valve (DUAL consistometer only). The components in this section are used to fill and drain oil from the pressure vessel and to power the air driven hydraulic pump that applies pressure to the sample.

The AIR PRESSURE gauge indicates how much air pressure is being supplied to the instrument. Air at the pressure indicated on the gauge is supplied to the oil reservoir to force oil out through the dip tube(s) and into the pump inlet. If there is no pressure indicated on this gauge, the pump will not operate.

If the PUMP AIR PRESSURE drops off significantly when the pump is operating, an airline may be blocked or the compressor may be insufficient to deliver the volume of air required.

The air pressure REGULATOR is used to control the air pressure to the air driven hydraulic pump. Higher hydraulic pressures require higher air pressures. To adjust the pressure of the air supplied to the pump, pull the knob on the regulator out to unlock it. Turn the regulator knob clockwise to increase the pressure and counterclockwise to decrease the pressure. When the adjustment is finished, push the knob in to lock it in place if desired.

The PUMP AIR PRESSURE gauge shows the pressure of the air delivered to the pump. The pressure may be changed by adjusting the air pressure REGULATOR as described above.

DUAL UNITS: AIR SUPPLY / AIR EXHAUST switch. This switch accompanies the FILL/DRAIN. Any time you wish to FILL a cylinder or RUN a test, the AIR SUPPLY must be ON. Any time you wish to drain a cylinder, you must select AIR EXHAUST to relieve air pressure from the oil reservoir. If only one cylinder is to be drained of oil, the AIR EXHAUST must still be active. During the draining process the other side of the instrument cannot activate the pump until AIR SUPPLY is turned back on. Do this immediately after fully draining the non-active cell.

10.3 Cooling Water Controls

The cooling water controls are used to cool the cylinder and oil reservoir at the completion of a test. The Fann pressurized consistometers are optionally equipped with an industry first: internal cooling coils in the oil reservoir for quick cooling of the hydraulic oil and faster turnaround between tests. The cooling water controls consist of a COOLING WATER switch and a RESERVOIR COOLING switch.

The COOLING WATER switch allows water to flow through the cooling jacket surrounding the pressure vessel. This valve should be turned on at the completion of a test to cool the pressure vessel. Alternatively, software can be used to cool the cylinder automatically.

The RESERVOIR COOLING switch allows water to flow through the internal cooling coils in the oil reservoir to cool the hydraulic oil. This valve may be opened at the completion of a test to or it may be opened during a test if the oil in the reservoir becomes too hot or if it is desired to keep the oil cool to reduce turnaround time for the next test.

10.4 Other Electrical and Electronic Controls

Additional primary electrical/electronic controls may include the POWER, HEATER, MOTOR, and TIMER switches, the pump controls, and motor speed adjustments. The primary display is the touch screen. These controls are discussed in detail below.

The switch labeled POWER controls electrical power to the entire instrument. Nothing else is operable if this switch is not on. If available, switches labeled HEATER and MOTOR can be used to disable power to the heater and motor. Under normal conditions, these switches may be left in the ON position. Leaving the HEATER switch ON will not heat the instrument unless a test is running. If equipped with an external timer, a TIMER switch will enable the elapsed timer.

An optional MOTOR SPEED tachometer displays the rotational speed of the slurry cup when the motor is running. The SPEED CONTROL potentiometer is used to vary the speed between approximately 25 and 250 rpm.

The touch screen is used to control temperature and pressure or other parameters when available. The screen will also display a plot of consistency and temperature, pressure, etc. as a function of elapsed time. More in-depth explanation of the touch screen capabilities may be found in section 6.

A thermocouple is plugged into the THERMOCOUPLE connector so the centerline temperature of the slurry cup may be monitored. The CALIBRATOR socket accepts any standard consistometer calibrator.

The pump switch may be one of two varieties, depending on whether the automatic pressure control option is installed. If automatic pressure control is not installed, the instrument will be equipped with a switch that is used to turn the pump on and off. If the pressure control option is installed, the unit will be equipped with a three-position switch, labeled ON, OFF, and AUTO. When the switch is in the OFF position, the pump will not run. When the switch is in the ON position, the pump will run until turned to the OFF position. When the switch is in the AUTO position, the pump will be turned on and off by the pressure control software.

This completes our tour of the front panel components. The operation of these components will be discussed in greater detail along with examples in section 11.

11 Operation and Calibration

11.1 Running a Thickening Time Test

The steps listed below are for experienced users who are familiar with consistometer operation.

1. Close the PRESSURE RELEASE valve if supplied.
2. Turn the POWER switch to the ON position.
3. Turn the MOTOR and HEATER switches to the ON position if available.

A light coating of grease on the threads is important to prevent cement from filling the threads.

4. Program temperature (and pressure if unit is so equipped) ramp and soak on the touch screen.
5. Mix the slurry and fill the slurry cup.
6. Place the slurry cup and the potentiometer mechanism (pot mech) into the pressure vessel and engage the slurry cup to the cup table. The motor may be turned on now or at any time using the software selector switch.

It is not necessary to pound the lid closed with a sledgehammer.

7. Close the lid on the pressure vessel. Insert the thermocouple, but do not tighten thermocouple fitting
8. Turn **FILL/DRAIN** switch to **FILL** and fill the pressure vessel with oil. On a dual consistometer, the AIT SUPPLY switch must also be ON. When oil begins to run out the top, tighten the thermocouple.
9. Verify the instrument is reading consistency and start the test using the touch screen.
10. Adjust the pressure during the test as desired. On units without automatic pressure control, releasing pressure may be necessary to prevent an over-pressure condition while heating.

11.2 Stopping a Thickening Time Test

The steps listed below are for experienced users who are familiar with consistometer operation.

1. Stop the test using the touch screen.
2. Turn COOLING ON
3. When temperature has cooled below 212F/100C, open the PRESSURE RELEASE valve and set AIR EXHAUST on DUAL units.
4. When the pressure is at zero, select DRAIN. This will blow the oil from the pressure vessel into the oil reservoir. You will hear AIR escaping from the rear of the instrument once the cylinder is empty of oil. At this point you must turn the FILL/DRAIN switch to OFF.
5. Open the RESERVOIR COOLING valve to cool the oil in the reservoir if equipped and desired.
6. When the cylinder is cool enough, remove the slurry from the slurry cup before it sets and becomes too hard. Press the cement plug out from bottom to top.

Slurry cups are tapered, with the large end at the top. This makes it easier to press the cement plug out of the slurry cup..

11.3 Calibration

The potentiometer mechanism, thermocouple, and pressure transducer (optional) should be recalibrated on a regular basis. It is recommended that the thermocouple and pressure transducer (if so equipped) be calibrated at least annually and anytime new thermocouples or pressure transducers are installed. The potentiometer mechanism (pot mech) should be recalibrated whenever the spring, contact arm, or resistor is adjusted or replaced. Higher operating temperatures generally require more frequent recalibration.

If the instrument is within tolerance after several calibration checks, extend the calibration interval. If it is out of tolerance, shorten the interval.

11.4 Temperature Calibration Procedure

Temperature may be calibrated using a temperature calibrator.

1. With Instrument ON and CementLab running, select INSTRUMENT SETUP – CALIBRATE TEMPERATURE.
2. Disconnect thermocouple from inside instrument. The plug is located behind the heater. Connect the Temperature calibrator to this plug.
3. Enter a value of 125C or 275F in the calibrator.
4. Verify that the RAW VALUE on the touchscreen is changing as you enter a new number into the calibrator. This time enter 25C or 60F into the calibrator.
5. Enter the same temperature value into the LOW VALUE box in CementLab.
6. Select SAVE LOW VALUE.
7. On the calibrator, input 220C or 400F.
8. Enter the same number into the HIGH VALUE box in CementLab.
9. Select SAVE HIGH VALUE.
10. On the calibrator, enter 100C or 200F.
11. Verify the calibration is reading the same value on the touchscreen.
12. Select SAVE or DONE and Exit Calibration screen.

11.5 Pressure Calibration Procedure

Pressure may be calibrated using a Digital Pressure Calibrator. Simply remove pressure vessel and attach calibrator to the thermocouple port on top of the cylinder. If equipped with software pressure display, start the CALIBRATE PRESSURE routine as was done for Temperature. Ensure no pressure is on the pressure vessel and enter zero as the LOW VALUE, SAVE LOW VALUE.

FILL the cylinder with oil and then verify pressure gauge readings at different pressures. If optional software pressure display has been purchased pressure unit to maximum typical operating pressure and input the digital calibrator gauge reading into the HIGH VALUE of the software calibration screen. Be sure you are in the correct units and SAVE HIGHVALUE. Next, release some pressure and verify the CALIBRATED VALUE is correct. SAVE and depressurize/drain instrument.

11.6 Consistency Calibration Procedure

The consistency should be calibrated by using the consistency calibrator assembly.

The potentiometer mechanism and the digital meter, which indicates consistency, should be calibrated by using the potentiometer mechanism calibrator. This device applies a known torque to the potentiometer mechanism spring, allowing the readout to be observed on the CALIBRATE CONSISTENCY screen (In TEST SETUP of software program). Calibration of the potentiometer mechanism is described in the example below.

1. Set the calibrator near the front edge of the consistometer.

2. Install the potentiometer mechanism to be calibrated on the holder. Insert the wedge into the open slot nearest the potentiometer ground spring.

3. Wind the cord around the potentiometer mechanism frame and over the pulley. Place the hanger weight hook in the loop on the end of the cord.

4. Install the alligator clips to the potentiometer mechanism springs matching the wire colors to the contact pin wire colors.

5. Insert the calibrator plug into the CALIBRATOR socket on the front panel of the instrument.

6. From the software IDLE screen, select INSTRUMENT SETUP and then select CALIBRATE – CONSISTENCY.

7. The weight of the hook on the string is 50g. This is an equivalent of 9 Bc. On the touchscreen in the box labeled LOW DATA POINT input 9 on the touchpad. Select SAVE LOW VALUE.

8. Place 400g of weights on the weight hanger. This is the equivalent of 100 Bearden Units of Consistency (Bc). On the touchscreen in the box labeled HIGH DATA POINT input 100 on the touchpad. Select SAVE HIGH VALUE.

9. The touch screen should indicate 100Bc in the CALIBRATED VALUE display.

10. Remove some weight and check the CALIBRATED VALUE. If the values are correct, calibration is complete. If the values are incorrect, repeat steps making adjustments to Potentiometer Mechanism as required. Refer to Table 11-1 for weight to Bc conversions for your pot-mech.

Table 11-1 Consistency as a Function of Weight vs Torque*

Weight (g)	Consistency (Bc)
0	-4
50	9
100	22
150	35
200	48
250	61
300	74
350	87
400	100

* Based on the equation from API Spec 10, Section 8.2T = 78.2 + 20.02 Bc
T = Torque, g.cm
Bc = Bearden units of slurry consistency

By applying additional weights between 0 and 400g and plotting consistency display as a function of applied weight, the linearity of the potentiometer mechanism may be assessed.

12 Maintenance and Servicing

Consistometers can be relatively reliable and trouble free - provided they are serviced and maintained properly. Instruments that are neglected and receive infrequent service or are subject to abuse are certain to cause trouble.

12.1 Pressure Valve and Hydraulic System Maintenance

The metal o-ring, the pressure vessel o-ring seat, and the bottom of the seal shaft are the keys to reliable pressure sealing. If these components are free from debris and scratches/dents, reliable sealing will be easily achieved.

1. Inspect the pressure vessel's metal o-ring and the seat below it after each test and wipe it free of cement particles and other debris. Do not use sharp objects, such as screwdrivers, when removing the metal o-ring as it will likely bend or scratch the o-ring, ruining it. Should the seat below the o-ring or the seal shaft become pitted or scratched from cement particles that have migrated into the seal, lapping of the seat and seal shaft may be required.

2. The cylinder plug threads have been coated with a friction reducing PTFE coating by the factory to help prevent thread seizing and galling. However, it is still recommended to apply a molybdenum disulfide anti-seize compound to the threads periodically.

If the transfer of the oil from the pressure vessel to the reservoir is slow, the filter needs to be cleaned or replaced

3. The high-pressure filter is located in the 3/8-inch stainless steel pressure lines, between the pressure vessel and the pressure release valve. This filter protects the pressure release valve, air operated valve (if equipped), and capillary tube (if equipped) from cement particle damage and/or blockage. It also prevents cement particles from being carried into the oil reservoir. This filter must be disassembled and the filter element cleaned or replaced periodically.

4. The mineral oil in the reservoir should be drained and replaced when it becomes dirty. The low-pressure oil filter element should also be replaced periodically. These filters are located in a blue housing. The oil reservoir is equipped with drain valve on the bottom and a filling plug at the top. To thoroughly clean the reservoir, the entire unit may be taken out of the instrument and the bottom removed. Mineral oil may be conveniently added by pouring oil into the pressure cylinder and transferring it to the oil reservoir.

The mineral oil supplied with the instrument has an open cup flash point of approximately 188C/370 F.

5. The magnetic drive should be flushed with clean solvent periodically and whenever cement spills into the cylinder or particles contaminate the drive. If cement enters the magnetic drive, it will cause the bearings to wear quickly. If the worn bearings are not replaced, it may cause the inner magnetic drive shaft to wear out prematurely. Worn bearings may also cause excessive slurry cup run-out.

6. The filter, regulator, lubricator unit (FRL), supplies lubrication and filtration for the pump air. This unit is attached to the pump air inlet, after the solenoid valve. The filter unit is upstream of the regulator unit and it should be checked periodically and the bowl cleaned if filled with water or debris. The lubricator is located just downstream of the filter. A quality grade of lubricating oil, approximately SAE 10, should be added routinely to the plastic reservoir, otherwise it will run dry and leave the air side of the pump un-lubricated, perhaps leading to premature failure of the pump.

Do not pour the lubricating oil into the filter bowl by mistake.

12.2 Potentiometer Mechanism (Pot Mech) Maintenance

1. Check upper and lower bearings for smooth, friction free operation. If bearing operation is not smooth, clean or replace the bearings. If the bearings do not operate smoothly, it may cause thickening times to increase.

2. Check for broken wires in the potentiometer resistor. The resistance should measure between 80 and 100. The surface of the resistor that is in contact with the wiper may be burnished with a smooth, round rod (such as a screwdriver blade) to reduce noise in the consistency signal if necessary.

3. Periodically check that the wiper is making contact with the potentiometer resistor throughout its entire length of travel.

12.3 Slurry Cup Maintenance

1. Check the slurry cup after every test to be certain the threads are not contaminated with cement. Lubricate the threads with grease prior to the start of every test.

2. It is recommended that hardened cement slugs be pressed out, rather than pounded out with a hammer. Pressing tends to cause less damage. When

pressing the slug out, be careful not to damage the paddle shaft point or the paddle itself. If the slug is not pressed out straight, it may cause the cup sleeve to become oval and prevent the threaded closures from threading into the sleeve.

3. Periodically disassembly the diaphragm hub and clean any cement from the Teflon o-rings. Replace the o-rings if they are badly worn.

4. Check the rubber diaphragm for signs of brittleness or cracking. Replace if necessary.

5. Check the point on the bottom of the paddle shaft. Replace it if it is worn to the point that the paddle rubs on the bottom of the slurry cup. Check to see that the paddle shaft is not excessively worn where the shaft extends through the diaphragm hub. Replace if wear is excessive.

6. Check the slurry cup seal plug for wear. Replace it if it is worn to the point that the paddle rubs on the bottom of the slurry cup.

12.4 Changing the Metal O-ring on the Cylinder Assembly

Pry the old o-ring out using a plastic or soft metal tool so as not to damage the sealing surfaces.

1. Coat the new o-ring with a light coating of grease.

2. Press the new o-ring into the seal groove using your fingers. Do not bend or scratch the new o-ring.

3. Place the plug in the pressure vessel and thread in place until the seal shaft contacts the new o-ring.

4. Using a rubber mallet or dead blow hammer and light blows, begin to close the plug and compress the o-ring. After three hits with the hammer, unscrew the plug part way. Repeat this process until the scribe lines on the plug and cylinder are lined up. Installation is now complete.

5. Realignment of the witness marks on the plug and cylinder is recommended each time the seats are lapped or if pressure leakage persists. In time, plug and cylinder threads wear and heat-induced flexing of the plug and cylinder require witness mark realignment because the marks no longer represent the actual seating of the seal shaft.

12.5 Changing/Cleaning the High Pressure Filter Element

1. Disconnect the 3/8-inch high-pressure connections and remove the filter assembly.

2. Secure the Filter Housing in a vise and remove the Seat Retainer.

3. Compressed air may be forced through the filter element to remove the debris attached to the filter. The filter element may also be unscrewed from the filter nipple and cleaned with solvent or a weak acid solution.

4. Thread the filter onto the filter nipple. Install the filter element and filter seat into the housing and secure tightly with the seat retainer.

5. Install the filter back in the instrument. If transferring the oil from the pressure vessel to the reservoir is still slow, replace the filter element.

12.6 Replacing the Low Pressure Filter Element

1. Make certain all valves are closed.

2. Open the AIR EXHAUST valve.

3. Locate the blue, low-pressure oil filter housing.

4. Remove the nut on the top of the filter housing. The filter bowl and filter element will come off.

5. Replace the filter element with a new element.

6. Inspect the gasket and replace if necessary.

7. Replace the bowl and filter element and install the nut. It may appear that the filter element is too long, but the element will be compressed as the nut is tightened which separates the filtered oil from the unfiltered oil.

8. Check for leaks.

To minimize the mess, place a bucket or cup under the filter housing to catch any oil that might spill.

12.7 Potentiometer Mechanism Resistor Replacement

1. Remove shaft bearing retainer and potentiometer slider.

2. Remove old resistor from mounting frame, being careful not to damage slot.

3. Position new resistor over the slot in the mounting frame with the straight side down. The connecting strip must be installed under the resistor in the groove

in the mounting frame. The length of resistor extending past the connecting strip should be approximately even on both ends.

4. Seat the resistor securely in the slot in the mounting frame. Use care to avoid damage to the resistor. The top surface of resistor must be level with the top of the mounting frame.

5. Use a smooth, round rod (such as the round shank of a screwdriver) to rub top surface of resistor, burnishing resistance wire lightly so potentiometer slider will slide smoothly with minimal noise.

6. Rotate potentiometer slider by hand. Assure that slider makes contact with the resistor during its entire range of motion. If necessary, adjust slider by bending it up or down.

7. Replace shaft bearing retainer and check the potentiometer mechanism with a calibrating device.

12.8 Potentiometer Mechanism Spring Replacement

The spring should wind tighter when the slider is moved in the counter-clockwise direction.

1. Remove shaft bearing retainer and potentiometer Slider.

2. Remove old spring.

3. Install new spring.

4. Replace potentiometer slider.

5. Loosen the three spring adjuster clamp screws on underside of the frame, but do not remove the screws.

6. Rotate the spring adjuster until the potentiometer slider lines up with the front contact strip. Tighten adjuster clamp screws.

7. Rotate potentiometer slider by hand. Assure that slider makes contact with the resistor during its entire range of motion. If necessary, adjust slider by bending it up or down.

8. Replace shaft bearing retainer and check the potentiometer mechanism with a calibrating device.

12.9 Servicing the Inner Magnetic Drive Shaft

It is sometimes necessary to remove the 3-0065 Plug Assembly from the bottom of the 3-0062 Magnetic Drive Housing. The oil in the magnetic drive can create a vacuum that makes removal of the inner shaft difficult, especially if the housing is contaminated.

The inner shaft is composed of extremely powerful magnets. If these magnets are allowed to get too close to steel objects the magnetic force may cause injury or damage to the shaft. Also keep the shaft away from metal filings, as they will adhere to the shaft and cause premature wear.

1. Pull the inner magnet shaft assembly out through the top of the pressure vessel.
2. Unscrew the cup table from the magnet shaft assembly.
3. Press the roll pin out of the thrust ring and remove the thrust ring. Take care not to bend the shaft. Replace the thrust ring if badly worn.
4. The upper bronze bearing may now be removed. Replace if badly worn.
5. Remove the snap ring. Replace is corroded or damaged. The carbon bearing or the 3-0073-1 Bronze Bearing may now be removed. Replace if badly worn.
6. Remove the hex head screw and washer from the other end of the shaft to remove the second bearing. Replace if badly worn.
7. Assemble in reverse order of disassembly.

12.10 Servicing the Outer Magnetic Drive Rotator

Make certain that the power to the instrument is disconnected before servicing the magnetic drive rotator. The rotator is very close to the heater terminals and severe shock or electrocution could occur if contact is made with a live heater circuit.

The inner shaft is composed of extremely powerful magnets. If these magnets are allowed to get too close to steel objects the magnetic force may cause injury or damage to the shaft. Also keep the shaft away from metal filings, as they will adhere to the shaft and cause premature wear.

1. Loosen two of the three setscrews on the outer magnetic drive support. The outer magnetic drive rotator assembly will fall off. It may be necessary to loosen the 3-0061 Magnetic Drive Sprocket to completely remove the rotator.

2. To remove the upper bearing, remove the retaining ring and slide the bearing out. Expect for excess wear and replace if needed.

3. To remove the lower bearing, remove the retaining ring and slide the bearing out. Inspect for excessive runout or rough operation and replace if necessary.

4. Removal of the inner magnet sleeve is usually not necessary and is not recommended.

5. Assembly is the reverse of disassembly.

12.11 Removal of the Magnetic Drive Housing

Make certain that the power to the instrument is disconnected before servicing the magnetic drive rotator. The rotator is very close to the heater terminals and severe shock or electrocution could occur if contact is made with a live heater circuit.

The inner shaft is composed of extremely powerful magnets. If these magnets are allowed to get too close to steel objects the magnetic force may cause injury or damage to the shaft. Also keep the shaft away from metal filings, as they will adhere to the shaft and cause premature wear.

1. Loosen two of the three setscrews on the outer magnetic drive support. The outer magnetic drive rotator assembly will fall off.

Use care when working near the heater terminals. They are easily bent or broken.

2. With a spanner wrench, loosen lock ring is found in the recessed hole in the bottom of the pressure vessel.

3. Push the magnetic drive housing up through the pressure vessel bore and out the top. It may be necessary to gently tap the housing with a hammer to break it loose if it is cemented in place. If cement contamination is severe, cement may have to be removed out through the bore of the pressure vessel before the housing can be removed.

4. Replace the Teflon o-ring prior to assembly.

5. Assembly is the opposite of disassembly.

12.12 Heater Replacement

Heater should be replaced if a hole burns through the sheath or if the heater fails to heat. The replacement steps are listed below.

Make certain that the power to the instrument is disconnected before servicing the heater. Severe shock or electrocution could occur if contact is made with a live heater circuit.

1. Remove the upper heater spreader from the pressure vessel bore.

2. Remove the contact pin shield.

3. Remove wires from the contact pins and the ground pin and note to which pin each wire is connected.

4. Remove the lower heater spreader.

5. Remove the magnetic drive rotator assembly as described above.

6. Remove wires from heater terminals.

7. Remove both heater nuts.

8. Tap on heater ferrules until loosened then pull heater out through bore of pressure vessel.

9. Make certain that heater gaskets came out with the heater. If the gaskets did not come out, a 7/16-inch bolt or rod inserted through the bottom of the heater holes will normally snag the gasket and push it out. In lieu of this, a screwdriver may be used to push the gasket out. Be careful not to damage the sealing surface inside the heater holes.

10. Clean the bottom of the pressure vessel and the heater holes before installing new heater. Assembly is the reverse of assembly.

A deep socket or a piece of 3/8-inch tubing may be placed over the heater terminals and used as punch to loosen the heater ferrules.

With the heater gaskets removed from the heater insure that the heater is bent so that it drops through the heater holes with minimal effort and that the heater coils lay flat against the pressure vessel bore. Forcing the heater into the holes usually deforms the heater and makes the slurry rub the heater. An installed heater is almost impossible to bend.

13 Troubleshooting

The following section consists of a table listing possible remedies for the most common consistometer problems.

Table 13-1 Troubleshooting Model 640 & 640 CC

Symptom	Cause(s)	Remedy
System builds pressure but will not hold pressure	Leak	Check fittings for leaks and tighten fittings. Heater ferrules, contact pins, and magnetic drive housing are also possibilities.
	PRESSURE RELEASE and AIR TO CYLINDER valves are not closed tightly	Close valves tightly.
	PRESSURE RELEASE or AIR TO CYLINDER valves worn out.	Replace valve stem or entire valve. PRESSURE RELEASE valve is most likely to wear out.
System builds pressure and oil runs out between pressure vessel and top plug.	Metal o-ring (C-0061) is scratched or dented.	Replace o-ring.
	O-ring sealing surfaces and/or seal shaft are worn, pitted, or scratched.	Lap o-ring sealing surfaces.
Pump strokes but little or no pressure is obtained.	Valve open, severe leak, blown rupture disc.	Locate problem and correct.
	Pressure vessel has trapped air.	Open thermocouple connector slightly and release trapped air.
	Oil reservoir is empty	Fill reservoir with oil
	OIL SUPPLY valve is closed (dual consistometer only)	Open OIL SUPPLY valve.
	AIR SUPPLY valve not opened or air not connected to instrument.	Connect air supply and open AIR SUPPLY valve.
	Severely clogged low-pressure filter.	Replace low-pressure filter element.
	Faulty pump check valve.	Clean and/or overhaul pump outlet check valve.
	No air supplied to air operated valve (if so equipped).	Check air lines leading to valve. Check valve solenoid valve. Restore air supply.
Pump builds and maintains pressure to a certain level than then stops.	If not oil is coming from pump muffler, oil reservoir ran dry.	Add oil to reservoir.
	If oil is coming from	Overhaul or replace pump.

	pump muffler, the pump high-pressure seal is probably worn out.	
Pressure cannot be released.	Stainless steel lines (3/8 inch) are plugged with cement.	Remove lines and inspect for blockage. Replace any that are plugged.
Air operated valves will not release pressure on units equipped with automatic pressure control.	If valves cannot be heard exhausting air, the problem is a faulty solenoid valve on the air-operated valve.	Repair or replace solenoid valve.
	If valves can be heard exhausting air, the problem is most likely a plugged capillary tube connected to the exit port of the valve.	Replace capillary tube.
Slurry cup rubs on heater or heater spreader.	Heater does not sit flush with bore of pressure vessel or heater spreaders missing.	Bend heater to sit flush with bore of vessel and add heater spreaders.
	Magnet drive bearings are worn.	Check bearings on inner magnet shaft and replace if necessary.
	Missing pin on slurry cup base.	Replace pin or base.
Slurry cup will not turn.	Magnetic drive severely contaminated with cement.	Remove magnetic drive plug and inner magnet shaft and clean magnetic drive thoroughly.
	Blown fuse on motor control board.	Check fuses on motor control board located inside electrical box.
	Faulty motor or controller.	Replace as necessary.
	Broken drive belt.	Replace drive belt.
Erratic motor speed control.	Magnetic pickup holder has come loose.	Check magnetic pickup holder on bottom magnetic drive and tighten if necessary.
	Worn out bearings in magnetic drive outer rotator.	Check rotator for excessive runout or wobble with motor running. Remove rotator and inspect bearings. Replace if necessary.
Consistency display always indicates zero.	Blown fuse.	Replace fuse.

	Measure voltage between blue and yellow contact pins. If voltage is zero, the 15 VDC power supply has failed or there is an open circuit in the blue or yellow wires.	Check the power supply output. If output is approximately 15 VDC, use and ohm meter to check for open circuits in the yellow or blue wires. Isolate and correct. If power supply voltage is zero when the yellow and blue wires are removed, replace the power supply. It the power supply voltage is 0 VDC when the wires are connected but 15 VDC when the wires are disconnected, there is a short circuit in the yellow wire.
	Broken potentiometer mechanism resistor.	With the potentiometer out of the instrument, check the resistance of the potentiometer resistor. If it is greater than 200Ω, replace the resistor.
	Broken or corroded potentiometer connecting strips.	Replace.
	Broken, severely worn, or corroded contact springs.	Inspect and replace if necessary.
	Broken or corroded ground pin.	Check electrical continuity between ground pin and cylinder. If continuity does not exist, replace ground pin.
	Faulty CONSISTENCY SPAN potentiometer.	Check electrical continuity between the two yellow connections on the potentiometer. If no continuity exists, replace the potentiometer.
Consistency meter always displays approximately 150 Bc.	Shorted contact pin.	Check electrical continuity between contact pins and cylinder. If continuity exists, replace contact pin. This does not apply to the ground pin, which always has continuity with cylinder.
Heater will not get hot.	Blown fuse.	Check fuses inside electrical box. Replace any that are blown.
	Loose heater wire.	Check heater terminals for loose wires and reconnect if

		necessary.
	Faulty heater.	Replace.
	Faulty solid state relay.	Replace.
Temperature display is erratic.	Faulty thermocouple.	Replace thermocouple.
	Loose connection in thermocouple wiring.	Check for loose wiring and correct if necessary.
Temperature displays and unusually high number (>1500°F)	Open circuit in thermocouple.	Replace thermocouple.
	Open circuit in thermocouple circuitry	Check thermocouple circuitry for open circuits or loose connections. Correct if necessary.
Oil comes out pump muffler. Pump may or may not stroke.	AIR TO CYLINDER valve has been opened while cylinder is pressurized, flooding the airlines and pump pneumatic side with oil.	Remove air lines and drain oil. Remove pump and disassemble pump pneumatic side to remove oil. If contamination is not too severe, you may let the pump stroke under no pressure until the oil is removed. This tends to create an oil mist that will fill the entire lab.
	Air lubricator is putting too much oil in the pump air.	Adjust lubricator to supply less oil.

14 Warranty and Returns

14.1 Warranty

Fann Instrument Company warrants only title to the equipment, products and materials supplied and that the same are free from defects in workmanship and materials for one year from date of delivery. THERE ARE NO WARRANTIES, EXPRESS OR IMPLIED OF MERCHANTABILITY, FITNESS OR OTHERWISE BEYOND THOSE STATED IN THE IMMEDIATELY PRECEDING SENTENCE. Fann's sole liability and Customer's exclusive remedy in any cause of action (whether in contract, tort, breach of warranty or otherwise) arising out of the sale, lease or use of any equipment, products or materials is expressly limited to the replacement of such on their return to Fann or, at Fann's option, to the allowance to Customer of credit for the cost of such items. In no event shall Fann be liable for special, incidental, indirect, consequential or punitive damages. Notwithstanding any specification or description in its catalogs, literature or brochures of materials used in the manufacture of its products, Fann reserves the right to substitute other materials without notice. Fann does not warrant in any way equipment, products, and material not manufactured by Fann, and such will be sold only with the warranties, if any, that are given by the manufacturer thereof. Fann will only pass through to Customer the warranty granted to it by the manufacturer of such items.

14.2 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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