INSTRUCTION MANUAL
MODEL 5550 Viscometer

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P/N: 5550-1050

S/N: _____

CHANDLER ENGINEERING®

AMETEK®

2001 N. Indianwood Ave.
Broken Arrow, Oklahoma 74012 U.S.A.
Telephone: 918-250-7200
Fax: 918-459-0165
E-mail: chandler.sales@ametek.com
Website: http://www.chandlereng.com

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General Information

Introduction

This manual contains installation, operation and maintenance instructions for the Chandler Engineering Model 5550 High Pressure High Temperature Viscometer.

Purpose and Use

The Chandler Model 5550 pressurized viscometer is a compact instrument designed to measure the rheological properties of common oil field fluids. It incorporates numerous innovations, which address long awaited needs of the industry, including user friendliness, improved measurement technology, temperature performance, and ease of service.

Description

The Chandler Engineering Model 5550 Viscometer is a high pressure high temperature viscometer designed to test a variety of oilfield fluids with superior reproducibility and ease of use.

The viscometer can be equipped with a variety of bob and rotor combinations. This provides the user with a wide measurement range in addition to providing different gap sizes depending upon the fluid being tested.

The measurement fluid is contained within the annular space or shear gap between the rotor and bob. The rotor is rotated at known velocities (shear rates) and the viscous drag exerted by the test fluid creates torque on the bob. This torque is transmitted to a precision encoder. The torque is measured and related to shear stress. The equations used to calculate the fluid viscosity are presented later in the manual (*Viscosity Calculations* in *Section 2 – Operating Instructions*).

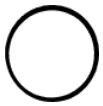
Features and Benefits

- Fully automated viscometer for control and data acquisition.
- Easy to set-up, easy to operate, easy to clean and maintain.
- Broad range of sensitivity/scalability through the use of different rotor/bob and spring combinations to accommodate a wide variety of fluid types.
- Precision machining of the rotor, the bob, and support pieces allow perfect alignment each time the instrument is used.
- Comprehensive, easy to use and flexible software
- Automated calibration.
- Dry, high performance heater bath
- Gel climb arrestor assures accurate measurement of difficult fluids
- Enhanced service features:
    - Seal replacement without disassembly of head
    - Easy bearing replacement
- Hastelloy C-276 wetted components standard

Specifications

Maximum Sample Temperature:	500°F / 260°C
Maximum Sample Pressure:	2000 psi / 13.9 MPa
Operating Temperature Range:	32-500°F / 0-260°C
Main Input Voltage:	230 VAC, 50/60 Hz, 6A Max
Power:	1200 Watts / 6A @ 220V
Environment:	Indoor use, altitude up to 6562 feet / 2000m
Ambient Temperature:	60-120°F / 16-50°C
Storage Temperature:	40-120°F / 5-50°C
Max Relative Humidity:	80% RH for temperatures up to 88°F / 31°C Decreasing linearity to 50% RH at 104°F / 40°C
Nitrogen Inlet:	0-2000 psi
Instrument Dimensions:	11 in./ 30 cm x 16 in./ 41 cm x 25 in./ 56 cm
Shipping Dimensions: cm	**Instrument**: 37 in./ 94 cm x 29 in./74 cm x 39 in./ 99 **Spares, Accessories, & PC**: 37 in./ 94 x 34 in./ 86 x 39 in./99 cm
Net Weight:	80 lbs / 36 kg
Shipping Weight:	Instrument: 270 lb / 86 kg Spares, Accessories, & PC: 216 lb / 97.98 kg
Shear Rate Accuracy:	± 0.01 rpm
Operating Speeds:	0.01 – 1000 rpm
Shear Rate Range:	See Table 1

Symbols Used on Equipment

Symbol	Meaning
	Protective Conductor Terminal
	Caution, hot surface. Do NOT touch. Allow to cool before servicing.
	On (Supply)
	Off (Supply)
	Warning, Potential Hazard

Symbols Used in this Manual

Symbol	Meaning
	Note, Important Information
	Warning, Potential Hazard

Rheology Equations

The following equations are used to calculate the values for Shear Stress, Shear Rate, and Viscosity in the 5550 HPHT Viscometer:

$$Angular\ Velocity, \omega = RPM\frac{2\pi}{60}\ , sec^{-1}$$

$$Shear\ Rate,\ \ \gamma = 2\omega\frac{{R_o}^2}{{R_o}^2 - {R_i}^2}\ , sec^{-1}$$

$$Shear\ Stress, \tau = \frac{M}{2\pi {R_i}^2 L}\ , \frac{dyne}{cm^2}$$

$$Viscosity, \mu = \frac{\tau}{\gamma}\ , \frac{dyne - sec}{cm^2}, Poise$$

$$Dial\ Reading, \theta = \frac{\tau 2\pi {R_i}^2 L}{F}, cPoise$$

$$Plastic\ Viscosity\ = \theta_{600} - \theta_{300}\ , cPoise$$

$$Yield\ Point = \theta_{300} - Plastic\ Viscosity\ , lbf/100ft^2$$

$$Apparent\ Viscosity = \frac{\theta_{600}}{2}, cPoise$$

Where,

RPM= Motor Speed (Revolutions Per Minute)
R_o= Rotor Radius, cm
R_i= Bob Radius, cm
M= Torque on Bob shaft (dyne-cm)
L= Bob Height, cm
F= 386 (F1 Spring Constant)

The Plastic Viscosity and Yield Point equations above require Dial Readings at the specified motor RPM. If those speeds are used, PV and YP are calculated as above. Otherwise, they are calculated from the Model.

Rheological Models

The Rheo software system automatically calculates values for the following rheological models:

Bingham Plastic Model

The Bingham Plastic Model is expressed as:

$$\tau = YP + PV(\gamma)$$

Where:

τ = Shear Stress

YP = Yield Point

PV = Plastic Viscosity

γ = Shear Rate

For these calculations, the Rheo software automatically collects data at a rate of 1 sample per second for each desired schedule step. The average of this data is calculated for each schedule step and applied to the following formula:

$$PV = ((\Sigma\gamma_{avg} * \Sigma\tau_{avg}) - (N * \Sigma\gamma_{avg}\tau_{avg})) / ((\Sigma\gamma_{avg})^2 - (N * \Sigma\gamma_{avg}^2))$$
$$YP = ((\Sigma\gamma_{avg}\tau_{avg} * \Sigma\gamma_{avg}) - (\Sigma\tau_{avg} * \Sigma\gamma_{avg}^2))/((\Sigma\gamma_{avg})^2 - (N * \Sigma\gamma_{avg}^2))$$

Where:

γ_{avg} = Average Shear Rate for an individual schedule step

N = Number of schedule steps

The accuracy of the model is expressed as:

$$R^2 = 1 - (\Sigma\varepsilon_i^2/(\Sigma\gamma_{avg}^2 - (\Sigma\gamma_{avg})^2 / N)$$

Where ε_i represents the difference between the measured shear stress and the calculated shear stress using the Bingham Plastic equation $\tau = YP + PV(\gamma)$ for schedule step i.

For a perfect model, $R^2 = 1$.

API RP 13D defines “simplified” calculations that use the Dial Reading at 300 and 600 RPM. If these speeds exist in the schedule, the simplified calculations are used for Yield Point and Plastic Viscosity. Otherwise, the model described above is used. The R^2 value is always calculated as described above.

Power Law Model

The Power Law Model is expressed as:

$$\tau = K * \gamma^n$$

Where:

τ = Shear Stress

K = Consistency

n = Power Law Exponent

γ = Shear Rate

For these calculations, the Rheo software automatically collects data at a rate of 1 sample per second for each desired schedule step. The average of this data is calculated for each schedule step and applied to the following formula:

$$n = ((\Sigma Log_{10}(\gamma_{avg}) * \Sigma Log_{10}(\tau_{avg})) - (N * \Sigma Log_{10}(\gamma_{avg})Log_{10}(\tau_{avg}))) / ((\Sigma Log_{10}(\gamma_{avg}))^2 - (N * \Sigma Log_{10}(\gamma_{avg})^2))$$

$$K = 10\text{^}((\Sigma Log_{10}(\gamma_{avg})Log_{10}(\tau_{avg}) * \Sigma Log_{10}(\gamma_{avg})) - (\Sigma Log_{10}(\tau_{avg}) * \Sigma Log_{10}(\gamma_{avg})^2))/((\Sigma Log_{10}(\gamma_{avg}))^2 - (N * \Sigma Log_{10}(\gamma_{avg})^2))$$

Where:

τ_{avg} = Average Shear Stress for an individual schedule step during the data collection period.

γ_{avg} = Average Shear Rate for an individual schedule step

N = Number of schedule steps

The accuracy of the model is expressed as:

$$R^2 = 1 - (\Sigma \varepsilon_i^2/(\Sigma Log_{10}(\gamma_{avg})^2 - (\Sigma Log_{10}(\gamma_{avg}))^2 / N)$$

Where ε_i represents the difference between the base-10 logarithm of measured shear stress and the calculated shear stress using the Power Law equation $\tau = K \times \gamma^n$ for schedule step i.

For a perfect model, $R^2 = 1$.

Herschel-Bulkley Model

The Herschel-Bulkley Model is expressed as:

$$\tau = YP + K * \gamma^n$$

Where τ = Shear Stress
YP = Yield Point
K = Consistency
n = Power Law Exponent
γ = Shear Rate

For these calculations, the Rheo software automatically collects data at a rate of 1 sample per second for each desired schedule step. The average of this data is calculated for each schedule step and applied to a nonlinear least-squares regression analysis to arrive at the model described above.

Casson Model

The Casson Model is expressed as:

$$F^{1/2} = k_0 + k_1 D^{1/2}$$

Where F = Shear Stress
k_0 = Yield Point
k_1 = Plastic Viscosity
D = Shear Rate

For these calculations, the Rheo software automatically collects data at a rate of 1 sample per second for each desired schedule step. The average of this data is calculated for each schedule step and applied to formulas similar as used in the Bingham Plastic model except the square root of Shear Stress and Shear Rate are used.

The Casson model allows for “simplified” calculations that use the Dial Reading at 100 and 600 RPM. If these speeds exist in the schedule, the simplified calculations are used for Yield Point and Plastic Viscosity. Otherwise, the model described above is used. The R^2 value is always calculated as described above.

Table 1 - Shear Rate Range

	Shear Rate for Specified RPM (sec-1)					
RPM	**R1/B5**	**R1/B5X**	**R1/B1**	**R1/B1X**	**R1/B2**	**R1/B2X**
0.1	0.09	0.09	0.17	0.17	0.04	0.04
0.2	0.17	0.17	0.34	0.34	0.08	0.08
0.3	0.26	0.26	0.51	0.51	0.11	0.11
0.6	0.51	0.51	1.02	1.02	0.23	0.23
1.0	0.85	0.85	1.70	1.70	0.38	0.38
2.0	1.70	1.70	3.40	3.40	0.75	0.75
3.0	2.55	2.55	5.11	5.11	1.13	1.13
6.0	5.10	5.10	10.2	10.2	2.26	2.26
10	8.50	8.50	17.0	17.0	3.77	3.77
20	17.0	17.0	34.0	34.0	7.54	7.54
30	25.5	25.5	51.1	51.1	11.3	11.3
60	51.0	51.0	102	102	22.6	22.6
100	85.0	85.0	170	170	38	38
200	170	170	340	340	75	75
300	255	255	511	511	113	113
600	510	510	1021	1021	226	226
1000	850	850	1702	1702	380	380
Sample Volume (ml)	52	44	42	31	77	73

Safety Requirements

READ BEFORE ATTEMPTING OPERATION OF INSTRUMENT

	*If this equipment is not used in a manner consistent with the manufacturer's specifications the protection provided by the equipment may be impaired.*
	**Warning: Read before attempting operation of this instrument.** This instrument is capable of high temperatures and pressures and must always be operated with CAUTION. The instrument is designed for operator safety. To ensure that safety, it is essential the general instructions outlined below are followed. This instrument should only be operated by trained personnel that have completed the appropriate safety training.
	**Warning: High Temperatures** During a test, the instrument can become hot and cause injury if touched. Allow the cylinder to cool to below 95°F / 35°C prior to touching.

The following safety procedures are advisable:

- Use appropriate Personal Protective Equipment such as safety glasses, latex gloves, etc.
- This is a bench top device; place the instrument on a suitable, level, and stable surface.
- Locate the instrument in a low traffic area. Allow a minimum of 12 in. / 305mm unobstructed clearance around side, back and top faces to provide for adequate ventilation. Position the back of the instrument to allow access to disconnect cords in the event of an emergency.
- Use the lifting handle and latching knob to move the heater bath.
- Never exceed the instrument maximum temperature ratings. The particular safety requirements associated with the handling and use of the medium to be tested, especially the additional requirements associated with handling potentially flammable liquids or otherwise hazardous agents are the responsibility of the customer – proper precautions must be taken to reduce the risk of fire or explosion.
- Always disconnect main power to the instrument before attempting any repair.
- Keep hands and clothing away from rotating components.
- Operate equipment with safety shields properly installed.
- Have the safety officer at your location review the safety aspects of the instrument and this manual and approve the operational and installation procedures.
- Observe and follow the warning labels on the instrument and observe caution notes!

Do not use bearings that have been dropped or have been allowed to touch the magnets. Accurate measurements cannot be made with bearings that have been dropped or slightly magnetized.

Before attempting to operate the instrument, the operator should read and understand this manual.

Where to Find Help

In the event of problems, contact your local sales representative or Chandler Engineering:

- Telephone: 918-250-7200
- Fax: 918-459-0165
- E-mail: chandler.sales@chandlereng.com
- Website: www.chandlereng.com

Instrument training classes are also available.

Section 1 – Installation

Unpacking the Instrument

Remove the instrument from the packing crate carefully. The unit comes fully equipped with all the necessary components and ordered spare parts. Make sure that no parts are lost when discarding the packing materials. Place the instrument on a firm table, close to the required service connections.

After the instrument is removed from the shipping crate, the equipment and spare parts should be checked against the packing list to ensure that all parts have been received and none are damaged.

File an insurance claim with your freight carrier if damage has occurred during shipping. Verify all parts shown on the enclosed packing list have been received. If items are missing, immediately notify Chandler Engineering.

Tools/Equipment Required

Adjustable Wrench
Allen Wrench Set
5/16 inch open end wrench
7/16 inch open end wrench
9/16 inch open end wrench
#2 Phillips Head Screwdriver

Instrument Setup

1. Leave computer off until instructed to turn it on. This will insure proper installation of drivers later in the process.

2. Install the USB serial port hub by connecting the USB cable from the hub to the PC, and connecting the two (2) supplied Serial Communication Cables from the hub to the "MOTOR" and "DATA" ports on the rear panel of the Viscometer:

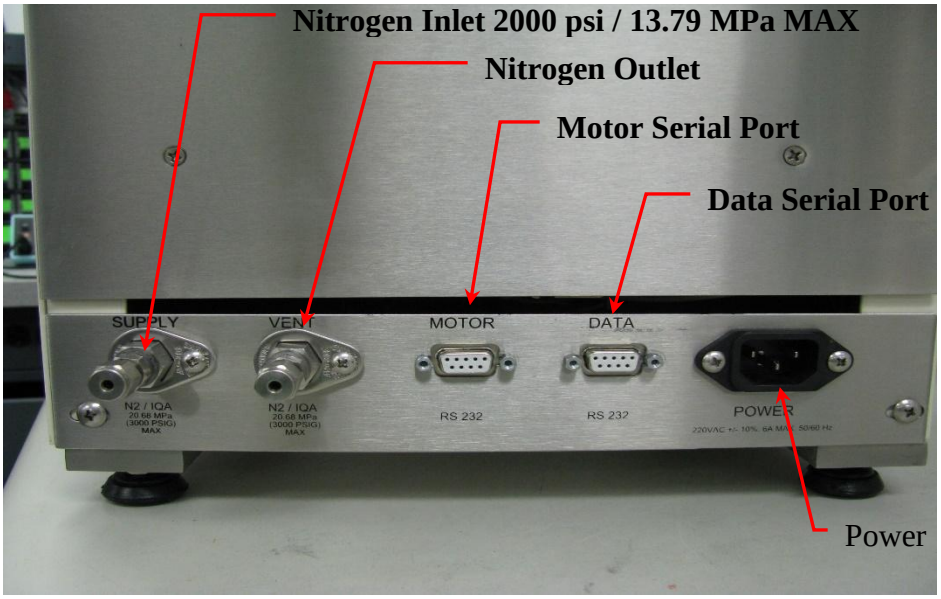


Figure 1-1 Rear Panel

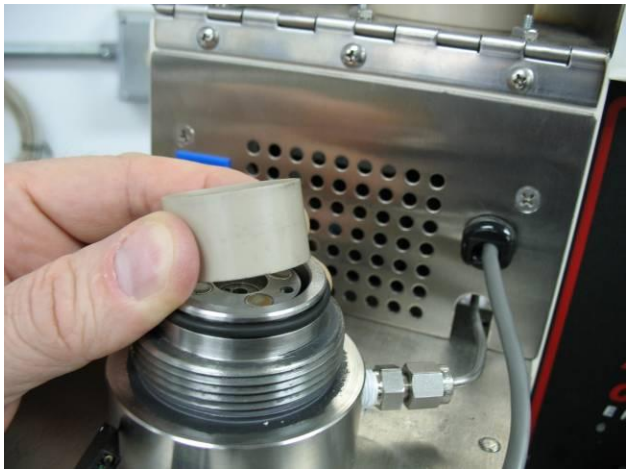
3. Connect the nitrogen source.

4. Connect the power cable.

Warning: Verify that the proper input voltage is applied before connecting power (110 VAC or 240 VAC).
Damage can occur if the wrong line voltage is applied, verify that the proper input voltage is applied. To prevent shock hazard, connect the instrument to an electrical outlet using a three-prong socket to provide positive ground.

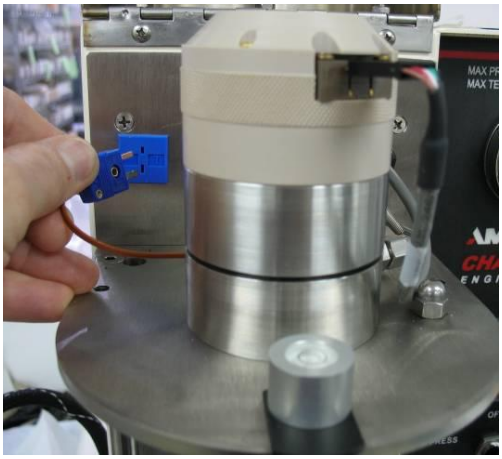
5. Install bob-shaft assembly. Make sure that the slot in the bob-shaft assembly aligns with the pressurization tube.

6. Install the spacer.

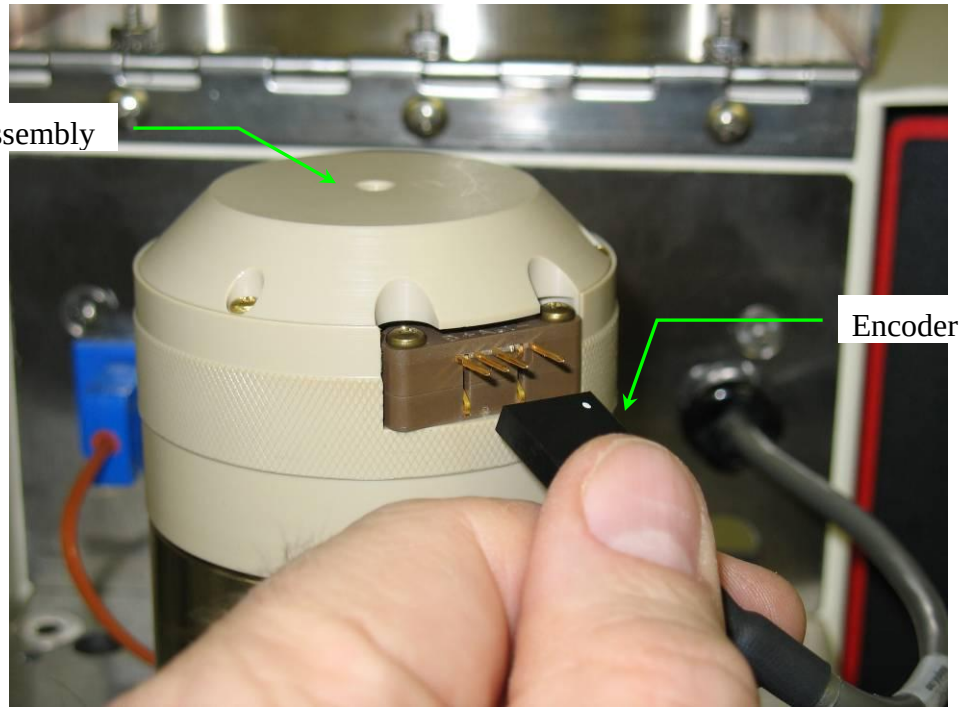


7. Screw on the threaded cap.

8. Install the thermocouple, being careful not to flex or bend it. Bending the thermocouple can cause it to contact the wall of the bob-shaft which will affect the measurement or even prevent a measurement from being possible. Tighten the thermocouple so that it is positioned approximately as shown which will properly position the encoder assembly in the next step. Plug the thermocouple into the bulkhead connector.



9. Install the encoder assembly on the top of the viscometer and connect the encoder cable. The encoder is a very low-friction assembly that contains jewel bearings and should be handled with care.



The instrument is tested and calibrated at the factory before shipment, but it is recommended that it be calibrated before first use. See the Maintenance Section of this manual for calibration instructions.

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Section 2 – Operating Instructions

Accurate measurements are dependent upon having a clean and well-maintained instrument. Always remove the cup and bob for cleaning after each use of the instrument, and protect them from dents, scratches, abrasions, and other damage.

Test Preparation

This section is intended to provide a brief overview of how to start an automated test. The complete functionality of the software is described in the Software Operation section below.

1. Turn on the instrument using the power switch located on front panel.

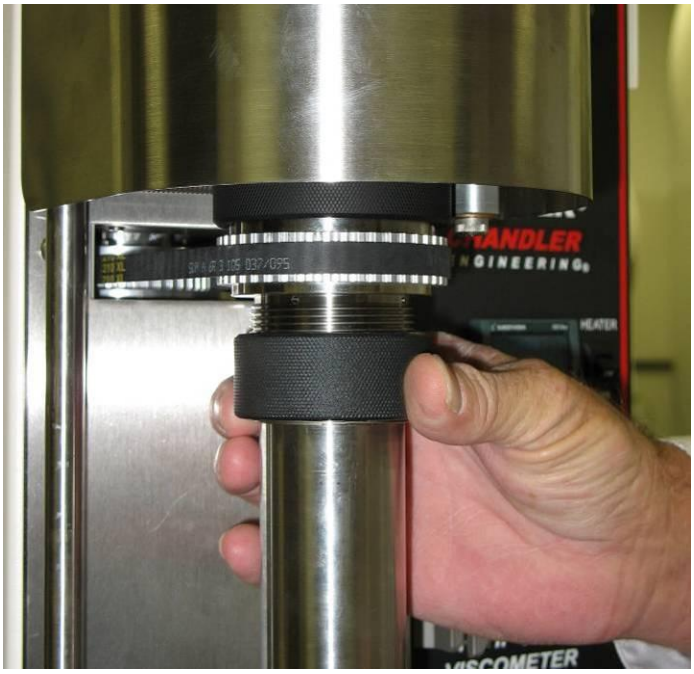
2. Lower the heater bath. Remove the sample cup by applying firm upward pressure to the cup while unscrewing the retaining ring.

3. Install the Climb Arrestor. Push toward the top of the instrument until it snaps into place.

4. Install the bob onto the shaft gently so as not to induce unnecessary shock to the encoder or bearings. This is a left-hand thread so rotate counterclockwise to install.

5. Fill the cup with the appropriate volume of fluid, per Table 1 in *Specifications* found in the *General Information* section of this manual, and mount onto rotor.

6. Install the cup and tighten the retaining ring to secure the cup to the instrument.



7. Turn the computer ON and start the Rheo 5000 software.

8. From the File menu, create a new instrument or open a previously created instrument.

9. If necessary, Calibrate the instrument (see Software Calibration)

10. Set up the schedule to run as desired. See the Automated Instrument Operation section below for detailed instructions on how to set up a schedule.

11. Fill the sample cup with an appropriate amount of the fluid to be tested. Refer to Table 1 in *Specifications* found in the *General Information* section of this manual for sample volumes for each rotor/bob combination.

12. Attach the cup to the instrument and apply the desired pressure (maximum pressure of 2000 psi).

13. Tare the torque measurement by clicking the “Tare” button.

14. In the “Log File” section of the main screen, specify the log interval between ramps and during ramps.

15. On the “Parameters” tab, set the desired rotor speed control units and viscosity stabilization criteria. In the “File Header Information Text Box” enter any desired test information. This information will be appended to the data file.

16. Raise the bath so that it is in place and ready for testing. No preheating of the bath is necessary. To raise the heater bath, use the lever on the bottom front of the heater bath for support and slide up into place. Pull the knob on the right side of the heater bath to allow it to click into position (see picture below).

The temperature read-out on the front of the instrument is the bath temperature NOT the sample temperature. The sample temperature should be viewed on the computer monitor. The bath temperature may be slightly higher than the sample temperature.

17. On the main screen, choose automatic under "Rotor Control" and under "Pressure / Temperature Control."

18. Click the "Start Schedule" button. A dialog will appear asking to start the data logger. If "Yes" is selected, another dialog will appear asking for the file name and location.

19. Allow the test to run. The test data may be displayed on the screen during test by selecting the desired plot from the "Plot" menu.

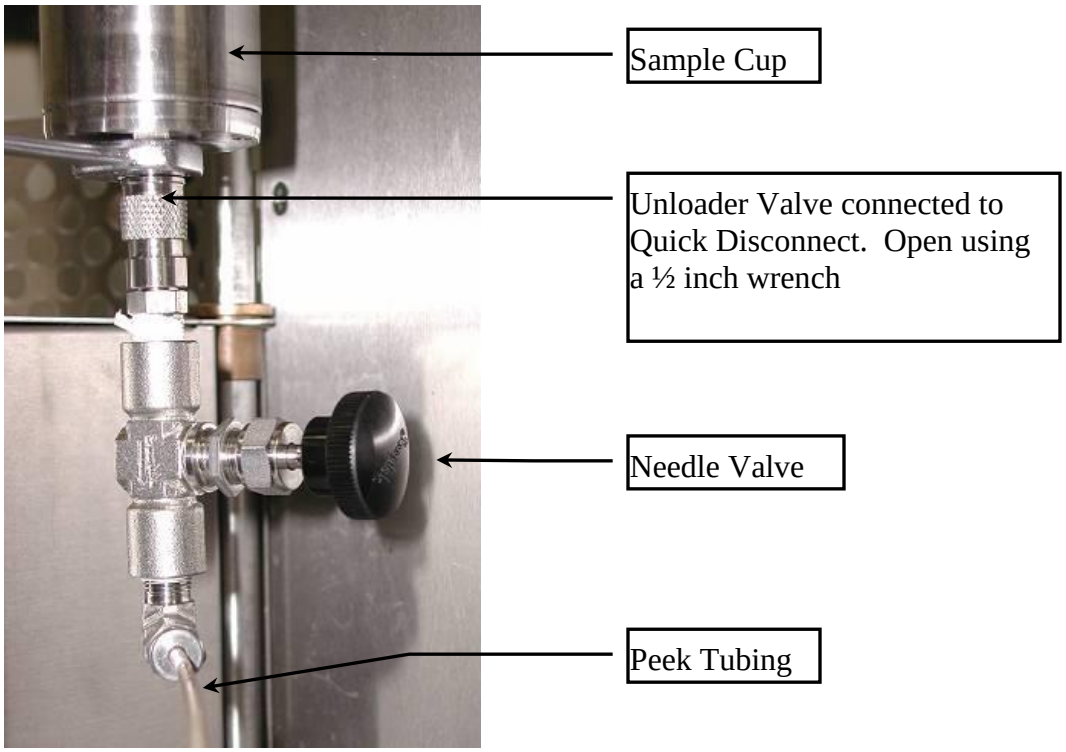
Test Completion and Clean-up

1. Be sure that the heater is off and the test is complete. Verify that the rotor has stopped turning.
2. Lower heat bath from the rotor.
3. Cool the sample to temperature to below 100^{o}F before proceeding. If rapid cooling is desired, a cup of cool water can be used to cool the rotor.
4. Slowly release pressure from the system using the unloader valve on the bottom of the rotor (See Using the Unloader Valve). **Relieving the pressure using the vent valve will allow fluid migration into the bob-shaft bearings which will then need to be replaced. Relieving the pressure using the pressure regulator will contaminate the regulator which will then need to be replaced.**
5. Remove, empty and thoroughly clean the rotor and bob using soft brushes and appropriate cleaning agents for removing the fluid being tested.

Using the Unloader Valve

1. Close the needle valve on the assembly prior to connecting to the unloader valve.
2. Attach the needle valve and plumbing to the unloader valve located on the bottom of the rotor by sliding the quick-disconnect onto the unloader valve stem. The quick-disconnect should lock onto the unloader valve stem.
3. Place the Peek tubing into the sample collection container.
4. Open the unloader valve by turning the valve 1/4 turn counterclockwise.
5. Use the needle valve to slowly bleed the pressure into the sample collection container.
6. After the fluid and pressure have been released through the bottom port, turn the valve on the front panel to the vent position.

Figure 2-5 Unloader Valve



Software Operation

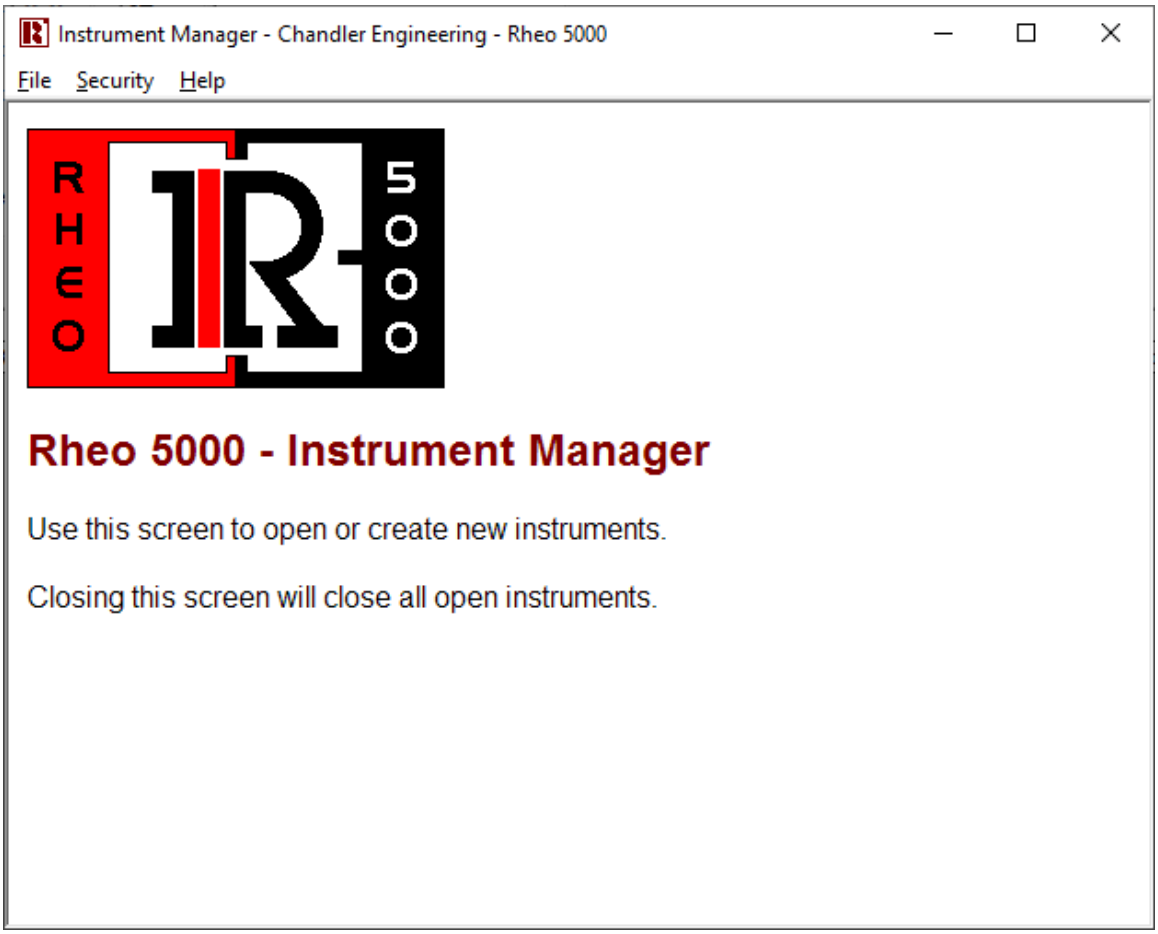
The 5550 Rheometer can be operated remotely via PC serial interface, using the supplied Rheo 5000 software. This section provides details on each of the software functions. Online documentation is also available under the Help menu.

Major Features of Rheo 5000

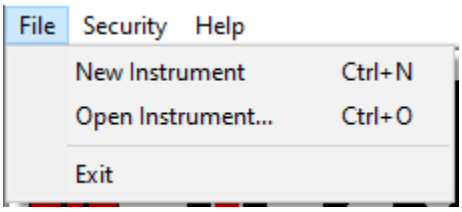
- Remote control of a stepping motor system to provide rotor speeds (step changes, linear ramps, constant speed)
- Automatic calibration of torque measurement using a Newtonian calibration oil.
- Data storage in an Excel compatible file.
- Automatic calculation of Bingham Plastic, Power Law, Herschel-Bulkley and Casson Parameters.

Instrument Manager Window

The Rheo 5000 software is cable of running multiple independent instruments. These instruments are opened from the Instrument Manager window.



File Menu



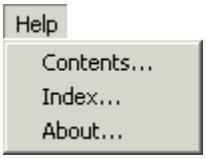
- **New Instrument** – starts the process of defining a new Instrument. The software will ask for:
  - Instrument Type: Normal Operation or Simulation Mode
  - Instrument Name
  - After entering the above information, a new Instrument window will appear.
- **Open Instrument** - Opens an existing instrument file, effectively connecting the software to the rheometer.
- **Exit** – Exits the Rheo 5000 software. If any Instrument windows are open, any running tests will be stopped (the user will be prompted to confirm) and the software will exit.

Security Menu

The security menu allows different user access levels. If enabled, an Administrator password is required for the creation of custom schedules.
To prevent a user from entering custom schedules, the Restricted User setting must be selected. When selecting Administrator, a password prompt will appear, unless no Administrator password has been specified.

To specify an Administrator password, select Change Password. To disable the administrator password protection, simply enter the Administrator password in the Old Password entry box and leave the New Password and Confirm entries blank.

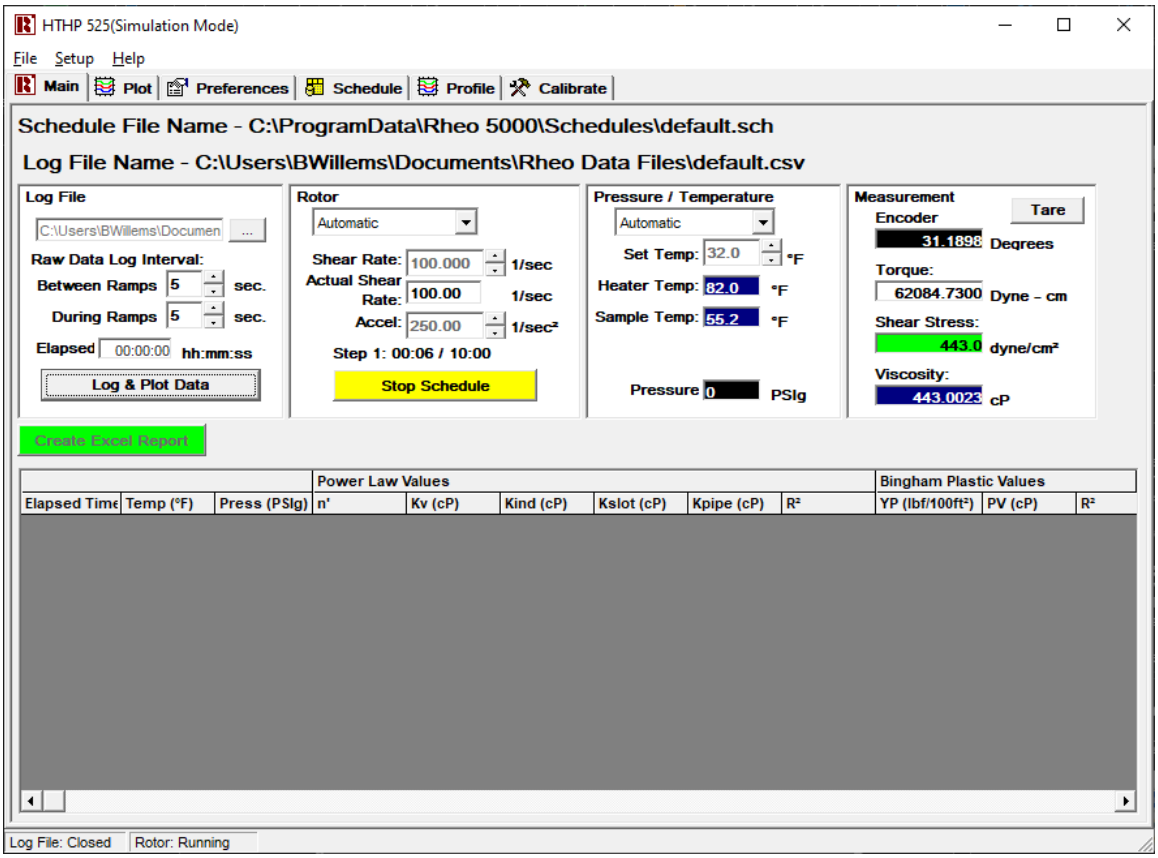
Help Menu



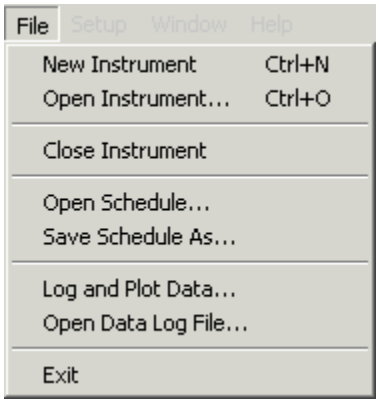
The Help menu provides access to the online help system (Contents and Index). About displays the About dialog showing software version number, contact information, etc.

Instrument Window

The Instrument Window provides all displays and indicators to operate a single 5550 Rheometer. Multiple Instrument Windows can be open and operated independently.



File Menu



The File menu provides access to the following commands:

- **Open Instrument** - Opens an existing instrument file, effectively connecting the software to the rheometer.

- **Close Instrument** - Closes an open instrument file, effectively disconnecting the software from the rheometer.

- **Open Schedule** - Used to open an existing test schedule that is stored on the disk drive. Test schedules use a proprietary binary file format that is only recognizable by the Rheo software.

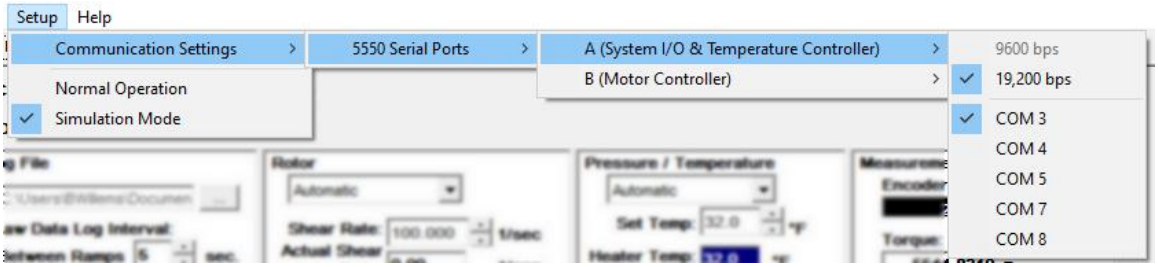
- **Save Schedule As** - Used to save an open schedule file to a new file name.

- **Log and Plot Data** - Starts logging data to a ".csv" file and resets the data plot. The ".csv" file extension is recognized by Microsoft Excel. Thus, a log file may be opened by double-clicking on its icon from within Windows, or from within Excel. Raw data is logged to the specified file, as well as Bingham Plastic and Power Law calculations.

- **Open Data Log File** - Opens an existing data log file, displaying its contents in the data plot and in the calculation grid.

- **Exit** - Exits the program.

Setup Menu



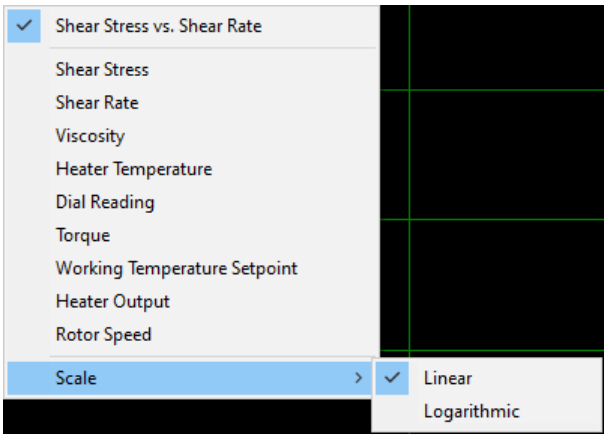
The Setup menu provides access to the following commands:

- **Communication Settings** - The communication settings sub-menu allows assignment of a specific PC serial ports for Data (A) and Motor (B) to the Model 5550 Instrument.

- **Normal Operation** - When selected, this option allows the software to communicate with the instrument.

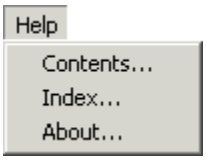
- **Simulation Mode** - When selected, this option allows the software to operate without the presence of an instrument. If an instrument is connected, it will be ignored in simulation mode, and no rheological tests can be performed without first selecting **Normal Operation**.

Plot Menu



The plot menu is only visible when the Plot Tab is selected. The same menu can be shown by right-clicking anywhere in the Plot area on the Plot Tab. This menu shows a list of available channels for display.

Help Menu

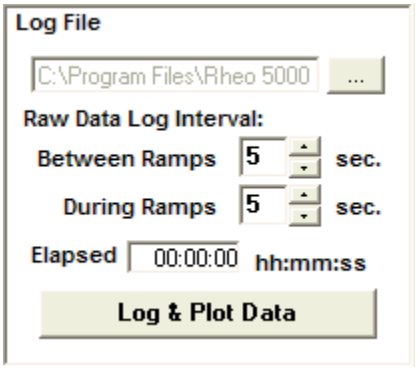


The Help menu provides access to the online help system (Contents and Index). About displays the About dialog showing software version number, contact information, etc.

Main Software Tab

The Main Tab provides feedback and allows the user to control a test. It is divided into the following sections:

Log File



Allows a user to specify the following parameters for data logging and trending:

- The **Raw Data Log Interval** parameters define how often a data point for each measurement is written to the log file.

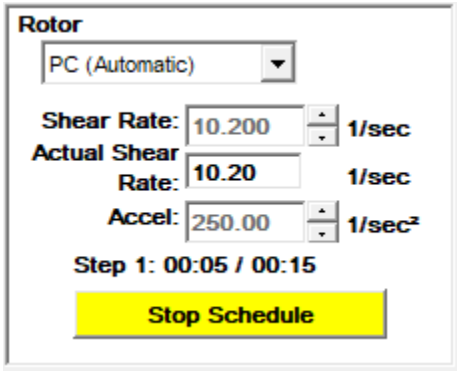
    - Between Ramps - Defines the log interval for manual operation, or for schedule steps where the raw data checkbox is selected but the model data checkbox is not selected.

    - During Ramps - Defines the raw data log interval for schedule steps where the raw data and model data checkboxes are selected.

- **Elapsed Time** displays the elapsed time in hours, minutes and seconds since an active log file was started.

- **Log & Plot Data** allows the user to start and stop Data Logging. Clicking this button will clear the Plot.

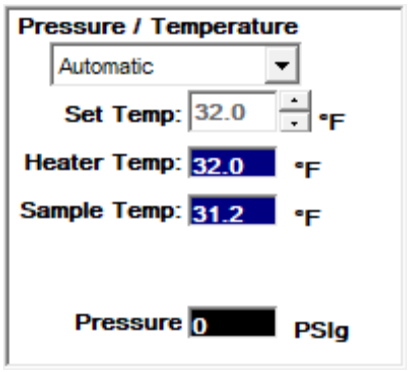
Rotor Control



Allows a user to start and stop a schedule, or control the rotor manually using the following parameters:

- Control Mode
    - **PC (Manual)** - the rotor may be controlled manually through the software. In this mode, any parameters specified in the loaded schedule are ignored.
    - **PC (Automatic)** - the rotor is controlled via the current schedule.
    - **Dial (Manual)** - the rotor is controlled via the built-in speed control dial on the instrument.
- **Shear Rate or Rotor Speed -** allows the user to manually enter a desired rotor speed, when Manual Mode is selected. When Automatic mode is selected, the shear rate from the current schedule stage is displayed. Units are defined on the Preferences Tab.
- **Actual Shear Rate or Rotor Speed -** displays the current rotor speed. Units are defined on the Preferences Tab
- **Accel -** allows the user to prescribe an acceleration/deceleration rate. If the motor stalls during a run, the acceleration rate should be decreased to 250 or lower.
- **Step Indicator -** shows the run time of the current step vs the total run time of the current step.
- **Start / Stop Schedule -** allows the user to start and stop the currently loaded schedule.

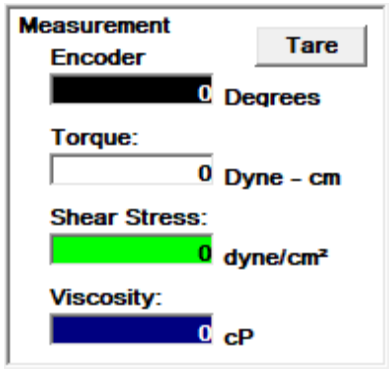
Pressure / Temperature



Allows the user to start and stop Temperature control.

- **Control Mode**
  - **Automatic** - Temperature is controlled via the current schedule.
  - **Manual** - Temperature may be controlled manually through the software. In this mode, any parameters specified in the loaded schedule are ignored.
- **Set Temp -** Displays the current set point. When **Control Mode** is **Automatic**, the set point is updated automatically by the software. When **Control Mode** is **Manual**, the user may enter the Set Point.
- **Heater Temp -** Displays the current Temperature as read from the controller. Units are defined on the Preferences Tab.
- **Sample Temp –** Displays the current Temperature as read for the Sample Thermocouple. Units are defined on the Preferences Tab. This input is Calibrated on the Calibrate Tab.
- **Pressure –** Displays the current Pressure as read from the Pressure Transducer. Units are defined on the Preferences Tab. This input is Calibrated on the Calibrate Tab.

Calculations



Displays values for the following measured and calculated values:

•**Encoder (Degrees)** - Measured directly from the dial. Zero this reading by clicking the **Tare** button.

•**Torque (Dyne - cm)** - Based on the lookup table generated during instrument calibration.

- **Shear Stress (Dyne/cm^2)** - Based on the following formula:

$$\tau = \frac{Torque(Dyne \cdot cm)}{2\pi \cdot BobRadius(cm)^2 \cdot BobLength(cm)}$$

- **Viscosity (cP)** - Apparent Viscosity, based on the following formula:

$$\mu = \frac{ShearStress\left(\frac{Dynes}{cm^2}\right)}{ShearRate\left(Sec^{-1}\right)}$$

Calculation Grid

Elapsed Time	n'	Kv (cP)	Kinf (cP)	Kslot (cP)	R²	YP (dyne/cm²)	PV (cP)	R²
00:07:04	0.956790	121.1515	120.816	122.5556	0.999032	4.398339	94.56212	0.998403

The Calculation Grid displays a list of automatically generated Model calculations. By default, only the Model results are shown. Right-click on the Grid and check or uncheck "Show Details" to show or hide the individual Model Data points

Model Calculations

The Rheo 5000 Software provides automated calculation of several rheological models. These values are logged to a data file if the logger is enabled during a test.

To generate these calculations the following steps are performed:

1. The user must define a schedule that includes a series of contiguous checked boxes in the "Log Model Data" column.

2. The schedule is executed by pressing the "Start Schedule" button on the Main Tab.

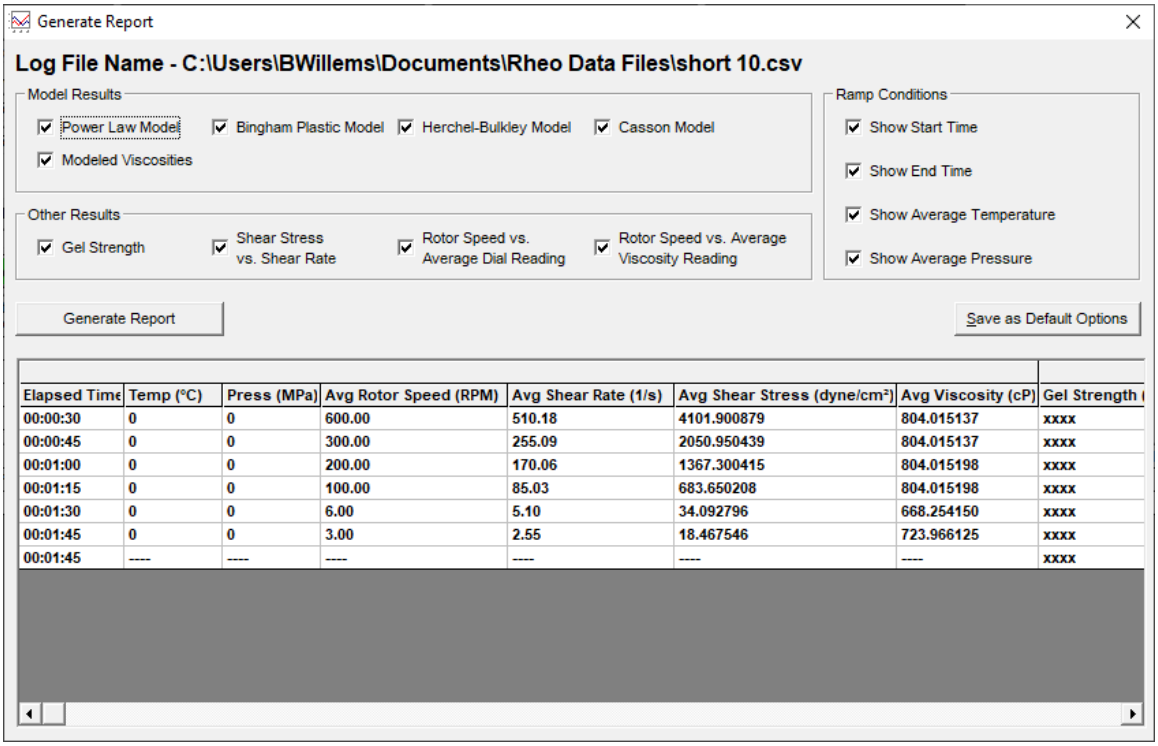
3. For each schedule step with the check box selected in the "Log Model Data" column, a data point depicting shear stress vs. shear rate is collected. Each data point is generated by averaging data (1 sample per second) over a specific time window (Viscosity Stabilization Criteria on the Preferences Tab). The window ends when the next step in a schedule is encountered. For example, if the user has entered 15 seconds for the Viscosity Stabilization value and a schedule step has a duration of 20 seconds, data will be collected once per second over the last 15 seconds of the schedule step and the average will become a single data point for Model calculation.

4. When either a schedule step with an unchecked box in the "Log Model Data" column is encountered, or the end of a schedule is encountered, the series of data points are used to calculate a set of Model values.

5. Each valid calculation is recorded in the data log file and displayed on the Calculation Grid of the Main Tab.

Generate Report Window

The Generate Report Window is opened when the user clicks the “Create Excel Report” button on the Main tab of the Instrument Window. This window will send a report directly to Excel. Microsoft Excel must be installed.



Elapsed Time	Temp (°C)	Press (MPa)	Avg Rotor Speed (RPM)	Avg Shear Rate (1/s)	Avg Shear Stress (dyne/cm²)	Avg Viscosity (cP)	Gel Strength
00:00:30	0	0	600.00	510.18	4101.900879	804.015137	xxxx
00:00:45	0	0	300.00	255.09	2050.950439	804.015137	xxxx
00:01:00	0	0	200.00	170.06	1367.300415	804.015198	xxxx
00:01:15	0	0	100.00	85.03	683.650208	804.015198	xxxx
00:01:30	0	0	6.00	5.10	34.092796	668.254150	xxxx
00:01:45	0	0	3.00	2.55	18.467546	723.966125	xxxx
00:01:45	----	----	----	----	----	----	xxxx

Model Results: Select the desired Model(s) to include in the generated report. Each Model is a separate page. If **Modeled Viscosities** is checked, a Modeled Viscosities section will be added to each selected Model.

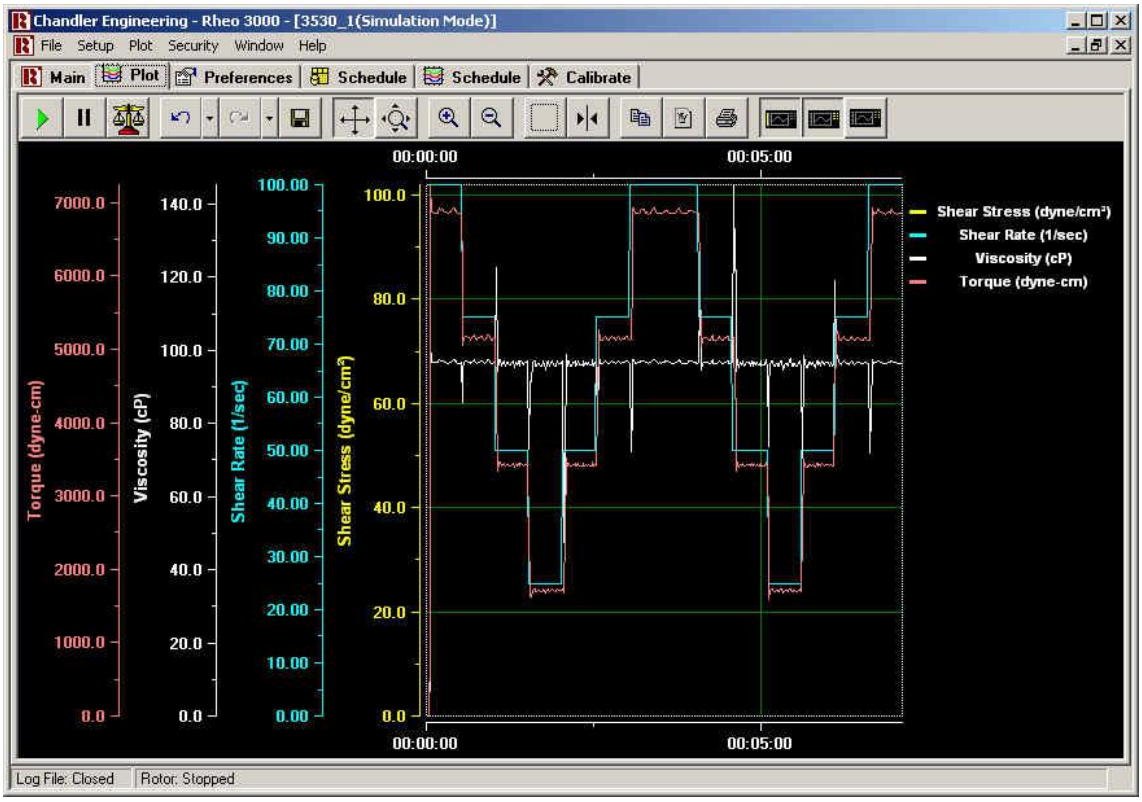
Ramp Conditions: Select the desired Ramp Conditions to be shown with each Model Calculation.

Other Results: If any of these options are selected a table with the appropriate Ramp Conditions vs “Other Results” is added to the last page of the Generated Report.

Generate Report: starts the Report Generation process. A new Excel window will open and the Report will be created.

Save as Default Options: Saves the current state of all check boxes for the next time the Generate Report window is opened.

Plot Tab



Once per second, all readings are sent to the Plot. Data from channels that are not currently visible are still saved to the Plot. At the start of a test, the Plot is cleared. The Plot can store about 24 hours of data.

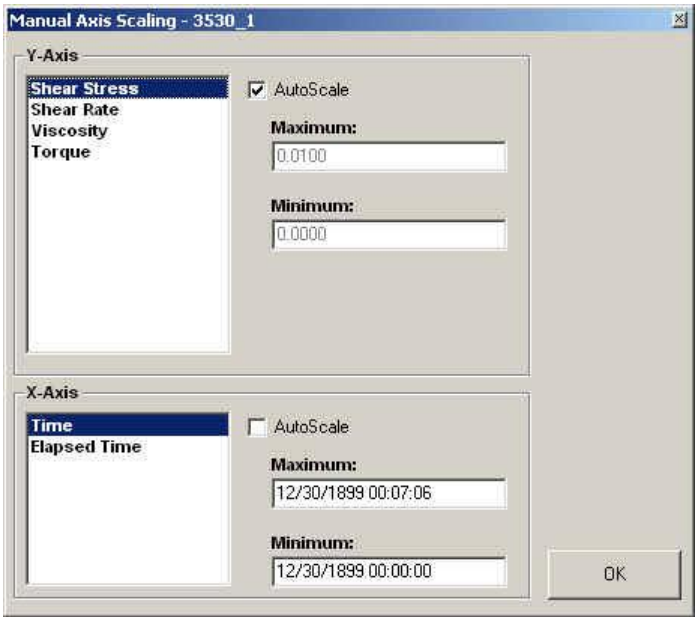
Plot Toolbar

The Plot Toolbar provides flexibility in manipulating the displayed contents of the chart. The following selections are provided.

- **Enable X-Axis Tracking** - Causes the X-Axis to automatically adjust its scale.
- **Disable X-Axis Tracking** - Causes the X-Axis to stop automatically adjusting its scale.
- **Manual Axis Scaling** - Pressing this button displays the manual axis scaling screen.
- **Undo** - Restores the plot settings, ignoring the last action. A drop-down menu allows multiple undo operations with a single mouse click.
- **Redo** - Restores the plot settings, ignoring the last undo action. A drop-down menu allows multiple redo operations with a single mouse click.
- **Save as Default Setting** - Saves the current plot configuration to the instrument file.

-  **Scroll (Axes)** - Selecting this button allows scrolling of the X and Y axes by clicking and dragging the desired axis scale.
-  **Zoom (Axes)** - Selecting this button allows zooming of the X and Y axes by clicking and dragging the desired axis scale.
-  **Zoom In** - Zooms in toward the center of the chart.
-  **Zoom Out** - Zooms out from the center of the chart.
-  **Zoom Box** - Zooms in on the chart around a window that is drawn by clicking and dragging.
-  **Cursor** - Displays or hides the **data cursor**. Note: Selecting a data cursor effectively disables X-Axis Tracking. To re-enable X-Axis Tracking, press the **Enable X-Axis Tracking** button.
-  **Copy to Clipboard** - Copies the displayed chart contents to the windows clipboard for pasting into other applications as a bitmap image.
-  **Save as Image** - Allows the displayed chart contents to be saved to a bitmap (.bmp), JPEG (.jpg) or enhanced metafile (.emf) file.
-  **Print** - Automatically rescales and prints the displayed chart contents on the default printer. The **Test File Name** is printed at the bottom of the page, and the **Log File Header** contents are printed at the top of the page.
-  **Show/Hide Y-Axis Titles** - Allows the user to hide Y-Axis titles to reserve more screen space for plot data.
-  **Show/Hide Legend** - Allows the user to hide the legend to reserve more screen space for plot data.
-  **Show/Hide Y Values in Legend** - Allows the user to display or hide current Y Values for each visible plot in the legend (if visible).

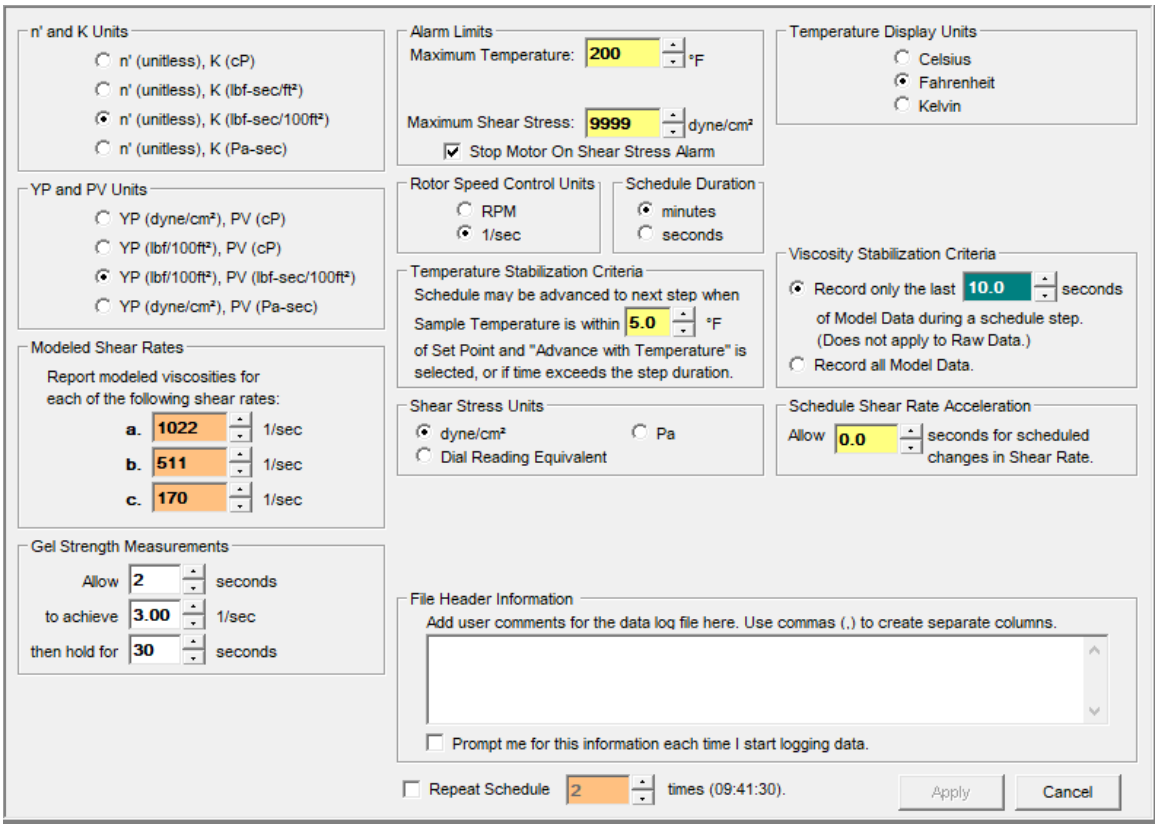
Manual Axis Scaling Screen



The Manual Axis Scaling Screen provides precise manual control over the displayed range of each plot.

- **Y-Axis** - Allows selection of individual plots in a list. By clicking on a plot title, auto-scale may be selected or deselected. If auto-scale is not selected, a maximum and minimum displayed scale value may be entered for the selected plot.
- **X-Axis** - Allows manual or auto-scaling of the X-Axes.

Preferences Tab



The **Preferences Tab** provides the following adjustable User Parameters:

- **n' and K' Units** - Defines the units to display the Power Law Model results, both on the Main Tab and in the Data Log File.

- **YP and PV Units** - Defines the units to display the Bingham Plastic and Casson Model results, both on the Main Tab and in the Data Log File.

- **Modeled Shear Rates** - The modeled viscosity at each of these shear rates is logged to the Data Log File for each Rheological Model.

- **Alarm Limits**
  - **Maximum Temperature** - Defines the temperature at which the "Over Temperature" alarm will display on the main screen. This value also represents the maximum allowable temperature entry value for a schedule or manual temperature control.

  - **Maximum Pressure** - Defines the pressure at which the "Over Pressure" alarm will display on the main screen. This value also represents the maximum allowable pressure entry value for a schedule or manual pressure control.

  - **Maximum Shear Stress** - Defines the shear stress value at which the "Shear Stress" alarm will display on the main screen.

- **Stop Motor On Shear Stress Alarm** – If checked, the motor will automatically be stopped on a Shear Stress Alarm.

- **Rotor Speed Control Units** - Allows rotor speed to be controlled as rpm or 1/sec.

- **Temperature Display Units** - Allows the selection of degrees Fahrenheit, Celsius or Kelvin. This selection applies to the log file, as well as the schedule, alarm limits and any other place that temperature is displayed. Temperature display units may not be changed while data is being logged to a file. This promotes concurrency between the units advertised at the top of each column and the units for any data being logged.

The temperature controller on the instrument may be configured to display degrees Celsius, Kelvin or Fahrenheit. The display unit setting on the front panel of the controller functions independently of the software unit selection. Thus, a different temperature unit may be displayed on the front panel of the controller, than on the main screen of the Rheo software. Refer to the temperature controller manual for details on how to change the units displayed on the front panel.

- **Temperature Stabilization Criteria** - When "Advance with Temperature" is selected within a schedule, and the measured sample temperature reaches a value within this specified tolerance, the schedule execution will advance to the next schedule step. If this target is not reached, the schedule will advance when the specified duration for the given schedule step expires.

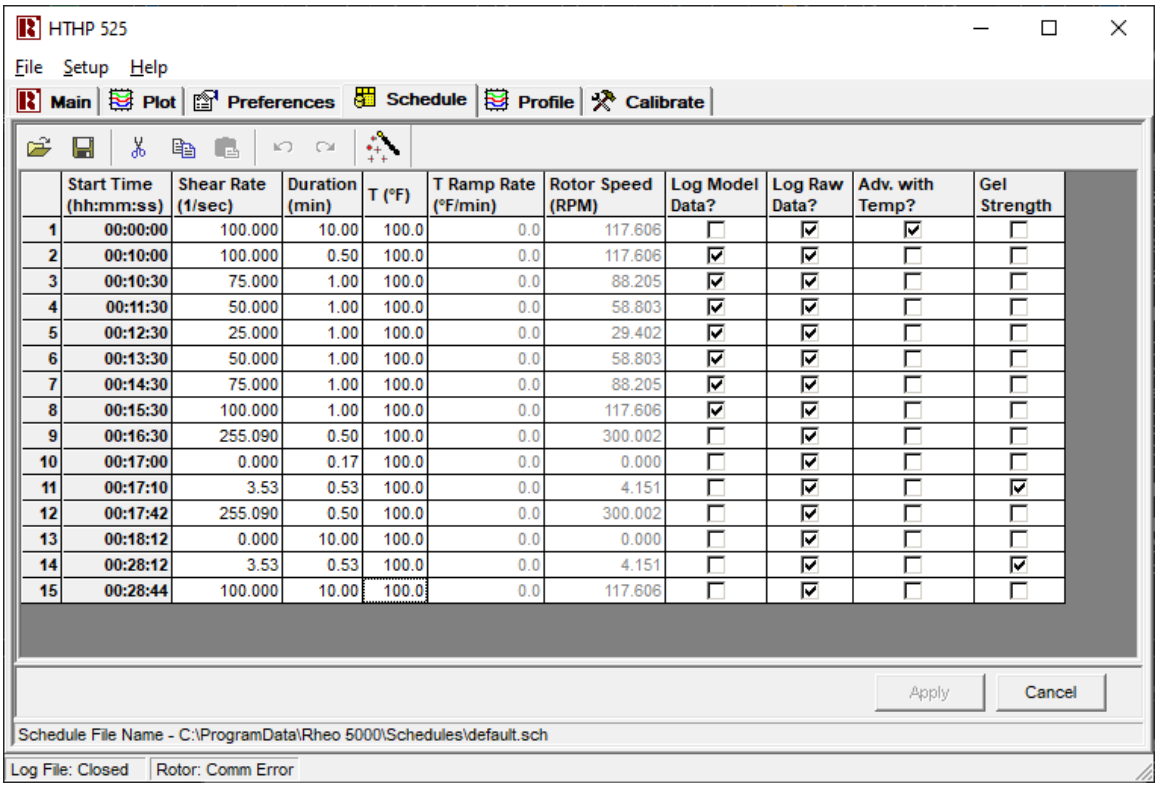
- **Pressure Display Units** - Allows the selection of MPa or KPSIg. This selection applies to the log file, as well as the schedule, alarm limits and any other place that pressure is displayed. Pressure display units may not be changed while data is being logged to a file. This promotes concurrency between the units advertised at the top of each column and the units for any data being logged.

- **Viscosity Stabilization Criteria** - Viscosity stabilization refers to the stabilization of measured Shear Stress that occurs after a change in Shear Rate. See Rheological Models Section for more information on how this feature is used. The user defines the length of the stabilization period.

- **Schedule Shear Rate Acceleration** - when this value is set to zero, the Accel field on the Main Tab overrides it. If a higher value is selected, each shear rate change within a schedule will utilize the specified period to provide a smooth, linear change in rotor speed. The initial acceleration (acceleration to the rotor speed prescribed by the first schedule step) always uses the acceleration value specified in the **Accel** field of the Main Tab.

- **File Header Information** - Information to be included at the top of each data log file is entered here.

Schedule Entry Tab



	Start Time (hh:mm:ss)	Shear Rate (1/sec)	Duration (min)	T (°F)	T Ramp Rate (°F/min)	Rotor Speed (RPM)	Log Model Data?	Log Raw Data?	Adv. with Temp?	Gel Strength
1	00:00:00	100.000	10.00	100.0	0.0	117.606	☐	☑	☑	☐
2	00:10:00	100.000	0.50	100.0	0.0	117.606	☑	☑	☐	☐
3	00:10:30	75.000	1.00	100.0	0.0	88.205	☑	☑	☐	☐
4	00:11:30	50.000	1.00	100.0	0.0	58.803	☑	☑	☐	☐
5	00:12:30	25.000	1.00	100.0	0.0	29.402	☑	☑	☐	☐
6	00:13:30	50.000	1.00	100.0	0.0	58.803	☑	☑	☐	☐
7	00:14:30	75.000	1.00	100.0	0.0	88.205	☑	☑	☐	☐
8	00:15:30	100.000	1.00	100.0	0.0	117.606	☑	☑	☐	☐
9	00:16:30	255.090	0.50	100.0	0.0	300.002	☐	☑	☐	☐
10	00:17:00	0.000	0.17	100.0	0.0	0.000	☐	☑	☐	☐
11	00:17:10	3.53	0.53	100.0	0.0	4.151	☐	☑	☐	☑
12	00:17:42	255.090	0.50	100.0	0.0	300.002	☐	☑	☐	☐
13	00:18:12	0.000	10.00	100.0	0.0	0.000	☐	☑	☐	☐
14	00:28:12	3.53	0.53	100.0	0.0	4.151	☐	☑	☐	☑
15	00:28:44	100.000	10.00	100.0	0.0	117.606	☐	☑	☐	☐

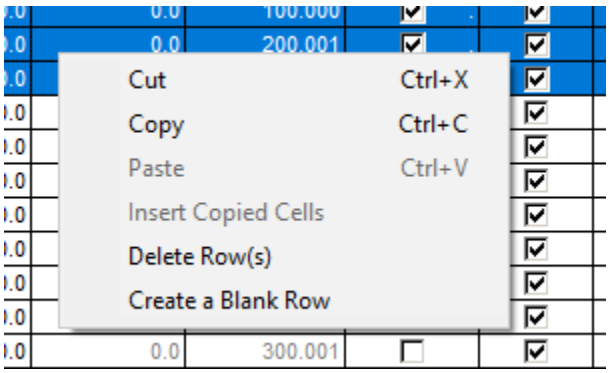
The Rheo software system allows user-defined schedules for automatic test control. Schedules are created and edited using the Schedule section of the Setup screen. Cells may be edited individually. Entire rows and groups of rows may be cut, copied and pasted.

A toolbar at the top of the schedule grid provides the following selections:

- **Open Schedule File** - Opens a previously defined schedule file.
- **Save Schedule As** - Creates a copy of the current schedule with a new filename.
- **Cut** - Makes a copy of the current selection, then deletes the selection. This operation is also available on the Schedule Right-Click menu.
- **Copy** - Makes a copy of the current selection. This operation is also available on the Schedule Right-Click menu.
- **Paste** - Pastes the copied selection onto the selected location. This operation is also available on the Schedule Right-Click menu.
- **Undo** - Restores the schedule to a previous state.
- **Redo** - Reverses the Undo action
- **Schedule Setup Wizard** - Opens the Schedule Setup Wizard Screen.

The Apply button in the lower-right corner of this screen will save the current schedule to disk and apply the changes to the working schedule. A schedule may be edited as it is executed.

A popup menu appears when the user presses the right mouse button over the schedule grid area.



In addition to the same actions that are available on the Schedule Toolbar, the following actions are available:

- **Delete Row(s)** - Removes the selected rows from the schedule.
- **Create a Blank Row** - Adds a blank row to the schedule at the currently selected point.

A schedule may also be verified visually as it is being edited via the Profile Tab.

Each step of a schedule contains the following information:

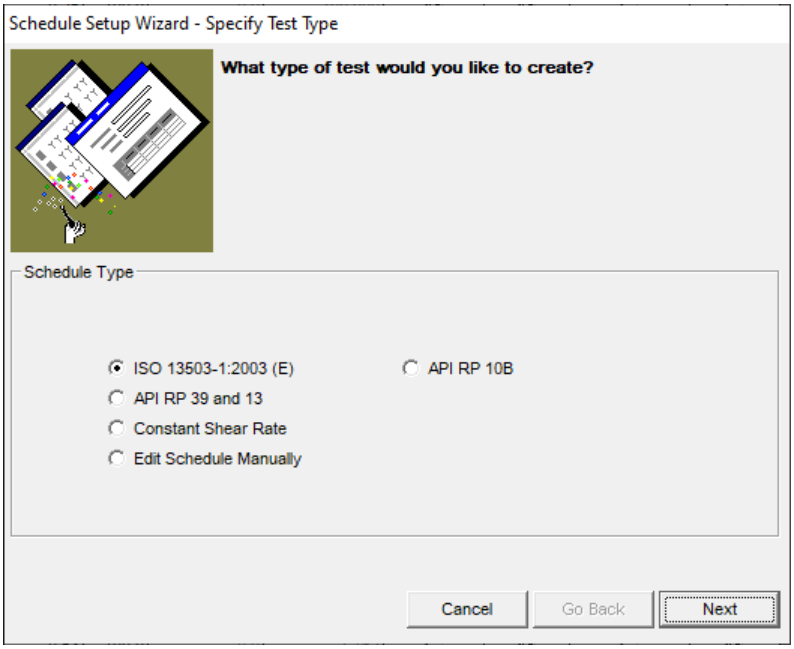
- **Start Time** - The relative time from the beginning of the schedule that a step will begin. This parameter is automatically calculated and updated by the Rheo program.
- **Shear Rate** - Defines the shear rate for a given schedule step.
- **Duration** - Defines the duration of a given schedule step in minutes.
- **T** - Defines the Temperature at the start of the current step. The software will ramp Temperature from the current step to the next step.
- **T Ramp Rate** - Displays the temperature ramp rate for a given schedule step. This parameter is calculated and updated automatically by the Rheo software.
- **Rotor Speed** - Displays the rotor speed in RPM, based on the desired shear rate.
- **Log Model Data** - Allows the user to specify which schedule steps are used for Model calculations. When an UNchecked Log Model Data step is encountered, the previous set of Log Model Data steps will be used to calculate the Models.

- **Log Raw Data** – Allows the user to specify whether if Raw Data will be logged during the given step. Data during this step will still be plotted.

- **Adv. with Temp? –** Determines if the given step will advance to the next step when the defined Temperature (T) is within the Temperature Stabilization Criteria defined on the Preferences Tab.

- **Gel Strength –** Allows the user to specify that this step is a Gel Strength Measurement and that Gel Strength calculations will be added to the Model Data. **Shear Rate**, **Rotor Speed** and **Duration** will be changed to match the **Gel Strength Measurement** parameters defined on the Preferences Tab.

Schedule Setup Wizard



The Schedule Setup Wizard provides a simple way to set up a standard test. To start the wizard as an Administrator, select the rightmost button of the toolbar on the Schedule Entry Tab. If Restricted User is selected from the Security Menu, the wizard screen will appear automatically when the Schedule Entry Tab is selected.

To create a schedule using the wizard, simply follow the on-screen instructions. The following schedule types are provided.

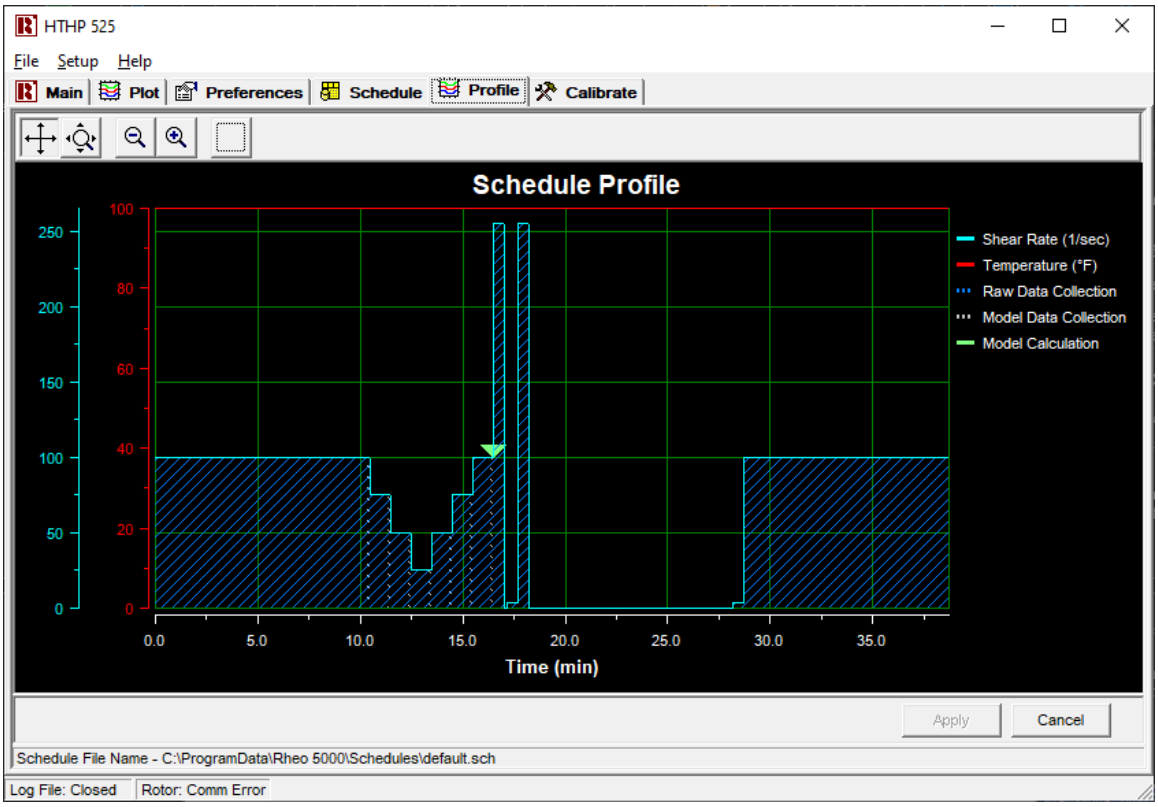
- **ISO 13503-1:2003 (E)** - Allows a schedule of user-defined duration to be created with either increasing or decreasing shear rate ramps. Any test duration may be selected. Ramp schedules are determined according to the ISO standard (100, 75, 50, 25 sec^{-1} in increasing or decreasing order).

- **API RP 39 and 13** - Provides an implementation of the API standard. Shear rate ramps are performed from 100 1/sec to 75, 50, 25, 50, 75 and 100 1/sec. Any test duration may be selected.

- **Constant Shear Rate** - Any constant shear rate and duration may be specified.

- **Edit Schedule Manually** - Closes the wizard and opens the Schedule Entry Tab. (Requires Administrator password if Restricted User is selected from the Security Menu.)

Schedule Plot Tab



A schedule may be verified visually via the Plot Schedule Tab. The shear rate or rotor speed set point is displayed over time. The shaded areas in the plot represent data collection windows for raw data and model data.

Calibrate Tab

The Calibrate Tab is discussed in the next section.

Section 3 – Maintenance

Important Cleaning and Service Tips

- The rotor and bob should be thoroughly cleaned after each test using brushes and appropriate cleaners.
- Care should be taken to ensure that the bob shaft and thermocouple do not become bent. If bent, contact between the parts may cause drag that affects the measurement or even prevents a measurement from being possible.
- When replacing bearings, if they are dropped or allowed to touch the magnets, discard them. Reliable results cannot be obtained with bearings that have even minor damage or that have been slightly magnetized.
- Care must be taken not to overfill the cup with fluid or calibration oil. If overfilled, bearing contamination may result. Be sure to allow for the fluid contained in the tips of large syringes and take care to match the fluid amount to the bob being used.
- Make sure that the proper calibration fluid is selected. And that the table of numbers from the calibration report has been entered, at least up to, and slightly beyond the temperature used during calibration. Otherwise calibration accuracy will be affected
- Use the bob shaft spacing tool to assure proper spacing of the bob shaft assembly for free rotation and proper spacing of the rotation stop pins.

Instrument Calibration

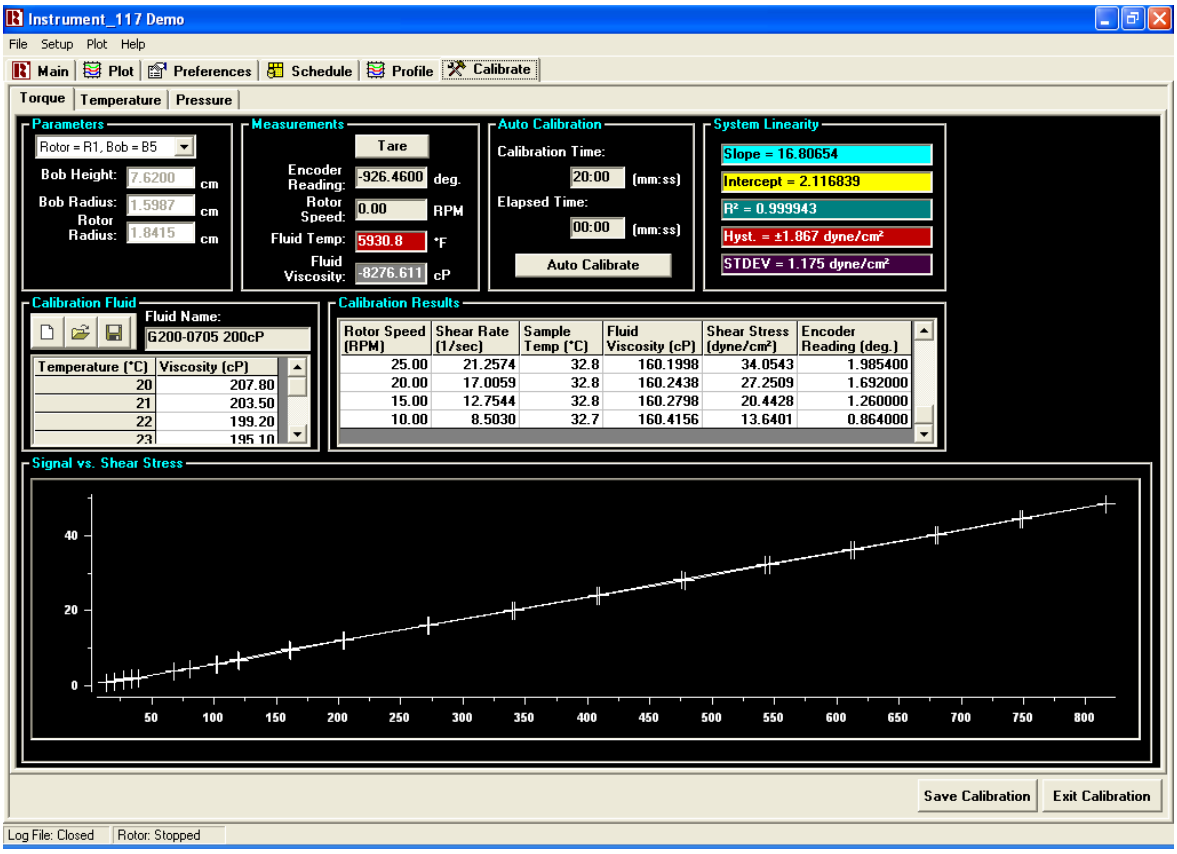


Figure 3-1 Calibration Screen

Calibration Overview

The Model 5550 HPHT Viscometer uses an automated software calibration procedure, which relates angular bob shaft deflection to shear stress. Measurements made at a variety of rotor speeds are compared to a stored table of values for a known calibration fluid to establish a torque vs. shear stress relationship. A predefined schedule takes the instrument from low speed to high speed, and back to low speed, waiting for a user-defined period at each of 40 predefined speeds (20 increasing and 20 decreasing) to allow for measurement stabilization and data averaging. The result is a curve from which system linearity and hysteresis can be inferred.

Since this curve provides a reasonable impression of the instrument performance, a system of metrics has been established to compare what can be construed as a "good" calibration to a "bad" one. These metrics include linearity, slope, intercept, hysteresis standard deviation and maximum hysteresis. An acceptable calibration is a STDEV less than 4 dynes per cm^2 and Hysteresis of less than 8 dynes per cm^2.

System Linearity

The linearity of a calibration curve is noted by the value of R^2, which is an indication of how precisely a straight line can be plotted against the calibration data using the linear least-squares method. In general, an R^2 value of 1 indicates perfect linearity. An R^2 value of slightly less than one is generally expected.

While the linearity can provide clues to the performance of the instrument, analyzing the R^2 value of a given calibration only makes it possible to detect gross errors, such as frozen bearings, etc.

Slope

Since a good calibration result is reasonably linear, the slope of the same line generated by the least-squares method to produce R^2 provides an estimate of the spring constant in dyne/cm^2 per degree. In turn, this constant can be used to predict the maximum measurable shear stress by the formula τ_{max} = slope (dyne/cm^2) * 300 degrees.

Intercept

The intercept of the line generated by the least-squares method provides an indication of sensor offset. Although any effects of a non-zero intercept are compensated for by the calibration, the intercept should typically be near zero, because "re-zeroing" the sensor can otherwise have an adverse effect on the effectiveness of a given calibration. If the offset is near zero, the sensor can be "re-zeroed" or "tared" without the need for recalibration.

Hysteresis

Hysteresis provides an indication of overall friction in the system. When increasing the bob shaft torque to a given value, the resultant angular deflection may be less than that observed by approaching the same torque from a higher value. This is typically assumed to be the result of friction, although other factors can influence the reported hysteresis.

To characterize the hysteresis from a given calibration, each data point is compared with the lookup table generated by the calibration procedure itself. Since the calibration routine includes 1 data point for increasing shear rate and 1 data point for decreasing shear rate at each pre-defined speed, each lookup table entry is determined by the average of two bob shaft deflection measurements and the average of two shear stresses.

Standard Deviation

During and after calibration, the deviation of each data point (in dyne/cm²) from the lookup table (shear stress vs. angular deflection) is recorded. Standard deviation is calculated based on the data set containing these points. The formula for standard deviation is defined as:

$\sigma = \sqrt{\frac{\sum(X-M)^2}{(N-1)}}$, where M is the mean and N = the number of data points.

Since each pair of data points is generated by comparison to their averages, M=0.

Maximum Hysteresis

Maximum Hysteresis is defined as the largest deviation found in the calibration data set from the calibration table. Whereas standard deviation provides a normalized indication of the overall bearing friction, maximum hysteresis provides a meaningful measurement of worst-case hysteresis.

Typical Hysteresis Curve

A typical hysteresis curve is shown below. The numbers for Maximum Hysteresis (±3.634 dyne/cm²) and Standard Deviation (1.765 dyne/cm²) are reported on the calibration screen of the Rheo 5000 software, as well as reported in each data file. The curve below represents the calculated difference between each data point and the calibration lookup table. It is symmetrical about the X-Axis by definition.

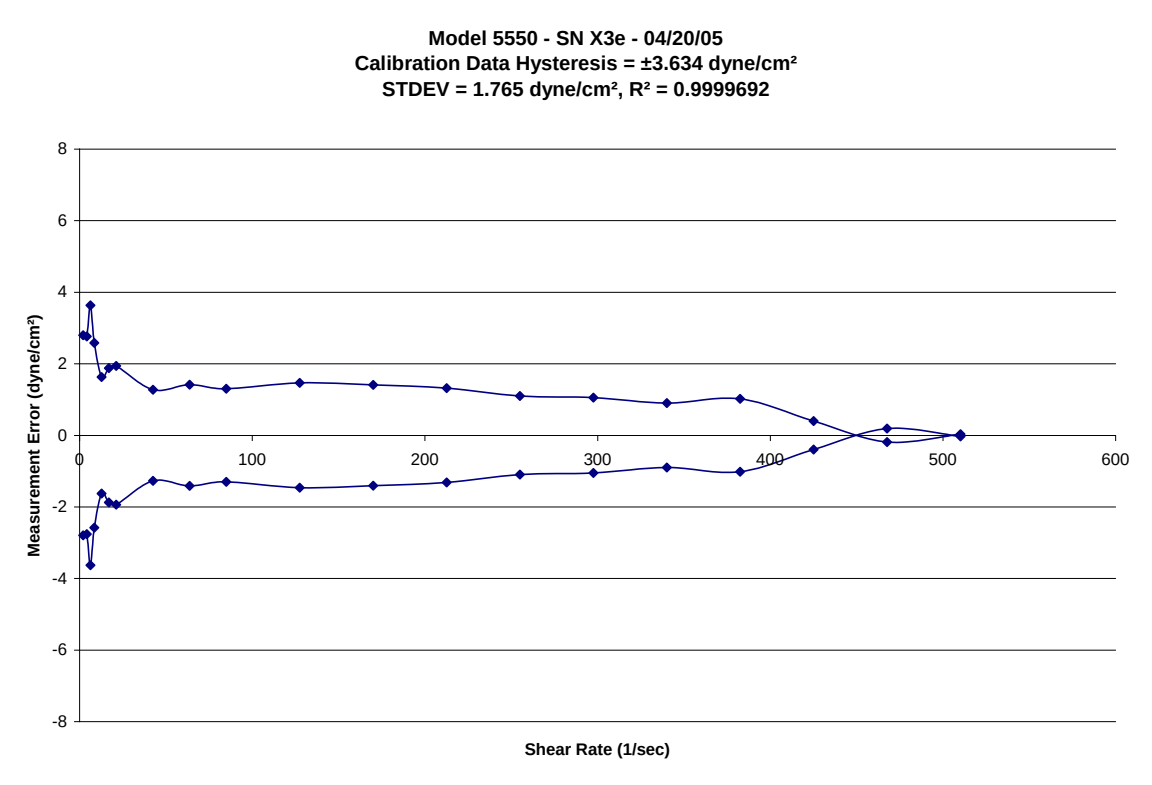


Figure 3-2 Hysteresis Plot

Calibration Procedure

1. Click the calibrate tab on the Instrument screen.
2. Select the rotor and bob geometry
3. Select the calibration fluid to be used. If using a new fluid, enter the fluid viscosity values from the certification certificate.
4. Fill the sample cup with the proper volume from Table 1.
5. Click the “Main” tab on the instrument screen.
6. Set “Rotor Control” to “Manual” and about 50 rpm.
7. Set “Pressure / Temperature Control” to “Manual” and about 90° F.
8. Allow the temperature of the sample and instrument to stabilize.
9. Stop the rotor.
10. Set “Rotor Control” and “Pressure / Temperature Control” to “Automatic.”
11. Click the “Calibrate” Tab.
12. Tare the instrument by clicking the “Tare” button.
13. Start the calibration by clicking the “Auto Calibrate” button.
14. When the calibration routine completes successfully, click “Save Calibration” to store the calibration values that will be used when running subsequent tests.
15. Allow the instrument to cool
16. Depressurize using the Unloader Valve as described in Section 2.
17. Remove the sample cup, empty the fluid, and clean the instrument.

Calibration Summary

Each of the parameters listed above are reported by the Rheo 5000 software. In addition to reporting each of these values on-screen, they are also recorded, along with all other calibration data and parameters, near the top of each individual log file. Analysis of the maximum hysteresis, hysteresis standard deviation, R^2, slope and intercept can provide a quick and easy verification of the state of an instrument, upon recalibration.

- **Parameters** - allows the user to select from a list of standard Rotor / Bob combinations. Bob Height, Bob Radius and Rotor Radius are automatically populated. If "Custom Geometery" is selected, Bob Height, Bob Radius and Rotor Radius are editable.

- **Measurements**
    - **Encoder Reading –** displays the current Encoder reading in degrees.
    - **Rotor Speed –** displays the current Rotor Speed
    - **Fluid Temp –** displays the current Fluid Temperature.
    - **Fluid Viscosity -** The known viscosity value of the calibration fluid. This value is calculated from the entered **Calibration Fluid** data. Working Viscosity reference values are generated via linear interpolation within the defined Calibration Fluid table.

- **Auto Calibration**
    - **Calibration Time -** displays the total time required to Calibrate during an Auto Calibrate Sequence.
    - **Elapsed Time -** displays the elapsed time of an Auto Calibrate Sequence.
    - **Auto Calibrate** - Starts the auto-calibration sequence (see below).

- **Calibration Fluid** - The Viscosity of the Calibration Fluid at known temperatures are entered from the Calibration Certificate supplied with the Calibration Fluid. Use the New, Open and Save buttons to define a New Calibration Fluid, Open a previously saved Calibration Fluid or Save the currently defined Calibration Fluid.

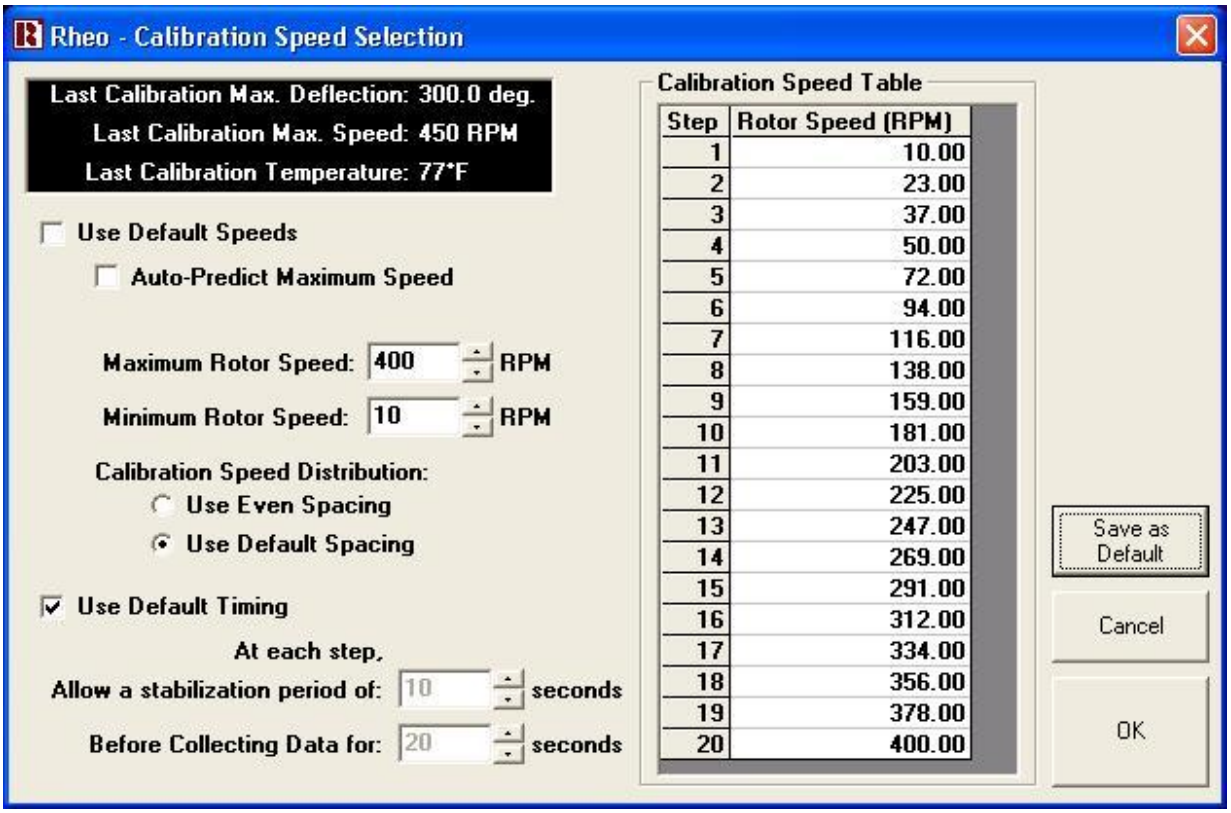
- **Save Calibration** - Saves the calibration data. The Rheo 5000 software will begin using the new values.

- **Tare Button -** Zeros the **Encoder Reading**.

- **System Linearity –** displays the Linearity calculations (discussed above). These values are updated during calibration. It is normal for them to display out-of-tolerance values while an Auto-Calibration Sequence is in progress.

- **Encoder Reading vs Shear Stress (Plot)** is a graphical representation of the Calibration Data. This should be a very straight, increasing line. It is normal for this line to have several "corners" while an Auto-Calibration Sequence is in progress.

Auto Calibration



- **Use Default Speeds** – Uses default rotor speeds for calibration.
- **Auto-Predict Maximum Speed** – Using previous calibration data for the same nominal viscosity calibration fluid, Rheo 5000 determines the maximum rotor speed without exceeding the target spring deflection. The maximum speed should never exceed 600 rpm, and if so, manually change the speed to 600 rpm.
- **Target** – Maximum deflection of the spring. Maximum value is 300 degrees.
- **Maximum Rotor Speed** – Maximum rotor speed at which to determine a calibration value. This value should never exceed 600 rpm.
- **Minimum Rotor Speed** – Minimum rotor speed at which to determine a calibration value. Generally, this is set between 10 and 20 rpm.
- **Use Even Spacing** – Evenly disperses the tabular calibration rotor speeds.
- **Use Default Spacing** – Uses the default tabular calibration rotor speeds, the lower speeds are more narrowly spaced.
- **Use Default Timing** – Default durations for the stabilization period and data averaging period.
- **Allow a stabilization period of:** – Specify a duration, in seconds, for stabilization of the shear stress value before collecting data.
- **Before Collecting Data for:** – Specify a duration, in seconds, during which shear stress data is collected and averaged.

Replacement of Bob Shaft Bearings and Spring Assembly

1. Verify that pressure has been relieved from the instrument.
2. Turn the Power OFF.
3. Open the top cover of the instrument.
4. Disconnect the thermocouple cable.
5. Disconnect the encoder cable.
6. Remove the encoder housing by pulling upward. Do not twist the encoder off as this may bend the thermocouple.

Lift Encoder Upward as Shown

Figure 3-3 Encoder removal

7. Using a 5/16 inch wrench, remove the thermocouple **taking care not to flex or bend it. This is very important in order to avoid drag against the bob-shaft that can adversely affect measurement sensitivity.** Put the thermocouple in a safe place until ready for installation.
8. Turn the viscometer top cap counterclockwise to remove it. It may be necessary to use the spanner wrench provided to initially loosen the top cap.
9. Remove the rotor and bob from the instrument.
10. Remove the climb arrestor from the bob shaft.
11. Gently push the bob shaft directly upward to remove the bob shaft assembly.

Figure 3-4 Bob Shaft Removal

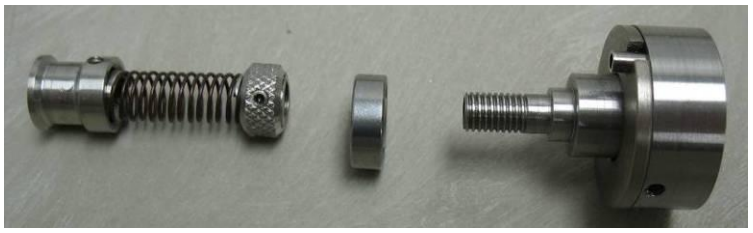
12. Remove the plastic spacer sleeve that loosely sits atop of the bob shaft assembly and set aside.

13. Using the 1/16 inch hex wrench loosen but DO NOT remove the set screws at the top of the bob-shaft assembly.

14. Remove the bob-shaft from the spring housing.

15. Using the 1/16 inch hex wrench loosen (approximately 2 full turns) but DO NOT remove the set screws at the center of the spring housing.

16. To remove the upper bob shaft bearing, turn the spring assembly counterclockwise to remove it.



17. Once the spring assembly is removed, the bearing can also be removed.

18. Replace both bearings. **Do not use bearings that have been dropped or have been allowed to touch the magnets.** Accurate measurements cannot be made with bearings that have been dropped or slightly magnetized.

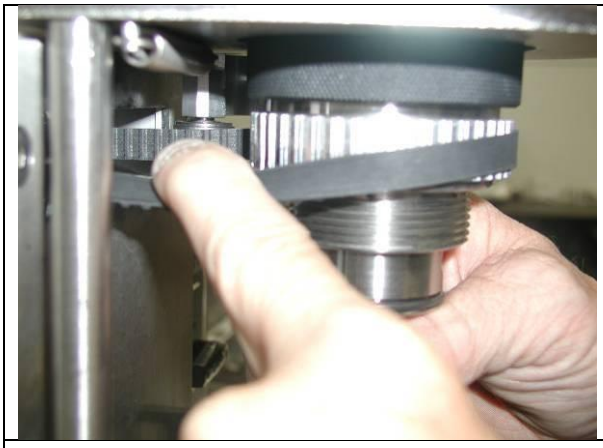
19. Assemble the instrument in reverse order.

20. Use the spacer tool (right) to properly space the magnet head on the bob-shaft and to align the stop pins. Tighten the set screws to hold the bob-shaft securely.

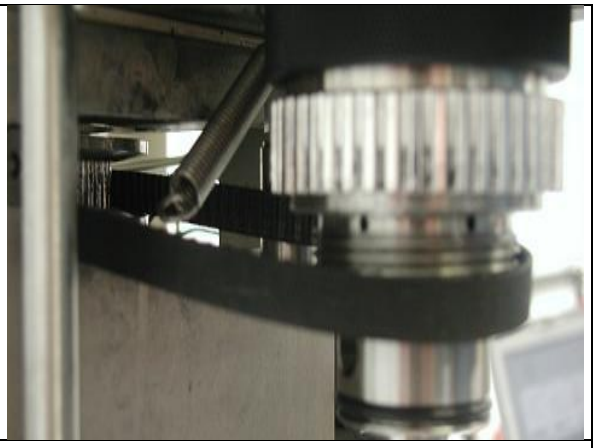
21. Calibrate the instrument.

Replacement of the Belt

1. Disconnect the instrument from the power mains.
2. Lower the heater bath and swing away.
3. Remove the two screws that hold the belt guard in place.
4. Pull downward on the belt while turning the rotor pulley counterclockwise. (See images below.)
5. Continue rotating the pulley until the belt turns off of the pulley (See images below.)
6. Disconnect the spring from the tensioner on the left side of the instrument. This will allow you to swing the tensioner to the right and out of the way when replacing the belt.
7. Put the belt on the motor pulley and thread it thru the belt slot in the front of the instrument.
8. Place the belt onto the rotor spindle pulley. Note the belt will be loose until the tensioner is in place.
9. Swing the tensioner back into position. It should be resting on the outside belt surface.
10. Use a small set of needle nose pliers to pull the spring back onto the pin from which it was removed.
11. Replace the belt guard.



Pull the belt while turning rotor CCW



Once the belt is loose, Release the spring

Figure 3-5 Belt Removal

Replacement of the High Pressure Seal

For the high pressure seal to work properly it must seal on a precision ground surface. Nicks and scratches on this surface will cause premature seal failure or possibly prevent sealing all together. A special seal removal tool is included to prevent such scratches from occuring. DO NOT use sharp instruments in an attempt to remove the seal

The high-pressure seal may be accessed without removing the bob shaft or the bob shaft bearings. After removing the bob and the climb arrestor, the tool may be used to remove the high-pressure seal without disassembling the remainder of the head.

Removing the Seal

Seal Removal Tool

1. To remove the high-pressure seal, use the tool pictured at the right.
2. Place the tool in the hole with the pin at the top of the hole. (See picture below.)
3. Rotate the tool until the high-pressure seal and metal seal spacer drops out.

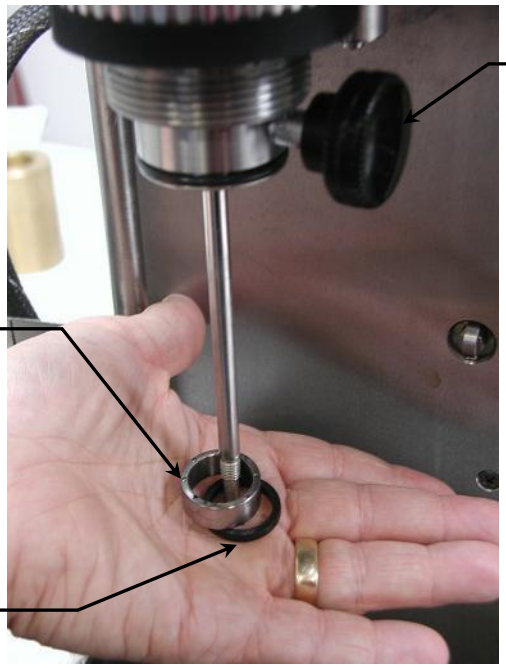


Figure 3-6 Seal Removal

Installing the Seal

1. Apply a small amount of Krytox or other suitable high temperature grease on the inner and outer faces of the seal.
2. Place the seal onto the face of the tool with the spring side facing the tool.

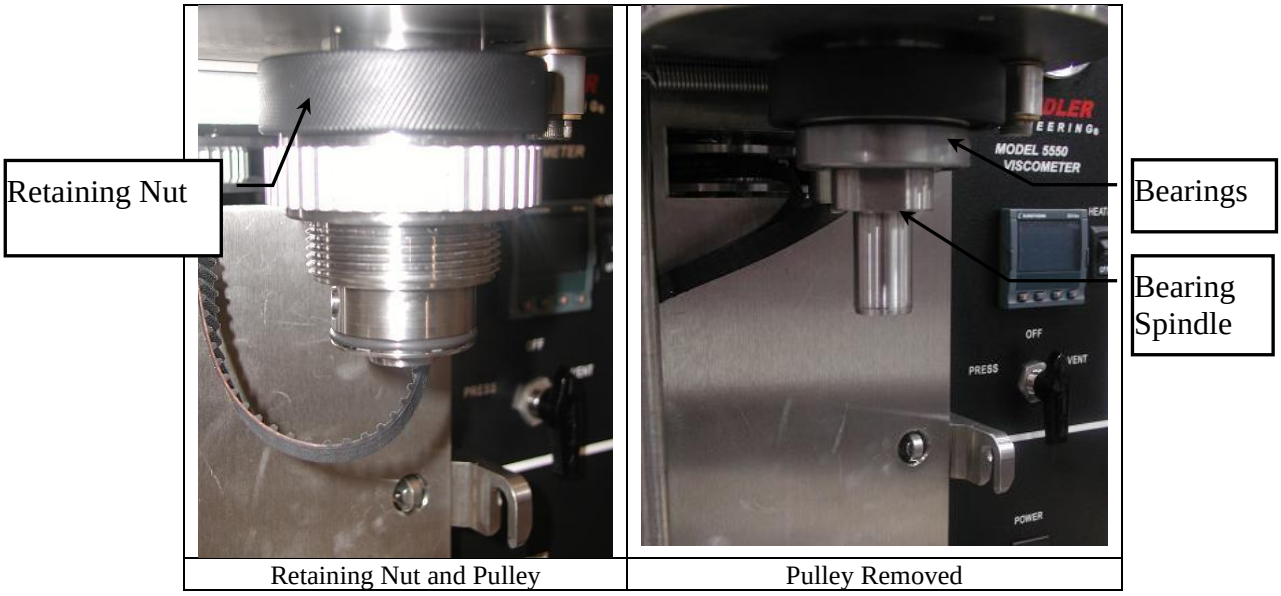
3. Place the metal spacer ring on top of the seal.

4. Slide the tool up the bob shaft and push upwards firmly until the seal snaps into place. Usually an audible click can be heard when installing the seal properly.

Replacement of the Rotor Bearings

The rotor bearings are a precision ground matched set of bearings. Under normal operation they will provide excellent service with long life. This procedure covers the removal and maintenance of the bearings.

1. Make sure that pressure has been removed from the instrument.
2. Turn the power off.
3. Unscrew the rotor sample cup.
4. Remove the bob and climb arrestor.
5. Remove the bob shaft. (Refer to the Replacement of Bob Shaft Bearings section of this manual).
6. Remove the two screws that attach the belt guard.
7. Remove the belt. (Refer to the Replacement of the Belt section of this manual.)
8. Firmly grasp the black retaining nut above the rotor pulley with one hand.
9. Grasp the rotor pulley with the other hand and rotate counterclockwise from the black retaining nut. After the thread is disengaged pull downward on the pulley to remove it from the bearings.



Retaining Nut and Pulley | Pulley Removed

10. Next, using a large adjustable wrench, turn the bearing spindle ***clockwise*** to remove.

The bearing spindle has LEFT HAND threads and must be turned clockwise to remove.

11. The bearings can be removed by simply pulling them off the spindle. It is recommended that when replacing or cleaning the bearings, to inspect and replace as necessary the spindle O-ring.

12. If the bearings are to be cleaned and reused, the bearings can be cleaned in IPA or similar solvent. Allow the bearing to dry but do not dry using compressed air.
13. Grease the bearing with the Krytox high temperature grease provided with the instrument.
14. Since the bearings are a matched set their installation is a key function to their performance. The thrust faces of the bearings must be placed together when installing. The thrust faces are usually denoted by the word "**thrust**" or an "*****" printed on the face.

Figure 3-7 Rotor Bearing

Warning: Failure to install the bearings correctly could result in immediate bearing failure when load is applied. *Thrust faces must be placed so that the printed words "thrust" on each bearing face each other when installed.*

15. Place the thrust faces together and slide over the spindle.
16. Place the black retaining nut over the spindle and insert the spindle into the head assembly.
17. Rotate the spindle counterclockwise (since it is left hand threads) and tighten with the large adjustable wrench.
18. Before replacing the spindle pulley make sure that the Teflon bearing shield is in the bottom of the spindle pulley. This shield helps prevent fluids from contaminating the bearing in the event of a seal failure during a test.
19. The remainder of the reassembly is the reverse order of disassembly.

Fuses and Circuit Breakers

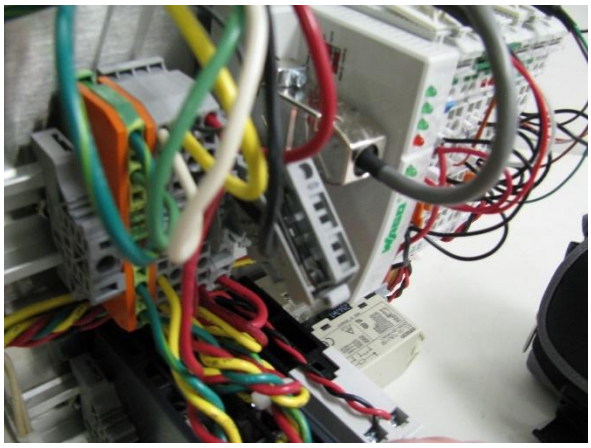
The back panel of this instrument does not need to be opened during periodic or routine maintenance/inspection activities. ***Only qualified personnel should perform maintenance or repair.***

Main Power Circuit Breaker Switch

The main power switch on the front panel is also a circuit breaker. If necessary to reset the breaker switch, turn the switch completely off and then back on.

Additional Instrument Fuse

There is a fuse located inside of a fuse holder on the rear door of the instrument. Before accessing the fuse, make sure that power is off and the power cord has been removed from the instrument.



1. To access the fuses pull the fuse holder up and open the access panel to eject the fuse (to the right).
2. Replace the fuse with the appropriate rated fuse (Refer to the Replacement Parts Section of this manual).
3. Push the fuse holder down into its original position.

Maintenance Schedule

The Model 5550 is designed for infrequent and easy maintenance. Generally maintenance is not required unless performance of the instrument indicates a problem such as a nitrogen leak or unrealistic data. Below is a list of items that are likely to require service over the life of the instrument. The frequency listed below is only intended as an initial guide. Service frequency and usable life of each component is highly dependant on the severity of testing and the frequency of use. Clean exterior surfaces of the instrument as required using mild soap and water. Dry all surfaces thoroughly and do not soak vents, fan or back electrical panel with water.

MAINTENANCE SCHEDULE INSTRUMENT NAME					
COMPONENT	EACH TEST	MONTHLY	3 MONTHS	6 MONTHS	ANNUAL
Rotor	Clean				
Bob	Clean				
Rotary Seal		Clean and Lubricate (Replace as needed)			
O-rings	Clean		Replace as needed		
Instrument Calibration	Calibrate weekly or as required				
Bob Shaft Bearings		Clean (Replace when cleaning no longer restores sensitivity)			
Rotor Bearings					Replace
Thermocouples					Calibrate
Pressure					Calibrate
Belt					Replace after 2 years or as needed

This maintenance schedule applies to normal usage of two tests per day. Detailed procedures for these operations are contained in your manual.

Section 4 – Troubleshooting Guide

Problem	Solution
Instrument does not operate when power switch is ON.	• Check utility circuit. • Check Circuit Breaker Switch on the front panel. • Check the component fuses.
Nitrogen leak at rotor nut.	• Check the O-ring at the cup. Replace if necessary. • Check the High Pressure seal. Replace if necessary.
No communication with the computer.	• Check communication cables and verify that they are all plugged into the correct ports. • Be sure that the instrument is ON before the software is started. • Shut down and restart the PC with the instrument ON.
Noise or grinding when rotating, that amplifies as the speed increases.	• Grease or replace rotor bearings. Refer to drawing Replacement of Rotor Bearings section of this manual.
Irregular Torque Reading	• Run auto calibration. • Replace bob shaft bearings. • Check to see if thermocouple is bent. • Encoder may need repair.
Zero Viscosity reading	• Tare the encoder just prior to installing the fluid filled rotor.
No Rheological Model Data	• Check the schedule to ensure that the "Log Model Data" check box is unchecked at the end of each ramp.
Loss of encoder signal.	• Check that the encoder cable is connected.
No heating.	• Check that the heater switch on the front panel is in the "On" position. • Check to see if the heater control is Automatic Mode on the "Main" software tab. • Check that the roller switch on the front panel is activated when the heater bath is in the raised position. • Check that the controller is calling for heat. (Indicated by a periodic flashing on the controller face.)
Heater Set Point will not exceed 194°F (90°C).	• This is a software safety feature preventing higher temperature heating when no pressure is present. Increase the pressure on the instrument higher than 50 psi. • Loss of temperature calibration.
Sample cup difficult to remove.	• Sample cup may be under pressure. Release pressure, verify with pressure gauge and software pressure reading. • Sometimes after long, high temperature tests, the O-ring can become deformed or stick to metal surfaces. Always put a thin coating of high temperature lubricant on O-rings when assembling to minimize potential sticking.
Belt not running true.	• Check belt alignment. Check to be sure the idler arm pivots freely and the idler roller smoothly rotates.

Problem	Solution
Belt squeaking.	• Dirt accumulation on the belt can cause a squeaking sound as it rotates. Simply use a cloth with a mild cleaner or Isopropyl Alcohol to clean belt surfaces and the idler pulley.
Instrument power but no motor response.	• Check fuse on motor power supply. • Check communication cables, reboot computer.
Motor squeals loudly but no rotation.	• Stop rotor from the software and restart. • Grease or replace rotor bearings
Pressure will not bleed off using pressure bleed valve on the cup.	• Clogged port, slowly bleed the pressure using the vent selection on the pressure valve. This may put fluid into the bob shaft bearings and could require replacement of bob shaft bearings.

Calibration failure due to high hysteresis.	• This is usually caused by friction in the bob-shaft bearings, between thermocouple and bob-shaft, or in the encoder. Try the following:
	  • Replace the bob-shaft bearings
	  • Remove the thermocouple, and run the calibration again to determine if the thermocouple is dragging against the bob-shaft.
	  • Replace the encoder assembly.

Section 5 - Replacement Parts

Part Number	Description
35-0180	Fluid, Newtonian, 200cP
5550-0016	Tool, Seal Ejector Cam
5550-0124	Tool, Seal Installation
5550-0246	Wrench, Spanner, 1/8 x 1.5
5550-0328	Assembly, F440 Spring
5550-0355	Shield, Bearing Isolator
5550-0426	Tool, Bob-shaft Setting
5550-0456	Assembly, Thermocouple
70602-62	Nut, SS, 1/8T
70603-86	Ferrule, SS, Back, 1/8T
70603-87	Ferrule, SS, FR, 1/8T
C09275	O-ring, Viton, AS028-75
C09466	O-ring, Viton, AS007-V75
C09781	O-ring, Viton, AS118-V75
C09833	O-ring, Viton, AS137-75
C10293	Ring, Retaining, Ext, WS-175
C10599	Fuse,4A/250V, 3AG,SLO-BLO
C10788	O-ring, Viton, AS125-V75
C10874	Seal, Rotary, .75 x .937 x .124
C10888	Bearing, Rotor
C11032	RTD, 3-wire, 2 inch
C11039	Grease, Hi-temp, Krytox
C11258	O-ring, Viton, AS127-V75
C11288	Belt, Timing, Neoprene
C11289	Bearing, 6x15x5, SS
H-4103	Screw, Set (Bob Shaft Assembly)
P-2838	Fluid, Newtonian, 100cP

To ensure correct part replacement, always specify Model and Serial Number of instrument when ordering or corresponding.

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Section 6 - Drawings and Schematics

Drawing Number	Description
5550-0020	Schematic, Piping
5550-0043	Assembly, Bottom Plug
5550-0189	Assembly, Bath
5550-0219	Assembly, Heater
5550-0325	Assembly, Encoder
5550-0454	Assembly, Viscometer Head
5550-0457	Assembly, Extended Bob Shaft
5550-0506	Electrical Schematic
5550-0507-XXXX	Assembly, Drive

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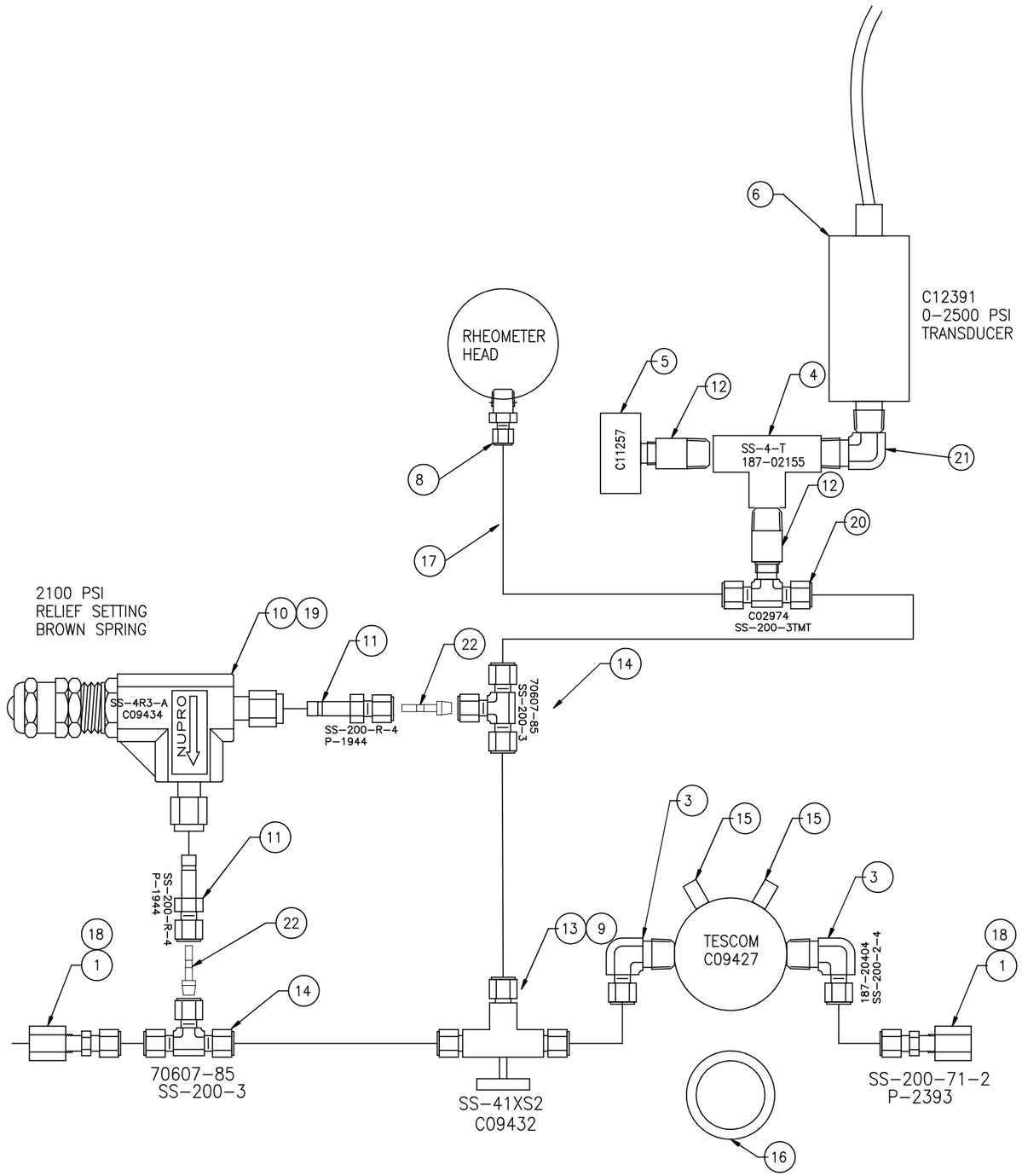
REVISIONS				
ZONE	REV	DESCRIPTION OF REVISION	DATE	APPROVALS
ALL	A	ECN T1321; PRODUCT LAUNCH	11/9/07	TC TC
	B	ECN T1573, UPDATED BOM	3/29/08	JB TC
B7–C6	C	ECN# T4126, ADD ITEM 22 QTY 2	8/24/11	SS TC
	D	ECN T6507; MOVE BOM TO TOP LEVEL	3/27/15	ES TC
D8	E	ECN T7285; RELIEF VALVE TO 2100 PSI	5/25/16	JS JS
	F	ECN T7390; CHANGE R–0289 QTY TO 6FT	09/02/16	JS JS



–04	–03	–02	–01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
			2	C09705	CONN,PORT,1/8		22
			1	C05973	STREET ELBOW,1/4NPT,316SS	SST	21
			1	C02974	TEE,SST,1/8Tx1/8Tx1/8MP,SW	SST	20
			1	C09236	SPRING,REL. VALVE,177–R3A–K1–E		19
			2	C04263	RETANR,ZPSTL,3/16T,BHD		18
			6	R–0289	SS,TBG,0.125 X 0.035W, 304	304	17
			1	299–00684	GASKET	PLASTIC	16
			2	188–13190	PLUG,1/4MP,SQ HD,SS	SST	15
			2	70607–85	TEE,1/8 t	SST	14
			1	C09432	VLV,3–WAY,SS–41XS2	SST	13
			2	P–2577	BSHG,SST,1/8FP X 1/4MP,RED	SST	12
			2	P–1944	RDCR,SS–200–R4	SST	11
			1	C09434	VLV,PR, SS–4R3–A,C SPRNG	SST	10
			1	5550–0477	WASHER, PRESSURE VALVE		9
			3	188–13044	CONN,1/8MP X 1/8T,SS	SST	8
			1	C09427	REGULATOR	SST	7
			1	C12391	PRESSURE SNSR,0–5V,2500PSI		6
			1	C11257	PRESSURE GAGE,3000 PSI, DUAL SCALE	SST	5
			1	188–02155	TEE,SST,1/4FP X 1/4FP X 1/FP	SST	4
			2	187–20404	ELB,1/4MP X 1/8T	SST	3
			–				2
			2	P–2393	CONN,BLKHD,1/8FPX1/8T	SST	1

QTY. REQD. | PARTS LIST

NEXT ASSY | USED ON

APPLICATION

BREAK SHARP EDGES, DEBURR

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES [mm]

TOLERANCES:
1 PLACE ±
2 PLACE ±
3 PLACE ±
ANGLES ±
SURF. FINISH ✓

APPROVALS	DATE
DRAWN: DLB	04/05/04
CHECKED: RW	11/16/04
ENGR.: DLB	04/05/04

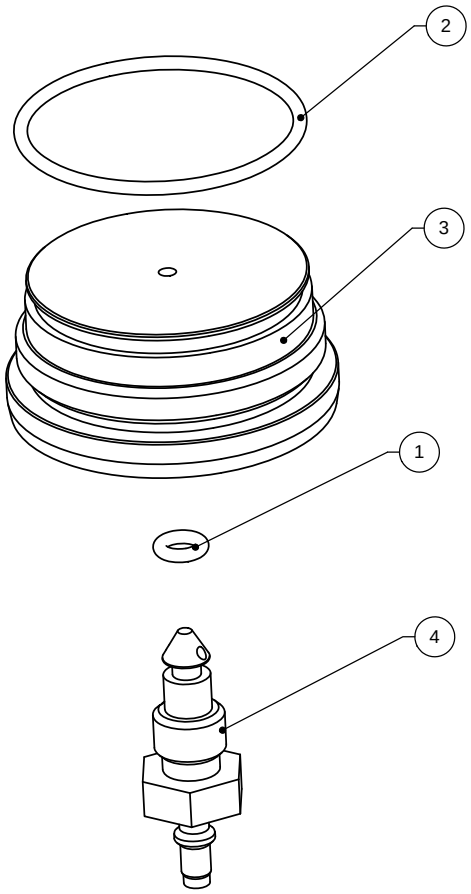
CHANDLER ENGINEERING

TITLE: DIAGRAM,PIPING

SIZE	S.O. NO.	DWG NO.	REV.
D		5550–0020	F

SCALE: 1 = 1 | TITLE BLOCK REV: 1.0 | SHEET: 1 of 1

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	ECN T1321; PRODUCT LAUNCH	11/14/07	TC



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	C09466	ORING, VITON,AS007-V75	1
2	C09275	ORING,VITON,AS028-V75	1
3	5550-0249	PLUG, SAMPLE CUP	1
4	5550-0248	QC VALVE NEEDLE	1

			.	.	SEE BOM	.	1
-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
QTY. REQD.				PARTS LIST			
.				.	UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES		
.				.	TOLERANCES:		
.				.	1 PLACE ±0.030 2 PLACE ±0.010 3 PLACE ±0.005 ANGLES ±1/2° SURF. FINISH		
NEXT ASSY				USED ON			
APPLICATION							
BREAK SHARP EDGES, DEBURR					APPROVALS	DATE	

DRAWN:	JJM	03/30/05
CHECKED:	DBL	04/01/05
ENGR.:	JJM	03/30/05

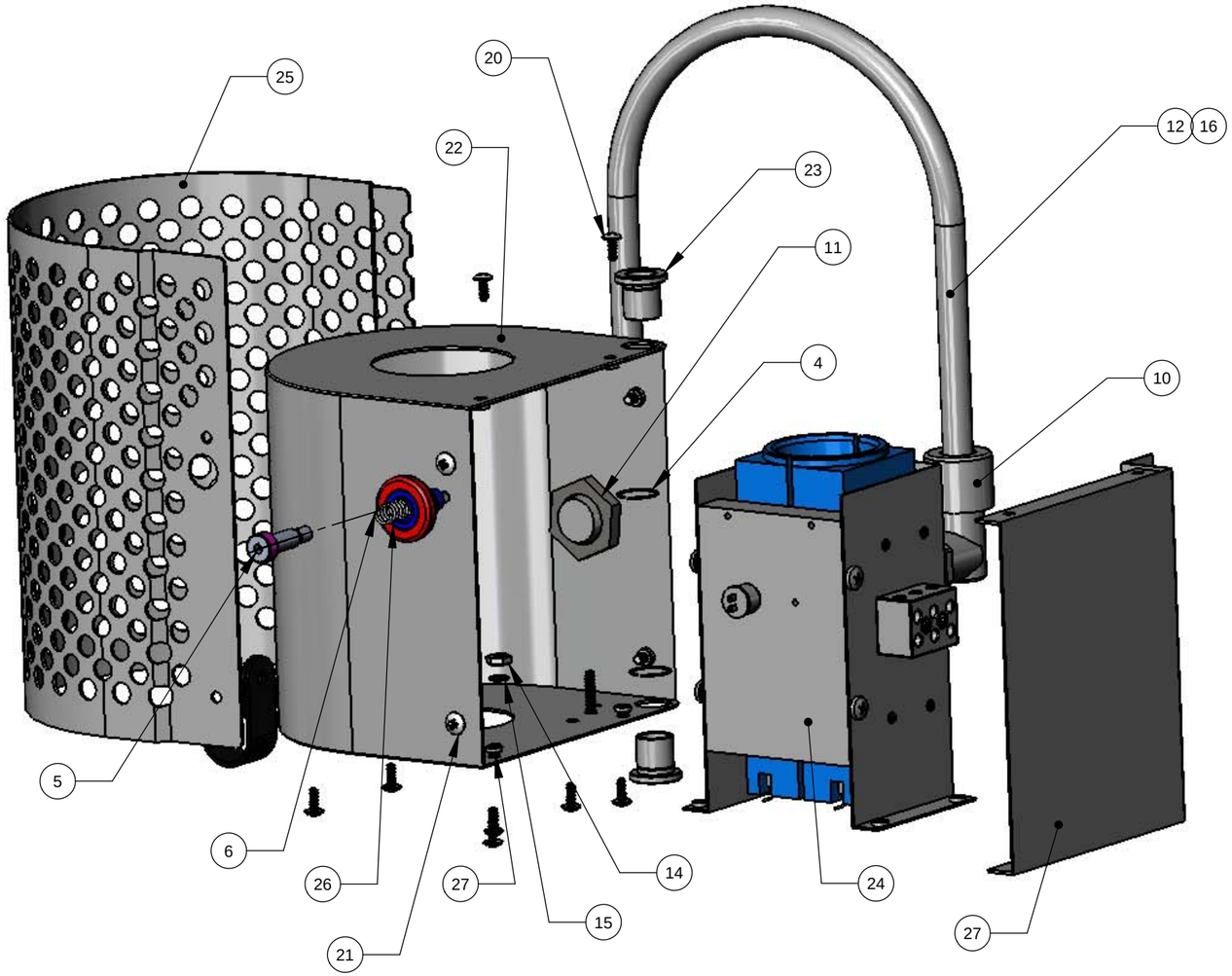
CHANDLER ENGINEERING

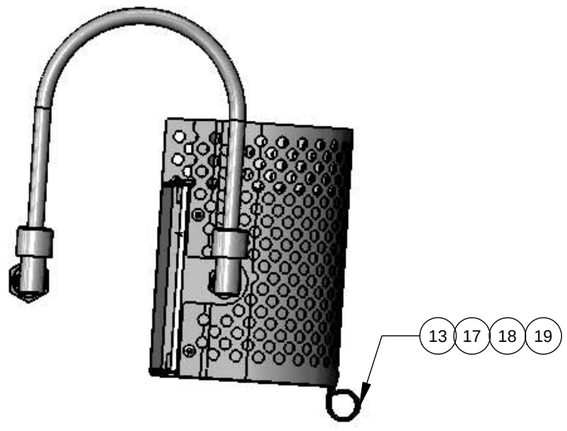
TITLE

BOTTOM PLUG ASSEMBLY

SIZE	S.O. NO.	DWG NO.	REV.
C		5550-0043	A

SCALE: 1:1 | TITLE BLOCK REV: 1.0 | SHEET: 1 of 1





REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	ECN T1321; PRODUCT LAUNCH	11/14/2007	TC
	B	ECN T6507; REPL H-6007 WITH H-6015	3/27/15	TC

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1			
2			
3			
4	C10896	RING,RET,EXT,VS-62	2
5	C10958	SCREW,SHLDR,5/16X3/4,SST	1
6	C10959	SPRING,COMP,SST,360X.026X1	1
7			
8			
9			
10	C11043	CORD GRIP,RA,ALU,1/2	2
11	P-1012	SEAL NUT, 1/2 P	2
12	C11044	LOOM,SPLIT,1/4"OD,BLK	18"
13	C11057	CLAMP,7/8" ID, BLACK VINYL INSULATED	1
14	H-10-006	NUT,HEX,10-24,SS	1
15	19396-00	TERMINAL,RING TONGUE HIGH TEMP	1
16	C11045	LOOM,EXPANDABLE,1/2" ID	18"
17	H-10-002	WSHR,LOCK,SS,#10	1
18	H-10-101	NUT,HEX,10-32,SS	1
19	H-10-110	SCREW,THMS,SS,10-32X0.50,PHIL	1
20	H-6015	SCREW,THMS,SS,6-32X0.375,PHIL	8
21	H-8026	SCREW,THMS,SS,8-32X0.375,PHIL	4
22	5550-0455	COVER, REAR BATH	1
23	5550-0193	BSHNG,FLNG,0.5 ID,W/RET. GRV	2
24	5550-0219	ASSY; HEATER	1
25	5550-0446	SHIELD	1
26	5550-0265	PLUNGER ASSEMBLY	1
27	5550-0463	COVER, REAR BATH	1

BREAK EDGES, DEBURR
UON DIMS ARE IN INCHES
1 PLC ±0.030 2 PLC ±0.010
3 PLC ±0.005 ANGL ±1/2°
SURFACE FINISH 63 RMS
THIRD ANGLE PROJECTION

DRAWN: DBL 01-02-04
MFG: JJM 01-04-04
ENGR: DBL 01-02-04
TYPE:
STRUCT:

CHANDLER ENGINEERING

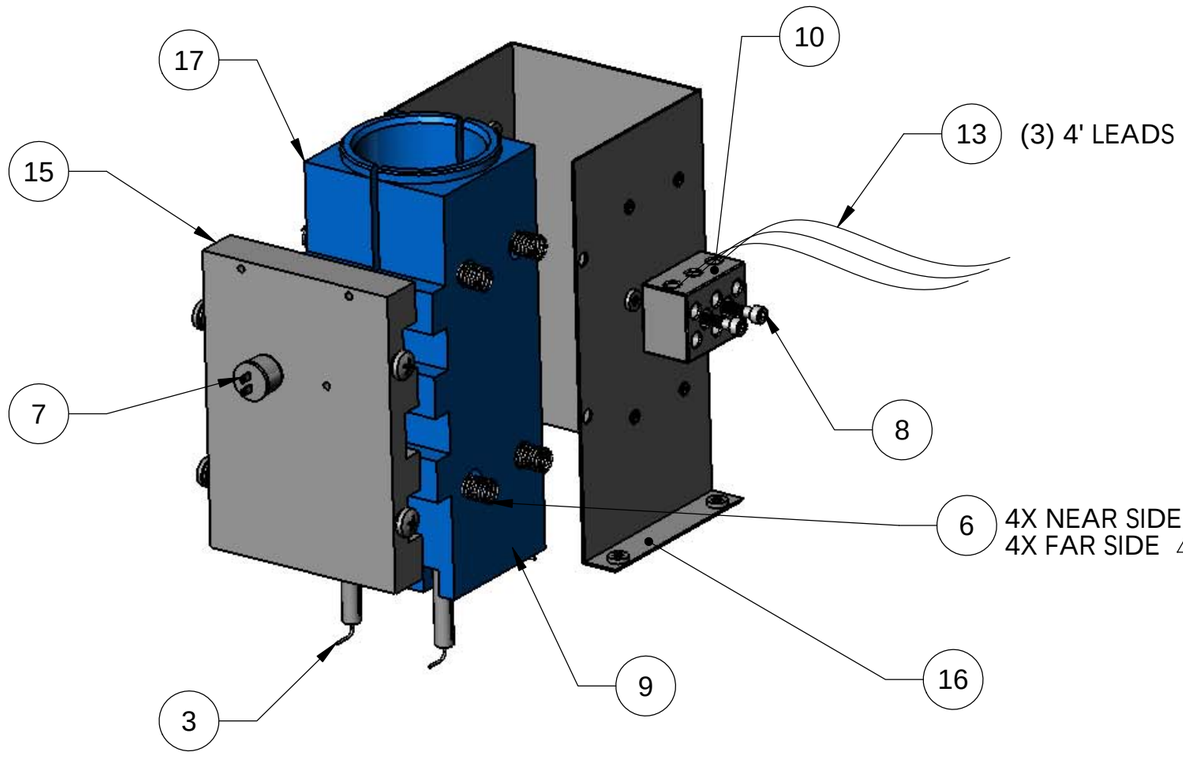
BATH ASSY

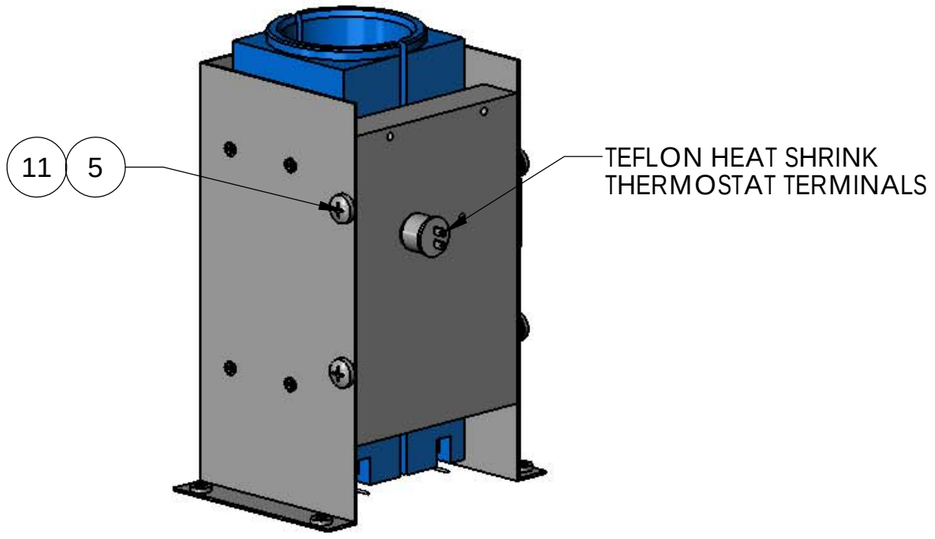
PN: 5550-0189 | REV B | SIZE B
PROJ: | SHEET 1 OF 1

TITLE BLOCK REV 3

NOTES:
1. ASSEMBLE MANIFOLD, SHELL AND SHOES
2. SNAP SPRINGS INTO POCKETS AND OVER PEM NUTS
3. SLIDE HEATERS INTO HOLES
4. INDIVIDUAL HEATERS ARE 110V, REFER TO APPROPRIATE DWG FOR WIRING DETAILS: -5550-0274 FOR 110V
   -5550-0271 FOR 220V.
5. INSTALL CAP
6. REFER TO DWG 5550-0273 FOR INSULATION DETAILS
7. HEAT SHRINK THERMOSTAT CONNECTIONS
8. WRAP AND SECURE INSULATION (ITEM 12) AROUND ASSEMBLY.

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	B	ECN T5080; RMVD C11010 FROM BOM, RPLCD W/ C15632	1/15/13	SB
	C	ECN T6507; C15632 QTY 8 WAS 4	3/27/15	ES/TC





C

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
3	C11458	HTR,CRTRG,.25 X5.25,300W,120V	4
5	H-10-105	SCREW,BHMS,SS,10-32X0.375,PHIL	4
6	C15632	SPRING,COMP,SS.375X1L, 1.2#/IN	8
7	C11048	THERMOSTAT, 550-F	1
8	H-6036	SCREW,SHC,6-32X5/8,SS	2
9	C11032	RTD,1/8 X 2, THREE WIRE	1
10	C10945	TERMINAL BLK, CERAMIC	1
11	H-10-002	WSHR,LOCK,SS,#10	4
12	5550-0273	ASSY, INSULATION	1
13	94-366	WIRE 18AWG TAN 250C TYPE TGGT	12'
14	07324-04	TERM,SPLICE,WIRE RNG 22-18 AWG	2
15	5550-0218	MNFLD, COOLING	1
16	5550-0220	SHELL, HEATER	1
17	5550-0404	SHOE,HEAT TRANSFER (EXT PAIR)	1

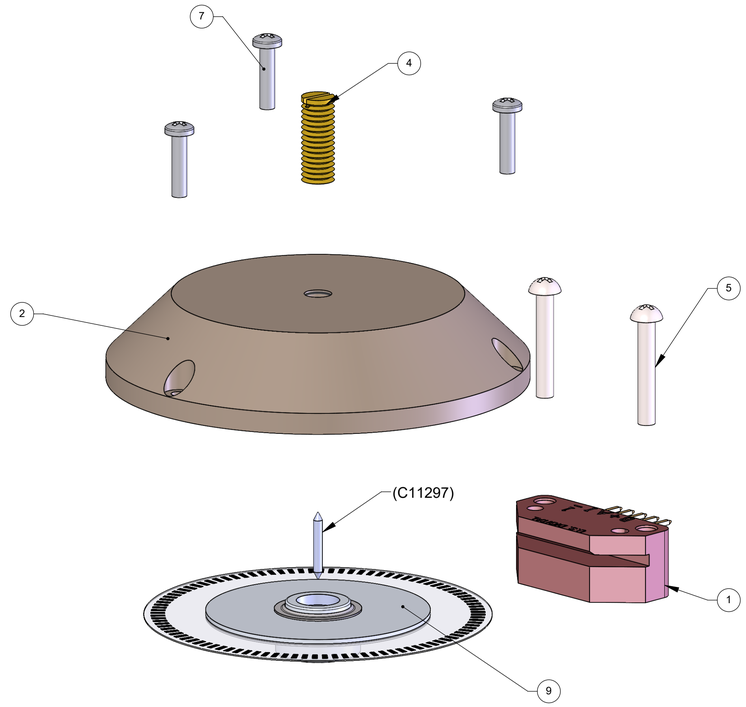
BREAK EDGES, DEBURR
UON DIMS ARE IN INCHES
1 PLC ±0.030 2 PLC ±0.010
3 PLC ±0.005 ANGL ±1/2°
SURFACE FINISH 63 RMS
THIRD ANGLE PROJECTION

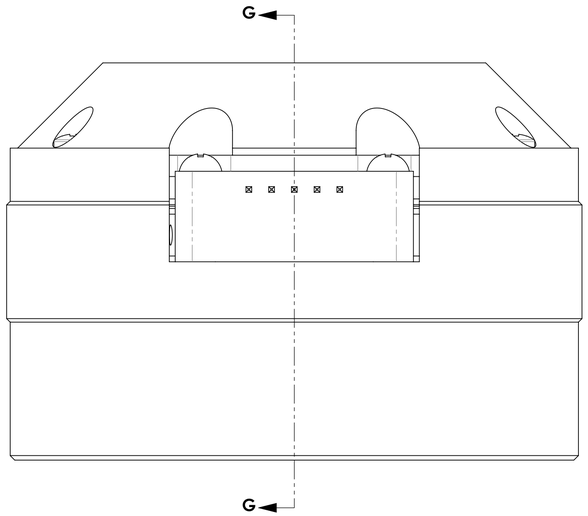
DRAWN: DBL 1/6/2004
MFG: RW 5/20/2004
ENGR: DBL 1/6/2004
TYPE:
STRUCT:

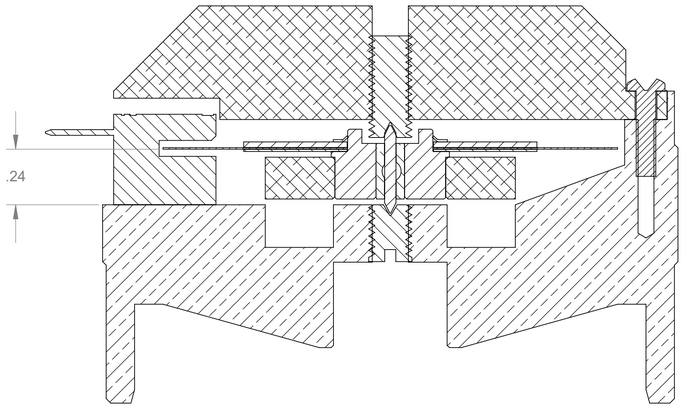
CHANDLER ENGINEERING
ASSY; HEATER
PN: 5550-0219 REV C SIZE B
PROJ: 5550 SHEET 1 OF 1
TITLE BLOCK REV 3

ASSEMBLY INSTRUCTIONS:
1. Follow 5550-0524 instructions for assembly and test.

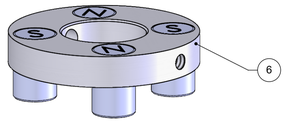
REV.	DESCRIPTION	DATE	APPROVED
B	ECN T1372, C11304 WAS H-4004	12/17/2007	JB/TC
C	ECN T2658; ADDED A REFERENCE TO C11297	1/12/10	TC
D	ECN T5043; CLARIFIED ASSEMBLY PROCEDURES	2/21/13	TC
E	ECN T5774; ADDED TEST PROCEDURE NUMBER TO LINE 11	2/19/14	TC
F	ECN T9650; REPLACED NOTES WITH 5550-0524	7/24/2023	JS

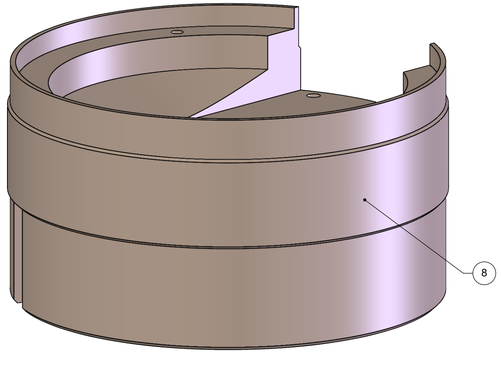


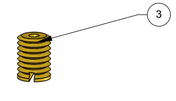


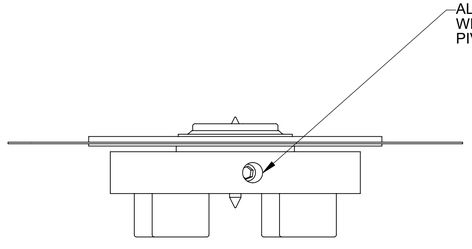


SECTION G-G









ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	C11174	MODULE,OPTICAL ENCODER	1
2	5550-0329	COVER,TOP,ENCODER	1
3	C11298	BRG,JEWEL,VEE,#10-32X1/4"L,BR	1
4	C11294	BRG,JEWEL,VEE,#10-32-1/2"L,BR	1
5	C11304	SCREW,RHMS,SS,3-48X0.62	2
6	5550-0331	MAGNET ASSY,ENCODER	1
7	C11303	SCREW,PHMS,BR,2-56X0.375,PHIL	3
8	5550-0327	HSG,ENCODER	1
9	5550-0364	CODEWHEEL ASSEMBLY,ENCODER	1
10	5550-0523	FIXTURE,CODEWHEEL,ENCODER	REF

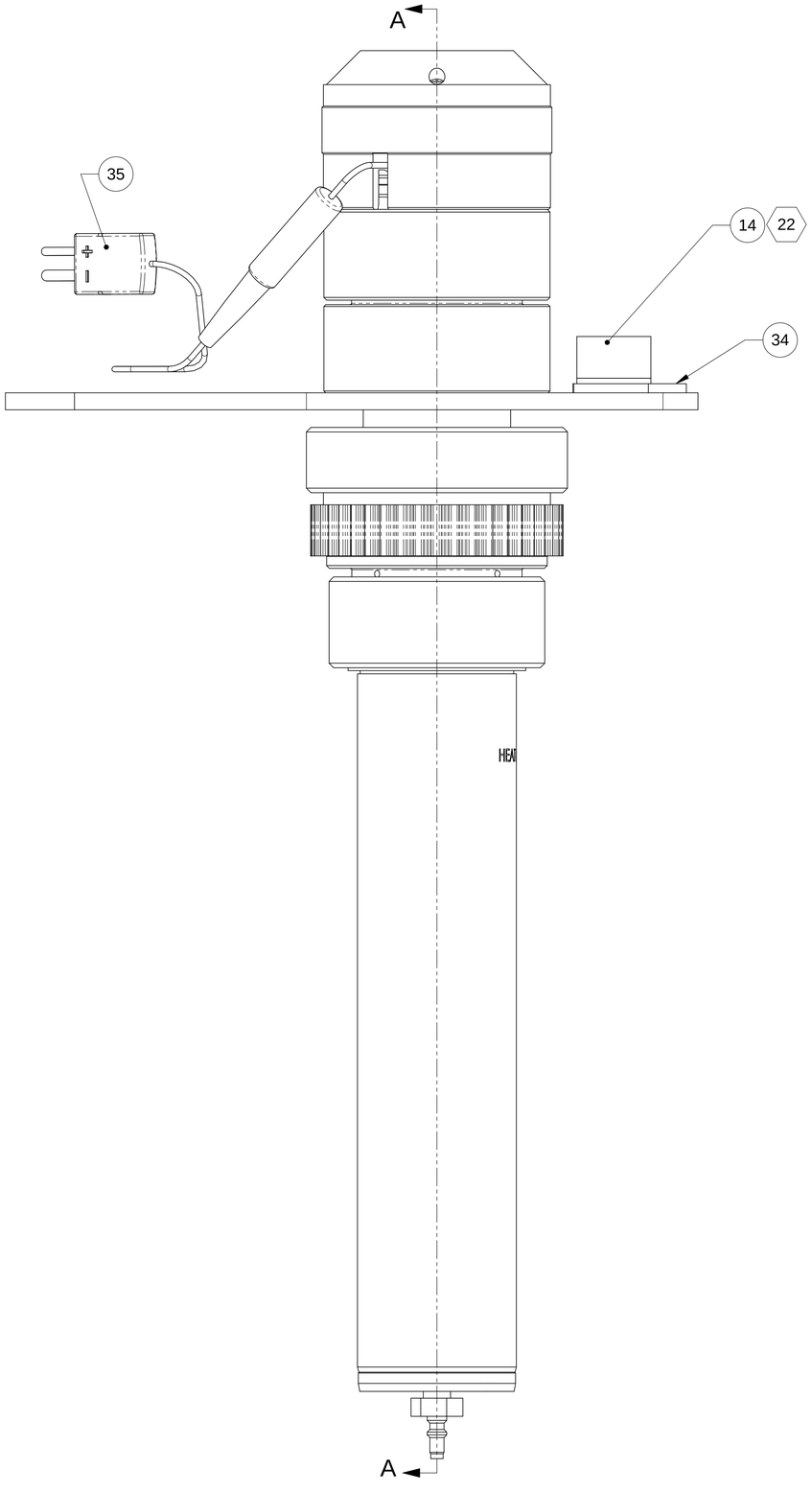
BREAK EDGES, DEBURR UON DIMS ARE IN INCHES
1 PLC ±0.030 2 PLC ±0.010
3 PLC ±0.005 ANGL ±1/2°
SURFACE FINISH 63 RMS
THIRD ANGLE PROJECTION

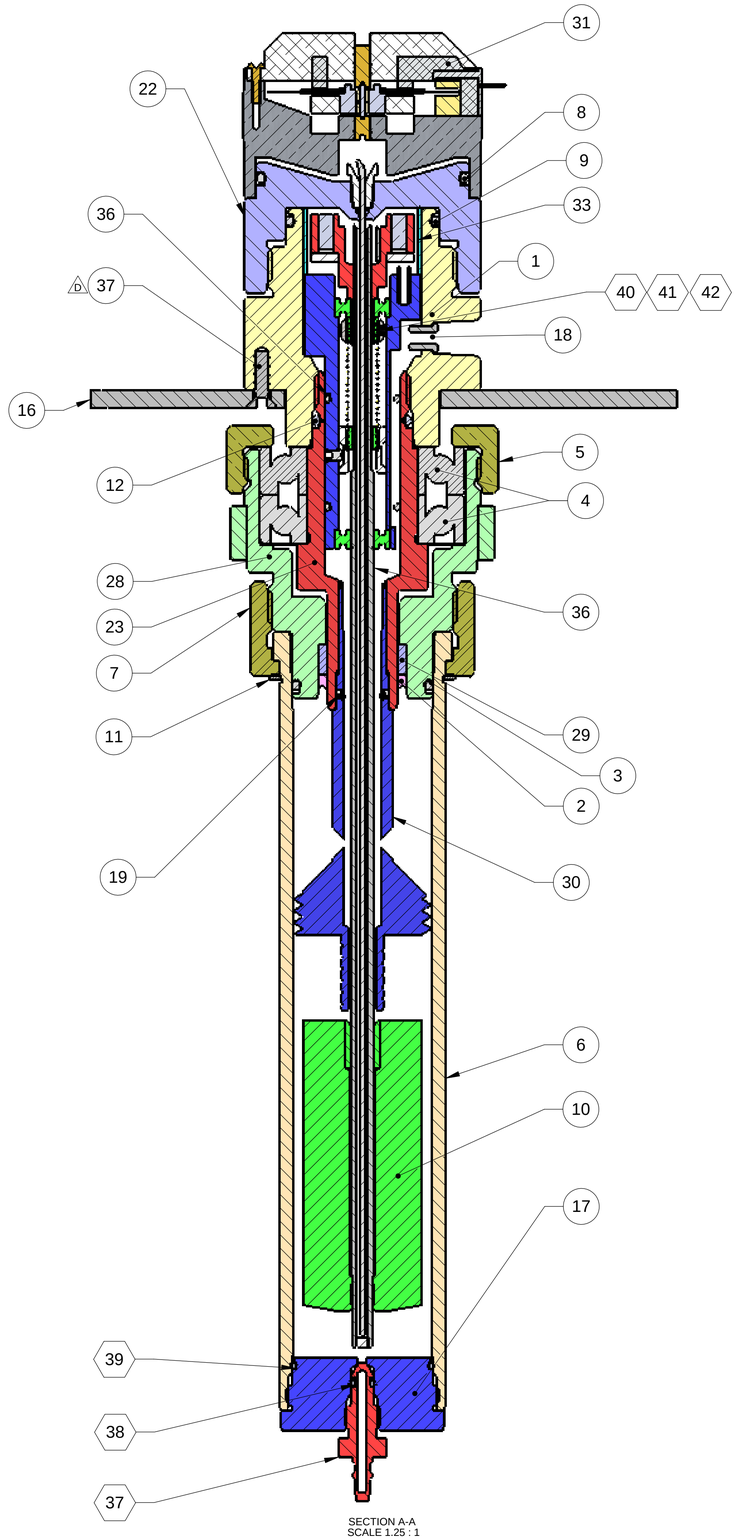
DRAWN: JJM 03-30-05
MFG: DBL 04-01-05
ENGR: JJM 03-30-05
TYPE:
STRUCT:

CHANDLER ENGINEERING
ENCODER ASSEMBLY
PN: 5550-0325
PROJ: Imported Data Set
REV F SIZE D
SHEET 1 OF 1

TITLE BLOCK REV 3

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	C	ECN T4762; ADDED VIEW E-E SHOWING THRUST BEARING DETAIL	8/21/12	TC
	D	ECN T6507; ADD H8015 QTY 3, DEL H-6009	3/27/15	ES/TC





SECTION A-A
SCALE 1.25 : 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	5550-0332	HEAD, VISCOMETER	1
2	C10874	BAL SEAL	1
3	C10788	ORING, VITON, AS125-75	1
4	C10888	BRG,30X55x13MM,NTN6006,SEALED	1
5	5550-0108	RETAINING COLLAR	1
6	5550-0432	CUP, SAMPLE - R1 ROTOR	1
7	5550-0102	COLLAR, CUP RETAINING	1
8	C09833	ORING,VITON,2-137-V75	1
9	C11258	ORING,VITON,2-127-V75	1
10	5550-0110	BOB, B5	1
11	C10293	RING,RTNG,EXT,WS-175	1
12	C09781	ORING,AS118-V75	1
14	P-0984	LEVEL, CIRC. 875MTG FLG,	1
D 15			
16	5550-0150	PLATE, HEAD MOUNTING	1
17	5550-0043	BOTTOM PLUG ASSEMBLY	1
18	5550-0344	FERRULE, LOCATING	1
19	P-2676	ORING,VITON,2-012-V75	1
22	5550-0333	CAP, TOP	1
23	5550-0120	SPINDLE, BEARING, LARGE ID	1
28	5550-0245	ROTOR ASSY	1
29	5550-0115	SLEEVE, SEAL EJECTOR	1
30	5550-0441	CLIMB ARRESTOR FOR xTD cUP	1
31	5550-0325	ENCODER ASSEMBLY	1
32	5550-0355	SHIELD, BEARING ISOLATOR.	1
33	5550-0366	AXIAL RETAINER	1
34	5550-0375	STOP, HOOD	1
35	5550-0456	ASSEMBLY, TC	1
36	5550-0457	ASSEMBLY, BOB SHAFT	1
D 37	H-8015	SCREW,FHMS,SS,8-32x.50	3
38	5550-0248	QC VALVE NEEDLE	REF
39	C09466	O-RING, VITON AS0007-75	REF
40	C09275	ORING, VITON AS028-V75	REF
41	5550-0328	SPRING ASSEMBLY, 440 (STANDARD)	REF
42	5550-0368	SPRING ASSEMBLY, 410 (AS OPTION)	REF
43	5550-0367	SPRING ASSEMBLY, 420 (AS OPTION)	REF

BREAK EDGES, DEBURR
UON DIMS ARE IN INCHES
1 PLC ±0.030 2 PLC ±0.010
3 PLC ±0.005 ANGL ±1/2°
SURFACE FINISH 63 RMS
THIRD ANGLE PROJECTION

DRAWN: DBL 8/7/2006
MFG: RW 8/7/2006
ENGR: DBL 8/7/2006

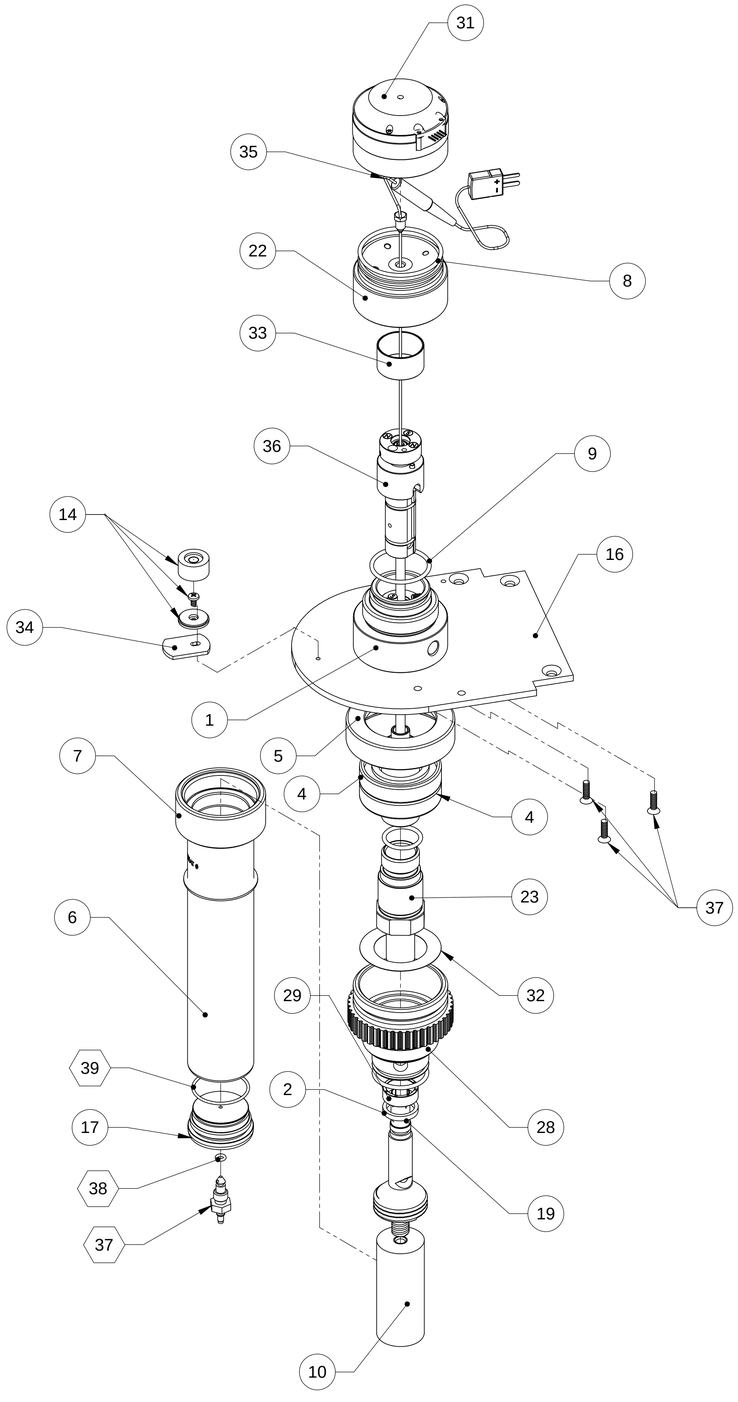
TYPE:
STRUCT:

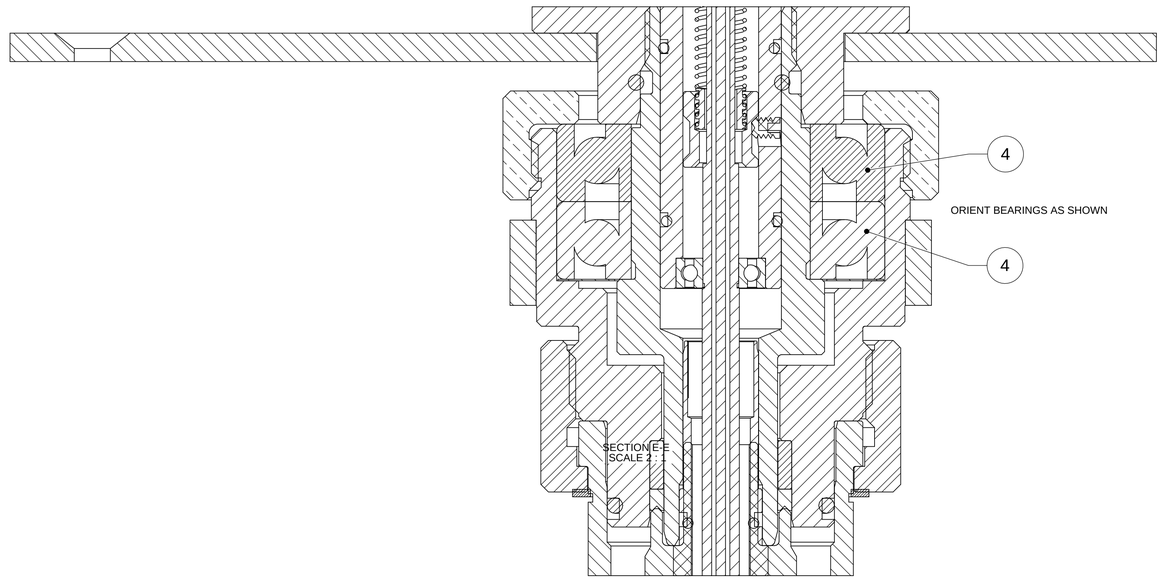
CHANDLER ENGINEERING

HEAD ASSEMBLY, VISCOMETER

PN: 5550-0454 REV D SIZE D
PROJ: 5550 SHEET 1 OF 2

TITLE BLOCK REV 3





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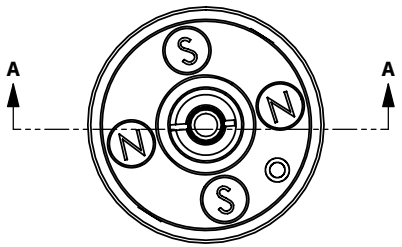
BREAK EDGES, DEBURR
UON DIMS ARE IN INCHES
1 PLC ±0.030 2 PLC ±0.010
3 PLC ±0.005 ANGL ±1/2°
SURFACE FINISH 63 RMS
THIRD ANGLE PROJECTION

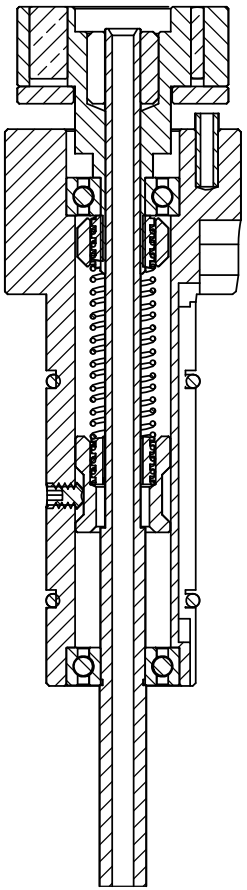
DRAWN: DBL 8/7/2006
MFG: RW 8/7/2006
ENGR: DBL 8/7/2006
TYPE:
STRUCT:

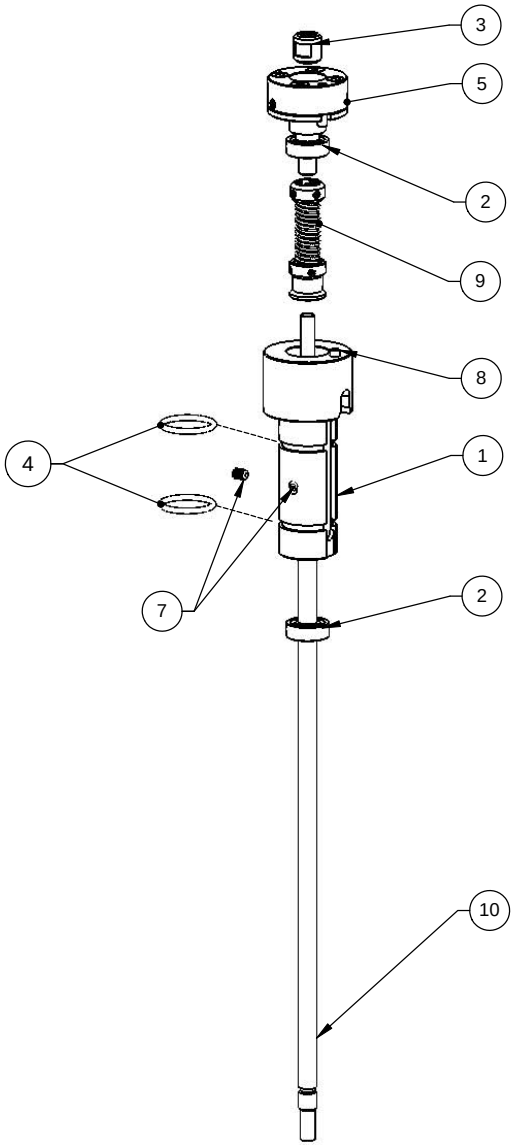
CHANDLER ENGINEERING
HEAD ASSEMBLY, VISCOMETER
PN: 5550-0454
PROJ: 5550
REV D
SIZE D
SHEET 2 OF 2

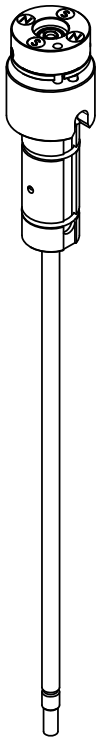
TITLE BLOCK REV 3

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	ECN T1321; PRODUCT LAUNCH	11/13/07	TC
	B	ECN# T2265, REMOVED 5550-0374	4/16/09	SS/TC









ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	5550-0336	SLEEVE, BEARING	1
2	C11289	BEARING, 6X15X5 SS	2
3	5550-0360	COLLET	1
4	C09832	ORING,VITON,2-017-V75	2
5	5550-0342	MAGNET ASSEMBLY, INNER	1
6	.	.	.
7	H-6005	SCR,SKT SET,6-32X.187,SS	2
8	5550-0345	PIN, LIMIT STOP	1
9	5550-0328	SPRING ASSY,F440,LEFT HAND	1
10	5550-0390	SHAFT, BOB	1

			.	.	SEE BOM	.	1
-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
QTY. REQD.				PARTS LIST			
.				.			
.				.			
.				.			
NEXT ASSY				USED ON			
APPLICATION							
BREAK SHARP EDGES, DEBURR							

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES

TOLERANCES:
1 PLACE ±0.030
2 PLACE ±0.010
3 PLACE ±0.005
ANGLES ±1/2°
SURF. FINISH √

APPROVALS		DATE
DRAWN:	DBL	8/18/06
CHECKED:	TC	8/15/06
ENGR.:	DBL	8/15/06

CHANDLER ENGINEERING

TITLE
XTD BOB SHAFT ASSEMBLY

SIZE	S.O. NO.	DWG NO.	REV.
C		5550-0457	B

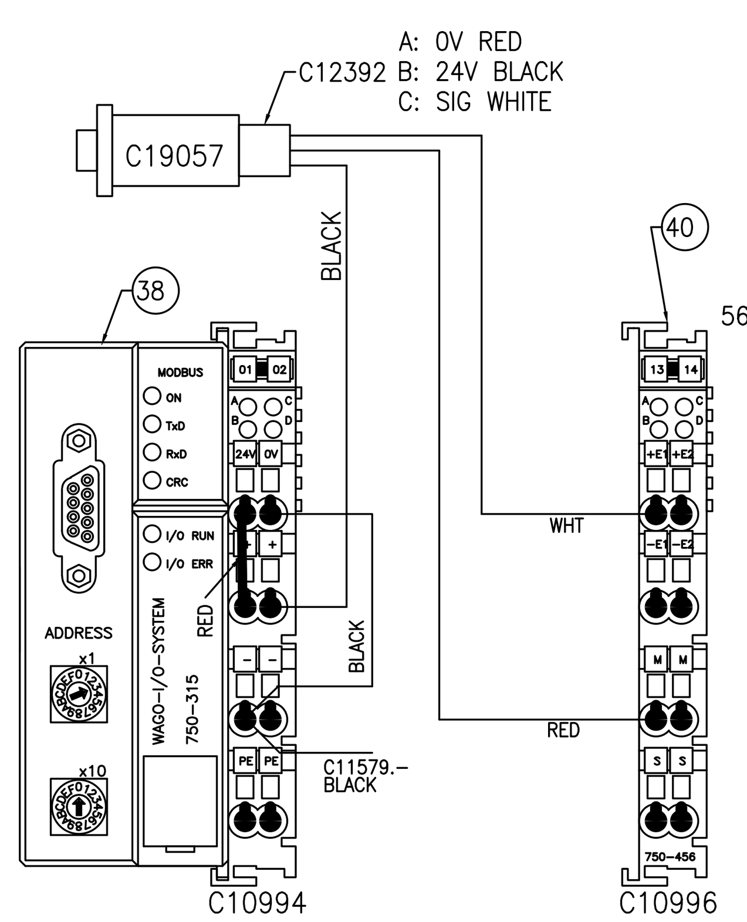
SCALE: 1:2 | TITLE BLOCK REV: 1.0 | SHEET: 1 of 1

NOTES:

1. INSTALL C09583 INTO C09772.
2. USE THE WIRE PART NUMBERS AS INDICATED IN THIS DRAWING – NO SUBSTITUTIONS ARE ALLOWED.
3. ROUTE AC AND DC WIRING SEPARATELY.
4. (4) CLEARLY MARK CHASSIS GROUND CONNECTIONS WITH C12232 LABEL (GROUND SYMBOL): ⏚ SECURE THE INLET POWER GROUND WIRE (GREEN/YELLOW) UNDER ITS OWN NUT (ALL OTHER GROUND WIRES CAN BE HELD UNDER A SINGLE NUT).
5. USE TWIN WIRE FERRULES (PANDUIT FTD77-8-D OR SIMILAR) TO CAPTURE WIRE LEADS WHEN TWO CONDUCTORS (WIRES) ARE WIRED INTO THE SAME ENTRY OF THE WAGO I/O MODULES.

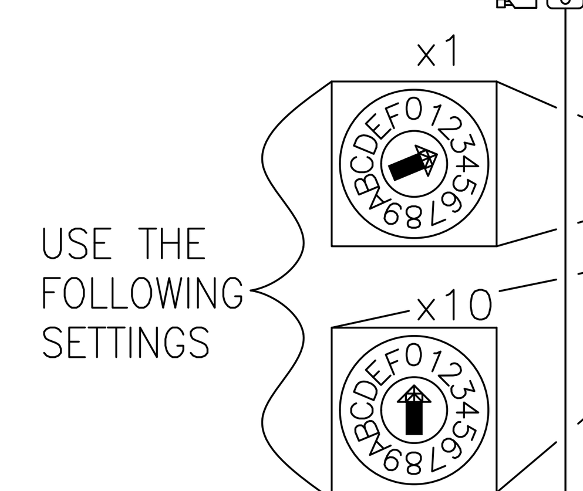
REVISIONS

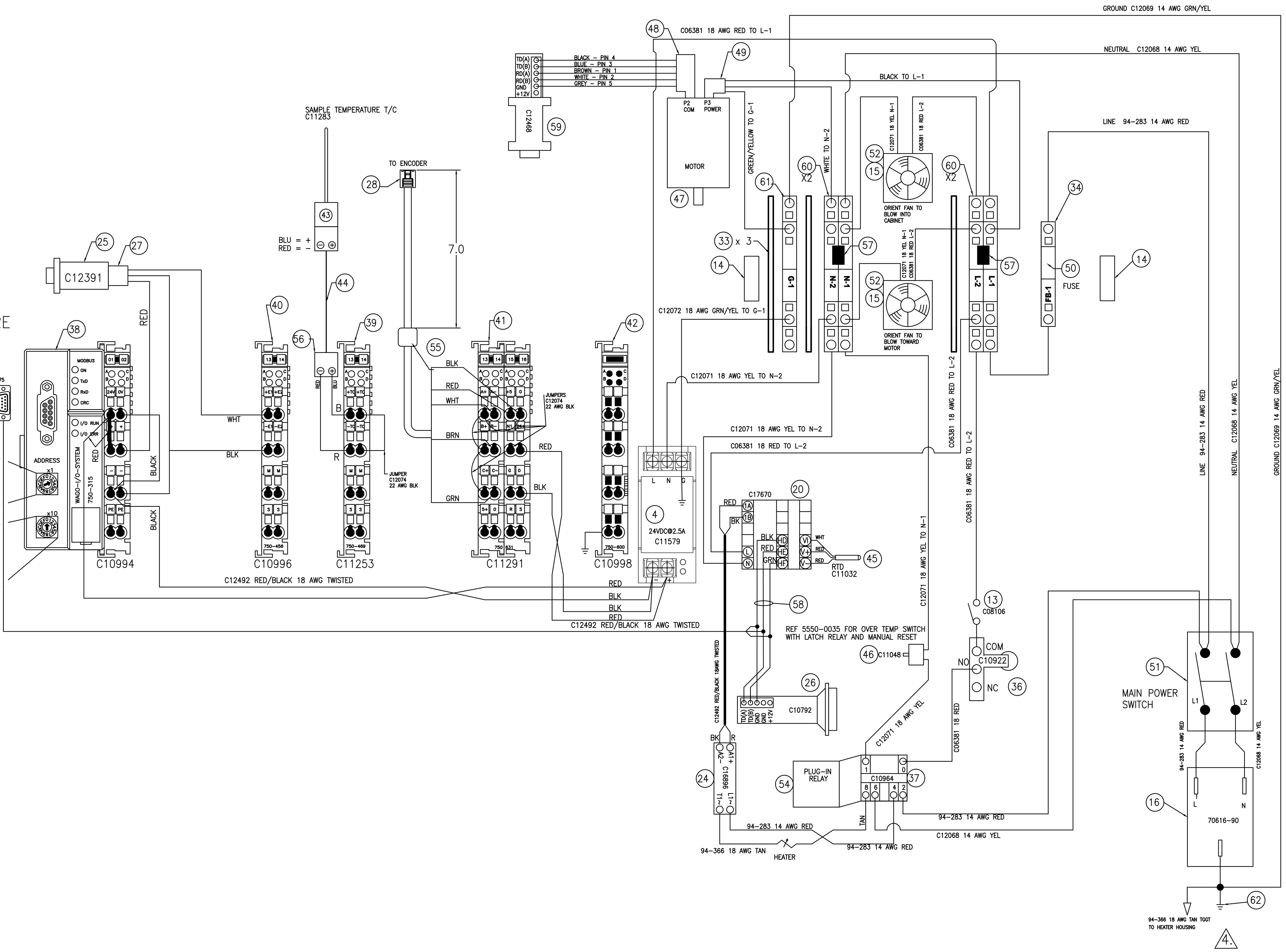
ZONE	REV	DESCRIPTION	DATE	APPROVED
	P	ECN T6507; MAKE REF DWG, DEL NAV BOM	3/26/15	TC
C4	R	ECN T6874; UPDATED WIRING TO C11579	11/13/15	TC
B3	T	ECN T7626; CHANGED C10353 TO C16896	03/29/17	JS
	U	ECN T7633; CORRECTED WAGO P/N FOR C11291	04/02/17	JJM
	V	ECN T9009; REPLACED C09772 W/ C17670	09/16/20	BW
C3	W	ECN T9031; REPLACED WHT WIRE W/ RED FOR RTD	10/26/20	BW
D6	Y	ECN T9408; UPDATED WAGO CONFIGURATION	03/18/22	WJW
C7	AA	ECN T9601; ALTERNATE XDCR WIRING	04/11/23	WJW
D7	AB	ECN Txxxx; CORRECTED ALTERNATE XDCR WIRING	08/24/23	WJW



ALTERNATE TRANSDUCER WIRING

C10994
MODBUS I/O
ADDRESS = 3
REORDER: C10994-5550
USE PROCEDURE
WAGO-0002 TO CONFIGURE





QTY	PN	DESCRIPTION	ITEM
			1
1	5550-0504	DIN RAIL 8-5/8" LGTH	2
1	5550-0275	ASSY,CABLE,WAGO COM	3
1	C11579	POWER SUPPLY,24VDC,2.5A,DIN	4
1	5550-0622-115V	FAN ASSEMBLY,AUXILIARY	5
1	5550-0622-230V	FAN ASSEMBLY,AUXILIARY	6
			7
REF	C04263	Bulkhead retainer	8
			9
			10
			11
			12
1	C12161	SWITCH,SPST,RCKR,10A,240V,0-1	13
2	C08226	END STOP, ENTRALEC	14
1	C08890	GUARD, FAN, 3-1/8",AC & DC	15
1	70616-90	CONN,AC RCPT LINE FILTER 3 CK	16
			17
			18
1	C11241	INTERFACE,USB,RS232,4PORT	19
1	C17670	CONTROLLER,EUROTHERM,EPC3016,1	20
			21
			22
2	C10127	CABLE,B9 M/F,25 FT	23
1	C16896	RELAY,SPST,32VDC,23A,DIN RAIL	24
1	C12391	XDCR,PRESS,1-5V, 2500 PSI	25
1	C10792	CONV, COMM, RS232-RS485	26
1	C12392	3WAY,FEMALE CONNCTR 3FT CABLE	27
1	C11255	CABLE, ENCODER INTERFACE	28
			29
			30
			31
			32

QTY	PN	DESCRIPTION	ITEM
3	C12495	END PLATE, WAGO 280-315	33
1	C10906	BLOCK,FUSE,WAGO 281-623	34
			35
1	C10922	SWITCH,ROLLER PLUNGER,10A	36
1	C10964	Relay base OmronP7LF-06	37
1	C10994	WAGO, MODBUS BASE, 750-315	38
1	C11253	Wago,T-TC MODULE,750-469/000-002	39
1	C10996	Wago,AN IN MODULE,750-456	40
2	C11291	Wago, ENCODER MODULE 750-631	41
1	C10998	Wago,END MODULE,750-600	42
1	5550-0456	ASSY,THERMOCOUPLE,14.5	43
3'	C11287	CABLE, TYPE T THERMOCOUPLE	44
1	C11032	RTD, .125 X 2	45
1	C11048	THERMOSTAT, 550 F	46
1	5550-0510(220V)	MOTOR,34AC 240V	47
1	5550-0513(110V)	MOTOR,34AC 120V	48
1	C12486	CABLE,M12,5 POLE,RT ANGLE	48
1	C12487	CABLE,LUMBERG,RKW 30-638/6F	49
1	C10599	FUSE,4A/250V, 3AG,SLO-BLO	50
1	C12684	SWITCH,BRKR,16A,0-1	51
1	C08889(220V)	Fan, 80 x 42 mm, 230vac	52
1	C09923(110V)	Fan, 80 x 42 mm, 120vac	52
1	C09373	RELAY,DPST,120VAC,25A	54
1	P-1253	CORD, STRAIN RELIEF, SR-6	55
1	C11285	JACK, SQ, TYPE T BLKHD MINI	56
2	C10903	JUMPER,ADJ,GRY,WAGO 280-402	57
2	C09911	CABLE, SHIELDED 22AWG	58
1	C12468	CONV, COMM, RS232-RS422	59
4	C12475	BLOCK,TERM,GRAY,4,WAGO 280-833	60
1	C12476	BLOCK,TERM,GRD,4,WAGO 280-833	61
1	C12233	LABEL, GROUND	62

NEXT ASSY	USED ON
APPLICATION	
BREAK SHARP EDGES, DEBURR	

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES [mm]

TOLERANCES:
1 PLACE ±0.030 [.76]
2 PLACE ±0.010 [.25]
3 PLACE ±0.005 [.127]
ANGLES ±1/2°
SURF. FINISH 32

APPROVALS		DATE
DRAWN:	DBL	3/25/04
CHECKED:	JD	2/36/04
ENGR.:	DBL	3/25/04

CHANDLER ENGINEERING

TITLE WIRING SCHEMATIC MODEL 5550

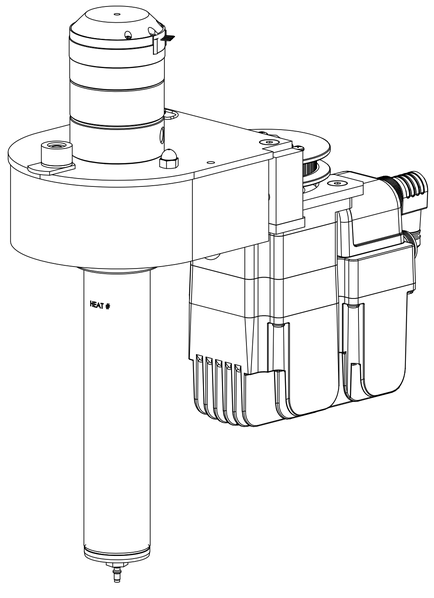
SIZE	S.O. NO.	DWG NO.	REV.
C		5550-0506	AB

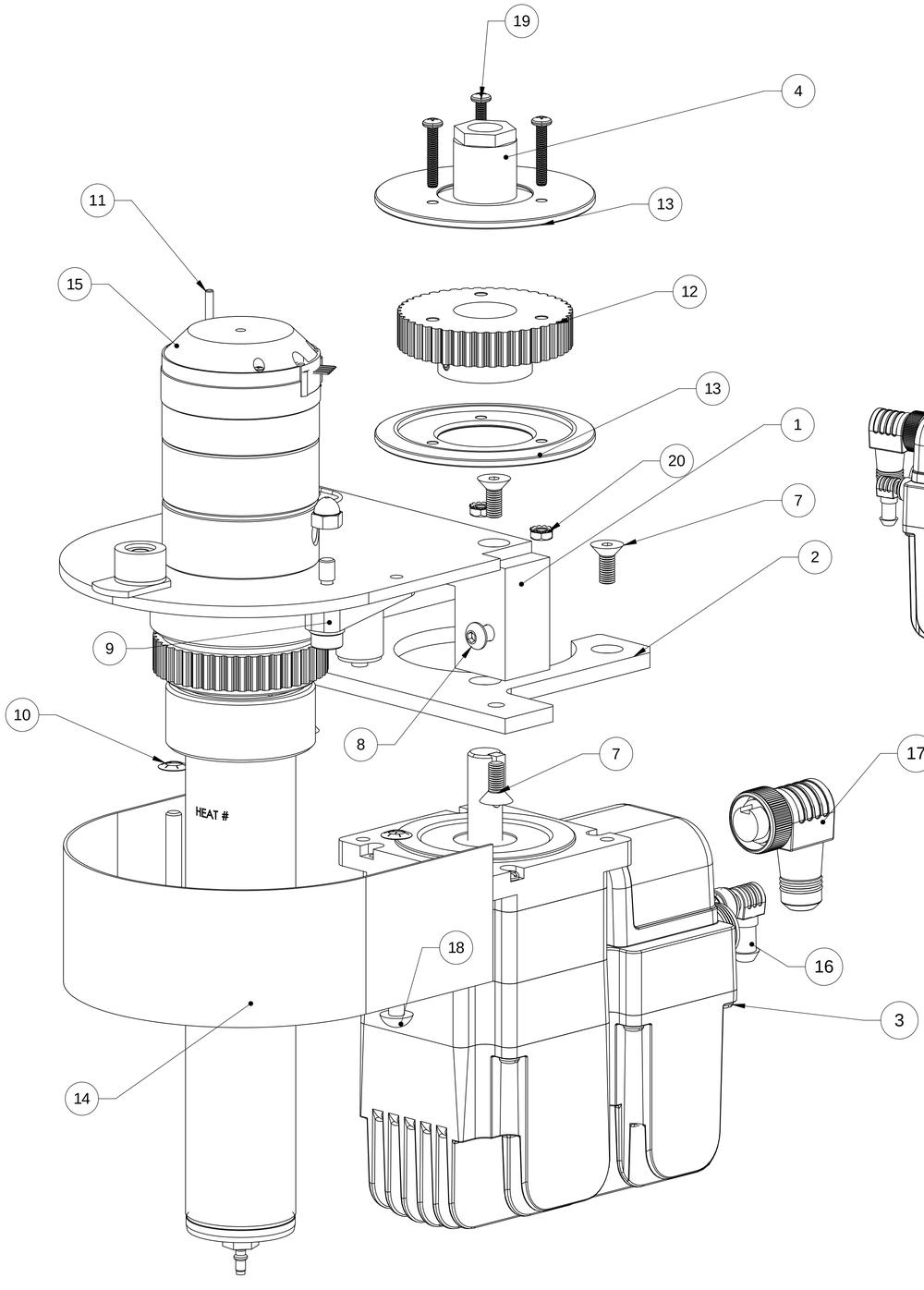
SCALE: 1 = 1 | TITLE BLOCK REV: 1.0 | SHEET: 1 of 1

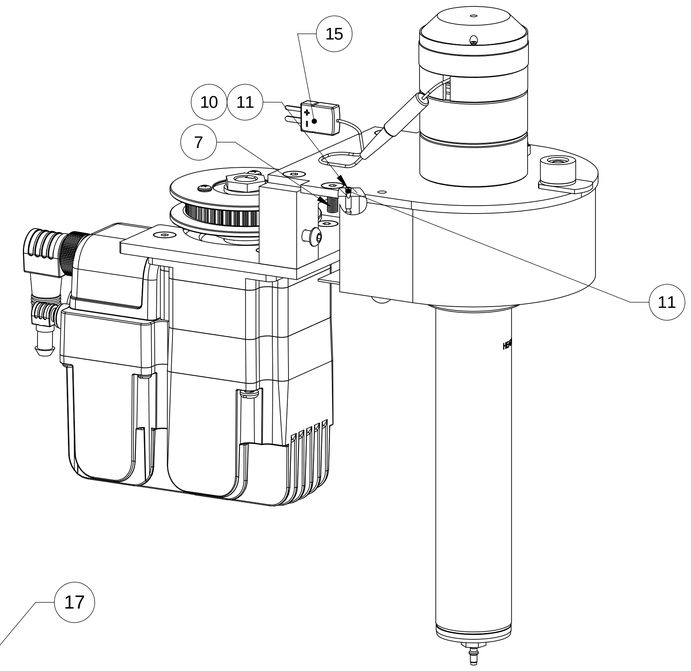
NOTES:

1. MOUNT BRACKET 1 TO CHASSIS THROUGH FRONT APPEARANCE PANEL
2. MOUNT PLATE 2 TO BRACKET 1.
3. GRIND PIN TO .5 LONG. PRESS PIN 11 INTO PLATE 2 FROM THE TOP.
4. MOUNT MOTOR TO PLATE 2.
5. MOUNT FLANGES 13 TO PULLEY 12.
6. MOUNT PULLEY TO MOTOR USING COUPLER 4.
7. MOUNT 9 IDLER ARM ASSY AND SPRING.
8. MOUNT HEAD ASSY TO 5550-0454 MOUNTING PLATE.
9. MOUNT BELT. AND ADJUST POSITION OF PULLEY FOR BELT TO CENTER UP.
10. MOUNT BELT GUARD

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	G	ECN T5342; CHG ITEMS 16 AND 17 TO REF	5/23/13	TC
	H	ECN T6507;; DEL H-24-111,ADD H-24-108; CREATED - 110V AND -220V AND ADDED MOTORS	3/27/15	ES/TC







ITEM	PART NUMBER	DESCRIPTION	-110V	-220V
1	5550-0503	BRACKET, DRIVE MOUNT MODIFIED	1	1
2	5550-0500	PLATE, MTR MNT,MODIFIED	1	1
3	5550-0510	MOTOR, 34AC MOD, 220V	-	1
3	5550-0513	MOTOR,34AC,MOD,110V	1	-
4	C10867	COUPLER,TRANTORQUE, 14MM	1	1
5	C10960	SPRING,EXT,3/8X.035X2.5,SS	1	1
6	C11288	BELT,105T,.20PITCH,3/8W,NEOPRENE	1	1
7	H-24-112	SCREW,FLHS,250-28X625,SST	9	9
8	H-24-108	SCREW,PHCS,SS,1/4-28X1.000,AL	2	2
9	5550-0223	IDLER ARM ASSEMBLY	1	1
10	C11064	RET,PUSH-ON,1/4,CS	2	2
11	C11096	POST,SPRING,1/8X5/8	1	1
12	5550-0143	PULLEY, TIMING BELT	1	1
13	5550-0146	FLANGE	2	2
14	5550-0268	BELT GUARD	1	1
15	5550-0454	HEAD ASSEMBLY, VISCOMETER	1	1
16	C12486	CABLE, LUMBERG RKT 5-228/2M	REF	REF
17	C12487	CABLE, LUMBERG, RKW 30-638/6F	REF	REF
18	H-25-037	SCREW,RHMS,SS 1/4-20X2-1/4	2	2
19	H-8022	SCREW,BHMS,SS,8-32X1.000,PHIL	3	3
20	H-8031	NUT, HEX, SS, 8-32, KEPS	3	3
21	H-25-004	NUT, ACORN, 1/4-20	1	1

BREAK EDGES, DEBURR
UON DIMS ARE IN INCHES
1 PLC ±0.030 2 PLC ±0.010
3 PLC ±0.005 ANGL ±1/2°
SURFACE FINISH 63 RMS
THIRD ANGLE PROJECTION

DRAWN: CIV 6/8/2008
MFG: TC 06-08-08
ENGR: CIV 6/8/2008

TYPE:
STRUCT:

CHANDLER ENGINEERING
VISCOMETER AND MOTOR ASSEMBLY

PN: 5550-0507-XXXX
PROJ:

REV H | SIZE D
SHEET 1 OF 1

TITLE BLOCK REV 3

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Please Send Us Your Comments on This Manual

Model Number _____ Serial Number _____

Printing Date of this manual (from the Title Page) _____

Please circle a response for each of the following statements. Use:

(1)= Strongly agree (2) =Agree (3) =Neutral, no opinion (4) =Disagree (5) =Strongly disagree

a) The manual is well organized.	**1**	**2**	**3**	**4**	**5**
b) I can find the information I want.	**1**	**2**	**3**	**4**	**5**
c) The information in the manual is accurate.	**1**	**2**	**3**	**4**	**5**
d) I can easily understand the instructions.	**1**	**2**	**3**	**4**	**5**
e) The manual contains enough examples.	**1**	**2**	**3**	**4**	**5**
f) The examples are appropriate and helpful.	**1**	**2**	**3**	**4**	**5**
g) The manual layout is attractive and useful.	**1**	**2**	**3**	**4**	**5**
h) The figures are clear and helpful.	**1**	**2**	**3**	**4**	**5**

i) The sections I refer to most often are _____

_____

Other comments _____

_____

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