Model 7550
High Temperature
High Pressure Viscometer
Operating Manual

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S/N ______________

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General Information

Figure 1 - Model 7550 HPHT Viscometer

Purpose and Use

The Model 7550 high pressure high temperature (HPHT) couette viscometer is designed for determining the rheology of well completion fluids under varying conditions in accordance with applicable API and ISO standards.

Description of Instrument

The shear stress created between a stationary bob and rotating rotor is measured using a precision torsion spring and high-resolution encoder. Known sample shear rates are created between the bob and rotor using defined bob/rotor geometry and a stepper motor sub-system providing rotational speeds ranging from 0 – 600 rpm. Suspended solids in the sample are circulated during a test using a helical screw on the outside diameter of the rotor.

The sample viscosity is determined as the ratio of shear stress (dyne/cm^2) to shear rate (sec^{-1}) resulting in dyne-sec/cm^2, otherwise expressed as Poise.

These measurements are made at sample conditions ranging from 0 - 30000 psi (207 MPa), and 32°F - 500°F (0°C - 260°C). A chiller is a separate option.

The system is controlled using a program that provides data acquisition, multi-axis data display options and automatic instrument operation and calibration features.

Features and Benefits

The major features of the Model 7550 HPHT Viscometer are listed below:

- Viscometer meets applicable API and ISO requirements
- Bench-top instrument
- Data acquisition and control system
- Automatic control of sample temperature and pressure using PID controllers
- High pressure (30000 psi, 207 MPa), high temperature (500°F, 260°C) sample testing
- Mixing of sample during test using helical screw on outside diameter of rotor
- Automatic control of instrument, including data collection, shear rate scheduling, power-law model coefficients (n' and K'), display and calibration
- Automatic 10 second and 10 minute gel strength measurements
- Sample wetted parts made from stainless steel and other corrosion resistant high strength materials
- Stepper motor and magnetic drive used to generate shear rates, providing high accuracy and stability
- High resolution measurement of shear stress
- Safety systems designed into the instrument and software (over-pressure, over-temperature)
- Microsoft Excel compatible data output

Specifications

Instrument Utilities:

- Main Power: 208-240 VAC, 50/60Hz, 10A maximum
- Instrument Air or N_2: 150 psi, 1034 kPa ±10% (filtered and dry)
- Coolant: Water

Sample Environment:

- Maximum Pressure: 30000 psi, 207 MPa
- Maximum Temperature: 500˚F, 260˚C
- Minimum Temperature: 32˚F, 0˚C

Sample Rheology:

- Minimum Shear Stress: 2.0 dyne/cm^2
- Maximum Shear Stress (approximate, varies with spring assembly):
  - F4: 6000 dyne/cm^2
  - F2: 3000 dyne/cm^2
  - F1: 1500 dyne/cm^2
- Shear Stress Resolution: ±0.02% of F.S. (encoder resolution 2:10000)
- Motor Speed Range: 0.001– 600 RPM
- Shear Rate Range: .0017 – 1022 sec^{-1}, corresponding to 1 – 600 RPM (B1/R1)
- Sample Gel Strength: Peak value at 3 RPM

Couette Geometry:

- Bob Radius (R_i): 1.7245 cm (B1) – other bobs are available, contact Chandler Engineering
- Rotor Radius (R_0): 1.8415 cm (R1)
- Bob Length (L): 3.805 cm (B1)
- Sample mixing via helical screw on OD of rotor with circulation ports in rotor and bob. A rotor without the helical mixing option is available.

Pressure Vessel:

- Removable sample plug assembly with support stand
- Sample/Oil separation zone
- High pressure magnetic drive for rotor
- High strength, corrosion resistant superalloy construction
- High pressure pressure ports (F250C), knurled nuts and wrench flats
- Elastomer with metal backup seals
- Material heat traceability, hydrostatically tested to 1.5x rated pressure (45000 psi, 310 MPa)

Test Fluids:

- Well completion fluids containing hematite, barite, calcium carbonate

Torque Measurement System:

- External cooled torque sensor, magnetically coupled to bob shaft

Motor System:

- Stepper motor subsystem

Temperature Control:

- Programmable PID Controller
- Resistance heaters with contactor and redundant over-temperature protection
- Temperature steady-state control stability: ±2˚F, ±1˚C
- J-type thermocouple located on centerline of bob and within cast heater

Pressure Control (Pump and Valve):

- Programmable PID Controller
- Air/Liquid Pump
- Diaphragm operated high pressure valve and flow restriction
- Pressure control stability: ±500 psi at F.S.
- Pressure transducer
- High pressure rupture disk (31000 psi, 214 MPa)
- Pressurizing fluid: heat transfer fluid

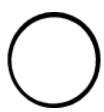
Control System:

- Microsoft Windows based program providing the following:
    - Temperature and Pressure control time-based profiles with data collection inhibits during temperature and pressure stabilization periods
    - Motor RPM (shear rate) time or temperature based profiles providing standard speeds (600, 300, 200, 100, 6, 3) or other user-defined speeds
    - Saved user defined test profiles
    - Configurable multiple axis plots of all variables (T, P, Shear Rate, Shear Stress, Viscosity, Dial Reading, etc.)
    - Automatic calibration using Newtonian oil and multiple shear rates
    - Serial interface to instrument temperature, pressure, motor controllers
    - Data export in CSV format, compatible with Microsoft Excel
    - Configurable alarms for maximum shear stress, temperature, pressure
    - Pause, Resume, Jump feature for profile steps
    - Schedule "wizard" to simplify new schedule creation

Environmental Conditions:

- Pollution degree 2
- Altitude 2000 m
- Humidity 50 to 80%
- Indoor use only
- Temperature 5°C to 40°C (41°F to 104°F)
- The mains supply voltage fluctuations are not to exceed ±10% of the nominal supply voltage

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 7550 HPHT Viscometer:

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

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

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

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

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

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

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

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 7500 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 7500 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 7500 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 Stress

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.

Safety Requirements

READ BEFORE ATTEMPTING OPERATION OF THE INSTRUMENT

The Chandler Engineering Model 7550 HPHT Viscometer is designed with operator safety in mind. Any instrument that is capable of high temperatures and pressures should always be operated with **CAUTION**.

If this is equipment is not used in a manner consistent with manufacturer's specifications, the protection provided by the equipment may be impaired.

Read before attempting operation of instrument. This instrument is capable of extremely 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 to follow the instructions outlined below.

During a test, the top panel around the test cell can become hot and cause injury.

Remove oil from surfaces prior to conducting tests at high temperatures to avoid the possibility of creating fumes. The instrument should be mounted under a vent hood, or equivalent ventilation, if sample temperatures will be above 400°F, 204°C for extended time periods.

The instrument is calibrated with known viscosity silicone oils, do not expose these oils to temperature above ambient to avoid thermal decomposition of the silicone oil that may form dangerous fumes.

The instrument must be mounted under a vent hood, or equivalent ventilation, if sample temperatures will be above 400°F, 204°C for extended time periods.

To further ensure safety:

- Provide adequate training of all personnel that will operate the instrument.
- Locate the instrument in a low traffic, well-ventilated area.
- This is a bench top device; place the instrument on a suitable level and stable surface. Allow a minimum of 5-inches (127mm) unobstructed clearance around the instrument to provide adequate ventilation.
- Post signs where the instrument is being operated to warn non-operating personnel that high pressure, high temperature equipment is in use.
- Read and understand instructions before attempting instrument operation.

- Observe caution notes.
- Observe and follow the warning labels on the instrument.
- Never exceed the instrument maximum temperature and pressure ratings.
- Always disconnect main power to the instrument before attempting any service or repair.
- Turn OFF the heater at completion of each test.
- Remove oil on heated surfaces that may pose a hazard prior to starting a test that will exceed 400°F, 204°C.
- Although the pressure vessel was designed using suitable materials and techniques, due to the extreme pressure rating, it is imperative to monitor the condition of the vessel and related components with a focus on safety. Any damage to the vessel or related high-pressure components must be brought to the attention of Chandler Engineering.
- Note that AMETEK Chandler Engineering recommends periodic re-inspection and testing of the pressure vessel assembly to maintain the rated temperature and pressure ratings. Without re-inspection and testing, the pressure rating of the vessel assembly must be de-rated as a function of age, usage and condition in accordance with established vessel de-rating schedules at Chandler Engineering. Chandler Engineering supports the design and offers periodic vessel testing services and component replacement if/when required.
- A fire extinguisher, type 8 BC, should be located within 50 feet (15 meters) of the instrument.
- Have the safety officer at your location or laboratory review the safety aspects of the instrument and installation and approve the operational and installation procedures.

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

Where To Find Help

In the event of problems, the local sales representatives will be able to help or the personnel at Chandler Engineering can be contacted.

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

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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 any spare parts that were ordered with the unit. Make sure that no parts or tools are lost when discarding the packing materials. Place the instrument on a firm table, close to the coolant and air sources and required electrical outlet.

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.

Utilities Required

- Main Power to Instrument: 208-240 VAC, 50/60 Hz, 10A maximum.
- A suitable uninterruptible power supply is recommended to prevent data loss during a power failure.
- Coolant: Clean water
- Optional Chiller subsystem
- Drain: Suitable for steam
- Air or Nitrogen: Filtered, dry; 75-150 psi, 517-1034 kPa.

To achieve 30000 psi, 207 MPa using the internal pump, a supply of at least 130 psi, 900 kPa Air or Nitrogen is required.

Equipment Required

- Set of English open-end wrenches
- Set of English size hex wrenches (supplied with instrument)
- Solvent based parts cleaning equipment
- Mounted bench vise

Setup Instructions

READ BEFORE ATTEMPTING OPERATION OF INSTRUMENT

1. Locate the instrument near power, air, water, and drain connections.

2. Level the instrument by adjusting the legs under the instrument. A bubble level is provided on the top panel of the instrument. Place the bubble on the top of the vessel when leveling the instrument. This approach ensures that the bob shaft is vertical.

3. This instrument requires 208-240VAC.

> **Warning: Verify that the proper input voltage is applied before connecting power (220 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.

4. Connect power to the instrument using the power cord supplied with the instrument. All power and grounding must be consistent with local wiring codes.

5. The power plug may need to be changed if the local receptacle is incompatible with the plug supplied with the instrument.

6. Connect the Air (or N_2), Coolant, and Vent connections to the instrument. The coolant outlet connection must be rated for high temperature steam.

7. The Vent port is connected to the rupture disk discharge. If the rupture disk fails, potentially hot fluid will discharge from this port. Route the discharge from this port to a safe location.

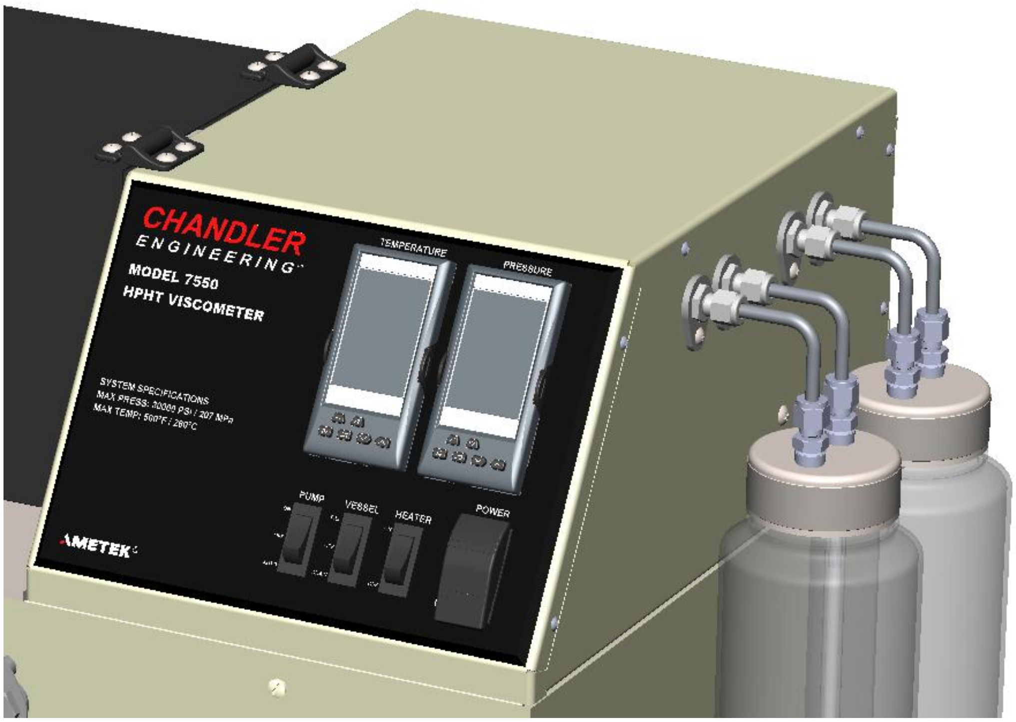
8. An additional Exhaust port is used to discharge low pressure air during valve switching. Discharge from this port may include oil mist. Route the discharge from this port to a safe location.

9. 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.

10. Connect the power cable.

Section 2 – Operating Instructions

Front Panel Controls



Power

Controls the main power to the instrument.

Pump

ON: Provides manual control of the internal pump
OFF: Disables the internal pump
AUTO: Controller provides pressure control of the pump

Vessel

FILL: Fills the pressure vessel with pressurizing fluid from the right-front supply bottle
OFF: Vents the low pressure air or nitrogen to the supply vessel
DRAIN: Drains the pressurizing fluid from the pressure vessel once the pressure release valve is open.

Heater

ON: Enables the heater
OFF: Disables the heater

Pressure Gauge

The instrument is equipped with a 30000 psi, 207 MPa pressure gauge in addition to the internal pressure transducer.

Pressure Release Valve

The pressure release valve must be closed for pressure to build inside the vessel. When opened, pressure is released from the vessel and the fluid drains to the rear bottle located at the right-rear of the instrument.

Temperature and Pressure Controllers

The instrument is equipped with two controllers that are interfaced to the computer-based software.

Operational Guidelines

- Thoroughly clean vessel components and threads after each test.
- Replace top cap and plug o-rings at the first sign of wear. These o-rings must be discarded after each test that exceeds 450°F. Use the FFKM o-rings when the sample temperature will exceed 450°F. Below this temperature the FKM o-rings may be used.
- Routinely inspect the pivot bearing and pivot, replacing if the instrument sensitivity has diminished.
- Routinely inspect the bushing that is located below the rotor, replacing as needed.
- Routinely inspect the o-rings (2) that are used on the sample cup baffle, replacing as necessary. Note that neglecting these o-rings will result in contamination of the sample, pressurizing oil and incorrect results.
- Assemble the plug assembly without sample. Verify that bob and spring assemblies move freely, and the top pivot is supported by the top clip. Verify that the top pivot does not extend beyond the top clip.
- Mount the plug assembly in the vessel.
- Mount the top seal ring and o-ring (FFKM or FKM) and screw the top cap into place.
- Attach the high-pressure interconnection tube.
- Mount the encoder and attach cable and cooling air tube.
- Zero the encoder electronics.
- Open the pressure release valve.
- Operate the motor at 50 rpm, use the syringe adapter and luer-tip syringe to slowly fill the sample cup with 110 mL of sample.
- In cases where the sample viscosity is excessive, zero the encoder, remove the plug assembly and fill the sample cup with 80 mL of sample. Replace the plug assembly and encoder, noting that the encoder reading may indicate a positive deflection due to the gel strength of the sample.
- Use the syringe adapter and luer-tip syringe to slowly fill the sample cup with 30 mL of sample.
- Remove the syringe adapter and install the high-pressure plug.

Sample Volume

The sample is pressurized with an inert mineral oil. To eliminate frictional effects, seals are not used to separate the sample from the mineral oil. The oil/sample interface exists within the plug above the sample volume. During use, provided the interface remains within the plug, mixing of the oil and sample does not occur.

During a test over a range of temperatures and pressures it is important to be aware of sample PVT characteristics. In other words, the sample volume varies with pressure and temperature.

The volume of the sample cup below the plug is 100 mL. The 7500 Viscometer is designed with adequate volume in the plug needed for changes in sample volume during a test.

At no time during a test can the mineral oil exceed the 100 mL sample volume since this will cause incorrect measurement results.

A sample fill volume of 105 - 110 mL is satisfactory in most cases. Other cases involving sample volumes that change more than 10% as a function of temperature and pressure (increasing or decreasing) during a test may require adjustment of the starting sample volume.

The sample volume up to the level of the front fill port may be determined using the syringe adapter and syringe. With the plug assembly mounted on the stand, fill the plug assembly with water using a 60mL syringe. The sample volume is determined when it is apparent that the water level is level with the fill port.

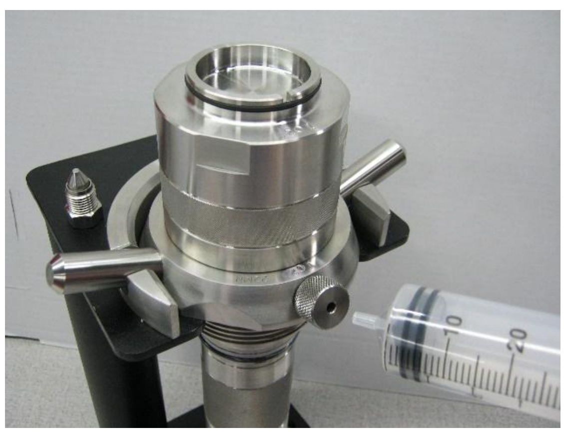


Figure 2 – Sample Injection

Vessel Disassembly

1. Remove the encoder assembly, disconnecting the cable and air-cooling tube.
2. Disconnect the high-pressure tube between the top cap of the vessel and the top panel of the instrument. The nuts on each end of the tube require a 5/8-inch open-end wrench.
3. Unscrew the top plug assembly from the vessel. The plug is loosened by turning counterclockwise.

4. Once the plug assembly is removed, place the assembly in the plug support bracket.

Figure 3 - Plug Assembly in Stand

5. Remove the top cap, rotating counterclockwise. Remove the top o-ring and metal backup ring. You may use the Seal Extractor tool 7500-2292, when necessary. Replace the o-ring after each high temperature test.

Figure 4 - Removal/Installation of Top Seals

6. Secure pivot by hand or remove before inverting the sample cup. Unscrew and remove the sample cup, rotating clockwise. *Secure the pivot by hand or remove before inverting the sample cup (see Figure 10).* While supporting the rotor assembly inside the sample cup, empty the sample from the cup into a suitable disposal container.

Figure 6 – Removal/Installation of Sample Cup

7. Invert the sample cup and remove the internal rotor and magnet assembly.
8. Note that the rotor support bearing may become unseated and may be retained by the rotor magnet.
9. Use tool 7500-2204 to retain the bob shaft and unscrew the bob by hand, rotating clockwise. Note that the tool engages the groove in the baffle.
10. Secure the tungsten carbide insert. It can easily drop out if the bob is inverted (see *Section 3 – Maintenance and Servicing*).

Figure 7 - Bob Removal Tool Installed

11. Remove the hex socket head screw from the shaft clip. Remove the spring module assembly from the plug.

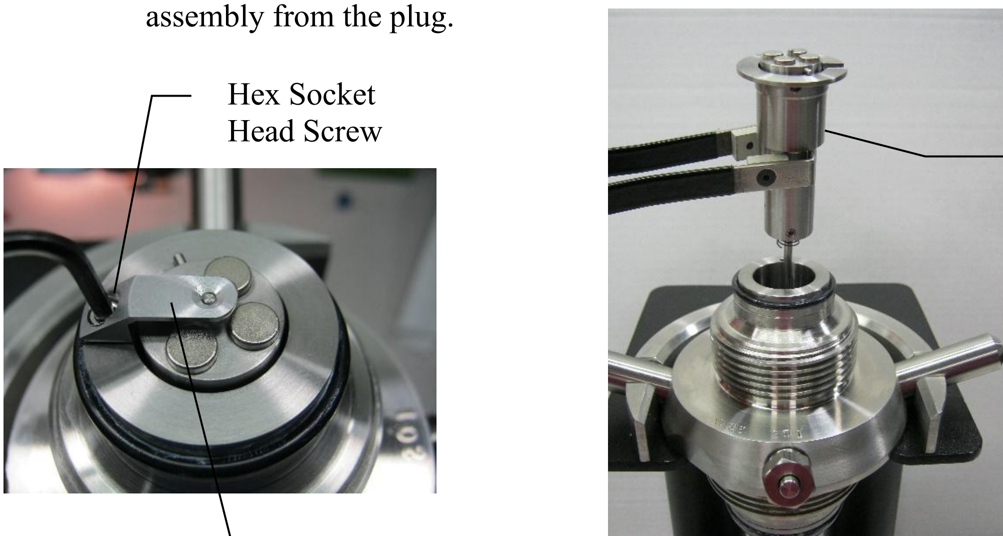


Figure 8 - Removal/Installation of Spring Module

12. Invert the plug and remove the hex socket head screws (4) and remove the baffle and o-ring located between the baffle and plug and sample cup threads. Discard and replace the baffle o-rings (2) as needed to ensure separation between the pressurizing oil and sample.
13. Remove the high-pressure seal o-ring and metal backup ring. Discard and replace the o-rings after each high temperature test.
14. Remove the high-pressure gland and plug from the front of plug assembly using a 5/8-inch open end wrench.
15. Carefully and thoroughly clean all parts using a solvent tank in preparation for re-assembly. Rinse all parts with water. Dry all parts thoroughly.

Figure 9 – Removal/Installation of Baffle and Seals

Vessel Assembly

1. Use tool 7600-1160 to seat the support bearing in the rotor. Retain the bearing in place inside the rotor by applying a small amount of grease prior to assembly. Alternately, place the bearing on the thermowell; it will rest inside the rotor when the rotor assembly is inserted into the sample cup.
2. Install the bushing in the bottom of the rotor assembly. Verify that it is not excessively worn.

Bearing Extraction Tool

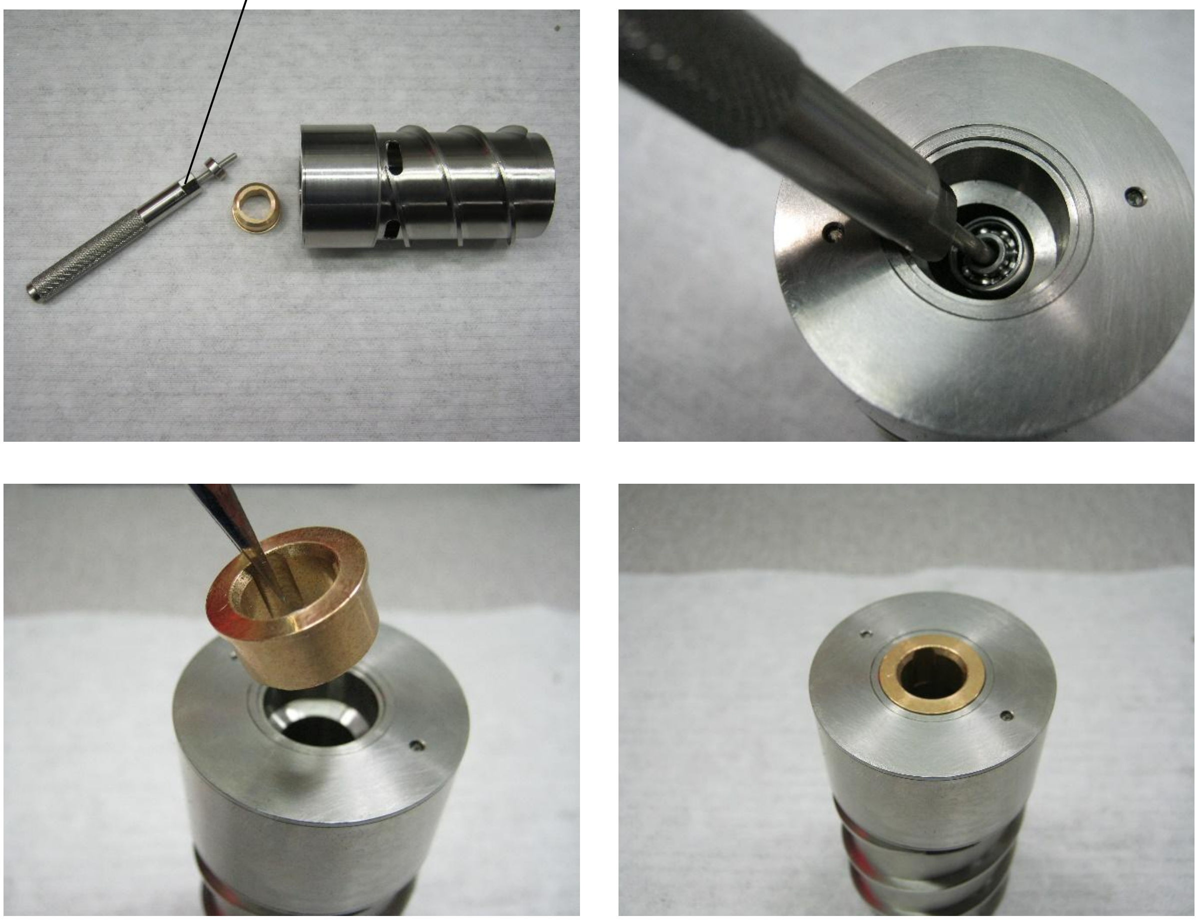


Figure 10 - Rotor Bearing and Outer Race Installation

3. Insert the rotor and magnet assembly into the sample cup. Verify that the rotor bearing rests on the top of the thermowell and the pivot extends through the bearing. Verify that the rotor rotates freely.

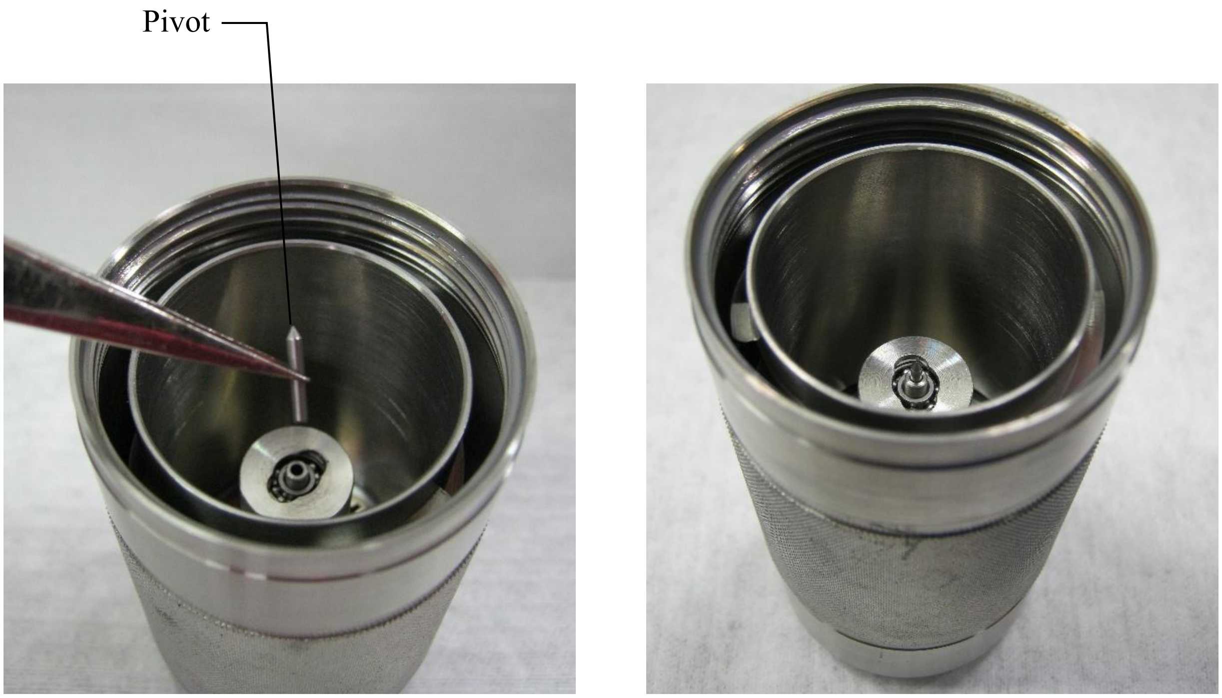


Figure 11 - Sample Cup with Rotor Installed, Ready to Fill with Sample

4. Install the baffle o-ring between the baffle and plug and at the root of the sample cup threads. Mount the baffle. Tighten the hex socket screws (4).
5. Position the plug assembly upright in the support bracket.
6. Assemble the spring module, adjusting the spring and magnet assembly to ensure that the dowel pin is positioned properly (see Section *3 – Maintenance and Servicing*).
7. Insert the spring module assembly into the top of the plug.
8. Mount the shaft clip and hex socket head screw.

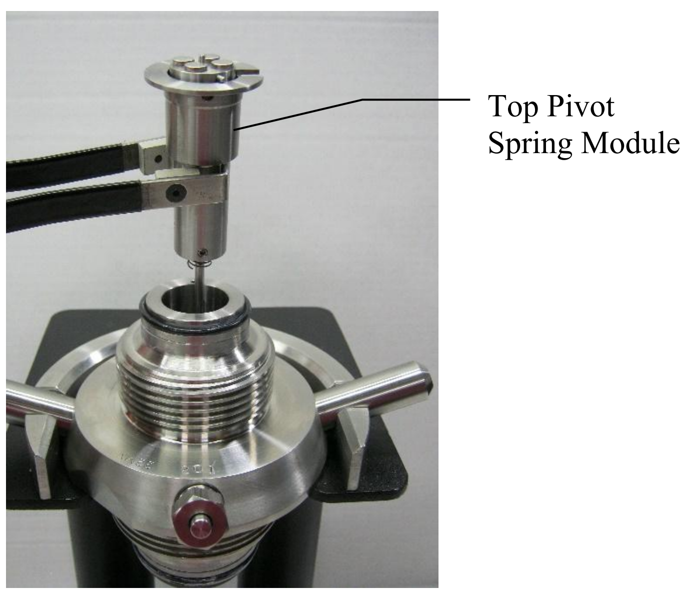


Figure 52 - Installation of Spring Module

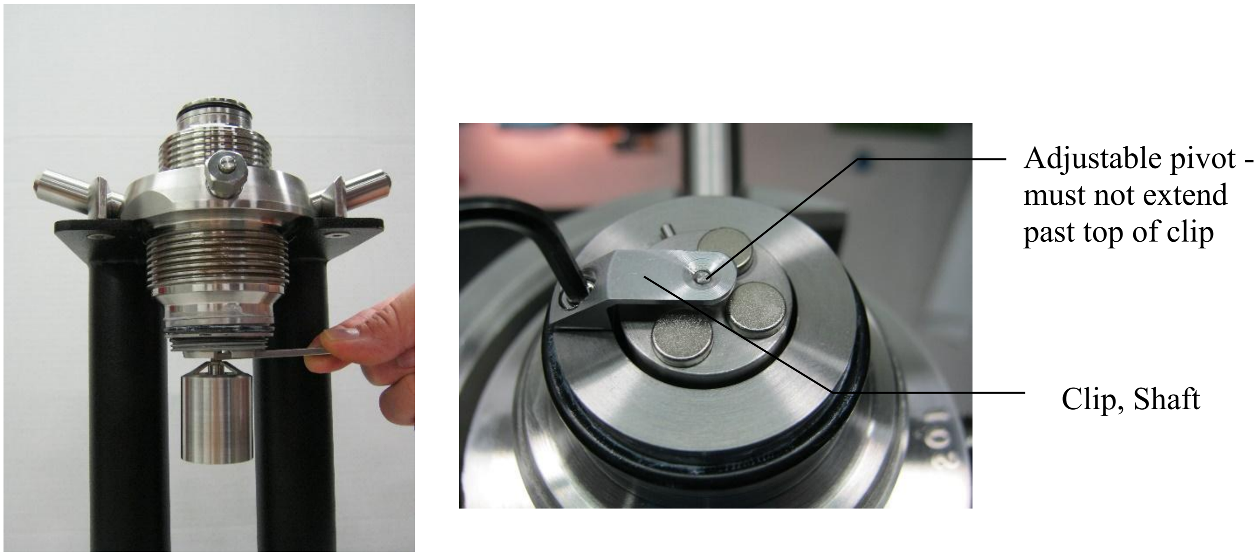


Figure 13 - Installation of Spring Module

9. Mount the bob assembly to the bob shaft. Gently tighten the bob on the shaft, using the bob tool.

Excessive tightening may bend the bob shaft.

10. Apply a small amount of anti-seize compound to the threads on the sample cup.
11. While empty, screw the sample cup onto the baffle. Verify that the center magnet assembly elevates slightly as the sample cup is screwed into place.
12. Verify that the pivot pin passes through the shaft clip as the sample cup is mounted.

The pivot must not extend past the top of the clip to avoid interference with the top cap. The limit stop dowel pin and magnets must not contact the supporting housing or shaft clip while rotating.

13. The center pivot may be axially positioned to position the magnet support housing assembly on the bob shaft. This may be accomplished by removing the spring module and bob shaft and screwing or unscrewing the pivot using needle-nose pliers.
14. Verify that the magnet assembly and bob rotate freely against the spring torsion. An oscillation must be observed when displacing the spring and releasing. If any binding exists, disassemble, locate the problem and reassemble.
15. Position the top metal backup ring and o-ring.
16. If needed, add a small amount of pressurizing fluid to the top and bottom elastomeric seals.
17. Insert the plug assembly into the pressure vessel. Tighten by turning clockwise. Screw the plug until lightly shouldering then loosen until the high-pressure port faces the front of the instrument.
18. Screw the top cap onto the plug. Screw the cap until lightly shouldering then loosen. The top high-pressure port must face the right of the instrument, aligning with the high-pressure interconnection tube.

19. Verify that the collars on the high-pressure interconnection tube are fully screwed onto each end of the tube, noting that they have LH threads.
20. Connect the high-pressure interconnection tube between the top cap and the top panel of the instrument. Tighten using a 5/8-inch wrench.
21. Mount the encoder to the top of the vessel, aligning the encoder alignment pin with the groove in the top cap.
22. Connect the encoder cable to the 9-pin connector on the encoder; tighten the retaining screw(s).
23. Connect the cooling air tube to the encoder. The air flow may be adjusted using the side mounted needle valve to cool the encoder during long duration high temperature tests.
24. Using the software Tare button, zero the encoder.

Figure 64 – Encoder and High-Pressure Connections

25. Attach the 7600-1164 syringe adapter to the front high-pressure port on the plug. Open the pressure release valve.
26. Using a syringe (C10480) inserted into the syringe adapter, slowly fill the plug and cup assembly with 110mL of sample.

The sample cup volume including the B1 bob, R1 rotor and related components is 100mL, the total sample volume may need to be increased based on the PVT characteristics of the sample.

27. Remove the 7600-1164 syringe adapter from the front high-pressure port on the plug.
28. Install the high pressure plug into the front high-pressure port on the plug assembly. Tighten with a 5/8-inch open end wrench. Do not over-tighten the nut (recommended torque: approx. 25 ft-lbf)

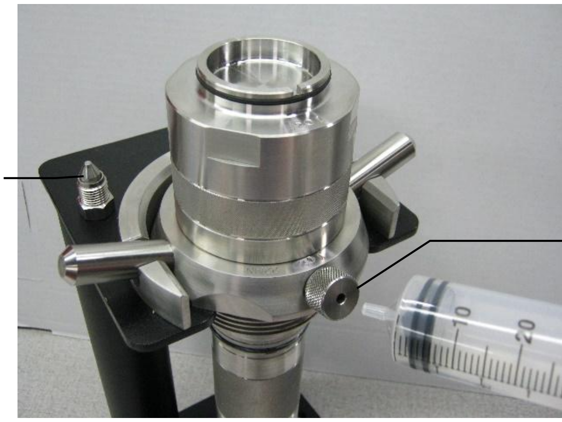


Figure 75 - Sample Injection

Preparing to Pressurize and Heat the Sample

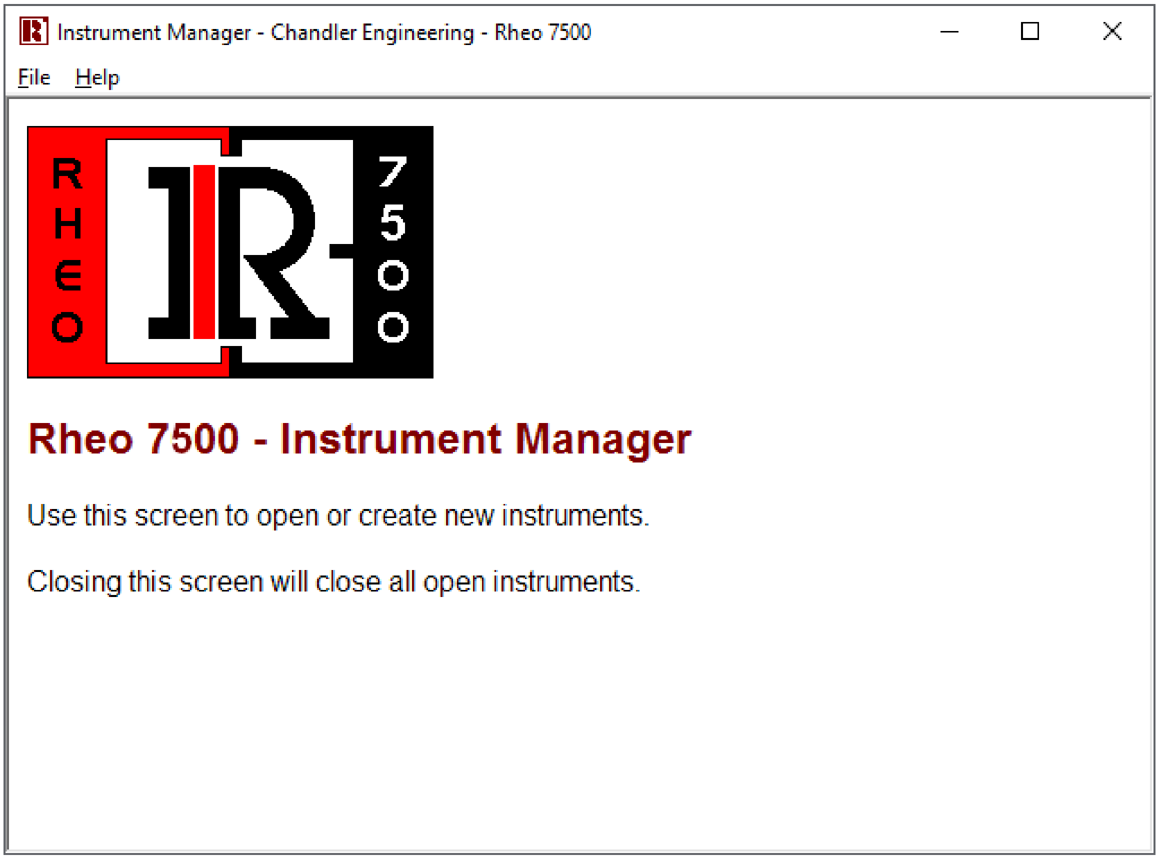
1. Verify that the supply container (right - front) is at least 1/2-full of the pressurizing fluid. Only use the fluid part number that is supplied with the instrument. Empty the collection vessel (right - rear). The supply containers are hand tightened.
2. Once the vessel is closed and the high-pressure tube is connected, open the pressure release valve, if needed. DO NOT ATTEMPT TO OPERATE THE PUMP UNLESS THE HIGH-PRESSURE TUBE IS CONNECTED.

3. Turn the Vessel switch to Fill.
4. Operate the pump manually (pump switch ON) until oil is observed filling the rear oil reservoir. Watch for any leaks as the vessel fills with mineral oil. If a leak is discovered, turn the vessel and pump switches Off (center position) and correct the leak.
5. Close the pressure release valve and place the Pump switch in the Auto position.
6. Turn the Heater switch to On.
7. Verify that the temperature and pressure controllers are ready for use. If the controllers are in the OFF mode, press the EZ1 button once.
8. Mount the encoder on top of the plug assembly; connect the airline to the encoder. Adjust the air flow to the encoder as needed for an elevated temperature test (>350°F, 177°C)
9. Close the cover over the encoder.

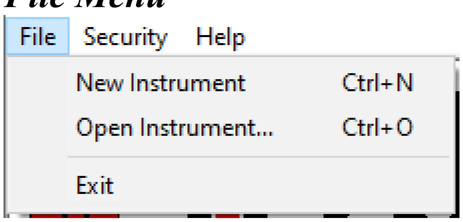
Software Operation

Instrument Manager Window

The Rheo 7500 software is cable of running multiple independent instruments. These instruments are opened from the Instrument Manager window.

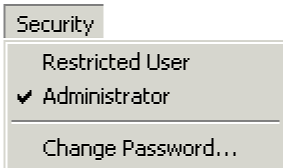


File Menu



- **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 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.

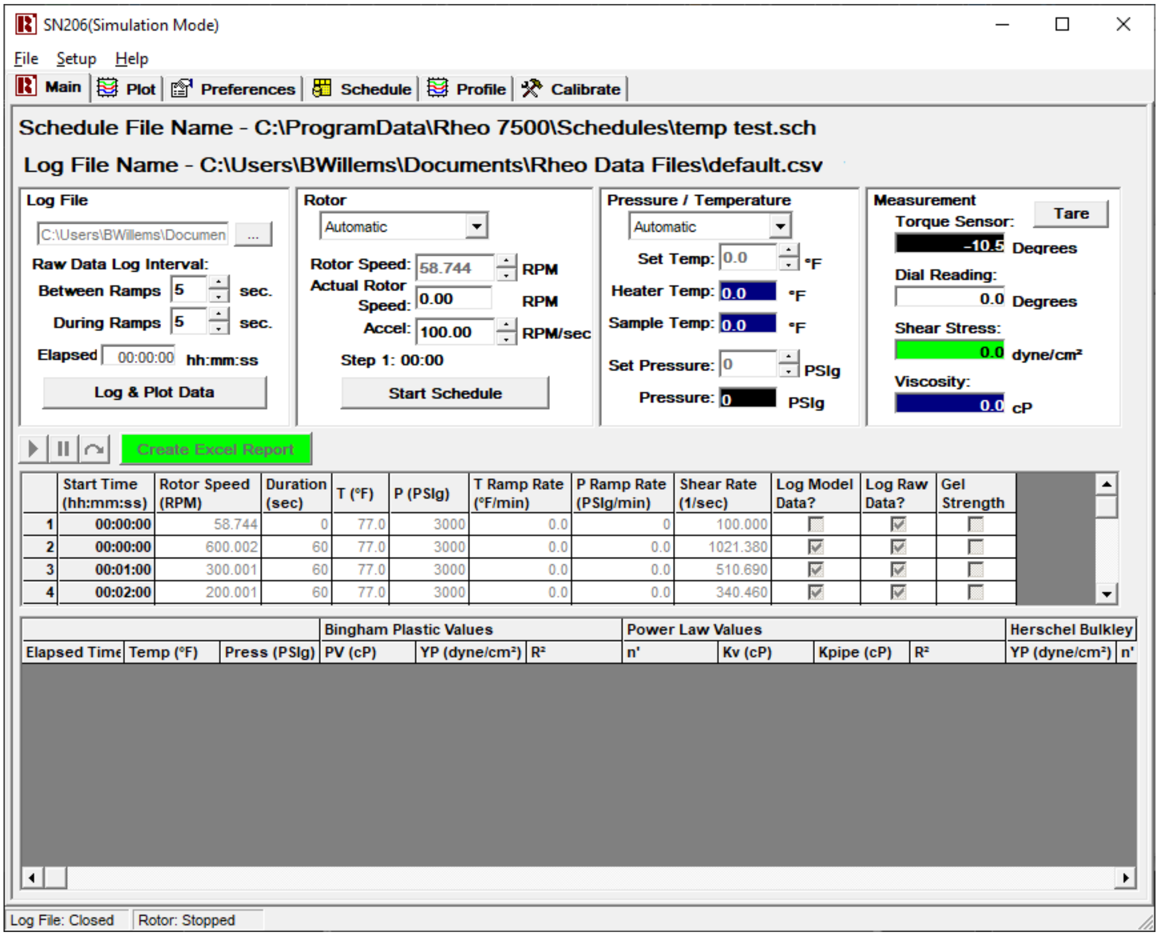
To specify an Administrator password, select Change Password. To disable the administrator password protection, simply enter the Administrator password in the Old Password entry box and leave the New Password and Confirm entries blank.

Help Menu

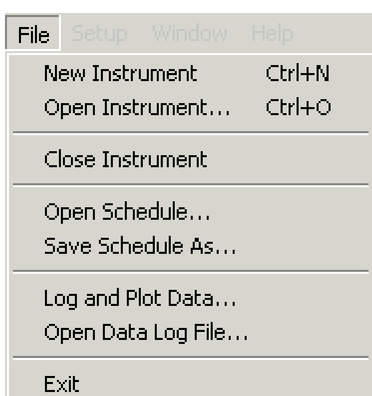
The Help menu provides access to the online help system (Contents and Index).
About displays the About dialog showing software version number, contact information, etc.

Instrument Window

The Instrument Window provides all displays and indicators to operate a single 7550 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.

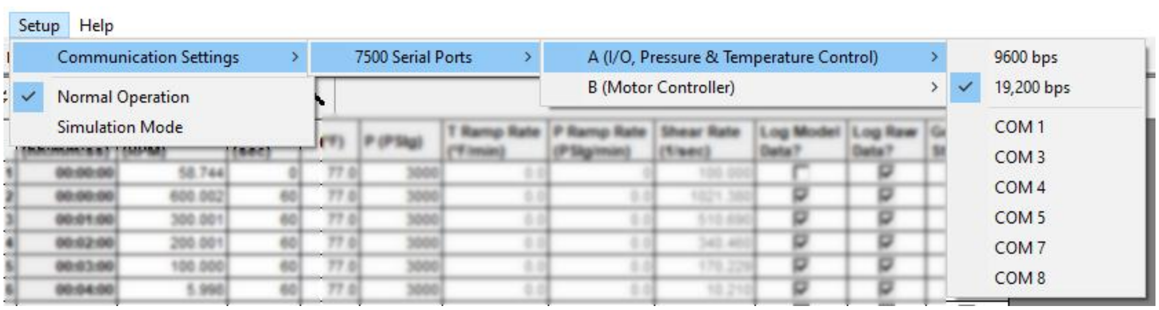
- **Save Schedule As** - Used to save an open schedule file to a new file name.

- **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



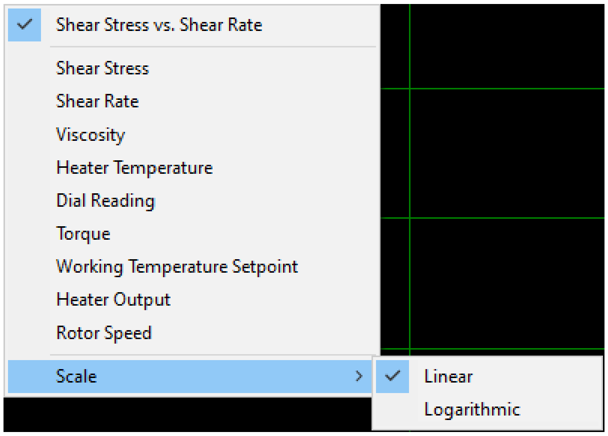
The Setup menu provides access to the following commands:

- **Communication Settings** - The communication settings sub-menu allows assignment of a specific PC serial ports for Data (A) and Motor (B) to the 7550 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.

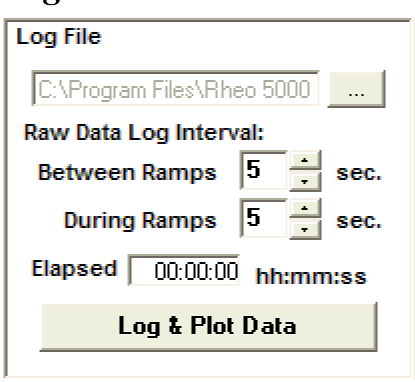
Help Menu

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.

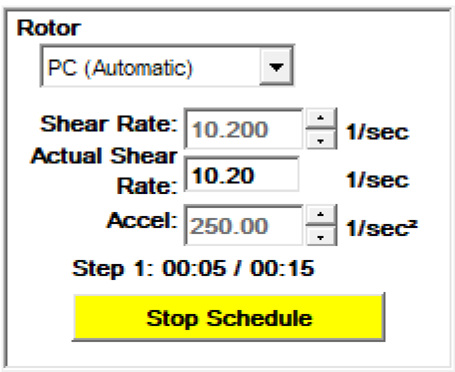
    - Between Ramps - Defines the log interval for manual operation, or for schedule steps where the raw data checkbox is selected but the model data checkbox is not selected.

    - 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.

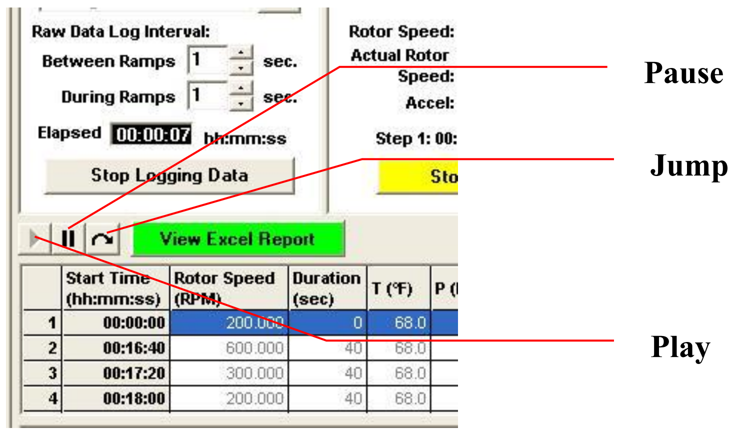
- **Actual Shear Rate or Rotor Speed -** displays the current rotor speed. Units are defined on the Preferences Tab

- **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.

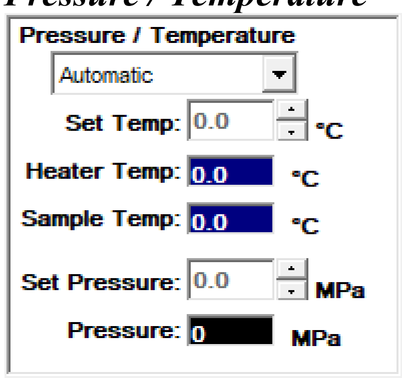
- **Start / Stop Schedule -** allows the user to start and stop the currently loaded schedule.

Schedule Controls



During the execution of a schedule, operation of the instrument may be **Paused** or **Jumped**. This feature is useful to pause the schedule and resume by selecting the Play button. Alternately, a schedule step can be "jumped" either forward or backwards in the schedule.

Pressure / Temperature



Allows the user to start and stop Temperature control.

- **Control Mode**
  - **Automatic** – Temperature and Pressure are controlled via the current schedule.

  - **Manual** - Temperature and Pressure may be controlled manually through the software. In this mode, any parameters specified in the loaded schedule are ignored.

- **Set Temp -** Displays the current Temperature 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.

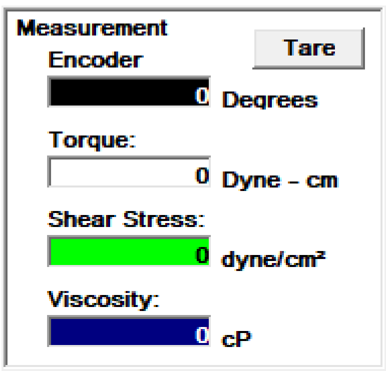
- **Heater Temp -** Displays the current Temperature as read from the controller. Units are defined on the Preferences Tab.

- **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.

- **Set Pressure** – Displays the current Pressure 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.

- **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)	Kind (cP)	Kslot (cP)	R^2	YP (dyne/cm²)	PV (cP)	R^2
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

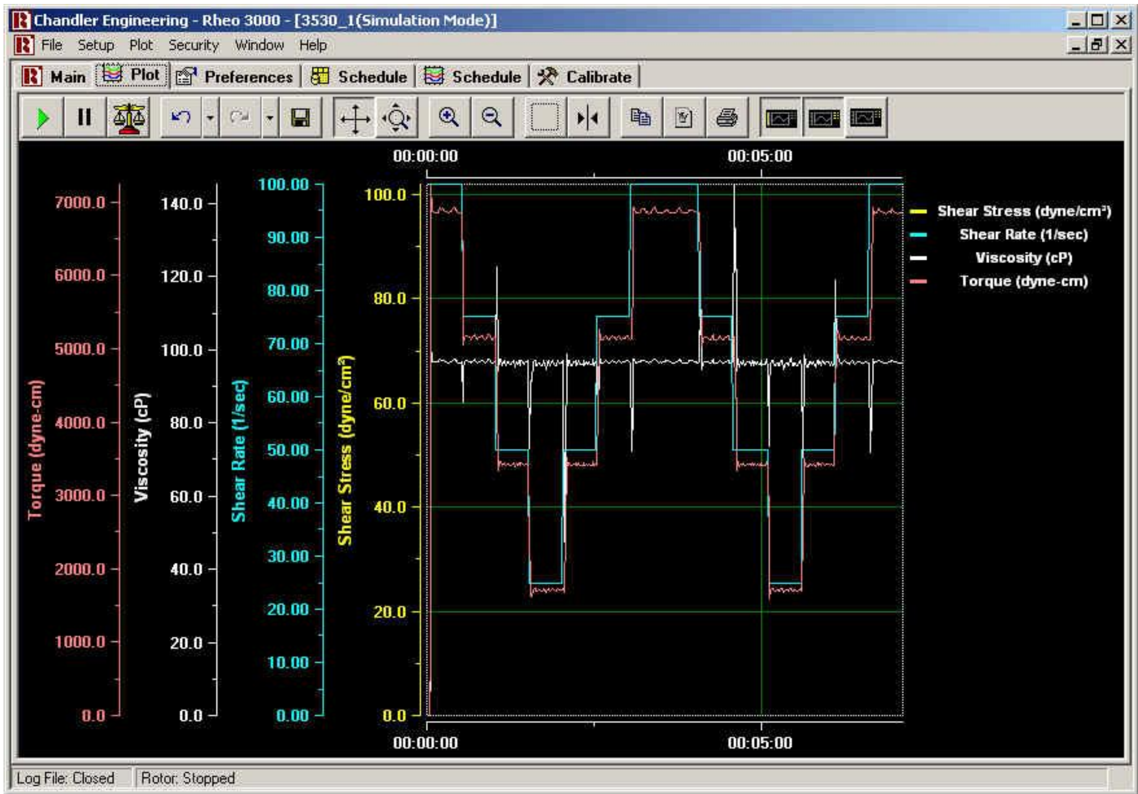
Model Calculations

The Rheo 7500 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.

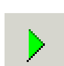
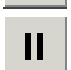
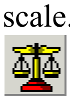
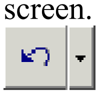
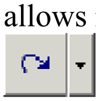
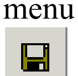
Data Plotting

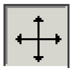
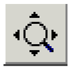
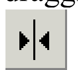
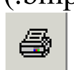
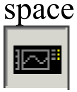


Once per second, all readings are sent to the Plot. Data from channels that are not currently visible are still saved to the Plot. At the start of a test, the Plot is cleared. The Plot can store about 24 hours of data.

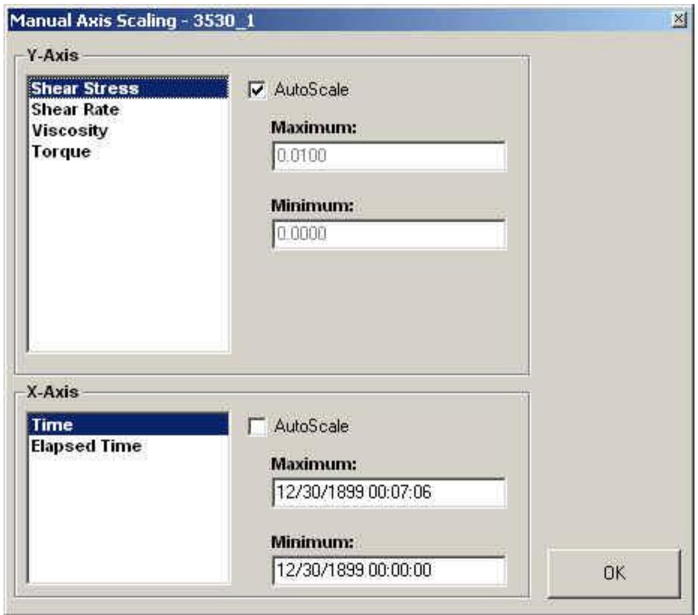
Plot Toolbar

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

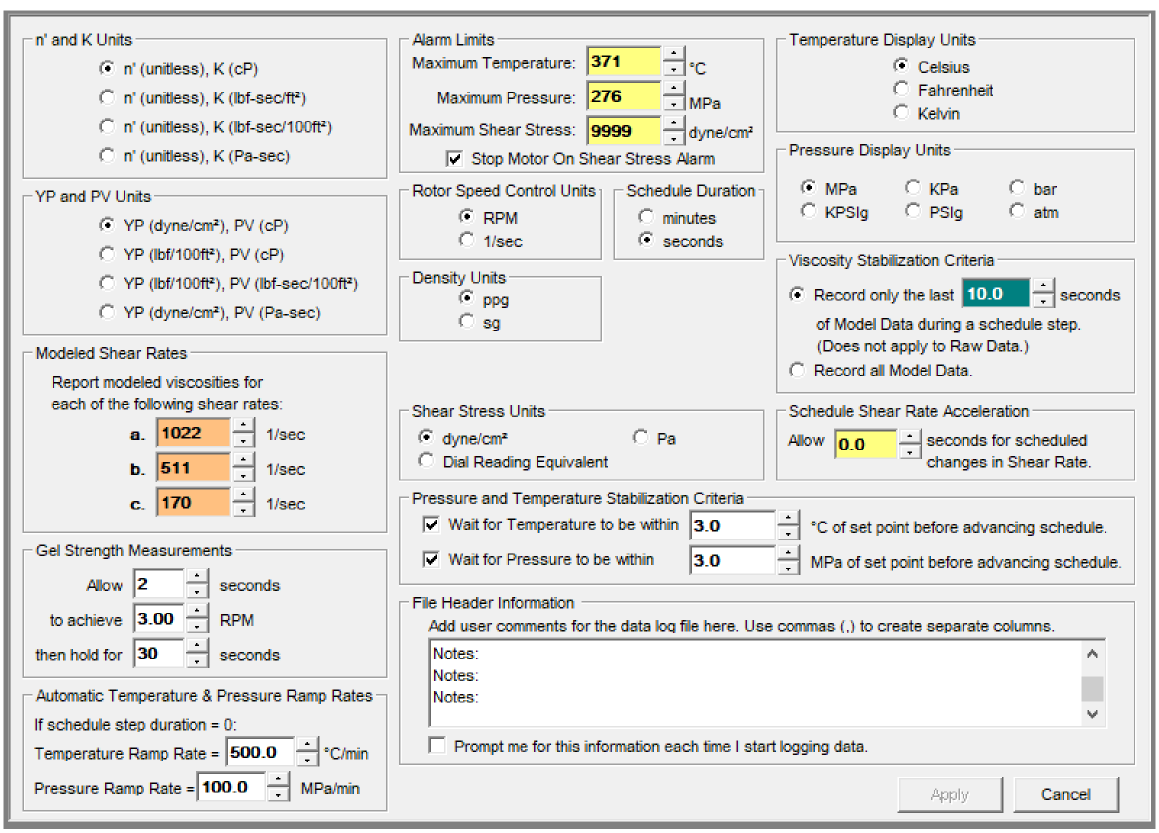


The Manual Axis Scaling Screen provides precise manual control over the displayed range of each plot.

- **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 –** an Alarm will be displayed on the Main tab and the software will "beep" if the defined alarm limit is reached.

    - **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.

- **Pressure and Temperature Stabilization Criteria** - When the measured Sample Temperature AND Sample Pressure are within the specified tolerances, 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.

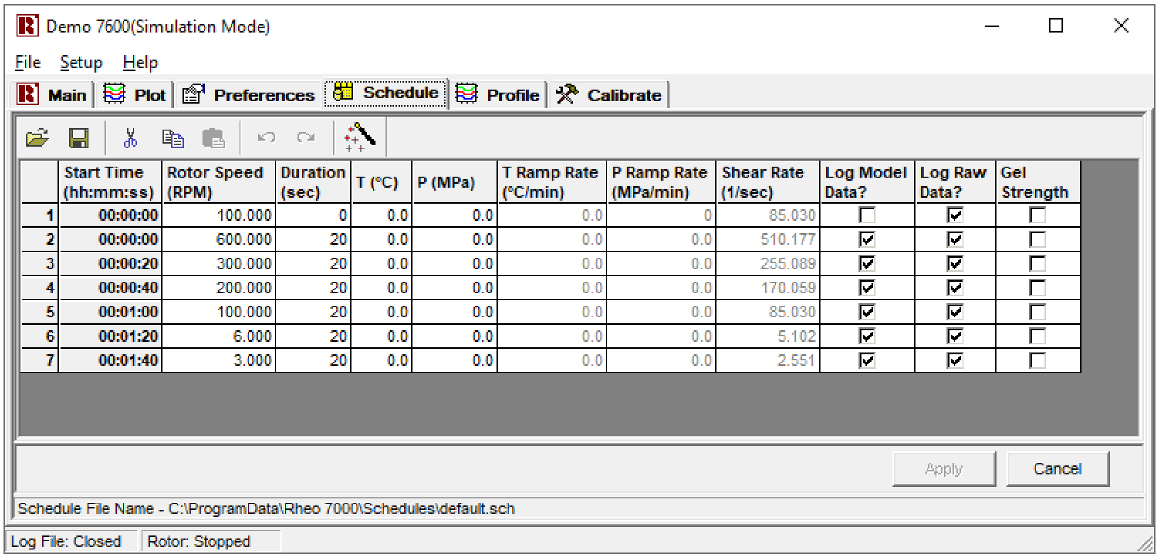
- **Pressure Display Units** - Allows the selection of Pressure Units. This selection applies to the log file, as well as the schedule, alarm limits and any other place that pressure is displayed. Pressure display units may not be changed while data is being logged to a file. This promotes concurrency 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 the 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)	Rotor Speed (RPM)	Duration (sec)	T (°C)	P (MPa)	T Ramp Rate (°C/min)	P Ramp Rate (MPa/min)	Shear Rate (1/sec)	Log Model Data?	Log Raw Data?	Gel Strength
1	00:00:00	100.000	0	0.0	0.0	0.0	0	85.030	☐	☑	☐
2	00:00:00	600.000	20	0.0	0.0	0.0	0.0	510.177	☑	☑	☐
3	00:00:20	300.000	20	0.0	0.0	0.0	0.0	255.089	☑	☑	☐
4	00:00:40	200.000	20	0.0	0.0	0.0	0.0	170.059	☑	☑	☐
5	00:01:00	100.000	20	0.0	0.0	0.0	0.0	85.030	☑	☑	☐
6	00:01:20	6.000	20	0.0	0.0	0.0	0.0	5.102	☑	☑	☐
7	00:01:40	3.000	20	0.0	0.0	0.0	0.0	2.551	☑	☑	☐

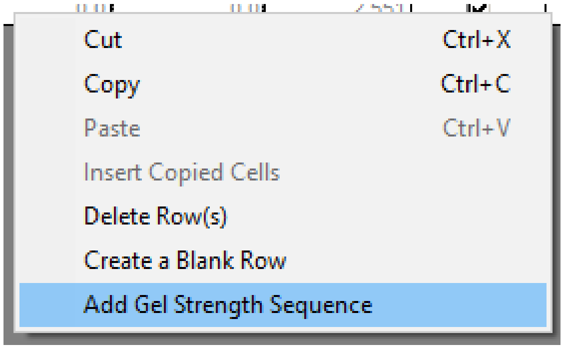
The Rheo software system allows user-defined schedules for automatic test control. Schedules are created and edited using the Schedule section of the Setup screen. Cells may be edited individually. Entire rows and groups of rows may be cut, copied and pasted.

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.
- **Add Gel Strength Sequence** – Adds steps to the schedule to perform a Gel Strength Test. A 10 second Gel and a 1 minute Gel are added. In the example below, the Gel Strength Measurements Parameters defined on the Preferences tab are set for Allow 2 seconds to achieve 3 RPM then hold for 30 seconds. The highlighted rows were added.

	Start Time (hh:mm:ss)	Rotor Speed (RPM)	Duration (sec)	T (°C)	P (MPa)	T Ramp Rate (°C/min)	P Ramp Rate (MPa/min)	Shear Rate (1/sec)	Log Model Data?	Log Raw Data?	Gel Strength
1	00:00:00	100.000	0	0.0	0.0	0.0	0	85.030	☐	☑	☐
2	00:00:00	600.000	20	0.0	0.0	0.0	0.0	510.177	☑	☑	☐
3	00:00:20	300.000	20	0.0	0.0	0.0	0.0	255.089	☑	☑	☐
4	00:00:40	200.000	20	0.0	0.0	0.0	0.0	170.059	☑	☑	☐
5	00:01:00	100.000	20	0.0	0.0	0.0	0.0	85.030	☑	☑	☐
6	00:01:20	6.000	20	0.0	0.0	0.0	0.0	5.102	☑	☑	☐
7	00:01:40	3.000	20	0.0	0.0	0.0	0.0	2.551	☑	☑	☐
8	00:02:00	300.00	30	0.0	0.0	0.0	0.0	255.089	☐	☑	☐
9	00:02:30	0.00	10	0.0	0.0	0.0	0.0	0.000	☐	☑	☐
10	00:02:40	3.00	32	0.0	0.0	0.0	0.0	2.551	☐	☑	☑
11	00:03:12	300.00	30	0.0	0.0	0.0	0.0	255.089	☐	☑	☐
12	00:03:42	0.00	600	0.0	0.0	0.0	0.0	0.000	☐	☑	☐
13	00:13:42	3.00	32	0.0	0.0	0.0	0.0	2.551	☐	☑	☑

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

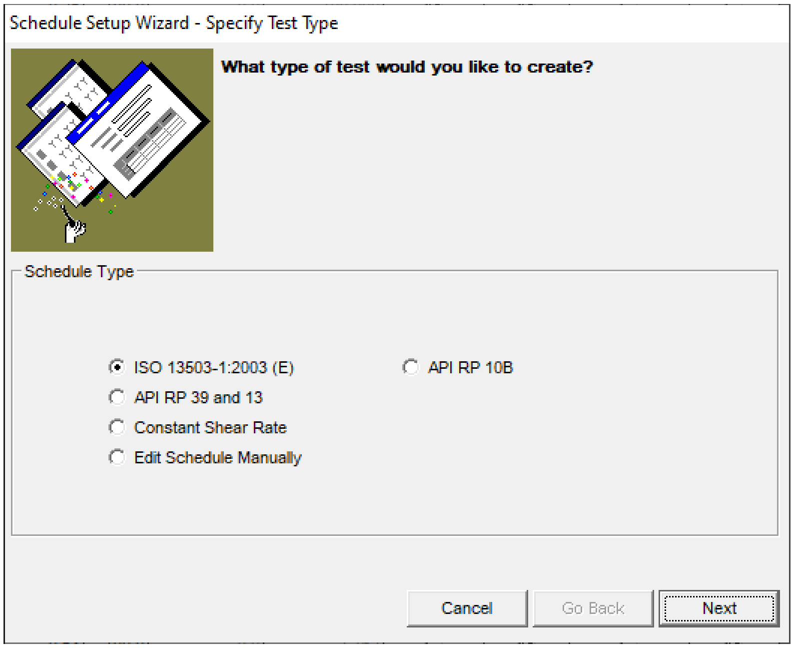
Each step of a schedule contains the following information:

- **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. Units are defined by the **Schedule Duration** selection on the **Preferences** tab (minutes or seconds).
- **T** - Defines the Temperature at the start of the current step. The software will ramp Temperature from the current step to the next step.
- **P** – Defines the Pressure at the start of the current step. The software will ramp Pressure from the current step to the next step. The ramp rate is defined in the

Automatic Temperature & Pressure Ramp Rates section on the **Preferences** tab.

- **T Ramp Rate** - Displays the temperature ramp rate for a given schedule step. This parameter is calculated and updated automatically by the Rheo software.
- P Ramp Rate – Displays the Pressure 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.

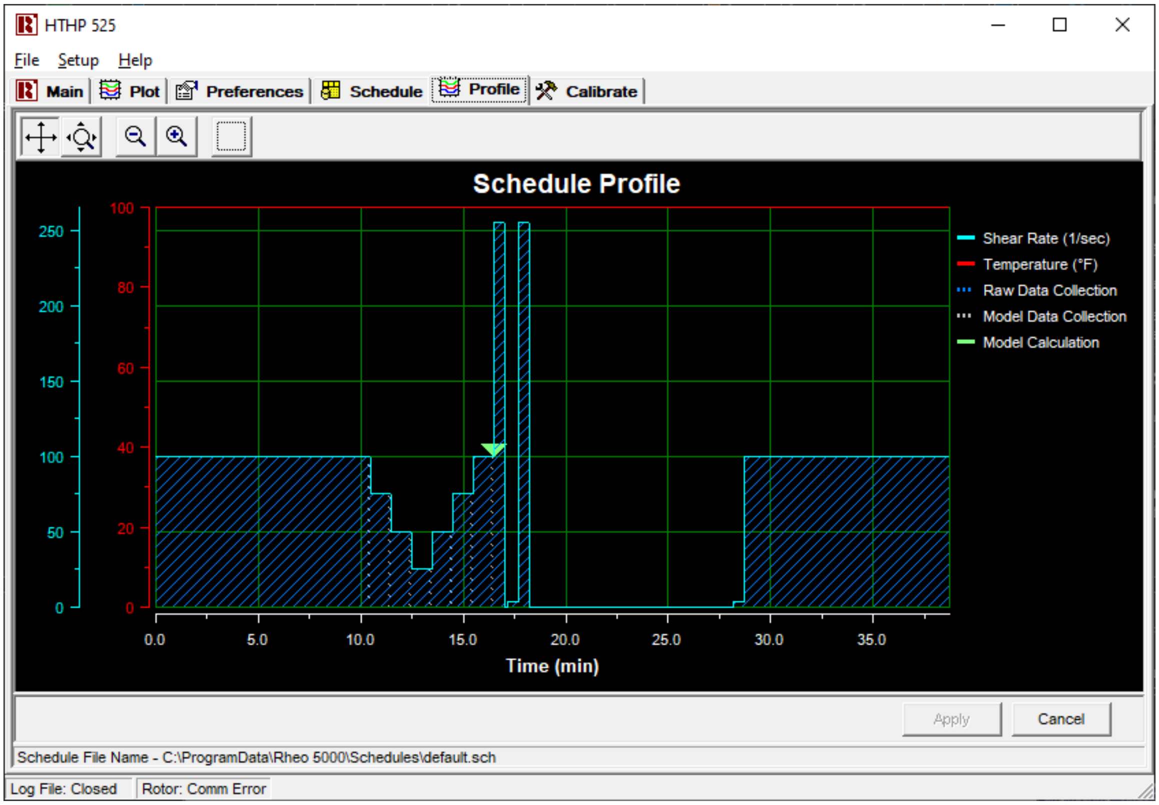
- **ISO 13503-1:2003 (E)** - Allows a schedule of user-defined duration to be created with either increasing or decreasing shear rate ramps. Any test duration may be selected. Ramp schedules are determined according to the ISO standard (100, 75, 50, 25 sec^{-1} in increasing or decreasing order).

- **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.

Ending a Test

1. A test will end automatically when the schedule completes. The last temperature and pressure set point are retained.

2. Remove the encoder from the top of the vessel.

3. To end a test in mid-schedule, press the Stop Schedule option, the motor will stop. Change the motor control and temperature/pressure control to Manual mode. Enter new temperature and pressure set-point values, 32°F and 1000 psi respectively.

At least 1000 psi oil pressure should be retained until the heater temperature is below 150°F.

4. Turn the heater switch Off.

5. Turn the pump switch to Off (center position).

6. After cooling and all pressure is released, place the temperature and pressure control in manual mode, enter temperature and pressure set-points of 32°F (0°C) and 0 psi, respectively.

7. Open the pressure release valve.

8. Turn the Vessel switch to Drain. This will force oil from the vessel to the supply container. Once air is heard escaping from the vent port (about 30 seconds or less), turn the Vessel switch to Off. Wait another 30 seconds for residual air pressure to decrease.

9. Remove the plug assembly by unscrewing counterclockwise. Refer to Vessel Disassembly instructions.

Instrument Calibration

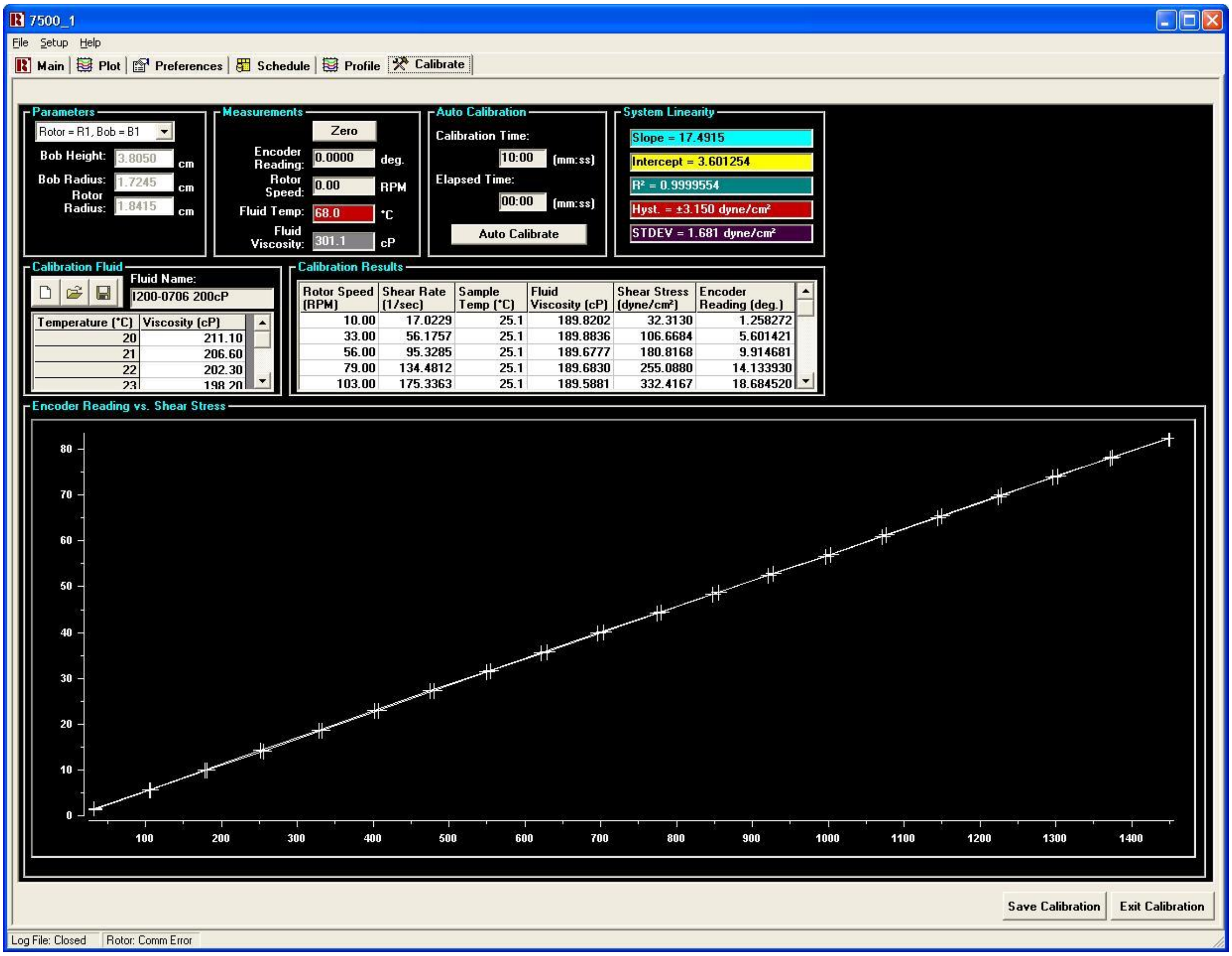


Figure 31 - Rheo 7500 Calibration Screen

Calibration Overview

The Model 7500 HPHT Viscometer uses an automated software calibration procedure, relating angular spring 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 linear 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 collection of data from which system linearity and hysteresis are determined.

Using the calibration data, the instrument performance may be determined. Parameters are used to determine a calibration pass / fail criterion. These parameters include linearity, slope, intercept, standard deviation and maximum hysteresis. An acceptable calibration is a STDEV less than 8 dynes/cm^2 and Hysteresis less than 16 dynes/cm^2. The STDDEV and HYST values provide an indication of the performance of the instrument, making it possible to detect performance problems due to worn pivot bearings, pivots, bent bob shaft, friction, etc.

System Linearity

The linearity of the calibration data is indicated by the value of R^2. In general, an R^2 value of 1.0000 indicates perfect linearity. An R^2 value of slightly less than one is generally expected (0.9990).

Slope

Since a good calibration result is 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/cm² per degree. This constant can be used to predict the maximum measurable shear stress by the formula τmax = slope (dyne/cm²) * 300 degrees. When a B1/R1 bob and rotor combination is used, the slope value must exceed 5.11 to ensure the measurement range extends beyond 300 degrees dial reading.

Intercept

The intercept of the line generated by the least-squares method provides an indication of the shear stress offset. The intercept value is typically within the bottom 1% of the shear stress range, in the positive or negative directions.

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. Standard deviation provides a normalized indication of the overall bearing friction; maximum hysteresis provides a meaningful measurement of worst-case hysteresis.

Typical Hysteresis Curve

The numbers for Maximum Hysteresis (±x.xxx dyne/cm²) and Standard Deviation (x.xxx dyne/cm²) are reported on the calibration screen of the Rheo 7500 software, as well as reported in each data file.

Calibration Procedure

1. Using the Vessel Disassembly and Assembly instructions, fill the sample cup with 100 mL of certified silicone oil.
2. Mount the encoder to the top of the vessel.
3. Connect the encoder cable to the 9-pin connector on the encoder, tighten the retaining screws.
4. Click the calibrate tab on the Instrument screen.
5. Select the rotor and bob geometry, generally R1 and B1.
6. Select the calibration fluid that was loaded in the sample cup. If using a new fluid, enter the fluid viscosity values from the certification certificate.
7. Zero the encoder by clicking the “Zero” button.
8. Start the calibration by clicking the “Auto Calibrate” button.
9. Allow the automatic calibration sequence to complete. The HYST and STDDEV values should be less than 16 and 8 dyne/cm^2 respectively. If these values are not achieved, check the following:
    - Instrument is level.
    - Mechanical friction is not preventing free motion of the bob shaft and torsion spring.
    - Pivot bearing and pivot are not damaged (once removed, a microscope or loupe may be used to inspect these components)
10. When the calibration routine completes successfully, click “Save Calibration” to store the calibration values that will be used when running subsequent tests.
11. Remove the sample cup, empty the fluid, and clean the instrument.

Calibration Summary

Each of the parameters listed above are reported by the 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.

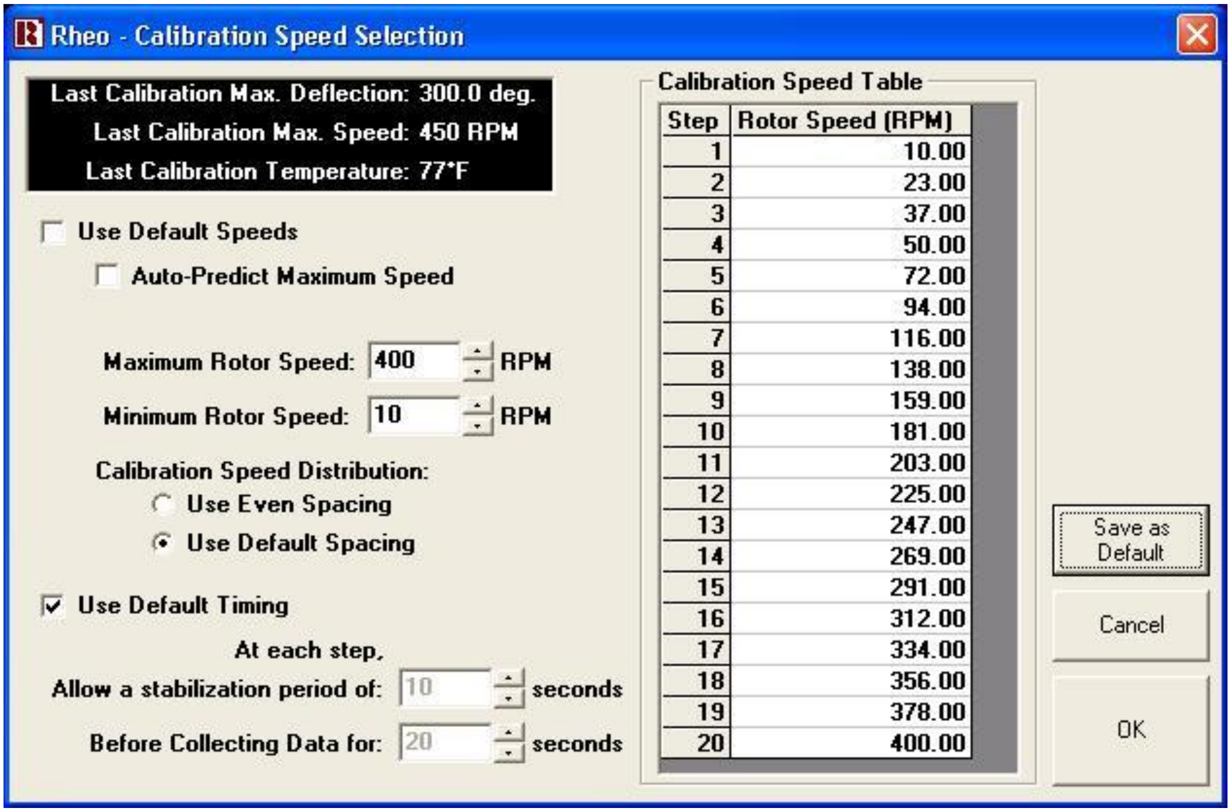
- **Save Calibration** - Saves the calibration data. The software will begin using the new values.

- **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, the software 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.

Section 3 - Maintenance and Servicing

Always disconnect the power connection prior to service.

Tools Required

- 5/8-inch Wrench (supplied with instrument)
- Hex wrenches (supplied with instrument)
- Screwdriver (supplied with instrument)
- Needle nose pliers (supplied with instrument)
- Bench Vise

Cleaning and Service Tips

- Keep the threads and ports free from sample.
- Lubricate the threads on the top plug periodically with lithium grease (or equivalent).
- During instrument operation, avoid rapid release of pressure to prevent the sample from entering the connection tubing.
- Remove debris that may collect in the supply container.

Controller Calibration and Configuration Procedure

The temperature and pressure controllers and transducers require periodic calibration.

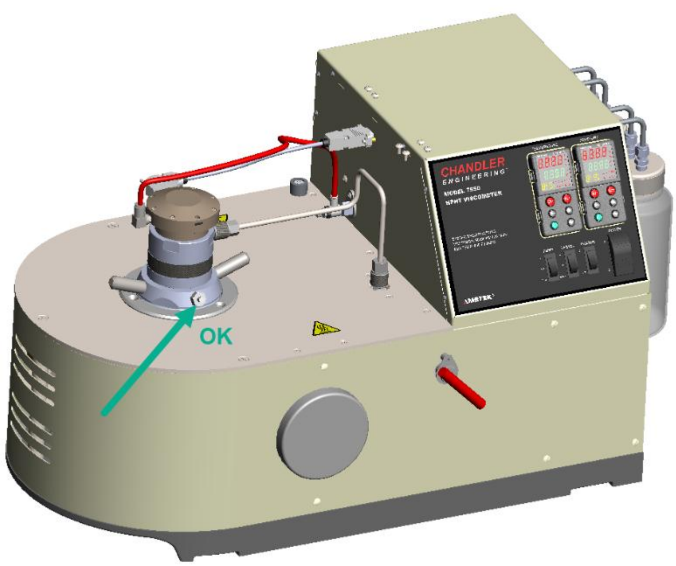
Temperature calibration involves applying known values to the thermocouple electronics using a thermocouple simulator.

Pressure calibration involves setting the ZERO of the transducer at atmospheric pressure, then using a certified pressure transducer (connected to the front port of the plug), pressurizing the system to near full scale and adjusting the SPAN of the controller to agree with the known value.

Do not connect the reference pressure transducer calibrator to the top panel port of the instrument or connect the reference pressure transducer calibrator to the top port on the pressure vessel. This action will cause damage to the internal sample container that must remain pressure balanced.

Prior to calibrating the instrument, remove the internal sample cup, bob, and spring module.

Remove the port plug from the front of the pressure vessel top plug used with loading the sample with a syringe. Connect the reference pressure transducer calibrator to the port.


OK

Each Eurotherm controller is configured using a utility (iTools) and configuration files (UIC files). The utility is installed on the computer. Each configuration file is uploaded to the controllers via the serial interface.

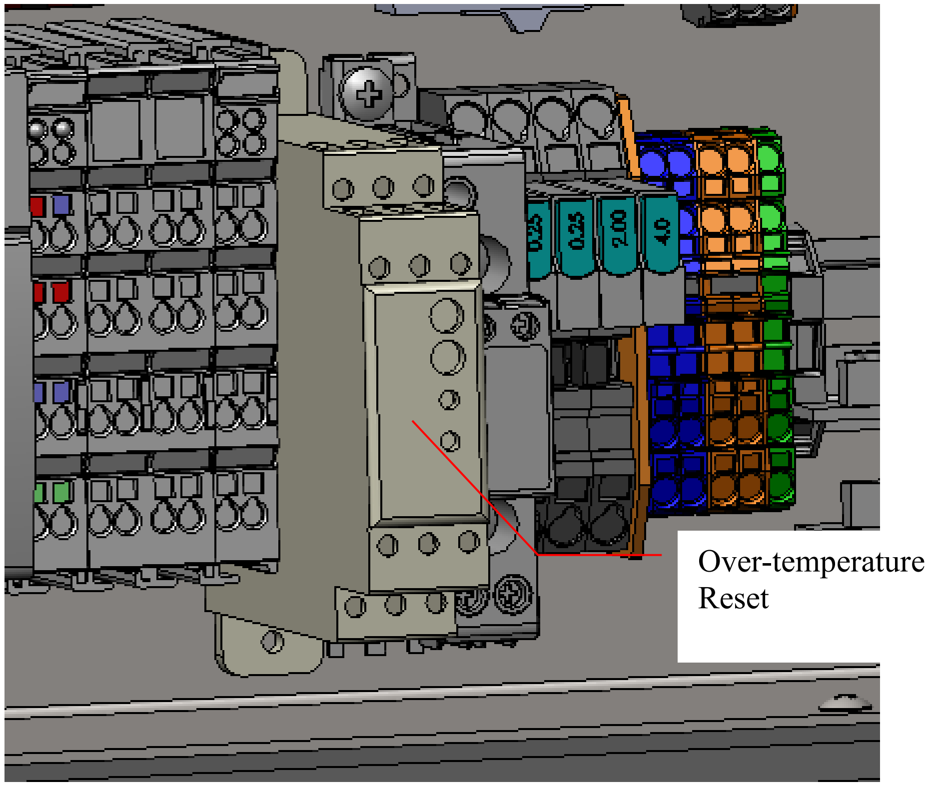


Figure 34 – Over-temperature Circuit

Periodic verification of the over-temperature relay set point (385°C) is recommended. Note that the over-temperature relay will latch open, requiring resetting if/when an over-temperature event occurs. The relay may be reset by removing the right-side panel and pressing the button on the front of the DIN mounted relay located in the electronics assembly (7500-3002).

Additionally, the temperature controller will disable the heater when the sample or heater alarm set point is exceeded or if a shorted thermocouple is detected. These alarms are cleared once the temperature has decreased below the alarm set point by pressing the EZ2 button.

High Pressure Diaphragm Valve

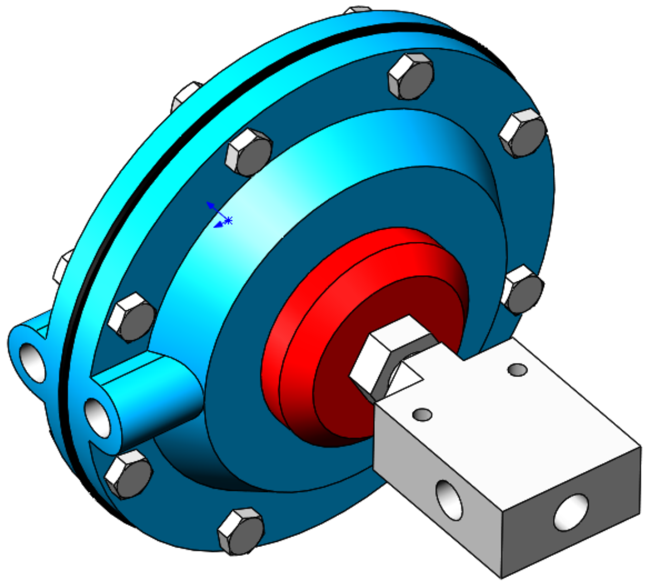


Figure 85 - High Pressure Diaphragm Valve

The instrument is equipped with a diaphragm valve that is rated for use at 30000 psi, 207 MPa. A length of capillary tubing is located downstream of the valve to provide a slow release of pressure when the diaphragm valve is opened by the controller.

The pressure on the valve diaphragm must be set at 70 psi, 480 kPa. The pressure adjustment is located inside the electronics console (right-most regulator, facing the front of the instrument)

The valve is equipped with a stem packing that may be tightened or replaced as required. Contact Chandler Engineering if service on this valve is required.

Rupture Disk

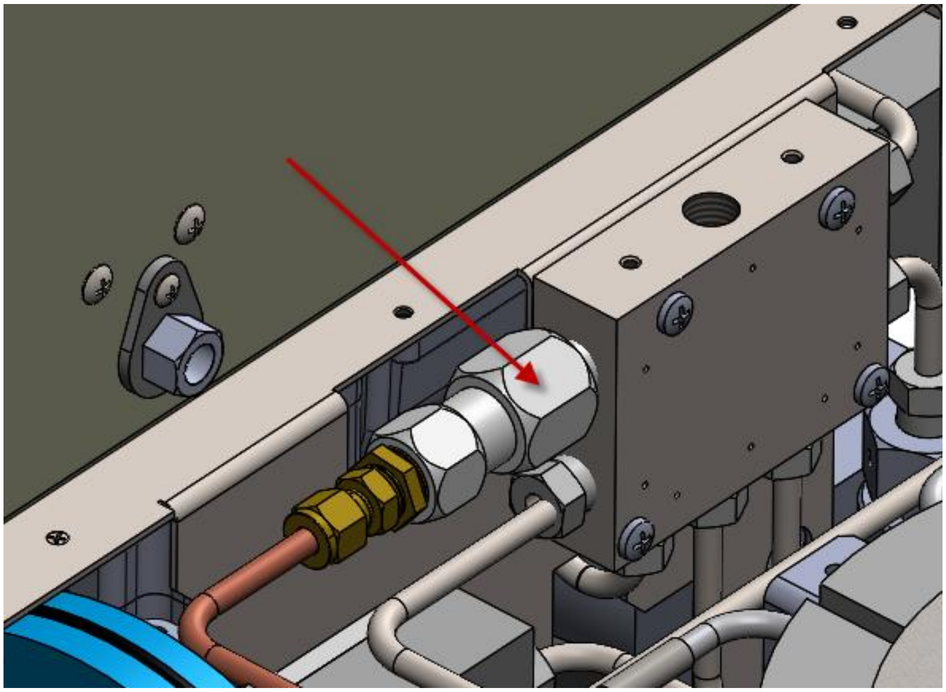


Figure 96 - Rupture Disk Assembly

The instrument is equipped with a rupture disk that will fail if the maximum pressure rating is exceeded. As a safety feature, a separate vent port is used for the discharge from the rupture disk if/when failure occurs.

Determine and resolve the reason for the failure of the disk prior to replacing the disk.

The rupture disk is located towards the left-front of the instrument. The rupture disk assembly must be removed from the instrument and mounted in a vise for removal of the internal disk. Replace the disk and tighten. Attach the new certification plate that accompanies the replacement disk.

High Pressure Transducer

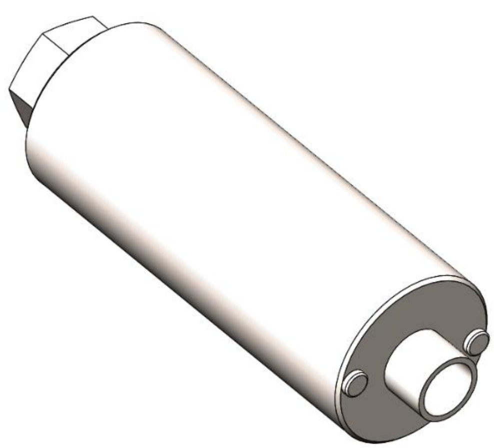


Figure 107 - High Pressure Transducer

The instrument is equipped with a high-pressure transducer. The transducer was calibrated by the manufacturer and calibration traceability is provided with the instrument. The output of the transducer corresponding to 40000 psi is 5.00 VDC.

The transducer is not serviceable and must be replaced as an assembly. Contact Chandler Engineering if replacement parts are required.

Pressure signal calibration is performed by scaling the pressure controller to agree with a known pressure transfer standard.

Pivot Bearing and Pivot

Figure 118 - Bob and Pivot Bearing Assembly

The bob rests on a pivot that is located on the centerline of the sample cup on the thermowell. The pivot may be removed with a pair of needle-nose pliers.

Heating / Cooling Jacket

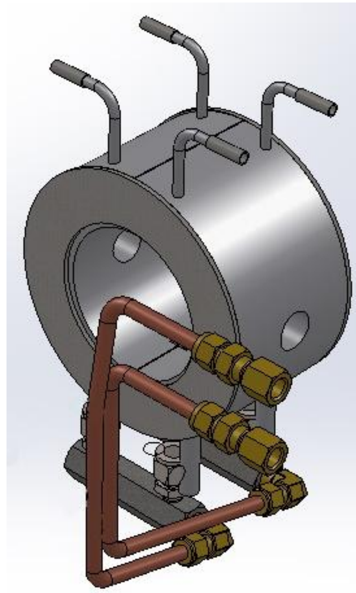


Figure 129 - Heating and Cooling Jacket Assembly

The instrument is equipped with a combination heating and cooling jacket.

The heaters are controlled with a solid-state relay and PID controller. A master heater switch must be ON to enable the heaters. In addition to the solid-state relay (SSR), both legs of the heater power are switched using a contactor.

The over-temperature module will disable the heater if the temperature exceeds 725°F, 385°C. Similarly, if the pressure increases beyond 31000 psi, 214 MPa, the heater circuit is disabled.

Pressure Vessel

O-rings and Backup Rings

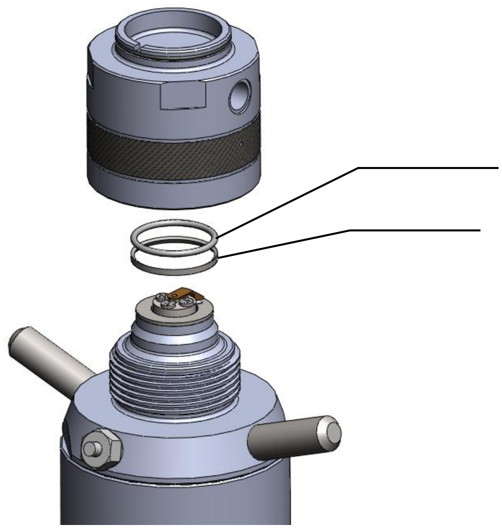


Figure 40 - Top Seal Ring Assembly

As a precaution, the elastomeric o-rings used to seal the top cap and vessel must be replaced after high temperature tests that exceed 450°F. The metal backup rings are long lasting and may be reused. For tests at temperatures exceeding 450°F, FFKM o-rings are required. For tests at temperatures below 450°F, FKM o-rings may be used.

The top cap o-ring and backup ring must be removed once the top cap is removed. The bottom plug o-ring and backup ring may be removed when the baffle is removed.

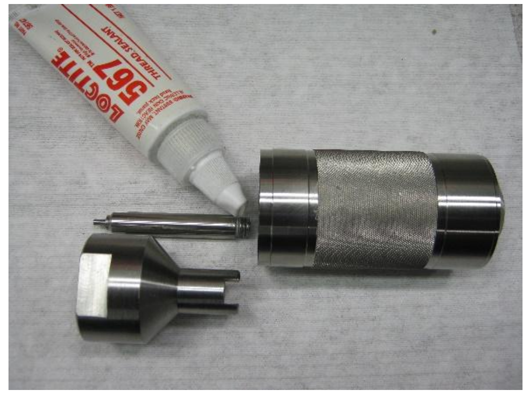
The baffle serves as a mounting point for the sample cup and a retainer for the seal and backup ring. Two o-rings are used to seal the baffle and the sample cup, both must be replaced when wear is evident to prevent loss of sample into the pressurizing fluid.

At no time should a sample be tested without the baffle o-rings installed. Doing so will contaminate the sample with pressurizing oil, leading to poor results and possible damage to the instrument.

If contamination occurs, clean the vessel and flush the system with clean pressurizing fluid. Clean the high-pressure filter.

Sample Cup

Thermowell



The thermowell at the bottom center of the sample cup serves multiple functions. It provides a location for the center thermocouple that is near the sample, providing an accurate sample temperature measurement.

The thermowell also provides a support for the pivot bearing pivot and a shoulder for the rotor bearing.

The thermowell may be removed from the sample cup by unscrewing it from the cup using tool 7500-2205. This tool also serves to verify the axial alignment of the thermowell in the sample cup.

Magnetic Drive

Inner Magnetic Rotor

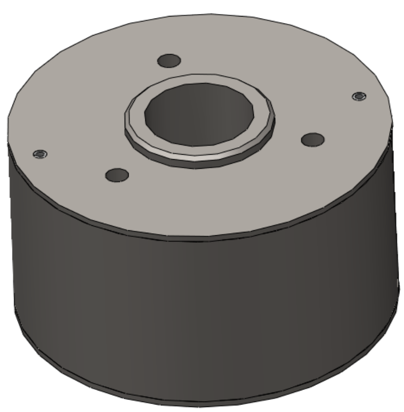


Figure 41 - Internal Magnetic Drive Rotor

The inner magnetic drive rotor is equipped with a bushing that must be replaced if worn. Verify that the bushing rotates freely on the thermowell. There are no other serviceable components on the inner magnetic drive rotor. If damaged, the assembly must be replaced. Contact Chandler Engineering if replacement parts are required.

Outer Magnetic Drive Rotor

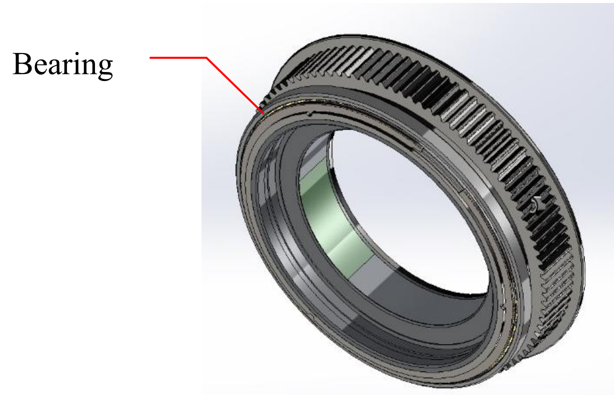


Figure 132 - Outer Magnetic Drive Rotor

The outer magnetic drive rotor is equipped with bearings that may be replaced if worn. There are no other serviceable components on the outer magnetic drive rotor. If damaged, the assembly must be replaced as a component. Contact Chandler Engineering if replacement parts are required.

The magnetic drive rotor bearings are lubricated using small amounts of Krytox grease.

The internal magnets are very strong and easily damaged during installation.

Encoder Assembly

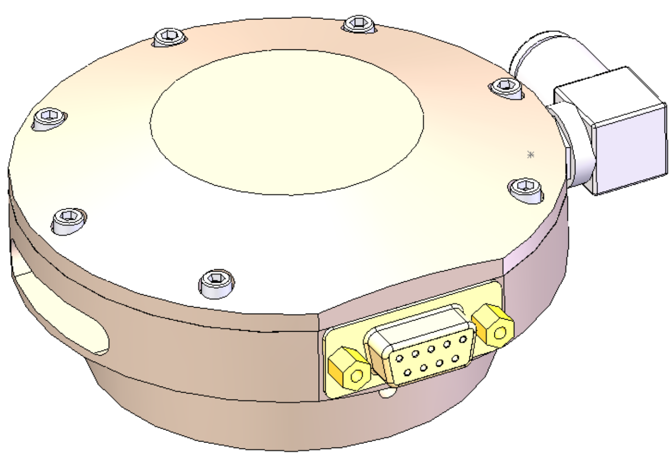


Figure 143 - Encoder Assembly

The instrument is equipped with a high-resolution encoder that senses the angular displacement of the magnet and spring assembly inside the pressure vessel. The encoder code wheel is suspended between precision pivot bearings.

The encoder may be disconnected by removing the interconnection cable. The encoder may be cleaned and rebuilt using tools and procedures defined on the assembly drawing. Contact Chandler Engineering for additional details.

The encoder assembly is equipped with a cooling jacket that is used during extended high temperature tests (>350°F / 177°C). The air flow may be controlled using a needle valve located on the left side of the electronics enclosure.

The encoder assembly is fragile. If dropped, the assembly will require service or replacement.

Supply Containers

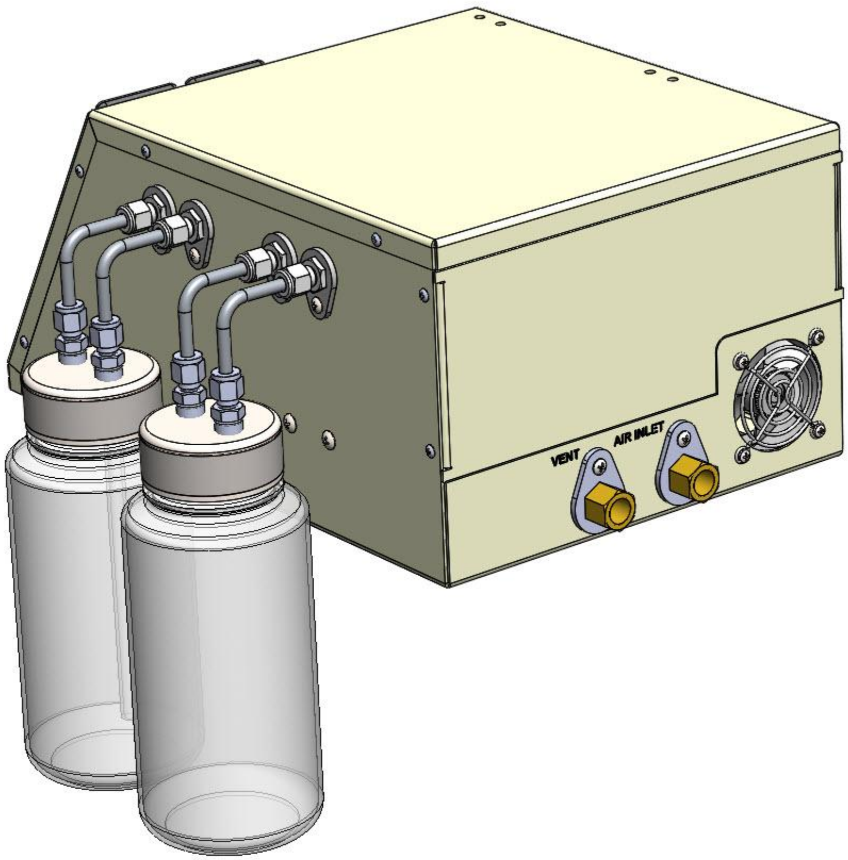


Figure 154 – Supply Containers

The container located at the right-front of the instrument chassis contains the heat transfer fluid used to pressurize the sample. The container is pressurized to approximately 20 psi, 138 kPa to provide the pump with a positive inlet pressure. The container located at the right-rear of the instrument chassis is used to capture the fluid that is discharged during normal operation of the instrument. This container must be emptied periodically.

An internal relief valve is provided to limit the pressure in the container right-front container to 30 psi, 207 kPa. The right-rear container is not pressurized.

Fluid may be added to the right-front container with a test in progress by placing the vessel switch in the OFF (middle) position. Add fluid to the container, replace and hand-tighten the container and place the switch in the Fill position.

The containers are equipped with elastomeric seals that may be replaced as required.

Internal Regulator Pressures

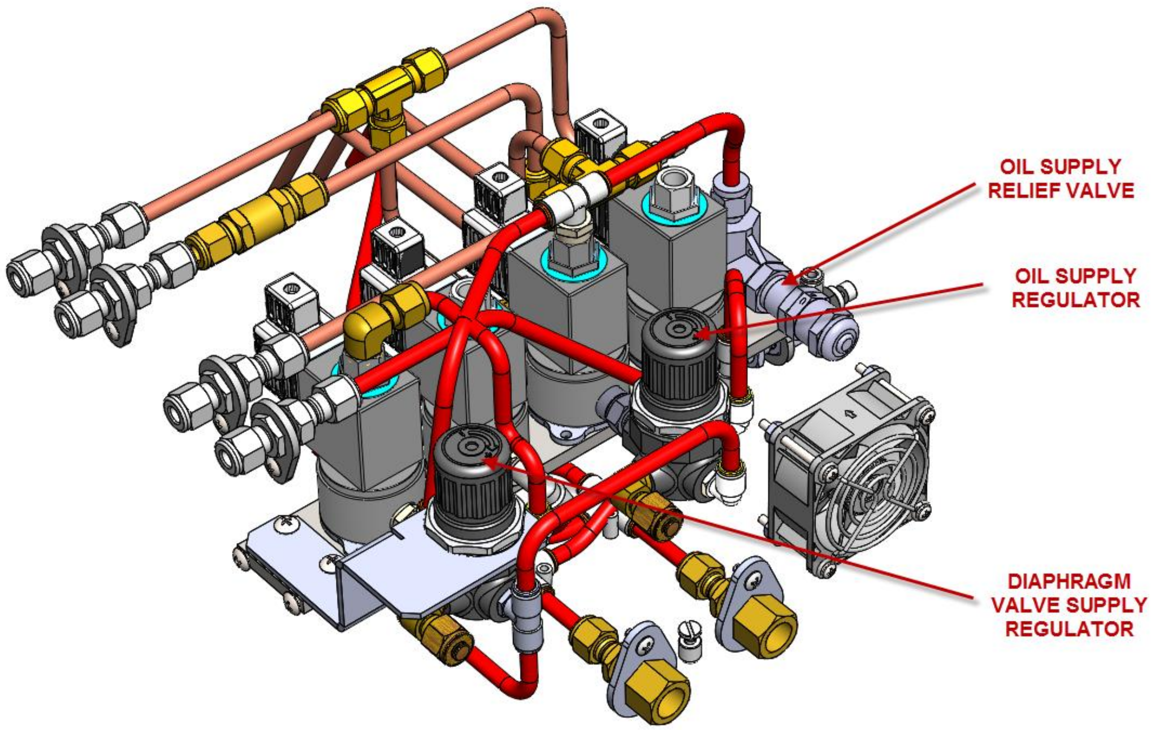


Figure 45 - Pump and Diaphragm Valve Pressure Regulators

The instrument includes two pressure regulators that are used to control the supply pressure to the supply container and diaphragm valve. These regulators are located in the Top Electronics Assembly (7500-3003) and may be accessed by removing the rear cover from the assembly. Unlock the adjustment knob by pulling vertically, adjust to the desired discharge pressure, and lock the knob by pressing the knob vertically.

The discharge pressures are measured individually by removing a pressure port cap and connecting a pressure gauge accessory. Disconnect air pressure from the instrument until the pressure gauge accessory is connected. Set the pressure values to the following values:

- Supply container: 20 psi (138 kPa)
- Diaphragm valve: 70 psi (480 kPa)

Remove the supply container pressure relief valve and set to 30 psi (207 kPa). Lock the adjustment knob in place.

Motor Drive Belt and Stepper Motor

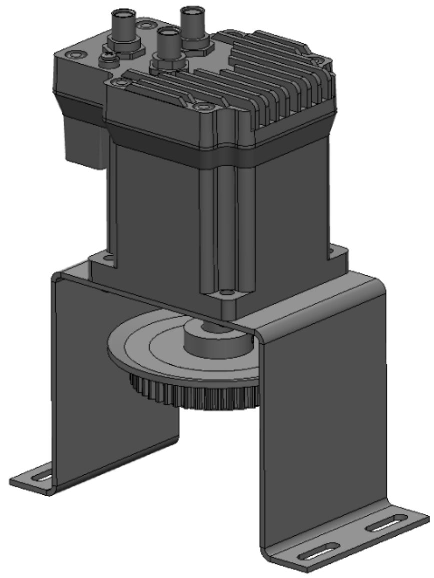


Figure 46 - Stepper Motor and Pulley

The motor drive belt tension is set by loosening the motor bracket mounting screws and sliding the motor assembly. The belt tension must not be excessive, approximately 0.25 - 0.50-inch of deflection halfway between the motor and magnetic drive centerlines is sufficient.

The stepper motor is not serviceable; the motor is replaced as a unit once the pulley and mounting bracket are removed.

Use the following procedure to replace the motor drive belt:

1. Remove the covers from the instrument.
2. Remove the Top Electronics Assembly (7500-3003) after disconnecting the marked cables and 1/4-inch tube connections.
3. Remove the top panel.
4. Remove the Electronics Module Assembly (7500-3002).
5. Disconnect the two cables to the motor.
6. Loosen or remove the four bolts that retain the motor assembly to the base plate. Remove the motor assembly if the motor must be replaced.
7. Remove the four bolts that retain the vessel mounting flange to the base plate.
8. Remove the centerline thermocouple from the bottom of the vessel.
9. Replace the belt by sliding the belt between the top of the base plate and the bottom of the vessel mounting flange. For this to occur, the high pressure port connections at the bottom of the vessel must be loosened or removed. A special wrench is supplied for use in loosening and re-tightening the bottom connections.
10. Reassemble in reverse order.

Pump and High Pressure Valves

The instrument is equipped with an air over liquid pump with a 220:1 ratio. The pump is capable of generating a discharge pressure up to 30000 psi, 207 MPa provided adequate air pressure is provided (130 psi, 900 kPa).

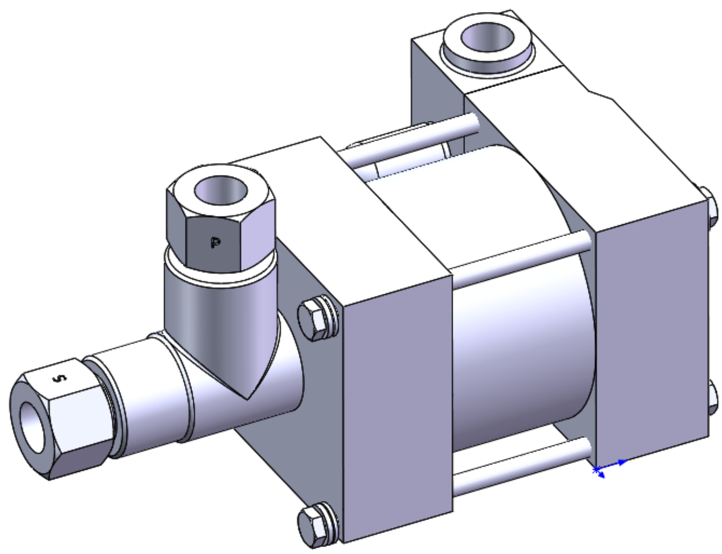


Figure 167 - High Pressure Pump

The high-pressure pump may be rebuilt using two kits (high pressure seals, low pressure seals). Once the pump is removed from the instrument it may be rebuilt in accordance with the manufacturer instructions. Alternately, the pump may be replaced as an assembly.

The high-pressure valves (pressure release valve, diaphragm valve) are replaced as separate units. Contact Chandler Engineering if replacement parts are required.

Instrument Voltage Selection

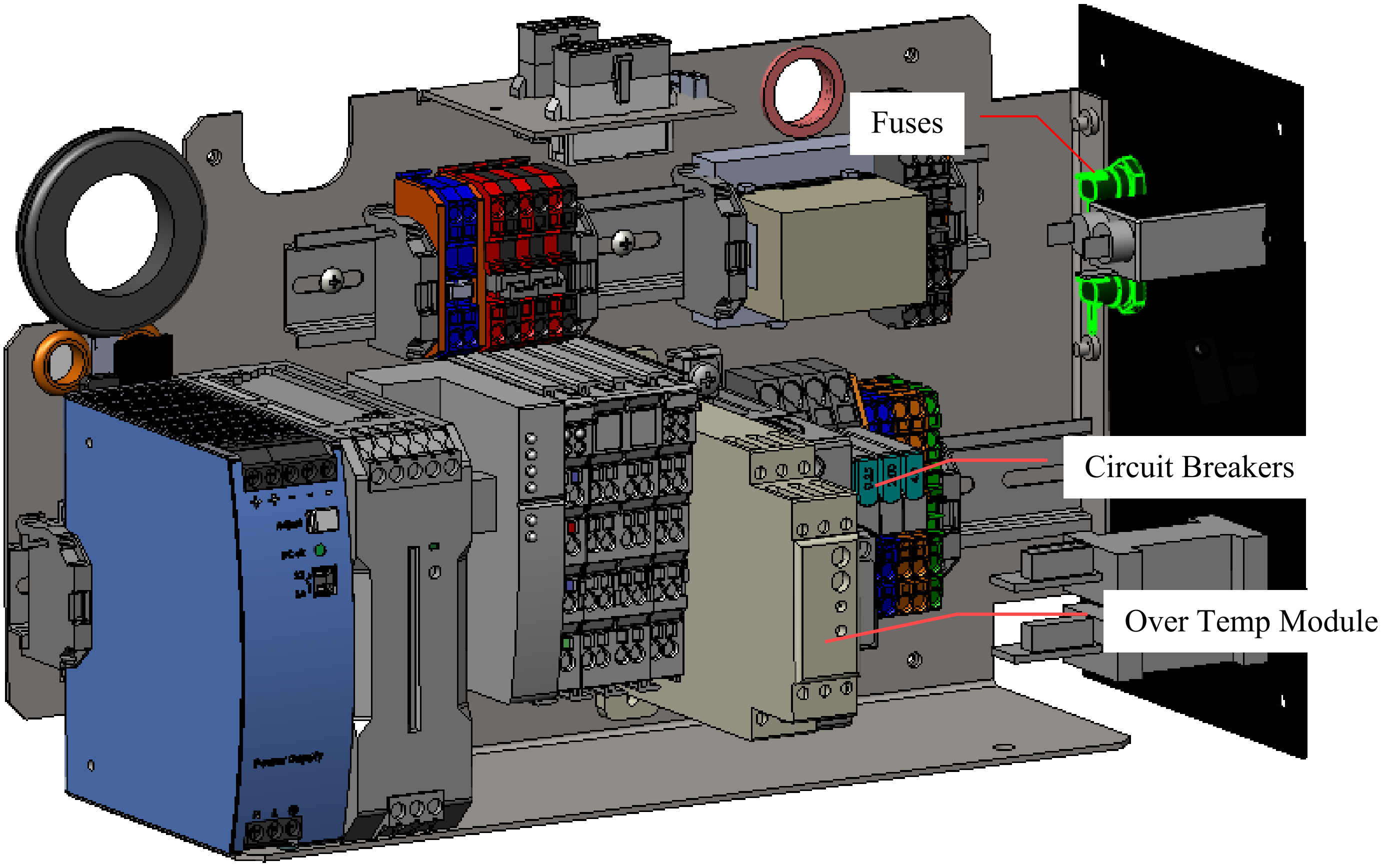


Figure 178 – Electronics Assembly

The instrument is designed to operate using 208-240 VAC, 50/60 Hz supply voltage. The fuse ratings are listed as follows:

- 208-240 VAC: 5A Slow Blow (two 3AG fuses)

Instrument Circuit Breakers

All circuits in the instrument (except the heater) are protected using circuit breakers. If a breaker opens, the fault must be determined and corrected. The breaker may be reset by pressing the button on the breaker. Individual breakers may be replaced by unplugging from the DIN rail mounted receptacle. Refer to the wiring diagram 7550-3030 for additional details.

The vessel heater is protected using two 3AG fuses that are located on the rear panel of the instrument.

Instrument Solenoid Valves

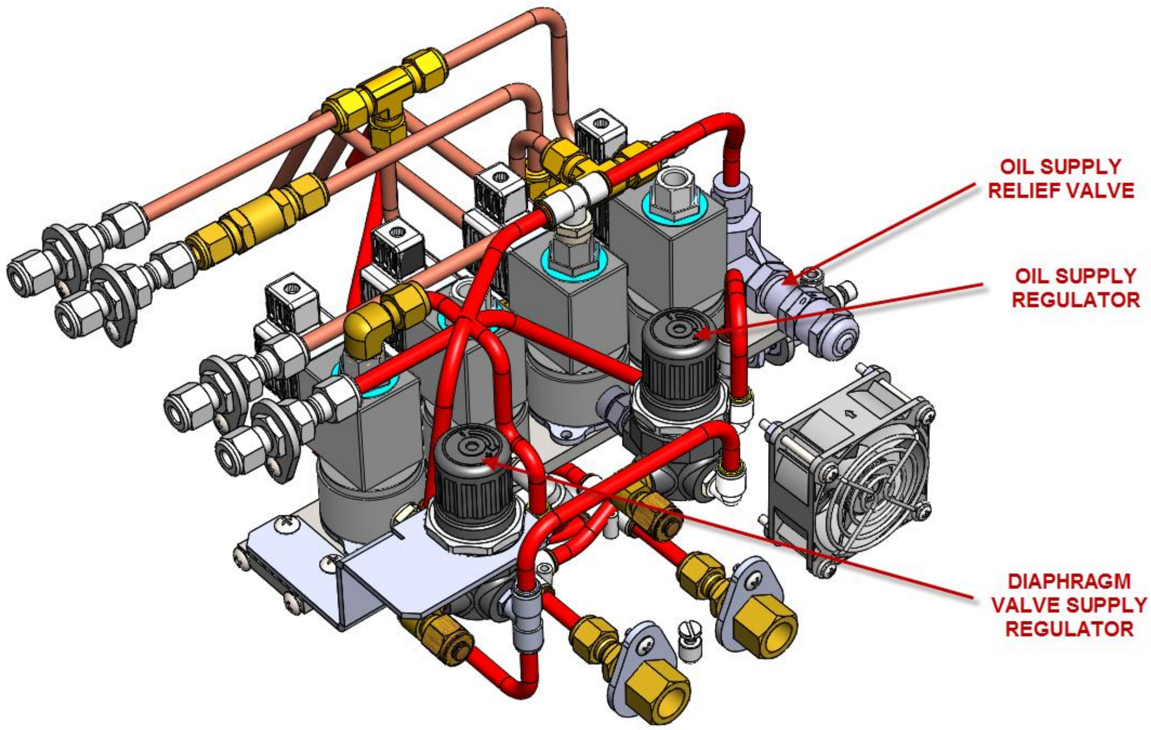


Figure 181 - Solenoid Valve Assembly

The instrument contains four solenoid valves. Care must be used during servicing not to interchange the valves; the 3-way and 2-way valves appear similar with identical connections. Each valve is equipped with 24vdc solenoid valve coils. Refer to the wiring diagram 7550-3030 for additional details.

Section 4 - Troubleshooting Guide

The following table lists symptoms of several common problems, the possible cause of the problem, and the possible solution to the problem.

MAINTENANCE SCHEDULE Model 7550 HPHT Viscometer					
COMPONENT	EACH TEST	MONTHLY	3 MONTHS	6 MONTHS	ANNUAL
Vessel Seals	Inspect & replace as required				
Vessel Assembly	Clean as needed				Inspect and pressure test vessel
Rupture disc					Replace
Temperature - Centerline				● Calibrate	
Temperature – Heating/Cooling Jacket				● Calibrate	
Pressure Transducer				● Calibrate	
Torque (Shear Stress)		Calibration using certified fluid			
Motor (Shear Rate)					Verify with a digital tachometer
This maintenance schedule applies to normal usage of two tests per day. ● Per API/ISO Specifications					

Problem	Solution
System will not pressurize	1. Verify that the air supply is present, and the vessel switch is set to Fill. 2. Verify that the controller is enabled using the EZ1 button. 3. Verify that fluid is present in the front supply container. 4. Check for leaks at the vessel or interconnecting tube fittings. 5. Check that the line size to the Air Inlet port is at least ¼-inch to supply adequate volume flow to the pump.
System will not heat	1. Verify that communication cables are connected. 2. Verify that the controller is enabled using the EZ1 button. 3. Verify that heater switch is ON. 4. Check heater fuses on back panel. 5. Check that the over-temperature relay does not need to be reset.
Poor temperature or pressure control	1. Defective thermocouple or pressure transducer. 2. Defective capillary tubing. 3. Incorrect control schedule. 4. Incorrect controller configuration parameters.

Problem	Solution
	5. Defective controller, controller parameters or related electronics.
Stepper motor will not run	1. Verify proper operation of the Rheo7500 software 2. Verify operation of motor in Manual mode. 3. Verify that communication cables are connected and COMM port assignments are correct 4. Verify that circuit breaker is not tripped.
Poor STDDEV and HYST values	1. Worn bob pivot bearing and pivot. 2. Incorrect calibration data 3. Instrument is not level. 4. Check for friction in the spring module assembly. 5. Check for bent bob shaft or other damage to internal components.
Erratic Readings	1. Sample container not full. 2. Encoder assembly requires service.

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Section 5 – Replacement Parts List

Model Number 7550

Part Number	Description
70610-68	Fuse, 5.000A, 250V, 3AG, Timedelay
7500-2010	Vessel Assembly
7500-2106	Jacket, Heat/Cool
7500-2155	Motor Pulley Assembly
7500-2178	Gasket, Insulating
7500-2181	Jacket, Insulation
7500-2204	Tool,Bob Installation
7500-2312-1	Tube 1, Lower, Heat Exchanger
7500-2312-2	Tube 2, Upper, Heat Exchanger
7500-3107	Tube Set, LP, Copper
7500-3172	Tube Set, HP, SS
7500-3172-9	Tube 9
7500-3186	Valve, Air Operated, 30000 psi
7500-3229	Magnetic Drive Assembly
7600-1188	Gasket, Reservoir Cap
80-0021	TC, Special Type J, 2.57"L
C17096	Transducer, Pressure, 40 kpsi
C08974	Pump, Maxpro
C10380	Valve, Check, Brass, 1/4T x 1/4T, 3000 psi
C11114	Bottle, Nalgene, 32 oz, Grey
C11293	Gage, 30000 psi, 4", 1/4HPF, Panel mount
C11316	VALVE,RLF,SS,1/4TX1/4T,2WY-ANG
C12886	Fan, DC, 60mm, 24VDC
C19218	MOTOR,STEP,DC,NEMA 34,RS422,IP65,336OZIN
C13160	Valve, Needle, SS, Speed Control, Elbow
9051-7550	CONTROLLER,TEMP,7550,F
9061-7550	CONTROLLER,PRESS,7550,PSI
C15903	Belt, Timing, XL, 205 Teeth
C16085	Sling, Lifting,1" x 6Ft
P-1954	Conn, Brass,1/4FP x 1/4T, Bulkhead
P-3544	Conn, TC, Type J, Female

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
7550	MODEL 7550 HPHT VISC,220V
7550-3030	DIAGRAM,WIRING,MODEL 7550 HPHT
7550-3031	TUBING DIAGRAM,MODEL 7550 HPHT VISCOMETER
7500-2010	VESSEL ASSEMBLY,MODEL 7500
7550-ACCESS	ACCESSORIES,MODEL 7550 HPHT

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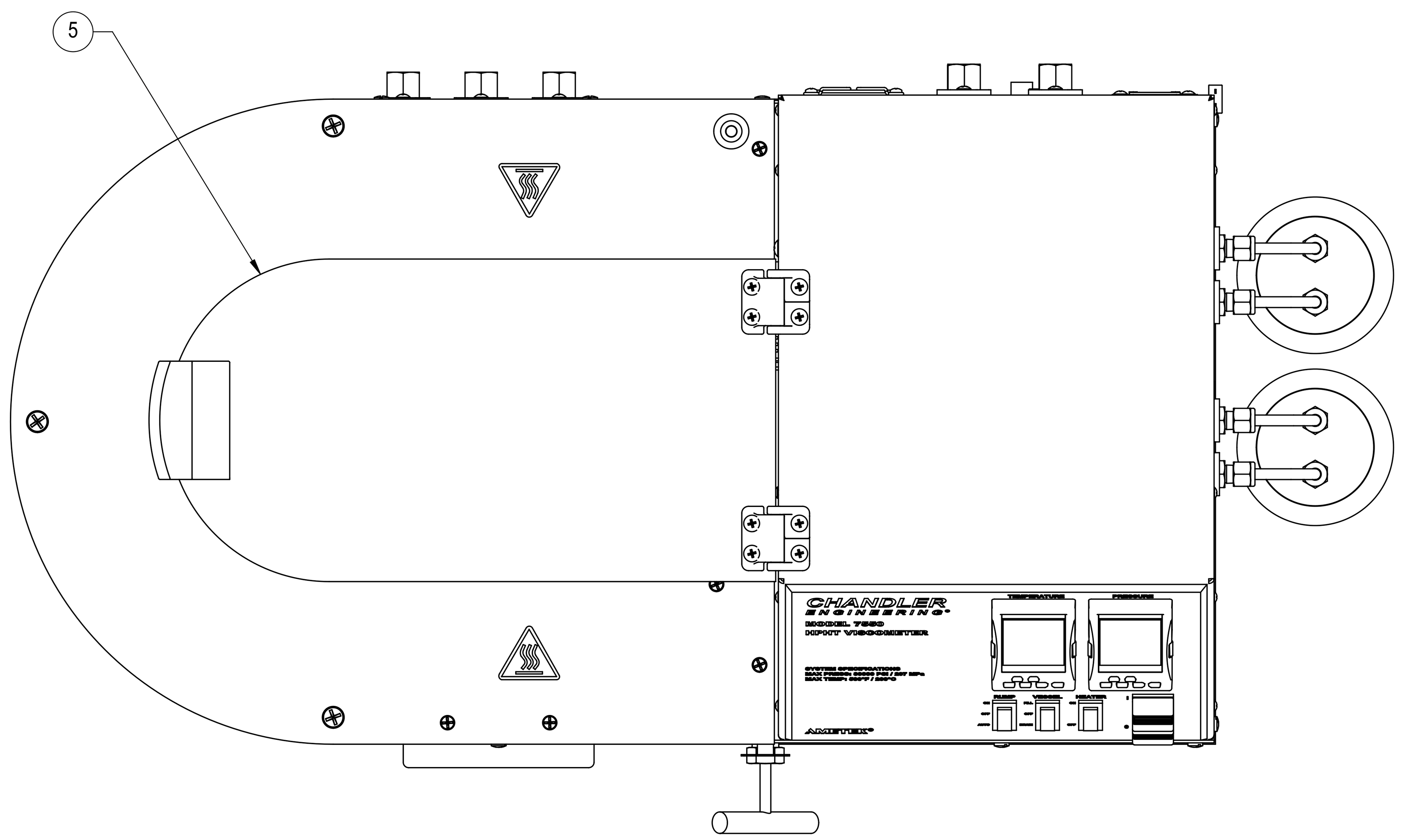
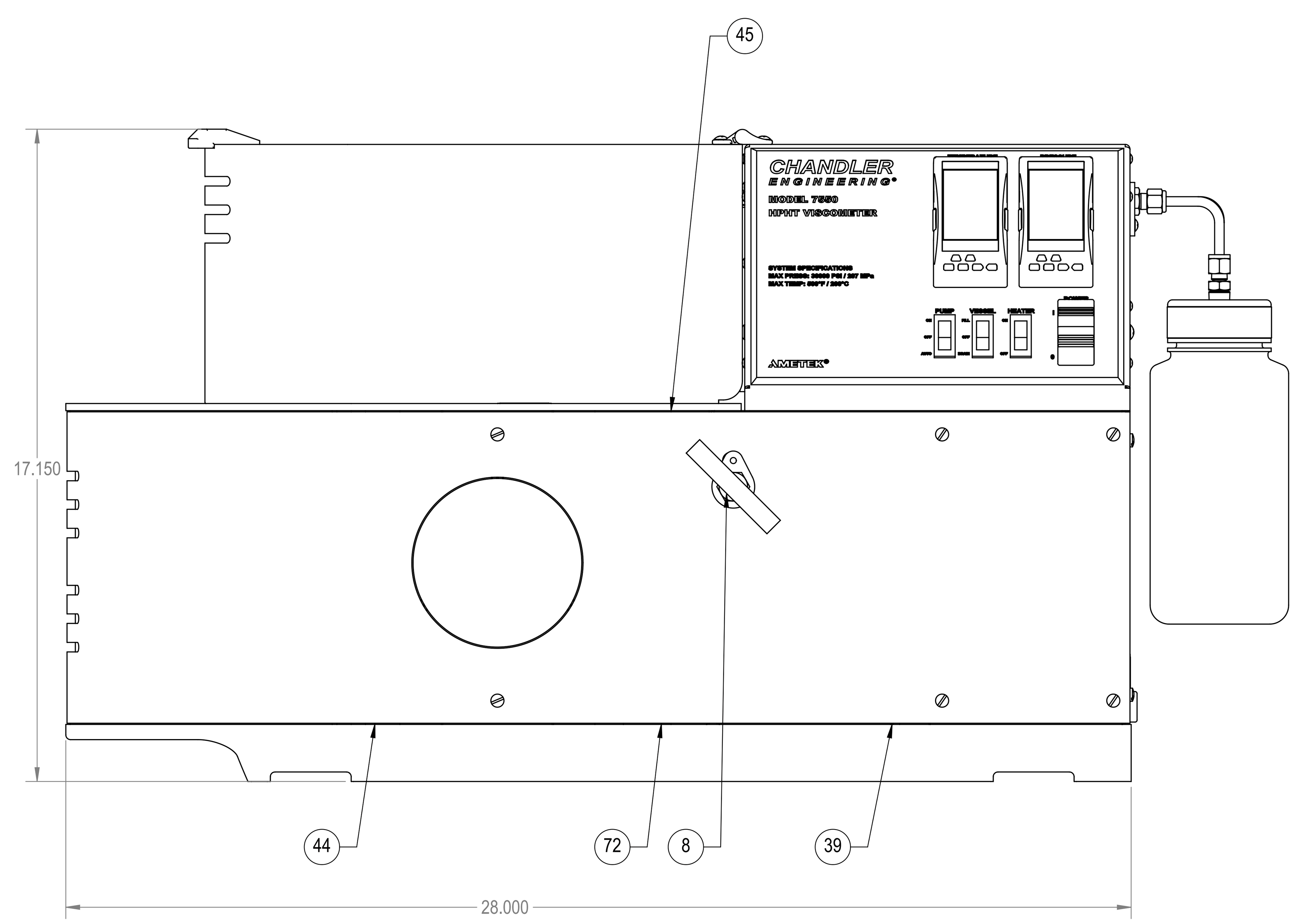
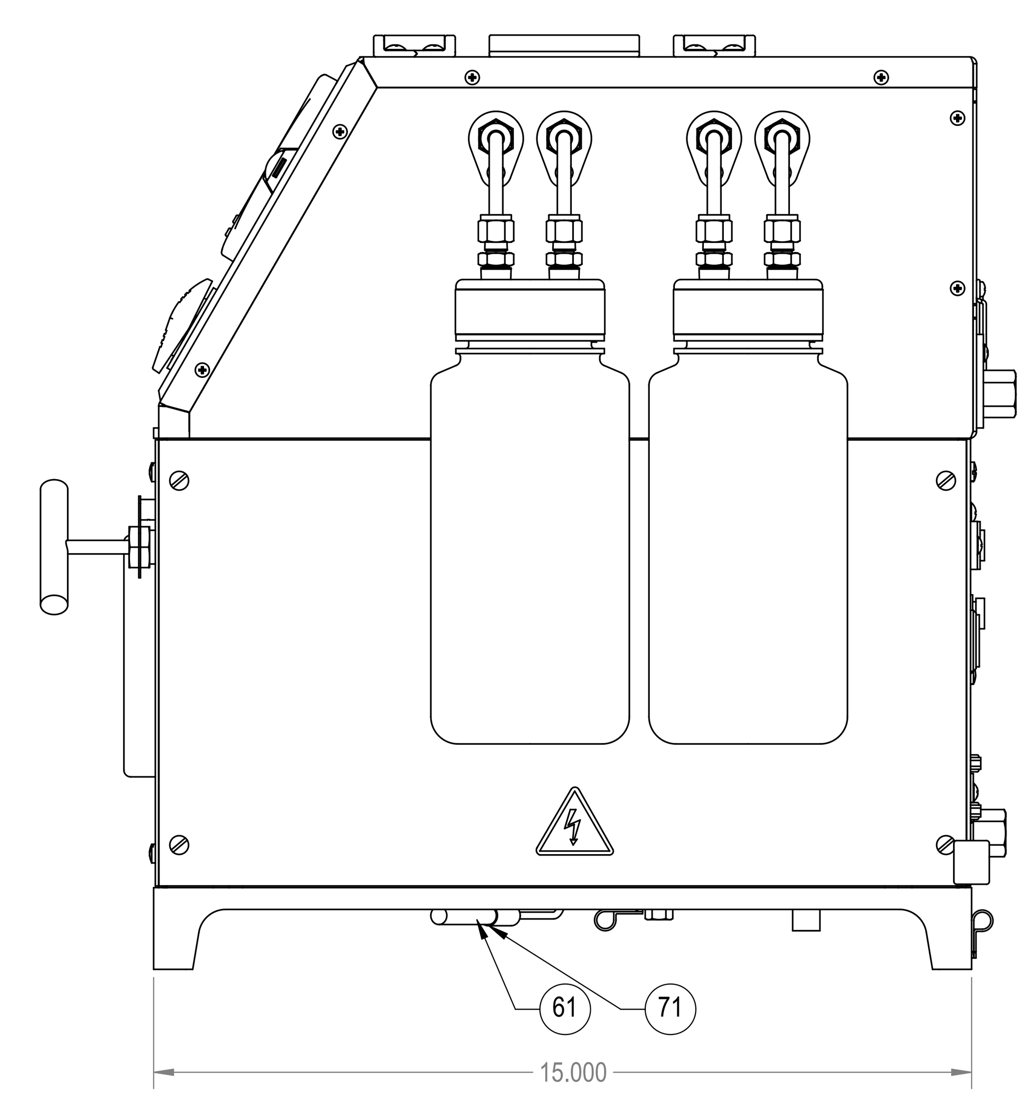
NOTES:
1. REFER TO 7500-3172 FOR HIGH PRESSURE TUBE SET.
2. REFER TO 7500-3107 FOR LOW PRESSURE TUBE SET.
3. REFER TO 7500-3321 FOR PLASTIC TUBE SET.
4. CONFIGURE C08974 PUMP FOR USE WITH 7500-2228 BRACKET, REMOVING BRACKETS SUPPLIED WITH PUMP.
5. ROTATE C08259-7500 VALVE AS SHOWN.

REV	DESCRIPTION	DATE	APPROVED
AA	ECN T9835; REPLACE C13044 STEPPER MOTOR WITH C19218	2023-12-18	JJM
AB	ECN T9888; ADDED 7550-3030	5/31/2024	JS
AC	ECN T9906; REPLACED C07833 W/ C17096	6/28/2024	JS
AD	ECN 10338; REPLACE C17096 W/ C07833	5/8/2025	JS







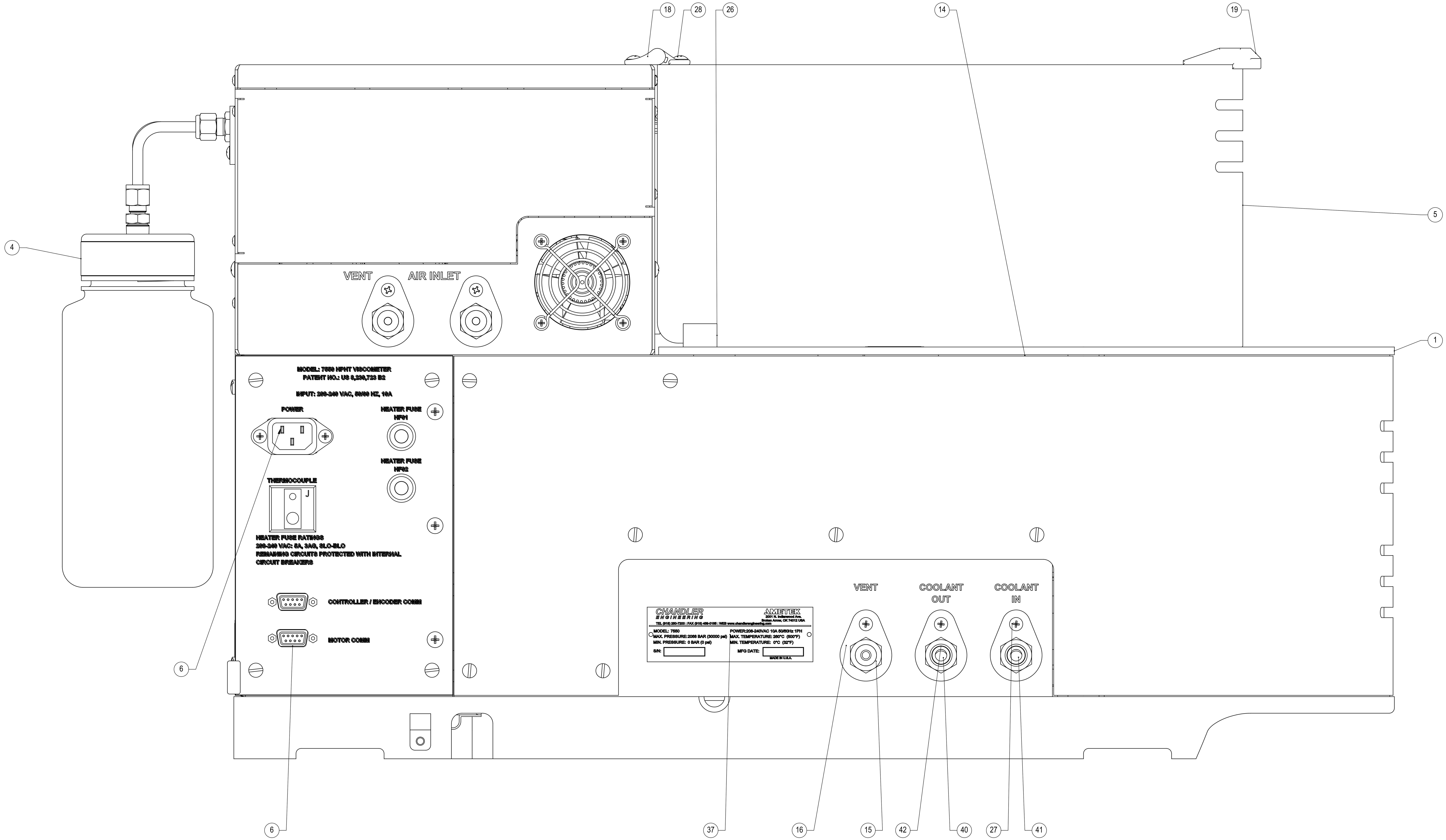
ITEM	PART NUMBER	DESCRIPTION	QTY
	7550-1050	OPERATING MANUAL	1
1	7500-3019	ENCLOSURE ASSEMBLY	1
2	7500-2010	VESSEL ASSEMBLY,MODEL 7500/7550	1
3	7500-2155	PULLEY ASSEMBLY, MOTOR	1
4	7500-3003	ENCLOSURE ASSEMBLY, TOP	1
5	7500-3173	COVER, VESSEL	1
6	7500-3002	ELECTRONICS MODULE ASSY, 220V	1
7	7500-2141	RING, BEZEL	1
8	P-2188	VALVE,ANGLE,60KPSI,SST,1/4 HPT	1
9	C08974	PUMP, MAXPRO, PP189	1
10	C08259	VALVE,AIR OPR,30000PSI,7500	1
11	7500-3172-2	TUBE 2	REF
12	C16370	CORD,PWR,NORTH AMERICA,250VAC,10A,2M,IEC C13	1
13	C07833	XDCR,PRESSURE,40KPSI,W/CABLE	2
14	7500-2178	GASKET, INSULATING	2
15	P-1954	CONN,BRS,1/4FPX1/4T,BHD,SW	1
16	C08268	RETAINER,SST,3/4ID,BHD,SW	3
17	7500-2182	GLAND, EXTENDED	1
18	C12406	HINGE,SPRG,10MMX40MMX38MM,AL	2
19	7500-2187	HANDLE, COVER	1
20	7500-2189	NUT, TUBING	2
21	C11293	GAUGE,30000PSI,4IN,1/4HPF,PNLMT	1
22	C12470	CABLE,LUMBERG RST 5-228/2M	1
23	C12471	CABLE,LUMBERG RK 30-738/6F	1
24	C15903	BELT,TIMING,XL,205 TEETH	1
25	7500-ACCESS	ACCESSORIES,MODEL 7500 HPHT	1
26	P-0984	LEVEL,CIRC,0.875MTG FLG,0.625DIA	1
27	H-6015	SCREW,THMS,SS,6-32X0.375,PHIL	3
28	H-8026	SCREW,THMS,SS,8-32X0.375,PHIL	9
29	P-0193	GLAND,SST,TUBE,1/4TX9/16-18RH	3
30	7500-3208	TUBE ASSEMBLY, HP CAPILLARY	1
31	7500-3172-11	TUBE 11	REF
32	69-793	SAFETY HEAD,0.25X0.083TBG F/1/4A	1
33	7500-3272	ENCODER ASSEMBLY, 7500/7600	1
34	7500-3321-B	TUBING,POLYURETHANE,1/4	REF
35	C15746	LABEL,WARNING,HOT SURFACE HAZARD,1.00" BASE	2
36	70610-68	FUSE,5.000A,250V,3AG,TIMEDELAY	2
37	7550-0084	NPL,SN.PWR RATING,7750,220V	1
38	C09393	COMPUTER,LAPTOP	1
39	7500-2228	BRACKET, PUMP	1
40	7500-2312-1	TUBE, LOWER, HEAT EXCHANGER	1
41	7500-2312-2	TUBE, UPPER, HEAT EXCHANGER	1
42	C09880	CONN 3/8T X 1/4NPT,BLKHD	2
43	C13898	DISK,RUPTURE,31000PSI,0.25",CE	1
44	7500-3229	MAGNETIC DRIVE ASSEMBLY	1
45	7500-3310	MANIFOLD, HP	1
46	7500-3172	7500, TUBE SET, HP, SS	1
47	7500-3172-1	TUBE 1	REF
48	7500-3172-3	TUBE 3	REF
49	7500-3172-4	TUBE 4	REF
50	7500-3172-5	TUBE 5	REF
51	7500-3172-7	TUBE 7	REF
52	C08582	CONN,1/4HPTX1/4HPT,60KPSI,BHD	1
53	7500-3172-8	TUBE 8	REF
54	70605-69	HSG,3PIN	1
55	P-1254	CONN,BRS,1/4 MP x 1/4 T,SW	1
56	7500-3107-9	COPPER TUBE 8	REF
57	P-0915	PLUG,SS,1/4T,HP	2
58	C14023	LABEL,WARNING,HAZARD VOLTAGE,1.00" BASE	1
59	H-10-120	SCREW,BHMS,SS,10-32X1.250	6
60	H-8015	SCREW, FHMS, SS 8-32X0.500, PHIL	5
61	H-25-019	SCREW,1/4-20X3/4,HHCS,SS	4
62	7500-3017	CABLE ASSEMBLY, ENCODER	1
63	C15217	CONN,BLKHD,SMC,1/4TX1/4T	1
64	C03321	UNION,SS,BHD,1/4TX1/4T,SW	2
65	7500-2106	JACKET,HEAT/COOL	1
66	7500-2181	JACKET, INSULATION	1
67	C14168	ELBOW,SS,1/2TX1/2T,UN	2
68	P-3200	ELBOW,BR,3/8MPX3/8T	2
69	P-1400	ELBOW,BR,1/4TX3/8MP	1
70	7500-3107-10	COPPER TUBE 10	REF
71	80-0021	TC,SPECIAL TYPE J,2.57"L,UCA	1
72	P-3544	CONN,TC,TYPE J,FEMALE	1
73	7500-3107-11	COPPER TUBE 12	REF
74	C07279	UNION,SS,BHD,1/16T,SW	2
75	7500-3321-M	TUBING,POLYURETHANE,1/4	1
76	C15968	TEE,RUN,SS,1/2TX3/8FNPTX1/2T	2
77	7500-3107	TUBESET, LP, COPPER	1
78	C13395-7550	CRATE,FOAM 7550,OMNI	1
79	C13396	BOX,PLASTIC W/FOAM INSERT,OMNI	1
80	C16085	LIFTING STRAPS	2
81	H-8033	SCREW,SHCS,SS,10-24X1.250	2
82	C11292	POLYSEAL TUBING	.03
83	C12233	LABEL, EARTH GROUND	1
84	7500-3172-9	TUBE 9	REF
85	C16152	RETAINER,SS,1/16T,BHD	2
86	7500-3179	BRACKET, MOTOR	1
87	7500-2203	RETAINER, FITTING	1
88	C16481	ELBOW, SMC 3/8MNPT X 1/4	1
89	7500-3182	CABLE MOUNTING BRACKET	1

ITEM	PART NUMBER	DESCRIPTION	QTY
90	H-4105	SCREW,FHMS,SS,4-40X0.250,PHIL	1
91	7500-3187	HIP VALVE SPACER PLATE	1
92	3000-1014-202	BRACKET,T/C MOUNTING	1
93	7500-3321	TUBESET,7550,POLYURETHANE	1
94	C16723	CABLE CLIP	3
95	7550-REF	REFERENCE DOCUMENTS	REF
96	7500-3186	VALVE MODIFICATION,30000PSI,7500	1
97	C15216	ELBOW,PL,1/4MPX1/4T,PNEU	1
98	C11204	TC,TYPE J,SS,4"LONG	1
99	7550-3031	TUBING DIAGRAM,MODEL 7550 HPHT VISCOMETER	REF
100	P-2429	CONN,TC,TYPE J,MALE	1
101	P-2778	PLUG,ELEC,TC,SUBMIN	1
102	C08266	CONN,T/C,SUBM,TYPE J,FEMALE	1
103	C08266	CONN,T/C,SUBM,TYPE J,FEMALE	1
104	C19218	MOTOR,STEP,DC,NEMA 34,RS422,IP65,336OZIN	1
105	7550-3030	WIRING DIAGRAM,MODEL 7550 HPHT VISCOMETER	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: JJM 9/27/2013
MFG: LDR 10/18/2013
ENGR: JJM 9/27/2013
TYPE:
STRUCT:

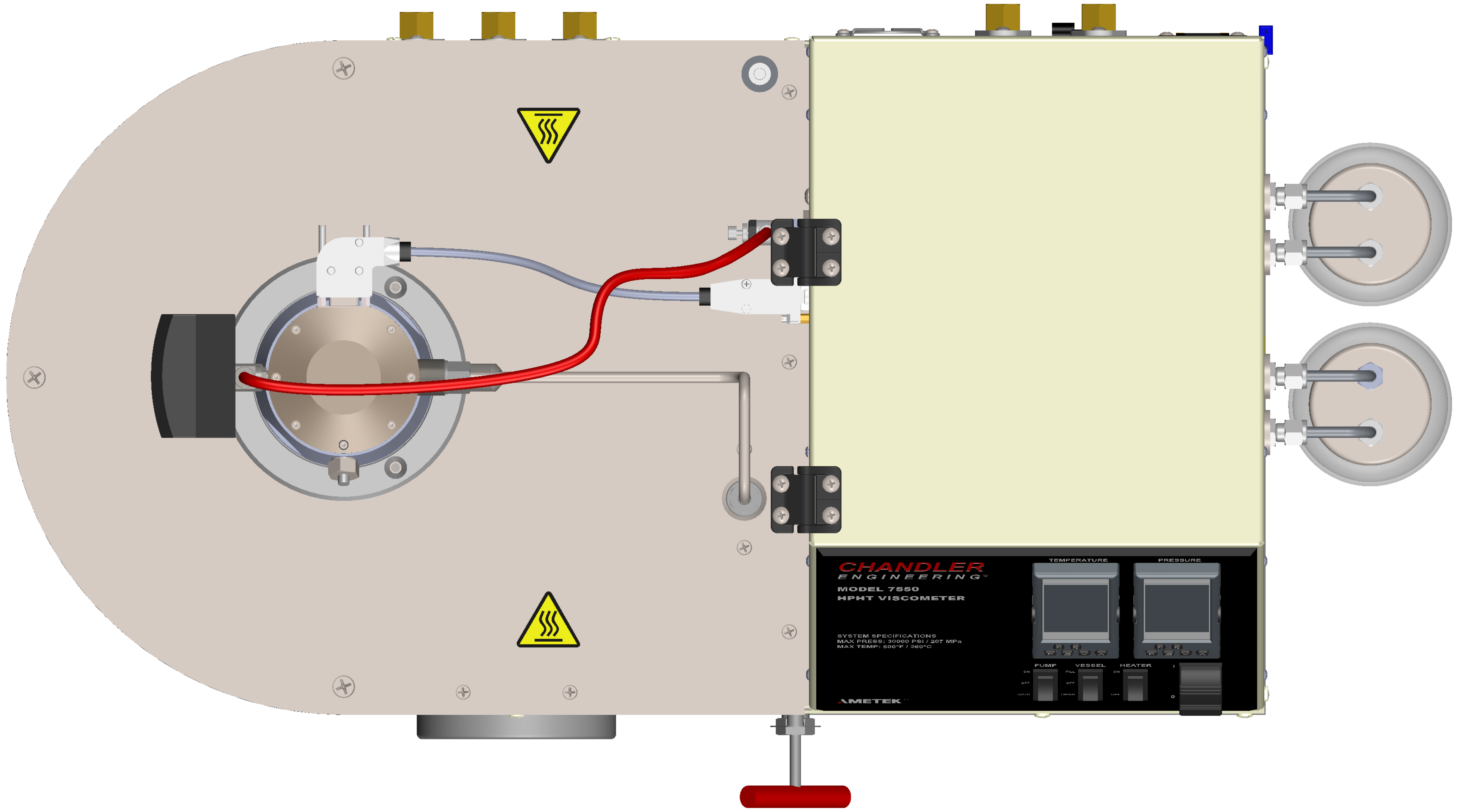
CHANDLER ENGINEERING
MODEL 7550 HPHT VISCOMETER
PN: 7550
PROJ: 7550
REV AD SIZE D
SHEET 1 OF 3
TITLE BLOCK REV 3

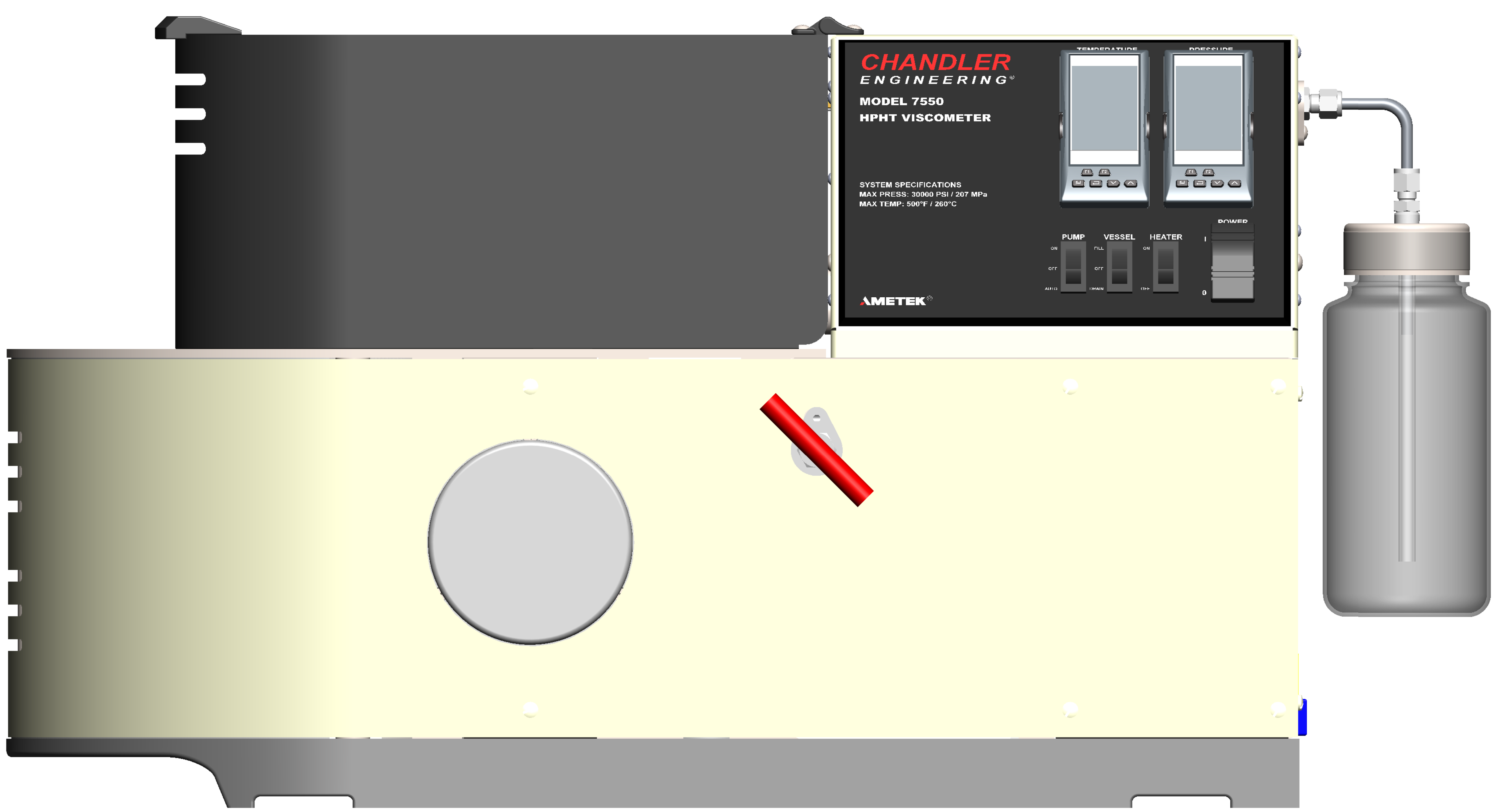


BREAK EDGES, DEBURR **UON DIMS ARE IN INCHES** 1 PLC ±0.030 2 PLC ±0.010 3 PLC ±0.005 ANGL ±1/2° SURFACE FINISH 63 RMS THIRD ANGLE PROJECTION	DRAWN: JJM 9/27/2013 MFG: LDR 10/18/2013 ENGR: JJM 9/27/2013	***CHANDLER ENGINEERING*** MODEL 7550 HPHT VISCOMETER	
	TYPE: STRUCT:	PN: 7550 PROJ: 7550	REV AD SIZE D SHEET 2 OF 3

TITLE BLOCK REV 3

NOTES:
1. INTERNAL COMPONENT VIEWS FOR REFERENCE ONLY.





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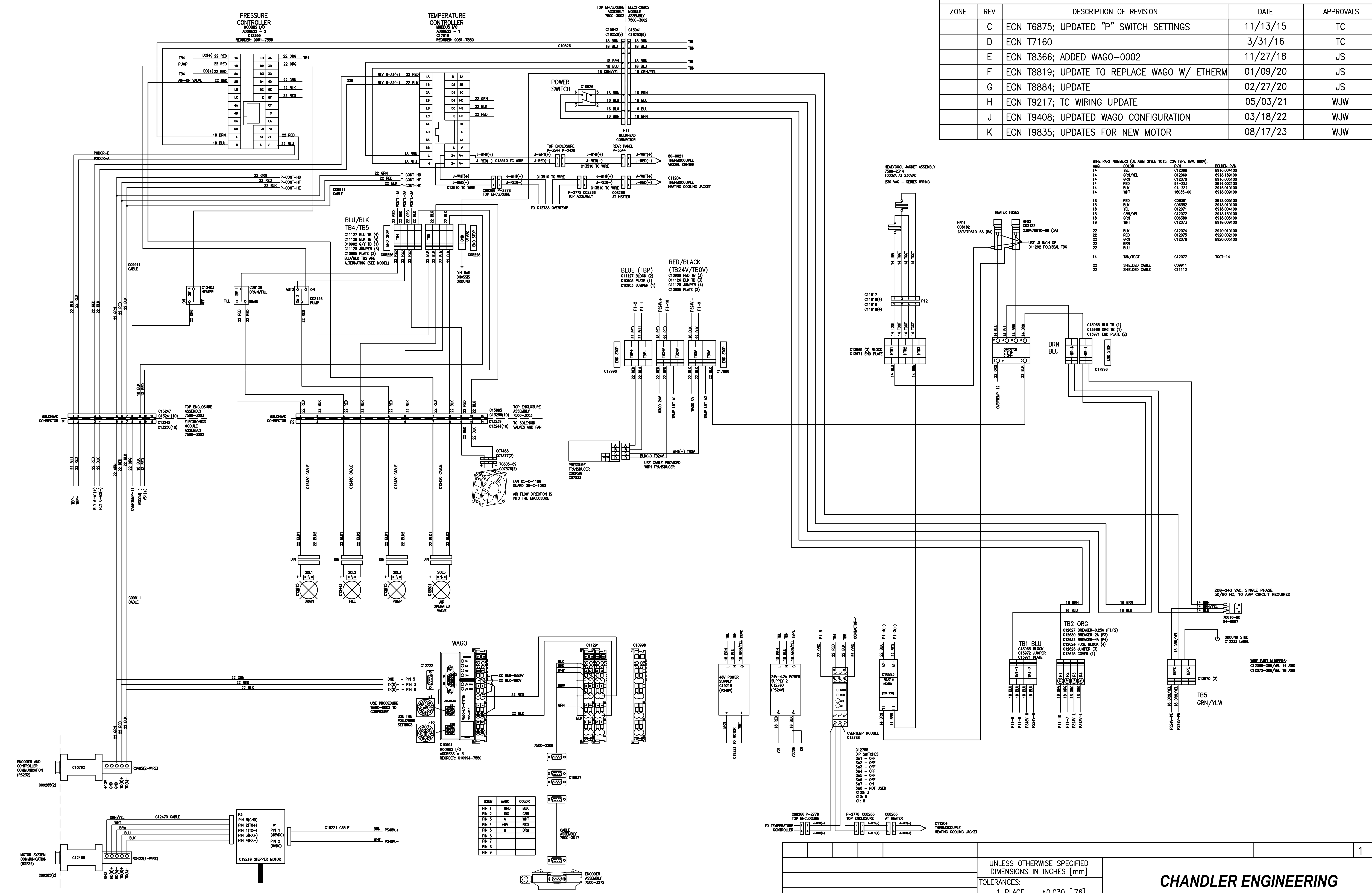
TITLE BLOCK REV 3

REVISIONS				
ZONE	REV	DESCRIPTION OF REVISION	DATE	APPROVALS
	C	ECN T6875; UPDATED "P" SWITCH SETTINGS	11/13/15	TC
	D	ECN T7160	3/31/16	TC
	E	ECN T8366; ADDED WAGO-0002	11/27/18	JS
	F	ECN T8819; UPDATE TO REPLACE WAGO W/ ETHERM	01/09/20	JS
	G	ECN T8884; UPDATE	02/27/20	JS
	H	ECN T9217; TC WIRING UPDATE	05/03/21	WJW
	J	ECN T9408; UPDATED WAGO CONFIGURATION	03/18/22	WJW
	K	ECN T9835; UPDATES FOR NEW MOTOR	08/17/23	WJW



NOTES:
1. ROUTE AC AND DC SIGNAL WIRING SEPARATELY.
2. USE CRIMP TERMINALS FOR ALL CONNECTIONS TO WAGO AND CONTROLLERS EXCEPT 14 GAUGE WHICH MUST BE TINNED.
3. USE MOLEX TERMINAL CRIMPING TOOL WITH ALL MOLEX PINS AND SOCKETS.
4. USE CSA/UL APPROVED WIRE PART NUMBERS STATED IN THE TABLE.

NEXT ASSY	USED ON
APPLICATION	

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

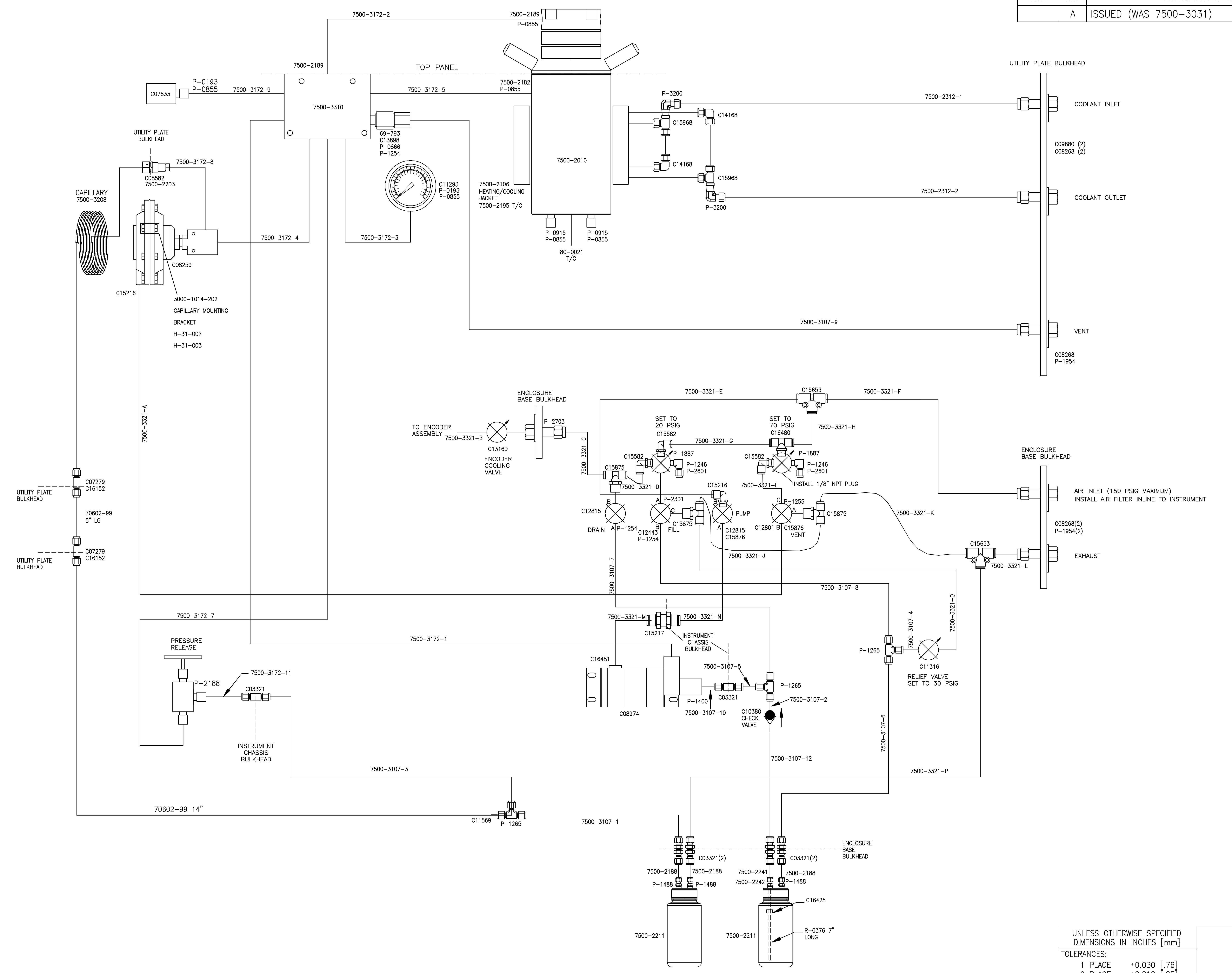
APPROVALS		DATE
DRAWN:	WJW	01/09/20
CHECKED:	WJW	01/09/20
ENGR.:	WJW	01/09/20

CHANDLER ENGINEERING

TITLE
WIRING DIAGRAM
MODEL 7550 HPHT VISCOMETER

SIZE	S.O. NO.	DWG NO.	REV.
C		7550-3030	K
SCALE: NTS	DO NOT SCALE DRAWING	SHEET: 1 of 1	

REVISIONS				
ZONE	REV	DESCRIPTION OF REVISION	DATE	APPROVALS
	A	ISSUED (WAS 7500-3031)	7/24/15	TC



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

CHANDLER ENGINEERING

TITLE
TUBING DIAGRAM
MODEL 7550 HPHT VISCOMETER

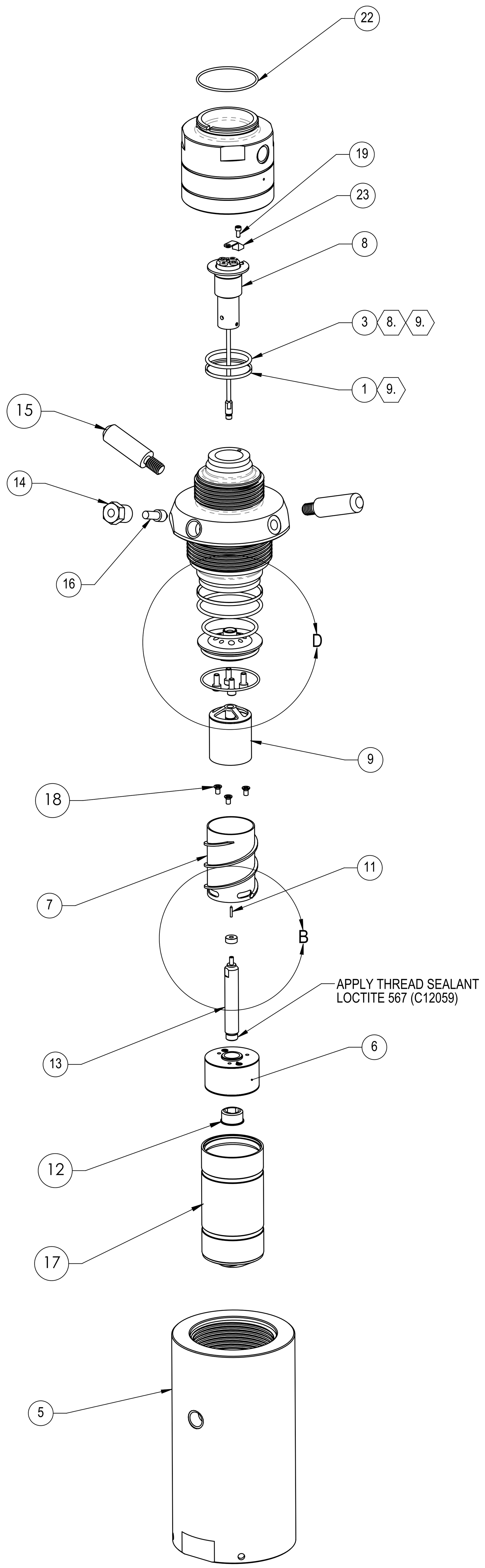
APPROVALS		DATE
DRAWN:	JJM	01/12/14
CHECKED:	JG	5/18/15
ENGR.:	JJM	01/12/14

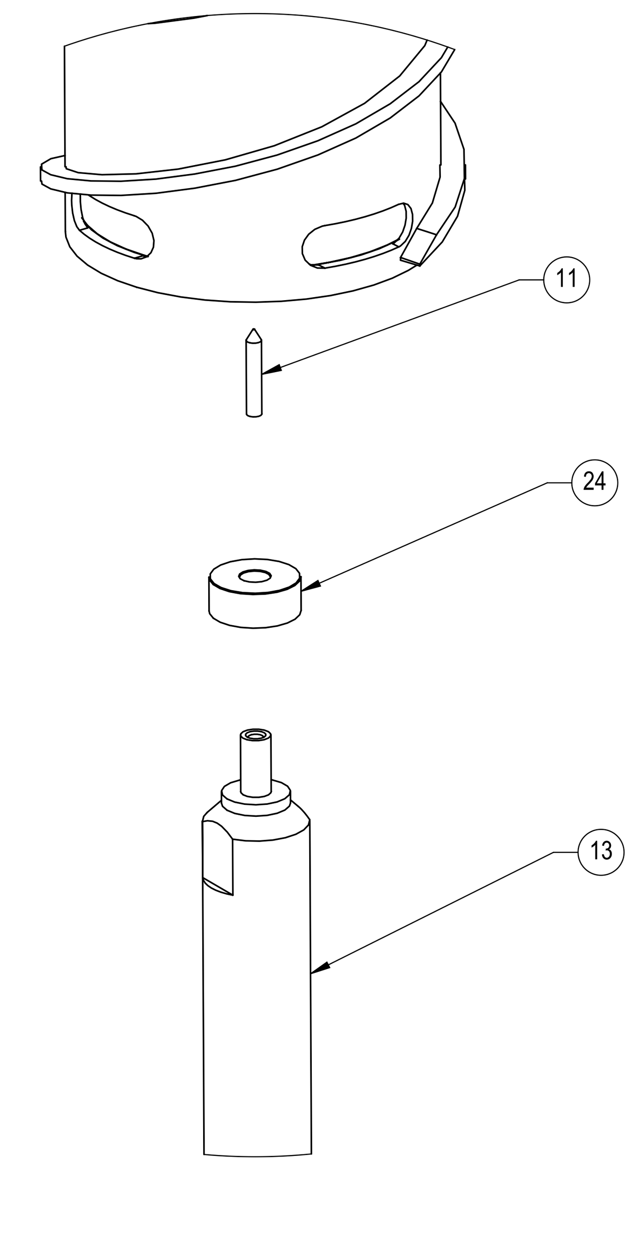
SIZE	S.O. NO.	DWG NO.	REV.
C		7550-3031	A
SCALE: NTS	DO NOT SCALE DRAWING	SHEET: 1 of 1	

NOTES:
1. MUST BE PRESSURE TESTED PER PROCEDURE 7500-2064.
2. APPLY LUBRIPLATE GREASE TO RETAIN BUSHING IN PLACE IN THE MAGNETIC ROTOR.
3. REFER TO BOB ASSEMBLY DRAWING 7500-2025.
4. PLUG AND CAP ARE MATCHED AND MUST NOT BE INTERCHANGED.
5. REFER TO SPRING MODULE ASSEMBLY DRAWING 7500-2022, 7500-2219, 7600-1013, 7600-1336 AND 7500-2027.
6. USE TOOL 7500-2205 TO INSTALL OR REMOVE THERMOWELL.
7. USE TOOL 7500-2204 TO INSTALL OR REMOVE BOB ASSEMBLY.
8. INSTALL THE C10788 AND C12385 STANDARD VITON ORINGS FOR THE HYDROSTATIC TEST AND DISPOSE OF AFTER TEST.
9. INSTALL THE FIRST SET OF FFKM ORINGS FOR THE MAX TEMPERATURE AND PRESSURE TEST. THE SECOND SET WILL BE INSTALLED FOR FINAL ASSEMBLY AFTER TESTS.

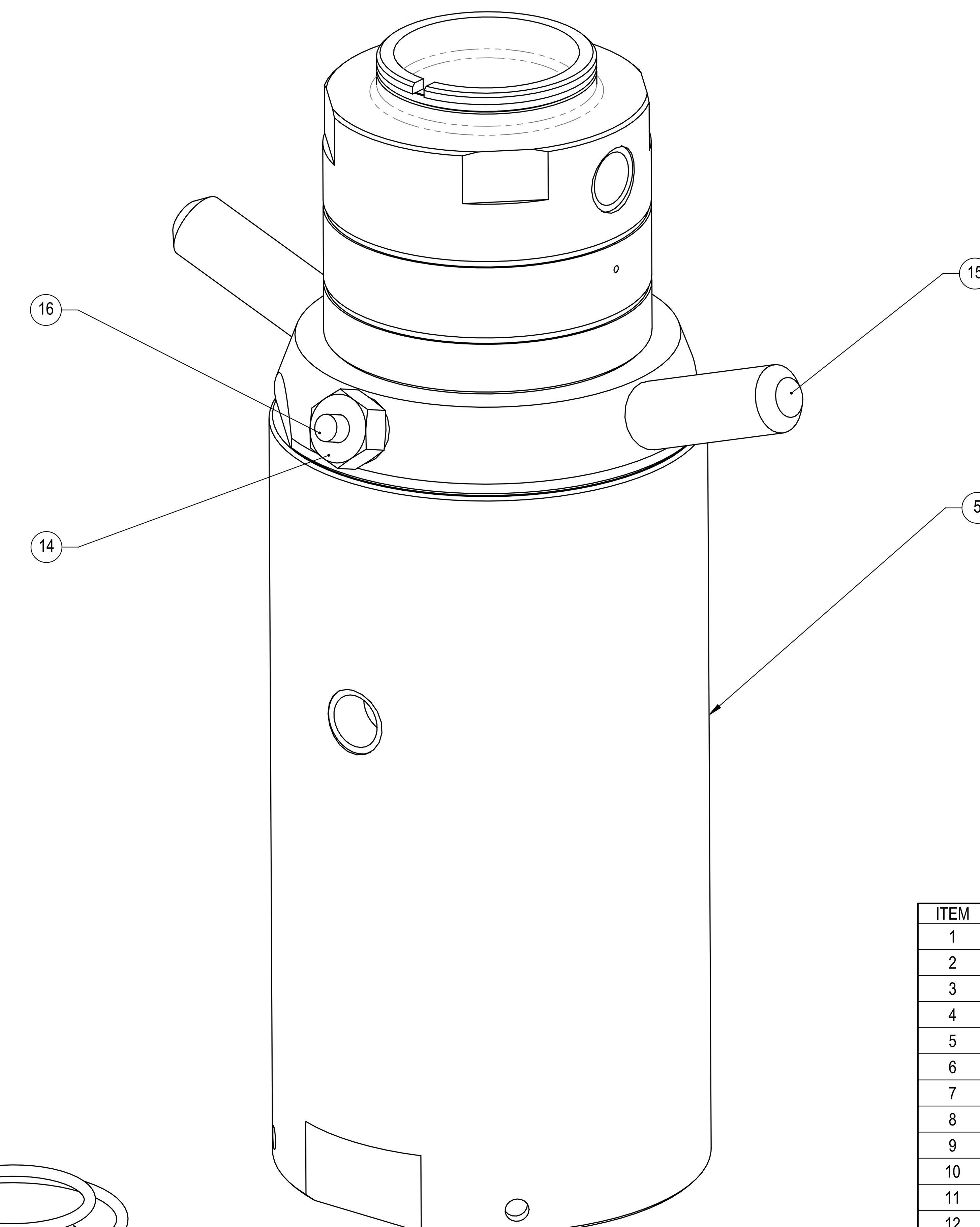
SAMPLE TEMPERATURE	TOP CAP SEAL	PLUG SEAL	TOP BAFFLE SEAL	SAMPLE CUP SEAL
LESS THAN 205°C/400°F	C10788	C12385	C15527	C15503
GREATER THAN 205°C/400°F	C12806	C12807	C15527	C15503

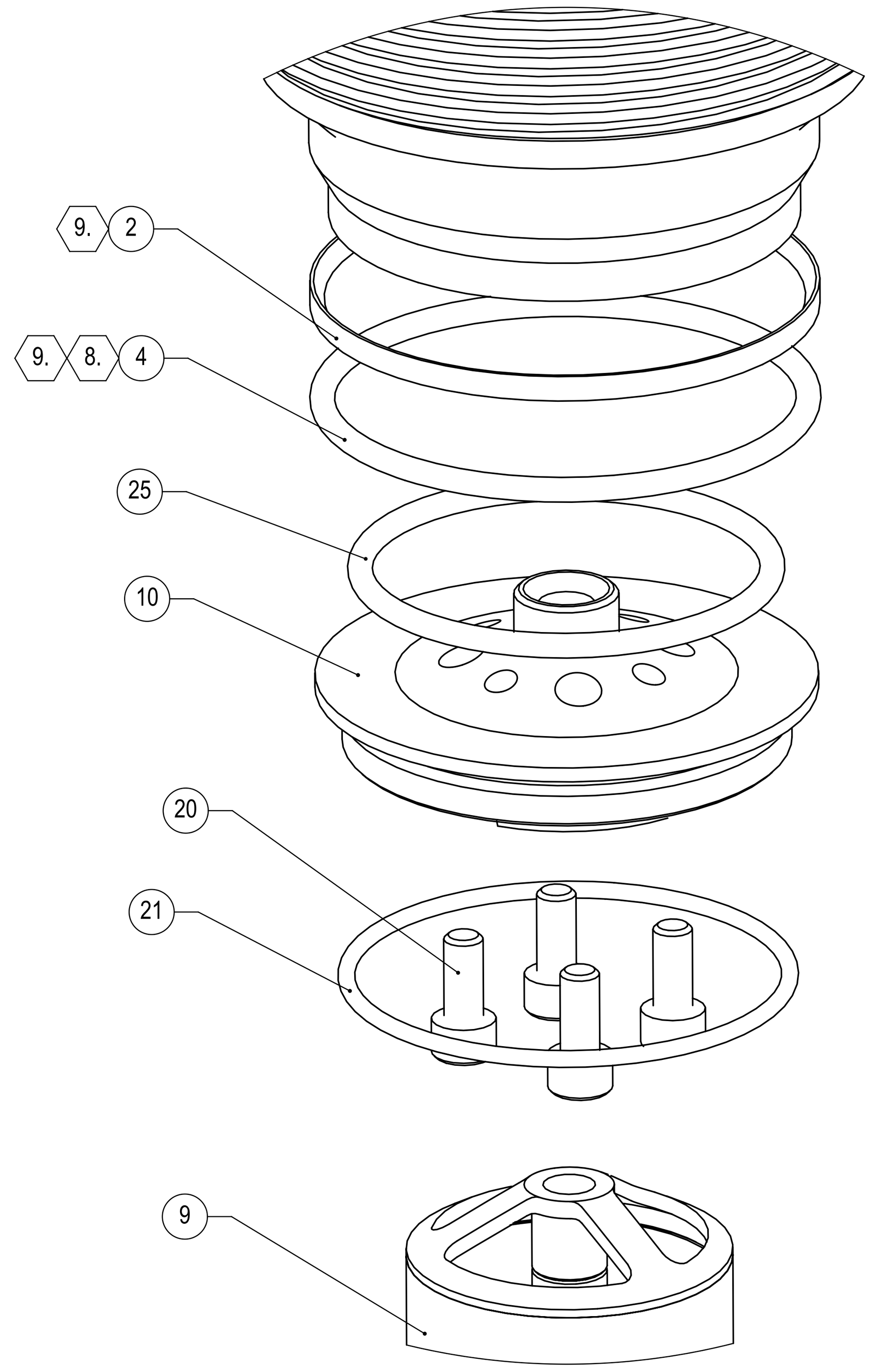
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	H	ECN T7128; ELIMINATED UNUSED PORTS AT THE BOTTOM OF THE 7500-2500 VESSEL ASSEMBLY. SHORTENED SPRING MODULE AND ADDED 7500-3317 BOTTOM SPRING MANDREL	3/11/2016	JJM
	J	ECN T7348; CORRECTED BUBBLE ASSIGNEMENTS ON SHEET 2	8/9/2016	JJM
	K	ECN T9244; ADDED MISSING BALLOONS,COMBINED INTO ONE SHEET	6/17/2021	DLR





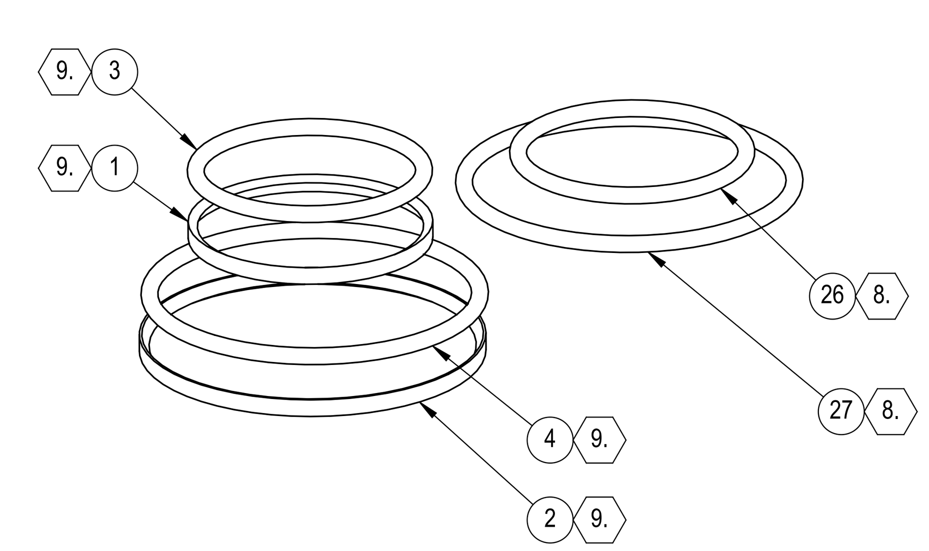
DETAIL B





DETAIL D

TEST COMPONENTS



ITEM	PART NUMBER	DESCRIPTION	QTY
1	7500-2132	SEAL,CAP,HIGH PRESSURE	2
2	7500-2133	SEAL,VESSEL,HIGH PRESSURE	2
3	C12806	ORING,FFKM COMPOUND,AS568-125	2
4	C12807	ORING,FFKM COMPOUND,AS568-135	2
5	7500-2500	PRESSURE VESSEL ASSEMBLY	1
6	7500-2020	ROTOR ASSEMBLY, INNER, MAGNETIC DRIVE	1
7	7500-2018	ROTOR ASSEMBLY,R1	1
8	7500-2027	MODULE ASSEMBLY, SPRING	1
9	7500-2025	BOB ASSEMBLY, B1	1
10	7500-2122	BAFFLE, BOB	1
11	7600-1223	PIVOT, SAPPHIRE BEARING	1
12	7500-2111	BUSHING, INNER MAGNET	1
13	7500-2152	SUPPORT, BOB	1
14	P-0193	GLAND,SST,TUBE,1/4TX9/16-18RH	1
15	7750-0115	HANDLE,PLUG,CYLINDER	2
16	P-0915	PLUG,SS,1/4T,HP	1
17	7500-2149	SLEEVE, SAMPLE CUP	1
18	H-6011	SCREW,FHMS,SS,6-32X0.250,PHIL	3
19	70612-09	SCREW,SHCS,SS,4-40X0.250,ALLEN	1
20	43098-00	SCREW,SHCS,SS,8-32X0.375	4
21	C15503	ORING,FFKM COMPOUND,AS568-031	1
22	C11190	ORING,VITON,AS032-75	1
23	7500-2263	BRKT,RETAINING,TOP PIVOT	1
24	C11219	BRG,BALL,RAD,0.125X0.375X0.156	1
25	C15527	ORING,FFKM COMPOUND,AS130-75	1
26	C10788	ORING,VITON,AS125-75	1
27	C12385	ORING,VITON,AS568-135,75D,COMPOUND V1475-75	1
28	7500-2064	PROC,PRESSURE TEST,VESSEL ASSY	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 8/26/2012
MFG: TWC 8/28/2012
ENGR: JJM 8/26/2012
TYPE:
STRUCT:

CHANDLER ENGINEERING

VESSEL ASSEMBLY, MODEL 7500/7550

PN: 7500-2010 | REV K | SIZE D
PROJ: | SHEET 1 OF 1

TITLE BLOCK REV 3

AMETEK CHANDLER ENGINEERING

Part Number	Title			Page
7550-ACCESS	ACCESSORIES, MODEL 7550 VISCOMETER			1 OF 1
Revision	Date	Description	Revised By:	Checked By:
C	12/07/20	ECN T9059; REPLACE P-3412 W/ C16956	JS	JS

ITEM #	PART NO	DESCRIPTION	QTY	UOM	PULLED	CK'D
1	35-0180	FLUID,NEWTONIAN,200 CP	2	PT	☐	☐
2	71-490	SCREWDRIVER,PRECISION ELECTRON	1	EA	☐	☐
3	7500-2065	PROCEDURE,FINAL TEST (SUMMARY)	1	EA	☐	☐
4	7600-1160	TOOL,BEARING,EXTRACTION	1	EA	☐	☐
5	7600-1164	PLUG,PORT,SYRINGE	1	EA	☐	☐
6	C10127	CABLE,DB9 M/F 25FT MOLDED	2	EA	☐	☐
7	C10480	SYRINGE,60CC/2OZ,LUER SLIP	2	EA	☐	☐
8	C10987	CLAMP, HOSE, 9/16"	8	EA	☐	☐
9	C15013	HEX KEY SET	1	EA	☐	☐
10	C13791	OIL,SYNTHETIC,HEAT TRANSFER,(5GAL)	1	EA	☐	☐
11	C09614	INTERFACE,USB/RS232,4 PORT	1	EA	☐	☐
12	C11321	GREASE, ANTI-SEIZE	1	EA	☐	☐
13	C11567	HOSE,0.250IDx2PLY,WLDG,RED,40'	1	EA	☐	☐
14	P-0193	GLAND,SST,TUBE,1/4TX9/16-18RH	2	EA	☐	☐
15	P-0915	PLUG,SS,1/4T,HP,HIP	2	EA	☐	☐
16	P-1280	FILTER,AIR,.25FPX.25FP	1	EA	☐	☐
17	P-3217	GREASE,LITHIUM,WHT,14oz	1	CN	☐	☐
18	C16956	ADPTR, 1/4" HOSE BARB MALE X MNPT	8	EA	☐	☐
19	7500-2204	TOOL, BOB INSTALLATION	1	EA	☐	☐
20	C12679	WRENCH, FLARE NUT, 5/8-INCH	1	EA	☐	☐
21	7500-2205	TOOL, THERMOWELL INSTALLATION	1	EA	☐	☐
22	C12806	ORING,FFKM COMP,AS568-125 (HT-PLUG TOP)	5	EA	☐	☐
23	C12807	ORING,FFKM COMP,AS568-135 (HT-PLUG BOTTOM)	5	EA	☐	☐
24	C10788	ORING,VITON,AS125-75 (PLUG TOP)	25	EA	☐	☐
25	C12385	ORING,VITON,AS135-75 (PLUG BOTTOM)	25	EA	☐	☐
26	7600-1223	PIVOT,JEWEL BEARING BOB	2	EA	☐	☐
27	188-13359	SCREW,SKHSS,SS,6-32X0.125,DOG	2	EA	☐	☐
28	7500-2296	INSERT, TUNGSTEN CARBIDE	1	EA	☐	☐
29	70612-09	SCREW,SHCS,SS,4-40X0.250,ALLEN	7	EA	☐	☐
30	43098-00	SCREW,SHCS,SS,8-32X0.375	8	EA	☐	☐
31	7500-2024	PLUG SUPPORT ASSEMBLY	1	EA	☐	☐
32	C15527	ORING,FFKM COMP,AS568-025 (HT-BAFFLE TOP)	5	EA	☐	☐
33	C15503	ORING,FFKM COMP,AS568-031 (HT-BAFFLE BOT)	5	EA	☐	☐
34	Q6-C-1098	WRENCH, OPEN,5/8,15/75 DEG	1	EA	☐	☐
35	C15009	PLIERS, 8", NEEDLE NOSE	1	EA	☐	☐
36	7600-1013	SPRING ASSEMBLY, F1	1	EA	☐	☐
37	C11181	WRENCH,STRAP,1/8-5"	1	EA	☐	☐
38	7500-2111	BUSHING, INNER MAGNET	5	EA	☐	☐
39	7500-2292	SEAL EXTRACTOR ASSY	1	EA	☐	☐
40	7500-3316	FIXTURE, CODEWHEEL, ENCODER	1	EA	☐	☐

INITIAL INITIAL

DATE DATE

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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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