INSTRUCTION MANUAL
Model 7600
HPHT Viscometer

Revision Y – February 2025
P/N: 7600-1050

S/N: ____________

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General Information

Introduction

Purpose and Use

The 7600 high pressure, high temperature (HPHT) couette viscometer is designed for determining the rheology of drilling fluids while subjected to varying well conditions in accordance with ISO 10414-1, 10414-2 and API 13 Recommended Practices.

Description

The shear stress (torque) created between a stationary bob rotating rotor is measured using a precision torsion spring and high-resolution encoder in accordance with ISO/API Specifications. Known sample shear rates are created between the bob and rotor using pre-defined bob/rotor geometry and a stepper motor subsystem providing rotational speeds ranging from 0 – 600 rpm (0 – 1022 sec^{-1}). 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 $dyne\text{-}sec/cm^2$, otherwise expressed as Poise.

These measurements are made at sample conditions reaching an upper limit of 40,000 psig / 276 MPa, 600°F/316°C.

The system is controlled using a computer-based program that provides multi-axis data display options and automatic instrument control and calibration features.

Features and Benefits

- Viscometer that meets ISO 10414-1, 10414-2 and API RP13 requirements
- Bench-top instrument
- PC based data acquisition and control system
- Automatic control of sample temperature and pressure using PID controllers
- High pressure (40,000 psi/276 MPa), high temperature (600°F/316°C) sample testing
- Mixing of sample during test using mixing screw on outside diameter of rotor
- Automatic control of instrument, including data collection, shear rate scheduling, rheological model fits (n' and K'), display and calibration
- Automatic 10 second and 10-minute gel strength measurements
- Remote magnetic drive system, eliminating interference with ferromagnetic suspended solids
- Sample wetted parts made from 300 series stainless steel and other corrosion resistant high strength steel (Inconel 718)
- Stepper motor and magnetic drive used to generate shear rates, providing high accuracy and stability
- High resolution measurement of torque (shear stress)
- Safety systems designed into the instrument and software (over-pressure, over-temperature)
- Microsoft Excel® compatible data output

Specifications

Instrument Utilities:

- Main Power: 220-240 VAC, 50/60Hz, 15A
- Instrumentation Power: 110-120 VAC / 208-240 VAC, 50/60 Hz , 2A
- Instrument Air: 120 psig ±10% (filtered and dry)
- Coolant: Water, chilled ethylene glycol/water mixture optional

Sample Environment:

- Maximum Pressure: 40,000 psi/276 MPa
- Maximum Temperature: 600˚F/316˚C
- Minimum Temperature: 40˚F/4˚C

Sample Rheology:

- Minimum Shear Stress: 5.1 dyne/cm^2
- Maximum Shear Stress 1022 dyne/cm^2
- Minimum Viscosity: 5 cP @ 600 rpm
- Maximum Viscosity: 300 cP @ 300 rpm
- Shear Stress Resolution: 0.1 degree, 5.1 dyne/cm^2, 1 cP @ 300 rpm
- Shear Stress Accuracy: ±0.50% of F.S. from 51.1 – 1533 dyne/cm^2
- Minimum Motor Speed: 1 rpm
- Minimum Shear Rate: 1.7 sec^{-1} (using R1/B1 Rotor/Bob)
- Shear Rate Range: 1.7 – 1022 sec^{-1}, corresponding to 1 – 600 rpm
- Sample Gel Strength: 10 sec, 10 min, 30 min gel values

Couette Geometry:

- Bob Radius (R_i): 1.7245 cm (B1) – B5 bob optional
- 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.

Pressure Vessel:

- Removable sample vessel assembly with support bracket
- Sample/Oil separation baffle zone
- High pressure magnetic drive for rotor
- High strength, corrosion resistant steel
- High pressure Autoclave-style pressure ports (F250C), knurled nuts and wrench flats
- Elastomer and metal backup ring seals (Viton)
- Material heat traceability, hydrostatically tested to 1.5x rated pressure (60,000 psig)

Test Fluids:

- Drilling fluids containing hematite, barite, calcium carbonate

Torque Measurement System:

- F1 Spring standard – F2, F4 springs optional
- External torque sensor, magnetic drive coupling to bob shaft

Motor System:

- Stepper Motor subsystem
- Motor Speed Accuracy: ±0.003 rpm at 200 rpm (measured at magnetic drive)

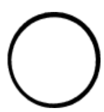
Temperature Control:

- Programmable PID Controller
- Resistance heaters with contactor and over-temperature protection
- Temperature steady-state control accuracy: ±1˚F
- J-type thermocouple located on centerline of bob and heater wall

Pressure Control (Pump and Valve):
- Programmable PID Controller
- Air/Liquid Pump (1:400)
- Diaphragm operated high pressure valve and flow restriction
- Pressure control accuracy: ±500 psig at F.S.
- Pressure transducer
- High pressure rupture disk (45,000 psi)
- Pressurizing fluid: Duratherm HF– Refer to associated MSDS

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 API 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, n’, K’, 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

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 7600 HPHT Rheometer:

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

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

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

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

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

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

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

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

Where,

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

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

Rheological Models

The Rheo 7000 software 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 7000 software automatically collects data at a rate of one 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: 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:

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

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 7000 software automatically collects data at a rate of one 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:

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

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

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 $\tau = K * \gamma^n$ 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 7600 High Pressure, High Temperature 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:

- Locate the instrument in a low traffic area.
- Post signs where the instrument is being operated to warn non-operating personnel.
- 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 repair.
- Turn OFF the heater at completion of each test.
- Locate appropriately rated fire extinguishers within proximity to the instrument.

- Note the fact that the temperature rating of the instrument exceeds the flash point of the pressurizing fluid. Remove oil on heated surfaces that may pose a hazard prior to starting a test that will exceed 400°F/204°C.
- Note that the vessel suspension system must be properly maintained to ensure operator safety. The components of the pressure vessel are heavy, appropriate safety precautions need to exist to ensure operator safety.
- Although the pressure vessel was designed using state-of-the-art materials and techniques, due to the extreme pressure rating, it is imperative to monitor the condition of the assembly with a focus on safety.
- Note that Chandler Engineering recommends periodic re-inspection and testing of the pressure vessel to maintain the rated temperature and pressure ratings. Without re-inspection and testing, the pressure rating of the vessel assembly should 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.

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

Where to Find Help

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

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

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: 220-240 VAC, 50/60 Hz, 15A – Used for high current components
- Instrument Power to Instrument: 110-120 VAC / 208-240 VAC, 50/60 Hz, 5A – Used for data acquisition components. An uninterruptible power supply is recommended for this power source to prevent data loss during a power failure.
- Coolant: Clean water or ethylene glycol + water solution.
  - Note: Automotive anti-freeze should not be used in the optional chiller.
- Air: Filtered, dry compressed air; 75-125 psig/5.2-8.6 bar. Note: To achieve 40,000 psig, a supply of 120 psig is required.
- Drain: Suitable for steam.

Tools/Equipment Required to Operate Instrument

- 5/8-inch Wrench
- Set of hex wrenches (supplied with instrument)
- Strap wrench (supplied with instrument)
- Bench that is rated for a load of 500 lbm
- Solvent based parts cleaning equipment that is suitable for use with oil or water based drilling fluids
- Bench Vise

Installing the Instrument

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

2. Connect power to the instrument using the power cords supplied with the instrument.

3. The top receptacle may be connected to 110-120 VAC or 208-240 VAC, 50/60 Hz power and the current draw is compatible with most uninterruptible power supplies (UPS). This option preserves the encoder zero value if a brief power failure occurs. An 850 VA uninterruptible power supply (UPS) is recommended for the computer to protect the data from brief power failures.

4. The bottom receptacle must be connected to 220-240 VAC, 50/60 Hz power for the heater and motor power source. A 20A fuse or circuit breaker is recommended.

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

6. Connect the Air, 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, the potentially hot fluid will discharge from this port.

8. Fill the front Nalgene bottle located to the left of the instrument with Duratherm HF heat transfer fluid (C13791).

9. Install the USB-to-serial 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 "STEPPER MOTOR" and "CONTROLLER AND ENCODER" Communication ports on the side of the instrument.

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Section 2 – Operating Instructions

Viscometer Controls

Pressure Gauges

The instrument is equipped with an 80,000 psi/552 MPa pressure gauge in addition to the internal pressure transducer.

Additionally, gauges are provided to indicate the inlet air pressure and pressure supplied to the pump. Recent instruments do not include the Pump Pressure gauge, full air pressure is always delivered to the pump inlet when in use.

Pump Control and Pressure Release Valve

The pressure release valve must be closed for pressure to build inside the vessel. When opened, the fluid drains to the discharge container on the left side of the instrument.

Temperature and Pressure Controllers

The instrument is equipped with two PID controllers that are interfaced to the computer-based software. The controllers are operated using the Rheo7000 software.

Viscometer Components Assembly and Disassembly

Raising the Vessel from the Heating/Cooling Jacket

1. Remove the encoder assembly from the top of the vessel assembly.
2. Disconnect and remove the top and bottom high-pressure tubes between the vessel and bulkhead connections.
3. Remove the timing belt between the motor and magnetic drive.
4. Raise the vessel assembly by placing the motor switch in the UP position.
5. To lower the vessel, place the motor switch in the DOWN position. The switch center position provides a motor brake.

The vessel transport is equipped with upper and lower limit switches that automatically stop the motor. Be certain to keep hands away from the transport while in motion. Note that the Air Supply switch must be OFF, otherwise the elevator motor is disabled.

Be certain to remove the vessel support plate prior to lowering the vessel transport without the vessel installed.

Figure 1 - Vessel without Belt Guard Installed

Figure 2 - Vessel Raised from Jacket

Removing and Installing the Vessel from the Plug

1. Once the vessel has cleared the heating/cooling jacket, install the vessel support plate.
2. Position the bottom of the vessel within 2 inches of the plate.
3. Unscrew the vessel until the threads are disengaged. This may require raising the transport as the vessel is un-threaded.
4. Once the vessel is free from the plug, raise the transport until the rotor assembly is above the vessel.
5. Carefully remove the vessel without hitting the rotor assembly. Note that the vessel and contents weigh approximately 36 lbm/16.3 kg.

Always unscrew the vessel from the plug approximately 5 degrees after being fully tightened. This reduces the effort required to remove the vessel after a high temperature, high pressure test.

Figure 3 - Vessel Support Plate

Removing and Installing the Top Cap

1. Unscrew the cap from the top of the vessel assembly. Note that the top cap weighs approximately 15 lbm/6.8 kg.
2. Remove the o-ring and metal backup ring from inside the top cap. Discard the o-ring if damaged.
3. To install, place the metal o-ring on the top plug followed by a new oring.
4. Completely screw the top plug onto the vessel assembly. Unscrew the cap until the top port faces the right. The top cap does not need to be fully tightened to seal.

Removing and Installing the Rotor Bearing

1. The rotor bearing may be removed using tool 7600-1160.
2. Gently push the bearing from the top of the rotor until the bearing can be removed.
3. Install the bearing in the bottom of the rotor. It is helpful to place a small amount of lithium grease on the end of the tool to retain the bearing as it is being installed in the vessel.

Removing and Installing the Bob Assembly

1. While supporting the Bob Assembly, loosen the set screw inside the Spring Module Assembly.
2. Slide the Bob and Shaft out of the bottom of the top plug. The vessel support plate must be removed to allow removal of the bob and shaft. Replace the vessel support plate after the bob has been removed.

The bob is unscrewed from the shaft in the CCW direction. Take care not to bend the shaft.

Removing and Installing the Bob Pivot Bearing and Pivot

1. Unscrew the bob shaft from the bob being careful not to bend the shaft.
2. Remove the bearing support assembly from the bottom of the bob.
3. The tungsten carbide bearing is loose inside the housing. Install with the concave surface towards the bottom of the bob.
4. The tungsten carbide pivot is located at the top of the vessel thermowell. Use a pair of needle nose pliers to pull the pivot out of the thermowell. Do not damage the tip of the pivot.

Removing and Installing the Spring Module Assembly

1. Remove the module assembly cap.
2. Loosen the set screw that attaches the magnet to the bob shaft.
3. Replace the module assembly cap.
4. Remove the three hex socket head screws that mount the spring module assembly to the top plug assembly.
5. Lift the spring module assembly from the top of the vessel assembly.

Disassembling and Assembling the Spring Module

1. Remove the spring module from the top of the vessel assembly.
2. Loosen the set screw that locks the bottom of the spring assembly in place.
3. Gently push the spring and magnet assembly out of the module.
4. Loosen the set screws that retain the spring guard to the magnet shaft. Remove the spring guard.
5. Loosen the set screw that locks the top of the spring assembly to the magnet shaft.
6. During reassembly, note the starting location of the spring stop. It must be within a few degrees of the hard stop to provide a full 300° angular deflection range.

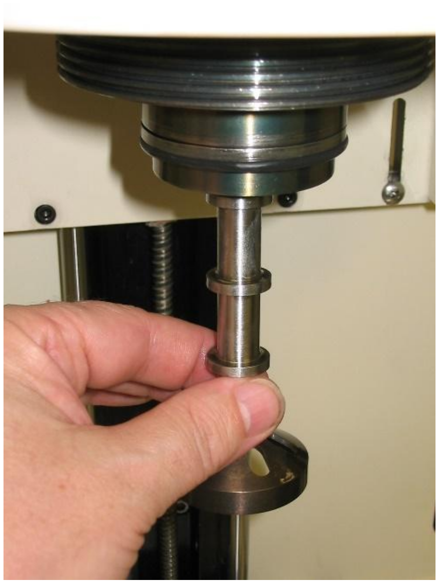
The magnet in the spring module is powerful. It is easily damaged if dropped. Keep the magnet away from any electronic media that would be damaged by a strong magnetic field.

Removing and Installing the Isolation Shaft Assembly

1. Unscrew the baffle assembly above the bob. Note that the threads are left-hand.
2. Reach into the top plug assembly to grasp the isolation shaft.
3. Slide the isolation shaft out of the top plug assembly.

Removing and Installing the Inner and Outer Magnetic Drive

1. Loosen the rotor drive shaft from the inner magnet drive rotor. With the rotor drive shaft in place, remove the outer magnetic drive rotor.
2. Unscrew the rotor drive shaft from the inner magnetic drive.
3. If the shaft connection is tight, use the support tool to hold the inner magnetic drive as the rotor is unscrewed.
4. Remove the plug to a work bench.
5. Tip the plug to allow the inner magnetic drive rotor and support sleeve to slide out of the plug.



Removing and Installing the Top Plug in the Transport Bracket

The top plug may be lifted from the top bracket noting that it weighs approximately 23 lbm/10.4 kg.

Zeroing the Encoder

The encoder senses the angular defection of the spring inside the pressure vessel. This is achieved using coupled bar magnets. The magnetic drive uses magnet coupling to drive the rotor.

Preparing the Viscometer for Use

Assembling the Pressure Vessel

1. On a work bench, tilt the top plug at a 45° angle.
2. Drop in the support sleeve with the bevel side down.
3. Slide the inner drive magnet into the cell with the threads down.
4. Push the isolation tube support (with the o-rings on top) until it bottoms out.
5. Place the top cell on the lift with the pin in the anti-rotation block.
6. Screw the rotor shaft onto the inner drive magnet to retain the magnet while the outer magnet rotor is installed.
7. Place outer drive magnet over the top cell making sure that the step is up. Caution: Magnet is very strong so make sure your fingers are not below the magnet.
8. Push the isolation tube support again until it bottoms out.
9. Insert the 1/16-inch spring module alignment pin on the top of the plug.
10. Tighten the rotor shaft into plug from below. Screw onto inner magnet – right-hand threads – hand tight.
11. Insert baffle into rotor shaft and plug. Screw baffle into the isolation tube support– left-handed threads – hand tight.
12. Remove the bottom plate.
13. **Apply nickel anti-seize compound to the threads on rotor cup.**
14. Insert bob shaft assembly into baffle. Hold bob.
15. Gently lower bob into rotor cup assembly.
16. Screw the rotor cup assembly into the rotor drive shaft – hand tight.
17. Replace the bottom plate.
18. Place the beveled backup ring on the bottom of the top plug - bevel ring first then Viton elastomer oring.
19. Inspect the cell and make certain the rotor cup bearing and pivot are in place on the thermowell. The rotor bearing may be placed in the bottom of the rotor.
20. Transfer the cell to the plate.
21. Lower the lift until it contacts the threads on the top plug. Place a small amount of lubricant on the threads.
22. Slowly screw cell into place – once it seats; back off 2-3 degrees to prevent binding after a high temperature test.
23. Remove the bottom plate.
24. Lower the lift until the cell is fully into the heating/cooling jacket.
25. Align flat on the bob shaft to approximately 8:00.
26. Install the spring assembly (keep plastic cap on), aligning with alignment pin.
27. Tighten the 3 hex socket head screws on the spring module assembly.
28. Remove the plastic cap.
29. Gently lift the magnet and tighten set screw. The set screw must tighten on the flat on the bob shaft.
30. Verify free rotation of the magnet and bob shaft. If binding is detected, locate and correct the interference.
31. Screw the plastic cap on.
32. Place the beveled backup ring on the top of the top plug - bevel ring first then Viton elastomer oring.
33. Carefully place the top cap over the spring module – Screw cap until it lightly touches.

34. Verify that the collar on the end of the lines is approximately 1/8 inch from the end of the cone. Attach the lower pressure line and tighten both line nuts. Tighten with a 5/8-inch wrench.
35. Install the drive belt. The drive belt is routed to the front of the belt tensioner assembly.
36. Verify that the collar on the end of the lines is approximately 1/8-inch from the end of the cone. Attach the upper pressure line and tighten both line nuts. Tighten with a 5/8-inch wrench.
37. Install the belt guard.
38. Install the encoder assembly. Verify that the encoder aligns with the notch on the top of the cell assembly. Verify that the encoder connections are tight.
39. Using RHEO 7000 in Calibrate mode, zero the encoder.
40. Carefully remove the encoder assembly without disconnecting the cable or turning OFF the instrument to preserve the zero value.
41. Remove the belt guard.
42. Disconnect the top high-pressure tube.
43. Raise the vessel out of the heating/cooling jacket.
44. Install the vessel support plate.
45. Unscrew the cell bottom.
46. Fully lift the plug and magnetic drive assembly out of the cell.
47. Remove the cell.
48. Fill the cell with 175 mL of sample.
49. Replace the cell on the vessel support plate.
50. Slowly screw cell into place – once it seats; back off approximately 5 degrees to prevent binding after a high temperature test.
51. Remove the vessel support plate.
52. Lower the vessel assembly into the heating/cooling jacket.
53. Install the syringe adapter plug in the front port.
54. In manual mode, start the motor at 50 rpm.
55. Inject 25 mL of sample using a syringe.

The 25 mL fill volume is a nominal value. The volume may be changed to accommodate the PVT characteristics of the sample and the testing conditions, a typical range is 20 – 35 mL.

56. Stop the motor.
57. Remove syringe adapter and install high pressure plug. Tighten with a 5/8-inch wrench.
58. Verify that the collar on the end of the lines is approximately 1/8-inch from the end of the cone. Attach the upper and lower pressure lines and tighten both line nuts. Tighten with a 5/8-inch wrench.
59. Remove any oil from the surfaces of the instrument that will become hot.
60. Install belt guard.
61. Install the encoder assembly. Verify that the encoder aligns with the notch on the top of the cell assembly.

Applying Pressure to the Sample

1. Fill front Nalgene bottle with pressurizing oil. The rear Nalgene bottle captures waste oil to be discarded.
2. Ensure vessel pressure lines are made up and tight.

3. Ensure syringe port is plugged.
4. Open T-valve (pressure release valve) to allow oil to flow through the system and prime the pump.
5. Turn ON air supply switch.
6. Turn ON pump switch.
7. Wait until the oil flows into the discharge bottle.
8. Turn OFF the pump switch.
9. Close the T-valve.
10. Configure the controllers to AUTO mode.
11. Run the RHEO 7000 program, set the Rotor Control and Temperature and Pressure modes to AUTO mode.
12. Verify that the pump switch is OFF.
13. Turn the Heater Switch to ON.
14. Using RHEO 7000, start the schedule.
15. Enter sample density.
16. Start the data logging.
17. Choose a file name and create the new file.
18. Enter the test ID number for the file header. Edit any comments
19. Click “Apply” to start test.

Cooling the Vessel

1. The instrument is equipped with a combination heating and cooling jacket. External heating elements are used for applying heat to the vessel. Cooling water is circulated to cool the vessel.
2. An external full-opening ball valve should be used to control the vessel coolant.
3. Note that water should not be turned ON when the vessel and cooling jacket are at temperatures above 400°F/204°C. Do so will generate steam that is potentially dangerous to the operator. Allow the vessel to air cool until the temperature is less than 400°F/204°C then turn ON the coolant.

The pump may be operated manually or automatically via the Rheo7000 software. For automatic operation, the Air Supply switch must be ON, the vessel transport switch in the Center or OFF position, the Pressure Release valve closed and the Pressure Release Switch in the Center or OFF position. The pressure controller will operate the pump and release valve in accordance with the program schedule.

Removing Pressure from Sample – Using computer

1. Use RHEO 7000 schedule “pressure down sequence” to a programmed value.
2. Wait until the sample temperature is less than 150°F.
3. Turn the air supply switch OFF.
4. Open the T-valve to release remaining pressure to the Nalgene waste bottle.
5. Follow cell disassembly procedure.

Removing Pressure from the Sample - Manually

1. Using RHEO 7000, change the temperature and pressure control to MANUAL mode.
2. Turn the heater switch on instrument to OFF.
3. Slowly bleed the pressure by toggling the Pressure Release switch ON and OFF.
4. Gradually reduce pressure.
5. Wait until the sample temperature is less than 150°F.
6. Follow cell disassembly procedure.

Disassembling the Pressure Vessel

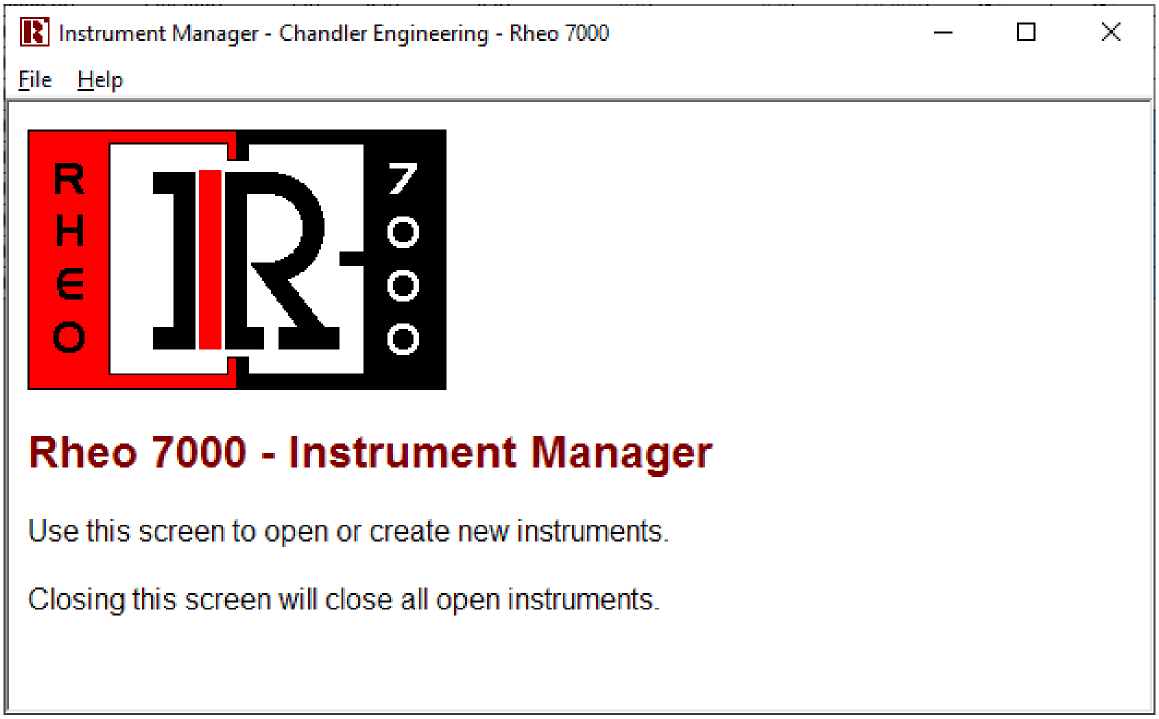
1. Open Pressure Release valve to relieve any pressure remaining in the cell.
2. Turn OFF the Air Supply switch. All remaining air pressure on the cell and oil reservoir is relieved.
3. Verify cell centerline and jacket temperature are less than 150°F.
4. Remove encoder assembly and set on top of machine.
5. Lift off belt guard.
6. Loosen the rear high-pressure port. Disconnect the upper pressure line from the top of the cell; install a blind high pressure plug to reduce the amount of oil that may spill. Pivot the line out of the way.
7. Loosen the rear high-pressure port. Disconnect the pressure line at the base of the cell and pivot out of the way.
8. Remove belt.

9. Remove top cell cap. Wrapping absorbent material around the top cap will capture oil as the cap is removed.
10. Remove three socket head cap screw holding the spring cartridge.
11. Remove the spring cartridge and locating pin.
12. Raise the table and cover the heating jacket with the cell plate.
13. Unscrew the bottom cell (raise table up to near the bottom of the cell so the cell does not fall hard on the plate).
14. Raise the lift table to top (as high as it can go; it will automatically stop).
15. Transport the vessel to the solvent tank or work bench.
16. Remove o-rings and metal back-up rings from the plug and vessel.
17. Remove the plastic spring cover and loosen the spring set screw.
18. Replace the plastic spring cover.
19. Remove the cell plate.
20. Unscrew the rotor sleeve from the rotor drive shaft (note: remove very carefully since the bob and shaft are also supported).
21. Remove rotor sleeve and bob assemblies.
22. Remove baffle (left hand thread).
23. Remove rotor drive shaft.
24. Remove outer drive magnet assembly.
25. Remove the cell top from the lift table and set on work bench.
26. In the cell top, remove the isolation tube support with removal tool, pliers may also be used.
27. Gently tip the cell over and ease out the inner magnet and support sleeve (spacer).

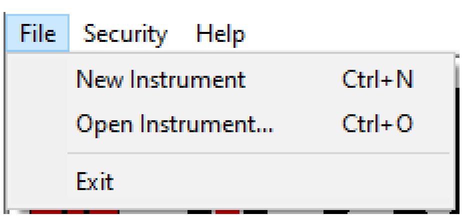
Software Operation

Instrument Manager Window

The Rheo 7000 software is cable of running multiple independent instruments. These instruments are opened from the Instrument Manager window.

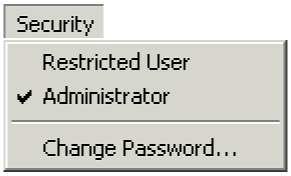


File Menu



- **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.

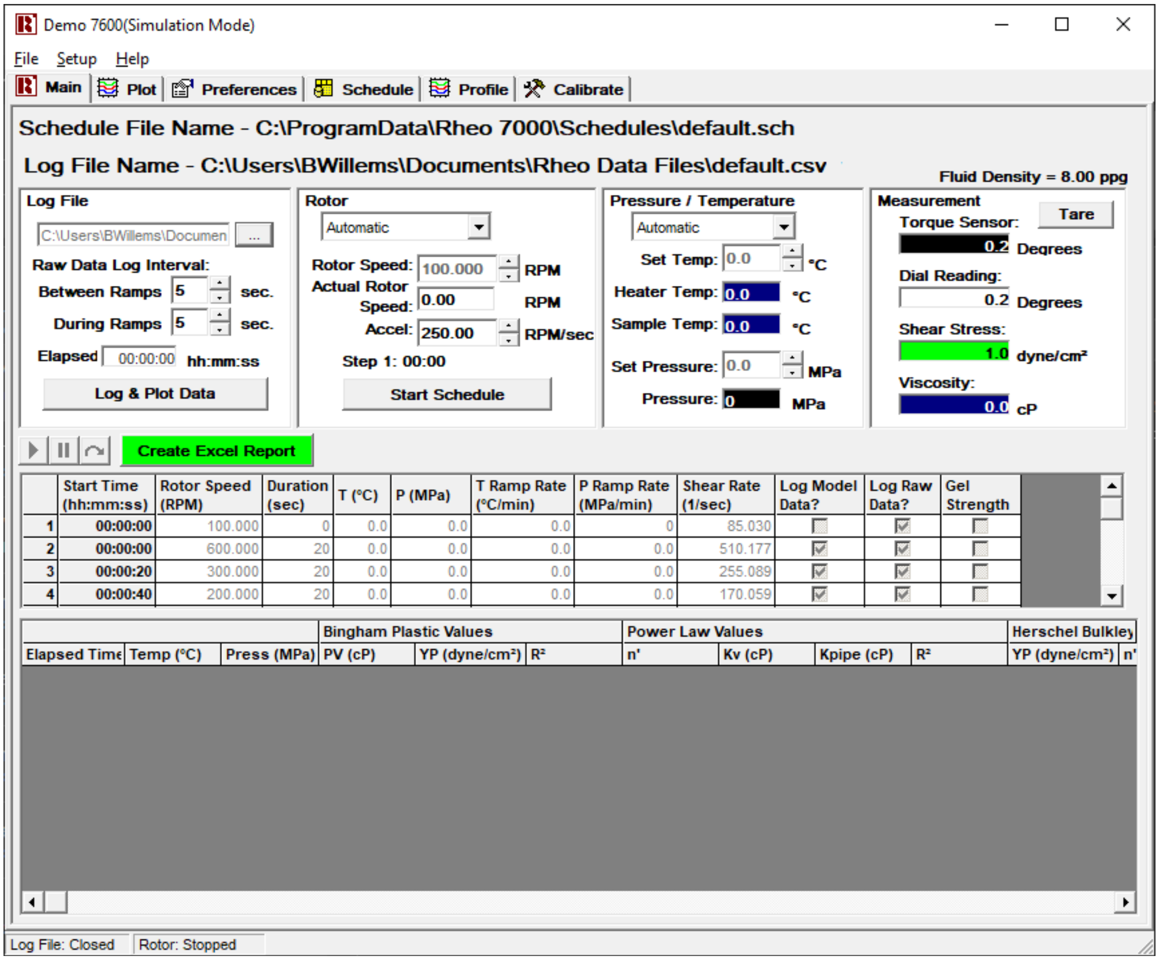
To specify an Administrator password, select Change Password. To disable the administrator password protection, simply enter the Administrator password in the Old Password entry box and leave the New Password and Confirm entries blank.

Help Menu

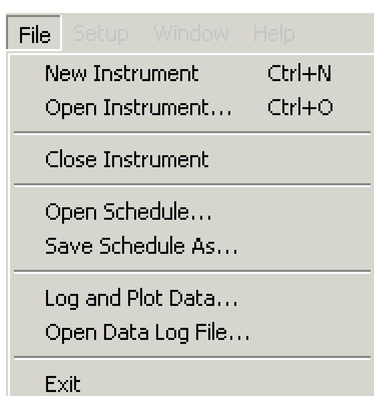
The Help menu provides access to the online help system (Contents and Index). About displays the About dialog showing software version number, contact information, etc.

Instrument Window

The Instrument Window provides all displays and indicators to operate a single 7600 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.

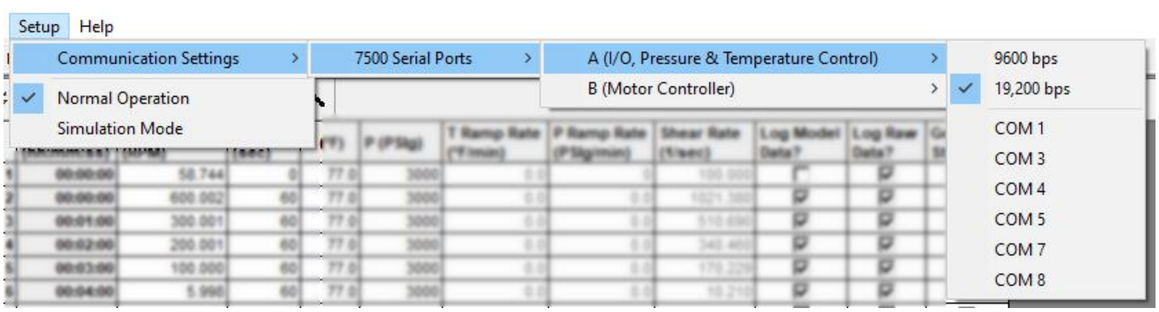
- **Save Schedule As** - Used to save an open schedule file to a new file name.

- **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



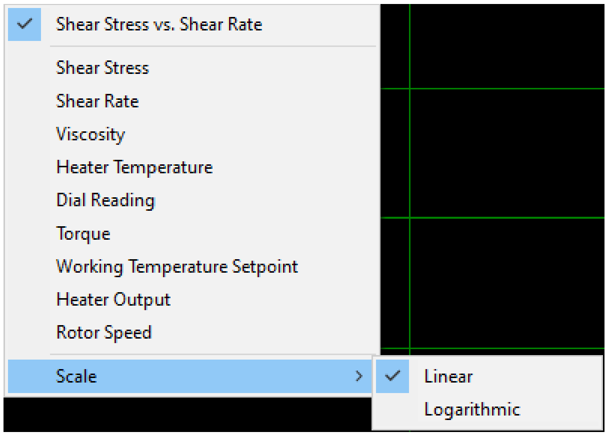
The Setup menu provides access to the following commands:

- **Communication Settings** - The communication settings sub-menu allows assignment of a specific PC serial ports for Data (A) and Motor (B) to the 7600 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. <u>If an instrument is connected, it will be ignored in simulation mode, and no rheological tests can be performed without first selecting **Normal Operation**.</u>

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.

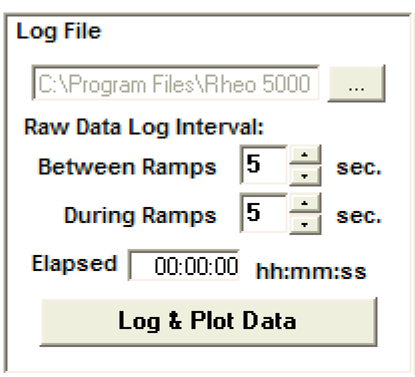
Help Menu

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.

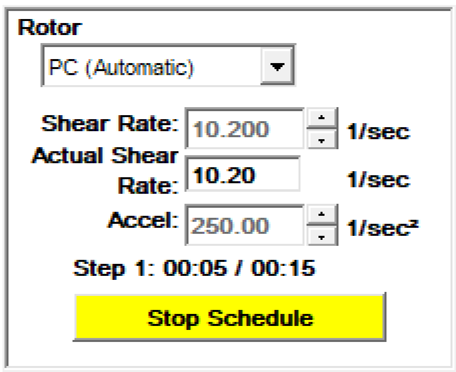
- Between Ramps - Defines the log interval for manual operation, or for schedule steps where the raw data checkbox is selected but the model data checkbox is not selected.

- 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.

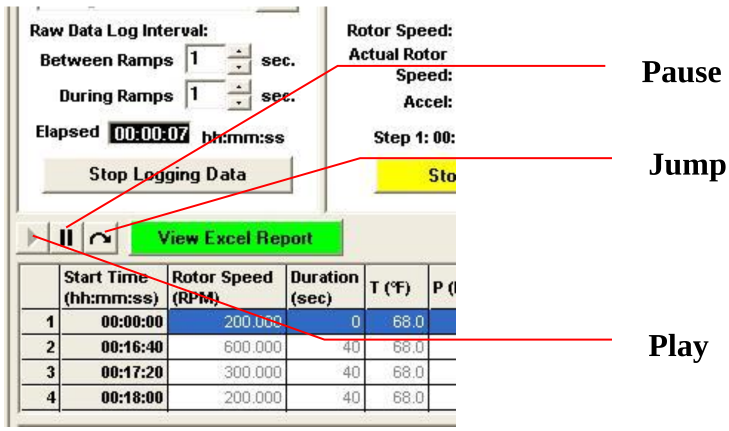
- **Actual Shear Rate or Rotor Speed -** displays the current rotor speed. Units are defined on the Preferences Tab

- **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.

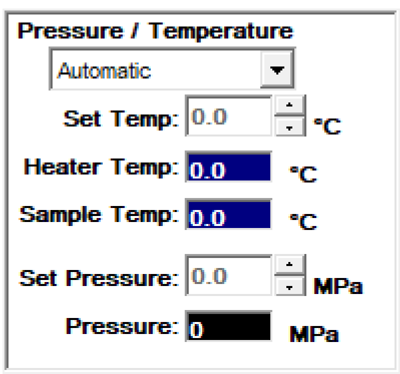
- **Start / Stop Schedule -** allows the user to start and stop the currently loaded schedule.

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.

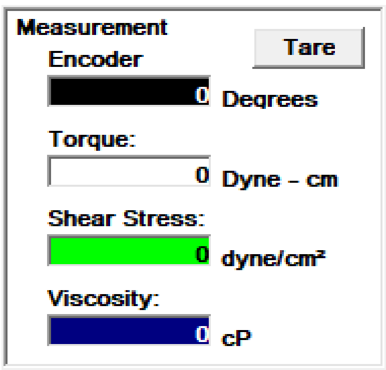
- **Heater Temp -** Displays the current Temperature as read from the controller. Units are defined on the Preferences Tab.

- **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 7000 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.

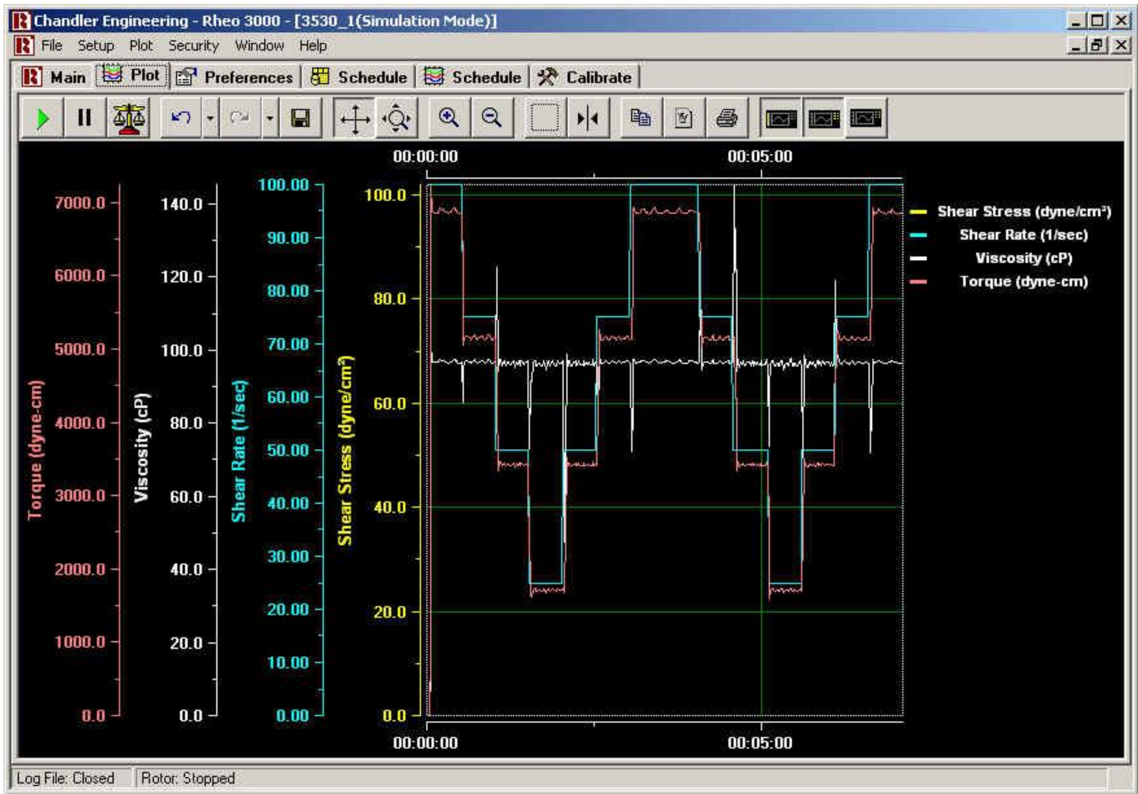
2. The schedule is executed by pressing the “Start Schedule” button on the Main Tab.

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.

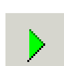
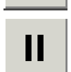
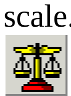
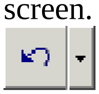
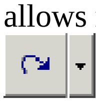
Data Plotting



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.

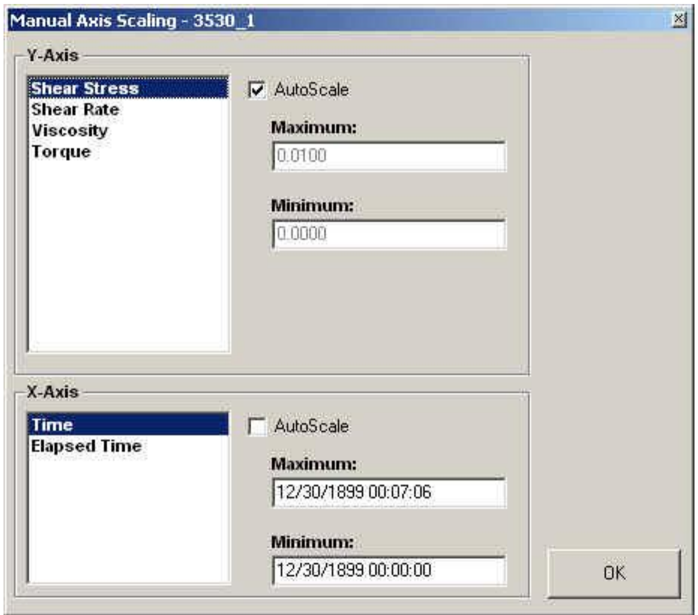
Plot Toolbar

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

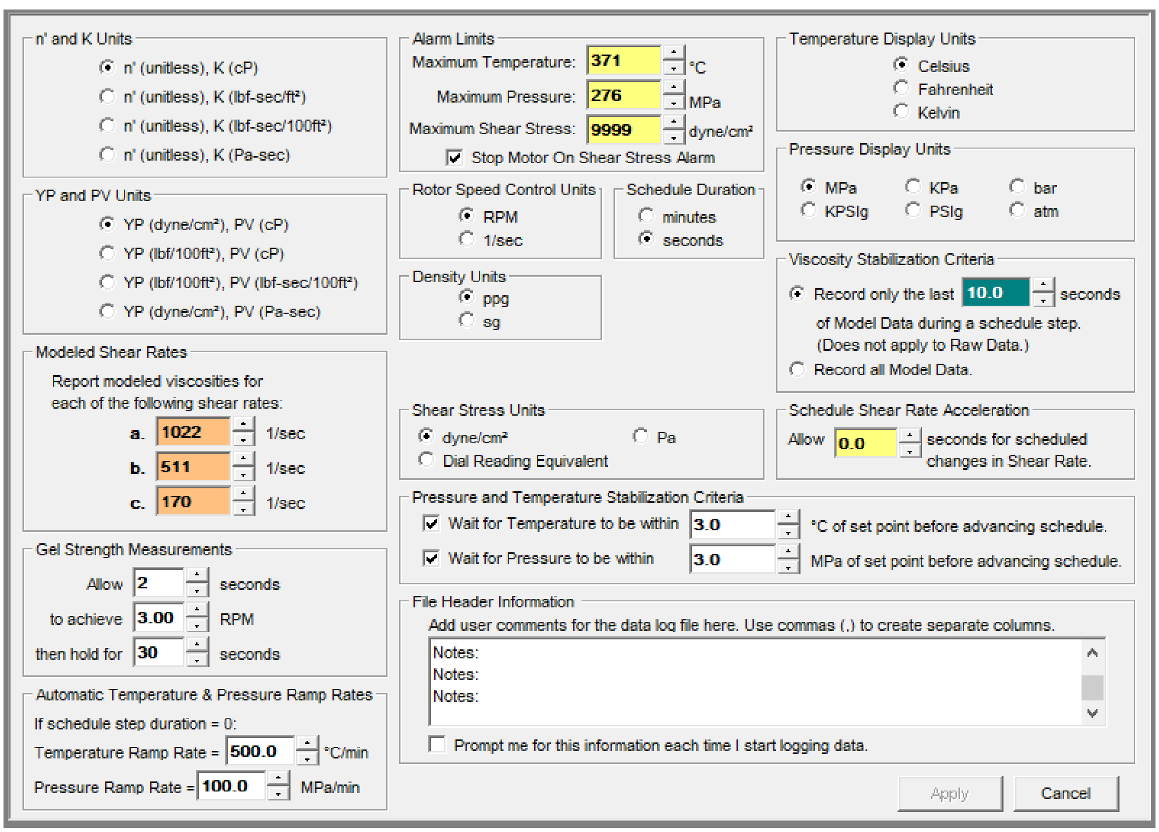


The Manual Axis Scaling Screen provides precise manual control over the displayed range of each plot.

- **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.

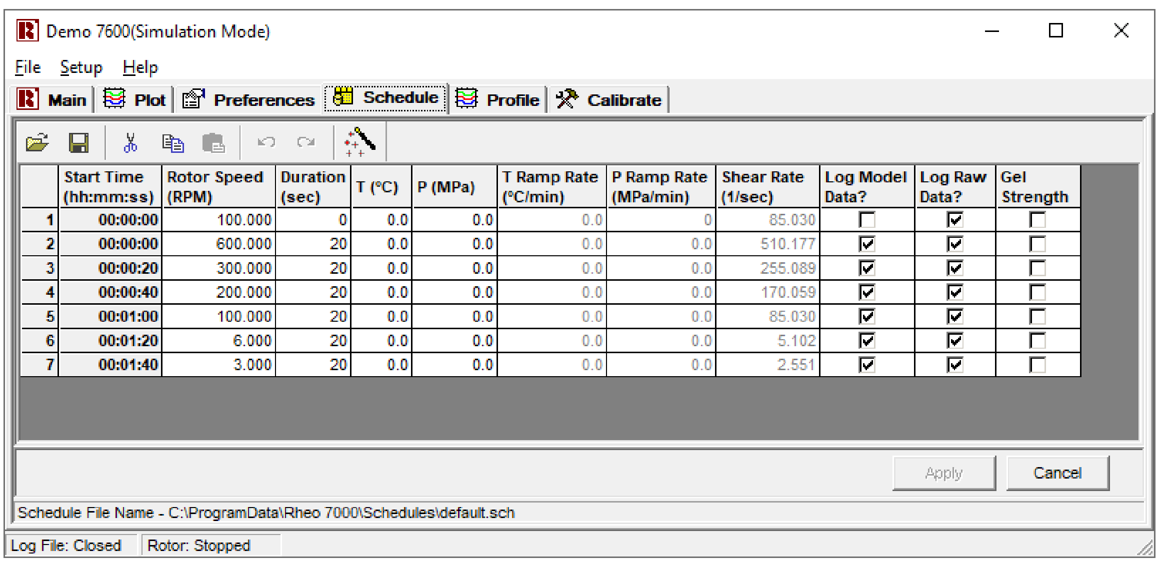
- **Pressure Display Units** - Allows the selection of Pressure Units. This selection applies to the log file, as well as the schedule, alarm limits and any other place that pressure is displayed. Pressure display units may not be changed while data is being logged to a file. This promotes concurrency 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	☑	☑	☐

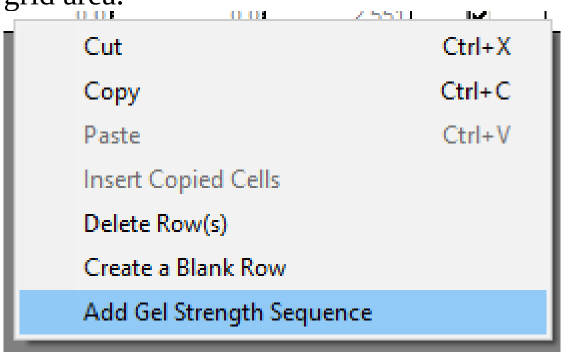
The Rheo software system allows user-defined schedules for automatic test control. Schedules are created and edited using the Schedule section of the Setup screen. Cells may be edited individually. Entire rows and groups of rows may be cut, copied and pasted.

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.

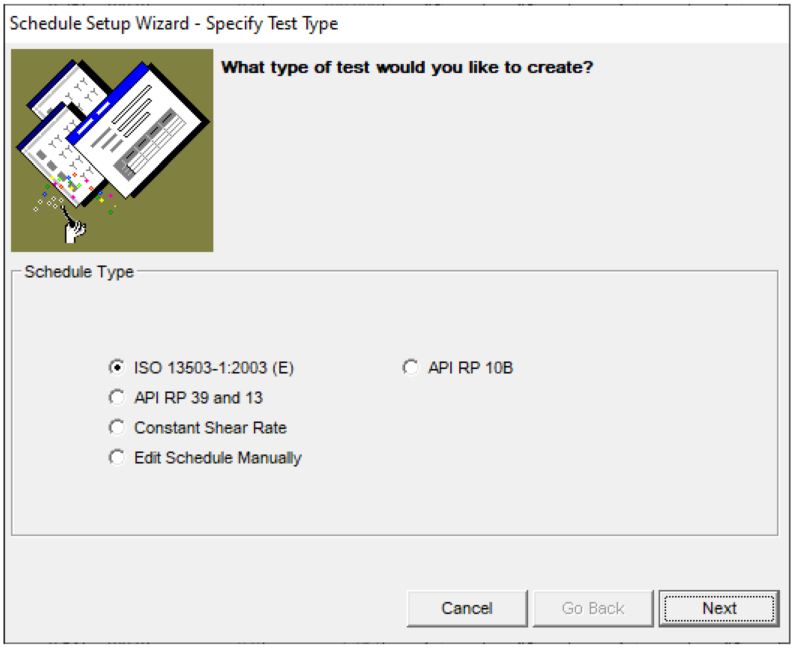
- **Log Model Data** - Allows the user to specify which schedule steps are used for Model calculations. When an UNchecked Log Model Data step is encountered, the previous set of Log Model Data steps will be used to calculate the Models.

- **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.

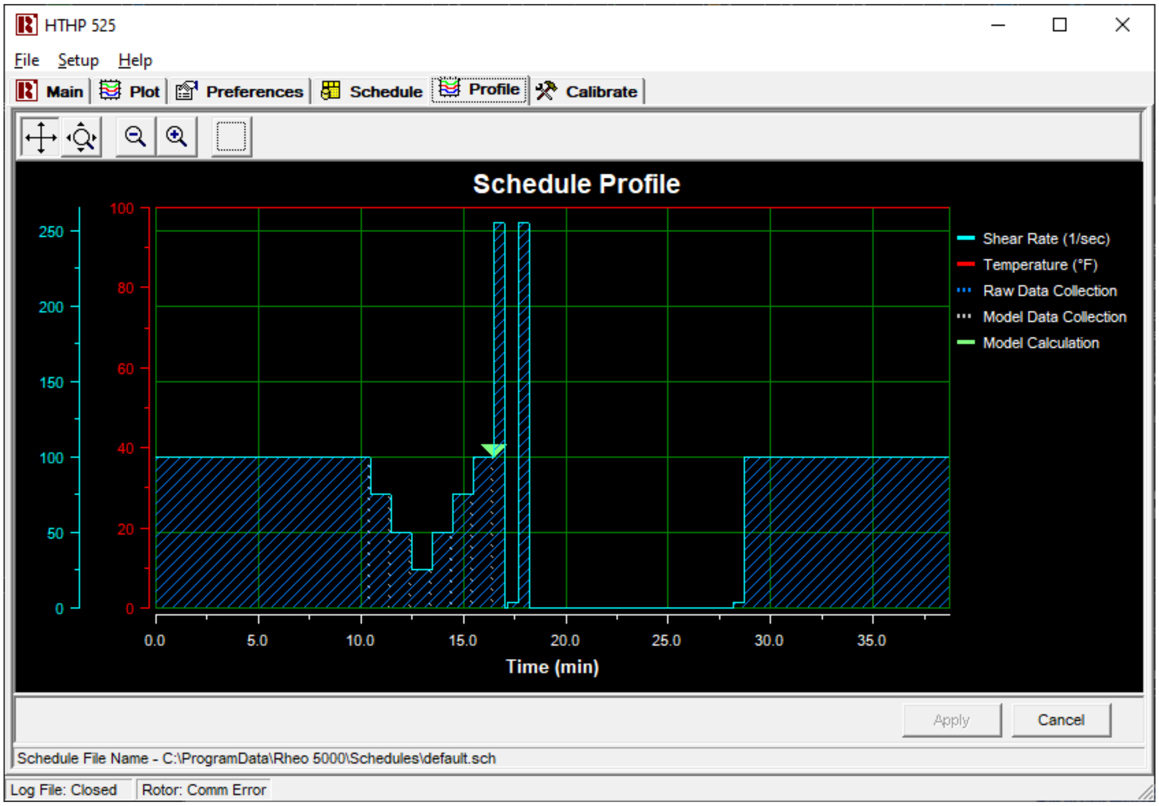
- **ISO 13503-1:2003 (E)** - Allows a schedule of user-defined duration to be created with either increasing or decreasing shear rate ramps. Any test duration may be selected. Ramp schedules are determined according to the ISO standard (100, 75, 50, 25 sec^{-1} in increasing or decreasing order).

- **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).

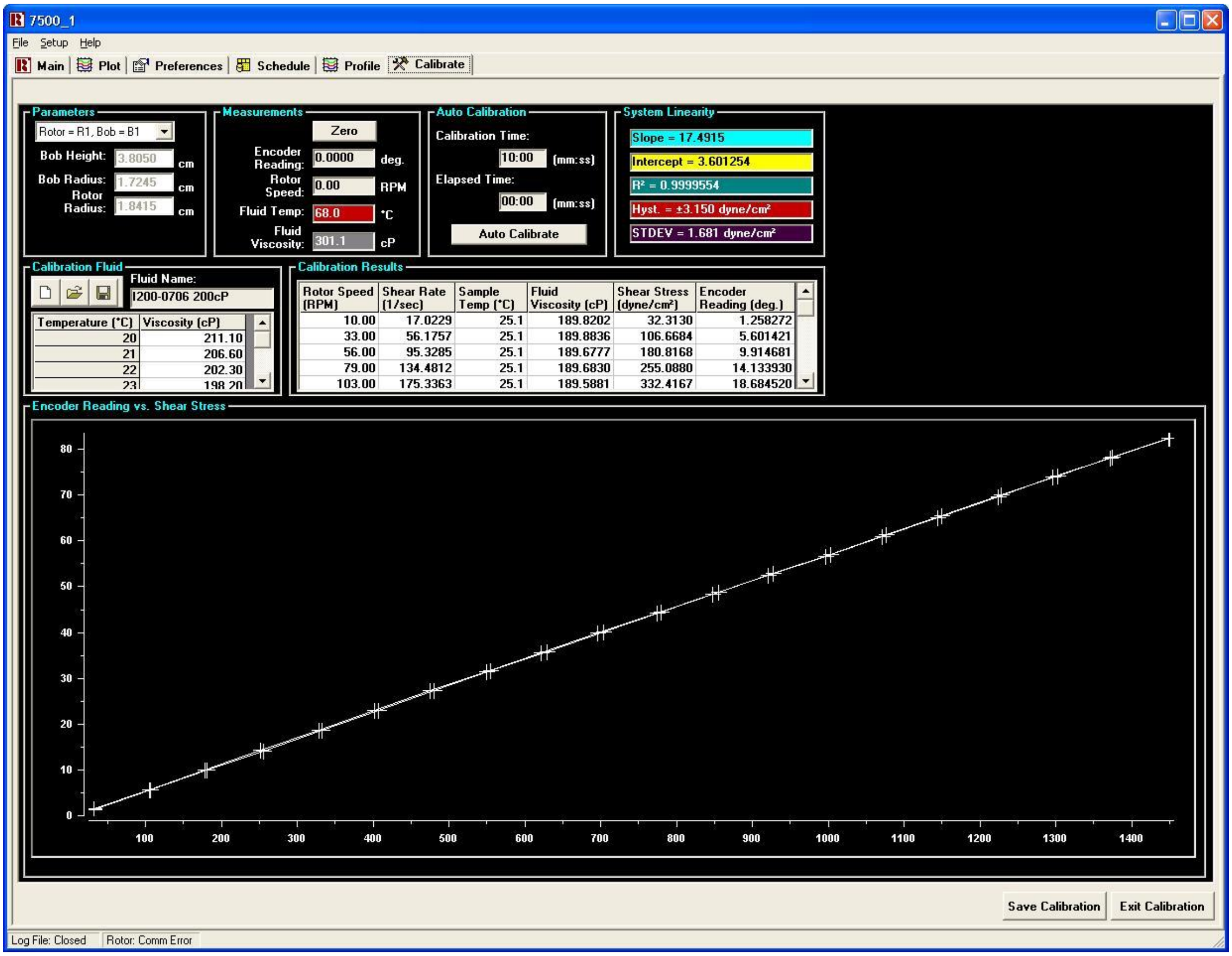
6. After cooling and all pressure is released, place the temperature and pressure control in manual mode, enter temperature and pressure set-points of 32°F (0°C) and 0 psi, respectively.

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



Calibration Overview

The 7600 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/cm^2 per degree. This constant can be used to predict the maximum measurable shear stress by the formula τmax = slope (dyne/cm^2) * 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/cm^2) 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/cm^2) and Standard Deviation (x.xxx dyne/cm^2) are reported on the calibration screen of the Rheo 7000 software, as well as reported in each data file.

Calibration Procedure

1. Using the Vessel Disassembly and Assembly instructions, fill the sample cup with 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.

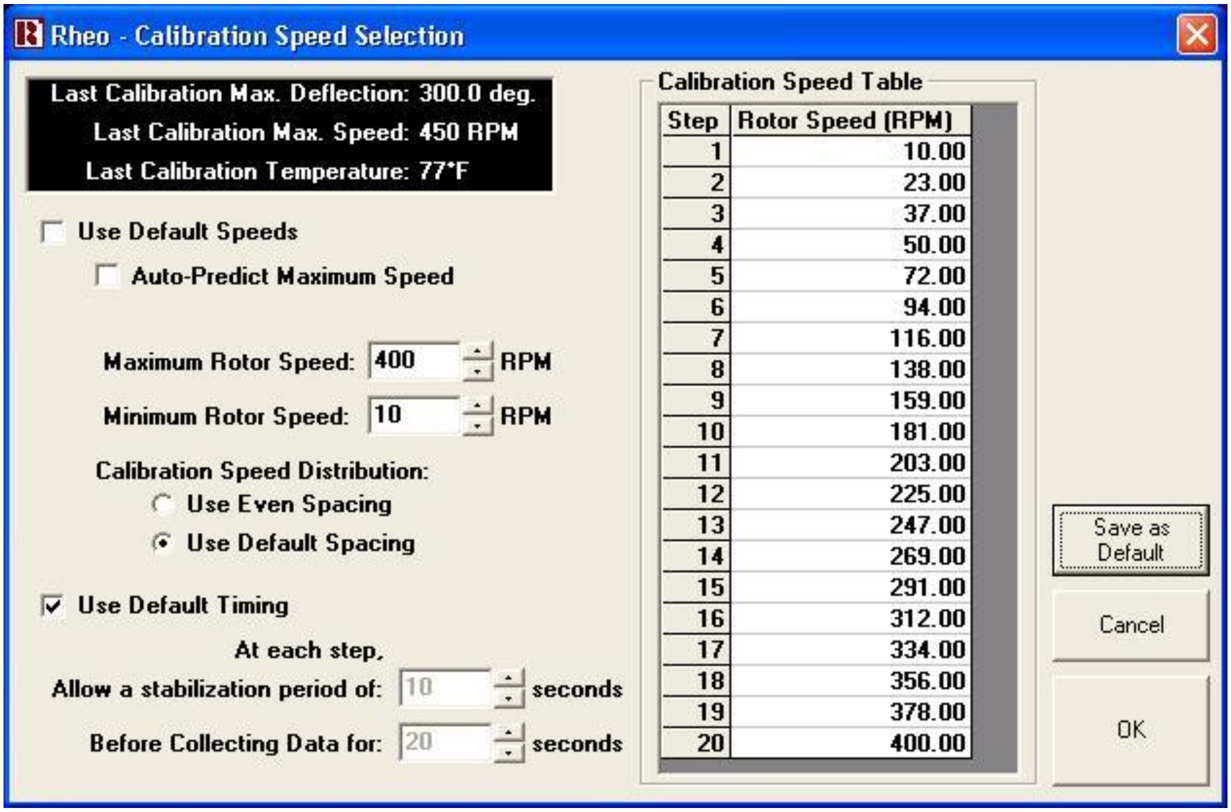
- **Save Calibration** - Saves the calibration data. The software will begin using the new values.

- **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

Tools Required

- 5/8-inch Wrench
- Hex wrenches
- Screwdrivers
- Bench Vise

Cleaning and Service Tips

- Keep the threads and ports free from sample.
- Lubricate the threads on the top plug and top cap periodically with a small amount of nickel anti-seize compound.
- Avoid rapid release of pressure since the sample may enter the connection tubing.

Controller Calibration Procedure

The temperature and pressure controllers and transducers require periodic calibration.

Temperature calibration involves applying known value to the thermocouple electronics using a thermocouple simulator or dry-block calibrator.

Pressure calibration involves setting the ZERO of the transducer at atmospheric pressure, then using an electronic transfer standard, pressurizing the system to near full scale (40000 psig) and adjusting the SPAN of the controller to agree with the known value.

High Pressure Diaphragm Valve

The instrument is equipped with a diaphragm valve that is rated for use up to 40000 psig. A length of capillary tubing is located downstream of the valve to provide a flow restriction.

The pressure on the valve diaphragm should be set at 70 psig.

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.

Figure 4 - High Pressure Valve and Regulator

High Pressure Pump and Lubricator

The instrument is equipped with an air over liquid pump with a ratio of approximately 1:400. The pump can generate a discharge pressure up to 40000 psig provided adequate air pressure is provided.

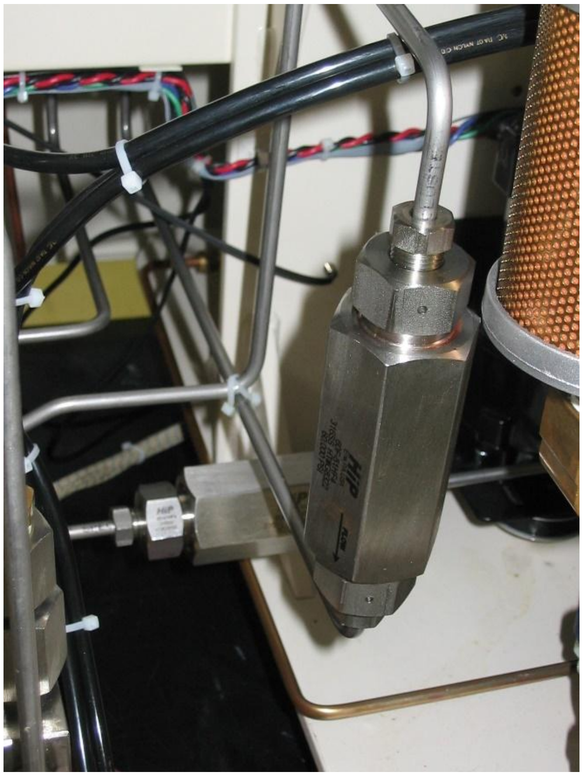
The pump may be rebuilt using a kit and instructions from the manufacturer. Contact Chandler Engineering if service on this pump is required.

The lubricator upstream of the pump must be adjusted to provide one drop of oil every 20 strokes of the pump. The pump may be lubricated using the pressurizing fluid.

Figure 5 - High Pressure Pump and Lubricator

High Pressure Filters

The instrument is equipped with two high pressure filters. Each filter media is 100 micron. The filters may be removed and disassembled for cleaning. Replacement filter media is available if required. Contact Chandler Engineering if replacement parts are required.



High Pressure Transducer

The instrument is equipped with a 40000 psig transducer. The transducer was calibrated by the manufacturer, calibration traceability is provided with the instrument. The output of the transducer corresponding to 40000 psig 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.

Air Filter

The inlet air to the instrument is conditioned using a coalescing filter. Periodic draining or replacement of this filter may be required. A replacement filter is available if required. Contact Chandler Engineering if replacement parts are required.

Vessel Transport System

The instrument is equipped with an ACME lead screw, nut and gear motor that is used to translate the vessel assembly into or out of the heating/cooling jacket. Optical limit switches are used to halt the motor at top and bottom limits of the lead screw.

Potential operator danger exists if the lead screw, nut, flexible coupling or gear motor drive fail due to misuse or wear. This system must be maintained to ensure safety.

Be certain to remove the vessel support plate prior to lowering the vessel transport without the vessel installed.

The vessel transport will not operate unless the Air Supply Switch is in the OFF position. This action reduces the chance that the transport will be engaged with the high-pressure tubes attached to the vessel.

The lead screw must be lubricated periodically using the lithium grease supplied with the accessories.

The gear motor used to drive the lead screw uses a timing belt. This belt must be replaced every year to prevent failure. The weight of the transport bracket and vessel will drive the lead screw. The motor mount includes slotted holes that are used to adjust the tightness of the timing belt.

The bolts that attach the transport bracket to the lead screw must be inspected periodically and replaced if any wear or damage is observed or suspected. Contact Chandler Engineering if replacement parts are required.

The transport system drive electronics are accessed from the right side of the instrument. Remove the side access panel. The drive electronics provides a speed adjustment which is factory set at full speed (fully clockwise). There no adjustments inside the drive electronics enclosure. An armature fuse exists that is factory sized based on the motor rating. If this fuse fails, the motor should be inspected.

Bob Bearing and Pivot

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

The bob is suspended on the pivot using a tungsten carbide bearing (earlier version of the instrument used a sapphire bearing). The bearing adapter may be unscrewed from the bottom of the bob. Once removed, the tungsten carbide bearing may be removed. The tungsten carbide bearing is inserted in the bearing adapter, it is retained once the adapter is attached to the bob.

Heating / Cooling Jacket

The instrument is equipped with a cast heating and cooling jacket. Internal tubing provides a circulation path for coolant.

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), each leg of the heater power is switched using a contactor.

An over-temperature module will disable the heater if the temperature exceeds 750°F/400°C. Similarly, if the pressure increases beyond 42,000 psig/290 MPa, the heater circuit is disabled.

Pressure Vessel

Thermowell

The thermowell at the bottom center of the vessel serves multiple functions. It provides a location for the center thermocouple that is near the sample, providing an accurate sample measurement. It also provides a pivot point for the jewel bearing mounted in the bob and a shoulder for the inner race of the rotor bearing. Lastly, it provides a high-pressure seal at the bottom of the vessel.

The thermowell should not be removed unless necessary. The vessel was hydrostatically tested with this component installed, removal and replacement may compromise the bottom seal.

The thermowell may be removed from the vessel by removing the 3/8-inch nut from the bottom of the vessel. When replaced, install the flat washer, and tighten the nut to 25 ft-lbf torque. Conduct a pressure test of the vessel prior to testing sample to verify that the thermowell has sealed.

The thermowell is subjected to the internal pressure and must be replaced if any damage is observed or suspected. Contact Chandler Engineering if replacement parts are required.

O-rings and Backup Rings

The Viton elastomer o-rings and metallic backup rings used to seal the top cap and vessel are identical and may be interchanged.

The metal backup rings are long lasting however, the elastomer o-rings must be replaced after any sign of wear or deformation.

Each sealing location is equipped with a drain hole that will release oil if a seal fails during a test. This design feature prevents the pressure from acting across the larger thread area.

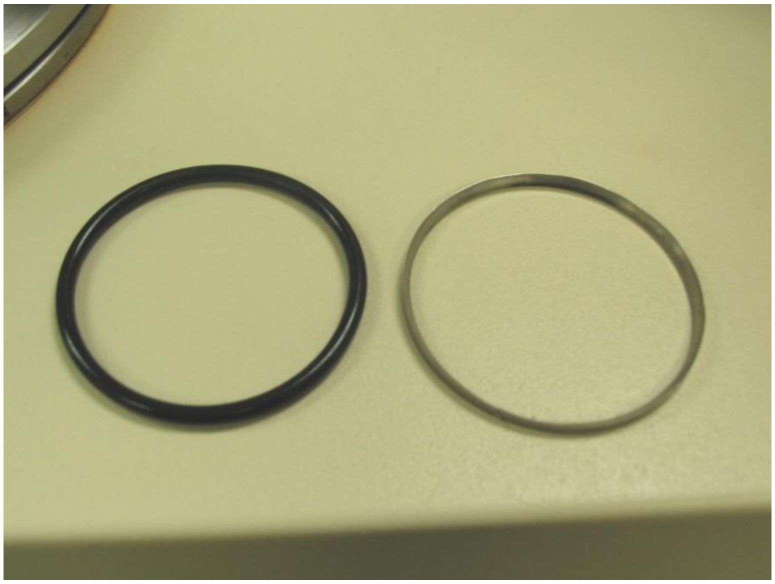


Figure 6 – O-ring and Backup Ring

Magnetic Drive

Inner Magnetic Rotor

The inner magnetic drive rotor is equipped with bushings that may be replaced if worn. 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

The outer magnetic drive rotor is equipped with bearings that may be replaced if worn. These bearing must spin freely. When new, the bearings are packed with libricant and must be removed. The bearings are lubricated with Duratherm HF heat transfer fluid. 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.

Figure 7 - Outer Magnetic Drive Rotor

Torque Sensing Encoder

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

Turn OFF the instrument power prior to connecting or disconnecting the encoder assembly. The encoder may be disconnected by removing the interconnection cable. Contact Chandler Engineering if replacement parts are required.

Plastic Sample Containers

The Nalgene® bottles contain mineral oil used to pressurize the sample. One bottle contains fresh oil, the other used oil. The supply bottle is pressurized to approximately 20 psig to provide the pump with a positive inlet pressure.

A relief valve is provided to limit the pressure on the supply bottle to 30 psig.

Each bottle is equipped with an elastomer seal that may be replaced as required. Each bottle may be replaced if worn. Contact Chandler Engineering if replacement parts are required.

Maintenance Schedule

MAINTENANCE SCHEDULE Model 7600 HPHT Viscometer					
COMPONENT	EACH TEST	MONTHLY	3 MONTHS	6 MONTHS	ANNUAL
Vessel Seals	Inspect & replace as required				
Vessel Assembly	Clean and replace as needed				Inspect and pressure test vessel
Rupture disc					Replace
Temperature - Centerline				● Calibrate	
Temperature – Heating/Cooling Jacket				● Calibrate	
Pressure Transducer				● Calibrate	
Vessel Transport		Apply lithium grease to lead screw			
Shear Stress		Calibration using certified fluid			
Shear Rate					Verify with a digital tachometer
This maintenance schedule applies to normal usage of two tests per day. ● Per API/ISO Specifications					

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Section 4 – Troubleshooting Guide

PROBLEM	SOLUTION
System will not pressurize	1. Verify that the air supply is present. 2. Verify that oil is present in the supply vessel 3. Verify that air is not present in the lines 4. Check for leaks at the vessel or interconnecting tube fittings.
System will not heat	1. Verify that communication cables are connected 2. Verify that heater switch is ON 3. Verify that over-pressure alarm is not active 4. Check heater circuit breaker
Poor temperature or pressure control	1. Defective thermocouple or pressure transducer 2. Incorrect control schedule 3. Incorrect controller configuration parameters 4. Defective controller or related electronics
Stepper motor will not run	1. Verify proper operation of the Rheo700 software 2. Shut down Rheo7000 software, cycle power to the instrument, restart Rheo7000 software 3. Verify operation of motor in software Manual mode. 4. Verify that communication cables are connected and COMM port assignments are correct 5. Verify that fuse is not blown.
Poor Sensitivity	1. Worn bob pivot bearing and pivot. 2. Incorrect calibration. 3. Check for friction in encoder assembly.
Erratic Readings	1. Vessel not full, bob and rotor are not totally immersed in sample. 2. Encoder assembly requires service.

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Section 5 – Replacement Parts

Part Number	Description
70616-90	Receptacle, 15A, Power Cord
70617-89	Cord,Pwr,3 Cond,14 Awg,Strd
7500-2209	Cable Assembly, Internal, Encoder
7600-1010	Vessel Assembly
7600-1011	Rotor Assembly, Inner, Magnetic Drive
7600-1012	Rotor Assembly, Outer, Magnetic Drive
7600-1013	Spring Assembly, F1
7600-1014	Heating/Cooling Jacket Assembly (earlier revisions)
7600-1015	Shaft Assembly, Bob
7600-1018-2	Rotor Assembly, 2H, R1
7600-1022	Tensioner Assembly, Belt
7600-1024	Motor Assembly
7600-1026	Reservoir Assembly, Supply, Oil
7600-1027	Reservoir Assembly, Return, Oil
7600-1029	Spring Module Assembly
7600-1103	Bob, B1
7600-1107	Thermowell, Sample
7600-1114	Bushing, Inner Rotor, Magnetic Drive
7600-1123	Housing, Spring Assembly
7600-1127	Seal, High Pressure
7600-1128	Ring, Vessel Support
7600-1129	Shaft, Magnet Support
7600-1133	Nut, Connection, Pressure
7600-1142	Plate, Vessel Support
7600-1145	Pulley, Motor
7600-1146	Pulley, Magnetic Drive
7600-1150	Panel, Right Side, Enclosure
7600-1151	Panel, Left Side, Enclosure
7600-1153	Panel, Back Right, Enclosure
7600-1156	Bracket, Motor Mounting
7600-1158	Support, Isolation Tube
7600-1159	Sleeve, Support, Magnetic Drive
7600-1160	Tool, Bearing Removal
7600-1161	Tool, Bearing Installation
7600-1162	Plate, Translation
7600-1164	Plug, Port, Syringe
7600-1165	Pulley, Drive, Lead Screw
7600-1167	Hub, Drive, Lead Screw
7600-1168	Block, Motor Adaptor
7600-1169	Shaft, Drive, Lead Screw
7600-1172	Cover, Belt
7600-1175	Bushing, Bottom, Belt Tensioner
7600-1176	Bushing, Top, Belt Tensioner

Part Number	Description
7600-1181	Pin, Vessel Alignment
7600-1182	Anchor, Vessel Alignment
7600-1184	Pulley, Motor, Lead Screw
7600-1185	Spacer, Insulating, Heating/Cooling Jacket
7600-1187	Cap, Top, Reservoir
7600-1188	Gasket, Reservoir Cap
7600-1189	Block, Limit Switch
7600-1194	Cable, Encoder Connection
7600-1204	Tool, Magnetic Drive
7600-1219	Cap, PEEK, Spring Module
7600-1223	Pivot, Jewel Bearing, Bob
7600-1228	Tool, Removal, Isolation Shaft
7600-1234	Baffle, Adjustable, Bob
7600-1235	Adapter, Extension, Jewel Bearing
7600-1240	Housing Assembly - Jewel Bearing
7600-1263	Gauge, Sample Volume
7600-1265	Capillary Tubing Assembly
80-0031	Bracket, Anti Rotation, Bulkhead
C04480	Fuse, 1/2A 250VAC SB
C07833	Transducer, Pressure, 40Kpsi
C08126	Switch, Panel
C08582	Fitting, Bulkhead, 60 Kpsi
C08725	Cable, Serial
C08889	Fan, Air
C08975	Converter, RS232/RS485
C08999	Relay, 25A, DPST, 240VAC
C12788	RELAY,SPDT,24VAC/DC,0-399C,DIN
C10526	Switch, Panel, On/Off
C10964	Base, Relay
C10994	Base, Modbus
C10998	Module, End
C10999	Power Supply, 24VDC
C11037	Fuse, 2A 250VAC SB
C11207	Regulator, 1 - 30 psi
C11209	O-ring, Viton, #226
C11215	Pump, Hydraulic, 40 Kpsi
C11216	Gauge, 80 Kpsi
C11218	Valve, Diaphragm
C11219	Bearing, Rotor
C11224	Belt, Timing, 163XL
C11291	Module, Incremental Encoder
9051-7600	Controller,Temperature,7600
9061-7600	Controller,Pressure,7600
C16896	Relay,SPST,32VDC,23A,Din Rail
P-0915	Plug, Port, 1/4 inch
P-1130	Fuse, 1 Amp, 250V

Part Number	Description
P-1280	Filter, Air
P-1593	Disk, Rupture, 45,000 psi
P-1887	Gauge, Air, 100 psi
P-2192	Valve, HP

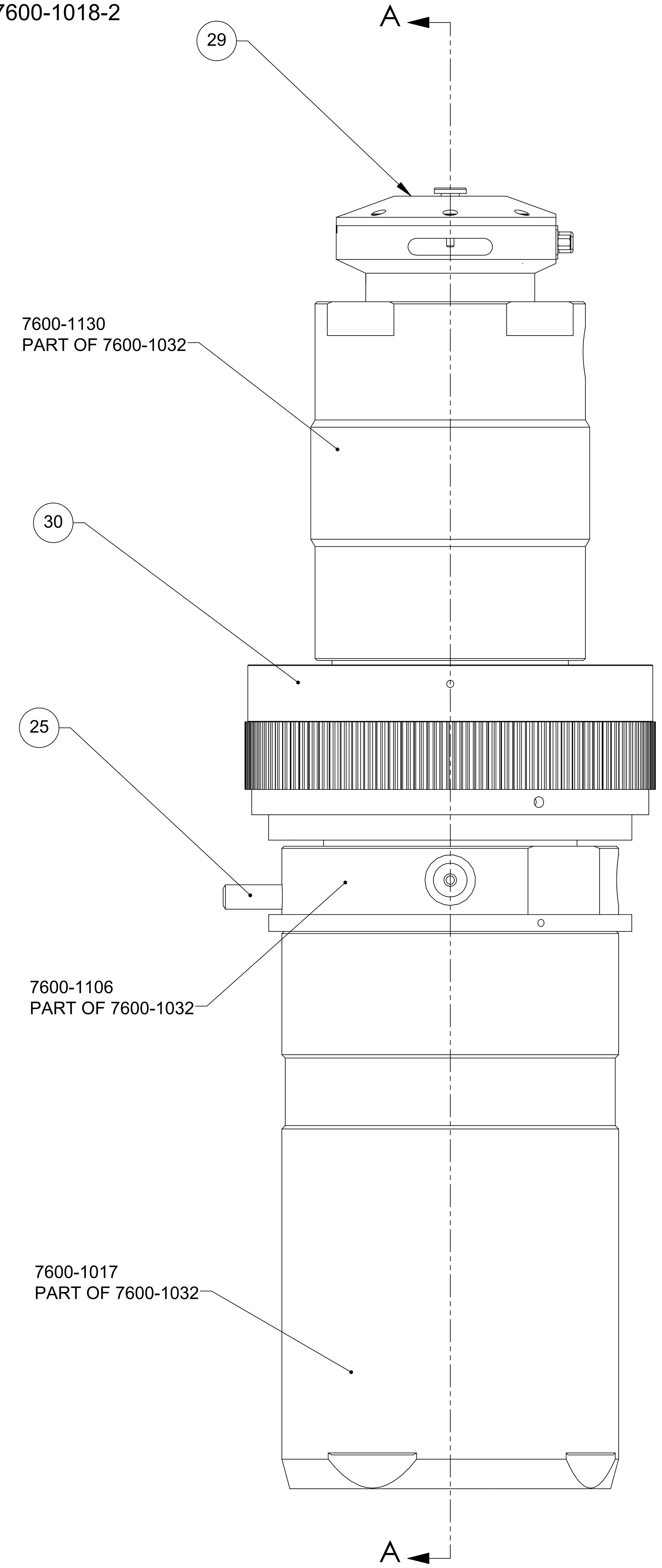
To ensure correct part replacement, always specify Model and Serial Number of instrument when ordering or corresponding.

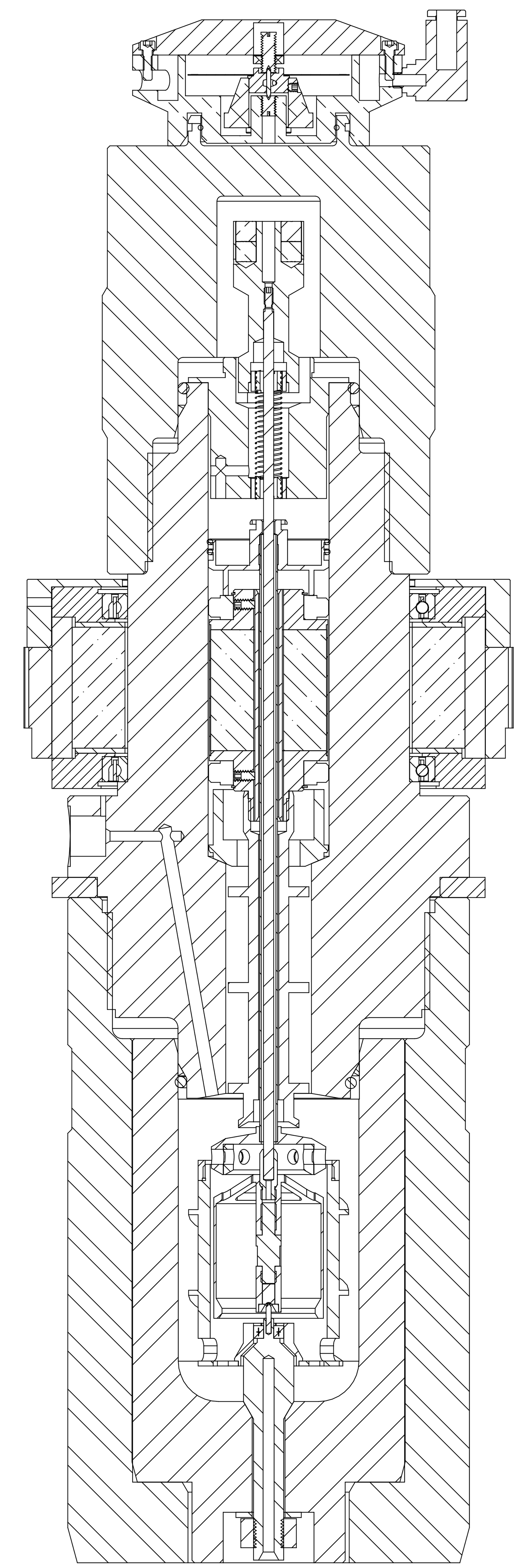
Section 6 – Drawings and Schematics

Drawing Number	Description
7600-1010	Vessel Assembly
7600-1013	Spring Assembly, F1
7600-1022	Belt Tensioner Assembly
7600-1023	Encoder Assembly
7600-1024	Stepper Motor Assembly
7600-1026	Reservoir Assembly, Oil Supply
7600-1027	Reservoir Assembly, Oil Return
7600-1029	Spring Module Assembly
7600-1030	Diagram, Wiring
7600-1031	Diagram, Tubing

NOTES:
1. ASSEMBLE INTERNAL COMPONENTS AS A PART OF FINAL TESTING. THE ELEVATOR IS USED TO FACILIATE ASSEMBLY AND TO PREVENT DAMAGE TO CRITICAL COMPONENTS.
2. THE ROTOR AND SHAFT AND SUPPLIED AS AN ASSEMBLY, 7600-1018-2
3. TEST PRESSURE VESSEL IN ACCORDANCE WITH 7600-1064.

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	J	ECN T5175; DELETED 7600-1260 ASSY. ADDED 7600-1332, 7600-1333	2/20/2013	JJM
	K	ECN T5206; CHANGE 7600-1115 TO A REFERENCE AS IT IS NOW PART OF 7600-1018-2	3/13/13	TC
	L	ECN T5549; REPLACED 7500-2272 WITH 7500-3272	9/25/13	TC
	M	ECN T5552; REPLACE C11212 WITH 7500-2296	10/1/13	TC
	N	ECN T7047; DELETE 7600-1333	2/9/16	TC
	P	ECN T7316; UPDATED 7600-1018-2 ROTOR	6/28/2016	JJM
	R	ECN T7802; ADDED 7600-1032 VESSEL ASSEMBLY TO STATE NEED FOR MANUFACTURING VESSEL COMPONENTS AT THE SAME SUPPLIER	9/14/2017	JJM
	T	ECN T8395; CORRECTED LOCATION OF C11219 BEARING	1/2/2019	JJM
	U	ECN T9075; ELIMINATE EXTRA 7600-1115 ROTOR SHAFT THAT IS A PART OF THE 7600-1018-2 ASSEMBLY	1/14/2021	JJM





SECTION A-A
SCALE 3 : 4

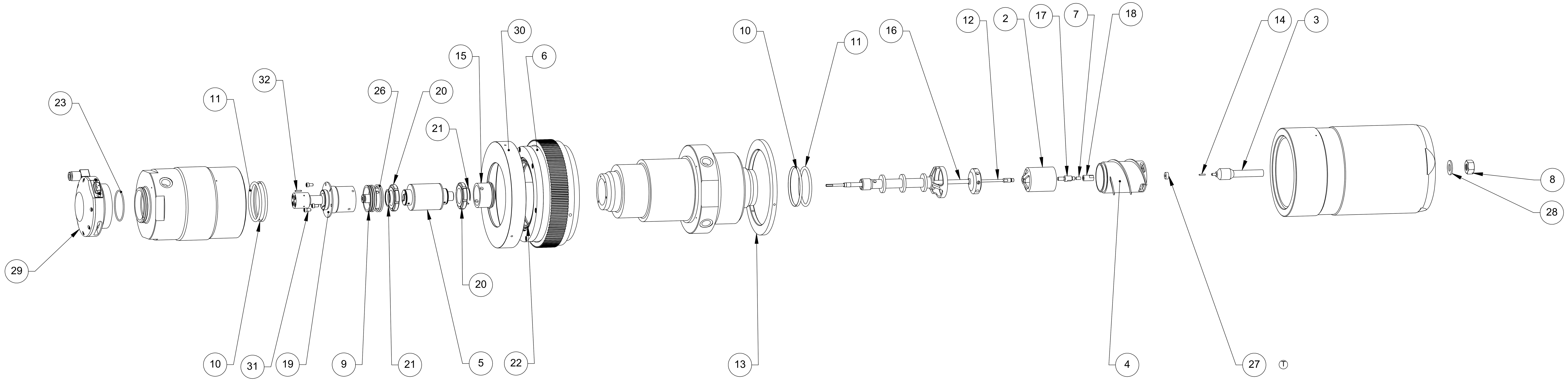
ITEM	PART NUMBER	DESCRIPTION	QTY	UoM
1	7600-1032	VESSEL ASSEMBLY	1	
2	7600-1103	BOB,B1	1	
3	7600-1107	THERMOWELL,SAMPLE	1	
4	7600-1018-2	ROTOR ASSEMBLY,2H,R1	1	
5	7600-1011	MAGNET DRIVE ASSEMBLY	1	
6	7600-1012	ROTOR, OUTER MAGNETIC DRIVE	1	
7	7500-2296	INSERT, TUNGSTEN CARBIDE	1	
8	C11208	NUT,HEX,SS,GRADE 8,18-8	1	
9	7600-1158	SUPPORT,ISOLATION TUBE,LH	1	
10	7600-1127	SEAL, HIGH PRESSURE	2	
11	C11209	ORING,VITON,AS226-75D	2	
12	7600-1015	BOB SHAFT ASSEMBLY	1	
13	7600-1128	RING,VESSEL SUPPORT	1	
14	7600-1223	PIVOT, SAPPHIRE BEARING	1	
15	7600-1159	SLEEVE, SUPPORT, MAGNETIC DRIVE	1	
16	7600-1234	BAFFLE,BOB,ADJUSTABLE	1	
17	7600-1235	ADAPTER, EXTENSION, JEWEL BEARING	1	
18	7600-1240	HOUSING ASSEMBLY - JEWEL BEARING	1	
19	7600-1029	SPRING MODULE ASSEMBLY	1	
20	7600-1114	BUSHING,INNER ROTOR,MAG DRIVE	2	
21	C11221	RING,RET,EXT,0.875,BASIC	2	
22	C11220	BRG,BALL,ANG,3.500X4.125X0.312	2	
23	P-3423	ORING,VITON,AS030-75	1	
24	7600-1146	PULLEY,TIMG BLT,MAGNETIC DRIVE	1	
25	7600-1181	PIN, VESSEL ALIGNMENT	1	
26	C09275	ORING,VITON,AS028-75	2	
27	C11219	BRG,BALL,RAD,0.125X0.375X0.156	1	
28	H-37-001	WSHR,FLAT,SS,3/8	1	
29	7500-3272	ENCODER ASSEMBLY, 7500/7600	1	
30	7600-1332	SHIELD, MAGNETIC	1	
31	H-6012	SCREW, SHCS, SS, 6-32 X .250, ALN	3	
32	99074-3-375	PIN,DOWEL,1/16DIA X 3/8 SS	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 02-25-13
MFG: TC 02-25-13
ENGR: JJM 02-25-13
TYPE:
STRUCT:

CHANDLER ENGINEERING
VESSEL ASSEMBLY
PN: 7600-1010
PROJ:
REV U | SIZE D
SHEET 1 OF 2

TITLE BLOCK REV 3



ITEM	PART NUMBER	DESCRIPTION	QTY	UoM
1	7600-1032	VESSEL ASSEMBLY	1	
2	7600-1103	BOB,B1	1	
3	7600-1107	THERMOWELL,SAMPLE	1	
4	7600-1018-2	ROTOR ASSEMBLY,2H,R1	1	
5	7600-1011	MAGNET DRIVE ASSEMBLY	1	
6	7600-1012	ROTOR, OUTER MAGNETIC DRIVE	1	
7	7500-2296	INSERT, TUNGSTEN CARBIDE	1	
8	C11208	NUT,HEX,SS,GRADE 8,18-8	1	
9	7600-1158	SUPPORT,ISOLATION TUBE,LH	1	
10	7600-1127	SEAL, HIGH PRESSURE	2	
11	C11209	ORING,VITON,AS226-75D	2	
12	7600-1015	BOB SHAFT ASSEMBLY	1	
13	7600-1128	RING,VESSEL SUPPORT	1	
14	7600-1223	PIVOT, SAPPHIRE BEARING	1	
15	7600-1159	SLEEVE, SUPPORT, MAGNETIC DRIVE	1	
16	7600-1234	BAFFLE,BOB,ADJUSTABLE	1	
17	7600-1235	ADAPTER, EXTENSION, JEWEL BEARING	1	
18	7600-1240	HOUSING ASSEMBLY - JEWEL BEARING	1	
19	7600-1029	SPRING MODULE ASSEMBLY	1	
20	7600-1114	BUSHING,INNER ROTOR,MAG DRIVE	2	
21	C11221	RING,RET,EXT,0.875,BASIC	2	
22	C11220	BRG,BALL,ANG,3.500X4.125X0.312	2	
23	P-3423	ORING,VITON,AS030-75	1	
24	7600-1146	PULLEY,TIMG BLT,MAGNETIC DRIVE	1	
25	7600-1181	PIN, VESSEL ALIGNMENT	1	
26	C09275	ORING,VITON,AS028-75	2	
27	C11219	BRG,BALL,RAD,0.125X0.375X0.156	1	
28	H-37-001	WSHR,FLAT,SS,3/8	1	
29	7500-3272	ENCODER ASSEMBLY, 7500/7600	1	
30	7600-1332	SHIELD, MAGNETIC	1	
31	H-6012	SCREW, SHCS, SS, 6-32 X .250, ALN	3	
32	99074-3-375	PIN,DOWEL,1/16DIA X 3/8 SS	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

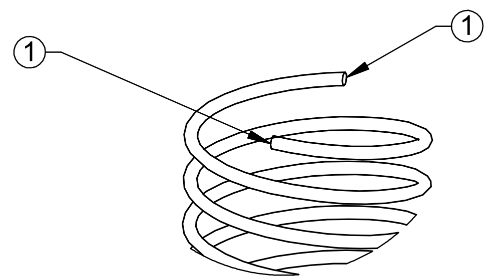
DRAWN: JJM 02-25-13
MFG: TC 02-25-13
ENGR: JJM 02-25-13
TYPE:
STRUCT:

CHANDLER ENGINEERING
VESSEL ASSEMBLY
PN: 7600-1010
PROJ:
REV U SIZE D
SHEET 2 OF 2

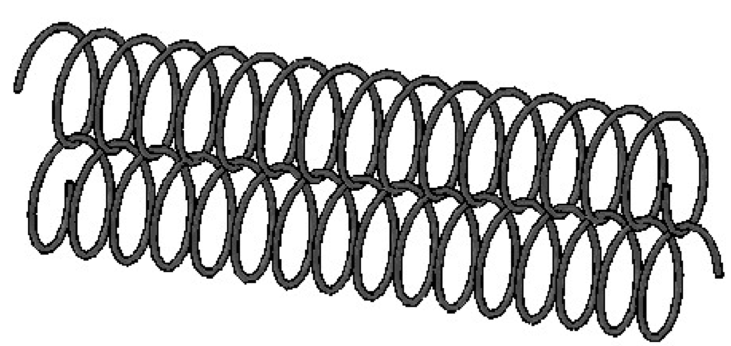
TITLE BLOCK REV 3

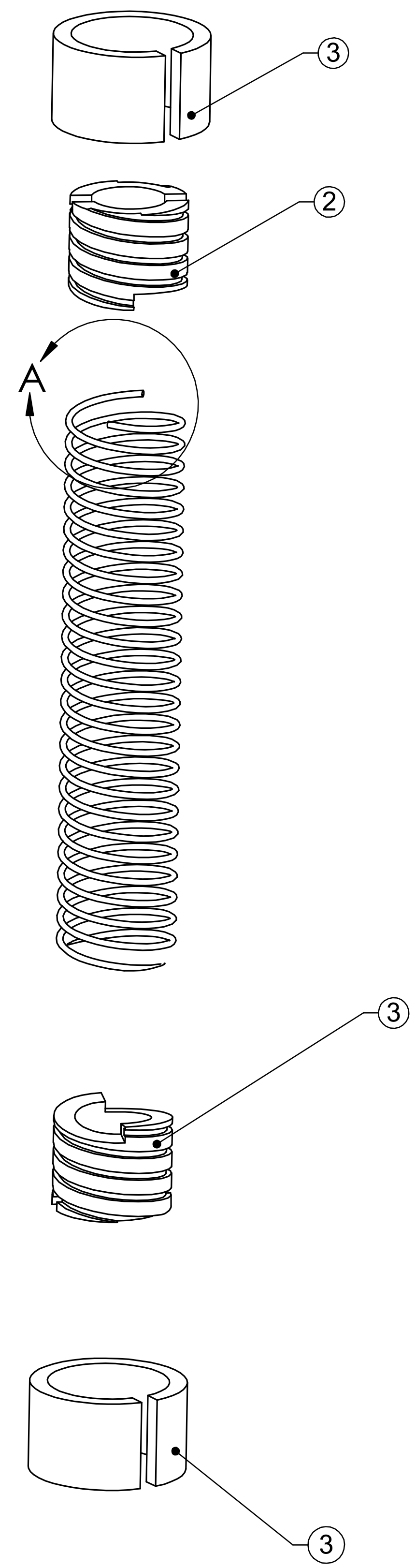
REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	E	ECN T5825; ADDED 35-0115	3/21/14	TC
	F	ECN T6109; UPDATED VIEWS, ADDED NOTES 5 AND 6	9/16/14	TC
	G	ECN T7126; UPDATED ASSEMBLY, INCLUDING 7500-3317	3/11/2016	JJM
	H	ECN T7336, ELIMINATED THE 7500-3317 MANDREL, IT CAUSES INTERFERENCE WITH THE 7600-1010 ASSEMBLY	7/30/2016	JJM

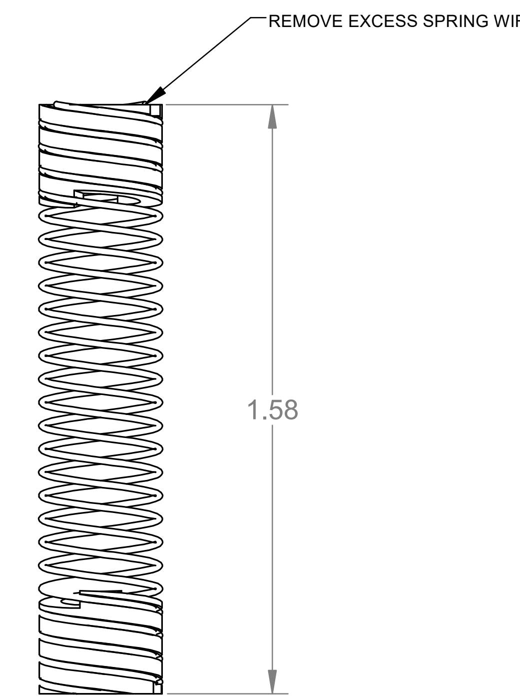
NOTE THAT ENDS ARE OPPOSITE EACH OTHER



DETAIL A
SCALE 6 : 1
SHOWN WITHOUT 35-0115 CLAMP







NOTES:
1. THREAD BOTH SPRINGS TOGETHER WHILE MAINTAINING PARTIAL SEPARATION. LET ONE SPRING HANG FROM THE OTHER.
2. PLACE THE SPRING ENDS OPPOSITE EACH OTHER ON ONE END.
3. THREAD THE MANDRELS IN THE TOP AND BOTTOM USING THE SLOT TO ADJUST TO THE DIMENSION SHOWN.
4. TRIM THE LEFTOVER SPRING FROM MANDRELS.
5. TRIM ENDS OPPOSITE EACH OTHER.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	7600-1200	SPRING, BeCu, LEFT HAND, 0.018D	2
2	5550-0338	MANDREL, SPRING, F410	2
3	35-0115	CLAMP - SPRING	2

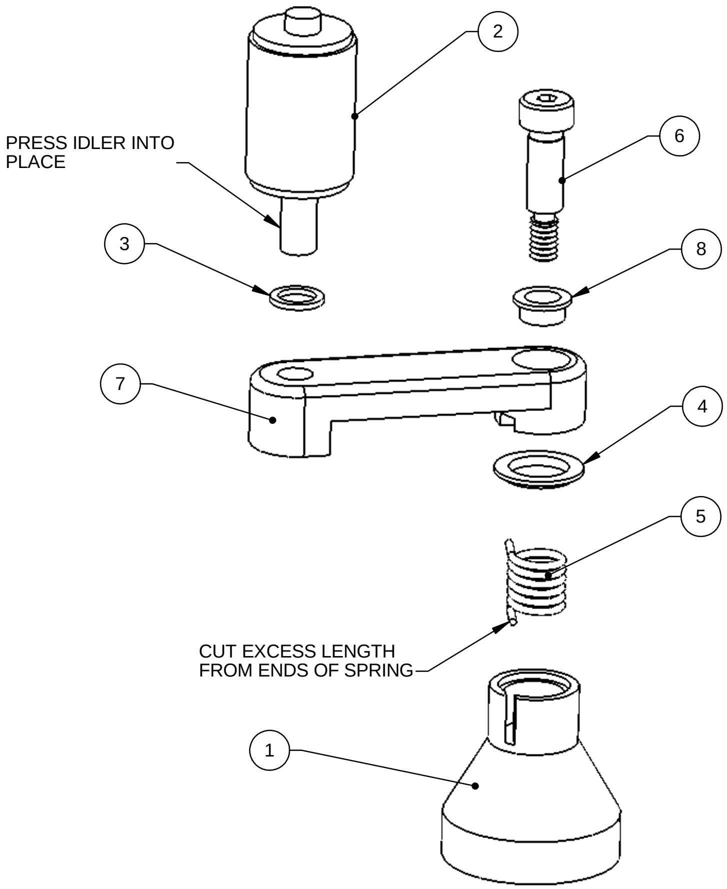
BREAK EDGES, DEBURR
UON DIMS ARE IN INCHES
1 PLC ±0.030 2 PLC ±0.010
3 PLC ±0.005 ANGL ±1/2°
SURFACE FINISH 63 RMS
THIRD ANGLE PROJECTION

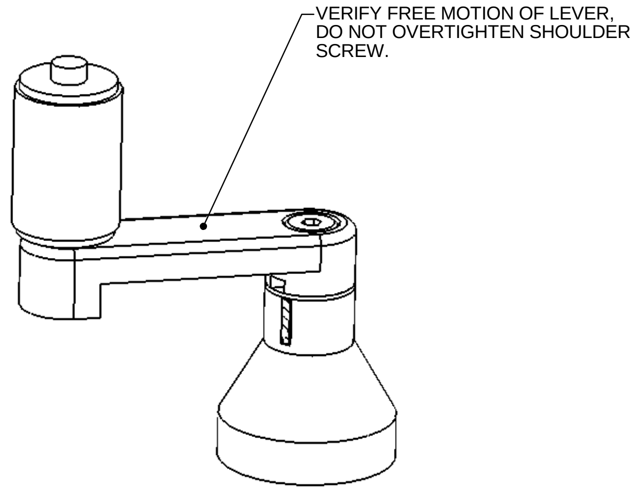
DRAWN: JJM 11-04-13
MFG: TC 11-04-13
ENGR: JJM 11-04-13
TYPE:
STRUCT:

CHANDLER ENGINEERING
SPRING ASSEMBLY,F1,LEFT HAND
PN: 7600-1013
PROJ:
REV H SIZE C
SHEET 1 OF 1

TITLE BLOCK REV 3

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	ECN 130, RELEASED	9/29/06	JB/TC





ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	7600-1173	BASE, BELT TENSIONER	1
2	C10949	IDLER,3/4X1,SST	1
3	5550-0251	SPACER, IDLER PULLEY	1
4	7600-1175	BUSHING, BOTTOM, BELT TENSIONER	1
5	C11206	SPRING, TORSION, T048-180-250-L	1
6	C11205	SCREW, SS, SHLDR, 0.250 x 0.625L	1
7	7600-1174	LEVER, BELT TENSIONER	1
8	7600-1176	BUSHING, TOP, BELT TENSIONER	1

			.	.	SEE BOM	.	
-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
QTY. REQD.				PARTS LIST			

.	.
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS IN INCHES
TOLERANCES:
1 PLACE ±0.030
2 PLACE ±0.010
3 PLACE ±0.005
ANGLES ±1/2°
SURF. FINISH

APPROVALS		DATE
DRAWN:	JJM	09/23/04
CHECKED:	DH	9/30/2004
ENGR.:	JJM	09/23/04

CHANDLER ENGINEERING

TITLE

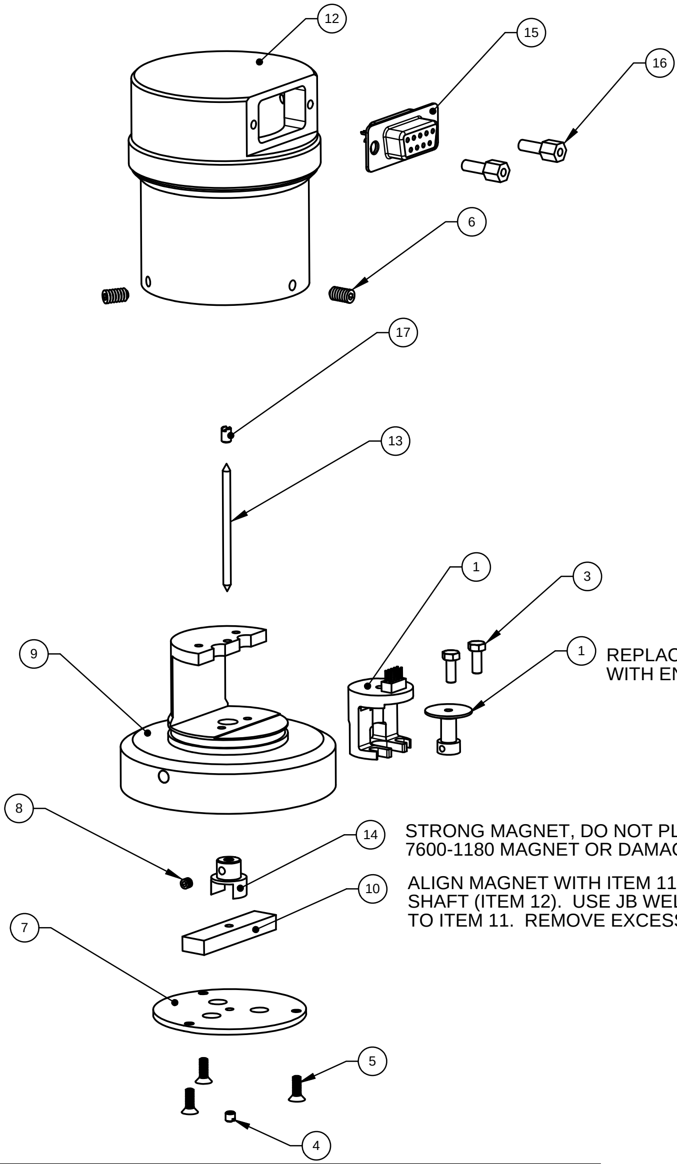
BELT TENSIONER ASSEMBLY

SIZE	S.O. NO.	DWG NO.	REV.
C		7600-1022	A

SCALE: 1:0.333333 SHEET: 1 of 1

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	C	ECN T3244; UPDATED ASSEMBLY PROCEDURE 7600-1066, CHANGED TOP JEWEL BEARING TO SPRING LOADED VERSION	08/20/2010	JJM
	D	ECN T3897; ADDED NON-MAGNETIC SET SCREW C13856	6/7/11	TC

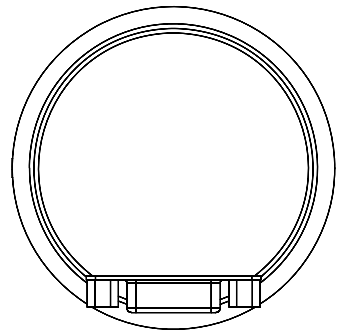
NOTE: ASSEMBLE PER PROCEDURE 7500-1066

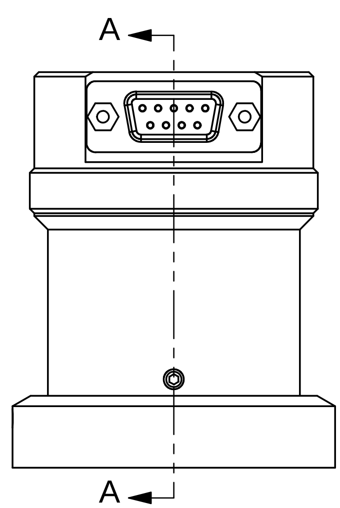


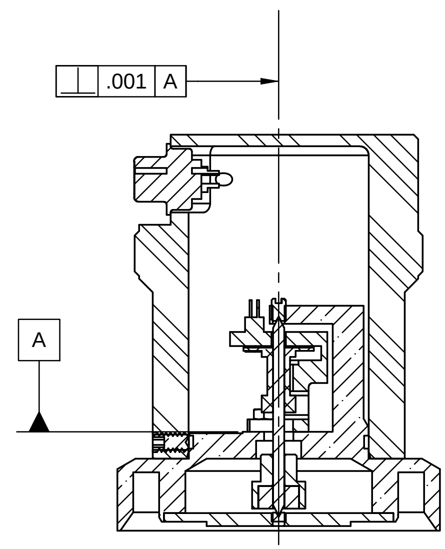
REPLACE METRIC SET SCREW PROVIDED
WITH ENCODER ASSEMBLY WITH C13856

STRONG MAGNET, DO NOT PLACE NEAR ANOTHER
7600-1180 MAGNET OR DAMAGE MAY OCCUR

ALIGN MAGNET WITH ITEM 11 USING ENCODER
SHAFT (ITEM 12). USE JB WELD EPOXY TO BOND MAGNET
TO ITEM 11. REMOVE EXCESS EPOXY WITH COTTON TIP.







SECTION A-A

ITEM NO.	PART NUMBER	DESCRIPTION	Default/QTY.
1	C11223	ENCODER ASSEMBLY	1
2			
3	C11229	SCREW,HHMS,BR,3-48X0.250	2
4	C11182	BEARING, SAPPHIRE, VS-50, #3-56	1
5	C11184	SCREW, BRASS, FH, #2-56 x 0.25L	3
6	C11238	SCREW, BRASS, CUP SET, 6-32 x 0.25L	3
7	7600-1210	PLATE, MAGNET COVER	1
8	C11509	SCREW, SS, CUP PT SET, 3-48 x 0.094L	1
9	7600-1177	BASE, ENCODER HOUSING	1
10	7600-1180	MAGNET, ENCODER COUPLING	1
11	7600-1198	PIN, ENCODER ALIGNMENT	1
12	7600-1179	HOUSING, ENCODER	1
13	7600-1215	SHAFT, ENCODER PIVOT	1
14	7600-1178	SHAFT, ENCODER	1
15	7600-1193	CABLE ASSEMBLY, ENCODER	1
16	C09285	STDF,HEX,ZN,0.18X0.31,4-40,M/F	2
17	C13157	BEARING, SAPPHIRE, VS-50-SPRING, #3-56	1
18	C13856	SCREW,SKHSS,SS,M2 x 2mm	1

.	.			.	SEE BOM	.	
-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
QTY. REQD.				PARTS LIST			

.	.
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS IN INCHES
TOLERANCES:
1 PLACE ±0.030
2 PLACE ±0.010
3 PLACE ±0.005
ANGLES ±1/2°
SURF. FINISH

APPROVALS		DATE
DRAWN:	JJM	12/28/04
CHECKED:	DH	12/28/04
ENGR.:	JJM	12/28/04

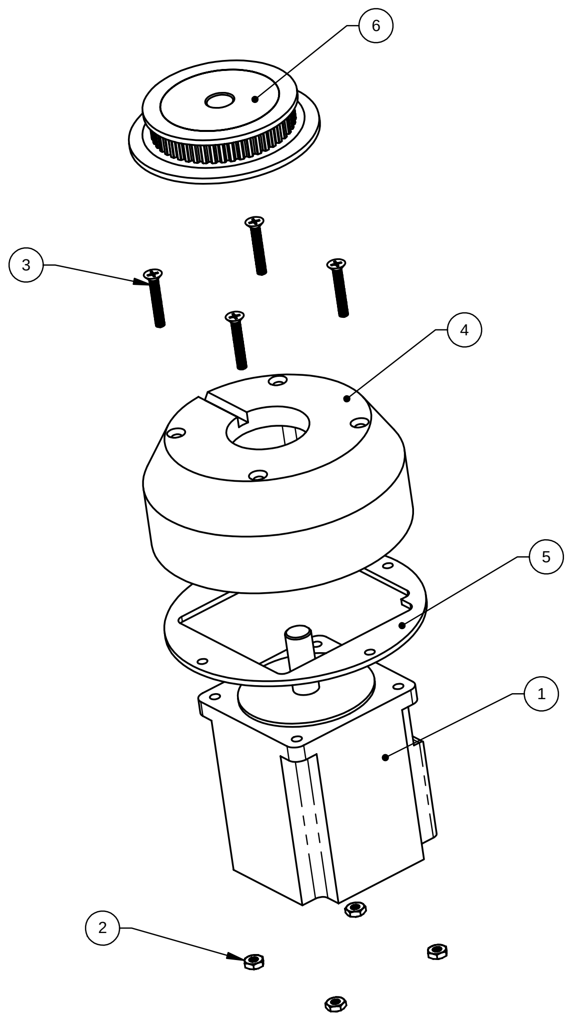
CHANDLER ENGINEERING

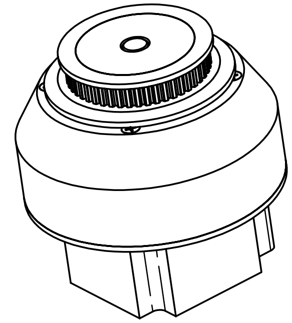
TITLE
ENCODER ASSEMBLY

SIZE C | S.O. NO. | DWG NO. 7600-1023 | REV. D

SCALE: 1.5:1 | SHEET: 1 of 1

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	ECN 130, RELEASED	9/29/06	JB/TC





ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	C10883	M-DRIVE34 W/ENCODER	1
2	H-10-101	NUT, SS, HEX, 10-32	4
3	C11230	SCREW, SS, FH, 10-32 x 1.25L	4
4	7600-1171	HOUSING, MOTOR	1
5	7600-1211	GASKET, MOTOR MOUNT	1
6	7600-1145	PULLEY ASSEMBLY, MOTOR	1

-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
			.	.	SEE BOM	.	
QTY. REQD.					PARTS LIST		

NEXT ASSY	USED ON
.	.
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES

TOLERANCES:
- 1 PLACE ±0.030
- 2 PLACE ±0.010
- 3 PLACE ±0.005
- ANGLES ±1/2°
- SURF. FINISH 63

APPROVALS		DATE
DRAWN:	JJM	09/26/04
CHECKED:	DH	9/30/2004
ENGR.:	JJM	09/26/04

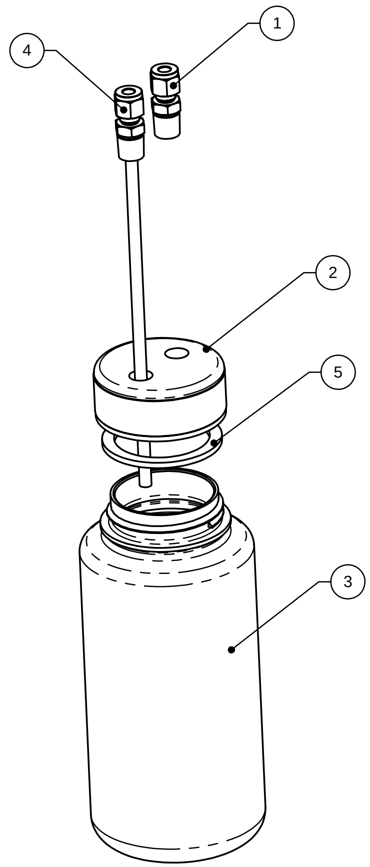
CHANDLER ENGINEERING

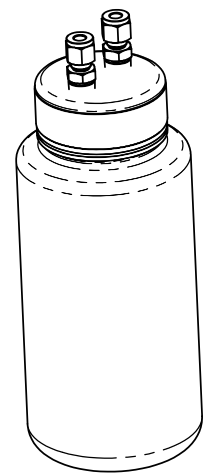
TITLE

MOTOR ASSEMBLY, STEPPER

SIZE	S.O. NO.	DWG NO.	REV.
C		7600-1024	A
SCALE: 1:0.333333		SHEET: 1 of 1	

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	ECN 130, RELEASED	9/29/06	JB/TC





ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	P-1488	FITTING, SWAGELOK, SS-400-4-1	1
2	7600-1187	CAP, TOP, RESERVOIR	1
3	C11114	BOTTLE, 1000mL, NALGENE	1
4	7600-1155	TUBE ASSEMBLY, RESERVOIR, OIL SUPPLY	1
5	7600-1188	GASKET, RESERVOIR CAP	1

			.	.	SEE BOM	.	
-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
QTY. REQD.				PARTS LIST			

.	.
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS IN INCHES
TOLERANCES:
1 PLACE ±0.030
2 PLACE ±0.010
3 PLACE ±0.005
ANGLES ±1/2°
SURF. FINISH

APPROVALS		DATE
DRAWN:	JJM	09/26/04
CHECKED:	DH	9/30/2004
ENGR.:	JJM	09/26/04

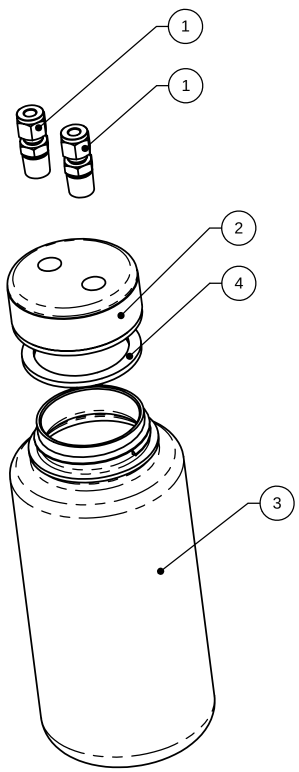
CHANDLER ENGINEERING

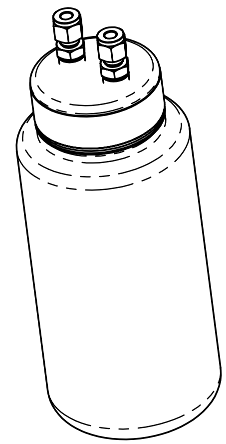
TITLE
RESERVOIR ASSEMBLY, OIL SUPPLY

SIZE	S.O. NO.	DWG NO.	REV.
C		7600-1026	A

SCALE: 1:0.333333 SHEET: 1 of 1

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	ECN 130, RELEASED	9/29/06	JB/TC





ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	P-1488	FITTING, SWAGELOK, SS-400-4-1	2
2	7600-1187	CAP, TOP, RESERVOIR	1
3	C11114	BOTTLE, 1000mL, NALGENE	1
4	7600-1188	GASKET, RESERVOIR CAP	1

			.	.	SEE BOM	.	
-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
QTY. REQD.				PARTS LIST			

.	.
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES

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

APPROVALS		DATE
DRAWN:	JJM	09/26/04
CHECKED:	DH	9/30/2004
ENGR.:	JJM	09/26/04

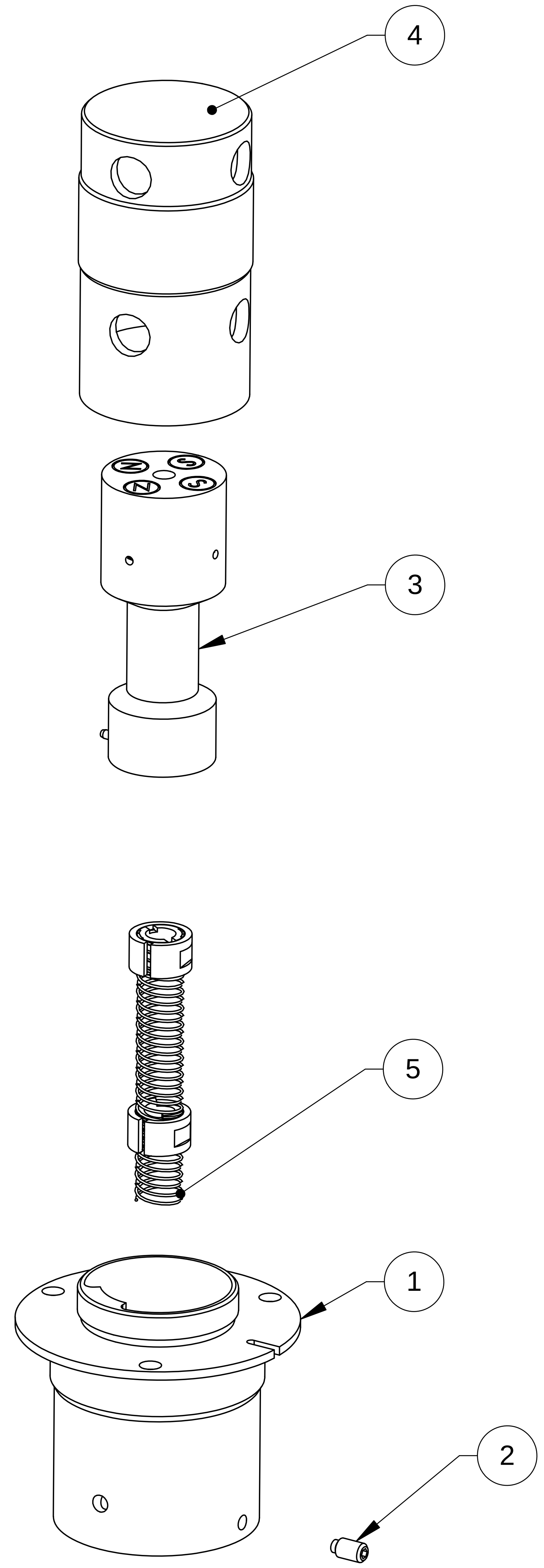
CHANDLER ENGINEERING

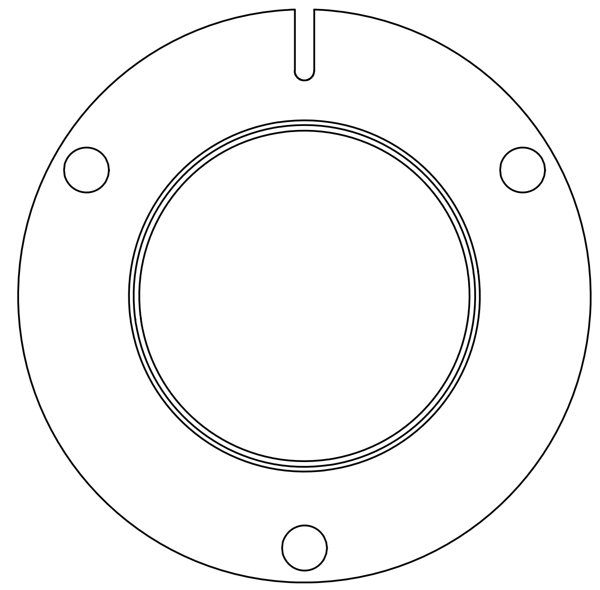
TITLE

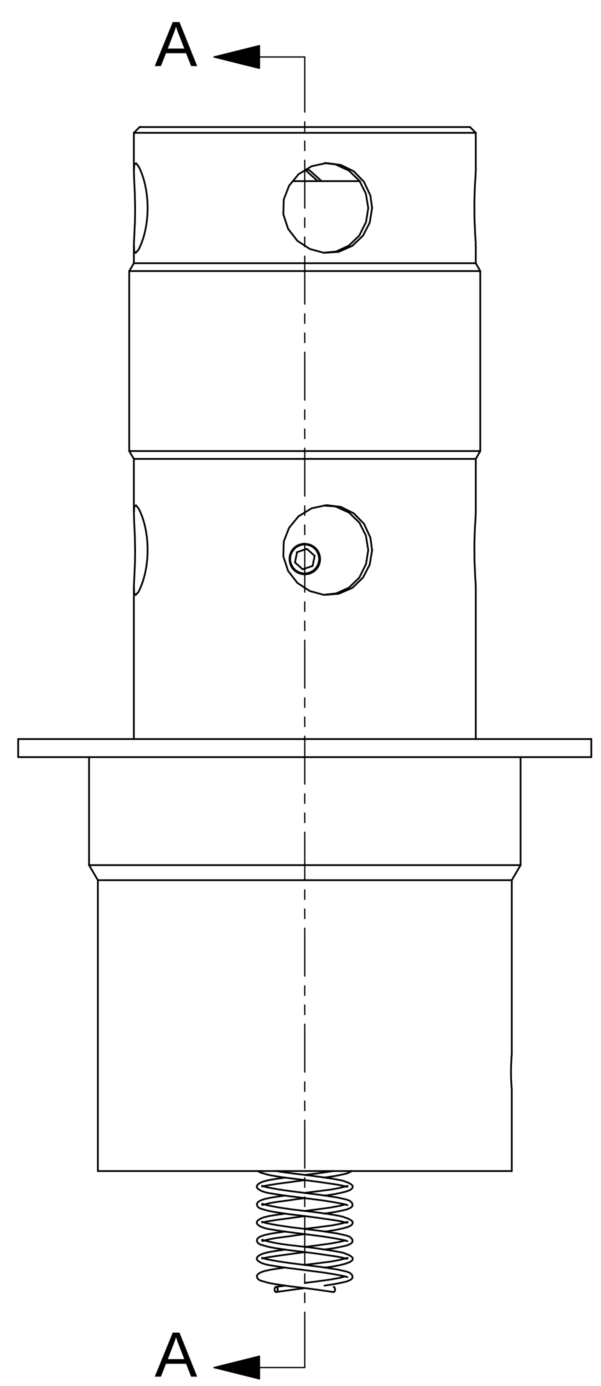
RESERVOIR ASSEMBLY, OIL RETURN

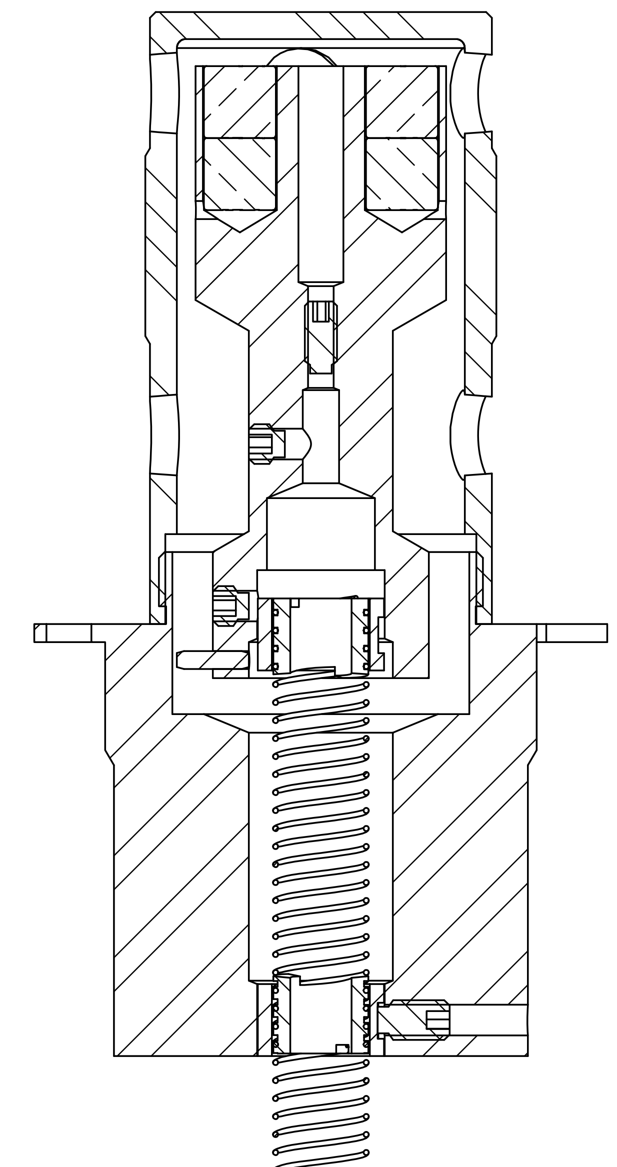
SIZE	S.O. NO.	DWG NO.	REV.
C		7600-1027	A
SCALE: 1:0.333333		SHEET: 1 of 1	

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	G	ECN T5706; REPLACE 7600-1136 WITH 35-0115	1/17/14	TC
	H	ECN T5825; MOVED 35-0115 TO 7600-1013	3/21/14	TC
	J	ECN T7046; ADD NOTE 2.	1/14/2016	JJM









SECTION A-A
SCALE 1.5 : 1

NOTES:
1. ASSEMBLE PER 7600-1063.
2. REFER TO DWG 7600-1021 TO ASSMBLE SHAFT & INNER ENCODER. J

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	7600-1123	HOUSING, SPRING ASSEMBLY	1
2	C08333	SCREW,SKHSS,SS,6-32X0.250,DOG	1
3	7600-1021	SHAFT ASSEMBLY, INNER ENCODER	1
4	7600-1219	CAP, TOP PIVOT, PEEK	1
5	7600-1013	SPRING ASSEMBLY, F1	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 02-13-13
MFG: TC 02-13-13
ENGR: JJM 02-13-13
TYPE:
STRUCT:

CHANDLER ENGINEERING

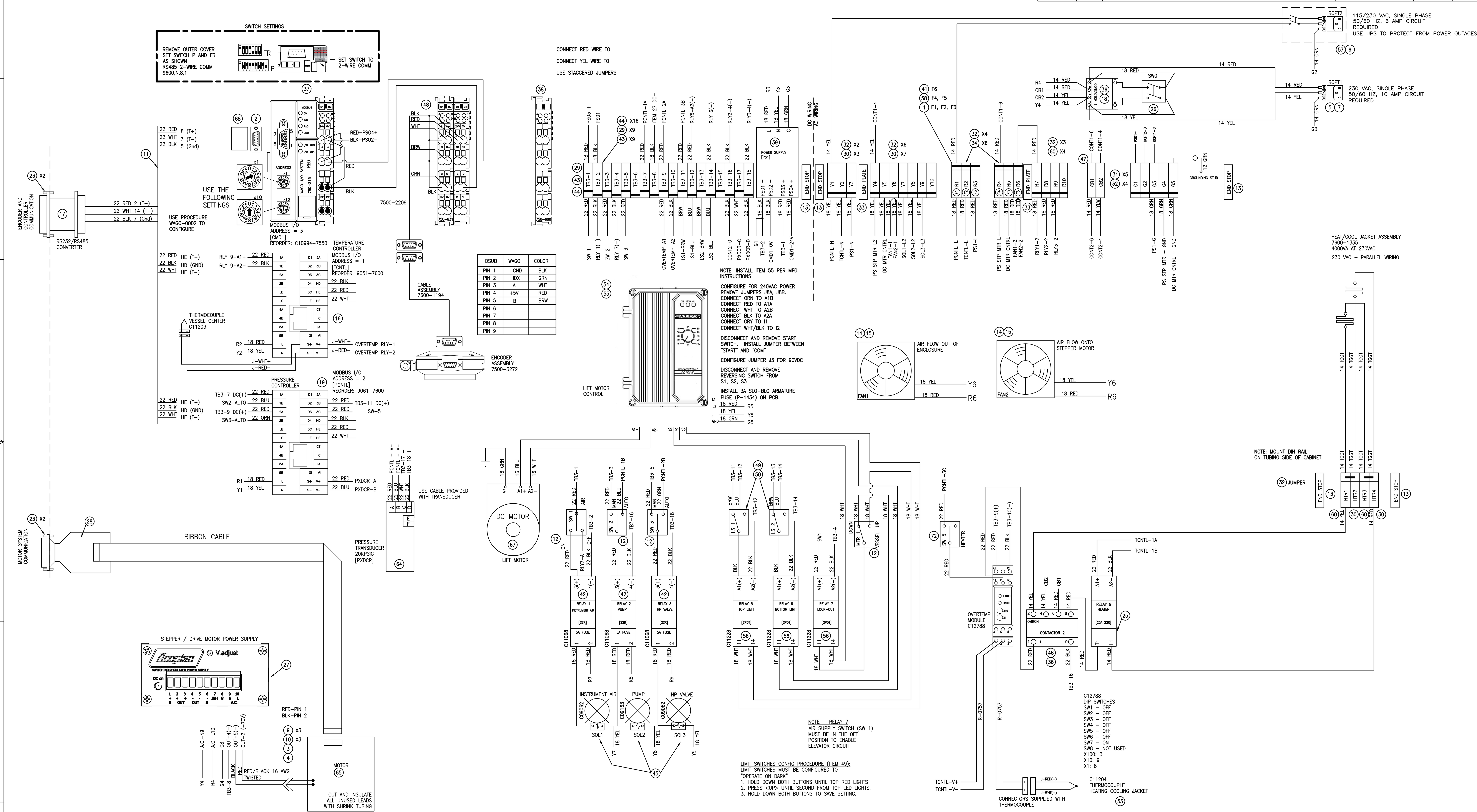
SPRING MODULE ASSEMBLY

PN: 7600-1029
PROJ:

REV J | SIZE C
SHEET 1 OF 1

TITLE BLOCK REV 3

REVISIONS					
ZONE	REV	DESCRIPTION OF REVISION	DATE	APPROVALS	
	AF	ECN T9165; MULTIPLE CLARIFICATIONS	04/09/21	WJW	JS
	AG	ECN T9408; ADDED REORDER NUMBERS	03/18/22	WJW	JS
	AH	ECN T9738; ADDED NOTES	12/07/23	DWC	JS



DSUB	WAGO	COLOR
PIN 1	GND	BLK
PIN 2	IDX	GRN
PIN 3	A	WHT
PIN 4	+5V	RED
PIN 5	B	BRW
PIN 6		
PIN 7		
PIN 8		
PIN 9		

NOTES:
1. ROUTE ALL DC WIRING SEPARATE FROM AC WIRING.
2. CONFIGURE JUMPER J3 FOR 90VDC.
3. INSTALL 3A SLO-BLO ARMATURE FUSE (P-1434) ON PCB.

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:	JJM	10/18/04
CHECKED:	RW	11/06/04
ENGR.:	JJM	10/18/04

CHANDLER ENGINEERING

TITLE
WIRING DIAGRAM
7600 VISCOMETER

SIZE	S.O. NO.	DWG NO.	REV.
D		7600-1030	AH
SCALE: 1 = 1	DO NOT SCALE DRAWING	SHEET: 1 of 2	

QTY	P/N	DESCRIPTION	ITEM		QTY	P/N	DESCRIPTION	ITEM
1	C11037	FUSE 2AMP 250V,SLOBLO 5X20MM	40					
1	C10999	PS,SW,DIN,24VDC,2A,WAGO	39					
1	C10998	MODULE,WAGO END,750-600	38					
1	C10994	BASE,MODBUS,WAGO,750-315	37					
2	C10964	SOCKET,RELAY,DIN RAIL MOUNTING	36					
			35		1	P-1434	FUSE,3.000A,250V,3AG,TIMEDELAY	76
6	C10906	BLOCK,FUSE,WAGO 281-623	34		1	7500-2209	CABLE ASSY, INTERNAL ENCODER	75
8	C10905	PLATE,END,WAGO 280-309	33		REF	7600-1261	LIMIT SWITCH ASSEMBLY	74
16	C10903	JUMPER,ADJ,WAGO 280-402	32					73
5	C10902	BLOCK,GND,WAGO 280-907	31		1	C12403	SWITCH,RCKR,PNL,SPDT,ON-OFF	72
12	C10901	BLOCK,TERM,YEL,WAGO 280-906	30		1	C07085	RES ,4.75K,1/4W,1%,MF	71
9	C10900	BLOCK,TERM,RED,WAGO 280-903	29					70
1	C10885	MDRIVE,CONVERTER/CABLE	28					69
1	C18724	POWER SUPPLY,70V,STEPPER MOTC	27		1	C07981	HOOD ,FOR 9 PIN CONN (CO7980)	68
1	C10526	SWITCH, SEALED, 250V, 10A	26		REF	C19403	MOTOR,GEAR,DC,1/20HP,90VDC	67
1	C16896	RELAY,SPST,32VDC,23A,DIN RAIL	25		REF	C11202	HEATER,CARTRIDGE,350W	66
1	C12788	RELAY,SPDT,24VAC/DC,0-399C,DIN	24		REF	C10883	MOTOR,STEPPER DRIVE 34	65
4	C09285	SCREW, JACK, 0.312 LENGTH	23		REF	C07833	XDCR, PRESSURE, 40,000 PSI	64
			22		REF	7600-1194	CABLE,ENCODER INTERFACE	63
			21		REF	7600-1123	HOUSING,SPRING	62
			20		6	C11127	BLOCK,TERM,BLUE	60
1	C18299	CONTROLLER,ETHERM,EPC3008,1/8D	19					59
1	C08999	RELAY,DPST 240VAC 25A	18		2	70610-68	FUSE,5A,250V,3AG,SLOW BLOW	58
1	C10792	CONVERTER,RS232-RS485,9 PIN	17		1	C11315	MODULE,PWR ENTRY,250V 6A	57
1	C17915	CONTROLLER,ETHERM,EPC3008,1/8D	16		3	C11228	RELAY,DIN MOUNT	56
2	C08890	GUARD, FAN, 3-1/8",AC & DC	15		1	C11227	FBR CARD,MOTOR	55
2	C08889	FAN, 80 x 42 mm, 230 VAC	14		1	C11226	CONTROLLER,MOTOR	54
8	C08226	STOP,END, ENTRELEC #103002.26	13		1	C11204	THERMOCOUPLE,J-TYPE,SS,4"LONG	53
4	C08126	SWITCH,SPDT,ROCKER,ON/OFF/ON	12		1	C11203	THERMOCOUPLE,J-TYPE,SS,6"LONG	52
6	C07646	CABLE, 3 CNDCT,20 AWG,SHLD W/D	11					
3	C07377	TERM,FEMALE,MOLEX 02-06-5103	10		2	C11199	CABLE,FIBER OPTIC	50
3	C07376	TERM,MALE,MOLEX 02-06-6103	9		2	C11198	SENSOR,FIBER OPTIC	49
1	C07364	CONN,9 PIN D SUB,PIN CONTACT	8		1	C11291	MODULE, INCR ENCODER, WAG	48
			7		1	C16147	BREAKER,30A,TYPE D,DIN,2P	47
			6		1	C11189	RELAY,DPST,25A,24VDC COIL	46
1	70616-90	CONN,AC RCPT LINE FILTER 3 CK	5		REF	C11122	VALVE,SOLENOID,220VAC,60HZ	45
1	C07458	RCPT ,3 PIN,MOLEX 03-06-1032	4		17	C11128	JUMPER,STAGGERED	44
1	70605-69	HOUSING,3 PIN,MOLEX 03-06-2032	3		9	C11126	BLOCK,TERM,BLK	43
1	14-1128	CONN,PLUG:9 TERM, D-SUB, CINCH	2		3	C11068	RELAY,SS,4-32VDC IN,5 AMP	42
3	P-1130	FUSE,1A,250V,3AG,SLO-BLO	1		1	C04480	FUSE,0.5AMP 250V,3AG,FAST	41

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:	JJM	10/18/04
CHECKED:	RW	11/06/04
ENGR.:	JJM	10/18/04

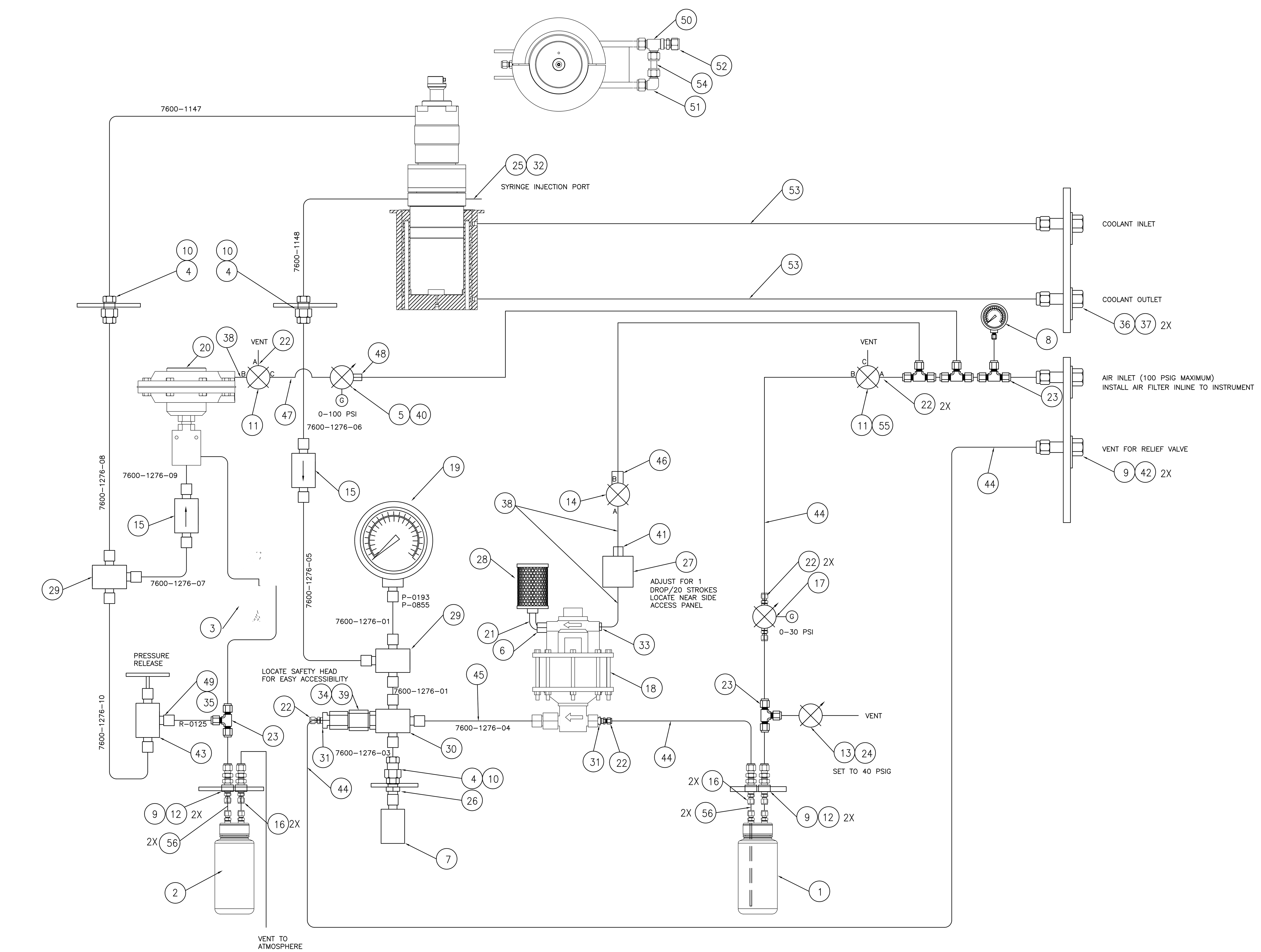
CHANDLER ENGINEERING

TITLE
WIRING DIAGRAM
MODIFIED 7600 VISCOMETER

SIZE	S.O. NO.	DWG NO.	REV.
D		7600-1030	AH

SCALE: 1 = 1 | DO NOT SCALE DRAWING | SHEET: 2 of 2

ZONE	REV	DESCRIPTION OF REVISION	DATE	APPROVALS	
	J	ECN T6747; ADOPTED CHANGES PER CP368	08/22/15	JJM	JJM
	K	ECN T7046; UPDATED BOM	2/3/16	TC	TC
	L	ECN T7364; CHG CAP TBG TO 7600-1352	08/17/16	JJM	JJM
	M	ECN T8776; CORRECTED PART NUMBERS AT GAUGE	11/05/19	JJM	JJM



			4	7600-1255	TUBE,SS,90DEGREE		56
			1	107490	SPACER, SOLENOID VALVE		55
			2	7600-1342-T2	HEAT EXCHANGER TUBE		54
			2	7600-1342-T1	HEAT EXCHANGER TUBE		53
			2	C14098	CONN,SS,3/8MPTX1/2T,SW		52
			2	C14168	ELBOW,SS,1/2TX1/2T,UN		51
			2	C15968	TEE,SS,RUN,1/2TX3/8FNPT		50
			1	P-1059	ADPTR,SS,1/4HPTX1/8FP,HIP		49
			1	P-1246	ELBOW,BR,1/8MPX1/4T		48
			1	P-1313	NIPPLE,BR,1/4MPX1/8MP,HEX,RDCG		47
			1	P-1255	ELBOW,BR,1/4MPX1/4T		46
			1	7600-1276	TUBESET		45
			20	R-0125	TBG,COP,0.250ODX0.032W		44
			1	P-2189	VALVE, ANGLE, 60KPSI,SST,1/4HPT		43
			2	P-1954	CONN, BRS, 1/4 FPX1/4T, BHD, SW		42
			1	P-1496	ELBOW,BR,1/4FPX1/4MP,ST,90DEG		41
			1	P-1887	REG, PRESS, 300/100 PSI, 1/8 FP		40
			1	P-1593	DISK, RUPTURE, 45000 PSI, 1/4, INC		39
			3	P-1480	NIPPLE, SS, 1/4MPX1/4MP, HEX, CA		38
			2	C16140	CONN,BRS,1/2TX1/2FNPT,BLKHD		37
			2	C16141	RETAINER,SS,1/2T		36
			1	P-1244	CONN, BRS, 1/4TX1/8 MP SW		35
			1	69-793	SAFETY HEAD,.25X.083TBG F/1/4A		34
			1	P-0256	BUSHG,BRS,1/4FPX1/2MP		33
			1	P-0915	PLUG, SS, 1/4T,HP,HIP		32
			2	P-0866	BUSHG,BRS,RDCG,1/4FPX3/8MP		31
			1	P-0756	CROSS, SS, 1/4T, 60000PSIG		30
			2	P-0754	TEE, SS, 1/4T, 60000PSI, HIP		29
			1	P-0674	MUFFLER, 1/2 MPT, 3.75D X 5.5 LG		28
			1	P-0518	LUBR, HYDR, .33PT, .25FPX .25FP		27
			1	C08702	ADPTR,HIP,SS,1/4HPMX1/4HPM,60K		26
			3	P-0193	GLAND, SST, TUBE, 1/4TX9/16-18RH		25
			1	C09545	KIT, SPRING, RELIEF VALVE		24
			4	P-1265	TEE,BRS,UN,1/4TX1/4TX1/4T,SW		23
			7	P-1254	CONN,BRS,1/4MPX1/4T,SW		22
			1	P-1285	ELBOW,BRS,ST,1/2FPX1/2MP		21
			1	C11218	VALVE, DIAGPHRAGM, NO, 60000PSIG		20
			1	C11216	GAUGE, INCONEL, 6" 8000 PSIG		19
			1	C11215	PUMP, HP, 40000 PSIG		18
			1	C11207	REG, AIR, .25NPT, 0-10PS		17
			4	P-1488	CONN,SS,1/4MPTX1/4T,SW		16
			2	C11191	FILTER, .25"T, HP, 60000PSIG		15
			1	P-3107	VALVE,SOL,SS,1/4F,2WY,240VAC		14
			1	C11316	VALVE, RELIEF NUPRO		13
			4	C09283	CONN,SS,1/4FPTX1/4T,BHD,SW		12
			2	C09062	VAL, SOL, 3-WAY, VERSA, 240VAC		11
			3	C08582	CONN, 1/4HPTX1/4HPT,60KPSI,BHD		10
			6	C08268	RETAINER, SST, 3/4ID, BHD, SW		9
			1	C07946	PG, 160 PSI, 1 1/2, 1/8 MP, CB		8
			1	C07833	XDCR, PRESSURE, 40,000 PSI		7
			1	C06833	BUSHG, STL, RDCG, 1/2 FP X 3/4 MP, CA		6
			1	C06572	PG, 100 PSI, 1 1/2, 1/8 MP, CB		5
			3	80-0031	BRACKET, ANTI-ROTATION		4
			1	7600-1352	ASSY, CAPILLARY TUBE		3
			1	7600-1027	ASSY, RESERVOIR, OIL RETURN		2
			1	7600-1026	ASSY, RESERVOIR, OIL SUPPLY		1
-04	-03	-02	-01	PART NUMBER	DESCRIPTION	MATERIAL SPEC.	ITEM
QTY. REQD.				PARTS LIST			

NOTES:
1. USE TUBE SET DRAWING 7600-1276 FOR HIGH PRESSURE TUBING.
2. USE TUBE SET DRAWING 7600-Tx FOR THE LOW PRESSURE TUBING.

NEXT ASSY	USED ON	UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES [mm] TOLERANCES: 1 PLACE ±0.030 2 PLACE ±0.010 3 PLACE ±0.005 ANGLES ±1/2° SURF. FINISH 63		CHANDLER ENGINEERING
APPLICATION				TITLE TUBING DIAGRAM 7600 VISCOMETER
BREAK SHARP EDGES, DEBURR		APPROVALS	DATE	
		DRAWN: JJM	04/21/14	SIZE D / S.O. NO. / DWG NO. 7600-1031 / REV. M
		CHECKED: LDR	04/21/14	
		ENGR.: JJM	04/21/14	SCALE: 1 = 1 / TITLE BLOCK REV: 1.0 / SHEET: 1 of 1

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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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COMMERCIAL INSTRUMENTATION MANUFACTURED BY OTHERS

Commercial instrumentation manufactured by others is covered by separate manufacturer warranty, generally for one year. Contact Chandler Engineering for instructions on obtaining the service directly from the manufacturer.

Our warranty does not cover damage or failure caused by abuse, misuse, abnormal usage, faulty installation, improper maintenance, or any repairs other than those provided by authorized Chandler Engineering personnel.

This warranty is in lieu of all other warranties, expressed or implied, and of all obligations or liabilities on its part for damages including but not limited to consequential damages, following the use or misuse of instruments manufactured by Chandler Engineering Company L.L.C.

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