

**BROOKFIELD MODEL PVS RHEOMETER INSTALLATION
AND RHEOVISION SOFTWARE OPERATION
INSTRUCTIONS**

Manual No. M/97-580-B0502



**SPECIALISTS IN THE
MEASUREMENT AND
CONTROL OF VISCOSITY**

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Section 1 - PVS Rheometer Description

Introduction

The Brookfield Model PVS Rheometer is designed to test small complex samples by simulating process conditions in a bench top environment (sample boil-off problems are eliminated). The PVS Rheometer measures with a coaxial cylinder geometry and delivers excellent accuracy and outstanding sensitivity. Brookfield's Rheovision software controls the PVS Rheometer to ensure that test parameters are followed under the most demanding test requirements.

Brookfield's unique sensor design responds to minute changes in viscosity, mechanically transmitting a rotational torque signal from the pressure containment area without friction.

The Brookfield Model PVS Rheometer, shown in Figures 1-1, can be used in a variety of applications where the viscosity of a fluid must be measured at temperatures which cause samples to vaporize or boil off.

Features and Benefits

The Brookfield Model PVS Rheometer incorporates the following features:

- Portable and compact
- Quick and easy to operate
- Simulates process conditions
- Designed for reliable operation even in severe environments

The PVS Rheometer provides the following benefits:

- Low maintenance required
- Ability to test samples pressurized under many different gases
- Allows testing of samples at extremely low shear rate

Standard Equipment

The PVS Rheometer includes the following components:

- Rheometer sensing unit and power base with over pressure relief valve
- Choice of one geometry including sample cup and one stator/bob geometry set: B1, B2, or B5 with fluid contact parts manufactured from Hastelloy C corrosion-resistant alloy.
- Desktop Computer (PC)
- Rheovision Software which runs on Windows 9X, Windows ME
- Interconnecting Cables

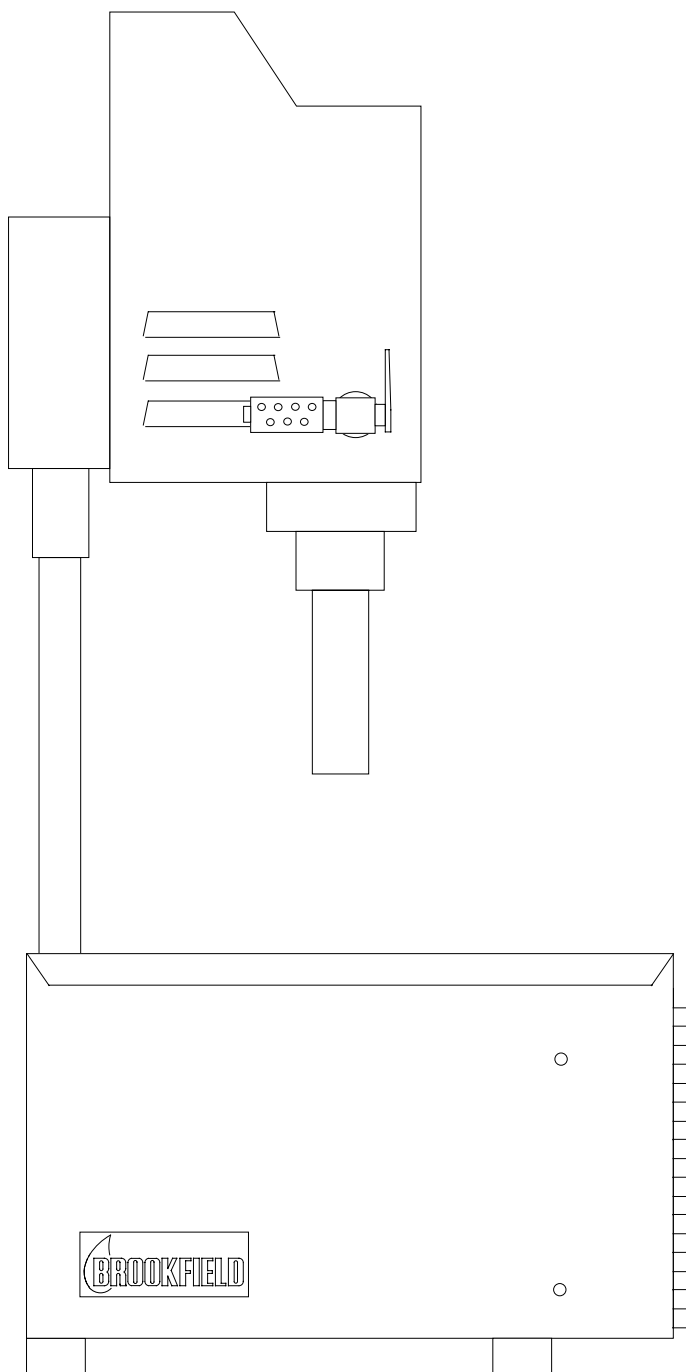


Figure 1-1: Typical Brookfield Model PVS Rheometer

Rheovision Software

Rheovision is designed for use with the Brookfield Engineering Laboratories, Inc. PVS Rheometer and Windows 9X or Windows ME computer operating systems. Its purpose is to control and collect data from the rheometer and allow it to be saved, viewed, printed, plotted, and analyzed. Its features include:

- An easy to learn and use graphical user interface.
- A scripting language to allow flexible data collection.
- Background execution of data gathers (due to the multitasking nature of the MS-Windows operating system).
- On-line plotting of data during a data gather.
- Background printing of data, graphs, and programs.
- Mathematical analysis of collected data.
- Control of an optional Brookfield Engineering Labs temperature bath.
- Calculation of industry specific data (Example: API power law calculations for the oil and gas industries). Refer to Appendix C for more information.

Rheovision System Requirements

The system requirements outlined in Table 1-1 must be met in order for Rheovision software to operate properly.

Table 1-1: Rheovision System Requirements

System Parameter	Requirement
Microprocessor	Pentium II (minimum)
Memory	32 MB minimum, 64 MB recommended
Hard Drive	20 MB minimum
Video	VGA (640 x480 resolution) minimum
Operating System	MS-Windows 9X, Windows ME
Mouse	Required
RS-232 Port	One free COM port required.

Registering Rheovision

Fill out and FAX the Rheovision Registration form, included with Rheovision to Brookfield Engineering Laboratories, Inc.

Theory of Operation

Brookfield's unique sensor design responds to minute changes in viscosity, mechanically transmitting a rotational torque signal from the pressure containment area without friction.

The outer cylinder (sample cup) is driven by a stepper motor at speeds from 0.05 - 1000 rpm. The RTD probe measures temperature on the inner cylinder surface (stator/bob) where the shear stress is being measured. The entire sensor assembly is unaffected by changes in either pressure or temperature.

All electronics, bearings, and other sensitive components are completely protected from the influences of both the sample fluid and its vapor. The small angle of deflection ($1/2^\circ$ full scale) provides quick response and minimizes hysteresis and lag during speed ramping.

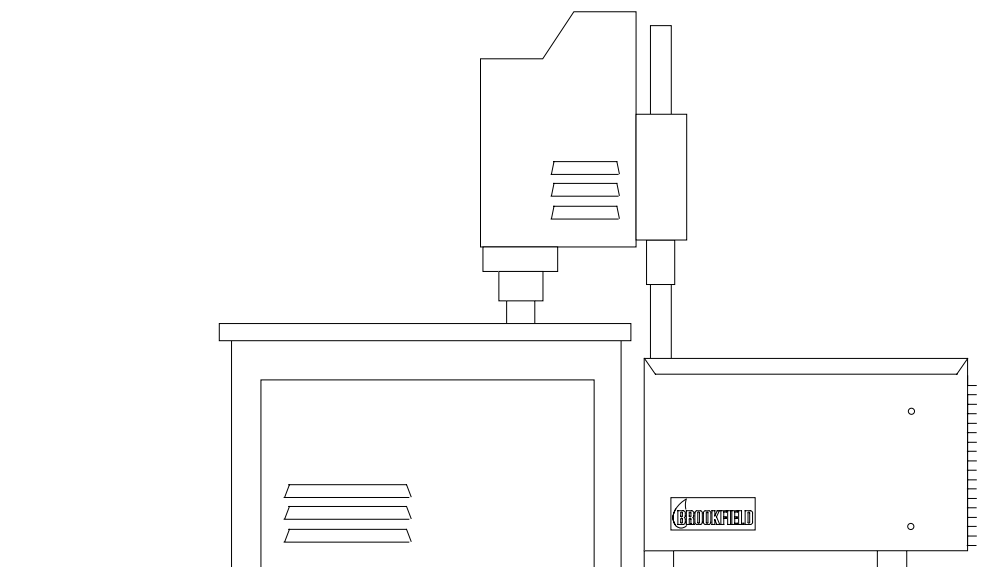


Figure 1-2: PVS Rheometer and Optional Bath

Specifications

The PVS Rheometer specifications are listed in Table 1-2.

Table 1-2: Model PVS Rheometer Specifications

Parameter	Specification
Sample Size	30 - 140 ml
Vapor Space	90 ml
Pressure	0 -1000 psi
Speed Range	0.05 - 1000 rpm
Shear Rate Range	0.01 sec. ⁻¹ - 1700 sec. ⁻¹
Repeatability	± 0.2% of full scale range
Temperature Range	-40 - 200° C
Dimensions	12 x 12 x 24 inches (W x L x H) (30.5 x 30.5 x 61.0 cm)
Carrying Case Dimensions	17.5 x 32 x 16 inches (W x L x H) (44.5 x 81.28 x 40.64 cm)
Construction	Hastelloy C Alloy wetted parts

Table 1-2: Model PVS Rheometer Specifications

Parameter	Specification
Computer	Desktop PC with Pentium Processor and Windows Operating System
Weight (without computer)	40 lbs. (18 kg)
Complete System Weight (in optional carrying case without computer)	75 lbs. (34.01 kg)

Required Utilities

The PVS Rheometer requires the utility connections listed in Table 1-3 to operate.

Table 1-3: Utility Requirements

Parameter	Value
Supply Voltage*	115/230 VAC
Line Frequency	50 or 60 Hz
Power Consumption	~ 65 VA
Certification	CE, UL

* Supply voltage of 230 VAC requires a step down transformer.

Geometry Sets

The geometry sets available for use with the PVS Rheometer are listed in Table 1-4.

Table 1-4: Geometry Sets

Set	Sec ⁻¹ /RPM	Annulus (inches/cm)	Sample Volume (ml)
B1	1.703	0.046 (0.117)	30
B2	0.377	0.241 (0.612)	53

Table 1-4: Geometry Sets (Continued)

Set	Sec ⁻¹ /RPM	Annulus (inches/cm)	Sample Volume (ml)
B5	0.85	0.095 (0.241)	40
TA5*	0.85	0.095 (0.241)	140
* Optional Triple Annulus Geometry Set			

NOTE: Refer to Appendix A and contact your local customer support center to order additional geometry sets.

Component Identification

The following paragraphs provide a brief description of each component within the PVS Rheometer. Refer to Figure 1-5 for the component location within the viscometer.

Rheometer Head

The Rheometer head contains the rheometer motor, torque transducer, torsion element and drive assembly. The Rheometer head is supported above the power base by the upright rod and is connected to the power base by motor and torque/temperature signal cables.

Sample Cup

The Sample Cup (outer cylinder) contains the pressurized sample fluid. The sample cup is rotated by a motor and drive assembly which causes the sample fluid to be sheared in the annular space between the cup and the stator/bob.

Power Base

CAUTION

Do not connect/disconnect the Rheometer motor power, signal, or computer cables with power applied to the Rheometer.

The Power Base supports the Rheometer head, and houses the motor drive electronics and signal processors for torque and temperature, power switch and cable connectors for power, signal and computer connections.

Sensing Stack

The Sensing Stack is a replaceable component consisting of a torsion element, mounting tube and drive mounting sleeve.

Stator/Bob

The Stator, also referred to as a bob or inner cylinder, which is mounted on the torsion element, applies torque generated by viscous drag to the torsion element. The dimensions of the stator/bob, in conjunction with the sample cup, are critical to the accuracy of the viscometer. Many different stator/bob sizes are available which provide different viscometer measurement ranges. An Resistive Temperature Detector (RTD) is mounted within the stator/bob.

Torsion Element/Mounting Tube Assembly

The Torsion Element, which is part of the mounting tube assembly, senses the torque from the viscous drag on the stator. The twist or deflection of the torsion element is proportional to the torque applied to it. The torsion element converts shear stress applied to the stator to angular movement.

The mounting tube assembly is used to mount the stator on the torsion element and provides electrical connection between the RTD within the stator and the electronics in the PVS Rheometer power base.

Torsion Element Guard

The Torsion Element Guard is installed with the sample cup and stator removed to protect the torsion element from being damaged.

Safety Relief Valve

The Safety Relief Valve protects the system from excess pressurization and is mounted on the Rheometer pressurization connection. The Safety Relief Valve is designed to open and release pressures in excess of 1200 psi, 200 psi above the maximum operating pressure of 1000 psi.

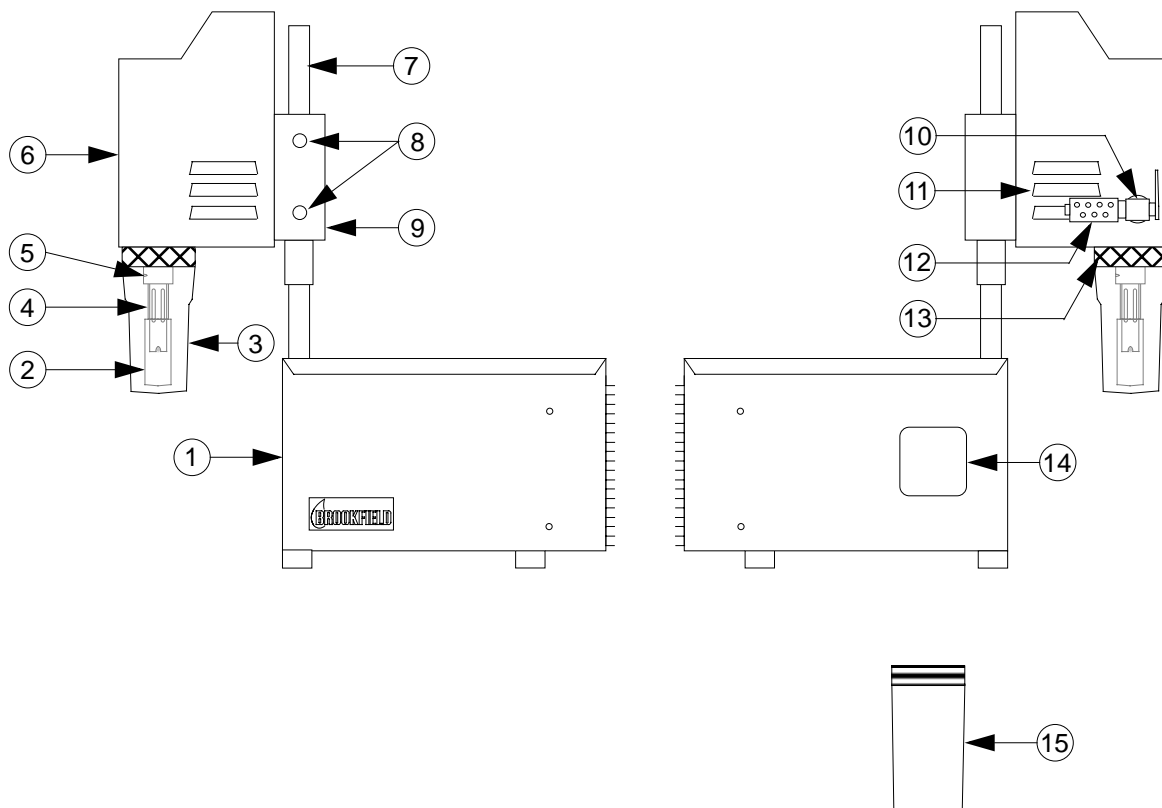
Personal Computer

NOTE: An optional laptop computer can also be ordered from Brookfield Engineering Laboratories, Inc.

The Personal Computer (PC) is used to operate the Rheovision software that controls the PVS Rheometer. The personal computer runs on Windows 9X or Windows ME software and should only be used to operate and control the PVS Rheometer.

CAUTION

No other software programs should be running while Rheovision is running. Various software programs may interfere with the operation of Rheovision software and the PVS Rheometer.



LEGEND

1. POWER BASE
2. STATOR/BOB
3. SAMPLE CUP
4. TORSION ELEMENT/MOUNTING TUBE ASSEMBLY
5. BAFFLE
6. RHEOMETER HEAD COVER
7. UPRIGHT ROD
8. PVS RHEOMETER HEAD CLAMPING SCREW
9. RHEOMETER HEAD CLAMP
10. THREE-WAY VALVE
11. LOUVER
12. SAFETY RELIEF VALVE
13. KNURLED RING
14. CABLE CONNECTOR PANEL
15. TORSION ELEMENT GUARD

Figure 1-3: Typical PVS Rheometer Component Identification

Options

The following optional equipment is available to enhance the operation of the PVS Rheometer when installed within certain product applications. Refer to Appendix A and contact Brookfield Engineering Laboratories, Inc. for more information on these options and accessories.

Heating/Cooling Bath

The Heating/Cooling Bath maintains sample temperature to a user selected level. The sample cup is immersed in the bath medium and transmits heat to or from the sample through the sample cup wall. Certain types of heating/cooling baths may be controlled along with the instrument by Rheovision software.

Portable Computer

The Portable Computer is a specially configured laptop personal computer which can be used to control the PVS Rheometer when portable operation is required. The Portable computer can also be used in installations where laboratory space limitations exist.

Additional Geometry Sets

One geometry set is provided with the PVS Rheometer. Additional geometry sets are available that contain stator/bobs with different dimensions for measuring various samples. Refer to Table 1-4 for more information.

High Surface Area Triple Annulus

The High Surface Area Triple Annulus geometry is for extra low shear rate measurement (includes one special sample cup, one stator/bob, and two adapters) is also available as an additional geometry set. It uses a B5 stator/bob as the inner component. For a given sample and rotational speed, it provides approximately eight times as much torque as with a B5 geometry set alone.

Contacting Brookfield Engineering Laboratories, Inc.

Refer to Appendix A for customer support information.

Section 2 - Installation

Unpacking and Inspection

NOTE: Upon receipt, inspect the case and PVS Rheometer components for shipping damage. Report any damage to the shipping company immediately.

The shipping cartons should contain the following components:

- PVS Rheometer Head, with torque sensor guard installed
- Power Base
- Personal Computer (shipped separately)
- Bath (if specified - including RS-232 cable) (shipped separately)
- Instruction Manual
- Software Diskettes
- Data Cable (power base to computer RS-232 cable)
- Torque/Temperature Cable (attached to rheometer head)
- Rheometer Head/ Motor Power Cable (attached to rheometer head)
- Stator/bob
- Sample Cup

CAUTION

Whenever the PVS Rheometer is transported, the stator/bob must be removed and the sample cup or torsion element protector installed to prevent torsion element damage.

Tools Required for Installation

The following tools are required to install the PVS Rheometer:

- Flat blade screwdriver
- 7/64 inch hex wrench
- 5/64 inch hex wrench

PVS Rheometer Installation (Without Triple Annulus)

NOTE: Refer to PVS Rheometer Installation (With Triple Annulus) for systems being installed with a triple annulus.

Bath Installation

1. Refer to the Bath Operators Manual to install and setup the bath in the location in which it will operate.
2. Proceed with Power Base Installation.

Power Base Installation

1. Install the power base next to the bath as shown in Figure 2-1.

CAUTION

The PVS Rheometer head is mounted on the support shaft via a spring loaded clamp. Make sure you hold the head in place before releasing the clamp screws to prevent the head from falling or the spring-loaded support shaft from sliding up through the head. Personal injury or possible equipment damage may result.

NOTE: The upright rod is designed to be free to rotate approximately 120° in its suspended position and will allow the head to be lowered only when rotated to the extreme clockwise position. The upright rod will support the head in the upper most position when it is lifted and rotated away from the bath. Refer to Figure 2-2.

2. Install the sample cup on the PVS Rheometer head.
3. Install the PVS Rheometer head loosely on the upright rod.

NOTE: If a pressure connection is required, install enough flexible tubing to allow the PVS Rheometer head to be moved in and out of the bath.

4. If required, connect flexible tubing between the three-way valve (1/8 inch x 27 NPT ferrule) on the PVS Rheometer head and the pressure source.
5. While supporting the PVS Rheometer head, lower the head into the bath so that the bath fluid level is approximately one inch (25.4 mm) from the knurled ring as shown in Figure 2-1. Push the upright rod down (against spring tension) to its lowest position and while maintaining that position, tighten the clamp screws.

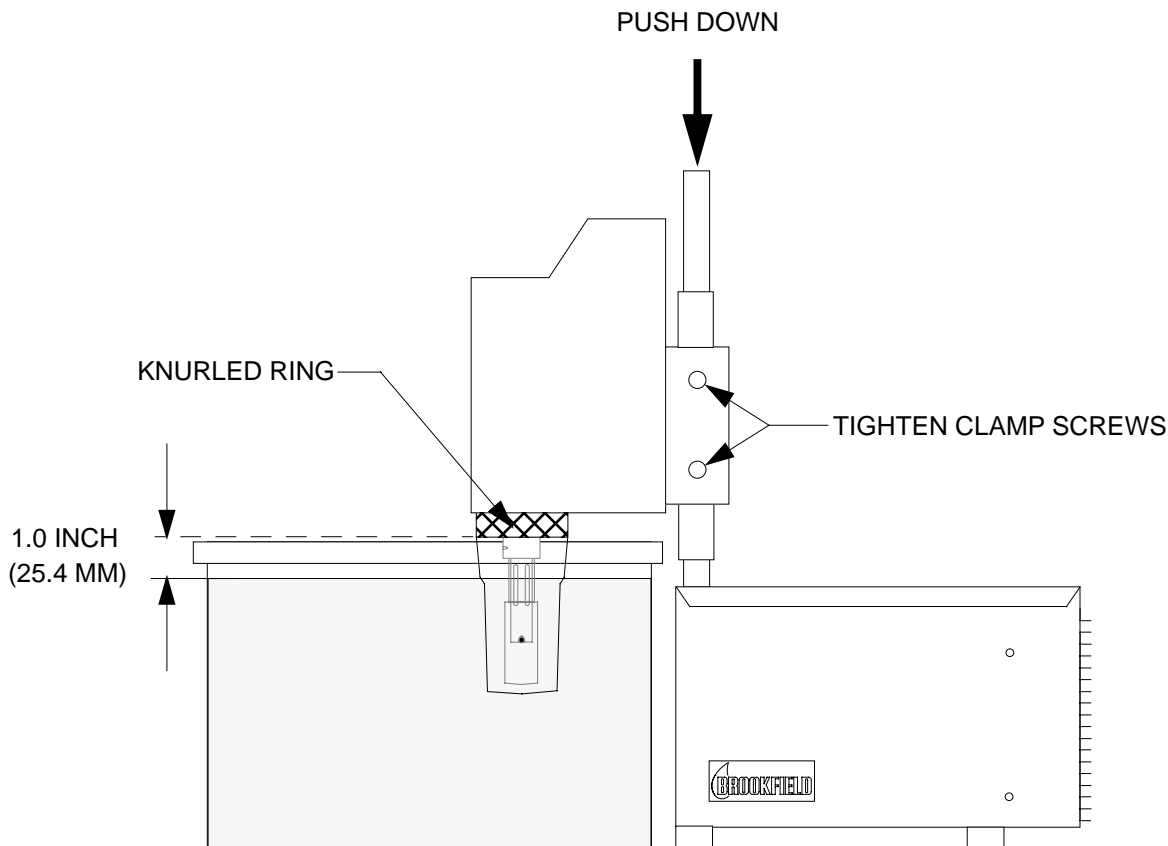



Figure 2-1 Rheometer Head Position and Sample Cup Height

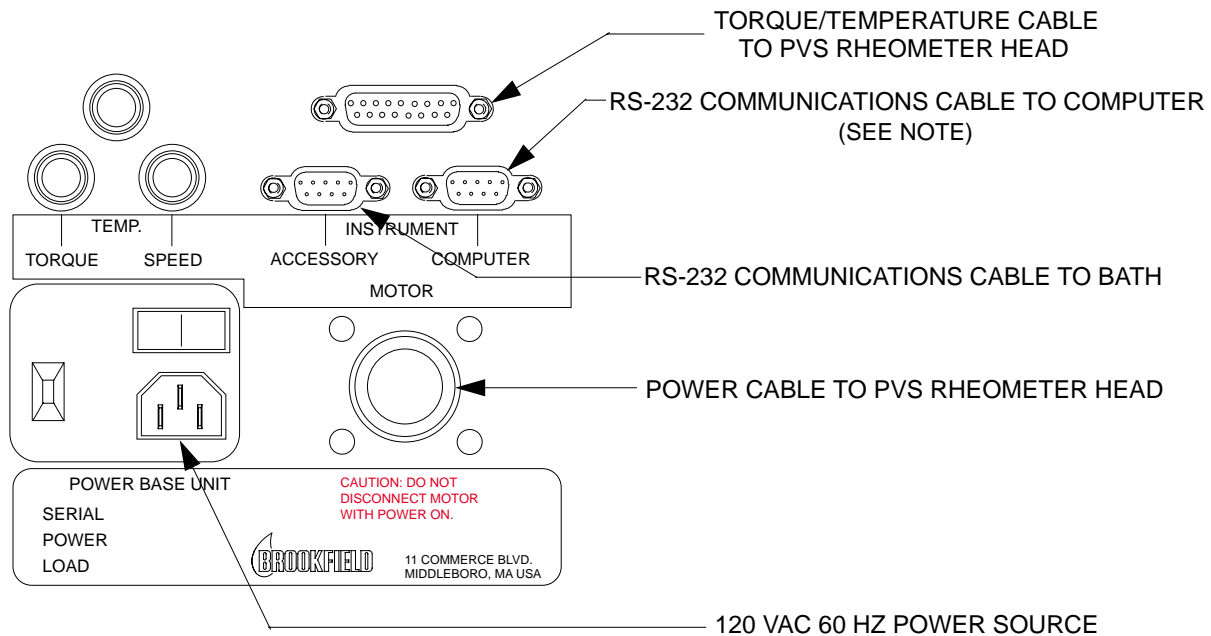
6. Route the motor and RS-232 cables from the PVS Rheometer head to the connectors on the rear panel of the power base as shown in Figure 2-2.



WARNING

Do not connect or disconnect the power cable to/from the PVS Rheometer when connected to a power source. Serious injury and equipment damage may result.

7. Connect the cables to the PVS Rheometer as shown in Figure 2-2 and as follows:
 - a. Torque/Temperature cable from Rheometer head.
 - b. Bath RS-232 Communications cable.
 - c. Computer RS-232 communications cable to the 9 pin connector.
 - d. PVS Rheometer Head power cable
 - e. PVS Rheometer power cord to a 120 VAC 60 Hz power source.



NOTE: Use either the 9 or 25 pin connector for computer RS-232 connections. Do not connect both connectors to the computer.

Figure 2-2: PVS Rheometer Rear Panel Cable Connections

Personal Computer Installation

1. Place the computer in a suitable location that will allow it to be connected to the PVS Rheometer.
2. Install the computer according to the manufacturer's instructions.
3. Connect the RS-232 cable between the COMPUTER connector on the PVS Rheometer and the COM connector (RS-232) on the computer.
4. Turn power on to the computer and monitor and allow the Windows operating system to initialize.
5. Refer to Rheovision Software Installation.

Rheovision Software Installation

NOTE: Make sure all other software applications on your computer have been closed before proceeding with Rheovision software installation.

1. Insert Disk #1 or the CD-ROM disk into the appropriate drive on your computer.
2. Run the setup.exe program by performing one of the following steps:
 - a. Using Windows Explorer, open the window of the appropriate drive then select the setup.exe file icon. The setup routine will be executed.
 - b. Choose START from the desktop, then select RUN. Select BROWSE and locate the appropriate drive and directory that contains the setup.exe file, then select the setup.exe file icon. Select the OK button. The setup routine will be executed.
3. Once the setup routine has been executed, follow the on-screen prompts to complete Rheovision software installation.
4. Once Rheovision has been loaded, the Windows operating system must be restarted to complete the installation.



Section 3 - Operation

Power

Turning Power ON

1. Set the power switch on the PVS Rheometer rear panel to the ON position.
2. Refer to the Bath Operators Manual to turn power ON to the bath.
3. Refer to Starting Rheovision to initialize Rheovision.

Turning Power OFF

1. Select Exit on the Rheovision Dashboard page.
2. Refer to the Bath Operators Manual to turn power OFF to the bath.
3. Set the power switch on the PVS Rheometer rear panel to the OFF position.

Starting Rheovision

1. Turn computer power ON and allow the operating system software desktop to appear.
2. Locate and select the Rheovision32 icon within the Rheovision folder on the Start menu. Rheovision software will be initiated.
3. Select the DASHBOARD tab.
4. From the Instrument Status section, select the appropriate computer COM port to which the Rheometer is connected.
5. Once communication with the PVS Rheometer has been established, the data boxes on the Dashboard page will display live rheometer data and the red light next to PVS will change to green.

NOTE: If live data is not visible within the data boxes, refer to Section 6 - Troubleshooting.

Baffle, Stator/Bob and Sample Cup Installation

NOTE: Refer to Figures 3-1 and 3-2 throughout this procedure.

1. Lift and rotate the PVS Rheometer head out of and away from the bath.
2. Remove the sample cup or torsion element guard by holding the cup or guard and by rotating the locking ring.

CAUTION

Do not strike the stator/bob mounting tube or push it sideways during baffle installation.

3. Slide the baffle (split end up) up the length of the stator/bob mounting tube until the baffle seats into the boss immediately above the mounting tube.
4. Using a 5/64 inch hex wrench, tighten the two baffle clamp screws.
5. Install the stator/bob as follows:
 - a. Lubricate the stator/bob mounting tube O-ring with an appropriate lubricant compatible with the fluid type and temperature being measured.
 - b. While looking down into the stator/bob, rotate the stator/bob so the internal cross bar is aligned in the same orientation as the slot in the stator/bob mounting tube as shown in Figure 3-3.

NOTE: A small depression in the upper horizontal surface of the stator/bob should be positioned away from the mounting post.

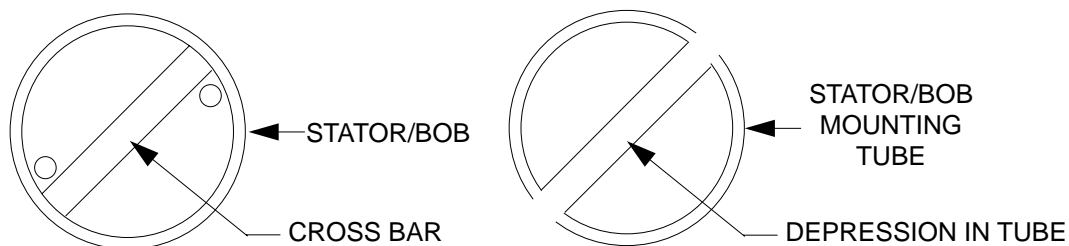


Figure 3-1: Stator/Bob Mounting Tube Alignment (End View)

CAUTION

Forces applied to the stator/bob must be in the same axis of the stator/bob mounting tube. Keep the stator/bob parallel to the stator/bob mounting tube at all times during installation. Otherwise, the stator/bob mounting torque sensor may become damaged.

- c. While maintaining the orientation of the stator/bob, push the stator/bob vertically up along the length of the stator/bob mounting tube, as shown in Figure 3-2, until the stator/bob stops at the top of the tube. When properly installed, there should be approximately a 1/8 inch (3 mm) gap between the stator/bob and the baffle. The stator/bob should gently snap into place.

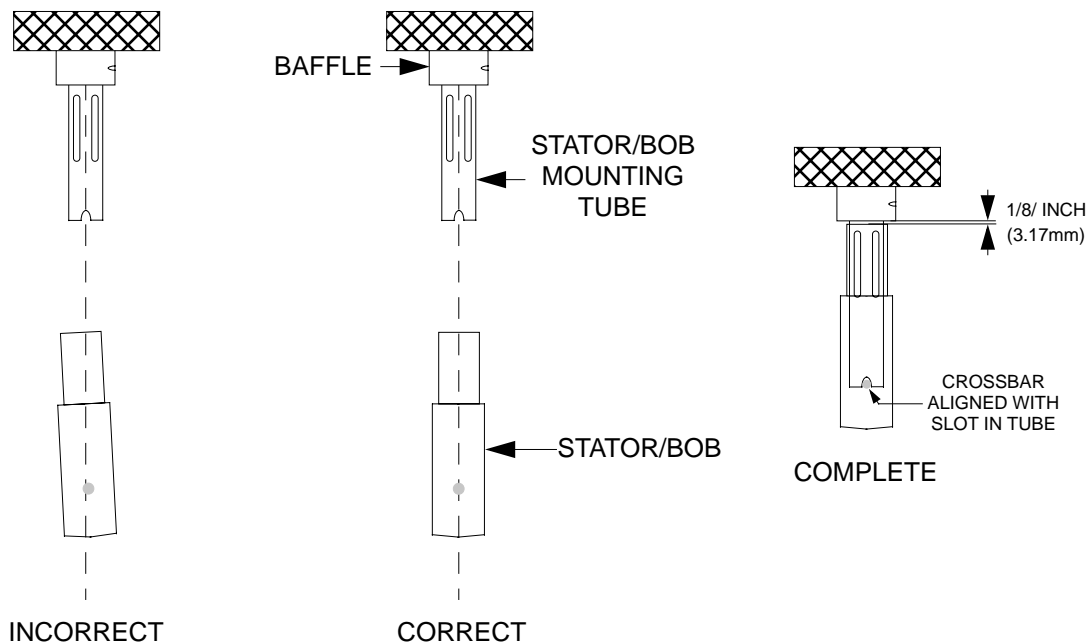


Figure 3-2: Orientation and Force Applied to Stator/Bob During Installation

- 6. Depending upon the stator/bob being used, fill the sample cup with process fluid as specified in Table 3-1.

Table 3-1: Stator/Bob Sample Volume

Stator/Bob	Sample Volume (ml)
B1	30
B2	53
B5	40

CAUTION

The knurled locking ring that holds the sample cup in place should only be tightened by hand. Do not use a wrench to tighten the locking ring or to hold the cup.

- Lubricate the sample cup top inner surface with a lubricant that is compatible with the sample fluid and temperature.

NOTE: The knurled ring has a right-hand thread.

- Carefully install the sample cup by pushing it up squarely. Tighten the knurled locking ring using your other hand.
- Rotate the sample cup and visually check for run-out errors. If a run-out error is observed, remove the sample cup and repeat steps 7 and 8.
- Lower and rotate the PVS Rheometer head into the bath.

CAUTION

Do not exceed 1000 psi when adjusting the pressure system regulator. Damage to the sealing components may occur.

- If required, adjust the pressure source to the appropriate system pressure. Adjust the three-way valve on the PVS Rheometer head to pressurize the head.

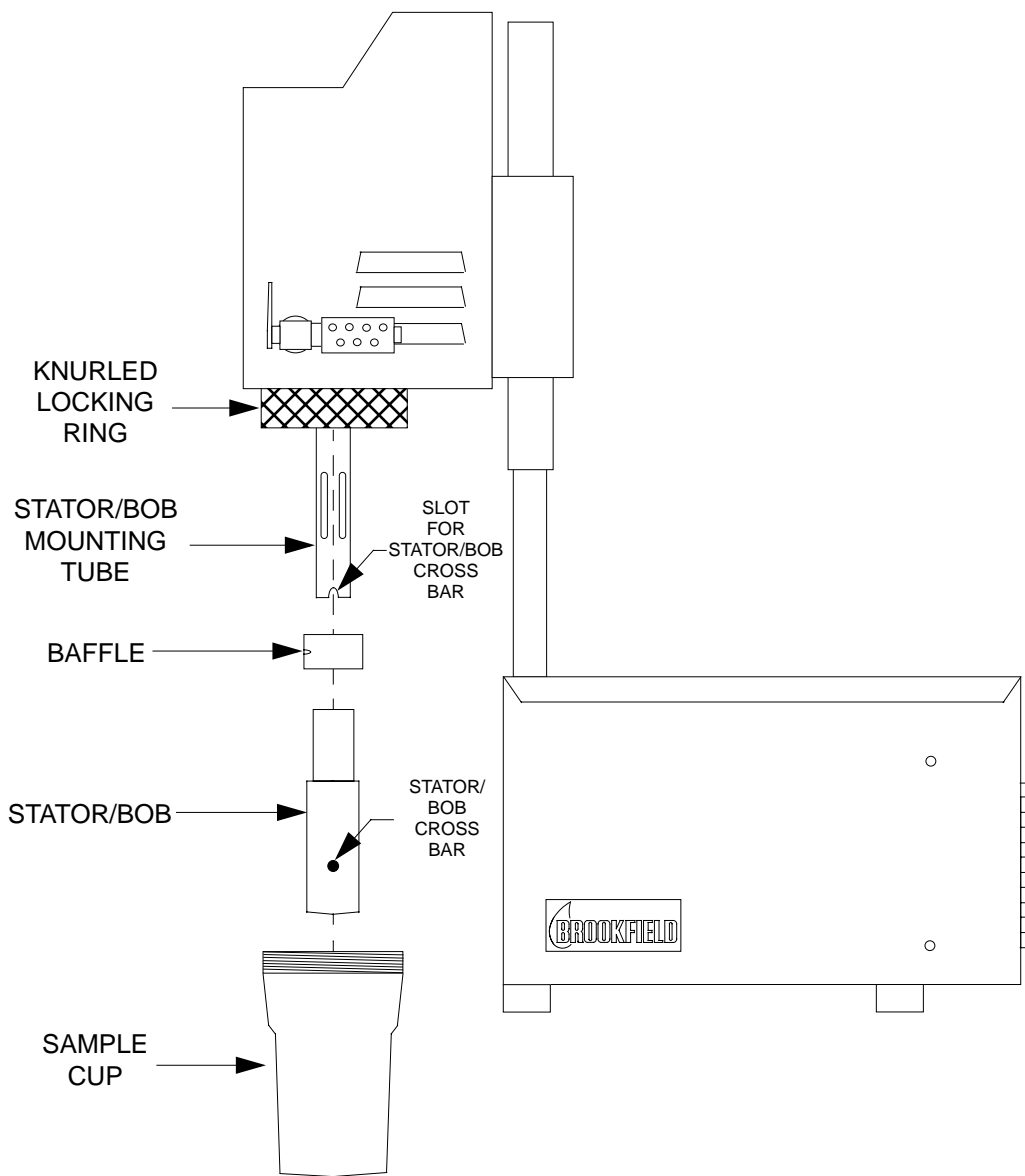


Figure 3-3: Sample Cup, Stator/Bob and Baffle Installation

PVS Rheometer Installation (with Triple Annulus)

The Triple Annulus can be used when low speed, low shear rate measurements are required for solids that are transported within fracturing and drilling fluids.

NOTE: This procedure requires the stator/bob, stator skirt and sample cup and insert.

WARNING

Do not attempt to install the triple annulus until the pressure in the PVS Rheometer head is at 0 psi.

1. Turn the three-way valve on the PVS Rheometer head to depressurize the head.
2. Lift and rotate the PVS Rheometer head out of and away from the bath.
3. Remove the sample cup by rotating the locking ring.
4. Remove the stator/bob and baffle.

CAUTION

Do not strike the stator/bob mounting tube or push it sideways during triple annulus installation.

5. Place the stator skirt over the stator/bob. Position the skirt so the anti-rotation pin in the guard fits into the depression in the upper horizontal stator/bob surface as shown in Figure 3-5.
6. Place the sample cup insert into the cup. Position the insert so the anti-rotation pin in the insert fits into the depression in the sample cup lower inner surface as shown in Figure 3-5.

CAUTION

The baffle is not used with the triple annulus. **DO NOT** reinstall the baffle.

7. Install the stator skirt/bob/stator assembly as follows:
 - a. Lubricate the stator/bob mounting tube O-ring with an appropriate lubricant compatible with the fluid being measured.

- b. While looking down into the stator/bob, rotate the stator/bob so the internal cross bar is aligned in the same orientation as the slot in the stator/bob mounting tube as shown in Figure 3-4.

NOTE: The small depression in the upper horizontal surface of the stator/bob used to position the guard should be positioned away from the mounting post.

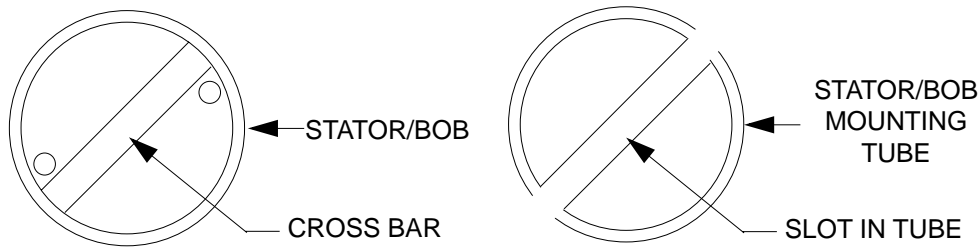


Figure 3-4: Stator/Bob Mounting Tube Alignment (End View)

8. Lubricate the sample cup top inner surface with a lubricant that is compatible with the sample fluid and temperature.
9. Place process fluid into the cup/insert assembly as specified in Table C-1.
10. Carefully install the sample cup by pushing it up squarely. Tighten the knurled locking ring using your other hand.
11. Rotate the sample cup and visually check for run-out errors. If a run-out error is observed, remove the sample cup and repeat steps 10 and 11.
12. Lower and rotate the PVS Rheometer head into the bath.

CAUTION

Do not exceed 1000 psi when adjusting the pressure system regulator. Damage to the sealing components may occur.

13. If required, adjust the pressure source to the appropriate system pressure. Adjust the three-way valve on the PVS Rheometer head to pressurize the head.

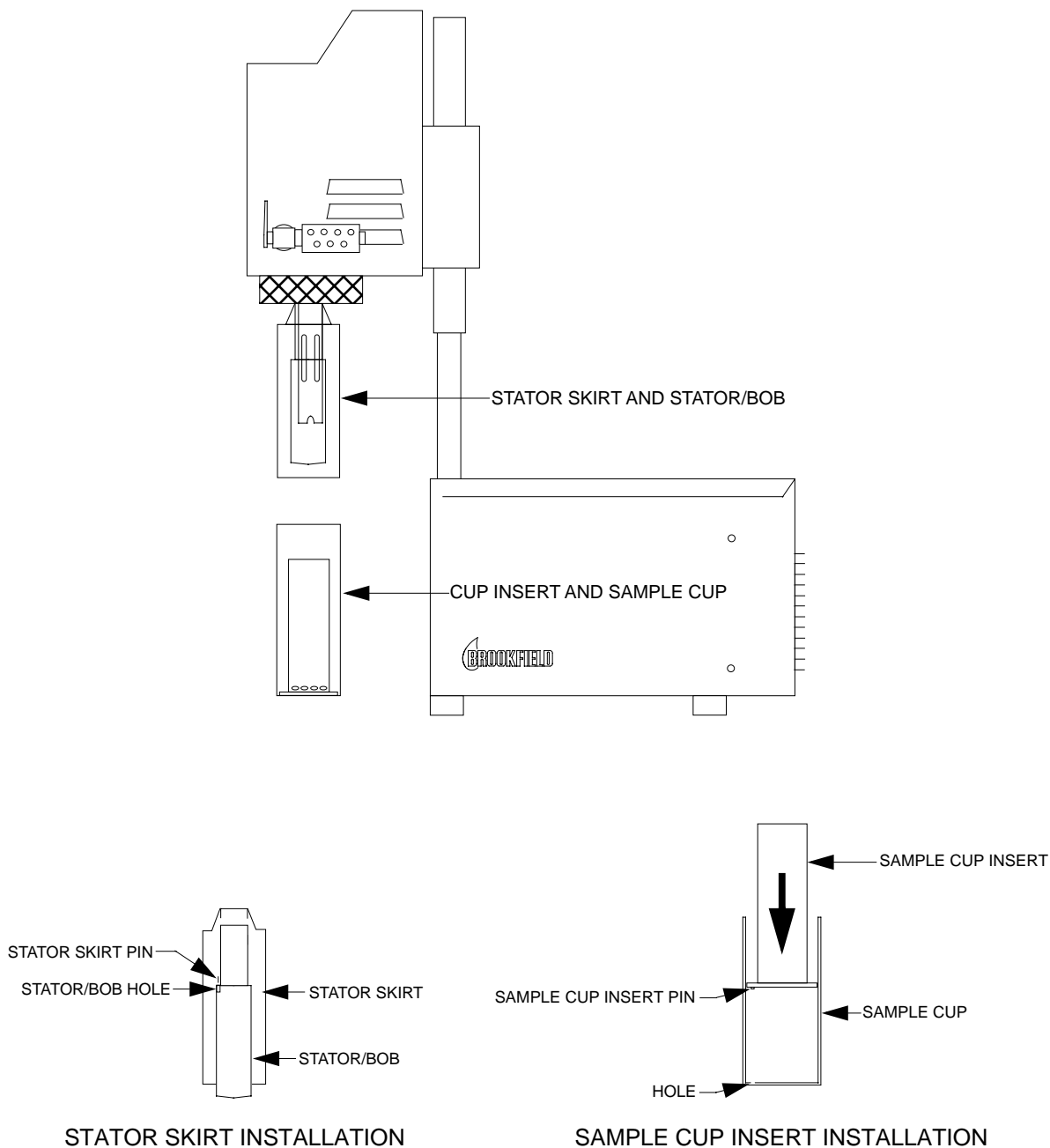


Figure 3-5: Triple Annulus Installation

Cleaning of Wetted Parts

CAUTION

To make sure the PVS Rheometer provides accurate readings, all fluid wetted parts must be kept meticulously clean at all times. Solids can build up on the measuring surfaces and cause inaccurate readings or damage the internal measuring components.

1. Set the power switch on the rear panel of the PVS Rheometer to the OFF position.
2. Shut off the pressure supply to the three-way valve.

NOTE: The three-way valve vents when the arrow on the handle points to the unconnected or venting port.

3. Open the three-way valve to the VENT position to relieve internal PVS Rheometer pressure.
4. Lift and rotate the PVS Rheometer head out of and away from the bath.

NOTE: The knurled locking ring will not be able to be rotated until all internal pressure has been relieved. The knurled locking ring contains a right-handed thread.

5. Remove the sample cup by rotating the knurled locking ring.

CAUTION

Do not strike the stator mounting tube or push it sideways during baffle or stator removal. Forces applied to the stator must be along the axis of the stator mounting tube. Keep the stator parallel to the stator mounting tube at all times during installation. Otherwise, the torsion element may become damaged.

6. While maintaining the orientation of the stator, pull the stator vertically down along the length of the stator mounting tube.
7. Using a 5/64 inch (2 mm) hex wrench, loosen the baffle clamp screws.

NOTE: The baffle is not used with the optional triple annulus geometry set.

8. Slide the baffle down the length of the stator mounting tube and remove it from the mounting tube.

9. Install the PVS Rheometer shipping guard to protect the torsion element.

CAUTION

The sample cup, stator and baffle are made from Hastelloy C alloy. Make sure that these components are not scratched, chemically attacked or dropped while being cleaned.

10. Using an appropriate solvent for the process fluid being measured, clean all surfaces of the sample cup, stator and baffle.

CAUTION

Do not strike the torsion element/mounting tube or push it sideways while cleaning. Otherwise, the torsion element may become damaged.

11. Remove the shipping guard and check the entire length of the torsion element and mounting tube to make sure it is clean. Carefully clean the torsion element to remove debris from all surfaces.
12. Check the inside of the stator for debris. The two pins at the base of the of the torsion element mounting tube and the receptacles inside the stator must be clean in order to provide a temperature signal. Clean and dry if required.

NOTE: Refer to Appendix A and contact Brookfield if the stator must be disassembled for cleaning purposes.

NOTE: Step 13 is not required when using the triple annulus.

13. Install the baffle and tighten the mounting screws.
14. If the PVS Rheometer is to be used immediately, proceed with step 15. If the PVS Rheometer is NOT to be used immediately, reinstall the shipping guard.

CAUTION

Do not strike the stator mounting tube or push it sideways during baffle or stator removal or replacement. Forces applied to the stator must be in the same axis of the stator mounting tube. Keep the stator parallel to the stator mounting tube at all times during installation. Otherwise, the torsion element may become damaged.

15. Carefully install the stator.
16. Charge the sample cup with an appropriate amount sample fluid and install the sample cup.
17. Place the PVS head back into the bath.
18. Close the vent valve.
19. Turn ON the pressure supply to the three-way valve.

Torque Sensor Calibration Test

This procedure can be used to determine if the torque sensor within the PVS Rheometer head is properly calibrated.

1. Lift the PVS Rheometer head out of the bath.
2. Shut off the pressure supply to the three-way valve.
3. Rotate the three-way valve to the VENT position to relieve internal PVS Rheometer pressure.
4. While holding the sample cup, loosen the knurled ring and remove the sample cup.

NOTE: Steps 5 and 6 ensure a raw % torque reading is obtained.

5. Exit from the Rheovision software.
6. Restart Rheovision.
7. Observe the torque display on the Rheovision dashboard. The torque reading must be within 0 +/- 10%. If the reading is not within specification, refer to Appendix A and contact Brookfield.

Section 4 - Rheovision Software

Introduction

Section 3 describes the features and functions of each Rheovision page and dialog box.

Dashboard Page

The Dashboard Page, shown in Figure 4-1, displays the data from, and the status of the PVS Rheometer.



Figure 4-1: Dashboard Page

Dashboard Page Operation

Once the Rheovision software has been loaded, the rheometer operation parameters must be selected to ensure proper operation.

1. Select the **DASHBOARD** tab.
2. From the Instrument Status section, select the appropriate communication port for the rheometer from pull-down list.

3. Select the appropriate stator/bob and cup combination in the geometry section.

Dashboard Page Description

The Dashboard page is shown in Figure 4-1 and described in the following paragraphs.

Viscosity

The Viscosity display indicates the fluid viscosity data measured by the rheometer in units of centepoise (cP) or milliPascal-seconds (mPa·s).

Speed

The Speed display indicates the current rotational speed of the cup (in rpm).

Torque

The Torque display indicates the % of scale (the % of the rheometer's full scale torque range capability for the model in use) measured by the rheometer.

Alarm

The Alarm LED illuminates if the Torque Alarms are enabled and a torque alarm condition occurs.

Shear Stress

The Shear Stress display indicates the force per unit area required to move the fluid in units of dynes per square centimeter (D/cm^2) or Newtons per square meter (N/m^2).

Shear Rate

The Shear Rate display indicates the velocity gradient of fluid rotating with the cup in units of inverse seconds (sec^{-1}).

Temperature

The Temperature display indicates the fluid sample temperature measured by the temperature probe in units of degrees Celsius ($^{\circ}\text{C}$) or degrees Fahrenheit ($^{\circ}\text{F}$).

Temperature Controller Setpoint

The Temperature Controller Setpoint display indicates the current temperature set point if a temperature bath is connected, in units of degrees Celsius ($^{\circ}$ C) or degrees Fahrenheit ($^{\circ}$ F).

NOTE: This Temperature Controller Setpoint display is blank if no bath is present.

Instrument Status

The Instrument Status display indicates the type of rheometer and temperature bath connected to the computer. A green light is displayed along with the instrument/bath identification.

NOTE: A dim light indicates that an instrument or bath is not connected.

COM Port

The COM Port drop down box is used to select a COM (RS-232) port for the rheometer and attached temperature bath. If the port selected is already in use by another application or is unavailable for any other reason, a message box is displayed.

If communication is lost with the PVS Rheometer, the data display will go blank after approximately 10 seconds. If this problem occurs, Refer to Section 5 - Troubleshooting for more information.

NOTE: Use the appropriate cables for connecting the rheometer and temperature bath (P/N DVP-80) for the PVS rheometer and Julabo temperature bath). The RS-232 cable for the TC-501 bath is supplied with the bath.

Date/Time

The Date and Time Display indicates the time and date that is set within the CPU of the computer in which Rheovision has been installed.

Geometry

The Geometry display indicates the stator/bob and cup combination currently installed on the rheometer.

NOTE: The Geometry selected must be manually updated when the actual stator/bob or cup is changed to ensure correct viscosity, shear stress and shear rate calculations.

Maximum Viscosity @ RPM

The Maximum Viscosity @ RPM display indicates the maximum measurable (mathematically) viscosity based on the torque multiplier, geometry, and speed (rpm) in use. As different geometries are selected using the geometry box on this page, this maximum value is automatically updated.

Zero Button

The Zero button causes the PVS Rheometer to subtract the current % torque reading from all future % torque readings. (ie: the torque is zeroed).

NOTE: Make sure the system is at rest, (i.e. speed is 0 rpm, the torque reading is stable and vibration sources have been eliminated) before pressing the Zero button.

NOTE: It may be necessary to remove the sample cup and zero the PVS Rheometer in air if the fluid to be tested has a significant yield stress value.

Go Button

The Go button displays the Speed/Temperature entry dialog box, in which speed and/or temperature values may be entered for manual operation.

Stop Button

The Stop button ramps the rheometer speed to 0 RPM using the last current acceleration.

Emergency Stop Button

The Emergency Stop button immediately sets the Rheometer speed to 0 RPM without ramping down.

Geometry Table Button

The Geometry Table button displays the Geometry Table dialog box as shown in Figure 4-2.

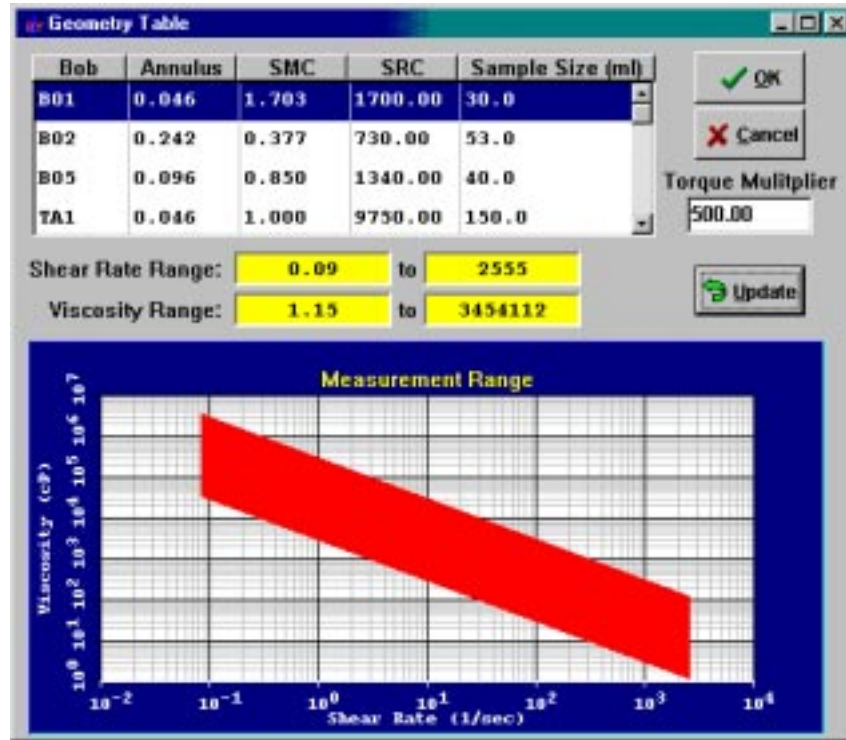


Figure 4-2: Geometry Table

The grid at the top lists the different spindles (bobs) along with the following information:

Bob: The name of the Bob used to obtain the data

Annulus: The gap defined by the surface of the bob and the inner surface of the cylinder (cup) surrounding it.

SMC: The stress constant for the geometry.

SRC: The shear constant for the geometry.

Sample Size: The recommended sample size (in ml) for the geometry.

Save Button

The Save button displays the Save File dialog box, shown in Figure 4-3, which allows the user to save data to the user selected drive and directory.

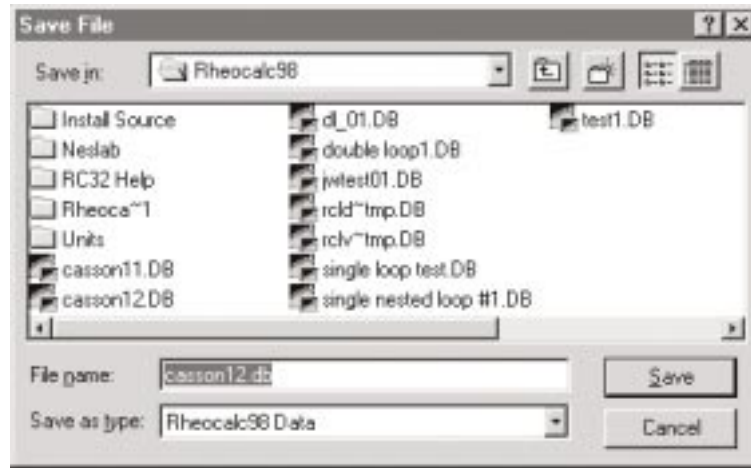


Figure 4-3: Save File Dialog Box

Open Button

The Open button displays the Load File dialog box, shown in Figure 4-4, which can be used to open saved data.

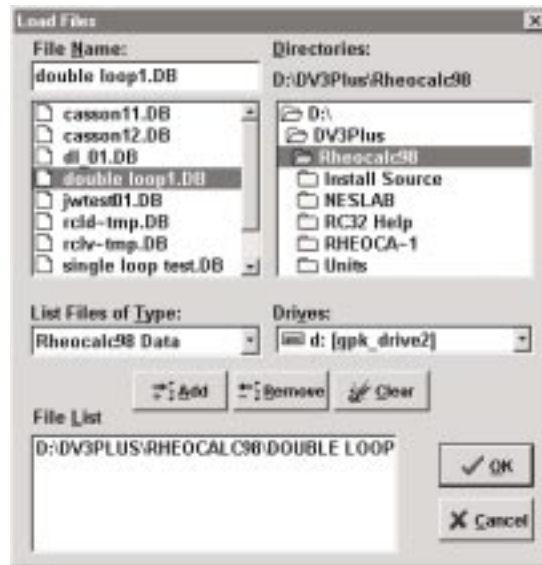


Figure 4-4: Load File Dialog Box

About Button

The About button displays the current Rheovision software version and instrument (rheometer and bath) on-line status.

Help Button

The Help button displays the Rheovision on-line help file.

Exit Button

The Exit button exits the user from Rheovision. Any open data files are closed as well as any open COM (RS-232) ports.

Setup Page

The Setup page, shown in Figure 4-5, allows hardware, geometry, and general program options to be selected.

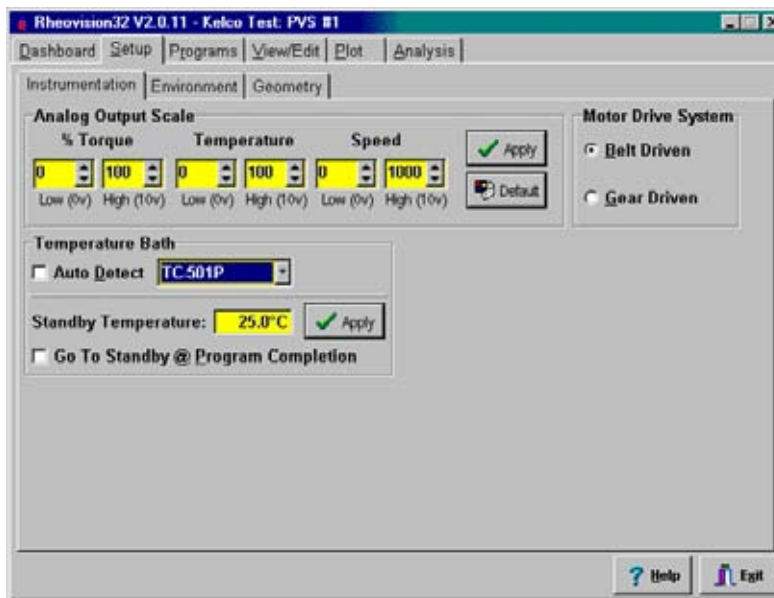


Figure 4-5: Setup Page

Setup Page Operation

1. Select the **SETUP** tab.
2. From the Setup page, select the **Instrumentation, Environment Options or Geometry (Spindle)** tab.
3. Select the parameters on the selected page for use as described in Setup Page Description.

Setup Page Description

Instrumentation

The Setup Page Hardware parameters are shown in Figure 4-5 and described in the following paragraphs.

Analog Output Scale

All analog voltage (VDC) outputs on the PVS are 0 to 10 volts. This voltage span can be scaled individually for the % Torque, Temperature, and Speed outputs.

Use the Low and High Limit spin boxes to adjust what 0v and 10v corresponds to for each of these data values (torque, temperature, speed).

Click the **Apply** button to use these settings.

Click the **Default** button to set the spin boxes back to the factory default values.

NOTE: The Apply button must be clicked to begin using these defaults.

Motor Drive System

The Motor Drive System buttons select the type of drive unit in your PVS Rheometer.

NOTE: The Belt Drive system has been in production for a long time and Gear Driven systems are very rare.

Select the Belt Driven (2.1:1 gear ratio) or Gear Driven (2:1 gear ratio) system.

Temperature Bath

Auto Detect

If the Auto Detect box is checked when Rheovision starts, it will detect the bath type and temperature of the bath.

NOTE: When Auto Detect is enabled, Rheovision will take longer to start because it is searching for the bath type connected to the PVS Rheometer.

If the Auto Detect box is not checked, Rheovision assumes the bath type connected to the PVS Rheometer is in the bath type drop-down box to the right of the Auto Detect box.

NOTE: If a bath is not being used, make sure the Auto Detect box is NOT checked and that NONE is selected in the bath type drop-down box.

Standby Temperature

The Standby temperature controls the temperature of the bath when a data collection program is not running.

Select the **Apply** button to set the temperature.

NOTE: Enabling the standby temperature does not immediately cause the temperature bath to reach the selected temperature. The next time Rheovision is in standby mode, the bath temperature will be adjusted to the standby temperature.

Go To Standby @ Program Complete

When this box selected and a data collection program is complete, the bath temperature will be automatically adjusted to the standby temperature. If this box is not selected, the bath will remain at the temperature required for the last data collection program.

Environment

The Setup Environment Page is shown in Figure 4-6 and described in the following paragraphs.

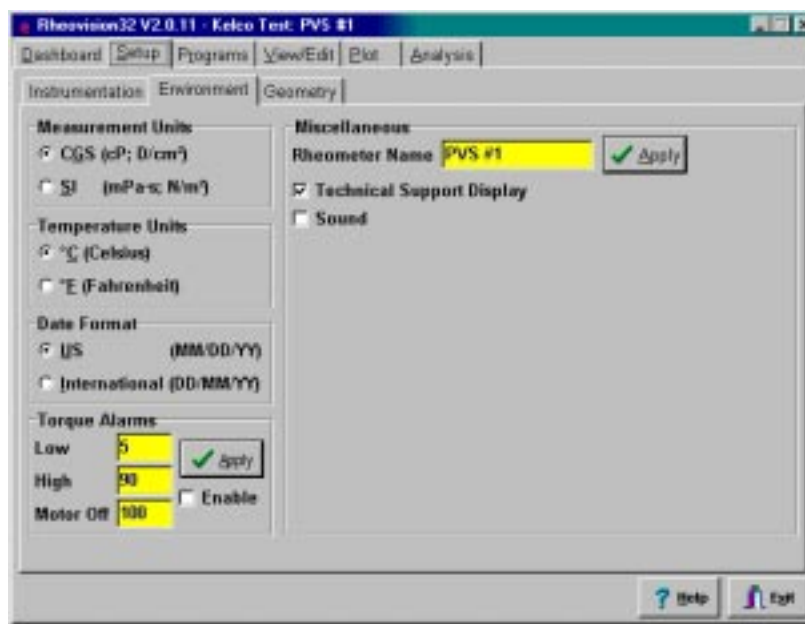


Figure 4-6: Setup/Environment Options Page

Measurement Units

The Measurement Units radio buttons allow the user to select the CGS or SI units to be used during Rheovision operation.

NOTE: Rheovision must be restarted after changing the Measurement Units setting.

Temperature Units

The Temperature Units radio buttons allow the user to select the temperature scale units Fahrenheit (°F) or Celsius (°C) to be used during Rheovision operation.

NOTE: Rheovision must be restarted after changing the Temperature Units setting.

Date Format

The Date Format radio buttons allow the user to select the date format (U.S.: mm/dd/yyyy) or (International: dd/mm/yyyy) to be used during Rheovision operation.

Torque Alarms

The Torque Alarm warns the user that the % torque value has either fallen below (Low Alarm) a preset value or risen above (High Alarm) a preset value.

Torque Alarms can only be tripped if the % torque value falls outside the alarm values and if the PVS Rheometer speed is greater than 0 rpm. Alarms can be enabled by selecting the Enable check box in the Torque Alarms section of the Setup page.

Once alarm values are changed, click the **Apply** button to use the new values.

When an alarm is tripped, a beep will be heard, and the red ALARM LED next to the % Torque display on the Dashboard page will illuminate.

NOTE: If the Motor Off alarm is tripped, in addition to the indications stated above, the rheometer speed is set to 0 rpm. If a program is running at the time, the rheometer remains at 0 rpm for the remainder of the program.

Miscellaneous

Rheometer Name

Enter a customizable name that appears on the Rheovision caption bar and also on the icon tag when the Rheovision main window is minimized on the desktop.

Click the Apply button to use the name.

Technical Support Display

NOTE: The Technical Support Display is intended for troubleshooting purposes by Brookfield Engineering Laboratories Inc. personnel.

When this box is selected, incoming data from the PVS Rheometer is displayed in its raw format on the Dashboard page.

Sound

When the Sound box is selected and the bob/stator is removed from the PVS Rheometer, a continuous *beep* will be heard until the bob/stator is replaced. The beep is a reminder to the operator that the bob/stator must be replaced before the installing the sample cup. If the Sound box is not selected, the beep will not be heard.

Geometry

The Setup Geometry Page is shown in Figure 4-7 and described in the following paragraphs.

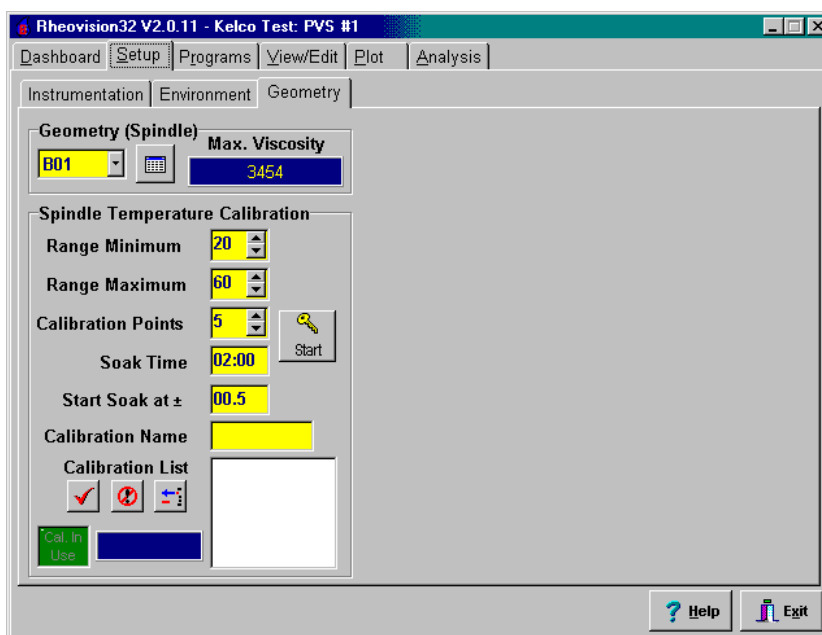


Figure 4-7: Setup Page/Geometry (Stator)

Geometry (Spindle)

The Geometry drop down box is used to select the geometry (stator and cup combination) for use in the data collection program.

Max. Viscosity

This panel displays the maximum mathematically computable viscosity for the geometry, torsion element, and speed in use.

Geometry Table Button

Use the Geometry Table button to display the Geometry Table dialog box as shown in Figure 4-8.

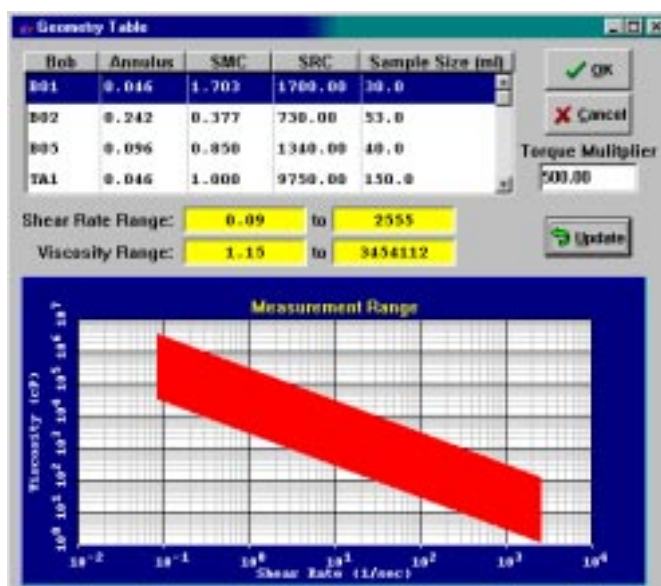


Figure 4-8: Geometry Table

The grid at the top lists the different stators (bobs) along with the following information:

Bob: The name of the Bob used to obtain the data

Annulus: The gap defined by the surface of the bob and the inner surface of the cylinder (cup) surrounding it.

SMC: The stress constant for the geometry.

SRC: The shear constant for the geometry.

Sample Size: The recommended sample size (in ml) for the geometry.

Update Button

Use the Update button to display the range information for the selected geometry. The viscosity and shear rate range information is displayed both numerically and graphically in the dialog box.

Torque Multiplier

Enter the Torque Multiplier for the torque sensor (torsion element) in this box. Refer to Table 4-2 for PVS Rheometer torque multiplier values. The Torque Multiplier for a Standard PVS (PVS002) should be between 450 and 550. The Torque Multiplier for a High Torque PVS (PVS003) should be between 900 and 1100.

OK Button

Use the OK button to accept the selections made in and close the dialog box.

Cancel Button

Use the Cancel button to close the dialog box without accepting the selections made.

Stator Temperature Calibration

When using an appropriate temperature bath (models TC501P and Julabo FM26), stators (bobs) should be calibrated to the bath due to the fact that the location of the temperature sensor in the bath is not in the same location as the temperature sensor in the spindle (i.e. the bath's sensor reports the temperature of the bath fluid while the stator's sensor reports the PVS sample temperature). Stator calibration is performed for a user-defined temperature range, usually the temperature range for which viscosity will be measured.

NOTE: When Rheovision is first started, the raw, un-calibrated, sample temperature is used. Calibration data is not applied to the incoming temperature until a new calibration is performed or a previous calibration is selected and used.

The parameters listed in Table 4-1 must be defined for the calibration:

Table 4-1: Stator Calibration Parameters

Parameter	Description
Range Minimum	The low end of the temperature range.
Range Maximum	The high end of the temperature range
Calibration Points	The total number of temperatures at which data will be taken to perform the calibration. These temperatures are spaced evenly between the Range Minimum and Range Maximum.
Soak Time	The time that the temperature bath remains at each calibration temperature.
Start Soak At \pm	This number indicates how close the temperature bath must be to the next calibration temperature before the Soak Time starts counting down (Ex: 0.5 indicates that when the temperature bath is within 0.5° of the next calibration temperature, the timer for Soak Time begins).

Table 4-1: Stator Calibration Parameters (Continued)

Parameter	Description
Calibration Name	Assign a name to the temperature calibration to be performed. Once the calibration is complete, the name will be added to the Calibration List.
Calibration List	<p>All Stator Temperature Calibrations are listed here. The three buttons to the left of this list perform the following functions:</p> <p>Use Selected Calibration Button: Use the calibration data selected in the Calibration List box.</p> <p>Use Raw Temperature Button: Use NO calibration. Display and record the raw, un-calibrated sample temperature data.</p> <p>Remove Cal From List: Remove the selected calibration name from the Calibration List.</p> <p>NOTE: Once a calibration is removed, it cannot be retrieved.</p>

Start Button

Use the Start button to begin the calibration. The Program page will be displayed and the calibration program begins to run. When the calibration program is complete, a calibration curve is calculated using the acquired data. This calibration curve data is saved in the user parameter file (Rheovis.Ini).

NOTE: After stator installation and with the cup removed, lower the PVS Rheometer head into the bath so that the stator is immersed at least three inches but not so high that the bath fluid overflows into the center of the stator/bob.

Cal. In Use

This indicator will be lit (bright green) when a temperature calibration is in use. The name of the calibration in use is also displayed in the box to the right of the indicator.

Programs Page

The Programs page, shown in Figure 4-9, is used to create, save, print and execute B.E.A.V.I.S (Brookfield Engineering Advanced Viscometer Instruction Set) programs.

NOTE: Refer to Section 5 - **B.E.A.V.I.S Programs** for more information on B.E.A.V.I.S Programs.

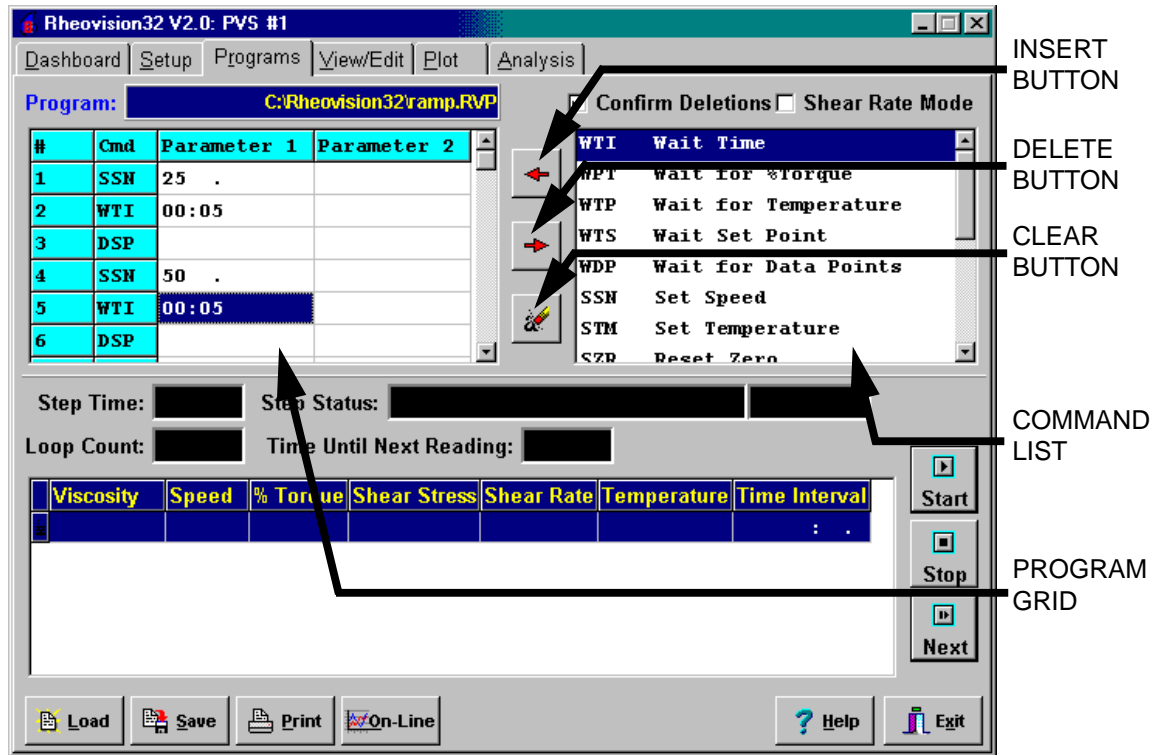


Figure 4-9: Programs Page

Programs Page Operation

Loading an Existing Program

1. Select the **LOAD** button.
2. Using the standard Load File dialog box, select and load the appropriate program file (*.RVP).

Creating a New Program

1. Highlight the line in the Program Grid where or above which you want to insert a command.

2. Highlight the appropriate command in the Command List and either double-click the command or select the **INSERT** button to place the command in the Program Grid.
3. Continue to build your program in this manner using the **INSERT** button to add commands and the **DELETE** button to remove unwanted commands.

NOTE: A new command cannot be added until the appropriate command parameter has been entered on the previous line if required.

Saving/Printing Programs

1. Select the **SAVE** button to save the program to disk using the standard Save File dialog box.
2. Select the **PRINT** button to print the program using the standard Print dialog box.

Executing a Program

1. Ensure a new or existing program is displayed in the Program Grid
2. If On-Line plotting is not desired, select the **START** button to begin the program.
3. If On-Line plotting is desired, ensure the desired plot parameters have been set on the Plot page. Select the **ON-LINE** button to enter the low and high limits for the X and Y axes.
4. Select **OK** in this Plot Limit dialog box to begin the program and initiate on-line plotting.

The program status is displayed in the middle of this page (i.e. Step Time, Step Status, Loop Count, Reading Time). Live data is displayed in the Data Grid at the bottom of the page. If on-line plotting was enabled, data points are plotted on the graph on the Plot page as they are being put in the Capture Buffer.

Programs Page Description

The Programs page is shown in Figure 4-9 and described in the following paragraphs.

Program Grid

The Program Grid displays the current user program. Each line consists of a line number, a three letter command mnemonic, and one or more parameters required.

Insert Button

The Insert button inserts the command highlighted in the command list into the program grid.

Delete Button

The Delete button removes the highlighted line in the program grid.

Clear Button

The Clear button clears the program grid.

Step Time

The Step Time box displays the amount of time the current step (as displayed in the program grid) has been executing.

Loop Count

The Loop Count box displays the number of loop iterations remaining in the current loop block (consisting of an LSC and LEC command).

Step Status

The first box within the Step Status area displays the current step's action (i.e. for a WTI command, the box displays the message: *COUNTING DOWN TIME INTERVAL*).

The second box displays the pertinent step parameter (i.e. for a wait for torque (WPT)) command, the box displays the current % torque value so the user knows how far from the target torque the step is).

Reading Time

The Reading Time box displays one of the following:

Time Since Last Reading

The elapsed time since a data point was last put in the Capture Buffer. If a data interval is not in effect (i.e. the time of the next data point is not known), this is the time that is displayed.

Time Until Next Reading

The time that must elapse until another data point is placed in the Capture Buffer. This value is displayed when a fixed data interval is in effect (using the Data Collection Interval (DCI) command).

Data Grid Display

The Data Grid Display shows data as it is being collected due to the execution of the program. Only un-saved data is displayed here. If the data is saved as a result of a File Save-Append (FSA) or File Save-Overwrite (FSO) command, this grid is cleared until new data is collected.

NOTE: Refer to **Section 5 - B.E.A.V.I.S. Programs** for more information on the FSA and FSO commands.

Confirm Deletions

When checked, the Confirm Deletions check box causes a message box to be displayed requesting confirmation whenever an attempt is made to delete a program line or to clear the entire program.

Shear Rate Mode

When checked, the Shear Rate Mode check box causes all speed entries (i.e. for SSN and SSI commands) to represent shear rates (units of sec^{-1}) instead of rotational speed (rpm).

Load Button

The Load button displays a standard File Load dialog box. This dialog box displays Rheovision program files that were previously saved and can now be loaded.

Save Button

The Save button displays a standard file save dialog box. This dialog box allows programs to be saved for later use. B.E.A.V.I.S. programs are saved as lines of ASCII text consisting of a line number, command, and parameters.

Print Button

The Print button displays the standard Windows Print dialog box which allows a printer to be selected, its properties changed and the data to be printed.

NOTE: Refer to the MS-Windows on-line help for more information regarding printing and printer setup.

On-Line Button

The On-Line button allows data to be plotted on the Plot page as it is being collected. Use the following procedure to plot data on the Plot page:

1. Prepare a sample in the rheometer.
2. Select the plot options for the graph on the Plot page.
3. Create or load a B.E.A.V.I.S. program on the Programs page.
4. On either the Programs page or the Plot page, Select the **ON-LINE** button.
5. Enter the low and high limits for both the X and Y axes according to the axis values chosen. (Ex: For a % torque vs. speed plot, one might enter 0 to 100 for the Y-axis (torque) and 10 to 50 for the X-axis (speed).
6. Selecting the **OK** button in this entry dialog box automatically starts the program and begins plotting the data as it is collected. If incoming data goes beyond the axis limits chosen, the graph automatically re-scales adding approximately 25% of the total axis scale each time a re-scale is necessary.

When the program is complete, the Plot page is displayed, and the graph automatically re-scales to show the least amount of white space for the plot.

Start Button

The Start button starts the program displayed in the Program Grid, if on-line plotting is not being used.

Stop Button

The Stop button stops the program displayed in the Program Grid. The rheometer will stop and any bath is set to the user defined default temperature.

Help Button

The Help button displays the on-line Rheovision software help system.

Exit Button

The Exit button exits Rheovision. Any open data files are closed as are any open COM (RS-232) ports.

View/Edit Page

The View/Edit page shown in Figure 4-10 allows browsing and editing of any valid Rheovision data file.

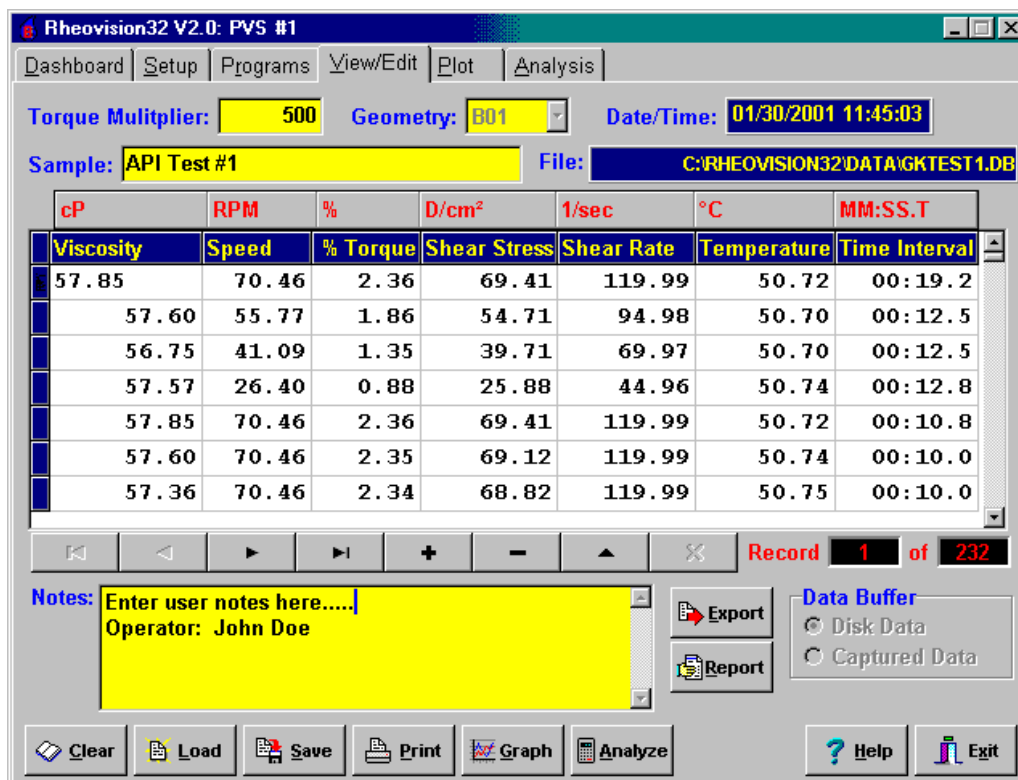


Figure 4-10: View/Edit Page

View/Edit Page Operation

The View/Edit page is used primarily to view, edit, load, save, export and print data. It also provides a fast, easy way to view a graph or analyze the displayed data.

Loading Existing Data

1. Select the **LOAD** button.
2. Using the Load File dialog box, select and load the appropriate data file (*.DB).
3. Loading disk data causes the Disk Data option in the Data Buffer box to be selected.

Saving/Printing Data

1. Select the **SAVE** button to save the data to disk using the standard Save File dialog box.
2. Select the **PRINT** button to print the data using the standard Print dialog box. The data, sample name, and user notes are all printed.

NOTE: Saving data to disk causes the Disk Data option in the Data Buffer box to be selected.

Exporting Data

1. Select the **EXPORT** button. Use the standard Save File dialog box to save the data in MS-Excel format (*.XLS) for use in other programs.

Report Button

The report button displays the open file dialog box from which a report database file is selected and opened. Opening a report file displays an application specific report dialog box.

NOTE: Currently the only application specific report available is the API Power Law data report.

Graphing Data

Select the **GRAPH** button. The Plot page is displayed with the data displayed on the View/Edit page shown graphically using the current plot settings.

Analyzing Data

Select the **ANALYZE** button. The Analysis page is displayed showing the results and graph for the selected equation using the data displayed on the View/Edit page.

View/Edit Page Description

The View/Edit page is shown in Figure 4-10 and described in the following paragraphs.

Torque Multiplier

The Torque Multiplier box displays the torque multiplier for the torque sensor (torsion element). The torque multiplier is a rheometer calibration parameter. Refer to Table 4-2 for PVS Rheometer torque multiplier values.

Table 4-2: PVS Rheometer Torque Multiplier Values

Rheometer Model Number	Normal Range of Values
PVS002	450 - 550
PVS003	900 - 1100

Geometry

The Geometry box displays the stator/bob and cup used to take the data. When in edit mode, this value can be changed by using the arrow to the right of the box. Once a change is made, all data in the grid is re-calculated based upon the new choice.

File

The File box displays the file and path of the data file being used.

Sample

The sample name of the data file is entered the Sample box.

NOTE: The sample name is saved in a text file using the same name as the data file (Paradox database file) but with an .RVH file extension.

Date/Time

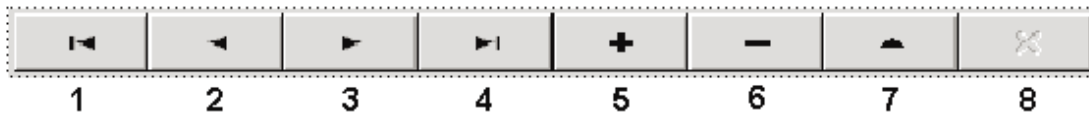
When a data line is highlighted in the data grid, the date and time the data point was taken is displayed the Date/Time box.

Data Display Grid

The Data Display grid displays the data (newly gathered or loaded from disk). Use the mouse to select a field to be edited when in edit mode.

Data Base Navigation Bar

Refer to Figure 4-11 for a description of the button functions with in the Data Base Navigation Bar.



BUTTON LEGEND

1. Moves the highlight to the first record in the data grid.
2. Moves the highlight to the previous line in the data grid.
3. Moves the highlight to the next line in the data grid.
4. Moves the highlight to the last record in the data grid.
5. Adds a blank record (data line) at the highlighted line in the data grid.
6. Deletes the highlighted data line in the data grid.
7. Turns edit mode ON.
8. Turns edit mode off and locks the database.

Figure 4-11: Data Base Navigation Bar Buttons

NOTE: When in Edit mode, only the Speed, % Torque, Temperature, and Time Interval fields may be changed by the user. All other parameters are automatically calculated by Rheovision. The data will not change until the data field being edited has been exited.

Record

The Record boxes indicate the total number of records in the data set and the number of the record currently selected.

Notes

The Notes box allows additional user data to be entered and saved within the data.

NOTE: The notes are saved in a text file using the same name as the data file (Paradox database file) but with an .RVH file extension.

Data Buffer

There are two buffers that hold data in Rheovision. The first is the Disk Buffer that holds data loaded from disk files. Selecting Disk Data on the View/Edit page displays data that has been loaded from a disk file. The second buffer is the Capture Buffer that holds freshly gathered or edited data (i.e. data that has not yet been saved). Selecting Captured Data on the View/Edit Page displays data in this buffer.

Clear Button

The Clear button clears the data grid.

Load Button

The Load button displays a standard file load dialog box. This dialog box displays Rheovision data files that were previously saved and can now be loaded.

Save Button

The Save button displays a standard file save dialog box. This dialog box allows data to be saved for later use. Data is saved in a Paradox database file along with an ASCII text file of the same name which contains user sample name and notes.

Print Button

The Print button displays the standard Windows Print dialog box which allows a printer to be selected, its properties changed and data to be printed.

NOTE: Refer to the MS-Windows on-line help for more information regarding printing and printer setup.

Report Button

The report button displays the open file dialog box from which a report database file is selected and opened. Opening a report field displays an application specific report dialog box.

NOTE: Currently the only application specific report is the API Power Law data for the Oil and Gas industries.

Graph Button

The Graph button switches to the Plot page and displays a data graph of the currently displayed data as shown in Figure 4-12.

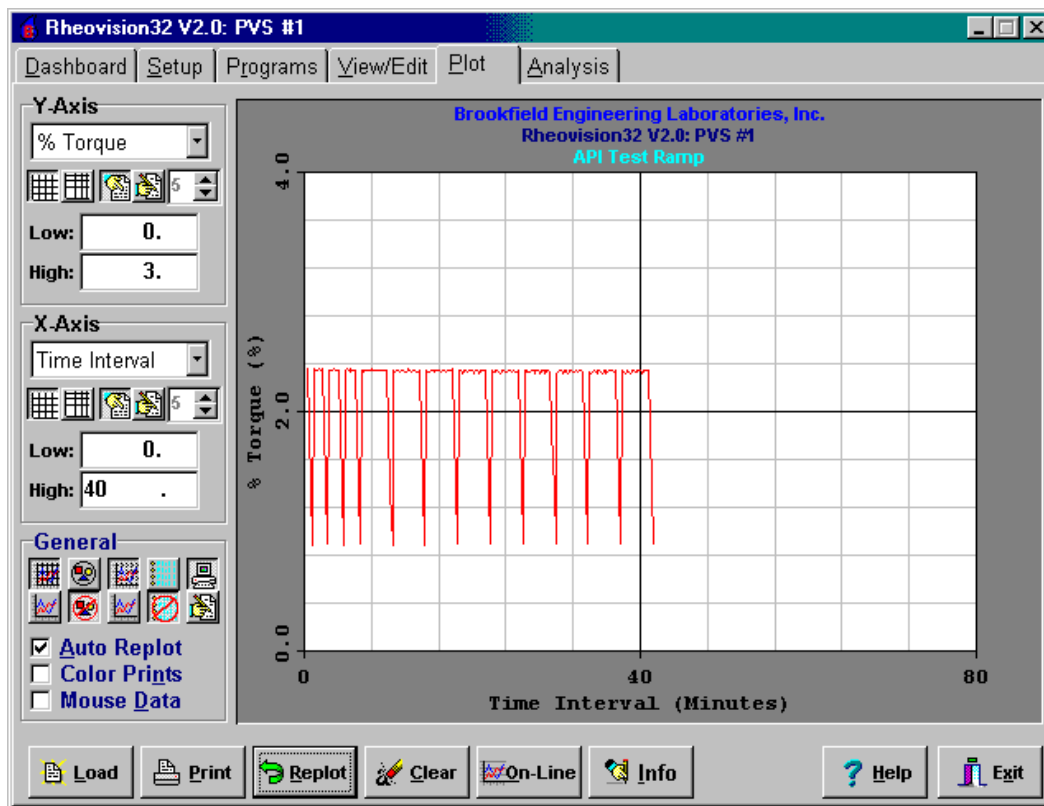


Figure 4-12: Plot Page Data Graph Example

Analyze Button

The Analyze button switches to the Analysis page and displays the results and a graph of the selected math model for the currently displayed data as shown in Figure 4-13.

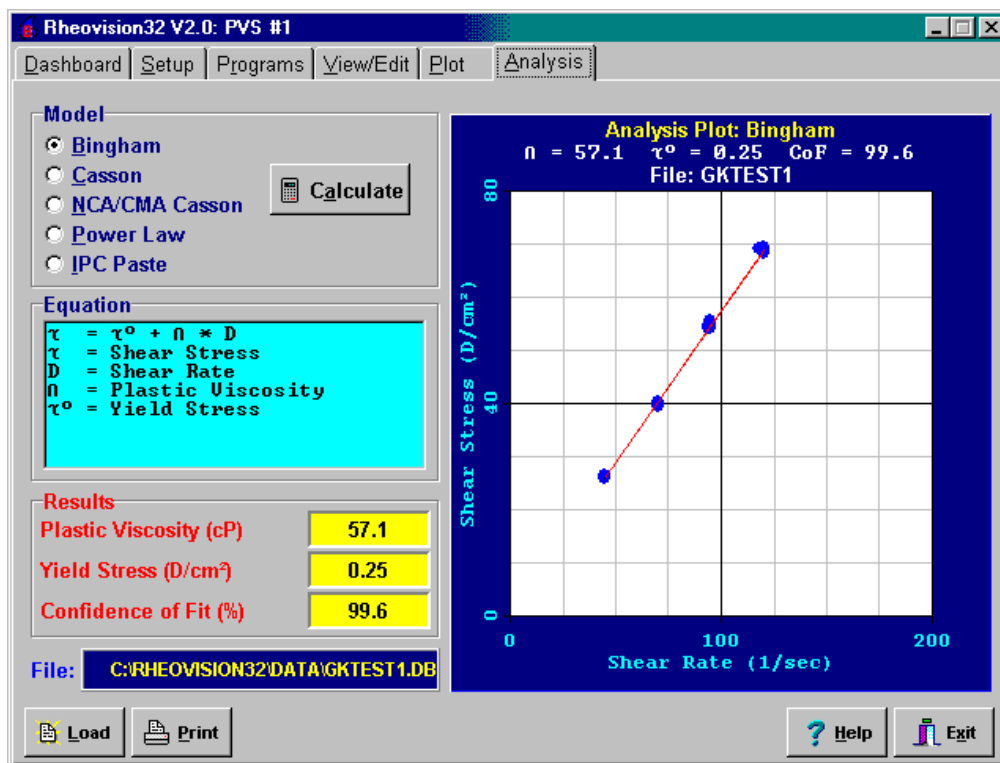


Figure 4-13: Analyze Graph Example of Bingham Math Model Equation

Export Button

The Export button opens a dialog (similar to a Save dialog) that allows the displayed data to be exported to an MS-Excel spreadsheet.

Help Button

The Help button displays the on-line Rheovision software help system.

Exit Button

The Exit button exits Rheovision. Any open data files are closed as are any open COM (RS-232) ports.

Plot Page

The Plot page shown in Figure 4-14 displays all data plots.

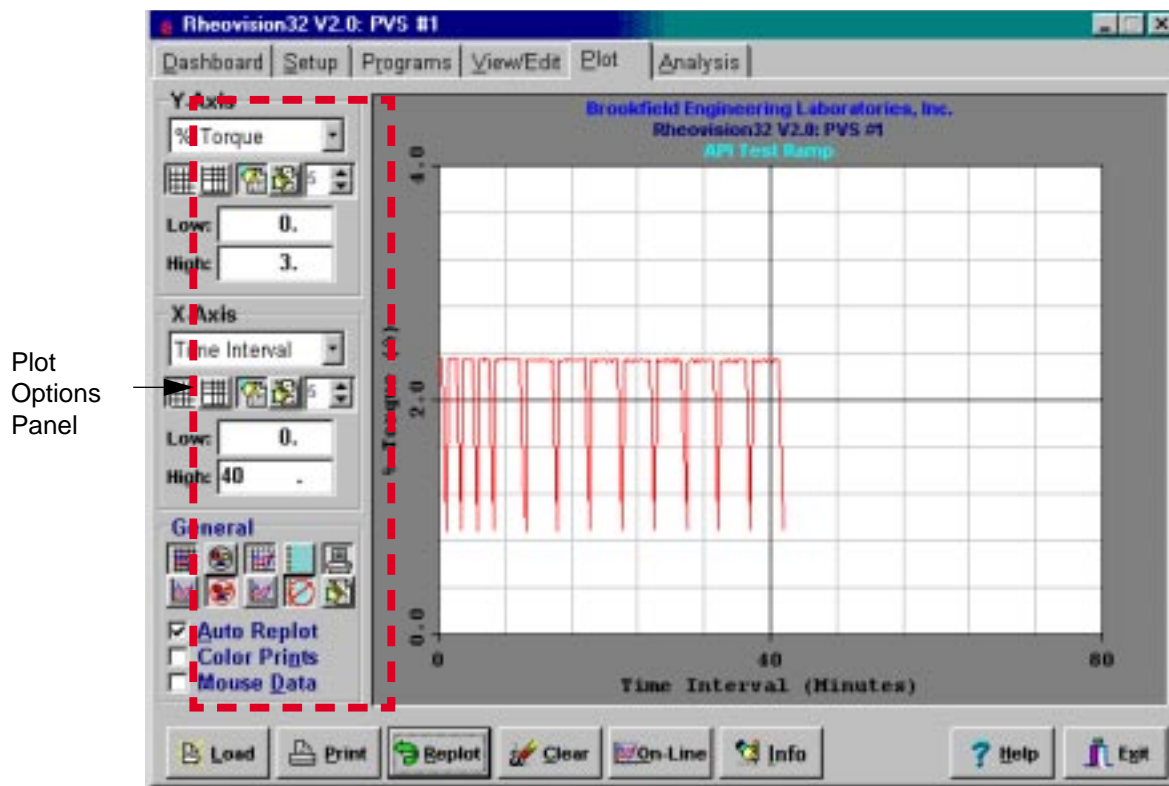


Figure 4-14: Plot Page

Plot Page Operation

On-Line Plotting

1. Prepare a sample in the rheometer.
2. Select the plot options for the graph.
3. Create or load a B.E.A.V.I.S. program on the Programs page.
4. On either the Programs page or the Plot page, select the **ON-LINE** button.
5. Enter the low and high limits for both the X and Y axes according to the axis values chosen (Ex: For a % torque vs. speed plot, one might enter 0 to 100 for the Y-axis (torque) and 10 to 50 for the X-axis (speed)).

6. Select the **OK** button. This entry dialog box automatically starts the program and begins plotting the data as it is collected. If incoming data goes beyond the axis limits chosen, the graph automatically re-scales adding approximately 25% of the total axis scale each time a re-scale is necessary.

When the program is complete, the Plot page is displayed, and the graph automatically re-scales to show the least amount of white space for the plot.

Graphing Disk Data

1. Select the **LOAD** button. Use the Load File dialog box to select data files to be plotted. Up to five data files may be plotted at one time.
2. Navigate to the desired files, then double-click on the file name, or highlight the file then select the **ADD** button to add it to the plot file list.
3. Highlight a file in the file list then select the **REMOVE** button to remove a data file.
4. Select the **CLEAR** button to clear the file list.
5. Once the appropriate files are selected, select the **OK** button to plot the selected data files.

Plot Page Description

The Plot page is shown in Figure 4-14 and described in the following paragraphs.

Plot Options Panel

The X and Y-Axis areas within the Plot Options panel, as shown in Figure 4-11, provide control for the data that can be plotted. The following paragraphs describe each element of the Plot Options Panel.

X or Y Axis Sub Panel

The various controls within the X or Y Axis sub panels control the data in each respective axis. The sub panel is shown in Figure 4-15 and described in the following paragraphs.

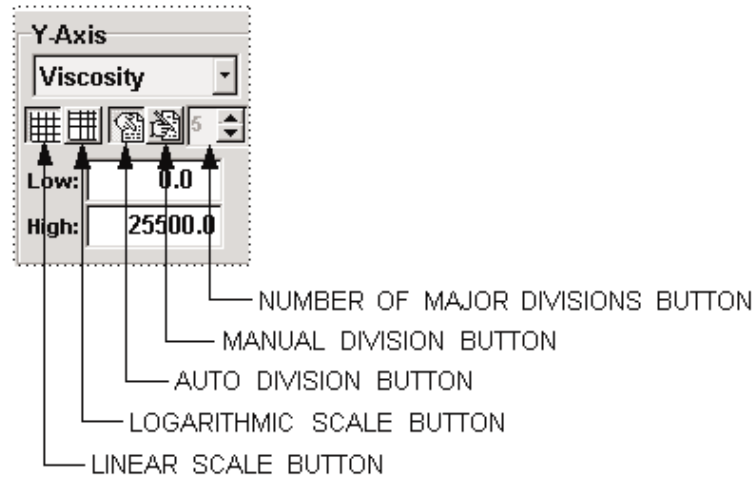


Figure 4-15: X or Y Axis Sub Panel

Pull-down List

The Pull-down list allows selection of the value to be plotted for the corresponding axis (X or Y).

NOTE: If Auto Replot is checked in the General Options, the graph is automatically replotted after changing this option.

Linear Scale Button

When selected, the Linear Scale button displays the corresponding axis in linear scale.

NOTE: If Auto Replot is checked, the graph is automatically replotted after changing this option.

Logarithmic Scale Button

When selected, the Logarithmic Scale button displays the corresponding axis in logarithmic scale.

NOTE: If Auto Replot is checked, the graph is automatically replotted after changing this option.

Auto Division Button

When selected, the Auto Division button displays the most appropriate number of major divisions for the axis selected on the plot.

NOTE: If Auto Replot is checked, the graph is automatically replotted after changing this option.

Manual Divisions Button

When selected, the Manual Divisions button displays the number of major divisions selected using the spin box to the right of the button. Major divisions between 2 and 10 are permitted.

NOTE: If Auto Replot is checked, the graph is automatically replotted after changing this option.

Low/High Limits

If the Manual Scale button is depressed, whenever a replot of the graph is done, the Low and High limits entered by the user for each axis in these boxes will be used. If these values are changed, select the REPLOT button to re-draw the graph using these scale values.

General Sub Panel

The General Sub panel controls the manner in which the data is displayed on the Plot page. The General sub panel is shown in Figure 4-16 and described in the following paragraphs.

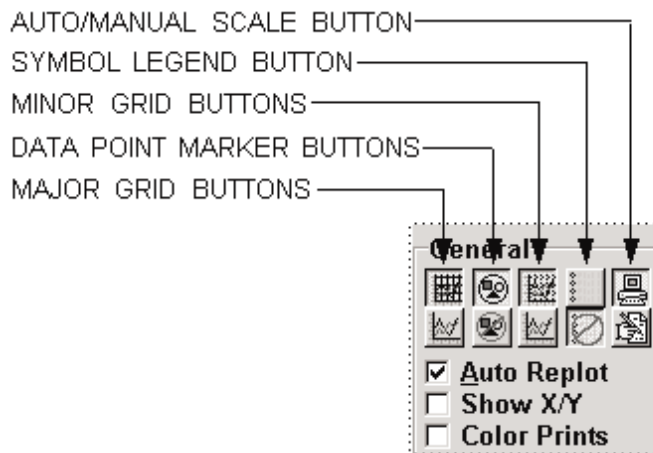


Figure 4-16: General Sub Panel Buttons

Major Grid Buttons

The Major Grid buttons turn major grid lines (black) on the graph ON or OFF. The top button turns the grid ON. The bottom button turns the grid OFF.

NOTE: If Auto Replot is checked, the graph is automatically replotted after changing this option.

Data Point Marker Buttons

The Data Point Marker buttons display a distinct marker for each data point. The top button turns the data point ON. The bottom button turns the data point OFF.

NOTE: If Auto Replot is checked, the graph is automatically replotted after changing this option.

Minor Grid Buttons

The Minor Grid Lines button displays minor grid lines (gray) on the graph. The top button turns the grid line ON. The bottom button turns the grid line OFF.

NOTE: If Auto Replot is checked, the graph is automatically replotted after changing this option.

Symbol Legend Button

The Symbol Legend Button displays a legend shown to the right of the graph depicting a distinct symbol for each data set along with the data file name. The top button turns the legend ON. The bottom button turns the legend OFF.

NOTE: If Auto Replot is checked, the graph is automatically replotted after changing this option.

Auto/Manual Scale Button

The Auto Button (top) displays upper and lower plot limits for graphs leaving as little white space as possible. The Manual Scale button (bottom) displays the graph using the high/low limits specified in the boxes for each axis.

NOTE: If Auto Replot is checked, the graph is automatically replotted after changing this option.

Auto Replot

When checked, the Auto Replot check box causes an automatic replot of the data when changes in plot options or changes to the plot list occur. If the box is unchecked, the above changes do not take effect.

Show X/Y

When checked, the Show X/Y check box causes a small box to be displayed showing the X and Y coordinates (based on the axis types selected) when moving the mouse in the graph area. The box follows the tip of the mouse pointer.

Color Prints

When checked, the Color Prints check box causes a color graph to be printed (if the selected printer supports color) and is properly configured.

Load Button

The Load button displays the File Load dialog box. This dialog box displays Rheovision data files to be loaded for plotting. Up to five (5) files may be loaded at once for concurrent plotting.

Print Button

The Print button prints the current graph displayed on the Plot page. The standard Windows Print dialog box is displayed allowing a printer to be selected and its properties to be changed.

NOTE: Refer to the MS-Windows on-line help for more information regarding printing and printer setup.

Replot Button

Clicking this button causes all selected data sets to be replotted on the graph using the current plot options. This button is disabled during on-line plotting.

Clear Button

The Clear button clears the graph.

On-Line Button

The On-Line button allows data to be plotted on the Plot page as it is being collected. Use the following procedure to plot data on the Plot page:

1. Prepare a sample in the rheometer.
2. Select the plot options for the graph on the Plot page.
3. Create or load a B.E.A.V.I.S. program on the Programs page.
4. On either the Programs page or the Plot page, Select the **ON-LINE** button.
5. Enter the low and high limits for both the X and Y axes according to the axis values chosen (Ex: For a % torque vs. speed plot, one might enter 0 to 100 for the Y-axis (torque) and 10 to 50 for the X-axis (speed)).

6. Selecting the **OK** button in this entry dialog box automatically starts the program and begins plotting the data as it is collected. If incoming data goes beyond the axis limits chosen, the graph automatically re-scales adding approximately 25% of the total axis scale each time a re-scale is necessary.

When the program is complete, the Plot page is displayed, and the graph automatically re-scales to show the least amount of white space for the plot.

Info Button

The Info button allows the user to enter one line of information to describe the current graph. Select the Info button once to enter one line of user information. Selecting the button again after data entry removes the entry box and places the information at the top of the graph.

Help Button

The Help button displays the on-line Rheovision software help system.

Exit Button

The Exit button exits Rheovision. Any open data files are closed as are any open COM (RS-232) ports.

Analysis Page

The Analysis page, shown in Figure 4-17, is used to mathematically analyze selected data using various models associated with viscosity measurement and rheology. The results are displayed both numerically and graphically, and they can also be printed to hard copy.

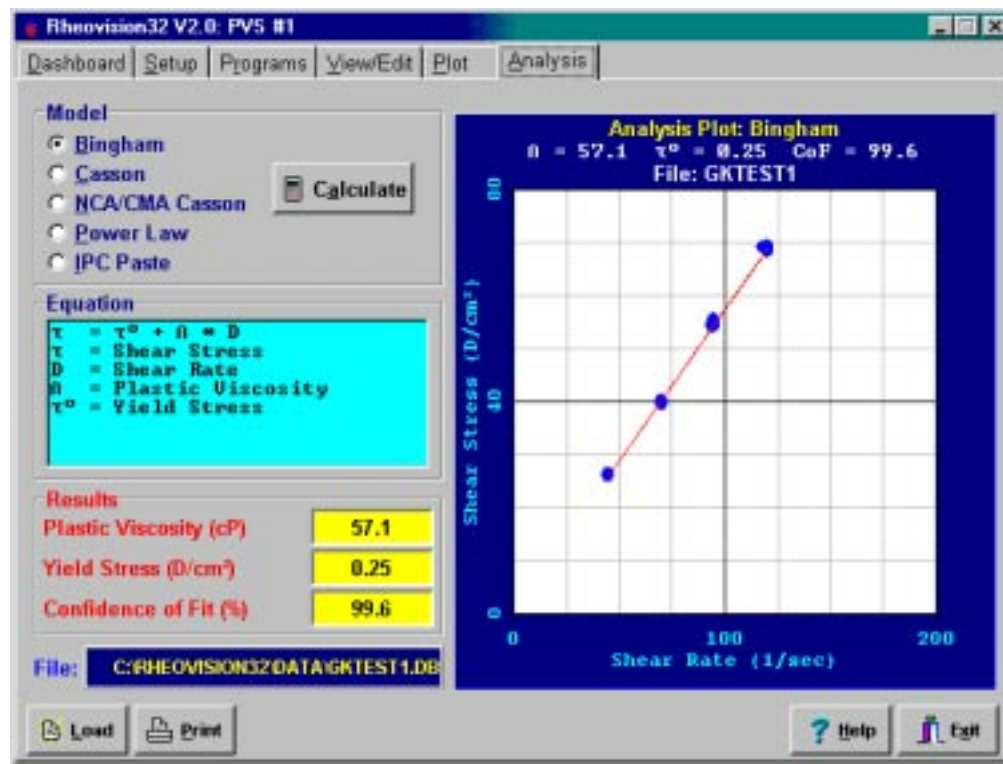


Figure 4-17: Analysis Page

Analysis Page Operation

1. Select the **LOAD** button to select and load a data file.
2. Choose the analysis method from the Model box. As each model is selected, the equation for that model is displayed in the equation box.
3. Select the **CALCULATE** button to perform the selected calculations and display the numeric and graphical results. The graph displays the data and the best fit straight line using the selected equation.
4. Select the **PRINT** button to print the data, numeric results, and corresponding graph.

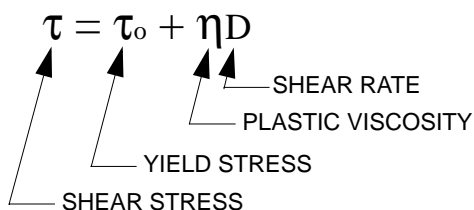
Analysis Page Description

The Analysis page is shown in Figure 4-17 and described in the following paragraphs.

Model

Bingham

The Bingham equation is used to calculate the viscosity of materials that only flow after the application of a sufficiently large yield stress, τ_o . These materials are referred to as Bingham plastic fluids and are described by the equation in Figure 4-18.

$$\tau = \tau_o + \eta D$$


Labels in the diagram:

- SHEAR STRESS (points to τ)
- YIELD STRESS (points to τ_o)
- PLASTIC VISCOSITY (points to η)
- SHEAR RATE (points to D)

Figure 4-18: Bingham Equation

The calculated parameters for this model are:

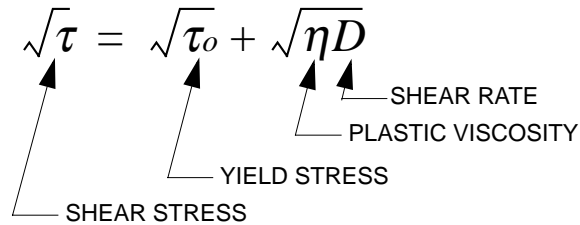
- Plastic Viscosity (cP or mPa·s)
- Yield Stress (Dynes/cm² or Newtons/m²)
- Confidence of fit (%)

NOTE: In all cases, confidence of fit is a measure of how well the data fits the best fit curve for this equation with 100% being the best fit.

A plot of shear stress versus shear rate is displayed for this model.

Casson

The Standard Casson method is a direct implementation of the original Casson equation. A plot of the square root of shear stress versus the square root of shear rate is displayed for this model. The Standard Casson equation is shown in Figure 4-19.

$$\sqrt{\tau} = \sqrt{\tau_o} + \sqrt{\eta D}$$


Labels in the diagram:

- SHEAR STRESS (points to $\sqrt{\tau}$)
- YIELD STRESS (points to $\sqrt{\tau_o}$)
- SHEAR RATE (points to D)
- PLASTIC VISCOSITY (points to η)

Figure 4-19: Casson Equation

The calculated parameters for this model are:

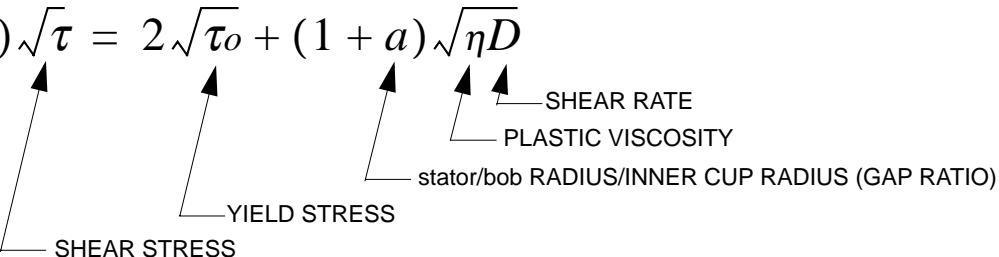
- Plastic Viscosity (cP or mPa·s)
- Yield Stress (Dynes/cm² or Newtons/m²)
- Confidence of fit (%)

NOTE: In all cases, confidence of fit is a measure of how well the data fits the best fit curve for this equation with 100% being the best fit.

A plot of the square root of shear stress versus the square root of shear rate is displayed for this model.

NCA/CMA Casson

This Casson method is derived from the standard set forth by the National Confectioners Association (NCA) and the Chocolate Manufacturers Association (CMA). Although based on the original Casson equation, this implementation has been tailored by the NCA and CMA specifically to applications involving chocolate. The Chocolate Casson equation is shown in Figure 4-20.

$$(1 + a)\sqrt{\tau} = 2\sqrt{\tau_0} + (1 + a)\sqrt{\eta D}$$


Labels in the diagram:

- SHEAR STRESS (points to $(1 + a)\sqrt{\tau}$)
- YIELD STRESS (points to $2\sqrt{\tau_0}$)
- SHEAR RATE (points to D)
- PLASTIC VISCOSITY (points to η)
- stator/bob RADIUS/INNER CUP RADIUS (GAP RATIO) (points to $\sqrt{\eta D}$)

Figure 4-20: Chocolate Casson Equation

The calculated parameters for this model are:

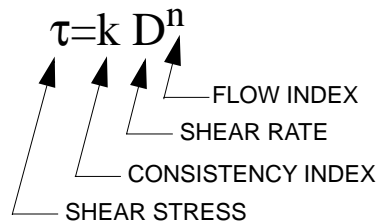
- Plastic Viscosity(cP or mPa·s)
- Yield Stress (Dynes/cm² or Newtons/m²)
- Confidence of fit(%)

NOTE: In all cases, confidence of fit is a measure of how well the data fits the best fit curve for this equation with 100% being the best fit.

A plot of $(1 + a)$ times the square root of shear stress versus $(1 + a)$ times the square root of shear rate is displayed for this model.

Power Law

The Power Law equation is shown in Figure 4-21.

$$\tau = k D^n$$


Labels for the equation $\tau = k D^n$:

- τ : SHEAR STRESS
- k : CONSISTENCY INDEX
- D : SHEAR RATE
- n : FLOW INDEX

Figure 4-21: Power Law Equation

The calculated parameters for this model are:

- Flow Index (no units)
- Consistency Index (cP or mPa·s)
- Confidence of fit (%)

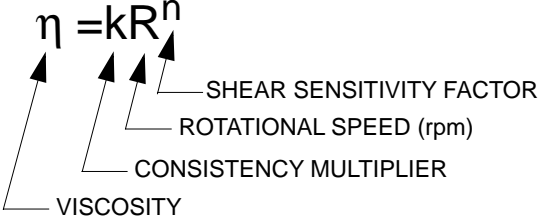
NOTE: In all cases, confidence of fit is a measure of how well the data fits the best fit curve for this equation with 100% being the best fit.

A plot of the LOG of shear stress versus the LOG of shear rate is displayed for this model.

NOTE: In accordance with common usage, k is displayed in cP or mPa·s units in lieu of those obtained from data insertion in the formula shown in Figure 4-17: CGS units, dyne-secⁿ/cm², SI units, newton-secⁿ/cm². Numerical values in these units are smaller than these shown by the factors: 100 (CGS units), 1000 (SI units).

IPC Paste

The IPC Paste Analysis method is based on the power law equation and is intended to calculate the Shear Sensitivity Factor (pseudo plasticity) of pastes. A prime example of its use is in the solder paste industry, thus the name IPC (Institute for Interconnecting and Packaging Electronic Circuits). The Paste equation is shown in Figure 4-22.

$$\eta = kR^n$$


Labels in the diagram:

- VISCOSITY (points to η)
- CONSISTENCY MULTIPLIER (points to k)
- ROTATIONAL SPEED (rpm) (points to R)
- SHEAR SENSITIVITY FACTOR (points to n)

Figure 4-22: IPC Paste Analysis Calculation

The calculated parameters for this model are:

- Shear Sensitivity Factor (slope of line; no units)
- Viscosity (cP or mPa-s)
- Confidence of fit(%)

NOTE: In all cases, confidence of fit is a measure of how well the data fits the best fit curve for this equation with 100% being the best fit.

A plot of the LOG of viscosity versus the LOG of speed (rpm) is displayed for this model.

Calculate

The Calculate button updates the results box and the graph using the data and model type selected.

Equation

The Equation box displays the equation and variables for the model selected.

Results

The Results box displays the appropriate results, yield stress and confidence of fit results of the analysis using the data and model type selected.

File

The File box displays the file and path of the data file being analyzed.

Data Graph

The Data Graph presents a plot of the raw data and the best fit line using the model selected.

Load Button

The Load button displays the Load Files dialog box which can be used to load a saved file for analysis.

Print Button

The Print button displays the standard Windows Print dialog box which allows a printer to be selected, its properties changed and data analysis results and graph to be printed.

NOTE: Refer to the MS-Windows on-line help for more information regarding printing and printer setup.

Help Button

The Help button displays the on-line Rheovision software help system.

Exit Button

The Exit button exits Rheovision. Any open data files are closed as are any open COM (RS-232) ports.

Add-On Modules

Rheovision supports add-on modules to perform application specific calculations and display the results in a Report dialog box. Presently, the only supported add-on is the API Power Law module described below.

API Test Ramp

For those customers who have a need to observe changes in fluid rheology while testing over a period of time, an add-on is included which calculates Power Law constants on the fly (i.e. while data is being collected) for multiple shear rate ramps. The Report dialog box is displayed each time a

new calculation is added to this table. Table 4-3 describes the Power Law Table Parameters for each set of data sent to the report (i.e. for each ramp run):

Table 4-3: Power Law Table Parameters

Parameter	Description
Test Time	A relative time marker indicating the time elapsed since the last data point was added to the report
Date/Time	The actual date and time the data point was added to the report
N	The Power Law Flow Index
K	The Power Law Consistency Index
Correlation	A measure of how closely the raw data fits the Power Law model; a value of one (1) indicates an optimal fit.
Avg. Temp	The average temperature of the raw data supplied (i.e. average temperature during the ramp run)
Viscosities	The next four columns display the calculated viscosity values at the user defined shear rates using the calculated Power Law constants for the data set.

NOTE: In accordance with API recommended practices, K' is displayed in English units, lbf-secⁿ/ft². These values can be converted to CGS units (dyne-secⁿ/cm²) by multiplying by 478.8 and to SI units (newton-secⁿ/m²) by multiplying by 47.88.

Section 5 - B.E.A.V.I.S. Programs

What is a B.E.A.V.I.S. Program?

B.E.A.V.I.S. Brookfield Engineering Advanced Viscometer Instruction Set is a command language developed at Brookfield Engineering Labs that allows control of Brookfield viscometers/rheometers and associated accessories (i.e. temperature controllers). The commands allow the creation of both simple and complex test programs that provide maximum flexibility in completely unattended data gathering.

B.E.A.V.I.S. Commands

Command Groups

Commands are grouped into functional groups which are identified by the graphic to the left of the command. Icons for each group are shown in Figure 5-1.



Figure 5-1: Command Group Icons

Wait Command Group

Wait Commands wait for a certain condition to be reached. The time to reach the condition is displayed as Step Time on the Program page.

Setup Command Group

Setup Commands set program parameters (i.e. speed or temperature).

Data Command Group

Data Commands dictate the manner in which data is collected.

Loop Commands Group

Loop Commands mark the beginning and end of a loop (i.e. commands between the loop start and end are repeated).

Save Data Commands Group

Save Data Commands save or append data to a disk file.

Table 5-1: B.E.A.V.I.S. Commands used in Rheovision

Command	Function	Description
WTI	Wait for time	Remains at the step until the specified time interval (MM:SS) has elapsed.
WPT	Wait for % torque	Remains at the step until the specified % torque value is reached.
WTP	Wait for temperature	Remains at the step until the specified temperature value is reached.
WTS	Wait for set point temperature	Remains at the step until the temperature reaches the set point value in the associated temperature controller +/- the specified value.
WDP	Wait for data points	Remains at the step until the specified number of data points are collected from the time this command is issued.
SSN	Set speed	Run the rheometer at the specified speed
STM	Set temperature	Set the temperature controller set point to the specified value and control to this temperature
SZR	Reset Zero	Record the current % Torque value and subtract it from all future torque readings (zero the torque).
DCI	Data collection interval	Begin collecting data at the specified time interval (MM:SS). Data is collected at this interval until a DSD command is issued.
DSP	Collect a single data point	Immediately collect a single data point.

Table 5-1: B.E.A.V.I.S. Commands used in Rheovision

Command	Function	Description
DSD	Stop data collection	Terminate any DCI already in progress.
LSC	Start count loop	Marks the start of a loop. Perform all commands starting after this one up to the next LEC (loop end) the number of times specified.
LEC	End count loop	Marks the end of a loop. Perform all commands before this one back to the most recent LSC the number of times stated in the LSC.
FSA	Append to Data File	<p>Append any data in the capture buffer at the end of the file specified in the first parameter. If a file is specified in the second parameter, perform the appropriate add-on module calculations (for example: API Power Law) on only the data being appended and add that calculation to the end of the second file. The report is then displayed in the dialog box showing all calculations.</p> <p>NOTE: If a full path name is not specified, the file is saved in the current directory. If the files specified do not exist, then they are created.</p> <p>NOTE: Refer to Add-On Modules in Section 4 - Rheovision Software for more information.</p>

Table 5-1: B.E.A.V.I.S. Commands used in Rheovision

Command	Function	Description
FSO	Save data to disk file	<p>Save any data in the capture buffer to the file specified in the first parameter over-writing any data that was already in the file. If a file is specified in the second parameter, perform the appropriate add-on module calculations (for example: API Power Law) on only the data being appended and add that calculation to the end of the second file. The report is then displayed in the dialog box showing all calculations.</p> <p>NOTE: If a full path name is not specified, the file is saved in the current directory. If the files specified do not exist, then they are created.</p> <p>NOTE: Refer to Add-On Modules in Section 4 - Rheovision Software for more information.</p>

Section 6 - Troubleshooting

Introduction

The information in Section 6 will help you troubleshoot problems when they occur. The problems presented in Table 6-1 are followed by possible causes and corrective actions listed in their order of probability of occurrence.

Table 6-1: PVS Rheometer Troubleshooting Procedures

Problem	Possible Cause	Corrective Action
Dashboard temperature display is erratic or incorrect.	Poor contact between mounting tube pins and stator receptacles.	Refer to Cleaning of Wetted Parts in Section 3.
	Shorted or open RTD wiring,	Refer to Appendix A and contact the Brookfield for assistance.
No torque response.	Cable from PVS Rheometer head to base is disconnected	Refer to Figure 2-2 and connect the cable.
	Foreign matter between mounting tube and stops.	Refer to Cleaning of Wetted Parts in Section 3.
	Bent torsion element.	Refer to Appendix A and contact the Brookfield for assistance.
	Open Field coil wiring.	Refer to Appendix A and contact the Brookfield for assistance.

Table 6-1: PVS Rheometer Troubleshooting Procedures (Continued)

Problem	Possible Cause	Corrective Action
No communication to PVS Rheometer.	PVS Rheometer power OFF. Loose or disconnected RS-232 cable. Software/PC communication error.	Refer to Turning Power ON in Section 3. Refer to Figure 2-2 and check RS-232 cable connections. Refer to Communication Problems within this section.
No communication to PVS Bath.	Power OFF. Loose or disconnected RS-232 cable.	Refer to Turning Power ON in Section 3. Refer to Figure 2-2 and check RS-232 cable connections. Refer to Communication Problems within this section.
Dashboard window display indicates dashes upon startup a value higher than 10%.	Zero Offset calibration incorrect.	Refer to Appendix A and contact the Brookfield for assistance.
Cannot install stator/bob.	Mis-aligned stator/bob or lack of lubrication on stator/bob O-ring. Broken/bent element.	Refer to Sample Cup, Stator/Bob and Baffle Installation in Section 3. Refer to Appendix A and contact the Brookfield for assistance.
Stator cannot be removed	Mis-aligned stator/bob or lack of lubrication on stator/bob O-ring. Broken/bent element.	Refer to Sample Cup, Stator/Bob and Baffle Installation in Section 3. Refer to Appendix A and contact the Brookfield for assistance.

Table 6-1: PVS Rheometer Troubleshooting Procedures (Continued)

Problem	Possible Cause	Corrective Action
Fluid inside of stator/bob	Sample foaming and climbing on stator/bob or too much sample in cup.	Reduce the sample fluid level and refer to Cleaning of Wetted Parts in Section 3.
PVS Rheometer will not retain pressure.	Damaged lip seal or other sealing components. Broken torsion element.	Refer to Appendix A and contact the Brookfield for assistance.
Sample cup wobbles	Loose knurled ring or sample cup not installed properly on hub.	Refer to Sample Cup, Stator/Bob and Baffle Installation in Section 3.
Sample cup cannot be removed. Knurled ring will not turn.	Residual pressure inside sample cup.	Refer to Sample Cup Removal in Section 3.
Sample cup cannot be removed. Knurled ring turns.	Sample cup O-ring is binding between cup and hub.	Refer to Appendix A and contact the Brookfield for assistance.
Torque hang-up (Zero point return from the positive direction is different from the negative direction by more than 0.3%.)	Friction in the torque sensor assembly.	Refer to Appendix A and contact the Brookfield for assistance.
Spikes in the torque readings	Solids bridging measuring annulus. Cup contacting stator/bob.	Refer to Cleaning of Wetted Parts in Section 3. Refer to Appendix A and contact the Brookfield for assistance.

Communication Problems

If the warning shown in Figure 6-1 is displayed for either the rheometer or the temperature controller, use the troubleshooting procedures in this section to resolve the problem.



Figure 6-1: Communications Warning Pop-up Window

Instrumentation Setup

1. Ensure that the rheometer or temperature controller (or both) have the appropriate communications cable connected to them and that the opposite end of the cable is connected to a valid COM (serial) port on the host PC.
2. Ensure the rheometer, temperature controller, or both are powered ON.

NOTE: For any optional temperature bath, check the bath's operation manual for RS-232 communication information

3. If communication problems still exist, perform one of the following procedures based the computer operating system being used.

Windows 9X/Windows ME

1. Select the START button.
2. Select SETTINGS then CONTROL PANEL.
3. Select the SYSTEM icon.
4. Select the DEVICE MANAGER tab.
5. Select PORTS. Highlight the COM port in use and select the PROPERTIES button (or double click the COM port in use).
6. Select PORT SETTINGS then ADVANCED.
7. Make sure the check box labeled USE FIFO BUFFERS (requires 16550 compatible UART) is checked. Make sure the sliders for the RECEIVE BUFFER and the TRANSMIT BUFFER are both set all the way to the left (Low).

8. Select the OK buttons to accept the changes and get back to the desktop.
9. If there is still a communication problem, follow the above procedure, but this time, remove the check from the box labeled USE FIFO BUFFERS (REQUIRES 16550 COMPATIBLE UART).
10. Select the OK buttons to accept the changes and get back to the desktop.
11. If communication problems still exist, refer to Appendix A and contact Brookfield Engineering, Inc. technical support.

Section 7 - PVS Sensing Stack Replacement

Tools Required

- Medium slotted screwdriver
- Small slotted screwdriver
- Phillips head screwdriver
- Armature wrench (P/N TT-100-1T)
- Retaining ring pliers (45 degree angle tips)
- 7/64 hex wrench
- 5/32 hex wrench
- 5/64 hex wrench
- 9/32 open end wrench

NOTE: Refer to Figures 7-1 and 7-2 throughout this section for parts identification.

Disassembly

1. Power down the PVS base and disconnect the PVS head cord from the PVS base and disconnect any pressure connections.

CAUTION

Never disconnect the PVS head power cord from the PVS base when the base power switch is in the on position. Damage could occur to the motor drive electronics.

2. Remove the sample cup and stator. Remove the baffle by loosening the (2) hex socket cap screws with a 5/64 hex wrench.

CAUTION

Throughout this section be careful when handling the sensing stack assembly and always protect the mounting tube assembly/torque sensor assembly with the gray PVC guard (PVS-80) when possible.

3. Invert the PVS head on the upright rod of the base so the underneath of the head is accessible by loosening the two hex socket cap screws located on the clamp with a 7/64 hex wrench, which secure the head to the upright rod. Then remove the head from the rod and turn the head upside down, install it back onto the rod and tighten the (2) hex socket cap screws to secure the head to the rod.

CAUTION

Extend the upright rod to the highest position before loosening the clamp screws to prevent the rod from springing upward. Support the PVS head so that the head will not slip down the upright rod when loose and become damaged.

4. Remove the lip seal and retainer assembly (PVS-194Y) by removing the (4) phillips head screws. Two of the holes which the (4) phillips head screws were in are tapped with a 6-32 thread and (1) 6-32 x 1" screw should be installed into each of the two 6-32 tapped holes, turning each screw clockwise 1/4 turn at a time until the lip seal is released.
5. Remove the O-ring (PVS-195) and backup ring (PVS-192). There are three small holes provided in the backup ring for inserting a tool to lift out the backup ring. Once the backup ring is lifted it can be removed with a pair of tweezers.
6. Remove the retaining ring (PVS-36) using a pair of retaining ring pliers with tips positioned at a 45 degree angle.
7. Loosen the clamp screws again and return the PVS head to the normal operating position on the upright rod. Tighten the clamp screws to secure the head to rod.

8. Remove the pressure connections and hardware from the side of the head and remove the (4) slotted screws located on the back of the cover, which secure the cover to the head. Once the screws are removed lift upward on the cover until it is free of the head.
9. Remove the (2) hex socket cap screw with a 5/64 hex wrench, which secure the fan to the PVS head back panel and set aside the fan assembly then remove the strain relief fitting from the side of the sensing stack assembly. Remove the (2) slotted screws, which secure the sensing stack cover and ring terminal to the sensing stack. Remove the sensing stack cover by gently pulling upwards until free.

CAUTION

Do not disconnect the wire ends from the sockets in the microsyn field assembly located under the cover.

10. Remove the two slotted screws and washers that secure the microsyn field assembly to the microsyn housing w/jewel (PVS-204Y). Once the microsyn field is removed the cover, wire and microsyn field can hang off to the side together while finishing the section.
11. The violet and yellow wires which come through the sensing stack assembly must be disconnected from the wires that they are connected to (yellow to black and red, violet to black and white).

CAUTION

Do not cut the wires, try and unsolder them from the other wires to maintain the length for future repair.

12. Remove the Armature assembly using the TT-100-1T armature wrench and 9/32 wrench. Install the armature wrench so that the fingers on the end of the tool fit gently into the cutouts of the armature to hold the armature in place while using the 9/32 wrench to loosen the brass nut of the armature assembly in a counter clockwise direction. Once the nut is loosened sufficiently the remainder of the armature assembly must be pulled gently up and straight off the wire it is attached to.

13. Using a 5/32 hex wrench loosen and remove the (4) hex socket cap screws (10-32x1”) which secure the sensing stack to the base plate using a 5/32 hex wrench. Once the screws are removed the sensing stack assembly can be carefully pulled upward to release it from the Drive hub assembly (PVS-190PY). Make sure to remove the wave spring (PVS-37) and preload spacer (PVS-14) from under the sensing stack, as you will need these during the rebuilding section.
14. Package the old sensing stack assembly and return to Brookfield Engineering Labs, Inc. for refurbishing.

Reassembly

1. Carefully remove the shipping tubes from the new sensing stack assembly.

CAUTION

Be careful not to damage the sensing stack assembly when removing the shipping tubes as damage to the assembly could occur.

2. Place the preload washer (PVS-14) onto the Drive hub assembly with the extended I.D. going into the hub assembly. Place the wave disc spring (PVS-37) onto the preload washer
3. Carefully install the new sensing stack assembly through the base plate, wave disc and preload spacer into the Drive Hub assembly (PVS-190PY) without applying force to the mounting tube assembly/torque sensor assembly. Once the new sensing stack is resting on the base plate rotate the assembly until the (4) 10-32x1 “ can be installed through the torsion element into the base plate and semi tighten the (4) screws using a 5/32 hex wrench. Pull the drive hub assembly forward to put tension onto the motor belt and tighten the (4) 10-32x1” in place ensuring tension on the belt. Install the gray PVC guard (PVS-80) to protect the mounting tube assembly from damage.

NOTE: The screw locations in the base are asymmetrical, so the sensing stack may be installed in one orientation only.

4. Install the armature assembly (armature, clamp and nut) onto the wire, which extend through the microsyn housing w/ jewel until the armature is resting on the jewel in the housing. Once the armature is resting on the jewel the nut should be hand tightened just enough to allow it to secure the armature assembly to the wire yet loose

enough to allow the assembly to be slid up and down on the wire. Slide the armature down the wire until it contacts the jewel then pull up slightly so that the bottom of the armature will not rub on the jewel, then the nut should be tightened to the wire using the TT-100-1T wrench and 9/32 wrench so that it is secure.

CAUTION

Do not bend the wire when tightening the armature nut as damage to the jewel or torsion element may occur.

5. Support the head while loosening the (2) hex socket cap screws, which clamp the head to the upright rod. Once the screws are loose and the head is free remove the head and reinstall on the rod upside down so that the bottom of the head is accessible and tighten the (2) hex socket cap screws to hold the head secure onto the rod. With the head mounted on the rod upside down remove the guard and install the retaining ring (PVS-36) into the groove on the drive mounting sleeve by compressing downward on the drive hub assembly until the groove is exposed.

CAUTION

Be careful not to damage the mounting tube assembly while turning the head upside down on the rod and when installing the retaining ring as serious damage to the torsion element could occur.

6. Once the retaining ring is installed place the backup ring (PVS-192) on top of the retaining ring and install the o-ring (PVS-195). The lip seal in its retainer should be lubricated with Krytox grease (PVS-256) prior to installation. Once lubricated the lip seal & retainer assembly should be carefully installed over the mounting tube assembly and secured into place with the (4) 4-40 phillips head screws. The torsion element guard (PVS-80) should be screwed onto the drive hub assembly to protect the torsion element.
7. Loosen the (2) clamp screws while supporting the head, remove the head from the rod, reinstall the head upright onto the rod and secure by tightening the (2) clamp screws.
8. Carefully replace the microsyn field assembly in to the microsyn housing w/jewel and replace the two slotted screws and washers, and secure it to the housing finger tight. Secure the ring connector

and wire onto the microsyn housing with (1) of the slotted screws which, hold the sensing stack cover onto the sensing stack. Do not at this time install the sensing stack cover until the next steps are completed.

CAUTION

Be sure to secure the ring connector and wire to the microsyn housing or step 11 will be difficult to complete.

9. Reconnect the violet and yellow RTD wires (violet to white/black and yellow to red/black). Solder the wires together to ensure proper contact and cover with shrink tubing to eliminate the possibility of shorting out under the sensing stack cover.
10. Replace one of the screws which hold the fan in place and position so that when the fan operates that the fan blades will not come into contact with anything. Reconnect the PVS head to the base and the CPU to the base.
11. Power up the CPU, PVS base and remove the gray PVC torsion element protector (PVS-80). Open the Rheovision software and click on the dashboard tab. The % torque display should indicate four dashes. Slowly rotate the microsyn field assembly until between -1% and -2% a torque is shown in the % torque display. Tighten the (2) slotted screws, which secure the microsyn field assembly into the microsyn housing w/jewel ensuring that the -1% and -2% torque is maintained. Once this is done gently apply torque to the mounting tube assembly with your hand from right to left when looking at the PVS from the front to ensure that the % torque readings increase to a positive number. Should the % torque value decrease to more negative number while applying torque, then a resetting of the microsyn field assembly will be required because the phase orientation of the microsyn needs to be changed. Should the phase need to be reoriented you must repeat step 11 and find a different position for the microsyn to be secured to give the negative 1-2 % of torque. Once a positive torque is attained by gently applying torque by hand to the mounting tube (right to left) the % torque reading should increase to a positive % torque and return to the original value $\pm .05\%$ torque.

NOTE: There are 45 degrees between each phase position. Torque response alternates direction as each successive position is reached.

CAUTION

When the PVS is powered up the fan will be rotating so be careful, as there are not guards in place to prevent injury with the cover to the PVS head is off.

12. Install the baffle onto the drive mounting sleeve by carefully sliding the baffle up the mounting tube (PVS-125Y) and tightening the (2) hex socket cap screws with a 5/64 hex wrench, captivating the baffle onto the drive mounting sleeve.
13. Remove the slotted screw that secures the ring connector and wire to the microsyn housing. Reinstall the sensing stack cover and secure with the (2) slotted screws with the ring connector and wire secure under one of the screws. Carefully replace the shielded cable into the sensing stack cover using the strain relief connector.
14. Secure the other end of the fan to the back panel of the head and make sure both screws are tightened. Replace the PVS cover onto the head and secure with the (4) cover screws. Reconnect pressure fittings, install stator, and sample cup.
15. Before running, a test calibration should be preformed using a sample with a known centipoise value.

CALIBRATION

Calibration must be performed with the B5 or B1 bob and PVS-30 sample cup. From the Dashboard page of the Rheovision software, click on the geometry table button and set the torque multiplier to a value of 500. Highlight the bob you have decided to use during the calibration, either B01 or B05 on the geometry page of the Rheovision program. Click on the Programs tab in the Rheovision software. Write a program controlling the calibration fluid at the proper fluid calibration temperature using a temperature bath. Take data points at 100, 50, 25 and 10 rpm (allow 30 seconds of wait time for each rpm setting before each data point is taken to ensure proper calibration). Introduce calibration fluid into the PVS-30 sample cup: 2000 cp or higher for calibration using a B5 bob and 1000 cP or higher using a B1 bob. Tighten the sample cup with fluid onto the PVS and run the program you created with the four 4 rpm settings.

NOTE: Shear rates above 200 sec⁻¹ could add error during calibration and data with % torque values below 10% of scale should be disregarded.

Once the program has run, plot the data onto a graph, viscosity vs. rpm. The plotted viscosity of the fluid may be higher or lower than the actual value of the fluid. Should the plotted value of the fluid be lower than the actual value of the fluid, then increase the value of the torque multiplier and rerun the program until the plotted viscosity line is at the actual value of the fluid being measured. Should the plotted value of the fluid be higher than the actual value of the fluid, then decrease the value of the torque multiplier and rerun the program until the plotted viscosity line is at the actual value of the fluid being measured. The torque multiplier can be set from a value of 450-550 for calibration purposes. Should you find that in order to calibrate that the multiplier must be set outside of the 450-550 value, then contact Brookfield Engineering, Process Service Department.

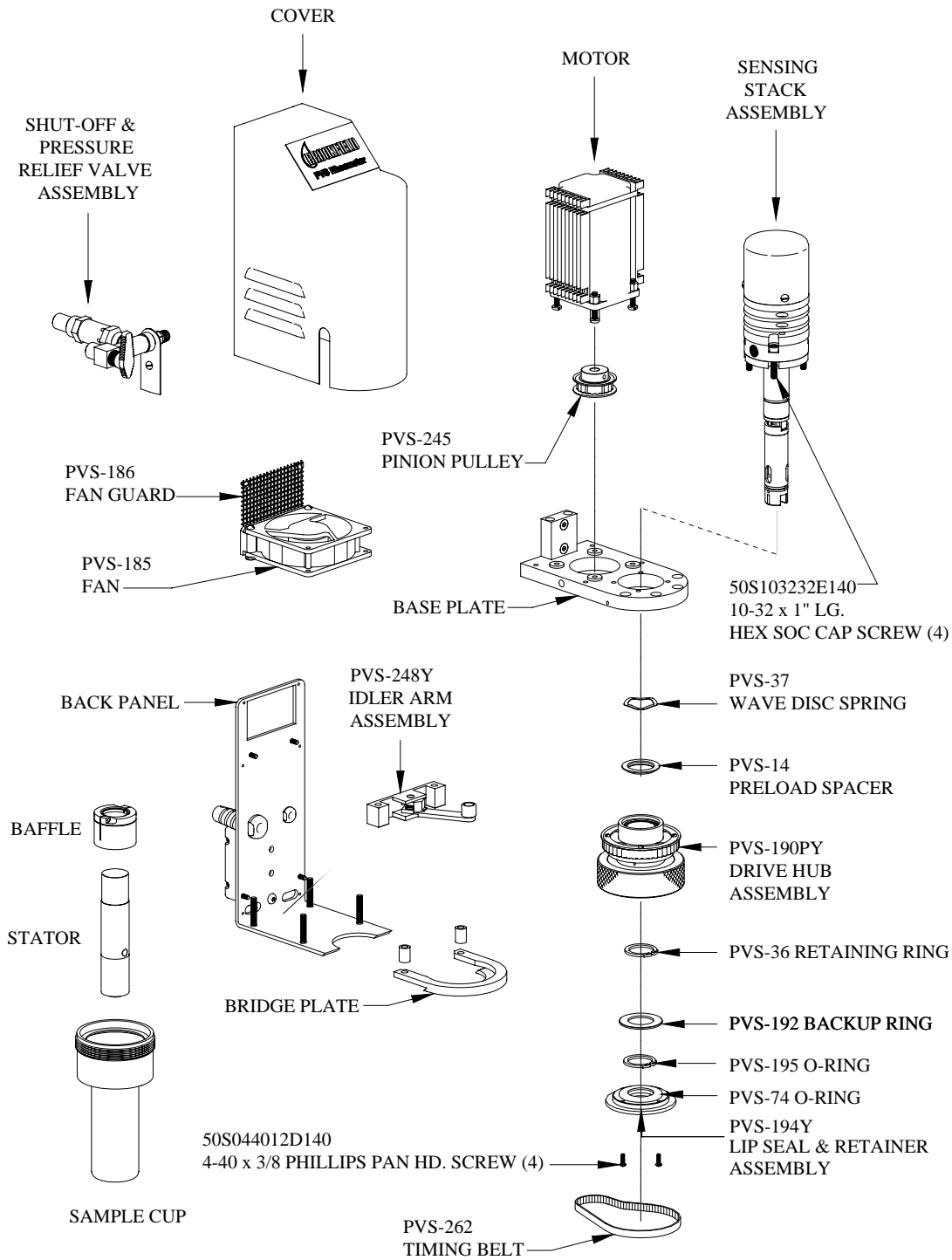


Figure 7-1: PVS Rheometer Component Identification

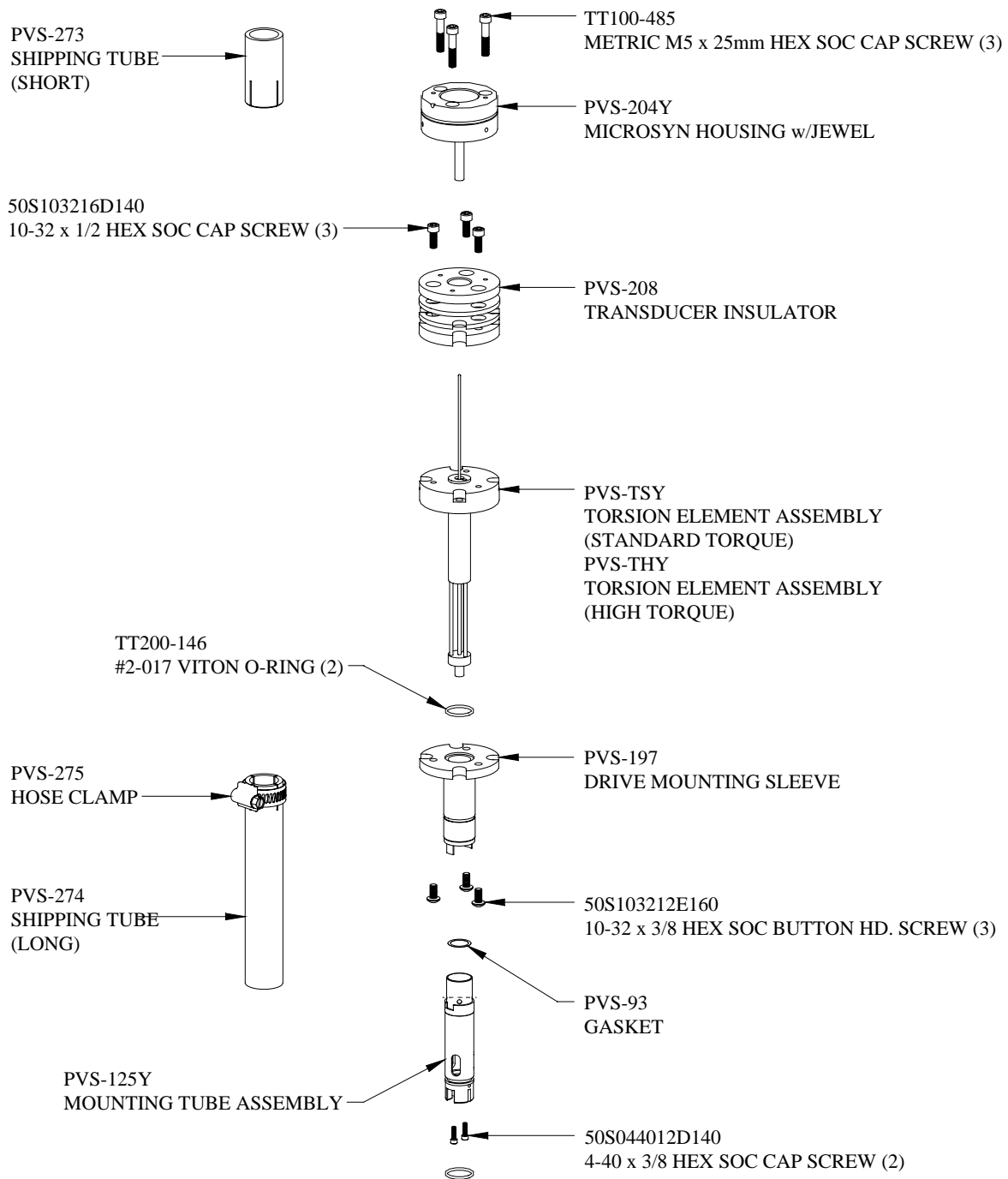


Figure 7-2: PVS Sensing Stack (Exploded View)

Appendix A - Customer Support

Introduction

Use the following information to Contact Brookfield Engineering Laboratories, Inc. for technical assistance or service:

Brookfield Engineering Laboratories, Inc.
11 Commerce Boulevard
Middleboro, Massachusetts 02346 U.S.A.
TEL: 508-946-6200
800-628-8139 (USA only - excluding MA)
FAX: 508-946-6262

Please have the following information available when calling so that we may assist you:

- Product Part Number
- Product Serial Number
- Product Application
- Specific Problem Area
- Hours of Operation
- Equipment Type

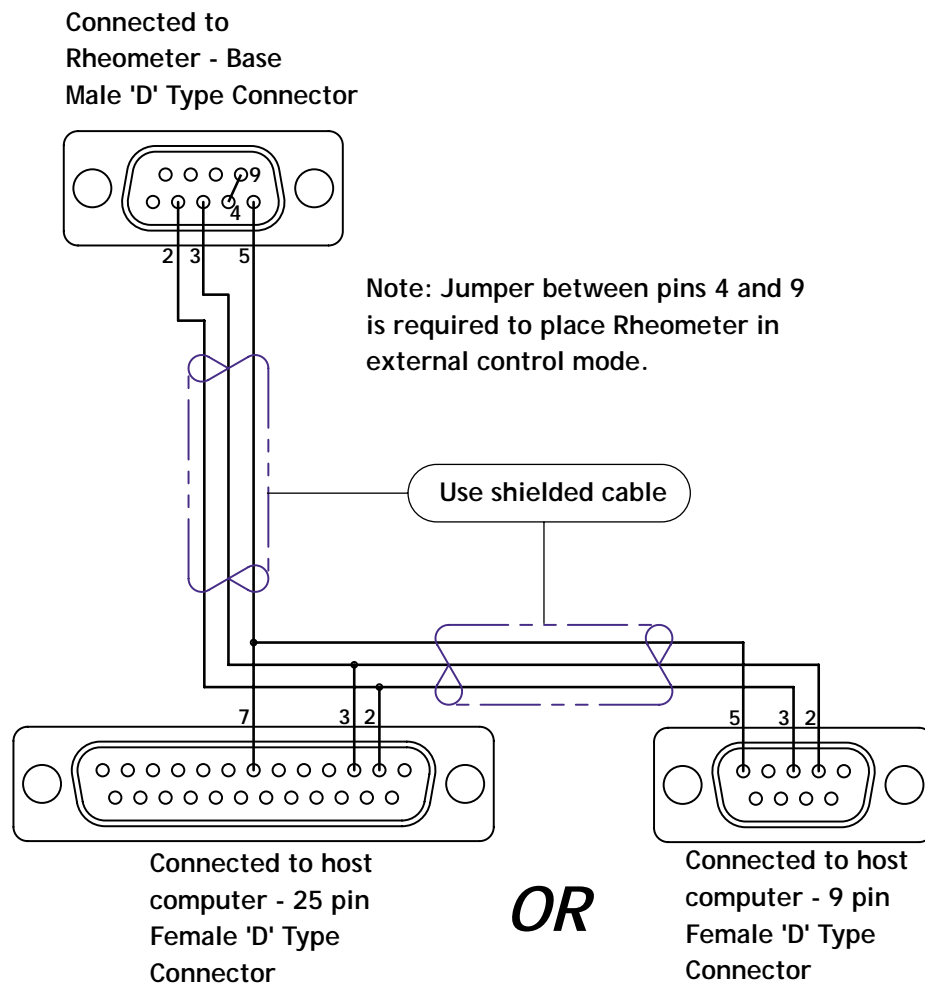
NOTE: Contact Brookfield to obtain a Return Material Authorization number before returning any equipment. The instrument must be cleaned prior to shipment and an MSDS must be provided for the materials being handled.

Appendix B - Drawings

RS-232 Cables, Part No. DVP-80

Use the information in Figure B-1 to test or to make your own RS-232 communication cable.

NOTE: Your computer may use either a standard 9-pin or 25-pin (male or female) D-type connector.



NOTE: This cable is used in two places: between the PVS Rheometer, host computer between the PVS and the Julabo temperature bath.

Figure B-1: RS-232 Cable Drawing

Appendix C – Calculations

Geometry (Stator) Factors

Each measurement geometry is made up of a stator (sometimes referred to as a bob) and a cup with optional inserts in between the two. The purpose of having multiple geometries is to increase the measurement range of the instrument.

Each geometry has two constants used to calculate viscosity, shear stress, and shear rate. The Geometry Torque Constant (SMC) is used in viscosity and shear stress calculations. The Shear Rate Constant (SRC) is used in viscosity and shear rate calculations.

The particulars for each of the geometries is as follows:

Table C-1: Geometry (Spindle) Factors

Bob (Spindle)	Annulus	SRC	SMC	Recommended Sample Size (ml)
B01	0.046	1.703	1700.0	30.0
B02	0.242	0.377	730.0	53.0
B05	0.096	0.850	1340.0	40.0
TA1	0.46	1.0	9750.0	150
4C	0.110	1.161	2500	120
TA5	0.096	0.850	8900.0	175.0
TC5*	0.590	0.285	1430.0	250.0

NOTE: TC5 geometry set uses the triple annulus cup (only) and the B5 stator (only). Neither stator shroud or cup insert are used.

NOTE: The Annulus refers to the gap between the outer diameter of the spindle and the inner diameter of the surrounding cup or sleeve.

Torque Multiplier

The Torque Multiplier is an instrument calibration parameter. The Torque Multiplier for a Standard PVS (PVS002) should be between 450 and 550. The Torque Multiplier for a High Torque PVS (PVS003) should be between 900 and 1100. The Torque Multiplier is strictly related to the properties of the sensor (torsion element) and not the geometry in use.

NOTE: Refer to Torque Multiplier in Section 4 - Rheovision Software for more information

Viscosity Calculation

The viscosity for any rheometer model and geometry may be calculated using the equation:

$$\text{Viscosity [cP]} = (\text{TM} * \% \text{torque} * 10,000) / (\text{rpm} * \text{SMC} * \text{SRC})$$

Where:

TM = Torque Multiplier

SMC = Geometry Torque Constant

SRC = Shear Rate Constant

Shear Stress Calculation

The shear stress for any rheometer model and geometry may be calculated using the equation:

$$\text{Shear Stress [dyne/cm}^2\text{]} = (\text{TM} * \% \text{torque}) / \text{SMC}$$

Where:

TM = Torque Multiplier

SMC = Geometry Torque Constant

Shear Rate Calculation

The shear rate for any geometry may be calculated using the equation:

$$\text{Shear Rate [1/sec}^1\text{]} = \text{rpm} * \text{SRC}$$

Where:

SRC = Shear Rate Constant

NOTE: All the above constants can be found in the Geometry Table dialog box.

Appendix D - Spare Parts List

Tables D-1 through D-3 provide part numbers and a description of commonly used replacement parts. Refer to Appendix A and contact Brookfield or your Brookfield agent for price and delivery information.

Table D-1: Bob/Stator Spare Parts

Part Number	Description
PVS-221HC	Hastelloy C B1 bob (1.358 inches OD) for use with PVS-B1-D-HC set.
PVS-222HC	Hastelloy C B2 bob (0.968 inches OD) for use with PVS-B2-D-HC set.
PVS-223HC	Hastelloy C B5 bob (1.260 inches OD) for use with PVS-B1-D-HC or PVS-TA5B5-D-HC sets.

Table D-2: Cup and Baffle Spare Parts

Part Number	Description
PVS-30HC	Hastelloy C Cup (1.450 inch ID) for use with any stator//bob.
PVS-211HC	Hastelloy C Cup (2.440 inch ID) for use with PVS-TA5B5-d-HC triple annulus set.
PVS-27HC	Hastelloy C baffle for use with any bob/stator.

Table D-3: Miscellaneous Spare Parts

Part Number	Description
PVS-125Y	Mounting tube assembly
PVS-93	Gasket, mounting tube to torsion element
PVS-194Y	Lip seal and retainer assembly

Table D-3: Miscellaneous Spare Parts

Part Number	Description
PVS-193	Lip seal
PVS-195	O-ring, 2-029, Viton lip seal retainer
PVS-252YHC	Hastelloy, C sample cup insert 1.450 inch ID, 1.776 inch OD for use with PVS-TA5B5-D-HC set.
PVS-253YHC	Hastelloy, C stator skirt 2.042 inch ID, 2.122 inch OD for use with PVS-TA5B5-D-HC set.
TT200-146	O-ring, 2-017, Viton (bob/stator to mounting tube or torsion element)
PVS-74	O-ring, 2-140 Viton (sample cup)
PVS-THY	Torsion element, high torque
PVS-TSY	Torsion element, standard torque
PVS-34	Bearing
PVS-90	Protector, PVC, torsion element
PVS-123	Stator gasket (B1 or B5 bob/stator)
PVS-217	Stator gasket (B2 bob/stator)
PVS-105Y	Insulating disc assembly (B1, B5 only, includes RTD)
PVS-244	Pressure relief valve
PVS-268	Carrying case
PVS-126Y	Mounting tube spring replacement kit
PVS-SK	PVS head service tool kit
PVS-SSY-S	Complete torque sensor assembly