BROOKFIELD DIGITAL VISCOMETER

MODEL DV-I+

Operating Instructions

Manual No. **M/92-021-N0902**

Please record the Model and Serial Number of your viscometer. Having this information readily available will help us to assist you should there be any questions regarding your instrument.

Model No. ________________________

Serial No. ________________________

BROOKFIELD

SPECIALISTS IN THE MEASUREMENT AND CONTROL OF VISCOSITY

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I. INTRODUCTION

The Brookfield DV-I+ Viscometer measures fluid viscosity at given shear rates. Viscosity is a measure of a fluid's resistance to flow. You will find a detailed description of the mathematics of viscosity in the Brookfield publication *"More Solutions to Sticky Problems"* a copy of which was included with your DV-I+.

The principle of operation of the DV-I+ is to drive a spindle (which is immersed in the test fluid) through a calibrated spring. The viscous drag of the fluid against the spindle is measured by the spring deflection. Spring deflection is measured with a rotary transducer. The measurement range of a DV-I+ (in centipoise or milliPascal seconds) is determined by the rotational speed of the spindle, the size and shape of the spindle, the container the spindle is rotating in, and the full scale torque of the calibrated spring.

There are four basic spring torque series offered by Brookfield:

	Spring Torque	
Model	dyne-cm	milli Newton-m
LVDV-I+	673.7	0.0673
RVDV-I+	7,187.0	0.7187
HADV-I+	14,374.0	1.4374
HBDV-I+	57,496.0	5.7496

The higher the torque calibration, the higher the measurement range. The viscosity measurement range for each torque calibration may be found in **Appendix B.**

All units of measurement are displayed according to either the CGS system or the SI system.

1. Viscosity appears in units of centipoise (shown as "cP") or milliPascal-seconds (shown as mPa•s) on the **DV-I+** Viscometer display.
2. Torque appears in units of dyne-centimeters or Newton-meters (shown as percent "%") in both cases) on the **DV-I+** Viscometer display.

The equivalent units of measurement in the SI system are calculated using the following conversions:

	SI		**CGS**
Viscosity:	1 mPa•s	=	1 cP
Torque:	1 Newton-m	=	10^7 dyne-cm

References to viscosity throughout this manual are done in CGS units. The DV-I+ Viscometer provides equivalent information in SI units.

I.1 Components

Component	Part Number	Quantity
DV-I+ Viscometer	varies	1
Model S Laboratory Stand	Model S	1
Spindle Set with Case	varies	1
LVDV-I+ set of four spindles or	(SSL)	1
RVDV-I+ set of six spindles (#2 through #7)	(SSR)	1
HA/HBDV-I+ set of six spindles (#2 through #7)	(SSH)	1

For cone/plate versions, a spindle wrench, one cone spindle and sample cup, Part No. CPE-44Y replace the spindle set.

Component	Part Number	Quantity
Shipping Cap	B-30-2	1
Power Cord	DVP-65	1
Guardleg (not supplied with Cone/Plate versions)		
LVDV-I+ or	B-20Y	1
RVDV-I+	B-21Y	1
Carrying Case	DVE-7Y	1

The following applies to DV-I+ Viscometers with the temperature probe option. Look for this symbol Tp throughout this manual for instructions pertaining specifically to DV-I+ Viscometers with temperature probe option.

Component	Part Number	Quantity
RTD Temperature Probe	DVP-94Y	1
Probe Clip	DVE-50	1

Please check to be sure that you have received all components and that there is no damage. If you are missing any parts, please notify Brookfield Engineering or your local Brookfield agent immediately. Any shipping damage must be reported to the carrier.

I.2 Utilities

Input Voltage:	115 VAC or 230 VAC
Input Frequency:	50/60 Hz
Power Consumption:	Less than 20 WATTS

Power Cord Color Code:

	United States	Outside United States
Hot (live)	Black	Brown
Neutral	White	Blue
Ground (earth)	Green	Green/Yellow

I.3 Specifications

Speeds: (rpm)	**LVDV-I+**:	0.0, 0.3, 0.6, 1.5, 3, 6, 12, 30, 60, 0.0, 0.5, 1, 2, 2.5, 4, 5, 10, 20, 50, 100
	RV/HA/HBDV-I+:	0.0, 0.5, 1, 2, 2.5, 4, 5, 10, 20, 50, 100, 0.0, 0.3, 0.6, 1.5, 3, 6, 12, 30, 60

Weight:	Gross Weight	20	lb	9	kg
	Net Weight	17	lb	7.7	kg
	Carton Volume	1.65	cu ft	0.05	m^3

Temperature Sensing Range: -100°C to +300°C (-148°F to +572°F)

Operating Environment: 0°C to 40°C Temperature Range (32°F to 104°F)
20% - 80% R.H.: non-condensing atmosphere

Analog Torque Output: 0 - 1 Volt DC (0 - 100% Torque)

Analog Temperature Output: 0-4 Volt DC (10 mV/°C)

Viscosity Accuracy: ±1% Full Scale Range in Use (See **Appendix E** for details)

Viscosity Repeatability: 0.2% of Full Scale Range in Use

Temperature Accuracy: ±1°C: -100°C to +149°C
±2°C: +150°C to +300°C

Electrical Certifications:
Conforms to CE Standards:
BSEN 50081-1: Emission Standard - Light Industrial
BSEN 50082-1: Immunity Standard - Light Industrial
BSEN 50081-2: Emission Standard - Industrial
BSEN 50082-2: Immunity Standard - Industrial
BSEN 61010-1: Safety requirements for electrical equipment, for measurement, control and laboratory use

Approved Standards: CSA Std. C22.2 No. 151-M1986 - Laboratory Equipment
CSA Class 8721 01 - Laboratory Equipment

Installation Category (over-voltage category) II: Classification of parts of installation systems or circuits in local level, portable equipment, appliances, etc.

I.4 Set-Up

1) To assemble the Model S Laboratory Stand, place the upright rod into the base (refer to assembly instructions in **Appendix H**). The rack gear and clamp assembly should face the front of the base. The upright rod is held in place with the jam nut which is attached from the bottom of the base. Tighten this nut with a suitable wrench (spanner). Attach leveling feet.

2) Insert the mounting rod on the back of the **DV-I+** Viscometer into the hole on the clamp assembly. Be sure that the clamp screw, VS-41Y, is loose.

3) Tighten the VS-41Y clamp screw**.** Adjust the Viscometer to be as close to level as possible while tightening the clamp screw.

4) Connect the RTD temperature probe to the temperature port on the rear panel of the DV-I+.

5) The Viscometer must be leveled. The level is adjusted using the three leveling screws on the base. Adjust so that the bubble level on top of the **DV-I+** is centered within the circle. Check level periodically during use.

6) Make sure that the AC power switch at the rear of the **DV-I+** is in the **OFF** position. Connect the power cord to the socket on the back panel of the instrument and plug it into the appropriate AC line.

The AC input voltage and frequency must be within the appropriate range as shown on the name plate of the viscometer. The DV-I+ must be earth grounded to ensure against electronic failure!

7) For Cone/Plate models, refer to **Appendix A**.

I.5 Safety Symbols and Precautions

Safety Symbols

The following explains safety symbols which may be found in this operating manual.

Indicates hazardous voltages may be present.

Refer to the manual for specific warning or caution information to avoid personal injury or damage to the instrument.

Precautions

If this instrument is used in a manner not specified by the manufacturer, the protection provided by the instrument may be impaired.

This instrument is not intended for use in a potentially hazardous environment.

In case of emergency, turn off the instrument and then disconnect the electrical cord from the wall outlet.

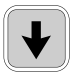
The user should ensure that the substances placed under test do not release poisonous, toxic or flammable gases at the temperatures to which they are subjected to during the testing.

I.6 Key Functions

Figure I-1 shows the control keys on the face of the **DV-I+** Viscometer. The following describes each key's function.

UP ARROW

This key is used to scroll **UP** (in an increasing value direction) through the available speed or spindle tables.



DOWN ARROW

This key is used to scroll **DOWN** (in a decreasing value direction) through the available speed or spindle tables.

> **Note:** Pressing and holding the **DOWN ARROW** key during the POWER ON will enable the temperature display to be read in °C or °F. See Section II.1.

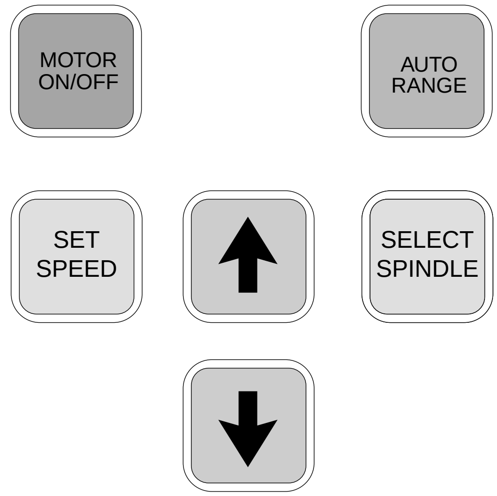
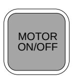
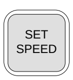


Figure I-1



MOTOR ON/OFF

Turns the motor **ON** or **OFF**.



SET SPEED

Causes the **DV-I+** to begin running at the currently selected speed. Used for Time to Torque and Timed Stop tests. (See Section II.9 - Timed Modes for Viscosity Measurement.)

AUTO RANGE

Presents the maximum (100% torque) viscosity attainable (known as full scale range) for the spindle speed selected. This feature is functional when the motor is running. Viscometer allowable error is 1% of the maximum (100% torque) viscosity value.

> **Note:** Pressing and holding the **AUTO RANGE** key during power on will enable the viscosity display to be changed between **CGS** and **SI** units (see Section II.5).

SELECT SPINDLE

Initiates spindle selection on the first press and then selects the currently scrolled-to spindle when pressed a second time. Used for Time to Torque and Timed Stop tests. (See Section II.9 - Timed Modes for Viscosity Measurement.)

I.7 Cleaning

⚠ Be sure to remove spindle from instrument prior to cleaning. Severe instrument damage may result if cleaned in place.

Instrument and Keypad: Clean with dry, non-abrasive cloth. Do not use solvents or cleaners.

Immersed Components (spindles): Spindles are made of stainless steel. Clean with non-abrasive cloth and solvent appropriate for sample material that is not aggressive to immersed components.

⚠ When cleaning, do not apply excessive force which may result in bending spindles.

II. GETTING STARTED

II.1 Auto Zero

Before readings may be taken, the Viscometer must be Autozeroed. This action is performed each time the power switch is turned on. The display window on the Viscometer will guide you through the procedure as follows:

Turn the power switch (located on the rear panel) to the ON position. This will result in the following screen display:

```
BROOKFIELD DV-I+
RV    VISCOMETER
```

Figure II-1

After a few seconds, the following screen appears:

```
BROOKFIELD DV-I+
  VERSION 5.0
```

Figure II-2

No key press is required at this point. After a short time, the display will clear and the following will be displayed:

```
 REMOVE SPINDLE
 PRESS ANY KEY
```

Figure II-3

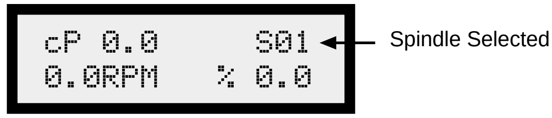
After removing the spindle and pressing any key, the **DV-I+** begins its Autozero. The screen will flash "*Autozeroing*". Note: Be sure that the viscometer is level before initiating Autozero.

After approximately 15 seconds, the flashing stops and the following screen appears:

```
REPLACE SPINDLE
 PRESS ANY KEY
```

Figure II-4

Pressing any key at this point results in the display of the **DV-I+** default screen:



(without Temperature Probe)

(with Temperature Probe)

Figure II-5

The display will vary slightly depending upon the status of the last spindle entry.

> **NOTE:** If the viscosity value exceeds 99,999, scientific notation is used. In FigureII-5, the viscosity value is 123,000 cP.

II.2 Spindle Selection

LVDV-I+ Viscometers are provided with a set of four spindles and a narrow guardleg; RVDV-I+ Viscometers come with a set of six spindles and a wider guardleg; HADV-I+ and HBDV-I+ Viscometers come with a set of six spindles and no guardleg. (See Appendix E for more information on the guardleg.)

The spindles are attached to the viscometer by screwing them to the lower shaft. Note that the spindles have a **left-hand thread**. The lower shaft should be held in one hand and lifted up. The spindles should be screwed to the left. The face of the spindle nut and the matching surface on the lower shaft should be smooth and clean to prevent eccentric rotation of the spindle. Spindles can be identified by the number on the side of the spindle nut.

The DV-I+ requires a Spindle Entry Code number to calculate viscosity values. The two digit entry code for each spindle may be found in Appendix D.

> **NOTE:** The DV-I+ will remember the Spindle Entry Code which was in use when power was turned off.

II.2.1 Spindle Selection for Models WITHOUT Temperature Display

Pressing the **SELECT SPINDLE** key will cause the characters on the top line of the display to begin to *blink* . It will *blink* for about three seconds. If the **UP** or **DOWN ARROW** keys are pressed (while **S** is blinking) the two character spindle value to the right of the **S** character will begin to change (in either an increasing or decreasing direction depending upon which **ARROW** key is pressed) for each press of the key. If the **ARROW** key is pressed and held, the display will scroll through the spindle codes for as long as the **ARROW** key is depressed. When it reaches the last item in the list (either at the *top* or *bottom* of the list) the spindle code displayed will *"roll-over"* to either the first or last spindle code and the scroll action will continue.

When the desired spindle code is displayed, release the **ARROW** key to halt further scrolling. Press the **SELECT SPINDLE** key once again. This will cause the **S** character to cease *blinking* and the new spindle code will be accepted for use in viscometer calculations.

NOTE:	You have approximately three seconds in which to press the **SELECT SPINDLE** key before the *blinking* stops. If you fail to press the **SELECT SPINDLE** key before the *blinking* stops you will have to repeat the above steps and re-select the desired spindle.

The DV-I+ will begin to calculate using the new spindle parameters as soon as the **SELECT SPINDLE** key *is pressed the second time.*

II.2.2 Spindle Section for Models WITH Temperature Display

The steps for selecting and accepting a spindle entry are the same as Section II.2.1 except that when **SELECT SPINDLE** is depressed, the temperature display is temporarily replaced by the spindle entry code until the entry code is accepted (Figure II-6):

Figure II-6

Once the spindle entry code is accepted, the screen will return to the default display:

Figure II-7

The DV-I+ may also be programmed at Brookfield Engineering for "special" user spindles. These "special" spindles will show up on the spindle scroll list starting with the designation "**AA**" and continuing through "**AZ**". Contact Brookfield Engineering regarding your needs for special spindles.

II.3 Speed Selection & Setting

Table II-1 shows the available speed selections.

DV-I+ SPEEDS SETS			
	LV	RV/HA/HB	
Beginning	0.0	0.0	Beginning
	0.3	0.5	
When scrolling	0.6	1.0	When scrolling
"UP"	1.5	2.0	"UP"
	3.0	2.5	
	6.0	4.0	
	12.0	5.0	
	30.0	10.0	
	60.0	20.0	
	0.0	50.0	
	0.5	100.0	
	1.0	0.0	
	2.0	0.3	
	2.5	0.6	
	4.0	1.5	
	5.0	3.0	
	10.0	6.0	
	20.0	12.0	
	50.0	30.0	
↓	100.0	60.0	↓

Table II-1

The DV-I+ may also be programmed with "special" speed sets. A list of special speed sets is included in Appendix F. Please consult Brookfield Engineering or your local dealer/distributor for any special speed requirements not addressed by the standard or special speed sets.

To *select* a viscometer speed first press either the **UP** or **DOWN ARROW** keys which will cause the area to the right of **RPM** (on the bottom line) to display the currently *selected* speed. **Figure II-8** shows the DV-I+ had been operating at 10 RPM, and the current *selected* speed is 10 RPM.

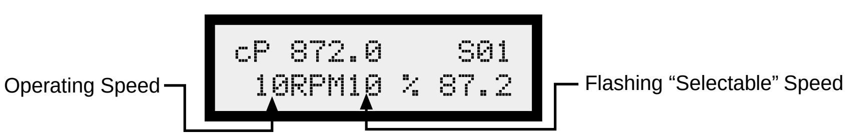


Figure II-8

If the ARROW key is pressed *just once* and then released, the characters **RPM** will *blink* for three seconds, then will cease *blinking* resulting in no change to the speed entry.

> **NOTE:** The speed selection process <u>remembers</u> the last value of scrolled-to speed so that the next time you initiate a speed change (by pressing an **ARROW** key), the DV-I+ will begin its scroll display from the <u>last</u> entered value.

The last-scrolled-to speed *does not* necessarily have to be the same as the speed at which the

DV-I+ is currently running. The user may operate at a given speed and pre-set the DV-I+ to the next desired speed before that speed will be used. For example, if the DV-I+ is currently running at 10 RPM and was *previously* scrolled to 20 RPM, a *single* press of *either* **ARROW** key would result in the **Figure II-9** screen display:

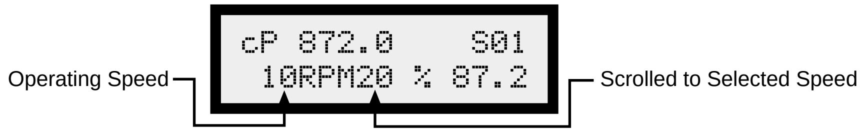


Figure II-9

Pressing the **SET SPEED** key would cause the DV-I+ to begin running at 20 RPM.

Pressing the **MOTOR ON/OFF** again immediately starts the DV-I+ running at the *last scrolled-to-speed*. If you had been running at 10 RPM, pressed **MOTOR ON/OFF** and then re-started the **DV-I+** by pressing **MOTOR ON/OFF** once again, you would again be running at 10 RPM. However, if while the motor was off you had scrolled to a new speed of 20 RPM, pressing the **MOTOR ON/OFF** key would start the DV-I+ running at 20 RPM.

NOTE:	During both spindle or speed selection and scrolling operations, the DV-I+ will continue to calculate and display viscosity (cP) and torque (%).

II.4 Autorange

The **AUTO RANGE** key allows you to determine the maximum calculated viscosity (full scale reading) possible with the current spindle/speed setting. Pressing the key *at any time* will cause the current viscosity display to change and show *that* maximum viscosity. The screen torque display will now display a flashing “%100.0” to indicate this special condition. This maximum viscosity and flashing %100.0 value will be displayed for as long as the **AUTO RANGE** key is depressed. **Figure II-10** shows the **AUTO RANGE** function for the situation where the No. 1 RV spindle is rotating at 10 RPM. The full scale range is 1000 cP (or 1000 mPa·s).

NOTE:	If the motor is **off** or the RPM is **0.0**, the maximum viscosity displayed will be **0.0** cP (or 0.0 mPa·s).

Figure II-10

II.5 CGS or SI Units Selection

Pressing and holding the **AUTO RANGE** key during power on will enable the viscosity display to be read in either CGS or SI units. To change the unit format:

1. Turn the power off.
2. Press and hold the **AUTO RANGE** key and turn the power ON.

The DV-I+ will retain the unit selection when the viscometer is turned OFF.

	CGS	SI
Viscosity	cP	mPa·s

DV-I+ Viscometers without this function can be updated. Contact Brookfield or your local Brookfield dealer for this service.

II.6 Temperature Display in °F or °C Selection

Pressing and holding the **DOWN ARROW** key during power on will enable the temperature display to be read in either degrees Fahrenheit or degrees Centigrade. To change the units format:

1. Turn the power **OFF**.
2. Press and hold the **DOWN ARROW** key and turn power **ON**.

The DV-I+ will retain the unit selection when the viscometer is turned **OFF**.

The following screen depicts the changes to the default screen when displaying temperature in the Fahrenheit scale and viscosity display in SI units:

```
mPas123.4 70.1°F
 10 RPM   % 89.7
```

Figure II-11

II.7 Out of Range

Brookfield recommends taking viscosity readings between 10% and 100% of scale. The DV-I+ gives indications for out of specification or out-of-range operation. When **%** (**Torque**) readings exceed 100.0 % (over-range), the display changes to that shown in **Figure II-12**:

```
cP EEEE      S01
10 RPM   % EEEE
```

Figure II-12

You must change either speed or spindle to correct this condition. If you operate at spindle speeds that produce **%** (**Torque**) below 10.0 % (under-range), the **DV-I+** displays both **%** (**Torque**) and **cP (Viscosity)** preceded by a "**?**" as shown in **Figure II-13**:

```
cP? 78.0    S01
 10RPM20 % ?7.8
```

Figure II-13

Negative **%** (**Torque**) will be displayed as shown in **Figure II-14**:

```
cP ----      S01
 10RPM20 % -0.2
```

Figure II-14

Viscosity values will be displayed as "**- - - -**" when the **%** (**Torque**) is below zero.

II.8 Operation

The following procedure is outlined for making a viscosity measurement in a 600 ml low form Griffin beaker.

1. Mount the guardleg on the DV-I+ Viscometer (LV and RV series). Attach the spindle to the lower shaft. Lift the shaft slightly, holding it firmly with one hand while screwing the spindle on with the other (note left-hand thread). Avoid putting side thrust on the shaft.

2. Insert and center spindle in the test material until the fluid's level is at the immersion groove in the spindle's shaft. With a disc-type spindle, it is sometimes necessary to tilt the spindle slightly while immersing to avoid trapping air bubbles on its surface. (You may find it more convenient to immerse the spindle in this fashion before attaching it to the Viscometer.)

3. To make a viscosity measurement, select the desired speed setting. Allow time for the indicated reading to stabilize. The time required for stabilization will depend on the speed at which the Viscometer is running and the characteristics of the sample fluid. For maximum accuracy, readings below 10% should be avoided. Additional information on making viscosity measurements is available in Appendix C or the Brookfield publication *"More Solutions to Sticky Problems"*.

4. Press the **MOTOR ON/OFF** key to turn the motor "**OFF**" when changing a spindle or changing samples. Remove spindle before cleaning. Clean spindles after use.

5. Interpretation of results and the instrument's use with non-Newtonian and thixotropic materials is discussed in the booklet, *"More Solutions to Sticky Problems"*, and in Appendix C, Variables in Viscosity Measurements.

II.9 Timed Modes for Viscosity Measurement (available in instruments with V3.0 or greater)

The **Timed Modes** allow the viscometer user to implement **Timed Stop** and **Time to Torque** capabilities with the DV-I+ Viscometer. This feature will allow the user to set up the viscometer (i.e. select spindle and speed) and then record readings for a fixed period of time (Timed Stop) or until a set torque value is attained (Time to Torque). A series of menus will ask the user to input minutes and seconds (Timed Stop) or % torque (Time to Torque) and will then begin timing when the user presses the **MOTOR ON/OFF** key to ON. A message will be displayed showing time remaining (or time elapsed) and the appropriate display item (viscosity or torque) will be updated continuously during the event. Upon completion, the viscometer will display a screen stating that the test is complete and will also display the final recorded value for the viscosity in the first case, and the time in minutes and seconds to reach the torque limit in the second case. Pressing the **UP** or **DOWN** arrow keys will allow alternate data to be examined and pressing any other key will bring the user back to the default (normal) viscometer display with the motor **OFF**. If the user wishes to run another test, repeat the above steps.

II.9.1 Set Up

1. The user must pre-select the display unit option: **CGS** or **SI**.

2. The user then selects (via the **UP** and **DOWN** arrows) the spindle speed.

NOTE: If 0.0 RPM is the selected speed setting (the default after executing **AUTOZERO**) the timed modes can be executed; however, the results will be meaningless showing no viscosity values.

3. Next, the user selects the spindle number corresponding to the spindle attached.

4. Now, the user presses the **MOTOR ON/OFF** key to ensure that the motor is OFF. Setting the motor to the OFF condition sets up the viscometer for executing the **Timed Modes**.

5. The user presses the **SET SPEED** and **SELECT SPINDLE** keys ***simultaneously*** to enter either of the timed test modes. Immediately, the following screen appears:

```
↑TIMED STOP
↓TIME TO TORQUE
```

Figure II-15

The user presses either the **UP** or **DOWN ARROW** key to select the test method of choice and is immediately presented with the corresponding opening screen.

II.9.2 Timed Stop

1. After pressing the **UP ARROW** key when in the display of **Figure II-16**, the user is presented with the following screen:

```
  TIMED STOP
SET MIN'S: 00
```

Figure II-16

Using the **UP** and **DOWN ARROW** keys, the user enters a value for the minutes portion of the time to stop. This value can be as high as 99 minutes.

2. When satisfied, the user presses the **SELECT SPINDLE** key again to enter the seconds setting display:

```
  TIMED STOP
SET SEC'S: 00
```

Figure II-17

Using the **UP** and **DOWN ARROW** keys, the user enters a value for the seconds portion of the time to stop. This value will be between 0 and 59 seconds.

NOTE:	The value for minutes or seconds must be other than zero or you will not be able to exit this mode.

The user presses the **SELECT SPINDLE** key one more time at which point the viscometer will display the following screen:

```
TIMED STOP:PRESS
 MOTOR ON/OFF
```

Figure II-18

3. At this point, the user need only press the **MOTOR ON/OFF** key to begin the timed stop operation. Any other key will abort the process and the user will have to begin again by ***simultaneously*** pressing the **SET SPEED** and **SELECT SPINDLE** keys.

4. We will assume that the user pressed the **MOTOR ON/OFF** key to ON and is now presented with the following screen for the duration of the timed run:

```
cP 123456789
MIN: 15  SEC:13
```

Figure II-19

NOTE: When this mode has begun, a press of the **MOTOR ON/OFF** key will interrupt the Timed Stop sequence and return the user to normal operation.

The seconds display will decrement from 59 to zero (0) in one (1) second intervals. When seconds reaches zero (0), the minutes value will decrement by one (1) minute. This will continue until all of the time has elapsed at which point the viscometer will display the following screen:

```
cP 123456789
TIMED STOP DONE
```

Figure II-20

At this point, the viscometer will stop the motor and continue to display this screen until the user presses the **UP** or **DOWN ARROW** keys to view the Torque and Speed that were current at the Timed Stop completion. This display would appear as follows:

```
%=76.4   RPM=100
TIMED STOP DONE
```

Figure II-21

The display will switch between that of **Figures II-20** and **II-21** for each press of either the **UP** or **DOWN ARROW** key. Pressing any key except the **UP** or **DOWN ARROW** keys will cause the viscometer to exit the Timed Stop mode and resume normal operation.

NOTE: For the Timed Stop method, the DV-I+ Viscometer will retain the last value for the time interval in **EEPROM** so that it will become the default the next time the user elects to use this method.

II.9.3 Time to Torque

1. After pressing the **DOWN ARROW** key when in the display of **Figure II-15**, the user is presented with the following screen:

```
 TIMED TORQUE
SET TORQUE: 00%
```

Figure II-22

Using the **UP** and **DOWN ARROW** keys, the user enters a value for the torque level which the viscometer must achieve. This value can be as high as 99%.

> **NOTE:** The value for torque must be other than zero or you will not be able to exit this mode.

2. The user presses the **SELECT SPINDLE** key one more time to end the torque input at which point the viscometer will display the following screen:

```
TIMED TORQ:PRESS
 MOTOR ON/OFF
```

Figure II-23

The time to torque value can be as high as **99** minutes and **59** seconds.

3. At this point, the user need only press the **MOTOR ON/OFF** key to begin the timed torque operation. Any other key will abort the process and the user will have to begin again by ***simultaneously*** pressing the **SET SPEED** and **SELECT SPINDLE** keys.

4. We will assume that the user pressed the **MOTOR ON/OFF** key to ON and is now presented with the following display for the duration of the timed torque run:

```
 TORQUE = 24.2%
MIN: 15  SEC: 13
```

Figure II-24

> **NOTE:** When this mode has begun, a press of the **MOTOR ON/OFF** key will interrupt the time to torque operation and return the user to normal operation.

The seconds display will increment from zero (0) to 59 in one (1) second intervals and the current value of the viscometer torque will be updated continuously. When seconds reach 59, the minutes value will increment by one (1) minute. This will continue until the user selected torque value is attained at which point the viscometer will display the following screen:

```
 22M 54S TO 85%
TIMED TORQ DONE
```

Figure II-25

At this point, the viscometer will stop the motor and continue to display this screen until the user presses the **UP** or **DOWN ARROW** keys to view the viscosity that was current at the Timed Torque completion. The display would appear as follows:

```
CP 123456789
TIMED TORQ DONE
```

Figure II-26

The display will switch between that of **Figures II-25** and **II-26** for each press of either the **UP** or **DOWN ARROW** key. Pressing any key except the **UP** or **DOWN ARROW** key will cause the viscometer to exit the Timed Torque mode and resume normal operation.

NOTE:	For the Time to Torque method, the DV-I+ Viscometer will retain the last entered torque in **EEPROM** for use when the user elects to perform a time to torque test again.

Appendix A - Cone/Plate Viscometer Set-Up

This Cone/Plate version of the DV-I+ uses the same operating instruction procedures as described in this manual. However, the “gap” between the cone and the plate must be verified/adjusted before measurements are made. This is done by moving the plate (built into the sample cup) up towards the cone until the pin in the center of the cone touches the surface of the plate, and then by separating (lowering) the plate 0.0005 inch (0.013mm).

DV-I+ Cone/Plate Viscometers, S/N 50969 and higher, have an Electronic Gap Setting feature. This feature enables the user to easily find the 0.0005 inch gap setting that was established at Brookfield prior to shipment.

The following information explains how to set the Electronic Gap and verify calibration of the DV-I+ Viscometer.

A.1 ELECTRONIC GAP SETTING FEATURES

TOGGLE SWITCH allows you to enable/disable the Electronic Gap Setting Feature: left position is OFF (disabled), right position is ON (enabled).

PILOT LIGHT is the red (LED) light; when illuminated, it means the Electronic Setting Function is sensing (enabled).

CONTACT LIGHT is the yellow (LED) light; when it first turns on, the “hit point” has been found.

SLIDING REFERENCE MARKER is used after finding the “hit point;” it is the reference for establishing the 0.0005 inch gap.

MICROMETER ADJUSTMENT RING is used to move the cup up or down in relation to the cone spindle. Turning the ring left (clockwise) lowers the cup; turning it right (counterclockwise) raises the cup. Each line on the ring represents one scale division and is equivalent to 0.0005 inch movement of the plate relative to the cone.

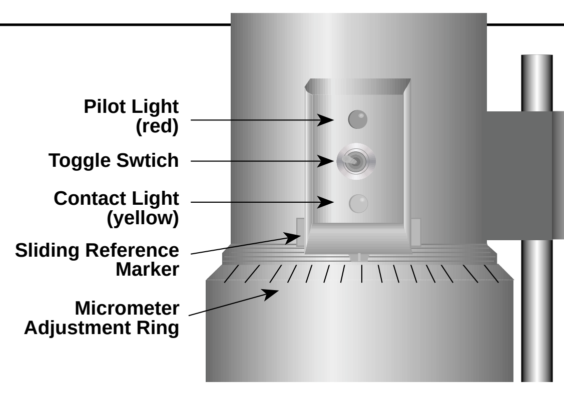


Figure A-1

A.2 SETUP

1. Be sure that the Viscometer is securely mounted to the Laboratory Stand, leveled and zeroed with no cone or cup attached and 0% torque is displayed.

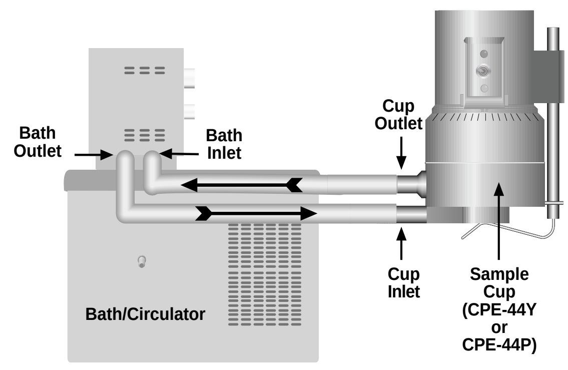


Figure A-2

2. **Figure A-2** shows a typical water bath setup. Connect the sample cup inlet/outlet ports to the water bath inlet and outlet and set the bath to the desired test temperature. Allow sufficient time for the bath to reach the test temperature.

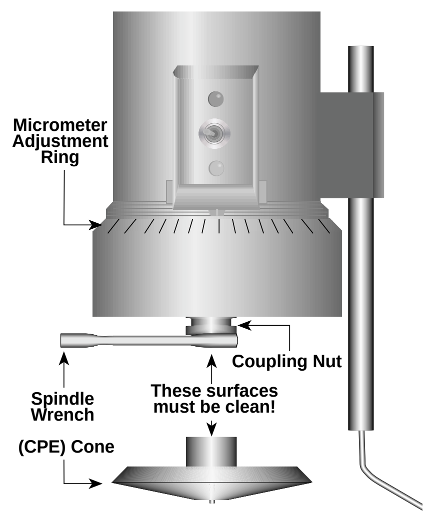


Figure A-3

3. The Viscometer has been supplied with a special cone spindle(s) which contains the Electronic Gap Setting feature. The "CPE" part number designation on the cone verifies the Electronic Gap Setting feature. Note: The "CPE" cone or cup cannot be used with earlier DV-I+ cone/plate Viscometers (below S/N50969) which do not have the electronic gap setting feature.

4. With the motor off, thread the cone spindle by using the spindle wrench to secure the viscometer coupling nut (see **Figure A-3**); gently push up on the coupling nut and hold this securely with the wrench. Thread the cone spindle by hand. Note: <u>Left Hand Threads.</u>

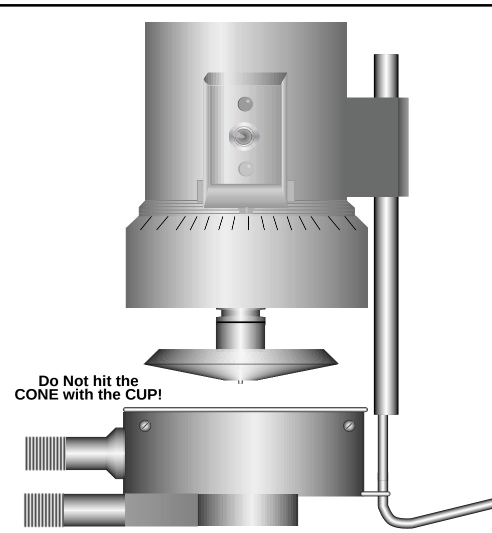


Figure A-4

5. Attach the cup, taking care not to hit the cone with the cup (**Figure A-4**). There must be no fluid in the cup.

> The viscosity of electrically conductive fluids may be affected if readings are taken with the Electronic Gap Setting feature "on". Be sure to shut the feature "off" before taking readings!

A.3 SETTING THE GAP

1. Move the toggle switch to the right; this will turn on (enable) the Gap Setting Feature. The Pilot (red) light will be illuminated.

2. If the contact light (yellow) is illuminated, turn the micrometer adjustment ring clockwise (as you look down on the instrument) until the light is just breaking contact, i.e., flickering (see **Figure A-5**).

3. If the yellow contact light is not illuminated, *slowly* turn the micrometer adjustment ring in small increments (one or two scale divisions) counter-clockwise.

   Continue moving the micrometer adjustment ring *slowly* counter-clockwise until the contact light (yellow) turns on. Back off (rotate clockwise) until the light is just breaking contact, i.e., flickering.

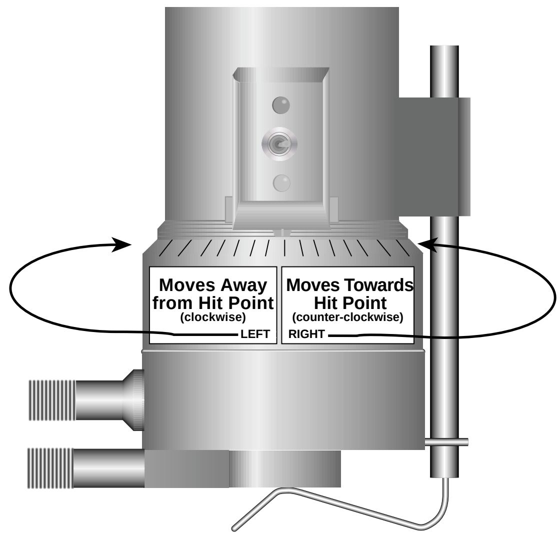


Figure A-5

4. Adjust the sliding reference marker, right or left, to the closest full scale division mark **(see Figure A-6)**.

5. Turn the micrometer adjustment ring one scale division to the left to meet the line on the sliding reference marker. **THE YELLOW CONTACT LIGHT SHOULD GO OFF**.

6. You have established the gap space needed for measurement. Now turn the toggle switch OFF (left); the red pilot light should go off.

7. Carefully remove the sample cup.

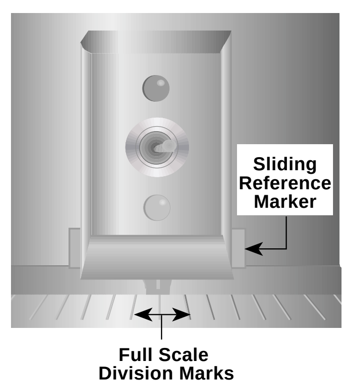


Figure A-6

Notes

1. The cup may be removed and replaced without resetting the gap if the micrometer adjustment ring has not been moved.
2. Remove the spindle from the viscometer when cleaning.
3. Re-establish the hit point every time the spindle is attached/detached.

A.4 VERIFYING CALIBRATION

1. Determine the appropriate sample volume. Refer to Table A-1 to determine the correct sample volume required for the spindle to be utilized.

2. Select a Brookfield Viscosity Standard fluid that will give viscosity readings between 10% and 100% of full scale range. Refer to **Appendix B** for viscosity ranges of cone spindles; ranges listed apply to CPE cones.

   Do not use a silicone viscosity standard fluid with a viscosity value greater than 5000 cP with a Cone/Plate. Brookfield offers a complete range of mineral oil viscosity standards suitable for use with Cone/Plates for viscosities above 5,000 cP or shear rates above 500 sec^{-1}; see Table E1 in Appendix E for a list of available fluids.

   It is best to use a viscosity standard fluid that will be close to the maximum viscosity for a given cone spindle/speed combination.

   Example: LVDV-I+ Viscometer, Cone Spindle CPE-42, Brookfield Silicone Viscosity Standard having a viscosity of 9.7 cP at 25°C.

   At 60 RPM, the full scale viscosity range is 10.0 cP. Thus, the Viscometer reading should be 97% torque and 9.7 cP viscosity ± 0.197 (closer to ±0.2) cP. The accuracy is a combination of Viscometer and fluid tolerance (refer to **Interpretation of Calibration Test Results** in Appendix E).

3. With the motor off, remove the sample cup and place the viscosity standard fluid into the cup.

Table A6

Cone Part No.	Sample Volume
CPE-40	0.5 ml
CPE-41	2.0 ml
CPE-42	1.0 ml
CPE-51	0.5 ml
CPE-52	0.5 ml

Table A-1

4. Attach the sample cup to the Viscometer and allow sufficient time for the sample, cup and cone to reach temperature equilibrium.

5. Turn the motor on. Set the desired speed(s). Measure the viscosity and record the reading in both % torque and centipoise (cP).

   NOTE: The cone spindle must rotate at least five (5) times before a viscosity reading is taken.

6. Verify that the viscosity reading is within the allowable 1% deviation, as explained earlier, for the specific viscosity standard fluid(s) that you are using.

***** The CPE designation on the cone spindle indicates use with Electronic Gap Setting Cone/Plate Viscometers/ Rheometers **only**.

Appendix B - Viscosity Ranges

LV(#1-4) and RV,HA,HB(#1-7) Viscometers

Viscosity Range (cP)		
Viscometer	**Minimum**	**Maximum**
LVDV-I+	15	2,000,000
RVDV-I+	100	13,300,000
HADV-I+	200	26,600,000
HBDV-I+	800	106,400,000

Vane Spindles

Spindle	Torque Range	Shear Stress Range Pa	dyne/cm^2	Viscosity Range cP (mPa•s) @ 10 rpm
V-71	RV	.5-5	5-50	262 - 2620
V-72	RV	2-20	20-200	1110 - 11100
V-73	RV	10-100	100-1000	5350 - 53500
V-71	HA	1-10	10-100	524 - 5240
V-72	HA	4-40	40-400	2220 - 22200
V-73	HA	20-200	200-2000	10700 - 107000
V-71	HB	4-40	40-400	2096 - 20960
V-72	HB	16-160	160-1600	8880 - 88800
V-73	HB	80-800	800-8000	42800 - 428000
V-71	5xHB	20-200	200-2000	10480 - 104800
V-72	5xHB	80-800	800-8000	44400 - 444000
V-73	5xHB	400-4000	4000-40000	214000 - 2140000

Notes: 1) *1 Pa = 10 dyne/cm^2*
2) *1 cP = 1 mPa•s*
3) *Possibility of turbulence at speeds above 10 rpm may give artificially higher viscosity readings.*

Small Sample Adapter and Thermosel

SSA and Thermosel Spindle	Viscosity (cP) LVDV-I+	Shear Rate sec-1
SC4-16	120 - 400,000	.29N
SC4-18	3 - 10,000	1.32N
SC4-25	480 - 1,600,000	.22N
SC4-31	30 - 100,000	.34N
SC4-34	60 - 200,000	.28N
SC4-81	3 - 10,000	1.29N
SC4-82	3 - 10,000	1.29N
SC4-83	11 - 38,000	1.29N

SSA and Thermosel Spindle	Viscosity (cP)			Shear Rate sec-1
	RVDV-I+	HADV-I+	HBDV-I+	
SC4-14	1,250 - 4,165,000	2,500 - 8,330,000	10,000 - 33,360,000	.40N
SC4-15	500 - 1,660,000	1,000 - 3,320,000	4,000 - 13,280,000	.48N
SC4-25	0 - 167,000	100 - 334,000	400 - 1,336,000	.93N
SC4-27	250 - 830,000	500 - 1,660,000	2,000 - 6,640,000	.34N
SC4-28	500 - 1,660,000	1,000 - 3,320,000	4,000 - 13,280,000	.28N
SC4-29	1,000 - 3,330,000	2,000 - 6,660,000	8,000 - 26,640,000	.25N
SC4-81	37 - 10,000	73.0 - 10,000	292 - 10,000	1.29N
SC4-82	37 - 10,000	73.0 - 10,000	292 - 10,000	1.29N
SC4-83	121 - 50,000	243 - 50,000	970 - 50,000	1.29N

UL Adapter

UL Spindle	Viscosity (cP)				Shear Rate sec-1
	LVDV-I+	RVDV-I+	HADV-I+	HBDV-I+	
YULA-15 or 15Z	1 - 2,000	7 - 2,000	13 - 2,000	52 - 2,000	1.22N
ULA-DIN-Y	1 - 3,800	11 - 5,000	22 - 5,000	85 - 2,000	1.29N

DIN Adapter Accessory

DAA Spindle	Viscosity (cP)				Shear Rate sec-1
	LVDV-I+	RVDV-I+	HADV-I+	HBDV-I+	
85	2 - 4,000	12 - 5,000	24 - 5,000	98 - 5,000	1.22N
86	4 - 3,800	37 - 10,000	73 - 10,000	292 - 10,000	1.29N
87	11 - 38,000	121 - 50,000	243 - 50,000	970 - 50,000	1.29N

Spiral Adapter

Spiral Spindle	Viscosity (cP)				Shear Rate sec-1
	LVDV-I+	RVDV-I+	HADV-I+	HBDV-I+	
SA-70	98 - 98,500	1,000-1,050,000	2,100-2,100,000	8,400-8,400,000	.00677 - .67.7N (1-100 RPM)

Cone/Plate Viscometer

Cone Spindle	Viscosity (cP)				Shear Rate sec-1
	LVDV-I+	RVDV-I+	HADV-I+	HBDV-I+	
CPE-40	.30 - 1,028	3 - 10,900	7 - 21,800	26 - 87,200	7.5N
CPE-41	1.15 - 3,840	12 - 41,000	25 - 82,000	98 - 328,000	2.0N
CPE-42	.60 - 2,000	6 - 21,300	13 - 42,600	51 - 170,400	3.84N
CPE-51	4.8 - 16,178	51.8 - 172,600	103.4 - 345,200	414.2 - 1,380,800	3.84N
CPE-52	9.3 - 31,000	99.2 - 330,733	198.4 - 661,466	793.6 - 2,645,866	2.0N

Helipath with T-Bar Spindles

T-Bar Spindle	Viscosity (cP)			
	LVDV-I+	RVDV-I+	HADV-I+	HBDV-I+
T-A	156 - 62,400	2,000 - 400,000	4,000 - 800,000	16,000 - 3,200,000
T-B	312 - 124,800	4,000 - 800,000	8,000 - 1,600,000	32,000 - 6,400,000
T-C	780 - 312,000	10,000 - 2,000,000	20,000 - 4,000,000	80,000 - 16,000,000
T-D	1,560 - 624,000	20,000 - 4,000,000	40,000 - 8,000,000	160,000 - 32,000,000
T-E	3,900 - 1,560,000	50,000 - 10,000,000	100,000 - 20,000,000	400,000 - 80,000,000
T-F	7,800 - 3,120,000	100,000 - 20,000,000	200,000 - 40,000,000	800,000 - 160,000,000

In taking viscosity measurements with the DV-I+ Viscometer there are two considerations which pertain to the low viscosity limit of effective measurement.

1) Viscosity measurements should be accepted within the equivalent % Torque Range from 10% to 100% for any combination of spindle/speed rotation.

2) Viscosity measurements should be taken under laminar flow conditions, not under turbulent flow conditions.

The first consideration has to do with the accuracy of the instrument. All DV-I+ Viscometers have a full scale range allowable error of (+/-) 1% of any spindle/speed in use. We discourage taking readings below 10% of range because the potential viscosity error of (+/-) 1% is a relatively high number compared to the instrument reading.

The second consideration involves the mechanics of fluid flow. All rheological measurements of fluid flow properties should be made under laminar flow conditions. Laminar flow is flow wherein all particle movement is in layers directed by the shearing force. For rotational systems, this means all fluid movement must be circumferential. When the inertial forces on the fluid become too great, the fluid can break into turbulent flow wherein the movement of fluid particles becomes random and the flow can not be analyzed with standard math models. This turbulence creates a falsely high viscometer reading with the degree of non-linear increase in reading being directly related to the degree of turbulence in the fluid.

For the following geometries, we have found that an approximate transition point to turbulent flow occurs:

1) No. 1 LV Spindle: 15 **cP** at 60 RPM
2) No. 1 RV Spindle: 100 **cP** at 50 RPM
3) UL Adapter: 0.85 **cP** at 60 RPM

Turbulent conditions will exist in these situations whenever the RPM/cP ratio exceeds the values listed above.

Appendix C - Variables in Viscosity Measurement

As with any instrument measurement, there are variables that can affect a viscometer measurement. These variables may be related to the instrument (viscometer), or the test fluid. Variables related to the test fluid deal with the rheological properties of the fluid, while instrument variables would include the viscometer design and the spindle geometry system utilized.

Rheological Properties

Fluids have different rheological characteristics that can be described by viscometer measurements. We can then work with these fluids to suit the lab or process conditions.

There are two categories of fluids:

Newtonian - These fluids have the same viscosity at different Shear Rates (different RPM's) and are called Newtonian over the Shear Rate range they are measured.

Non-Newtonian - These fluids have different viscosities at different shear rates (different RPM's). They fall into two groups:

1) Time Independent
2) Time Dependent

Time Independent means that the viscosity behavior does not change as a function of time when measuring at a specific shear rate.

Pseudoplastic - A pseudoplastic material displays a decrease in viscosity with an increase in shear rate, and is also known as "shear thinning". If you take viscometer readings from a low to a high RPM and then back to the low RPM, and the readings fall upon themselves, the material is time independent ,pseudoplastic and shear thinning.

Time Dependent means that the viscosity behavior changes as a function of time when measuring at a specific shear rate.

Thixotropic - A thixotropic material has decreasing viscosity under constant shear rate. If you set a viscometer at a constant speed recording viscosity values over time and find that the viscosity values decrease with time, the material is thixotropic.

Brookfield publication, *"More Solutions to Sticky Problems"*, includes a more detailed discussion of rheological properties and non-Newtonian behavior.

Viscometer Related Variables

Most fluid viscosities are found to be non-Newtonian. They are dependent on Shear Rate and the spindle geometry conditions. The specifications of the viscometer spindle and chamber geometry will affect the viscosity readings. If one reading is taken at 2.5 rpm, and a second at 50 rpm, the two viscosity values produced will be different because the readings were made at different shear rates. The faster the spindle speed, the higher the shear rate.

The shear rate of a given measurement is determined by: the rotational speed of the spindle, the size and shape of the spindle, the size and shape of the container used and therefore, the distance between the container wall and the spindle surface.

A repeatable viscosity test should control or specify the following:

1) Test temperature
2) Sample container size (or spindle/chamber geometry)
3) Sample volume
4) Viscometer model
5) Spindle used (if using LVDV-I+ (#1-4) or RVDV-I+ (#1-7) attach the guard leg)
6) Test speed or speeds (or the shear rate)
7) Length of time or number of spindle revolutions to record viscosity.

Appendix D - Spindle and Model Codes

Each spindle has a two digit code which is scrolled to via the keypad on the **DV-I+**. The spindle code directs the **DV-I+** to calculate viscosity for the spindle that is being used. The spindle multiplyer constant (**SMC**) is used to calculate full scale viscosity range for any spindle/speed combination (refer to **Appendix E**). Spindle codes are listed in **Table D-1**.

SPINDLE	CODE	SMC
RV1	01	1
RV2	02	4
RV3	03	10
RV4	04	20
RV5	05	40
RV6	06	100
RV7	07	400
HA1	01	1
HA2	02	4
HA3	03	10
HA4	04	20
HA5	05	40
HA6	06	100
HA7	07	400
HB1	01	1
HB2	02	4
HB3	03	10
HB4	04	20
HB5	05	40
HB6	06	100
HB7	07	400
LV1	61	6.4
LV2	62	32
LV3	63	128
LV4	64	640
LV5	65	1280
SPIRAL	70	105
T-A	91	20
T-B	92	40
T-C	93	100
T-D	94	200
T-E	95	500
T-F	96	1000

SPINDLE	CODE	SMC
ULA	00	0.64
DIN-ULA	85	1.22
TSEL-DIN-81	81	3.7
SSA-DIN-82	82	3.75
SSA-DIN-83	83	12.09
ULA-DIN-85	85	1.22
ULA-DIN-86	86	3.65
ULA-DIN-87	87	12.13
SC4-14	14	125
SC4-15	15	50
SC4-16	16	128
SC4-18	18	3.2
SC4-21	21	5
SC4-25	25	512
SC4-27	27	25
SC4-28	28	50
SC4-29	29	100
SC4-31	31	32
SC4-34	34	64
SC4-37	37	25
CPE40	40	0.327
CPE41	41	1.228
CPE42	42	0.64
CPE51	51	5.178
CPE52	52	9.922
V-71	71	2.62
V-72	72	11.10
V-73	73	53.50

Table D-1

Table D-2 lists the model codes and spring torque constants for each viscometer model.

VISCOMETER MODEL	TORQUE CONSTANT TK	MODEL CODE ON DV-I+ SCREEN
LVDV-I+	0.09373	LV
2.5xLVDV-I+	0.2343	4L
5xLVDV-I+	0.4686	5L
1/4 RVDV-I+	0.25	1R
1/2 RVDV-I+	0.5	2R
RVDV-I+	1	RV
HADV-I+	2	HA
2xHADV-I+	4	3A
2.5xHADV-I+	5	4A
HBDV-I+	8	HB
2xHBDV-I+	16	3B
2.5xHBDV-I+	20	4B
5xHBDV-I+	40	5B

Table D-2

Appendix E - Calibration Procedures

The accuracy of the DV-I+ is verified using viscosity standard fluids which are available from Brookfield Engineering Laboratories or your local Brookfield agent. Viscosity standards are Newtonian, and therefore, have the same viscosity regardless of spindle speed (or shear rate). Viscosity standards, calibrated at 25°C, are shown in **Table E-1** (Silicone Oils) and **Table E-2** (Mineral Oils).

Container size: For Viscosity Standards < 30,000 cP, use a 600 ml Low Form Griffin Beaker having a working volume of 500 ml.

For Viscosity Standards ≥ 30,000 cP, use the fluid container.

Inside Diameter: 3.25"(8.25cm)
Height: 4.75"(12.1cm)

Note: Container may be larger, but may not be smaller.

Temperature: As stated on the fluid standard label: (+/-) 0.1°C

Conditions: The DV-I+ should be set according to the operating instructions. The water bath must be stabilized at test temperature. Viscometers with the letters "**LV**" or "**RV**" in the model designation must have the guard leg attached (see page 34 for more information on the guard leg).

Normal 25°C Standard Fluids Viscosity (cP)	Viscosity (cP)	High Temperature Standard Fluids Three Viscosity/Temperatures**
5	5,000	HT-30,000
10	12,500	HT-60,000
50	30,000	HT-100,000
100	60,000	
500	100,000	**25°C, 93.3°C, 149°C
1,000		Refer to Brookfield catalog for more information.

Table E-1

MINERAL OIL VISCOSITY STANDARD FLUIDS BEL Part No.	Viscosity (cP) 25°C
B31	31
B210	210
B750	750
B1400	1,400
B2000	2,000
B11000	11,000
B20000	20,000
B80000	80,000
B200000	200,000
B420000	420,000

Table E-2

Brookfield Viscosity Standard Fluid - General Information

We recommend that Brookfield Viscosity Standard Fluids be replaced on an annual basis, one year from date of initial use. These fluids are either pure silicone or mineral oil and are not subject to change over time. However, exposure to outside contaminants through normal use requires replacement on an annual basis. Contamination may occur by the introduction of solvent, standard of different viscosity or other foreign material.

Viscosity Standard Fluids may be stored under normal laboratory conditions. Disposal should be in accordance with state, local and federal regulations as specified on the material safety data sheet; MSDS information is available upon request.

Brookfield Engineering Laboratories does not recertify Viscosity Standard Fluids. We will issue duplicate copies of the Certificate of Calibration for any fluid within two years of the purchase date.

Brookfield Viscosity Standard Fluids are reusable provided they are not contaminated. Normal practice for usage in a 600 ml beaker is to return the material from the beaker back into the bottle. When using smaller volumes in accessories such as Small Sample Adapter, UL Adapter, Thermosel or Spiral Adapter, the fluid is normally discarded.

Calibration Procedure for LV(#1-4) and RV,HA,HB(#1-7) Brookfield spindles:

1) Place the viscosity standard fluid (in the proper container) into the water bath.

2) Lower the **DV-I+** into measurement position (with guard leg if **LV** or **RV** series viscometer is used).

3) Attach the spindle to the viscometer. If you are using a disk shaped spindle, avoid trapping air bubbles beneath the disk by first immersing the spindle at an angle, and then connecting it to the viscometer.

4) The viscosity standard fluid, together with the spindle and guardleg, should be immersed in the bath for a **minimum** of 1 hour, stirring the fluid periodically, prior to taking measurements. The spindle can be rotated in the fluid to accelerate temperature equilibrium.

5) After 1 hour, check the temperature of the viscosity standard fluid with an accurate thermometer. Fluid must be within ± 0.1°C of the specified temperature, normally 25°C. Allow longer soak time if required to come to test temperature.

6) If the fluid is at test temperature, measure the viscosity and record the viscometer reading; include % and cP (m•Pas).

NOTE: The spindle must rotate at least five (5) times before readings are taken.

7) The viscosity reading should equal the **cP** value on the viscosity fluid standard to within the combined accuracies of the viscometer and the standard (as discussed in the section entitled, **Interpretation of Calibration Test Results**).

Calibration Procedure for a Small Sample Adapter

When a Small Sample Adapter is used, the water jacket is connected to the water bath and the water is stabilized at the proper temperature:

1) Put the proper amount of viscosity standard fluid into the sample chamber. The amount varies with each spindle/chamber combination. (Refer to the Small Sample Adapter instruction manual.)

2) Place the sample chamber into the water jacket.

3) Put the spindle into the test fluid and attach the extension link, coupling nut and free hanging spindle (or directly attach the solid shaft spindle) to the **DV-I+**.

4) Allow sufficient time for the viscosity standard, sample chamber and spindle to reach test temperature.

5) Measure the viscosity and record the viscometer reading; include % and cP (m•Pas).

NOTE: The spindle must rotate at least five (5) times before a viscosity reading is taken.

Calibration Procedure for a Thermosel System

A two-step process is recommended for the Thermosel.

1) Evaluate the calibration of the Viscometer alone according to the procedure outlined in **this** section, entitled **Calibration Procedure for LV (#1-4) and RV,HA,HB (#1-7) Brookfield spindles**.

2) Evaluate the Viscometer with the Thermosel according to the procedure decribed below.

When a Thermosel System is used, the controller stabilizes the Thermo Container at the test temperature. DO NOT USE THE THERMOSEL TO CONTROL TO TEMPERATURES WITHIN 15° OF AMBIENT TEMPERATURES. Consult your Thermosel manual for details.

1) Put the proper amount of HT viscosity standard fluid into the HT-2 sample chamber. The amount varies with the spindle used. (Refer to the Thermosel instruction manual).

2) Place the sample chamber into the Thermo Container.

3) Put the spindle into the test fluid and attach the extension link, coupling nut and free hanging spindle (or directly attach the solid shaft spindle) to the **DV-I+**.

4) Allow sufficient time for the viscosity standard, sample chamber and spindle to reach test temperature.

5) Measure the viscosity and record the viscometer reading; include % and cp (m•Pas).

NOTE: The spindle must rotate at least five (5) times before a viscosity reading is taken.

Calibration Procedure for UL Adapter

When a UL Adapter is used, the water bath is stabilized at the proper temperature:

1) Put the proper amount of viscosity standard fluid into the UL Tube. (Refer to the UL Adapter instruction manual).

2) Attach the spindle (with extension link and coupling nut) onto the **DV-I+**.

3) Attach the tube to the mounting channel.

4) Lower the tube into the water bath reservoir, or if using the ULA-40Y water jacket, connect the inlet/outlets to the bath external circulating pump.

5) Allow sufficient time for the viscosity standard, sample chamber and spindle to reach test temperature.

6) Measure the viscosity and record the viscometer reading; include % and cP (m•Pas).

NOTE: The spindle must rotate at least five (5) times before a viscosity reading is taken.

Calibration Procedure for DIN Adapter

When a DIN UL Adapter is used, the water bath is stabilized at the proper temperature:

1) Put the proper amount of viscosity standard fluid into the UL Tube. (Refer to the UL Adapter instruction manual).

2) Attach the spindle (with extension link and coupling nut) onto the **DV-I+**.

3) Attach the tube to the mounting channel.

4) Lower the tube into the water bath reservoir, or if using the ULA-40Y water jacket, connect the inlet/outlets to the bath external circulating pump.

5) Allow sufficient time for the viscosity standard, sample chamber and spindle to reach test temperature.

6) Measure the viscosity and record the viscometer reading; include % and cP (m•Pas).

NOTE: The spindle must rotate at least five (5) times before a viscosity reading is taken.

Calibration Procedure for a Helipath Stand and T-Bar Spindles

When a Helipath Stand and T-Bar spindles are used:

Remove the T-bar spindle and select a standard LV(#1-4) or RV,HA,HB(#1-7) spindle. Follow the procedures for LV(#1-4) and RV,HA,HB (#1-7) Brookfield spindles outlined above.

T-Bar spindles **should not** be used for verifying calibration of the **DV-I+** Viscometer.

Calibration Procedure for Spiral Adapter

1) Place the viscosity standard fluid (in the proper container) into the water bath.

2) Attach the spindle to the viscometer. Attach chamber (SA-1Y) and clamp to the viscometer.

3) Lower the DV-I+ into measurement position. Operate the viscometer at 50 or 60 RPM until the chamber is fully flooded.

4) The viscosity standard fluid, together with the spindle, should be immersed in the bath. Stirring the fluid periodically (operate at 50 or 60 RPM), prior to taking measurements to encourage temperature equilibrium.

NOTE: The spindle must rotate at least five (5) times for one minute, whichever is greater before readings are taken.

5) Measure viscosity and record the viscometer reading; include % and cP (m•Pas).

Calibration Procedure for Cone/Plate Viscometers:

1) Follow the procedures outlined in **Appendix A** for mechanically adjusting the setting of the cone to the plate.

2) Refer to **Appendix A**, **Table 1**, and determine the correct sample volume required for the spindle to be utilized.

3) Select a viscosity standard fluid that will give viscosity readings between 10% and 100% of full scale range. Refer to **Appendix B** for viscosity ranges of cone spindles. Do not use a silicone viscosity standard fluid with a viscosity value greater than 5000 cP with a Cone/Plate Viscometer. Brookfield offers a complete range of mineral oil viscosity standards suitable for use with Cone/Plate Viscometers. **See Table E-2**. It is best to use a viscosity standard fluid that will be close to the maximum viscosity for a given cone spindle/speed combination.

Example: LVDV-I+ Viscometer, Cone CP-42, Fluid 10
Having a viscosity of 9.7 cP at 25°C

At 60 RPM, the full scale viscosity range is 10.0 cP. Thus, the Viscometer reading should be 97% torque and 9.7 cP viscosity ± 0.197 (closer to ±0.2) cP. The accuracy is a combination of Viscometer and fluid tolerance (refer to **Interpretation of Calibration Test Results**).

4) With the viscometer stopped, remove the sample cup and place the viscosity standard fluid into the cup.

5) Allow sufficient time for temperature to reach equilibrium, and connect the sample cup to the Viscometer.

6) Measure the viscosity and record the Viscometer reading in both % torque and centipoise.

NOTE: The spindle must rotate at least five (5) times before a viscosity reading is taken.

Interpretation of Calibration Test Results:

When verifying the calibration of the DV-I+, the instrument and viscosity standard fluid error must be combined to calculate the total allowable error.

The **DV-I+** is accurate to (+/-) 1% of any full scale spindle/speed viscosity range.

Brookfield Viscosity Standards Fluids are accurate to (+/-) 1% of their stated value.

Example: Calculate the acceptable range of viscosity using RVDV-I+ with RV-3 Spindle at 2 RPM; Brookfield Standard Fluid 12,500 with a viscosity of 12,257 **cP** at 25°C:

1) Calculate full scale viscosity range using the equation:

$$\text{Full Scale Viscosity Range [cP]} = \mathbf{TK} * \mathbf{SMC} * \frac{\mathbf{10{,}000}}{\mathbf{RPM}}$$

Where:
TK = 1.0 from **Table D2**
SMC = 10 from **Table D1**

$$\text{Full Scale Viscosity Range } \frac{1 * 10 * 10{,}000}{2} = \mathbf{50{,}000\ cP}$$

The viscosity is accurate to (+/-) 500 **cP** (which is 1% of 50,000)

2) The viscosity standard fluid is 12,257 **cP**. Its accuracy is (+/-)1% of 12,257 or (+/-) 122.57 **cP**.

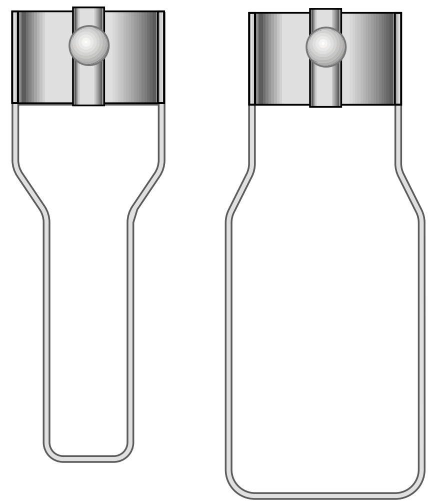
3) Total allowable error is (122.57 + 500) **cP** = (+/-) 622.57 **cP**.

4) Therefore, any viscosity reading between 11,634.4 and 12,879.6 **cP** indicates that the viscometer is operating correctly. Any reading outside these limits may indicate a viscometer problem. Contact the Brookfield technical sales department or your local Brookfield dealer/distributor with test results to determine the nature of the problem.

The Brookfield Guardleg

The *guard leg* was originally designed to protect the spindle during use. The first applications of the Brookfield Viscometer included hand held operation while measuring fluids in a 55 gallon drum. It is clear that under those conditions the potential for damage to the spindle was great. Original construction included a sleeve that protected the spindle from side impact. Early RV guard legs attached to the dial housing and LV guard legs attached to the bottom of the pivot cup with a twist and lock mechanism.

The current guard leg is a band of metal in the shape of the letter U with a bracket at the top that attaches to the pivot cup of a Brookfield Viscometer/Rheometer. Because it must attach to the pivot cup, the guard leg cannot be used with a Cone/Plate instrument. A guard leg is supplied with all LV and RV series instruments, but not with the HA or HB series. It's shape is designed to accommodate the spindles of the appropriate spindle set; therefore, the RV guard leg is wider than the LV due to the large diameter of the RV #1 spindle. They are not interchangeable.



LV Guardleg RV Guardleg

The calibration of the Brookfield Viscometer/Rheometer is determined using a 600 ml Low Form Griffin Beaker. The calibration of LV and RV series instruments includes the guard leg. The beaker wall (for HA/HB instruments) or the guard leg (for LV/RV instruments) define what is called the "outer boundary" of the measurement. The spindle factors for the LV, RV, and HA/HB spindles were developed with the above boundary conditions. The spindle *factors* are used to convert the instrument torque (expressed as the dial reading or %Torque value) into centipoise. Theoretically, if measurements are made with different boundary conditions, e.g., without the guard leg or in a container other than 600 ml beaker, then the spindle factors found on the Factor Finder cannot be used to accurately calculate an absolute viscosity. Changing the boundary conditions does not change the viscosity of the fluid, but it does change how the instrument torque is converted to centipoise. Without changing the spindle factor to suit the new boundary conditions, the calculation from instrument torque to viscosity will be incorrect.

Practically speaking, the guard leg has the greatest effect when used with the #1 & #2 spindles of the LV and RV spindle sets. Any other LV (#3 & #4) or RV (#3 - #7) spindle can be used in a 600 ml beaker with or without the guard leg to produce correct results. The HA and HB series Viscometers/Rheometers are not supplied with guard legs in order to reduce the potential problems when measuring high viscosity materials. HA/HB spindles #3 through #7 are identical to those spindle numbers in the RV spindle set. The HA/HB #1 & #2 have slightly different dimensions than the corresponding RV spindles. This dimensional difference allows the factors between the RV and HA/HB #1&#2 spindles to follow the same ratios as the instrument torque even though the boundary conditions are different.

The recommended procedures of using a 600 ml beaker and the guard leg are difficult for some customers to follow. The guard leg is one more item to clean. In some applications the 500 ml of test fluid required to immerse the spindles in a 600 ml beaker is not available. In practice, a smaller vessel may be used and the guard leg is removed. The Brookfield Viscometer/Rheometer will produce an accurate and repeatable torque reading under any measurement circumstance. However, the conversion of this torque reading to centipoise will only be correct if the factor used was developed for those specific conditions. Brookfield has outlined a method for recalibrating a Brookfield Viscometer/Rheometer to any measurement circumstance in *"More Solutions to Sticky Problems"*, Section 3.3.10. It is important to note that for many viscometer users the true viscosity is not as important as a repeatable day to day value. This repeatable value can be obtained without any special effort for any measurement circumstance. But, it should be known that this type of torque reading will not convert into a correct centipoise value when using a Brookfield factor if the boundary conditions are not those specified by Brookfield.

The guard leg is a part of the calibration check of the Brookfield LV and RV series Viscometer/Rheometer. Our customers should be aware of its existence, its purpose and the effect that it may have on data. With this knowledge, the viscometer user may make modifications to the recommended method of operation to suit their needs.

Appendix F - Special Speed Sets

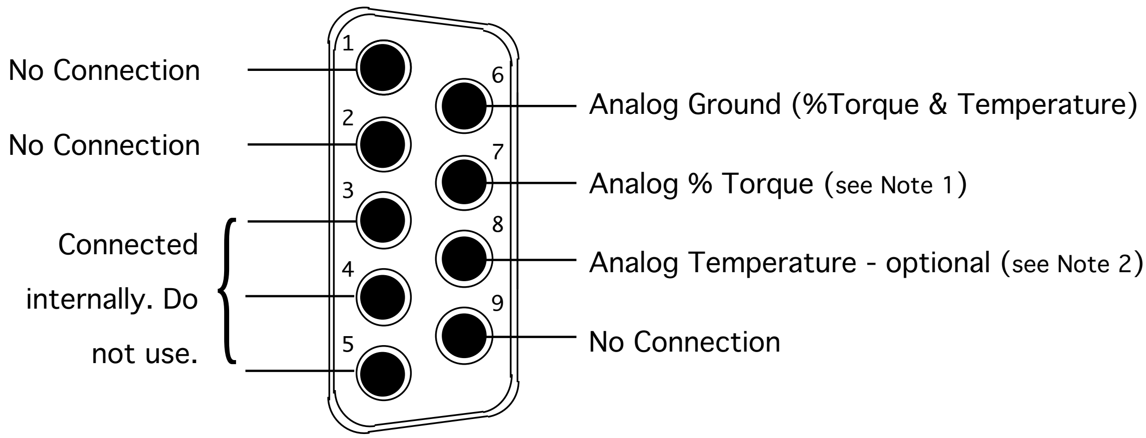
The following special speeds sets are available from Brookfield Engineering Laboratories. All speeds are in units of RPM.

RPM	SPEED SET (RPM)					
Step	SS200	SS150	SS100	SS50	SS25	SSINT
1	0.0	0.0	0.0	0.0	0.0	0.0
2	1.0	0.8	0.5	0.2	0.1	0.3
3	1.4	1.1	0.7	0.3	0.2	0.5
4	1.8	1.4	0.9	0.4	0.3	0.6
5	2.0	1.5	1.0	0.5	0.4	1.0
6	4.0	3.0	2.0	1.0	0.5	1.5
7	6.0	4.0	3.0	1.5	0.7	2.0
8	8.0	6.0	4.0	2.0	1.0	2.5
9	10	7.5	5.0	2.5	1.2	3.0
10	20	15	10	5.0	2.5	4.0
11	40	30	20	10	5.0	5.0
12	60	40	30	15	7.5	6.0
13	80	60	40	20	10	10
14	100	75	50	25	12	12
15	120	90	60	30	15	20
16	140	105	70	35	17	30
17	160	120	80	40	20	50
18	180	135	90	45	22	60
19	200	150	100	50	25	100

Table F-1

Please consult **Brookfield Engineering** or your local dealer/distributor for any special speed requirements not addressed by either the standard speed sets shown in **Table 1** (page 8) or in **Table F-1**.

DV-I+ with Temperature Option Analog Outputs



NOTES:
1. This is a 0-1 volt d.c. output where 0 volts corresponds to 0% torque and 1 volt corresponds to 100% torque with a resolutuion of 1 millivolt (0.1%).
2. This is a 0-4 volt d.c. output where 0 volts corresponds to -100°C and 4 volts correpsonds to +300°C with a resolution of 1 millivolt (0.1°C).

Figure G-1

Analog Output:

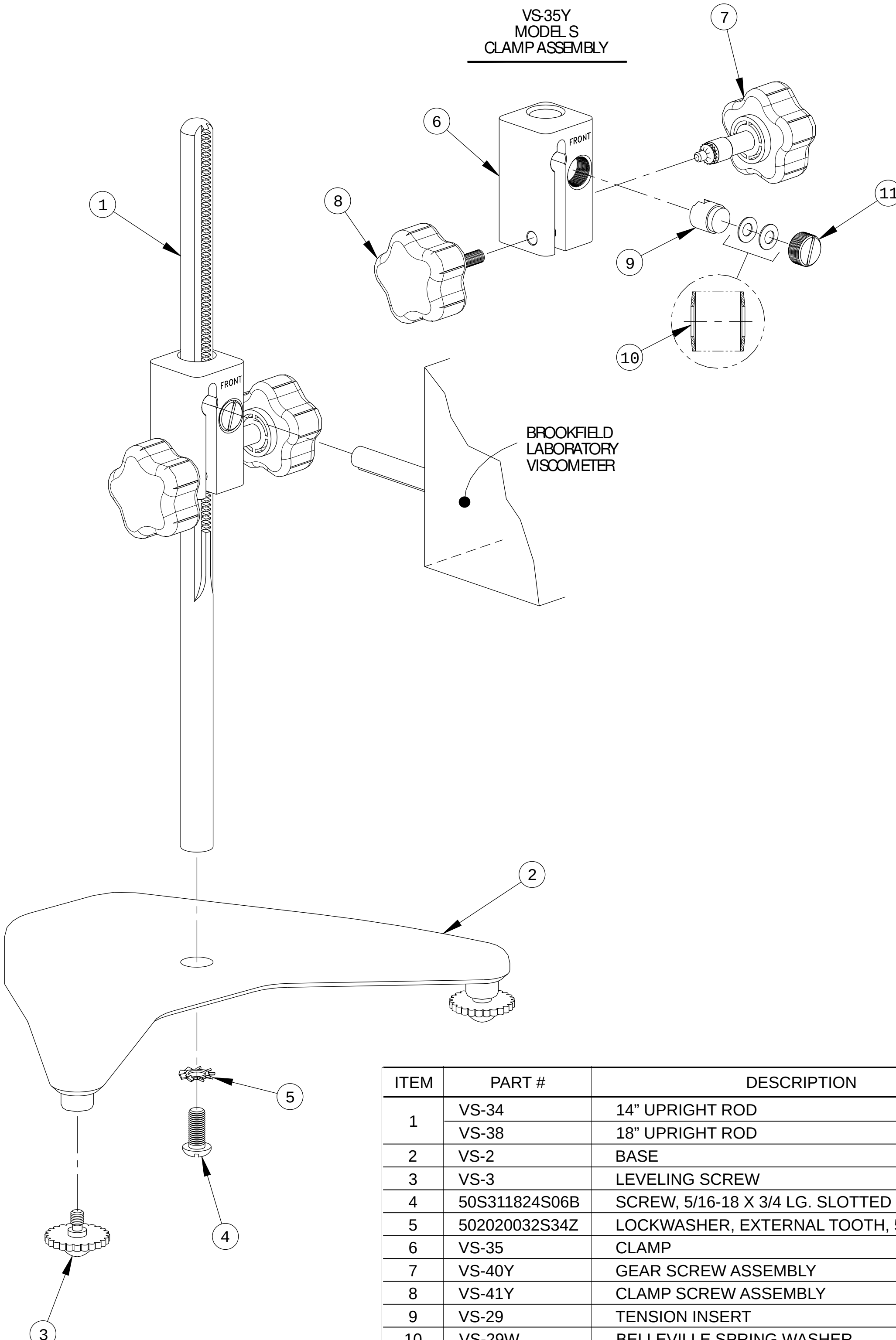
The analog outputs for % torque is accessed from the 9-pin connector located on the rear panel of the DV-I+. The pin connections are shown in **Figure G-1**.

The output cable (Part No. DVP-96Y) connections are:

Red Wire:	(Not used with DV-I+)
Black Wire:	(Not used with DV-I+)
White Wire:	% Torque Output
Green Wire:	% Torque Ground

Please contact Brookfield Engineering Laboratories or your local dealer/distributor for purchase of the **DVP-96Y** analog output cable.

Appendix H - Model S Laboratory Stand with Parts Identification*



ITEM	PART #	DESCRIPTION	QTY.
1	VS-34	14” UPRIGHT ROD	1
	VS-38	18” UPRIGHT ROD	OPTIONAL
2	VS-2	BASE	1
3	VS-3	LEVELING SCREW	2
4	50S311824S06B	SCREW, 5/16-18 X 3/4 LG. SLOTTED PAN HD.	1
5	502020032S34Z	LOCKWASHER, EXTERNAL TOOTH, 5/16 X 5/8 X 1/32	1
6	VS-35	CLAMP	1
7	VS-40Y	GEAR SCREW ASSEMBLY	1
8	VS-41Y	CLAMP SCREW ASSEMBLY	1
9	VS-29	TENSION INSERT	1
10	VS-29W	BELLEVILLE SPRING WASHER	2
11	VS-28	TENSION SCREW	1

Figure H-1

***Provided with instruments shipped after October 1, 1999. Replaced Model A Laboratory Stand.**

Unpacking

Check carefully to see that all the components are received with no concealed damage.

1 Base, VS-2, with 2 Leveling Screws, VS-3, packed in a cardboard carton
1 Upright Rod, VS-34, with attached Clamp Assembly, VS-35Y

Assembly (Refer to Figure H-1)

1. Remove the base assembly from the carton.
2. Remove the screw and washer from the upright rod. Place the rod and clamp assembly into the hole in the top of the base.

Note: The "Front" designation on the clamp assembly should face the opening of the legs, i.e., parallel to the leveling feet.

3. Rotate the rod/clamp assembly slightly until the slot on the bottom of the rod intersects the pin located in the base.
4. While holding the rod and base together, insert the slotted screw and washer as shown and tighten securely.

Viscometer Mounting

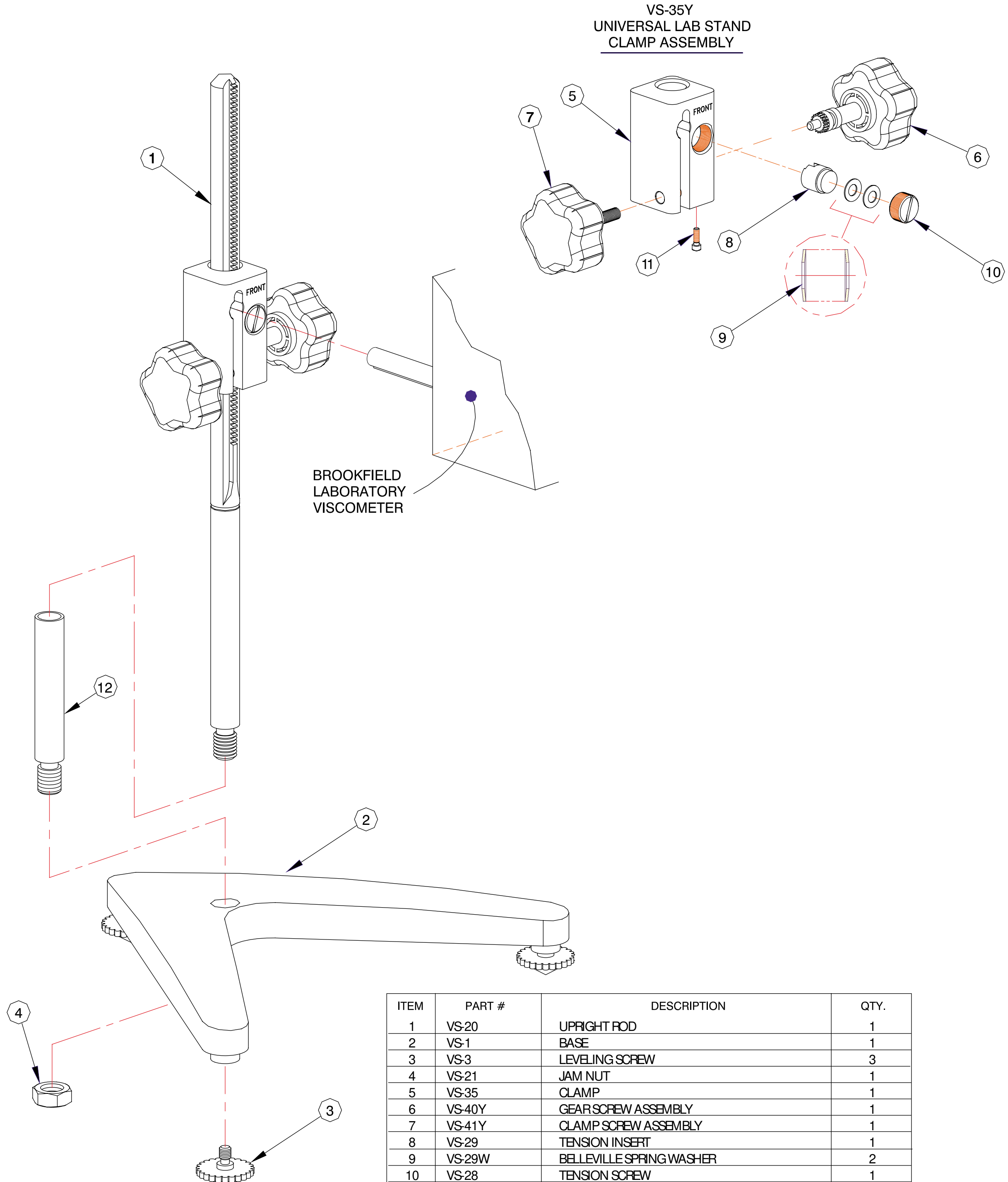
Insert the Viscometer mounting rod into the hole (with the cut-away slot) in the clamp assembly. Adjust the instrument level until the bubble is centered from right to left and tighten the clamp knob (clockwise). Use the leveling screws to "fine" adjust the viscometer level. ***Note: If the Digital Viscometer cannot be leveled, check to insure that the rod is installed with the gear rack facing forward.***

Note: If the clamp is taken off the upright rod, the tension insert (Part No. VS-29) must be properly aligned for the clamp to fit back onto the upright rod.
When the tension insert (Part No. VS-29) is inserted, its slot must be in the vertical position parallel to the upright rod. If the slot is not in the correct position, the clamp will not slide down over the upright rod. Use a small screwdriver or pencil to move it into the correct position. The VS-29W Belleville spring washers must face each other as illustrated. Adjust the VS-28 tension screw so that the clamp assembly is not loose on the upright rod.

⚠ **Do not tighten the clamp knob unless the viscometer mounting rod is inserted in the clamp assembly.**

Center the Viscometer relative to the stand base and retighten the large slotted pan head screw as required. Referring to the Viscometer bubble level, adjust the leveling screws until the instrument is level.

Model A Laboratory Stand**



ITEM	PART #	DESCRIPTION	QTY.
1	VS-20	UPRIGHT ROD	1
2	VS-1	BASE	1
3	VS-3	LEVELING SCREW	3
4	VS-21	JAM NUT	1
5	VS-35	CLAMP	1
6	VS-40Y	GEAR SCREW ASSEMBLY	1
7	VS-41Y	CLAMP SCREW ASSEMBLY	1
8	VS-29	TENSION INSERT	1
9	VS-29W	BELLEVILLE SPRING WASHER	2
10	VS-28	TENSION SCREW	1
11	50S103208S25B	SCREW, 4-40 X 3/8 LG. SOC. HD. CAP, 18-8 SS	1
12	BLM-4E	ROD EXTENSION-4" LONG	OPTIONAL
	BLM-4E2	RODE EXTENSION - 8" LONG	OPTIONAL

Figure H-2

Provided with instruments shipped before October 1, 1999

Unpacking

Check carefully to see that all the components are received with no concealed damage.

1 base	1 jam nut
3 leveling screws	1 clamp assembly
1 upright rod	

Remove the three (3) leveling screws from the base and discard the packing material. Remove the jam nut from the upright rod.

Assembly (Refer to Figure H-2)

Screw the leveling screws into the base. Insert the threaded end of the upright rod into the hole in the top of the base and attach the jam nut to the rod on the underside of the base. With the rod gear rack facing forward (toward the "V" in the base), gently tighten the jam nut.

Viscometer Mounting

The VS-41Y clamp assembly should be positioned so that the word 'front' is facing the operator. This will ensure the cut-away slot of the clamp assembly will align properly with the machined key ridge of the viscometer handle. Insert the viscometer handle into the cut-away hole of the clamp assembly. Adjust the instrument level until the bubble is centered within the target and tighten the clamp screw, VS-41Y.

Note: The small clamp adjusting screw (Figure H2) on the front of the clamp assembly should be loosened or tightened as necessary to provide smooth height adjustment and adequate support for the Viscometer.

Center the Viscometer relative to the stand base and retighten the jam nut as required. Referring to the Viscometer bubble level, adjust the leveling screws until the instrument is level.

Operation

Rotate the Gear Screw to raise or lower the viscometer.

Appendix I - DVE-50 Probe Clip

Probe Clip DVE-50 is supplied with all model DV-II+ Viscometers, DV-III Rheometers, and Digital Temperature Indicators. It is used to attach the RTD temperature probe to the LV Guard Leg (Part No. B-20Y) or 600 ml low form Griffin beaker. Figure I-1 is a view of the Probe Clip, showing the hole into which the RTD probe is inserted, and the slot which fits onto the LV guard leg. When inserting the RTD probe into the Probe Clip, the upper part of the Clip is compressed by squeezing the points shown in Figure I-1. Note: All Viscometer/Rheometer models — except LV — use the Probe Clip as shown in Figure I-1 through I-3.

Figure I-1 shows the Probe Clip (with RTD temperature probe installed) mounted on the LV guard leg.

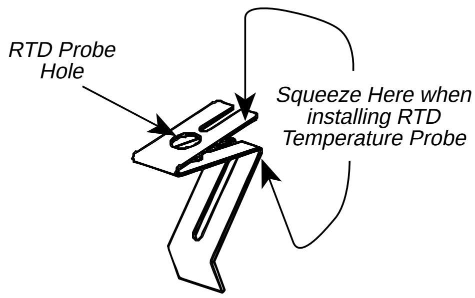


Figure I-1

Figure I-3 shows the Probe Clip mounted in a 600 ml low form Griffin beaker. This mounting may be used with LV, RV, HA and HB series instruments.

> Note: The RTD probe must be parallel to the beaker wall so as not to interfere with the viscosity measurement.

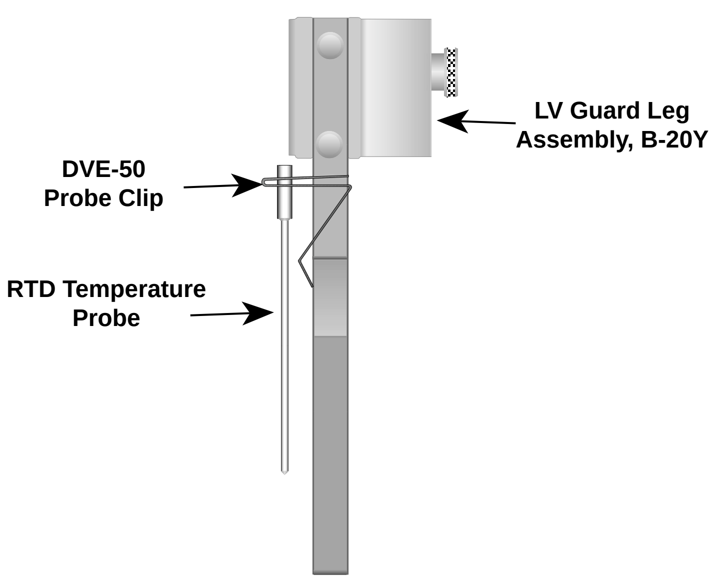


Figure I-2

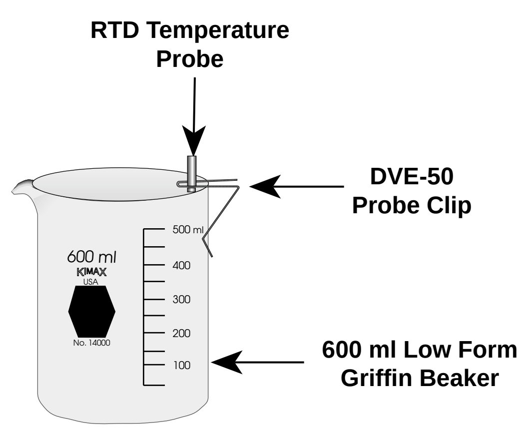


Figure I-3

Appendix J - Fault Diagnosis and Troubleshooting

Listed are some of the more common problems that you may encounter while using your Viscometer.

Spindle Does Not Rotate

- ❏ Make sure the viscometer is plugged in.
- ❏ Check the voltage rating on your viscometer (115V, 220V): it must match wall voltage.
- ❏ Make sure the power switch is in the ON position.
- ❏ Verify rpm: make sure rotational speed (rpm) has been correctly selected.

Spindle Wobbles When Rotating or Looks Bent

- ❏ Make sure the spindle is tightened securely to the viscometer coupling.
- ❏ Check the straightness of all other spindles; replace them if bent.
- ❏ Inspect viscometer coupling and spindle coupling mating areas and threads for dirt: clean threads on spindle coupling with a 3/56 left-hand tap.
- ❏ Inspect threads for wear; if the threads are worn, the unit needs service (see Appendix G).
- ❏ Check to see if spindles rotate eccentrically or wobble. There is an allowable runout for 1/32-inch in each direction (1/16-ionch total) when measured from the bottom of the spindle rotating in air.
- ❏ Check to see if the viscometer coupling is bent; if so, the unit is in need of service.

If you are continuing to experience problems with your viscometer, follow this troubleshooting section to help isolate the potential problem.

Perform an Oscillation Check

- ❏ Remove the spindle and turn the motor OFF.
- ❏ Gently push up on the viscometer coupling.
- ❏ Turn the coupling until the % on the display reads 15% - 20%.
- ❏ Gently let go of the coupling.
- ❏ Watch the coupling screw swing freely and rest on zero; watch the % values decrease and rest at 0.0 (±0.1%)

If the viscometer does not rest at zero, the unit is need of service. See Appendix G for details on how to return your viscometer.

Inaccurate Readings

- ❏ Verify spindle, speed and model selection
- ❏ Verify test parameters: temperature, container, volume, method. Refer to:
  - "More Solutions to Sticky Problems"; Section II.2A - Considerations for Making Measurements
  - Dial Viscometer Operating Manual; Appendix B - Viscosity Ranges
  - Dial Viscometer Operating Manual; Appendix C - Variables in Viscosity Measurement

- ❏ Perform a calibration check. Follow the instructions in Appendix D.
  - Verify tolerances are calculated correctly.
  - Verify calibration check procedures were followed exactly.

If the unit is found to be out of tolerance, the unit may be in need of service. See Appendix G for details on how to return your viscometer.

Appendix K - Warranty Repair and Service

Warranty

Brookfield Viscometers are guaranteed for one year from date of purchase against defects in materials and workmanship. They are certified against primary viscosity standards traceable to the National Institute of Standards and Technology (NIST). The Viscometer must be returned to **Brookfield Engineering Laboratories, Inc.** or the Brookfield dealer from whom it was purchased for no charge warranty service. Transportation is at the purchaser's expense. The Viscometer should be shipped in its carrying case together with all spindles originally provided with the instrument.

For repair or service in the **United States** return to:

Brookfield Engineering Laboratories, Inc.
11 Commerce Boulevard
Middleboro, MA 02346 U.S.A.

Telephone: (508) 946-6200 FAX: (508) 946-6262
www.brookfieldengineering.com

For repair or service outside the United States consult Brookfield Engineering Laboratories, Inc. or the dealer from whom you purchased the instrument.

For repair or service in the **United Kingdom** return to:

Brookfield Viscometers Limited
1 Whitehall Estate
Flex Meadow
Pinnacles West
Harlow, Essex CM19 5TJ, United Kingdom

Telephone: (44) 27/945 1774 FAX: (44) 27/945 1775
www.brookfield.co.uk

For repair or service in **Germany** return to:

Brookfield Engineering Laboratories Vertriebs GmbH
Hauptstrasse 18
D-73547 Lorch, Germany

Telephone: (49) 7172/927100 FAX: (49) 7172/927105
www.brookfield-gmbh.de

On-site service at your facility is also available from Brookfield. Please contact our Service Department for details.

Packaging Instructions to Return a Viscometer for Repair or Calibration

FIGURE L1

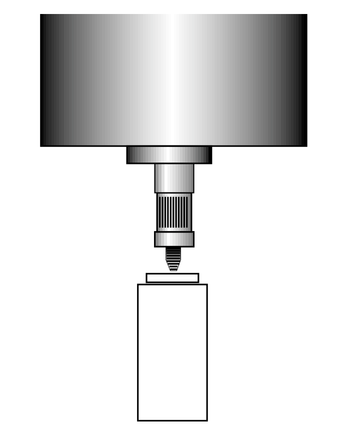
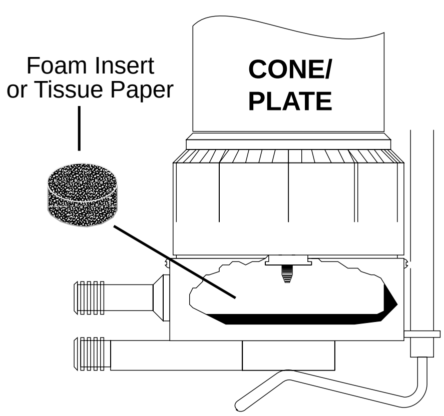


FIGURE L2



- ❑ Remove and return all spindles (properly packed for shipping).
- ❑ Clean excess testing material off the instrument.
- ❑ Include MSDS sheets for all materials tested with this instrument.
- ❑ Support pointer shaft with white, nylon shipping cap, as shown in Figure K1, or with white plastic shipping cap originally supplied with instrument.
- ❑ Pack the instrument in its original case. Cases are available for immediate shipment from Brookfield. If the case is not available, take care to wrap the instrument with enough material to support it. Avoid using foam peanuts or shredded paper.
- ❑ DO NOT send the laboratory stand unless there is a problem with the upright rod, clamp or base. If there is a problem with the stand, remove the upright rod from the base and individually wrap each item to avoid contact with the instrument. Do not put lab stand in viscometer carrying case.
- ❑ Fill out the Viscometer Information Sheet with as much information as possible to help expedite your service. If you do not have this form, please include a memo indicating the type of problem you are experiencing or the service you need performed. Please also include a purchase order number for us to bill against.
- ❑ Package the instrument and related items in a strong box for shipping. Mark the outside of the box with handling instructions.

  Example: "Handle with Care" or
  "Fragile - Delicate Instrument"

For cone/plate instruments, please remove the cone spindle and carefully pack in place in the shipping case. If available, use the original foam insert or roll up one sheet of tissue paper (or similar) and place between the spindle coupling and cup assembly (see Figure K2). This will help prevent damage in shipping.

When returning your instrument for repair, please use this tear-off sheet.

Providing us with the following information will help us to service your equipment more quickly and efficiently. Please fill out and return a copy of this form with your instrument.

Brookfield recommends that all viscometers be returned for annual calibration to ensure that your equipment continues to provide the same accuracy you have come to expect from Brookfield products.

1 VISCOMETER INFORMATION

Date: ______________________

Serial Number: ______________________ **Model:** ______________________

2 COMPANY INFORMATION

Company: ______________________ Primary User: ______________________

Telephone: ______________________ Fax: ______________________

P.O. Number: ______________________ (to cover repair and shipping)

Billing Address: ______________________ Shipping Address: ______________________

______________________ ______________________

______________________ ______________________

______________________ ______________________

Return Shipment Instructions: UPS ground ❑ UPS Next Day ❑ UPS 2nd Day ❑

Federal Express ❑ ______________________

(Federal Express Account Number required)

3 SERVICE INFORMATION

Operating Conditions (Spindle; Speed; Viscosity Range; Temp. Control; Temperature of Sample):

____

____

Did you contacting Brookfield before returning this instrument? Y❑ N❑

If yes, whom did you contact? ______________________

Description/Symptoms of Present Problem/Malfunction (please list all):

____

____

____

Time Since Last Serviced (if known): ______ Before & After Calibration Check? Y❑ N❑

Other Comments: ______________________

____

____

STEPS:
- ❑ Return the Viscometer to the attention of the Repair Department at the address above.
- ❑ Package the Viscometer for shipment as outlined.
- ❑ Include a purchase order or purchase order number with this form.

VISCOSITY TEST REPORT

DATE:

BY:

FOR:

TEST INFORMATION:

SAMPLE	MODEL	SPINDLE	RPM	DIAL READING % TORQUE	FACTOR	VISCOSITY cP	SHEAR RATE	TEMP °C	TIME	NOTES

CONCLUSIONS:

BROOKFIELD ENGINEERING LABORATORIES, INC. • 11 Commerce Boulevard • Middleboro, MA 02346 • TEL: 508-946-6200 or 800-628-8139 (USA) FAX: 508-946-6262 • www.brookfieldengineering.com