

BROOKFIELD SPIRAL ADAPTER

Operating Instructions

Manual No. **M/93-270-C1003**



SPECIALISTS IN THE
MEASUREMENT AND
CONTROL OF VISCOSITY

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I. INTRODUCTION

When used with any Brookfield Viscometer/Rheometer, the Spiral Adapter can measure fluid viscosity at various 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 Viscometer/Rheometer and is also available as a pdf file on the Brookfield website.

The Spiral Adapter has an inner, threaded spindle surrounded by a concentric outer cylinder, as shown in **Figure 1**. This combination causes the sample to be continuously pumped up through the gap between the rotating spindle and the outer cylinder. The material reaches a steady state of flow during which viscosity is measured.

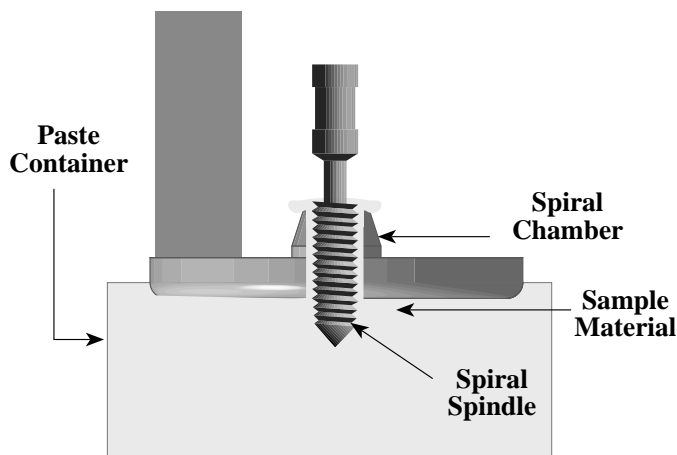


Figure 1

The principle of viscosity measurement is to drive the spiral spindle (which is immersed in the test fluid) through a calibrated spring in the Viscometer/Rheometer. The viscous drag of the fluid against the spindle is measured by the spring deflection.

The measuring range of the Spiral Adapter (in centipoise (cP) or milliPascal seconds (mPa•s)) is determined by the rotational speed of the spindle, the length and effective diameter of the spindle, the length and diameter of the chamber the spindle is rotating in, and the full scale torque of the viscometer's calibrated spring.

II. COMPONENTS

The following components are included in the Spiral Adapter Accessory (part number SAA):

<u>Item</u>	<u>Part Number</u>
Two (2) Spindles of identical design	SA-70
One (1) Chamber	SA-1Y
One (1) Assembly Clamp	SA-5Y
One (1) Carrying Case	SA-8
One (1) Cleaning Brush	SA-4
One (1) Operator Manual	M/93-270

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

III. SPECIFICATIONS FOR TEST SET UP

The Spiral Adapter can be used with any Brookfield Viscometer/Rheometer. Selection of the appropriate Viscometer/Rheometer depends upon the viscosity range of the sample fluid over the shear rates at which it will be tested.

There are four basic spring torque series offered by Brookfield as shown in **Table 1**. The higher the torque range, the higher the viscosity measurement range. The corresponding ranges for viscosity measurement when the spiral spindle is rotating at 1.0 RPM are also shown. Lower spindle speeds are possible, but the pumping action within the spiral chamber may not be sufficient to provide meaningful viscosity data.

Brookfield Viscometer/Rheometer Series Designation	Spring Torque		Spiral Adapter Viscosity Range at 1.0 RPM cP (mPa•s)	
	dyne-cm	milli Newton-m	minimum	maximum
LV	673.7	.0673	1.0×10^4	1.0×10^5
RV	7,187.0	.7187	1.1×10^5	1.1×10^6
HA	14,374.0	1.4374	2.2×10^5	2.2×10^6
HB	57,496.0	5.7496	9.0×10^5	9.0×10^6

Table 1

Table 2 provides general information on Brookfield Viscometers/Rheometers and the type of data that can be generated when using the Spiral Adapter.

Measurement accuracy for any viscosity value obtained during a test is $\pm 2.0\%$ of the full scale viscosity range (i.e. at 100% torque) for the specific rotational speed in use. See **Appendix A** for the necessary information to determine full scale range.

Model	Dial	DV-E	DV-I+	DV-II+	DV-III+
Speeds	8	18	18	54	2,600
Shear Rate	0.677 sec ⁻¹ per RPM				
Signal outputs					
Torque	No	No	Yes	Yes	Yes
Viscosity	No	No	No	Yes	Yes
Temperature	No	No	No	Yes	Yes
Software	No	No	No	Yes	Yes
Temperature probe	No			Yes	

Table 2

Note: At speeds of 1 RPM and lower, additional time may be required to allow for complete deflection of the torque sensor.

IV. INSTALLATION

Install the spiral spindle by lifting and holding the pointer shaft of the Viscometer/Rheometer while screwing the spindle onto it. The threads are left-hand so the spindle must be turned to the left. Gently lift the chamber over the spindle up against the pivot cup until it rests over the locating shoulder. While holding the chamber in place, fasten the assembly clamp onto the pivot cup, thereby securing the chamber in place. The thread in this case is right hand.

See **Figure 2** which shows an assembly schematic for the Spiral Adapter.

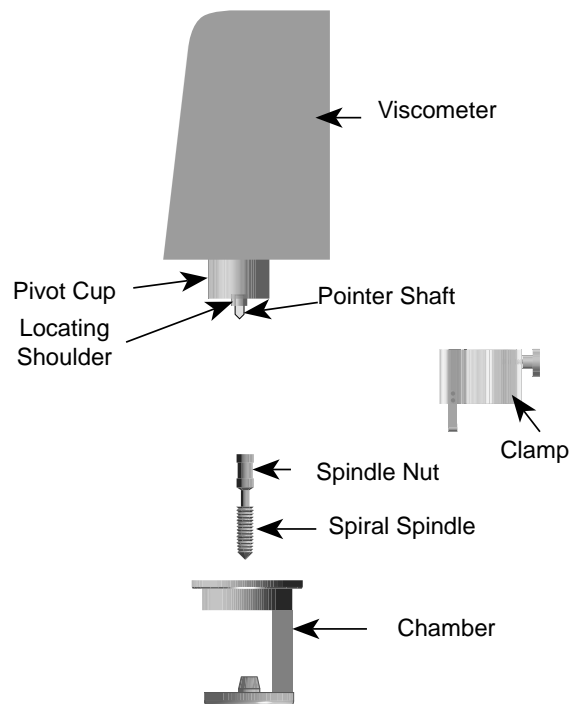


Figure 2

Turn on the Viscometer/Rheometer and rotate the spindle at various speeds. Observe the spiral spindle to make sure there is no interference with steady and even rotation. If the spindle does not run "true", then inspect the spindle and Viscometer/Rheometer shaft for straightness. Rotate the Viscometer/Rheometer shaft without the spindle and confirm that the rotation is steady and even.

Notify Brookfield or your authorized Brookfield agent if you experience any difficulty in performing the above procedure.

The spiral spindle code number is **70**. If you have a Brookfield digital viscometer or rheometer which does not contain this number, you must do the following:

- For DV-I and Dial Viscometers, use the torque reading and manually convert to a viscosity value using the table in **Appendix A**.
- For DV-II Viscometers, use the spindle **99** entry. Enter the following values:
SMC (Spindle Multiplier Constant) = 105
SRC (Shear Rate Constant) = .677

Note: Customers who use the Brookfield Spiral Adapter may need to have their Brookfield Viscometer/Rheometer serviced before using this accessory device. All Brookfield digital viscometers/rheometers with serial number lower than 24250 may not have proper alignment between bearings and pivot cup. The same applies to all Brookfield dial viscometers.

This does not present any problem for normal Brookfield Viscometer/Rheometer use. However, it may result in erroneous data when using the Spiral Adapter. For this reason, please return your Brookfield Viscometer/Rheometer to Brookfield for servicing before using it with the Spiral Adapter.

V. OPERATION

V.1 Theory

The Spiral Adapter has an inner, threaded spindle surrounded by a concentric outer cylinder, as shown previously in **Figure 1**. This combination causes the sample to be continuously pumped up through the gap between the rotating spindle and the outer cylinder. The material reaches a steady state of flow during which viscosity is measured.

At its various rotating speeds, the Brookfield Viscometer/Rheometer with the Spiral Adapter provides viscosity data at different shear rates. The resulting rheogram from an up/down speed ramp supplies important information on the pseudoplastic and thixotropic behavior of the test material which may correlate with actual use in a process. In addition, the measurement method may be less sensitive to sample handling and minor material variations than other viscosity measuring methods.

V.2 Test Procedure

Ensure that the test material has been prepared properly in accordance with your prescribed procedure. Lower the Spiral Adapter into the test fluid as shown in **Figure 1**.

Start the Viscometer/Rheometer and allow it to run at high speed for quick flooding of the chamber. This speed will vary with the nature of the test fluid, but will typically be between 20 and 60 RPM for 2 to 10 minutes. The speed and time of the flood cycle may be an important part of the test procedure. This is because the fluid in the chamber will experience a shear history before the start of the test.

When the chamber is flooded, you will observe test fluid covering the top of the spindle. Stop the Viscometer/Rheometer and allow a settling period per your defined procedure. Run the viscosity test and record the data. An example of a test procedure is as follows:

<u>Speed</u>	<u>Duration</u>
50 RPM	6 min.
0 RPM	2 min.
5 RPM	1 min.
10 RPM	1 min.
15 RPM	1 min.
20 RPM	1 min.
30 RPM	1 min.

A strip chart recorder can be used with digital Brookfield Viscometers/Rheometers during the above procedure. An example of data output is shown in **Figure 3**.

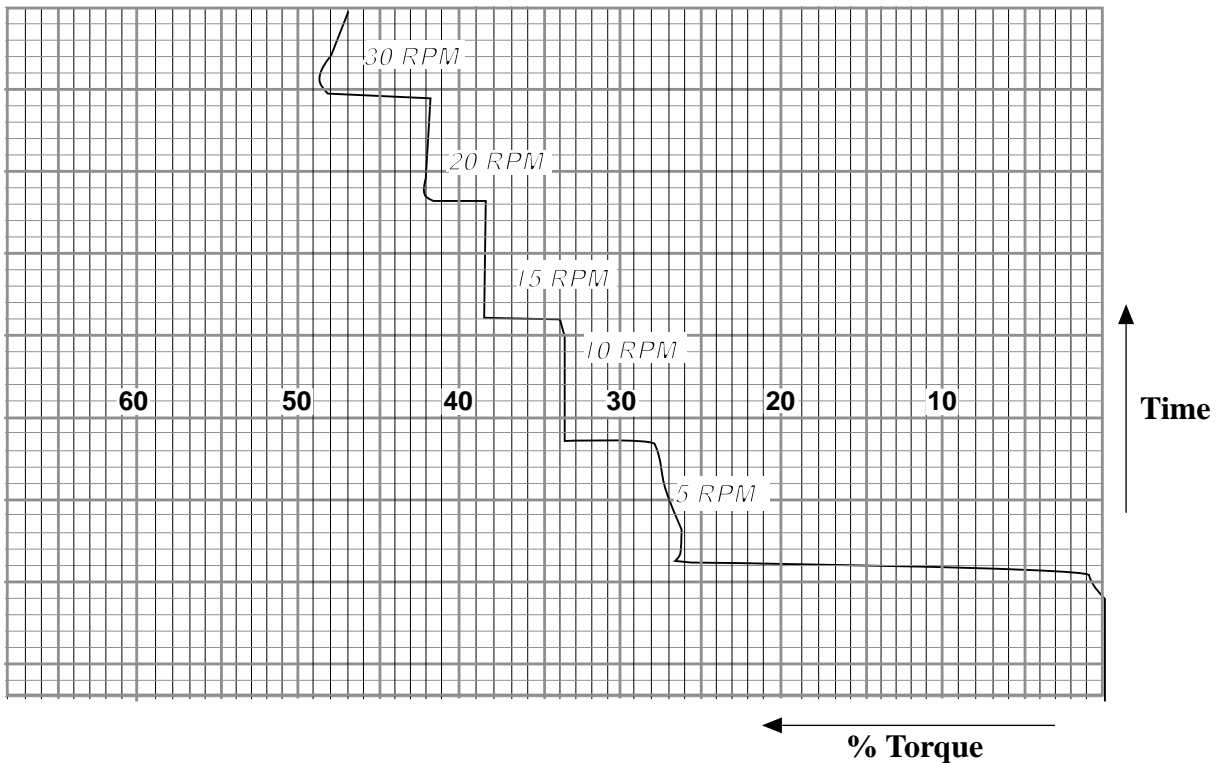


Figure 3

V.3 Data Gathering

Brookfield offers applications software for comprehensive data gathering with any IBM compatible PC.

Brookfield software will capture and display the following data in tabular and/or graphical format when used with the appropriate Brookfield Viscometer.

- Viscosity in centipoise (cP) or milliPascal seconds (mPa•s)
- % scale (Brookfield units)
- RPM
- Shear rate (sec⁻¹)
- Shear stress (dynes/cm² or N/m²)
- Temperature (°F or °C)

The data from a Brookfield dial reading, DV-E or DV-I+ (or DV-I) Viscometer can be manually entered into one of our software applications.

In addition, the Brookfield Strip Chart Recorder (Model 1201) can be used to obtain a permanent record of the Viscometer/Rheometer torque signal output, as shown in **Figure 3**. The Model 1202 can be used to record a second parameter, such as temperature, at the same time.

Contact Brookfield or an authorized dealer for more details on the appropriate software to use with your viscometer/rheometer.

V.4 Application Example - Solder Paste

Applying solder paste is a printing operation that shears the materials as the paste “rolls” on the stencil surface. Solder paste typically shows pseudoplastic behavior (exponential decrease in viscosity with increasing shear rate) as shown in **Figure 4**.

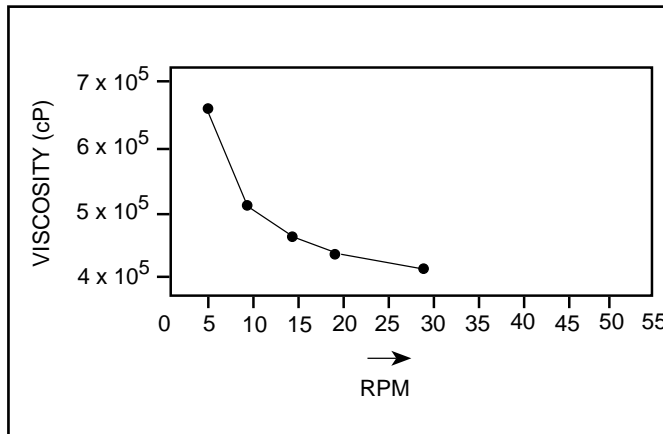


Figure 4

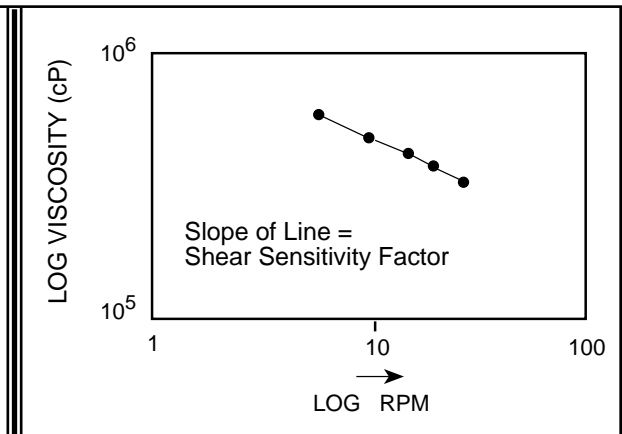


Figure 5

A plot of viscosity vs. RPM on a log/log scale approximates a straight line as shown in **Figure 5**. The slope of the line provides information about the shear thinning of the paste. The absolute value of the slope is called the “shear sensitivity factor”. Experimental correlations of these slope values to actual printing properties allow the user to establish acceptable ranges of the shear sensitivity factor.

The plots shown in **Figures 4** and **5** can be generated easily when using Brookfield application software. There is a math model (IPC Paste Analysis) included in the software which converts viscosity vs. RPM data (**Figure 4**) into a log/log plot (**Figure 5**) and automatically computes the "shear sensitivity factor."

V.5 Cleaning the Spiral Adapter

Support the chamber and remove the clamp. Carefully lower the chamber off the spindle. Soak in appropriate solvent. Remove spindle by lifting the lower shaft and holding it firm. Turn the spindle nut to the right (counter-clockwise) to remove. Clean by wiping and soaking in appropriate solvent. A soft brush is provided to aid in cleaning the threads. This brush should also be cleaned in solvent.

APPENDIX A - Spiral Spindle Factors for Torque (% Scale) Measurements

Table A-1 applies to Brookfield Viscometer models with series designation LV, RV, HA, and HB. The procedure for converting a torque value (% scale) into a viscosity value (cP) is accomplished by multiplying the appropriate factor shown in **Table A-1** by the torque reading on your Brookfield Viscometer.

Spindle Speeds (RPM)	Spiral Spindle Factors			
	LV	RV	HA	HB
0.3	3,280.0	35,000	70,000	280,000
0.5	1,968.0	21,000	42,000	168,000
0.6	1,640.0	17,500	35,000	140,000
1.0	984.0	10,500	21,000	84,000
1.5	656.0	7,000	14,000	56,000
2.0	492.0	5,250	10,500	42,000
2.5	394.0	4,200	8,400	33,600
3.0	328.0	3,500	7,000	28,000
4.0	246.0	2,625	5,250	21,000
5.0	197.0	2,100	4,200	16,800
6.0	164.0	1,750	3,500	14,000
10.0	98.4	1,050	2,100	8,400
12.0	82.0	875	1,750	7,000
20.0	49.2	525	1,050	4,200
30.0	32.8	350	700	2,800
50.0	19.7	210	420	1,680
60.0	16.4	175	350	1,400
100.0	9.8	105	210	840

Table A-1

The full scale viscosity measurement range (in cP or mPa•s) for any given speed is obtained by multiplying the corresponding spiral spindle factor in the above table by 100.

APPENDIX B - Warranty Repair and Service

The Brookfield Spiral Adapter is guaranteed for one year from date of purchase against defects in materials and workmanship. The Spiral Adapter 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 Spiral Adapter should be shipped together with all components originally provided with the system.

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

Brookfield Engineering Labs., Inc.

11 Commerce Boulevard
Middleboro, MA 02346 U.S.A.

Telephone: (508) 946-6200 FAX: (508) 946-6262
email: service@brookfieldengineering.com
website: 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
email: service@brookfield.co.uk
website: www.brookfield.co.uk

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

Brookfield Engineering Labs. Vertriebs

Hauptstrasse 18
D-73547 Lorch, Germany

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