

BROOKFIELD DIAL READING VISCOMETER

with Electronic Drive

Operating Instructions

Manual No. **M00-151-I0614**



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I. INTRODUCTION

The Brookfield Dial Reading 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 Dial Viscometer. The Dial Viscometer rotates a sensing element in a fluid and measures the torque necessary to overcome the viscous resistance to the induced movement. This is accomplished by driving the immersed element, which is called a spindle, through a beryllium copper spring. The degree to which the spring is wound, indicated by the red pointer, is proportional to the viscosity of the fluid.

The Viscometer is able to measure over a number of ranges since, for a given spring deflection, the actual viscosity is proportional to the spindle speed and is related to the spindle's size and shape. For a material of given viscosity, the resistance will be greater as the spindle size and/or rotational speed increase. The minimum viscosity range is obtained by using the largest spindle at the highest speed; the maximum range by using the smallest spindle at the slowest speed.

There are four basic spring torque series offered by Brookfield:

<u>Model</u>	<u>Spring Torque (Dyne-cm)</u>
LV	673.7
RV	7,187.0
HA	14,374.0
HB	57,496.0

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

All units of measurement are calculated in units of centipoise (cP) by using a look-up table known as "the Brookfield Factor Finder" to convert torque reading. The equivalent units of measurement in the SI system are calculated using the following conversions:

	<u>CGS</u>	=	<u>SI</u>
Viscosity:	1 cP	=	1 mPa•s
Torque:	10 ⁷ dyne-cm	=	1 Newton•m

I.1 Components


The following items are provided with your instrument:

<u>Quantity</u>	<u>Description</u>	<u>Part No.</u>
1	Dial Reading Viscometer	Depends on Model (Spring Torque)
1	Laboratory Stand	Model A
1	Spindle Set (depends on torque range)	SSL (LV 61-64, formerly called LV 1-4) <i>or</i> SSR (RV 2-7) <i>or</i> SSH (HA/HB 2-7)
1	Guard Leg	B-20Y (LV) <i>or</i> B-21Y (RV) <i>or</i> No guardleg for HA/HB torque range
1	Power Supply	AV-6 115 includes DVP-65 Power Cord AV-6 230 includes DVP-66 Power Cord
1	Carrying Case	001Y
1	Shipping Cap	B-30-1
1	Instruction Manual	M00-151
1	Factor Finder	CC-9

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

VAC; Hz Limits	100 - 240 VAC; 50/60 Hz \pm 5%
Power Supply	15 Watts, Class II certified plug-in power supply rated: 12V @ 1.25A

 Main supply voltage fluctuations are not to exceed 10% of the nominal supply voltage.

I.3 Specifications

Speeds:

LVT	60, 30, 12, 6, 3, 1.5, 0.6, 0.3
RVT	100, 50, 20, 10, 5, 4, 2.5, 2, 1, 0.5
HAT	100, 50, 20, 10, 5, 4, 2.5, 2, 1, 0.5
HBT	100, 50, 20, 10, 5, 4, 2.5, 2, 1, 0.5

Accuracy:

\pm 1% of Full Scale Range in use
(See Appendix C for details)

Repeatability:

\pm 0.2% of Full Scale Range in use

Weight:

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

Operating Temperature Range:

5°C to 40°C (41°F to 104°F)

Operating Relative Humidity:

80% up to 30°C decreasing linearly to 50% at 40°C

Electrical Certifications:

Conforms to CE Standards:

BSEN 61326:	Electrical equipment for measurement, control and laboratory use - EMC requirements
BSEN 61010-1:	Safety requirements for electrical equipment, for measurement, control and laboratory use

Notice to customers:



This symbol indicates that this product is to be recycled at an appropriate collection center.

Users within the European Union:

Please contact your dealer or the local authorities in charge of waste management on how to dispose of this product properly. All Brookfield offices and our network of representatives and dealers can be found on our website: www.brookfieldengineering.com

Users outside of the European Union:

Please dispose of this product according to your local laws.

Installation Category I, Pollution Degree II, Altitude 2000m (max).

UL Certification File No. E22083 for explosion-proof version of Dial Reading Viscometer: Built to Class 1, Division 1, Group D standards.

Brookfield Dial Reading Viscometers now have two year limited warranty from date of purchase against defects in materials and workmanship. The Viscometer must be returned to Brookfield Engineering Laboratories, Inc. or the Brookfield dealer from whom it was purchased for no charge warranty evaluation service. Prior to the return of the viscometer, you must call for a return authorization number.

I.4 Set-Up

The shipping box containing your instrument should be saved for future use when returning your instrument to Brookfield or an authorized dealer for service. The carrying case for standard viscometers/rheometers should also be saved since this provides added protection for these instruments during shipment. Failure to use these specially designed containers for transportation can negate the warranty on your instrument. Please contact Brookfield if you misplace or damage these containers. Replacements are available for a small cost.

- 1) Assemble laboratory stand as shown in **Appendix D**.
- 2) Mount the Viscometer securely on a Brookfield laboratory stand. The metal handle should be inserted into the laboratory stand clamp.

Level the viscometer, referring to the bubble level on the instrument. If the viscometer cannot be leveled, recheck the laboratory stand assembly.



Verify that the viscometer's power requirements match your power source before connecting it to power.

I.5 IQ, OQ, PQ

Please refer to our website, www.brookfieldengineering.com, for a guideline document for validating this instrument to meet IQ, OQ, PQ (Installation Qualification, Operation Qualification, Performance Qualification) requirements for those customers who need such documentation.

I.6 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. Contact Brookfield for special application instruments.



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



For indoor use only.



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.7 Cleaning



Make sure the instrument is in a decent working environment (dust-free, moderate temperature, low humidity, etc.).



Make sure the instrument is on a level surface.



Hands/fingers must be clean and free of residue sample. Not doing so may result in deposit build up on the upper part of the shaft and cause interference between the shaft and the pivot cup.



Be sure to remove the spindle from the instrument prior to cleaning. Note left-handed thread. Severe instrument damage may result if the spindle is cleaned in place.

Instrument and Keypad:

Clean with a dry, non-abrasive cloth. Do not use solvents or cleaners.

Immersed Components (spindles):

Spindles are made of stainless steel. Clean with a non-abrasive cloth and solvent appropriate for sample material.



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

II. GETTING STARTED

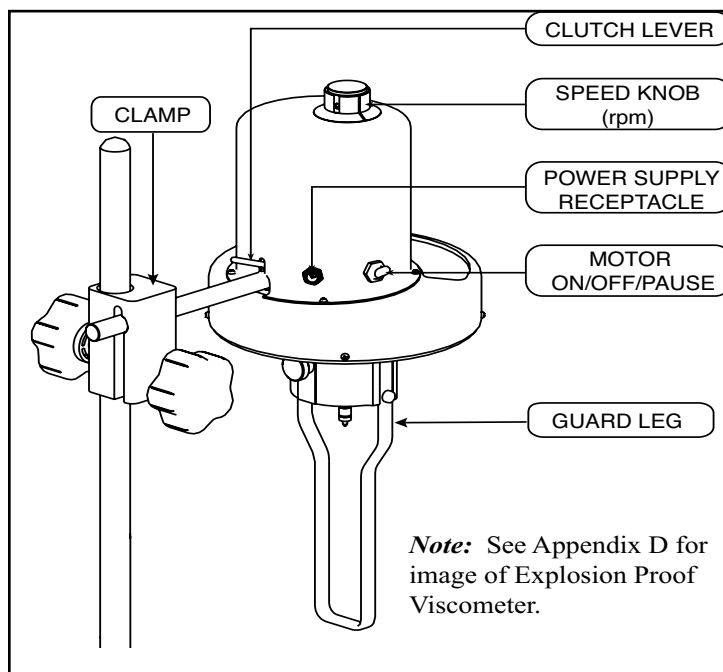
II.1 Operation

1. Be sure the plug of the power supply is securely plugged into your power source.
2. Plug the metal jack of the power supply into the circular receptacle on the back of the Viscometer.
3. The black, rubber baton switch on the viscometer controls the motor and has three positions:

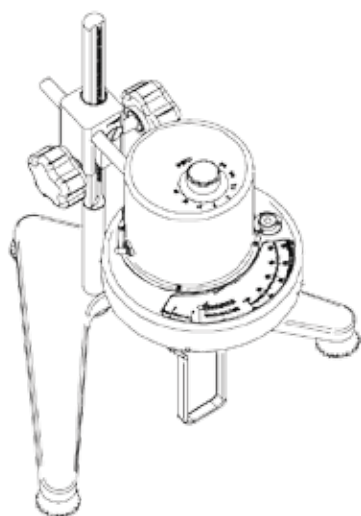
UP: Off - turns the motor off and stops the dial from turning

MIDDLE: On - causes the dial to rotate at the selected speed

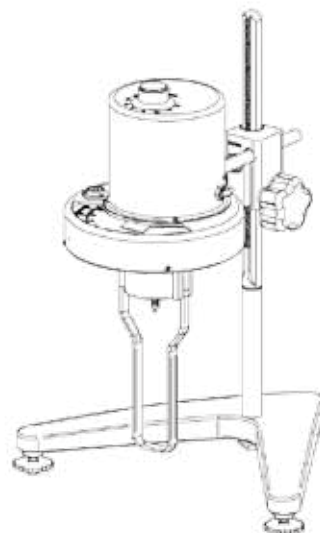
DOWN: Pause (or motor stop) - causes the dial to pause when rotating



4. LV Viscometers use a set of four spindles and a narrow guard leg; RV Viscometers use a set of six spindles and a wider guard leg; HA and HB Viscometers use a set of six spindles and no guard leg.
5. Speeds (rpm) are changed by turning the black knob on the top of the viscometer (to the left or right) to the desired speed.
6. The clutch lever, when depressed, raises the dial against the red pointer and "holds" the Viscometer reading. Releasing the clutch lowers the dial and frees the pointer.



Top View



Front View

II.2 Using the Viscometer for Measurements

1. Mount the guard leg (if used) on the Viscometer.
2. With no spindle attached, lower the Viscometer by turning the black knob on the right side of the clamp. Center the viscometer over the test material.
3. Take care to avoid trapping air bubbles under the spindles, especially the disk-type. Begin by immersing the spindle on a diagonal path across the surface of the fluid. Slowly drag the spindle across the fluid surface and then bring the spindle to the upright position. Thread the spindle onto the Viscometer.
4. Attaching the spindle correctly is important. Gently push up on the Viscometer coupling screw, avoiding any side to side movements. Hold it securely while screwing the spindle on (Note: left hand thread).
5. Lower the Viscometer and center the spindle in the test material until the meniscus is in the middle of the immersion mark.

II.3 Taking Readings and Calculating Viscosity

1. Select the desired speed.
2. Turn the Viscometer motor switch to the ON position.
3. Allow time for the indicated reading to stabilize; this time may vary, depending on your fluid, or your test method. A minimum of 5 revolutions is recommended before taking any reading.
4. To take a reading, depress the clutch lever and hold it in the down position. With the lever still depressed, move the motor switch to the "Pause" or "Off" position. Adjust the dial position, if necessary, to allow the red pointer to appear in the viscometer window.

Depressing the clutch lever locks the calibrated spring deflection in place, thereby providing the dial reading; holding the motor switch in the "Pause" position (or moving it to the "OFF" position) stops the motor and causes the dial to stop turning so you can record the reading.

5. Record the reading indicated by the red pointer on the dial: this number is known as % torque. To convert the % torque reading to viscosity in centipoise (cP), multiply the dial reading by the appropriate factor for the spindle and speed in use.

Dial reading x Factor = Viscosity in cP (mPa•s)

Example: LVT Viscometer with #61 spindle at 6 rpm

Dial Reading: 75 Factor: 10

$75 \times 10 = 750 \text{ cP (mPa}\cdot\text{s)}$

Full scale viscosity range for any speed and spindle combination is equal to the factor x 100.

Factor x 100 = Full scale range

Example: LVT Viscometer with #61 spindle at 6 RPM

Full Scale Range: $10 \times 100 = 1,000 \text{ cP}$

For maximum accuracy do not take readings below 10% torque. Do not run your Viscometer for extended periods of time at a % torque greater than 100%.

6. Switch the motor to the OFF position when changing spindles and samples. Remove the spindle before cleaning.
7. Interpretation of results is discussed in Appendix B of this manual and in our publication "More Solutions to Sticky Problems."

The following tables apply to Brookfield Viscometer Models LV, RV, HA and HB with standard spindles. They enable the user to convert the percent scale reading into a viscosity value in units of centipoise (or milli-Pascal-seconds.) To convert the viscometer dial reading to a viscosity value in units of centipoise, multiply the reading noted on dial viscometer by the appropriate factor in the following tables.

LV Series Viscometer

Spindle Number							
1 & 61		2 & 62		3 & 63		4 & 64	
0.3	200	0.3	1K	0.3	4K	0.3	20K
0.6	100	0.6	500	0.6	2K	0.6	10K
1.5	40	1.5	200	1.5	800	1.5	4K
3	20	3	100	3	400	3	2K
6	10	6	50	6	200	6	1K
12	5	12	25	12	100	12	500
30	2	30	10	30	40	30	200
60	1	60	5	60	20	60	100

Note: LV spindles had designations 1, 2, 3, 4. Digital viscometers require 2-digit entry codes. Therefore, 61, 62, 63, 64 are the corresponding codes. Spindles supplied with new viscometers are marked 61, 62, 63, 64.

RV Series Viscometer

Spindle Number													
*	1	2		3		4		5		6		7	
0.5	200	0.5	800	0.5	2K	0.5	4K	0.5	8K	0.5	20K	0.5	80K
1	100	1	400	1	1K	1	2K	1	4K	1	10K	1	140K
2	50	2	200	2	500	2	1K	2	2K	2	5K	2	20K
2.5	40	2.5	160	2.5	400	2.5	800	2.5	1.6K	2.5	4K	2.5	16K
4	25	4	100	4	250	4	500	4	1K	4	2.5K	4	10K
5	20	5	80	5	200	5	400	5	800	5	2K	5	8K
10	10	10	40	10	100	10	200	10	400	10	1K	10	4K
20	5	20	20	20	50	20	100	20	200	20	500	20	2K
50	2	50	8	50	20	50	40	50	80	50	200	50	800
100	1	100	4	100	10	100	20	100	40	100	100	100	400

* Optional = Spindle = Spindle Speed = Factor K = 1000

HA Series Viscometer

Spindle Number													
*	1	2		3		4		5		6		7	
0.5	400	0.5	1.6K	0.5	4K	0.5	8K	0.5	16K	0.5	40K	0.5	160K
1	200	1	800	1	2K	1	4K	1	8K	1	20K	1	80K
2	100	2	400	2	1K	2	2K	2	4K	2	10K	2	40K
2.5	80	2.5	320	2.5	800	2.5	1.6K	2.5	3.2K	2.5	8K	2.5	32K
4	50	4	200	4	500	4	1K	4	2K	4	5K	4	20K
5	40	5	160	5	400	5	800	5	1.6K	5	4K	5	16K
10	20	10	80	10	200	10	400	10	800	10	2K	10	8K
20	10	20	40	20	100	20	200	20	400	20	1K	20	4K
50	4	50	16	50	40	50	80	50	160	50	400	50	1.6K
100	2	100	8	100	20	100	40	100	80	100	200	100	800

HB Series Viscometer

Spindle Number													
*	1	2		3		4		5		6		7	
0.5	1.6K	0.5	6.4K	0.5	16K	0.5	32K	0.5	64K	0.5	160K	0.5	640K
1	800	1	3.2K	1	8K	1	16K	1	32K	1	80K	1	320K
2	400	2	1.6K	2	4K	2	8K	2	16K	2	40K	2	160K
2.5	320	2.5	1.28K	2.5	3.2K	2.5	6.4K	2.5	12.8K	2.5	32K	2.5	128K
4	200	4	800	4	2K	4	4K	4	8K	4	20K	4	80K
5	160	5	640	5	1.6K	5	3.2K	5	6.4K	5	16K	5	64K
10	80	10	320	10	800	10	1.63K	10	3.2K	10	8K	10	32K
20	40	20	160	20	400	20	800	20	1.6K	20	4K	20	16K
50	16	50	64	50	160	50	320	50	640	50	1.6K	50	6.4K
100	8	100	32	100	80	100	160	100	320	100	800	100	3.2K

* Optional = Spindle = Spindle Speed = Factor K = 1000

II.4 Consideration for Making Measurements

In taking viscosity measurements with the Dial 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 Dial Viscometers have a full scale range precision of $\pm 1\%$ for any spindle/speed combination. We discourage taking readings below 10% of range because the potential viscosity error of $\pm 1\%$ 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 as follows:

- 1) No. 61 LV Spindle: 15 cP at 60 RPM
- 2) No. LV-2 Spindle: 100 cP at 200 RPM
- 3) No. 1 RV Spindle: 100 cP at 50 RPM
- 4) UL Adapter: 0.85 cP at 60 RPM
- 5) SC4-18/13R: 1.25 cP at around 240 RPM

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

APPENDIX A - Viscosity Range Table

The range coefficient is a convenient tool for quickly determining the maximum viscosity that can be measured with a specific spindle/speed combination. Identify the spindle in use and the torque range (LV, RV, HA, HB) of the Viscometer/Rheometer. Look up the Range Coefficient in the following table. Divide the Range Coefficient by the spindle speed to determine the maximum viscosity in centipoise that can be measured.

E.g. RV Viscometer with RV3 spindle: Range Coefficient is 100,000. At 50 RPM, the maximum viscosity that can be measured is 100,000/50 or 2,000 cP.

Table A-1
(Continued on following page)

Spindle	Entry Code	Range Coefficient			
		LV	RV	HA	HB
RV1	01	937	10,000	20,000	80,000
RV2	02	3,750	40,000	80,000	320,000
RV3	03	9,375	100,000	200,000	800,000
RV4	04	18,750	200,000	400,000	1,600,000
RV5	05	37,500	400,000	800,000	3,200,000
RV6	06	93,750	1,000,000	2,000,000	8,000,000
RV7	07	375,000	4,000,000	8,000,000	32,000,000
HA1	01	937	10,000	20,000	80,000
HA2	02	3,750	40,000	80,000	320,000
HA3	03	9,375	100,000	200,000	800,000
HA4	04	18,750	200,000	400,000	1,600,000
HA5	05	37,500	400,000	800,000	3,200,000
HA6	06	93,750	1,000,000	2,000,000	8,000,000
HA7	07	375,000	4,000,000	8,000,000	32,000,000
HB1	01	937	10,000	20,000	80,000
HB2	02	3,750	40,000	80,000	320,000
HB3	03	9,375	100,000	200,000	800,000
HB4	04	18,750	200,000	400,000	1,600,000
HB5	05	37,500	400,000	800,000	3,200,000
HB6	06	93,750	1,000,000	2,000,000	8,000,000
HB7	07	375,000	4,000,000	8,000,000	32,000,000
LV1	61	6,000	64,000	128,000	512,000
LV2	62	30,000	320,000	640,000	2,560,000
LV3	63	120,000	1,280,000	2,560,000	10,240,000
LV4 or 4B2	64	600,000	6,400,000	12,800,000	51,200,000
LV5	65	1,200,000	12,800,000	25,600,000	102,400,000
LV-2C	66	30,000	320,000	640,000	2,560,000
LV-3C	67	120,000	1,280,000	2,560,000	10,240,000

Spindle	Entry Code	Range Coefficient			
		LV	RV	HA	HB
T-A	91	18,750	200,000	400,000	1,600,000
T-B	92	37,440	400,000	800,000	3,200,000
T-C	93	9,3600	1,000,000	2,000,000	8,000,000
T-D	94	187,200	2,000,000	4,000,000	16,000,000
T-E	95	468,000	5,000,000	10,000,000	40,000,000
T-F	96	936,000	10,000,000	20,000,000	80,000,000
Spiral	70	98,400	1,050,000	2,100,000	8,400,000
ULA	00	600	6,400	12,800	51,200
HT-DIN-81	81	3,420	36,500	73,000	292,000
SC4-DIN-82	82	3,420	36,500	73,000	292,000
SC4-DIN-83	83	11,340	121,300	242,600	970,400
ULA-DIN-85	85	1,144	12,200	24,400	97,600
ULA-DIN-86	86	3,420	36,500	73,000	292,000
ULA-DIN-87	87	11,340	121,300	242,600	970,400
SC4-14/6R	14	117,200	1,250,000	2,500,000	10,000,000
SC4-15/7R	15	46,880	500,000	1,000,000	4,000,000
SC4-16/8R	16	120,000	1,280,000	2,560,000	10,240,000
SC4-18/13R	18	3,000	32,000	64,000	256,000
SC4-21/13R	21	4,688	50,000	100,000	400,000
SC4-25/13R	25	480,000	5,120,000	10,240,000	40,960,000
SC4-27/13R	27	23,440	250,000	500,000	2,000,000
SC4-28/13R	28	46,880	500,000	1,000,000	4,000,000
SC4-29/13R	29	93,750	1,000,000	2,000,000	8,000,000
SC4-31/13R	31	30,000	320,000	640,000	2,560,000
SC4-34/13R	34	60,000	640,000	1,280,000	5,120,000
CPA-40, CPE-40, CP-40	40	307	3,270	6,540	26,160
CPA-41, CPE-41, CP-41	41	1,151	12,280	24,560	98,240
CPA-42, CPE-42, CP-42	42	600	6,400	12,800	51,200
CPA-51, CPE-51, CP-51	51	4,854	51,780	103,560	414,240
CPA-52, CPE-52, CP-52	52	9,300	99,220	198,440	793,760
V-71	71	2,456	26,200	52,400	209,600
V-72	72	10,404	111,000	222,000	888,000
V-73	73	50,146	535,000	1,070,000	4,280,000
V-74	74	508,954	5,430,000	10,860,000	43,440,000
V-75	75	199,645	2,130,000	4,260,000	8,520,000

Table A-1
(Continued on previous page)

APPENDIX B - Variables in Viscosity Measurements

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 our 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 non-Newtonian
 - 2) Time Dependent non-Newtonian - The time dependency pertains to the length of time the fluid is measured at a given Shear Rate (rpm). Therefore, these fluids will exhibit changes in viscosity with both changes in shear rate and the passage of time.

Time Independent

- 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.
- Plastic** - A plastic fluid behaves as a solid under static conditions. A certain amount of force, or "yield value," must be applied before the fluid begins to flow. Once this yield value is exceeded, flow begins. Plastic fluids then may display Newtonian, Pseudoplastic or Dilatant flow.
- Dilatant** - A dilatant fluid increases in viscosity with an increase in shear rate (rpm).

Time Dependent

- Thixotropic** - A thixotropic material has decreasing viscosity under constant shear rate (rpm). If you set a viscometer at a constant speed, recording cP values over time and find that the cP values decrease with time, the material is thixotropic.
- Rheopectic** - A rheopectic fluid has an increasing viscosity under a constant shear rate (rpm).

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 Shear Rate dependent on the measurement 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 cP 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 (report 2-digit spindle identification code)
- 6) Test speed or speeds (or the shear rate)
- 7) Length of time or number of spindle revolutions to record viscosity.

APPENDIX C - Calibration Verification

The accuracy of the Dial Viscometer 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 C-1.

*For a copy of the Repair Return Form, go to the Brookfield website,
www.brookfieldengineering.com*

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 Viscometer should be set according to the operating instructions. The water bath should be stabilized at test temperature. Viscometers with the letters "LV" or "RV" in the model designation should have the guard leg attached.

Table C-1

SILICONE VISCOSITY STANDARD FLUIDS		
Normal 25°C Standard Fluids		High Temperature Standard Fluids
Viscosity (cP)	Viscosity (cP)	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

MINERAL OIL VISCOSITY STANDARD FLUIDS	
BEL Part No.	Viscosity (cP) 25°C
B29	29
B200	200
B600	600
B1060	1,060
B2000	2,000
B10200	10,200
B21000	21,000
B73000	73,000
B200000	200,000
B360000	360,000

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. Exposure to outside contaminants, such as solvent, standard of different viscosity or other foreign material, requires replacement annually. Oil Fluids do have an expiration date on the label that should be adhered to.

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.

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 or Thermosel, the fluid is normally discarded.

The following sections explain how to perform a calibration check on your viscometer using different spindle geometries. For additional assistance, videos on these procedures are available on the Brookfield website, www.brookfieldengineering.com.

Calibration Procedure for LV #1-3(61-63) and RV,HA,HB #1-6(01-06) Brookfield Spindles

Please note that the LV #4 and the RV, HA and HB #7 spindles have been omitted from this procedure. Brookfield does not recommend the use of these spindles to perform a calibration check on your instrument. Reasons pertain to the small amount of spindle surface area that makes contact with the viscosity standard. The difficulty establishing the immersion mark precisely and the need for precise temperature control at 25°C in the immediate vicinity of the spindle.

Follow these steps by using one of the recommended spindles to verify calibration of your instrument:

- 1) Place the viscosity standard fluid (in a 600 mL low form beaker) into the water bath.
- 2) Lower the Viscometer 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 (if used), should be immersed in the bath for a minimum of 1 hour, stirring the fluid periodically, prior to taking measurements.
- 5) After 1 hour, check the temperature of the viscosity standard fluid with an accurate thermometer.
- 6) If the fluid is at test temperature ($\pm 0.1^\circ\text{C}$ of the specified temperature, normally 25°C), measure the viscosity and record the Viscometer reading.

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 standard fluid to within the combined accuracies of the Viscometer and the viscosity standard (as discussed in the section entitled, Interpretation of Calibration Test Results) which appears later in this section.

Verification Procedure for a Small Sample Adapter

When a Small Sample Adapter is used, the water jacket should be connected to a water bath and the sample 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 instructions).
- 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 Viscometer.
- 4) Allow 30 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.
- 5) Measure the viscosity and record the Viscometer reading.

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

- 6) The viscosity reading should equal the cP value on the viscosity standard fluid to within the combined accuracies of the Viscometer and the viscosity standard (as discussed in the section entitled, Interpretation of Calibration Test Results) which appears later in this section.

Verification Procedure for a Thermosel System

Before verifying the Thermosel and controller, follow the verification procedure for regular spindles RV/HA/HB 2-6 or LV 61-63. When a Thermosel System is used, the controller stabilizes the Thermo Container at the test temperature.

- 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 Viscometer.
- 4) Allow 30 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.
- 5) Measure the viscosity and record the Viscometer reading.

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

- 6) The viscosity reading should equal the cP value on the viscosity standard fluid to within the combined accuracies of the Viscometer and the viscosity standard (as discussed in the section entitled, Interpretation of Calibration Test Results) which appears later in this section.

Calibration Procedure using UL or DIN Adapters

When a UL or DIN Adapter is used, a water bath should be 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 Viscometer.
- 3) Attach the tube to the mounting channel.
- 4) Lower the tube into the water bath reservoir, or if using the ULA-49EAY water jacket, connect the inlet/outlets to the bath external circulating pump.
- 5) Allow 30 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.
- 6) Measure the viscosity and record the Viscometer reading.

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

- 7) The viscosity reading should equal the cP value on the viscosity standard fluid to within the combined accuracies of the Viscometer and the viscosity standard (as discussed in the section entitled, Interpretation of Calibration Test Results) which appears later in this section.

Calibration Procedure using a Helipath Stand and T-Bar Spindles

T-Bar spindles should not be used for verifying calibration of the Viscometer.

Calibration Procedure for Spiral Adapter

- 1) Place the viscosity standard fluid (in the proper container) into a water bath and stabilize at the proper temperature.
- 2) Attach the spindle to the viscometer. Attach chamber (SA-1Y) and clamp to the viscometer.
- 3) Lower the viscometer 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 for a minimum of 1 hour, stirring the fluid periodically (operate at 50 or 60 RPM periodically), prior to taking measurements.
- 5) After 1 hour, check the temperature of the viscosity standard fluid with an accurate thermometer.
- 6) If the fluid is at test temperature (+/- 0.1°C of the specified temperature, normally 25°C), measure the viscosity and record the viscometer reading.

Note: The spindle must rotate until fluid emerges out from the top of the chamber 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). However, instrument accuracy is \pm of the maximum viscosity range and not the standard 1%.

Interpretation of Calibration Test Results:

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

The Dial Viscometer is accurate to \pm 1% of any full scale spindle/speed viscosity range.
Brookfield Viscosity Standard Fluids are accurate to \pm 1% of their stated value.

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

- 1) Refer to the instructions on the FACTOR FINDER. Calculate the full scale viscosity range by multiplying the spindle/speed FACTOR by 100.

Spindle RV-3, 2 RPM FACTOR = 500

Full scale viscosity range is $500 \times 100 = 50,000$ cP

The viscosity is accurate to \pm 500 cP (which is 1% of 50,000)

Note: All spindle/speed factors found on the FACTOR FINDER are equivalent to 1% of the spindle/speed full scale viscosity range.

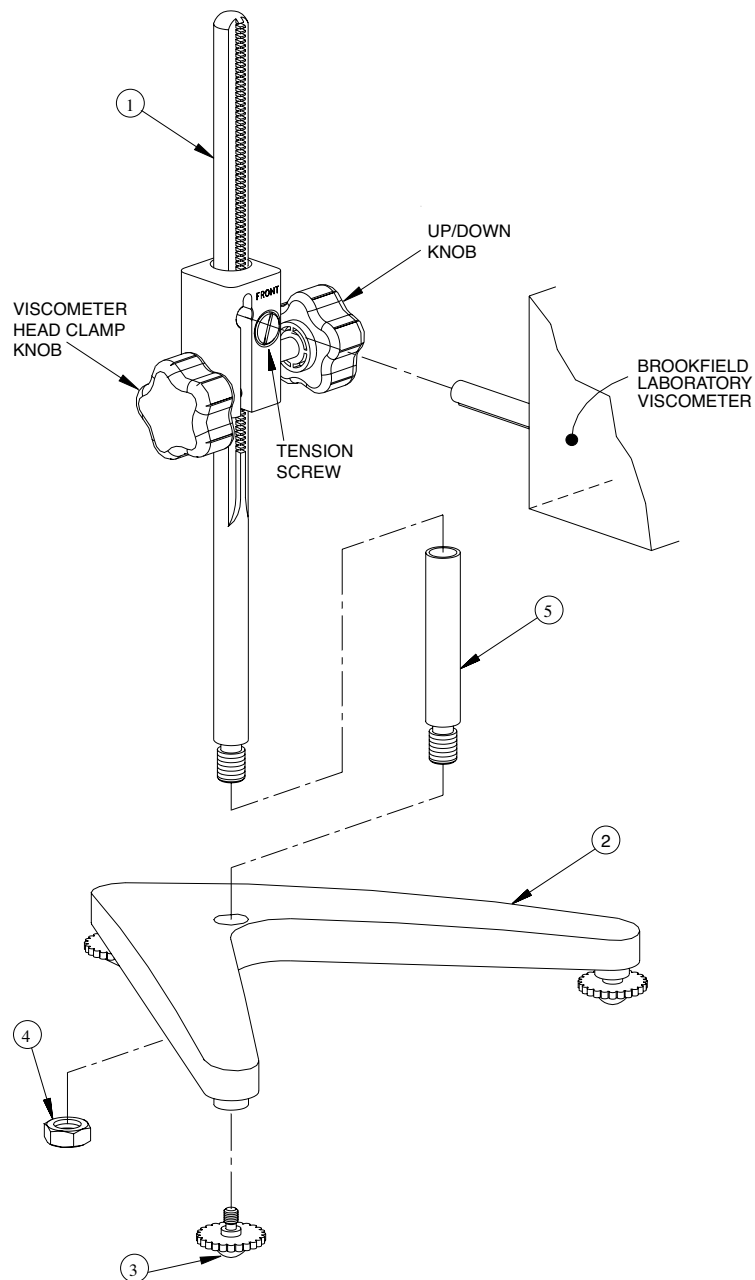
- 2) The viscosity standard fluid is 12,257 cP. Its accuracy is \pm 1% of 12,257 or \pm 122.57 cP.
- 3) Total allowable error is $122.57 + 500$ cP = \pm 622.57 cP.
- 4) Therefore, any viscosity reading between 11,634.4 and 12,879.6 cP indicates that the viscometer is operating correctly. Any reading 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.

Note: Excel Spreadsheet template is available on our website for analyzing calibration results.

APPENDIX D - Laboratory Stands

Model A Laboratory Stand

This Lab Stand is provided with all standard Dial Reading Viscometers.



ITEM	PART #	DESCRIPTION	QTY.
1	VS-CRA-14A	UPRIGHT ROD AND CLAMP ASSEMBLY	1
2	VS-1	BASE	1
3	VS-3	LEVELING SCREW	3
4	VS-21	JAM NUT	1
5	BLM-4E	ROD EXTENSION - 4" LONG *	OPTIONAL

*for use with Thermosel and Water Baths

Figure D-1

UNPACKING

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


- 1 VS-1 Base with three leveling screws
- 1 VS-CRA-14S rod and clamp assembly with one mounting screw and washer.

ASSEMBLY

1. Remove the mounting screw and washer from the upright rod. Place the rod and clamp assembly into the hole in the top of the base.
2. Position the rod and clamp assembly so that the clamp assembly has the “FRONT” marking facing forward.
3. While holding the rod and base together, insert the screw and washer as shown and tighten securely.
4. Adjust the tension screw so that the clamp assembly is not loose on the upright rod.

VISCOMETER MOUNTING AND USE

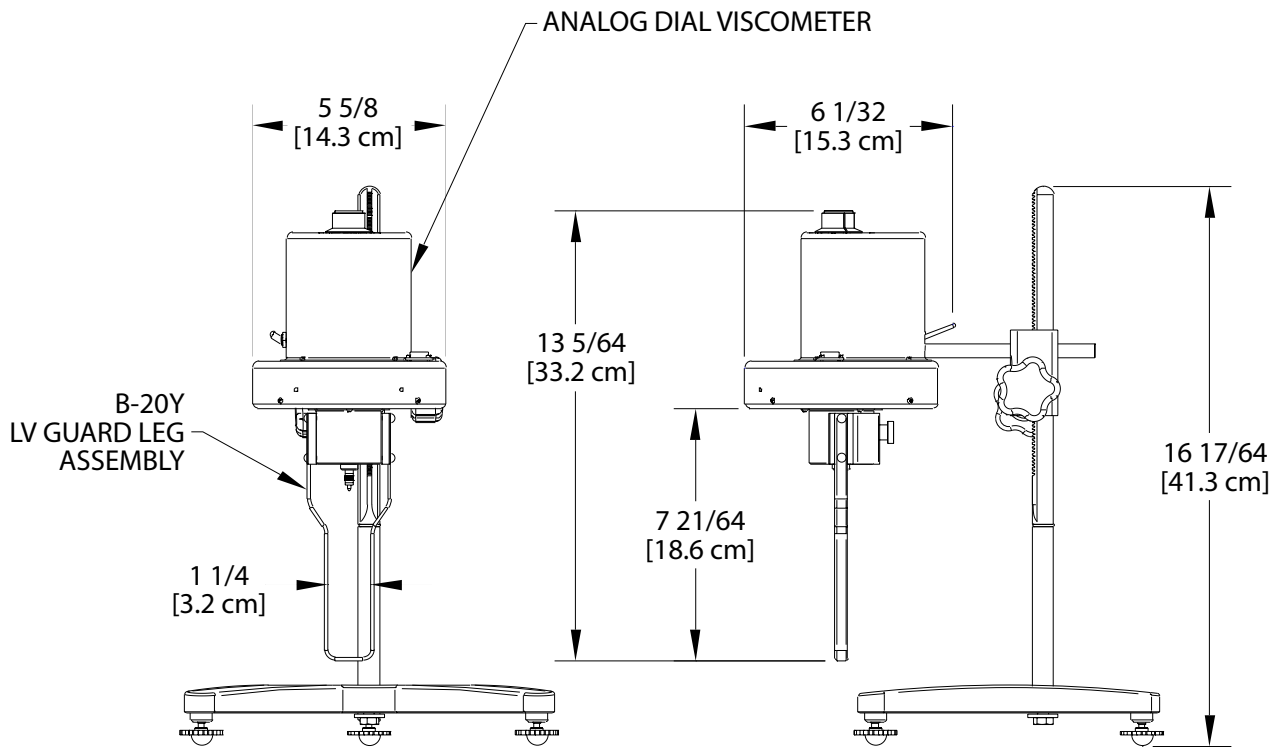
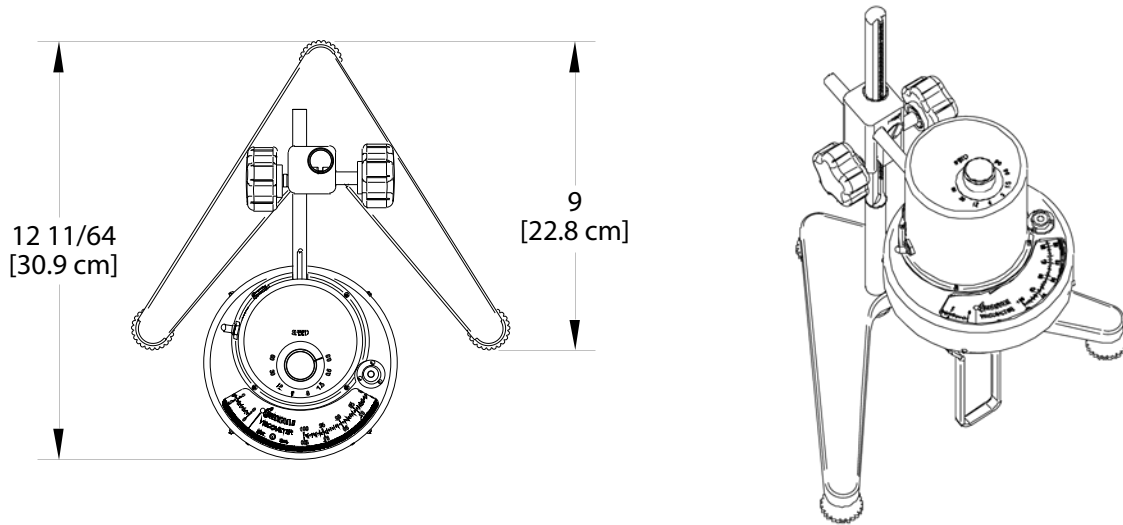
Insert the Viscometer mounting rod into the hole (with the cut-away slot) in the clamp assembly. Adjust the viscometer level until the bubble level is centered and tighten the clamp knob (clockwise). Use the leveling screws to “fine” adjust the viscometer level.

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

Note: Do not remove the clamp from the upright rod. 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.

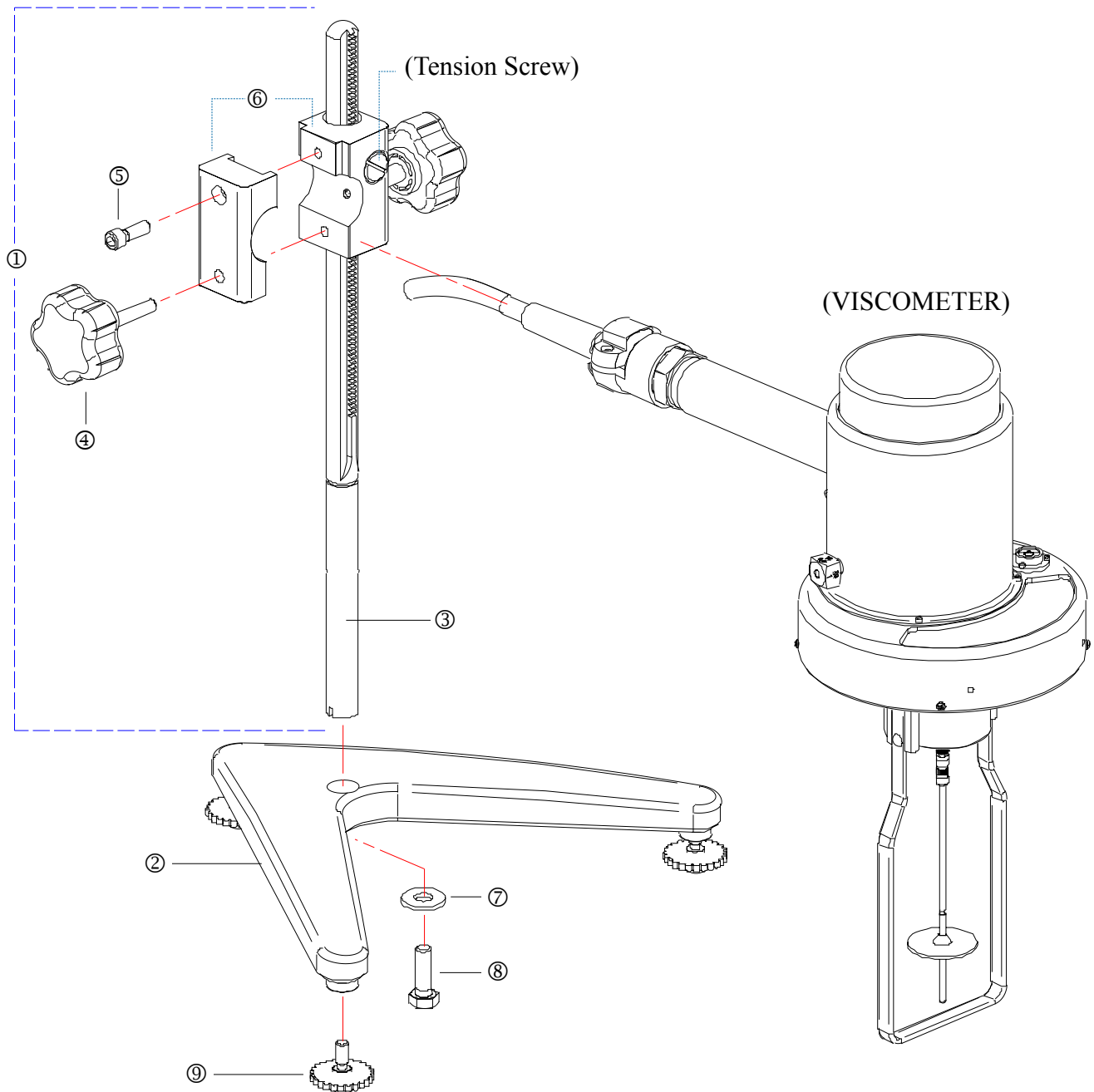
When the tension insert (Part No. VS-29) is inserted, its slot must be in the vertical position parallel to the upright rod. If the slot is not in the correct position, the clamp will not slide down over the upright rod. Use a small screwdriver or pencil to move it into the correct position. The VS-29W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

ANALOG DIAL VISCOMETER WITH MODEL A LAB STAND OVERALL DIMENSIONS



Model A-E Laboratory Stand

This Lab Stand is provided only with the Explosion-Proof Dial Reading Viscometer.



Item	Part Number	Description	Qty.
1	VS-17SY/VS-34	Rod and Clamp Assembly	1
2	VS-1Y	Base, Model A (includes 3 VS-3 leveling screws)	1
3	N/A	14" Upright Rod	1
4	VS-41Y	Knob Assembly	1
5	505252024E140	Screw, 1/4-20x3/4 Hex Socket 18-855	1

Item	Part Number	Description	Qty.
6	VSXA-17Y	Clamp	1
7	502028071S33B	Flat washer 5/16 x 7/8 x .071"	1
8	505311832S01B	Screw, 5/16-18 x 1" lg. slotted head	1
9	VS-3	Leveling Screw (3)	1
	N/A	Hex socket wrench (not shown)	1

UNPACKING

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

- (1) VS-17SY Rod and Clamp Assembly ① (includes ③④⑤⑥)
- (1) VS-1Y Base ② (includes ⑦⑧⑨)
- (1) Hex socket wrench

ASSEMBLY/MOUNTING THE VISCOMETER

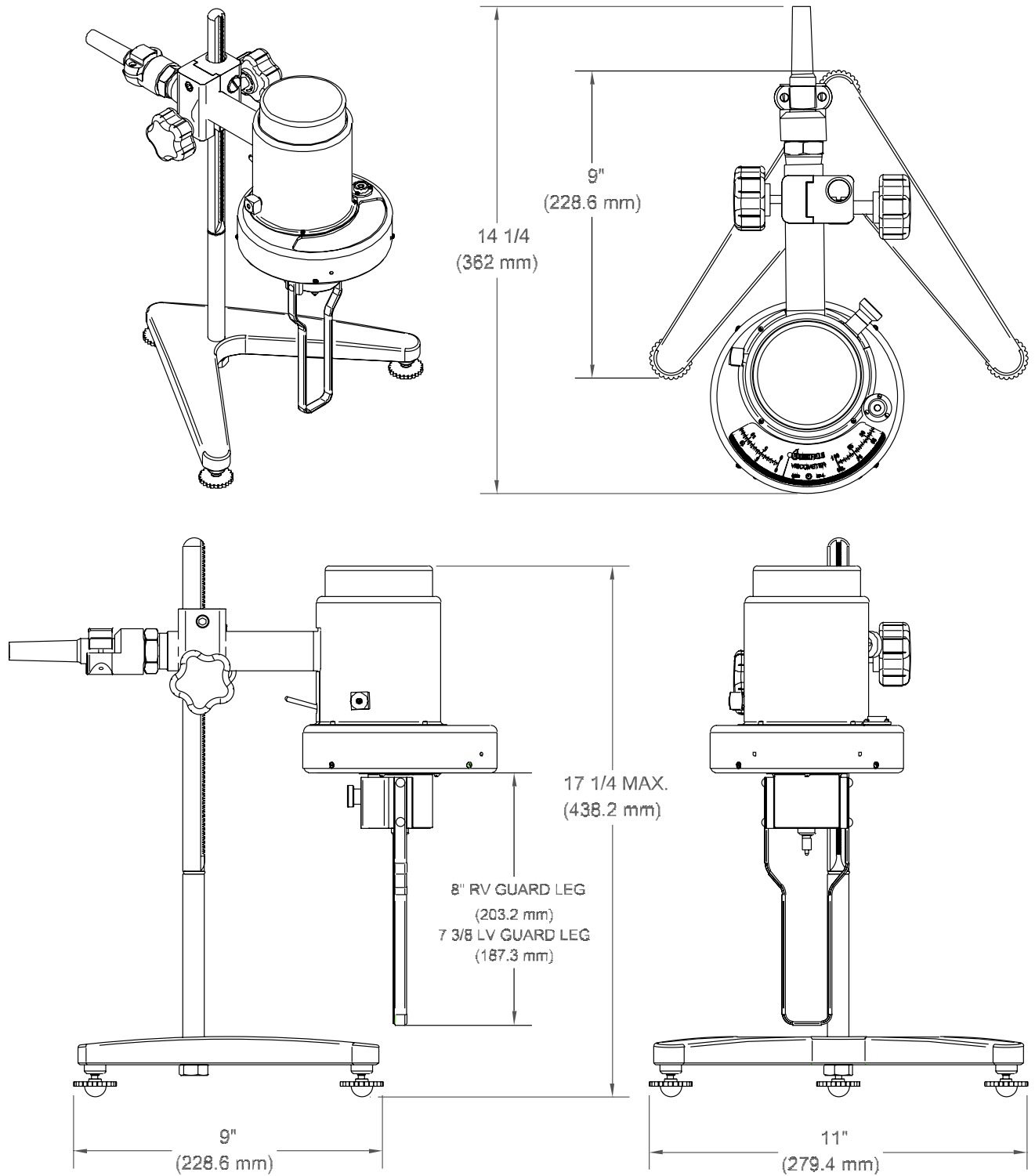
1. Remove the mounting screw and washer from the upright rod. Place the rod and clamp assembly into the hole in the top of the base.
3. While holding the rod and base together, insert the screw and washer as shown and tighten securely.
4. Adjust the tension screw so that the clamp assembly is not loose on the upright rod.
5. Remove the hex socket screw from the clamp assembly and separate the clamp. Place the mounting rod of the Viscometer against the clamp/rod assembly and reinstall the clamp and hex socket screw. Adjust the instrument level until the bubble is centered from right to left and tighten the clamp knob (clockwise).

Caution: Do not tighten the clamp knob unless the viscometer mounting rod is inserted in the clamp assembly.

6. Center the Viscometer relative to the stand base and re-tighten the 50S311832S01B screw as required. Referring to the Viscometer bubble level, adjust the VS-3 leveling screws until the instrument is level.

Note: If the clamp is taken off the upright rod, the tension insert must be properly aligned for the clamp to fit back onto the upright rod.

**ANALOG X-PROOF VISCOMETER
WITH MODEL A-E LAB STAND OVERALL DIMENSIONS**



APPENDIX E - 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. Its shape (shown in Figure E-1) 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 and RV #2 spindles. The LV and RV guardlegs are not interchangeable.

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 (Note: RV/HA/HB #1 spindle is not included in standard spindle set). 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. 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.

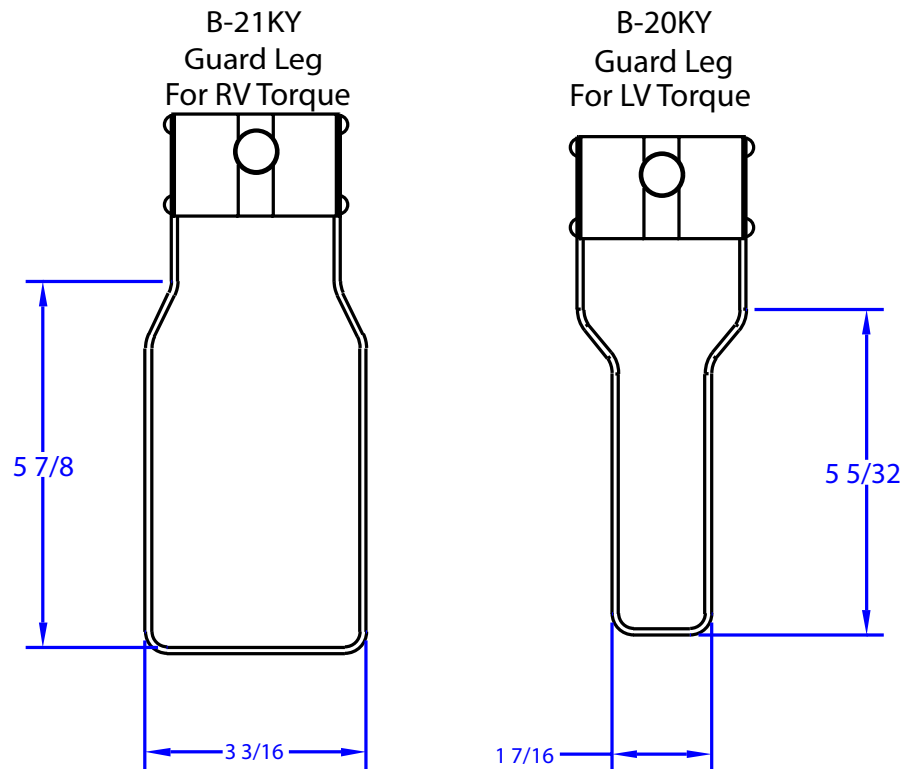


Figure E-1

APPENDIX F - Fault Diagnosis and Troubleshooting

Listed are some of the more common problems that you may encounter while using your Viscometer. Review these items *before* you contact Brookfield.

Spindle Does Not Rotate

- Make sure the universal power supply is plugged in.
- Make sure the universal power supply connector is attached to the Viscometer.
- Make sure the power switch is in the ON position.
- Make sure the speed set knob is set properly and securely at the desired speed.

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-inch left-hand tap.
- Inspect threads for wear; if the threads are worn, the unit needs service (see **Appendix H**).
- Check to see if spindles rotate eccentrically or wobble. There is an allowable runout for 1/32-inch in each direction (1/16-inch 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 red pointer reaches 15-20 on the dial.
- Gently let go of the coupling.
- Watch the pointer swing freely and rest on zero.

If the pointer sticks and/or does not rest at zero, the unit most likely is in need of service. See **Appendix H** for details on how to return your viscometer.

Inaccurate Readings

- ❑ Verify spindle, speed and model
- ❑ Verify test parameters: temperature, container, volume, method. Refer to:
 - Dial Viscometer Operating Manual; Section II.4—Considerations for Making Measurements
 - Dial Viscometer Operating Manual; Appendix A — Viscosity Ranges
 - Dial Viscometer Operating Manual; Appendix B — Variables in Viscosity Measurement
- ❑ Perform a calibration check. Follow the instructions in **Appendix C**.
 - 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 H** for details on how to return your viscometer.

APPENDIX G - Online Help and Additional Resources

www.brookfieldengineering.com**

The Brookfield website is a good resource for additional and self-help whenever you need it. Our website offers a selection of “how-to” videos, application notes, conversion tables, instructional manuals, material safety data sheets, calibration templates and other technical resources.

<http://www.youtube.com/user/BrookfieldEng>

Brookfield has its own YouTube channel. Videos posted to our website can be found here as well as other “home-made” videos made by our own technical sales group.

Viscosityjournal.com

Brookfield is involved with a satellite website that should be your first stop in viscosity research. This site serves as a library of interviews with experts in the viscosity field as well as Brookfield technical articles and conversion charts. Registration is required, so that you can be notified of upcoming interviews and events, however, this information will not be shared with other vendors, institutions, etc.

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More Solutions to Sticky Problems

Learn more about viscosity and rheology with our most popular publication. This informative booklet will provide you with measurement techniques, advice and much more. It's a must-have for any Brookfield Viscometer or Rheometer operator. More Solutions is available in print and also as a downloadable pdf on the Brookfield website by following this path:

<http://www.brookfieldengineering.com/support/documentation>

Training/Courses

Whether it is instrument-specific courses, training to help you better prepare for auditing concerns, or just a better understanding of your methods, who better to learn from than the worldwide leaders of viscosity measuring equipment? Visit our Services section on our website to learn more about training.

** Downloads will require you to register your name, company and email address. We respect your privacy and will not share this information outside of Brookfield.

APPENDIX H - Warranty Repair and Service

Brookfield Dial Viscometers are guaranteed for two 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 warranty evaluation. 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. **If returning to Brookfield, you must contact us for a return authorization number prior to shipping.**

*For a copy of the Repair Return Form, go to the Brookfield website,
www.brookfieldengineering.com*

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) 923-5009
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
Brookfield Technical Centre
Stadium Way
Harlow, Essex CM19 5GX, England

Telephone: (44) 1279/451774 FAX: (44) 1279/451775
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

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

Guangzhou Brookfield Viscometers and Texture Instruments Service Company Ltd.
Suite 905, South Tower, Xindacheng Plaza
193 Guangzhou Da Dao Bei, Yuexiu District
Guangzhou, 510075 P. R. China

Telephone: (86) 20/3760-0548 FAX: (86) 20/3760-0548
www.brookfield.com.cn

On-site service at your facility is also available from Brookfield. Please contact our Service Department in the United States, United Kingdom, Germany or China for details.

