

BROOKFIELD CAP1000+ VISCOMETER

MODEL CAP 1000+

Operating Instructions

Manual No. **M02-312**



SPECIALISTS IN THE
MEASUREMENT AND
CONTROL OF VISCOSITY

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TABLE OF CONTENTS

I. INTRODUCTION	3
I.1 Components	3
I.2 Utilities	4
I.3 Specifications	4
I.4 Installation	5
I.5 Safety Symbols and Precautions	5
I.6 Key Functions	6
I.7 Viscosity and Temperature Display	6
I.8 Cleaning	7
II. GETTING STARTED	8
II.1 Power ON	8
II.2 Cone Spindle Selection and Setting	8
II.3 Speed Setting	10
II.4 Temperature Control Setting	10
II.5 Hold Time Settings	11
II.6 Run Time	11
II.7 Printing	11
II.8 Run and Stop Keys	12
III. OPERATION	13
III.1 Accuracy of Measurement	13
III.2 Repeatability	14
III.3 Making Viscosity Measurements	14
APPENDIX A - Cone Numbers, Sample Sizes, Viscosity Ranges	17
APPENDIX B - Calibration Procedures	20
APPENDIX C - Variables in Viscosity Measurement	23
APPENDIX D - Warranty Repair and Service	25

This manual intended for use with CAP1000+ series viscometers which have serial numbers beginning with a prefix of “**CPN**”.

CAP1000 and 2000 Viscometers with a serial number prefix of “**CP**” require a different manual. Please contact Brookfield or your an authorized dealer/representative to obtain this manual.

I. INTRODUCTION

The CAP Series Viscometers are Cone and Plate geometry high shear rate instruments with integrated temperature control of the test sample material. The CAP 1000+ is a fixed shear rate viscometer rotating at 750 RPM and 900 RPM. The instruments operate by digital setting and display; rotational speed can be automatically timed to stop. High shear rate viscosity measurements are made over various viscosity ranges depending upon the cone spindle and the rotational speed (shear rate). Viscosity is selectively displayed in units of centipoise (cP), poise (P), milliPascal seconds (mPa•s) or Pascal seconds (Pa•s). Temperature control of sample is possible between either 5°C (or 15°C below ambient, whichever is higher) and 75°C or 50°C and 235°C depending on viscometer model.

The CAP1000+ can also be ordered with a single, customized speed between 5 and 1000 rpm. In this case, the CAP can offer, when necessary, low shear rate capability.

The CAP 1000+ Viscometer selectably display in either the **CGS** or **SI** units (see page 7):

	<u>CGS</u>	<u>SI</u>	<u>Comment</u>
Viscosity:	P or CP	Pa•s or mPa•s	0.1 Pa•s = 1 P (= 100 cP)
Shear Rate:	SEC ⁻¹	SEC ⁻¹	
Speed:	RPM	RPM	
Temperature:	°C	°C	

The CAP 1000+ Viscometer output data to a parallel printer in the **CGS** and **SI** units:

	<u>CGS</u>	<u>SI</u>	<u>Comment</u>
Viscosity:	P or cP	Pa•s or mPa•s	0.1 Pa•s = 1 P (= 100 cP)
Full Scale Range (F.S.R.):	%	%	
Shear Stress:	Dynes/cm ²	N/m ²	1.0 N•m = 10 ⁷ dyne•cm
Shear Rate:	SEC ⁻¹	SEC ⁻¹	
Speed:	RPM	RPM	
Run Time:	Seconds	Seconds	
Temperature:	°C	°C	
Cone Spindle Number:	No.	No.	

I.1 Components

The following items are included:

	<u>Part No.</u>
1. CAP 1000+ Viscometer	
2. Cone Spindle(s)	CAP-S-0X (X will be shown as a number 1-10)
3. Spindle Case	CAP-106Y
4. Solvent Trap	CAP-118
5. Power Cord: 115V	DVP-65
220V	DVP-66
UK	DE-8
Germany	DE-7
6. Operating Instructions Manual	M/02-312

The following optional items may have been included:

7. Viscosity Standard Fluid for calibration Part No.
.... See Table A-1 in Appendix A

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 dealer immediately. Any shipping damage must be reported to the carrier. Save the packing container, if possible, for future use when returning the viscometer to Brookfield or an authorized dealer for service.

I.2 Utilities

Input Voltage:	115 VAC or 230 VAC	
Input Frequency:	50/60 Hz	
Power Consumption:	Less than 345 WATTS	
Fuses:	(2) 5x20mm, 3A, 250V, Fast Acting for 125VAC (2) 5x20mm, 1.6A, 250V. Fast Acting for 250VAC	
Power Cord Color Code:		
	<u>United States</u>	<u>Outside United States</u>
Hot (live)	Black	Brown
Neutral	White	Blue
Ground (earth)	Green	Green/Yellow

I.3 Specifications

Speeds:	750 RPM and 900 RPM <i>or</i> single speed from 5-900 RPM as specified at time of order (see instrument serial tag)		
Temperatures:	CAP 1000+L	5°C (or 15°C below ambient, whichever is higher) to 75°C	
	CAP 1000+H	50°C to 235°C	
	All models provide 0.1°C increments		
Weight:	Gross Weight	36 lb	16.3 kg
	Net Weight	27 lb	12.3 kg
	Carton Volume	4.9 cu ft	0.15 m ³
	Carton Dimensions	18 in. L x 18 in. W x 26 in. H 48 cm. L x 48 cm. W x 66 cm. H	
Materials:	CAP cone spindles and temperature plates are made of tungsten carbide.		
Operating Environment:	CAP 1000+ Viscometers <i>must</i> be operated within the following ambient temperatures: +5°C (41°F) to 40°C (149°F) and humidity: 20% to 80% R.H. (non-condensing atmosphere)		

I.4 Installation

Note: DO NOT lift the viscometer by the handle or display panel! LIFT by the base console or column!

- 1) Set the viscometer on a clean level bench surface.
- 2) **Remove shipping spindle blank and foam packing from CAP Viscometer.** Store the spindle blank in the spindle case. Use again only when transporting CAP Viscometer.
- 3) Verify that the viscometer's power requirements match your power source **BEFORE** connecting it to power.

The AC input voltage and frequency must be within the appropriate range as shown on the name plate of the viscometer.

Note: The CAP Viscometer must be earth grounded. Use the three (3) wire power cord! Do not alter!

- 4) Connect the power cord to the viscometer and to the power supply (source).
- 5) If using a printer, connect the printer cable to the printer port and printer.

Note: Ensure that both the printer and the CAP-1000+ are off when connecting cables.

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.



Caution: HOT surface.



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

Safety Overview



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.

I.6 Key Functions

Figure I-1 shows the control keys on the face of the viscometer display panel:

NUMERIC 0 - 9

These keys are used for data entry

ENTER

This key accepts entered data.

STOP / ESCAPE

Stops cone spindle rotation at any time. Exits data entry field.

DELETE

This key overwrites entered data.

PRINT

This key sends data to the parallel port.

RUN

This key starts spindle rotation.

RUN TIME

This key selects time entry mode (time of spindle rotation).

HOLD TIME

This key selects time entry mode (wait time before spindle rotates).

SPINDLE

This key selects the cone spindle entry mode:

TEMP

This key selects the temperature entry mode.

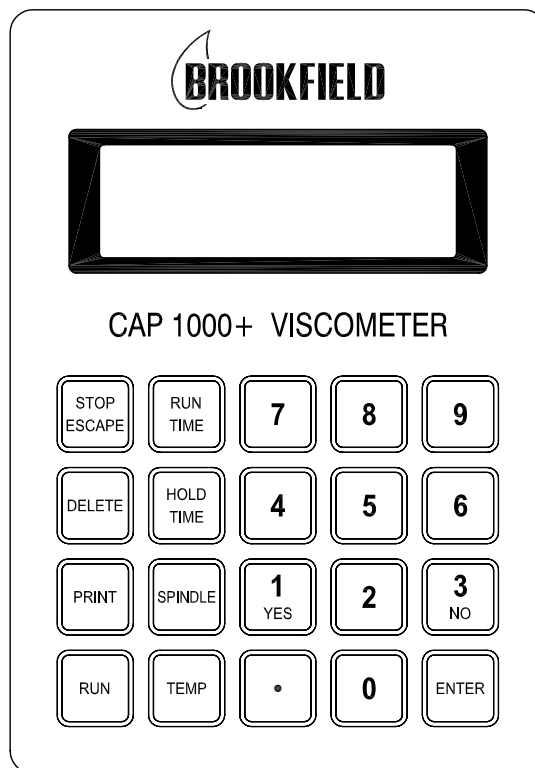


Figure I-1

I.7 Viscosity and Temperature Display

Viscosity is displayed in either **P=Poise** or **cP=Centipoise** (CGS system) or **Pa•s=Pascal seconds** or **mPa•s=milliPascal seconds** (SI system). If the viscosity measurement is over range, “EEEE” will be displayed. Brookfield recommends a minimum reading of 10%. If the display value is between 0 and 10%, the unit display will flash to indicate an out of range condition. If the viscometer settles out with a final reading below zero, negative values will be displayed.

Temperature is displayed in **°C=degrees centigrade**.

I.8 Cleaning

Instrument, Keypad & Painted Surfaces:

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

Immersed Components (spindles/cones) and insulation plate:

All immersed components are made of carbide steel. Clean with non-abrasive cloth and solvent appropriate for sample material that is not aggressive to immersed components.

Note: When cleaning, take care not to apply excessive force which may bend the spindle shaft or otherwise damage the instrument.

II. GETTING STARTED

II.1 Power ON

Turn the power **ON** using the switch located on the rear of the base console.

The display will sequentially show **BROOKFIELD**, then the model of the viscometer and the version number. After about four seconds, the **main screen** will be displayed (Figure II-1), indicating the temperature of the sample plate. The instrument will be set to the default temperature.

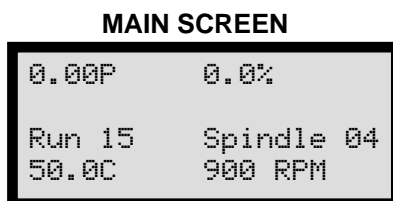


Figure II-1

Default Temperatures

CAP L Series Viscometer	25.0°C
CAP H Series Viscometer	50.0°C

Special Functions

Units of measure and speed of rotation may be selected through the **special functions screen**. This screen is accessed by pressing the **STOP** key during instrument power up.

The CAP-1000+ can be configured to operate at 750 RPM or 900 RPM. This selection is set by choosing **1=SPEED** in the **special functions screen**, then selecting **1=750 RPM** or **2=900 RPM** and pressing **ENTER**.

The CAP-1000+ can be configured to display viscosity in one of four units: **Poise (P)**, **Centipoise (cP)**, **Pascal Seconds (Pa•s)** or **milliPascal seconds (mPa•s)**. This selection is set by choosing **2=U** in the **special functions screen**, selecting **1=P**, **2=cP**, **3=Pa•s**, or **4=mPa•s**, and then pressing **ENTER**.

Once the CAP-1000+ has been configured, the instrument must be turned **OFF**. The configuration will be stored in memory.

II.2 Cone Spindle Selection and Setting

Raise the viscometer handle to its highest position.

The CAP cones have viscosity ranges as shown in Appendix A. After selecting the appropriate cone for the viscosity range to be utilized, *carefully* attach the cone to the viscometer as shown:

Be sure to align the flats on the spindle shaft with the thumb screw.

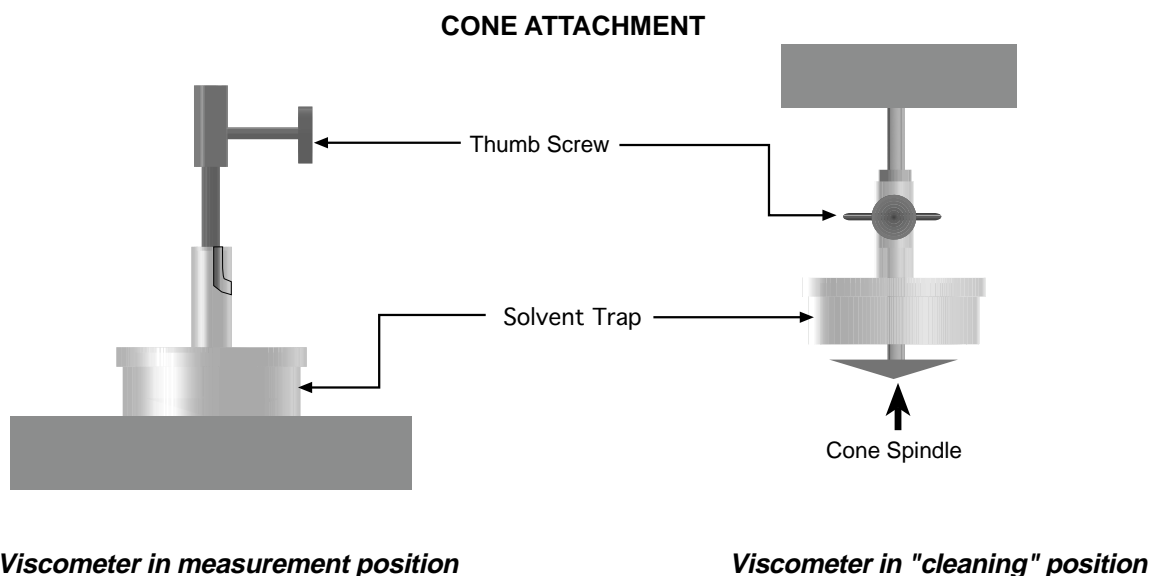


Figure II-2

When using the solvent trap, connect it to the cone adapter by sliding it up, passing the slot by the thumb screw and turning the trap clockwise onto the thumbscrew. Slide the cone up into the adapter as far as it will go and hand lock it in place with the thumb screw. Tighten the thumb screw firmly and securely.

Press the **SPINDLE** key. The display will change to the spindle entry screen. Using the number keys, type in the required spindle number.

Two digits must be entered for the cone number. For cone **01** through **09**, the first number remains as "0".

Note: The default cone setting on power-up will be the last cone entry prior to shutting off the viscometer.

After the correct two (2) digits have been entered, press the **ENTER** key and the cone will be accepted for viscometer calculations. The screen will display the following message:

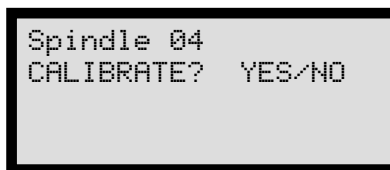


Figure II-3

Normally there is no requirement to perform a cone calibration. Cones supplied at the time of order are calibrated to the viscometer prior to shipment.

Note: 1. CAP Viscometers allow for **only one** cone at a time of the **same cone number** to be calibrated to the viscometer. Multiple cones of the same cone number **must each be calibrated** to the viscometer before operation (refer to **Appendix B**).

2. Cones entered as 11 through 99 must be first calibrated following the directions in **Appendix B**.

If you are not going to calibrate the cone, continue by pressing the **NO** key then **ENTER**. The viscometer will display the **MAIN SCREEN (Figure II-1)**.

If you are going to calibrate the cone, press the **YES** key, refer to **Appendix B**, and follow the calibration instructions under **Cone Calibration**.

II.3 Speed Setting

The CAP1000+ is a single speed viscometer. It is supplied from the factory in two configurations: standard and custom. The speed of rotation is shown in the lower right corner of the display.

Standard

The CAP1000+ Viscometer is supplied with two speeds: 750 RPM and 900 RPM. All CAP1000+ Viscometers are factory-set at 900 RPM. To change the setting, press and hold the **STOP** key during the power up sequence. Choose "1=SPEED (RPM)" from the special functions screen and select the required speed. This selection will become the default speed.

Custom

The CAP1000+ Viscometer is configured to operate at one speed as specified at the time of order. This speed is indicated on the instrument serial tag.

To begin spindle rotation, press the **RUN** key.

II.4 Temperature Control Setting

Press the **TEMP** key and the current temperature setting will blink. The default temperature on start-up is **25.0°C** on low temperature models and **50°C** on high temperature models.

The temperature ranges are:

- Low temperature: 5°C (or 15°C below ambient, whichever is higher) to 75°C
- High temperature: 50°C to 235°C

Note: The temperature can be set in increments of **0.1°C**.

Use the number keys to type in the required set point.

Use the **ENTER** key to accept the new set point.

Note: *Thermal equilibrium* of the sample and of the spindle must be considered for best measurement results. Upon powering up the Viscometer or after changing the temperature set point, allow sufficient time for the plate to reach the desired temperature. It is recommended to have the spindle in contact with the plate prior to introducing the sample material to ensure that the spindle is also at the temperature of test. Brookfield recommends using the solvent trap at all times to enhance the temperature control of the sample material. After inserting the sample material onto the plate, lower the spindle and solvent trap and allow sufficient time for thermal equilibrium prior to starting the test.

II.5 Hold Time Settings

Hold time sets the time period between when the **RUN** key is pressed and when the spindle begins to rotate. This time period is normally used to ensure thermal equilibrium of the sample and spindle. The hold time range is 0 to 999 seconds.

Press the **HOLD TIME** key and the current hold time will blink on the default screen. Use the number keys to type in the required hold time and press the **ENTER** key.

Note: When the hold time is set to zero, it is not displayed on the default screen.

II.6 Run Time

Run time sets the the time period of spindle rotation. The run time range is 0 to 999.

Press the **RUN TIME** key and the current run time will blink on the default screen. Use the number keys to type in the required run time and press the **ENTER** key.

Note: Run time will be shown on the default screen only when hold time is set to zero.

A run time of zero sets the viscometer to infinite run mode. In this mode, the spindle will rotate at the set speed for as long as the **RUN** button is pressed. When the **RUN** key is released, the spindle will stop rotating.

Note: With a run time of zero, the hold time will not be used.

II.7 Printing

Pressing the **PRINT** key at any time sends information on test parameters to the printer port. However, viscosity, full scale range and shear stress data will only be printed after it is first displayed during a test run.

At the end of a timed speed execution, data will automatically be sent to the printer port.

To print a heading, press and hold the **STOP/ESCAPE** key and press the **PRINT** key.

CAP 1000+ PRINT OUTPUT

VISCOSITY (POISE)	F.S.R. (%)	TEMP (Deg C)	S.STRESS (D/CM2)	S.RATE (1/sec)	SPEED (RPM)	TIMER (SEC)	CONE No.
-	-	25.0	-	10000	0750	20	02

A maximum of 999 seconds can be printed when running in manual **TIMER** mode (00). Over 999 seconds will print **EEE**.

Note: The **TIMER (SEC)** column will indicate the accumulated time of running at the moment the print key is pressed while the cone is rotating. This time value will not include the hold time.

II.8 Run and Stop Keys

The **RUN** key has three functions:

1. Press **RUN** to execute a timed measurement.
2. Press and hold the **RUN** key for continuous rotation when **00** is the timer setting.
3. Used in executing a cone calibration.

The **STOP** key has three functions:

1. Stops the cone rotation at any time.
2. Pressing and holding the **STOP/ESCAPE** key during power up selects the viscosity display units and speed of rotation.
3. Pressing and holding the **STOP** and **PRINT** keys simultaneously executes the printing of a new heading (Section II.7).

III. OPERATION

The CAP Series Viscometers rotate a very precisely machined conical spindle over a temperature controlled plate shearing the test sample at a single rotational speed. The CAP 1000+ operates at 750 RPM and 900 RPM.

III.1 Accuracy of Measurement

Table III.1 indicates the accuracy of the viscosity measurement with CAP spindles 1-6. This accuracy depends on both the rotational speed of the cone and the percent of full scale range (in Poise) at which viscosity is measured. The accuracy for viscosity data provided by CAP Viscometers is the indicated percentage of the full scale range. See **Appendix A** for information on how to determine Full Scale Viscosity Range (FSR).

Please contact Brookfield for accuracy information for CAP spindles 07-10.

Table III-1 Accuracy of Viscosity Measurement

CAP 1000+L VISCOMETERS				
Cone	FULLSCALE VISCOSITY RANGE ACCURACY			Over 900 RPM to 1000 RPM
	750 RPM	900RPM		
01	≤ ± 2.0%	≤ ±2.0%		Varies depending on the thermal conductivity of the sample being measured
02	≤ ± 2.0%	≤ ±2.0%		
03	≤ ± 2.0%	≤ ±2.0%		
04	≤ ± 3.0%	≤ ±4.0%		
05	≤ ± 4.0%	≤ ±6.0%		
06	≤ ± 7.0%	≤ ±10.0%		
CAP 1000+H VISCOMETERS				
Cone	FULLSCALE VISCOSITY RANGE ACCURACY			Over 900 RPM to 1000 RPM
	750 RPM	900RPM		
	10 to 100% FSR	≤50% FSR	>50% FSR	FSR = Full Scale Range
01	≤ ± 2.0%	≤ ±2.0%	≤ ±4.0%	Varies depending on the thermal conductivity of the sample being measured
02	≤ ± 2.0%	≤ ±2.0%	≤ ±4.0%	
03	≤ ± 2.0%	≤ ±2.0%	≤ ±4.0%	
04	≤ ± 3.0%	≤ ±3.0%	≤ ±6.0%	
05	≤ ± 4.0%	≤ ±4.0%	≤ ±8.0%	
06	≤ ± 5.0%	≤ ±5.0%	≤ ±10.0%	
Viscometer		Temperature Control Accuracy		
CAP1000L & H		± 0.2°C		

III.2 Repeatability

The CAP 1000+ Viscometer is repeatable to $\pm 0.5\%$ of the full scale viscosity range (FSR). Due to shear heating considerations which occur in high shear rate instrumentation, the measurement of NIST Viscosity Standard Fluids at rotational speeds above 900 RPM will show a decrease in viscosity with an increase in rotational speed (shear rate).

Normal forces due to the shearing of a viscoelastic fluid (such as paint) are accounted for in the CAP Series Viscometers by weight on the spindle column of 3.4 Newtons (340,000 Dynes) total force. This is done to avoid having the cone lift off the plate, thereby changing the cone plate geometry and producing incorrect viscosity readings. For normal forces greater than 3.4 Newtons (340,000 Dynes) total force, additional externally mounted weights are required. However, more weight means more wear on the cone and plate. Additional weights should only be considered when definitely required and removed when not required.

Contact Brookfield Engineering Laboratories or your Brookfield Dealer/Distributor/Representative for details on the above information.

III.3 Making Viscosity Measurements

The following procedure is recommended for making a viscosity measurement.

With the viscometer on a clean, level surface, connect it to the proper power supply (Section I.4).

1. Turn the power switch **ON** (Section II.1).

The procedure assumes that the following list has been done:

- a) If the viscometer has been “off” for an extended period (i.e., overnight) a “warm up” period of 30 minutes is suggested. The default temperature (25°C) is used for low temperature instruments (i.e., CAP1000+L). The default temperature for high temperature is 50°C (i.e., CAP1000+H). If a cone calibration is to be done immediately after the warm up period, temperature should be set to 60°C (calibration temperature for high temperature instruments) to save some time.
- b) The cone calibration procedure (Appendix B) should have been done for all cones which are used with the instrument. Cone calibration is only required when a new cone (i.e., replacement for lost/damaged cone) is used, or when calibration check fails.
- c) When making measurements with low temperature instruments (CAP1000+L), the solvent trap may not be required (for the containment of solvents and/or prevention of sample “drying”). The trap should be used for all measurements with high temperature instruments (CAP1000+H).
- d) If a printer is to be used, it should be connected (AC power & viscometer to printer cable). The CAP1000+ will print automatically when a reading is taken if the printer is connected and “on line.”

Select and attach the cone (Section II.2).

Notes: 1. Lock the cone tightly into the adapter.