Model 2020 Viscometer

Operating Instructions

Manual No. **CM/98-350-B0806**

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I. INTRODUCTION

The CANNON **Model 2020** Viscometer measures fluid viscosity at given shear rates. Viscosity is a measure of a fluid's resistance to flow.

The principle of operation of the **Model 2020** is to rotate 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 which provides a torque signal. The measurement range of a **Model 2020** (in centipoise or milliPascal seconds) is determined by the rotational speed of the spindle, the size and shape of the spindle, the container in which the spindle is rotating, and the full scale torque of the calibrated spring.

There are two basic spring torque ranges offered by CANNON:

	Spring Torque	
Model	dyne-cm	milli Newton-m
LVModel 2020	673.7	0.0673
MVModel 2020	7,187.0	0.7187

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

All units of measurement are displayed according to either the CGS (cP) system or the SI (mPa•s) system.

1. Viscosity appears in units of centipoise (shown as "cP") or milliPascal-seconds (shown as "mPa•s") on the **Model 2020** display.

2. Torque appears in units of dyne-centimeters or Newton-meters (shown as percent "%" in both cases) on the **Model 2020** 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 made in CGS units. The **Model 2020** Viscometer provides equivalent information in SI units (see Section II.4 AUTORANGE).

I.1 Components

1) **Model 2020** Viscometer
2) Laboratory Stand
3) Spindle Set with Case (four spindles for **LV-2020**; six spindles for **MV-2020**).
4) Power Cord
5) Guard Leg
6) Carrying Case
7) Shipping Cap
8) Instruction Manual CM/98-350

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 CANNON Instrument Company or your local CANNON 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: 0.3, 0.5, 0.6, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 10, 12, 20, 30, 50, 60, 100

Weight:			
	Gross Weight	20 lb	9 kg
	Net Weight	17 lb	7.7 kg
	Carton Volume	1.65 cu ft	0.05 m^3
	Carton Dimension	19 x 10 x 15 in	48 x 25 x 38 cm

Accuracy: ±1.0% Full Scale Range in Use (See **Appendix D** for details)

Reproducibility: 0.2% of Full Scale Range

I.4 Set-Up

1) To assemble the Laboratory Stand, place the upright rod into the base (refer to assembly instructions in **Appendix E**). 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 **Model 2020** Viscometer into the hole on the clamp assembly. Be sure that the clamp screw, VS-41Y, is loose.

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

4) 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 **Model 2020** is centered within the circle.

   Note: Check level periodically during use.

5) Remove the Viscometer shipping cap from the pivot cup (see Figure G1, page 23). This cap is designed to protect the Viscometer spindle coupling nut during shipment. ***Do not attempt to operate the Viscometer with the shipping cap in place!*** Retain the shipping cap to use if instrument is put in storage or shipment.

6) Make sure that the AC power switch at the rear of the **Model 2020** 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 Model 2020 must be earth grounded to ensure against electronic failure!!

I.5 Instrument Controls

The following describes each switch's function:

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

AUTO RANGE
Presents the maximum (100% torque) viscosity attainable using the selected spindle at the selected speed. This value is referred to as *full scale range*. The allowable error for the viscosity measurement is ± 1% of full scale range.

Note: Pressing and holding the AUTO RANGE **key during power on will enable the viscosity display to be read in either** CGS (cP) **or** SI (mPa•s) **units.**

SPEED/SPINDLE
Sets the viscometer in either speed select or spindle select mode. When set in the left position, the operator may select speed of rotation. When set in the right position, the operator may select spindle.

Note: This is a three (3) position switch. We recommend that the switch be set to the middle position when finished with spindle or speed adjustment. This will prevent an accidental change of parameters during a test.

SELECT KNOB
This knob is used to scroll through the available speed or spindle selections. This knob is active when the speed/spindle switch is set to the left or right position.

Rotate the knob clockwise to increase value and counter-clockwise to decrease value.

II. GETTING STARTED

II.1 Power Up

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

Figure 1

After a few seconds, the following screen appears:

Figure 2

After a short time, the display will clear and the default screen is displayed:

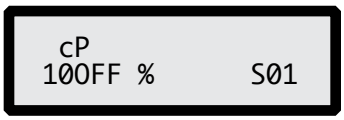


Figure 3

II.2 Spindle Selection

LV-2020 Viscometers are provided with a set of four spindles and a narrow guardleg; MV-2020 Viscometers come with a set of six spindles and a "wider" guardleg. (See **Appendix D** for more information on the guardleg.)

The spindles are attached to the viscometer by screwing them to the male coupling nut. Note that the spindles and coupling have a **left-hand thread**. The lower shaft should be held in one hand (lifted slightly), and the spindle screwed to the left. The face of the spindle nut and the matching surface on the coupling nut 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 coupling nut.

The **Model 2020** must have a *Spindle Entry Code* number to calculate viscosity values. The **Model 2020** memory contains parameters for all standard 2020 spindles and the two digit entry code for each spindle (the complete list of spindle entry codes may be found in **Appendix C**).

Note: The Model 2020 will display the Spindle Entry Code which was in use when power was turned off.

Setting the **SPEED/SPINDLE** switch to the right position will allow the operator to adjust the spindle selection. The **SELECT** knob can be rotated until the desired spindle number is selected. Once the desired spindle number is shown on the display, set the **SPINDLE/SPEED** switch to the middle position.

Note: Verify the proper spindle entry code for the selected spindle found in Appendix C. Not all spindles have an entry code number that is the same as the spindle number. For example: the spindle entry code for spindle LV1 is 61 and the spindle entry code for UL Adapter is 00.

The **Model 2020** will begin to calculate using the new spindle parameters after the spindle number is shown in the display.

II.3 Speed Selection & Setting

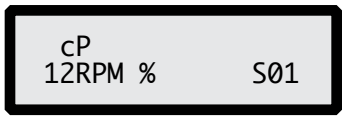
There are 18 rotational speeds available on the **Model 2020** Viscometer. Please see Table 1 below.

Table 1: Model 2020 Speeds

0.3	10
0.5	12
0.6	20
1.0	30
1.5	50
2.0	60
2.5	100
3.0	
4.0	
5.0	
6.0	

Setting the **SPEED/SPINDLE** switch in the left position will allow the operator to adjust the speed selection. The **SELECT** knob can be rotated until the desired speed is selected. Once the desired speed is shown on the display, set the **SPINDLE/SPEED** switch to the middle position.

The viscometer will rotate the spindle at the selected speed when the motor switch is in the **ON** position. A motor on condition is indicated on the display by **RPM** shown beside the speed. When the motor switch is in the **OFF** position, **OFF** will be displayed beside the speed.



(MOTOR ON)

(MOTOR OFF)

Figure 4

Note: When the motor switch is in the ON position, any change to the selected speed will be effective immediately. When collecting data at multiple speeds, you may wish to leave the SPEED/SPINDLE switch in the left position to facilitate speed changes.

To make a viscosity measurement, follow the instructions in **II.6**. Allow time for the indicated reading to stabilize.

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

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 B .

The **Model 2020** Viscometer will remember the selected speed and spindle when power is turned off. On start-up, the Viscometer will be set to the previously selected spindle and speed.

II.4 Autorange and CGS or SI Units Selection

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 "**%100**" to indicate this special condition. This maximum viscosity and **%100** value will be displayed for as long as the **AUTO RANGE** key is depressed. **Figure 5** shows the AUTO RANGE function for the situation where the No. 3 LV spindle is rotating at 12 RPM on an LV Model 2020 viscometer. The full scale range is 10000 cP (or 10000 mPa·s).

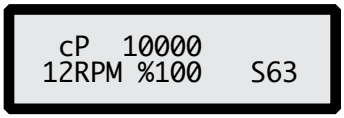


Figure 5

Pressing and holding the **AUTO RANGE** key during power on will enable the viscosity unit displayed to toggle between CGS (cP) and SI (mPa•s) 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 **Model 2020** will retain the unit selection when the viscometer is turned **OFF**.

	CGS	**SI**
Viscosity:	cP	mPa·s

1 cP = 1 mPa•s

II.5 Out of Range

The **Model 2020** 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 6**:

Figure 6

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 **Model 2020** displays both **%** (**Torque**) and **cP (Viscosity)** with flashing unit designations. The parameters of % (Torque) and cP (Viscosity) will also flash prior to one complete spindle revolution. It is not recommended that readings are taken while parameters are flashing.

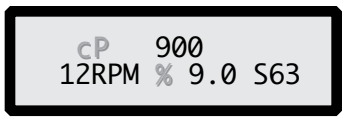


Figure 7

Negative **%** (**Torque**) will be displayed as shown in **Figure 8**:

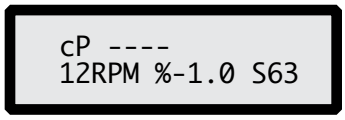


Figure 8

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

II.6 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 **Model 2020** Viscometer. Be sure that the motor is OFF before attaching the spindle. Select a spindle and attach it 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 on 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 a speed and follow the instructions in **II.2** and **II.3**. 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 B.

4. Switch the **MOTOR ON/OFF** switch to turn the motor "**OFF**" when changing a spindle or changing samples. Remove spindle before cleaning.

5. Interpretation of results and the instrument's use with non-Newtonian and thixotropic materials is discussed in **Appendix B, Variables in Viscosity Measurements**.

Appendix A - Viscosity Ranges

LV(#1-4) and MV (#1-7) Viscometers

(Note: #1 MV spindle is not included in standard spindle set but is available as an optional purchase.)

Viscosity Range (cP)		
Viscometer	**Minimum**	**Maximum**
LV-2020	15	2 M
MV-2020	100	13 M

Small Sample Adapter

Small Sample Adaper (SSA) Spindle	Shear Rate (1/SEC)	Viscosity (cP)
		LV-2020
SC4-16	0.29 N	120 - 400 K
SC4-18	1.32 N	3 - 10 K
SC4-25	0.22 N	800 - 1.60 M
SC4-31	0.34 N	30 - 100 K
SC4-34	0.28 N	60 - 200 K
SC4-82	1.29 N	3.5 - 10 K
SC4-83	1.29 N	11.0 - 38 K

Small Sample Adapter (SSA) Spindle	Shear Rate (1/SEC)	Viscosity (cP)
		MV-2020
SC4-14	0.40N	1.25K - 4.2 M
SC4-15	0.48N	500 - 1.7 M
SC4-21	0.93N	50 - 170 K
SC4-27	0.34N	250 - 830 K
SC4-28	0.28N	500 - 1.7 M
SC4-29	0.25N	1 K - 3.3 M
SC4-82	1.29N	36 - 10 K
SC4-83	1.29N	121 - 50 K

UL Adapter

UL Spindle	Shear Rate (1/SEC)	Viscosity (cP)	
		LV-2020	MV-2020
YULA-15	1.224N	1.0 - 2 K	6.4 - 2 K

K = 1,000 ***M = 1,000,000*** ***N = RPM***

When taking viscosity measurements with the **Model 2020** Viscometer, there are two considerations which pertain to the low viscosity limit of effective measurement.

1) Viscosity measurements should be taken within the 10-100 % Torque Range for any combination of spindle/speed rotation.

   This has to do with the precision of the instrument. All **Model 2020** Viscometers have a full scale range precision of (+/-) 1% of any spindle/speed rotation. 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.

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

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 MV Spindle: 100 **cP** at 50 RPM *(Note: No. 1 MV spindle is optional)*
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 B - 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.

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:

2) Sample container size (or spindle/chamber geometry)
3) Sample volume
4) Viscometer model
5) Spindle used (if using LV-2020 (#1-4) or MV-2020 (#2-7) 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 C - Spindle and Model Codes

Each spindle has a two digit code which is scrolled via the select knob on the **Model 2020**. The spindle code directs the **Model 2020** 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 D**). Spindle codes are listed in **Table C1**.

Table C1

SPINDLE	CODE	SMC
MV1 (optional)	01	1
MV2	02	4
MV3	03	10
MV4	04	20
MV5	05	40
MV6	06	100
MV7	07	400
LV1	61	6.4
LV2	62	32
LV3	63	128
LV4	64	640
LV5 (optional)	65	1280
ULA	00	0.64
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

Table C2 lists the model codes and spring torque constants for each viscometer model.

Table C2

VISCOMETER MODEL	TORQUE CONSTANT TK	MODEL CODE ON DV-E SCREEN
LV-2020	0.09373	LV
MV-2020	1	MV

Appendix D - Verification Procedures

The accuracy of the **Model 2020** is verified using viscosity standard fluids which are available from CANNON Instrument Company or your local CANNON agent. Viscosity standards are Newtonian, and therefore, have the same viscosity regardless of spindle speed (or shear rate).

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 **Model 2020** should be set according to the operating instructions. The water bath should be stabilized at test temperature.

Verification Procedure for LV and MV spindles:

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

2) Lower the **Model 2020** into measurement position

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. Make sure guardleg is attached.

4) The viscosity standard fluid, together with the spindle and guard leg, 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. 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.

   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 uncertainties of the viscometer and the standard (as discussed in the section entitled, **Interpretation of Test Results**).

Verification 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 **Model 2020**.

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.

Verification Procedure for UL Adapter

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

1) Install the tube end cap and 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 **Model 2020**.

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 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.

Interpretation of VerificationTest Results:

When verifying the accuracy of the **Model 2020**, the instrument and viscosity standard fluid error must be combined to calculate the total allowable error.

The **Model 2020** is accurate to (+/-) 1% of any full scale spindle/speed viscosity range.

When using a viscosity standard fluid for verification, make certain to factor in any uncertainty associated with the standard. Refer to the standard bottle to determine the measurement uncertainty associated with the standard (ordinarily expressed as a percentage).

Calculate full scale viscosity range using the equation:

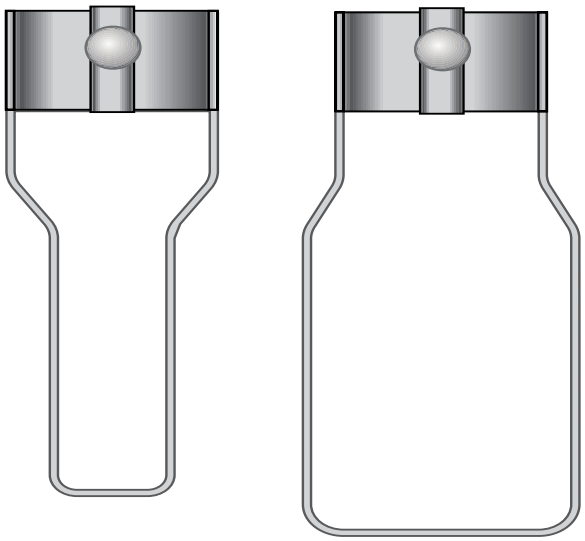
$$\text{Full Scale Viscosity Range [cP]} = \mathbf{TK} * \mathbf{SMC} * \frac{10{,}000}{\text{RPM}}$$

Where: **TK** = 1.0 from **Table C2**
SMC = 10 from **Table C1**

Any reading outside these limits may indicate a viscometer problem. Contact the CANNON technical sales department or your local CANNON dealer/distributor with test results to determine the nature of the problem.

The Guard leg

The *guard leg* was designed to protect the spindle during use; it is a band of metal in the shape of the letter U with a bracket at the top that attaches to the pivot cup. It's shape is designed to accommodate the spindles of the appropriate spindle set; therefore, the MV-2020 guard leg is wider than the LV-2020 due to the large diameter of the optional MV #1 spindle. They are not interchangeable.



LV Guardleg **MV Guardleg**

The verification of the viscometer is determined using a 600 ml Low Form Griffin Beaker and includes the guard leg. The guard leg defines what is called the "outer boundary" of the measurement. The spindle factors were developed with these boundary conditions. The spindle *factors* are used to convert the instrument torque (expressed as the dial reading or %Torque value) into centipoise. 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.

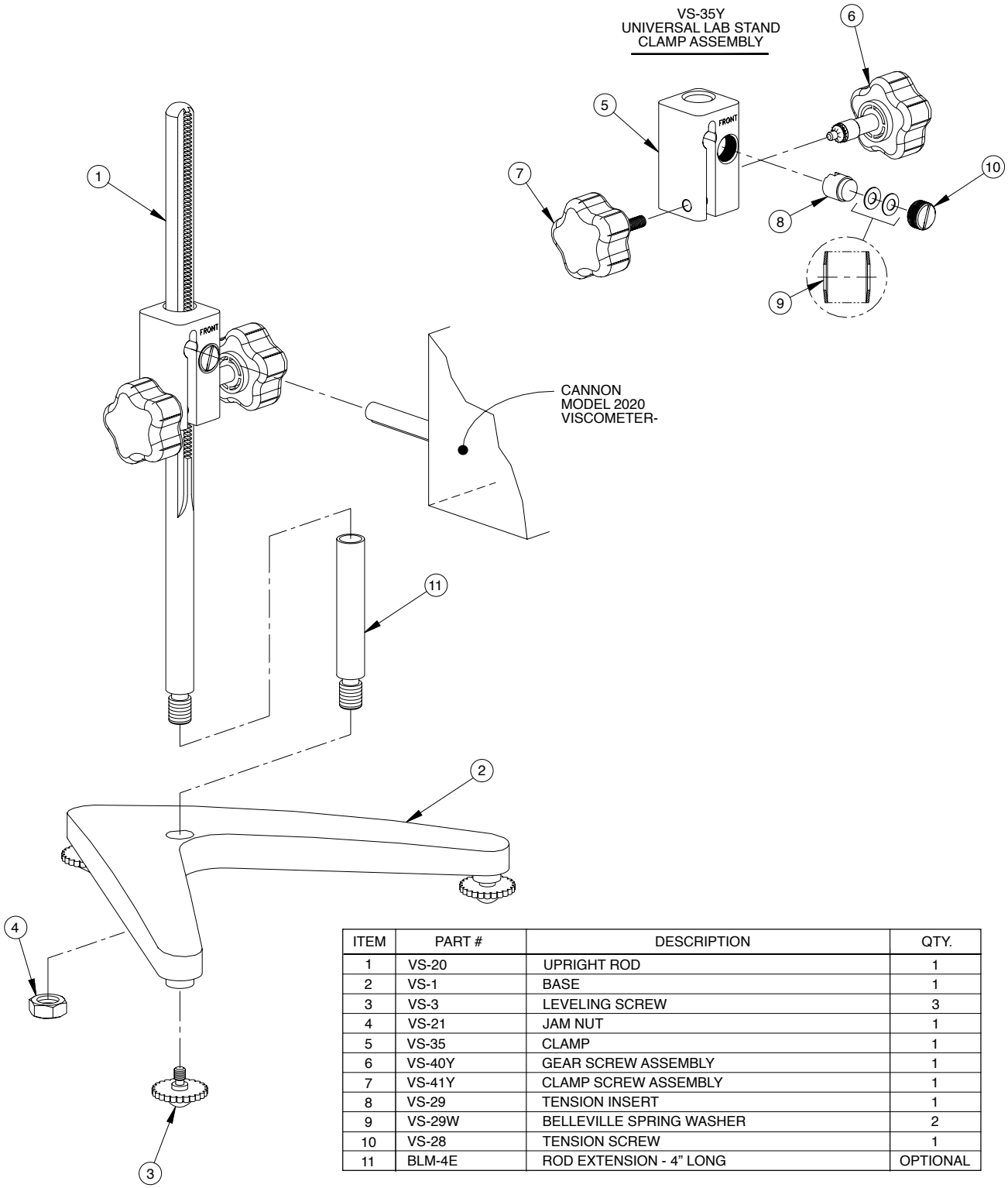
Practically speaking, the guard leg has the greatest effect when used with the #1 & #2 spindles of the LV and MV spindle sets (Note: MV #1 spindle is not part of the standard spindle set).

Any other LV (#3 and #4) or MV (#3 - #7) spindle can be used in a 600 ml beaker with or without the guard leg to produce correct results.

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 CANNON Model 2020 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. 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 CANNON factor if the boundary conditions are not those specified by CANNON.

The guard leg is a part of the calibration check of the CANNON LV and MV series Viscometer. 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 E - Laboratory Stand with Parts Identification



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	BLM-4E	ROD EXTENSION - 4” LONG	OPTIONAL

Figure E1

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 E1)

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

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The VS-35Y 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 rod 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.

The small clamp adjusting screw (Figure E1) 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 F - Fault Diagnosis and Troubleshooting

Listed are some of the more common problems that you may encounter while using your Model 2020 Viscometer. Review these items *before* you contact CANNON.

Spindle Does Not Rotate

- ❏ Make sure the viscometer is plugged in.
- ❏ Check the voltage rating on your viscometer (115V, 220V): it must match the wall voltage.
- ❏ 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 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-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. Make sure the motor is on.
- ❏ Gently push up on the viscometer coupling.
- ❏ Turn the coupling until the % torque on the display reaches 15-20.
- ❏ Gently let go of the coupling.
- ❏ Watch the digital display provide a run of decreasing % values and then rest on zero.

If the pointer sticks and/or does not rest at zero, the unit is in 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:
  - Appendix B — Viscosity Ranges
  - 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 G - Warranty Repair and Service

Warranty

The CANNON Model 2020 Viscometers are guaranteed for one year from date of purchase against defects in materials and workmanship. The Viscometer must be returned to **CANNON Instrument Company** or the CANNON dealer from whom it was purchased for no charge warranty evaluation 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 as shown below.

- ❑ 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.
- ❑ Protect the pointer shaft with a shipping cap as shown in Figure G1.
- ❑ Pack the instrument in its original case. Cases are available for immediate shipment from CANNON. 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 (included with the information packet you received on purchase) 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.
- ❑ Mark the outside of the shipping box with handling instructions, for example: "Handle with Care" or "Fragile - Delicate Instrument".

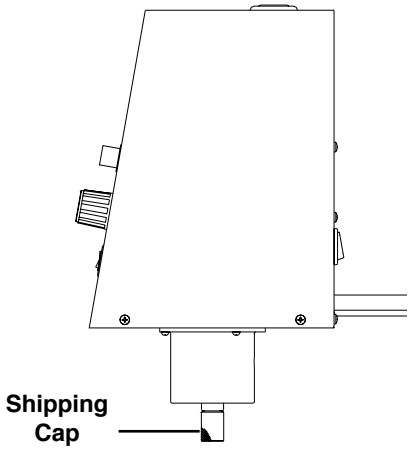

Figure G1

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

CANNON Instrument Company
2139 High Tech Road
State College, PA 16803

Phone: 814-353-8000
Fax: 814-353-8007
email: cannon@cannoninstrument.com

Note: Please contact CANNON for a Return Authorization prior to returning a product.

For repair or service outside the **United States**, consult your authorized CANNON dealer.

VISCOSITY TEST REPORT

DATE:

BY:

FOR:

TEST INFORMATION:

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

CONCLUSIONS:

This sheet is a typical example of recorded test data. Please photocopy and retain this template so that additional copies may be made as needed.