Operation Instructions

DVPlus Digital Viscometer

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Table of Contents

1. INTRODUCTION 5

1.1 Components 6

1.2 Utilities 7

1.3 Component Diagram 9

1.4 Specifications 11

1.5 Installation 11

1.6 Safety Symbols and Precautions 12

1.7 Key Functions 13

1.8 Preventative Maintenance and Cleaning 14

2. GETTING STARTED 15

2.1 Power up 15

2.2 Digital Leveling 15

2.3 AutoZero 16

2.4 Navigation 17

2.5 Spindle Selection 18

2.6 Speed Selection 21

2.7 Full-Scale Range 22

2.8 Display Resolution 23

2.9 Settings 23

2.10 End Conditions 29

2.11 QC Limits 30

2.12 Viscosity Wizard 31

2.13 Custom Spindle 35

3. MAKING VISCOSITY MEASUREMENTS 37

3.1 Quick Start 37

3.1.1 Instrument Setup 37

3.1.2 Power Up 37

3.1.3 Product Registration 37

3.1.4 Digital Leveling 37

3.1.5 Auto Zero 37

3.1.6 Configure Viscosity Test 37

3.2 Preparations for Making Measurements 38

3.3 Selecting a Spindle/Speed 39
3.4 Running a Test 40
3.5 Communication with Optional DVPlus Connect 41
3.5.1 Connecting to the DVPlus Connect App 42
3.5.2 Establishing Bluetooth® connection to the app for a first time 43
3.5.3 Establishing Bluetooth connection to a Paired Instrument 45
3.5.4 Setting up Bluetooth Automatic reconnection 45
3.5.5 Connecting to the App via USB 46
3.5.6 Disconnecting from the App 46
APPENDIX A - VISCOSITY RANGES 47
APPENDIX B - VARIABLES IN VISCOSITY MEASUREMENTS 51
APPENDIX C - SPINDLE ENTRY CODES AND SMC/SRC VALUES 53
APPENDIX D - SPINDLE ENTRY CODES AND RANGE COEFFICIENTS 58
APPENDIX E - CALIBRATION PROCEDURES 60
APPENDIX F - THE AMETEK BROOKFIELD GUARD LEG 65
APPENDIX G - AUTOMATIC OSCILLATION CHECK 67
APPENDIX H - DVE 50-A PROBE CLIP 68
APPENDIX I - LABORATORY STANDS 69
APPENDIX J - SCREEN PROTECTOR 72
APPENDIX K - FAULT DIAGNOSIS AND TROUBLESHOOTING 73
APPENDIX L – INTEGRATED HELIPATH QUICK ACTION, HPQA, OPERATION WITH THE DVPLUS 75
APPENDIX M - ONLINE HELP AND ADDITIONAL RESOURCES 79
APPENDIX N - WARRANTY REPAIR AND SERVICE 80

1. INTRODUCTION

The AMETEK Brookfield DV Viscometer series has provided exceptional value for viscometer users since its introduction in 1981. AMETEK Brookfield has continued to develop and improve to maintain its position in the market as the best value for QC applications. The DVPlus Viscometer continues in this tradition of innovation, quality, and value. The incorporation of a 5-inch touch screen allowed for a new and improved user interface that preserves single speed data collection methods, which makes using the DVPlus Viscometer easier than ever before.

The DVPlus Viscometer measures fluid viscosity which is a measure of a fluid's resistance to flow. You will find a detailed description of the science of viscosity in the AMETEK Brookfield publication "More Solutions to Sticky Problems".

The principle of operation of the DVPlus is to drive a spindle, which is immersed in the test fluid, through a calibrated spring. The viscous drag of the fluid against the spindle is measured by the spring deflection, which is measured with a rotary transducer. This system provides continuous sensing and display of the measurement during the entire test. The measurement range of a DVPlus (in centiPoise, Poise, Pascal-seconds, or milliPascal-seconds) is determined by the rotational speed of the spindle, the size and shape of the spindle, the container the spindle is rotating in, and the full-scale torque of the calibrated spring.

There are four basic spring torque series offered by AMETEK Brookfield:

Spring Torque

Model	**dyne•cm** **dyn•cm**	**milliNewton•m** **mN•m**
DVPLUS LV	673.7	0.0673
DVPLUS RV	7,187.0	0.7187
DVPLUS HA	14,374.0	1.4374
DVPLUS HB	57,469.0	5.7469

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

The DVPlus can be configured to accept an optional temperature probe, which allows temperature readout over the range -100°C to +300°C (-148°F to + 572°F, +173K to +573K). This option allows ambient temperature measurement or temperature measurement of the sample during viscosity testing. Contact AMETEK Brookfield or your local authorized dealer for more information on this instrument option.

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

- Viscosity appears in units of centiPoise (shown as "cP") or milliPascal-seconds (shown as mPa•s) on the DVPlus Viscometer display. (Poise "P" or Pascal seconds "Pa•s")
- Torque appears in units of dyne-centimeters (shown as dyne.cm), percent (shown as %), or milli Newton-meters (Shown as mNm) on the DVPlus Viscometer display.
- Temperature appears in units of Celsius (shown as °C), Kelvin (shown as K), or Fahrenheit (shown as °F) on the DVPlus Viscometer display.

The following applies to DVPlus Viscometers when using an optional temperature probe. Look for the symbol Tp throughout this manual for instructions pertaining specifically to DVPlus Viscometers with temperature probe option.

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

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

References to viscosity throughout this manual are done in CGS units. The DVPlus Viscometer provides equivalent information in SI units.

1.1 Components

Components	Part Number	Quantity
DVPLUS	Varies	1
Model G Laboratory Stand	MODEL G	1
Spindle Set with Case DVPLUS LV set of four spindles (#1 - #4) DVPLUS RV set of six spindles (#2 - #7) DVPLUS HA / HB set of six spindles (#2 - #7)	Varies SSL or SSLM† SSR or SSRM† SSH or SSHM†	1
Power Cord	Varies	1
Power Supply	DPV-2019	1
Guard Leg DVPLUS LV DVPLUS RV	Varies B-20Y B-21Y	1
Shipping Cap	B-30-3Y or B-30KY†	1
Carrying Case	DV-3401	1
Operation Manual	M21-400	1

† “M” in the part number identifies magnetic spindles.

OPTIONAL ITEMS		
Probe Kit, DVPlus (includes DVP- 94Y RTD) Temperature Probe and DVE-50 Probe Clip	DPV-8001	1
		1
Screen Protector Kit	DPV-1025	1

Please check to be sure that you have received all components and that there is no damage. If you are missing any parts, please notify AMETEK Brookfield or your local authorized dealer immediately. Any shipping damage must be reported to the carrier. Please save packaging materials in case the instrument needs to be shipped for service.

1.2 Utilities

VAC; Hz Limits: 100 - 240 VAC; 50/60 Hz ±5%

Power Supply: 24 Watts, Class II certified plug-in power supply

	Main supply voltage fluctuations are not to exceed 10% of the nominal supply voltage.
	Must be used with DPV-2019 Power Supply. Alternative power sources may cause damage to the instrument.

If equipped with Bluetooth:

FCC Bluetooth RF Transmitter Characteristics

- Contains FCC ID: XPYANNAB1
- Contains IC: 8595A-ANNAB1
- Frequency 2402-2480 MHz, Spread Spectrum

ISED Canada Bluetooth RF Transmitter Characteristics

- Certification No. 8595A-ANNAB1

FCC/IC Statements
This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End users must follow the specific operating instructions for satisfying RF exposure compliance. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter, except in accordance with FCC test procedures. This transmitter is considered a mobile device.

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

The minimum separation distance to human body is 10 mm. RF exposure or SAR evaluations are not required when the separation distance is 10 mm or more.

CE Compliance
BS EN IEC 61326-1:2021
Electrical equipment for measurement, control, and laboratory use. EMC requirements - General requirements

BS EN 61010-1:2010+A1:2019
Safety requirements for electrical equipment for measurement, control, and laboratory use General requirements

FCC Compliance
FCC 47 CFR Part 15 – Class B Digital Device – Unintentional Radiators
FCC 47 CFR Part 18 – Class B Digital Device – Intentional Radiators

KS C 9610-6-2:2019 Generic standards - Immunity standard for industrial environments

KS C 9610-6-4:2017 Generic standards - Emission standard for industrial environments

AS/NZS CISPR32
Electromagnetic compatibility of multimedia equipment - Emission requirements

ETSI EN 301 489-1:2019-11 Ed. V2.2.3
Electromagnetic Compatibility (EMC) standard for radio equipment and services;
Part 1: Common technical requirements; Harmonized Standard for Electromagnetic Compatibility

ETSI EN 301 489-17:2017-03 Ed. V3.2.2
Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems; Harmonized Standard for Electromagnetic Compatibility

IC (INDUSTRY CANADA):
ISED ICES-003:2016 Ed. 6
ISED ICES-003, Issue 6, Class A – Information Technology Equipment (Including Digital Apparatus) – Limits and methods of measurement

Compliance is suggested by ISED Canada as CAN ICES-3 (A) / NMB-3 (A) Method of compliance per each standard above and ANSI C63.4:2014

MIC Japan Compliance
Low power data communications in the 2.4GHz band - Radio Equipment
Radio Law: Law No. 131, 1950 and Amendments
Standards: MIC Notification No. 88 Annex 43 Certificate No: JN0834 i02

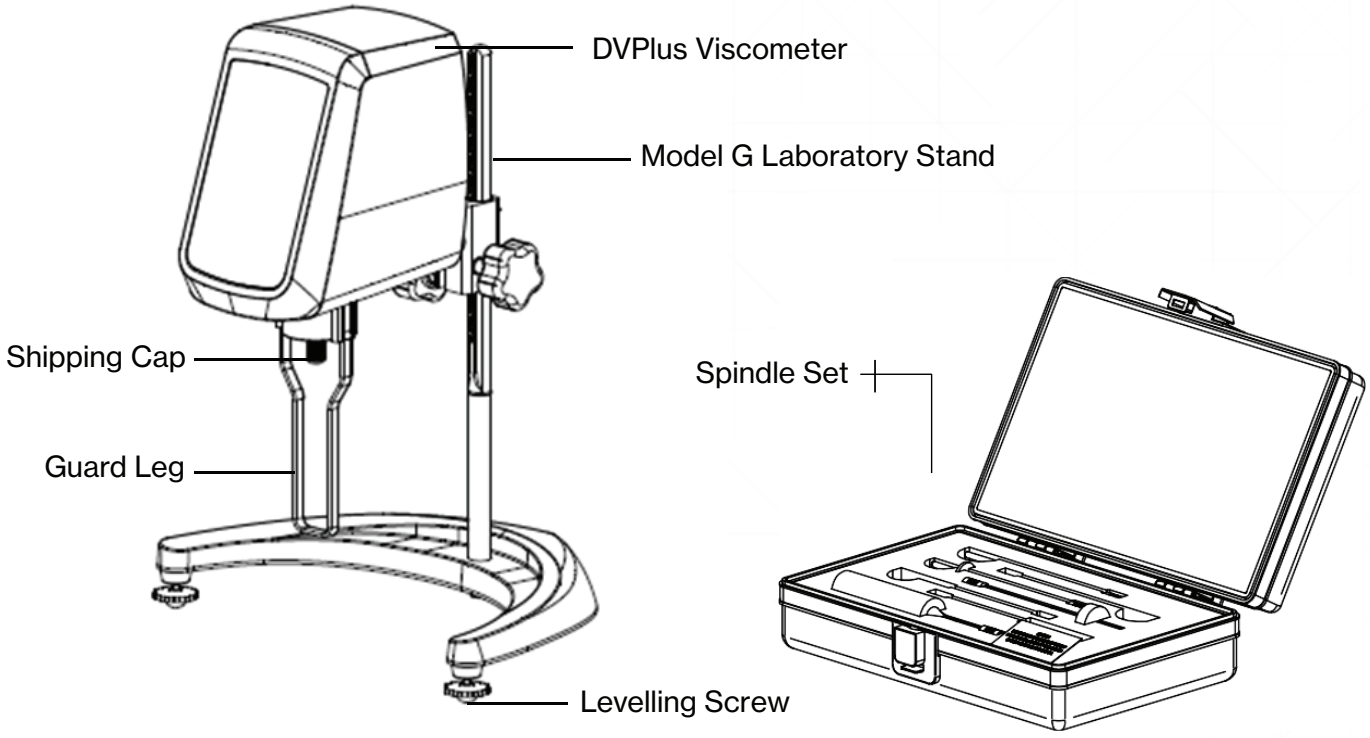
Brazil:
Este equipamento opera em caráter secundário, isto é, não tem direito a proteção contra interferência prejudicial, mesmo de estações do mesmo tipo, e não pode causar interferência a sistemas operando em caráter primário.

This equipment operates on a secondary basis and, consequently, must accept harmful interference, including from stations of the same kind, and may not cause harmful interference to systems operating on a primary basis.

South Korea:
The DVPlus Viscometer is certified by the Korea Communications Commission (KCC).

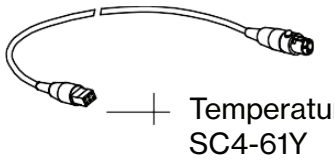
R-R-DpV-DVPL

1.3 Component Diagram



Temperature Probe Option

- For use with SSA:



- For use in beaker:

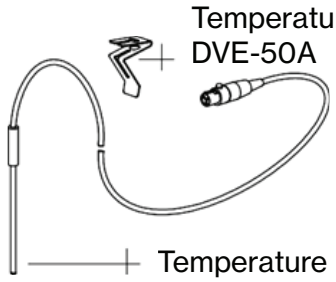


Figure 1-3.1

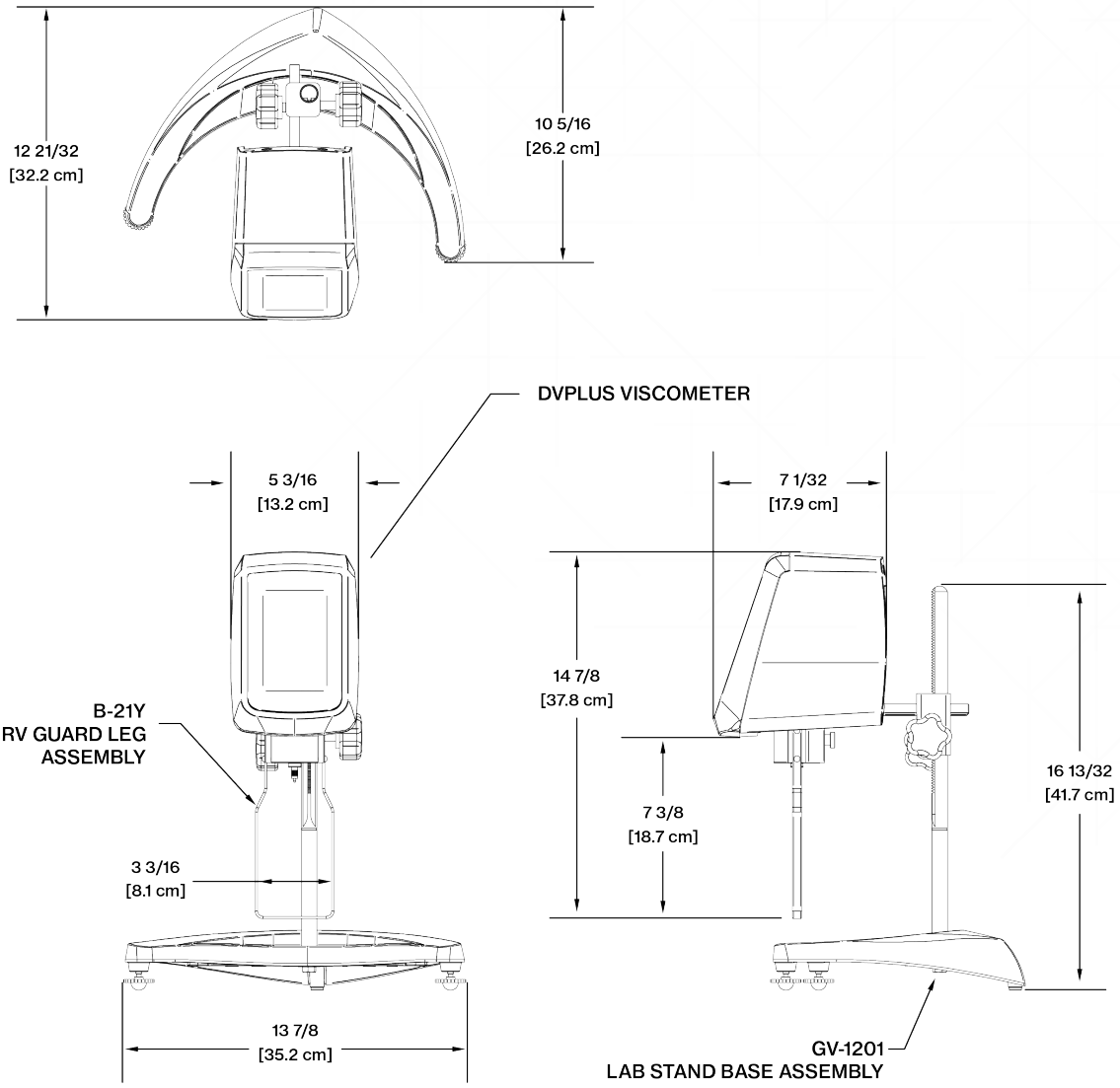

12 21/32
[32.2 cm]
10 5/16
[26.2 cm]
DVPLUS VISCOMETER
5 3/16
[13.2 cm]
7 1/32
[17.9 cm]
14 7/8
[37.8 cm]
B-21Y
RV GUARD LEG
ASSEMBLY
7 3/8
[18.7 cm]
16 13/32
[41.7 cm]
3 3/16
[8.1 cm]
13 7/8
[35.2 cm]
GV-1201
LAB STAND BASE ASSEMBLY

Figure 1-3.2

1.4 Specifications

Speed:	0.0 to 59.9 RPM in increments of 0.1 RPM. 60 -200 RPM in increments of 1 RPM, 740 total speeds.
Weight:	Gross Weight: 24.5 lbs.; 11.11 kg. Net Weight: 19.5 lbs.; 8.85 kg. Carton Volume: 2.48 cu. ft.; 0.07 m3
Operating Environment:	0°C to 40°C Temperature Range (32F to 104F, 273.15K to 313.15K) 20% - 80% R.H.: non-condensing atmosphere
Viscosity Accuracy:	±1.0% Full Scale Range in Use (See Appendix D for range calculation)
Viscosity Repeatability:	±0.2% of Full-Scale Range in Use
Temperature Sensing Range:	-100°C to +300°C (-148F to +572F, +173K to 573K)
Temperature Accuracy:	±1°C: -100°C to +149°C ±2°C: +150°C to +300°C
Ingress Protection Rating:	IP30*
Electrical Certification:	**Conforms to CE Standards:** **EN IEC 61326-1:2021:** Electrical equipment for measurement, control, and laboratory use - EMC requirements. **EN 61010-1:2010+A1:2019:** Safety requirements for electrical equipment, for measurement, control, and laboratory use. **EN IEC 63000:2018:** Technical documentation for the assessment of electrical and electronic products with respect to the Restriction of Hazardous Substances Directive (RoHS 3)

* when used with any of the following accessories: Thermosel, Small Sample Adapter, UL Adapter, DIN Adapter, Spiral Adapter, LV Spindle Guard Leg or RV Spindle Guard Leg. Otherwise, ingress protection rating is IP20.

Notice to customer:

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 AMETEK 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.

1.5 Installation

We request our customers to save the packaging material and reuse it while shipping for servicing/repairs.

Note:
"IQ, OQ, PQ", an abbreviated guideline document for installation, operation, and performance validation for your DVPlus Viscometer is available for purchase from AMETEK Brookfield or your local authorized distributor.

1. Assemble the Model G Laboratory Stand (refer to assembly instructions in Appendix I)
2. Attach the Viscometer head to the clamp on the laboratory stand rod.
3. Connect the RTD probe to the socket on the rear panel of the DVPlus.
4. Remove the shipping cap which secures the coupling nut on the Viscometer to the pivot cup.
5. Make sure that the power switch at the rear of the DVPlus is in the OFF position. Connect the power cord to the power supply provided. Do not use any other power supply or the warranty may be voided. Plug the power supply cable into the DVPlus power in outlet only. Important, if the power supply cable is plugged in anywhere else damage may occur and warranty may be voided

The DVPlus must be used with the provided power supply.

The power supply must be earth grounded to maintain compliance with electrical certifications.

6. Turn the power switch to the ON position and allow the Viscometer to warm up for 10 minutes before leveling and performing autozero.
7. If the DVPlus prompts that the Viscometer must be leveled, follow the instructions on the screen to level the instrument. Please note: The leveling prompt will not appear if instrument has already been leveled.
8. If appropriate, connect USB cable (DVP-202) to USB port for connection of DVPlus to the PC.

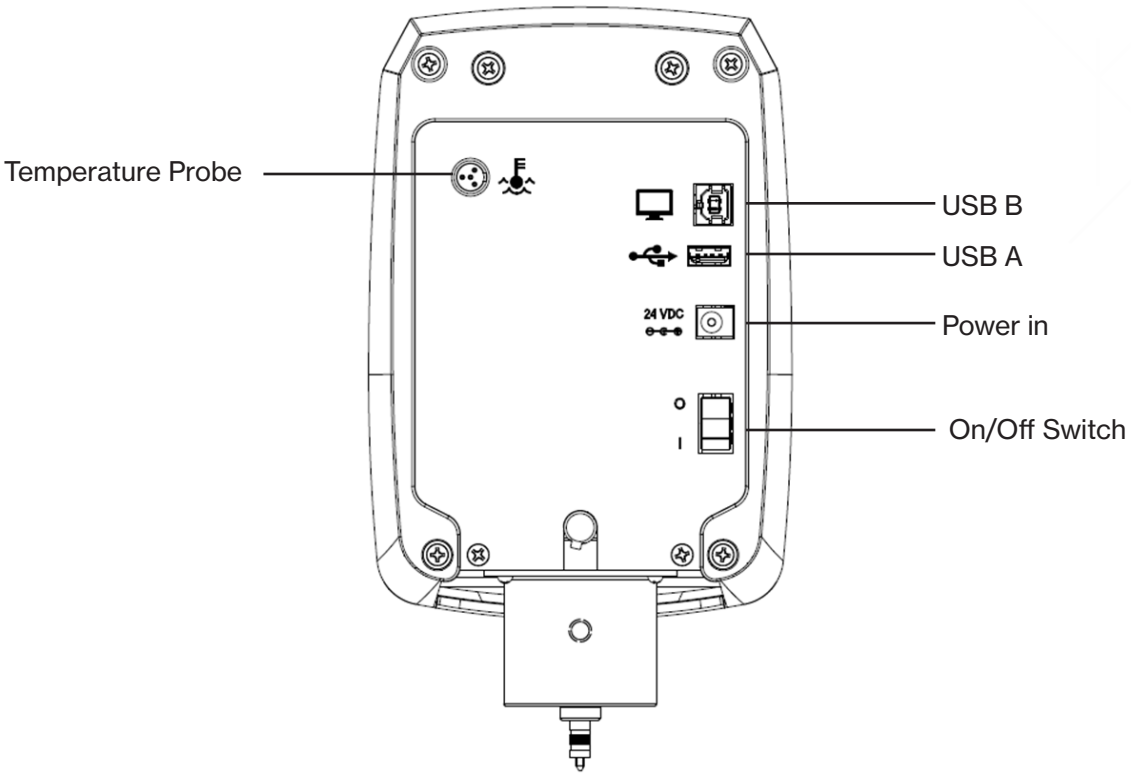


Figure 1-5

1.6 Safety Symbols and Precautions

Safety Symbols:
The following explains the safety symbols that may be found in this operating manual.

	Indicates hazardous voltages may be present.

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

Precautions:

⚠	If this instrument is used in a manner not specified by the manufacturer, the protection provided by the instrument may be impaired.
⚠	This instrument is not intended for use in a potentially hazardous environment.
⚠	In case of emergency, turn off the instrument and then disconnect the electrical cord from the wall outlet.
⚠	The user should ensure that the substances placed under test do not release poisonous, toxic, or flammable gases at the temperatures to which they are subjected during the testing.
⚠	The safety of any system incorporating this equipment is the responsibility of the assembler of the system.

1.7 Key Functions

The DVPlus utilizes a touch screen display and interface. The user will provide all input to the viscometer through the touch screen. Figure 1-7 details the different types of information and actions available.

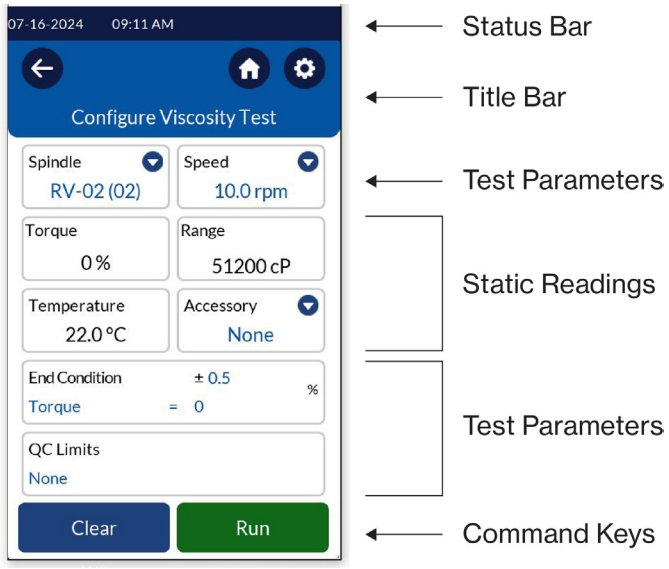


Figure 1-7

Status Bar	The Status Bar provides information relating to the date and time (as configured by the user) and various connections to the DVPlus Viscometer.
Title Bar	The Title Bar identifies the activity to be conducted in the current view and includes any navigation icons that are relevant.
Test Parameters	The Test Parameters are where the user enters the test factors relevant for the test to be conducted.
Static Readings	The Static Readings are the DVPlus data while at rest.
Command Keys	The Command Keys indicate the action that can be taken. These keys will vary from view to view depending on what actions are relevant.

1.8 Preventative Maintenance and Cleaning

	Make sure that the instrument is in a clean, dry 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 sample residue. 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.
	When cleaning, do not apply excessive force, which may result in bending spindles. Instrument and Display: Clean with a dry, non-abrasive cloth. Do not use solvents or cleaners. The instrument housing is manufactured from polycarbonate ABS. Clean Instrument housing with mild soap and water. Do not apply solvent to the instrument! Immersed Components (spindles): Spindles are made of stainless steel. Clean with a non-abrasive cloth and solvent appropriate for the sample material.

2. GETTING STARTED

2.1 Power up

The DVPlus Viscometer will go through a Power Up sequence when the power is turned on. The Viscometer will present a black screen for approximately 4 seconds and then the Splash screen for 5 seconds. The Splash screen is shown below (Figure 2-1) and includes several critical parameters about the Viscometer including viscometer torque (LV, RV, HA, HB, or other), serial number, and the firmware version number.

Note: A product registration screen appears the first 6 times the instrument is powered up, and again in 1 month.

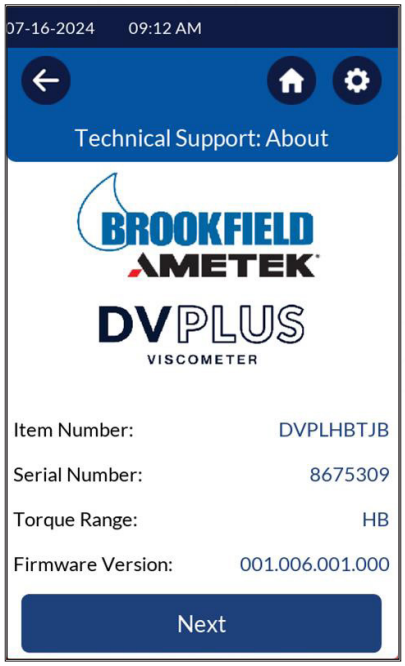


Figure 2-1

The Splash screen information can also be accessed through the Main Menu, using the Technical Support Button. (see Section 2.9)

If the DVPlus Viscometer is Level, it will automatically transition from the Splash screen to the AutoZero screen. If it is not Level, then it will transition to the Adjust Level screen. (see Section 2.2)

2.2 Digital Leveling

Upon powering up the DVPlus, the user will be prompted to level the DVPlus device if not already level. To level the DVPlus, adjust the leveling feet on the lab stand base. When the device is not level, the centering bubble will be red. While adjusting to a level position, the dot will become yellow, signifying that the device is approaching a position where it will be level. Once the dot is within specified limits of the center circle, the bubble will turn green to signify that the DVPlus is now level and ready to operate (see Figures 2-2.1, 2-2.2, and 2-2.3 below). Following this process, the device will then move onto the Auto Zero function (Section 2.2). Pressing the Skip button will trigger a message warning the user that “Results may not be accurate” if the DVPlus is not level (Figure 2-2.4). It is recommended to let the instrument warm up for 10 minutes before leveling. Recheck the level prior to running any tests, especially the test with accessories and try to get the level as close as possible.

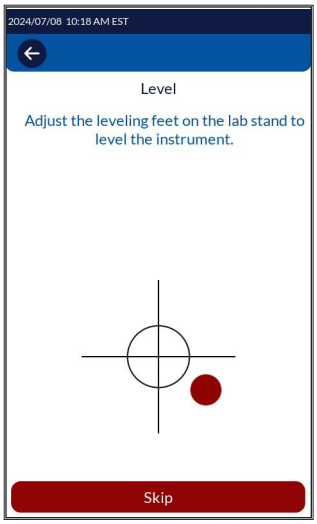


Figure 2-2.1

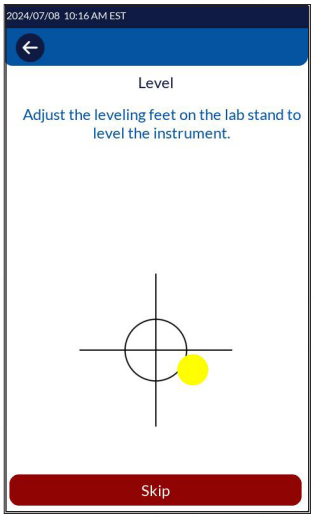


Figure 2-2.2

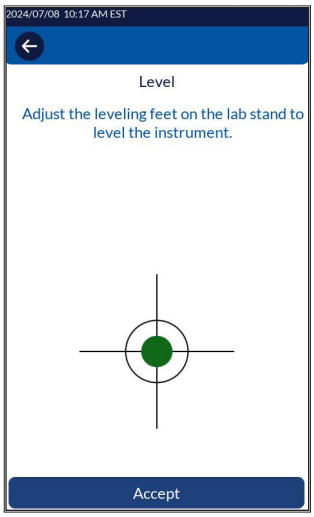


Figure 2-2.3

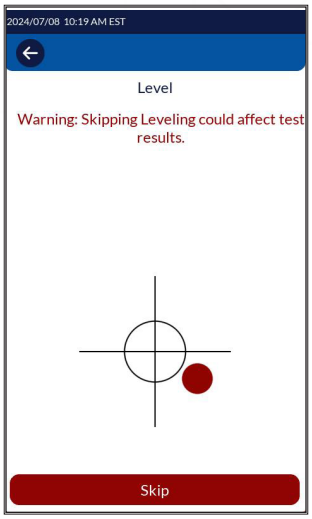


Figure 2-2.4

If you are having trouble achieving the correct level status, try the following:

Check the Stability of your table, bench, or other work surface.
Check the Stability of your lab stand. Ensure the Clamp Assembly Knob is tight. (See Appendix I: Laboratory Stands)
Call AMETEK Brookfield for additional assistance.

NOTE: When contacting AMETEK Brookfield or your local authorized dealer for technical support or repair services, please record the information on the Splash screen and the serial number (found on the serial tag located on the back of the instrument head) in any correspondence or shipping paperwork.

2.3 AutoZero

The DVPlus Viscometer must perform an AutoZero prior to making viscosity measurements. This process sets the zero reading for the measurement system. The AutoZero will be performed every time the instrument is turned on. It is not necessary to perform an AutoZero before each test.

Proper AutoZero function requires that the Viscometer be level (see Section 2.2) and that the spindle be removed from the coupling shaft. Additionally, any spindle coupling, or extension links used with accessory devices should be removed from the coupling shaft. The DVPlus display presents a reminder screen to remove the spindle. The operator must press the Run button (see Figure 2-3.1) to initiate the AutoZero. (Figure 2-3.2) Once finished, the DVPlus presents a message that the AutoZero has completed. (Figure 2-3.3) The operator must press the OK button

to proceed.
TIP: Do not touch the Viscometer during the AutoZero process to ensure the best zero value.

TIP: The AutoZero sets the zero point of the viscometer range. A failure to properly level the Viscometer or to remove the spindle may affect the zero value and all measurement results.

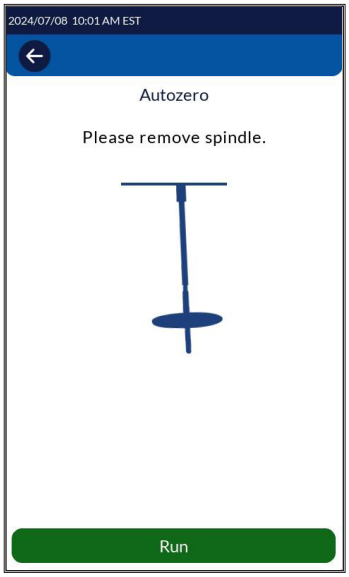


Figure 2-3.1

Figure 2-3.2

Figure 2-3.3

2.4 Navigation

The DVPlus Viscometer uses a 5-inch Color Graphical LCD Capacitive Touch Screen with RGB Interface display. All user input is made through the touch screen.

After completing the AutoZero and pressing OK, the DVPlus switches to the Configure Viscosity Test screen. (Figure 2-4)

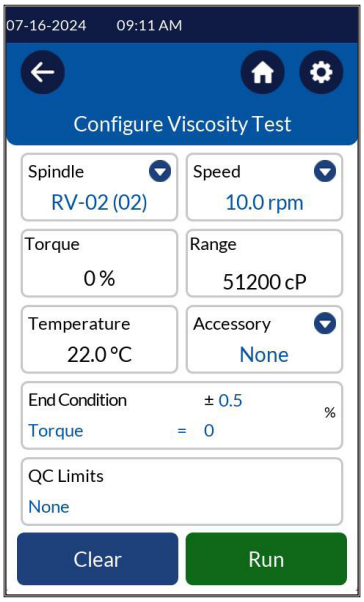
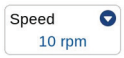
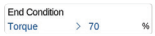


Figure 2-4

	Back Arrow	Return to the previous screen.
	Home Icon	Return to the Main Menu screen.
	Spindle	Enter Spindle Selection screen.
	Speed	Enter Speed Selection screen.
	End Condition	Choose the desired end condition.
	QC Limits	Choose the desired QC Limit.
	Run	Start Configured Test.
	Settings	Various instrument settings. See section 2.9.
	Accessory	Choose whether or not HPQA will be used
	Clear	Reset test parameters to factory default

2.5 Spindle Selection

DVPlus LV Viscometers are provided with a set of four spindles and a narrow guard leg. DVPlus RV Viscometers are provided with a set of six spindles and a wider guard leg. DVPlus HA and DVPlus HB Viscometers come with a set of six spindles and no guard leg (see Appendix F for more information on the guard leg).

The motor must be OFF whenever spindles are being removed or attached.

DVPlus Viscometers and spindles are offered in two different coupling configurations: Threaded and Magnetic.

The threaded spindles are attached to the Viscometer by screwing them onto the coupling nut on the lower shaft (see Figure 2-5.1). Note that the spindles have a left-hand thread. The lower shaft should be secured and slightly lifted with one hand while screwing the spindle to the left. The face of the spindle nut and the matching surface on the lower shaft should be smooth and clean to prevent eccentric rotation of the spindle.

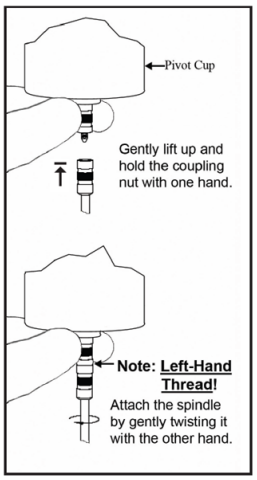


Figure 2-5.1

To remove the spindle, the lower shaft should be secured and slightly lifted with one hand while unscrewing the spindle to the right. Spindles can be identified by the number on the side of the spindle coupling nut.

If your instrument has the magnetic coupling system, the spindles are attached as follows:

Align two opposing spindle slots (Figure 2-5.2) with the two pins inside the coupling (Figure 2-5.3).

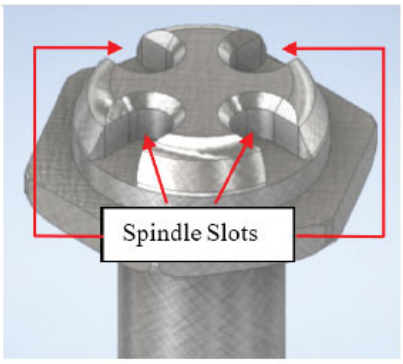


Figure 2-5.2

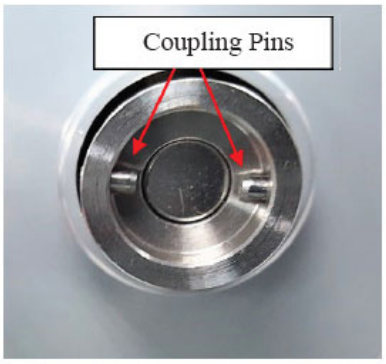


Figure 2-5.3

Carefully insert the spindle into the coupling, so the slots are fully engaged with the pins. You should feel the pull of the magnet as the spindle seats into the coupling.

When properly aligned, there should be no gap between the spindle and the coupling. (Figures 2-5.4 and 2-5.5)

Figure 2-5.4

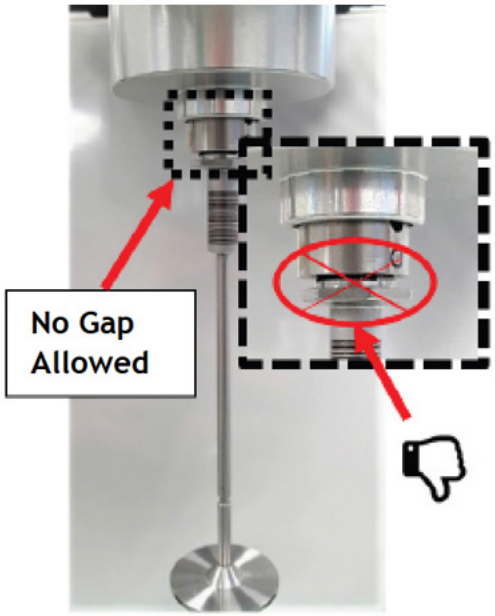


Figure 2-5.5

To remove the magnetic spindle :

- Carefully grasp the spindle shaft and gently lift it up just enough to minimize any pressure on the pivot point and jewel inside the DVPlus.
- DO NOT PULL DOWN THE SPINDLE!!!!
- While lifting, gently push the spindle to the side like a pendulum to disengage it from the magnetic coupling. The spindle and coupling should separate easily. If they do not separate easily, DO NOT FORCE IT! Stop and try pushing in a different direction.
- Continue pushing the spindle in an unrestrictive direction until it is completely detached from the magnetic coupling. (Figures 2-5.6 and 2-5.7)

Figure 2-5.6

Figure 2-5.7

The DVPlus requires a Spindle Entry Code number to calculate viscosity values. The two-digit code for each spindle can be found in Appendix D.

Pressing the Spindle field on the Configure Viscosity Test screen will present the Set Spindle screen. Spindle Codes can be entered using a digital numeric keypad or a scrollable spindle list.

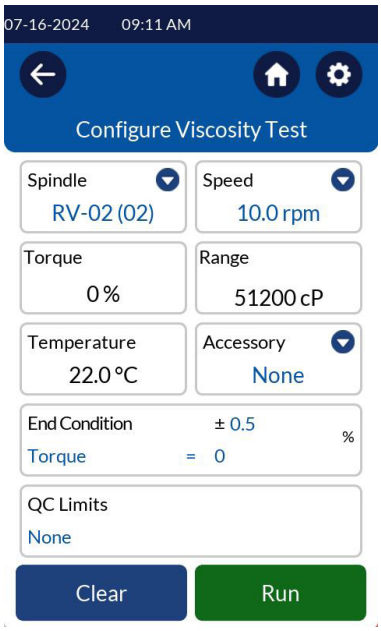


Figure 2-5.8

If using the keypad, delete any unwanted values in the entry box by pressing the clear data radio button (x). Enter the Spindle Code you want in the entry box and press Confirm. The display will return to the **Configure Viscosity Test screen.**

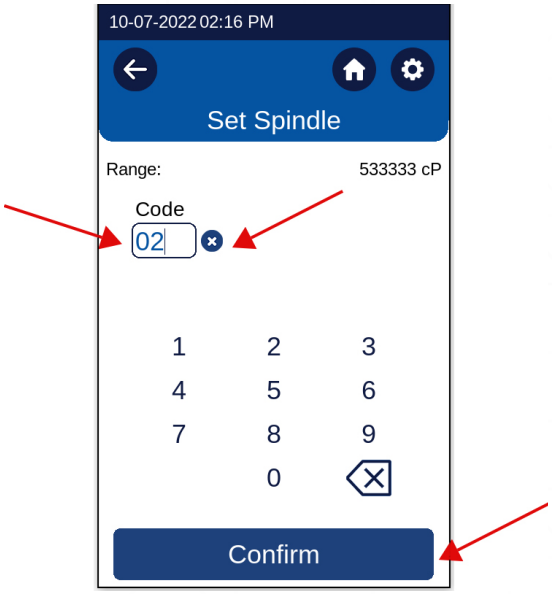


Figure 2-5.9

If using the scrollable spindle list, press the dropdown button in the Spindle box to open the spindle list . Scroll up or down through the list of available spindles until you find the spindle you want. Then simply touch the spindle name/part number to select it.

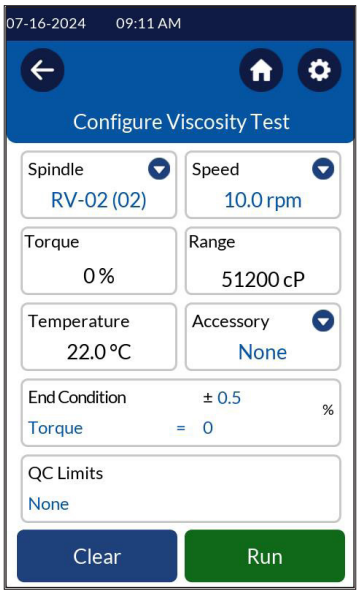


Figure 2-5.10

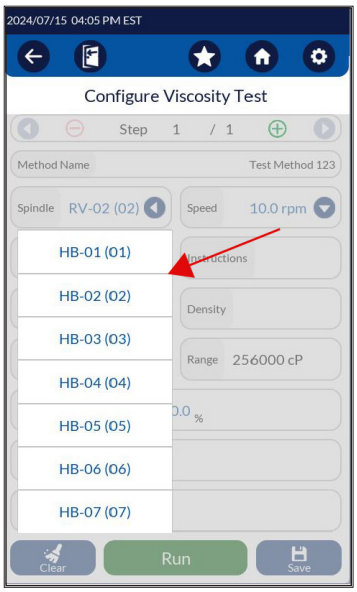


Figure 2-5.11

2.6 Speed Selection

The DVPlus rotational speed can be set from 0.0 to 200rpm using two methods. Rotational speed can be set using a digital numeric keypad or a scrollable pre-set speed list.

If using the keypad, delete any unwanted values in the entry box by pressing the clear data radio button . Enter the Speed you want from 0.0 to 200 rpm in the entry box and press Confirm.

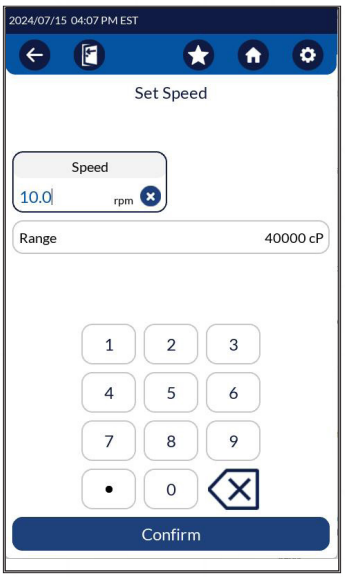


Figure 2-6

If using the scrollable speed list, press the dropdown button in the Speed box to open the list of available pre-set speeds . Scroll up or down through the list until you find the pre-set speed you want, then simply touch it to select it.
Table 2-6.2 shows the available pre-set speed selections:

DVPlus Pre-Set Speed List (RPM)
0.0
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

Table 2-6.2

2.7 Full-Scale Range

The Full-scale Range (FSR) is a calculation of the maximum viscosity value that can be measured by a spindle and speed combination when used with the specific spring torque of the DVPlus Viscometer. This value represents the measured viscosity that will be displayed when the instrument's % torque reading is at 100. The FSR will be displayed

during the spindle selection process and the speed selection process. The FSR value will change as the selected speed or spindle is changed and will be displayed in the viscosity measurement units selected by the user in the Settings Menu (see Section 2.9).

AMETEK Brookfield recommends that viscosity measurements be made only when the instrument's % torque value is between 10 and 100. The FSR represents the maximum value that can be measured (i.e., 100% on the Torque scale). The minimum viscosity that can be measured is 10% of the FSR, which is equivalent to 10 on the Torque scale.

The accuracy of the AMETEK Brookfield Viscometer is expressed as a percentage of the instrument's Full-scale Range. When using the standard LV (61-64) and RV (2-7) spindles, the instrument's accuracy is +/-1% of the Full-scale Range.

2.8 Display Resolution

The DVPlus Viscometer offers a wide range of viscosity measurements. The data displayed will present a specific resolution depending upon the magnitude of the data. This resolution is consistent with the stated accuracy of the AMETEK Brookfield Viscometer. The table below shows the display resolution for viscosity, which will be utilized by the DVPlus Viscometer.

Viscosity								
				X	.	X	X	0.00 to 9.99
			X	X	.	X	X	10.00 to 99.99
		X	X	X	.	X		100.0 to 999.9
	X	X	X	X				1000 to 9999
X	X	X	X	0				10000 to 99990
X	X	X	X	0	0			100000 to 999900
X	X	X	X	0	0	0		1000000 to 9999000
X	X	X	X	0	0	0	0	10000000 to 99990000
X	.	X	X	X	E	X	X	100000000+

2.9 Settings

The Settings Menu is accessed by pressing the Settings icon in the top right corner of the screen. The following settings are found in this scrolling menu:

- **Viscosity Units** Set the unit of viscosity measurement, cP, Pa•s, mPa•s, P

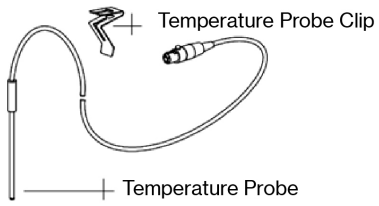
Unit Abbreviation	Unit	Equivalency
cP	centiPoise	100 cP = 1 P = 100 mPa•s = 0.1 Pa•s
Pa•s	Pascal Second	1 Pa•s = 1000 mPa•s = 1000 cP = 10 P
mPa•s	milliPascal Second	1 mPa•s = 1 cP = 0.01 P = 0.001 Pa•s
P	Poise	1 P = 100 cP = 100 mPa•s = 0.1 Pa•s

- **Torque Units** Set the unit of torque measurement, %, mNm, dyne•cm
- **Temperature Units** Set the unit of temperature measurement, °C, °F, K.
- **Temperature Offset** Set an offset value for the temperature probe (optional).

Note: Temperature measurement requires the use of a DVP-94Y external temperature probe.

Temperature Probe Option

- For use in beaker:



- **Beeper Volume** Set the volume level for the internal beeper signal.
- **Screen Brightness** Set the brightness level of the touch screen display.
- **Custom Spindles** Enter the specifications for custom spindles.
- **Custom Speed** Add a speed to the pre-set speed list.
- **Language** Choose from available languages.
- **Reset Settings** Restore all settings to factory defaults.
- **Set Date and Time** Set the current date and time
- **Firmware Update** Update the firmware to the latest version.
- **Bluetooth Setup** Enable/disable the Bluetooth feature. Includes options for renaming the viscometer and connection settings

Viscosity Units

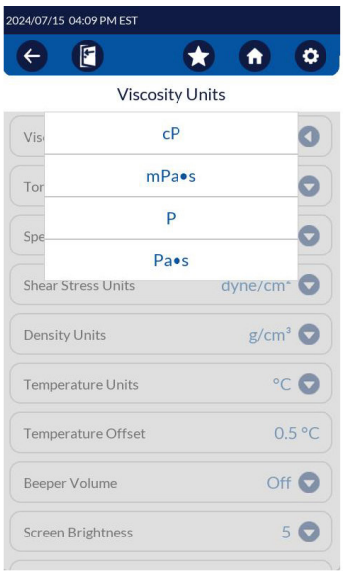


Figure 2-9.1

Torque Units

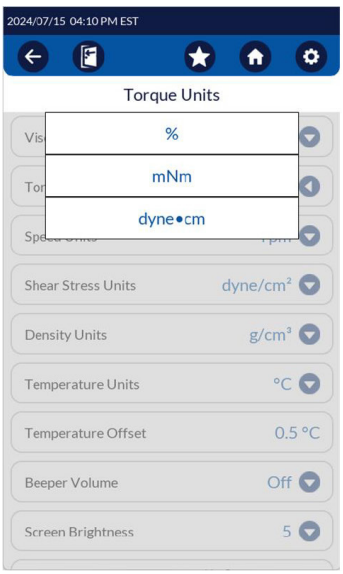


Figure 2-9.2

Temperature Units

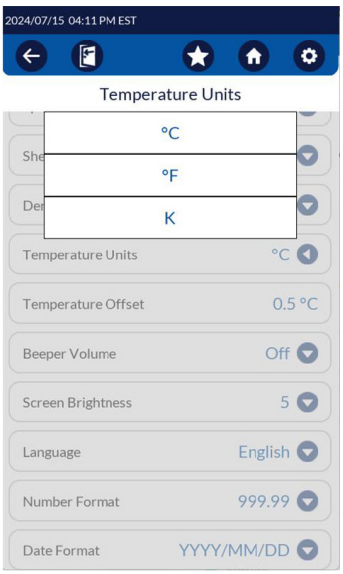


Figure 2-9.3

Temperature Offset

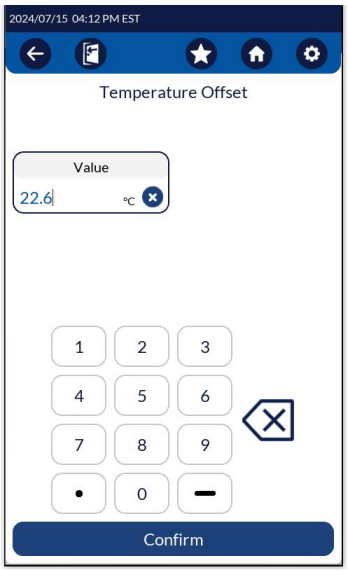


Figure 2-9.4

Beeper Volume

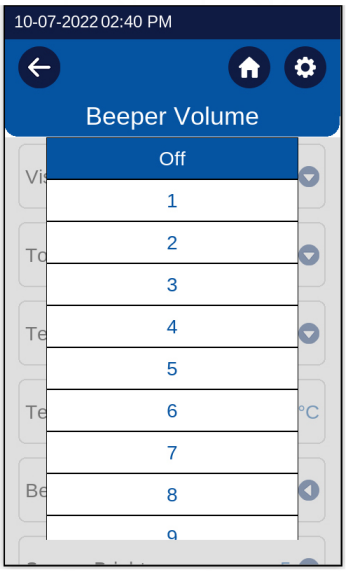


Figure 2-9.5

Screen Brightness

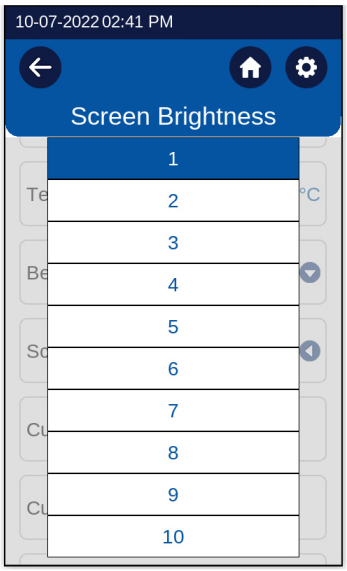


Figure 2-9.6

Custom Spindles

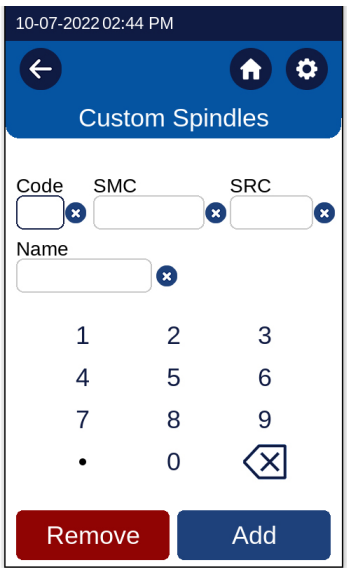


Figure 2-9.7

Custom Speeds

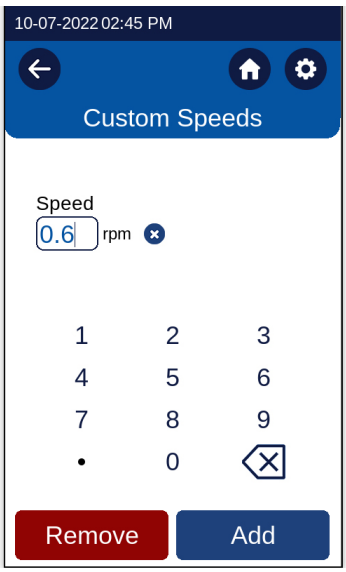


Figure 2-9.8

Language

Figure 2-9.9

Reset Settings

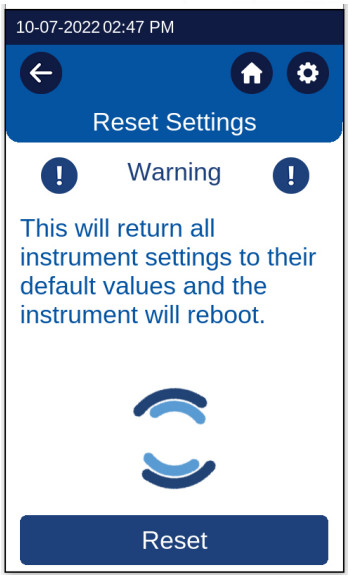


Figure 2-9.10

Set Date & Time

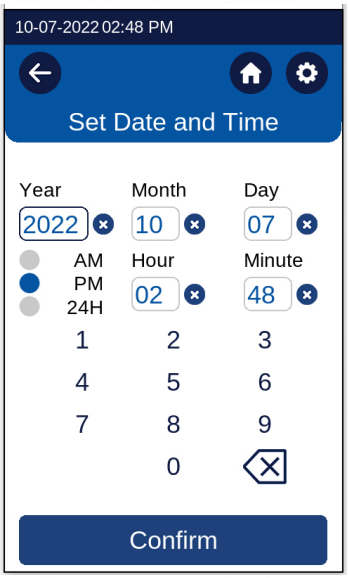


Figure 2-9.11

Firmware Update

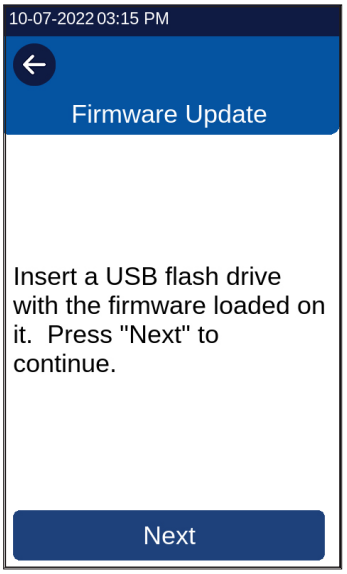


Figure 2-9.12

Bluetooth Setup

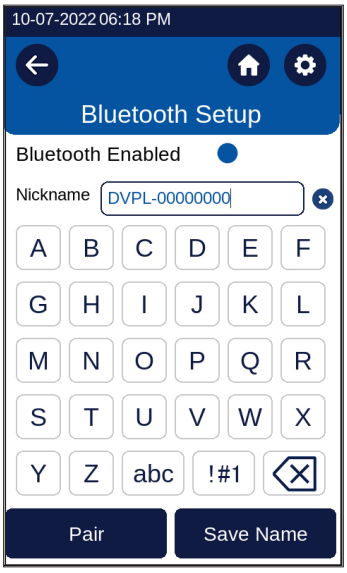


Figure 2-9.13

FIRMWARE UPDATE

WARNING: It is critical that you only install Firmware intended for the DVPlus on your instrument. Please insure that no other .fwu files exist on your USB Flash Drive and that the only firmware files that exist are those you are trying to install

NOTE: USB Flash Drives must be formatted to FAT32 for DVPlus Firmware Updating

Insert a USB Flash Drive (FAT32 Format) with the Firmware Update into the USB A Port on the back of the DVPlus. DO NOT Remove the USB Flash Drive at any point during the upgrade.

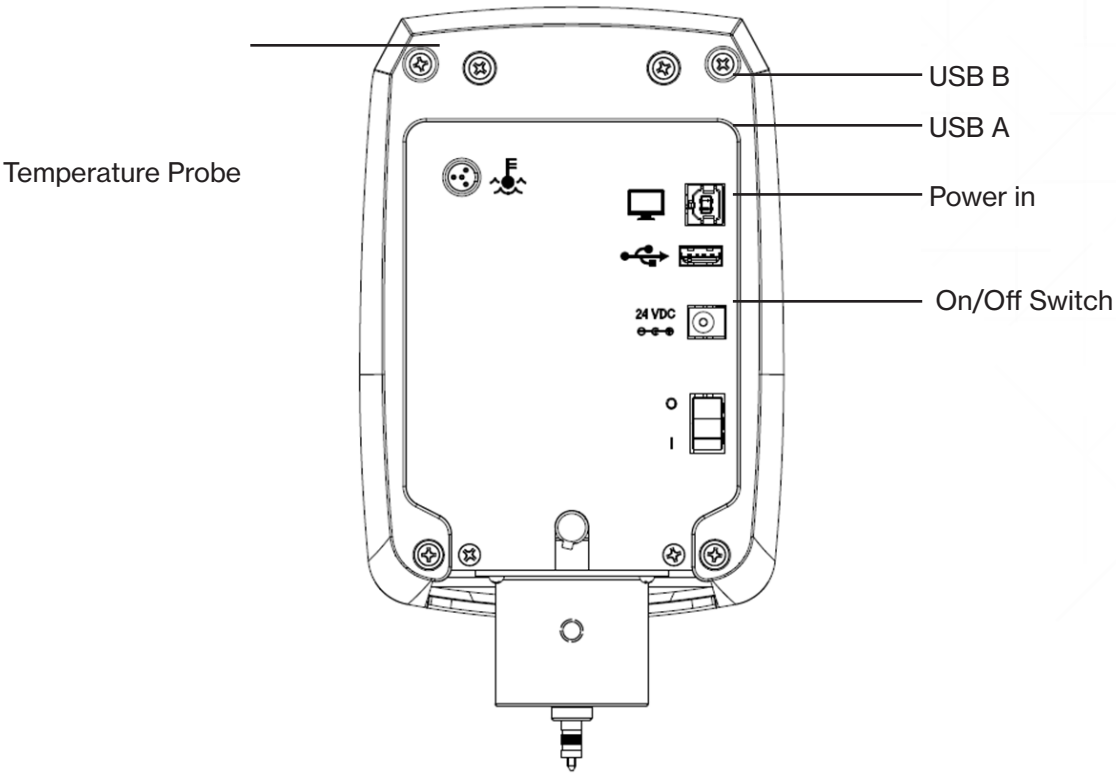


Figure 2-9.14

Turn the DVPlus On.
Level and AutoZero accordingly.
Go to Settings Menu and select Firmware Update.

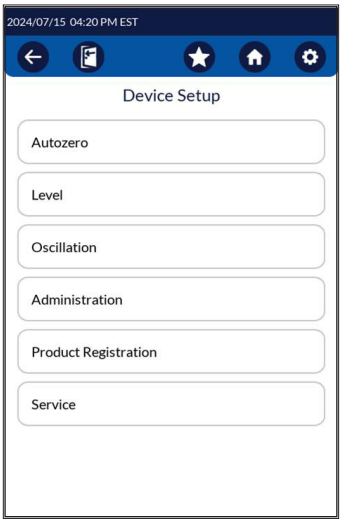


Figure 2-9.15

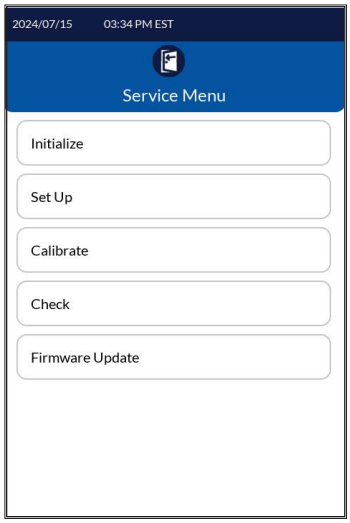


Figure 2-9.15

Select the desired Firmware version from the USB Drive.

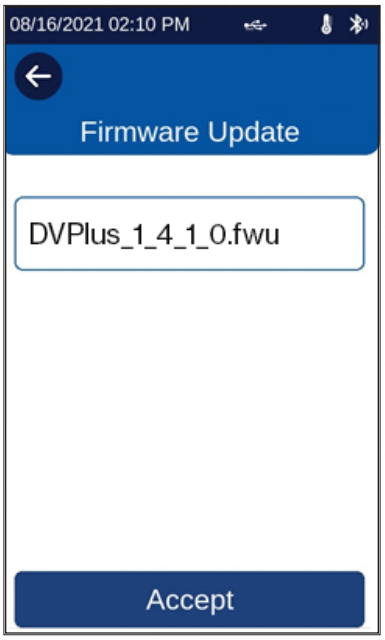


Figure 2-9.16

DVPlus will have you confirm your choice.

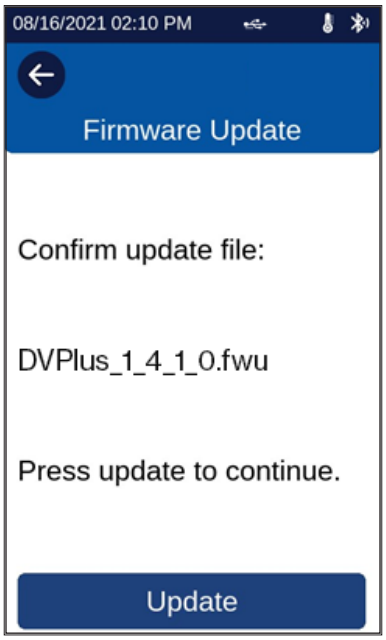


Figure 2-9.17

Press Update and the DVPlus will automatically update the firmware to the desired selection. When the update is complete, the DVPlus will automatically reboot. DO NOT Remove the USB Flash Drive at any point during the update.

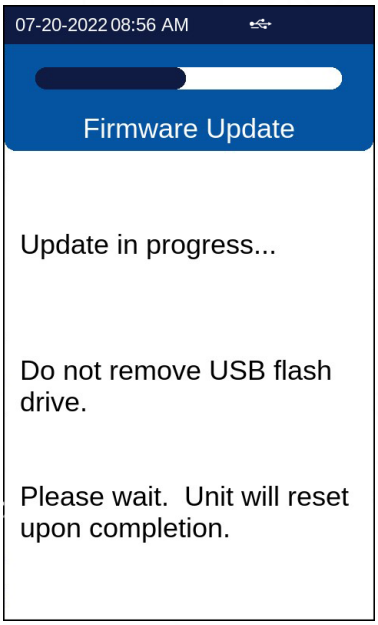


Figure 2-9.18

Verify that the desired Firmware version has been installed by viewing the startup Splash Screen.

Figure 2-9.19

After the DVPlus finishes booting, the USB Flash Drive can be removed.

2.10 End Conditions

The DVPlus Viscometer offers a variety of end conditions for the viscosity measurement. The end condition defines when the spindle will stop its rotation and a final data point will be shown on the display. The end conditions currently in use on the DVPlus can be identified by pressing the End Condition box on the **Configure Viscosity Test** screen. The Set End Condition screen will then be displayed. (Figures 2-10.1 & 2-10.2)

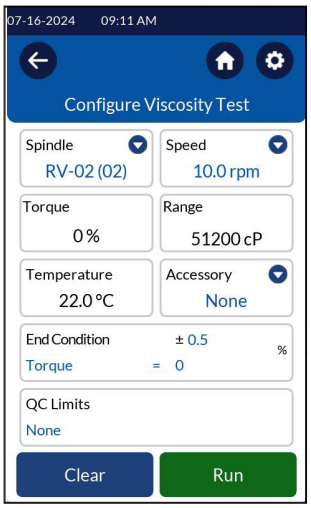


Figure 2-10.1

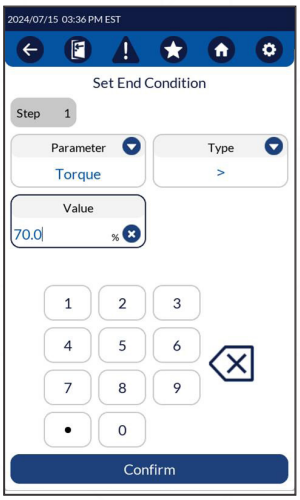


Figure 2-10.2

End conditions are defined in the table below:

Parameter	Type	Units (per Settings)	Range	Tolerance
Time	Equal to (=)	Seconds	1 second to 48 hours	n/a
Torque	Equal to (=) Greater Than (>) Less than (<)	% mNm dyne•cm	0.0-100%	Varies
Temperature	Equal to (=) Less Than (<) Greater Than (>)	°C °F K	-100 to 300°C	Varies
Viscosity	Equal to (=) Greater Than (>) Less than (<)	cP Pa•s mPa•s P	Varies	Varies
# of Revs	Equal to (=)	n/a	1-9999	n/a
None	n/a	n/a	n/a	n/a
Cycles	Equal to (=)	n/a	0.5-999	n/a

If “None” is selected, the DVPlus will run the test until stopped by the operator. The End Condition "Time" cannot be set for more than 48 hours.

TIP: Be sure to select a time value that provides sufficient time to allow for the equilibrium of the torque sensor. A short time value may result in erroneous data if the torque sensor has not achieved a stable deflection for the measurement condition. AMETEK Brookfield recommends a minimum time value of 20 seconds. However, this can be reduced based on user judgement by observing when the torque stabilizes.

TIP: Slow speeds require a longer time for the equilibrium of the measurement sensor. When using speeds less than 5 RPM, consider a time value of 60 seconds or longer.

2.11 QC Limits

The DVPlus Viscometer has a QC Limits feature that allows the operator to select an acceptable range for measurement results. The range may be defined by Torque, Viscosity, Temperature, and Time. The QC Limits feature can also be turned off by selecting None.

To set a QC Limit, press the QC Limits box on the Configure Viscosity Test screen. The Set QC Limits screen will then be displayed. (Figures 2-11.1 & 2-11.2). Use the keypad to enter the desired low and high limits.

The minimum Low Value for all parameters is 0 except Temperature, which can be set as low as -100°C.

The maximum High Value varies by parameter.

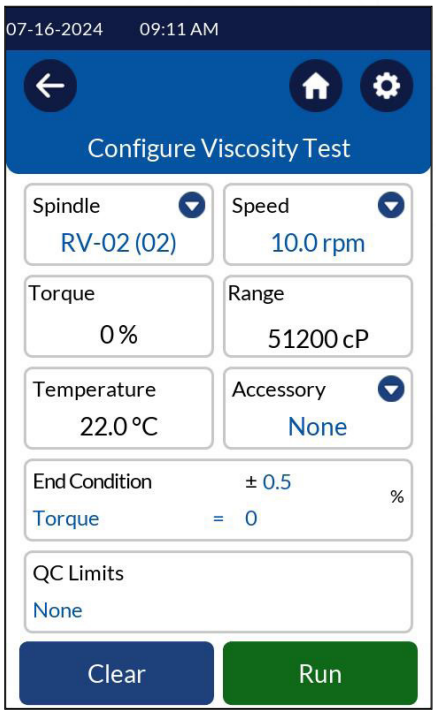


Figure 2-11.1

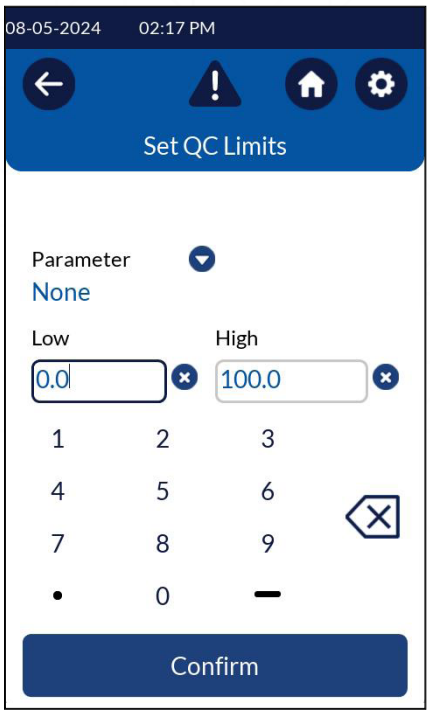


Figure 2-11.2

2.12 Viscosity Wizard

The DVPlus can help determine the test parameters for a viscosity test via the Viscosity Wizard. The Viscosity Wizard provides a step-by-step guide to setup and run a test. Accessing the viscosity wizard can be done from the Main Menu screen (see Figure 2-12.1).

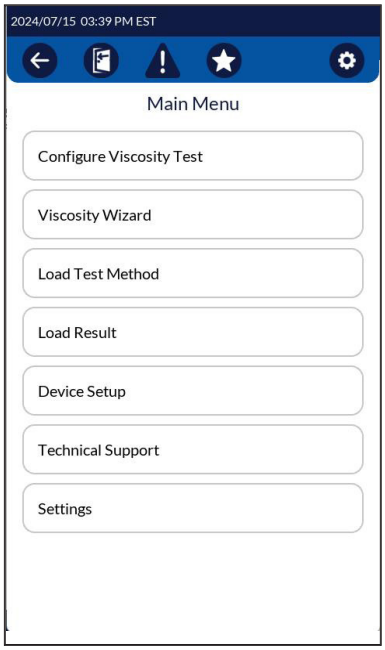


Figure 2-12.1

Estimate Viscosity:

Upon selecting the Viscosity Wizard, the DVPlus will display two options to estimate the viscosity. The first option is to select an example fluid that is like the intended test sample. The example fluids can be selected from a preset menu that includes Water, Olive Oil, Shampoo, Honey, Molasses, and Non-Flowing (see Figure 2-12.4). The second option is to input the Estimated Value of the viscosity for the intended test sample (see Figures 2-12.3). If the selected Example Liquid/Estimated Value is outside of your DVPlus optimal torque range, or if Non-Flowing is selected, the DVPlus will prompt the user to contact Ametek Brookfield to discuss options for measuring your fluid or non-flowing materials (see Figure 2-12.4).

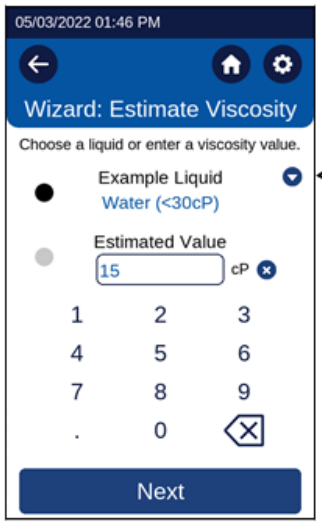


Figure 2-12.3

Figure 2-12.4

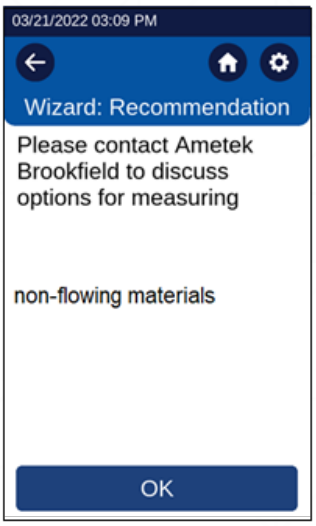


Figure 2-12.5

Choose Spindle:

There are two options for spindle selection. The first option is that the Wizard will recommend a spindle to be used based on the torque range of your DVPlus and the Estimated Viscosity of your fluid.
The second option will allow a spindle to be selected by manually entering the spindle code (see Figure 2-12.5).

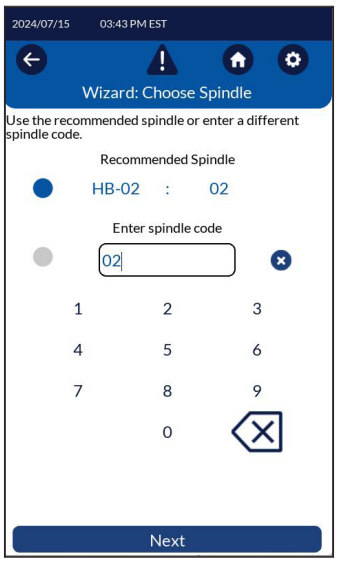


Figure 2-12.5

Once the desired spindle is selected, press the Next key to move on to the “Determine Speed” screen.

Determine Speed:

A message on the screen will alert the user that the DVPlus will run a test to determine the optimal measurement parameters (see Figure 2-12.6). When Next is selected, the DVPlus will instruct the user to set up the sample and recommended spindle (see Figure 2-12.7).

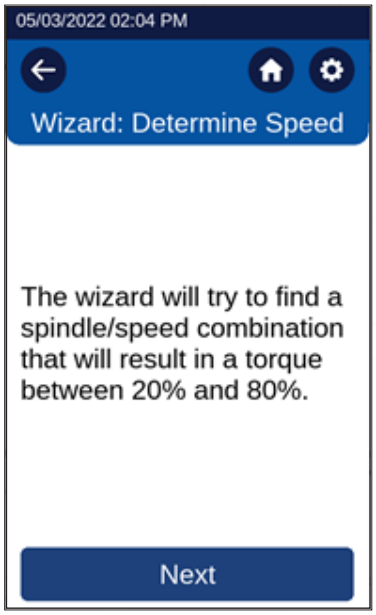


Figure 2-12.6

Figure 2-12.7

When Next is selected, the DVPlus will then begin the first attempt at optimizing the speed & spindle combination. In order to evaluate the spindle/speed combination, the DVPlus will run a viscosity test at a standard RPM with a torque stabilization end condition of 50% with a tolerance of +/- 0.5% and a one-minute time period for the stabilization. The goal of the Viscosity Wizard is to obtain the torque reading between 20% and 80%, ideally at 50%. Depending on the setup, the time to complete the Viscosity Wizard test could be up to five minutes.

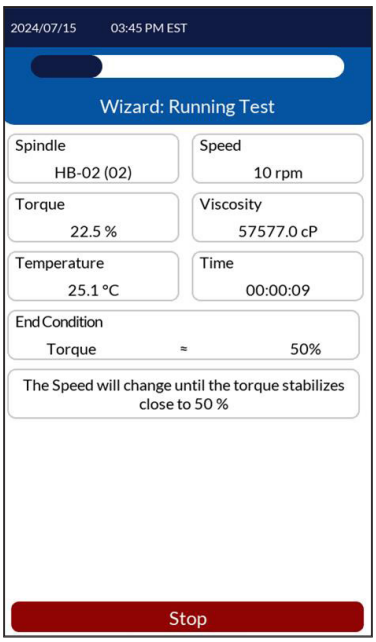


Figure 2-12.8

If the Viscosity Wizard cannot obtain a torque between 20% and 80%, the DVPlus will adjust the speed. In some cases, the DVPlus may recommend switching to a different spindle (see Figure 2-12.9).

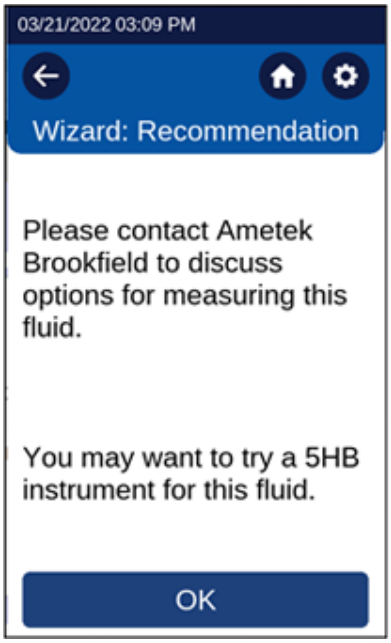


Figure 2-12.9

If the Viscosity Wizard has not been able to obtain torque measurements within 20-80% after three speed changes, the “Please Contact AMETEK Brookfield” screen will be displayed (see Figure 2-12.10).

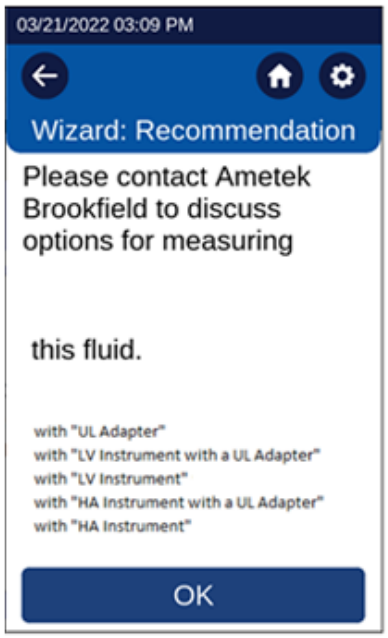


Figure 2-12.10

If the Viscosity Wizard obtains a torque measurement between 20-80%, the DVPlus may adjust the speed in order to get as close to 50% torque as possible. When the best torque is reached, the DVPlus will display the “Wizard: Results” screen (see Figure 2-12.11). The Wizard: Results screen will provide the user with the optimal spindle and speed for the sample tested. This screen will also give the user the run time that the wizard took to arrive at that conclusion.

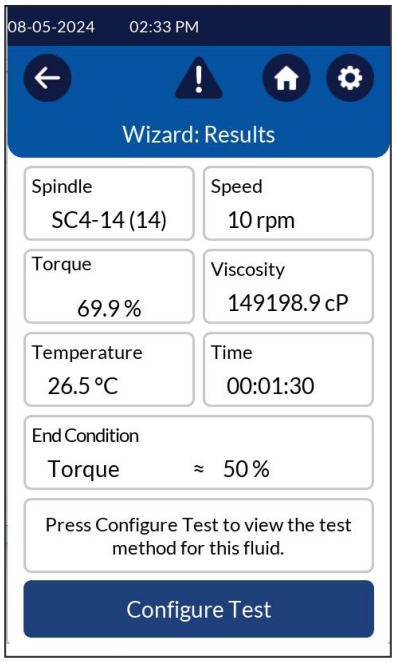


Figure 2-12.11

When Configure Test is pressed, the configure viscosity screen will be populated with the recommended Spindle and Speed parameters from the Viscosity Wizard.

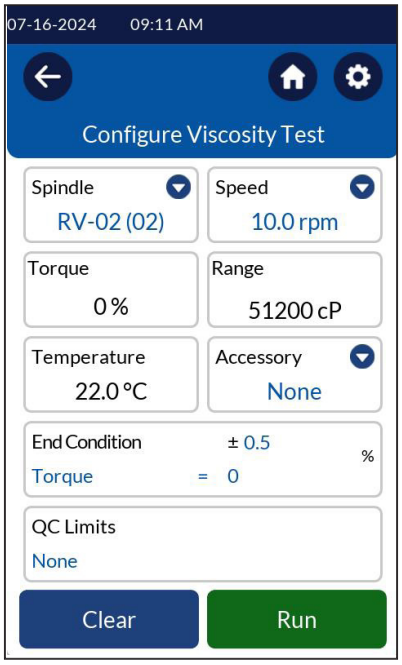


Figure 2-12.12

2.13 Custom Spindle

A Custom Spindle can be created when the user has developed a new spindle geometry or when using a standard AMETEK Brookfield spindle in a non-standard measurement container. The Custom Spindle, once created, will be available to users through the Spindle selection in Configure Viscosity Test.
A Custom Spindle is created by selecting the Custom Spindle button in the Settings menu. A Custom Spindle requires a code, a name, an SMC value and an SRC value.

Code - The code is the numerical value used to select the spindle. This value must be unique and cannot be the same as a standard Brookfield spindle. The acceptable range for Code is 100-199.

Name - The Name is a unique value to describe the spindle. The Name will be displayed in the Spindle field. The Name can be comprised of alpha and/or numeric characters. Note - Touching the Name box will change the keypad from numeric to alpha.

SMC – The SMC (Spindle Multiplier Constant) is used to convert the measured torque to viscosity. The acceptable range of SMC is 0.001 – 500.
The SMC value can be determined through the use of the Range equation found in appendix C. Some experimentation with the spindle and a calibrated viscosity standard is required.
Range (cP) = TK * SMC * 10,000/RPM
The Torque Constant (TK) can be found in Table D-2 in Appendix C.

SRC - The SRC (Shear Rate Constant) is used to convert the set RPM to shear rate and calculate Shear Stress. The acceptable range of SRC is 0.001 – 500.
The SRC value can be determined if the shear rate characteristics of the spindle geometry are known. Consult the Ametek Brookfield publication, "More Solutions to Sticky Problems", for a discussion about shear rate and some recommended equations. Shear Rate (1/s) = SRC * RPM

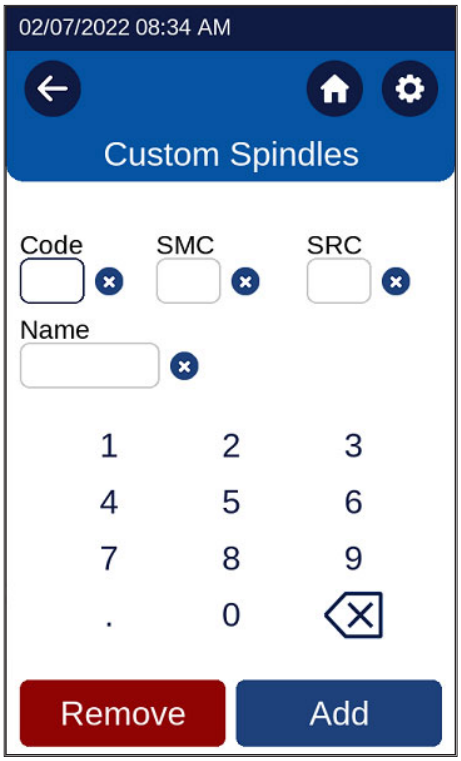


Figure 2-13.1

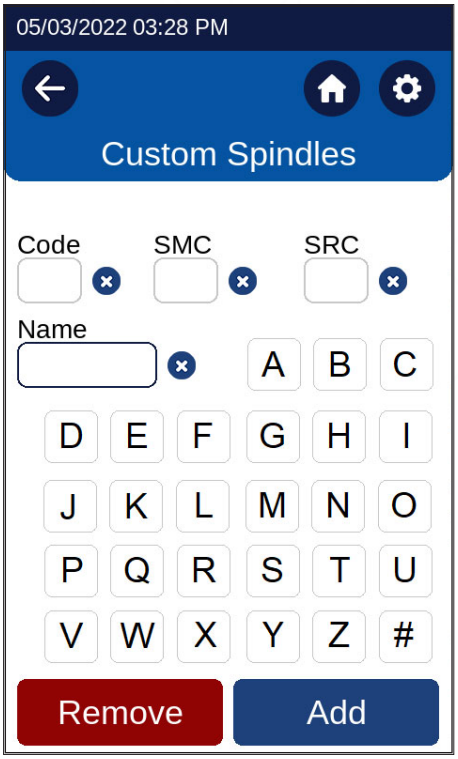


Figure 2-13.2

3. MAKING VISCOSITY MEASUREMENTS

3.1 Quick Start

3.1.1 Instrument Setup

- Assemble the Model G Laboratory Stand (refer to assembly instructions in Appendix I of this manual).
- Insert the instrument mounting rod into the lab stand clamp and tighten.
- Connect the RTD probe (optional) into the socket of the rear panel of the DVPlus Viscometer.
- Remove the shipping cap.

3.1.2 Power Up

- Connect the power cord to the provided power supply. Plug the power cord into an A/C outlet and the barrel connector into the rear of the DVPlus.
- Turn on the DVPlus by using the power switch on the rear of the instrument.

3.1.3 Product Registration

PRODUCT REGISTRATION	Use the QR code at initial instrument startup or below to register your product and receive information on how to download the instrument operating instructions. Ensure faster support by registering your instrument. Scan the QR code or visit: www.brookfieldengineering.com/contactus/register-product

3.1.4 Digital Leveling

After start-up, the user may be prompted to level the DVPlus, and follow the on-screen instructions.
Note: If the DVPlus is level, there will be no prompt for leveling.

3.1.5 Auto Zero

Once leveling is complete, an AutoZero must be performed before making a viscosity measurement.

3.1.6 Configure Viscosity Test

- In this screen, select spindle and speed.

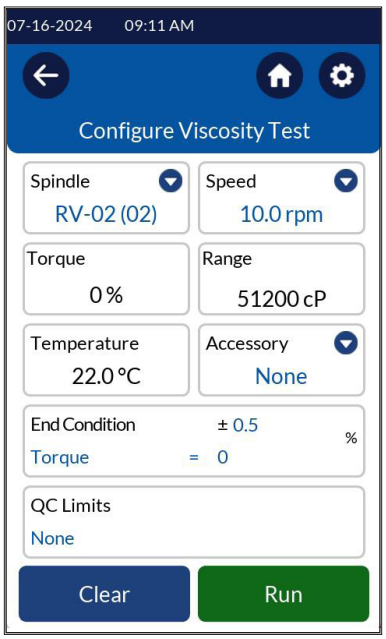


Figure 3-1.1

- Immerse the spindle gently at an angle into the test sample to prohibit any air bubbles from being trapped beneath the spindle.
- Lower the DVPlus using the lab stand.
- Attach the spindle to the coupling nut. Note: Left-hand thread. If equipped with magnetic coupling, use the appropriate procedure to connect the spindle (see Section 2.5 of User Manual).
- Align the immersion mark on the spindle to the fluid surface by adjusting the lab stand.
- Press the Run button and take appropriate action for pop-up dialogs. The screen will change to the Running Viscosity Test Screen.
- When ready to record the measurement results, press the Stop Test button. The screen will change to the Viscosity Test Results. Record the results as needed.
- To return to the Main Menu, press the Home Icon.

3.2 Preparations for Making Measurements

A. **VISCOMETER:** The DVPlus should be turned on, leveled, and auto-zeroed. The level is adjusted using the two feet on the bottom of the base and confirmed using the digital "bubble." Adjust the feet until the "bubble" is inside the center target and turns green. Set the level prior to performing the AutoZero and check the level prior to each measurement.

TIP: Proper level is essential for the correct operation of the DVPLUS.

B. **SAMPLE:** The fluid sample to be measured must be in an appropriate container. The standard spindles, supplied with the DVPlus (LV (1-4), RV (2-7), or HA/HB (2-7)), are designed to be used with a 600 mL low form Griffin beaker or equivalent container with a diameter of 8.25 cm. The same applies to the optional RV1, HA/HB1 spindle. Many other spindle systems are supplied from AMETEK Brookfield with specific sample chambers such as the Small Sample Adapter, UL Adapter, and Thermosel.

AMETEK Brookfield recommends that you use the appropriate container for the selected spindle. You may choose to use an alternate container for convenience. However, this may have an effect on the measured viscosity. The DVPlus is calibrated considering the specified container. Alternate containers will provide results that are repeatable but may not be "true."

The LV (1-4) and RV (1-7) spindles are designed to be used with the guard leg attached. Measurements made without the guard leg will provide repeatable results but may not provide "true" results.

TIP: When comparing data with others, be sure to specify the sample container and the presence/absence of the guard leg.

Please see our publication "More Solutions to Sticky Problems" for more details relating to sample preparation.

C. **TEMPERATURE PROBE:** Many samples must be controlled to a specific temperature for viscosity measurement. When conditioning a sample for temperature, be sure to temperature control the container and spindle, as well as the sample.

To monitor the temperature of your sample, plug the DVP-94Y Temperature Probe into the designated port on the back panel of the DVPlus. Once the Temperature Probe is connected, the Temperature Icon will appear in the bar at the top of the DVPlus display screen.

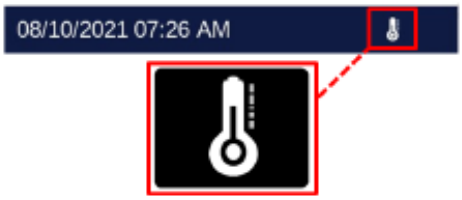


Figure 3-2.1

Use the Temperature Probe Clip to secure the Temperature Probe to the rim of your Sample Beaker/Container or Guard Leg

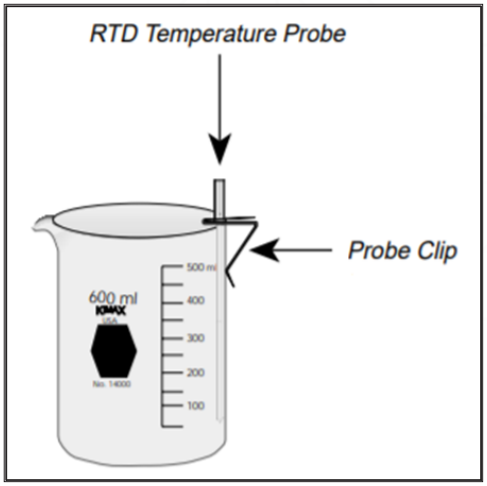


Figure 3-2.2

3.3 Selecting a Spindle/Speed

The DVPlus has the capability of measuring viscosity over a wide range. For example, the DVPlus RV-range can measure fluids within the range of 100-40,000,000 cP (see Appendix A). This range is achieved using several spindles over many speeds.

The process of selecting a spindle and speed for an unknown fluid is normally trial and error. **An appropriate selection will result in measurements between 10-100 on the instrument % torque scale and** two general rules will help in the trial-and-error process:

1. Viscosity range is inversely proportional to the size of the spindle.
2. Viscosity range is inversely proportional to the rotational speed.

In other words, to measure high viscosity, choose a small spindle and/or a slow speed. If the chosen spindle/speed results in a reading above 100%, then reduce the speed or choose a smaller spindle.

Experimentation may reveal that several spindle/speed combinations will produce satisfactory results between 10-100%. When this circumstance occurs, any of the spindles may be selected.

The DVPlus offers a Viscosity Wizard that provides a detailed step-by-step method to reduce the trial and error process listed above. See section 2.12.

Non-Newtonian fluid behavior can result in the measured viscosity changing if the spindle and/or speed is changed. See our publication “More Solutions to Sticky Problems” for more details.

When viscosity data must be compared, be sure to use the same test methodology: the same instrument, spindle,

speed, container, temperature, and test time.

3.4 Running a Test

A viscosity test is started by pressing the Run button while viewing the Configure Viscosity Test screen. Live measurement data will be displayed during the test. When the end condition is met, the final data will be displayed on the DVPlus until the user presses a key. The following procedure outlines the general steps necessary for making a viscosity measurement in a 600 mL low form Griffin beaker using the standard LV/RV/HA/HB spindles (61-64, 2-7).

- Level the DVPlus Viscometer, remove any attached spindles, and perform AutoZero (AutoZero is only necessary after power up).
- Prepare the sample to be tested and transfer to the 600 mL low form Griffin beaker.
- Attach the guard leg (LV and RV series). Attach the spindle to the lower shaft. Lift the shaft slightly, holding it firmly with one hand while either affixing the spindle using the magnetic coupling or screwing the spindle on with the other (NOTE: Left-handed threads). Avoid putting side thrust on the shaft.
- Enter the spindle number into the DVPlus Viscometer by using the Spindle box.
- Enter the speed of rotation by using the Speed box.
- Select an end condition for the test using the End Condition box.
- Select a QC Limits setting for the test by using the QC Limits box.
- Insert and center the spindle in the test material. The spindle should be inserted into the immersion groove located on the spindle shaft. Use the Laboratory Stand Clamp to adjust the height of the Viscometer. With a disc-type spindle, it is sometimes necessary to tilt the spindle slightly while immersing to avoid trapping air bubbles under the surface of the disc. **You may find it more convenient to immerse the spindle in this fashion before attaching it to the Viscometer.**
- To make a viscosity measurement, press the Run button. If using the “None” End Condition, 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. The live test data shows on the touch screen display. The Bar at the top of the screen is a torque meter. If the torque exceeds 100%, the bar will turn red to alert the operator of a potential problem. **Figure 3-4.1**
- When the end condition is reached, the motor will stop, and the measurement result will be displayed. **Figure 3-4.2**

If using the “None” End Condition, the test can be stopped by pressing the Stop button. Record the reading and relevant test parameters.

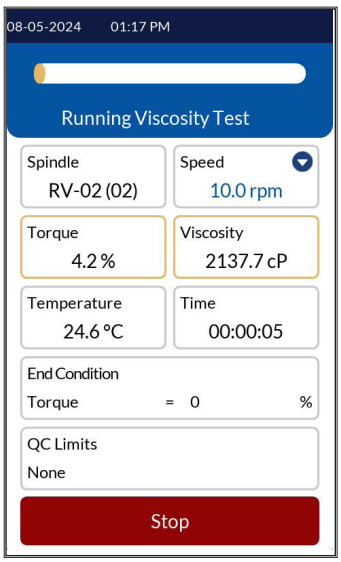


Figure 3-4.1

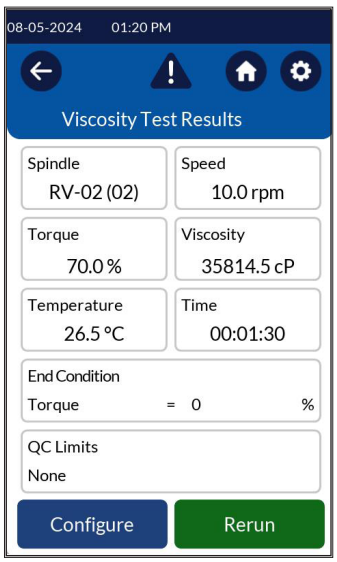


Figure 3-4.2

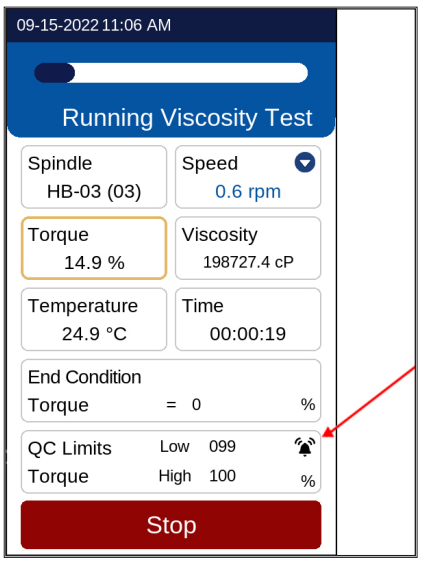


Figure 3-4.3

If the beeper sound is on and a QC limit is exceeded the DVPlus will provide an audible noise. To turn off the noise during the test, press on the alarm bell. To turn it back on repress. In Figure 3-4.3, the arrow is pointing to the alarm bell.

AMETEK Brookfield recommends you record at least both %torque and viscosity. Relevant test parameters might include viscometer model, spindle, speed, temperature, container size, and test duration (Time). See the sample Viscosity Test Report at the end of the Appendices.

- Remove the spindle and guard leg before cleaning. Remember to secure the viscometer shaft and lift up slightly while removing the spindle. Clean the spindles and guard leg after each use.
- Interpretation of results and the instrument's use with non-Newtonian and thixotropic materials is discussed in our publication "More Solutions to Sticky Problems" and in Appendix B: Variables in Viscosity Measurements.

3.5 Communication with Optional DVPlus Connect

The DVPlus Viscometer can be used in conjunction with the AMETEK Brookfield software program DVPlus Connect App. DVPlus Connect App will collect the data output from the DVPlus and allow for data storage and data printing.

DVPlus Connect App minimum requirements

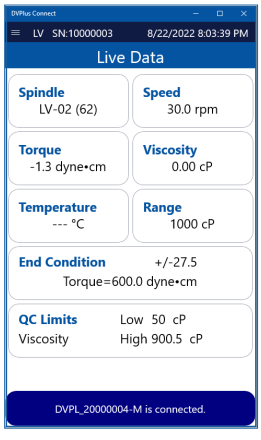
Microprocessor: 2 GHz Pentium processor (or equivalent)
Memory: 8 GB of RAM
Hard Drive Space: 100 GB available
Video: VGA (1920 x 1080 resolution)
Operating System: Windows 10 Windows 11 (32 or 64-bit)
Communications Port: One USB or Bluetooth, recommended Bluetooth 4.2 with Link Manager Protocol 8 or higher

The DVPlus Viscometer communicates to the PC through either a Bluetooth connection or a USB-B port. The communication cable will be supplied with the DVPlus Connect App software. Communication can be established once both the DVPlus Connect App software and the DVPLUS Viscometer are running. Use the Search or Connect button on the DVPlus Connect App dashboard. Successful communication will be indicated by a message on the App screen.

DVPlus Connect app provides means to connect to a DVPlus instrument via Bluetooth® or USB (Windows only) connection. The app enables users to collect, view, and save test data. DVPlus Connect has no control over the DVPlus instrument. Test setup needs to be done on the instrument side.

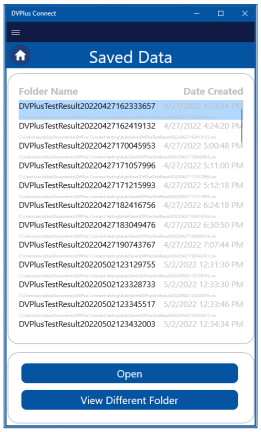
Live Data Page

The Live Data page reflects the instrument's "Running Viscosity Test" screen. The Bottom of the page displays status such as instrument connection and running test.



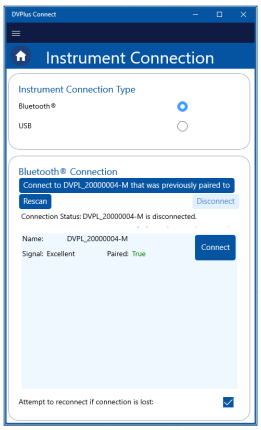
Saved Data Page

The Saved Data page lists test data files saved from your device. The User can select a file from the list and view it.



Instrument Connection Page

Instrument Connection Page allows a user to connect to an instrument via Bluetooth® or USB-B cable. When loaded, the page scans for and displays available Bluetooth connections. The User has the option to disconnect, rescan, or connect to a previously connected instrument.

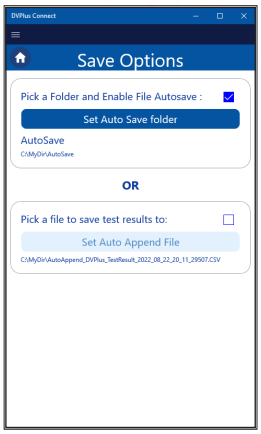


Save Option Page

Upon test completion, DVPlus Connect app can save test data into CSV format. The Save Option page provides controls for the way test data can be saved. Available options are:

- Pick a folder and enable file Autosave – Each test data will be saved into separate file.
- Pick a file to save test results to - Each test data will be appended to the same file.

If no option is chosen, the user will be prompted to save data upon completion of each test run.



3.5.1 Connecting to the DVPlus Connect App

DVPlus Connect App enables the user to connect to the DVPlus instrument via Bluetooth® or USB (see Figure 5). The following sections describe how to establish Bluetooth® and USB communication with the instrument. The instrument connection page of the DVPlus Connect App contains controls that enable the user to switch between Bluetooth® and USB instrument connection type.

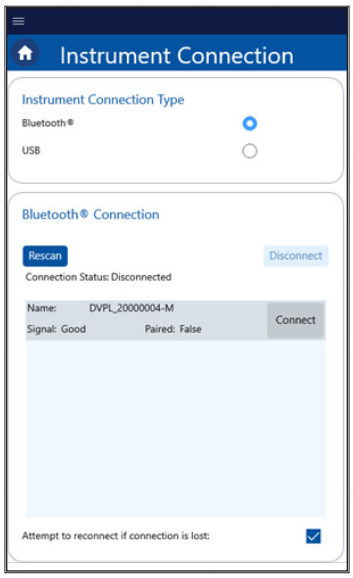


Figure- 5

3.5.2 Establishing Bluetooth® connection to the app for a first time

- Make sure that the PC and DVPlus instrument are next to each other.
- On your PC, make sure that Bluetooth® connection is enabled:
  - a. Windows 11
    - On the taskbar, select the Network icon. Select the Bluetooth quick setting to turn it On or Off.
    - Select Start > Settings > Bluetooth & devices, then turn Bluetooth on or off.
  - b. Windows 10
    - Select the Start button, then select Settings > Devices > Bluetooth & other devices.
    - Select the Bluetooth toggle to turn it On or Off.
- Turn on the instrument.
- On the instrument, navigate to Settings> Bluetooth® Setup and make sure that Bluetooth® Enable switch control is on (tap the grey button).

- Make a note of the instrument's Nickname.

- Press the Pair Button on the Bluetooth Setup screen.
- Launch the DVPlus Connect app.
- Within the App, Navigate to the Instrument Connection page.
- Make sure that Bluetooth® is selected as the Instrument Connection Type.
- Your DVPlus instrument should be listed within Bluetooth Connection section of the Instrument Connection page. Use Rescan button if you don't see your instrument listed.
- Note, instrument should be listed as Paired: False (see Figure 5).
- Locate the Connect button, that appears to be to the right of the instrument Nickname (for example, see Figure 5: DVPL_20000004-M)
- Click Connect button, read this step completely through, and follow onscreen instructions.
    - It is important to execute step # 1 of the below popup, before clicking the Pair button on the popup.
    - Please keep in mind, the 6-digit pairing code which is generated by the instrument will be timed out in 30 seconds, therefore it is important to finish step #2 right after the code is generated.
    - If for some reason the code times out, just click Cancel > then click Rescan and repeat this step.

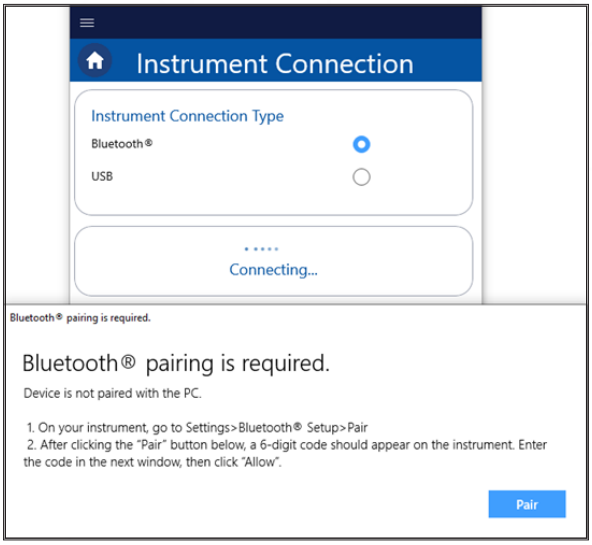
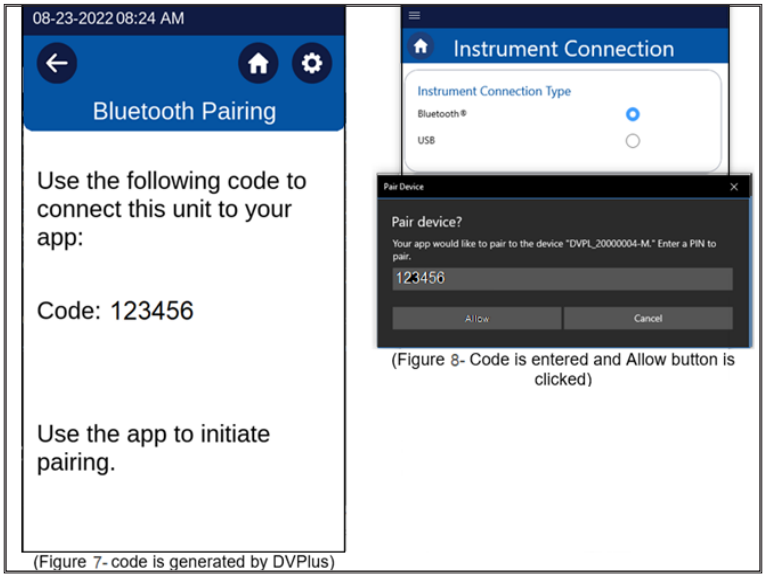


Figure- 6

- Here you can see screenshots of a successful connection.



(Figure 7- code is generated by DVPlus)

(Figure 8- Code is entered and Allow button is clicked)

Figure- 7 & 8

- Upon successful connection, the DVPlus Connect App will switch to the Live Data Page. The connected DVPlus' torque range and serial number will appear at the top of the app (see Figure 9).

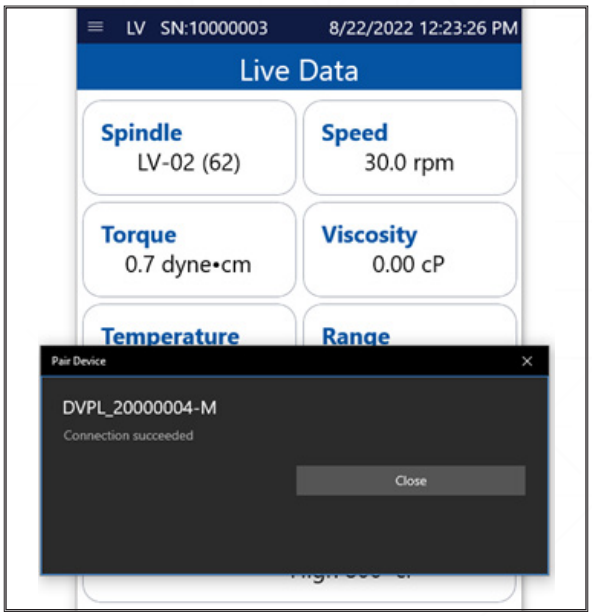


Figure- 9

- Once pairing is established, the status of the DVPlus under Bluetooth® Connection will change to Paired: True (see Figure 10).

3.5.3 Establishing Bluetooth connection to a Paired Instrument

- Make sure the DVPlus instrument is in the visible range, or no more than 50 ft. away.
- Make sure that the PC's Bluetooth® adapter is on.
- Turn on the instrument.
- Launch the DVPlus Connect app and click either Connect or Connect to a previously paired instrument button (see Figure 10).

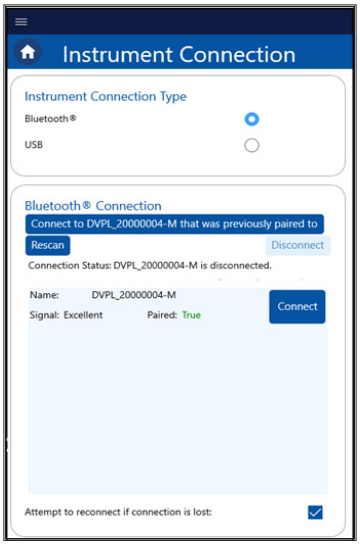


Figure- 10

3.5.4 Setting up Bluetooth Automatic reconnection

DVPlus Connect App can be set up to reconnect with a DVPlus instrument if:

- Instrument was out of the range after Bluetooth connection was established.
- Instrument was restarted after Bluetooth connection was established.

To enable this feature, navigate to the Instrument Connection page and check the Attempt to Reconnect if connection is lost option. (see Figure 10)

3.5.5 Connecting to the App via USB

- Make sure the instrument is connected to a PC via USB-B cable (P/N DVP-202). Instrument USB Type B connection to PC USB Type A connection.
- Power up the DVPlus instrument, wait until it is fully loaded.
- On the PC side, launch the DVPlus Connect app.
- Navigate to the Instrument Connection page.
- Select the USB option as instrument connection type (see Figure 11).
- Use dropdown control to select available USB port. Click Refresh if no COM Ports are listed (see Figure 11).
- Click Connect button.

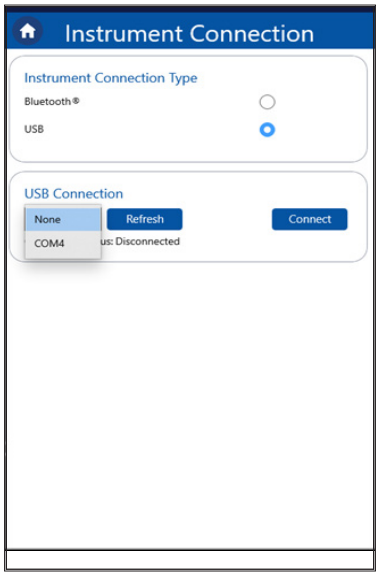


Figure- 11

3.5.6 Disconnecting from the App

To disconnect your DVPlus Instrument from the DVPlus Connect App whether connected via Bluetooth or USB, simply navigate to the Instrument Connection page and click the Disconnect button.

APPENDIX A - VISCOSITY RANGES

VISCOSITY RANGE TABLES
Viscosity ranges shown are for operational speeds 0.1 through 200 RPM.

LV Viscometer with LV spindles #1-4 and RV/HA/HB Viscometers with spindles #1-7

Viscosity Range cP		
Viscometer	**Minimum**	**Maximum**
DVPlusLV	15	6,000,000
DVPlusRV	100	40,000,000
DVPlusHA	200	80,000,000
DVPlusHB	800	320,000,000

Small Sample Adapter and Thermosel

SSA and Thermosel Spindle	**Viscosity (cP)**				**Shear Rate Sec-1** ⇦
	DVPlusLV	DVPlusRV	DVPlusHA	DVPlusHB	
Ⓢ SC4-14	58.6 - 1,171.00	625 - 12,500,000	1,250 - 25,000,000	5,000 - 100,000,000	0.40N
Ⓢ SC4-15	23.4 - 468,650	250 - 5,000,000	500 - 10,000,000	2,000 - 40,000,000	0.48N
Ⓢ SC4-16	60 - 1,199,700	640 - 12,800,000	1,280 - 25,600,000	5,120 - 102,400,000	0.29N
SC4-18	1.5 - 30,000	16 - 320,000	32 - 640,000	128 - 2,560,000	1.32N
SC4-21	2.4 - 46,865	25 - 500,000	50 - 1,000,000	200 - 4,000,000	0.93N
SC4-25	240 - 4,790,000	2,560 - 51,200,000	5,120 - 102,400,000	20,480 - 409,600,000	0.22N
SC4-27	11.7 - 234,325	125 - 2,500,000	250 - 5,000,000	1,000 - 20,000.000	0.34N
SC4-28	23.4 - 468,650	250 - 5,000,000	500 - 10,000,000	2,000 - 40,000,000	0.28N
SC4-29	46.9 - 937,300	500 - 10,000,000	1,000 - 20,000,000	4,000 - 80,000,000	0.25N
SC4-31	15 - 300,000	160 - 3,200,000	320 - 6,400,000	1,280 - 25,600,000	0.34N
SC4-34	30 - 600,000	320 - 6,400,000	640 - 12,800,000	2,560 - 51,200,000	0.28N
Ⓣ HT-DIN-81	3.4 - 10,000	36.5 - 10,000	73 - 10,000	292 - 10,000	1.29N
Ⓢ SC4-DIN-82	3.4 - 10,000	36.5 - 10,000	73 - 10,000	292 - 10,000	1.29N
Ⓢ SC4-DIN-83	11.3 - 37,898	121.3 - 50,000	242.6 - 50,000	292 - 10,000	1.29N

Ⓣ This spindle is used with Thermosel only
Ⓢ This spindle is used with Small Sample Adapter only
⇦ Represents speed in RPM. For example, spindle SC4-14 operated at 5 RPM has a shear rate of 0.40 x 5 = 2.0 sec-1

UL Adapter

UL Spindle	**Viscosity (cP)**				**Shear Rate Sec-1**
	DVPlusLV	DVPlusRV	DVPlusHA	DVPlusHB	
YULA-15 or 15Z	1 - 2,000	3.2 - 2,000	6.4 - 2,000	25.6 - 2,000	1.22N

DIN Adapter Accessory

DIN Spindle	Viscosity (cP)				Shear Rate Sec-1
	DVPlusLV	DVPlusRV	DVPlusHA	DVPlusHB	
85	0.6 - 5,000	6.1 - 5,000	12.2 - 5,000	48.8 - 5,000	1.29N
86	1.8 - 10,000	18.2 - 10,000	36.5 - 10,000	146 - 10,000	1.29N
87	5.7 - 50,000	61 - 50,000	121 - 50,000	485 - 50,000	1.29N

Spiral Adapter

Spiral Spindle	Viscosity (cP)				Shear Rate Sec-1
	DVPlusLV	DVPlusRV	DVPlusHA	DVPlusHB	
SA-70	98 - 98,500	1,050 - 1,050,000	2,100 - 2,100,000	8,400 - 8,400,000	0.667N

Helipath with T-Bar Spindle

T-Bar Spindle	Viscosity (cP)			
	DVPlusLV	DVPlusRV	DVPlusHA	DVPlusHB
T-A	156 - 187,460	2,000 - 2,000,000	4,000 - 4,000,000	16,000 - 16,000,000
T-B	312 - 374,920	4,000 - 4,000,000	8,000 - 8,000,000	32,000 - 32,000,000
T-C	780 - 937,300	10,000 - 10,000,000	20,000 - 20,000,000	80,000 - 80,000,000
T-D	1,560 - 1,874,600	20,000 - 20,000	40,000 - 40,000,000	60,000 - 160,000,000
T-E	3,900 - 4,686,500	50,000 - 50,000,000	100,000 - 100,000,000	400,000 - 400,000,000
T-F	7,800 - 9,373,000	100,000 - 100,000,000	200,000 - 200,000,000	800,000 - 800,000,000

Vane Spindles

Spindle	Torque Range	Shear Stress Range (Pa)	Viscosity Range cP(mPa•s)
V-71	NOT RECOMMENDED FOR USE ON LV TORQUE		
V-72	LV	0.188-1.88	104.04-1.04K
V-73	LV	0.938-9.38	502-5.02K
V-74	LV	9.38-93.8	5.09K-50.9K
V-75	LV	3.75-37.5	1.996K-19.96K
V-71	RV	0.5-5	262-2.62K
V-72	RV	2-20	1.11K-11.1K
V-73	RV	10-100	5.35K-53.5K
V-74	RV	100-1K	54.3K-543K
V-75	RV	0-400	21.3K-213K
V-71	HA	1-10	524-5.24K
V-72	HA	4-40	2.22K-22.2K
V-73	HA	20-200	10.7K-107K
V-74	HA	200-2K	108.6K-1.086M
V-75	HA	80-800	42.6K-426K
V-71	HB	4-40	2.096K-20.96K
V-72	HB	16-160	8.88K-88.8K
V-73	HB	80-800	42.8K-428K
V-74	HB	800-8K	434.4K-4.344M
V-75	HB	320-3.2K	170.4K-1.704M
V-71	5xHB	20-200	10.48K-104.8K
V-72	5xHB	80-800	44.4K-444K
V-73	5xHB	400-4000	214K-2.14M
V-74	5xHB	4K-40K	2.172M-21.72M
V-75	5xHB	1.6K-16K	852K-8.52M

Note:

- 1 Pa = 10 dyne/cm^2
- Viscosity Range is given at a rotational speed of 10 RPM
- HB is the highest torque range available

M = 1 million
K = 1 thousand
Pa = Pascal

cP = centiPoise
mPa•s = milliPascal•seconds

Special Considerations

In taking viscosity measurements with the DVPlus Viscometer, there are two considerations that 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 precision of the instrument. All DVPlus Viscometers have an accuracy of +/- 1% of the range in use for any standard spindle. (Note that accuracy values may be higher than 1% when using accessory devices with the DVPlus). We discourage taking readings below 10% of range because the potential viscosity error of +/- 1% is a relatively high number compared to the instrument reading.

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

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

1. No. 1 LV Spindle: 15 cP at 60 RPM
2. No. 2 LV Spindle: 100 cP at 200 RPM
3. No. 1 RV Spindle: 100 cP at 50 RPM
4. No. 2 RV Spindle: 500 cP at 60 RPM
5. UL Adapter: 0.85 cP at 60 RPM
6. SC4-18/13R: 1.25 cP at 200 RPM

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

Effect on accuracy when using accessory devices

The AMETEK Brookfield Viscometer has a stated accuracy of +/- 1% of the range in use. This stated accuracy applies when the Viscometer is used in accordance with the operating instructions detailed in the instrument instruction manual and the calibration test fluid is used in accordance with the instructions provided by the fluid supplier (including the critical parameters of temperature control and stated fluid accuracy). AMETEK Brookfield's accuracy statement of +/- 1% of the range in use applies to the AMETEK Brookfield rotational Viscometer when used with the standard spindles supplied with the instrument, including LV spindles 1 through 4 (supplied with LV series Viscometer), RV spindles 2 through 7 (supplied with RV series Viscometers), and HV series spindles 2 through 7 (supplied with HA series Viscometers and HB series Viscometers) in a 600 mL low form Griffin beaker.

AMETEK Brookfield offers a range of accessories for use with the AMETEK Brookfield Viscometer to accommodate special measurement circumstances. These accessories, while offering added capability to the user, also contribute to an expanded measurement tolerance beyond the instrument accuracy of +/- 1% of the range in use. This expanded measurement tolerance is a function of many parameters including spindle geometry, accessory alignment accuracy, sample volume requirement, and sample introduction techniques. The effect of these elements on measurement tolerance must be considered when verifying the calibration of your AMETEK Brookfield Viscometer. Sample temperature in all test circumstances is very important and will also add an additional expanded tolerance depending on the temperature control system and the calibration verification tests begin with the standard Viscometer spindles as detailed above.

Once the calibration of the Viscometer itself is confirmed, the expanded tolerance of the measurement system may be determined using accessory devices. In many cases, this additional tolerance will be very minimal, but as a general statement, the addition of +/- 1% of the range in use is reasonable for accessories.

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 RPMs) and are called Newtonian over the Shear Rate range they are measured.
Non-Newtonian	These fluids have different viscosities at different shear rates (different RPMs). They fall into two groups: 1. Time-Independent non-Newtonian 2. Time-Dependent non-Newtonian
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 (shear thinning).
Time-Dependent Thixotropic	A thixotropic material has decreasing viscosity under constant shear rate. 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. If you take Viscometer readings from a low RPM to a high RPM and then back to the low RPM, and the readings are lower for the descending step, the material is time dependent, thixotropic.

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

VISCOMETER RELATED VARIABLES

Most fluid viscosities are found to be non-Newtonian. They are dependent on Shear Rate, time of test, 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 cP values produced will be different because the readings were taken 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
6. Whether or not to attach the guard leg
7. Test speed or speeds (or the shear rate)
8. Length of time or number of spindle revolutions to record viscosity
9. How the sample was prepared and/or loaded into the container

APPENDIX C - SPINDLE ENTRY CODES AND SMC/SRC VALUES

Each spindle has a two-digit entry code which is entered via the keypad on the DVPlus. The entry code allows the DVPlus to calculate Viscosity, Shear Rate, and Shear Stress values. Each spindle has two constants that are used in these calculations. The Spindle Multiplier Constant (SMC) is used for viscosity and shear stress calculations, and the Shear Rate Constant (SRC) is used for shear rate and shear stress calculations. Note that where SRC = 0, no shear rate/shear stress calculations are done, and the data displayed is zero (0) for these functions.

Table D-1
(continued on following page)

SPINDLE	ENTRY CODE	SMC	SRC
RV1	01	1	0
RV2	02	4	0
RV3	03	10	0
RV4	04	20	0
RV5	05	40	0
RV6	06	100	0
RV7	07	400	0
HA1	01	1	0
HA2	02	4	0
HA3	03	10	0
HA4	04	20	0
HA5	05	40	0
HA6	06	100	0
HA7	07	400	0
HB1	01	1	0
HB2	02	4	0
HB3	03	10	0
HB4	04	20	0
HB5	05	40	0
HB6	06	100	0
HB7	07	400	0
LV1	61	6.4	0
LV2	62	32	0
LV3	63	128	0
LV4 or 4B2	64	640	0
LV5	65	1280	0
LV-2C	66	32	0.212
LV-3C	67	128	0.210
SA-70	70	105	0.677
T-A	91	20	0
T-B	92	40	0
T-C	93	100	0
T-D	94	200	0
T-E	95	500	0
T-F	96	1000	0

SPINDLE	ENTRY CODE	SMC	SRC
ULA	95	0.64	1.223
DIN81	81	3.7	1.29
DIN82	82	3.75	1.29
DIN83	83	12.09	1.29
DIN85	85	1.22	1.29
DIN86	86	3.65	1.29
DIN87	87	12.13	1.29
SC4-14	14	125	0.4
SC4-15	15	50	0.48
SC4-16	16	128	0.29
SC4-18	18	3.2	1.32
SC4-21	21	5	0.93
SC4-25	25	512	0.22
SC4-27	27	25	0.34
SC4-28	28	50	0.28
SC4-29	29	100	0.25
SC4-31	31	32	0.34
SC4-34	34	64	0.28

SPINDLE	ENTRY CODE	SMC	SRC	YMC
V-71	71	2.61	0	0.5
V-72	72	11.1	0	2
V-73	73	53.5	0	10
V-74	74	543	0	100
V-75	75	213	0	40

Table D-1
(continued from previous page)

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

Table D-2

Model	TK	Model Code on DVPlus Screen
DVPlusLV	0.09375	LV
DVPlusRV	1	RV
DVPlusHA	2	HA
DVPlusHB	8	HB

The full-scale viscosity range for any DVPlus model and spindle may be calculated using the equation:

Full-Scale Viscosity Range $$[cP] = TK * SMC * \frac{10000}{RPM}$$

Where:
TK = DVPlus Torque Constant from Table D-2
SMC = Spindle Multiplier Constant from Table D-1

The following equations can be used to calculate the strain data after each packet of data is obtained from the DVPlus:

(Shear Stress (D/cm2)) = Viscosity (P) * Shear Rate (1/sec)
= TK * SMC * SRC * TORQ

The immersion mark selected affects the stress calculations. Ensure the selected immersion mark reflects the mark in use.

Each spindle has a Yield Multiplier Constant (YMC) for stress calculations and a Spindle Multiplier Constant (SMC) for calibration checks (see Appendix E) as shown in Table D-3. Spindle dimensions are also listed.

Table D-3

Spindle	Entry Code	YMC	SMC	Vane Length		Vane Diameter	
				Inches	cm	Inches	cm
V-71	71	0.5	2.62	2.708	6.878	1.354	3.439
V-72	72	2.0	11.1	1.706	4.333	0.853	2.167
V-73	73	10.0	53.5	0.998	2.535	0.499	1.267
V-74	74	100.0	543	0.463	1.176	0.232	0.589
V-75	75	40.0	213	0.632	1.61	0.316	0.803

Note: If secondary immersion mark is selected, the YMC value is doubled.

The full scale Yield Stress range for any DVPlus model and spindle may be calculated using the equation:

Full Scale Yield Stress Range (Pa) = TK x YMC x 10

Where:
TK = DVPlus Torque Constant from Table D-2
YMC = Yield Multiplier Constant from Table D-3

The following speeds are available for yield tests.

Table D-4

PRE-SHEAR SPEEDS (RPM)	
Range	Increment
0.0	N/A
0.1 to 59.9	0.1
60 to 200	1.0

ZERO STEP SPEEDS (RPM)	
RANGE	INCREMENT
0.1 to 59.9	0.1

RUN SPEEDS (RPM)	
RANGE	INCREMENT
0.1 to 59.9	0.1

The shear stress measurement range for the three standard (or supplied) vane spindles at each spring torque is as follows:

Table D-5

SPINDLE	MODEL CODE ON DV-III ULTRA SCREEN	TK
V-71	LV	0.09375
V-72	LV	0.09375
V-73	LV	0.09375
V-71	RV	1
V-72	RV	1
V-73	RV	1
V-71	HB	8
V-72	HB	8
V-73	HB	8
V-71	5xHB	40
V-72	5xHB	40
V-73	5xHB	40

$$\theta M = \omega \times t \times \frac{2\pi}{60}$$

Where:

θ_M = Angular rotation of motor shaft (rad)
ω = Rotational speed (rpm)
t = Time of test (seconds)

$$S = \theta_{cal} \times (2\pi) \times 0.01$$

Where:

S	= Radial spring factor	(rad/%torque)
θ_{cal}	= Spring windup angle	(revolutions)

$$\theta_{cal} = \frac{V_{cal} \times t_{cal}}{6000}$$

Where:

θ_{cal}	= Spring windup angle	(revolutions)
v_{cal}	= Calibration speed	(fixed at 0.1 rpm) (rpm)
t_{cal}	= Calibration time (time for 0% to 100% spring windup)	(milliseconds)

$$t_{cal} = \frac{bi}{b_{cal}} \times \frac{v}{v_{cal}} \times 100$$

Where:

v_{cal}	= Calibration time (time for 0% to 100% spring wind up during calibration)	(milliseconds)
bi	= Base increment	(milliseconds)
b_{cal}	= Base increment calibration torque	(%torque/base increment)
v	= Speed	(rpm)
v_{cal}	= Calibration speed (fixed at 0.1 rpm)	(rpm)

APPENDIX D - SPINDLE ENTRY CODES AND RANGE COEFFICIENTS

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. 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.

The Entry Code is the two-digit number used to identify the spindle in use when operating a standard digital Viscometer.

Table E-1

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
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	93,600	1,000,000	2,000,000	8,000,000

Spindle	Entry Code	Range Coefficient			
		LV	RV	HA	HB
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
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

APPENDIX E - CALIBRATION PROCEDURES

The accuracy of the DVPlus is verified using viscosity standard fluids which are available from AMETEK Brookfield or your local authorized dealer. 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 F-1 (Silicone Oils) and Table F-2 (Mineral Oils).

Container Size:

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

For Viscosity Standards > 30,000 cP, use the fluid container. Inside Diameter: 3.25" (8.25 cm) Height: 4.75" (12.1 cm)

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

Temperature Conditions:

As stated on the fluid standard label: (+/-) 0.1°C
The DVPlus should be set according to the operating instructions. The water bath must be stabilized at test temperature. Viscometers with the letters "LV" or "RV" in the model designation must have the guard leg attached (see Appendix F for more information on the guard leg).

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

Table - F1

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

Table - F2

AMETEK BROOKFIELD VISCOSITY STANDARD FLUID GENERAL INFORMATION

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

Viscosity Standard Fluids may be stored under normal laboratory conditions. The Disposal should be in accordance with state, local and federal regulations as specified on the material safety data sheet.

AMETEK Brookfield does not re-certify Viscosity Standard Fluids. We will issue duplicate copies of the Certificate of Calibration for any fluid within two years of the purchase date. AMETEK 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.

CALIBRATION PROCEDURE FOR LV #1-3 (#61-63) AND RV, HA, HB #1-6 AMETEK BROOKFIELD SPINDLES

Please note that the LV#4(64) and RV, HA, HB#7 (07) Spindles have been omitted from this procedure. AMETEK Brookfield does not recommend the use of these spindles to perform a calibration check in your instrument. Reasons pertain to the small amount of spindle surface that contacts the viscosity standard, the difficulty of establishing the immersion mark precisely and the need for precise temperature control at 25^{0}C in the immediate vicinity of the spindle.

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

1. Place the viscosity standard fluid (in the proper container) into the water bath.
2. Lower the DVPlus 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, 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 (±0.1°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 fluid standard to within the combined accuracies of the Viscometer and the viscosity standard (as discussed in the section, at the end of this Appendix, entitled Interpretation of Calibration Test Results) which appears later in this section.

CALIBRATION PROCEDURE FOR A SMALL SAMPLE ADAPTER

AMETEK Brookfield recommends a two-step check. First, verify the calibration of the Viscometer using the standard Viscometer spindles (LV #1-3, RV #2-6, HA #2-6 and HB #2-6) as detailed in this Appendix. Second, verify the calibration of the Viscometer using the Small Sample Adapter. The use of an accessory device may increase the accuracy of measurement associated with the DVPlus.

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:

- 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).
- Place the sample chamber into the water jacket.
- Put the spindle into the test fluid and attach the extension link, coupling nut and freehanging spindle (or directly attach the solid shaft spindle) to the DVPlus.

- Allow 30 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.
- Measure the viscosity and record the Viscometer reading.
    - Note: The spindle must rotate at least five (5) times before readings are taken.
- 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 ±2% of the maximum viscosity range and not the standard 1%.

CALIBRATION PROCEDURE FOR A THERMOSEL SYSTEM

AMETEK Brookfield recommends a two-step check. First verify the calibration of the Viscometer using the standard Viscometer spindles (LV #1-3, RV #2-6, HA #2-6 and HB #2-6) as detailed in this Appendix. Second verify the calibration of the Viscometer using the Thermosel. The use of an accessory device may increase the accuracy of measurement associated with the DVPlus.

When a Thermosel System is used, the controller stabilizes the Thermo Container at the test temperature.

- 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).
- Place the sample chamber into the Thermo Container.
- Put the spindle into the test fluid and attach the extension link, coupling nut and freehanging spindle (or directly attach the solid shaft spindle) to the DVPlus.
- Allow 30 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.
- Measure the viscosity and record the Viscometer reading.
    - Note: The spindle must rotate at least five (5) times before readings are taken.
- 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 ±2% of the maximum viscosity range and not the standard 1%.

CALIBRATION PROCEDURE USING UL OR DIN ADAPTERS

AMETEK Brookfield recommends a two-step check. First, verify the calibration of the Viscometer using the standard Viscometer spindles (LV #1-3, RV #2-6, HA #2-6 and HB #2-6) as detailed in this Appendix. Second, verify the calibration of the Viscometer using the UL or DIN Adapters. The use of an accessory device may increase the accuracy of measurement associated with the DVPlus.

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

- Put the proper amount of viscosity standard fluid into the UL Tube (refer to the UL Adapter instruction manual).
- Attach the spindle (with extension link and coupling nut) onto the DVPlus.
- Attach the tube to the mounting channel.
- 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.
- Allow 30 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.
- Measure the viscosity and record the Viscometer reading.
    - Note: The spindle must rotate at least five (5) times before readings are taken.
- 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 ±2% of the maximum viscosity range and not the standard 1%.

CALIBRATION PROCEDURE USING HELIPATH STAND AND T-BAR SPINDLES

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

- Remove the T-bar spindle and select a standard LV (#1-3) or RV, HA, HB (#1-6) spindle. Follow the procedures for LV (#1-3) and RV, HA, HB (#1-6) AMETEK Brookfield spindles outlined above.
- T-Bar spindles should not be used for verifying calibration of the DVPlus Viscometer.

CALIBRATION PROCEDURE FOR SPIRAL ADAPTER

AMETEK Brookfield recommends a two-step check. First, verify the calibration of the Viscometer using the standard Viscometer spindles (LV #1-3, RV #2-6, HA #2-6 and HB #2-6) as detailed in this Appendix. Second, verify the calibration of the Viscometer using the Spiral Adapter. The use of an accessory device may increase the accuracy of measurement associated with the DVPlus.

- Place the viscosity standard fluid (in the proper container) into the water bath (refer to the Spiral Adapter instruction manual).
- Attach the spindle to the Viscometer. Attach chamber (SA-1Y) and clamp to the Viscometer.
- Lower the DVPlus into measurement position. Operate the Viscometer at 50 or 60 RPM until the chamber is fully flooded.
- 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.
- After 1 hour, check the temperature of the viscosity standard fluid with an accurate thermometer.
- 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 at least five (5) times or for one minute, whichever is greater before readings are taken.
- 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 ±2% of the maximum viscosity range and not the standard 1%.

Viscometers as shown in Table E-2. Consult with AMETEK Brookfield or an authorized dealer to determine which fluid is appropriate.

INTERPRETATION OF CALIBRATION TEST RESULTS

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

The DVPlus is accurate to (+/-) 1% of the range in use when using spindles LV #1-3, RV #2- 6, HA #2-6 and HB #2-6. When using an accessory device with the DVPlus such as Small Sample Adapter, UL Adapter, Thermosel, Spiral Adapter, and DIN Adapter the accuracy value may be increased. In general the increase in accuracy will be minimal, however, it could be as much as 1% for a total accuracy of +/- 2% of the range in use.

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

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

1) Calculate full scale viscosity range using the equation:

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

Where:

TK = 1.0 from **Table D-2**
SMC = 10 from **Table D-1**

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

2) The viscosity standard fluid is 12,257 cP. Its accuracy is (+/-)1% of 12,257 or (+/-)122.57 cP. Total allowable error is (122.57 + 500) cP = (+/-) 622.57 cP.

3) 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 AMETEK Brookfield technical sales department or your local AMETEK Brookfield dealer/distributor with test results to determine the nature of the problem.

Example: Calculate the acceptable accuracy for viscosity measurement using DVPlus LV with SC4-21 spindle in Small Sample Adapter at 6, 12, and 30 RPM. AMETEK Brookfield viscosity standard fluid 100 cPs has an actual value of 101.5 cP at 25ºC.

1) Calculate the full scale viscosity range either by using the Spindle Range Coefficient in Appendix A of "More Solutions to Sticky Problems" or range shown on the configure viscosity test screen.

The Spindle Range Coefficient for the 21 spindle on an LV Torque instrument is 4,688.

At 6 RPM, the Full Scale Range (FSR) viscosity is 781 cP. Allow +/- 1% for the Viscometer and +/- 1% for the Small Sample Adapter. Total allowable accuracy is:

+/- 2% x 781 cP = +/- 15.6 cP

A similar calculation at 12 RPM gives FSR = 391 cP: +/- 2% x 391 cP = +/- 7.8 cP

A similar calculation at 30 RPM gives FSR = 156 cP: +/- 2% x 156 cP = +/- 3.1 cP

2) The Viscosity Standard Fluid is 101.5 cP. Its accuracy is:

+/- 1% x 101.5 cP = +/- 1.015 cP or roughly +/- 1.0 cP for further calculations.

3) Total accuracy is the sum of the values n (1) and (2):

At 6 RPM, accuracy is: 15.6 cP + 1.0 cP = +/- 16.6 cP

At 12 RPM, accuracy is: 7.8 cP + 1.0 cP = +/- 9.8 cP

At 30 RPM, accuracy is: 3.1 cP = 1.0 cP = +/- 4.1 cP

4) Therefore, at each speed, the acceptable windows within which the measured viscosity value must lie is calculated relative to the viscosity value of the standard:

At 6 RPM: 84.9 cP to 118.1 cP

At 12 RPM: 91.7 cP to 111.3 cP

At 30 RPM: 97.4 cP to 105.6 cP

If your measured values fall outside of these windows, contact AMETEK Brookfield or your local authorized dealer to discuss your results and determine whether your instrument is out of calibration.

APPENDIX F - THE AMETEK BROOKFIELD GUARD LEG

The guard leg was originally designed to protect the spindle during use. The first applications of the AMETEK 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 are attached to the dial housing and LV guard legs are 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 an AMETEK Brookfield Viscometer/Rheometer. A guard leg is supplied with every LV and RV series instrument, but not with the HA or HB series. Its shape (shown in Figure G-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 #2 spindle. They are not interchangeable.

The calibration of the AMETEK 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 the 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 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 AMETEK Brookfield Viscometer 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. AMETEK Brookfield has outlined a method for re-calibrating a AMETEK Brookfield Viscometer 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 an AMETEK Brookfield factor if the boundary conditions are not those specified by AMETEK Brookfield.

The guard leg is a part of the calibration check of the AMETEK Brookfield LV and RV 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.

B-21Y
Guard Leg For RV Torque

B-20Y
Guard Leg for LV Torque

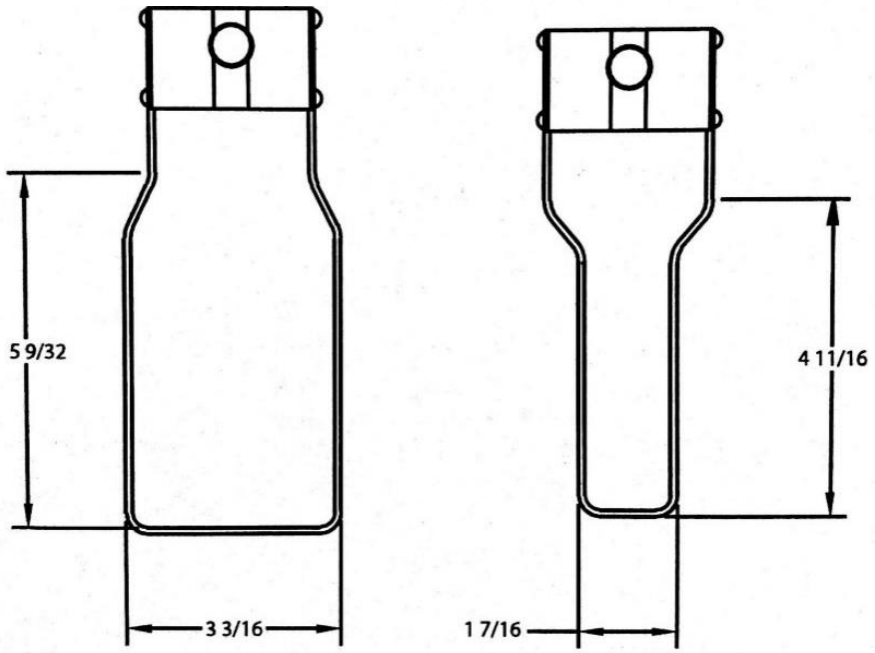
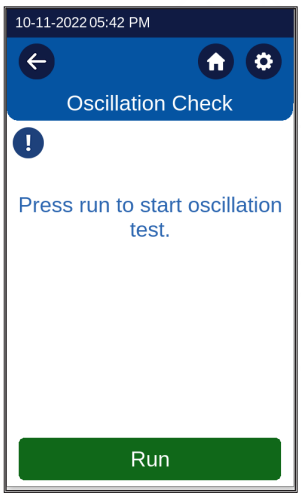


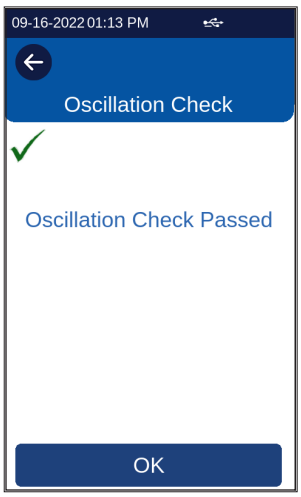
Figure G-1

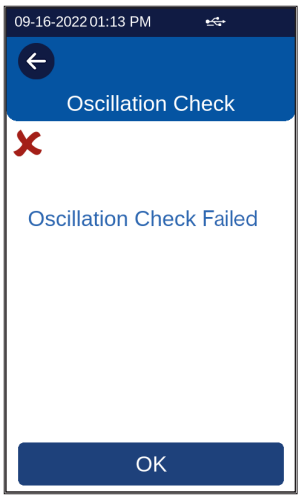
APPENDIX G - AUTOMATIC OSCILLATION CHECK

The Oscillation Check is a test of the performance of the lower bearing of the DVPlus Viscometer. The lower bearing is either Point and Jewel or Ball Bearing. Correct performance of the lower bearing is essential for proper operation of the Viscometer. A failed lower bearing will normally cause viscosity measurements to be lower than expected. Select the Oscillation Check from the Device Setup menu and follow the instructions on the touch screen display.



When the Oscillation Check is complete, the touch screen display will report results as either Pass or Fail.





If the Check passes, then press OK to continue. If the Check fails, contact your authorized AMETEK Brookfield representative for assistance.

APPENDIX H - DVE 50-A PROBE CLIP

Probe Clip DVE-50A is supplied with all model DV series Viscometers, Rheometers, and Digital Temperature Indicators. It is used to attach the RTD temperature probe to the LV Guard Leg (Part No. B-20Y) or 600 mL low form Griffin beaker. Figure J-1 is a view of the Probe Clip, showing the hole into which the RTD probe is inserted, and the slot which fits onto the LV guard leg. When inserting the RTD probe into the Probe Clip, the upper part of the Clip is compressed by squeezing the points shown in Figure J-1.

Note: All Viscometer/Viscometer models – except LV – use the Probe Clip only as shown in Figure J-3. The Probe clip is mounted in a 600-mL low form Griffin beaker. The geometry of the RV guard leg precludes the mounting directly to the guard leg.

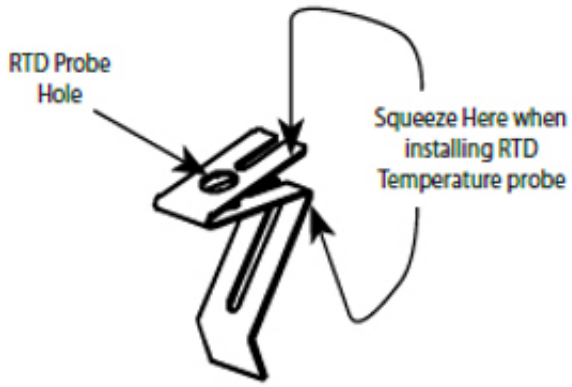


Figure J- 1

The LV uses the Probe clip (with RTD Temperature Probe installed) as shown in Figure J-2 or as shown in Figure J-3.

Temperature probe must not contact the spindle during measurement.

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

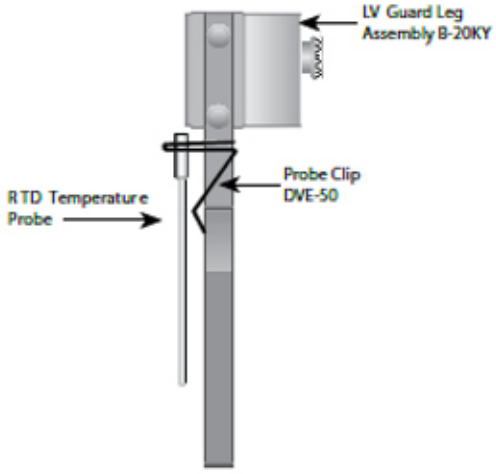


Figure J- 2

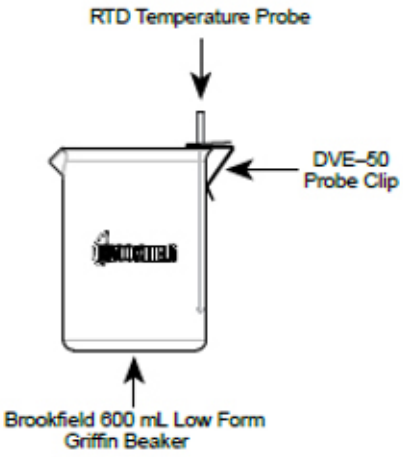


Figure J- 3

APPENDIX I - LABORATORY STANDS

Model G is the standard laboratory stand that comes with the DVPlus Viscometer.

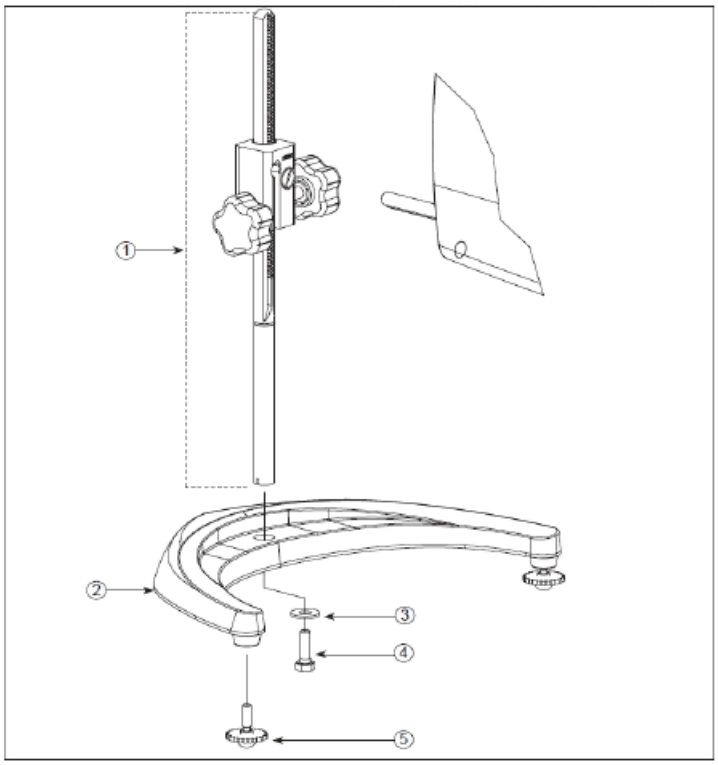


Figure K-1: Model G Laboratory Stand

Item	Part No.	Description	Qty
1	VS-CRA-14S	Upright Rod and Clamp Assembly	1
2	VS-CRA-18S	Upright Rod and Clamp Assembly	Optional
3	GV-1201	Base, includes 2 GV-1203 leveling screws	1
4	502028071S33B	Flat Washer 5/16 X 7/8 X .071	1
5	50S311832S01B	Screw, 5/16 - 18 X 1” Hex Head	1
6	GV-1203	Leveling Screws available separately or in assembly above	2

Model QB is an optional laboratory stand which can be ordered for use with the DVPlus Viscometer. The advantage is the rapid speed of movement for lowering and raising the Viscometer head.

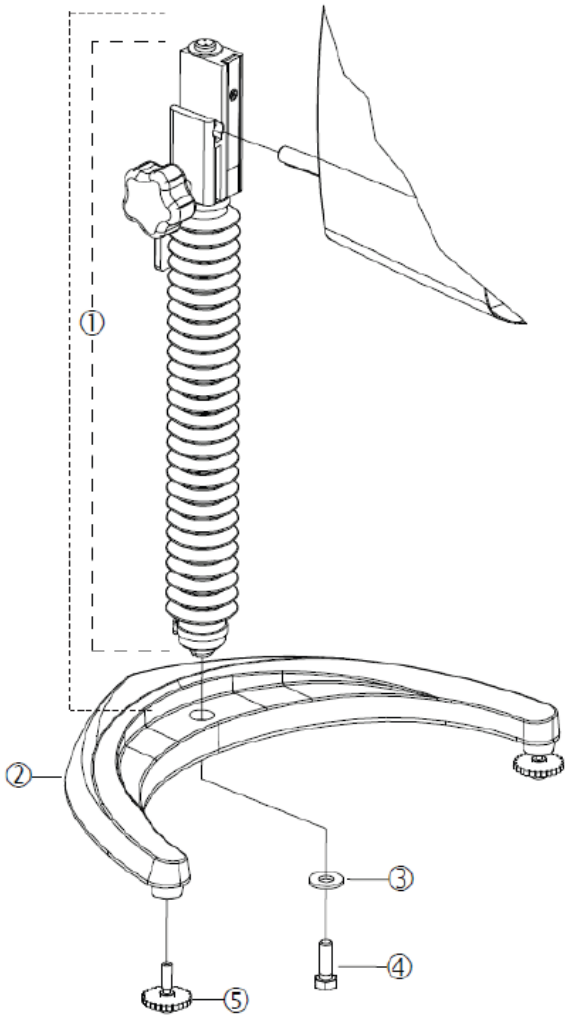


Figure K-2: Model QB Laboratory Stand

Item	Part No.	Description	Qty
1	VSQA-100Y	Upright Rod and Clamp Assembly	1
2	GV-1201	Base, includes 2 GV-1203 leveling screws	1
3	502028071S33B	Flat Washer 5/16 X 7/8 X .071	1
4	50S311832S01B	Screw, 5/16 - 18 X 1” Hex Head	1
5	GV-1203	Leveling Screws available separately or in assembly above	2

UNPACKING

We recommend our customers to save the packaging material and reuse it while shipping for servicing/repairs. Check carefully to see that all the components are received with no concealed damage:

- 1 Base, GV-1201, with 2 Leveling Screws
- GV-1203, packed in a cardboard carton
- 1 Upright Rod with attached Clamp Assembly in the instrument case

ASSEMBLY (REFER TO FIGURES K-1 OR K-2)

- Remove the base assembly from the carton.
- Remove the screw and washer from the upright rod. Place the rod and clamp assembly into the hole at the top of the base.
    - Note: The “Front” designation on the clamp assembly should face toward you.
- Rotate the rod/clamp assembly slightly until the slot on the bottom of the rod intersects the pin located in the base.
- While holding the rod and base together, insert the slotted screw and washer as shown and tighten securely.
- Adjust the tension screw so that the clamp assembly is not loose on the upright rod.

VISCOMETER MOUNTING

Insert the Viscometer mounting rod into the hole (with the cut-away slot) in the clamp assembly. Turn on the device and proceed to the leveling screen. Once this screen has been reached and the digital level can be seen, adjust the instrument level until the bubble is centered from right to left and tighten the clamp knob (clockwise). Use the leveling screws to “fine” adjust the Viscometer level.

Note: If the Digital Viscometer cannot be leveled, check to ensure that the rod is installed with the gear rack facing forward.

Do not tighten the clamp knob unless the Viscometer mounting rod is inserted in the clamp assembly.

Do not use the DVPlus Viscometer with any laboratory stand that does not utilize the GV-1201 base. This large base is necessary for stability of the DVPlus Viscometer during use. Earlier versions of the AMETEK Brookfield Laboratory Stand including the Model A and Model S should not be used with the DVPlus.

OPERATION

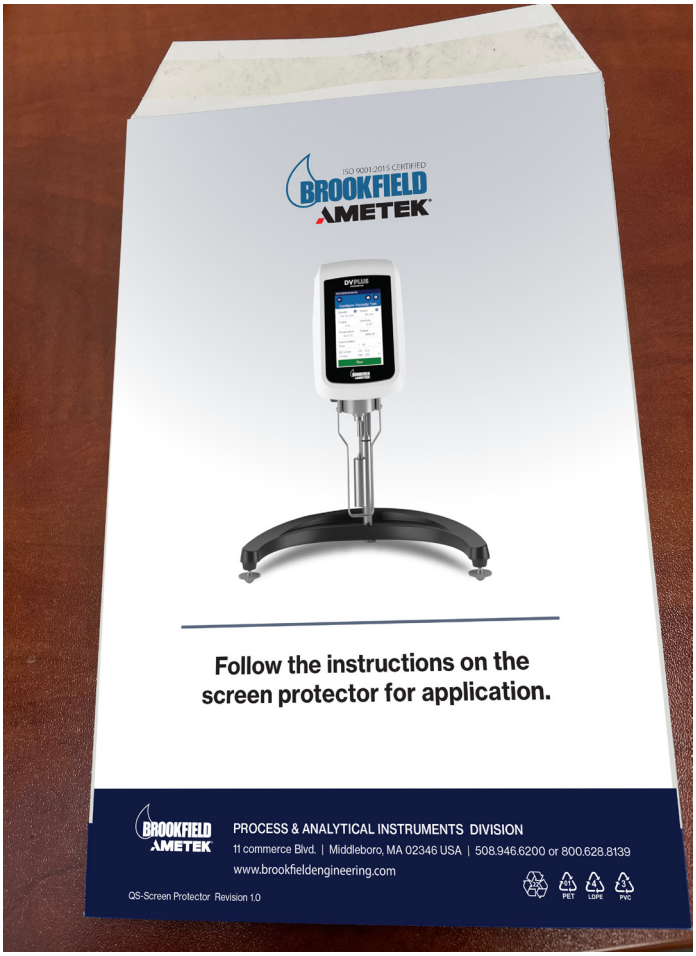
Rotate the UP/DOWN knob to raise or lower the Viscometer. Adjust the tension screw if the UP/ DOWN movement of the Viscometer head is not acceptable, i.e. too easy or too difficult.

APPENDIX J - SCREEN PROTECTOR

For optional Screen protector refer to screen protector packaging details for installation

For additional protection of the DVPlus device, we recommend the use of a Touch Screen Protector Kit. The 5" screen protector prevents scratches and smudges.

For more information on the AMETEK Brookfield Touch Screen Protector Kit, refer to the image below.



APPENDIX K - FAULT DIAGNOSIS AND TROUBLESHOOTING

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

SPINDLE DOES NOT ROTATE

- Make sure the Viscometer is plugged in.
- Check the voltage rating on your Viscometer (100-240 V); it must match the wall voltage.
- Make sure the motor is ON and the desired RPM is selected.

SPINDLE WOBBLES WHEN ROTATING OR LOOKS BENT

- Make sure the spindle is tightened securely to the Viscometer coupling.
- Check the straightness of all other spindles; replace if bent.
- Inspect Viscometer/spindle threaded coupling and mating areas for dirt; carefully clean threads in the spindle coupling with 3/56-inch left hand tap.
- Inspect Viscometer/spindle magnetic couplings and mating areas for debris, e.g. metallic chips or shavings.
- Inspect threads for wear; if the threads are worn, the unit needs service (see Appendix M). Check to see if spindles rotate eccentrically or wobble. There is an allowable run-out of 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 appears bent; if so, the unit is in need of service (see Appendix M: Warranty Repair and Service).

INACCURATE READINGS

- Verify spindle, speed, and model selection.
- Verify spindle selection is correct on DVPlus.
- If % readings are under-range (less than 10%), the edge of the Torque field will turn yellow, as will the Torque Bar at the top of the display. Change spindle and/or speed.
- "OVERRANGE" on the digital display means the unit is over-range (greater than 100%); reduce speed and/or change spindle.
- Verify test parameters: temperature, container, volume, method. Refer to: "More Solutions to Sticky Problems", Section III "DVPlus Viscometer Operating Instructions", Appendix C: Variables in Viscosity Measurements.
- Perform a calibration check; follow the instructions in Appendix E.
- Verify tolerances are calculated correctly.
- Verify the 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 M for details on Warranty Repair and Service.

VISCOMETER WILL NOT RETURN TO ZERO

- Viscometer is not level
    - Check with spindle out of the sample.
    - Adjust the laboratory stand.
- Pivot point or jewel bearing faulty
    - Perform an Oscillation Check
    - Refer to Appendix G for Automatic Oscillation Check.

DISPLAY READING WILL NOT STABILIZE

- Special characteristic of sample fluid. There is no problem with the Viscometer.
    - Refer to Appendix C.
- Check for erratic spindle rotation.
- Verify power supply.
    - Contact AMETEK Brookfield or your local authorized dealer for repair (see Appendix M).
- Bent spindle or spindle coupling.
    - Contact AMETEK Brookfield or your local authorized dealer for repair (see Appendix M).
- Temperature fluctuation in sample fluid.
    - Use temperature bath for control.
- Air Bubble under spindle
- Viscometer not Level
- Fluid Turbulence

REDUCED TOUCHSCREEN PERFORMANCE

To ensure the best performance from the DVPlus touchscreen a solid earth ground must be provided to the power supply. The power supply supports voltages in the range of 100-240 VAC and frequencies on the range of 50-60 Hz. Regardless of the input voltage the power supply must have a solid ground reference. The main symptom of a poor ground on the instrument is the touchscreen will lack sensitivity. If this is experienced the instrument should be moved and re-tested on a different circuit.

TECH SUPPORT

Information about the device and its functionalities can also be found on the product screen. Please access the support information through the Main Menu, using the Technical Support button.

APPENDIX L – INTEGRATED HELIPATH QUICK ACTION, HPQA, OPERATION WITH THE DVPLUS

INTRODUCTION

The Helipath Quick Action Stand (HPQA) and DVPlus offer users the ability to operate and program the HPQA directly from the DVPlus user interface. This capability offers several operating modes and unique features:

- Choose Integrated Helipath, Quick Action, and Manual Helipath Modes
- Helipath movement and action tied directly to Viscosity test program
- Automated end of test movements and actions
- Stop Helipath movement at end of viscosity test
- Move DVPlus to customer programmed location at completion of test
- Repeatable set up locations for different container sizes
- Standard Operating Procedures can be defined by HPQA location (defined in millimeters) for each container size and sample size
- Record of Helipath test setup and movement with viscosity data

INSTRUMENT SETUP AND FIRMWARE REQUIREMENTS

To program and operate the Helipath Quick Action (HPQA) Stand via the DVPlus user interface, the firmware of both instruments must meet the minimum levels shown below. If your device was purchased prior to this firmware release level, please download the latest firmware from the website locations listed below and update per the instructions in the DVPlus and HPQA manuals as required.

- Check Firmware for the DVPlus and HPQA meet minimum requirements:
  - DVPlus Firmware version 1.6.1.1 or higher
  - HPQA Firmware version 1.1.0.15 or higher

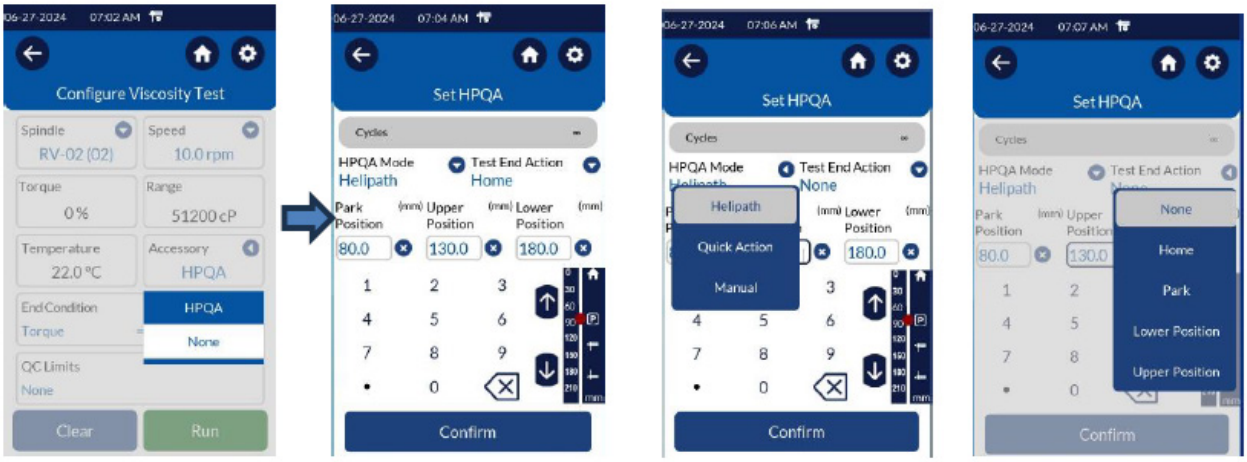
  Note: Visit the product pages at www.brookfieldengineering.com to find the latest firmware downloads and instructions.
- After the standard instrument setup instructions per the HPQA manual, connect the DVPlus to the HPQA with the supplied 18” USB A-B patch cable (Part Number HP-2011)
  - **Connect USB A side to DVPlus and USB B side to HPQA back panels**.
- Ensure the USB connection symbol is displayed at the top of the DVPlus screen as displayed in Figure Appendix L-1
- If not already Homed, press the large Home button when the HPQA powers on to establish the Home position.
- You are now ready to use the HPQA in Integrated modes.

Figure Appendix L-1

INTEGRATED HELIPATH TEST OPERATION

Integrated Helipath Testing allows users to automate and coordinate the action of the HPQA stand with the programmed viscosity test on your DVPlus. This will allow more repeatable test setups, visual indicators when testing is complete, and confirmation that the test utilized the HPQA during testing. The default travel speed during a Helipath test is 0.39 mm/s. To set up and run an integrated Helipath test, follow the steps below.

- Once you've entered the 'Configure Viscosity Test' Screen, click on the Accessory drop down menu and select 'HPQA'. This will automatically take you to the 'Set HPQA' settings screen.



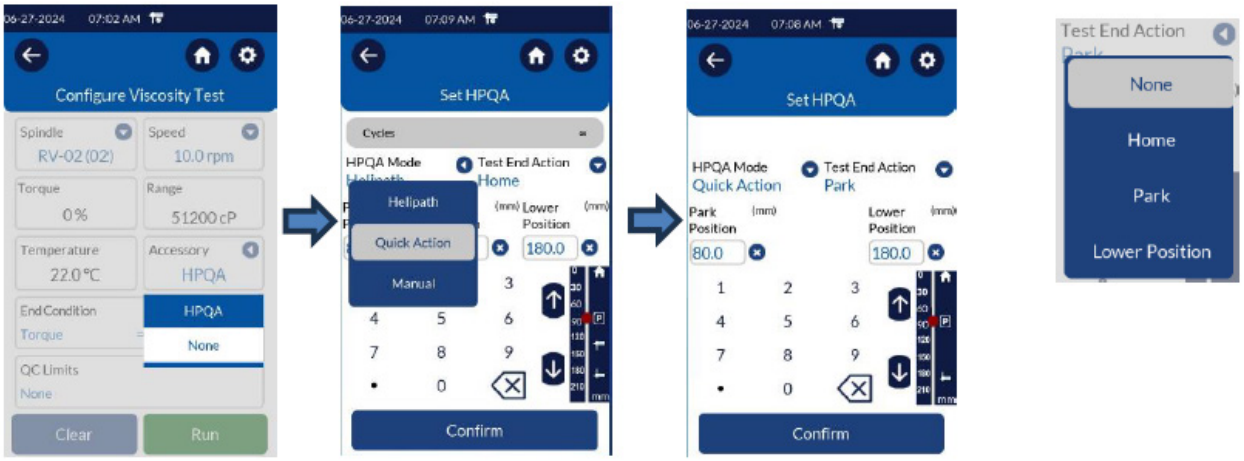
- In the 'Set HPQA' screen, there are a few options to configure your test.
  - HPQA Mode: Choose between Helipath, Quick Action, and Manual test modes. For this instruction, choose Helipath.
  - Test End Action: Allows user to choose what the motorized HPQA stand does at the completion of the viscosity test.
    - None: The DVPlus head and spindle will remain at the location it was when the test ended.
    - Home: Move to the Home position at the top of the stand.
    - Park: Move to the 'Park Position' as defined in the test setup. Park is typically a location above the sample that allows users to see the test is complete and the spindle is out of the fluid, ready to be cleaned.
    - Upper Position: This location is the Top Test position in the fluid. This defines where the Helical path motion will begin, moving from the top to bottom test positions.
    - Lower Position: This defines the height at which the HPQA stand will stop moving down and begin moving back up. (Can't exceed lower travel limit of 215mm in Helipath Test mode).
  - Cycles: Displays how many Helipath cycles will occur if the 'End Condition' for the Viscosity Test is set up to end on Helipath cycles. One cycle is defined as moving from the Upper position down to the Lower position and then traveling back to the starting Upper position. Users can choose cycles in 0.5 increments. A Half cycle would allow the user to travel from the Upper to Lower position and then end the test. If 'cycles' is not chosen as an End Condition, the set number will be infinity and the Helipath motion will run until commanded to stop by an alternate End Condition or manually stopped.
- After selecting 'Helipath' from the HPQA Mode drop down, select what action you'd like to happen at the completion of your test from the 'Test End Action' drop down.
- To set your Park, Upper Position, and Lower Positions:
  - It is recommended you place a container with your typical sample volume and container with the correct T-Bar spindle under the stand to help determine the appropriate test positions.
  - Touch the number entry box of the position you'd like to set.
  - You may type in the desired location (defined in millimeters down from the top Home position), drive the stand to the desired location with the Up/Down arrows on the screen, or use the Joystick on the HPQA stand.
- Once all positions have been programmed, hit the 'Confirm' button to go back to the Configure Viscosity Test screen.

- Configure the remainder of your Viscosity Test and you are now ready to run your test!
    - The Helipath configuration will remain as programmed per the last test for repeat testing on the DVPlus.

INTEGRATED QUICK ACTION OPERATION

Integrated Quick Action operation allows users to automate and coordinate the action of the HPQA stand with the programmed viscosity test on your DVPlus. This is useful for customers that want to automate the movements of the HPQA stand while running standard 'non-Helipath' tests. To set up and run the HPQA with Integrate Quick Action operation, follow the steps below.

- Once you've entered the 'Configure Viscosity Test' Screen, click on the Accessory drop down menu and select 'HPQA'. This will automatically take you to the 'Set HPQA' settings screen.



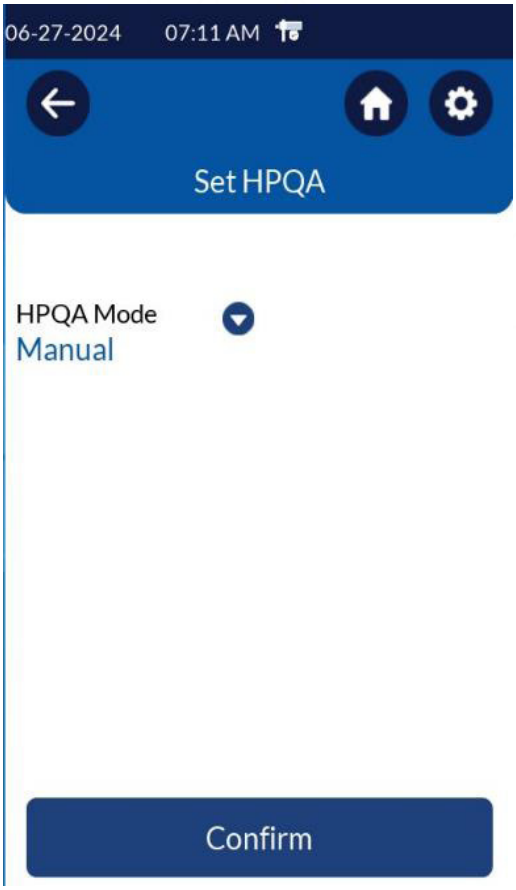
- In the 'Set HPQA' screen, there are a few options to configure your test.
    - HPQA Mode: Choose Quick Action.
    - Test End Action: Allows user to choose what the motorized HPQA stand does at the completion of the viscosity test.
        - None: The DVPlus head and spindle will remain at the location it was when the test ended.
        - Home: Move to the Home position at the top of the stand.
        - Park: Move to the 'Park Position' as defined in the test setup. Park is typically a location above the sample that allows users to see the test is complete and the spindle is out of the fluid, ready to be cleaned.
        - Lower Position: In 'Quick Action' mode, the Lower Position is defined as the depth you'd like to immerse the spindle to for running the Viscosity test.
- After selecting 'Quick Action' from the HPQA Mode drop down, select what action you'd like to happen at the completion of your test from the 'Test End Action' drop down.
- To set your Park and Lower Positions:
    - It is recommended you place a container with your typical sample volume and container with the correct spindle under the stand to help determine the appropriate Test positions.
    - Touch the number entry box of the position you'd like to set.
    - You may type in the desired location (defined in millimeters down from the top Home position), drive the stand to the desired location with the Up/Down arrows on the screen, or use the Joystick on the HPQA stand.
- Once all positions have been programmed, hit the 'Confirm' button to go back to the Configure Viscosity

Test screen.

- Configure the remainder of your Viscosity Test and you are now ready to run your test!
    - The Quick Action configuration will remain as programmed per the last test for repeat testing on the DVPlus.

STANDALONE/MANUAL HELIPATH TEST OPERATION

If you'd prefer to continue setting up your HPQA separate from your DVPlus Viscosity Test configuration, you can select 'Manual' under the HPQA Mode drop down as shown below. This will allow you to operate the devices separately and is known as 'Standalone or Manual' mode. Refer to your HPQA and DVPlus manuals for the independent set up and operation of each.



APPENDIX M - ONLINE HELP AND ADDITIONAL RESOURCES

www.brookfieldengineering.com

The AMETEK Brookfield website is a good resource for additional information 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.

www.youtube.com/user/brookfieldEng

AMETEK Brookfield has its own YouTube channel. Videos posted to our website can be found here as well as other "homemade" videos made by our own technical sales group.

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 AMETEK Brookfield Viscometer or Rheometer operator. "More Solutions to Sticky Problems" is available as a downloadable PDF on the AMETEK Brookfield website by following this path: www.brookfieldengineering.com/downloads/technical-documents.

AMETEK Brookfield University 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 store.brookfieldengineering.com/us-training-schedule/ to learn more about training.

APPENDIX N - WARRANTY REPAIR AND SERVICE

AMETEK Brookfield Viscometers are guaranteed for one year from the 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 AMETEK Brookfield or to the authorized dealer from whom it was purchased for a 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 AMETEK Brookfield, please contact us for a return authorization number prior to shipping.

All AMETEK Brookfield DVPlus Viscometers are supplied from the factory with a Calibration Seal (Located on the back of the viscometer). The warranty stated above will be voided if the Calibration Seal has been damaged. Only AMETEK Brookfield or our authorized servicing dealers may break the Calibration Seal for purposes of instrument repair or recalibration.

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

VISCOSITY TEST REPORT	DATE:	FOR:
	BY:	

TEST INFORMATION:

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

CONCLUSIONS:

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