Operation Instructions

DV2Plus

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Original Instructions

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I. INTRODUCTION

The Brookfield DV-II Viscometer series has been the leading industrial viscometer since it was first introduced in 1985. AMETEK Brookfield has continued to develop and improve the DV-II to provide the best value in the market for both quality control and research customers. The AMETEK Brookfield DV2Plus Viscometer continues in this tradition of innovation, quality and value. The incorporation of a full color graphical touch screen display has allowed for a new and improved user interface which preserves the single speed data collection methods while making all of the advanced features of the DV2Plus readily available. The DV2Plus is also capable of Dual Speed data collection via its two-step feature.

The AMETEK Brookfield DV2Plus Viscometer measures fluid viscosity at given shear rates. Viscosity is a measure of a fluid's resistance to flow. You will find a detailed description of the science of viscosity in the Brookfield publication "More Solutions to Sticky Problems", a copy of which is available on the AMETEK Brookfield website.

This manual covers the DV2Plus Viscometer. All references to the viscometer in this manual will be made as DV2Plus.

- The DV2Plus offers exceptional versatility in modes of control, allowing choice of traditional standalone operation and automatic operation through programs downloaded from the PC or with complete control by PC using AMETEK Brookfield DV360 Software.
- The DV2Plus can be used as a traditional Brookfield Viscometer for collection of single speed viscosity data through the easy to use touch screen; just select the spindle and speed and read the value from the display. [See Section II: Getting Started]
- The AMETEK Brookfield DV360 Software will perform all control and data collection functions of the DV2Plus from the PC while also providing a platform for advanced data collection and analysis. For additional details regarding how to use and connect DV360 with your DV2Plus, please download the DV360 Operating Instructions from the Ametek Brookfield Resource Library.'

In any of these modes of control, the DV2Plus will provide the best in viscosity measurement and control.

The principal of operation of the DV2Plus 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. Spring deflection is measured with a rotary transducer. The measurement range of a DV2Plus (in centipoise 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	milliNewton•m
DV2PLV DV2PRV DV2PHA DV2PHB	673.7 7,187.0 14,374.0 57,496.0	0.0673 0.7187 1.4374 5.7496

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

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

1. Viscosity appears in units of centipoise (cP), Poise (P), milliPascal-seconds (mPa•s) or Pascal-seconds (Pa•s) or centistokes (cSt) or millimeter squared per second (mm2/sec).
2. Shear Stress appears in units of dynes/square centimeter (dyne/cm2) or Newtons/square meter (N/m2)/ or Pascals (Pa).
3. Shear Rate appears in units of reciprocal seconds (1/sec).
4. Torque appears in units of dyne-centimeters or milliNewton meters (shown as percent "%" in both cases) on the DV2Plus Viscometer display.

5. Density appears in units of grams/cubic centimeter (g/cm3) kilograms/cubic meter (kg/m3), or specific gravity (SG).

Note: To change CGS to SI units on the display - see Section IV: Settings.

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

	SI	**CGS**
Viscosity: Shear Stress: Torque:	1 mPa•s 1 Newton/m^2 1 Newton•m	= 1 cP = 10 dyne/cm^2 = 10^7 dyne•cm

References to viscosity throughout this manual are done in CGS units. The DV2Plus Viscometer provides equivalent information in SI units.

I.1 Components

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.

Components	Part Number		Quantity
		DV2Plus	
DV2Plus Viscometer	Varies	1	
Model G Laboratory Stand HPQA, Helipath Quick Action Stand	MODEL G Varies	1 Purchased Separately	
Spindle Set with Case DV2PlusLV set of four spindles DV2PlusRV set of six spindles (#2 - #7) DV2PlusHA / HB set of six spindles (#2 - #7)	Varies SSL or SSLM† SSR or SSRM† SSH or SSHM†	1	
Power Cord		1	
RTD Temperature Probe	DVP-94Y	Purchased Separately	
Guard Leg DV2PLV DV2PRV	 B-20Y B-21Y	1	
Carrying Case DV360 Software Screen Cloth w/case Operating Manual Shipping Cap Screen Protector Kit	 Contact rep.	1 Purchased Separately Purchased Separately see website for electronic copy 1 Purchased Separately	

† For magnetic spindle coupling, there may be an "M" in the part number. Please contact your AMETEK Brookfield representative for more information.

COMPONENT DIAGRAM

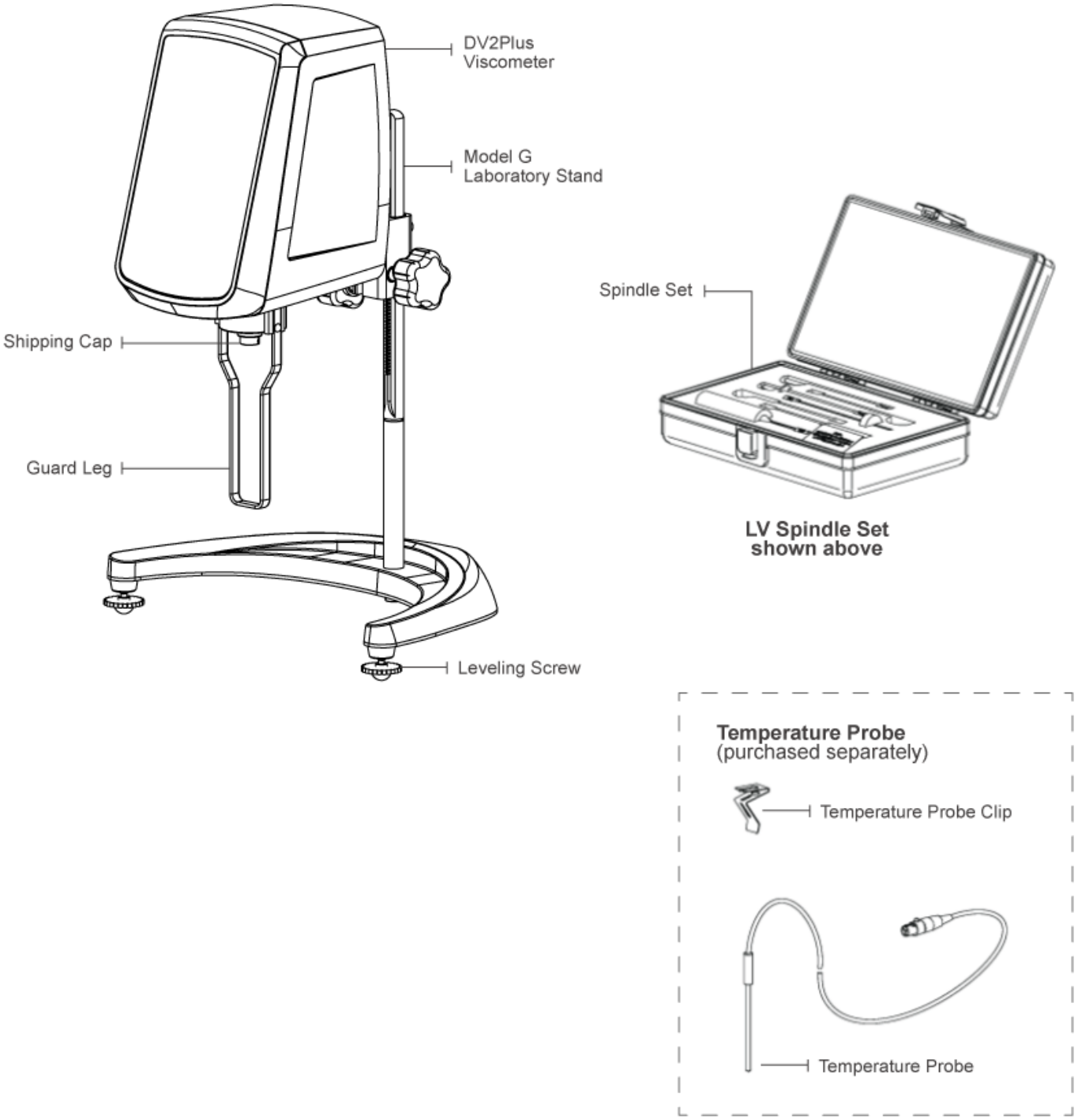


Figure I-1

I.2 Utilities

Input Voltage:	Universal Power Supply (90-264 VAC)	
Input Frequency: Power Consumption:	50/60 Hz 60 W	
Power Cord Color Code:		
	United States	**Outside United States**
Hot (live)	Black	Brown
Neutral	White	Blue
Ground (earth)	Green	Green/Yellow

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

Must be used with HP-2010 power supply. Alternative power sources may cause damage to the instrument.

To ensure the best performance from the DV2Plus 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.

I.3 Specifications

Speeds:	0.1 - 200 RPM		
Weight:	Gross Weight:	23 lbs.	10.5 kg.
	Net Weight:	20 lbs.	9 kg.
	Carton Volume:	2.5 cu. ft.	0.07 m^3
	Carton Dimensions:	22 in. (56 cm) W x 12 in. (30 cm) L x 17 in. (43 cm) H	
Temperature Sensing Range:	-100˚C to 300˚C (-148˚F to 572˚F)		
4 USB Type A Ports			
1 USB Type B Port			
Viscosity Accuracy:	±1.0% of full scale range The use of accessory items will have an effect on the measurement accuracy. See Appendix A.		
Viscosity Repeatability:	±0.2% of Full Scale Range		
Temperature Accuracy:	±1°C | -100°C to +149°C ±2°C | +150°C to +300°C		
Operating Environment:	0°C to 40°C temperature range (32°F to 104°F) 20% - 80%R.H.: non-condensing atmosphere		

Ball Bearing Option:
If you ordered the ball bearing suspension system with your new instrument please note the following:

1. 1) The ball bearing suspension in your Brookfield instrument is noted on the serial tag on the back of the head by the letter “B” in the part number (the ninth digit; for example: XDV2PHBTB00U00).
2. When attaching and detaching the spindle, it is not necessary to lift the coupling where the spindle connects to the instrument.
3. The Oscillation Check explained in Section II.5 Home Screen>Device Setup, does not pertain to this instrument.

Electrical Certifications:
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
Note: year of manufacture appears in the upper right corner of the product label.

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 9811:2019 - Emissions Requirements for Equipment for Measurement, Control, and Laboratory Uses

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:
Incorpora produto homologado pela Anatel sob número 01232-25-01056. 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.
Incorporates product approved by Anatel under number 01232-25-01056 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 DV2Plus Viscometer is certified by the Korea Communications Commission (KCC).

Taiwan NCC:
This product contains transmitter module u-blox ANNA-B112 NCC ID CCAI18LP2200T2 Working frequency: 2402-2480MHz. Without permission granted by the NCC, any company, enterprise, or user is not allowed to change frequency, enhance transmitting power or alter original characteristic as well as performance to an approved low power radio-frequency device.

Notice to customers:

This symbol indicates that this product is to be recycled at an appropriate collection center.
Users within the European Union:
Please contact your dealer or the local authorities in charge of waste management on how to dispose of this product properly. All 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.

I.4 Installation

Note: “IQ, OQ, PQ”, an abbreviated guideline document for installation, operation and performance validation for your DV2Plus digital viscometer is available for purchase from AMETEK Brookfield or your authorized dealer.

1. Assemble the Model G Laboratory Stand (refer to assembly instructions in Appendix H).
2. Put the viscometer on the stand.
3. Connect the RTD probe to the socket on the rear panel of the DV2Plus.
4. Remove the shipping cap which secures the coupling nut on the Viscometer to the pivot cup. Lower the cup and remove the foam insert.(Save for future shipments.)
5. Optional: Install the screen protector per the instructions on the package (and also shown in Appendix J). Failure to properly install the screen protector may result in touch screen malfunction.
6. Make sure that the power switch at the rear of the DV2Plus is in the OFF position. Connect the power cord to the socket on the back panel of the instrument and plug it into the appropriate AC line.

   Note: The DV2Plus must be earth grounded to ensure against electronic failure!!
7. Turn the power switch to the ON position and allow the viscometer to warm up for 10 minutes before performing AutoZero. The Viscometer must be leveled. The level is adjusted using the two leveling screws on the base. Adjust the leveling using the DV2Plus leveling feature in the instrument, ensure the green ball is centered

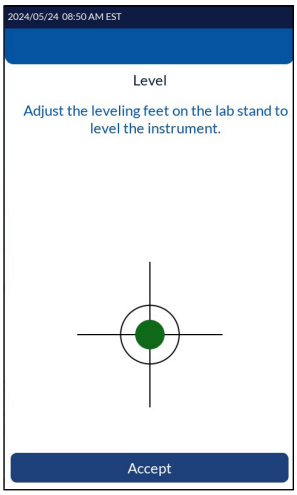


Figure I-1.1

Note: Check level periodically during use.

8. If appropriate, connect USB cable (DVP-202) to USB port for connection of DV2Plus to PC.

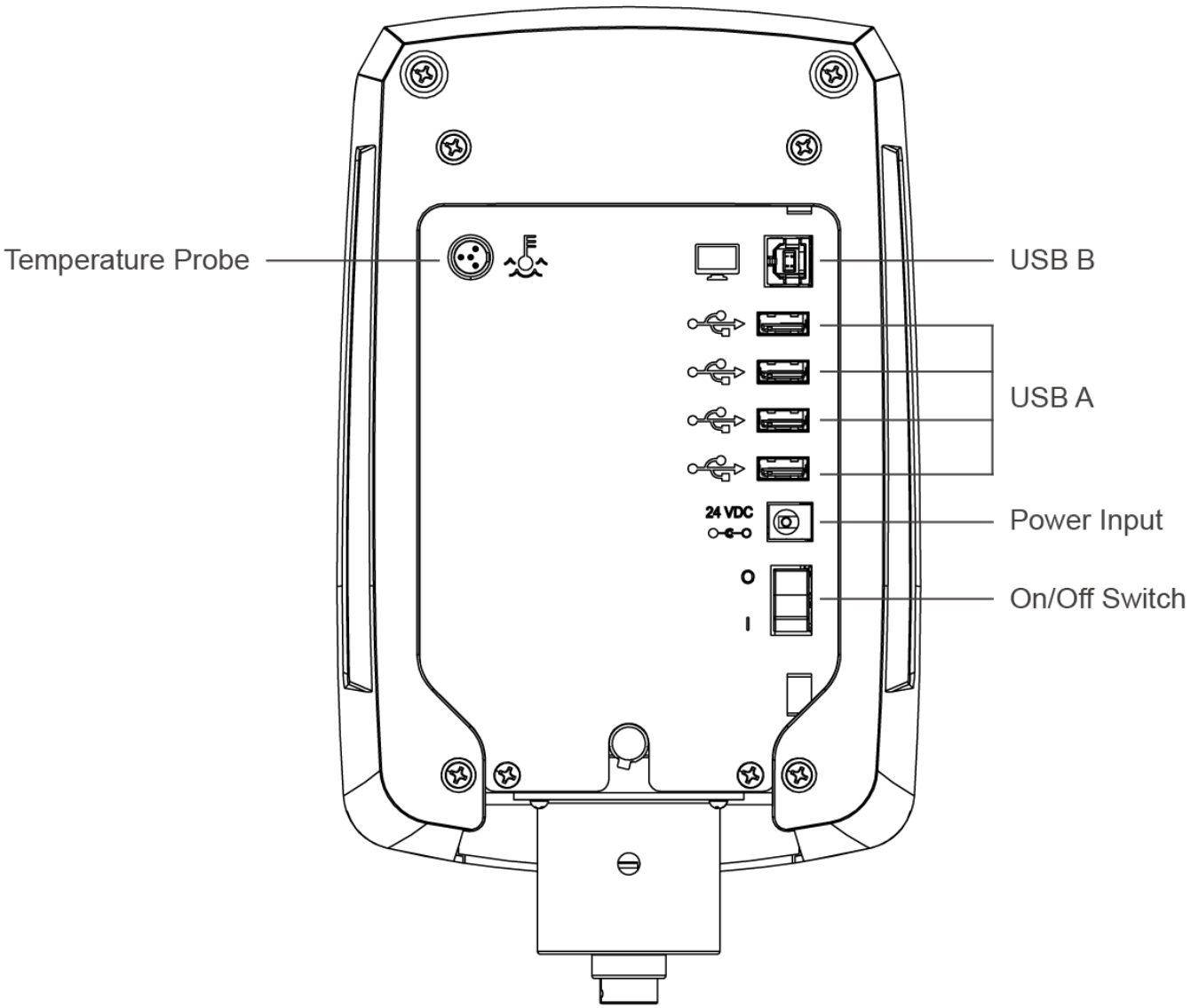


Figure I-2

I.5 Safety Symbols and Precautions

Safety Symbols
The following explains safety symbols which may be found in this operating manual.

Indicates hazardous voltages may be present.

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 which they are subjected to during the testing.

Do not operate high power devices from the USB ports.

I.6 Key Functions

The DV2Plus Viscometer utilizes a touch screen display and interface. The user will provide all input to the viscometer through the touch screen. Figure I-3 details the different types of information and actions available.

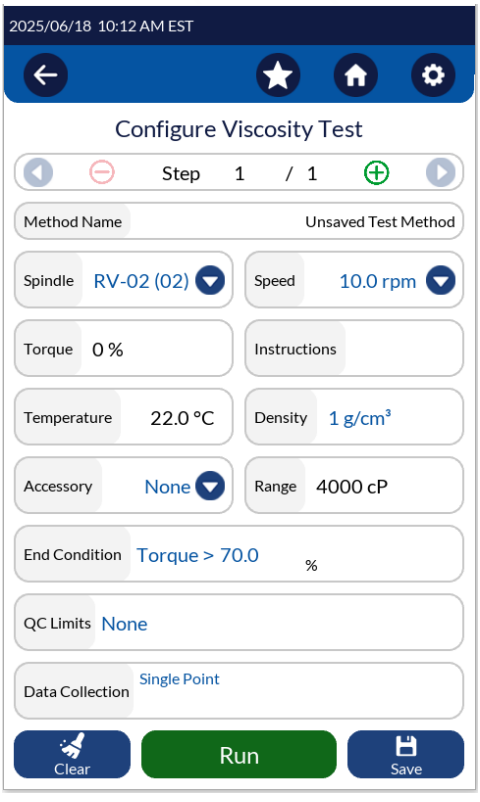


Figure I-3

Status Bar: The Status Bar provides information relating to the date and time (as configured by the user) and various connections to the DV2Plus Viscometer.

Method Name: The Test Name identifies the name of the currently loaded test.

Title Bar: The Title Bar identifies the activity to be conducted in the current view and includes any navigation icons that are relevant.

Data Fields: The Data Fields include measurement results and test parameters.

Command Keys: The Command Keys indicate action that can be taken. These keys will vary from view to view

depending on what actions are relevant.

I.7 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.

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 sample material.

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

II. GETTING STARTED

II.1 Power Up

The DV2Plus will go through a "Power Up" sequence when the power is turned on. The viscometer will issue a beep, present a startup screen, and finally show the DV2Plus About screen for 5 seconds. The "About" screen is shown below and includes several critical parameters about the viscometer including; viscometer torque (LV, RV, HA, HB, or other), firmware version number, model number (DV2PLV for example) and the serial number.

Figure II-1

The About screen can be accessed from the Main Menu- Technical Support screen.

The DV2Plus viscometer will automatically transition from the About screen to the AutoZero screen.

TIP: When contacting AMETEK Brookfield or your local authorized dealer for technical support or repair services, please record the information on the About screen and include this detail in your email.

II. 2 AutoZero

The DV2Plus 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. Additionally, you may perform an AutoZero at any time through the Device Setup Menu.

The AutoZero screen will be presented automatically, after the About screen, during a power up.

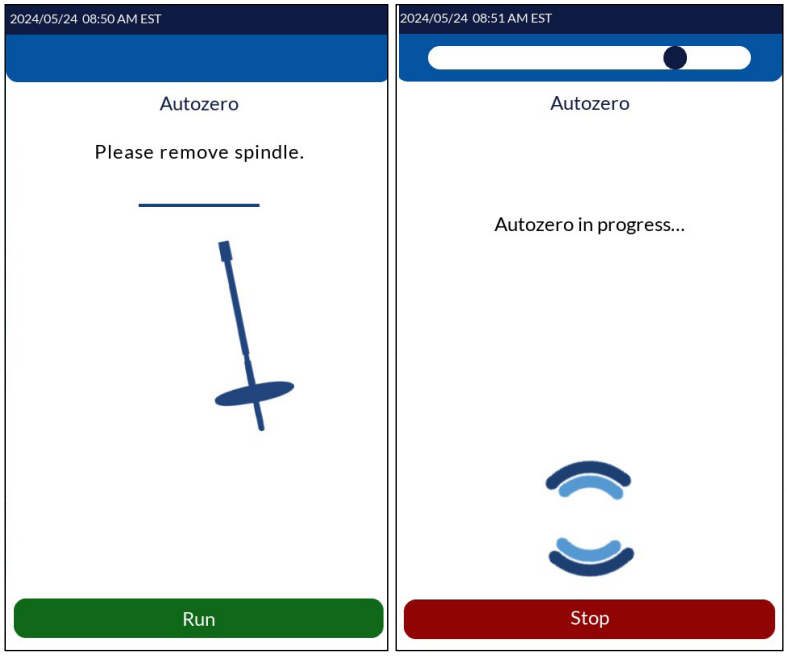


Figure II-2

The operator must ensure that the viscometer is level (see Section I.4) and remove any attached spindle or coupling. When the "Run" button is pressed, the viscometer will operate for approximately 13 seconds. After the AutoZero is complete and the operator presses the Next button, the viscometer will transition to the "Configure Viscosity Test" screen. If the AutoZero was performed from the Device Setup Menu, then the viscometer will return to the Device Setup Menu.

TIPS: Do not touch the viscometer during the AutoZero process to ensure the best zero value. For instruments with Magnetic Coupling System, keep spindle end and other magnetic materials 1-inch away from the coupling during AutoZero.

II.3 Status Bar

The DV2Plus Viscometer will display a status bar at the top of the screen at all times.

This status bar will indicate: time of day, date, and connection status for a variety of connection devices. The status icons are defined as:

	HPQA Icon:	The DV2Plus Viscometer can integrate directly with the HPQA, Helipath Quick Action Stand. This icon indicates that an HPQA is connected to the device.
	Printer Icon:	This icon will be shown when the DV2Plus is connected to a compatible printer.
	Barcode Icon:	This icon will be shown when the DV2Plus is connected to a Barcode reader.
	USB Icon:	The DV2Plus Viscometer can store data and tests to USB storage device (USB A) such as a USB Flash Drive and/or peripheral devices. There are four USB ports.
	Bluetooth Icon:	The DV2Plus Viscometer can communicate with a computer through a Bluetooth wireless connection (If available).

	Temperature Probe Icon:	The DV2Plus Viscometer can read the temperature probe sensor and show the icon when the probe is plugged in.

II.4 Navigation

The DV2Plus Viscometer uses a touch screen display. Navigation of the instrument features is done using a variety of Data Fields, Arrows, Command Keys and Navigation Icons. The operating system has been designed for intuitive operation and employs color to assist the user in identifying options.

Data Fields require that the user touch the screen to initiate the data entry / selection process. These fields are normally outlined in black. They may also include a blue arrow.

White arrows with a circular blue background indicate that options exist for a Data Field. The user may be required to press anywhere in the Data Field or they may have to press the Blue Arrow specifically.

Command Keys are buttons which direct the DV2Plus to perform a specific action such as SAVE a data set or STOP a program. Command Keys are presented in a variety of colors. These keys are normally found at the bottom of the screen.

Navigation Icons are normally found in the Title Bar to the left and right. These buttons will take you to specific areas of the operating system.

Navigation Icons are shown below.

 Home Menu

 Log In (will only be available if the administrator has activated user log in)

 Settings Menu

 Choose from additional options

 Back (return to previous screen)

 Calibration reminder

 Lists favorites

II.5 Home Screen

The DV2Plus Home screen can be accessed by using the Home Icon  . The Home screen shows the Main Menu functions and provides access to User Log In and Settings (see Section IV.4.2).

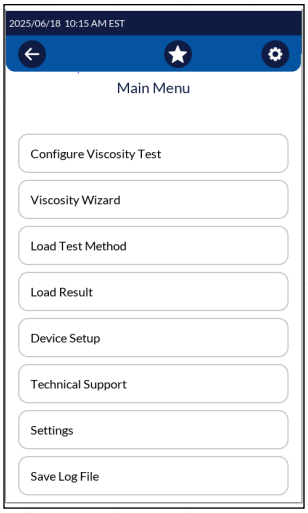


Figure II-3

Configure Viscosity Test: Create and Run viscosity tests.

Viscosity Wizard: Tool to help create viscosity tests with new materials.

Load Test Method: Load a test that has previously been saved. Tests may be loaded from internal memory or a USB Flash Drive.

Load Result: Load Results (saved test data) that have previously been saved. Results may be loaded from internal memory or a USB Flash Drive.

Device Setup: Perform AutoZero, Level, and Oscillation checks, access the Administration Menu, Register your Product, Advanced test settings, Printer paper size, Temperature offset, Bluetooth Setup, and access the Service Menu (for Authorized Service Personnel ONLY).

Technical Support: Provides instrument specific information

Settings: Access the settings menu.

Save Log File: Press this button to send Log File to USB Flash drive. Log file includes information similar to an audit trail.

Each of the Main Menu items are detailed in the following sections of the manual.

II.5.1 Configure Viscosity Test

Viscosity measurements are made on the DV2Plus Viscometer through the Configure Viscosity Test function. The user is presented with Configure Viscosity Test at the conclusion of the AutoZero function or by selection on the Home Menu .

All elements related to the measurement of viscosity are selected within Configure Viscosity Test. Tests that are created can be saved to the internal memory of the DV2Plus Viscometer or onto a connected USB Flash Drive. Tests can be loaded from memory by selecting Load Test from the Home Screen .

TIP: Many aspects of Configure Viscosity Test can be limited when User ID and Log In functions are implemented (see Section IV.4.2).

The basic Configure Viscosity Test view is shown in Figure II-4. This view includes the Status Bar (Section II.3), Title Bar (which includes the Home and Settings icons), test name, test parameters, and Command Keys (see Section II.4).

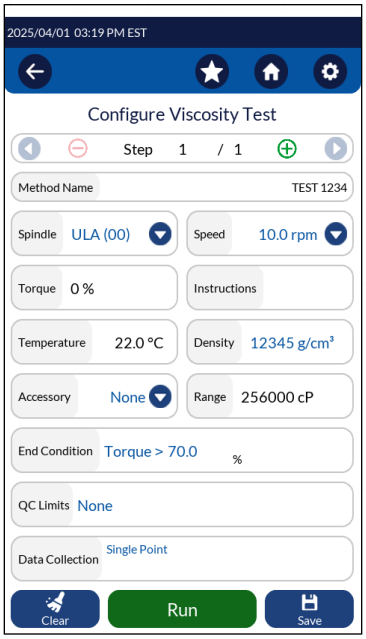


Figure II-4

The user can see the name of any test that has been loaded through the Load Test function in the Method Name field.

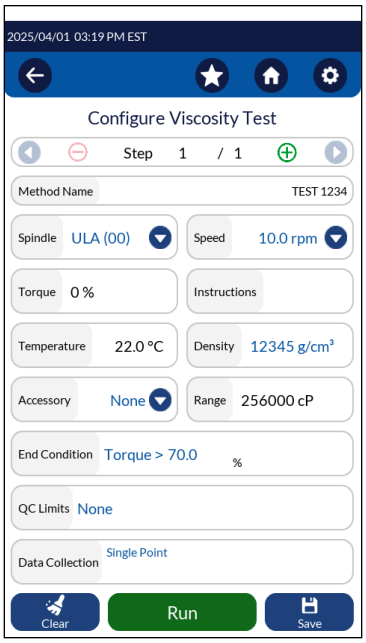


Figure II-5

Data Fields require that the user touch the screen to initiate the data entry / selection process. These fields are normally outlined in black. They may also include a blue arrow.

The Command Keys include Clear, Run, and Save.

Command Keys are buttons which direct the DV2Plus to perform a specific action such as SAVE a data set or STOP a program. Command Keys are presented in a variety of colors. These keys are normally found at the bottom of the screen.

Clear: Reset test parameters to factory default.

Run: Start Configured Test.

Save: Save Configured Test.

The Test Parameter area includes many elements of the viscosity test as well as live measurements of Torque % and Temperature. Temperature data will only be displayed if a Brookfield temperature probe is connected to the DV2Plus Viscometer.

Torque: A live signal from the viscometer.

Spindle: The currently selected spindle. All viscosity, shear rate, and shear stress calculations will be made based on this spindle. The spindle number may be changed by pressing the arrow.

Speed: The currently selected speed of rotation. The viscometer will operate at this speed once the RUN command key is pressed. The speed may be changed by pressing the arrow.

Temperature: A live signal from the viscometer when a temperature probe is attached (Brookfield part number DVP-94Y).

End Condition: Specify the condition that will end the test.

Data Collection: Specify the amount of data to be collected during the test.

Instructions: Create a message that the user will see when the test begins.

Accessory: Specify if an accessory is used for the test.

QC Limits: Define the limits for acceptable measurement data.

Density: Define the density of the test sample. This information will be used when kinematic viscosity units are selected for display (see Section III.8).

Range: Define test range.

II.5.2 Viscosity Wizard

The Viscosity Wizard will make a basic recommendation of spindle type and test speed.

During the first step, users will be able to choose a familiar ‘Example liquid’ from the drop-down list that they believe is closest to their sample, or they may enter the estimated viscosity value if known. After pressing ‘Next’, the Wizard will recommend a specific spindle number.

After the spindle has been selected, the Wizard will prompt users to attach the correct spindle and immerse the spindle into your sample. The Wizard will complete a speed sweep test to find a spindle/speed combination that will result in a torque that fits with the middle of your torque range.

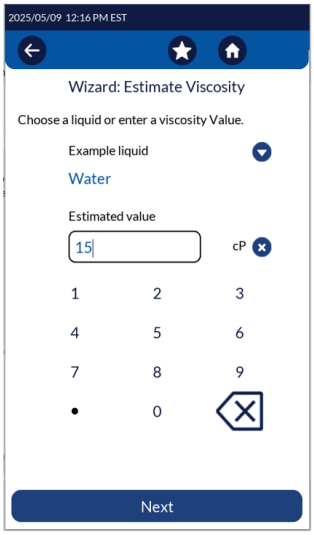


Figure II-6

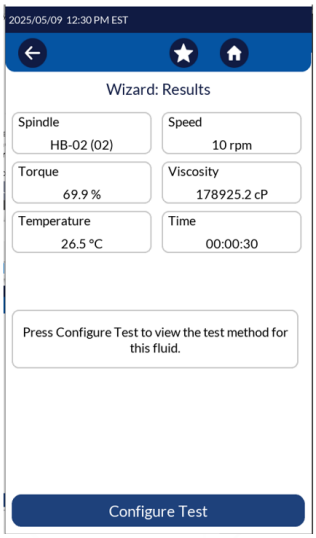


Figure II-7

Once the Wizard completes the initial testing, the Results screen will present the recommended Speed and Spindle combination. Pressing the 'Configure Test' button will automatically load these parameters into a new test configuration.

II.5.3 Load Test Method

Test programs that are created (Configure Viscosity Test) can be saved to the internal memory of the DV2Plus or to a USB Flash Drive. These files can be reloaded into the DV2Plus for immediate use through the "Load Test Method" function. A file that is placed onto a USB Flash Drive can be loaded onto any DV2Plus Viscometer.

Within the Load Test Method function, the user can access the internal memory of the viscometer or any USB Flash Drive that is connected to a USB port  . You can have as many as two USB Flash Drives connected to the DV2Plus at any time.

TIP: You can use the Manage Files function to move Test files from internal memory to a USB Flash Drive.

II.5.4 Load Results

Test results (data files) can be saved to the internal memory of the DV2Plus or to a USB Flash Drive. These files can be reloaded into the DV2Plus for review, analysis, or printing through the Load Results function. A file of Test Results that is saved onto a USB Flash Drive can be viewed on any DV2Plus Viscometer.

Within the "Load Results" function, the user can access the internal memory of the DV2Plus Viscometer or any USB Flash Drive that is connected to a USB port  . You can have as many as two USB Flash Drives connected to the DV2Plus at any time.

TIP: You can use the Manage Files function  to move Results files from internal memory to a USB Flash Drive.

II.5.5 Device Setup

Device Setup includes many tests and settings including: Perform AutoZero, Level, and Oscillation checks, access the Administration Menu, Register your Product, Advanced test settings, Printer paper size, Temperature offset, Bluetooth Setup, access the Service Menu (for Authorized Service Personnel ONLY), and Reset Admin password. These features will be covered in more detail in Section IV: Device Setup and Settings.

II.5.6 Technical Support

The Technical Support screen provides details about the instrument including Item Number, Serial Number, Torque Range, and Firmware Version. This information can be useful to verify firmware upgrades and when working with Customer Support personnel.

Figure II-8

II.5.7 Settings

The Settings menu allows users to set the default measurement units, and control setting related to sound, screen brightness, language, and time/date/number formats. This menu can be accessed through the Settings Navigation Icon in the Title Bar or from the Home screen options.

These features will be covered in more detail in Section IV: Device Setup and Settings.

II.5.8 Save Log File

The Save Log File button allows users to save a Log File to USB Flash drive. Log file includes information similar to an audit trail. A USB must be installed in order to save this data.

III. MAKING VISCOSITY MEASUREMENTS

III.1 Quick Start

The DV2Plus viscometer uses the same methodology for viscosity measurements as the Ametek Brookfield Dial Reading viscometers and DV series of viscometers. If you have experience with other AMETEK Brookfield equipment, this section will give you quick steps for taking a viscosity reading. If you have not used an AMETEK Brookfield Viscometer before, skip this section and go to Section III.2 for a detailed description.

A) Assemble.

B) Turn power on. Important: wait 10 minutes

C) Level.

D) AutoZero the viscometer (Section II.2).

E) The DV2Plus will display the "Configure Viscosity Test Screen". In this screen, select spindle and speed. Confirm that Data Collection is set to Single Point and that End Condition is set to None.

F) Introduce the spindle into the sample and attach the spindle to the coupling nut.

NOTE: Threaded spindles use left-hand thread.

G) Press the "Run" button. The screen will change to the "Running Viscosity Test Screen".

H) When you are ready to record the measurement and the end condition is NONE, result, press the "Stop Test" button. The screen will change to the Results Table.

I) Record the % torque and viscosity.

J) To run another test, press "the Back Arrow or Rerun Button". To return to the Home Screen, press the Home Icon.

III.2 Preparations for Making Measurements

A) VISCOMETER: The DV2Plus should be turned on, leveled and AutoZeroed. The level is adjusted using the two feet on the bottom of the base and using the leveling utility. Adjust the feet until the indicator is green and is inside the center target. Set the level prior to AutoZero and check the level prior to each measurement.

The proper level is essential for correct operation of the DV2Plus.

B) SAMPLE: The fluid to be measured (sample) must be in an appropriate container. The standard spindles supplied with the DV2Plus [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, and Vane spindles. 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 DV2Plus 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 guardleg attached. Measurements made without the guardleg will provide repeatable results but may not provide “true” results.

When comparing data with others, be sure to specify the sample container and presence/absence of the guardleg.

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.

Please see our publication, *More Solutions to Sticky Problems*, for more detail relating to sample preparation.

III.3 Selecting a Spindle/Speed

The DV2Plus has the capability of measuring viscosity over an extremely wide range. For example, the DV2PlusRV can measure fluids within the range of 100-40,000,000 cP. This range is achieved through the use of several spindles over many speeds. See Appendix B for details.

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

Non-Newtonian fluid behavior can result in the measured viscosity and yield stress 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: namely the same instrument, spindle, speed, container, temperature and test time.

DV2PLV Viscometers are provided with a set of four spindles and a narrow guardleg; DV2PRV Viscometers come with a set of six spindles and a wider guardleg; DV2PHA and DV2PHB viscometers come with a set of six spindles and **no guardleg**. (See Appendix F for more information on the guardleg.)

The spindles are attached to the viscometer by screwing them onto the coupling nut on the lower shaft (see Figure III-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. Spindles can be identified by the number on the side of the spindle coupling nut.

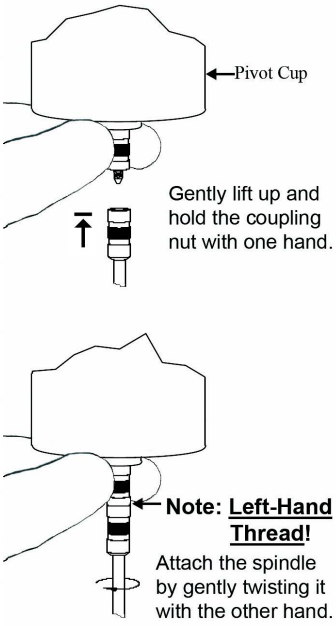


Figure III-1

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

⚠	Note: Keep the Magnetic Coupling and outer sleeve as clean as possible and free from debris that could become lodged inside the adapter.

III.3.1 Range

The DV2Plus viscometer will calculate the measurement range for a specific spindle and speed combination. This information is displayed on the screen while selecting the spindle number as shown in Figure II-6. The Range is also shown in the "Running Viscosity Test" view during the measurement. Viscosity will be displayed in the unit of measure specified in Settings and is set to centipoise (cP) from the factory.

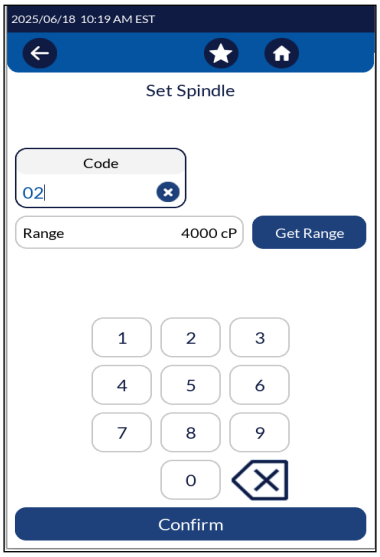


Figure III-1.1

TIP: The Range value is the same as the AutoRange available on earlier Brookfield Viscometer models.

III.3.2 Out of Range

The DV2Plus viscometer will give on screen indications when the measurement is out of range of the instrument. When the %Torque reading exceeds 100% (over range), the display of %Torque, Viscosity, and Shear Stress will be Over Range (see Figure II-7). If the %Torque value is between 0 - 9.9%, the data field label will flash. When the %Torque is below zero (negative values), the display of Viscosity and Shear Stress will be ----.

TIP: Brookfield recommends collecting data only when the %Torque reading is between 10 - 100%.

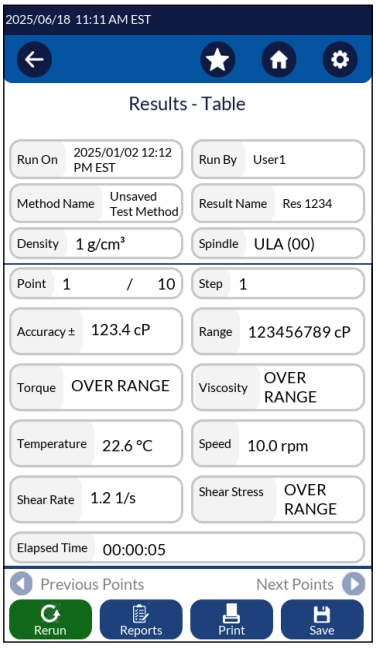


Figure III-1.2

Measurement data should not be collected when the %Torque reading is out of range. The out of range condition can be resolved by either changing the speed (reduce speed when reading is out of range: high) or changing the spindle (increase the spindle size when the reading is out of range: low).

TIP: When comparing data, the test method is critical. Be sure that you know the proper spindle and speed required for the test method. If readings are out of range, this condition should be reported as the test result.

III.4 Attaching a Spindle to the Magnetic Coupling

Align two opposing spindle slots (see Figure III-2.1) with the two pins inside the coupling (see Figure III-2.2).

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 in the coupling.

When properly aligned, there should be no gap between the spindle and the coupling (see Figures III-2.3 and III-2.4).

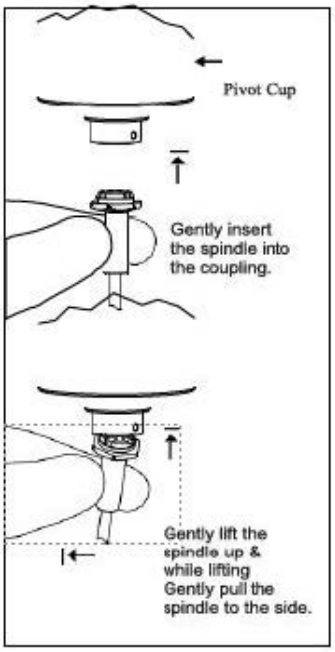


Figure III-2

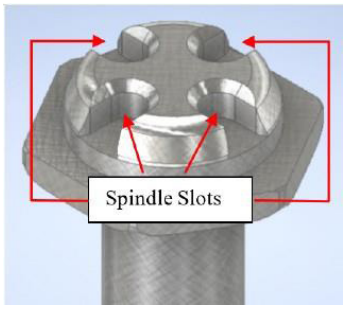


Figure III-2.1

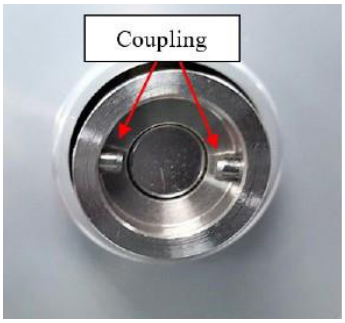


Figure III-2.2

Figure III-2.3: No Gap, Correct

Figure III-2.4: Gap, Not Correct

III.4 (continued) REMOVING A SPINDLE FROM THE MAGNETIC COUPLING

1. With the motor turned OFF, carefully grasp the spindle shaft (see Figure III-2.5). and pivot it sideways to separate it from the magnetic coupling (see Figure III-2.6). **DO NOT PULL DOWN ON THE SPINDLE!!**
2. Gently lift the spindle just enough to minimize any pressure on the pivot point and jewel inside the DV2Plus.
3. While still 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 it in a different direction.
4. Continue pushing the spindle in an unrestrictive direction until it is completely detached from the magnetic coupling.

Figure III-2.5

Figure III-2.6

III.5 Single and Multiple Data Points

The majority of viscosity and yield stress measurements are made at the quality control level and often consist of a single data point. The test is conducted with one spindle at one speed. The data point is a useful bench mark for the go/no-go decision in a production setting. The DV2Plus can be used for single point measurement.

Many fluids exhibit a characteristic change in viscosity and yield stress with a change in applied force. This non-Newtonian flow behavior is commonly seen in paints, coatings and food products as a decrease in viscosity as shear rate increases or an increase in yield stress as a rotational speed increases. This behavior cannot be detected or evaluated with the single point measurement.

Non-Newtonian flow is analyzed through the collection of viscosity data over a range of shear rates and the generation of a graph of viscosity versus shear rate (a rheogram). This information will allow for a more complete characterization of a fluid and may help in formulation and production of a product. More information on flow behavior, shear rate and rheograms is available in our publication, *More Solutions to Sticky Problems*.

III.6 Selecting Data Collection

The DV2Plus viscometer offers several options for data collection. The "Data Collection" setting is shown in "Configure Viscosity Test" directly under the QC Limits display. The factory setting is Single Point (see Figure III-3). Pressing the arrow, in this field, will present the "Data Collection" screen (see Figure III-4).

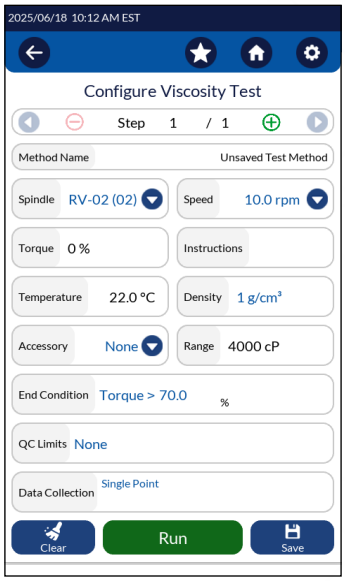


Figure III-3

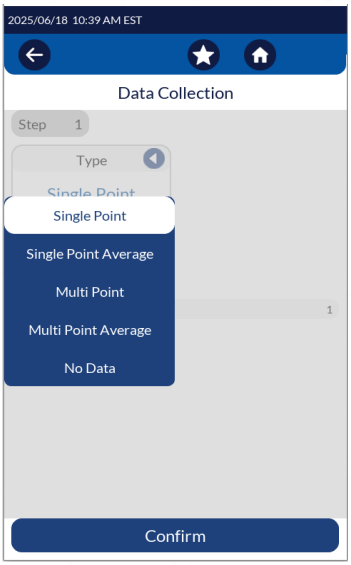


Figure III-4

Single Point: Collect only a single data point when the End Condition is met.

Single Point Average: Specify an amount of time over which to average measured data. Collect a single data point when the End Condition is met. This data point is an averaged value. If the time for averaging is shorter than the total time for the step, then the average will be performed for the specified time at the end of the test.

Example 1: The End Condition is Time with a value of 1 minute and 30 seconds, the Single Point Averaging Duration is 30 seconds, the single data point collected from this step will be an average of the data measured from 1 minute to 1 minute 30 seconds.

Multi Point: Collect multiple data points based on time. The Data Interval is specified in Hours:Mins:Secs. If the End Condition is set to Time, then the total number of points will be calculated and displayed in the Data Collection screen. If the End Condition is not based on time then it is possible that the step will conclude prior to a data point being collected. If you want a data point at the conclusion of the step regardless of the time interval, you can check the check box in the Data Interval screen.

Example 2: End Condition is Time = 2 minutes, Multi Point Data Interval is 10 seconds.
Total points collected will be 12 with the last data point taken in the last second of the step.

Example 3: End Condition is set to Viscosity = 200 cP, Multi Point Data Interval is 10 seconds. During the test the total time required to reach 200 cP is 65 seconds. Total points collected will be 6 with the last data point taken at 60 seconds, 5 seconds before the test is finished.

Example 4: End Condition is set to Viscosity = 200 cP, Multi Point Data Interval is 10 seconds. Check the check box to Also Collect Single Point at Step End. During the test, the total time required to reach 200 cP is 65 seconds. Total points collected will be 7 with the last data point taken at 65 seconds, 5 seconds after point #6 taken at 60 seconds.

Multi Point Average: Specify an amount of time over which to average measured data. Collect multiple data points based on time until the End Condition is met. Each data point is an averaged value. If the Averaging Duration is shorter than the Data Interval for the step, then the average will be performed for the specified time at the end of the Data Interval. The total number of points to be collected will be displayed if the End Condition is set to Time. If the End Condition is not based on time, then it is possible that the step will conclude prior to a data point being collected. If you want a data point at the conclusion of the step regardless of the time interval, you can check the check box in the Data Interval screen.

Example 5: End Condition is Time = 2 minutes, Multi Point Data Interval is 10 seconds. Averaging Duration is 5 seconds. Total points collected will be 12 with the last data point taken in the last second of the step. Each data point will be an average of the data measured in the last 5 seconds of each Data Interval.

Example 6: End Condition is set to Viscosity = 200 cP, Multi Point Data Interval is 10 seconds. Averaging Duration is 5 seconds. During the test, the total time required to reach 200 cP is 63 seconds. Total points collected will be 6 with the last data point taken at 60 seconds, 3 seconds before the test is finished. Each data point will be an average of the data measured in the last 5 seconds of each Data Interval.

Example 7: End Condition is set to Viscosity = 200 cP, Multi Point Data Interval is 10 seconds. Averaging Duration is 5 seconds. Check the check box to Also Collect Single Point at Step End. During the test, the total time required to reach 200 cP is 65 seconds. Total points collected will be 7 with the last data point taken at 65 seconds, an average of the 5 seconds after point #6.

Example 8: End Condition is set to Viscosity = 200 cP, Multi Point Data Interval is 1 minute. Averaging Duration is 20 seconds. Check the check box to Also Collect Single Point at Step End. During the test, the total time required to reach 200 cP is 10 minutes 40 seconds. Total points collected will be 11 with the last data point taken at 10 minutes 40 seconds, an average of the last 20 seconds of the step.

No Data: End Condition is met and no data is collected.

III.7 End Condition

The completion of a test is defined by the End Condition. Each time that you enter "Configure Viscosity Test", the End Condition will be set to the last value used. The End Condition parameter or values can be changed by pressing the End Condition button.

Within the End Condition screen, the currently selected End Condition parameter and values are displayed. The End Condition can be changed by pressing the blue down arrow within the parameter field. Eight End Conditions are available:

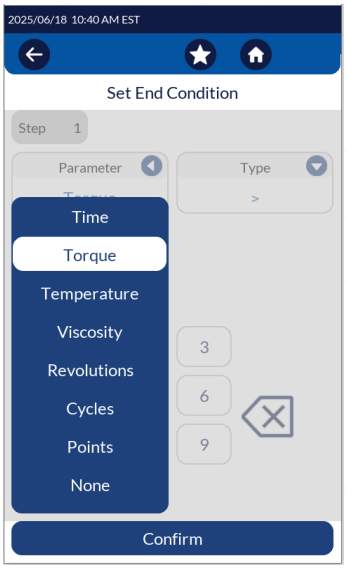


Figure III-5

Time: The test will complete when the specified amount of time has elapsed. Time is entered in Hours, Minutes, and Seconds.

Hours: 0-48
Minutes: 0-59
Seconds: 1-59

A time of zero hours, minutes and seconds may be selected. With this End Condition, the DV2Plus will operate at the selected speed until the operator selects Stop Test. Data will be collected according to the Data Collection setting (see Section III.6).

TIP: An End Condition of zero Time can be useful when measuring a new material. During the test, the speed can be changed without ending and then rerunning the test (see Section III.10). This method can allow you to quickly evaluate the spindle selection to determine the best speeds for testing.

# of Points: The test will complete when the specified number of data points has been collected. Data is collected according to the Data Collection setting (see Section III.6). The range of data points is: 1 – 5000.

# of Revolutions: The test will complete when the specified number of revolutions of the spindle has occurred. Data is collected according to the "Data Collection" setting (see Section III.6). The range for number of revolutions is: 1 – 9,999.

Torque %: The test will complete when the specified Torque value is measured. Data is collected according to the "Data Collection" setting (see Section III.6). The range of values for the measured Torque is: 0.0-100.0%.

Viscosity: The test will complete when the specified viscosity value is measured. Data is collected according to the Data Collection setting (see Section III.6). The range of measured Viscosity is 0 – 10,000,000,000 cP.

Note: The Viscosity End Condition should be selected in consideration of the Range provided by the spindle and speed selected. Check the Range value by selecting Spindle in Configure Viscosity Test.

Temperature: The test will complete when the specified Temperature value is measured to within the indicated Tolerance. The Tolerance specifies how close the measured temperature should be to the specified temperature value to consider the target reached. Temperature is measured through the use of a connected Brookfield temperature probe (DVP-94Y, SC4-XXRPY chamber). Data is collected according to the Data Collection setting (see Section III.6).

Temperature: -100 – 300°C
Tolerance: 0.0 – 9.9°C

TIP: A small tolerance value will require a much longer time to reach the End Condition.

Cycles: If using an HPQA in integrated mode, this 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. See Appendix L for more details..

III.8 Additional Test Parameters

QC Limits: Select an acceptable range for measurement results. The range may be defined by Viscosity, Torque, Time, Temperature, Cycles, Shear Stress, or None. The possible range for Viscosity will be defined by the spindle and speed selected. QC Limits are a visual and audible signal to the operator during the test. The data set does not include an indication of QC Limits violation.

A violation of the QC Limits during the test will be indicated by a red box around the display for the specified parameter. A violation will also result in an audible beep and a red "X" at the top of the screen as a warning message (see Figure III-6). Data will continue to be collected while the warning message is displayed.

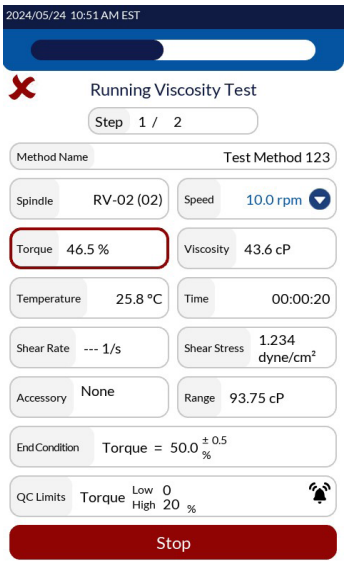


Figure III-6

When Viscosity or Torque are the selected QC Limits parameter, QC Limits will be shown during the test on the Trend Bar if that parameter is selected for display (see Figure III-7). The QC Limits are represented by the dashed lines.

TIP: Audible alarms may be turned off by touching the Bell Icon during the Test Run.

TIP: An indication of a QC Limit violation is not part of the data set. The user can record a violation by using the

Notes available when viewing test Results (see Section III.10).

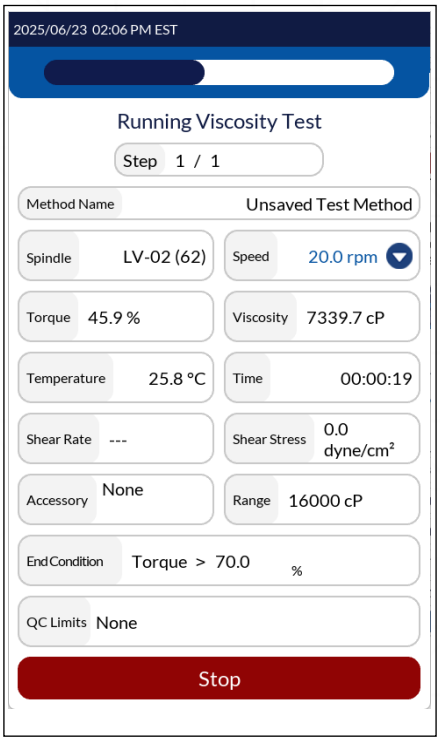


Figure III-7

Instructions: Record specific instructions to the operator. This information will be presented immediately when the program is run (see Figure III-8). The operator is required to acknowledge the message before the program will continue.

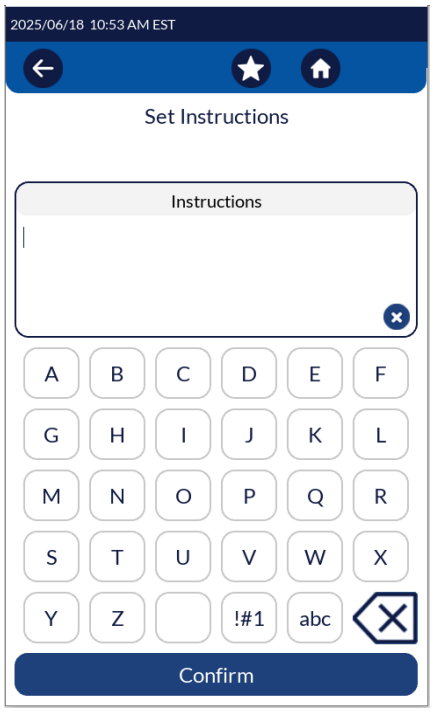


Figure III-8

Reports: Reports are available post-test on the Test Results screen.

Upon the conclusion of a test, the user will be presented with a data table. Once in the "Results" section, the down arrow can be used to change the view.

Post Test Averaging can be specified as either "Test Averaging" or "Step Averaging". Test Averaging allows you to select which step from the program is to be averaged and displayed. Step Averaging is used when there is a single test step (as created from the display of DV2Plus). See Section III.11 for more detail relating to Data Averaging.

Density: Input a density value for the sample to be tested. This value will be used to calculate viscosity when kinematic viscosity units have been chosen for display (see Section IV: Settings).

III.9 Running a Test

A viscosity test is started by pressing the Run button on the "Configure Viscosity Test" screen. When Run is pressed, the display will change to the "Running Viscosity Test" screen (see Figure III-9).

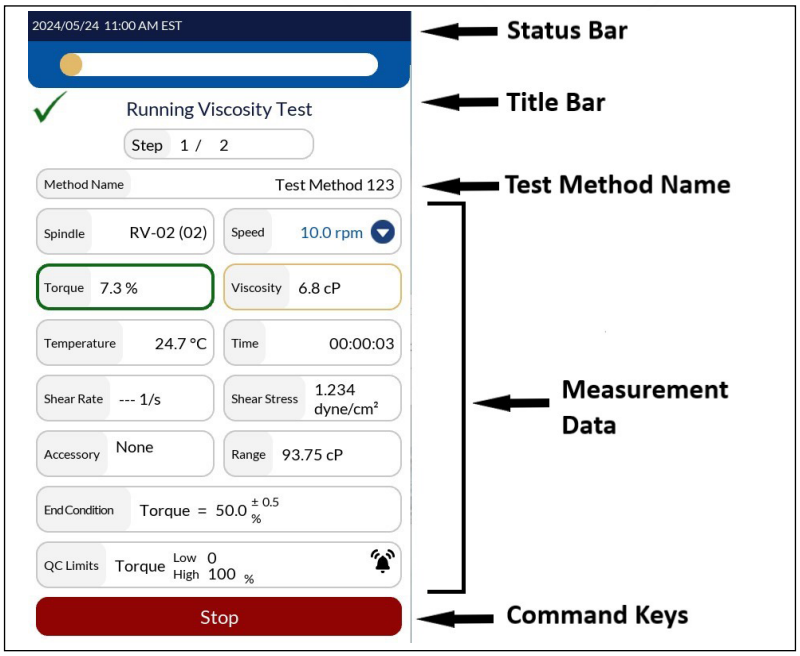


Figure III-9

The Running Viscosity Test screen provides information on the current measurement including: Torque, Viscosity, Shear Stress, Shear Rate, Temperature and Speed.

Torque is the deflection of the viscometer torque sensor. It is described as a percent (%) and has a range of 0 – 100%. The DV2Plus will provide measurement results within the stated accuracy provided the Torque reading is between 10 and 100%. If the Torque reading falls below 10% the border of the data field will turn yellow to indicate an error condition. Brookfield does not recommend that data be collected below 10% Torque; however, data collection is not restricted.

TIP: Torque on the DV2Plus is equivalent to the dial reading from the Brookfield Dial Reading Viscometer or the % reading from Brookfield Digital Viscometers (DV-E, DV-I, DV-II, DV-III).

Viscosity is calculated from the measured Torque based on the selected spindle and speed of rotation. The units of viscosity are defined in the Settings Menu . If the Torque reading falls below 10%, the border of the data field will turn yellow to indicate an error condition.

Shear Stress is calculated from the measured Torque based on the selected spindle. The units of shear stress are defined in the Settings Menu . If the Torque reading falls below 10%, the border of the data field will turn yellow to indicate an error condition.

TIP: Shear Stress will be displayed as --- for spindles that do not have SRC values.

Shear Rate is calculated from the selected speed based on the selected spindle.

TIP: Shear Rate will be displayed as --- for spindles that do not have SRC values.

Temperature is the input value from a connected AMETEK Brookfield DVP-94Y temperature probe. Some AMETEK Brookfield accessories include temperature probes (Thermosel) or optional chambers with embedded temperature probes (Small Sample Adapter). The units of temperature are defined in the Settings Menu

The temperature display will be ---- when no temperature probe is connected.

Speed is the selected speed from the "Configure Viscosity Test" screen.

TIP: Speed can be changed by simply touching the Speed field on the Running Test screen.
TIP: When Speed is changed, the Test Name will be changed to unsaved.

Command Keys are available on the Running Viscosity Test screen: Stop Test.

Stop Test: Immediately stops the current test. If any data had been collected during the test, the user will be presented with the "Results" screen (see Section III.10). If data was not collected, the user will be returned to the "Configure Viscosity Test" screen.

TIP: If the speed is changed during the execution of a saved test, then the test status will be changed to “Unsaved Test”. This will also be reflected if the collected data is saved.

III.10 Results

Measurement data is viewed in the "Results" screen. This screen is presented at the conclusion of a test or when data is loaded through the "Load Results" selection from the Home Menu.

The DV2Plus utilizes a comprehensive data format. Data files include the complete set of measurement results and calculated values along with the test protocol. All elements of the test can be viewed in the "Results" screen.

The DV2Plus Viscometer allows for 5,000 total data points per file. When viewing large data files, additional time is required when moving from the various Results options listed below. There may be some delay on the screen while the DV2Plus prepares the data.

The Results screen includes several Navigation Icons and Command Keys.

Home: Return to the Home Menu.

Print: Print Data to USB printer.

Save: Save data.

Reports: View report options

Rerun: Rerun last test.

The "Reports" screen offers several options for viewing test data. These options are accessed by selecting the desired report button on the Results-Reports screen. (see Figure III-11).

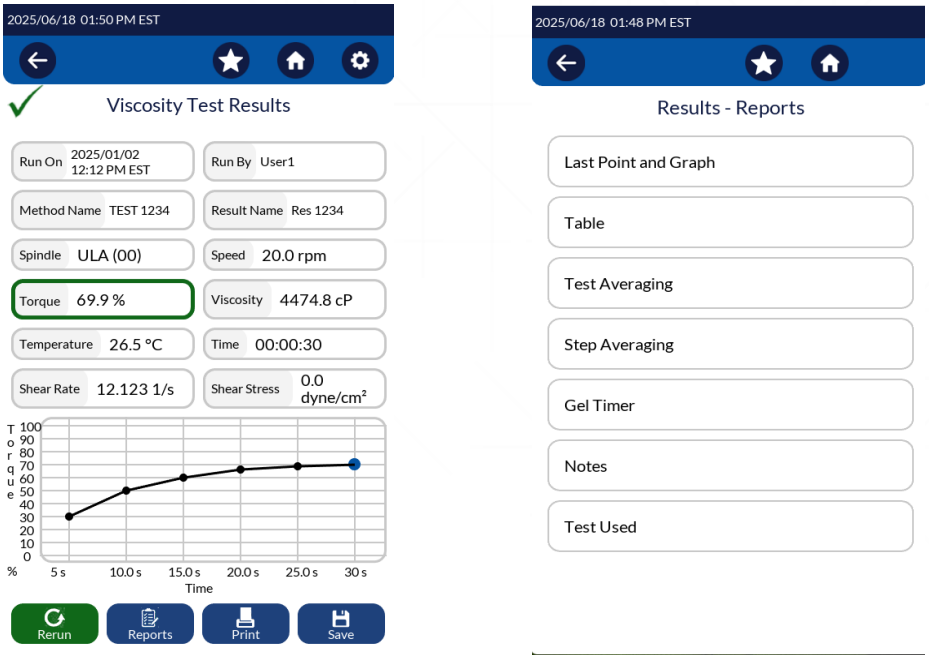


Figure III-11

Table: Display all data points. Data will be shown in a scroll list where each page can hold a maximum of 50 points. If the data set has more than 50 points, then additional pages will be indicated at the bottom of the screen. Additional pages of data can be accessed through the use of the Blue Arrows.

Each data point includes: Viscosity, Torque, Speed, Temperature, Time, Shear Stress (SS), Shear Rate (SR), Density, and Accuracy.

Test Averaging: Average and Standard Deviation are calculated for measured and calculated parameters including: Viscosity, Torque, Shear Stress, and Temperature.

Test Averaging is calculated regardless of the Data Collection setting. If Data Collection was set to Multipoint Averaging, then the Test Averaging will calculate an average of the averaged data.

Test Used: Display the test elements used to generate the data set. In this view, the "Configure Test" button is available. Selecting "Configure Test" will program the DV2Plus to run the same test utilized to collect the data set being viewed and present the "Configure Viscosity Test" screen.

Notes: Document any relevant information about the test or data. This information will be stored with the data set once saved.

Gel Timer: Display basic information about data related to gel timer tests.

III.11 Data Averaging

The DV2plus Viscometer offers two techniques to average data, Live Averaging and Post Test Averaging. Data averaging can be useful when measuring samples with entrained air or suspended particles that cause some variation in measurement results. Data averaging may not be useful when changes in measurement results are caused by the rheological properties of the test sample such as thixotropy or pseudoplasticity (shear thinning).

Materials that exhibit thixotropy will show a steadily decreasing measured viscosity over time. Materials that exhibit pseudoplasticity will show a changing viscosity as the spindle speed changes.

TIP: When averaging data for a thixotropic material, begin the Averaging Duration after the period of most significant change in measured viscosity. This will reduce the variability in the averaged value.

TIP: When averaging data for a pseudoplastic material, do not average together (Test Averaging) data collected at different speeds (or shear rates).

Live Averaging of data occurs during actual testing of a sample. Data can be collected as an average of readings over a specific time interval; each data point saved in the file is an averaged value. This averaging is defined in the "Data Collection" section of "Configure Viscosity Test".

Single Point Averaging requires a definition of Averaging Duration, the amount of time for which readings will be averaged. This time parameter will be applied at the end of the End Condition. In this case a single data point will be collected which represents the average of all data measured during the specified time period (Averaging Duration).

Multi Point Averaging requires a definition of 1) Data Interval: the frequency of data collection and 2) Averaging Duration: the amount of time for which readings will be averaged. These two parameters will work in conjunction to generate multiple data points each of which represent the average of all data measured during the average duration within the specified Data Interval.

Post Test Averaging of data occurs after the test is complete, through the "Results" screen. Averages and standard deviation values can be generated for data collected in a single step or across two steps. If the test used to collect data utilized Live Averaging (described above), then the Post Test Averaging will produce an average value of averaged data points.

Post Test Averaging offers two options: Step Averaging and Test Averaging

Step Averaging: Calculate Average and Standard Deviation for all data collected within a single step test (all tests created directly on the DV2Plus are single or two step tests). Step Averages will be displayed as shown below in Figure III-14.

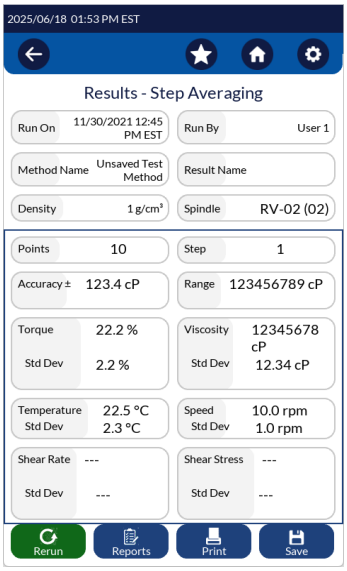


Figure III-14

Test Averaging: Calculate Average and Standard Deviation for all data collected within step specified. Test Averages will be displayed as shown below in Figure III-15.

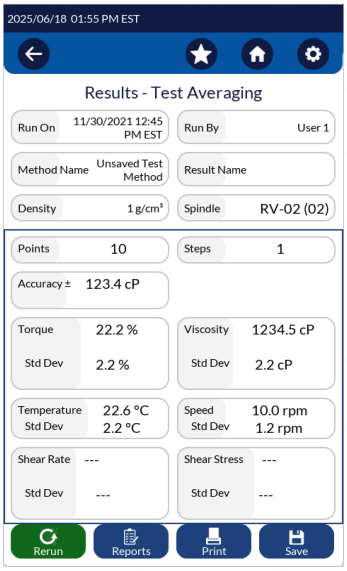


Figure III-15

IV. DEVICE SETUP, ADMINISTRATION, & SETTINGS

Many of the instrument controls, settings, administration features can be found under the Device Setup, Administration, and Settings menus. In this section we will cover the various options available in the DV2Plus viscometer.

IV.1 Device Setup

The DV2Plus Device Setup screen can be accessed from the Home Screen menu. Press the Home Icon and then select the Device Setup button. The Device Setup menu provides access to instrument setup and verification tests, Administrator tools, Printer settings, Advanced Test Settings, Bluetooth setup, and more

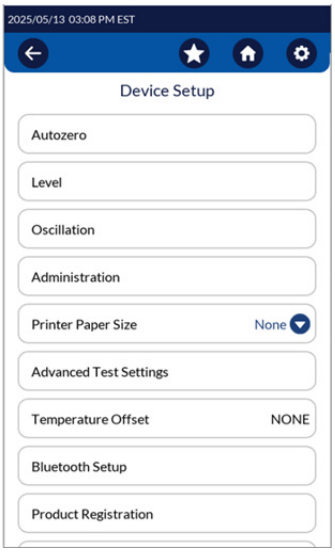


Figure IV-1

IV.1.1 Autozero, Level, and Oscillation Tools

Users can perform instrument setup and verification operations by accessing the Autozero, Level, and Oscillation Tools feature in the Device Setup Menu.

Autozero: The Autozero test will allow users to perform the Autozero test prior to any critical measurements if required. This test is performed at startup, but some users may want to run the test again. See Figure IV-2

Level: The Level feature will allow users to verify and adjust the level of the DV2Plus viscometer. After the viscometer has been setup in the intended testing location, users can adjust the two leveling feet located at the front of the base casting. Adjust the leveling screws until the level bubble is in the middle of the target and turns green.
See Figure IV-3

Oscillation: The Oscillation button will allow users to perform an Oscillation Check to verify the health of the measurement system. If the instrument does not pass the Oscillation Check, the instrument will need to be serviced.
See Figure IV-4

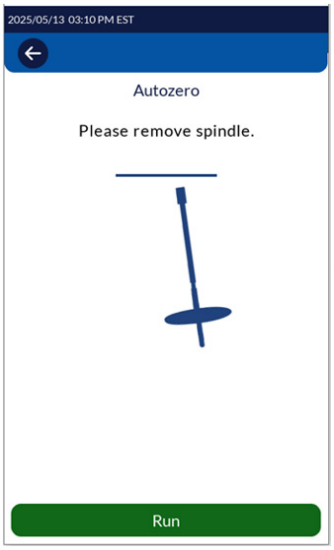


Figure IV-2

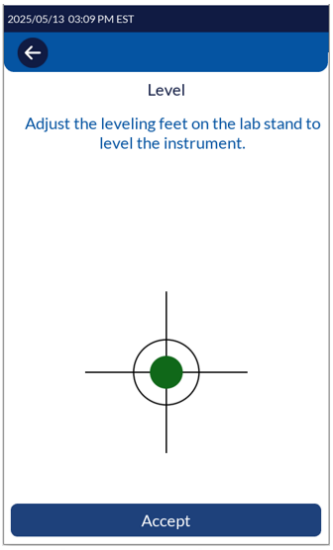


Figure IV-3

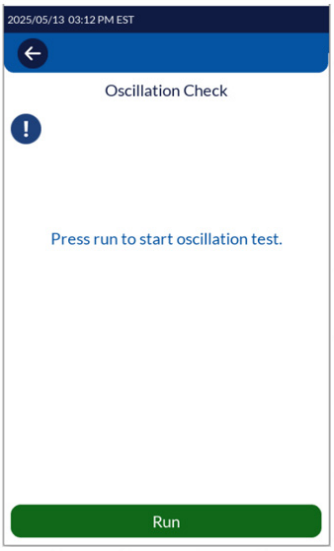


Figure IV-4

IV.1.2 Administration

The Administration menu allows access add custom spindles and speeds, set the date and time, define users and access levels, manage files and folders, manage favorite tests, perform Firmware updates, perform instrument backups, import files, and reset your system and settings. These features will be covered in detail in Section IV.2

IV.1.3 Printer Paper Size

The Printer Paper Size drop down box allows users to choose the type of paper they are using with the compatible Dymo LabelWriter 550 Turbo label printer. See Figure IV-5

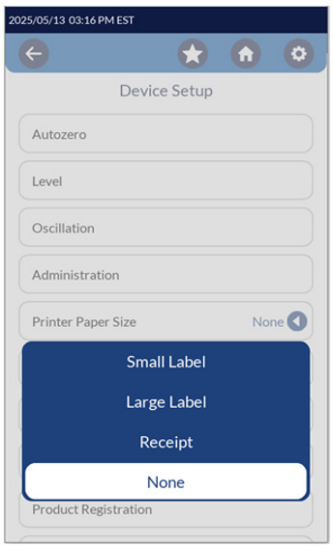


Figure IV-5

IV.1.4 Advanced Test Options

The Advanced Test Options screen allows customers to define alarms and actions that will apply to every test run.

The Global Alarm Parameter allows users to define an alarm to occur based on Torque, Viscosity, Temperature, or Shear Stress readings. Once the measurement parameter is chosen, the user will need to define the Low and High allowable limits. An alarm will sound during testing if the value goes outside these limits. See Figures IV-6, 7, & 8

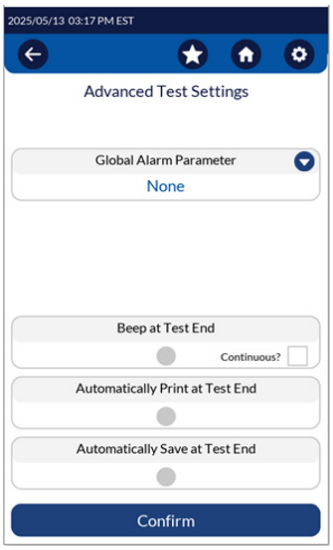


Figure IV-6

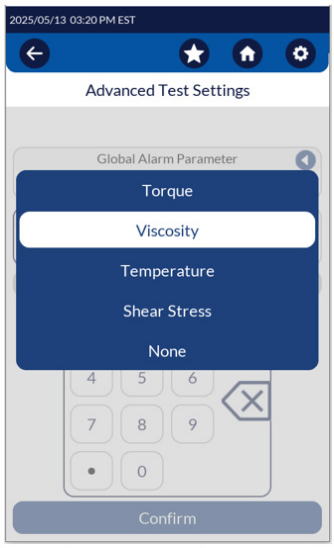


Figure IV-7

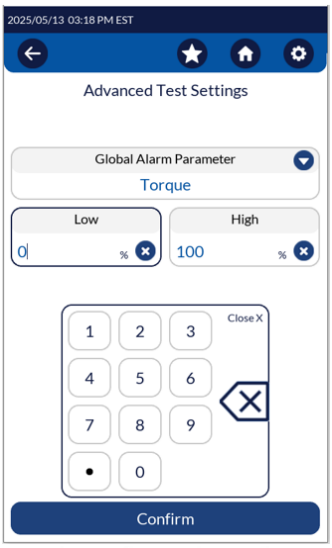


Figure IV-8

Users also have options to sound an audible Beep after each test, and Print and/or Save the results after every test.

IV.1.5 Temperature Offset

The Temperature Offset setting allows the user to create up to 10 temperature offset values for connected temperature probes. Brookfield offers several types of temperature probes for use with the DV2Plus including: DVP-94Y immersion probe (optional accessory with the DV2Plus), and SC4-13RP embedded probe (optional with Small Sample Adapter). Any of these probes can be calibrated locally against a standard reference thermometer to determine an offset (how far from the actual temperature does the probe read). This offset can be entered into the DV2Plus Viscometer and identified with a name defined by the user.

When Temperature Offset is selected in the Device Setup menu, the Temperature Offset menu is presented (see Figure IV-9). From this menu you can create new offset values by pressing the "Add Probe Offset" command key at the bottom of the screen and you can select which offset to utilize with the DV2Plus by pressing the circle beside the name.

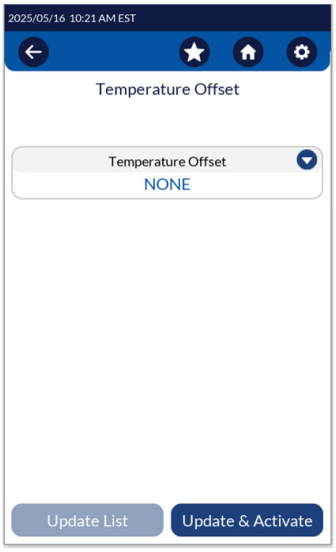


Figure IV-9

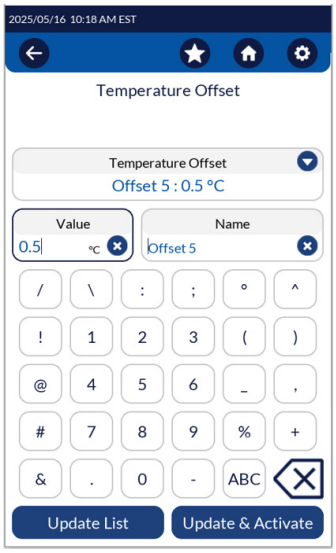


Figure IV-10

The creation of a Temperature Offset requires input of the offset value and a name. The offset value must be in the range of -9.9 to 9.9 C. The name can be up to 14 characters long. To delete an existing Temperature Offset, first select the offset from the list, then press the "Delete" command key at the bottom of the screen.

The use of a Temperature Offset will be indicated in the Temperature field displayed in the Configure Viscosity Test screen with a (o) beside the Live indication.

IV.1.6 Bluetooth Setup

Bluetooth connectivity is an optional feature that must be ordered as part of the DV2Plus configuration. This feature is not available in all countries. Bluetooth connectiivity can be used in conjuction with the DV Create software program.

DV Create features include:

- Live monitoring of tests
- Create new test methods
- Create Multi-step tests up to 25 steps
- Automatic data transfer at completion of test
- Convert DV2T and DVNext files (test methods and results) to DV2Plus file format

The Bluetooth Setup screen will allow users to create a name for their DV2Plus instrument that can be discovered when connecting to via Bluetooth. See Figure IV-11.

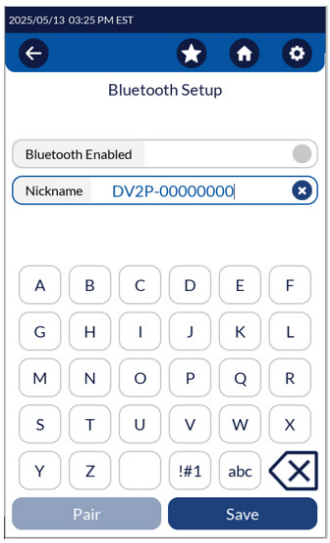


Figure IV-11

IV.1.7 Product Registration

The Product Registration page will provide a QR code for easy access to register your instrument. You may also use this direct link: https://www.brookfieldengineering.com/contactus/register-product

Registering your instrument will ensure better support and notification of new product updates and offerings.

Figure IV-12

IV.1.8 Service

The Service menu is only accessible to Authorized service technicians.

IV.1.9 Reset Admin Password

The Reset Admin Password button should only be used if all Administrators (up to 2) have forgotten their password. The DV2Plus allows 2 Administrators to be created. If one has forgotten their password, the other Administrator may reset their password via the Users and Access menu.

If all Administrators have forgotten their passwords, you will need to contact Ametek Brookfield's technical support team to get a Password Reset Key. This key file should be put on a USB stick and plugged into the back of the DV2Plus. The user will then have access to reset the password for all Administrator using this feature. Pressing this button will reset all Administrator accounts back to the default 'admin' login password. See Figure IV-13

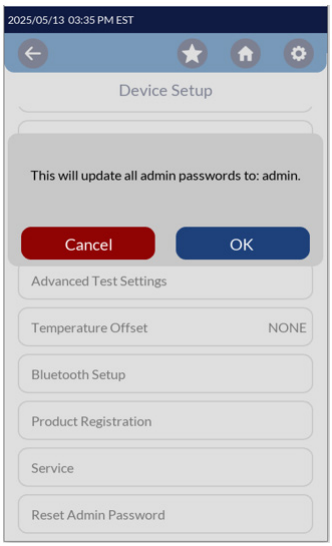


Figure IV-13

IV.2 Administration

The Administration menu allows access to add custom spindles and speeds, set the date and time, define users and access levels, manage files and folders, manage favorite tests, perform Firmware updates, perform instrument

backups, import files, and reset your system and settings.

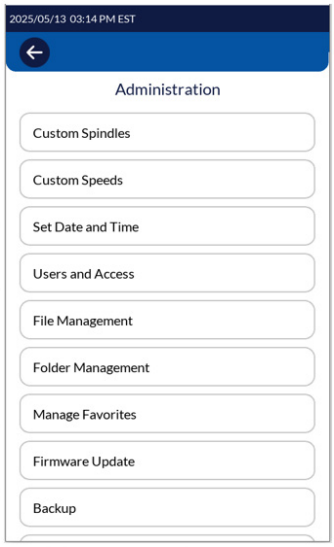


Figure IV-14

IV.2.1 Custom Spindles

The Custom Spindles screen allows users to add new and custom spindles that may not be part of the standard geometries. To add a custom spindle, enter the ID code, SMC, and SRC values that have been provided with your spindle or calculated. See Figure IV-15.

To modify a saved custom spindle, select the spindle from the list and remove it. Once it has been removed, you can add it again with the modified values.

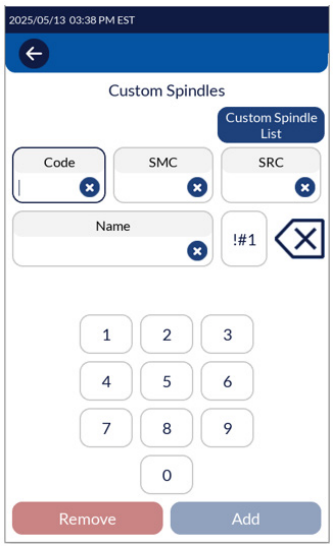


Figure IV-15

IV.2.2 Custom Speeds

The Custom Speeds screen allows users to add new custom speeds to the standard drop down list. This feature may be useful for users that routinely test at a speed that is not in the standard drop down list. The Range will automatically be calculated. See Figure IV-16.

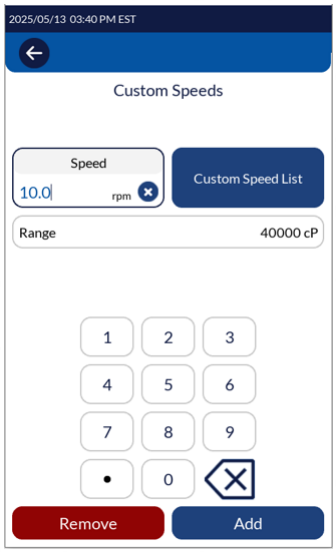


Figure IV-16

IV.2.3 Set Date and Time

The Time, Date, and Time Zone are displayed on the Status Bar at the top of every screen. These parameters are set within the "Set Date and Time" menu. The format for setting Time and Date will be based on the Settings (see Section IV.3: Settings). Select the proper Date, Time and Time Zone for your location and press 'Confirm' at the bottom of the page to accept the changes.

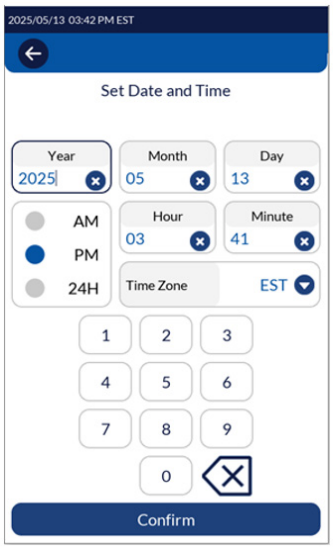


Figure IV-17

IV.2.4 Users and Access

The User and Access Permissions menu allows the user to define the Log In requirement and toggle the "Lock Out" feature within "Running Viscosity Test" (see Figure IV-9).

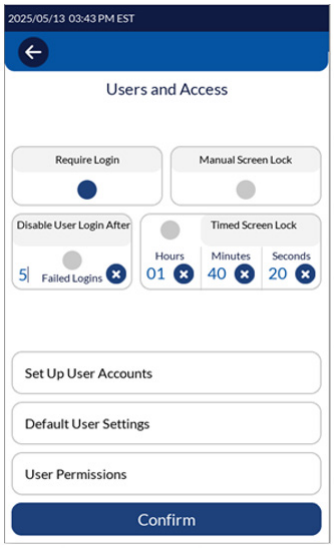


Figure IV-18

The "Require Login" check box controls the Login requirement. When Require Login is checked, the DV2Plus will require a User ID and Password prior to allowing any activity. The "Log In" screen is presented on power up or when the User Icon is selected from the Home Menu. The user must select their User ID from the drop-down list and then enter their password. The Log In requirement is removed when the check box is unchecked.

Note: Administrator default password is admin.

The "Manual Screen Lock" check box controls the Running Viscosity Test "Lock Out" function. This function is only available when User Login is required. When "Manual Screen Lock" is checked, the user may lock the DV2Plus during a test. The Lock Out is set by pressing the Lock Icon found in the Navigation Bar of Running Viscosity Test. Any touch of the screen during the Lock Out will show the user a Log In screen. No action can be taken on the DV2Plus until the proper password is entered. Only the User ID that was in effect when the Lock Out was initiated can unlock the DV2Plus. The test will continue to collect data during the Lock Out.

The “Timed Screen Lock” check box controls the automatic feature of "Lock Out". Set the Timed Lock Out time value hours, minutes, and seconds. The DV2Plus will lock automatically (without touching the Lock Icon) after the test is initiated (press "Run") when the screen has not been touched for the time specified. For example: Timed Lock Out is set to 1 minute; 30 seconds after the test has begun, the operator reviews the test parameters by touching Views Test; the DV2Plus will lock automatically 1 minute after that key press (90 seconds after the test began running).

TIP: The "Lock Out" feature can be useful if the operator must leave the DV2Plus unattended during a test.

The “Disable User Login After” parameter defines how many failed Log In attempts are allowed before the User ID is locked. The range for Lock Out After is 1 – 20. Once a User ID is locked, the administrator must reset the password.

User Accounts Setup and Permissions

The DV2Plus can be set up with User accounts to restrict access and enhance data tracking. One user level below the Administrator is available within the DV2Plus. This User level can be customized by the Administrator. All user accounts require a password for access to the DV2Plus.

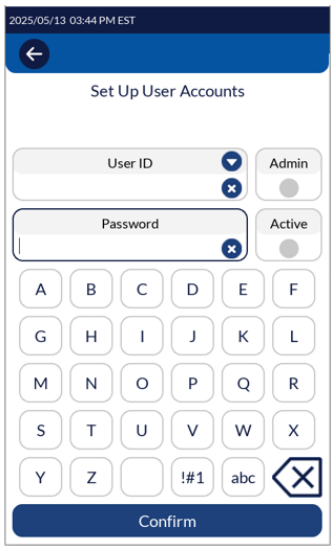


Figure IV-19

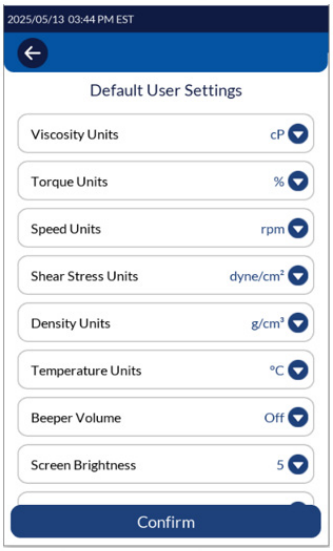


Figure IV-20

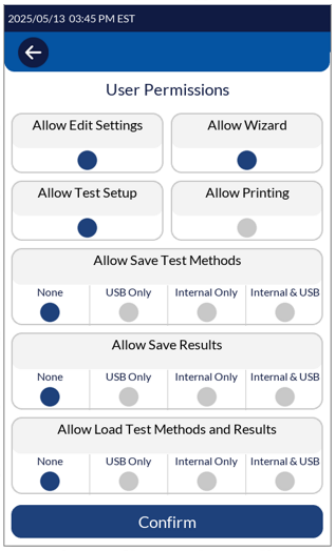


Figure IV-21

The User Settings are divided into three categories; Set Up User Accounts, Default User Settings, User Permissions. The administrator can customize User through the User Level Access in the Users and Access Menu. Place a check mark beside an attribute that is available to the user and remove the check mark from an attribute that will be unavailable to the user.

The User ID utilized at Log In will be reflected in a saved data set. This parameter is viewable in the Results screen by selecting Device Info.

TIP: The User ID information is only visible once a data set is loaded from memory. An unsaved data set will not show the User ID.

The Set Up User Accounts screen allows administrators to create new User IDs with unique passwords. Selecting the Admin box will set the new user as an Administrator. There can be 2 active Administrator accounts and up to 12 Users in total. By default, the unit starts with 2 administrator accounts and 10 user accounts with generic names. The Administrator can activate and change the names and access for these as needed. See Figure IV-19.

The Default User Settings allows administrators to set the default units and instrument settings for all User levels. See Figure IV-20.

The User Permissions screen allows administrators to customize the levels of access and actions that Users are able to perform. See Figure IV-21.

IV.2.5 File and Folder Management

With DV2Plus, users can Copy, Move, Rename, and Delete Files in the File Management screen and entire folders in the Folder Management screen. See Figures IV-22 & IV-23.

Figure IV-22

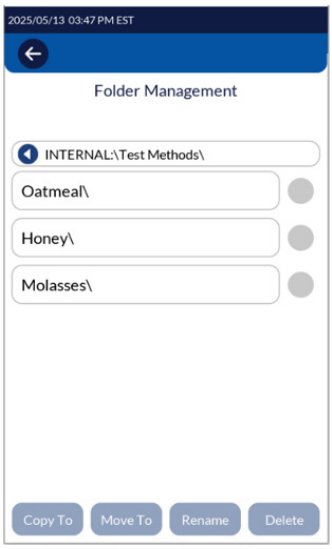


Figure IV-23

The features for both File and Folder Management are very similar. Examples below are shown via the Folder Management menu. Select Folder Management, then choose the desired Folder. Press the corresponding button to Copy, Move, Rename, or Delete the folder.

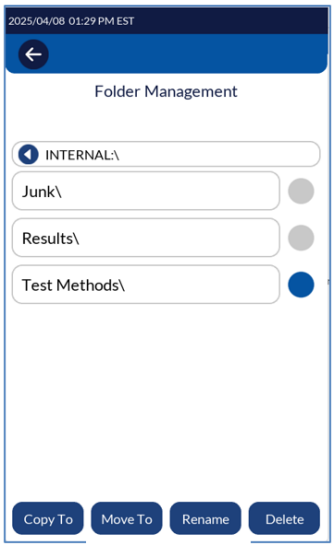


Figure IV-24

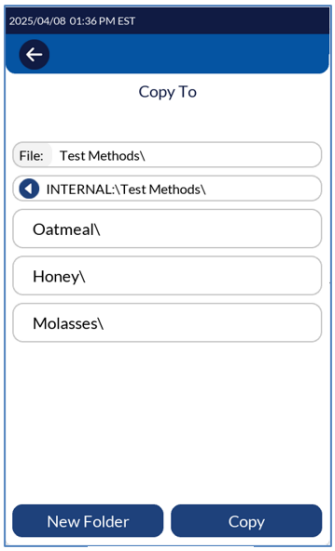


Figure IV-25

To copy a folder, choose the source folder, select Copy To, then select the destination for the folder to be copied to. Press Copy. See Figure IV-25.

To move a folder, choose the source folder, select Move To, then select the destination for the folder to be moved to. Press Move. See Figure IV-26.

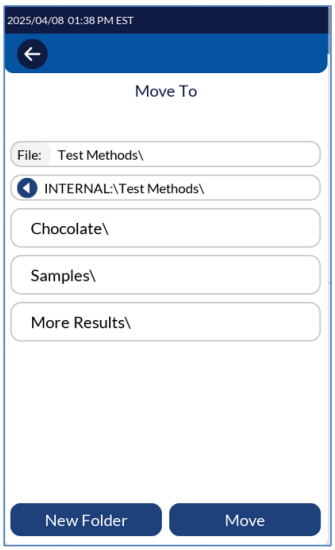


Figure IV-26

To rename a folder, choose the source folder, select Rename, then enter the new folder name. See Figure IV-27.

To delete a folder, choose the source folder, then select Delete. See Figure IV-28

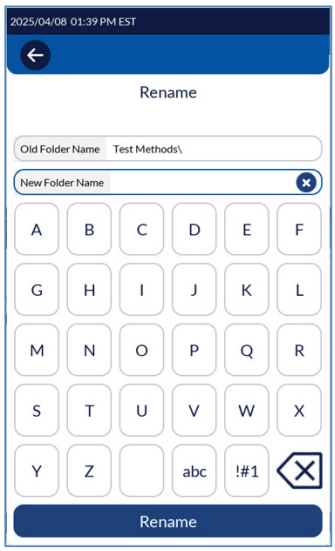


Figure IV-27

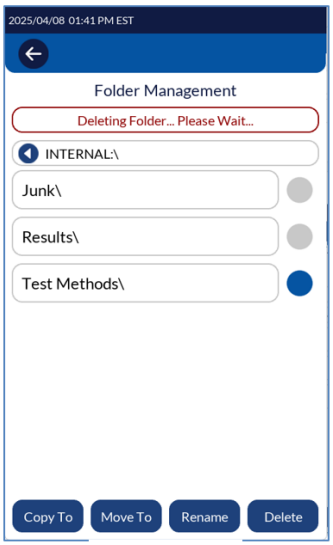


Figure IV-28

IV.2.6 Manage Favorites

The Manage Favorites menu allows users to Clear or Remove test methods from the list of saved favorites. Simply select the test method from the list of Favorites and press Remove Selected File. To completely clear the list, press Clear All Favorites at the bottom right of the screen. See Figure IV-29.

Figure IV-29

IV.2.7 Firmware Update

The internal operating software of the DV2Plus can be updated from a USB Flash Drive as new versions become available from Ametek Brookfield. Insert a USB Flash Drive into the DV2Plus that contains the operating software file in the root folder of the drive. Select Firmware Update from the Administration menu and select the appropriate file. Press the Next command button to begin the Firmware Update process. Wait until the DV2Plus has completely rebooted before continuing. See Figure IV-30.

Figure IV-30

IV.2.8 Backup and Import

The DV2Plus Viscometer provides several options relating to storage of Results, Tests and User Settings. Backup and Import menu options relate to creating back up files, updating instrument software, and updating language files.

Backup: Create a backup file from the DV2Plus internal memory including: Settings, User Profiles, Results, and Tests. This backup file is saved to a USB Flash Drive and can be uploaded (Import) to any DV2Plus Viscometer.

All files will be saved to the root folder of the USB Flash Drive. Press the Backup button to create the Backup file. See Figure IV-31.

TIP: You can preserve historical backup files by using multiple USB Flash Drives.

Import: Upload Test & Results Files, Settings, and Users from a Backup File.

Locate the Backup file on the USB Flash Drive. Press the Import button to upload Files, Settings, and/or Users, as desired, from the Backup file. See Figure IV-32.

Figure IV-31

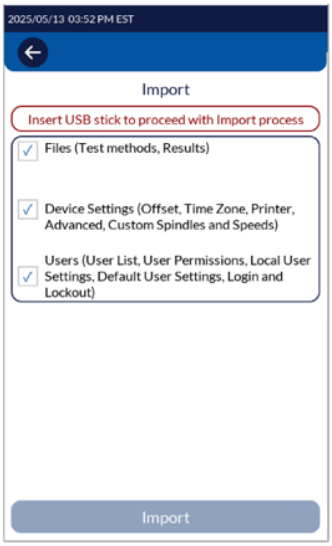


Figure IV-32

IV.2.9 Automatic Backup

Automatic Backup allows users to ensure that the backup of critical data can happen on a regular basis. To enable, check the Automatic Backup Enabled box and select a frequency from the drop down list. See Figure IV-33.

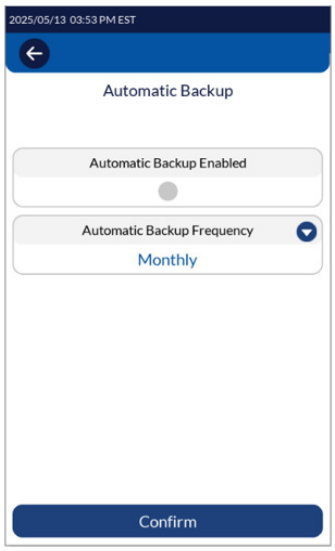


Figure IV-33

IV.2.10 Reset Settings

Settings Reset will return the DV2Plus settings (Device, User and Global) to the factory default. Internal memory will not be affected. User accounts will not be affected. See Figure IV-33.

IV.2.11 Reset System

DATA LOSS POSSIBLE!
Reset System will return the DV2Plus to the factory default condition. All data, tests and Audit Trails will be deleted

from internal memory. All User accounts will be deleted. See Figure IV-34.

TIP: Move data files and test files to a USB Flash Drive prior to selecting "Reset System"

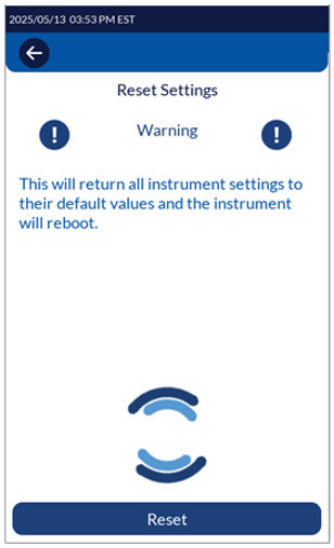


Figure IV-34

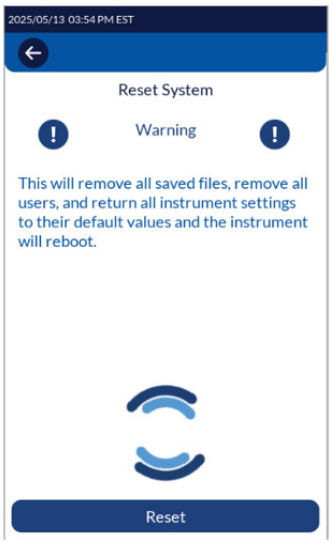


Figure IV-35

IV.2.12 Calibration Reminder

The DV2Plus has a calibration reminder feature that is designed to inform users that the instrument is due for a factory calibration. This is initially set by AMETEK Brookfield and is reset after each factory calibration.

The "Calibration Reminder" will be presented during the first power up on or after the specified day.

IV.3 Settings

The Settings Menu provides users the ability to control the default measurement units, beeper volume, screen brightness, system language, number format, and time and date formats. The settings menu can be accessed by pressing the gear icon in the title bar or directly from the Main Menu.

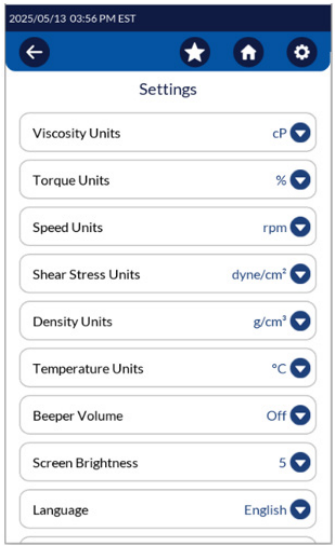


Figure IV-36

The following settings are found in this scrolling menu:

Viscosity Units Set the unit of viscosity measurement: cP, Pa•s, mPa•s, P, cSt, mm2/s

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
cSt	centistokes	100 cSt = 100 mm²/s = 1 St
mm²/s	square millimeters per second	1 mm²/s = 1 cSt

Torque Units Set the unit of torque measurement: %, mNm, dyne•cm

Speed Units Set the unit of speed: rpm (rotations per minute), 1/s (reciprocal seconds)

Shear Stress Units Set the unit of shear stress measurement: dyne/cm2, N/m2, Pa

Density Units Set the unit of density measurement: g/cm3, kg/m3, SG

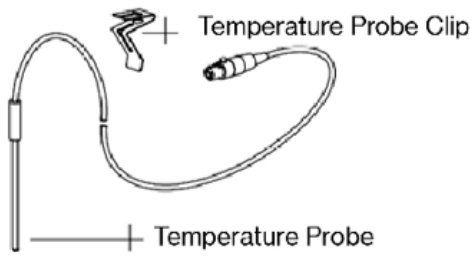
TIP: Density and viscosity are both sensitive to temperature. When using a density value in Configure Viscosity Test, be sure to enter a density value that was determined at the same temperature as that of the viscosity measurement.

Temperature Units Set the unit of temperature measurement: °C, °F, K

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.

Note: The screen brightness is dimmed automatically after 1 hour of no touch screen activity. The brightness will be dimmed to the lowest value. A single touch of the touch screen will return the display to the set brightness value. Screen will not dim while a test is running.

Language Choose system language: English, Spanish, French, Portuguese, German. Japanese, Chinese, Korean

Number Format Set numbers to use . or , to define decimal place.

Date Format Set the date format: YYYY/MM/DD, MM/DD/YYYY, DD/MM/YYYY

Date Separator Set the date separator: / - .

Time Format Set time format: 12:59, 12.59, 12 59

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
DV2PLV	15	6,000,000
DV2PRV	100	40,000,000
DV2PHA	200	80,000,000
DV2PHB	800	320,000,000

Small Sample Adapter and Thermosel

SSA and Thermosel Spindle	Viscosity (cP)				Shear Rate sec-1
	DV2PLV	DV2PRV	DV2PHA	DV2PHB	
Ⓢ SC4-14	58.6 - 1,171.00	625 - 12,500,000	1,250 - 25,000,000	5,000 - 100,000,000	.40N
Ⓢ SC4-15	23.4 - 468,650	250 - 5,000,000	500 - 10,000,000	2,000 - 40,000,000	.48N
Ⓢ SC4-16	60 - 1,199,700	640 - 12,800,000	1,280 - 25,600,000	5,120 - 102,400,000	.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	.93N
SC4-25	240 - 4,790,000	2,560 - 51,200,000	5,120 - 102,400,000	20,480 - 409,600,000	.22N
SC4-27	11.7 - 234,325	125 - 2,500,000	250 - 5,000,000	1,000 - 20,000.000	.34N
SC4-28	23.4 - 468,650	250 - 5,000,000	500 - 10,000,000	2,000 - 40,000,000	.28N
SC4-29	46.9 - 937,300	500 - 10,000,000	1,000 - 20,000,000	4,000 - 80,000,000	.25N
SC4-31	15 - 300,000	160 - 3,200,000	320 - 6,400,000	1,280 - 25,600,000	.34N
SC4-34	30 - 600,000	320 - 6,400,000	640 - 12,800,000	2,560 - 51,200,000	.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	970.4 - 50,000	1.29N

Ⓣ This spindle used with Thermosel only
Ⓢ This spindle used with Small Sample Adapter only
N 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
	DV2PLV	DV2PRV	DV2PHA	DV2PHB	
YULA-15 or 15Z	1 - 2,000	3.2 - 2,000	6.4 - 2,000	25.6 - 2,000	1.22N

DIN Adapter Accessory

DAA Spindle	Viscosity (cP)				Shear Rate sec-1
	DV2PLV	DV2PRV	DV2PHA	DV2PHB	
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
	DV2PLV	DV2PRV	DV2PHA	DV2PHB	
SA-70	98 - 98,500	1,050 - 1,050,000	2,100 - 2,100,000	8,400 - 8,400,000	0.667N
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

Helipath with T-Bar Spindle

T-Bar Spindle	Viscosity (cP)			
	DV2PLV	DV2PRV	DV2PHA	DV2PHB
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 - 20,000,000	40,000 - 40,000,000	160,000 - 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 - 100,000000	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	.188-1.88	104.04-1.04K
V-73	LV	.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	.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	40-400	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. 1 Pa = 10 dyne/cm2
2. Viscosity Range is given at rotational speed of 10 RPM
3. 5xHB is the highest torque range available
4. Not for use with DV-E Viscometers

M = 1 million
K = 1 thousand
Pa = Pascal

cP = Centipoise
mPa•s = Millipascal•seconds

Special Considerations

In taking viscosity measurements with the DV2Plus viscometer, there are two considerations which pertain to the low viscosity limit of effective measurement.

1. Viscosity measurements should be accepted within the equivalent % Torque Range from 10% to 100% for any combination of spindle/speed rotation.
2. Viscosity measurements should be taken under laminar flow conditions, not under turbulent flow conditions.

The first consideration has to do with the precision of the instrument. All DV2Plus 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 DV2Plus). 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 nonlinear 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: 500cP at 60 RPM
5. UL Adapter: 0.85 cP at 60 RPM
6. SC4-18/13R: 1.25 cP at around 240 RPM

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

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 viscometers), 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 dependant, thixotropic.

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 made at different shear rates. The faster the spindle speed, the higher the shear rate.

The shear rate of a given measurement is determined by: the rotational speed of the spindle, the size and shape of the spindle, the size and shape of the container used and therefore the distance between the container wall and the spindle surface.

A repeatable viscosity test should control or specify the following:

1. Test temperature
2. Sample container size (or spindle/chamber geometry)
3. Sample volume

4. Viscometer model
5. Spindle used
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

When using a standard Brookfield Viscometer or Rheometer, each spindle has a two digit entry code which is entered via the keypad on the DV2Plus. The entry code allows the DV2Plus to calculate Viscosity, Shear Rate and Shear Stress values and can also be calculated when using coaxial cylinder geometry (SSA, ULA, Thermosel, DAA, etc.).

Each spindle has two constants which are used in these calculations. The Spindle Multiplier Constant (SMC) used for viscosity and shear stress calculations, and the Shear Rate Constant (SRC), 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
Spiral	70	105	0.677
T-A	91	20	0
T-B	92	40	0
T-C	93	100	0

SPINDLE	ENTRY CODE	SMC	SRC
T-D	94	200	0
T-E	95	500	0
T-F	96	1000	0
ULA	00	0.64	1.223
DIN-81	81	3.7	1.29
DIN-82	82	3.75	1.29
DIN-83	83	12.09	1.29
DIN-85	85	1.22	1.29
DIN-86	86	3.65	1.29
DIN-87	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
GT-45	45	224	0.211

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 DV2PLUS SCREEN
DV2PLV	0.09375	LV
2.5DV2PLV	0.234375	L3
5DV2PLV	0.46875	L5
1/4 DV2PRV	0.25	RQ
1/2 DV2PRV	0.5	RH
DV2PRV	1	RV
DV2PHA	2	HA
2DV2PHA	4	A2
2.5DV2PHA	5	A3
DV2PHB	8	HB
2DV2PHB	16	B2
2.5DV2PHB	20	B3

The full scale viscosity range for any DV2Plus model and spindle may be calculated using the equation:

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

where:
TK = DV2Plus Torque Constant from Table D-2
SMC = Spindle Multiplier Constant from Table D-1

The Shear Rate calculation is:

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

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/rheometer. Look up the Range Coeffecient 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/rheometer.

Table E-1
(Continued on following page)

Spindle	Entry Code	Range Coefficient			
		LV	RV	HA	HB
RV1	01	937	10,000	20,000	80,000
RV2	02	3,750	40,000	80,000	320,000
RV3	03	9,375	100,000	200,000	800,000
RV4	04	18,750	200,000	400,000	1,600,000
RV5	05	37,500	400,000	800,000	3,200,000
RV6	06	93,750	1,000,000	2,000,000	8,000,000
RV7	07	375,000	4,000,000	8,000,000	32,000,000
HA1	01	937	10,000	20,000	80,000
HA2	02	3,750	40,000	80,000	320,000
HA3	03	9,375	100,000	200,000	800,000
HA4	04	18,750	200,000	400,000	1,600,000
HA5	05	3,7500	400,000	800,000	3,200,000
HA6	06	93,750	1,000,000	2,000,000	8,000,000
HA7	07	375,000	4,000,000	8,000,000	32,000,000
HB1	01	937	10,000	20,000	80,000
HB2	02	3,750	40,000	80,000	320,000
HB3	03	9,375	100,000	200,000	800,000
HB4	04	18,750	200,000	400,000	1,600,000
HB5	05	37,500	400,000	800,000	3,200,000
HB6	06	93,750	1,000,000	2,000,000	8,000,000
HB7	07	375,000	4,000,000	8,000,000	32,000,000
LV1	61	6,000	64,000	128,000	512,000
LV2	62	30,000	320,000	640,000	2,560,000
LV3	63	120,000	1,280,000	2,560,000	10,240,000
LV4 or 4B2	64	600,000	6,400,000	12,800,000	51,200,000
LV5	65	1,200,000	12,800,000	25,600,000	102,400,000
LV-2C	66	30,000	320,000	640,000	2,560,000
LV-3C	67	120,000	1,280,000	2,560,000	10,240,000

Spindle	Entry Code	Range Coefficient			
		LV	RV	HA	HB
T-A	91	18,750	200,000	400,000	1,600,000
T-B	92	37,440	400,000	800,000	3,200,000
T-C	93	9,3600	1,000,000	2,000,000	8,000,000
T-D	94	187,200	2,000,000	4,000,000	16,000,000
T-E	95	468,000	5,000,000	10,000,000	40,000,000
T-F	96	936,000	10,000,000	20,000,000	80,000,000
Spiral	70	98,400	1,050,000	2,100,000	8,400,000
ULA	00	600	6,400	12,800	51,200
HT-DIN-81	81	3,420	36,500	73,000	292,000
SC4-DIN-82	82	3,420	36,500	73,000	292,000
SC4-DIN-83	83	11,340	121,300	242,600	970,400
ULA-DIN-85	85	1,144	12,200	24,400	97,600
ULA-DIN-86	86	3,420	36,500	73,000	292,000
ULA-DIN-87	87	11,340	121,300	242,600	970,400
SC4-14/6R	14	117,200	1,250,000	2,500,000	10,000,000
SC4-15/7R	15	46,880	500,000	1,000,000	4,000,000
SC4-16/8R	16	120,000	1,280,000	2,560,000	10,240,000
SC4-18/13R	18	3,000	32,000	64,000	256,000
SC4-21/13R	21	4,688	50,000	100,000	400,000
SC4-25/13R	25	480,000	5,120,000	10,240,000	40,960,000
SC4-27/13R	27	23,440	250,000	500,000	2,000,000
SC4-28/13R	28	46,880	500,000	1,000,000	4,000,000
SC4-29/13R	29	93,750	1,000,000	2,000,000	8,000,000
SC4-31/13R	31	30,000	320,000	640,000	2,560,000
SC4-34/13R	34	60,000	640,000	1,280,000	5,120,000
CPA-40, CPE-40, CP-40	40	307	3,270	6,540	26,160
CPA-41, CPE-41, CP-41	41	1,151	12,280	24,560	98,240
CPA-42, CPE-42, CP-42	42	600	6,400	12,800	51,200
CPA-51, CPE-51, CP-51	51	4,854	51,780	103,560	414,240
CPA-52,CPE-52,CP-52	52	9,300	99,220	1,98,440	7,93,760
V-71	71	2,456	26,200	52,400	2,09,600
V-72	72	10,404	1,11,000	2,22,000	8,88,000
V-73	73	50,146	5,35,000	10,70,000	42,80,000
V-74	74	5,08,954	54,30,000	1,08,60,000	4,34,40,000
V-75	75	1,99,645	21,30,000	42,60,000	85,20,000

Table E-1

(Continued on previous page)

APPENDIX E - CALIBRATION PROCEDURES

The accuracy of the DV2Plus 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).

For more help, you can go to the website,
www.brookfieldengineering.com, and download the video.

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: As stated on the fluid standard label: (+/-) 0.1°C

Conditions: The DV2Plus 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 25ºC Standard Fluids		**High Temperature Standard Fluids Three Viscosity/Temperatures****
Viscosity (cP)	**Viscosity (cP)**	
5	5,000	HT-30,000
10	12,500	HT-60,000
50	30,000	HT-100,000
100	60,000	
500	100,000	**25°C, 93.3°C, 149°C
1,000		Refer to Brookfield catalog for more information

Table F-1

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 F-2

AMETEK Brookfield Viscosity Standard Fluid General Information

We recommend that Brookfield Viscosity standard fluids be replaced on an annual basis, one year from date of initial use. These fluids are pure silicone and are not subject to change over time. 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. Disposal should be in accordance with state, local and federal regulations as specified on the material safety data sheet.

Brookfield does not recertify viscosity standard fluids. We will issue duplicate copies of the Certificate of Calibration for any fluid within two years of the purchase date. 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 a 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 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 on your instrument. Reasons pertain to the small amount of spindle surface that makes contact with the viscosity standard, the difficulty of establishing the immersion mark precisely and the need for precise temperature control at 25°C in the immediate vicinity of the spindle.

Follow these steps 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 DV2Plus 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 DV2Plus.

When a Small Sample Adapter is used, the water jacket is connected to the water bath and the water is stabilized at the proper temperature:

1. Put the proper amount of viscosity standard fluid into the sample chamber. The amount varies with each spindle/chamber combination (refer to the Small Sample Adapter instruction manual).
2. Place the sample chamber into the water jacket.
3. Put the spindle into the test fluid and attach the extension link, coupling nut and free hanging spindle (or directly attach the solid shaft spindle) to the DV2Plus.
4. Allow 30 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.

5. Measure the viscosity and record the viscometer reading. Note: The spindle must rotate at least five (5) times before readings are taken.

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 DV2Plus.

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

1. Put the proper amount of HT viscosity standard fluid into the HT-2 sample chamber. The amount varies with the spindle used (refer to the Thermosel instruction manual).
2. Place the sample chamber into the Thermo Container.
3. Put the spindle into the test fluid and attach the extension link, coupling nut and free hanging spindle (or directly attach the solid shaft spindle) to the DV2Plus.
4. Allow 30 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.
5. Measure the viscosity and record the Viscometer reading. Note: The spindle must rotate at least five (5) times before readings are taken.

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 DV2Plus.

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

1. Put the proper amount of viscosity standard fluid into the UL Tube (refer to the UL Adapter instruction manual).
2. Attach the spindle (with extension link and coupling nut) onto the DV2Plus.
3. Attach the tube to the mounting channel.
4. Lower the tube into the water bath reservoir, or if using the ULA-40Y water jacket, connect the inlet/outlets to the bath external circulating pump.
5. Allow 30 minutes for the viscosity standard, sample chamber and spindle to reach test temperature.
6. Measure the viscosity and record the Viscometer reading. Note: The spindle must rotate at least five (5) times before readings are taken.

Calibration Procedure using a Helipath Stand and T-Bar Spindles

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

1. 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.
2. T-Bar spindles should not be used for verifying calibration of the DV2Plus 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 DV2Plus.

1. Place the viscosity standard fluid (in the proper container) into the water bath (refer to the Spiral Adapter instruction manual).
2. Attach the spindle to the viscometer. Attach chamber (SA-1Y) and clamp to the viscometer.
3. Lower the DV2Plus into measurement position. Operate the viscometer at 50 or 60 RPM until the chamber is fully flooded.
4. The viscosity standard fluid, together with the spindle, should be immersed in the bath for a minimum of 1 hour, stirring the fluid periodically (operate at 50 or 60 RPM periodically), prior to taking measurements.
5. After 1 hour, check the temperature of the viscosity standard fluid with an accurate thermometer.
6. If the fluid is at test temperature (+/- 0.1°C of the specified temperature, normally 25°C), measure the viscosity and record the viscometer reading. Note: The spindle must rotate at least five (5) times for one minute, whichever is greater before readings are taken.
7. The viscosity reading should equal the cP value on the viscosity fluid standard to within the combined accuracies of the viscometer and the standard (as discussed in the section entitled, "Interpretation of Calibration Test Results"). However, instrument accuracy is ±2% of the maximum viscosity range and not the standard 1%.

Interpretation of Calibration Test Results:

When verifying the calibration of the DV2Plus, the instrument and viscosity standard fluid error must be combined to calculate the total allowable error.

The DV2Plus 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 DV2Plus 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 DV2PlusRV 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 $\frac{1 * 10 * 10{,}000}{2} = 50{,}000\ cP$

   The viscosity is accurate to (+/-) 500 cP (which is 1% of 50,000)
2. The viscosity standard fluid is 12,257 cP. Its accuracy is (+/-)1% of 12,257 or (+/-)122.57 cP.
3. Total allowable error is (122.57 + 500) cP = (+/-) 622.57 cP.
4. Therefore, any viscosity reading between 11,634.4 and 12,879.6 cP indicates that the Viscometer is operating correctly. Any reading outside these limits may indicate a Viscometer problem. Contact the 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 DV2PlusLV with SC4-21 spindle in Small Sample Adapter at 6, 12, and 30 RPM. 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 D of More Solutions to Sticky Problems or by using the Auto Range button on your viscometer.

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 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 attached to the dial housing and LV guard legs attached to the bottom of the pivot cup with a twist and lock mechanism.

The current guard leg is a band of metal in the shape of the letter U with a bracket at the top that attaches to the pivot cup of a AMETEK Brookfield Viscometer/Rheometer. A guard leg is supplied with all LV and RV series instruments, but not with the HA or HB series. It's 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 standard spindle set). Any other LV (#3 & #4) or RV (#3 - #7) spindle can be used in a 600 mL beaker with or without the guard leg to produce correct results. The HA and HB series Viscometers/ Rheometers are not supplied with guard legs in order to reduce the potential problems when measuring high viscosity materials. HA/HB spindles #3 through #7 are identical to those spindle numbers in the RV spindle set. The HA/HB #1 & #2 have slightly different dimensions than the corresponding RV spindles. This dimensional difference allows the factors between the RV and HA/HB #1 & #2 spindles to follow the same ratios as the instrument torque even though the boundary conditions are different.

The recommended procedures of using a 600 mL beaker and the guard leg are difficult for some customers to follow. The guard leg is one more item to clean. In some applications the 500 mL of test fluid required to immerse the spindles in a 600 mL beaker is not available. In practice, a smaller vessel may be used and the guard leg is removed. The AMETEK Brookfield Viscometer/Rheometer will produce an accurate and repeatable torque reading under any measurement circumstance. However, the conversion of this torque reading to centipoise will only be correct if the factor used was developed for those specific conditions. Brookfield has outlined a method for re-calibrating an AMETEK Brookfield Viscometer/ Rheometer to any measurement circumstance in More Solutions to Sticky Problems.

It is important to note that for many viscometer users the true viscosity is not as important as a repeatable day to day value. This repeatable value can be obtained without any special effort for any measurement circumstance. But, it should be known that this type of torque reading will not convert into a correct centipoise value when using a 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/Rheometer. Our customers should be aware of its existence, its purpose and the effect that it may have on data. With this knowledge, the viscometer user may make modifications to the recommended method of operation to suit their needs.

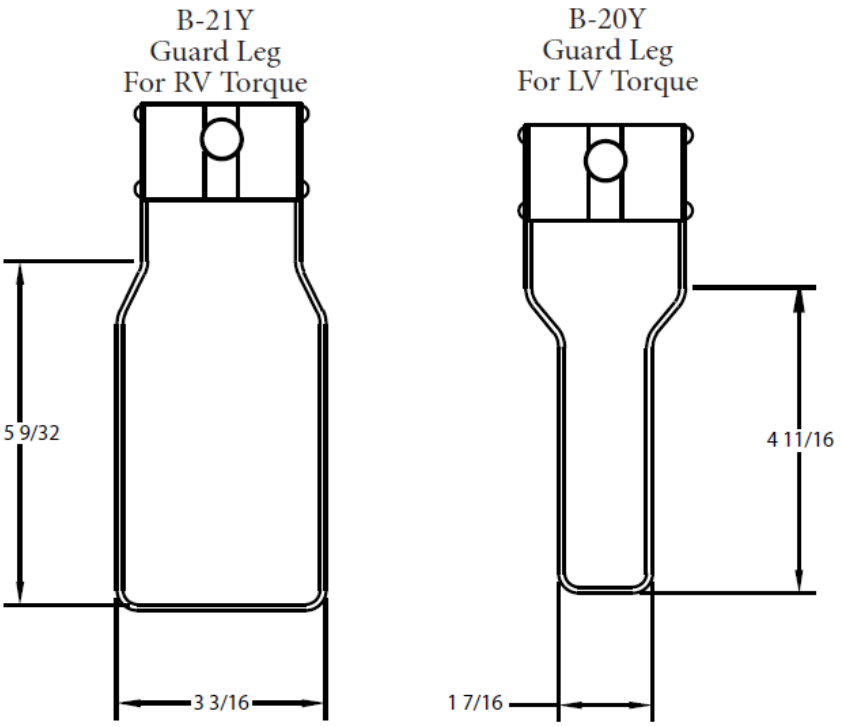


Figure G-1 - Brookfield Guard Leg

APPENDIX G - SPEED SELECTION

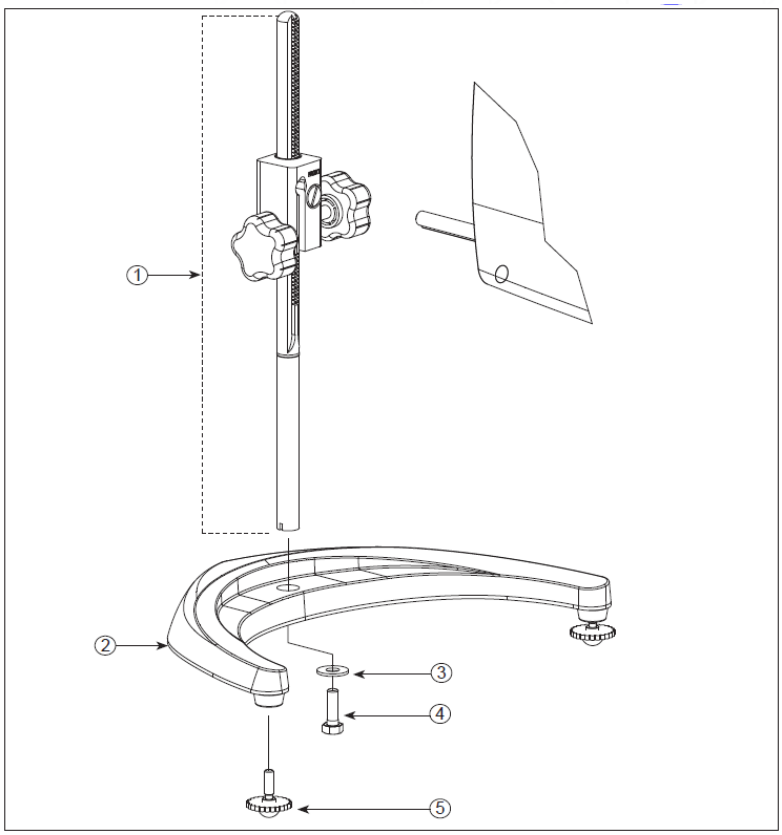
AMETEK Brookfield Viscometers offer a variety of speeds to provide for a wide range of viscosity measurement capabilities. AMETEK Brookfield has traditionally supplied a defined set of speeds with specific Torque ranges:

Speeds for both LV & RV:	0.0, 0.3, 0.5, 0.6, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 10.0, 12.0, 20.0, 30.0, 50.0, 60, 100

The DV2Plus and earlier DV2T series AMETEK Brookfield Viscometers offer additional speeds to enhance measurement capabilities. The DV2Plus offers speeds from 0.1 - 200 RPM with two options for speeds selection: numeric key pad for direct entry; Scroll List. The user can choose from these two entry options by using the Navigation Bar (see Section II.4: Navigation). The Scroll List is the format used with previous versions of the DV2T and DV-II viscometer. You may choose the Scroll List to provide the viscometer user with a familiar method for speed selection. The Scroll List can be customized to limit the available speeds and to add new speeds to the list of standard speeds.

APPENDIX H - LABORATORY STANDS

Model G is the standard laboratory stand which comes with the DV2Plus Viscometer.



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

Figure I-1: Model G Laboratory Stand

Unpacking

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 I-1 or I-2)

1. Remove the base assembly from the carton.
2. Remove the screw and washer from the upright rod. Place the rod and clamp assembly into the hole in the top of the base.

   Note: The “Front” designation on the clamp assembly should face toward you.

3. Rotate the rod/clamp assembly slightly until the slot on the bottom of the rod intersects the pin located in the base.
4. While holding the rod and base together, insert the slotted screw and washer as shown and tighten securely.
5. 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. 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 insure that the rod is installed with the gear rack facing forward.

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

	Caution:	Do not use the DV2Plus Viscometer with any laboratory stand that does not utilize the GV-1201 base. This large base is necessary for stability of the DV2Plus Viscometer during use. Earlier versions of the Brookfield Laboratory Stand including the Model A and Model S should not be used with the DV2Plus.

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 I - DVE-50A PROBE CLIP

Probe Clip DVE-50A 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/Rheometer models – except LV – use the Probe Clip as shown in Figure J-3.

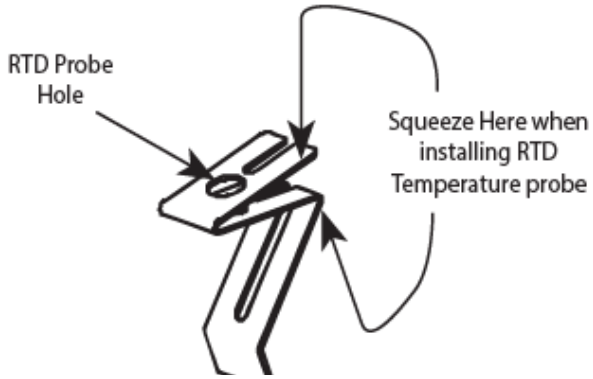


Figure J-1

Figure J-2 shows the Probe Clip (with RTD temperature probe installed) mounted on the LV guard leg.

Figure J-3 shows the Probe Clip mounted in a 600 mL low form Griffin beaker. This mounting may be used with LV, RV, HA and HB series instruments.

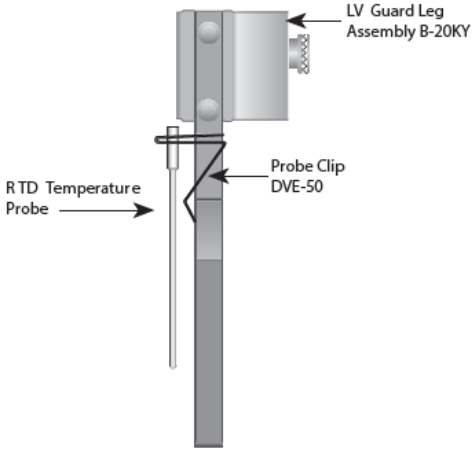


Figure J-2

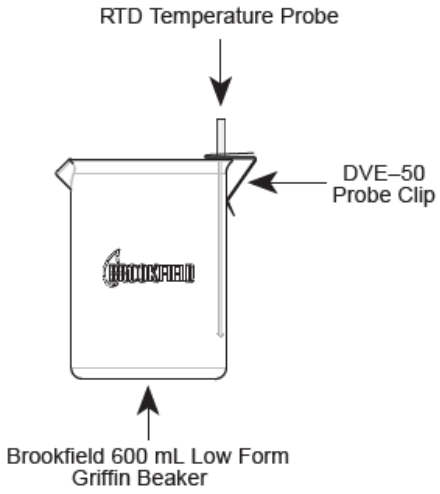


Figure J-3

⚠	Caution:	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.

APPENDIX J - SCREEN PROTECTOR

An optional screen protector may be purchased and applied to the touch screen of your DV2Plus viscometer. This screen protector is designed for prolonged use. AMETEK Brookfield recommends replacing the screen protector within 1 year of application. The screen protector is provided in a kit (part number GV-1019) that includes the following items:

- Two screen protectors
- One screen cloth (part number GV-1045)
- One soft card
- Instructions printed on the package

Retain the soft card and screen cloth with any unused screen protector.

Install the Screen Protector

Installation instructions for the screen protector are available in three methods:

1. Read printed instructions on the package
2. View the instructional video on the AMETEK Brookfield YouTube Channel: www.youtube.com/user/BrookfieldEng
3. Read the expanded printed instructions in this appendix (see below).

⚠	Note: A failure to properly install the screen protector may result in a disabled touch screen.

Step 1:

- Turn off the DV2Plus viscometer (power down) prior to installation.
- Clean the DV2Plus touch screen with the screen cloth prior to installation. Any debris, dust, or oil on the touch screen may prevent proper adhesion of the screen protector.
- Identify Tab 1 and Tab 2 prior to removing any protective layer. Peel back adhesive Tab 1, from the bottom, to expose half of the protector (see Figure K-1).
- Do not touch the exposed surface of the adhesive side of the screen protector.

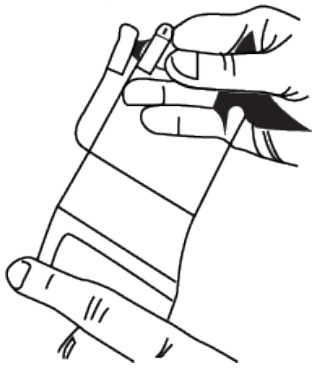


Figure K-1

Step 2:

- Alignment of the screen protector to the bezel (frame) of the DV2Plus is critical. Be sure to avoid mis-alignment which may result in the screen protector contacting or locating under the bezel (frame). A foam alignment tool is attached to the screen protector's outer layer and should be used to locate the screen protector to the lower right hand corner of the touch screen (see Figure K-2).

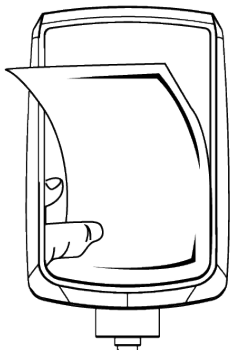
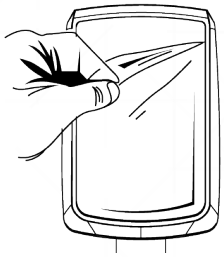
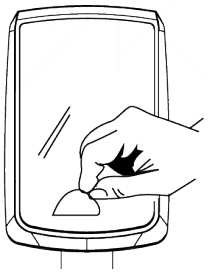


Figure K-2

	Note: Failure to properly align (install) the screen protector could result in a failure of the touch screen.

Step 3: • Completely remove Tab 1 (see Figure K-3). • Lightly press the screen protector to the touch screen. • Inspect the alignment of the screen protector. If the screen protector is touching the bezel (frame), them remove and reapply.	 Figure K-3
Step 4: • Peel back Tab 2 all the way to remove the backing, which also removes the alignment tool (see Figure K-4). The screen protector is now in place.	 Figure K-4
Step 5: • Use the soft card provided to push trapped air bubbles from the center of the screen to the edge (see Figure K-5). Small bubbles should go away within 48 hours. • DO NOT use the soft card to push the screen protector under the bezel (frame). If the screen protector is not properly aligned, remove and reapply. Two screen protectors are provided in this package in case the first attempt is unsuccessful. • Test the viscometer (power on) to ensure that the screen protector is properly attached. The screen protector is properly aligned if the DV2Plus Viscometer responds normally to a touch on the touch screen. If the DV2Plus Viscometer is unresponsive to touch then remove the screen protector and reapply.	 Figure K-5

Removal of the Screen Protector

The screen protector should be replaced when it has become dirty. It can be easily removed from the DV2Plus Viscometer by hand. The upper right hand corner of the screen protector has a small angle cut. Use a finger nail or blunt object to pry the screen protector away from the touch screen and peel it of the touch screen.

	Be careful not to scratch the touch screen when removing the screen protector.

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.
- 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 spindle threaded coupling and mating areas for dirt; carefully clean threads.
- 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 N). 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 spin- dle rotating in air.
- Check to see if the viscometer coupling appears bent; if so, the unit is in need of service (see Appendix N: Warranty Repair and Service).

Inaccurate Readings

- Verify spindle, speed and model selection.
- Verify spindle selection is correct on DV2Plus.
- If % readings are under-range (less than 10%), the display will flash; change spindle and/or speed.
- "OVER RANGE" 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
  - "DV2Plus Viscometer Operating Instructions", Appendix B: 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 N for details on Warranty Repair and Service.

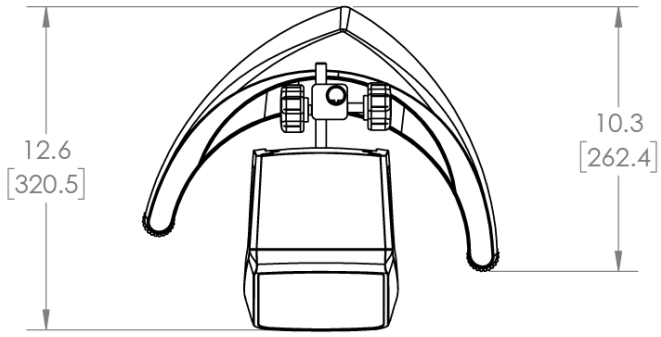
Viscometer Will Not Return to Zero

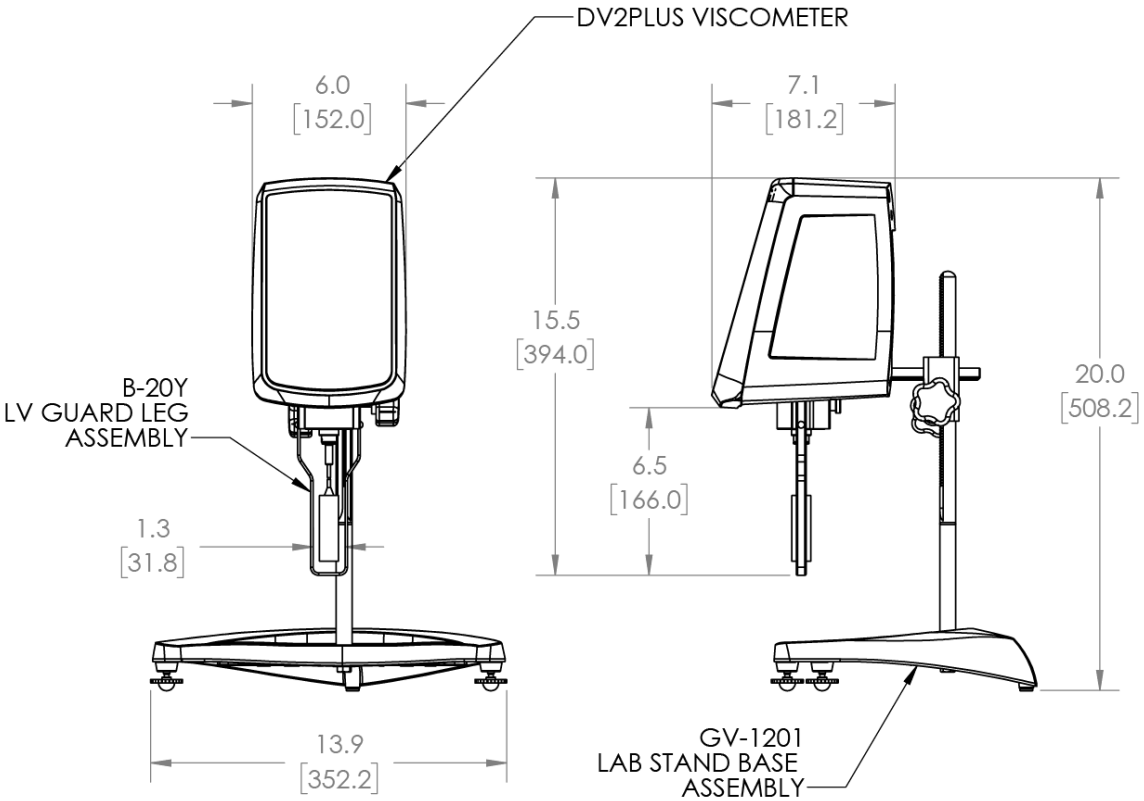
- Viscometer is not level
  - Check with spindle out of the sample.
  - Adjust the laboratory stand.
- Pivot point or jewel bearing faulty
  - Perform an Oscillation Check by going to the Device Setup menu and running the automated Oscillation test.
- If your instrument fails repeated Oscillation Checks, your instrument may need service.
- Contact AMETEK Brookfield or your authorized dealer for repair (see Appendix Q).

Display Reading Will Not Stabilize

- Special characteristic of sample fluid. There is no problem with the viscometer.
  - Refer to Appendix B.
- Check for erratic spindle rotation.
  - Verify power supply
  - Contact AMETEK Brookfield or your authorized dealer for repair.
- Bent spindle or spindle coupling.
  - Contact AMETEK Brookfield or your authorized dealer for repair(see Appendix Q).
- Temperature fluctuation in sample fluid.
  - Use temperature bath for control.

APPENDIX L - INSTRUMENT DIMENSIONS





APPENDIX M – INTEGRATED HELIPATH QUICK ACTION, HPQA, OPERATION WITH THE DV2PLUS

INTRODUCTION

The Helipath Quick Action Stand (HPQA) and DV2Plus offer users the ability to operate and program the HPQA directly from the DV2Plus 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 DV2Plus 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 DV2Plus user interface, the firmware of both instruments must meet the minimum levels shown below. Users may download the latest firmware from the website locations listed below and update per the instructions in the DV2Plus and HPQA manuals as required.

- Check Firmware for the DV2Plus and HPQA meet minimum requirements:
  - DV2Plus Firmware version 1.0.0.10 or higher
  - HPQA Firmware version 1.2.0.10 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 DV2Plus to the HPQA with the supplied 18” USB A-B patch cable (Part Number HP-2011)
  - **Connect USB A side to DV2Plus and USB B side to HPQA back panels**. (see Figure Appendix L-1)
- Ensure the USB connection symbol is displayed at the top of the DV2Plus screen
- 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 DV2Plus. 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 DV2Plus 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 DV2Plus.

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 DV2Plus. 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.

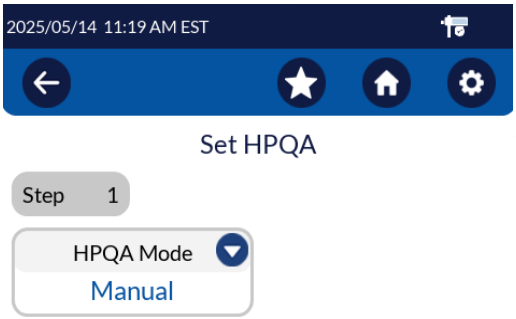
- In the ‘Set HPQA’ screen, there are a few options to configure your test.
    - HPQA Mode: Choose Quick Action.
    - Test End Action: Allows user to choose what the motorized HPQA stand does at the completion of the viscosity test.
        - None: The DV2Plus head and spindle will remain at the location 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 DV2Plus.

STANDALONE/MANUAL HELIPATH TEST OPERATION

If you'd prefer to continue setting up your HPQA separate from your DV2Plus 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 DV2Plus manuals for the independent set up and operation of each.



APPENDIX N - GEL TIMER MEASUREMENT USING THE DV2PLUS VISCOMETER

I: INTRODUCTION

The DV2Plus Viscometer includes Gel Time testing capability that is designed to replace the Sunshine Gel Timer or similar instruments which employ a rotational method to measure the gel time of thermoset materials.

Gel Time refers to the time required for a thermosetting material to cure to the point that it can no longer be used in a mold filling process. While Gel Time is an essential material characteristic for understanding working time and reducing material waste in the molding compound industry, Gel Time measurements can be applied to curing materials across a variety of industries.

In order to calculate Gel Time, the Gel Timer test monitors the torque required to turn a glass rod immersed in the sample at a fixed speed, usually 1 rpm. As the material cures, the required torque will increase. A sudden rapid increase in the instrument's torque reading indicates that the material has reached its gel point. When a pre-defined torque reading has been achieved, the DV2Plus will stop testing and report the time elapsed: the Gel Time.

II: COMPONENTS

If you ordered the Gel Timer DV2Plus bundle, your instrument will come with the following components (the Gel Timer kit may be ordered separately if not part of your original DV2Plus configuration):

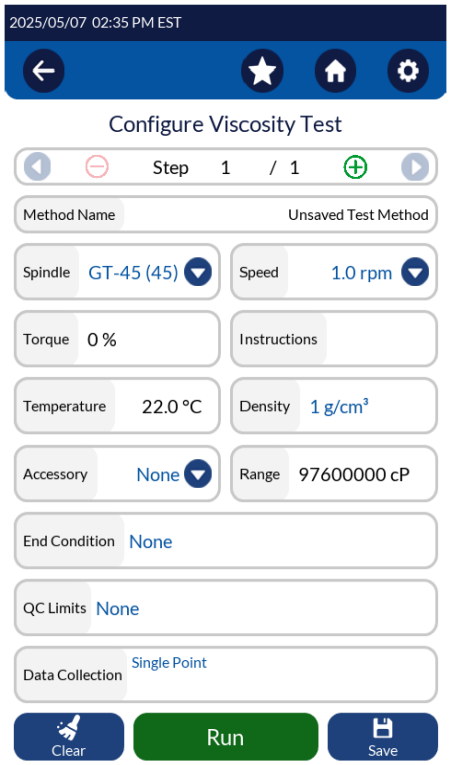
DV2Plus Instrument Head	varies*
Model G Laboratory Stand	MODEL G
Adjustable Stop	HS-23Y
Gel Timer Coupling Assembly with Glass Rod	GT-2000 (threaded) or GT-2002 (magnetic) or GT-2003 (magnetic, compliant)
RTD Temperature Probe	DVP-94Y
Power Cord	varies*
Carrying Case	GV-1302Y
Operating Manual	DV2Plus-M24
Optional Items:	
Pack of 10 Glass Rods	GT-1010
DV360 Software	SWL-07-

III: TEST PROCEDURE

III.1 Setup

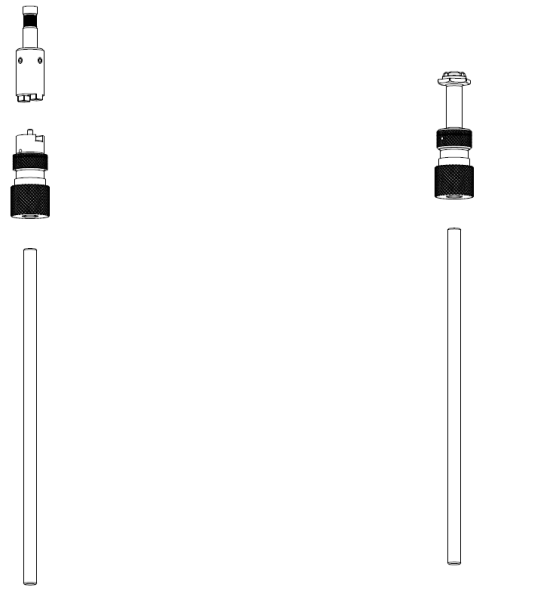
The Gel Timer Bundle includes an **HS-23Y adjustable stop** for use on the laboratory stand. The adjustable stop helps to regulate the spindle immersion depth and prevent the instrument head from being lowered so far that the glass rod spindle may hit the laboratory bench, which can cause damage to the spindle and the instrument. Install the HS-23Y adjustable stop on the upright rod of the laboratory stand before installing the clamp assembly so that the adjustable stop sits below the clamp assembly.

After the initial startup and AutoZero, the DV2Plus will transition to the "Configure Viscosity Test" screen. Set the spindle to the Gel Timer spindle(GT-45), with spindle code 45. Set the speed to 1 rpm, and the default end condition is None.



When using the GT-2000 (threaded) Gel Timer Assembly, attach the upper half of the magnetic coupling to the Gel Timer. Insert the glass rod into the compression fit coupling of the lower half of the magnetic coupling.

Note: The GT-2002 (magnetic) and GT-2003 (magnetic, compliant) options make their magnetic connection directly to the instrument and are a single piece assembly. Insert the glass rod into the compression fit coupling of the Gel Timer Assembly. The sample should be prepared before attaching the assembly to the instrument.



GT-2000 (threaded)

GT-2002 (magnetic)

Prepare the sample according to the material manufacturer's instructions.

Note: The sample preparation method, time to prepare the sample, and time to start the test after preparing your

sample will all affect your end results. A specific, well defined sample preparation method will produce the best accuracy and repeatability for your Gel Time measurements.

After the sample has been prepared, attach the glass rod to the DV2Plus. Lower the instrument head until the glass rod is immersed to the correct height as defined by the test method. If also testing for the sample material's peak temperature, insert the RTD temperature probe into the sample. Press "Run" to execute the test.

Note: If the RTD temperature probe is plugged into the DV2Plus after pressing "Run", a pop-up window will display the message "Would you like to select/create a probe temperature offset?" If you select Yes, select or add the desired temperature probe offset and then use the back arrow to accept. The test will begin to run. The selected temperature offset will be recorded as sample information.

III.2 Test Method for Gel Time

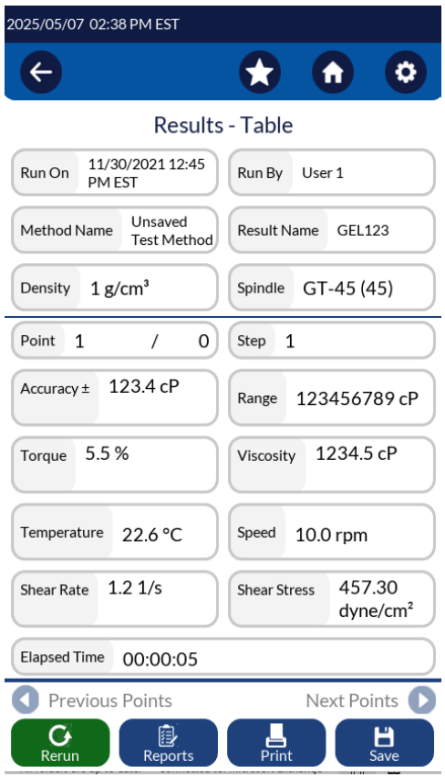
The Gel Time test method uses an end condition of torque (%) and a fixed speed of operation, typically 1 rpm. The value of the torque end condition should be selected so that it accurately represents the thickness of the material at its gel point.

In order to identify a proper torque end condition and define a Gel Time test for a specific material, first make sure the end condition is set to None. Under this condition, a test will run indefinitely until the "Stop Test" button is pressed. Keep the spindle set to the Gel Timer spindle, GT-45. Keep the speed set to 1 rpm.

Define a repeatable sample preparation procedure and prepare a sample accordingly.

Run the test. Observe the torque (%) reading as the test progresses. The torque reading may be constant or rising slowly at first. Press the "Stop Test" button when the torque reading begins to increase very rapidly. This indicates that the material is curing quickly and has reached its Gel Time.

The display shows the measured torque at the Gel Time and the elapsed time for the test in HH:MM:SS. The torque reading describes the Gel Point and the time elapsed is the Gel Time. Record the torque value and Gel Time.



Prepare a new test by hitting the Back button at top left of the results screen. The DV2Plus will return to the "Configure Viscosity Test" screen, showing the same parameters used for the previous test.

Change the end condition to Torque (%). Change the end condition value to the torque reading identified in your previous test. This will be your Gel Time test for the material. The test method can be saved directly to the Gel Timer's memory, or to a USB flash drive.

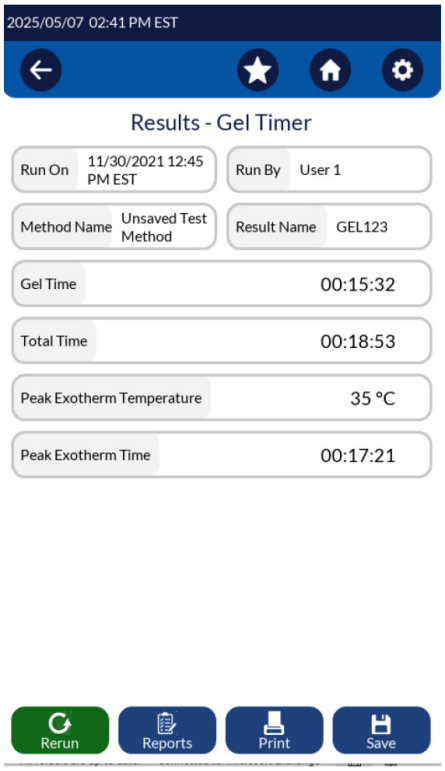
Press "Run" to execute the test. The test will automatically stop when the Gel Point is reached. Record the Gel Time. Repeat the test to assess the repeatability of your results.

III.3 Test Method for Peak Exotherm Temperature

To measure the peak temperature of a thermoset material in addition to Gel Time requires a two-step test. The first step is as defined in Section III.2 Designing a Test Method for Gel Time. When working with a DV2Plus Instrument, a second step can be added directly from the Configure Viscosity Test Screen.

Set the end condition for the second step to Temperature, and select Peak Exotherm as the temperature end condition type. Enter a tolerance value to define how much the observed temperature must decrease after reaching a maximum before the maximum temperature will be accepted as the peak temperature.

After executing a two-step Gel Time and peak temperature test, press OK to proceed to the Results screen. To view Gel Time, peak temperature, and time to reach peak temperature, press the down arrow on the top right of the Results screen and then select Gel Timer from the drop-down menu. The Results Gel Timer screen will display Gel Time, total test time, peak temperature, and time to reach peak temperature, as shown below.



Note: Peak temperature can be measured as a single-step test without the initial step for measuring Gel Time. In this case, Gel Time will be reported as "----".

APPENDIX O - COMMUNICATION WITH OPTIONAL DV CREATE

The DV2Plus Viscometer (versions with and without Bluetooth) can be used in conjunction with the AMETEK Brookfield DV Create software program. Functionality wise, the software will be an improvement to the existing DVPlus Connect App. Like the DVPlus Connect app, DV Create will collect the data output from the DV2Plus and allow for data storage and data printing. In addition, customers can use this to convert their previous results and test methods from the DV2T and DVNext into the new DV2Plus. The software will save data result files and test methods in the same format as the DV2Plus.

DVCreate software 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 DV2Plus Viscometer communicates to the PC through either a Bluetooth connection or a USB-B port. The communication cable will be supplied with the DV Create software. Communication can be established once both the DV Create software and the DV2Plus viscometer are running. Use the Search or Connect button on the DV Create dashboard. Successful communication will be indicated by a message on the software screen.

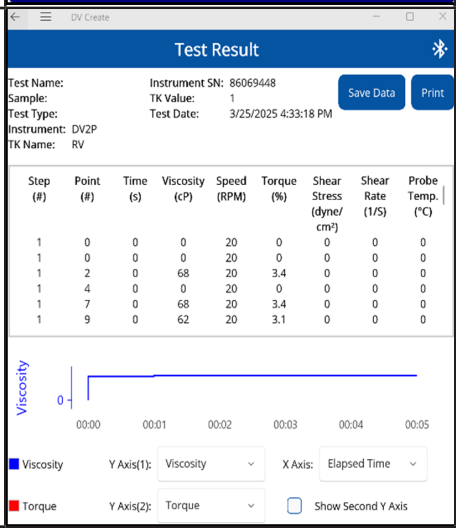
DV Create provides means to connect to a DV2Plus instrument via Bluetooth or USB (Windows only) connection. The software enables users to collect, view, and save test data. DVCreate has no control over the DV2Plus instrument. Test setup needs to be done on the instrument side.

Live Data Page

The Live Data page reflects the instrument's test parameters as well as current speed, torque, viscosity, and temperature. There is a test status label with live graph data under it. The graph will be shown only when data is being collected. The bottom of the page shows the instruments connection status.

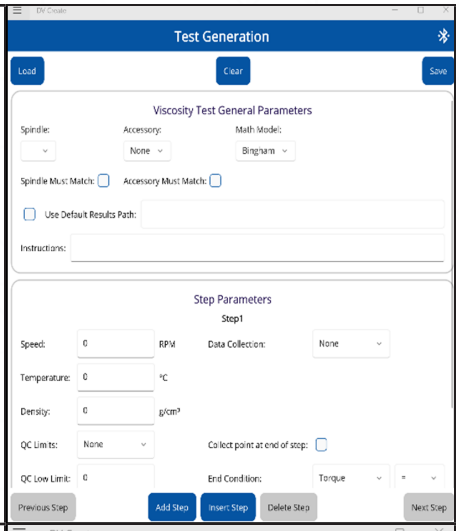
Test Result Page

When testing is complete, the page will automatically switch to this screen from live data. This includes all relevant test information such as instrument details, and the test date and time. The user will have an option to print or save in PDF, XML, or CSV format. This page will have test results in a data table, with a graph under it.



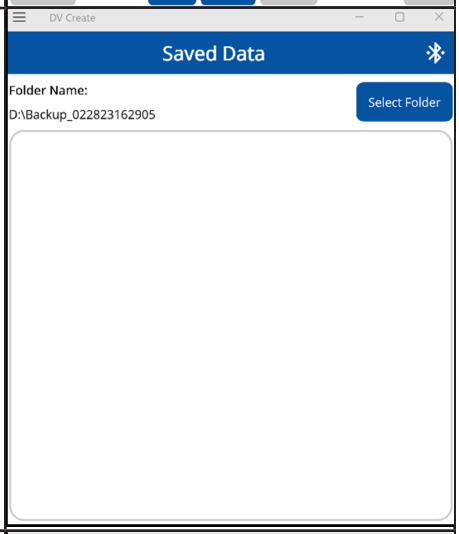
Create/Load Test Page

Allows users to load test method files from DV2Plus. There are fields for multi-step, spindles, QC limits, HPQA, data Collection, etc. There are also advanced parameters users can fill in.



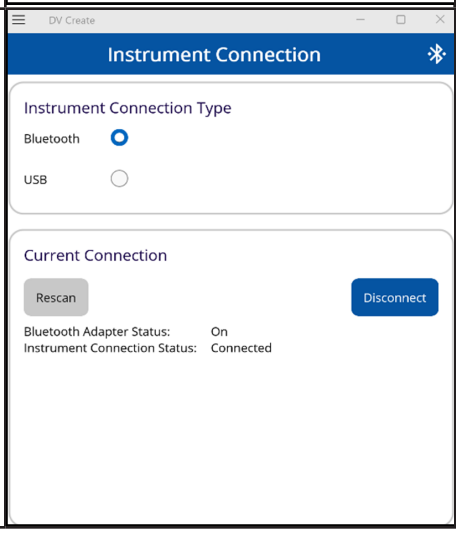
Saved Data Page

Lists test data saved from your device. The users can select a file from the list and view it.



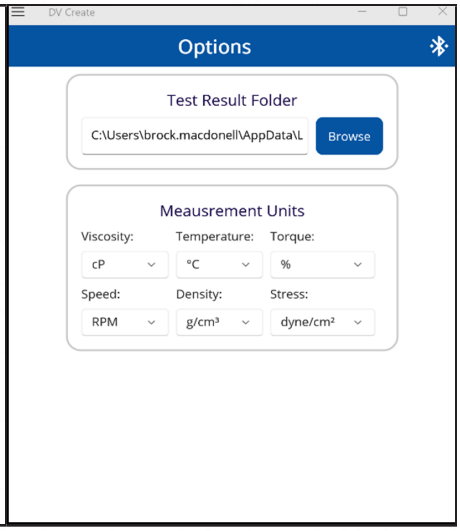
Instrument Connection Page

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 an option to disconnect, rescan, or connect to a previously connected instrument.



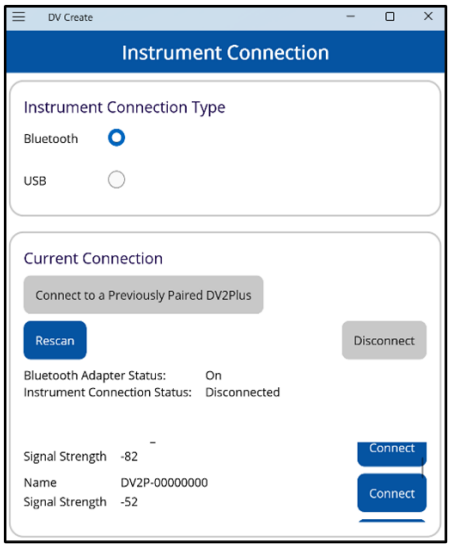
Options Page

Users are able choose a test results folder on DV Create. They can also change measurement units such as viscosity, torque, Temperature, speed, density, and stress.



Connecting to the DV Create Software

DV Create enables the user to connect to the DV2Plus instrument via Bluetooth or USB. The following sections describe how to establish Bluetooth and USB communication with the instrument. The instrument connection page of DV Create contains controls that enable the user to switch between Bluetooth and USB instrument connection type.

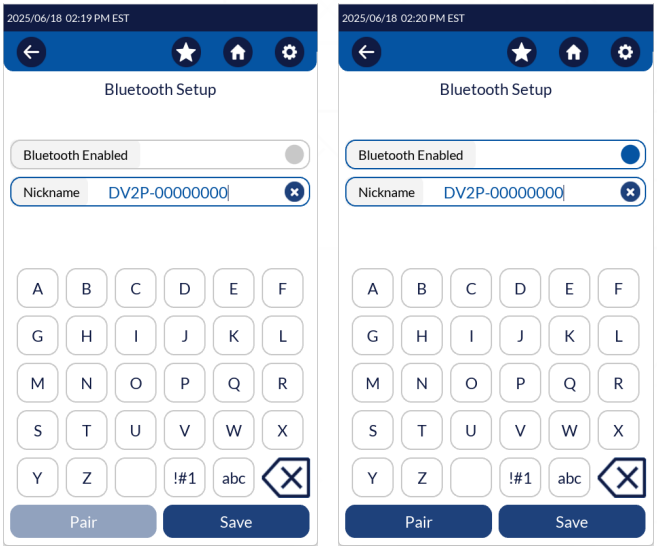


Establishing Bluetooth connection to the software for the first time

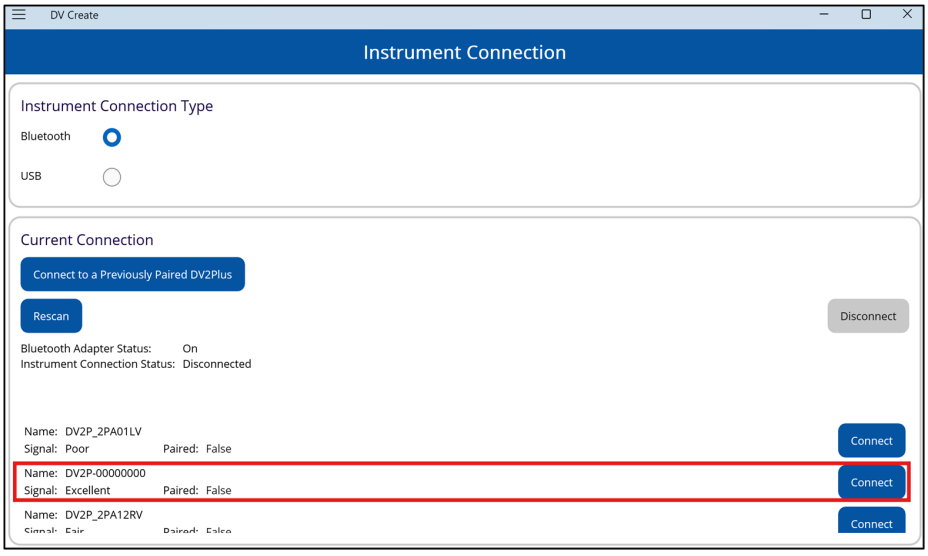
- Make sure that the PC and DV2Plus instrument are next to each other.
- On your PC, make sure that Bluetooth connection is enabled:
  - **Windows 11**
    - On the taskbar, select the Network icon. Select the Bluetooth quick setting to turn it On or Off.
    - Select Start > Settings > Bluetooth & devices, then turn Bluetooth on or off.
  - Windows 10
    - For Windows 10 users, Bluetooth must be set up manually
    - Select the Start button, then select Settings > Devices > Bluetooth & other devices.
    - Select the Bluetooth toggle to turn it On or Off.

Establishing Bluetooth connection for the first time with Windows 11

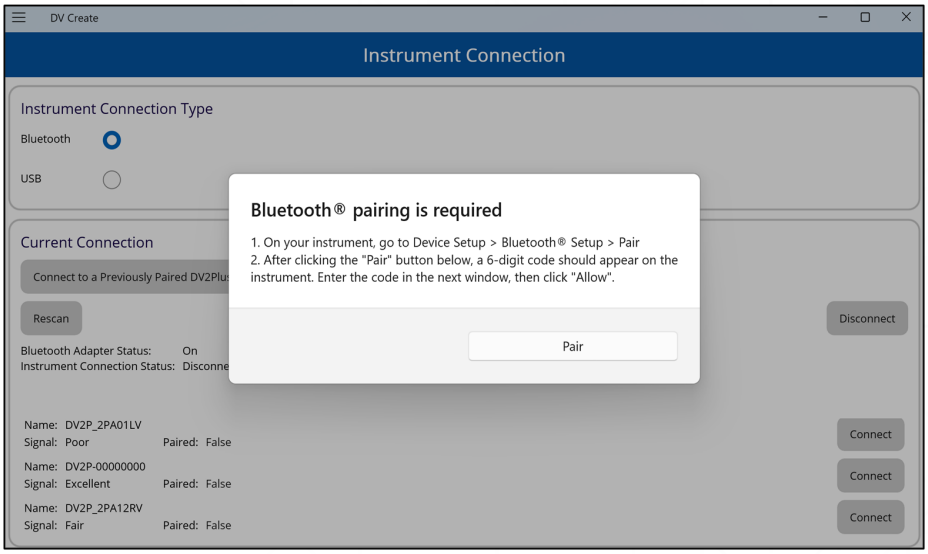
- Turn on the instrument.
- On the instrument, navigate to Settings> Bluetooth Setup and make sure that Bluetooth Enable switch control is on (tap the grey button).



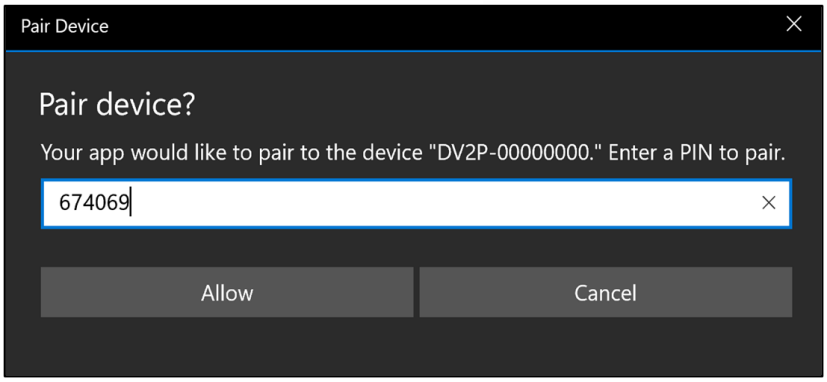
- Make a note of the instrument's Nickname
- Press save button, then press the Pair Button on the Bluetooth Setup screen
- Launch DV Create
- Within the software, Navigate to the Instrument Connection page
- Make sure that Bluetooth is selected as the Instrument Connection Type
- Your DV2Plus instrument should be listed within Bluetooth Connection section of the Instrument Connection page. Use Rescan button if you don't see your instrument listed

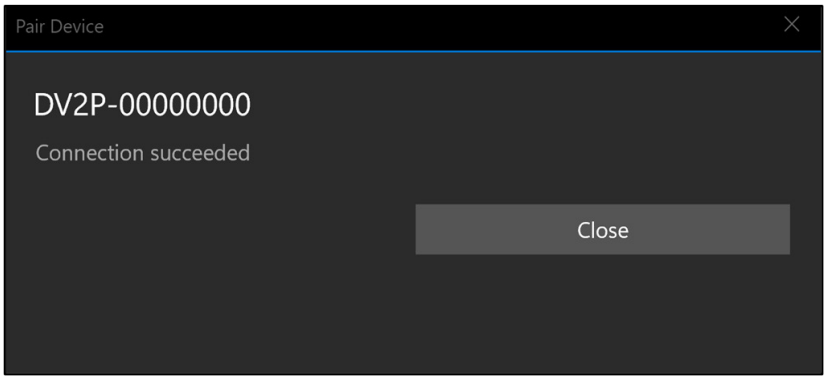


- Note, instrument should be listed as Paired: False
- Locate the Connect button, that appears to be to the right of the instrument Nickname (for example, DV2P_00000000)
- Click Connect button, read this step completely through, and follow onscreen instructions



- 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
  - Upon successful connection, the DV Create software will switch to the Live Data Page. The connected DV2Plus torque range and serial number will appear at the top of the screen
  - Once pairing is established, the status of the DV2Plus under Bluetooth Connection will change to Paired.

Establishing Bluetooth connection to a Paired Instrument

- Make sure the DV2Plus 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 DV Create and click either Connect or Connect to a previously paired instrument button.

DV Create can be set up to reconnect with a DV2Plus instrument if:

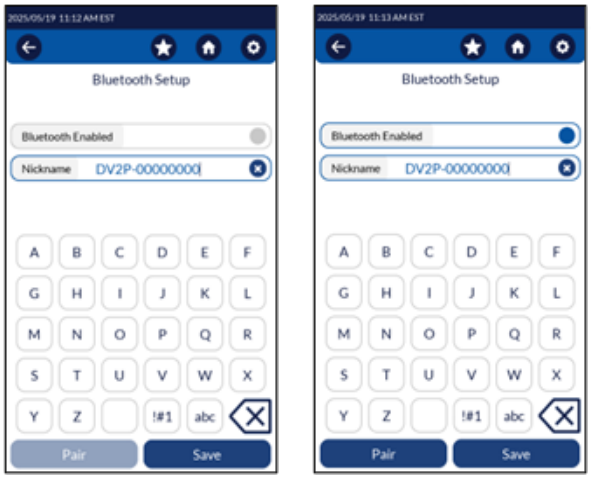
- Instrument was out of the range after Bluetooth connection was established.
- Instrument was restarted after Bluetooth connection was established.

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

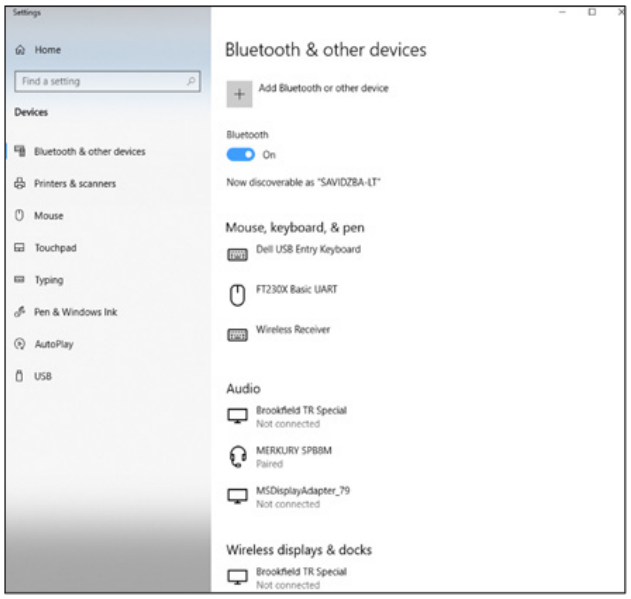
Establishing Bluetooth connection for the first time with Windows 10

- For Windows 10 users, the connection must be established manually. Here are the detailed steps

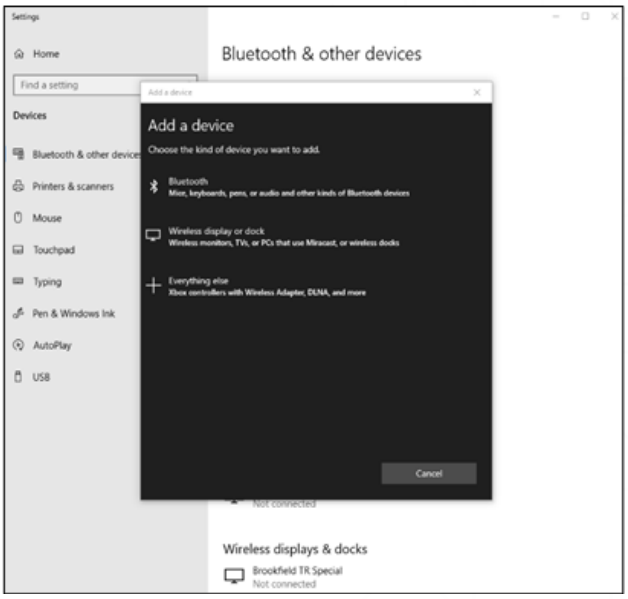
1. **Open Bluetooth Pairing Window**: Within the instrument, navigate to the Bluetooth pairing window.



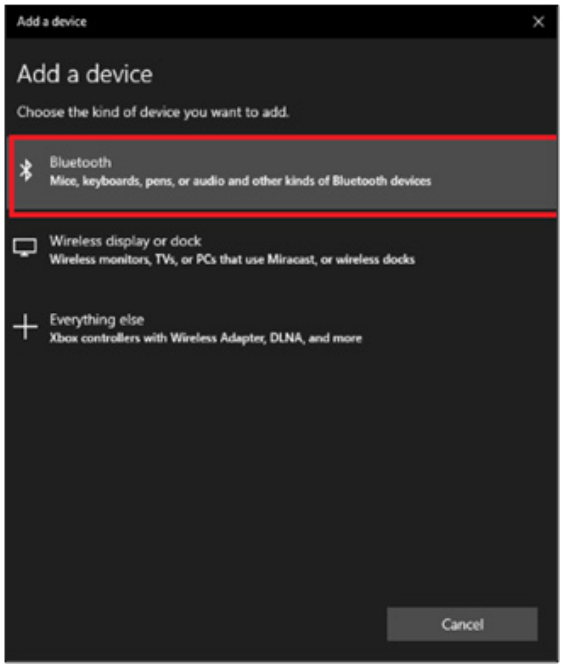
2. **Access Windows Settings**: On your Windows 10 device, go to **Settings**.



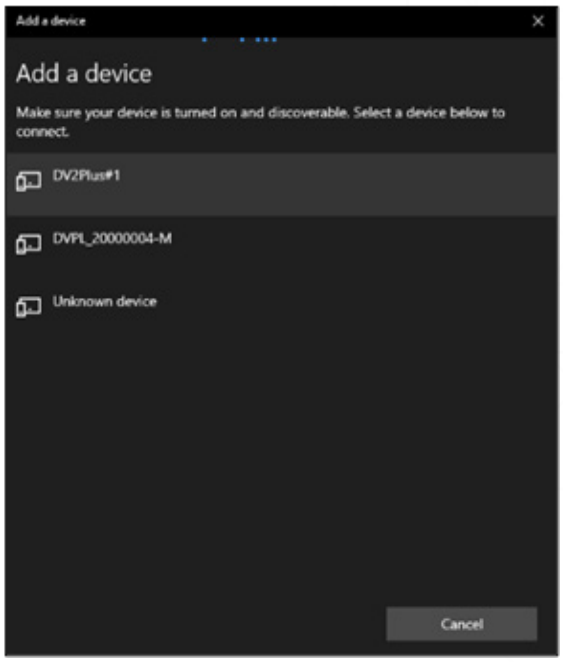
3. **Navigate to Bluetooth Devices**: Select **Bluetooth & other devices**.



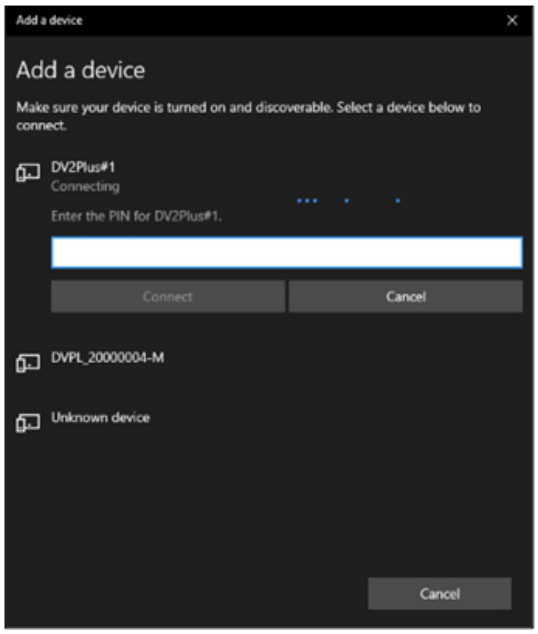
4. **Add Device**: Click on **Add Bluetooth or other device**.

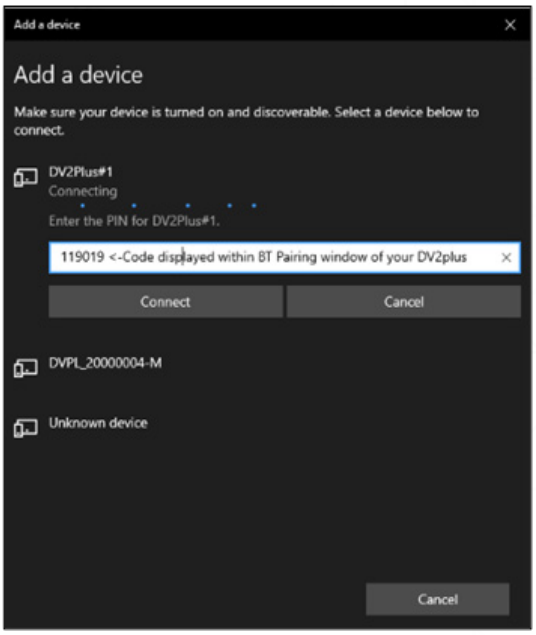


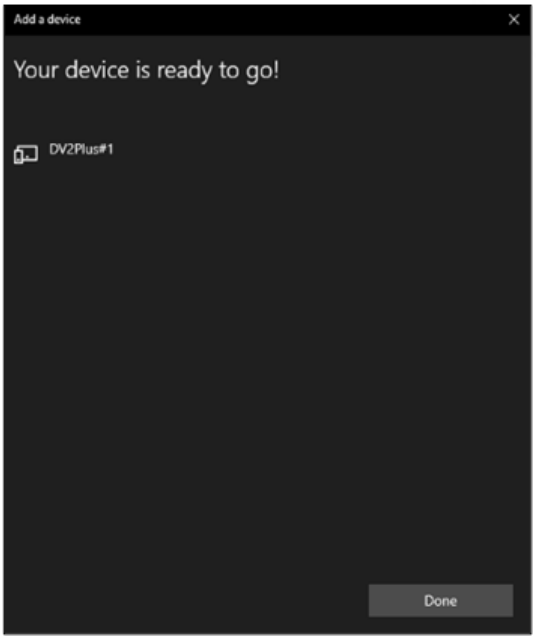
5. **Select Instrument**: Choose our instrument from the list of available devices.



6. **Enter Pairing Pin**: At this point, you will receive a pairing pin. Enter this pin to complete the connection.

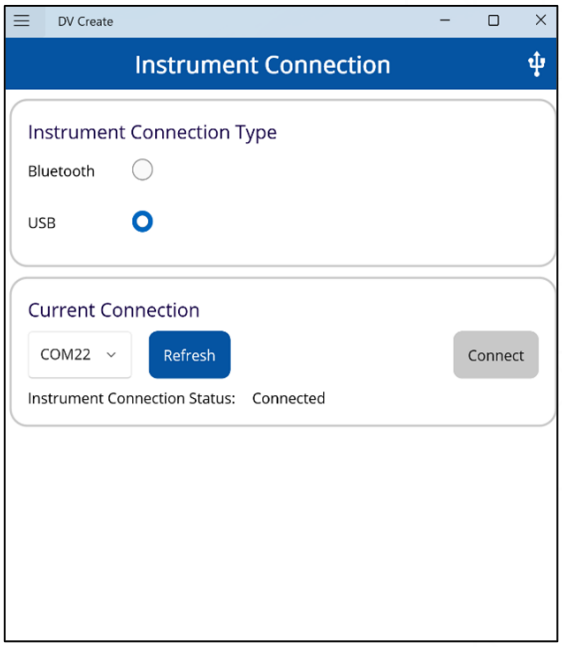






Connecting to the software via USB

- Make sure the instrument is connected to a PC via USB-B cable. Instrument USB Type B connection to PC USB Type A connection.
- Power up the DV2Plus instrument, wait until it is fully loaded.
- On the PC side, launch DV Create.
- Navigate to the Instrument Connection page.
- Select the USB option as instrument connection type.
- Use dropdown control to select available USB port. Click Refresh if no COM Ports are listed).
- Click Connect button.



Disconnecting from the software

To disconnect your DV2Plus Instrument from DV Create whether connected via Bluetooth or USB, simply navigate to the Instrument Connection page and click the Disconnect button.

APPENDIX P - ONLINE HELP AND ADDITIONAL RESOURCES

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

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 “home-made” videos made by our own technical sales group.

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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 AMETEK Brookfield University at https://www.brookfieldengineering.com/brookfield-university to learn more about training.

APPENDIX Q - WARRANTY REPAIR AND SERVICE

Brookfield Viscometers are guaranteed for one year from date of purchase against defects in materials and workmanship. They are certified against primary viscosity standards traceable to the National Institute of Standards and Technology (N.I.S.T.). 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 or go online for a return authorization number prior to shipping.

All AMETEK Brookfield DV2Plus 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 dealer may break the Calibration Seal for purposes of instrument repair or recalibration.

HEADQUARTERS

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11 Commerce Blvd. Middleboro, MA 02346 USA
1-508-946-6200 or 1-800-628-8139

Arizona, USA

AMETEK Brookfield
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VISCOSITY TEST REPORT

DATE:

BY:

FOR:

TEST INFORMATION:

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

CONCLUSIONS: