

CE

μVISCTM

User's Manual

The Revolutionary Viscometer



RHEOSENSE, INC.

RheoSense μ VISC Portable Viscometer

User's Manual Foreword

Rev 1.2

Thank you for your purchase of the μ VISC Viscometer! This instrument contains the most advanced microfluidic viscosity sensor on the market today. The μ VISC was designed to be intuitive and easy to use, but there are a few things that should be kept in mind when operating it. If you're like most people and don't like reading manuals, at least glance through the Precautions and Quick-Start sections before using the instrument for the first time. An understanding of the basics is all you need to get accurate, repeatable results right from the start. Once a few measurements have been taken, the rest of this manual can be used for reference and learning the advanced functions of the instrument.

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US Patent Numbers 7,290,441 and 6,892,583

The information contained in this document is believed to be correct, but Rheosense, Inc. accepts no liability for any errors it contains, and reserves the right to alter specifications without notice.

Precautions

1. Read these instructions.
2. Keep these instructions.
3. Heed all warnings.
4. Remove the waste container before flipping the unit over or the waste liquid will spill!
5. Never manually depress a pipette plunger once a full pipette has been mounted into the unit as permanent damage to the sensor may result.
6. Do not allow particles larger than 5% of the sensor channel depth in the sample (see the *System Information* menu for the sensor channel depth).
7. Use only the supplied power adapter to charge the unit.
8. Use only Rheosense μ VISC Pipette tips in the unit (accuracy is only guaranteed with a new pipette for each measurement).
9. Be careful not to spill liquid into the pusher trough opening or into the exposed sensor cartridge slot.
10. Always perform a cleaning cycle with an appropriate cleaning solution after measuring sample fluids that leave residues behind as they evaporate.

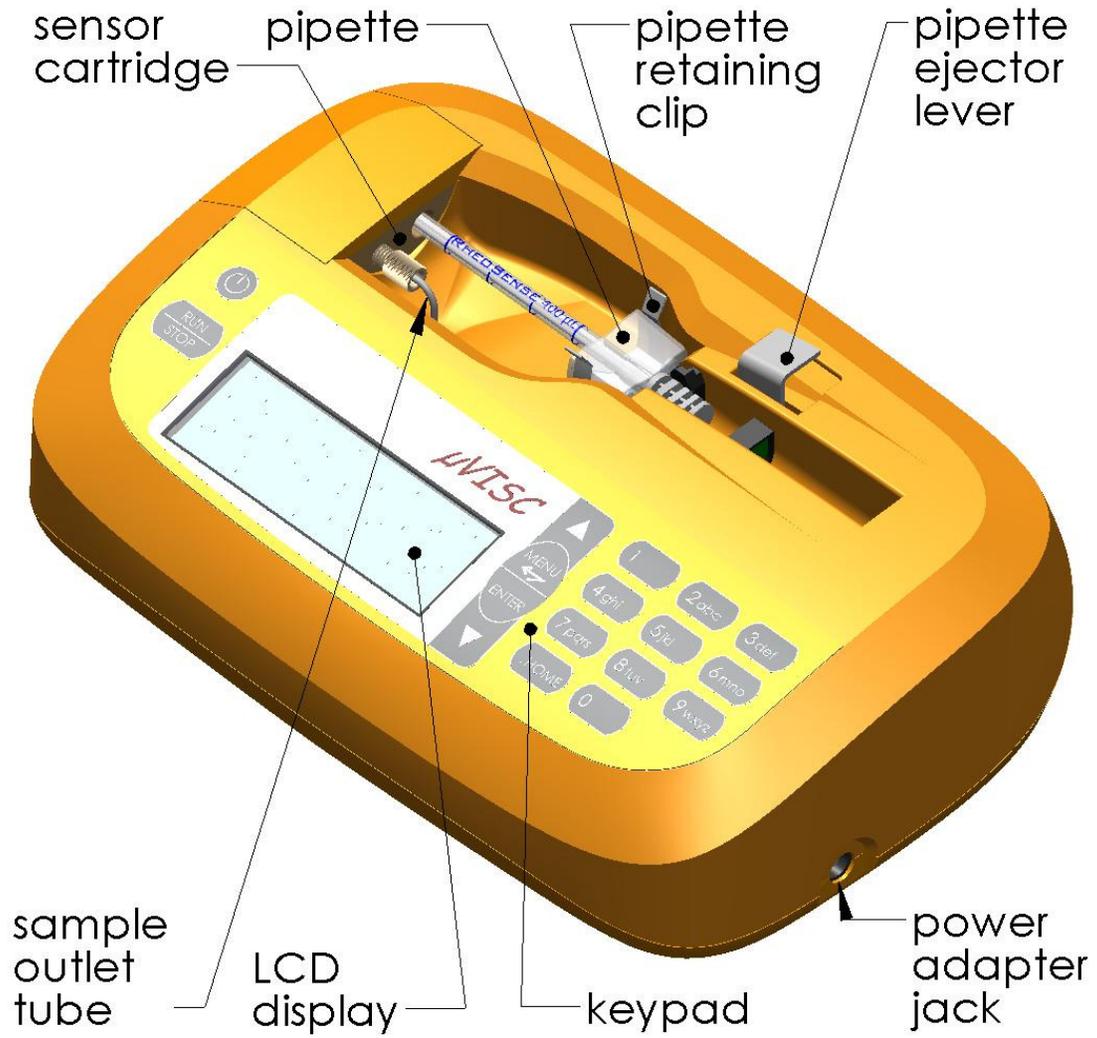
Precautions

11. Use only lint-free wipes to clean excess sample fluid from the tip of the pipette before mounting in the unit (available through Rheosense).
12. Use only lint-free swabs to clean the inlet port of the sensor cartridge (available through Rheosense).
13. Always replace the rubber stopper in the sensor cartridge inlet port when the cartridge is not in use (and there is no pipette in place).
14. Keep the original packaging material in case the unit should ever need to be shipped.
15. Do not attempt to open a sensor cartridge. Doing so will void the calibration and warranty, and may cause permanent damage to the sensor.
16. Contact only qualified Rheosense personnel for servicing. Servicing is required when the viscometer fails to operate normally, or has been damaged in any way, including but not limited to liquids having been spilled into the viscometer, exposure to rain or condensation, or the unit having been dropped.

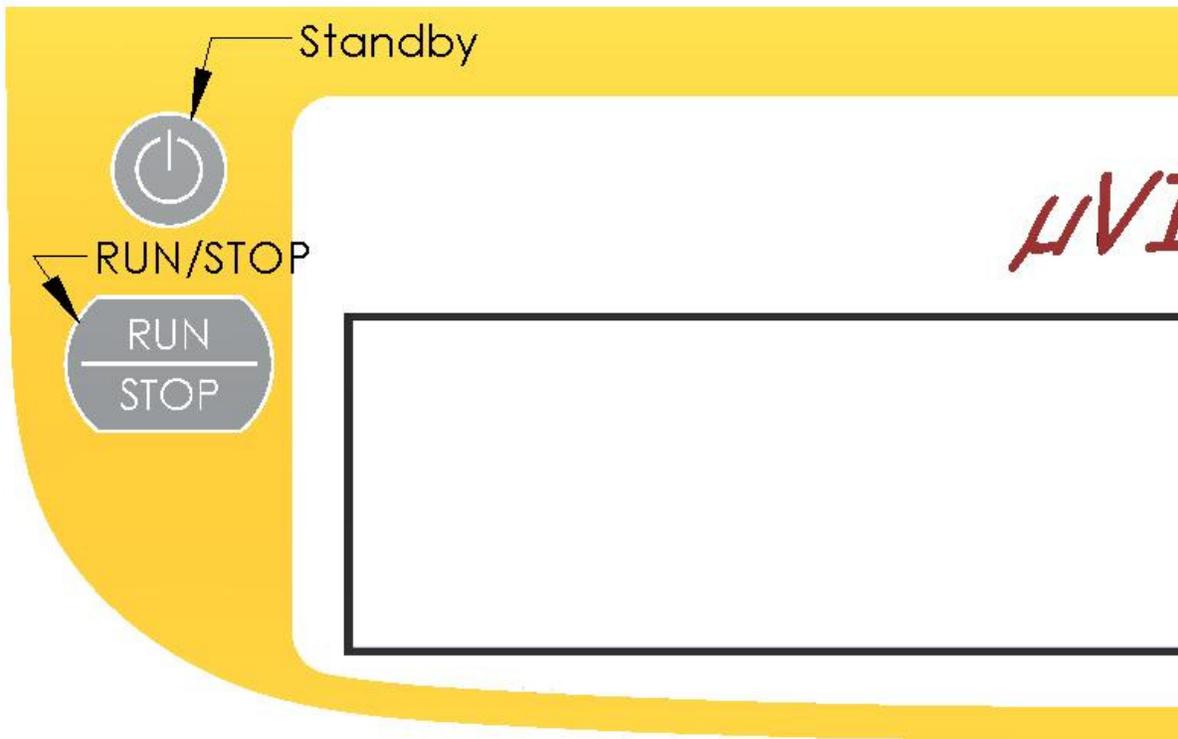
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Hardware Overview



Hardware Overview

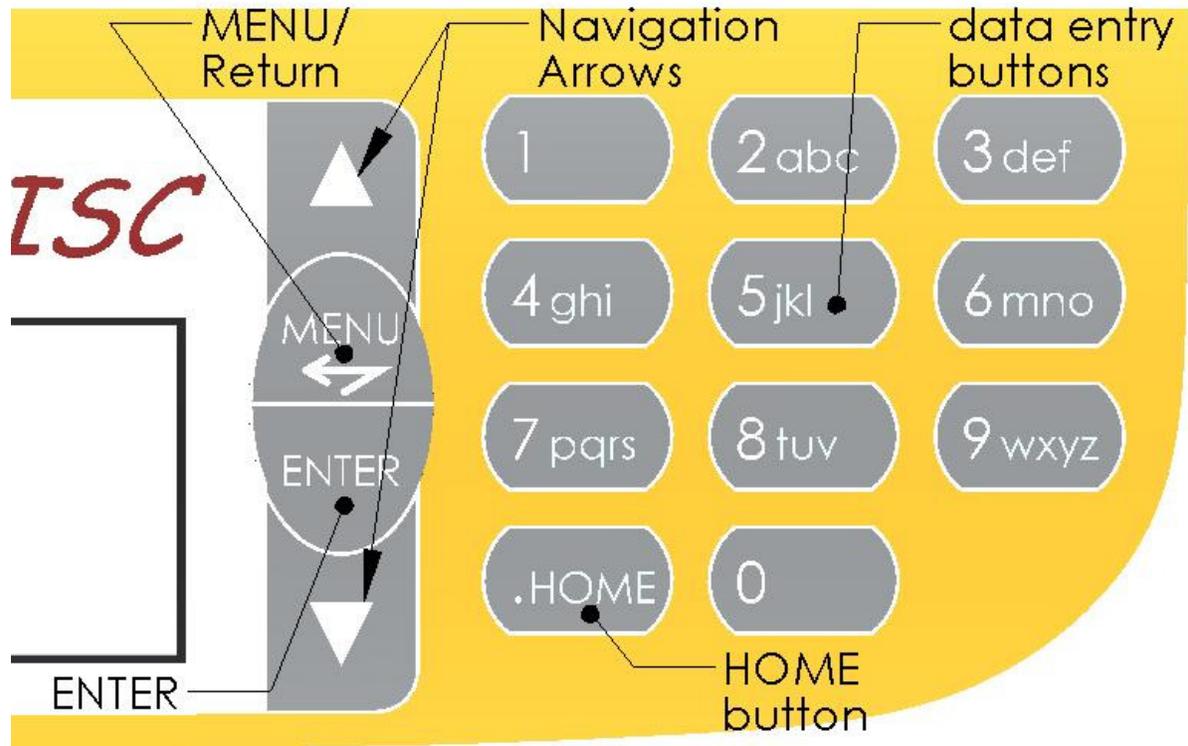


Standby: Toggles the unit in and out of sleep mode when the main power is on.

RUN/STOP: Starts a measurement from the *Ready* or *Results* screens, or stops a measurement at any point in the cycle. This will also halt the pusher when it is moving to the home position, except when the unit is first powered on.

MENU/Return: Selects a menu or navigates backwards.

Hardware Overview



Navigation Arrows: Moves between multiple pages of data or through menu items.

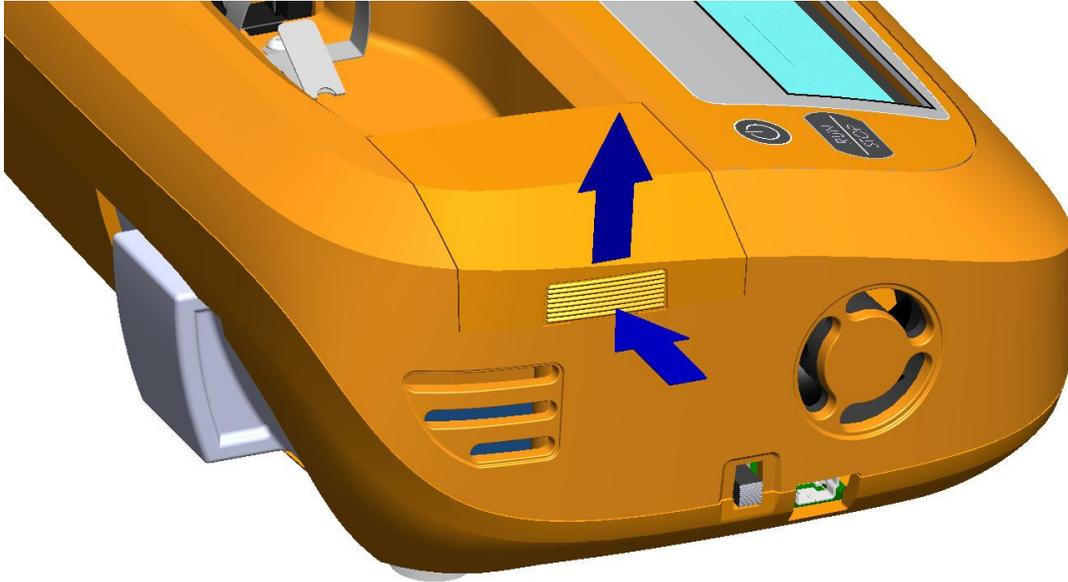
Data Entry Buttons: Use these to enter numeric parameters or alpha-numeric data labels.

ENTER: Confirms a keyed-in value.

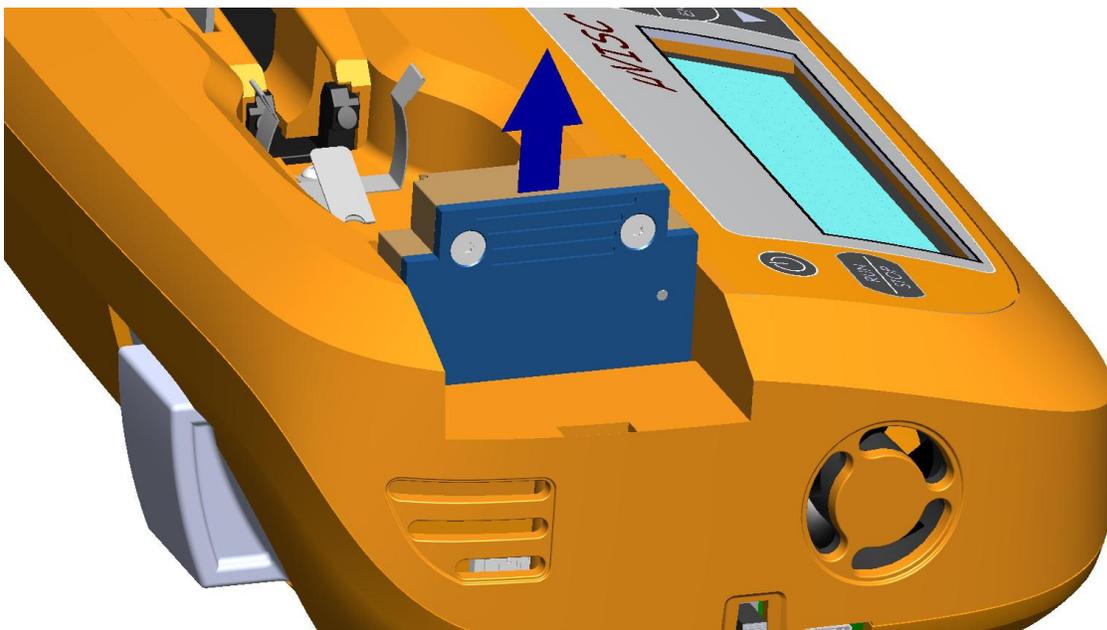
HOME Button: Sends the pusher to the home position from the *Ready* or *Results* screens to enable the removal or loading of a pipette.

Hardware Overview

Removing/Exchanging the sensor cartridge:



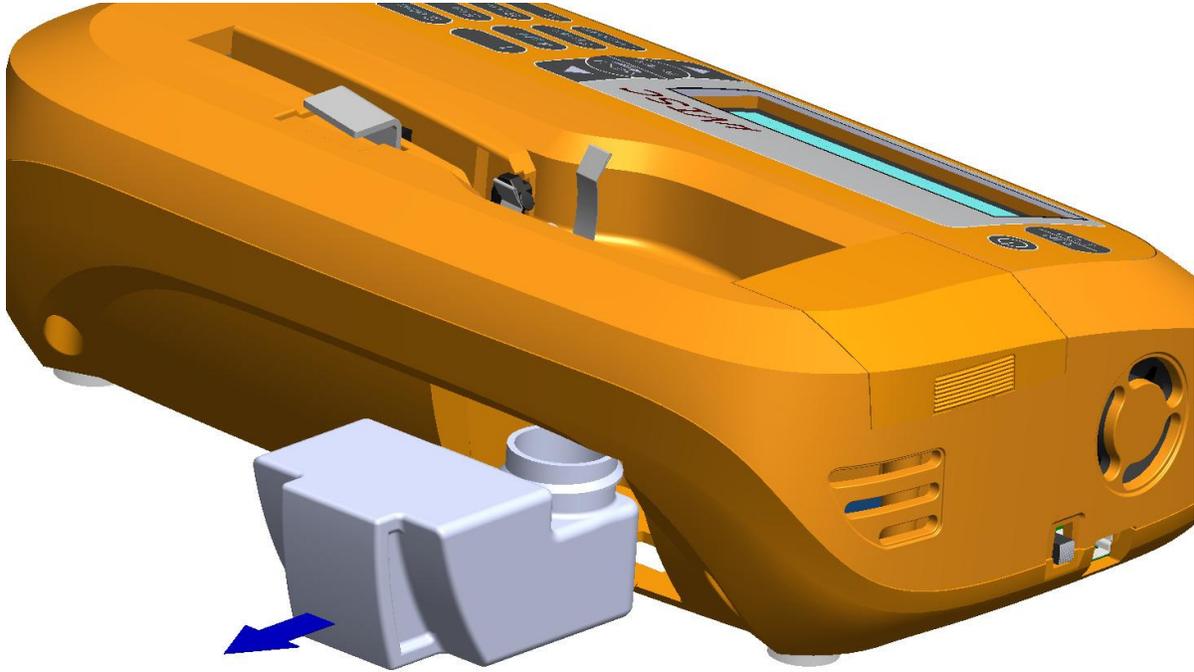
Push in and up on the sensor cartridge lid.



Grasp the top of the sensor cartridge and pull up.

Hardware Overview

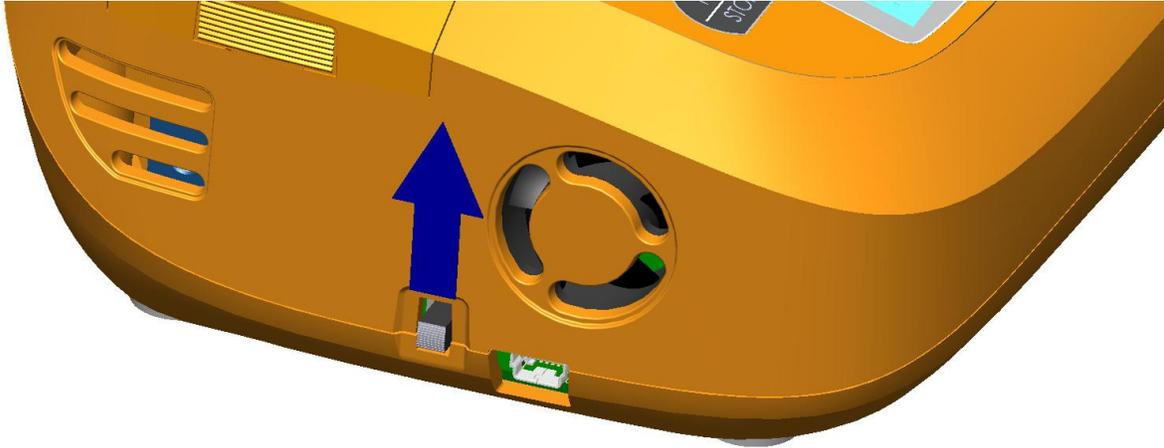
Removing the waste container:



Grasp the waste container by the protruding tab and pull outward.

Quick Start

1. Power the unit on with the On/Off Switch on the side:

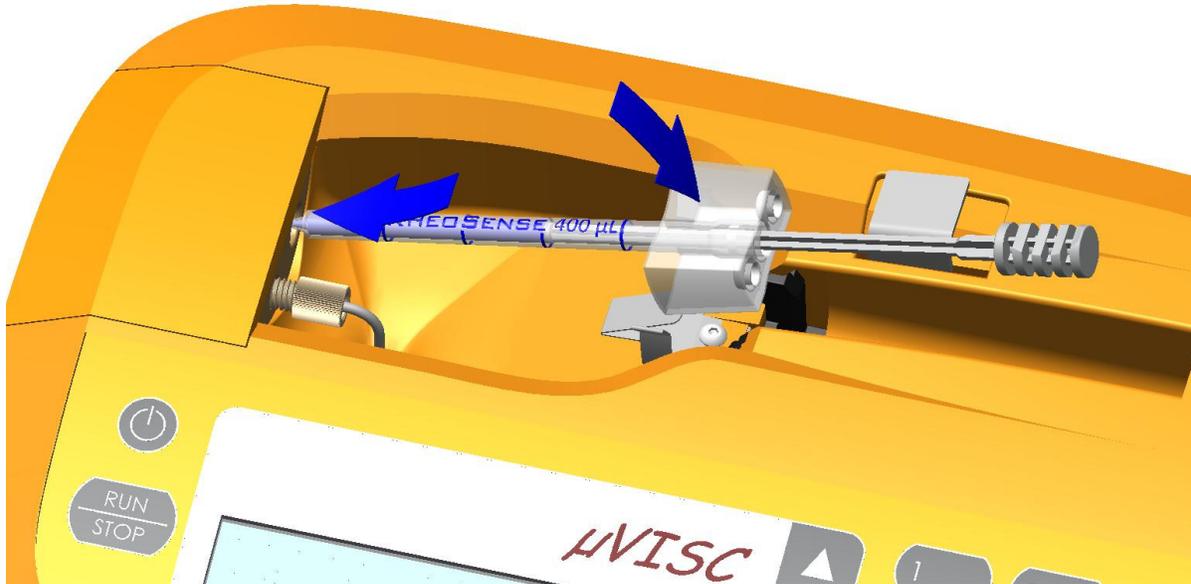


2. Load a pipette with sample by grasping the flange and slowly drawing back the plunger while the tip of the pipette is in the sample:



Quick Start

3. Mount the pipette in the unit by guiding the tip into the sample inlet port and firmly pushing down on the flange of the pipette until it clicks into place:



4. Press the RUN/STOP button on the keypad:



Loading the Pipette

General Considerations:

- Whenever handling a pipette, always hold it by the rectangular flange. This minimizes heat transfer to the sample fluid. Do not hold the pipette by the plunger when filled, as this may result in expelled sample or a bubble being drawn into the tip.
- After filling the pipette, wipe the excess fluid off the outside of the pipette with lint-free wipes. This will help prevent lint or foreign particles from entering the sensor element and damaging it.
- Do not over-fill the pipette, as this may prevent the pipette from fitting into the μ VISC unit.

Minimizing Bubbles:

The μ VISC disposable pipette has been designed with a very small dead volume, but a small bubble (about 1-1.5 μ l in volume) will always be trapped when drawing sample into a dry pipette. If the bubble is dispensed into the instrument, erroneous values may result. Always try to load the pipette so there are no bubbles in it. To remove the small bubble that results when first drawing sample, use one of the following two techniques.

Loading the Pipette

- A. This technique may be employed for samples of all viscosities:
 - 1. Insert the pipette into the sample and draw a small amount of liquid into the pipette. Only draw in enough liquid to see the formation of the bubble.
 - 2. Fully expel the liquid into a waste container.
 - 3. Insert the pipette back into the sample and slowly draw the desired amount of sample into the pipette.

- B. This technique will only work for lower viscosity samples:
 - 1. Insert the pipette tip into the sample and draw the desired amount of sample into the pipette.
 - 2. Hold the pipette vertically by the rectangular flange so the tip is pointing at the ceiling. Flick the side of the pipette until the bubble rises to the tip.
 - 3. Push the plunger slightly until the bubble is expelled from the tip.

Operating Modes

There are three operating modes available on the μ VISC: Automatic, Advanced, and Cleaning. Automatic mode is the “One Touch” measurement mode in which the system decides all parameters of the measurement. For Newtonian fluids (fluids that have the same viscosity at all shear rates), Automatic mode is generally all that is needed to get accurate repeatable data. Advanced mode gives the user control over all the parameters of the measurement. This can be beneficial when a test at a specific shear or flow rate is required, or a certain volume must be tested each time. Cleaning mode simplifies the task of cleaning the microfluidic flow channel in the sensor with optimized solvent flow rates.

From the *Ready* screen, switch between the 3 operating modes by pressing the Up/Down Navigation Arrows. From any of these screens, press the RUN/STOP button to start a measurement using any of these modes. The *Main Menu* screen can also be accessed from any of the operating modes' *Ready* screen by pressing the MENU button.

LOAD SAMPLE & 
PRESS RUN 23.00°C
Auto mode
Menu, \uparrow / \downarrow : Change mode

LOAD SAMPLE & 
PRESS RUN 23.00°C
Advanced 100.0 s ⁻¹
Menu, \uparrow / \downarrow : Change mode

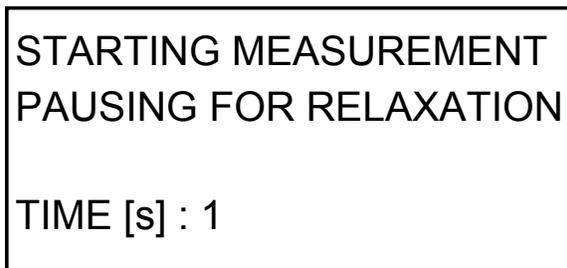
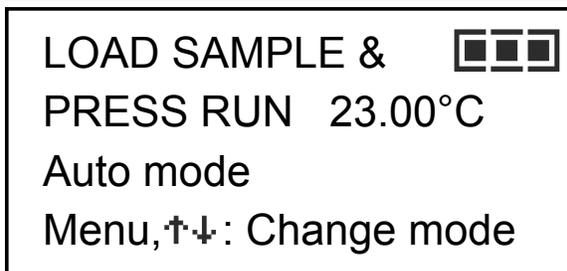
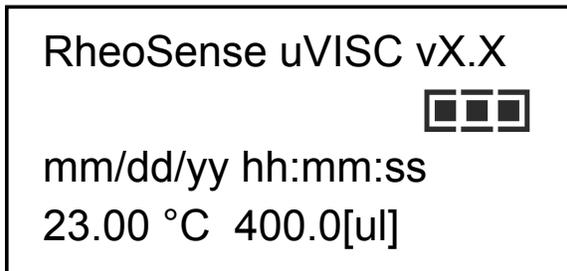
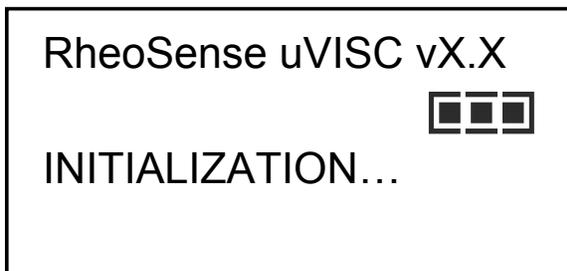
LOAD SAMPLE & 
PRESS RUN 23.00°C
Cleaning mode
Menu, \uparrow / \downarrow : Change mode

Operating Modes

Automatic Mode

Overview

The diagrams below show the screens that will appear as the μ VISC performs an automatic measurement.



1. The unit initializes when it is first turned on. This second screen appears briefly as initialization completes.
2. When this screen appears, load a pipette with sample and insert it into the unit.
3. This appears after the RUN/STOP button is pressed.

Operating Modes

STARTING MEASUREMENT
BASELINE MEAS...

STARTING MEASUREMENT
MOVING TO PLUNGER...
VOL [ul] : 400.0

4. The pusher moves to the plunger when this appears.

STARTING MEASUREMENT
PLUNGER DETECTED
PAUSING FOR RELAXATION
TIME [s] : 1

PRIMING...
23.00 °C 5.5 s⁻¹
0.1 ul 1 sec
P: 23.0 (0.5%)

5. When this screen appears, the sensor is being primed with test fluid.

STARTING MEASUREMENT
PAUSING FOR RELAXATION

TIME [s] : 1

Operating Modes

STARTING MEASUREMENT BASELINE MEAS...
VISC [mPa•s]: 2.13 23.00 °C 605.1 [s ⁻¹] 12.3 ul SCALE: 49.5% 39%
VISC [mPa•s]: 2.12 23.00 °C 604.7 [s ⁻¹] 70.4 ul SCALE: 50.8% Run, Menu, Home: _ 1/3
S-STRESS [Pa] : 128.64 F-RATE [ul/m] : 201.3 SLOPE [Pa / mm] : 30.4 Run, Menu, Home: _ 2/3
S/N : 10RC10100094 01/13/11 12:51:43 M-TIME [s] : 8 Run, Menu, Home: _ 3/3

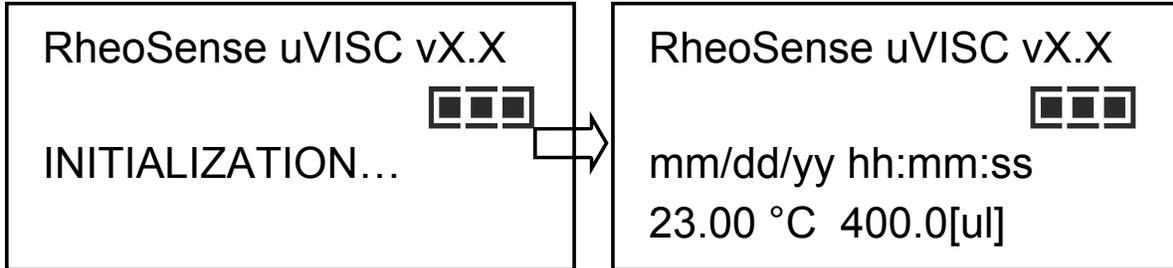
6. The viscosity measurement begins when this screen appears.

7. Here the final results are displayed.

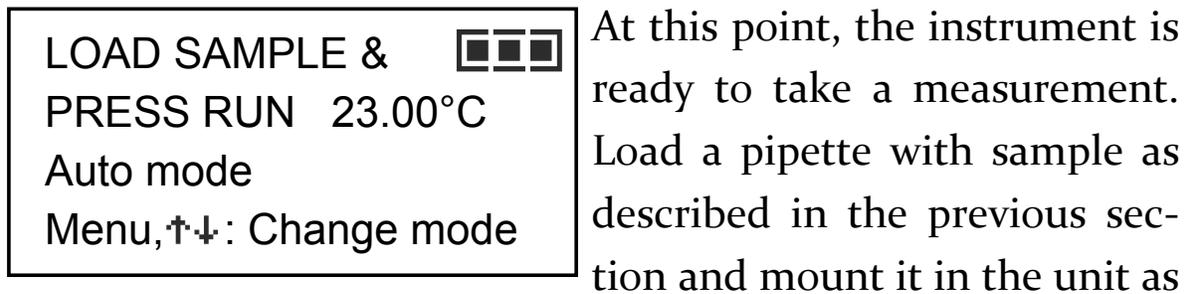
Operating Modes

Automatic Mode In Detail

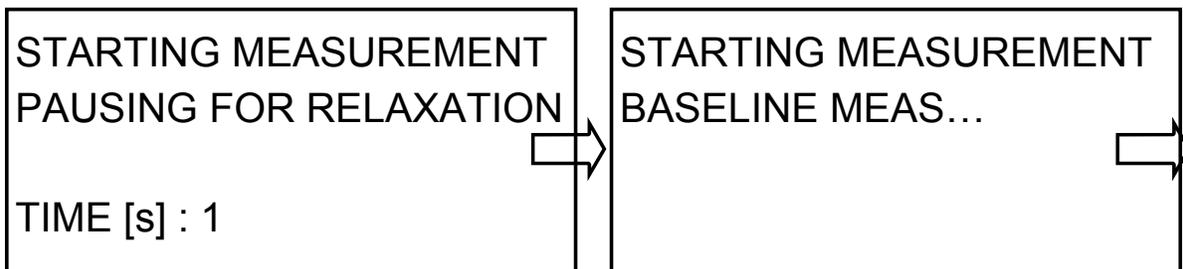
When the μ VISC is powered on using the ON/OFF switch on the left side of the unit, the LCD will briefly display:



vX.X is the product version number, mm/dd/yy is the date, and hh:mm:ss is the time in hours, minutes, and seconds. The box symbol is the battery charge indicator. After these two *Initialization* screens, the *Ready* screen will appear:



shown in the Quick Start section. Press the RUN/STOP button on the keypad to the left of the LCD display. The display will show:



Operating Modes

STARTING MEASUREMENT
MOVING TO PLUNGER...
VOL [ul] : 400.0

Checking relaxation and baseline measurement could take a few seconds. The pusher then moves towards the pipette until it contacts the plunger.

The decreasing volume readout while the pusher is moving represents the potential volume remaining in the pipette based on the position of the pusher. Once the plunger has been reached, the display will show:

STARTING MEASUREMENT
PLUNGER DETECTED
PAUSING FOR RELAXATION
TIME [s] : 1

The pause for relaxation could take a few seconds or longer, depending on the viscosity of the fluid.

PRIMING...
23.00 °C 5.5 s⁻¹
0.1 ul 1 sec
P: 23.0 (0.5%)

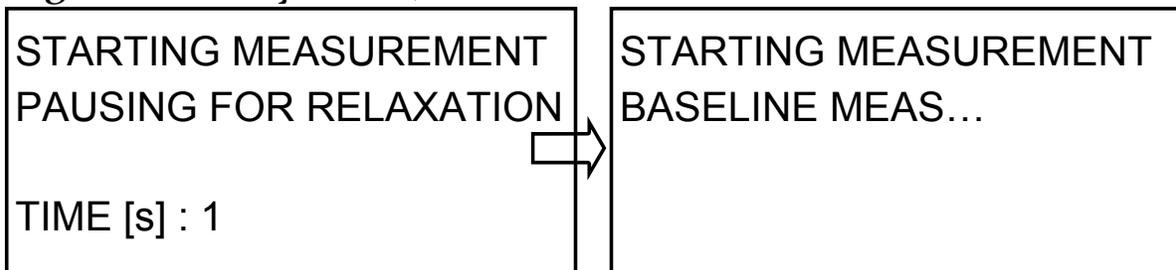
Priming now commences. Priming is the act of filling the microfluidic channel with the test fluid. Priming is always performed at the start of a

measurement when the pusher is not in contact with the pipette plunger. If the microfluidic channel is dry, it must be filled with sample before an accurate baseline can be read. If the channel is wet from a previous sample, the previous fluid must be completely replaced. Even trace amounts of a previous sample could cause significant error in the measurement.

Operating Modes

Priming volumes typically range from 10 to 200 μl . On the *Priming* screen, 5 pieces of data are displayed: the current temperature in degrees Celsius ($^{\circ}\text{C}$), the current pumping rate in inverse seconds (s^{-1}) or microliters per minute ($\mu\text{l}/\text{min}$), total pumped volume in microliters (μl), elapsed time in seconds, and the current pressure in Pascals (Pa). Also displayed with the pressure is a number which represents the percent of full-scale pressure of the sensor. The μVISC will attempt to pump the fluid at a rate that results in a pressure reading of 50% of full-scale. Once this value is reached and any previously measured sample has been moved through the sensor, priming stops. When replacing higher-viscosity fluid with lower-viscosity fluid, the system will generally require a larger priming volume. If 50% of full-scale cannot be reached even at the maximum pumping rate of the system, priming will be stopped after 200 μl have been pumped or the viscosity has stabilized.

After priming, the system waits for the stress created by the moving fluid to dissipate before the baseline is measured. For higher viscosity fluids, this could take 10-20 seconds.



Operating Modes

Once the measurement starts, the following information is displayed:

VISC [mPa•s]: 2.132	
23.00 °C	605.1 [s ⁻¹]
12.3 ul	SCALE: 49.5%
	39%

Viscosity (mPa-s), temperature (°C), pumping rate (s⁻¹ or µl/min), cumulative dispensed volume (µl), pressure represented as a percentage of full

scale, and the measurement progress bar. All the values except dispensed volume are instantaneous readings.

The measurement stops automatically when the reading has stabilized. The data displayed on the *Results* screen are all average values, except the volume (which is the cumulative amount dispensed including priming). To view other parameters of the measurement, use the Up/Down Navigation Arrows on the keypad to move among the 3 *Results* screens:

VISC [mPa•s]: 2.125	
23.00 °C	604.7 [s ⁻¹]
70.4 ul	SCALE: 50.8%
Run, Menu, Home: _	1/3

S-STRESS [Pa] : 128.64	
F-RATE [ul/m] : 173.0	
SLOPE [Pa / mm] : 30.4	
Run, Menu, Home: _	2/3

Shear Stress [Pascals]
Flow Rate [microliters/minute]
Pressure Slope [Pa/millimeter]

Operating Modes

SID : 10RC10100094	Sensor Serial Number
01/13/11 12:51:43	Time Stamp, Date and Time
M-TIME [s] : 8	Measurement Time [seconds]
Run, Menu, Home: _ 3/3	

After the Measurement

After the measurement has finished, 3 options will be available:

1. Press the RUN/STOP button: The system will take another measurement without running the priming operation. The μ VISC will continue to take measurements as long as there is sample remaining in the pipette. Once the sample has run out, the pusher will automatically return to the Home position.
2. Press the MENU button: The *Main Menu* screen is displayed. Advanced parameters and functions can be selected from here.
3. Press the HOME button: The pusher will return to the Home position to enable removal/loading of the pipette, and the display will return to the *Ready* screen. Press the RUN/STOP button at any point to halt the pusher.

Operating Modes

Advanced*

In the Advanced mode, you may set all the parameters of the measurement or leave them for the system to decide. This may be especially useful if a repetitive measurement needs to be done at a specific shear/flow rate, or the same amount of sample needs to be used for each measurement. In addition, measuring a given sample at multiple shear/flow rates may help you determine if a sample is Non-Newtonian. If a fluid is Newtonian (has the same viscosity at all shear rates), generally Auto mode is all that is needed. If a testing protocol requires a specific shear/flow rate, Advanced mode must be used since the shear/flow rate is always determined by the system in Auto mode. Two other parameters in Advanced mode may be left for the system to decide or specified by the user: Measurement Volume and Priming Volume. These two parameters are always handled by the system in Auto mode. The Advanced mode parameters are described fully in the Setting Advanced Parameters section. In general, customizing the parameters to a specific measurement task can make routine measurement processes more efficient.

*The Advanced mode is not available on all μ VISC models.

Operating Modes

The Advanced mode *Ready* screen shows the currently set shear/flow rate. The factory default setting is Auto mode (the system will determine the rate as it does in the Automatic Measurement mode). To change the system Rate units (shear s^{-1} or flow $\mu l/m$) see Section 8 (Menus and System Options).

Setting Advanced Parameters

From the *Ready* screen, press the MENU button to enter the *Main Menu* screen. Once the *Main Menu* screen has been entered, press the MENU button at any point to go back a

1.SET ADVANCED MEAS
2.SET SAMPLE ID
3.VIEW PREVIOUS MEAS
<MENU>†± No: _ 1/3

level.

Press 1 to enter the *Set Advanced Measurement* menu.

1.SET NEW PARAMETERS
2.VIEW/LOAD PROTOCOL
3.SAVE NEW PROTOCOL
Select No: _ 1/2

There are two screens in the *Set Advanced Measurement* menu. Press the Navigation Arrows to move between them.

4.DELETE A PROTOCOL
5.LOAD FACTORY PARAM

Select No: _ 2/2

Press 1 to enter the *Set New Parameters* menu.

Operating Modes

1.RATE [s ⁻¹]: AUTO
2.MEAS.VOL [ul]: AUTO
3.PRIME.VOL [ul]: AUTO
Run, Menu, or No: _ 1/2

4.PAUSE T [s]: 5
Run, Menu, or No: _ 2/2

There are two screens in the *Set New Parameters* menu. Press the Navigation Arrows to move between them. To edit a menu item, press the number button corresponding to that item. To change a parameter, enter a number value on the keypad while the value is blinking, then press ENTER.

To cancel the change, press the MENU button. To return to the previous menu, press the MENU button. To start a measurement with the newly set parameters, press the RUN/STOP button. The parameters are:

1. Rate: The units for Rate are either s⁻¹ (inverse seconds) for shear rate or µl/m (microliters/minute) for flow rate. This is the rate at which the sample fluid is pumped through the sensor cartridge. The available flow rate range is 0.5-450 µl/m. The available shear rate will depend on the specific sensor cartridge used. Factory default is Auto mode (the system will determine the rate as it does in the Automatic Measurement mode). See section 13 (Technical Specifications) for the shear rate ranges of available sensor cartridges.

Operating Modes

2. **Measurement Volume (μl):** The available measurement volume range is 5-400 μl . Auto mode may also be selected, in which case the system will determine when to end the measurement based on the stability of the viscosity reading. The factory default is Auto mode.
3. **Priming Volume (μl):** Priming is the act of filling the microfluidic channel with the test fluid. Priming is always performed at the start of a measurement when the pusher is not in contact with the pipette plunger. If the microfluidic channel is dry, it must be filled with sample before an accurate baseline can be read. If the channel is wet from a previous sample, the previous fluid must be completely replaced. Even trace amounts of a previous sample could significantly skew the measurement results. The available priming volume range is 1-200 μl . Auto mode may also be selected, in which case the system will end the priming once it determines all the previous sample fluid has been replaced. When replacing higher-viscosity fluid with lower-viscosity fluid, the system will generally require a larger priming volume. The factory default is Auto mode.

Operating Modes

4. **Pause Time (seconds).** After priming, the system must pause to wait for the stress created by the moving fluid to dissipate before an accurate baseline can be measured. The available pause times are 0-36,000 seconds. The factory default is 5 seconds. Note that the pause time function may also be used as a timer.

Saving Measurement Protocols

After the Advanced mode parameters have been set, they can be saved as a user protocol for future use. Up to 8 different protocols may be saved at a time. To save a user protocol, from the *Main Menu*, press 1 to enter the *Set Advanced Measurement* menu, then press 3 to enter the *Save New Protocol* function. If a previously-created protocol is loaded, its ID will

ID : EMPTY
SR: 334.5 PV: 25 ul
PT: 7s MV: 100 ul
[↑ : Edit ID , ↓ : GoNext] _

be shown above the protocol values. If no protocol is loaded, “EMPTY” will be displayed in the ID field. To change the protocol values,

press the MENU button to return to the *Set Advanced Measurement* menu and follow the instructions in the previous section. To edit or assign a protocol ID for the current set of parameters, press the Up Navigation Arrow.

Operating Modes

ID : USER PROTOCOL 1_
SR: 334.5 PV: 25 ul
PT: 7s MV: 100 ul
[↑: Del, HOME: Symbol]

When the *Edit ID* screen is active, the cursor will blink. Use the numeric keypad to enter alpha-numeric characters. Pressing a number button

in quick succession will scroll through the available number and letters for that button. Wait 1.5 seconds for the cursor to advance. Here is a list of button functions:

Up Navigation Arrow: Delete

Down Navigation Arrow: Space

MENU button: Cancel changes and exit edit mode

ENTER button: Confirm new protocol ID

Number buttons: Type numbers and letters

HOME button: Scrolls through 8 symbols: . • _ - # % ()

The protocol values displayed are:

SR or FR: Shear Rate (in inverse seconds) or Flow Rate (in microliters per minute), depending on the system setting

PV: Priming Volume (in microliters)

PT: Pause Time (in seconds)

MV: Measurement Volume in microliters.

Operating Modes

```
ID : USER PROTOCOL 1
SR: 334.5    PV: 25 ul
PT: 7s    MV: 100 ul
[ ↑ : Edit ID , ↓ : GoNext ] _
```

```
#1 : USER PROTOCOL 1
SR: 334.5    PV: 25 ul
PT: 7s    MV: 100 ul
ENT: Save, MENU: Ret _
```

```
ALL USER PROTOCOL
SLOTS FULL. CHOOSE
PROTOCOL TO DELETE
↑↓ : View, ENT: Del_ 8/8
```

After the protocol ID has been input, press the ENTER button. The *Edit ID* screen will be exited. Press the Down Arrow to go to the *Save Confirmation* screen. Press the ENTER button to commit the ID and protocol values to memory. Pressing the MENU button will return the system to the *Set Advanced Measurement* menu. Once saved, the Advanced mode *Ready* screen will be shown.

If all User Protocol Slots are filled when attempting to save a new protocol, the *Protocols full* screen will appear. In order to save the new protocol, a currently saved protocol must first be deleted. View the currently saved protocols by using the Up/Down Navigation Arrows. Press ENTER to delete the selected protocol, or press MENU to exit without deleting.

Operating Modes

Retrieving and Deleting Measurement Protocols

To load a previously saved protocol: From the *Main Menu*, press 1 to enter the *Set Advanced Measurement* menu, then

#1 : USER PROTOCOL 1
SR: 334.5 PV: 25 ul
PT: 7s MV: 100 ul
↑↓ : View, ENT: Load_1/8

press 2 to get to the *View/Load Protocol* screen. The first saved protocol will be displayed. Use the Up/Down Navigation Arrows to scroll

through the saved protocols. Press ENTER to load the protocol shown and return to the *Advanced mode Ready* screen. Press the MENU button to return to the *Set Advanced Measurement* screen.

To delete a previously saved protocol: From the *Main Menu*, press 1 to enter the *Set Advanced Measurement* menu. Press 4

#1 : USER PROTOCOL 1
SR: 334.5 PV: 25 ul
PT: 7s MV: 100 ul
↑↓ : View, ENT: Del_ 1/8

to get to the *Delete a Protocol* screen. The first saved protocol will be displayed. Use the Up/Down Navigation Arrows to scroll through the saved

protocols. Press ENTER to delete the protocol shown. Press the MENU button to return to the *Set Advanced Measurement* menu.

Operating Modes

Cleaning

In general, samples may be tested consecutively without cleaning the sensor cartridge in between. However, the sensor cartridge *must* be cleaned if:

- The μ VISC will not be used for a day or longer.
- The sensor cartridge will be removed from the unit and stored for a day or longer.
- The sensor cartridge is going to be removed from the unit for an hour or longer, and has been used with a sample comprised of particulate matter and high volatility solvent (such as ink).
- The sample fluid about to be tested is immiscible with the previous sample (i.e., testing an aqueous solution after testing an oil based calibration standard).
- You are unsure whether you should run a cleaning cycle! Cleaning is fast, easy, and will protect your instrument from damage.

To clean the sensor cartridge, fill a new pipette with a solvent that is miscible with the sample(s) used (a small mixture of the sample and solvent appears homogeneous and not cloudy). Mount the pipette in the μ VISC and from a *Ready*

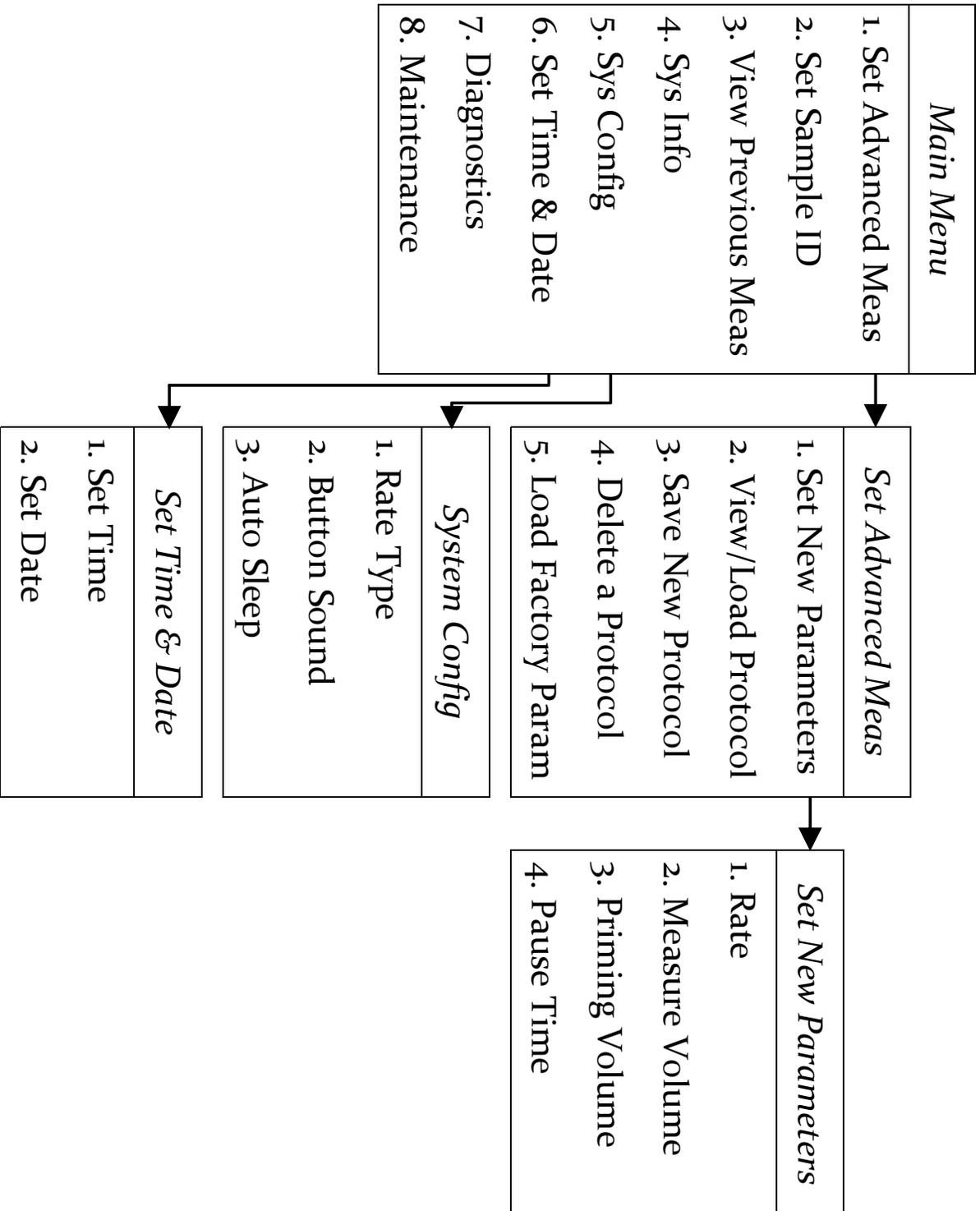
Operating Modes

screen, use the Up/Down Navigation Arrows to move to the Cleaning mode *Ready* screen. Press the RUN/STOP button to begin the cleaning procedure. The system will dispense the entire contents of the pipette at 100 $\mu\text{l}/\text{m}$, so for a full pipette, the cleaning cycle will take about 4 minutes. At the end of the cycle, the standard three *Results* screens will be displayed. Depending on the sensor cartridge in use, the percent full scale (SCALE) parameter may be very low. This is because cleaning is most effective when the solvent is pumped fairly slowly through the microfluidic channel, which leads to low full scale pressure readings. Because of this, the viscosity value of the cleaning fluid after a cleaning run may not be entirely accurate.

After cleaning, if there are no more measurements to be made, leave the empty solvent pipette in the μVISC unit. If removing the sensor cartridge, store the cartridge with the stopper firmly pressed into the inlet port.

Menus and System Options

The μ VISC has the following menu item structure:



Menus and System Options

The *Main Menu* consists of three screens. The *Main Menu* is accessed by pressing the MENU button while in any of the *Ready* screens.

1.SET ADVANCED MEAS 2.SET SAMPLE ID 3.VIEW PREVIOUS MEAS <MENU>↑↓ No: _ 1/3
4.SYS INFO 5.SYS CONFIG 6.SET TIME & DATE <MENU>↑↓ No: _ 2/3
7.DIAGNOSTICS 8.MAINTENANCE <MENU>↑↓ No: _ 3/3

Move among the three screens by pressing the Up/Down Navigation Arrows. To select a menu item, press the number on the keypad that corresponds to that item. To move back a level in any of the menus, press the MENU button. Each item is detailed below:

1. *Set Advanced Measurement*: See the detailed description in section 7.
2. *Set Sample ID*: Entering this function brings up the screen seen at the top of page 37. The ID must be set before a measurement is taken in order for it to appear in the data log.

Menus and System Options

```
SET SAMPLE ID :  
#1  
[ ↑ : Edit, ↓ : Return ]_
```

The current sample ID is shown. To edit the sample ID, press the Up Arrow. To exit, press the Down Arrow or MENU button.

```
SET SAMPLE ID :  
_  
[ ↑ : Del, HOME: Symbol ]
```

When the edit sample function is active, the cursor will blink. Use the numeric keypad to enter alpha-numeric characters. Pressing a number button

in quick succession will scroll through the available number and letters for that button. Wait 1.5 seconds for the cursor to advance. Button functions are:

Up Navigation Arrow: Delete

Down Navigation Arrow: Space

MENU button: Cancel changes and exit edit mode

ENTER button: Confirm new sample ID

Number buttons: Enter numbers and letters

HOME button: Scrolls through 8 symbols: . • _ - # % ()

Menus and System Options

3. *View Previous Measurements*: Entering this function brings up the data log display. The most recent measurement record is displayed first. A total of 20 records are held in memory. Once the 20 slots (labeled Mo-M19) are filled, new measurements overwrite the old records in order of date written, with the oldest record being overwritten by the newest measurement. The measurement record slots are static, so when one slot is filled, a new measurement will overwrite the next slot (i.e., after M19 is filled, Mo will be overwritten).

Pressing the ENTER button will allow you to scroll through the 3 screens in each record. The MENU button will return you to the *Main Menu*, and the Up/Down Navigation Arrows allow you to switch from one measurement record to another.

Each measurement record contains the following three screens:

ID : # 1	Sample ID
01 / 20 / 11 12 : 01 : 09	Time Stamp, Date and Time
23.10 °C 2.235 mPa•s	Temp (°C), Viscosity (mPa-s)
*M1 ↑↓, NxtPg <E> : 1/3	Measurement Number

The most recent measurement record is denoted by an asterisk (*) next to the measurement number.

Menus and System Options

```

F-RATE [ ul / m ] : 275.5
S-RATE [ s-1 ] : 539.60
S-STRESS [Pa] : 128.64
*M1  ↑↓ , NxtPg <E> : 2/3
```

Flow Rate (μl/m)

Shear Rate (s⁻¹)

Shear Stress (Pa)

```

S I D : 10RB05100143
P-SCALE : 50.3%
65.8ul      R^2: 1.000
*M1  ↑↓ , NxtPg <E> : 3/3
```

Sensor Serial Number

Percent Full Scale

Total volume (μl), R² value

The R² value is an indicator of

the quality of the measurement. It denotes how linear the pressure drop across the sensor is. Ideally it will equal 1.000. If the R² value is below 0.980, the measurement result may not be reliable.

4. *System Information*: Entering this function brings up three screens with detailed information on the system.

```

RheoSense uVISC v1.0
H / W : CTRL_C1.0(128K)
F / W : C1A_20110120
S / N : H1110-00001    1/3
```

Screen 1: Rheosense **μVISC** product version number, hardware version number, firmware version number, and the serial number of the **μVISC** unit

```

CH_WIDTH [ mm ] : 3.16
CH_DEPTH [ um ] : 49.83
MAX_P [ Pa ] : 40000.0
S I D : 10RB05100143    2/3
```

Screen 2: sensor element channel width in millimeters, sensor element channel depth in micrometers, maximum pres-

Menus and System Options

sure of the sensor element in Pascals, and the sensor ID number of the currently installed sensor cartridge

SAFETY LIMIT: 4078 DIAMETER [mm] : 3.18 VOLUME [ul] : 400 3/3
--

Screen 3: safety limit of the sensor element in UTI counts, inner diameter of the disposable pipette, nominal volume of the pipette

5. *System Configuration*: This function allows certain parameters of the system to be modified. The following options are available:

1. RATE: SHEAR [s ⁻¹] 2. BUTTON SOUND: ON 3. AUTO SLEEP: ON Select: _ 1/1
--

Rate: The system may be set to use either flow rate (in microliters per minute) or shear rate (in inverse seconds). To change the units, press 1 on the

keypad, use the Navigation Arrows to select the desired units, then press ENTER. Factory default is shear rate. Note that for a given shear rate, the flow rate will not always be the same for different sensor cartridges, and vice versa. For a given flow rate, the shear rate depends on the depth of the microfluidic flow channel in the sensor element which can vary between sensor cartridges.

Button Sound: Buttons on the front panel will “beep”

Menus and System Options

when pressed if this feature is turned on. To change the setting, press 2 on the keypad, use the Up/Down Navigation Arrows to select on or off, then press ENTER. Factory default is on.

Automatic Sleep: This function will allow the system to enter sleep mode automatically when there has been no activity for 10 minutes. Sleep mode greatly reduces battery consumption, but does not eliminate it entirely. Turn the main power switch off if the system will not be used for several hours or more. To change the setting, press 3 on the keypad, use the Navigation Arrows to select on or off, then press Enter. Factory default is on.

6. *Set Time & Date:* This function allows modification of the system time and date so the time stamp of stored measurements is accurate.

1. SET TIME : hh : mm : ss 2. SET DATE : mm / dd / yy Select: _

To change the time or date, press the number on the keypad that corresponds to that item. The first number (*hh* for time, or *mm* for date) will be-

gin blinking. Enter 2 digits on the keypad, and the next number will blink (*mm* for time, or *dd* for date). After entering the last 2 digits, press ENTER. Note that time is

Menus and System Options

only available in the 24 hour format.

7. *Diagnostics*: When the system boots up, it runs a self-

1. MEMS : OK
2. SENSOR BD : OK
3. EEPROM : OK
4. BATTERY : OK

diagnostic routine. This function shows the results of the diagnostics, and in the event of a system malfunction or failure can help in troubleshooting the

problem.

8. *Maintenance*: This screen shows information on the us-

1. WASTE VOL [ml] : 7.0
2. MEAS.COUNT : 176
3. V_BAT [V] : 8.0

age of the system. The system keeps track of the number of measurements performed and the total volume of fluid dispensed during those measure-

ments. When the Waste Volume counter reaches 40 ml, the system will show an alert that the waste container needs to be emptied. 40 ml corresponds to 100 measurements of 400 µl each. Item 3 is the current voltage level of the rechargeable battery.

Warning and Error Messages

The following Warning Messages may occur during operation of the μ VISC. A brief description and tips for correcting the problem are given. In most cases, press the MENU button to clear the warning. A typical *Warning* screen looks like this:

```
< WARNING ! >
Insufficient Meas.
(Measure more)
PRESS < MENU >
```

Warning Message	Description/Action Required
Insufficient Meas. (Measure More)	Too little sample was available to get an accurate reading. This could happen when the measurement is stopped prematurely by the user or if there was not enough sample remaining in the pipette when the measurement started. Let the measurement complete on its own or
Meas. Not Good (Measure Again)	The system was unable to take a stable measurement, most likely due to a bubble in the flow channel.

Warning and Error Messages

Warning Message	Description/Action Required
Over Full Scale (Use Auto Mode)	This appears in Advanced Mode when the shear/flow rate is too high for the pressure range of the sensor. Reduce the shear/flow rate or use Auto mode to find an appropriate shear/flow rate.
Low Full Scale (Change Flow Rate)	The pressure of the leading flow sensor did not go above 4% of full scale during the measurement. Increase the flow or shear rate to ensure accurate readings.
Low Pressure	This appears during priming if there is a bubble or the flow channel has not been entirely wetted with the sample. The system will attempt the priming step again.
Out of Sample Please wait...	The pusher reached the end of its travel before the measurement finished. This clears when the pusher returns to the home position.

Warning and Error Messages

Warning Message	Description/Action Required
Priming Time Out (Measure Again)	The system was unable to achieve a stable value during the priming operation. This can happen if the previously measured sample had a much different viscosity than the current sample, and residue is left. Repeat the measurement again or perform a cleaning cycle with an appropriate solvent.
No Pipette Please wait...	The system was told to take a measurement without a pipette loaded. This clears when the pusher returns to the home position.
Unstable Temperature $dT=0.5 [^{\circ}C/min]$	The system is measuring an unstable ambient temperature, which could affect measurement quality. Press ENTER to continue with the measurement, or the MENU button to abort.
Low Battery Level Please Recharge	The battery requires recharging. Use the supplied power adapter to recharge it.

Warning and Error Messages

Warning Message	Description/Action Required
No Data Exists	This appears when the user tries to view previous measurements, but none have been taken.
Sleep Mode in 30 sec. To Keep Operation Press Menu	The system has been idle and will enter sleep mode in 30 seconds. Press the MENU button to abort.
Waste Bottle Full (Check/Empty Bottle)	The internal flow counter has determined that 40 ml of sample have been pumped into the waste bottle since the last time the counter was cleared. Press ENTER to reset the counter, or the MENU button to ignore the warning.

Warning and Error Messages

When the system encounters a situation that prevents it from operating, the following Error Messages may occur. Try to clear the error by power cycling the unit using the ON/OFF switch. Contact Rheosense Customer Support if the problem persists. A typical *System Error* screen looks like this:

< System Error ! >
NO SENSOR BOARD

Error Message	Description/Action Required
No Sensor Board	The system was powered on without a sensor cartridge inserted, or the sensor cartridge was removed while the system was on. Insert a sensor cartridge to continue.
Wrong Temperature. (Check PT1K)	The internal temperature sensor has malfunctioned or failed. Contact Rheosense for assistance.
MEMS Error	The system has experienced an over-pressure event that could have permanently damaged the sensor element. Reduce the shear/flow rate if possible.

Warning and Error Messages

Error Message	Description/Action Required
Out Of Range. Use Higher Range Cartridge	The fluid being tested is too viscous for the current sensor cartridge. Switch to a cartridge that has a higher viscosity range.
Empty/ Invalid EEPROM	The memory of the sensor cartridge has malfunctioned or failed. Contact Rheosense for assistance.
Pump Stalled (Check Motor/ Switch)	The pump mechanism has malfunctioned or failed. Contact Rheosense for assistance.
Inter-CPU Comm	The system electronics have malfunctioned or failed. Contact Rheosense for assistance.

Tips For Best Results

- Be aware of possible temperature differences between samples and the μ VISC unit. If the samples and instrument were stored in different places prior to testing, let them sit together (with the unit on) at the same location for 20 minutes or so before taking a measurement. In some cases, a 1 °C difference in temperature can lead to an error of 5% or greater.
- When measuring several samples of different viscosities, start with the lower viscosities and move to the higher ones. Each new sample will require less priming volume, saving time and sample.
- If repeated measurements of one sample shows a gradual increase or decrease in viscosity, the priming volume may not have been sufficient. Repeat the measurement until the reading is stable, then note the total volume dispensed until that point for future reference.
- To conserve sample volume when measuring consecutive samples that have a difference of more than 50% in viscosity, run a cleaning cycle in between the two measurements. This will greatly reduce the priming volume needed.
- For critical measurements, always use a new pipette.

Calibration and Maintenance

Your μ VISC Viscometer has been calibrated with NIST traceable standards. The calibration of the unit is valid for 1 year from the date of purchase. Each sensor cartridge comes with its own calibration certificate, valid for 6 months from the date of calibration. For re-calibration, please contact Rheosense at service@rheosense.com.

The following maintenance schedule is recommended:

- Daily: Wipe excess sample away from the inlet of the sensor cartridge with lint-free wipes dampened with cleaning agent. Dip a lint-free swab in cleaning agent and wipe the interior walls of the sensor cartridge inlet. Use a cleaning agent that is compatible with the sample (s) that was (were) run. See the list on page 51 for recommended cleaning agents. Run 1-2 cleaning cycles with an appropriate solvent when done using the instrument for the day (2-3 if measuring inks). Turn off the power switch and leave the empty solvent pipette in the μ VISC unit until it will be used again. If removing the sensor cartridge, store the cartridge with the stopper firmly pressed into the inlet port.
- Monthly: Wipe residue away from the drain hole near the exit tube of the sensor cartridge using lint-free wipes dampened with an appropriate solvent.

Calibration and Maintenance

- As Needed: Empty the waste container. Charge the battery using only the supplied power adapter. Wipe down the keypad and housing using a soft cloth dampened with water and a mild detergent.

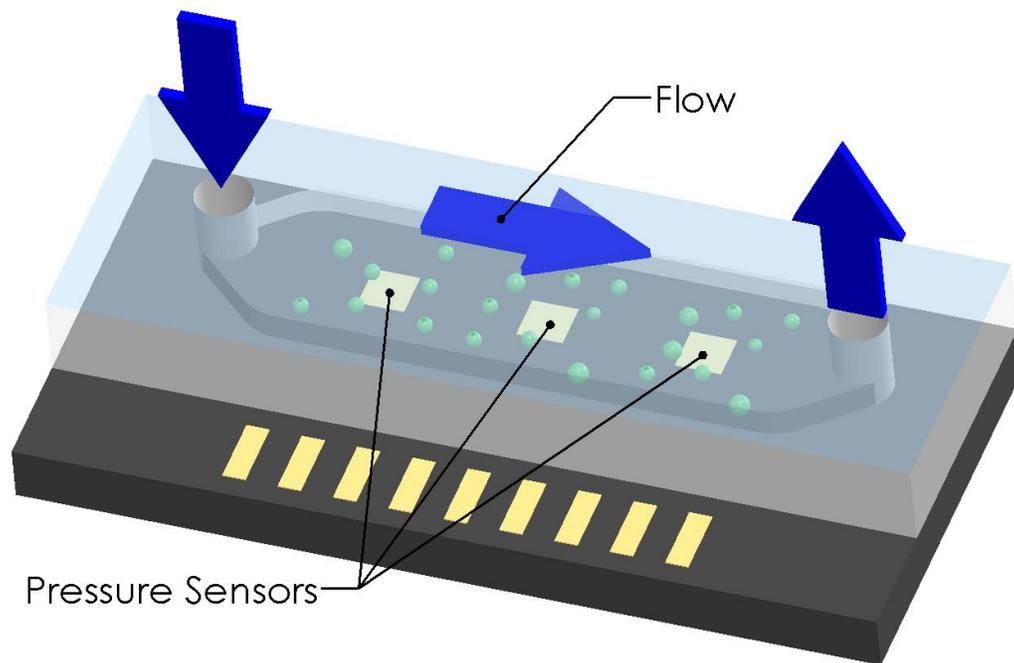
The classes of chemicals in the table below are compatible with the μ VISC Viscometer for measuring or cleaning[†]. The wetted parts of the fluid path include Polypropylene, HDPE, PEEK, Perlast[™], Borosilicate glass, silicon, and gold. When using solvents, always work in a well-ventilated area or fume hood. For information on chemicals not listed here, please contact Rheosense.

[†] Results may vary depending on usage.

Aquet Detergent (1%) and water	Phenols (avoid contact with the front panel)
Aliphatic Alcohols	Amides
Benzenes (aromatic)	Esters
Ethers	Hydrocarbons
Chlorinated Hydrocarbons	Ketones

Theory of Operation

The μ VISC Viscometer uses VROC[®] (Viscometer/Rheometer On-a-Chip) microfluidic sensor technology. The VROC[®] sensor measures viscosity from the pressure drop of a test liquid as it flows through a rectangular slit. This is a well-known scientific principle¹, and is described in Rheology textbooks. The VROC[®] sensor consists of a rectangular glass flow channel and a monolithic Silicon pressure sensor array as depicted in the diagram below (not to scale).



The width of the flow channel is much greater than the depth, so the flow effects from the edges of the channel are negligible. The geometry of the sensor also ensures a fully-developed laminar flow and a linear pressure drop along the

1) K. Walters, Rheometry, Chapman and Hall, London, 1975

Theory of Operation

pressure sensor array. Thus, the sensor can be treated as an ideal two-dimensional system, and the viscosity can be calculated from first principle equations:

$$\text{Apparent Shear Rate } (\dot{\gamma}_{app}) = \frac{6Q}{wh^2}$$

$$\text{Shear Stress } (\tau) = -\text{slope} \frac{wh}{(2w + 2h)}$$

$$\text{Viscosity } (\eta) = \frac{\tau}{\dot{\gamma}_{app}}$$

$Q = \text{flow rate}$

$w = \text{width of channel}$

$h = \text{height of channel}$

For Newtonian fluids, the above calculations are sufficient. For Non-Newtonian fluids the apparent shear rate is different from the true shear rate, and the Weissenberg-Rabinowitsch correction must be applied. For more information please visit:

www.rheosense.com/Principle.html

Technical Specifications

Part Number	HVROC-L
Accuracy, % of reading	± 2 †
Repeatability, %	± 1 †
Flow Rate, $\mu\text{l}/\text{minute}$	0.5 - 450
Temperature Range, $^{\circ}\text{C}$ ($^{\circ}\text{F}$)	18 - 40* (64 - 104)
Temperature Accuracy, $^{\circ}\text{C}$ ($^{\circ}\text{F}$)	± 0.15 (0.27)
Humidity Range, %	0 - 90, non-condensing
Battery Life	100 measurements per charge
Power, VDC	8 (Use only the supplied adaptor)
Pipette Volume, μl	400
Dimensions, L x W x H cm (in)	14.5 x 21.6 x 7.1 (5.7 x 8.5 x 2.8)
Weight, kg (lbs)	0.8 (1.76)
Waste Container Volume, ml	40
Advanced Operation Mode	Yes
Available Sensor Cartridges	HA01-01
Flow Channel Depth, μm	50
Shear Rate Range, 1/s	6.5 - 5,850
Viscosity Range, mPa-s	0.2 - 100

† Only when measurement is taken with a new pipette.

Technical Specifications

HVROC-E	
± 2 †	
± 1 †	
0.5 - 450	
18 - 40* (64 - 104)	
± 0.15 (0.27)	
0 - 90, non-condensing	
100 measurements per charge	
8 (Use only the supplied adaptor)	
400	
14.5 x 21.6 x 7.1 (5.7 x 8.5 x 2.8)	
0.8 (1.76)	
40	
No	
HB02-01	HCO2-01
100	100
1.7 - 1,453	1.7-1,453
60 - 5,000	500 - 20,000

* Contact Rheosense for applications outside this range.

Quick Reference Guide

To do This...	Do This...
Minimize bubbles while loading pipette	Draw small amount of sample, expel it, draw desired amount. p. 14
Take a measurement	Press the RUN/STOP button from: <ul style="list-style-type: none"> • Any <i>Ready</i> screen. p. 16 • Any <i>Results</i> screen. p. 23 • After setting any parameter in the <i>Set New Parameters</i> screen. p. 27
Reverse the pusher	Press the HOME button from most screens.
Measure at a specific shear/flow rate	From a <i>Ready</i> screen press: MENU, 1 (Set Advanced Meas), 1 (Set New Parameters), 1 (Rate). Enter a new value then press: ENTER, RUN/STOP. p. 27
Change system to Shear or Flow rate	From a <i>Ready</i> screen press: MENU, 5 (System Configuration), 1 (Rate), Up/Down Arrow to change, ENTER, RUN/STOP. p. 40
Load a User Protocol	From a <i>Ready</i> screen press: MENU, 1 (Set Advanced Meas), 2 (View/Load Protocol), Up/Down Arrow to change, ENTER. p. 32