Rheonics DVM Density and Viscosity Sensor Unit

SENSOR OPERATOR MANUAL

Inline HPHT Density and Viscosity Sensor

Doc. ID: DVM-OP-2501

rheonics

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Contents

1 Before you begin

1.1 About the manual

This manual provides information for operating Rheonics DVM density and viscosity sensor unit. This manual refers to external articles from Rheonics knowledge base, if any article link is not working, the user should refer to the main web page or contact Rheonics Support Team.

1.2 Contact

Contact the Rheonics team to help you with any inquiry. For sales and delivery-related questions contact the Sales Team at info@rheonics.com. For installation, integration, and troubleshooting contact the Support Team at support@rheonics.com.

1.3 Who should use this document?

Users of Rheonics inline DVM density and viscosity sensor unit.

1.4 Warning

The users should be trained in government and corporate safety standards that apply for their installation and use.

1.5 Nomenclature

Abbreviation (short form)	Full-term	Meaning
DVM	Density Viscosity Module	DVM sensor unit
SME	Smart Module Electronics	Sensor electronics
HPHT	High Pressure High Temperature	Rated for these conditions
RFQ	Request for Quotation	Ordering file

1.6 Related Documentation

You can find all product documentation on the USB storage device that was shipped with the sensors. You can also find them on the website: https://rheonics.com/resources
For more information on the sensor, refer to the following documents on Rheonics website. Contact Rheonics Support Team if you cannot find a document online.

Title	Code	Description
DVM Operator Manual	**DVM-OP**	**DVM Sensor Operator Manual**
DTCM-BB Operator Manual	DTCM-BB-OP	DTCM Bath-Based Operator Manual
SME Operator Manual	SME-OP	Sensor Electronics (all variants) Operator Manual
RCP Software Manual	RCP-OM	Rheonics Software Installation and User Manual
Communication Protocol Manuals	Various	Modbus TCP, Modbus RTU, HART, Profinet, Ethernet/IP, etc.
DVM Datasheet	DVM-DS	Rheonics DVM Datasheet

2 General Information

2.1 Scope of Delivery

The following items are delivered with the DVM unit:

- DVM-HPHT module with DV sensor installed
- Sensor Cable (Optional)
- Sensor electronics SME (Variant as ordered)
- RCP software installer
- Tools:
    - Removing and re-installing tool for DV sensor in module (ERT-DVM)
    - Spare O-Rings and backup rings for sensor (OR-DVM and BR-DVM)
    - Torque wrench (TOW-DVM)
- Other accessories and items as ordered

Notes:

- The items listed may vary for your delivery and depend on the order code.
- Customer should inspect the goods upon arrival. In case of damage or missing items, contact Rheonics Sales Team at info@rheonics.com.
- The DVM sensor is composed of different parts as explained in the next section, user should be familiar with the correct terminology.
- Rheonics offers different sensor cable variants and lengths. Review all variants here.
- Rheonics sensor electronics SME has different variants. Review all variants on the electronics and communication page, here.

Figure 1: Example of delivery box.

2.2 About Rheonics DVM

DVM is Rheonics' High-Pressure and High-Temperature density and viscosity sensor unit. It is based on a sensing element called "DV Sensor" placed inside the "DV Module".

Rheonics DVM unit measures the density, dynamic viscosity and temperature of a fluid in real-time.

DVM operates with Newtonian and non-Newtonian fluids. When configured, the sensor electronics can also output related parameters such as the fluid's temperature-compensated viscosity, compensated density, kinematic viscosity, etc.

Rheonics DVM sensor requires three main components for operation: the electronics (SME), the sensor cable, and the sensor module. Rheonics SME electronics have different variants available, which are described in section 3 of this manual.

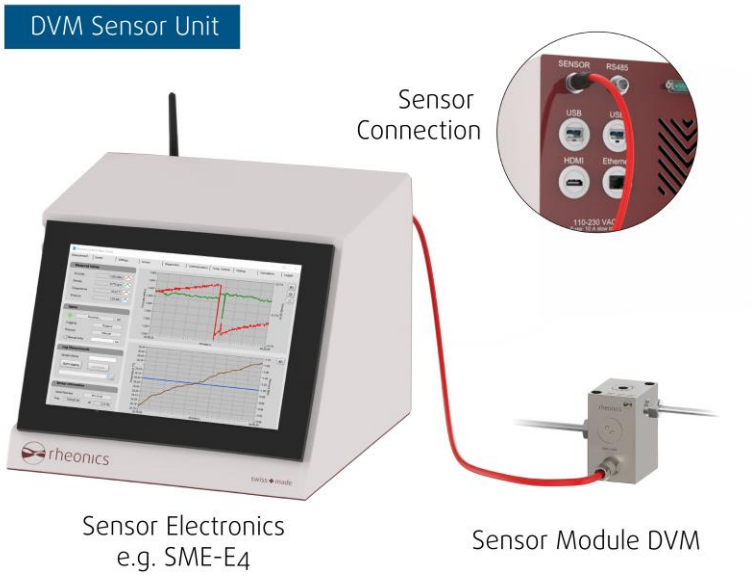

Figure 2: DVM Sensor Unit

Rheonics DVM unit has an integrated cable ending in a male M12 connector, which should be connected to the electronics using the sensor cable shipped with the unit.

Rheonics DVM unit has the DV Sensor inside that should be in contact with the fluid of interest. The DV Module works as a chamber that houses the DV Sensor and enables operations up to 2,000 bar (30,000 psi) and 200°C (400°F).

Next Figure shows the inner parts of the DVM module, these are:

- DV Sensor
- O-Ring (OR-DVM)
- Backup Ring (BR-DVM)

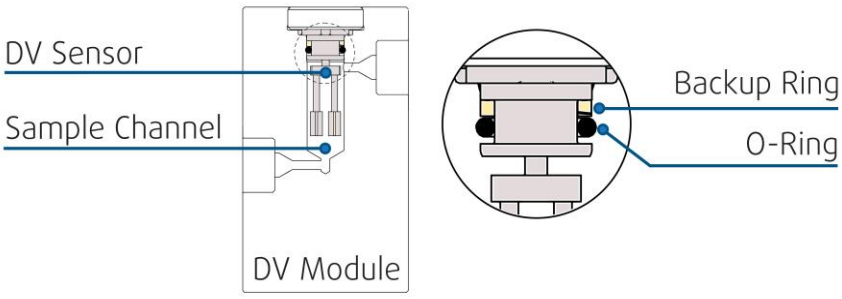

Figure 3: DV Sensor and sealing rings inside DVM

DVM module is delivered with the DV sensor already installed, but the client should be familiar with the removal and reinstallation steps for the DV sensor in case maintenance or cleaning requires it. Follow section 6 of this manual on handling the sensor.

Review Rheonics operating principle whitepaper for more information on the sensor operation.

2.3 Pressure compensation

Pressure compensation is required for high-accuracy DVM density and viscosity measurements at high pressures. Sensor electronics perform the compensation internally, only requiring a pressure input. The Pressure value (in bar) is provided to the SME in one of the following ways.

1. **Through RCP software**: A fixed value of pressure can be manually added to the RCP software connected to the sensor. An external pressure gauge can be set to communicate with the RCP using a LabVIEW driver. Rheonics supports drivers for some pressure gauges. Communication is set through serial port. Read more here and RCP Manual (RCP-OM).
2. **Through LabVIEW VI**: The user can create or ask Rheonics for a default LabVIEW VI to integrate a pressure gauge with the sensor. LabVIEW software is required. Read more here or in LabView COM API manual (RAPI-OP).
3. **Through Modbus communication**: Using an external PLC, the user can write to the Modbus register address for pressure measurement. Read more here and in the manuals of Modbus TCP (MTCP-OP) or Modbus RTU (MRTU-OP).

Contact Rheonics Support Team for further assistance.

2.4 Best practices

The following information can help you get the most from your DVM sensor unit.

- Handle the unit with care.
- Always store and transport the meter in its original packaging.
- Have the RCP software installed. Refer to the *RCP Software Manual* (RCP-OM) for installation. This software helps with the initial setup of the sensor but also for monitoring, further configuration, and troubleshooting if required.
- Do not use liquids incompatible with the wetted materials of the probe, i.e. highly corrosive chemicals when the wetted material is not specified for it. Follow the support article Chemical Compatibility List. Rheonics DVM standard wetted material for the probe is Titanium Grade 5 (3.7164/3.7165). Prior to use, always ensure that the sensor-wetted surface is compatible with your process fluid. Material certificates are available for the sensor when requested during ordering.
- For operation, the DV Sensor must be correctly installed in the DV Module.
- Sensor should always be used only for the pressure and temperature ratings specified for the sensor. This is often specified during the ordering process. Sensor electronics should be exposed to environmental conditions within its operational envelope to avoid performance issues.
- Ensure that all piping connections conform to the local and national regulations and codes of practice.
- Laboratory tests can be conducted before the final installation in process. For non-Newtonian fluids viscosity readings can differ between different viscosity measurement technologies and fluid states (static and flowing at different shear rates) . This means that a laboratory or offline instrument can give different results than the DVM inline readings of viscosity. This is expected and reasons are explained by Rheonics on web page and articles. Still, users do at times test the DVM unit in controlled environments to compare, verify, and even correlate readings.
- For the SME-TRD and SME-TR, properly tighten the transmitter housing cover after wiring to maintain ingress protection.
- Protect the M12 connection between the sensor cable and DVM cable from impacts. Avoid contact with fluids unless the operation is within the cable and connector ingress protection (IP) rating class.
- For any further questions related to the DVM sensor unit, visit Rheonics Support Portal or contact Rheonics Support Team at support@rheonics.com. Make sure to explain the issue or question, share pictures of the installation or setup, and share the sensor Serial Number (S/N).

2.5 Serial number, probe markings, and certifications

Rheonics DVM sensor units and electronics have specific markings on their bodies that make the parts unique and traceable. The part's identifier is the Serial Number (S/N), which may be requested by Rheonics if the client contacts the Sales or Support Team about the sensor. Examples of serial numbers are shown below, as well as images of where to find them.

Different variants of electronics are offered and are detailed in section 3. The electronics and sensor unit are sent in the same delivery and configured to operate together. The user should not exchange the electronics or unit with other DVM units as this can invalidate warranty, create erroneous calibration, and may create safety hazards. Check with Rheonics support teams when you need to exchange units. Replacement units are verified to be a drop-in replacement and may come with a configuration upgrade if necessary. For information contact the Support Team.

Example of probe S/N:	A01-0103
Example of electronics -E1, -E2, E3 S/N:	19101399
Example of electronics -E4 S/N:	E04-0000

Figure 4: DVM module markings.

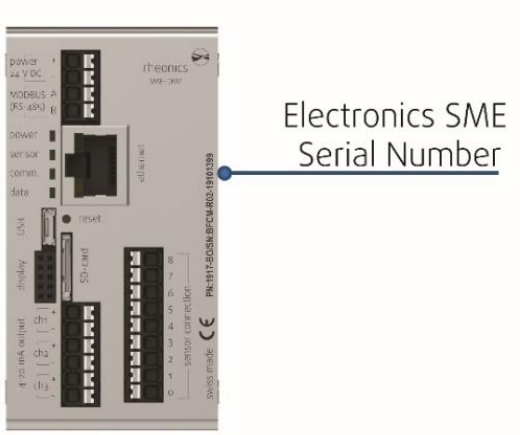

Figure 5: Sensor electronics markings for variants E1, E2 and E3.

Figure 6: Sensor electronics markings for variant E4.

Rheonics offers Calibration and Material certificates for the DVM if requested during sensor order. Review all Rheonics certifications at https://rheonics.com/resources/certificates/.

3 Technical Specifications

3.1 Sensor Specifications

Specifications of the sensor vary depending on the sensor configuration ordered through the RFQ (Request for Quotation) by the user.

Table 1: DVM general specifications

Specification	Value
Viscosity range	0.2 – 300 cP
Viscosity accuracy	As ordered
Density range	0 - 1.5 g/cc
Density accuracy	As ordered
Reproducibility	Better than 0.1% of reading
Temperature measurement	PT1000, Class AA, inbuilt
Temperature range	Specified in sensor order
Pressure range	Specified in sensor order
Max. Flow rate*	1 L/min (approx. 5m/s)
Module material	Titanium Grade 5 (3.7164/3.7165)
Backup square ring (BR) size	7.4x1.46 mm
Backup ring (BR) material	PEEK
O-Ring (OR) size	Ø7.4x1.66 mm
O-Ring (OR) material	Multiple materials available e.g. AFLAS, FKM
Inlet/Outlet Connection	Female Thread 1/4" HP (9/16-18 UNF)
DVM Module IP Rating	IP 69K
Cable IP Rating available	IP 68, IP69, IP69K
Sensor electronics IP Rating	IP40 (SME-DRM) IP66 (SME-TRD, SME-TR) IP40 (SME-BOX)

3.2 Sensor Electronics Variants

DVM sensor unit is composed of the electronics called Rheonics SME. Rheonics offers different SME variants. Variants differ in the housing and application use but have the same basic electronics unit inside.

3.2.1 SME-TRD (E1)

SME-TRD has the electronics unit inside a solid enclosure with a display. This is suitable for outdoor and indoor installations due to the higher ingress protection and works as a local view for the operator to see the data in real-time. The display can show a maximum of three variables at the same time.

Some characteristics of the SME-TRD are:

- Enclosure material: Aluminium with sprayed Polyurethane (PUR) coating
- O-Ring seal material: FKM

- Protection rating: IP66
- Weight: 1.7 kg (3.8 lbs)
- Ports: 3 ports of ½”NPT
- Installation: Outdoors and indoors with local display

Figure 7. Rheonics SME-TRD

3.2.2 SME-TR (E2)

SME-TR has the electronics unit inside a blind solid enclosure. This is suitable for outdoors and indoors installations due to the higher ingress protection. Some characteristics of the SME-TR are:

- Enclosure material: Aluminum with sprayed Polyurethane (PUR) coating
- O-Ring seal material: FKM
- Protection rating: IP66
- Weight: 1.7 kg (3.8 lbs)
- Ports: 3 ports of ½”NPT
- Installation: Outdoors and indoors

Figure 8. Rheonics SME-TR

3.2.3 SME-DRM (E3)

SME-DRM is designed for the installation of the electronics on DIN rails and inside cabinets.
Some characteristics of the SME-DRM are:

- Housing material: Stainless Steel 304 (1.4301)
- Protection rating: IP20
- Weight: 0.2 kg (0.4 lbs)
- Installation: DIN rail inside cabinets

Figure 9 Rheonics SME-DRM

3.2.4 SME-BOX (E4)

SME-BOX is a device designed for tabletop, desktop, or laboratory setups. It has a touch panel industrial PC integrated to run Rheonics software directly without using an additional PC. Using the SME-BOX with the DVM unit is a common solution for most applications where the DVM is required.

Some characteristics of the SME-BOX are:

- Dimensions: 365 x 280 x 220 (mm) [14.4 x 11 x 8.7 (inch)]
- Total Weight: 9.5 kg (21 lb)
- Operating temperature: Max 65°C/150°F ambient
- Communication interface: 2x USB, 1x Ethernet, 1x HDMI, 1xRS485, 1x Wi-Fi
- Sensor Connection: M12 Female
- Computer OS: Windows 10

Figure 10: Rheonics SME-BOX

3.3 Sensor Wiring

Rheonics DVM wiring varies depending on the electronics variant used.

3.3.1 DVM wiring with SME E1, E2 and E3

The figure below shows the typical connection of the DVM module with the SME electronics variants E1, E2 or E3. The physical connection is done between the M12 8-pin female A-coded connector (sensor cable) and the matching male connector (DVM module integrated cable).

The sensor electronics should be powered with 24V DC. Fuses are recommended to safeguard the sensor electronics.

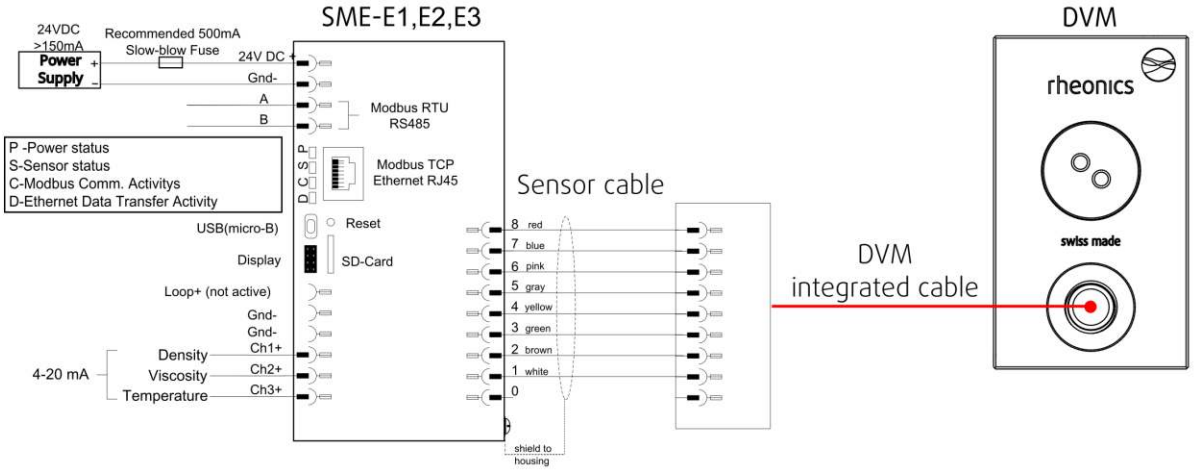

Figure 11: Rheonics sensor standard wiring for SME E1, E2 and E3.

A specific order should be followed when connecting the sensor cable to Rheonics SME variants E1, E2, and E3. Next table indicates the correct pairing of wire color and electronics numbered terminal.

Table 2: SME E1, E2 and E3 terminals number for sensor cable wires

Wire Color	Electronics terminal #
Red	8
Blue	7
Pink (Rose)	6
Grey	5
Yellow	4
Green	3
Brown	2
White	1
---not connected---	0

3.3.2 DVM wiring with SME E4

Rheonics SME-BOX (E4) is commonly used with the DVM unit for desktop or laboratory setups. All wiring is done on the SME-BOX and only connected to the DVM unit with an M12 female–male cable. For further wiring on this SME variant review the SME-E4 manual.

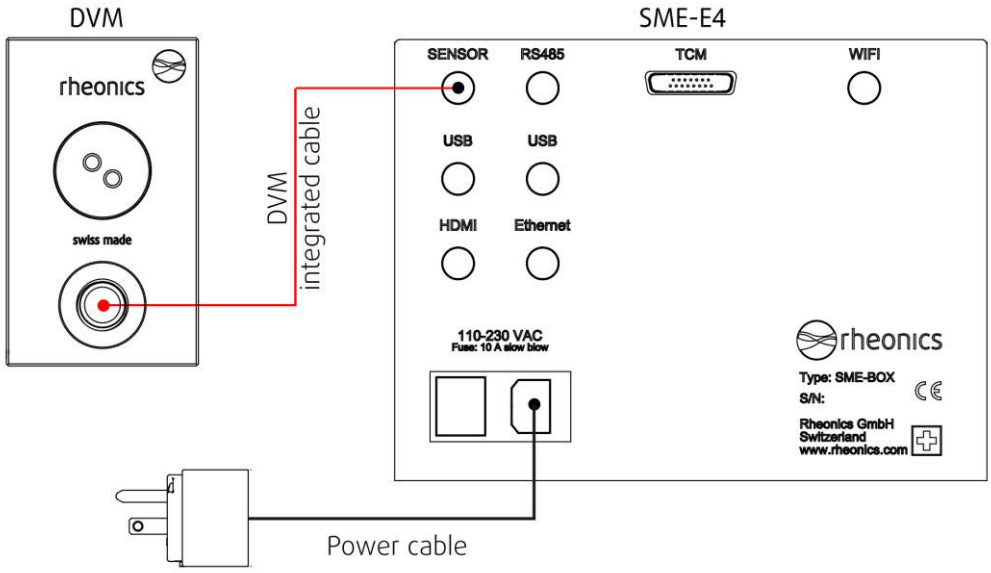

Figure 12: Rheonics sensor standard wiring for SME E4.

To download wiring drawings visit the Support Article: [Sensor electronics (SME) - Wiring drawing.]

3.4 Power requirements

All power connections are done on the sensor electronics. SME electronics have different variants as detailed in section 3.2.

3.4.1 Power requirements for SME E1, E2 and E3

When Rheonics DVM works with the electronics SME E1, E2 and E3 the power consumption is as follows:

- Voltage required: 24 V DC
- Voltage range acceptable: 18-36 V DC
- Current required (min): 120 mA
- Current recommended: 200 mA or higher
- Power required (maximum): 3 W
- Power recommended: at least 5 W
- Fuse (if required) rating: >500 mA Slow-blow fuse

Power input terminals are labeled with 24 V DC + and – GND.

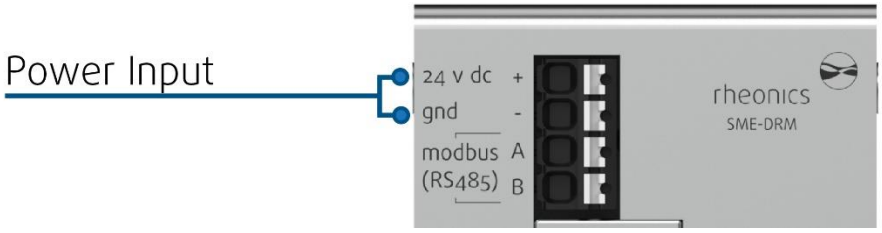

Figure 13: Power terminals in SME electronics.

It is important to avoid ground loops in the setup/plant where the SME is used. Ground loops can lead to excessive currents on the ground/return wire of the SME 24 V power supply which can damage the unit.

If there is a risk of ground loops in installation, it is recommended that the SME is powered by a separate 24 V power supply with galvanic separation.

Once the SME is powered on and connected to the sensor probe with the sensor cable, the sensor will start to measure and save data. The LEDs on the SME will start blinking indicating start up.

3.4.2 Power requirements for SME E4

When Rheonics DVM works with the electronics SME E4 the power consumption is as follows:

- Voltage required: 110 / 220 V AC
    - Power consumption (maximum): 700 W

3.5 DVM Installation Requirements

The DVM unit is designed to be installed inline as a flow-through cell instrument. The DV sensor placed inside the DVM module measures the density and viscosity of the fluid it is in contact with. The two main requirements for installation are the following:

i. **Ensure the whole sensing area is in contact with the fluid of interest**
The DV sensor is the sensing element of the DVM unit. The DV sensor has two parallel fins that should be in contact with the fluid of interest. To ensure repeatable, reproducible, and accurate data, avoid deposits, solids, or magnetic particles to attach and block the DV sensor. If manual cleaning is required follow Section 6 of this manual for proper removal of DV sensor.

ii. **DVM orientation**
The DVM should be mounted so that the final installation has the internal DV sensor on the top side and facing downwards. This ensures that small bubbles trapped in the module's chamber will collect around the base of the sensor where they will not influence the measurements. The recommended flow orientation is having the inlet flow lower than the outlet. Figures below show the recommended DV orientation and flow direction.

DVM Module has an inlet and outlet ports with a female thread 1/4" HP (9/16-18 UNF). User should connect adapters to these threads to integrate the unit in the process. Rheonics offers high-pressure fittings connectors for the DVM, i.e. Collar (60-2H4), Gland (60-2HM4) and Tube (OD 1/4" - ID 1/8"), that clients can request.
Contact Rheonics Support Team for more information and installation recommendations. Share your installation proposal and a representative will contact you.

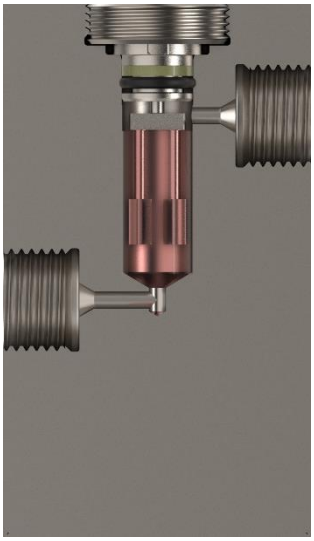

Figure 14: DV sensing area

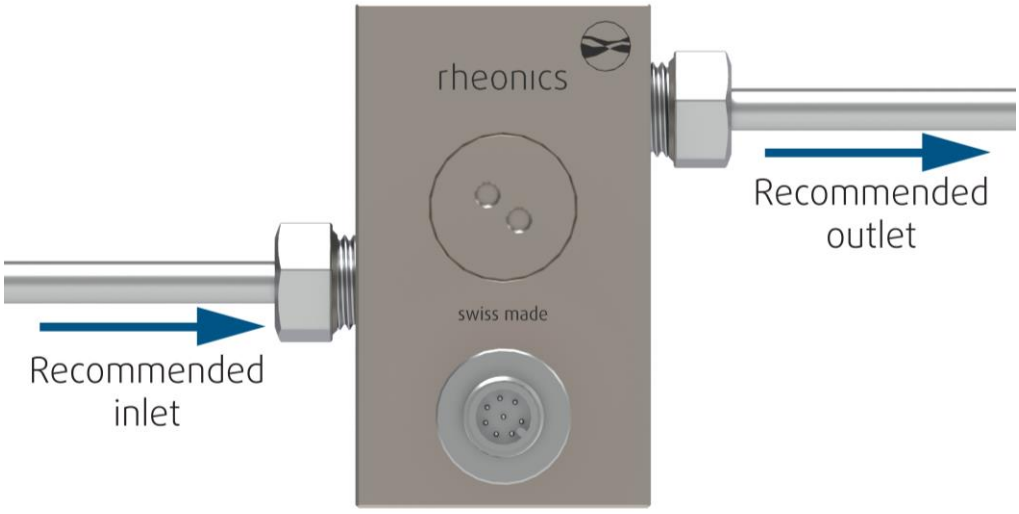

Figure 15: DVM recommended flow direction

Additional installation notes:

- Recommended fluid flow orientation, with the inlet port lower than the outlet, makes sure that fluid enters at the ends of the resonator tines or fins, and leaves near the base, sweeping any bubbles toward the inactive (base) end of the sensor.
- The DVM-HPHT will operate even with flow rates up to 1 l/min and with a flow orientation in either direction, subject to the previously mentioned caution about the effects of bubbles.
- Consider that it is difficult to get accurate measurements with plain water stationary in the DVM measurement chamber. Even degassed water tends to have air dissolved in it, which eventually forms microbubbles on the surface of the DV sensor, disturbing its geometry. This is not a problem at higher pressures, which tend to re-dissolve any gases present. Hydrocarbons, glycols, and other fluids with low surface tension are less prone to bubble formation.

4 Communication Protocols

4.1 General Information

Rheonics sensors are extremely easy to integrate into user applications or projects since the sensors have several industrial communication protocols available.

Rheonics provides extensive support resources on each communication protocol to enhance flexibility and convenience for our customers across diverse industries. **Some integration protocols come with the sensor by default, while others should be requested during sensor order**. Review all protocols at https://rheonics.com/electronics-and-communication/. For the latest communication manuals on each protocol visit https://rheonics.com/resources/manuals/.

4.2 4-20mA (C1 - Default)

Available for SME-E1, -E2 and -E3.

These SME variants have 3 channels for 4-20 mA signals, as indicated in the next Figure. The 4-20mA signals are used mostly for the simplicity of using just 2 wires to transmit the sensor readings to an external device. However, users should be aware that these analog signals are susceptible to noise and are accurate only under certain field conditions. By default, Rheonics DVM outputs the density, viscosity, and temperature parameters through the 4-20mA ports, but these are customizable from the RCP, Rheonics Software.

Check these support articles: 4-20 mA for more information.

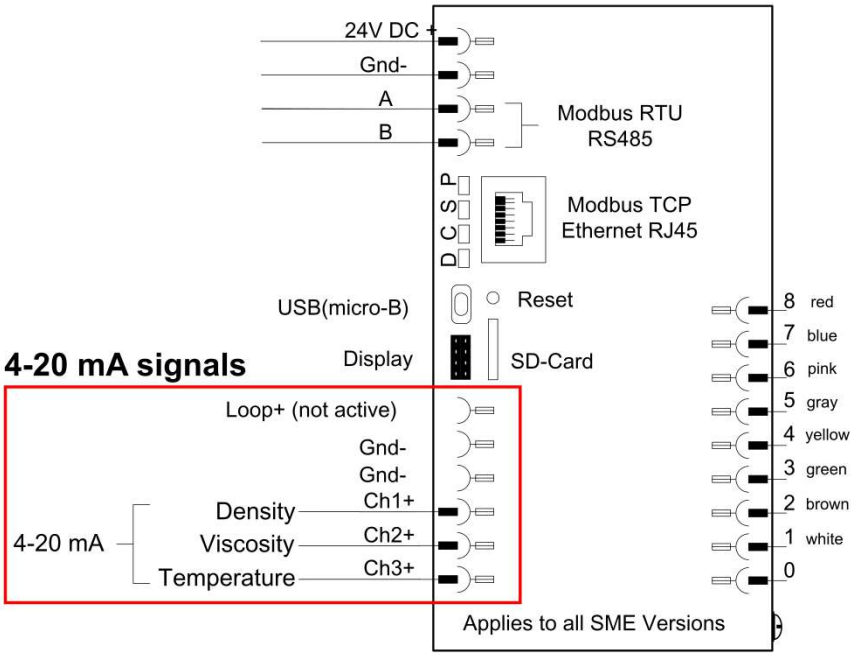

Figure 16. 4-20mA outputs available in the SME

4.3 Modbus RTU (C2 - Default)

Available for SME-E1, -E2 and -E3.

Rheonics SME offers Modbus RTU over an RS485 interface. This protocol gives the user access to multiple parameters read by the sensor in real time. The data over Modbus is exchanged in the form of registers. This interface allows interoperability between devices from different manufacturers. The Modbus RTU communication is established with Rheonics sensors through two wires labeled on the sensor electronics, as shown in Figure 11.

Check these support articles for more information on the integration and registers Modbus RTU (RS-485) and review the manual “MRTU-OP” on Rheonics resources webpage.

4.4 Serial USB (C3 - Default)

Available for SME-E1, -E2, -E3 and -E4.

All Rheonics sensor electronics (SME) come with a standard USB port for initial configuration and data monitoring. Check these support articles for more information about communication over USB with Rheonics Sensors.

4.5 Bluetooth (C5)

Available for SME-E3.

Rheonics supports Bluetooth LTE 4.0 in the SME-TRD device only. By using this technology, the sensors can transmit measured data wirelessly. Rheonics provides various software for Windows, Linux, MacOS, iOS, and Android devices to connect the sensor over BLE. Contact Rheonics or visit the Support Portal for more information.

4.6 Modbus TCP (C6)

Available for SME-E1, -E2, -E3 and -E4.

The Rheonics SME offers Modbus TCP protocol over the Ethernet interface. This protocol gives the user access to multiple registers that contain the parameters read by the sensor. Using Modbus TCP, the user can connect the sensor to the Ethernet TCP IP network through an Ethernet cable with Client-Server communication. Check Rheonics support articles for more information on the integration and registers Modbus TCP (Ethernet) and review the manual “MTCP-OP” on the Rheonics resources webpage.

4.7 Ethernet/IP (C7)

Available for SME-E1, -E2, -E3 and -E4.

All Rheonics SME variants can be ordered with Ethernet/IP. This communication protocol enables the fast delivery of extensive data from Rheonics SME sensors to external devices, like Allen-Bradley PLCs, through the SME Ethernet Port. Rheonics has extensive expertise with Ethernet/IP, hence comprehensive guidelines can be found on Rheonics Support Portal to ensure easy and effective integration. Check these support articles Ethernet/IP and review the user manual “ENIP-OP” on Rheonics resources webpage.

4.8 HART (C8)

All Rheonics SME variants can be ordered with HART. Using the HART protocol, Rheonics sensors deliver 4 parameter readings as digital data, which are PV, SV, TV, and QV. By default, the output parameters are the following:

Table 3: DVM HART Parameters

DVM default configuration	
PV	Density
SV	Viscosity
TV	Temperature
QV	Sensor Status

Check these support articles on HART and review the manual “HART-OP” on Rheonics resources webpage.

4.9 Profinet (C9)

All Rheonics SME variants can be ordered with Profinet. Using Profinet, Rheonics Sensors can transmit real-time data at 100 Mbps in full duplex communication through the SME ethernet port, resulting in improved operational performance, precision, and system integration.

Check these support articles PROFINET and review the manual “PNET-OP” on Rheonics webpage.

5 RCP Software

Rheonics DVM sensor unit is built to be a plug-and-play instrument. This means that the operator only needs to wire the DVM module to the electronics using the sensor cable, and power the sensor electronics to start measurements.

Rheonics Control Panel (RCP) is a software that allows the user to get the full potential of Rheonics sensors. The software is used for sensor configuration, measurement visualization, download of historical log files, and more. The software is included in the USB storage delivered with the sensor. If that is not the case, or you do not have the USB stick anymore, contact Rheonics Support Team and share the sensor serial number S/N to request the software.

Review the RCP Software Manual for complete instructions on installation and use. The software is included in the USB storage delivered with the sensor.

THE SME ELECTRONIC MUST BE CONNECTED TO THE COMPUTER WITH THE USB CABLE

AND POWERED UP CORRECTLY TO ESTABLISH THE FIRST COMMUNICATION WITH THE RCP

To start using the sensor and Rheonics software, the following should be done:

1. Connect the sensor probe to the SME transmitter
2. Connect the power supply to the transmitter
3. Connect the USB cable to the transmitter electronics. Connect the other end to a free USB port on the computer.
4. Run the Rheonics Control Panel software. The software can be opened from the PC's start menu.
5. Go to the Settings tab and select the correct USB port to detect the sensor by clicking in the button "Apply". Wait for the Status LED to turn green.
6. Go to the Measurements tab to visualize the readings in real time.

Find further steps on the RCP Software Manual "RCP-OM" and on Rheonics articles at RCP – Rheonics Control Panel - Articles.

For help with Rheonics Control Panel (RCP) and its settings, user can navigate to the Help tab within the software and access manuals or contact Rheonics Support Team at support@rheonics.com.

6 Handling the sensor

The DVM-HPHT is a stable, robust sensor unit that operates over a wide range of temperatures and pressures. All wetted parts of the sensor system are made of Titanium Grade 5, which resists attack by a wide variety of highly corrosive fluids.

In order to get optimum performance from the unit, some simple guidelines must be followed.

6.1 Cleaning

The DVM-HPHT is based on a resonant sensor that operates in the range of approximately 7-8 kHz. The sensor measures in a thin layer of fluid surrounding the resonant element. Any high-viscosity fluids or tenacious solids that adhere to the resonator will distort its readings.

The resonant element contains small permanent magnets. If the fluid in which the resonator is immersed contains suspended magnetic particles, these may likewise cling to the sensor and distort its readings. As a consequence, DVM is not suitable for magnetic fluids.

In any measurement scenario in which the sensor could become coated with tenacious fluids, solids, or magnetic particles, it is recommended to remove the DV sensor and mechanically clean it. Adherent films can be removed by using appropriate solvents and/or wiping with solvent-saturated cloth or paper. Under no circumstances should abrasives be used to clean the resonator, as these will change the geometry and destroy its calibration.

Magnetic particles may be removed by pressing scotch tape, masking tape, or similar pressure-sensitive adhesive against the sensor's surface. When pulled away from the sensor, it will remove any particles adhering by magnetic forces. Examine the sensor with a magnifying lens to satisfy yourself that its surface is clean of particles. Figure 17 shows a comparison between a cleaned DV sensor and one with deposits or layers on it that requires cleaning.

Figure 17: DV sensor clean and with deposits

Standard method of DVM cleaning: Flow a solvent or cleaning fluid through the DVM module, followed by distilled water and then compressed air. DVM can then be run in air or vacuum to check the baseline frequency of the sensor to ensure it is clean. Readings in air should be zero for both density and viscosity.

General recommendations for cleaning are:

- Check your sensor material and ensure only chemicals compatible with the material are used. Sometimes sensors have multiple materials and chemicals used must therefore be compatible with all, or appropriate safeguards should be in place to ensure that cleaning chemicals do not come in contact with incompatible materials on the sensor. Check sensor materials here.
- Rheonics DVM is CIP compatible.
- DVM sensor module should be cleaned by rinsing it with solvents. DVM Module cannot be cleaned with ultrasonic bath.
- DV sensing element or sensor can be removed from the module if CIP is not sufficient, especially if measured fluids that leave bubbles or deposits, or high viscous fluids were used.
- DV sensing element can be cleaned with an ultrasonic bath (for small deposits 5 to 10 minutes should be enough, 30 to 60 minutes are also common) or by immersing it in a beaker with solvents or wiping it with solvent-saturated cloth or paper.
- Tape can be used to remove magnetic particles from the DV sensing element.
- Backup ring and sealing O-ring should also be replaced if damaged, worn, or exposed to solvents like acetone.
- Under no circumstances should abrasives be used to clean the resonator since these will change its geometry and destroy its calibration.

Next sections describe the steps to remove and reinstall the DV sensor and sealing rings in case cleaning requires it.

6.2 Remove DV sensor from DV Module

Rheonics delivers the DVM unit with the DV sensor already installed. The client may need to remove the DV sensor for cleaning or maintenance. Tools used are listed below, these are included in the DVM delivery.

- Torque wrench (TOW-DVM)
- Sensor insertion and removal tool (ERT-DVM)

Figure 18: Tools for DV sensor removal from DVM

Follow next steps to remove the DV sensor from the DV Module. Steps also available in a tutorial video from Rheonics https://www.youtube.com/watch?v=Eo5IL0i9ExQ.

1. Using a torque wrench, like the one delivered by Rheonics, remove the sensor retaining screw. This will require approximately 20 N.m of torque (TOW-DVM is rated for this torque). It may be necessary to hold the DVM-HPHT in a bench vise to apply the necessary torque. Use soft jaw covers in the vise to avoid marring the DVM.

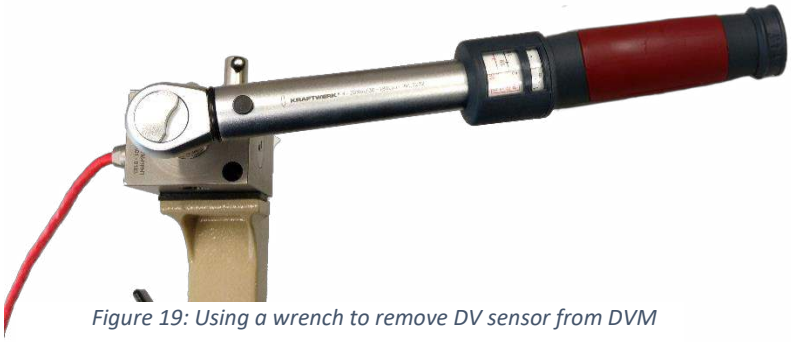

Figure 19: Using a wrench to remove DV sensor from DVM

2. This will reveal the back of the DV sensor, with its M4 threaded removal/insertion hole.

Figure 20: Access to DV Sensor in DVM

3. Use the sensor insertion and removal tool (ERT-DVM) and while holding the black screw grip, screw the threaded rod into the hole in the back of DV sensor as far as it will go, finger tight.

Figure 21: Threading the ERT-DVM into the DV sensor

4. Holding the back of the threaded rod, screw the black ring clockwise against the upper surface of the module until it has backed the sensor out of the module.

Figure 22: Removing the DV sensor from the DV module

6.3 O-Ring and Backup Ring Removal

The only cases where the O-Ring or Backup Ring need replacement is when these are damaged and can't create a correct sealing anymore.

Do not reuse a damaged O-ring or Backup Ring or one that was removed from the sensor.
To remove a damaged O-Ring and Backup Ring user can cut the ring right away since a damaged ring won't be of any use. Be careful to not damage or scrape the DV sensor with sharp tools. Alternatively, a small tweezer can be used to expand or stretch the rings slightly to remove them.

6.4 O-Ring and Backup Ring Installation

Tools used for the installation of the sealing rings on the DV sensor are listed below, these are included in the DVM delivery.

- ORT Tool
- ORT Base (Optional)
- Backup Ring (BR-DVM)
- DV O-ring (OR-DVM)

Figure 23: Tools and spare parts for sealing rings installation

FOLLOW STEP 1 to STEP 6 IF REPLACING BOTH BUR AND O-RING
FOLLOW STEP 3 TO STEP 6 IF REPLACING ONLY THE O-RING
Optional: The ORT Base can be used to fix the DV sensor in place by threading the M4 hole on its base to the ORT Base.

Figure 24: DV Sensor fixed on ORT Base

1. Slide the Backup ring (BR-DVM) carefully and slowly over the DV sensor as shown below. You can expand the BUR slightly to make it easier. Ensure the O-ring groove (convex surface) on the BUR is facing upwards.

Figure 25: Backup ring over the DV sensor

2. Slowly slide BUR all the way to the end. Be careful not to put too much stress on it as it will break (the cut in the ring can be stretched to make it easier to slide in on top of the tines).

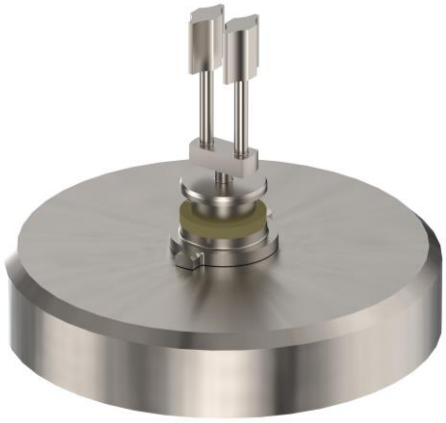

Figure 26: Backup ring installed in DV sensor

3. Slide the O-ring OR-DVM on the O-ring tube ORT as shown below.

Figure 27: O-ring placed on ORT Tube

4. Place the ORT on the DV sensor all the way in. You will hear a click sound confirming the correct positioning of the ORT on the DV sensor.

Figure 28: ORT Tube mounted on DV sensor

5. Slide the O-ring OR-DVM over the ORT tube into the DV sensor O-ring groove. The BUR should already be in place and below the O-ring as shown next. ENSURE O-RING SITS CORRECTLY IN THE O-RING GROOVE ON THE BUR.

Figure 29: O-ring installed on DV sensor

6. Remove the ORT tool from the DV Sensor by unplugging it and the process is done.

6.5 Mounting the DVM-HPHT

The DVM-HPHT module has four mounting holes. Two are through-holes for M5 socket head screws; the other two are tapped with ISO M5 threads. The whole pattern for a mounting plate is:

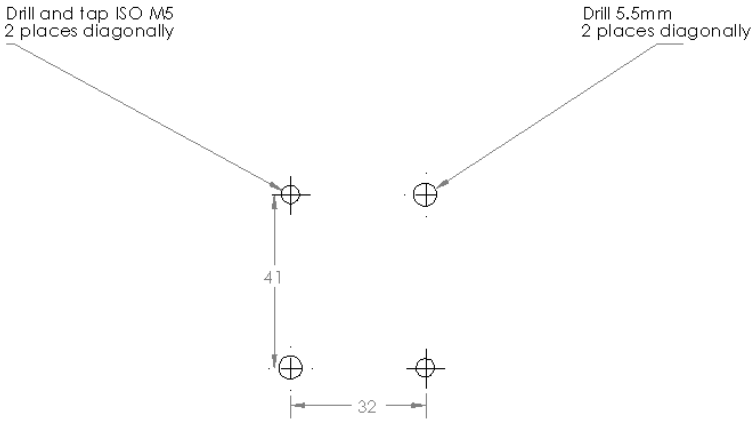

Figure 30: Mounting holes for DVM

Either the through holes or the tapped holes can be used, depending on the requirements of the test setup. The DVM-HPHT should be mounted with the sensor retaining screw on the top as detailed in Section 3.5.

6.6 Calibration

All Rheonics sensors are factory calibrated. Customer-specific calibration can be ordered that is NIST traceable. However, clients may still require calibration verification for instruments used in their industry. This can be part of Quality Control (QC) for ensuring high accuracy and reliability on readings, and/or Compliance with regulations or standards governed by law, such as ISO 17025 or FDA, for food and pharmaceutical industries. These regulations designate a standardized verification of sensor operation to ensure safety, quality, and correct production.
Rheonics offers the following verification methods:

a. **Quick verification in air**
   1. Make sure DVM chamber is clean and without fluids
   2. Verify the viscosity and density readings are zero. This can be checked through the SME-TRD display, RCP software, or any external integration system (e.g. PLC).

This “air check” is useful as a quick verification of the DVM calibration. The sensor does not use moving parts, so if readings in the air are zero, then the sensor is both clean and within calibration. However, this is not a replacement for the formal calibration verification required by ISO or FDA guidelines.

b. **Calibration report with Rheonics DTCM**

This method requires the use of the DTCM Calibrator to create a simple on-site calibration procedure. Contact Rheonics Sales Team for more information.

7 Use Cases

Rheonics DVM Density and Viscosity Module sensor is built for different application cases where a real-time value of density, viscosity and temperature are required in high-pressure and temperature applications, with minimal sample size needed.

Contact Rheonics Support Team to discuss the suitability of the DVM unit sensor in your application.

7.1 DVM in oven

DVM can be used inside an oven or bath for PVT (Pressure-Volume-Temperature) and coreflooding application studies. Rheonics DVM ensures highly accurate and reliable density and viscosity measurements at pressures up to 2,000 bar (30,000 psi) and temperatures up to 200°C (400°F).

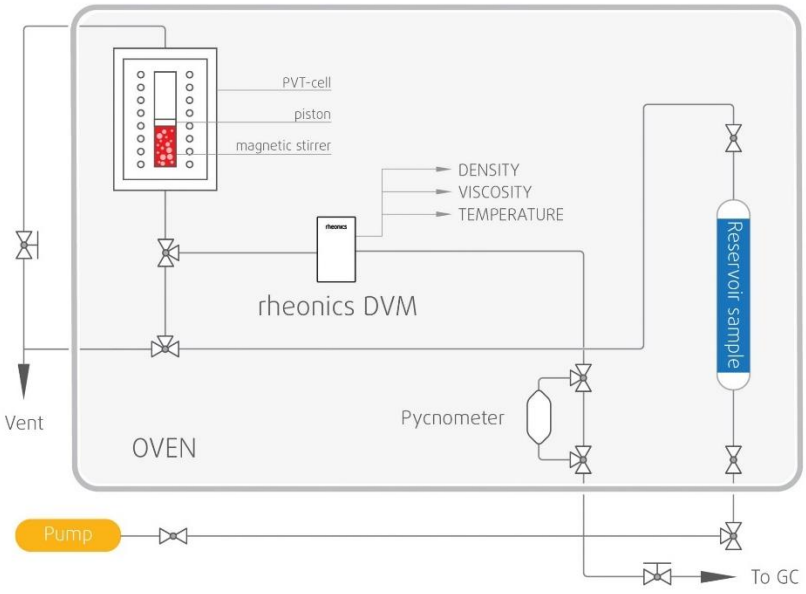

Figure 31: DVM for PVT systems

7.2 DVM in DTCM

Rheonics DTCM is a Thermal Control Module designed for the DVM to ensure the most uniform temperature distribution across the DV sensor with fluid in static and flowing conditions.

The DTCM eliminates the requirement of bulky and expensive thermal test chambers (also known as climate chambers) for temperature control. It reduces the size of the equipment while achieving 10 times better stability and uniformity as compared to a typical 100-liter commercial thermal chamber. It enables HPHT (High-Pressure High Temperature) fluid analysis with DVM (Digital Voltmeter) in the field and mobile units without compromising the integrity of data.

Figure 32: DVM in DTCM Thermal Module

7.3 DVM in Flow Loop

Rheonics DVM has a small form factor suitable for direct installation in flow lines. Some applications for the DVM in flow loops are:

- Jet fuel, aerosols, adhesives, automotive fluids, coatings, colloids, dispersions
- High pressure diesel injector development
- Lubricant viscosity profile under operational high pressure and high temperature conditions
- Gas mixture specific gravity measurement under HPHT conditions
- Simulation of deepwater conditions. Pipeline and umbilical restart tests
- Stability tests of emulsions for non-newtonian and newtonian fluids

8 Notes/Errata:

9 Revision and Approvals

Version	Nature of changes	Approvals	Date
1.0	Original version	S.K.	25.09.2024
1.1	Updates on cleaning and pressure compensation topics	P.P.	17.01.2025