



778

VISCOSENSE®3D

Viscosity and Density Sensor & Interface box

Publication nr
Supersedes

TIB-778-GB-0620
TIB-778-GB-0418(2)

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1. PREFACE

1.1 GENERAL

This manual contains instructions for installation, operation and maintenance (IOM) of the VAF *ViscoSense*[®]3*D* viscosity and density sensor (*VS3D*) and interface box.

For IOM information of associated equipment supplied by VAF Instruments, refer to the separate manual supplied with those products.

This manual contains important information for the installer, the operator and for your maintenance department.



Never use the equipment outside its specifications or beyond common engineering practice nor use the equipment for other applications or make connections to other equipment than explicitly described in the order acknowledgement and/or technical manuals of VAF Instruments.



It is not allowed to make any modifications to the sensor or the interface box without prior written permission of VAF Instruments BV.



To ensure safe and correct installation and operation, read this manual completely before installing the equipment and starting operations.



ViscoSense[®]2 and *ViscoSense*[®]3 sensor (from serial numbers 70000) and interface box (from serial numbers 1480000) are not interchangeable with previous model *ViscoSense*[®].

ViscoSense[®]2 and *ViscoSense*[®]3 sensor and interface box are interchangeable.

ViscoSense[®]3*D* sensor and box are not interchangeable with previous models.



The (micro) SD card should not be exposed to computer viruses, since this could contaminate the (micro) SD card. Contamination could disturb good working of the sensor.

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Or your local authorized VAF dealer.

Their addresses can be found on www.vaf.nl

1.2 SYMBOLS

The following symbols are used to call attention to specific types of information.



A warning to use caution! In some instances, personal injury or damage to the *ViscoSense® 3D* unit or control system may result if these instructions are not followed properly.



An explanation or information of interest.



Warning for hazardous voltages. Symbol is used on the interface box in combination with the requirement to switch of the power supply to the box before opening it, in order to avoid personal injury.

1.3 COPYRIGHT

This technical manual is copyrighted with all rights reserved.

While every precaution has been taken in the preparation of this manual, no responsibility for errors or omissions is assumed. Neither is any liability assumed for damages resulting from the use of the information contained herein. Specifications can be changed without notice.

ViscoSense® is a registered trademark of VAF Instruments B.V.

2. SYSTEM DESCRIPTION

2.1 SYSTEM DESCRIPTION

ViscoSense[®]3D is, besides other applications, intended for use in fuel oil treatment systems to obtain a correct measurement of fuel density and measurement and control of the fuel oil viscosity.

Figure 1 shows a typical fuel treatment system with return line from the engine. In this system, the degassing/mixing tank operates as a fuel buffer, ensuring gradual changes of viscosity which results in a stable control of the viscosity. The *ViscoSense*[®]3D sensor is used to measure the actual viscosity of the fuel oil. The signal from the sensor is compared to the setpoint of a viscosity controller, which regulates the output of the fuel heater via a control element (steam or thermal oil valve, or electric heater cabinet).

The density measurement can be used in mass flow calculations, or to obtain information about the CCAI number of the fuel. The density output signal can be connected to a display or flowcomputer.

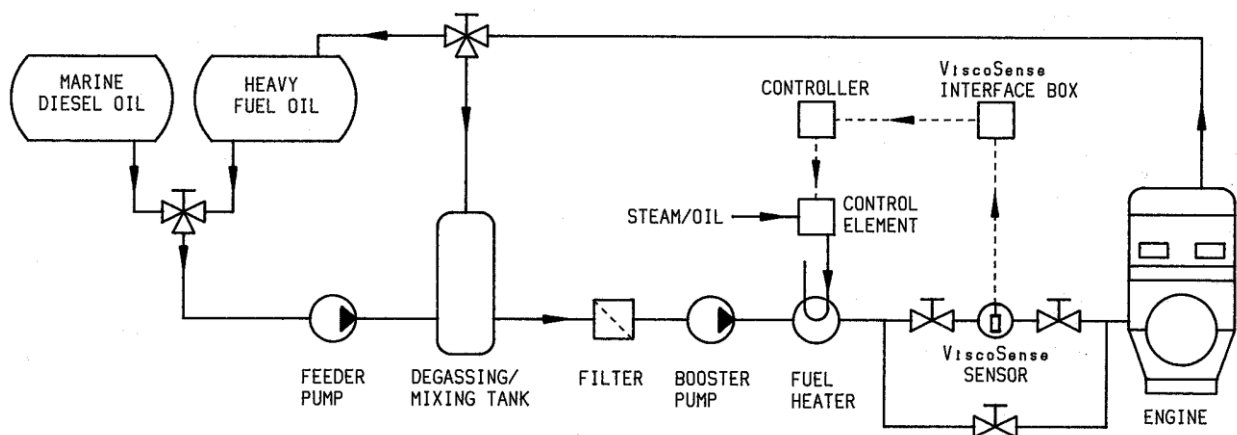


Figure 1 Typical example of an automatic control system using steam or thermal oil heater

2.2 SYSTEM COMPONENTS

The *ViscoSense*[®]3D viscosity system consists of:

- the combined viscosity, density and temperature measuring sensor
- the sensor housing
- Interface box

The sensor housing is made of ductile iron and has flanges for direct mounting in the fuel line. The sensor itself is made of stainless steel and is mounted in the housing. The sensor head has a special DLC coating and it is mechanically protected by a stainless steel flow tube with 3 slots. It is supplied with 5 metres of signal cable for connection to the interface box.

The *ViscoSense*[®]3D Interface box is a wall mount electronic unit, processing the signals to and from the sensor. It provides 4...20 mA signals for remote read-out of viscosity, density and temperature for a flowcomputer, controller or other system elements. Optionally Modbus TCP/IP is available. See separate technical manuals for a description of these components.



Figure 2 ViscoSense[®]3D components (sensor in housing and interface box)

2.3 PRINCIPLE OF OPERATION

The operating principle of the sensor is that of a torsion pendulum. The sensor consists of a stainless steel driver / sensor head (1), attached to the base plate (2) by means of a tubular torsion spring (3). In the head, one pair of piezo elements (driver piezos) (4) actuates the pendulum at its torsional resonance frequency, while another pair (the receiver piezos) probes the actual movement of the head. In a low viscosity medium, like air the resonance frequency is in the range of 1600 Hz. In a high viscosity medium the movement of the head is damped by the liquid. Consequently, the resonance frequency slightly shifts towards lower frequencies, whilst the width of the resonance peak increases, which is a measure for the viscosity.

The density of the fluid will increase the moment of inertia of the system, in which a higher density will cause a lower frequency.

A flow tube (5) is placed around the pendulum, to protect it against mechanical damage.

The flow tube is machined with a smooth surface, as well the three slots. These slots increase the refreshing rate between sensor and flow tube.

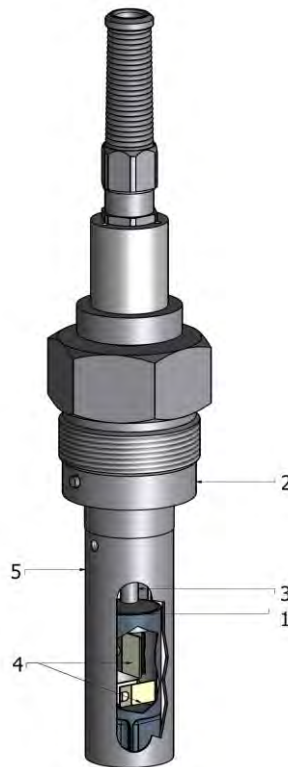


Figure 3 ViscoSense®3D sensor (VS3D)

3. TECHNICAL SPECIFICATION

3.1 SENSOR

Sensor type nr.	0279-0122	0279-0110
Viscosity range	0 - 25/50 mPa.s (other ranges on request)	0 - 25/50 mPa.s (other ranges on request)
Density range	750 – 1100 g/l	750 – 1100 g/l
Temperature range	0-200°C	0-200°C
Maximum operating temperature	180°C	180°C
Temperature transmitter	PT 100 element	PT 100 element
Accuracy		
<i>Viscosity</i>	±2% instantaneous or 0.5 mPa.s	±2% instantaneous or 0.5 mPa.s
<i>Temperature</i>	±1°C	±1°C
<i>Density</i>	±0,5% instantaneous or 5 g/l	±0,1% instantaneous or 1 g/l
Material		
<i>Sensor</i>	Stainless steel 316L	Stainless steel 316L / Ni-Alloy
<i>Coating</i>	Diamond Like Carbon (DLC)	Diamond Like Carbon (DLC)
Signal cable	length 5 metres, integrated with sensor	length 5 metres, integrated with sensor
Protection class	IP65	IP65
Weight	1 kg	1 kg

3.2 SENSOR HOUSING

Material housing	ductile iron
Flange connections	DN 50 mm (2"), DIN, ANSI or JIS DN 65 mm (2,5"), DIN, ANSI or JIS DN 80 mm (3"), DIN, ANSI or JIS DN 100 mm (4"), DIN, ANSI or JIS
Maximum pressure rating	40 bar
Weight	2" approx. 10 kg 2,5" approx. 11 kg 3" approx. 12 kg 4" approx. 13 kg

3.3 INTERFACE BOX

Interface box type nr.	0379-0383
Supply voltage	100-230 VAC, 50/60 Hz (Fluctuations should not exceed $\pm 10\%$ of the nominal value)
Power consumption	6 Watt
Internal battery	Lithium coin type 3V rechargeable, 5 mAh, 6,8 mm (Do not exchange without prior consulting VAF Instruments)
Output	
Viscosity	Isolated active output 4...20 mA, current loop, max. load 400 Ω typ. 0 - 25/50 mPa.s (depending on selected range)
Range	
Temperature	Isolated active output 4...20 mA, current loop, max. load 400 Ω typ. 0 - 200° C
Range	
Density	Isolated active output 4...20 mA, current loop, max. load 400 Ω typ. 750 - 1100 g/l (depending on selected range)
Range	
Temperature retransmission	Retransmission of the measured temperature
Bus	Modbus TCP/IP (optional) Setting to communicate with the web interface; IP address 192.168.144.241 Port 502 Function code 4 (Input registers)
	Available Modbus addresses;
	1014 Viscosity
	1016 Density
	1018 Pendulum temperature
	1020 Ccai
	1022 Time
Response time	Depending on application
Resolution	0,1 mPa.s and 0,1 g/l
Ambient temperature	-20 .. + 55 °C
Humidity range	0-95% RH
Protection class	IP 66
Mounting	Wall mounting
Cable connections	
Power supply	M20 x 1,5, Ø9-13 mm
Output signals	M20 x 1,5, Ø9-13 mm
Sensor	M16 x 1,5, Ø5-9 mm, integrated with sensor cable
Cable wire	
Power supply	3 x 1.5 mm ² , double isolated heavy duty PVC
Output signals	3 x 2 x 0,75 mm ² , twisted pair, individually screened, braid shielded
Modbus (optional)	1 x 2 x 0,75 mm ² , twisted pair, individually screened, braid shielded
Ventilation requirements	No special requirements
Weight	2,0 kg
Max. altitude for use	2000 m above sea-level

4. SAFETY INSTRUCTIONS

4.1 SAFETY PRECAUTIONS

To ensure the safety of personnel and equipment:

- Always follow the safety and installation recommendations in this manual.
- Always use personal protective means when working with hot, aggressive and toxic process liquids.
- Always use insulated tools when working on electrical installations.
- Ensure that local safety regulations are met when installing and operating the equipment.
- All personnel who operate and service the equipment should read this manual completely and make themselves acquainted with the equipment before installing or operating the equipment.
- The *ViscoSense*[®]3D sensor body will heat up to the process temperature; do not touch the body housing while process is running!

5. UNPACKING

Let the instruments acclimatize in the location where they are going to be installed for at least one hour inside their shipment box. This is to avoid moisture buildup inside the instrument, or on the connectors and wires.

When the equipment is taken out of the box, please leave the transport locking cap and the outside protection, in place as long as possible to avoid any damage.

The *ViscoSense*[®]3D sensor has a special DLC coating on the pendulum.

Damage of the coating will influence the working of the sensor.



Special care should be taken not to scratch or damage the DLC coating.

The transport locking cap and the outside protection should be stored, in the unlikely event the equipment has to be returned for repair.

Dispose of the packing material should be done according to the laws of the country where the equipment is installed, or according to the rules that are applicable on the vessel.



Figure 4 Transport locking cap



Figure 5 Outside protection

6. INSTALLATION

6.1 TO RECORD NAMEPLATE DATA

Before installing a *ViscoSense*[®]3D system, record type and serial numbers as stamped on the *ViscoSense*[®]3D sensor and interface box.



Always quote the instrument serial number and the variant number when contacting the factory or local service representative.



Never exceed the temperature and pressure limits specified on the nameplate of the *ViscoSense®3D*. Consult the factory if the *ViscoSense®3D* must be used for a different process liquid than originally ordered.

A *ViscoSense®3D* unit may be part of a complete VAF viscosity control system. For information and instructions covering the other components of this system, refer to the separate technical manuals as supplied with these components.

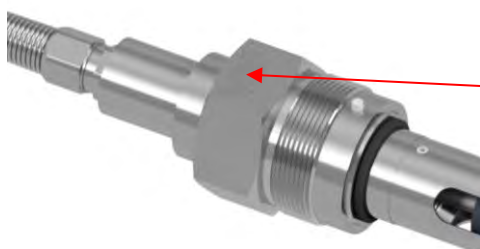
For identification purposes it is recommended to record also nameplate data of other *ViscoSense®3D* system components here.



Housing

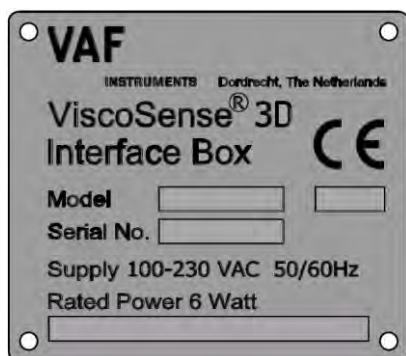
Serial number:

Variant:



Sensor

Serial number:



Interface box

Serial number:

Model:

6.2 CONDITIONS FOR CORRECT WORKING OF THE *VISCOSENSE®3D* SENSOR

The flow is recommended to be in-between the maximum and minimum fluid flow rate as mentioned in chapter 21.1.

The *ViscoSense®3D* housing should be placed in such a way, that no air can be trapped in the housing. This can easily happen if the inner diameter of the piping is smaller than the inner diameter of the *ViscoSense®3D* housing, if it has been installed horizontally.

If the inner diameter of the piping is smaller than the inner diameter of the *ViscoSense*[®]3D housing, the transitions between the two diameters should be tapered. The inner diameter of the *ViscoSense*[®]3D housing should not be smaller than the piping.
The fluid should be homogenous.
It should not contain any air bubbles or foam.



THE FLUID SHOULD NOT CONTAIN ANY CHEMICALS OR SOLID PARTICLES THAT CAN DAMAGE THE DLC COATING



THE FUEL SHOULD BE IN COMPLIANCE WITH ISO 8217:2010 (SPECIFICATIONS OF MARINE FUELS)

6.3 GENERAL INSTALLATION RECOMMENDATIONS

- Mount the *ViscoSense*[®]3D housing as low as possible, in the fuel system.
- Compare your process variables with the specifications. Make sure these are compatible!
- Pressure pulsations and variations should be avoided as much as possible.
- Mechanical vibrations should be avoided as much as possible.
- No special tools are required to install the *ViscoSense*[®]3D. Ensure that your standard tools are fit for the job.
- Make sure that the working environment is clean. Ensure that no dirt can enter the sensor.
- Insulate the pipes and the sensor housing well, to avoid any temperature loss of the fluid.
- When fuel viscosity is 500 mPa.s or thicker it is recommended to wrap steam tracing with sufficient capacity, or 20 Watts/metre resistance wiring around the *ViscoSense*[®]3D housing.
- VAF *ViscoSense*[®]3D sensor and interface box are precision instruments. Handle them with care.



Do not unscrew the cable gland on the top of the *ViscoSense*[®]3D sensor or disconnect the cable from the sensor. This will violate the correct operation of the *ViscoSense*[®]3D sensor.



Take care that the pendulum is not damaged and the torsion tube not bent by mechanical force.
This will violate the *ViscoSense*[®]3D signal.

6.4 MECHANICAL INSTALLATION

6.4.1 *ViscoSense*[®]3D interface box

1. Install the *ViscoSense*[®]3D interface box in a suitable location, free from excessive vibrations, humidity and excessive temperature variations.
2. The maximum distance between sensor and the interface box is determined by the cable length from the sensor, being approx. 5 metres.
3. Allow sufficient space for installation of cables and for servicing.
4. The surface on which the interface box is mounted should at least be able to bear a weight of 10 kg.

6.4.2 *ViscoSense*[®]3D housing

1. Remove dust caps from sensor housing and install housing stress-free, with shut-off valves and bypass valve in the fuel piping as illustrated in figure 6. Take care that the flow direction is in accordance with the indication on the housing (inlet, outlet and arrow) as illustrated in figure 8. Support inlet and outlet piping sufficiently.

These shut-off valves and bypass valve are not furnished by VAF Instruments.

2. Note that the distance between fuel heater and sensor housing inlet should not exceed 4 metres.
3. To protect the instrument from excessive vibrations, which can cause malfunctioning of the instrument, it is recommended to:

Install the *ViscoSense®3D* as low as possible in the fuel system close to a solid structure or beam.
Install suitable pipe clamps at both sides of the *ViscoSense®3D* sensor housing.

4. Allow at least 50 cm clearance to the sensor housing, to be able to take out the measuring sensor for service.
5. The sensor needs a stable environment to act as a counterweight for the pendulum movement. The support must prevent movement and excessive vibrations of the *ViscoSense®3D* housing, especially movement in the direction of the pendulum movement (see drawing- angular movement around the sensor axis). Therefore there must be two supports to the inlet and outlet perpendicular to the pipe and perpendicular to the *ViscoSense®3D*. If one support would be used the lateral vibrations would be converted to angular vibrations and the situation would be made worse instead of better.

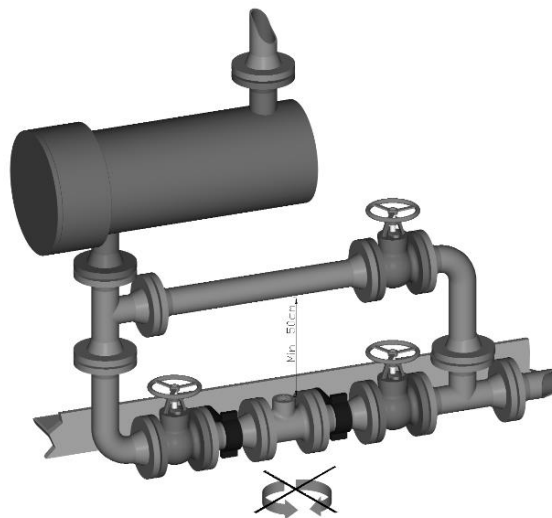
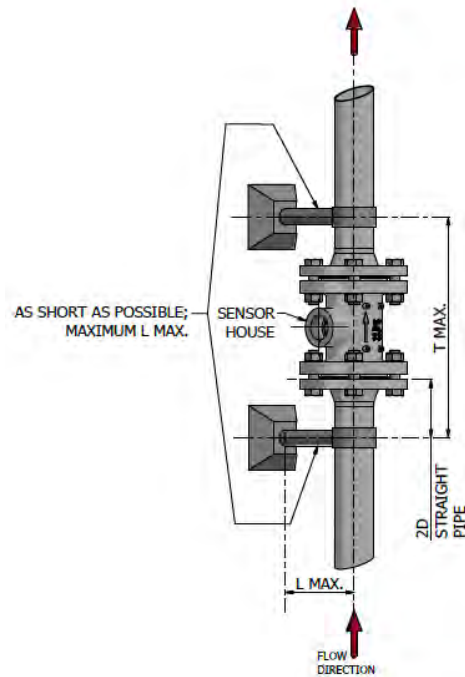
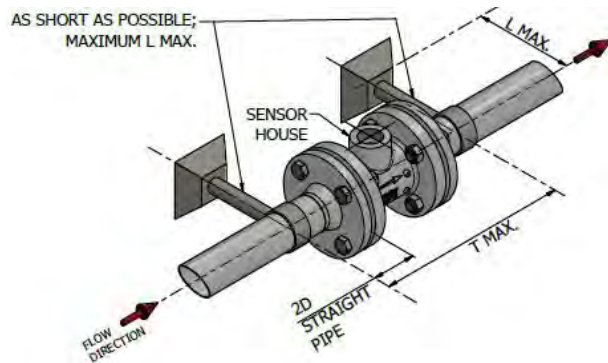


Figure 6 Sensor installation diagram



The angular position of the supports must always be 90° in relation to the sensor.
The distance from the flange to the support should be two times the diameter of the pipe.

ViscoSense®3D housing size	T. Max.	L. Max.
50 mm (2")	350 mm	150 mm
65 mm (2 ½")	400 mm	160 mm
80 mm (3")	400 mm	165 mm
100 mm (4")	450 mm	185 mm

Figure 7 Sensor installation diagram

6.4.3 To assemble ViscoSense®3D sensor

1. Check the O-ring for damage, before installing the ViscoSense®3D sensor. Replace if necessary. Make sure only one original o-ring is installed.
2. Remove transport locking cap from bottom side of flow tube.
3. Please make sure not to damage the DLC coating during installation.



Without the transport locking cap the sensor is not protected against excessive mechanical shocks which can occur during handling.

4. Install sensor carefully in housing with the closed surface facing the flow, illustrated in figure 8.



Make sure the flow tube closed surface is pointing towards the inlet of the sensor housing, see figure 8.
The sensor will not work correctly if installed wrongly.



Check if the position of the hole inside the housing and the fixation pin on the sensor match.

5. Tighten the nut (1) by hand. If there is a temperature difference between the sensor and the housing you should wait until they have the same temperature before tightening the nut.
6. Tighten the nut (1) with a wrench with a recommended torque of 100 Nm.



Make sure that all flange bolts and nuts are tightened correctly before re-pressurizing the system.



See chapter 15.1

7. The *ViscoSense*[®]3D system is now ready for electrical installation.

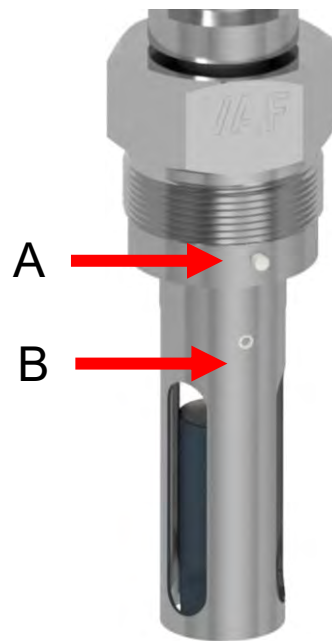
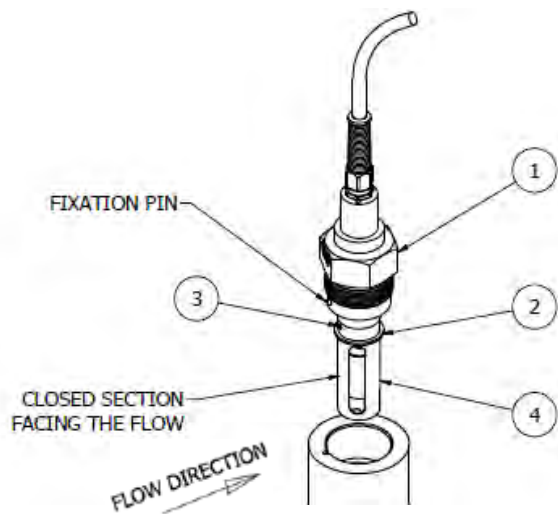


Figure 8 *ViscoSense*[®]3D sensor assembly

6.5 ELECTRICAL INSTALLATION



Provide correct power supply to the interface box.



In order to maintain proper EMC protection a shielded cable should be used for 4-20 mA output signals. Recommended cable: 0,50 mm², twisted pair, individually screened, braid shielded and PVC insulated.



For correct installation a suitable isolation switch shall be installed in the supply line as near as possible to the equipment. Maximum fuse current 16A.



To avoid signal grounding problems it is not recommended to connect more than one device to each 4-20 mA output of the interface box.

1. Remove cover from interface box.



Check that the power supply is connected to terminal J2 in accordance with power supply source and assure that power can be interrupted by a connector in the cable or circuit breaker in the proximity of the interface box.



Make sure that the wire to PE is always longer than power wires.

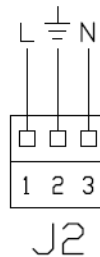


Figure 9 Power supply terminal J2

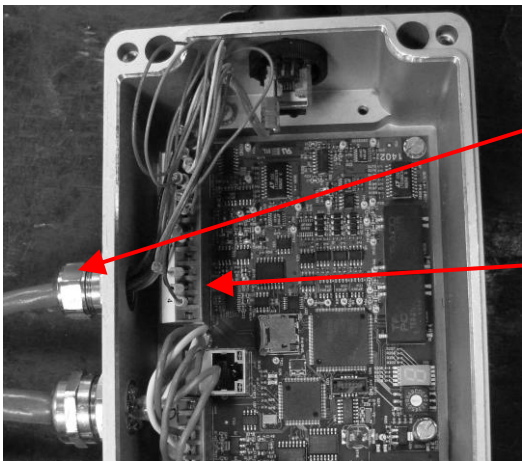
2. Feed the cable from *ViscoSense*[®]3D sensor through gland and connect wires to terminal J6 in accordance with figure 12.
3. Feed the cable for 4-20 mA viscosity, temperature and density output signals through the cable glands and connect wires to terminal J1 in accordance with figure 12. When no temperature output is connected to 3 and 4 on J1 (figure 12), terminals 3 and 4 must be connected together with a wire link. When no temperature output is connected to 7 and 8 on J1 (figure 12), terminals 7 and 8 must be connected together with a wire link.
4. Feed the cable for power supply through the cable gland and connect the wires to terminal J2 in accordance with figure 12.



To maintain proper EMC protection the cable glands provided with the interface box should not be exchanged for cable glands of any other make/type.

5. Make sure that all connectors are properly seated before closing the cover again.
6. Close the cover of the interface box.

6.6 CONNECTION OF SENSOR TO INTERFACE BOX



- 1. Tighten the cable glands with a spanner
- 2. Install the wires to the appropriate terminals of terminal J6

Figure 11 Connecting sensor to interface box

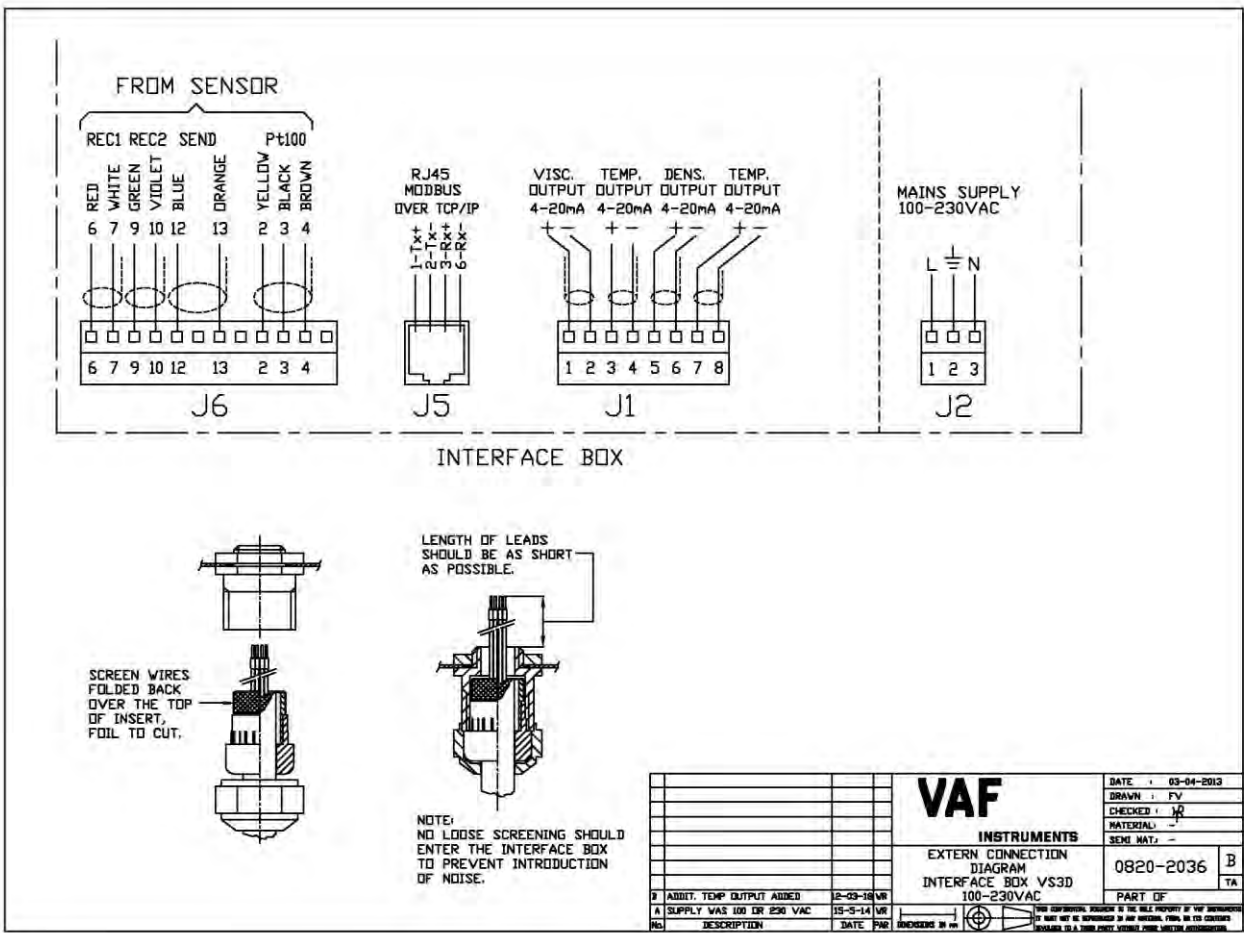


Figure 12 External connections at interface box

7. OPERATING INSTRUCTIONS

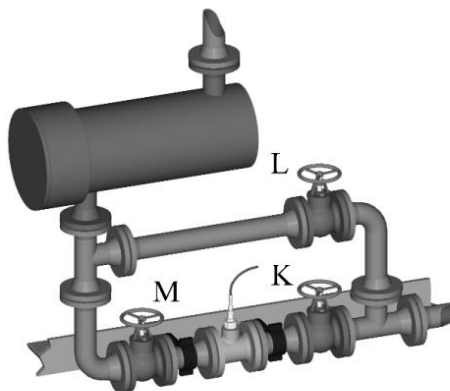


Figure 13

7.1 INITIAL START-UP

The initial start-up should always be done with diesel oil.

1. Fill the complete fuel system with diesel oil.
2. Open block valves (K and M) and bypass valve (L)
3. Allow diesel oil to enter the fuel system
4. Vent the fuel system
5. Start the booster pump in the fuel system and after approximately 15 minutes close bypass valve (L)
6. Switch on power supply to the *ViscoSense*[®]3D system. Depending upon the viscosity of the liquid it can take up to 30 seconds, before the first reading appears. This is due to the automatic signal gain control.
7. Gradually change over to HFO.

7.2 SHUT-DOWN ON HEAVY FUEL OIL

Maintain heat tracing on the *ViscoSense*[®]3D sensor housing after shut-down, to prevent clogging of the fuel to the sensor internal parts.

7.3 SHUT-DOWN ON DIESEL OIL

No special actions on the *ViscoSense*[®]3D unit are required.

7.4 ROUTINE START-UP

Make sure that the power is on.

No other special actions on the *ViscoSense*[®]3D unit are required.

8. MAINTENANCE

8.1 ROUTINE MAINTENANCE

Under normal conditions the *ViscoSense*[®]3D interface box requires no maintenance.

“Normal” means;

- A clean operating environment
- *ViscoSense*[®]3D interface box installed in accordance with the installation instructions given.
- Operation of the *ViscoSense*[®]3D interface box and related control system in accordance with this manual and other related publications
- Uninterrupted power supply at normal specified values.

8.2 TO CLEAN THE *VISCOSENSE*[®]3D SENSOR



When removing a *ViscoSense*[®]3D sensor from the piping system precautions must be taken to prevent personal injuries and damage to the sensor and process installation.



See chapter 15.1.

8.2.1 General procedure

1. Change over to manual viscosity control.
2. Shut off the flow through the *ViscoSense*[®]3D sensor, by closing the valves on both side of the sensor housing.
3. Switch off power supply to the *ViscoSense*[®]3D interface box.
4. If possible drain and empty the piping system.



Although the flow has been shut off, the *ViscoSense*[®]3D housing can still be under pressure and hot. If the sensor is removed from a sensor housing which has not been depressurized, hot oil will spray out.

5. Unscrew the *ViscoSense*[®]3D sensor from its housing by loosening nut 1 (Figure 8 *ViscoSense*[®]3D sensor assembly).
6. Take out the *ViscoSense*[®]3D sensor.
7. Do not remove the flow tube, do not stick any object in between the flow tube and pendulum.
8. Flush the space between the tube and the pendulum with diesel oil or non aggressive cleaning detergent.



Take care that the pendulum is not damaged or the torsion tube bent by mechanical force.



NEVER use abrasive materials like sandpaper, files etc., to clean the flow tube.

9. For the re-installation of the *ViscoSense*[®]3D sensor in the sensor housing please follow the instructions in chapter 6.



As it is important to install only one original o-ring, please verify that no parts of the old o-ring are left behind in the housing. Using other o-rings than original VAF o-rings can cause misreading of the sensor.

9. REPAIR OR REPLACEMENT

9.1 REPAIR

The *ViscoSense*[®]3D sensor and interface box cannot be repaired on site. They will be either exchanged for a spare unit or send back to VAF Instruments.

9.2 REPLACEMENT

When the sensor or interface box is replaced, we refer to chapter 5 and 6 for unpacking and installation instructions.

If the sensor is replaced, this will require that the correct settings for this sensor are made in the interface box. To make the correct settings, a spare sensor is supplied together with an micro SD card, which can be connected into the interface box.



Please note that the power supply should be connected to the interface box, when using the SD card.

Please take necessary precautions to avoid personal injury.

9.3 PROCEDURE FOR USING THE MICRO SD CARD

1. Disconnect power supply to the interface box
2. Open the interface box
3. Insert the micro SD card in the interface box into the SD Card slot. Please note that it is hinged, and therefore it should be pulled back (white arrow) before it can be lifted upwards (fig. 14)

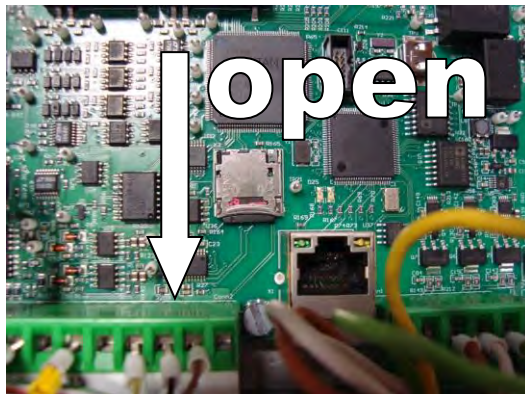


Figure 14

4. Connect power supply to the interface box
5. The settings of the new sensor are now uploaded to the pcb.
6. Close the interface box and the system is ready for use. The SD card is meant to be used for 1 specific sensor only, and can remain inside the interface box.

10. TAKE OUT OF SERVICE

Disconnect the power supply to the interface box. The *ViscoSense®3D* sensor should be taken out of the sensor housing and cleaned. See maintenance section for cleaning instructions. To protect the pendulum from damage due to mechanical shocks, the transport locking cap should be carefully placed in-between the flow tube and the pendulum.



Figure 16 Transport locking cap

11. REMOVAL AND STORAGE OF EQUIPMENT

Disconnect the power to the interface box. Disconnect the electrical connections of the sensor, outputs and power inside the interface box. The *ViscoSense®3D* sensor should be taken out of the sensor housing and cleaned. See maintenance section for cleaning instructions. To protect the pendulum from damaged due to mechanical shocks, the pendulum protection tube should carefully be placed in-between the flow tube and the pendulum. The sensor must be wrapped in protection material (preferably where it was shipped in) to protect it from damage.

Both the sensor and the interface box must be stored in a cool and dry place.

12. MALFUNCTION AND SEND FOR REPAIR

If the sensor or the interface box fails, they should be sent back to VAF Instruments for repair.

13. ENVIRONMENT

There are several electronics inside the Interface box. The sensor has DLC coating on the sensor head. During normal use all these components can not cause any harm to the environment.

14. DISPOSAL

Laws and restrictions for disposal of equipment will be different in most countries. If in doubt or unable to dispose the equipment it can be send back to VAF Instruments.
VAF Instruments will dispose the equipment in a correct way.

The *ViscoSense®3D* equipment has the following possible environmentally unfriendly components in minor quantities.

Sensor	DLC coating on the sensor head.
Sensor cable	Electrical cable with Teflon® coating.
Interface box	Electronic components.

15. TROUBLE SHOOTING

15.1 DISCONNECTION THE SENSOR

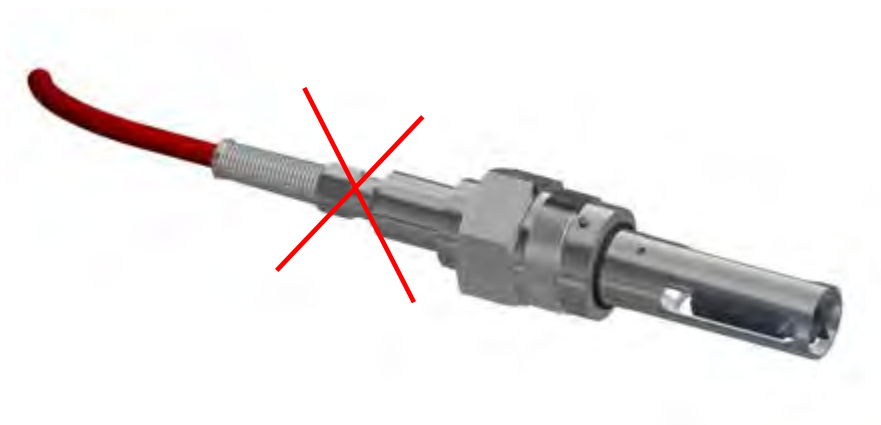


Figure 17 VS3D sensor

The sensor and electric wire are moulded together.



**NEVER TRY TO OPEN THE BACK OF THE SENSOR.
THIS WILL DAMAGE THE WIRE AND SENSOR BEYOND REPAIR.**

The sensor can only be disconnected at the interface box side.

15.2 GENERAL TROUBLE SHOOTING

Problem <i>No viscosity signal</i>	Possible cause No supply to interface box	Corrective action Check supply. Check fuses. Check electrical connections.
	Current loop connection broken	Check electrical wiring of 4-20 mA output signal
	Air entrapped in the fuel system	Vent the system
	<i>ViscoSense®3D</i> malfunctioning	Check diagnostic led
Problem <i>No temperature signal</i>	Possible cause No supply to interface box	Corrective action Check supply. Check fuses. Check electrical connections.
	Current loop connection broken	Check electrical wiring of 4-20 mA output signal
	<i>ViscoSense®3D</i> malfunctioning	Check diagnostic led
Problem <i>Viscosity output is lower than expected</i>	Possible cause Actual viscosity is lower than expected. E.g. bunker calculator only gives approx. value. Dilution with MDO. Temperature is higher than expected.	Corrective action None (For laboratory check of viscosity take sample according instructions in chapter 15.4).
	Range settings <i>ViscoSense®3D</i> and readout unit do not match	Check mA signal and range settings
	Air entrapped in the fuel system	Vent the system

Problem <i>Viscosity output is higher than expected</i>	Possible cause Actual viscosity is higher than expected. E.g. bunker calculator only gives approx. value. Temperature is lower than expected.	Corrective action None (For laboratory check of viscosity take sample according instructions in chapter 15.4).
	Range settings <i>ViscoSense</i> [®] 3D and readout unit do not match	Check mA signal and range settings
	Fuel is not pure, well mixed liquid (see chapter 6)	None
	Sensor is damaged or fouled	Clean and inspect the sensor (see chapter 8)
Problem <i>Viscosity output is max range</i>	Possible cause The viscosity in the sensor housing is higher than the max range	Corrective action Heat up the fluid
	Actual viscosity is higher than expected. E.g. bunker calculator only gives approx. value.	None
	<i>ViscoSense</i> [®] 3D interface box is malfunctioning	Check diagnostic led
	<i>ViscoSense</i> [®] 3D sensor is malfunctioning	
	Range settings <i>ViscoSense</i> [®] 3D and readout unit do not match	Check mA signal and range settings
	Sensor is damaged or fouled	Clean and inspect the sensor (see chapter 8)

15.3 PI SETTING ERRORS (FOR ADDITIONAL VISCOSITY CONTROLLER)

The heaters in the booster system are controlled by a viscosity controller.

In order to get a good working viscosity system an optimum adaptation of the control parameters (P,I) is necessary.

P = Proportional band Pb (%)

I = integral action time Ti (min)

Problem	Possible cause	Corrective action
<i>Oscillating temperature with distinct initial overshoot</i>	Pb too low	Increase Pb
<i>Set point is reached very slowly after initial exceeding</i>	Pb too high	Decrease Pb
<i>The set value is reached very slowly without overshooting</i>	Ti too high	Decrease Ti
<i>High initial overshoot followed by fading oscillation</i>	Ti too low	Increase Ti

15.4 HOW TO TAKE A HFO SAMPLE FOR ANALYSIS

The HFO sample must always be taken from the circulation system as close as possible to the viscosity sensor. Never take a sample from the bunker, settle or day tank.

The HFO sample must be collected and stored in a clean bottle or sample container. The bottle or sample container must be sealed in order to prevent contamination with other products. The sample quantity must be at least 200ml.





Write down the actual viscosity and temperature reading when the sample is taken. Send the sealed bottle or sample container with actual readings to a qualified laboratory or to VAF Instruments for analysis.



15.5 DIAGNOSTIC INFORMATION

The printed circuit board inside the *ViscoSense*[®]3D controller has a provision for diagnostic indication. Failures and errors are displayed by a blinking digit or character on a 7 segment LED. Dependent on the type of failure, error or warning, the viscosity and/or temperature outputs will go to 0, 4 or 20 mA, or will remain functioning normally.

If there is no failure, error or warning, the display indicates the state of the program by displaying a symbol (not blinking) on the display.

The following symbols are displayed during normal operation:

Display	Description
	Start-up of interface box and self-test
	Start-up of pendulum
	Measuring negative phase
	Measuring positive phase






Display	Description
	Adjusting phase
	Adjusting amplitude

During start-up the current outputs will be 4 mA.

When the display turns into 2. , 3. , 4. , 5. , or 6. after start-up of the interface box (0.) this indicates an error in software or electronics of the interface box.

The decimal point at the bottom of the display is always on after power is on. This point is only turned off while the *ViscoSense*[®]3D is writing to EEPROM, and if no measurement is possible due to extensive external vibrations.

Normally the *ViscoSense*[®]3D electronics will try to restart the unit if a faulty situation occurs. However, if the fault is persistent contact VAF Instruments or your local authorised VAF dealer and give a detailed description of the problem that occurred and the diagnostic information indicated at the 7 segment LED.

Display message	Viscosity output [mA]	Temperature output [mA]	Recovery action (attempt)	Fault description
	0	0	restart	Temperature out of range
	0	0	restart	Frequency of pendulum out of range
	0	0	restart	Unstable phase of pendulum or no pendulum
				Received measuring signal (Urec) too low (eg very high viscosity)
	Actual (open loop)	Actual (open loop)	NA	Open loop of analogue output signal(s)

Any other figure or letter indicates an error in the electronics or software.

16. CERTIFICATES

Certificates are delivered separately or can be downloaded from www.vaf.nl

17. DRAWINGS

17.1 VISCOSENSE®3D SENSOR AND SENSOR HOUSING

17.1.1 ViscoSense®3D sensor housing with sensor installed

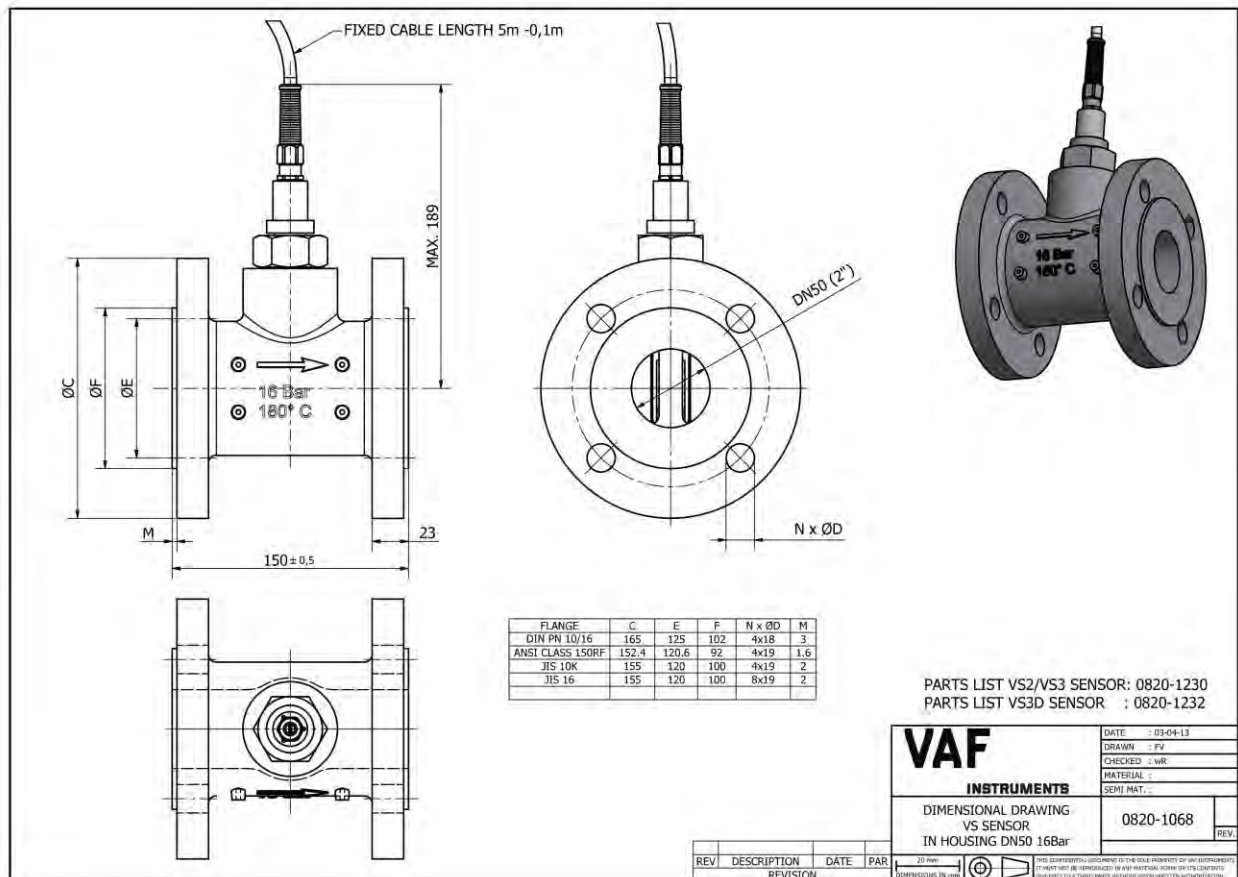


Figure 18 Dimensions of ViscoSense®3D sensor (All dimensions in millimetres)

17.2 VISCOSENSE®3D INTERFACE BOX

17.2.1 ViscoSense®3D interface box

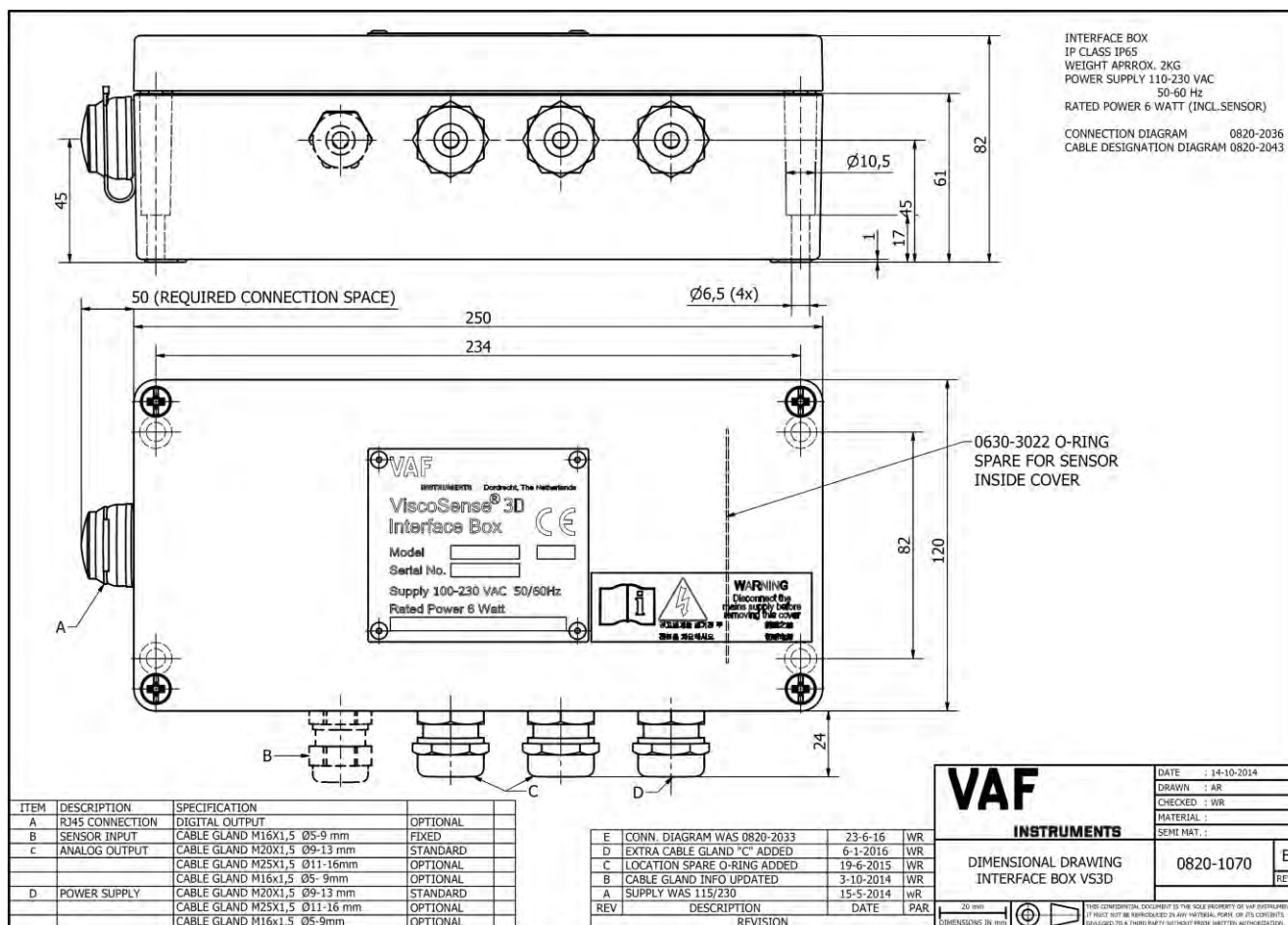


Figure 19 Dimensions of ViscoSense®3D interface box (All dimensions in millimetres)

18. ABBREVIATIONS

ANSI	American National Standards Institute
AWG	American Wire Gauge
dia	Diameter
DIN	Deutsches Institut für Normung
DN	Diameter Nominal
EEPROM	Electrically Erasable Programmable Read-Only Memory
EPROM	Erasable Programmable Read-Only Memory
Hz	Hertz (Frequency)
IEC	International Electrotechnical Commission
IOM	Installation, Operation and Maintenance
JIS	Japanese Industrial Standard
Kg	Kilograms
LED	Light Emitting Diode
mPa.s	Millipascal second
PAL	Programmable Array Logic
PT100	Temperature Sensor
RAM	Random Access Memory
RH	Relative Humidity
VAC	Volt Alternating Current
°C	Degrees Centigrade

20. WARRANTY CONDITIONS

1. Without prejudice to the restrictions stated hereinafter, the contractor guarantees both the soundness of the product delivered by him and the quality of the material used and/or delivered for it, insofar as this concerns faults in the product delivered which do not become apparent during inspection or transfer test, which the principal shall demonstrate to have arisen within 12 months from delivery in accordance with subarticle 1A exclusively or predominantly as a direct consequence of unsoundness of the construction used by the contractor or as a consequence of faulty finishing or the use of poor materials.
 - 1A. The product shall be deemed to have been delivered when it is ready for inspection (if inspection at the premises of the contractor has been agreed) and otherwise when it is ready for shipment.
2. Articles 1 and 1a shall equally apply to faults which do not become apparent during inspection or transfer test which are caused exclusively or predominantly by unsound assembly/installation by the contractor. If assembly/installation is carried out by the contractor, the guarantee period intended in article 1 shall last 12 months from the day on which assembly/installation is completed by the contractor, with the understanding that in this case the guarantee period shall end not later than 18 months after delivery in accordance with the terms of subarticle 1A.
3. Defects covered by the guarantee intended under articles 1, 1a and 2 shall be remedied by the contractor by repair or replacement of the faulty component either on or off the premises of the contractor, or by shipment of a replacement component, this remaining at the discretion of the contractor. Subarticle 3A shall equally apply if repair or replacement takes place at the site where the product has been assembled/installed. All costs accruing above the single obligation described in the first sentence, such as are not restricted to shipment costs, travelling and accommodation costs or disassembly or assembly costs insofar as they are not covered by the agreement, shall be paid by the principal.
 - 3A. If repair or replacement takes place at the site where the product has been assembled/installed, the principal shall ensure, at his own expense and risk, that:
 - a. the employees of the contractor shall be able to commence their work as soon as they have arrived at the erection site and continue to do so during normal working hours, and moreover, if the contractor deems it necessary, outside the normal working hours, with the proviso that the contractor informs the principal of this in good time;
 - b. suitable accommodation and/or all facilities required in accordance with government regulations, the agreement and common usage, shall be available for the employees of the contractor;
 - c. the access roads to the erection site shall be suitable for the transport required;
 - d. the allocated site shall be suitable for storage and assembly;
 - e. the necessary lockable storage sites for materials, tools and other goods shall be available;
 - f. the necessary and usual auxiliary workmen, auxiliary machines, auxiliary tools, materials and working materials (including process liquids, oils and greases, cleaning and other minor materials, gas, water, electricity, steam, compressed air, heating, lighting, etc.) and the measurement and testing equipment usual for in the business operations of the principal, shall be available at the correct place and at the disposal of the contractor at the correct time and without charge;

- g. all necessary safety and precautionary measures shall have been taken and adhered to, and all measures shall have been taken and adhered to necessary to observe the applicable government regulations in the context of assembly/installation;
 - h. the products shipped shall be available at the correct site at the commencement of and during assembly.
4. Defects not covered by the guarantee are those which occur partially or wholly as a result of:
 - A. non-observance of the operation and maintenance instructions or other than foreseeable normal usage;
 - B. normal wear and tear;
 - C. assembly/installation by third parties, including the principal;
 - D. the application of any government regulation regarding the nature or quality of the material used;
 - E. materials or goods used in consultation with the principal;
 - F. materials or goods provided by the principal to the contractor for processing;
 - G. materials, goods, working methods and constructions insofar as are applied at the express instruction of the principal, and materials or goods supplied by or on behalf of the principal.
 - H. components obtained from third parties by the contractor insofar as that party has given no guarantee to the contractor.
 5. If the principal fails to fulfil any obligation properly or on time ensuing from the agreement concluded between the principal and the contractor or any agreement connected to it, the contractor shall not be bound by any of these agreements to any guarantee regardless of how it is referred to. If, without previous written approval from the contractor, the principal commences disassembly, repair or other work on the product or allows it to be commenced, then every agreement with regard to guarantee shall be void
 6. Claims regarding defects must be submitted in writing as quickly as possible and not later than 14 days after the discovery of such. All claims against the contractor regarding faults shall be void if this term is exceeded. Claims pertaining to the guarantee must be submitted within one year of the valid complaint on penalty of invalidity.
 7. If the contractor replaces components/products under the terms of his guarantee obligations, the replaced components/products shall become the property of the contractor.
 8. Unless otherwise agreed, a guarantee on repair or overhaul work carried out by the contractor or other services shall only be given on the correctness of the manner in which the commissioned work is carried out, this for a period of 6 months. This guarantee only covers the single obligation of the contractor to carry out the work concerned once again in the event of unsound work. In this case, subarticle 3A shall apply equally.
 9. No guarantee shall be given regarded the inspection conducted, advice given and similar matters.
 10. Alleged failure to comply with his guarantee commitments on the part of the contractor shall not absolve the principal from his obligations ensuing from any agreement concluded with the contractor.
 11. No guarantee shall be given on products which form a part of, or on work and services on, goods older than 8 years.

21. ENCLOSURE

21.1 RECOMMENDATIONS FOR A GOOD WORKING BOOSTER UNIT

In order to get a good working booster unit we would like to point out a few things that are important.

Circulation

- The capacity of one circulation/booster pump should be 2,5 to 4 times the max fuel consumption
- The capacity of one feeder pump should be 1,5 to 2 times the max fuel consumption

Fuel velocity

Fuel velocity depends on the capacity of the circulation/booster pump and the inner diameter of the pipe that is used. A larger inner diameter will give a slower fuel velocity.

- The recommended fuel velocity in the booster unit is 1 - 2 m/sec
- The recommended fuel velocity to and from the engines is 0,25 – 0,5 m/sec

Remarks:

- A too high fuel velocity will result in larger pressure losses within the booster unit.
- A too high fuel velocity can result in unstable viscosity measurements.
- A too low fuel velocity will result in a slow and possibly unstable viscosity control

VAF Instruments delivers the *ViscoSense®3D* with housing. Refer to the table below for flow rate corresponding to the size of housing:

Fluid flow rate in piping (Recommended for correct control function)	All at 0-50 mPa.s 2" - Max 20 m ³ /h, Min 7m ³ /h 2.5" - Max 34 m ³ /h, Min 12m ³ /h 3" - Max 51 m ³ /h, Min 18m ³ /h 4" - Max 80 m ³ /h, Min 28m ³ /h For lower flowrates a smaller pipe diameter is recommended.
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Mixing tank

The mixing tank is an important part of the booster system that has several functions.

- The mixing of MDO and HFO to a homogeneous emulsion.
- The mixing of hot (+/- 130° C) with colder (+/- 80 °C) fuel, to a fuel with a single temperature
- Compensation of pressure pulses
- Prevention of a thermal shock of the engine when changing over from HFO to MDO.

Remarks

- If hot and cold HFO is not mixed well, it can result in incorrect viscosity measurements, which will result in an incorrect viscosity control of the system
- High or constant pressure pulses in the system can lead to damage to the *ViscoSense®3D* sensor or other components of the booster unit.

Fuel filters

There should be two fuel filters, placed parallel. One should be clean and on standby. Fuel filters should be placed in the HFO supply to the booster.

- The fuel flow is less; therefore the filter can be smaller.
- The fuel temperature is lower and the fuel is more stable.

Heaters

Heaters can be either steam, or electric.

There must be two heaters placed parallel in the system. Only one heater should be switched on. The other one should be clean and on standby.

Booster pump

There should be two booster pumps.

One active and the other one on standby

Revision 1216

Drawing 0820-1232 updated and layout updated.

Revision 1117

Chapter 2.2 Modbus TCP/IP option added

Chapter 3.3 Modbus TCP/IP settings/parameters added

Revision 0418:

Chapter 1.1 Warning added

Revision 0418(2)

Chapter 3.3, 6.5 and 6.6 updated

Revision 0620:

Chapter 3 Sensor table updated

Several 3D-pictures updated

Drawing 0820-1232 updated



VAF

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