

Rosemount™ 403/403VP

Contacting Conductivity Sensors



Essential Instructions

Read this page before proceeding!

Emerson designs, manufactures and tests its products to meet many national and international standards. Because these sensors are sophisticated technical products, you **MUST** properly install, use, and maintain them to ensure they continue to operate within their normal specifications. The following instructions **MUST** be adhered to and integrated into your safety program when installing, using, and maintaining Rosemount products. Failure to follow the proper instructions may cause any one of the following situations to occur: loss of life; personal injury; property damage; damage to this sensor; and warranty invalidation.

- Read all instructions prior to installing, operating, and servicing the product.
- If you do not understand any of the instructions, contact your Emerson representative for clarification.
- Follow all warnings, cautions, and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation, and maintenance of the product.
- Install your equipment as specified in the Installation Instructions of the appropriate Instruction Manual and per applicable local and national codes. Connect all products to the proper electrical and pressure sources.
- To ensure proper performance, use qualified personnel to install, operate, update, program, and maintain the product.
- When replacement parts are required, ensure that qualified people use replacement parts specified by Emerson. Unauthorized parts and procedures can affect the product's performance, place the safe operation of your process at risk, and **VOID YOUR WARRANTY**. Third-party substitutions may result in fire, electrical hazards, or improper operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified persons, to prevent electrical shock and personal injury.

The information contained in this document is subject to change without notice.

CAUTION

Sensor/Process Application Compatibility

The wetted sensor materials may not be compatible with process composition and operating conditions. Application compatibility is entirely the responsibility of the user.

CAUTION

Before removing the sensor, be absolutely certain the process pressure is reduced to 0 psig and the process temperature is at safe level.

About This Document

This manual contains instructions for installation and operation of the Rosemount 403/403VP Contacting Conductivity Sensors.

The following list provides concerning all revisions of this document.

Rev. Level	Date	Notes
Q	06/17	Reformatted to reflect the latest Emerson documentation style, Updated the Specifications and Wiring Diagrams.

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Section 1: Specifications

1.1 Specifications

Table 1-1: Rosemount 403/403VP Contacting Conductivity Sensor specifications

Cell constants	
0.01, 0.1 and 1.0/cm	
Wetted materials	
titanium; 316 stainless steel; PCTFE (Neoflon), compliant with 21CFR 177.1380; EP, compliant with 21CFR177.2600 and USP Class VI	
Surface finish	
All wetted surfaces have 16 micro in. (0.4 micrometer) Ra finish.	
Process connection	
1-1/2 in. or 2-in. sanitary flange	
Temperature	
32–221 °F (0–105 °C). Sensors are steam sterilizable to 275 °F (135 °C)	
Pressure	
250 psig (1825 kPa abs) maximum	
Cable length	
10 ft (3.1 m) standard; 50 ft (15.2 m) optional	
Weight/shipping weight	
403 sensor with 10 ft (3.1 m) cable	2 lb (1.0 kg)/3 lb (1.5 kg)
403 sensor with 50 ft (15.2 m) cable	4 lb (2.0 kg)/5 lb (2.5 kg)
403VP sensor	1 lb (0.5 kg)/2 lb (1.0 kg) (rounded up to nearest 1 lb or 0.5 kg)

NOTICE

Elastomers and fluorocarbon resins are compatible with 21CFR177. Elastomers also meet the requirements of USP Class VI. Stainless steel contains <5 % delta ferrite. All surfaces in have 16 microinch (0.4 micrometer) Ra finish.

1.2 Ordering Information

Table 1-2: Rosemount 403 Contacting Conductivity Sensor ordering information

Model	Sensor Type
403	Contacting Conductivity Sensor
Cell Constant	
11	0.01/cm
12	0.1/cm
13	1.0/cm
Flange Size	
20	1-1/2 in. Stainless Steel Sanitary Fitting
21	2 in. Stainless Steel Sanitary Fitting
Temperature Compensation	
_	No Selection – Pt-1000 ⁽¹⁾
54	Pt-100 ⁽²⁾

Optional Options

Insertion Length	
_	No Selection – Standard Insertion Length
36	Extended Insertion Length ⁽³⁾
Cable Length	
_	Standard 10 ft. Integral Cable
50	50 ft. Integral Cable
Special	
_	No Selection – Supplier Material Traceability Certificate not Included
99Q8	Supplier Material Traceability Certificate Included
Typical Model Number: 403-11-20-_-36-50-99Q8	

1. For compatibility with Rosemount 56, 1056, 1057, 1066, and 5081 Transmitters. Also compatible with legacy transmitter models 1055, 54e, 4081, 6081, and XMT.
2. For compatibility with legacy transmitter models 1054, 2054, and 2081.
3. Extended insertion length is 6 inches from inside face of flange to end of sensor.

Table 1-2: Rosemount 403VP Contacting Conductivity Sensor ordering information

Model	Sensor Type
403VP	Contacting Conductivity Sensor
Cell Constant	
11	0.01/cm
12	0.1/cm
13	1.0/cm
Flange Size	
20	1-1/2 in. Stainless Steel Sanitary Fitting
21	2 in. Stainless Steel Sanitary Fitting
Temperature Compensation	
_	No Selection – Pt-1000 ⁽¹⁾
54	Pt-100 ⁽²⁾

Optional Options

Insertion Length	
_	No Selection – Standard Insertion Length
36	Extended Insertion Length ⁽³⁾
Special	
_	No Selection – Supplier Material Traceability Certificate not Included
99Q8	Supplier Material Traceability Certificate Included
Typical Model Number: 403VP-11-20-_-36-99Q8	

1. For compatibility with Rosemount 56, 1056, 1057, 1066, and 5081 Transmitters. Also compatible with legacy transmitter models 1055, 54e, 4081, 6081, and XMT.
2. For compatibility with legacy transmitter models 1054, 2054, and 2081.
3. Extended insertion length is 6 inches from inside face of flange to end of sensor.

Section 2: Installation

2.1 Unpacking and Inspection

Inspect the outside of the carton for any damage. If damage is detected, contact the carrier immediately. Inspect the instrument and hardware. Make sure all items in the packing list are present and in good condition. Notify the factory if any part is missing.

2.2 Installation

Depending on the option selected, the sensor can be installed in either a 1 ½-inch or 2-inch Tri Clamp tee. The gasket, clamp, and tee must be supplied by the user. The electrodes must be completely submerged in the process liquid, i.e., up to the inside surface of the flange.

If the sensor is installed in a side stream with the sample draining to open atmosphere, bubbles may accumulate on the electrodes. Trapped bubbles will cause errors. Normally, as bubbles accumulate the conductivity reading drifts down. To control bubble formation, apply a small amount of back pressure to the sensor.

Figure 2-1 Sensor orientation

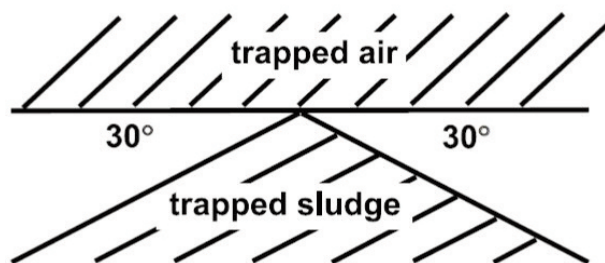
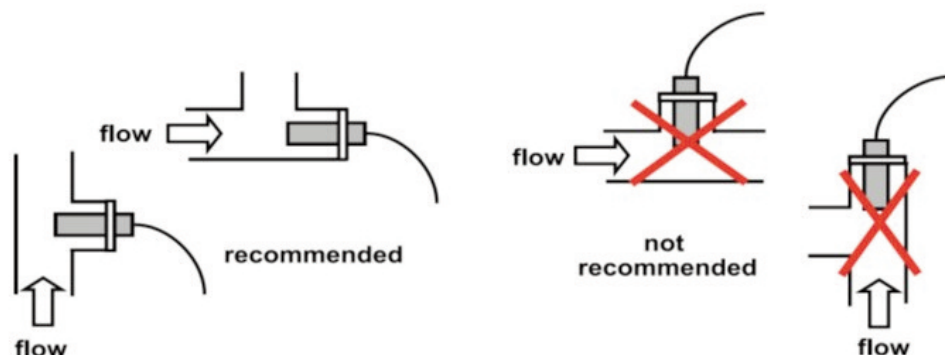


Figure 2-2 Recommended installation



Section 3: Wiring

3.1 Wiring for Rosemount 403/403VP

For additional wiring information on this product, including sensor combinations not shown here, please refer to the [Liquid Transmitter Wiring Diagrams](#).

Figure 3-1: Wire color and connections in sensor

COLOR	FUNCTION
Gray	Connects to outer electrode
Clear	Coaxial shield for gray wire
Orange	Connects to inner electrode
Clear	Coaxial shield for orange wire
Red	
White with red stripe	
White	
Clear	Shield for all RTD lead wires

Figure 3-2: Rosemount 403/403VP Sensor Wiring to Rosemount 56, 1056, and 1057 Transmitters

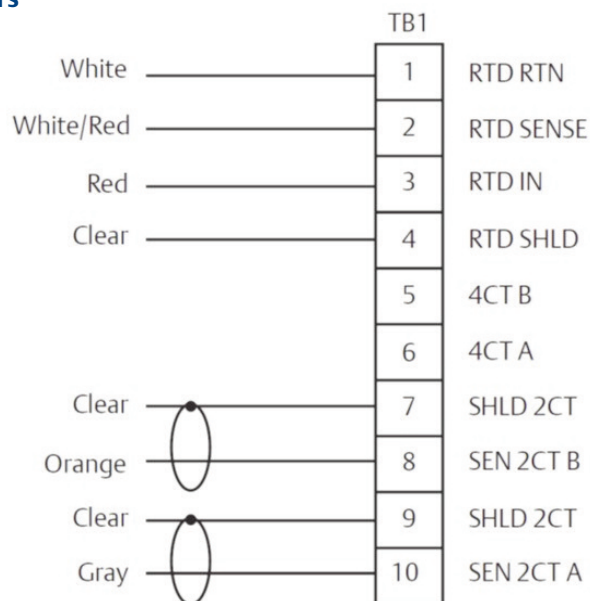
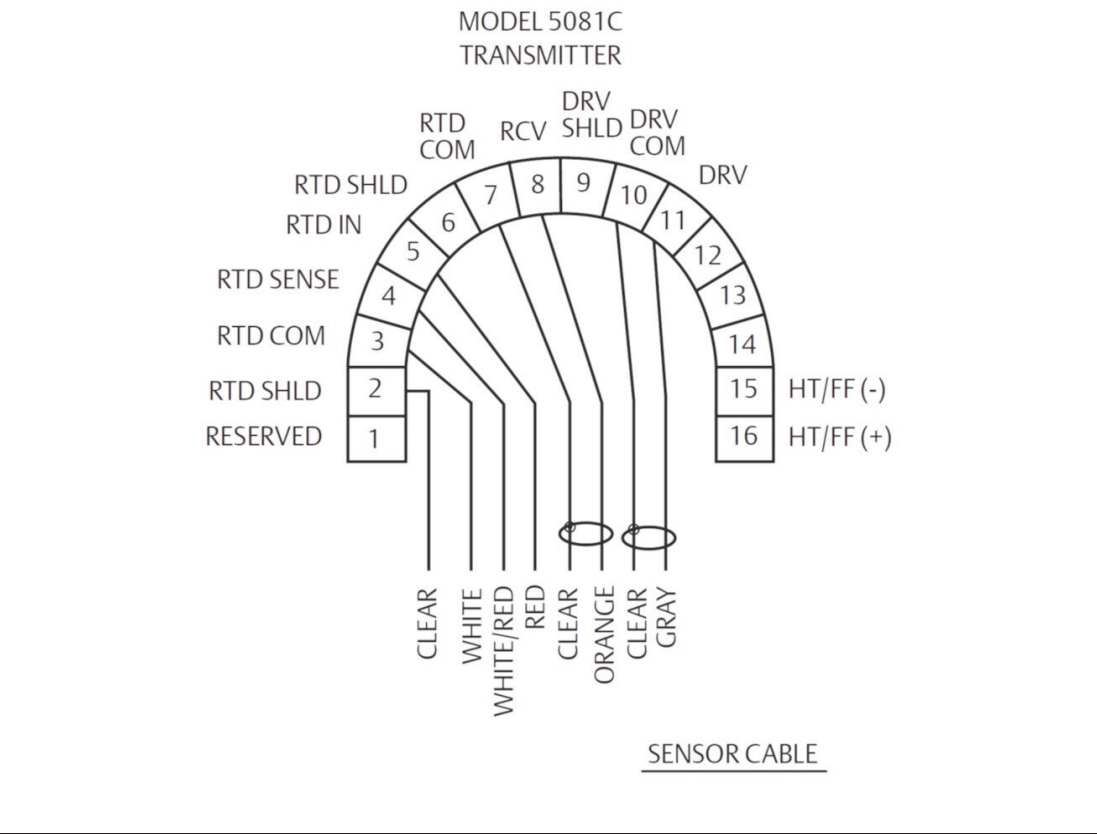


Figure 3-3: Rosemount 403/403VP Sensor Wiring to Rosemount 1066 Transmitter



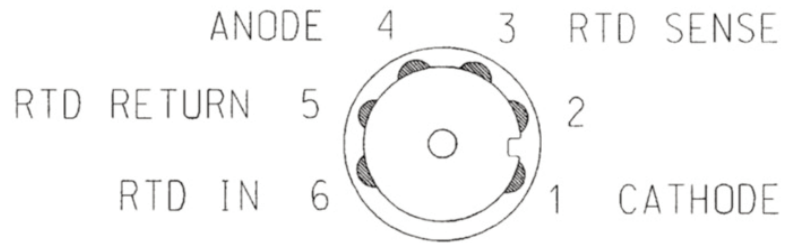
Figure 3-4: Rosemount 403/403VP Sensor Wiring to Rosemount 5081 Transmitter



3.2 Wiring through a Junction Box

If wiring connections are made through a remote junction box (PN 23550-00), wire point-to-point. Use cable 23747-00 (factory-terminated) or 9200275 (no terminations).

Figure 3-5: Pin Out Diagram for Rosemount 403VP Sensor (viewed from connector end of sensor, looking down)



Section 4: Calibration and Maintenance

4.1 Cleaning the Sensor

Use a warm detergent solution and a soft brush or pipe cleaner to remove oil and scale. Isopropyl alcohol (rubbing alcohol) can also be used to remove oily films. Avoid using strong mineral acids to clean conductivity sensors.

4.2 Calibration

PURSense conductivity sensors are calibrated at the factory and do not need calibration when first placed in service. Simply enter the cell constant printed on the label into the transmitter. After a period of service, the sensor may require calibration. The sensor can be calibrated against a solution having known conductivity or against a referee meter and sensor. If using a standard solution, choose one having conductivity in the recommended operating for the sensor cell constant. Refer to the transmitter manual or product data sheet for recommended ranges. Do not use standard solutions having conductivity less than about 100 $\mu\text{S}/\text{cm}$. They are susceptible to contamination by atmospheric carbon dioxide, which can alter the conductivity by a variable amount as great as 1.2 $\mu\text{S}/\text{cm}$ (at 25 °C). Because 0.01/cm sensors must be calibrated in low conductivity solutions, they are best calibrated against a referee meter and sensor in a closed system.

For more information about calibrating refer to [Application Data Sheet](#).

4.2.1 Calibrating using a standard solution

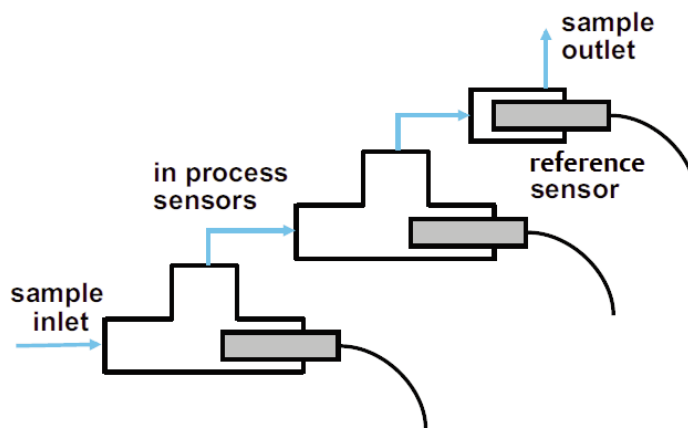
If using a standard solution, choose one having conductivity in the recommended operating range for the sensor cell constant.

1. Immerse the rinsed sensor in the standard solution and adjust the transmitter reading to match the conductivity of the standard.
2. For an accurate calibration:
 - a. Choose a calibration standard near the midpoint of the recommended conductivity range for the sensor.
 - b. Do not use calibration standards having conductivity less than 100 $\mu\text{S}/\text{cm}$.
 - c. Turn off automatic temperature compensation in the transmitter.
 - d. Use a standard for which the conductivity as a function of temperature is known.
 - e. Use a good quality calibrated thermometer with an error rate less than ± 0.1 °C to measure the temperature of the standard.
 - f. Follow good laboratory practice. Rinse the beaker and sensor at least twice with standard. Be sure the rinse solution reaches between the inner and outer electrodes by tapping and swirling the sensor while it is immersed in the standard.
 - g. Be sure air bubbles are not trapped between the electrodes. Place the sensor in the standard and tap and swirl to release bubbles. Note the reading and repeat. If readings agree, no trapped bubbles are present. Repeat until two subsequent readings agree.

4.2.2 Calibrating using a reference meter and sensor

1. Connect the process sensors and reference sensor in series and allow the process liquid to flow through all sensors.
2. Calibrate the process sensor by adjusting the process transmitter reading to match the conductivity measured by the reference meter. See [Figure 3-1](#) for the calibration setup.

Figure 3-1 In process calibration setup



NOTICE

The above figure shows two process sensors connected in series with a reference sensor. The horizontal sensor orientation ensures good circulation of the process liquid past the electrodes. The staircase orientation provides an escape path for bubbles.

3. The method is ideal for calibrating the sensors used in low conductivity water (0.01/cm cell constants) because the calibration system is closed and cannot be contaminated by atmospheric carbon dioxide.

Following precautions are necessary for successful calibration:

1. If the normal conductivity of the process liquid is less than about 1.0 $\mu\text{S}/\text{cm}$, adjust the conductivity so that it is near the upper end of the operating range.

The difference between the conductivity measured by the process and reference meter usually has both a fixed (constant error) and relative (proportional error) component. Because the cell constant calibration assumes the error is proportional only, calibration at low conductivity allows the fixed component to have an outsized influence on the result.

For example, assume the only difference between reference meter and process sensor is fixed and the process sensor always reads 0.002 $\mu\text{S}/\text{cm}$ high. If the process sensor is calibrated at 0.100 $\mu\text{S}/\text{cm}$, the new cell constant will be changed by 0.100/0.102 or 2%. If the sensor is calibrated at 0.500 $\mu\text{S}/\text{cm}$, the change will be only 0.500/0.502 or 0.4%.

Calibration at higher conductivity produces a better result because it minimizes the effect of the offset.

2. Orient the sensors so that air bubbles always have an easy escape path and cannot get trapped between the electrodes.
3. Turn off automatic temperature compensation in the transmitter.

Almost all process conductivity transmitter feature automatic temperature compensation in which the transmitter applies one of several temperature correction algorithms to convert the measured conductivity to the value at a reference temperature, typically 25 °C.

Although temperature correction algorithms are useful for routine measurements, they should not be used during calibration.

There are two following reasons:

- a. No temperature correction is perfect. If the assumptions behind the algorithm do not perfectly fit the solution being measured, the temperature-corrected conductivity will be in error.
- b. If the temperature measurement itself is in error, the corrected conductivity will be in error.

The purpose of calibrating the sensor is to determine the cell constant. To minimize the error in the cell constant, all sources of avoidable error, e.g., temperature compensation should be eliminated.

4. Keep tubing runs between the sensors short and adjust the sample flow as high as possible. Short tubing runs and high flow ensure the temperature of the liquid does not change as it flows from one sensor to another.

If the process temperature is appreciably different from ambient, high flow may not be enough to keep the temperature constant. In this case, pumping sample at room temperature from a reservoir through the sensors might be necessary. Because such a system is likely to be open to atmosphere, saturate the liquid with air to prevent drift caused by absorption of atmospheric carbon dioxide.

5. To prevent contamination of low conductivity ($<1 \mu\text{S}/\text{cm}$) process liquids, use clean tubing to connect the sensors. To prevent drift caused desorption of ionic contaminants from tube walls, keep the sample flow greater than 6 ft/sec (1.8 m/sec).

4.2.3 Calibrating using a grab sample

1. Use the grab sample method when it is impractical to remove the sensor for calibration or to connect a reference sensor to the process line.
2. Take a sample of the process liquid, measuring its conductivity using a reference instrument, and adjusting the reading from the process transmitter to match the measured conductivity.
3. Take the sample from a point as close to the process sensor as possible.
4. Keep temperature compensation turned on. There is likely to be a lag time between sampling and analysis, so temperature is likely to change.
5. Be sure the reference and process instruments are using the same temperature correction algorithm.

6. Grab sample calibration should be used only when the conductivity is fairly high.
 - a. The temperature compensation algorithm will most likely be linear slope.
 - b. Confirm that both instruments are using the same temperature coefficient in the linear slope calculation.
 - c. If the reference meter does not have automatic temperature correction, calculate the conductivity at 25 °C using the equation:

$$C_{25} = \frac{C_t}{1 + \alpha(t - 25)}$$

Where: C₂₅ = the conductivity at 25 °C

C_t = the conductivity at t °C

α = the temperature co-efficient expressed as a decimal fraction.

- d. Confirm the temperature measurements in both the process and reference instruments are accurate, ideally to within ±0.5 °C.
- e. Follow good laboratory practice when measuring the conductivity of the grab sample.
 - Rinse the beaker and sensor at least twice with sample. Be sure the rinse solution reaches between the inner and outer electrodes by tapping and swirling the sensor while it is immersed in the sample.
 - Be sure air bubbles are not trapped in the sensor. Place the sensor in the sample and tap and swirl to release bubbles. Note the reading. Then, remove the sensor and return it to the sample. Tap and swirl again and note the reading. If the two readings agree, trapped bubbles are absent. If they do not agree, bubbles are present. Continue the process until two subsequent readings agree.
 - While making the measurement, do not allow the sensor to touch the sides and, particularly, the bottom of the beaker. Keep at least 1/4 in. (6 mm) clearance.
- f. Be sure to compensate for process conductivity changes that might have occurred while the grab sample was being tested. Rosemount conductivity transmitters (Rosemount transmitter models 1056, 1066, and 56) do this automatically. They save the value of the process conductivity at the time the sample was taken and use that value to calculate the new cell constant when the user enters the result of the grab sample test. Older transmitters do not remember the process conductivity value. Therefore, the user must enter a value adjusted by an amount proportional to the change in the process conductivity. For example, suppose the process conductivity is 810 μS/cm when the sample is taken and 815 μS/cm when the test result is entered. If the grab sample conductivity is 819 μS/cm, the user should enter $(815/810) \times 819$ or 824 μS/cm.

Section 5: Troubleshooting

5.1 Troubleshooting

Table 5-1: Troubleshooting

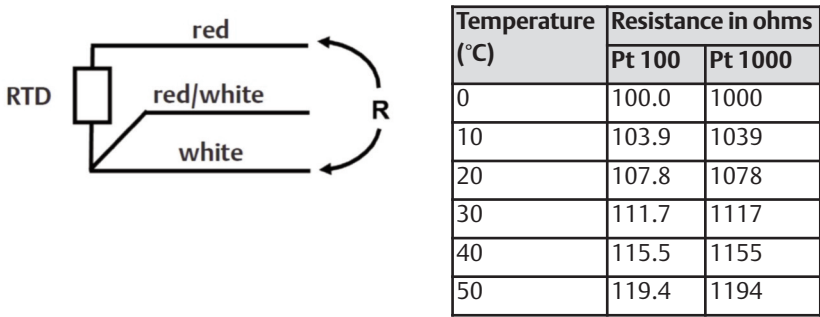
Trouble	Probable Cause	Remedy
Off-scale reading	Wiring is wrong.	Verify wiring.
	RTD is open or shorted.	Check RTD for open or short circuits. See Figure 5-1 .
	Sensor is not in process stream.	Be sure sensor is completely submerged in process stream.
	Variopol cable is not properly seated.	Loosen connector and reseal.
	Sensor has failed.	Perform isolation checks. See Figure 5-2 .
Noisy reading	Sensor is improperly installed in process stream.	Be sure sensor is completely submerged in process stream.
	Variopol cable is not properly seated.	Loosen connector and reseal.
Reading seems wrong (lower or higher than expected)	Bubbles trapped in sensor.	Be sure sensor is properly oriented in pipe or flow cell. See Figure 2-1 . Apply back pressure to flow cell.
	Wrong temperature correction algorithm.	Check that temperature correction is appropriate for the sample. See transmitter manual for more information.
	Wrong cell constant.	Verify that the correct cell constant has been entered in the transmitter and that the cell constant is appropriate for the conductivity of the sample. See transmitter manual.
Sluggish response	Electrodes are fouled.	Clean electrodes.
	Sensor is installed in dead area in piping	Move sensor to a location more representative of the process liquid.

Note: For any repair or warranty inquiries please contact our Customer Care group.

5.1.1 Checking RTD

Disconnect leads and measure resistance shown. The measured resistance at room temperature should be close to the value in the table.

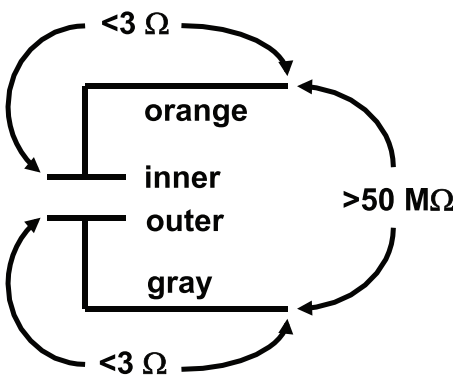
Figure 5-1 Checking RTD



5.1.2 Checking the continuity and leakage

Disconnect electrode leads and measure resistance and continuity as shown. Sensor must be dry when checking resistance between electrode leads.

Figure 5-2 Checking the continuity and leakage



Section 6: Accessories

6.1 Accessories

Table 6-1 Rosemount 403/403VP Sensor accessories information

Part Number	Description
23550-00	Interconnecting cable, VP 6, 2.5 ft (0.8 m)
23747-04	Interconnecting cable, VP 6, 4 ft (1.2m)
23747-02	Interconnecting cable, VP 6, 10 ft (3.0 m)
23747-07	Interconnecting cable, VP 6, 15 ft (4.6 m)
23747-08	Interconnecting cable, VP 6, 20 ft (6.1 m)
23747-09	Interconnecting cable, VP 6, 25 ft (7.6 m)
23747-10	Interconnecting cable, VP 6, 30 ft (9.1 m)
23747-03	Interconnecting cable, VP 6, 50 ft (15.2 m)
23747-11	Interconnecting cable, VP 6, 100 ft (30.5 m)
23550-00	Junction Box without Preamplifier
9200275	Interconnect Extension Cable, Unprepped (for use with Junction Box)
23747-00	Interconnect Extension Cable, Prepped (for use with Junction Box)
05010781899	Conductivity standard SS-6, 200 uS/cm, 32 oz (0.95 L)
05010797875	Conductivity standard SS-6A, 200 uS/cm, 1 gal (3.78 L)
05010782468	Conductivity standard SS-5, 1000 uS/cm, 32 oz (0.95 L)
05010783002	Conductivity standard SS-5A, 1000 uS/cm, 1 gal (3.78 L)
05000705464	Conductivity standard SS-1, 1409 uS/cm, 32 oz (0.95 L)
05000709672	Conductivity standard SS-1A, 1409 uS/cm, 1 gal (3.78 L)
05010782147	Conductivity standard SS-7, 5000 uS/cm, 32 oz (0.95 L)
05010782026	Conductivity standard SS-7A, 5000 uS/cm, 1 gal (3.78 L)

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