

Technical Description

706010En, Ed. 1, Rev A

April 2009

Multiple Spot and Single Spot Temperature Sensors for Rosemount Tank Gauging Systems



ROSEMOUNT[®]
Tank Gauging

www.rosemount-tg.com


EMERSON[™]
Process Management

Temperature Sensors

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Available documentation for temperature and water level sensors

- TankRadar Rex Technical Description (703010)
- TankRadar Rex Installation Manual (308014)
- TankMaster WinSetup Reference Manual (303027)
- Multispot Thermometers Product Sheet (106014)
- Water Level Sensor Product Sheet (109526)

Standard Drawings:

- Dimensional Drawing, flanged thermowell, Single Spot Temperature Sensor (9242 132-001)
- Dimensional Drawing Pt-100, Single Spot Temperature Sensor (9242 131-001)
- Electrical Installation Drawing. JB 36/42, temperature connection box, intrinsically safe cables (9150 072-096)
- Electrical Installation Drawing. Temperature sensor connection to radar gauge (W12/X12). (9150 072-941)
- Electrical Installation Drawing. WLS and temperature sensor connection to radar gauge (W12/X12). (9150 072-944)
- Electrical Installation Drawing. DAU, Pt-100, 3-wire, WLS. (9240 003-940)
- Electrical Installation Drawing. DAU, Pt-100, common return. (9240 003-912)
- Mechanical Installation Drawing. Recommended temperature sensor positions. (9240 003-942)
- Mechanical Installation Drawing. Multiple Spot Temperature Sensor in nylon. (9240 002-948)
- Mechanical Installation Drawing. Multiple Spot Temperature Sensor in stainless steel, Ø=20 mm. (9240 002-949)

- Mechanical Installation Drawing. Multiple Spot Temperature Sensor in stainless steel, Ø=29 mm. (9240 002-949)
- Mechanical Installation Drawing. 12 kg temperature sensor weight. (9240 003-008)
- Mechanical Installation Drawing. 4 kg temperature sensor weight. (9240 003-007)
- Mechanical Installation Drawing. Single Spot Temperature Sensor with flanged thermowell. (9242 133-001)
- Mechanical Installation Drawing. Single Spot Temperature Sensor, type BF. (9261 090-151)
- Mechanical Installation Drawing. Single Spot Temperature Sensor, type OPE. (9261 090-153)
- Mechanical Installation Drawing. Multiple Spot Temperature Sensor. (9150 044-905)
- Mechanical Installation Drawing. Multiple Spot Temperature Sensor in thermowell / LPG, 2-in. Sch.80. (9240 003-928),
- Mechanical Installation Drawing. Multiple Spot Temperature Sensor in thermowell, 2-in. Sch.40. (9240 003-906)
- Electrical Installation Drawing. Junction Box for WLS. (9261 090-232)
- Mechanical Installation Drawing. 5 kg WLS anchor weight. (9261 065-080)
- Mechanical Installation Drawing. WLS, closed version, for light products. (9261 090-235)
- Mechanical Installation Drawing. WLS, closed version, for sticky products, Crude, HFO etc. (9261 065-040)
- Dimensional Drawing Water Level Sensor (WLS). (9261 090-150)
- Mechanical Installation Drawing. WLS in still-pipe. (9261 090-154)

Abbreviations

- DAU (Data Acquisition Unit)
- DU (Display Unit)
- JB (Junction Box)
- MST sensor (Multiple Spot Temperature sensor)
- MSTW (Multiple Spot Temperature sensor with integrated WLS)
- SST (Single Spot Temperature sensor)
- WLS (Water Level Sensor)

Temperature Sensors

Temperature Measurement

Product temperature is an important parameter for accurate custody transfer and inventory measurement in liquid bulk storage tanks. High quality temperature sensors can be included in the Rex system delivery as an essential part.

Temperature sensors can be connected in two ways to the Radar Tank Gauge (RTG):

- Directly into the RTG (up to six temperature elements)
- Via the Data Acquisition Unit (DAU), with up to 14 temperature elements

This publication covers a selection of temperature sensors. For special requirements, call your supplier or Emerson Process Management / Rosemount Tank Gauging.

Spot Element Principle and Electrical Properties

Resistance Temperature Detectors (RTD) are sensors used to measure temperature.

The RTD element is made from a pure material, which has a predictable change in resistance as the temperature changes. This change is used to determine temperature.

It is a passive resistance element, which means the RTD does not create any electromotive force itself.

By using a known current, the voltage across the RTD is measured, which gives the resistance, and consequently also the temperature.

Standard RTD types

Platinum RTD's, made according to EN 60751/ IEC751, is today's common standard.

In the past, nickel RTD's were common. Such RTD's had higher resistance output with less linearity, and less long time stability.

Since instruments have become much more sophisticated, platinum has become the main sensor material due to the high stability.

RTD's can be wire-wound or made on substrate, and encapsulated in different ways.

Wire-wound platinum elements are used for the petrochemical industry.

The platinum elements are coiled from a wire with the length and the diameter to give exactly 100 ohm at 0 °C (32 °F) .

RTDs temperature dependance and tolerance classes

In EN 60751 the relationship between resistance and temperature is defined:

$$R(t) = R_0 * (1 + A * t + B * t^2 + C * (t - 100) * t^3)$$

where $A = 3.90802E-3 \text{ } ^\circ\text{C}^{-1}$, $B = -5.80200E-7 \text{ } ^\circ\text{C}^{-2}$

t is the temperature in °C

$$C = 0 \text{ } ^\circ\text{C}^{-4} \text{ if } t > 0$$

$$C = -4.27350E-12 \text{ } ^\circ\text{C}^{-4} \text{ if } t < 0$$

$R_0 = 100 \text{ } \Omega$ for Pt-100 (500 Ω for Pt-500 etc.)

Two grades or classes are stated for temperature element tolerances:

$$\text{Grade A: } \pm (0.15 + 0.002 * | t |)$$

$$\text{Grade B: } \pm (0.30 + 0.005 * | t |)$$

Grade B is used for temperatures close to 0 °C, and grade A is used for temperatures far away from 0 °C.

For many users Classes A and B are not sufficient. For this reason, suppliers deliver 1/3, 1/5, 1/6 and 1/10 of Class B, which are slightly better than Class A. When a platinum element is found to be 1/6 or 1/10 of Class B at 0 °C, the reason is a pure platinum wire.

For the relevant case, at temperatures close to 0 °C, only the fixed part is divided in the expression for the DIN B tolerance.

$$1/6 \text{ DIN B: } \pm (0.05 + 0.005 * | t |)$$

$$1/10 \text{ DIN B: } \pm (0.03 + 0.005 * | t |)$$

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Tolerances for temperature sensors in Rosemount Tank Gauging systems

The temperature sensors supplied by Emerson Process Management / Rosemount Tank Gauging, are made from a very pure platinum material with predictable and stable characteristics for very accurate temperature measurement. These sensors can be ordered as 1/6 and 1/10 DIN B, with an even better temperature tolerance than previously stated.

The temperature dependent part in the expression is more similar to the one for Grade A, which means that Grade B delivered by Emerson has $\pm (0.30 + 0.002 * |t|)$ tolerance. The following applies:

$$1/6 \text{ DIN B: } \pm (0.05 + 0.002 * |t|)$$

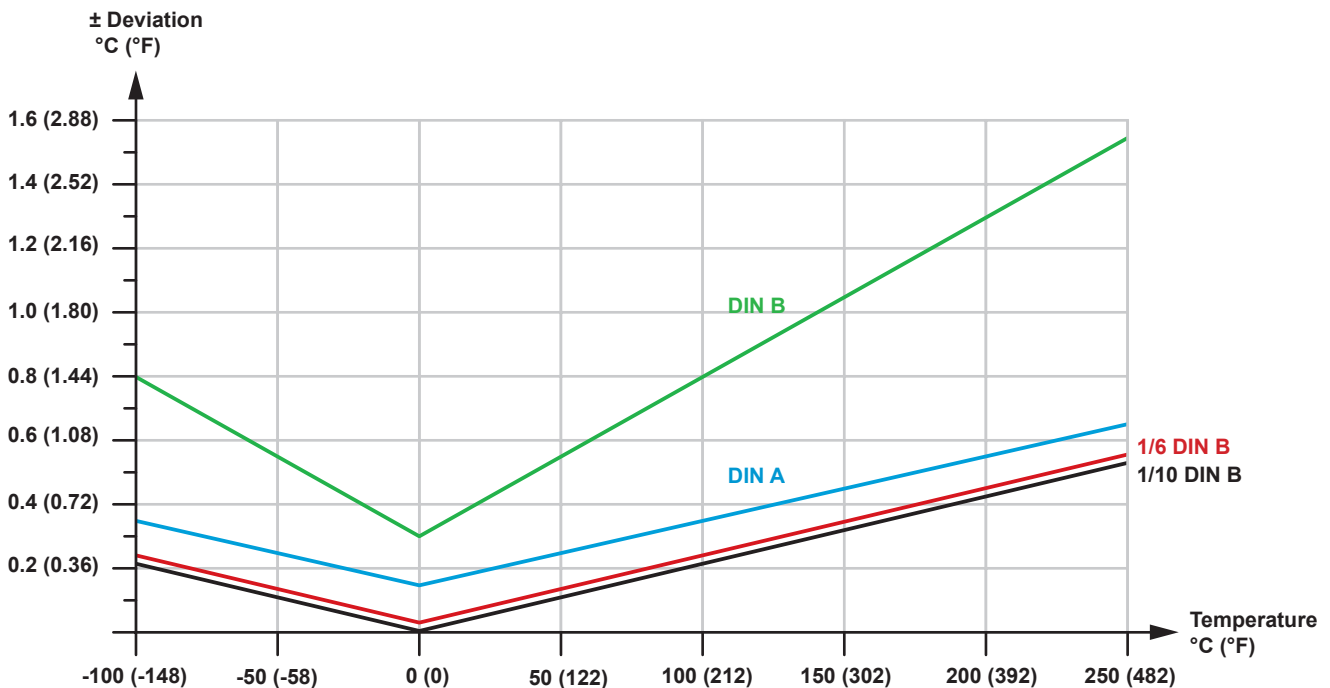
$$1/10 \text{ DIN B: } \pm (0.03 + 0.002 * |t|)$$

Calibration

Further verification than the described tolerance classes can be needed, in order to:

- achieve a higher accuracy than possible with such a tolerance class
- verify the sensors tolerance class
- satisfy quality systems

In these occasions calibration is needed. During calibration the sensor is compared in liquid thermostats with a traceable reference sensor in one or several temperature points. A certificate is issued with the exact reading of the sensor and the calculated uncertainty. Calibration is time consuming with a lot of waiting for stability and is not normally needed. Recalibration of sensors in service for 5 years in cryogenic tanks has shown negligible drift (few m°K) compared with the initial certificates.



Comparison between DIN A and DIN B according to the standard and 1/6 and 1/10 of DIN B delivered by Emerson.

$$\text{DIN A} = \pm (0.15 + 0.002 * |t|)$$

$$\text{DIN B} = \pm (0.30 + 0.005 * |t|)$$

$$1/6 \text{ DIN B: } \pm (0.05 + 0.002 * |t|)$$

$$1/10 \text{ DIN B: } \pm (0.03 + 0.002 * |t|)$$

Temperature Sensors

Multiple Spot Temperature (MST) Sensor

The easily installed MST sensor measures temperature with one to fourteen Pt-100 spot elements placed at different heights to provide a tank temperature profile and an average temperature. Up to six elements can be connected directly to the gauge. If more, the temperature sensor is connected to the gauge via a Data Acquisition Unit (DAU).

Temperature sensors are often used for volume measurement in oil or bitumen tanks, or for estimating the accumulated energy in bulk storage tanks. Only the fully immersed elements are used to determine the product temperature.

The MST sensor is mounted with a flange or a thread at the top of the tank.

The spot elements are placed in a flexible gas tight protection tube, made from convoluted stainless steel, for easier handling during installation.

All spot elements are attached to a 1.5 mm (0.06 in.) wire, which runs from the top to the bottom of the sensor. An anchor weight can be hung at the bottom, or the tube can be clamped to the bottom, to keep the sensor vertical, and avoid floating when the tank is filled.

API chapter 7 recommends minimum one element per 10 feet (3 m) tank height for custody transfer applications.

The protective tube is not designed for pressurized tanks, but the MST sensor can be installed in a closed thermowell, enabling service or inspection while the tank is in operation.

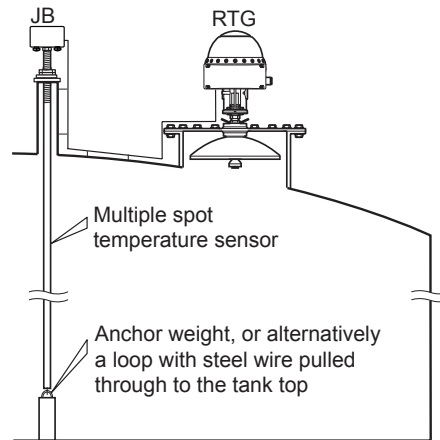
On fixed roof tanks the MST sensor is attached to a flange mounted on a suitable nozzle.

On floating roof tanks the MST sensor can be installed in a still-pipe.

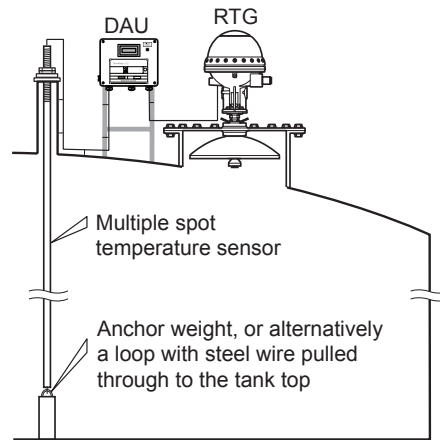
A water level sensor can be integrated in the MST sensor, see page 7.

The MST sensor may also be delivered with an Exe / Exi or UL approved junction box (premounted or bundled cables).

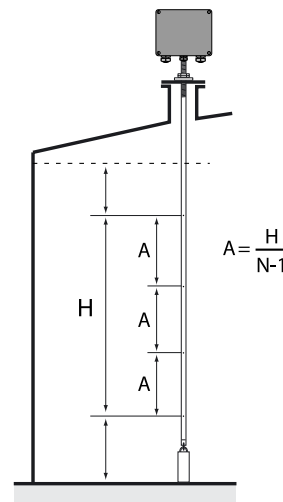
Multiple spot temperature sensor.



Up to 6 temperature elements can be connected directly to the radar gauge (here via a junction box – JB).



When the number of temperature elements is above 6 they are connected via a Data Acquisition Unit. Maximum 14 temperature elements can be connected.



Recommended temperature sensor positions for custody transfer according to API. Example: 4 spot elements, H=9 m. A=3 m.

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MST sensor for cryogenic applications

This version, NL-Cryo, is used for temperature measurements in LNG tanks. The spot elements are encapsulated in a stainless steel tube, filled with Argon gas to prevent condensation of water inside the sensor at low temperatures. Temperature stable type A elements are used for low temperatures. If the sensor is used in pressurized tanks, it must be protected by a thermowell with ambient pressure inside. The recommended minimum inner diameter of the thermowell is 49.8 mm (1.96 in.).



NL-cryo, supplied with a non-adjustable flange.



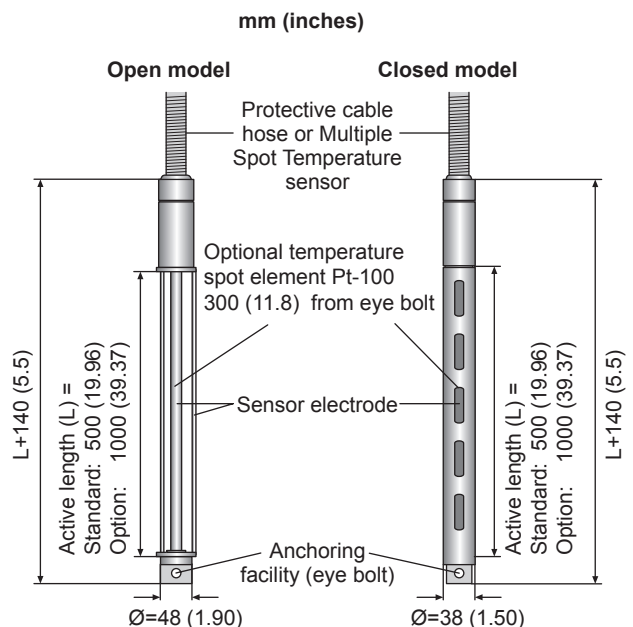
WLS integrated with MST sensor (MSTW), open model to the left and closed model to the right. It is hung vertically from the top of the tank, and the position/length is chosen according to the actual bottom water range. The WLS should be anchored to the tank bottom to ensure a fixed position in case of turbulence.

Water level sensor integrated with multiple spot temperature sensor (MSTW)

The capacitive Water Level Sensor (WLS) continuously measures free water level below the oil surface and provides input for on-line net inventory. The WLS is delivered in a stainless steel (AISI 316) housing, welded to the MST flexible tube. It has a heavy duty design with no moving parts. The WLS outputs an analog 4-20 mA signal, which is connected directly to a radar gauge. There can be a Pt-100 temperature sensor inside the probe allowing temperature measurements at low levels. The WLS is welded to the MST sensor to get a hermetic design. The open model WLS is suitable for crude oil applications and the closed model is suitable for lighter fuels such as diesel oil etc.

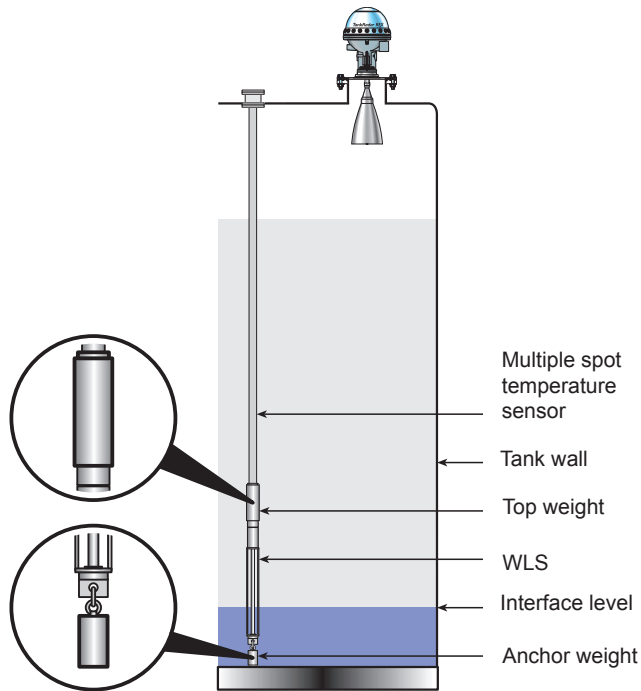
It is also possible to have an Exe / Exi or UL approved junction box connected to the MSTW.

Offset calibration can be done via HART® communication.



Water Level Sensor

Temperature Sensors



A weight can be mounted in the bottom eye bolt and / or above the WLS, in which case the weight is hollow and fitted on the MST.

Single Spot Temperature (SST) Sensor

The single spot version is available in three models:

- Type B, with extension length and removable insert
- Type BF, with/without extension length and fixed insert.
- Type OPE, with Ex-approved head, extension length and removable insert

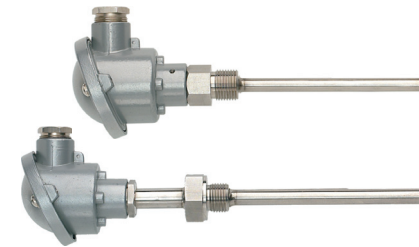
It can be used for measurements of fluid temperature (in sealed pipes), in refineries, chemical plants and other hazardous installations.

The spot element is placed in a gas tight protection tube made from stainless steel, either directly or in an insert tube (removable for service). The single spot temperature sensor is often mounted in a thermowell.

A stainless steel housing is available on request.



Single spot temperature sensor, type B.



Single spot temperature sensor, type BF.



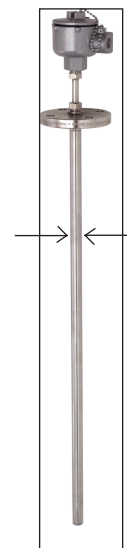
Single spot temperature sensor, type OPE.

Stainless steel thermowell with flange connection

Single spot temperature sensors in thermowells are used for pressurized tanks and when there is a requirement to be able to replace a sensor without having to drain or evacuate the process. It can be connected with a flange or a thread (see ordering information for details).

Immersion sheath:
 $\varnothing=16$ mm (0.63 in.) x 3 mm (0.12 in.)
 or
 21.3 mm (0.84 in.) x 2.65 mm (0.10 in.)

The length of the thermowell needs to be 15 mm (0.59 in) longer than the temperature sensor.



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Installation Considerations

Mechanical connection

Temperature and water level sensors should be located as far away as possible from heating coils and swing arms. If possible they should be located on the shaded side of the tank.

MST Note:

Be careful with the flexible MST protection tube. Avoid sharp bendings / tools.

If any leaks of the flexible tube should occur during mounting of the temperature sensor you should never try to fix it with seals or other materials. Leaks may damage the functionality of the wires inside.

If the wires are stripped of insulation there is always a risk of short-circuit or malfunctions.

Do never extend or in any other way rebuild the temperature sensor since this may cause serious malfunctions.

If any damages should occur please contact your supplier for further information.

WLS Note:

The open WLS version must be handled carefully since the PTFE coated inner core is fragile, and may be damaged if mistreated. This is why the WLS is delivered in a plastic tube for protection of the sensor during transportation and handling. Leave this protection on until the final positioning of the sensor in the tank.

Fixed roof tank installation

The MST/MSTW sensor must be equipped with a bottom weight to keep it in position (10 kg recommended for tanks up to 15 m, and 15 kg for higher tanks). The MSTW can also be installed with a top weight.

Floating roof tank installation

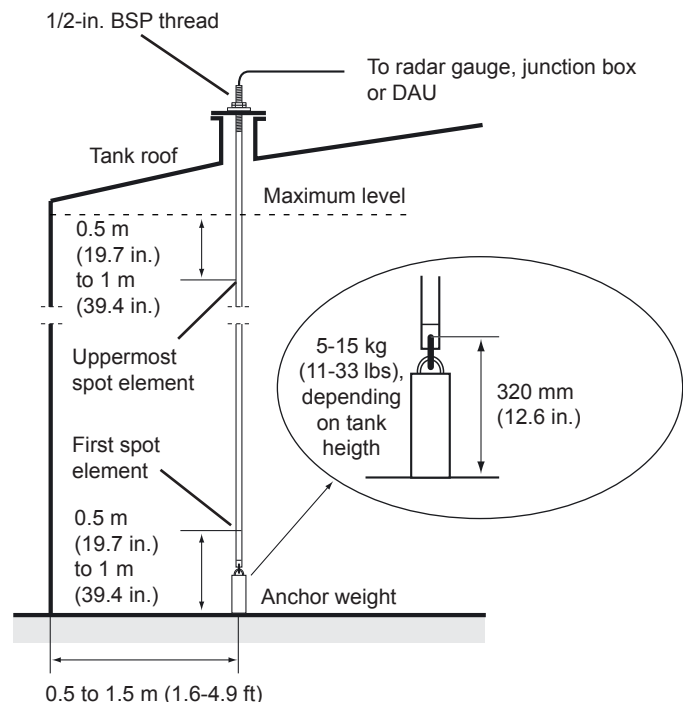
The MST/MSTW sensor is installed in a still-pipe and should be equipped with a bottom weight to keep it in position.



The MSTW can in addition be installed with a top weight.

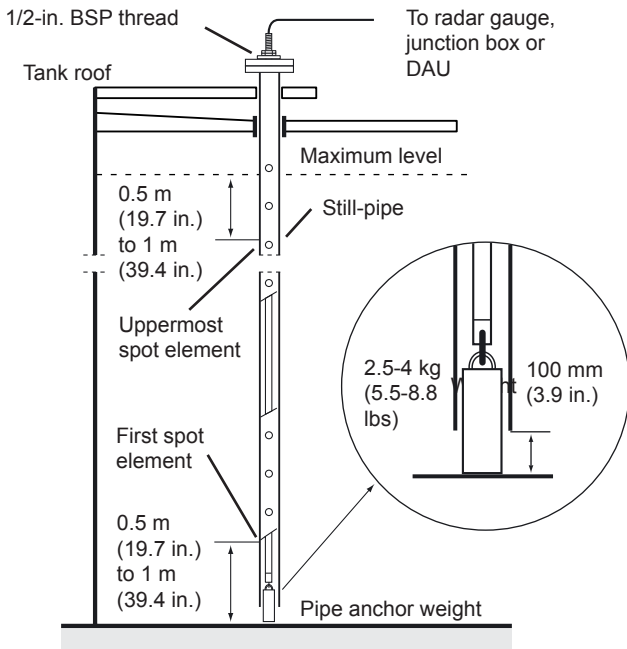
It is important that the still-pipe is cut above the active part of the water level sensor.

To measure water level close to the tank bottom, a top weight can be used instead of a bottom weight. To get the active part of the sensor even closer to the tank bottom it is also possible to remove the MSTW eye bolt (see page 11).



Fixed roof tank.

Temperature Sensors

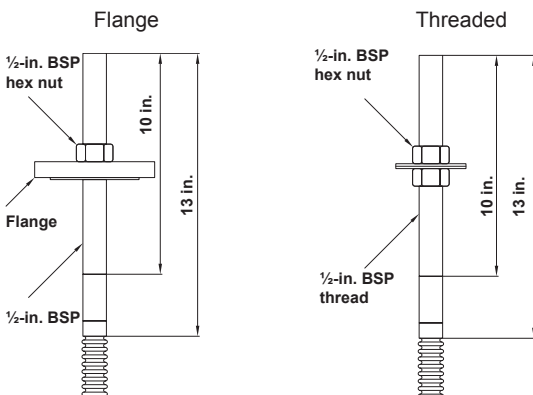


Floating roof tank.

Installation procedure for temperature sensors with / without integrated water level sensor – SST, MST and MSTW sensors

After bringing the sensor and necessary tools to the tank top, follow steps 1, 3, and 5-7 for the MST sensor, steps 1-7 for the MSTW, and steps 5-6 for the SST sensor:

1. Mount the anchor weight on the MST / MSTW sensor.



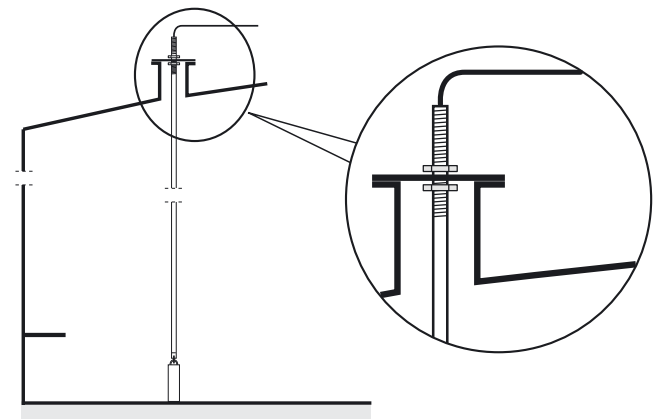
The MST sensor is mounted with a flange or a thread at the tank top.

2. To measure water level close to the tank bottom, the eye bolt on the MSTW can be removed.
If so, a special 5 kg top weight (see Accessories) is carefully pulled down from the top of the MST sensor to the position just above the WLS. The top weight can be combined with an anchor weight if the eyebolt is used. See page 8.
3. If using a flange, mount it at the lowest threaded part on the top end of the temperature sensor.
4. If installing an MSTW, the protective tube may carefully be removed from the WLS.
5. Carefully lower the temperature sensor, with weights and an integrated junction box if applicable, into the tank through the nozzle.

Note:

It is very important to make sure the weight is properly placed at the tank bottom, and that the MST / MSTW sensor is in an upright position. If not, measurement data might not be as expected.

6. When the temperature sensor is placed correctly, it is connected to the tank via a flange / thread.



Use the lock nuts to adjust the protection tube with temperature spot elements so that the weight barely touches the tank bottom.

7. Mount the hose kit for protection of wires. The hose kit is ordered for MST/MSTW sensors without an integrated junction box.