

Guidelines for Using Radar in Underground Tanks

Introduction	1
Application description	1
Challenges	2
Which radar type to use: GWR or NCR?	3
Installation guidelines	3
GWR selection guidelines	4
NCR selection guidelines	9
Configuration	10

Introduction

This document provides guidelines for using Rosemount radar devices on underground tanks. Such tanks have some particularities that impact radar measurements in a special way. This guide is intended to assist in radar device selection and installation for optimal performance.

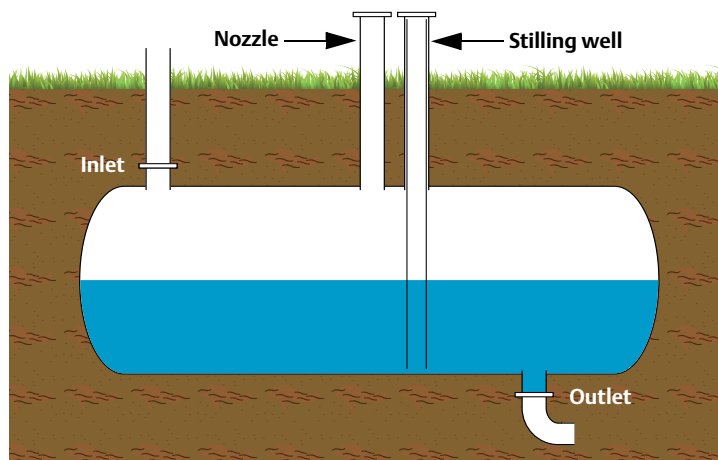
Application description

Underground tanks are used in different industries. Most often they are found in the upstream oil and gas industry, particularly in the Northern regions.

The purpose of these tanks is the same as for their above ground counterparts. They can function as flare knockout tanks, drainage tanks, and separators. A common reason to put them under the ground is to insulate their contents from very low ambient temperatures. In cold climates, these tanks are often buried at least 5 ft (1.5 m) under ground.

The simplest way to access the tank is with a nozzle or a stilling well that begins above ground level. Stilling wells usually protrude down to the bottom of the vessel.

Figure 1. Underground tank with a tall nozzle and a stilling well



Usually there is a need to monitor the temperature and level inside these tanks. One nozzle is typically used for temperature monitoring and another one for level measurements (continuous, point, or hand-dipping).

Given the purpose and mechanical properties of underground tanks, this kind of application has the following common characteristics:

- **Most common tank type:** horizontal bullet
Tank diameter: up to 10 ft (3 m), most often 6.5 - 10 ft (2 - 3 m)
- **Nozzles:** very often there are only 2 nozzles and it is common that they are 6.5 - 10 ft (2 - 3 m) tall
Diameter: 3 - 4 in. (75 - 100 mm)
- **Possible products inside:** oil, water, natural gas liquids, mixtures of hydrocarbons and water
- **Process conditions:** stable temperature and pressure, coating or build-up in the case of viscous products

Challenges

While tank storage conditions are stable, the contents may enter the tank at higher temperatures and cool. In the parts of the nozzles or stilling wells exposed to ambient conditions, heavy condensation or freezing of the material may occur on the instrumentation. The condensation or freezing may impact level measurement.

Some fluids may coat and build up on surfaces as the level rises and falls.

Because of accessibility reasons, only top-down level technologies can be used, such as mechanical level gauges or radars. In such applications, mechanical level gauges have the following limitations:

- Mechanical parts (e.g. floats) get stuck due to coating
- Ice is formed in nozzles because of condensate freezing
- Accuracy is low due to changing product properties (e.g. density)
- An increased number of cables are used when transducers and transmitters have separate housings and terminals
- There is high need for maintenance

Radar technology provides a versatile, reliable solution:

- No mechanical parts
- Less sensitive for ice formation, particularly guided wave radar
- Accuracy independent of product properties
- Integral probe-transmitter solution
- Virtually maintenance free

To achieve this, it is very important to select a correct radar type, as well as to perform installation and configuration according to application conditions.

Which radar type to use: GWR or NCR?

Guided Wave Radar (GWR) is preferred when:

- Oil/water interface measurement is required
- Inclined nozzle is present with no possibility to use NCR in a stilling well
- NCR cannot meet installation requirements
- Product to be measured has very low Dielectric Constant ($DC < 1.9$) and turbulent surface
- Condensation is present
- Higher measurement accuracy is required

Non-Contacting Radar (NCR) is preferred when:

- Long nozzle and viscous product causing heavy coating/build-up are present.
- Very narrow long nozzles are present. This includes nozzles smaller than 3 in. (75 mm) in diameter and up to 6.5 ft (2 m) in height.

NOTE:

In the event that the vessel has nozzles that are too restrictive for the use of either GWR or NCR, consider the use of vibrating fork switches. These are available with extended lengths and can fit into nozzles as small as 0.75 in. (19 mm). The active fork portion must extend to the high alarm region within the interior of the tank.

Installation guidelines

Ice formation

It is quite common for product vapors to condense near the top of a nozzle. When ambient temperatures are low, this condensate freezes, forming an ice bed. This creates false echoes and noise and can affect radar performance. To minimize this, insulate the nozzle and mounting flange.

Lightning induced transients

Lightning can produce excess transient energy that can enter transmitters via multiple paths.

To achieve optimum transient protection, a transient terminal block is required. This is included with the Rosemount 3300/3308 Series, but is an optional feature for the Rosemount 5300 and 5400 Series with HART output (option code T1). It is designed to provide a higher degree of protection against transients. These built-in surge arrestors limit the energy that is dispatched into the electronics but must be connected to a safety ground.

For more information on transient protection best practices, refer to the Best Practices for Power and Transient Protection on Rosemount Radar Transmitters Technical Note (Document No. [00840-2700-4811](#)).

Cathodic protection

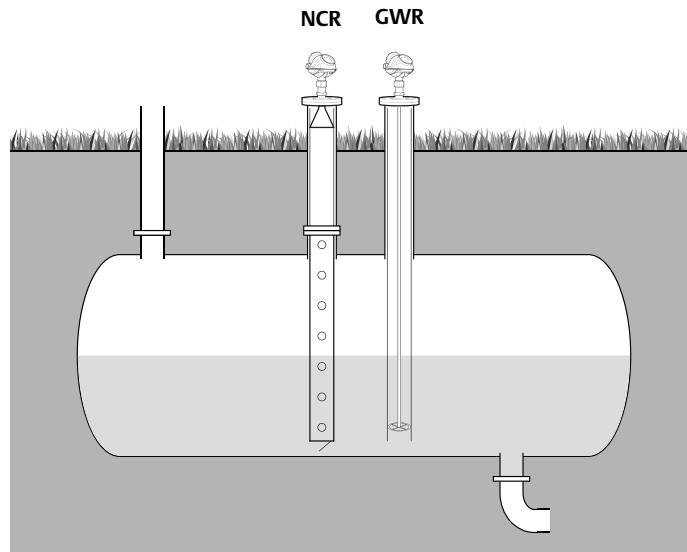
Underground tanks often have cathodic protection systems to reduce corrosion. Since the radar is installed in such a way to isolate it from the vessel, this requires the radar to be grounded

separately from the tank. The external ground terminal should be used to connect a ground wire from the radar to an earth ground that is outside of the cathodic protection system.

Retrofitting nozzles with stilling well

It is possible to retrofit nozzles with stilling wells or seamless tubing inserts for both GWR and NCR.

Figure 2. Nozzle retrofitted with stilling well



GWR selection guidelines

The Rosemount GWR offering consists of the following series:

- Rosemount 3300 Series: cost-effective solution
- Rosemount 5300 Series: superior device for challenging applications
- Rosemount 3308 Series: wireless guided wave radar

To achieve optimal performance level when using Rosemount GWR in underground tanks, several options are available (option codes are in brackets):

- **3301/5301/3308xx1**: when only level needs to be measured
- **3302/5302/3308xx2**: when both level and interface need to be measured
- **Twin rigid probe (1A) or twin flexible probe (2A)** in case of narrow nozzles

NOTE:

The Rosemount 3308 Series is only available with single flexible probes.

- **Single rigid probe** (4A or 4B) or **single flexible probe** (5A) in case of heavy coating or build-up

NOTE:

In case of heavy build-up, the Rosemount 5300 Series is preferred due to higher sensitivity.

- **Centering discs and spacers:** to prevent probe contact with stilling well walls (Sx)
- **Transient protection:** to prevent false readings created by transient currents (T1)

NOTE:

This option is required for the Rosemount 5300 and 5400 Series only. The 3300 and 3308 Series have integrated transient protection.

Using GWR in nozzles

The transmitter can be mounted in nozzles by using an appropriate flange. The nozzle sizes given in [Table 1](#) show the recommended dimensions.

NOTE:

The probe should not contact the nozzle. If the nozzle diameter is less than recommended, the measurement performance may be reduced, depending on process conditions.

Table 1. Nozzle consideration

Single (Rigid/Flexible)	
Recommended nozzle diameter (D)	6 in. (150 mm)
Minimum nozzle diameter (D) ⁽¹⁾	2 in. (50 mm)
Recommended nozzle height (H) ⁽²⁾	4 in. + nozzle diameter ⁽³⁾

⁽¹⁾ The Trim Near Zone function may be necessary or an Upper Null Zone setup may be required to mask the nozzle.

⁽²⁾ Longer nozzles may be used in certain applications.

⁽³⁾ When using single flexible probes in tall nozzles, it is recommended to use the Long Stud (LS).

A long stud - 10 in. (250 mm) - is recommended for single flexible probes in a nozzle up to 10 in. (250 mm) (option code LS).

For nozzles taller than the recommendations in [Table 1](#), there are some alternatives to consider:

1. Install a stilling well that extends the full height of the nozzle and the tank. (See [Configuration on page 10](#).)
2. For large diameter nozzles (6 to 8 in. [150 to 200 mm]) up to 6.5 ft (2 m) tall, a spacer can be used with single flexible lead probes. This prevents the probe from touching the edge of the nozzle. The upper null zone must be placed at a distance just beyond the edge of the nozzle (See [Configuration on page 10](#).)
3. For smaller diameter but tall nozzles, a twin lead probe could be used. In this case, the probe can be used in the taller nozzles, but care must be taken to prevent the probe from touching the wall. It should only be used with clean process fluids where risk of build-up is minimal. Single lead probes are not recommended for tall, small diameter nozzles.

Using GWR in stilling wells

For longer nozzles, sometimes a stilling well is required to screen out possible noise induced by nozzle walls. Single rigid or flexible probes may be used in stilling wells. When used in stilling wells, the probe must not touch the side walls of the stilling well. When used in metal stilling wells, single rigid probes offer stronger return signal than when used in open applications. This makes them suitable for low dielectric and interface applications.

Make sure the probe is suspended in a true vertical position and does not touch the nozzle wall.

As fluid moves into the tank, it may push the probe towards the pipe wall. If the probe touches the wall, false reflections will create false level measurements. Single rigid probes are less susceptible to these issues. Single flexible probes need more room. Narrow stilling wells allow little room for movement or flexing of the probe. If single flexible probes are to be used, stilling wells should have 4 in. (100 mm) or larger diameter to allow room for some flexing.

Probes should hang as straight as possible in the stilling well. Use a weight to pull the probe taut and be sure the total length of the probe and weight combination is cut slightly shorter than the length of the stilling well. This will allow the probe to hang freely. A centering disc at the bottom of the probe helps to keep the probe centered.

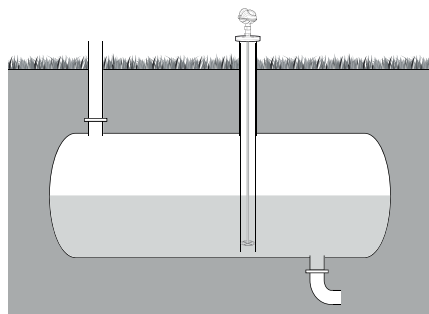
Stilling well requirements when using GWR:

- Recommended minimum diameter is 3 in. (75 mm).
- Preferred diameter is 4 in. (100 mm) or larger.
- The stilling well must be constructed of a metallic material and have smooth inside walls.
- At least 1 ventilation hole should be included above the maximum level surface.
- If an interface measurement is needed, there must be holes or slots along the submerged length of the stilling well. These holes must be smooth and de-burred on the inside of the stilling well.
- The length of the pipe should extend beyond the minimum level to be measured.
- Seamless tubing inserts may be used in place of pipes as long as all the above criteria is met.

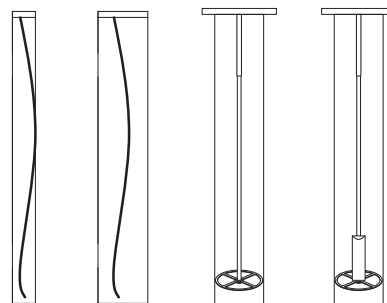
Centering discs

To prevent the probe from contacting nozzle or stilling well walls, centering discs are available for both single rigid and single flexible probes.

Figure 3. Rigid single lead probe in a stilling well



A centering disc at the bottom of the probe helps to keep the probe away from the stilling well walls. It is recommended for single rigid probes. Its applicability with long flexible probes is more limited.



Narrow pipes allow little room for movement or flexing of the probe.

For detailed information on centering disc size recommendations, see [Table 2](#).

Table 2. Centering disc size recommendation for different pipe schedules

Pipe and disc size	Actual disc diameter	Pipe schedule		
		5s,5 10s,10 40s,40 80s,80	120	160
2 in. (5 cm)	1.8 in. (45 mm)	2 in. (5 cm)	NA ⁽¹⁾	NA ⁽¹⁾
3 in. (7.5 cm)	2.7 in. (68 mm)	3 in. (7.5 cm)	NA ⁽¹⁾	2 in. (5 cm)
4 in. (10 cm)	3.6 in. (92 mm)	4 in. (10 cm)	4 in. (10 cm)	3 in. (7.5 cm)
6 in. (15 cm)	5.55 in. (141 mm)	6 in. (15 cm)	4 in. (10 cm)	4 in. (10 cm)
8 in. (20 cm)	7.4 in. (188 mm)	8 in. (20 cm)	6 in. (15 cm)	6 in. (15 cm)

(1) Schedule is not available for pipe size.

Centering spacers

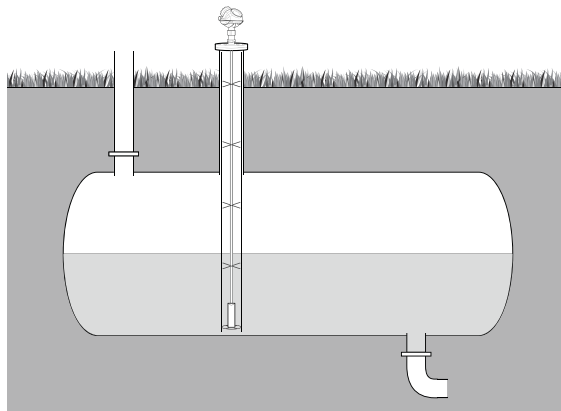
In some cases, such as narrow diameter stilling wells or wells that are slightly angled, it may be useful to add centering spacers along the length of the probe. To better center a flexible probe in a stilling well, it is possible to order a kit consisting of several spacers. These spacers can be moved along the probe to be positioned at desired points to prevent the probe from contacting the pipe. The quantity of centering spacers and their distribution along the probe depends on application conditions. A maximum of 5 spacers per probe at a minimum of 3 ft (1 m) distance between each can be used.

NOTE:

Consult factory for more details on spacer availability.

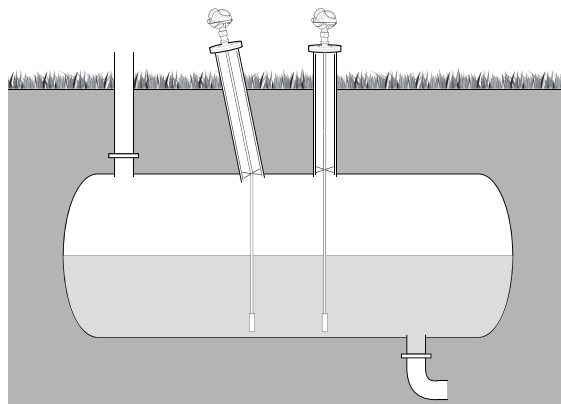
Each spacer creates a small reflection and can be a source for accumulation of debris. For these reasons, the number of spacers must be kept to a minimum. Avoid placing a spacer in critical measurement zone areas, such as the high level limit and critical interface levels.

Figure 4. Centering spacers along a flexible probe



When installing flexible probes into tall nozzles without stilling wells, it is recommended to install a centering spacer near the bottom of the nozzle. This prevents the probe from touching the edge of the nozzle in case of movement.

Figure 5. Flexible probe in a tall nozzle without a stilling well



NCR selection guidelines

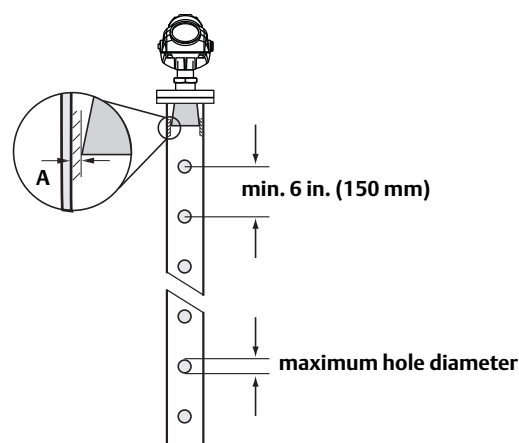
Follow these guidelines when choosing a Rosemount 5400 Series NCR:

- Select **5402**, the high frequency (~26 GHz) model for installations without stilling wells. While high frequency radar has slightly better performance specifications, it should be used on no more than 6.5 ft (2 m) tall clean and smooth nozzles.
- If the nozzle is of bad quality or taller than 6.5 ft (2 m), a stilling well with a Rosemount 5401 low frequency radar should be used. Low frequency radar handles dirty pipes, heavy vapors, and condensation better than high frequency units.
- In both cases, cone antennas must be used. The antenna size must match the nozzle or stilling well pipe diameter. If the pipe is 6 in.(15 cm) or 8 in. (200 mm), only the 5401 has a cone antenna that matches.

Stilling well requirements

With any radar unit, the antenna should match the stilling well pipe size as closely as possible. The antennas are sized to fit within schedule 80 or lower pipes. Ideally, the maximum gap between the antenna and the pipe wall should be as small as possible. See 'A' in Figure 6. For the Rosemount 5401, gaps of up to 0.2 in. (5 mm) are acceptable. Larger gaps may impact performance.

Figure 6. Stilling well requirements



Maximum hole diameter:

- Rosemount 5401: 0.8 in. (20 mm)

For a stilling well with a diameter smaller than 3 in. (75 mm), the antenna can be trimmed to fit the well diameter. When trimmed, the antenna edges must be smooth and sized to fit within 0.2 in. (5 mm) of the pipe wall (see 'A' in Figure 6).

If the Rosemount 5401 is to be installed in a stilling well, the following guidelines apply:

- Pipes must be of an all-metal material, with smooth inner surface. Seamless tubing inserts may be used in place of pipes.
- The internal diameter of the stilling well must be consistent throughout the whole length.
- The length of the pipe should extend beyond the minimum product level. Level will not be measured below the end of pipe.
- In heavy condensation applications, insulate the portion of the pipe which is outside the tank.

- Deposits, rust, gaps, and slots must be avoided.
- Holes should be drilled on one side and must be de-burred.
- Hole diameter may be up to 0.8 in. (20 mm).
- One hole must be above the product surface.
- Minimum distance between holes is 6 in. (150 mm).
- Ball valve or other full port valves must be completely open and there should be no change in the size of the internal diameter of the stilling well.

Failure to follow these requirements may affect the reliability of the level measurement.

Configuration

For reliable and accurate measurement, configure the Rosemount radar transmitters properly. Depending on the product type being used, this can be done using Radar Configuration Tools, Rosemount Radar Master, Field Communicator, AMS[®] Suite, or any other DD- or DTM-compatible host system.

To make the configuration process easier and quicker, use Guided Setup.

Radar measurement in pipes requires measurement optimization. The transmitter software contains a special measurement mode which is turned on during the guided setup procedure by enabling the stilling well option and entering the inner diameter of the stilling well. When this mode is turned on, the transmitter will be optimized for pipe measurements. For example, the dynamic gain curve will be adapted for stilling wells and the lower propagation velocity of the radar signal in the stilling well will be compensated.

With GWR, nozzle height and diameter dimensions are required. Entering the nozzle diameter and height into the transmitter is crucial and must not be omitted.

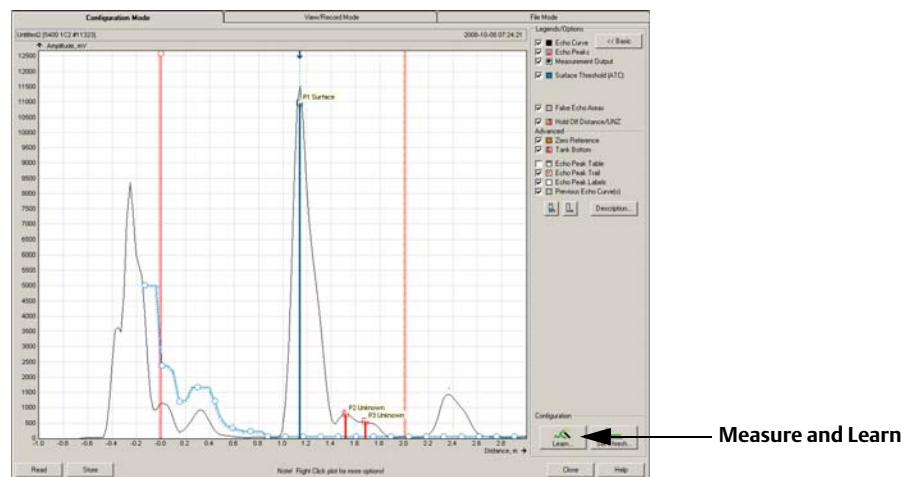
If spacers are used on the probe, it may be necessary to modify the threshold to a level high enough to exceed the peaks created by the spacers. This must be completed while the vessel is empty.

In both GWR and NCR installed in nozzles, it is recommended that the upper null zone be set at a distance that is slightly longer than the length of the nozzle, but above the URV.

With the Rosemount 5400 Series NCR, it is also recommended to run the Measure and Learn function to configure threshold areas and false echo areas automatically. This will adjust transmitter logic to a given tank geometry and process conditions. It is recommended that the vessel be empty when the Measure and Learn function is completed.

To activate the Measure and Learn function, go to **Echo Curve > Configuration Mode > Learn...**

Figure 1-3. Select Measure and Learn to configure threshold areas



Improving low DC product measurement performance

Underground tanks often contain low DC products, such as hydrocarbons, so the return signal from product surface may be weak. In this situation, measurement performance is worsened by tank geometry if stilling well is not used. Because of this, a lot of false echoes and double bounces appear, which makes the measurement quite challenging.

In this case, double bounce and false echoes must be masked out by using the ATC curve in the Rosemount Radar Master software. To improve transmitter performance when measuring low DC product in such conditions, the Probe End Projection (PEP) function can be activated. The PEP function is available for the Rosemount 5300 Series only.

The PEP function is accessible through all existing configuration tools. PEP can be activated in the Advanced configuration section. Guided setup provides detailed information on how to configure this.

NOTE:

The PEP function cannot be used for measurements of high DC liquids or interface. It also cannot be used when the end of the probe is under water or other high dielectric material that can mask the end of the probe position.

Resources

- More information about Rosemount level solutions: Rosemount.com/Level
- Best Practices for Power and Transient Protection on Rosemount Radar Transmitters Technical Note (Document No. [00840-2700-4811](#))
- Rosemount Proven Result: Using Non-contacting Radar on Underground Flare Knockout Tank Reduces Costs (Document No. [00830-0600-4026](#))
- Rosemount Technical Note: Guidelines for Choosing and Installing Radar in Stilling Wells and Bypass Chambers (Document No. [00840-0300-4024](#))

**Emerson Process Management
Rosemount Division**

8200 Market Boulevard
Chanhassen, MN 55317 USA
T (U.S.) 1 800 999 9307
T (International) 952 906 8888
F 952 906 8889
www.rosemount.com

Emerson Process Management

Blegistrasse 23
P.O. Box 1046
CH 6341 Baar
Switzerland
Tel +41 (0) 41 768 6111
Fax +41 (0) 41 768 6300

Emerson FZE

P.O. Box 17033
Jebel Ali Free Zone
Dubai UAE
Tel +971 4 811 8100
Fax +971 4 886 5465

**Emerson Process Management Asia
Pacific Private Limited**

1 Pandan Crescent
Singapore 128461
T 65 6777 8211
F 65 6777 0947
Enquiries@AP.EmersonProcess.com

**Emerson Process Management
Latin America**

1300 Concord Terrace, Suite 400
Sunrise Florida 33323 USA
Tel +1 954 846 5030

Emerson Beijing Instrument Co

No.6 North Street, Hepingli
Dongcheng District, Beijing
100013
China
Tel +8610 64282233
Fax +8610 642 87640

*Standard Terms and Conditions of Sale can be found at www.rosemount.com/terms_of_sale
The Emerson logo is a trademark and service mark of Emerson Electric Co.
Rosemount, the Rosemount logotype, and SMART FAMILY are registered trademarks of Rosemount Inc.
All other marks are the property of their respective owners.*

© April 2014 Rosemount, Inc. All rights reserved.