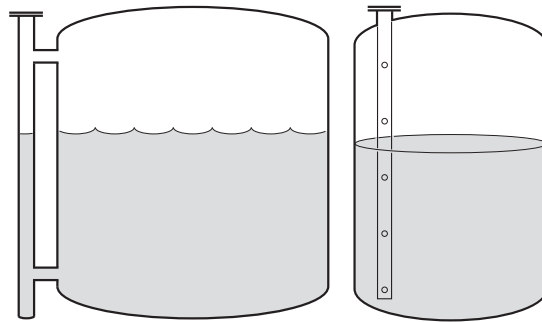


Guidelines for Choosing and Installing Radar in Stilling Wells and Bypass Chambers

1.0 Introduction

This document provides a guideline for choosing and installing Rosemount™ radar devices in stilling wells and bypass chambers.

Stilling wells and bypass chambers are used in many applications and many different types of tanks and vessels. The two installation methods will jointly be referred to as pipes. Radar transmitters can be used in these installations, but function differently in pipes than in normal vessel installations. This guide is intended to assist with radar device selection and installation for optimal performance.



Example of a bypass chamber mount (left) and a stilling well mount (right).

2.0 Advantages of using bypass chambers and stilling wells

Stilling wells and bypass chambers are used in many applications and many different types of tanks/vessels. The reasons for having the pipes in the vessels differ depending on the application but are typically beneficial from an application standpoint. Reasons for using pipes include:

2.1 Pipes offer a calmer, cleaner surface

A pipe can increase the reliability and robustness of the level measurement, especially for non-contacting radar.

It should be noted that the coaxial probe of a Guided Wave Radar (GWR) is essentially a probe within a small stilling well. It should be considered as an alternative to stilling wells for clean fluid applications.

2.2 Pipes eliminate issues with disturbing obstacles

Pipes completely isolate the transmitter from disturbances such as other pipes, agitation, fluid flow, foam, and other objects. The pipes can be located anywhere in the vessel that allows access. For GWR, the microwave signals are guided by the probe, making it resistant to disturbing objects.

2.3 Pipes may be more accessible to the area of interest

Bypass chambers may be located on a small portion of a tank or column and allow access to the measurement instrument. This may be especially important for interface measurements near the bottom of a taller vessel or for measurements in a distillation column.

2.4 Pipes allow instrumentation to be isolated from vessel

Bypass chambers often include valves to allow instrumentation calibration verification or removal for service.

Bypass chambers and stilling wells are not without limitations. Generally, pipes should be used with cleaner fluids that are less likely to leave deposits and that are not viscous or adhesive. Apart from the additional cost of installation, there are some sizing and selection criteria for the radar gauges that must be considered. This document outlines those considerations.

3.0 Which radar to use: Guided wave radar or non-contacting?

Although non-contacting radar works well in pipe applications, contacting or GWR may be a simpler choice. Non-contacting radar must meet certain installation requirements for optimum results. The GWR has simpler installation requirements and provides better performance than non-contacting radar. GWR can maintain its accuracy and sensitivity independently of the pipe.

GWR is the preferred technology for shorter installations where rigid probes may be used. This makes it a suitable replacement for caged displacers, which are often less than 10 ft. (3 m). (See the Guided Wave Radar [Technical Note](#), for more details.) The probes are available in a variety of materials to handle corrosive fluids.

For taller applications or those with limited head space for installing rigid probes, non-contacting radar may be advantageous. Non-contacting radar is also the preferred technology for applications with heavy deposition or very sticky and viscous fluids.

4.0 Installation guidelines for guided wave radar

4.1 Using GWR in pipes: Rigid or flexible?

In most cases, rigid probes are preferred for pipe installations. When used in a metal, small diameter pipe, single rigid probes offer a stronger return signal than when used in open applications. This makes them suitable for low dielectric and interface applications. Flexible probes may be used in longer pipes, but care must be taken to assure that the probe is suspended in a true vertical position and does not touch the pipe wall.

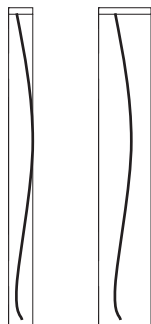
If flexible probes are to be used, the pipes should be 4 in. (100 mm) or larger to allow room for some flexing. Also, as fluid moves into the pipe, it may push the probe towards the pipe wall. If the probe touches the wall, false reflections will create false level measurements. Rigid probes are less susceptible to these issues. Flexible probes simply need more room. Very narrow pipes allow little room for movement or flexing of the probe.

4.2 Centering discs along the probe

To prevent the probe from contacting the chamber or pipe wall, centering discs are available for rigid single, flexible single, and flexible twin lead probes.

It is recommended to use maximum five centering discs for each probe. The space between each disc must be at least 3 ft (1 m). For more information, see [Table 1-6 on page 1-7](#) and [Table 1-7 on page 1-7](#).

When using a metallic centering disc, the lower transition zone is 8 in. (20 cm), including weight if applicable. When using a PTFE centering disc, the lower transition zone is not affected.



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



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

4.3 Pipe requirements

There are multiple styles and materials of probes available for the Rosemount GWR products. [Table 1-1](#) shows the various options and where each may be used with regard to pipe size and length. GWR may be used in pipes made of metal, plastic, and other non-metallic materials. All pipes will provide isolation from the process materials and conditions. Metallic pipes help to increase signal strength and shield the probe from EMI disturbances. If EMI is present and a non-metallic pipe must be used, then the Rosemount 5300 Guided Wave Radar Level Transmitter should be used.

Table 1-1. Probe Styles and Installation Considerations

	Single rigid ⁽¹⁾	Single flexible	Twin rigid	Twin flexible	Coaxial ⁽¹⁾⁽²⁾
Maximum recommended length of pipe	9.9 ft (3 m)	33 ft (10 m)	9.9 ft (3 m)	33 ft (10 m)	19.8 ft (6 m)
Centering disc?	Yes	Yes	No	Yes	No
Recommended pipe diameter	3 in. (8 cm) or 4 in. (10 cm)	4 in. (10 cm)	3 in. (8 cm) or 4 in. (10 cm)	4 in. (10 cm)	3 in. (8 cm) or 4 in. (10 cm)
Minimum dielectric⁽³⁾ Rosemount 3300	2.5	2.5	1.9	1.6	1.5 (STD)
Minimum dielectric⁽³⁾ Rosemount 5300	1.25 (STD) 1.4 (HP) 1.4 (HTHP)	1.4 (STD) 1.6 (HP) 1.6 (HTHP)	1.4	1.4	1.2 (STD) 1.4 (HP) 2.0 (HTHP)
Minimum dielectric⁽³⁾ Rosemount 3308	2.0	2.0	N/A	2.0	2.0
SST	Yes	Yes	Yes	Yes	Yes
PTFE coated	Yes	Yes	No	No	No
Alloy C-276	Yes	Yes	No	No	Yes
Alloy 400	Yes	No	No	No	Yes
Duplex 2205	Yes	Yes	No	No	Yes
Minimum chamber/still pipe diameter	2 in. (5 cm) ⁽⁴⁾	Consult factory	2 in. (5 cm) ⁽⁵⁾	Consult factory	1.5 in. (3.8 cm)

1. Single and coaxial probes are available with process seals for high pressure and high temperature conditions. SST or Alloy C-276.
2. Coaxial probes are not recommended for submerged probe applications
3. When installed in metal pipe.
4. The probe must be centered in the pipe/bypass. A centering disc, see [Table 1-6](#) and [Table 1-7](#), can be used to prevent the probe from contacting the chamber wall.
5. The centermost lead must be at least 0.6 in. (15 mm) away from the pipe/bypass wall.

When sizing a probe for use in a bypass chamber, it is important to allow for some extra length for the transition zones and Blind Zones of the probe, see [Figure 1-1](#) and [Figure 1-2](#). Level measurements are compromised in these areas.

Figure 1-1. Rosemount 3300: Transition Zones

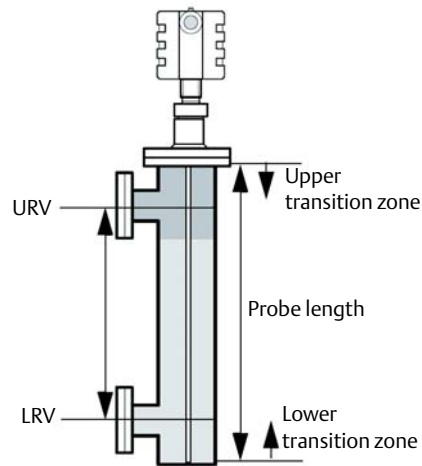


Figure 1-2. Rosemount 5300 and Rosemount 3308: Blind Zones

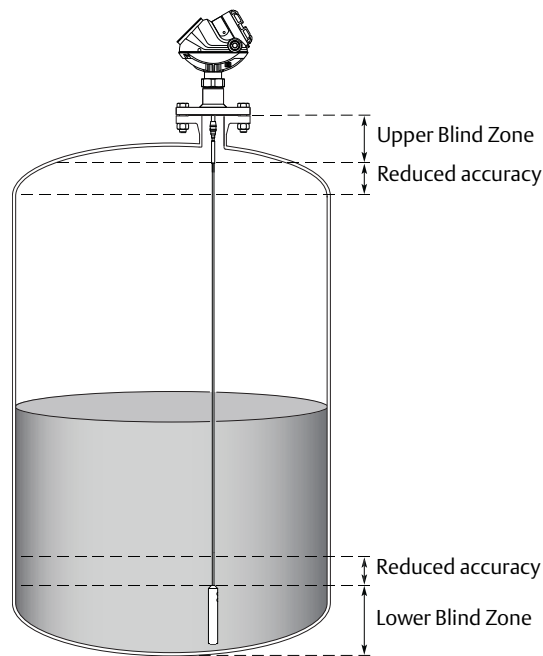


Table 1-2. Rosemount 3300: Transition Zones Vary with Probe Type when Installed in Metallic Pipes

Probe style	Upper transition zone		Lower transition zone	
	High dielectric	Low dielectric	High dielectric	Low dielectric
Single rigid ⁽¹⁾	4 in. (10 cm)	4 in. (10 cm)	2 in. (5 cm)	4 in. (10 cm)
Single flexible ⁽¹⁾	5.9 in. (15 cm)	8 in. (20 cm)	7.5 in. (19 cm) ⁽²⁾	10.2 in. (26 cm) ⁽²⁾
Twin rigid	4 in. (10 cm)	4 in. (10 cm)	2 in. (5 cm)	2.8 in. (7 cm)
Twins flexible	5.9 in. (15 cm)	8 in. (20 cm)	5.5 in. (14 cm) ⁽²⁾	9.4 in. (24 cm) ⁽²⁾
Coaxial ⁽³⁾	4 in. (10 cm)	4 in. (10 cm)	1.2 in. (3 cm)	2 in. (5 cm)

1. Single probes are the preferred choice.
2. Includes weight.
3. Coaxial should only be used for very clean or low DC applications.

Table 1-3. Rosemount 5300: Blind Zones Vary with Probe Type when Installed in Metallic Pipes

Probe style	Upper Blind Zone		Lower Blind Zone	
	High dielectric	Low dielectric	High dielectric	Low dielectric
Single rigid ⁽¹⁾	3.9 in. (10 cm)	3.5 in. (9 cm)	0.4 in. (1 cm)	4.7 in. (12cm)
Single flexible ⁽¹⁾	3.9 in. (10 cm)	3.5 in. (9 cm)	0.4 in. (1 cm)	4.7 in. (12cm)
Twin rigid	3.9 in. (10 cm)	3.2 in. (8 cm)	0.8 in. (2 cm)	4.7 in. (12cm)
Twins flexible	3.9 in. (10 cm)	3.2 in. (8 cm)	0.8 in. (2 cm)	4.7 in. (12cm)
Coaxial ⁽²⁾	2 in. (5 cm)	3.5 in. (9 cm)	0.8 in. (2 cm)	5.1 in. (13 cm)

1. Single probes are the preferred choice.
2. Coaxial should only be used for very clean or low DC applications.

Table 1-4. Rosemount 3308: Blind Zones Vary with Probe Type when Installed in Metallic Pipes

Probe style	Upper Blind Zone		Lower Blind Zone	
	High dielectric	Low dielectric	High dielectric	Low dielectric
Single rigid ⁽¹⁾	3.2 in. (8 cm)	4.3 in. (11 cm)	5.1 in. (13 cm)	4.3 in. (11 cm)
Single flexible ⁽¹⁾	3.2 in. (8 cm)	4.3 in. (11 cm)	5.1 in. (13 cm)	4.3 in. (11 cm)
Twin rigid	N/A	N/A	N/A	N/A
Twins flexible	3.2 in. (8 cm)	3.2 in. (8 cm)	2 in. (5 cm)	7.9 in. (20cm)
Coaxial ⁽²⁾	6.3 in. (16 cm)	5.9 in. (15 cm)	0 in. (0 cm)	3.2 in. (8 cm)

1. Single probes are the preferred choice.
2. Coaxial should only be used for very clean or low DC applications.

Table 1-5. Required Probe Length in Chambers

Chamber manufacturer	Probe length ⁽¹⁾
Major torque-tube manufacture (249B, 249C, 2449K, 249N, 259B)	Displacer+9 in. (229 mm)
Masoneilan™ (Torque tube operated), proprietary flange	Displacer+8 in. (203 mm)
Other - torque tube ⁽²⁾	Displacer+8 in. (203 mm)
Magnetrol® (spring operated) ⁽³⁾	Displacer+between 7.8 in. (195 mm) to 15 in. (383 mm)
Others - spring operated ⁽²⁾	Displacer+19.7 in. (500 mm)

1. If flushing ring is used, add 1 in. (25 mm).
2. For other manufacturers, there are small variations. This is an approximate value, actual length should be verified.
3. Lengths vary depending on model, SG and rating, and should be verified.

Table 1-6. Centering Disc Dimensions

Disc size	Actual disc diameter
2 in.	1.8 in. (45 mm)
3 in.	2.7 in. (68 mm)
4 in.	3.6 in. (92 mm)
6 in.	5.55 in. (141 mm)
8 in.	7.40 in. (188 mm)

Table 1-7. Centering Disc Size Recommendation for Different Pipe Schedules

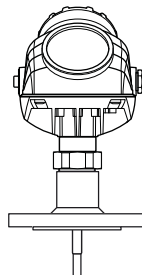
Pipe size	Pipe schedule					
	5s,5	10s, 10	40s, 40	80s, 80	120	160
2-in.	2 in.	2 in.	2 in.	2 in.	N/A ⁽¹⁾	N/A ⁽²⁾
3-in.	3 in.	3 in.	3 in.	3 in.	N/A ⁽¹⁾	2 in.
4-in.	4 in.	4 in.	4 in.	4 in.	4 in.	3 in.
5-in.	4 in.	4 in.	4 in.	4 in.	4 in.	4 in.
6-in.	6 in.	6 in.	6 in.	6 in.	4 in.	4 in.
7-in.	N/A ⁽¹⁾	N/A ⁽¹⁾	5 in.	6 in.	N/A ⁽¹⁾	N/A ⁽¹⁾
8-in.	8 in.	8 in.	8 in.	8 in.	6 in.	6 in.

1. Schedules is not available for pipe size.
2. No centering disc is available.

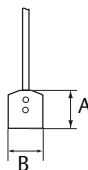
Table 1-8. Installation Parameters and Chamber Size Summary

Installation parameter	Chamber diameter		
	2-in.	3-in.	4-in.
Rigid probe	Ok	Ok	Ok
Flexible probe	Not recommended	Application dependent (use heavy weight)	Preferred
Coaxial probe	Ok ⁽¹⁾	Ok ⁽¹⁾	Ok ⁽¹⁾
Side connections, large (2 in.)	Not recommended	Application dependent	Preferred
Side connections, small (1 in.)	Ok	Ok	Ok
Overall length (< 2 m)	Ok	Ok	Ok
Overall length (> 2 m)	Application dependent (use centering discs/heavy weight)	Application dependent (use centering discs/heavy weight)	Ok
Low DC fluid (down to 1.4)	Ok	Ok	Ok
High DC fluid	Ok	Ok	Ok
Rapid fill rates	Application dependent	Ok	Ok
Boiling, turbulence	Application dependent	Ok	Preferred
Gas lift	Application dependent	Ok	Preferred
Viscous, clogging fluids	Application dependent, heat trace	Heat trace	Heat trace
Chambers with interface	Not recommended	Not recommended	Not recommended

1. Application dependent based on coating properties of the liquid.



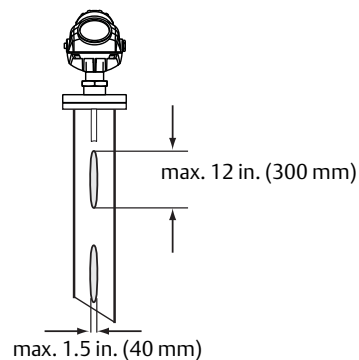
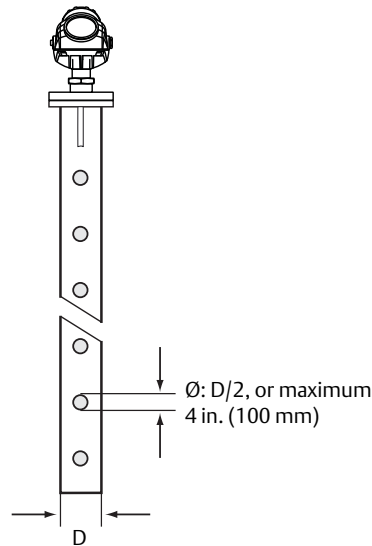
Short weight
A: 2 (50); 4 mm SST probes
B: 1.5 (37.5); 4 mm SST probes
Long weight
A: 5.5 (140); 4 mm SST probes
B: 1.5 (37.5); 4 mm SST probes



4.4 Stilling well requirements

Pipes should be an all-metal material. Non-metallic pipes or sections are not recommended for non-contacting radar. Plastic, plexiglas, or other non-metal materials do not shield the radar from outside disturbances and offer minimal, if any, application benefit. Other requirements include:

- Pipe should have a constant inside diameter.
- Pipe must be smooth on the inside (smooth pipe joints are acceptable, but may reduce accuracy).
- Avoid deposits, rust, and gaps.
- One hole above the product surface.
- Minimum hole diameter is 0.25 in. (6 mm).
- The hole diameter should be less than half of the diameter of the pipe, or maximum 4 in. (100 mm)⁽¹⁾. For example, a 4 in. pipe can have maximum 2 in. holes, and a 10 in. pipe can have maximum 4 in. holes.
- Slots should be less than 12 in. (300 mm) long and 1.5 in. (40 mm) wide⁽¹⁾.



Note
Holes/slots can be distributed around the pipe.

1. If slots/holes are larger than the above recommended figures, consult your local Emerson™ Process Management representative.

5.0 Installation guidelines for non-contacting radar

5.1 Using non-contacting radar in stilling wells and bypass chambers

When radar transmitters are used in metallic pipes, the microwave signal is guided and contained within the pipe. This restriction of the signal results in a stronger signal on the surface which can be an advantage for low dielectric and/or turbulent applications. Non-contacting radar can be advantageous over longer distances especially when the use of GWR is not convenient.

5.2 The impact of frequency

When radar is used inside the pipe, more than one microwave mode is generated and each mode has a unique propagation speed. The number of microwave modes that are generated varies with the frequency of the radar signal and the pipe diameter. Emerson Process Management recommends using a 2- or 3-in. pipe to minimize the number of microwave modes. The use of higher frequency radar transmitters should be restricted to smaller diameters. Conversely, lower frequency units perform better than higher frequency units on larger diameter pipes. Non-contacting radar transmitters should not be used on pipes larger than 8-in.

Low frequency radar handles dirty pipes, heavy vapors, and condensation better than high frequency units, e.g. Rosemount 5402 Non-Contacting Level Transmitter is not a good fit for applications with heavy condensation. High frequency may have slightly better performance, but should be used on clean applications. High frequency has better tolerance for installations that may not meet all mechanical requirements.

Rosemount 5401 Non-Contacting Level Transmitter is not recommended for chambers as its wider pulse frequency makes it sensitive for disturbances generated by the inlets and compromise level measurements nearby those areas.

5.3 Choosing the right antenna

The Rosemount 5400 and Rosemount 5600 Non-Contacting Level Transmitter offer a wide range of antennas, including rod antennas, cone antennas, and process seal antennas. Of these, the Cone antenna is the only suitable antenna for level measurement in pipes. All units are available with SST, Alloy C-276, and Alloy 400 antennas.

With any radar unit, the antenna should match the 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 1-3 on page 11](#). For the Rosemount 5600, gaps of up to 0.4 in. (10 mm) are acceptable. For the Rosemount 5400, gaps of up to 0.2 in. (5 mm) are acceptable. Larger gaps may result in inaccuracies.

Figure 1-3. Pipe Installation Dimensions

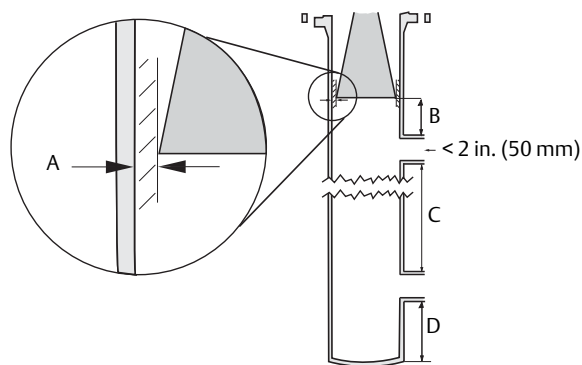


Table 1-9. Installation Guidelines for Non-Contacting Radar

	Rosemount 5401	Rosemount 5402	Rosemount 5600	
A: Maximum gap between antenna and pipe ⁽¹⁾	0.2 in. (5 mm)	0.2 in. (5 mm)	0.4 in. (10 mm) ⁽²⁾	
B: Minimum distance between antenna and inlet pipe	Not recommended	2 in. (50 mm)	4 in. (100 mm)	
C: Minimum distance between inlets	Not recommended	20 in. (500 mm)	20 in. (500 mm)	
D: Minimum distance between lower inlet and bottom of pipe	Not recommended	6 in. (150 mm)	6 in. (150 mm)	
Minimum dielectric constant	1.6	1.6	1.4	
Availability per pipe size				
	2-in. pipe	N/A	Yes ⁽³⁾	N/A
	3-in. pipe	Yes	Yes	Yes
	4-in. pipe	Yes	Yes	Yes
	6-in. pipe	Yes	Not recommended	Yes
	8-in. pipe	Yes	Not recommended	Not recommended
Can be used with full port valve	Yes	Yes	Yes	
Can be used in applications with heavy condensation	Yes	Not recommended	Yes	

1. In difficult measurement conditions (dirty pipes, steam, echoes from inlet pipes, welds, or valves), accuracy and range will be improved with a tighter fit between pipe and antenna.
2. In bypass chambers, the gap should be as small as possible.
3. Fits schedule 40 or lower pipes.

5.4 Stilling well requirement

Pipes should be an all-metal material. Non-metallic pipes or sections are not recommended for non-contacting radar. Plastic, plexiglas, or other non-metal materials do not shield the radar from outside disturbances and offer minimal, if any, application benefit. Other requirements include:

- Pipe should have a constant inside diameter.
- Pipe must be smooth on the inside (smooth pipe joints are acceptable, but may reduce accuracy).
- Avoid deposits, rust, gaps and slots.
- One hole above the product surface.
- Minimum hole diameter is 0.25 in. (6 mm).
- Hole diameter (\varnothing) should not exceed 10% of the pipe diameter (D).
- Minimum distance between holes is 6 in. (150 mm)⁽¹⁾.
- Holes should be drilled on one side and de-burred.
- Ball valve or other full port valves must be completely open.
- Level will not be measured accurately below the pipe opening.
- The length of the pipe should extend beyond minimum product level.
- In heavy condensation applications, insulate the pipe/nozzle which is outside the tank atmosphere.

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

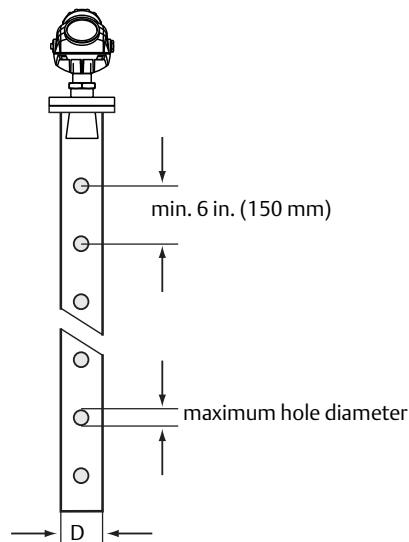
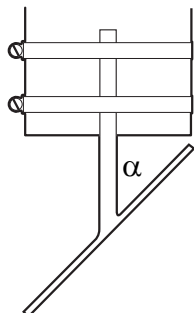


Table 1-10. Maximum Hole Diameter

Rosemount 5401	Rosemount 5402	Rosemount 5600
0.8 in. (20 mm)	0.4 in. (10 mm)	0.8 in. (20 mm)

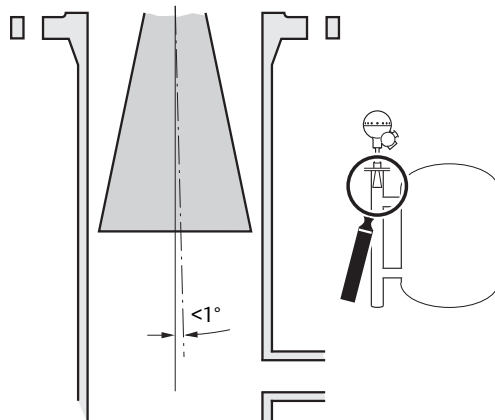
1. The minimum distance between holes is not always the optimal distance. Consult factory or product documentation for best installation practices.

In flat bottom tanks (20° incline), where the fluid has a low dielectric and a measurement close to the bottom of the tank is desired, a deflection plate should be used. This will suppress the bottom echo and allow measurements closer to the actual tank bottom. This is not necessary for dish- or cone-bottomed tanks where the slope is more than 20° .

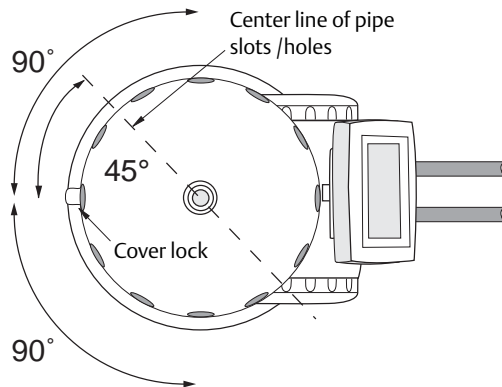


5.5 Bypass chamber requirements

The guidelines for stilling wells also apply to bypass chambers, with a few additions. Most importantly, the inlet pipes must not protrude into the measuring pipe and the edge should be as smooth as possible. In addition, the distances between the antenna and the chamber wall and inlet pipes should meet those shown in [Table 1-9 on page 1-11](#). If the inlet pipe tolerances are too restrictive, an alternative solution may be to mount a smaller pipe within the bypass chamber, or consider using GWR.



When the transmitter is mounted in a pipe, the inclination should be within 1° of vertical. Even small deviations can cause large measurement errors. Also, the cone should be mounted in the center of the pipe to achieve a uniform gap around the antenna.

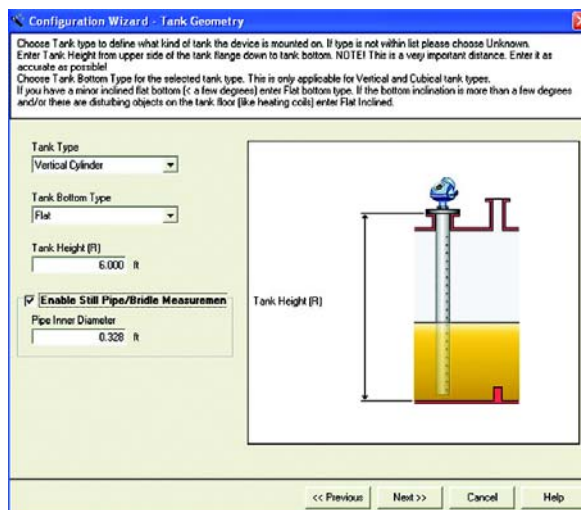


The Rosemount 5600 electronics head should be oriented so that the cover lock is 45° from any disturbances such as pipe inlets or stilling well holes. It is also good if the installation allows for a ±90° rotation from this point to allow alternative orientations. This is not necessary for the Rosemount 5400 thanks to circular polarization.

6.0 Transmitter configuration

The transmitter software contains a special pipe measurement mode which is turned on by entering the internal diameter of the pipe. This can be done using Rosemount Radar Master, the Field Communicator, AMS™ or any other DD-compatible host-system. When this mode is turned on, the transmitter will be optimized for pipe measurements. For example, the dynamic gain curve will be adapted for pipes and the lower propagation velocity of the radar signal in the pipe will be compensated. Entering the pipe diameter into the transmitter is therefore crucial and must not be omitted. Compensation is more important on higher frequency devices.

Figure 1-4. Transmitter Configuration Wizard



7.0 Performance and measuring range

The maximum measuring range is independent of the dielectric constant of the product. However, the dielectric constant has to be greater than 1.4 for the Rosemount 5600, and 1.6 for the Rosemount 5400. For the GWR the minimum dielectric and maximum range varies with probe type (see [Table 1-1 on page 1-4](#)). For lower dielectric constants, contact the factory.

Global Headquarters

Emerson Process Management

6021 Innovation Blvd.

Shakopee, MN 55379, USA

+1 800 999 9307 or +1 952 906 8888

+1 952 949 7001

RFQ.RMD-RCC@EmersonProcess.com

North America Regional Office

Emerson Process Management

8200 Market Blvd.

Chanhassen, MN 55317, USA

+1 800 999 9307 or +1 952 906 8888

+1 952 949 7001

RMT-NA.RCCRFQ@Emerson.com

Latin America Regional Office

Emerson Process Management

1300 Concord Terrace, Suite 400

Sunrise, FL 33323, USA

+1 954 846 5030

+1 954 846 5121

RFQ.RMD-RCC@EmersonProcess.com

Europe Regional Office

Emerson Process Management Europe GmbH

Neuhofstrasse 19a P.O. Box 1046

CH 6340 Baar

Switzerland

+41 (0) 41 768 6111

+41 (0) 41 768 6300

RFQ.RMD-RCC@EmersonProcess.com

Asia Pacific Regional Office

Emerson Process Management Asia Pacific Pte Ltd

1 Pandan Crescent

Singapore 128461

+65 6777 8211

+65 6777 0947

Enquiries@AP.EmersonProcess.com

Middle East and Africa Regional Office

Emerson Process Management

Emerson FZE P.O. Box 17033


Jebel Ali Free Zone - South 2


Dubai, United Arab Emirates

+971 4 8118100


+971 4 8865465


RFQ.RMTMEA@Emerson.com

 [Linkedin.com/company/Emerson-Process-Management](https://www.linkedin.com/company/Emerson-Process-Management)

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