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

KEY POINTS

- Advantages of Using Bypass Pipes and Stilling Wells
- Which Radar to Use: Guided Wave or Non-Contacting?
- Installation Guidelines for Guided Wave Radar (GWR)
- Installation Guidelines for Non-Contacting Radar
- Two Technologies in one pipe
- Performance and Measuring Range

Stilling wells and bypass pipes are used in many applications and many different types of tanks and vessels. 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.

Radar transmitters function differently in pipes. The guidelines contained here provide best performance results.

ADVANTAGES OF USING BYPASS PIPES AND STILLING WELLS

Stilling wells or pipes 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 stilling wells and bypasses include:

Pipes offer a calmer, cleaner surface

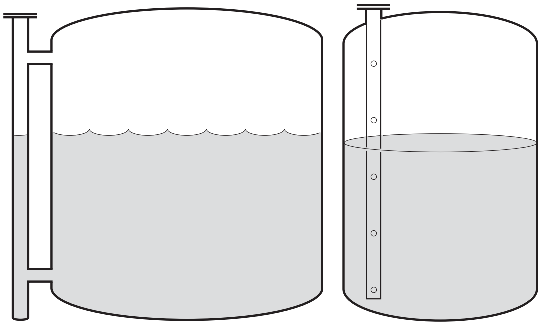
A pipe can increase the reliability and robustness of the level measurement, especially for non-contacting radar. It should be noted that the coaxial probe of a guided wave radar is essentially a probe within a small stilling well. It should be considered as an alternative to stilling wells for clean fluid applications.

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.

Pipes may be more accessible to the area of interest

Bypass pipes 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.



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

Allows instrumentation to be isolated from vessel

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

Bypass pipes 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.

WHICH RADAR TO USE: GUIDED WAVE OR NON-CONTACTING?

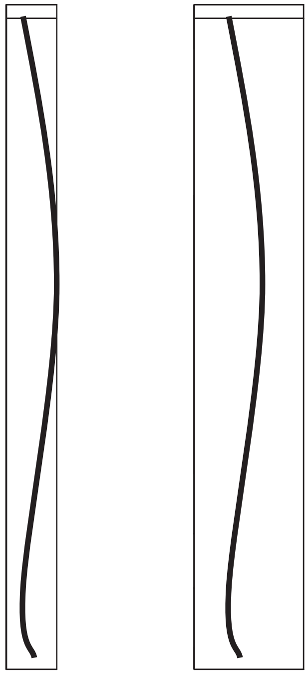
Although non-contacting radar works well in pipe applications, contacting or guided wave radar (GWR) may be a simpler choice. Non-contacting radar must meet certain installation requirements for optimum results. The guided wave radar has simpler installation requirements and provides better performance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

Guided Wave Radar 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 Rosemount technical note 00840-2200-4811, Replacing Displacers with Guided Wave Radar, for more details.) The probes are available in a variety of materials to handle corrosive fluids. For taller applications or those with limited headspace 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.

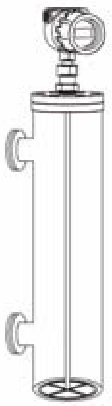
INSTALLATION GUIDELINES FOR GUIDED WAVE RADAR (GWR)

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 or bypass cage, 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” (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 may 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.



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



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

Pipe Requirements

There are multiple styles and materials of probes available for the Rosemount 3300 Guided Wave Radar. Table 1 shows the various options and where each may be used with regard to pipe size and length. The 3300 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. If a single lead probe is used in a plastic stilling well, the walls of the tank should be metal to provide electromagnetic interference shielding.

TABLE 1. Probe Styles and Installation Considerations

Probe Style	Maximum recommended length of pipe	Centering disk?	Min pipe diameter	Minimum Dielectric(1)	SST	PTFE Coated	Hastelloy	Monel
Single Rigid(2)	3 m (9.9 ft)	yes	5 cm (2")	1.7	yes	yes	yes	yes
Single Flexible	10 m (33 ft)	yes	10 cm (4")	2.0	yes	yes	no	no
Twin Rigid	3 m (9.9 f t)	no	5 cm (2")	1.9	yes	no	no	no
Twin Flexible	10 m (33 ft)	yes	10 cm (4")	1.6	yes	no	no	no
Coaxial(2)(3)	6 m (19.8 ft)	no	3.7 cm (1.5")	1.4 or 2.0(4)	yes	no	yes	yes

(1) When installed in metal pipe

(2) Single and coaxial probes are available with process seals for high pressure and high temperature conditions. SST only

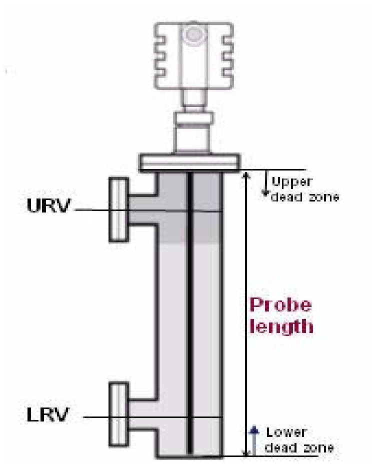
(3) Coaxial probes are not recommended for immersed probe applications

(4) High Temperature High Pressure version

TABLE 2. Dead Zones Vary with Probe Type when Installed in Metallic Pipes

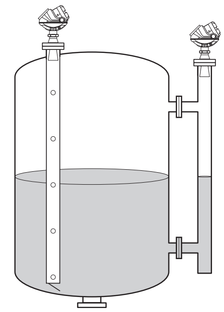
Probe Style	Upper Dead Zone		Lower Dead Zone	
	High Dielectric	Low Dielectric	High Dielectric	Low Dielectric
Single Rigid	10 cm (4")	10 cm (4")	5 cm (2")	10 cm (4")
Single Flexible	15 cm (5.9")	20 cm (8")	19 cm (7.5")(1)	26 cm (10.2")(1)
Twin Rigid	10 cm (4")	10 cm (4")	5 cm (2")	7 cm (2.8")
Twin Flexible	15 cm (5.9")	20 cm (8")	14 cm (5.5")(1)	24 cm (9.4")(1)
Coaxial	10 cm (4")	10 cm (4")	3 cm (1.2")	5 cm (2")

(1) Includes weight



When sizing a probe for use in a bypass cage, it is important to allow for some extra length for the upper and lower dead zones of the probe. Level measurements are compromised in these areas.

INSTALLATION GUIDELINES FOR NON-CONTACTING RADAR



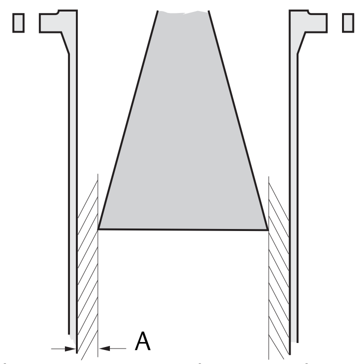
Using Non-contacting Radar in Pipes and Bypass Cages

When radar transmitters are used in 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.

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” 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”.

Low frequency radar handles dirty pipes, heavy vapors, and condensation better than high frequency units. 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.



Ideally, the maximum gap between the antenna and the pipe wall should be as small as possible. Larger gaps may result in larger inaccuracies.

Choosing the right antenna

The 5400 and 5600 Series transmitters 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, Hastelloy, and Monel 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. For the 5600, gaps of up to 10 mm are acceptable. For the 5400, gaps of up to 5 mm are acceptable. Larger gaps may result in innaccuracies.

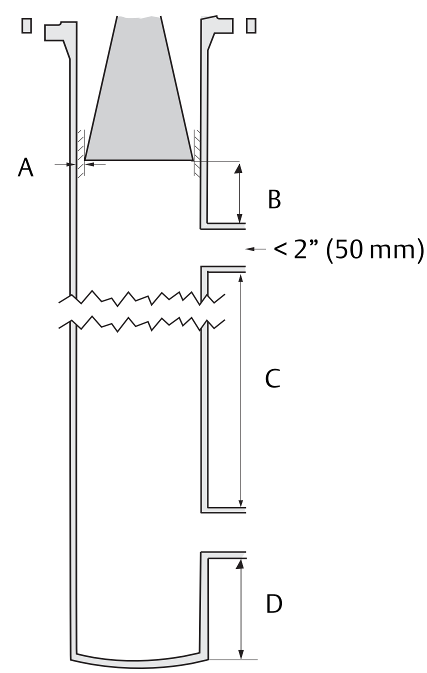
TABLE 3. Installation Guidelines for Non-contacting Radar

	5401	5402	5600
A: Maximum gap between antenna and pipe(1)	5 mm (0.2”)	5 mm (0.2”)	10 mm (0.4”)(2)
B: Min distance between antenna and inlet pipe	50 mm (2”)	50 mm (2”)	100 mm (4 “)
C: Minimum distance between inlets	> 500 mm	> 500 mm	> 500 mm
D: Minimum distance between lower inlet and bottom of pipe	150 mm	150 mm	150 mm
Minimum dielectric constant	1.6	1.6	1.4
Availability per pipe size			
2” pipe	NA	Yes(3)	NA
3” pipe	Yes	Yes	Yes
4” pipe	Yes	Yes	Yes
6” pipe	Yes	NA	Yes
8” pipe	Yes	NA	NA
Can be used with full port valve	yes	yes	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 pipes, the gap should be as small as possible.*

(3) *Fits schedule 40 or lower pipes*



Pipe 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:

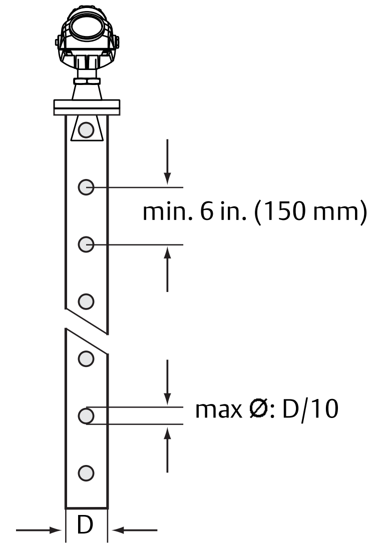
- Pipe should have a constant inside diameter
- Pipe must be smooth on the inside (smooth pipe joints are acceptable, but may reduce accuracy)
- Avoid deposits, rust, gaps and slots
- One hole above the product surface
- Hole diameter (Ø) should not exceed 10% of the pipe diameter (D)
- Minimum distance 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

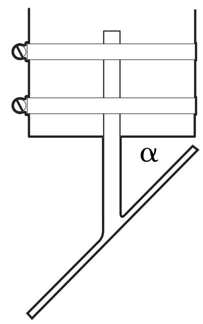
Failure to follow these requirements may affect the reliability of the level measurement.

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°.

Bypass pipe requirements

The guidelines for pipes also apply to bypass pipes, 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 pipe wall and inlet pipes should meet those shown in Table 3. If the inlet pipe tolerances are too restrictive, an alternative solution may be to mount a smaller pipe within the bypass pipe, or consider using guided wave radar.



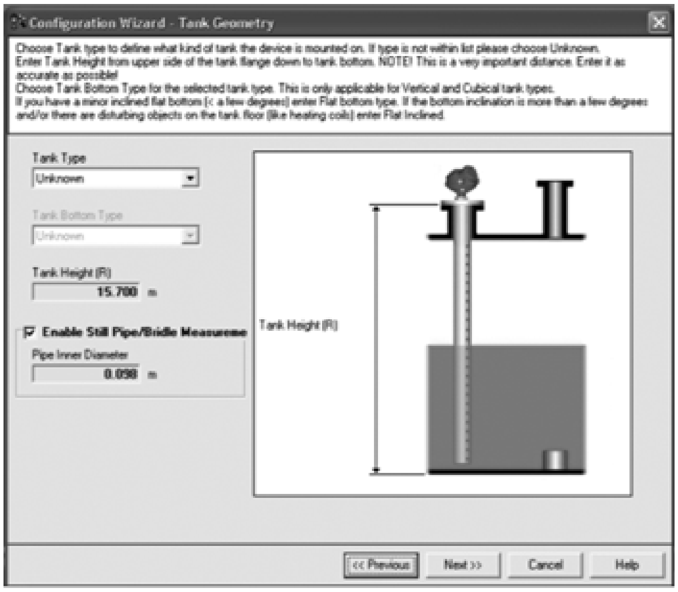


Deflection plate should have an angle (α) of 45 +/- 10 degrees.

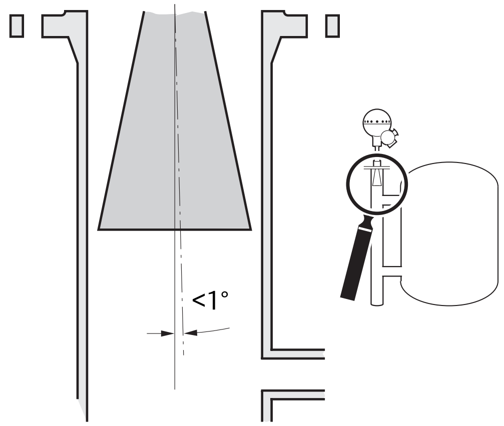
(1) *The minimum distance between holes is not always the optimal distance. Consult factory or product documentation for best installation practices.*

Transmitter Configuration

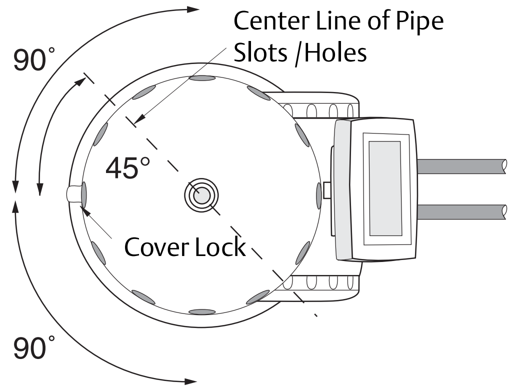
The transmitter software contains a special pipe measurement mode which is turned on by entering the internal diameter of the pipe. This can be done using Rosemount Radar Master, the 275/375, AMS™ or any other DD-compatible host-system. When this mode is turned on, the transmitter will be optimized for 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. The higher the frequency of the device is, the more important this compensation becomes.



Transmitter Configuration



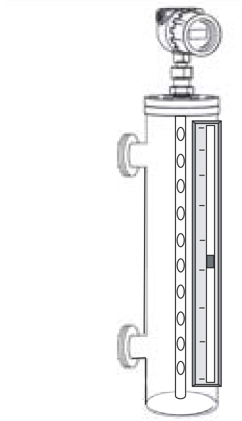
When the transmitter is mounted in a pipe, the inclination should be within 1° of vertical. Even small deviations can cause large measurement errors. Also, the cone should be mounted in the center of the pipe to achieve a uniform gap around the antenna.



The 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 5400 thanks to circular polarization.

TWO TECHNOLOGIES IN ONE PIPE

Non-contacting radar requires that it be centered in the pipe with smooth, clean edges. This makes it impossible to install another technology in the same pipe with non-contacting radar. Guided wave radar can share a pipe with another technology if a coaxial probe is used. The coaxial probe prevents signal interference from the other technology. Coaxial probes must be used in clean applications. If the application has dirty or sticky materials, then the single lead probe must be used. In this case, the probe must be shielded from the other technology. One way to do this is to use parallel pipes. Another alternative is to split the pipe so the probe is isolated.

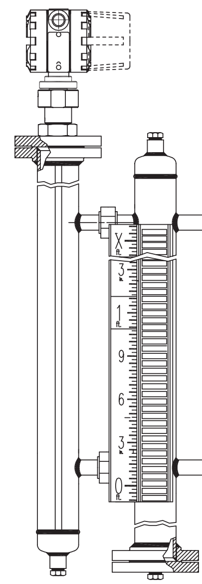


With a coaxial probe, the 3300 can be installed in the same pipe with other level technologies.

PERFORMANCE AND MEASURING RANGE

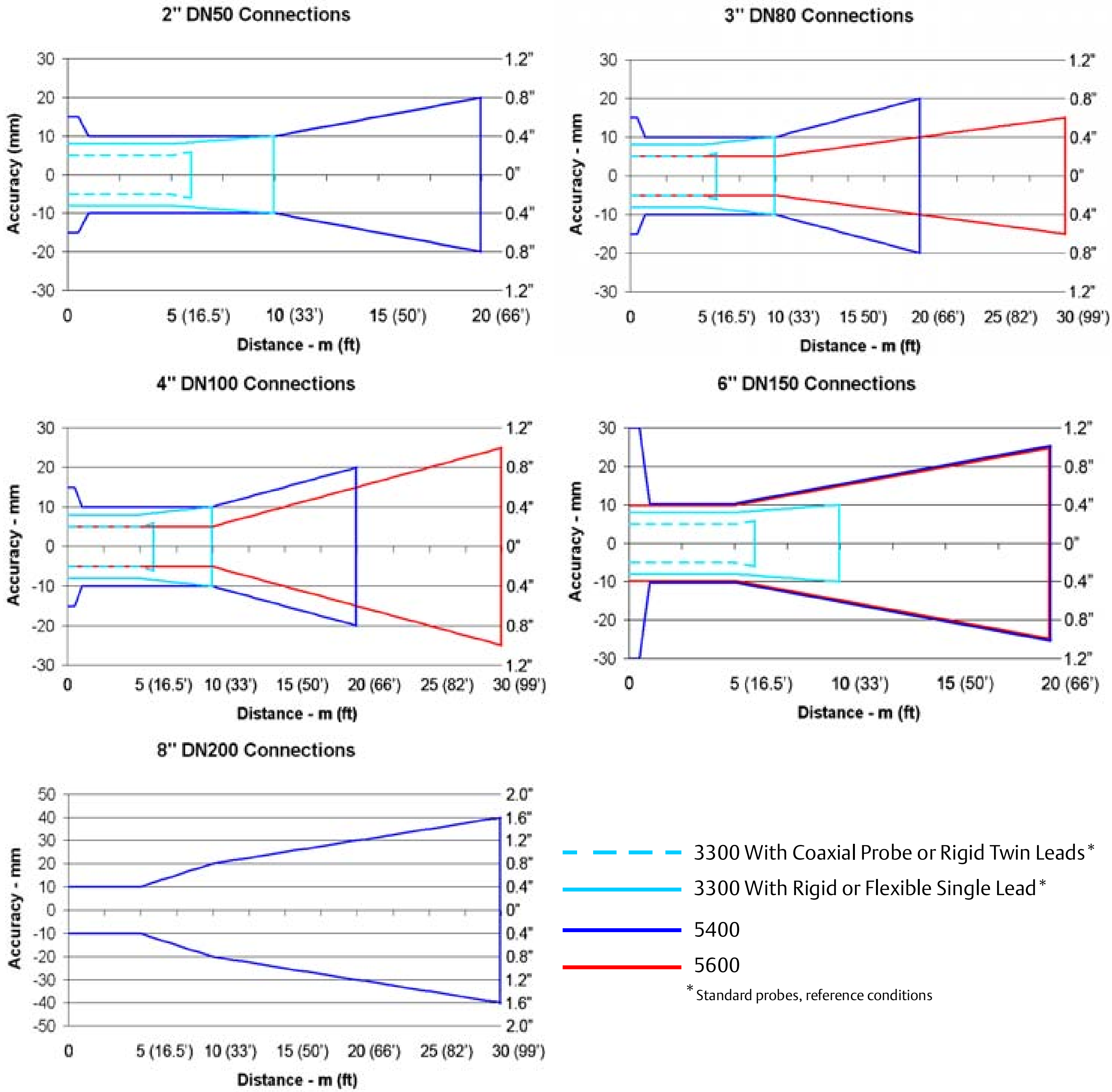
The charts in Table 4 reflect the anticipated performance for different radar devices when used in a pipe installation and following the guidelines contained in this document. The values in the table assume that all the installation requirements stated above have been fulfilled and that the pipe is made per our recommendations.

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 5600 and 1.6 for the 5400. For the 3300 the minimum dielectric and maximum range varies with probe type (see Table 1 on page 3). For lower dielectric constants, contact the factory.



If the application demands a single probe, a parallel pipe may be used to prevent interference of the signal.

TABLE 4. Accuracy and Maximum Distance Capability in Pipe Installations for Standard Probes at Reference Conditions



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