Guided Wave Radar in Solid Level Applications

KEY POINTS

- Measuring Range
- Probe End Projection function (PEP)
- Tensile Strength and Collapse Load
- Mounting Considerations
- Electrostatic Discharges and Electromagnetic Interference

OVERVIEW

Guided Wave Radar is a very reliable method for measuring solids, such as powders, granulates, or pellets with a grain size of up to 0.8 in. (20 mm). Materials include plastics, fly-ash, cement, sand, sugar, cereals, grains, and many others. With the Rosemount 5303, measurements can be made even on fine powders in dusty environments and in silos where the media surface is not flat and where free-propagation radar transmitters may be unsuitable.

The measurement is made where the probe comes in contact with the material, which means that the shape of the material surface is not critical for the measurement. Measurements are also independent of moisture, material fluctuations such as density and temperature.

MEASURING RANGE

For a Rosemount 5303 with a flexible single lead probe, the maximum probe length is 164 ft. (50 m).

Table 1 shows the maximum measuring range depending upon the dielectric constant of the product. The Rosemount 5303 Probe End Projection (PEP) function may improve the maximum measuring range.

Rosemount 5303 with flexible single lead probe

TABLE 1. Maximum measuring range

Dielectric Constant	Maximum Measuring Range w/o PEP	Maximum Measuring Range w. PEP
1.4	49 ft. (15 m)	138 ft. (42 m) + air gap(1)
1.8	82 ft. (25 m)	122 ft. (37 m) + air gap(1)
2.0	115 ft. (35 m)	116 ft. (35 m) + air gap(1)
3	138 ft. (42 m)	94 ft. (28 m) + air gap(1)
4	151 ft. (46 m)	82 ft. (25 m) + air gap(1)
6	164 ft. (50 m)	Not Needed

(1) The 'air gap' is the distance to the material surface. Note, however, that the maximum measuring range cannot exceed the probe length i.e. 164 ft. (50 m).

See the Probe End Projection function section for more information. Table 2 shows typical dielectric constants for several solids.

NOTE!
The maximum practical measuring range also depends on the tensile load in your application. See Tensile Strength and Collapse Load section for more information.

TABLE 2. Dielectric Constants of Typical Bulk Solids

Dielectric Constants(1)	Typical Bulk Solids	Rosemount 5303 Maximum Measuring Range
1.1 - 1.9	• Plastic powder, granulate • White lime, special cement • Dry sawdust • Sugar granulate • Cement, plain	See Table 1
1.9 - 2.5	• Fly ash • Burnt Lime • Coal dust, dry • Portland cement • Plaster	See Table 1
2.5 - 4.0	• Starch • Grain, seeds • Ground stones • Carbon black • Sand	See Table 1
4.0 - 7.0	• Naturally moist (ground) • Stones, ores • Salt • Cement powder	See Table 1
> 7.0	• Carbon black • Coal dust, moist • Brown coal • Metallic powders • Calcium Carbonate	164 ft. (50 m)

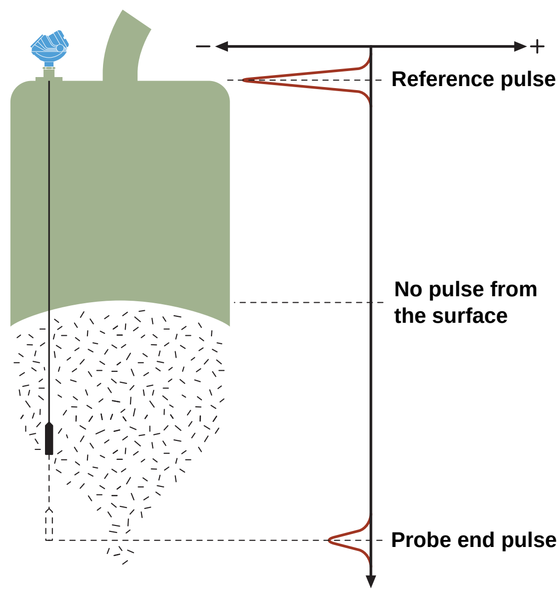
(1) *Dielectric values can differ depending on particle size and the amount of air or moisture in the material. More air will lower the dielectric value while more moisture will increase it. These tables provide a rough guideline.*

NOTE!
For dielectric constants <1.4, the surface pulse may be too weak to be detected and measurements cannot be made unless the Probe End Projection function is used.

NOTE!
For longer measuring ranges, non-contacting radar may be a better choice. See Technical Note *Measuring Solids with a Rosemount 5600 Non-Contacting Radar* (Document Number 00840-0100-4024).

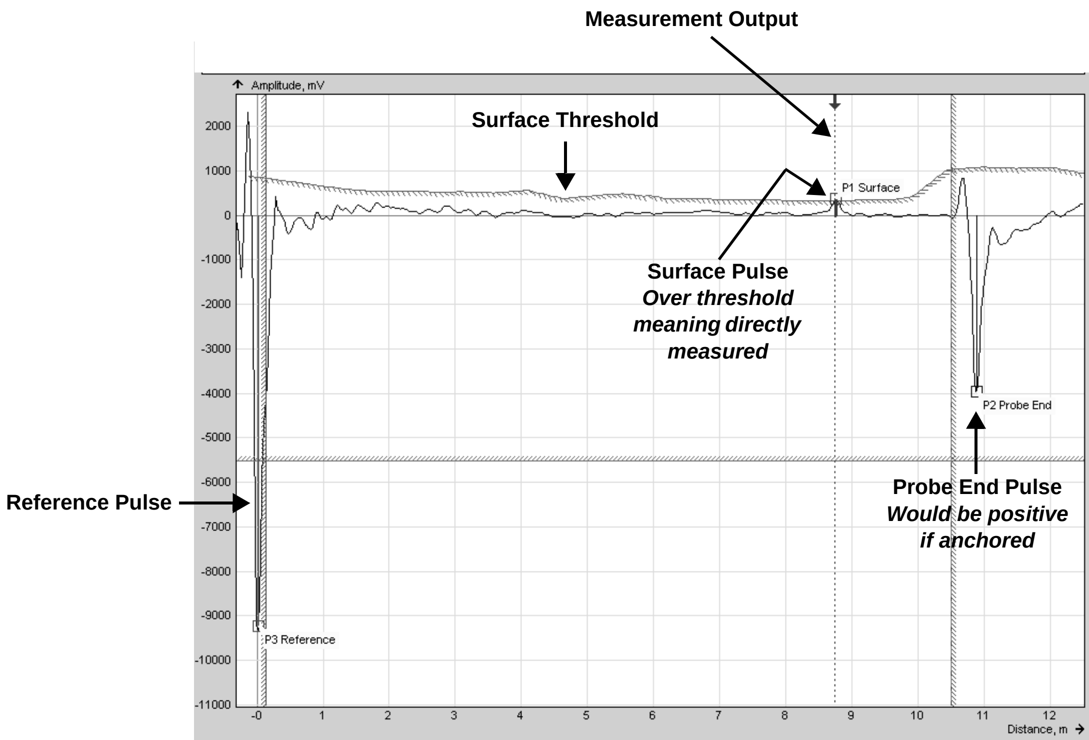
PROBE END PROJECTION FUNCTION

Probe End Projection (PEP) is a function in the 5303 transmitter that allows for measurements when the surface pulse is too weak to be detected. This commonly occurs when the material dielectric is very low, especially in combination with a long distance to the surface, or electromagnetic interference. The method is based on the fact that microwaves propagate slower through product than through air. By using the product dielectric constant and the probe end echo, the surface position is calculated when the surface echo is unavailable. The PEP function will only be activated as a backup if the surface echo is too weak.

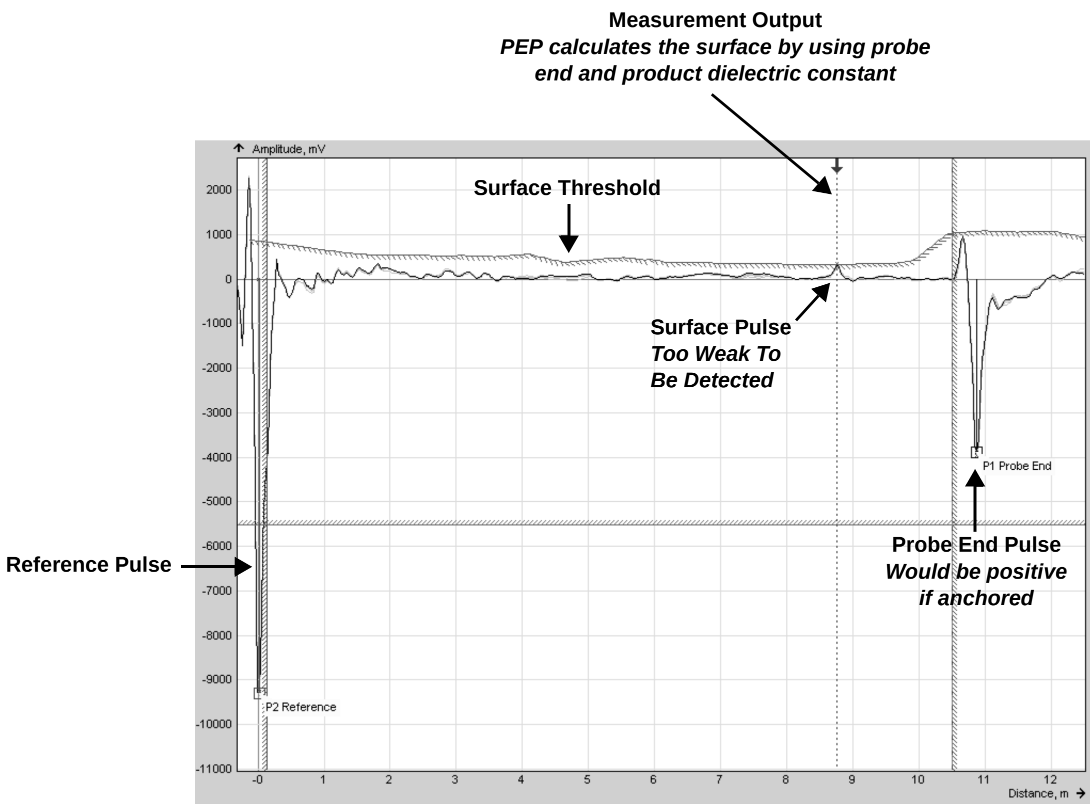


The PEP function is recommended for solids with a dielectric constant less than or equal to 2. The maximum measuring range with PEP is 164 ft. (50 m) (maximum probe length) divided by the square root (sqrt) of the material dielectric constant (DC) + the air gap to the material surface.

If the DC is 2 and the vessel is filled, the maximum measuring range is 115 ft. (35 m) (e.g. 164 ft. (50 m) / sqrt(2)). For a lower DC or with an air gap in the top of a vessel, it is possible to measure longer distances (see Table 1 on page 1 for details).



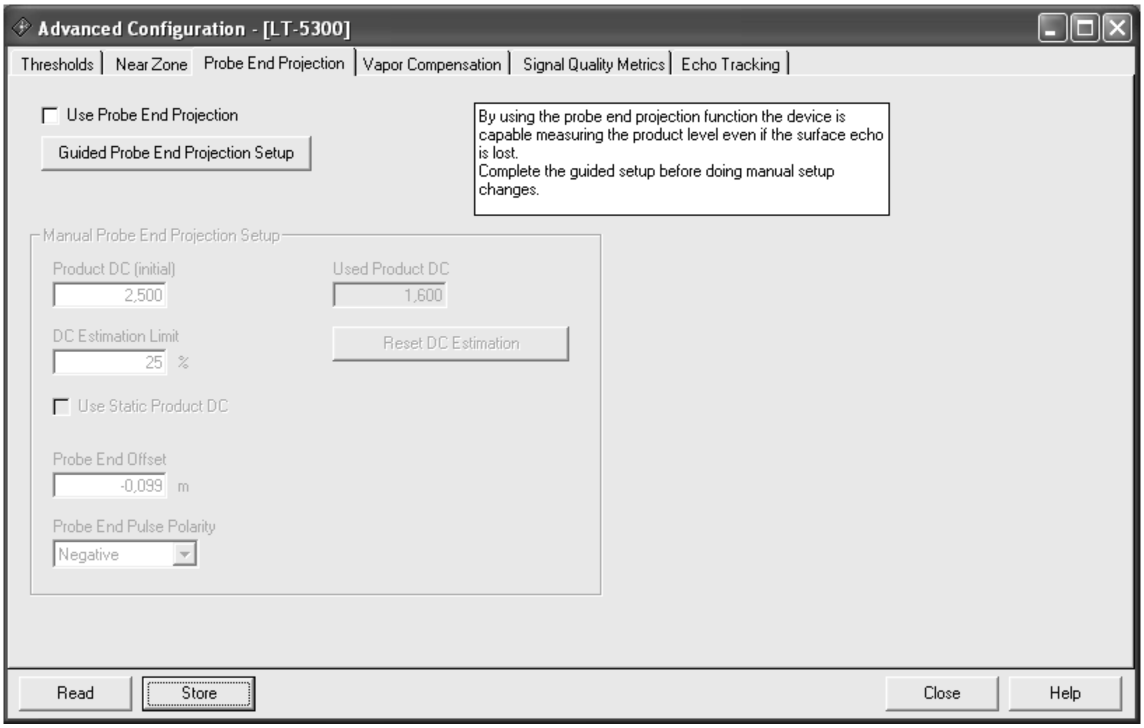
(a) Echo Curve Showing Surface Directly Measured



(b) Echo Curve Showing Surface Detected By PEP

The PEP is easily configured by using the guided setup in either Rosemount Radar Master, AMS®, or the Field communicator. For best performance, complete the guided setup with an empty vessel to accurately calibrate probe end offset and probe end pulse polarity, and then a second time with material in the vessel to get a surface echo to calculate the product dielectric constant.

For detailed information on configuring PEP, see the *Rosemount 5300 Series Reference Manual* (Document Number 00809-0100-4530)



NOTE!
Accuracy is highly dependent on a correctly configured DC value, and may be affected when using PEP. The longer the measuring range, the higher the error (e.g. sqrt(DC error)*measure range). It is therefore recommended to only use PEP when required and allow the transmitter to go into direct measuring mode. Obtaining the real surface echo will allow automatic correction of the DC. Do not set the surface echo threshold too high in areas where it is possible to reliably detect the real surface. Instead, allow the surface to sometimes be within the maximum measuring range without PEP (see Table 1). However, even if the accuracy may be affected, the repeatability will not be affected.

NOTE!
If PEP is used to measure in an application with EMI, the accuracy may be affected. For example, if the surface echo is too weak to distinguish from the noise and the surface threshold is raised to only use the probe end pulse, accuracy will be affected if the DC is not configured correctly.

NOTE!
Fixing the end of the probe to a surface (e.g. silo wall) affects the PEP accuracy. First, due to the slack of the probe needed to reduce the risk of probe breakage, the measurement is slightly non-linear. Secondly, if the fixing is not sufficient, the probe end pulse is not consistent. It is recommended to use the probe rope itself for anchoring (e.g. slot through a welded eye and then fasten with a chuck) rather than using a ring attached to the weight.

TENSILE STRENGTH AND COLLAPSE LOAD

The flexible single lead probe is recommended for solids. It is available in two versions to handle different loads and lengths:

- 0.16 in. (4 mm) diameter; Minimum tensile strength is 2698 lb. (12kN);
  Maximum collapse load is 3597 lb. (16 kN)
- 0.24 in (6 mm) diameter; Minimum tensile strength is 6519 lb. (29 kN);
  Maximum collapse load is 7868 lb. (35 kN)

Tensile strength is the amount of force the probe can withstand before any deformation occurs.

The definition for collapse load is the maximum amount of force needed to break the probe. The collapse load value should be less than what the roof can withstand. If the collapse load is reached, the probe will break before enough force is exerted on the roof to cause collapse. If the probe breaks, the process seal remains intact.

It is important to keep the following in mind when planning for installation:

- In solid applications, media may cause pull down forces on silo roofs. The silo roof must be able to withstand the probe collapse load, or at least the maximum probe tensile load
- In solid applications, there might be considerable tensile load caused by the media. The tensile load of the media should not exceed the tensile strength of the probe. The tensile load depends on the silo size, material density, and the friction coefficient. Forces increase with the buried length, the silo and probe diameter. In critical cases, such as products with a risk of build-up, it is better to use a 0.24 in. (6 mm) probe
- Forces on probes, depending on their position, are generally two to ten times greater on probes that are anchored to the vessel. The probe end should not be fixed for 100 ft. (30 m) or longer probes

Table 3 shows guidelines for the tensile load from free-flowing solids acting on a suspended probe, free-hanging, not anchored to the vessel, in a silo with smooth metallic walls. A safety factor of 2 is included for the calculations. Consult the factory if more information is needed.

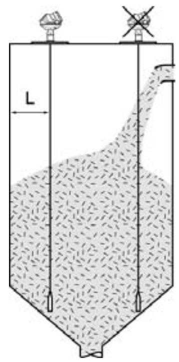
TABLE 3. Tensile Load Values[1]

	Tensile load for 0.16 in (4 mm) flexible single lead probe, lb (kN)				**Tensile load for 0.24 in (6 mm) flexible single lead probe, lb (kN)**			
	Probe length 49 ft. (15 m)		**Probe length 115 ft. (35 m)**		**Probe length 49 ft. (15 m)**		**Probe length 115 ft. (35 m)**	
Material	**Tank Ø= 10 ft. (3 m)**	**Tank Ø= 39 ft. (12 m)**	**Tank Ø= 10 ft. (3 m)**	**Tank Ø= 39ft. (12 m)**	**Tank Ø= 10 ft. (3 m)**	**Tank Ø= 39 ft. (12 m)**	**Tank Ø= 10 ft. (3 m)**	**Tank Ø= 39 ft. (12 m)**
Wheat	670 (3)	1120 (5)	1800 (8)	4500 (20) Exceeds tensile strength limit	900 (4)	1690 (7.5)	2810 (12.5)	6740 (30) Exceeds tensile strength limit
Plastic pellets	340 (1.5)	670 (3)	810 (3.6)	2360 (10.5)	450 (2)	920 (4.1)	1190 (5.3)	3510 (15.6)
Fly ash	770 (3.4)	1690 (7.5)	1980 (8.8)	5980 (26.6) Exceeds tensile strength limit	1130 (5)	2520 (11.2)	2950 (13.1)	8990 (40) Exceeds tensile strength limit
Coal dust	540 (2.4)	1190 (5.3)	1390 (6.2)	4230 (18.8) Exceeds tensile strength limit	790 (3.5)	1780 (7.9)	2070 (9.2)	6320 (28.1)
Cement	900 (4)	2020 (9)	2470 (11)	7310 (32.5) Exceeds tensile strength limit	1350 (6)	2920 (13)	3600 (16)	10790 (48) Exceeds tensile strength limit
Ground limestone	830 (3.7)	1820 (8.1)	2230 (9.9)	6650 (29.6) Exceeds tensile strength limit	1260 (5.6)	2740 (12.2)	3330 (14.8)	9960 (44.3) Exceeds tensile strength limit

(1) A safety factor of 2 is included for the figures.

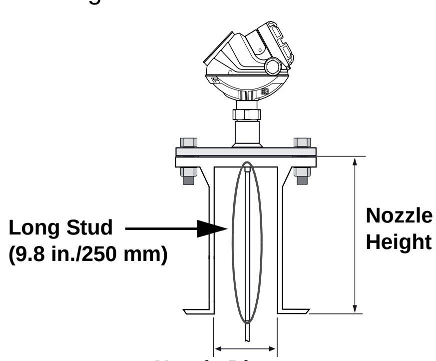
MOUNTING CONSIDERATIONS

- Mount the probe as far away as possible from filling and emptying ports. This will minimize load and wear and will help to avoid disturbances from the incoming product

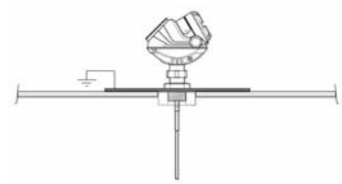


Recommended mounting position

- Installing the probe at about 1/3 to 1/2 of the silo radius is recommended to compensate for measurement errors caused by centered filling of the material cone
- The minimum recommended probe distance to tank wall or disturbing object is 20 in. (50 cm), unless the wall is comprised of smooth metal, then the distance is 4 in. (10 cm). In any case, the probe should not be able to touch the wall of the tank during operation
- The maximum recommended nozzle height is nozzle diameter + 4 in. (100 mm)
- When nozzles are more than 4 in. (100 mm) in height, a Long Stud (LS option) is recommended to prevent the probe from contacting the nozzle

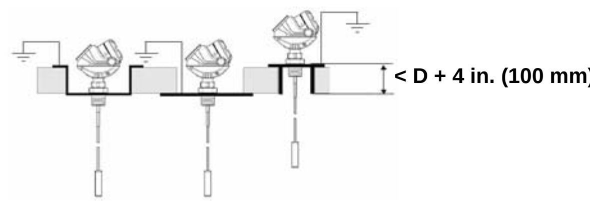


- Probe installation should occur when the silo is empty, and the probe should be regularly inspected for damage
- Avoid 10-in. (250 mm) / DN250 or larger diameter nozzles, especially in applications with low dielectric constant
- For environments where electrostatic discharges are likely to occur, e.g. plastics, it is recommended that the probe end is grounded with a proper grounding connection (R<1 Ohm)
- In case of non metallic tanks, a Rosemount 5303 should be mounted with a metal plate of minimum 8 in. (200 mm) diameter. Use metal shielding for the conduit connections



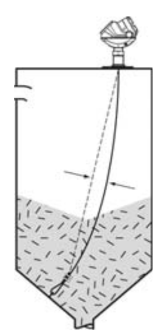
Installation with metal sheet
in non-metallic vessels

- In the case of bunkers with a concrete roof, a Rosemount 5303 should be installed flush with the inner roof surface or in a nozzle insert



Installation in concrete silo
with metal shielding

- To prevent an extremely high tensile load when fixing the probe, and to reduce the risk of probe breakage, the probe must be slack. Select a probe longer than the required measuring range so that there is a sag in the middle of the probe that is greater than or equal to 1 1/2 in. per 10 feet (1 cm per m) of the probe length



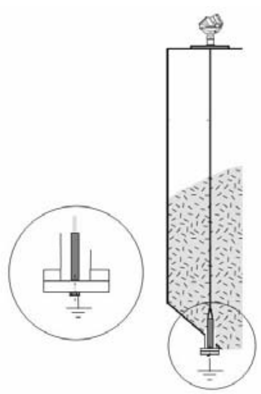
Fixing probe with slack

- For applications with a probe length longer than 115 ft. (35 m), please consult factory
- Consider using a non-contacting radar for abrasive media that can wear out the probe

ELECTROSTATIC DISCHARGES AND ELECTROMAGNETIC INTERFERENCE

In some applications, such as plastic pellets, electrostatic charges can build up and eventually discharge. While the Rosemount 5303 electronics can tolerate some static charge, providing a good earth ground for the electronics and attaching the end of the probe to the vessel will create ground paths for discharge away form the electronics. When the product can build up static electricity, the probe should be properly grounded (R<1 Ohm).

For further information grounding see Technical Note "Best Practices for Grounding and Transient Protection on Rosemount Radar Transmitters" (Document Number 00840-2700-4811).



Grounding the probe end in products building up static electricity

The Rosemount 5303 uses a patented smart Electromagnetic Interference (EMI) filter, which filters out most common EMI from rotating equipment, motor controllers, and other sources. With severe EMI, the sensitivity may be reduced. Probe End Projection offers additional measurement reliability (see "Probe End Projection function" on page 2).

In a metal silo there is no issue with EMI from rotating equipment, motor controllers, and other sources.

To avoid issues with EMI in non-metallic silos, the transmitter's threshold settings should be checked and Probe End Projection should be activated.

NOTE!
Forces on probes, depending on their position, are generally two to ten times greater on probes that are anchored to the vessel.

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