TABLE A

Type of Level Sensor	Saturation Capacitance
General Purpose:	
TFE Teflon® Insulated	76 pF per foot
Polyethylene Insulated	189 pF per foot
PVDF (Kynar) Insulated	350 pF per foot
Heavy Duty:	
TFE Teflon® Insulated	79 pF per foot
Polyethylene Insulated	198 pF per foot
PVDF (Kynar) Insulated	365 pF per foot
Flexible Cable:	
PFA Teflon® Insulated	58 pF per foot
Polyethylene Insulated	146 pF per foot
PVDF (Kynar) Insulated	254 pF per foot
Enhanced Performance:	
PFA Teflon® Insulated	207 pF per foot
Polyethylene Insulated	518 pF per foot
PVDF (Kynar) Insulated	950 pF per foot

Let's assume that the capacitance of a particular lining (C_L) in a vessel is about 15,000 pF per foot of height. The total capacitance measured will then depend on whether or not the material in the vessel is grounded. Examples 1 and 2 below illustrate the measured capacitance using two different sensors with and without a grounded measured material.

Example 1

Capacitance of Enhanced Performance Sensor w/PVDF Insulation In Conductive Material

Measured Material Not Grounded	Measured Material Grounded
$C_T = \frac{950 \times 15{,}000}{15{,}950} = 893.4\ pF/ft.$	$C_T = C_I = 950\ pF/ft.$

Example 2

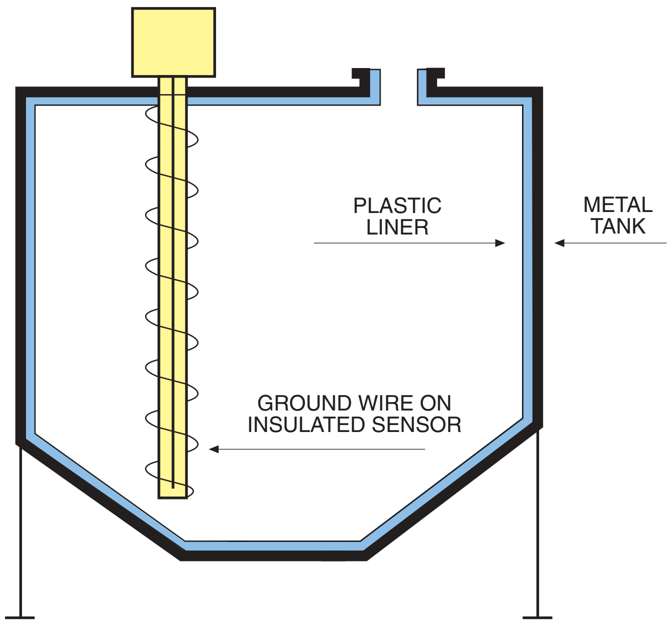
Capacitance of General Purpose Sensor w/PVDF Insulation In Conductive Material

Measured Material Not Grounded	Measured Material Grounded
$C_T = \frac{76 \times 15{,}000}{15{,}076} = 75.6\ pF/ft.$	$C_T = C_I = 76.0\ F/ft.$

When the conductive material is grounded, the second plate of the capacitor is no longer the vessel wall but the conductive material. Since the material is in contact with the sensor insulation, only the capacitance of the sensor determines the measured value. C_L is eliminated from the equation and C_T now equals C_1.

This is important when one does not intentionally ground the material and calibrates the system using the metal vessel as ground. As Example 1 shows, the difference between the two measurements is about 6%. Thus, if the material becomes grounded due to the opening of a valve or the generation of a small leak in the lining, the measured reading would shift by at least 6% of full scale. Each sensor and insulation will have its own characteristic shift, but when the best possible accuracy is desired, and the conductive material tends to coat the electrode, the "enhanced performance" sensor should be chosen. If one is not certain that the material will never get grounded accidentally, ALWAYS INTENTIONALLY GROUND THE MEASURED MATERIAL. This eliminates C_L from the measurement and prevents changes in capacitance caused by inadvertent grounding. The following methods of ground are recommended.

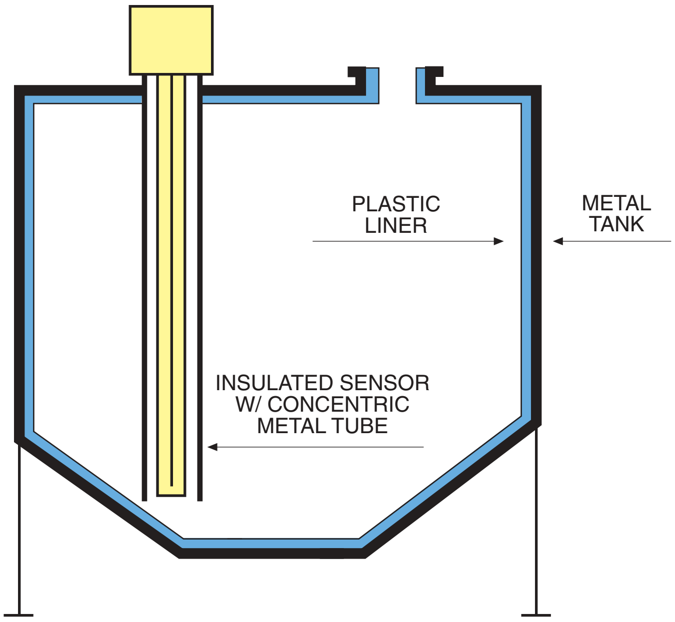
GROUNDING METHODS



1. Ground Wire Wrapped Electrode*

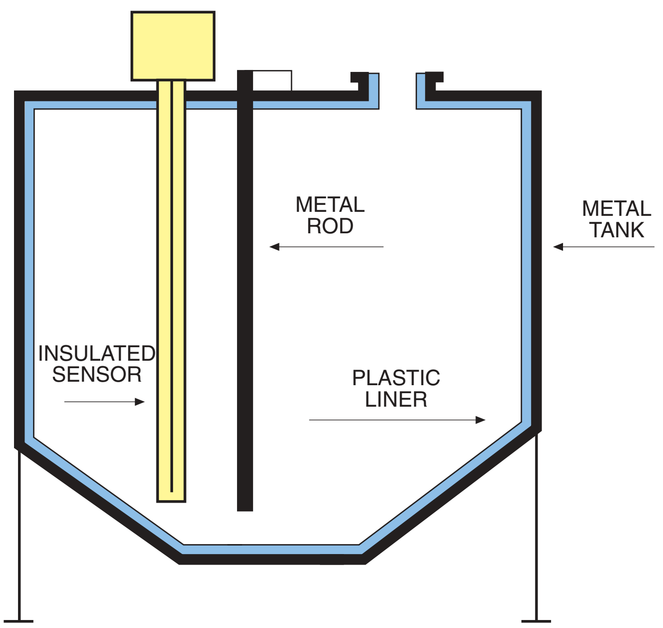
This is a popular method especially when an exotic metal must be used for compatibility. The exotic metal wire is less expensive than rod stock or concentric pipe or tube. The measuring electrode is normally mounted in a plastic-faced flange. The small diameter grounded wire (typically 0.032≤) is placed between the flange face and nozzle flange face and wrapped around the measuring electrode in a long open spiral. The wire is held against the electrode insulation with a few sections of heat shrink plastic tubing and is attached to the lower end of the electrode. When a measuring electrode with a threaded rather than flange fitting is used, the wetted portion of the entrance gland must be constructed of a compatible metal and the ground wire must be attached to the grounded face of the lining.

**This method Is not recommended in applications involving conductive materials that will coat on the level sensor.*



2. Metal Concentric Tube

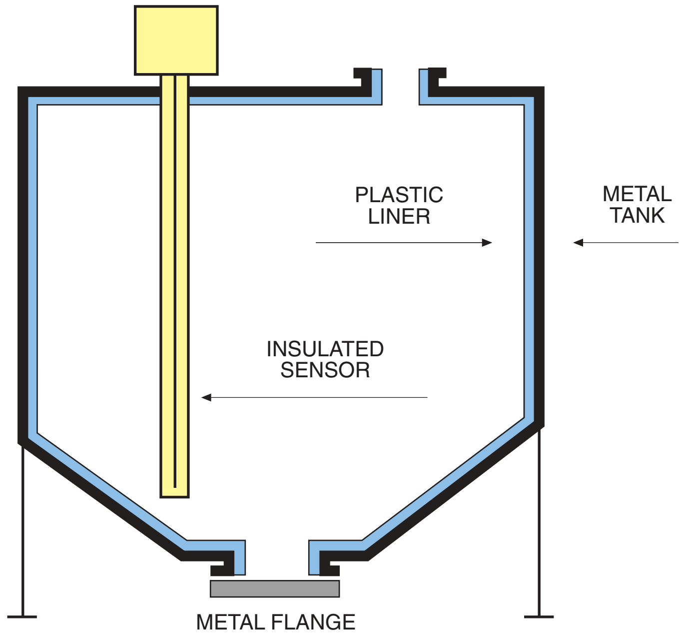
In some applications, a metal concentric tube serves as a grounding element and also as a stilling well. The advantage of the concentric tube is that it requires only one vessel entrance which may be threaded or flanged. However, if the concentric tube must be made of an exotic material, the cost may be prohibitive.



3. Ground Rod

A metal rod, sufficiently long so as to always contact the measured liquid, may be installed. It should be mounted no closer than two inches from the measuring electrode, with plastic spacers to maintain this distance. If the ground rod is mounted at a distance greater than two inches, the spacers may not be necessary. It is good practice to mount the ground rod as far from the measuring electrode as is practical. Please note that after about 10", a ground rod becomes ineffective in non-conductive materials. It is important to know that the level reading could change if the ground rod moves closer to the measuring electrode due to agitation.

Note: Insulated ground rods are not recommended in conductive materials because the result would be two capacitors in series, which could produce erroneous readings if intermittent grounds exist.



4. Metal Drain Fitting

Usually an above ground vessel will have a drain located in the bottom of the vessel. In a lined vessel, the drain is likely to be a nozzle with a cover flange. The nozzle and flange will contain the same protective coating. In some cases it is acceptable to replace the flange with a metal flange of compatible material, and then ground the flange. However, if an exotic material such as Hastelloy is required, the cost may be prohibitive.

OTHER IMPORTANT CONSIDERATIONS

- A vessel mounted on a concrete pad (with plastic or lined pipe inlet and outlet) is not necessarily grounded. If the vessel shell is not grounded, a person merely walking up to the vessel can influence the measurement. The best method of grounding a tank is by running a wire from the LV5900 electronics to the material in the tank.
- Excessive use of Teflon® thread sealing tape or pipe joint compound may actually insulate an electrode fitting from the vessel. Check for good grounding with an ohmmeter. Run a wire from the gland to the vessel wall to insure a good ground.

ABOUT CONDUCTIVITY

Non-conductive materials are defined to have a conductivity less than 0.1 microSiemens/cm. Conductive materials have a conductivity greater than 10 microSiemens/cm. For materials with a conductivity between these limits, more analysis is required to predict the various effects on calibration and accuracy. Fortunately, most common conductive materials such as aqueous solutions will be found to be above the high conductivity limit and non-conductive liquids such as petroleum-based products will be below the low limit. Unfortunately, pure alcohols typically fall between the conductive and non-conductive limits and cannot be used with the LV5000.

CONCLUSION

1. The vessel must be grounded in all cases.
2. Best accuracy carries a price tag. Consider the cost to obtain high accuracy.
3. If in doubt about buildup and conductivity, assume the material is conductive, ground it and use the "enhanced performance" sensor.
4. In general, aqueous solutions are conductive; petroleum-based materials are non-conductive.
5. When in doubt, ground conductive materials.

SENSOR SELECTION GUIDE FOR USE IN A LINED METAL VESSEL WITH GROUNDED SHELL