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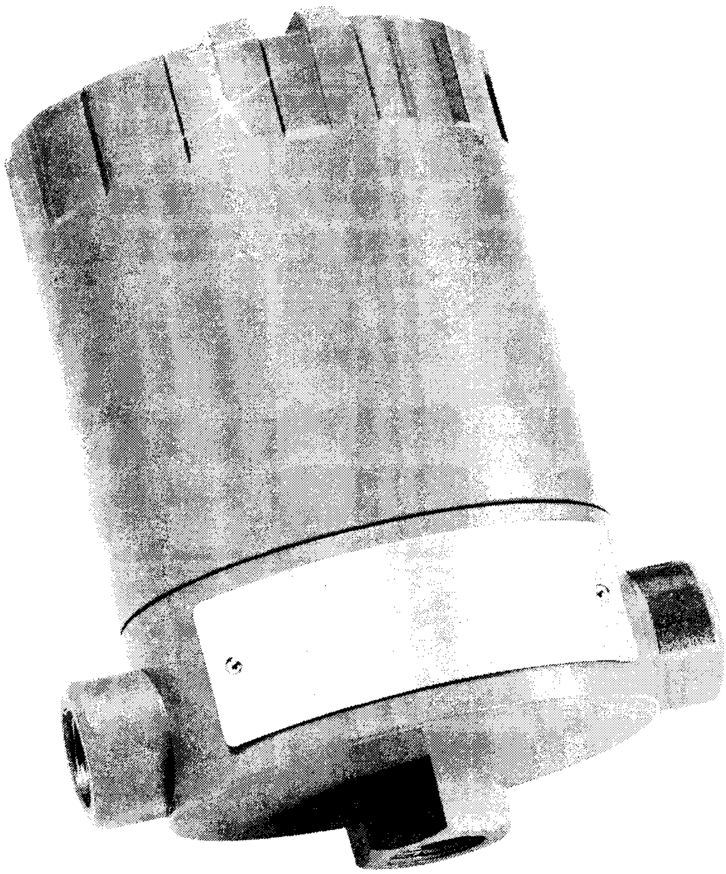
# User's Guide



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# LV5000 SERIES
## LV5900 Level Transmitters
## LV5000, 5100, 5200, 5300, 5500, 5603 Level Sensing Elements

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# TABLE OF CONTENTS

## SECTION 1 - INTRODUCTION



## SECTION 2 - INSTALLATION



## SECTION 3 - OPERATION



## SECTION 4 - PRINCIPLE OF OPERATION

# TABLE OF CONTENTS (Continued)

## SECTION 5 - SERVICE & MAINTENANCE



## SECTION 6 - SPARE PARTS AND ACCESSORIES



## SECTION 7 - LEVEL SENSING ELEMENTS

# SECTION 1 - INTRODUCTION

## 1.1 - GENERAL INFORMATION

### 1.1.1 Description

The OMEGA® LV5900 Series RF electronic level transmitters are designed for continuous level measurement of conductive and non-conductive liquids, granular materials, slurries and interface applications. They can be used with any OMEGA LV5000 through LV5600 Series insulated level sensing probes.

**Transmitter Versions**

The LV5900 Series are non-indicating (blind) transmitters. These transmitters may be mounted directly onto the level sensing probe or remotely mounted within 150 feet using special triaxial interconnect cable. The transmitter may be supplied in a DC-powered version that requires 18-35 VDC power. An AC line-powered (four-wire) version for operation with 115 or 230 VAC is optional.

**Anti-Coat Capability**

The instrument contains special "anti-coat" circuitry to compensate for the effect of conductive coating which may build up on the level sensing probe surface.

**Output Flexibility**

The transmitter provides a 4-20 mA isolated output with adjustable damping. The unit may be field-selected for direct or reverse acting output modes.

### 1.1.2 Product Identification

The serial # of your instrument is located on the electronic chassis next to the power input terminals. Write the serial # in the space provided below for convenient identification should technical assistance be required.

Serial # ________________

### 1.1.3 Available Models

| Model | Description |
|---|---|
| LV5900 | Blind transmitter, aluminum enclosure |
| LV5900P | Blind transmitter, PVC enclosure |

For AC-powered option, add either "115 Vac" or "230 Vac" to model number.

## 1.2 - SPECIFICATIONS

### 1.2.1 Operational

Ambient Conditions:
- In Aluminum Encl. ..............-40 to 160°F (-40 to 71°C), 0 to 95% relative humidity, non-condensing
- In PVC Enclosure ...............-40 to 122°F (-40 to 50°C), 0 to 95% relative humidity, non-condensing

Power Requirements:
- AC Line-Powered ...............115 or 230 VAC, 50/60 Hz.
- DC-Powered .......................18 to 35 VDC

Level Probe-to-Transmitter Distance .............. 150 feet maximum (when transmitter is remote mounted)

Analog Output .......................... Isolated 4-20 mA, field-selectable direct or reverse acting

Output Load:

- AC Line-Powered .............. 600 ohms max. load
- DC-Powered ...................... Max. Loop Load (in series with transmitter and power supply):
  - 550 ohms with 24 VDC power supply
  - 1100 ohms with 35 VDC power supply

  NOTE: For long cable runs, the resistance of the wire must be considered and may decrease max. load capacity

Output Damping ...................... Adjustable, 0.1 to 10 seconds

Anti-coat Circuitry ................... Phase-shift type; compensates automatically for conductive coatings

Protection ................................ RFI, EMI and static charge

## 1.2.2 Performance

Zero Adjustment Range ......... 0 to 500 pF

Span Adjustment Range ........ 10 to 10,000 pF

Zero/Span Ratio ..................... 10:1 maximum

Linearity.................................. 0.5% of full scale

Temperature Stability ............. Greater of 0.01 pF per °F or 0.01% of span per °F

## 1.2.3 Mechanical

Enclosure:

- Standard ............................ Cast aluminum w/urethane finish – NEMA 4, 7 and 9 (weatherproof, hosedown, dust and vapor explosion-resistant)
- Optional .............................. PVC – NEMA 4X for corrosive areas

Net Weight:

- Model LV5900 (in explosion-resistant enclosure) ........ 3.6 lbs. (1.63 kg) approx.
- Model LV5900P (in PVC enclosure) ....................... 3.4 lbs. (1.54 kg) approx.

# SECTION 2 - INSTALLATION

## 2.1 - UNPACKING

Remove the packing list and verify that you have received all equipment. If you have any questions about the shipment, please call the OMEGA Customer Service Department.

After unpacking, open the transmitter enclosure and inspect the electronic chassis for shipping damage. If there is evidence of damage, notify the carrier immediately. Save the small plastic screwdriver and banana plug for later use.

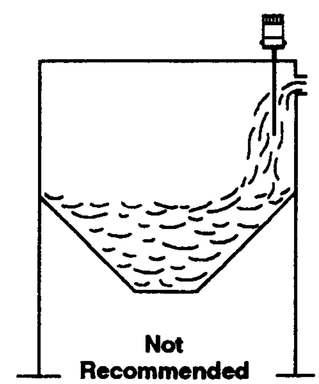
## 2.2 - MECHANICAL REQUIREMENTS

### 2.2.1 Location

Mounting positions for the level probe should be carefully considered. The probe must be installed vertically and its length must be sufficiently long to handle the entire measuring range. Do not locate the level probe in a position where the inflow of measured material could contact it. Also, locations should be well clear of obstructions and agitators. Figure 2-1 illustrates typical mounting locations.

Level probes used in granular material should be located halfway between the vessel wall and the apex of the material pile created by the incoming material. The output will then be representative of the average level.

For applications involving a vessel with non-conductive walls, a ground reference plate or grounded reference level element is required. However, if the measured material is conductive



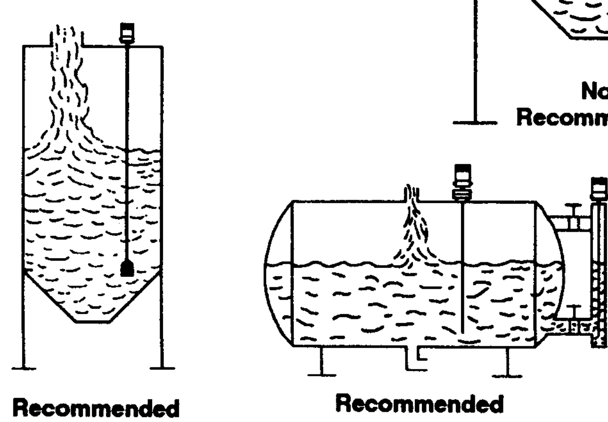




*FIGURE 2-1 Typical Level Probe/Transmitter Installation Locations*

and grounded, this is not necessary.

WARNING: ALL BARE ELEMENT PROBES MUST NOT BE USED WITH CONDUCTIVE (I.E. WATER-BASED) LIQUIDS OR CONDUCTIVE SOLIDS (LIKE METAL OR CARBON OR GRAPHITE POWDERS). THIS WILL CAUSE THE ELECTRONICS TO SHORT CIRCUIT AND FAIL.

TYPICAL APPLICATIONS FOR THE BARE ELEMENT PROBES ARE FOR OILS AND NON-CONDUCTIVE HYDROCARBONS OR SOLIDS. HOWEVER, IT MUST BE NOTED THAT WATER CAN CONDENSE IN TANKS CARRYING NON-CONDUCTIVE MATERIALS. IN OIL OR HYDROCARBON APPLICATIONS, THE CONDENSED WATER SINKS TO THE BOTTOM OF THE TANK, WHERE THE WATER THEN CAN TOUCH THE PROBE AND CAUSE DESTRUCTION OF THE ELECTRONICS.

***NOTE:*** *When measuring a non-conductive material in a non-linear vessel, a concentric shield level probe must be used or the probe must be mounted in a grounded metal standpipe. This is necessary because of the varying distance between the level probe and the vessel wall, which would otherwise cause the probe to generate a non-linear capacitance over its length. If the measured material is conductive and grounded, disregard this note.*

The transmitter may be installed directly onto the level probe (integral mounting) or in a remote location up to 150 feet from the level probe.

***NOTE:*** *Remote mounting is necessary when the temperature at the transmitter exceeds its rated specification (-40 to 160°F) or if severe vibration exists. Triaxial interconnect cable must be used for remote mounting.*

### 2.2.2 Integral Mounting

The transmitter has a 1/2-inch NPT hole on the bottom center of the enclosure for direct mounting onto the installed level probe. Follow these steps to install the level probe and transmitter:

1. Install level probe into vessel opening without the transmitter mounted on it. Use a wrench on the larger, lower hex nut portion only of the two-piece fitting to tighten level probe into vessel.

**CAUTION: Do not tighten or loosen the smaller, upper hex nut portion of the two-piece fitting. This is a compression seal that could be destroyed if the upper portion is turned.**

If the level probe is welded into a mounting flange, simply bolt flange to the mating flange on the vessel.

2. Install banana plug onto back end of level probe extension by screwing it into the threaded hole.

   **CAUTION: Do not tighten plug with excessive force as it can be easily twisted off.**

3. Carefully screw the transmitter enclosure onto threaded upper portion of fitting on back end of level probe. The banana plug makes the necessary electrical connection to the electronic chassis. Screw until tight, but without excessive force to avoid stripping the threads.

   *NOTE: It may be necessary to rotate enclosure to orient wiring entrances to a desired position. Use a wrench to hold the upper, smaller hex nut stationary while turning the enclosure.*

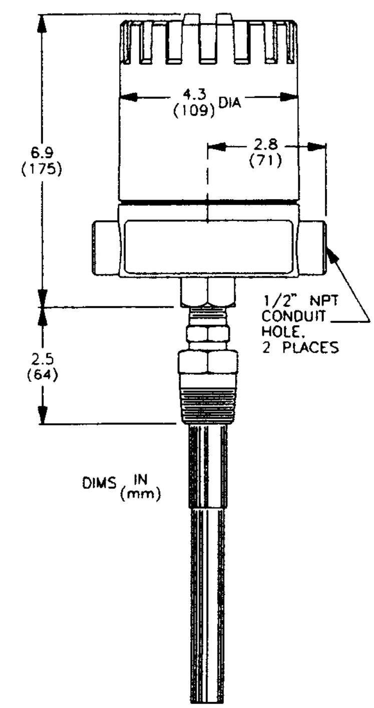



*FIGURE 2-2*
*Integral Mounting*

### 2.2.3 Remote Mounting

An explosion-resistant junction box, which mounts onto the level probe, an optional remote-mount threaded adapter, and triaxial interconnect cable are required to remote mount the transmitter:

1. Install level probe into vessel opening or flange mounting as previously described in Section 2.2.2, step 1.
2. Install banana plug onto back end of level probe extension by screwing it into the threaded hole.

   **CAUTION: Do not tighten plug with excessive force as it can be easily twisted off.**
3. Carefully screw junction box (LV5972) onto threaded upper portion of fitting on back end of level probe. The same "CAUTION" regarding the compression seal that's described in Section 2.2.2 — step 1 applies here when tightening and orienting junction box onto top of level probe.
4. Remote mount the transmitter in as clean and dry a location as possible where minimal mechanical vibration exists. Avoid locations where corrosive fluids may fall on the instrument or where ambient temperature limits (-40 to 160°F, -40 to 71°C) may be exceeded.
5. Install remote-mount threaded adapter (LV5971) into 1/2-inch NPT hole in bottom of enclosure.

   ***NOTE:** The adapter must be a solid fitting if transmitter is housed in aluminum enclosure to preserve the explosion-proof rating. (Should adapter become lost, do not use a pipe nipple in explosionproof installations. Also, use only approved explosionproof wiring seal fittings — not provided — in conduit entrance holes.)*

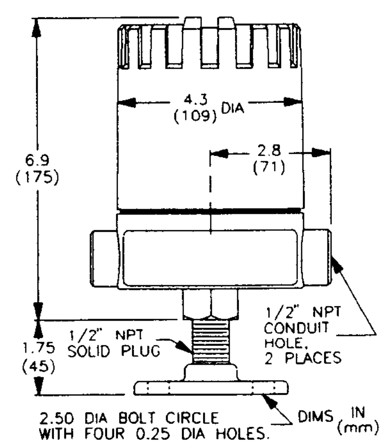



*FIGURE 2-3*
*Remote Mounting*

6. Surface mount the transmitter with the remote-mount threaded adapter within 150 feet of the installed level probe.

# 2.3 - ELECTRICAL CONNECTIONS

## 2.3.1 AC Line-Powered Transmitters

**Level Probe**

- Integrally Mounted

  Connect level probe to the transmitter via the banana plug installed onto back end of probe. The plug must be securely fastened and not damaged.

- Remotely Mounted

  Use only triaxial interconnect cable (LV5974) to connect junction box terminals to the transmitter. Any other type cable causes incorrect instrument operation. Refer to Figure 2-4 and connect triaxial cable, matching wires to terminals as follows:

| Triaxial Cable Wires | Terminal Designations |
|---|---|
| Center wire | PROBE |
| Blue wire (inner braided shield) | SHIELD |
| Green wire (outer braided shield) | Ground symbol |

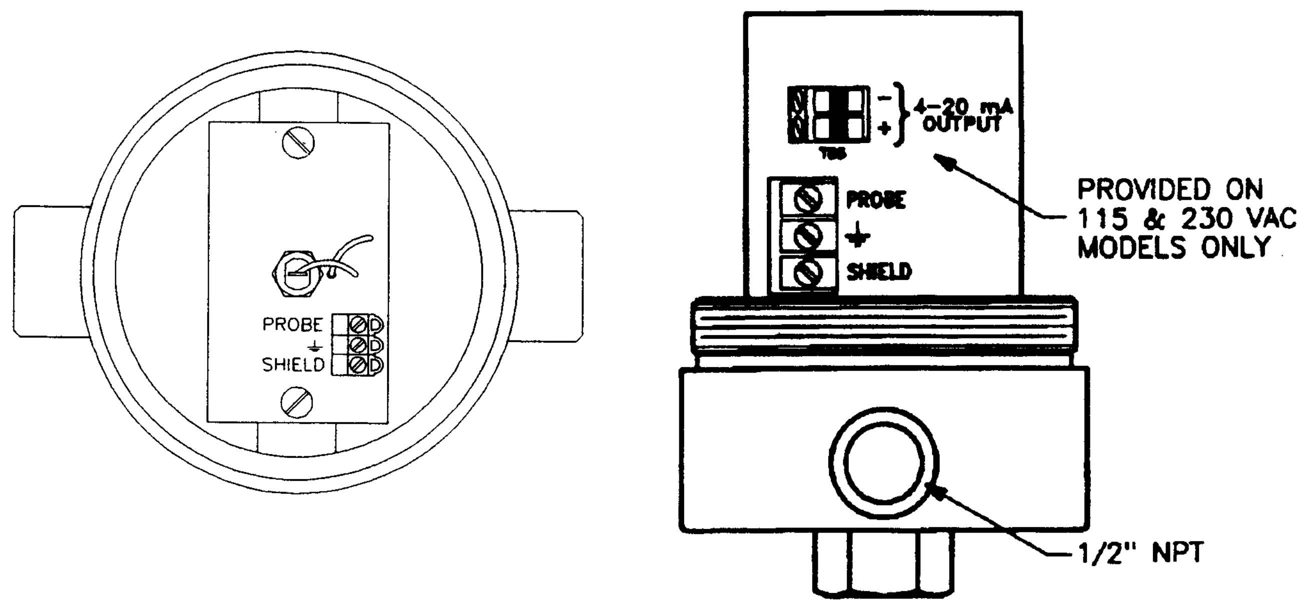



*FIGURE 2-4 Triaxial Cable Hook-Up Between Level Probe J-Box And Remote-Mounted Transmitter*

**4-20 mA Output**

Refer to Figure 2-4 and connect the load device to terminals designated "4-20 mA OUTPUT", matching polarity as indicated. This isolated output can drive a load of up to 600 ohms.

**Line Power**

Line power requirements may be 115 VAC or 230 VAC depending on the version provided. Check which voltage is correct for the unit being installed. Refer to Figure 2-5 and connect line power to terminals designated "L1/HOT" and "N". The "L1/HOT" terminal is fused to protect instrument circuits. Use wiring practices which conform to local codes (National Electrical Code Handbook in the U.S.A.). This includes:

- Using wire sizes as recommended by the local code for primary power wiring.
- Using only the standard three-wire connection for AC wiring. The ground symbol terminal grounds the instrument which is mandatory for safe operation.

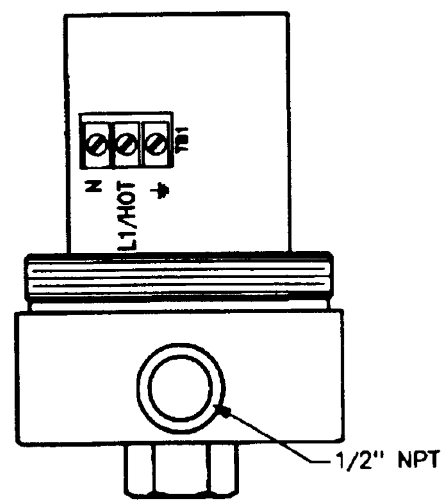



*FIGURE 2-5 AC Line Power Hookup*

Hazardous Area Wiring (transmitter with explosion-resistant enclosure only)

When installing an AC-powered transmitter in a hazardous area, it must be used with an insulated type Model LV5000, LV5100 or LV5500 series level probe. Also, explosionproof-rated conduit, hubs and fittings must be used for all wiring in Div. 1 or Div. 2 areas. This includes the line power and 4-20 mA signal wires.

### 2.3.2 DC-Powered Transmitters

Level Probe

Depending on the way in which the level probe is to be mounted, refer to the "Integrally Mounted" or "Remotely Mounted" subsection in Section 2.3.1.

DC Power and Output

- When Using A Non-indicating Power Supply

  1. Refer to Figure 2-6 and connect non-indicating DC voltage power supply to terminals designated "18-35 VDC", matching polarity as shown.
  2. Connect an indicating device to terminals designated

"4-20 mA OUTPUT", matching polarity as shown. This isolated output can drive a load of up to 550 ohms at 24 VDC.

■ When Using An OMEGA DPF64

1. Connect transmitter "18-35 VDC (+)" terminal to DPF64 #7 terminal.
2. Connect transmitter "4-20 mA (+)" terminal to DPF64 #4 terminal.
3. Connect transmitter "4-20 mA (-)" terminal to DPF64 #3 terminal. This isolated output can drive a load of up to 550 ohms at 24 VDC

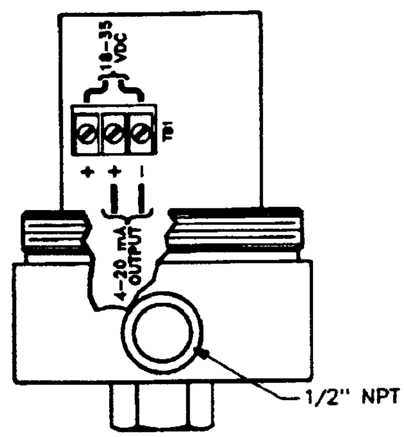



*FIGURE 2-6 DC Power and Output Hookup*

**Hazardous Area Wiring**

A DC-powered transmitter housed in the standard aluminum explosion-resistant enclosure is suitable for use in Div. 1 and Div. 2 hazardous areas. In the optional PVC enclosure, the transmitter is restricted to use in Div. 2 areas only.

When installing a DC-powered transmitter in a hazardous area, the transmitter must be used with an insulated type Model LV5000, LV5100, or LV5500-series level probe and explosion-proof-rated conduit, hubs and fittings must be used for all wiring in Div. 1 or Div. 2 areas.

# SECTION 3 - OPERATION

## 3.1 - OPERATING CONTROLS

All controls used for setup and operation are described in this section. Familiarize yourself with each item before operating the instrument. Use the small plastic screwdriver provided to make control adjustments. Do not force any adjustment past its stops to avoid breakage.

### 3.1.1 Calibration

1. **ZERO COARSE** switch

   Positions 0 through 9 progressively add 50 pF to the **ZERO FINE** control (item 2) adjustment. This switch is used in combination with the **ZERO FINE** control to establish the zero output signal.

2. **ZERO FINE** control

   Sets the exact zero level to 4 mA output. The range of adjustment is 60 pF in 40 turns.

   **CAUTION: Do not force this 40-turn control past its adjustment stops to avoid breakage.**

3. **SPAN COARSE** switch

   Positions 1 through 6 progressively changes the total span from a minimum of 0-10 pF to a maximum of 0-10,000 pF. This switch is used in combination with the **SPAN FINE** control (item 4) to establish the total span.

4. **SPAN FINE** control

   Sets the exact 100% level to 20 mA output. The range of adjustment is 30 turns.

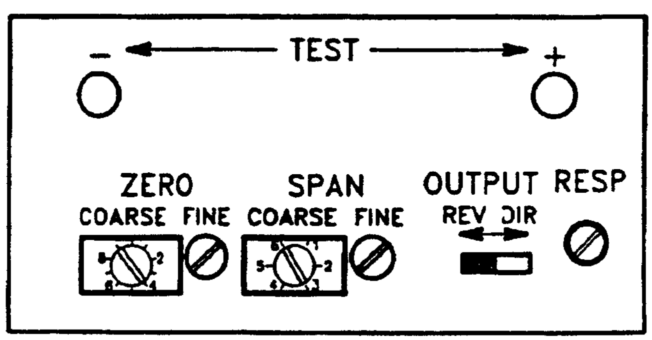



*FIGURE 3-1 Control Panel Layout*

### 3.1.2 Output Mode

5. **REV/DIR** switch

   Selects output to be direct (**DIR**) or inverted (**REV**):

   DIR - Output increases from 4 mA to 20 mA as measured level rises.

   REV - Output decreases from 20 mA to 4 mA as measured level rises.

### 3.1.3 Output Damping

6. **RESP** control

   Dampens output signal via an RC time constant circuit from 0.1 to 10 seconds by turning clockwise (270° rotation).

## 3.2 - CALIBRATION

### 3.2.1 With Output In Direct Acting Mode

Setting The Zero Level Output

With material at the desired low level (0% full) on the level probe:

1. Connect a milliammeter to the transmitter to monitor the 4-20 mA loop current:

   A. Connect milliammeter with test leads to "TEST" jacks located on control panel, matching polarity as indicated.

   B. Connect a load across — or short together — the "4-20 mA OUTPUT" terminals. See Section 1.2 specifications for maximum allowable load resistance.

   ***NOTE:*** *If milliammeter resistance is more than 25 ohms, disregard steps 1 and 2. Instead, connect milliammeter in series with a load across the "4-20 mA OUTPUT" terminals. Do not exceed maximum allowable load resistance.*

2. Place the following controls and switches to these settings:

| Control | Setting |
|---|---|
| **ZERO COARSE** switch | **0** |
| **ZERO FINE** control | Fully counterclockwise |
| **SPAN COARSE** switch | **1** |
| **SPAN FINE** control | Fully counterclockwise |
| **REV/DIR** switch | **DIR** |
| **RESP** control | Fully counterclockwise |

**CAUTION: The ZERO FINE control is a glass compo-**

**nent. To avoid breakage, do not force it past its 40-turn minimum and maximum adjustment stops.**

*NOTE: The **SPAN FINE** control does not have adjustment stops. To set it to the end of its travel, slowly turn counterclockwise (left) until a "soft clicking" sound is heard while turning.*

3. Apply power to the instrument. The milliammeter reading should be 20 mA or higher.

4. Increase **ZERO COARSE** switch setting in clockwise steps until the milliammeter reads 4 mA or lower. Then turn switch back (counterclockwise) one position step. The output should increase to 20 mA or higher again. Leave **ZERO COARSE** switch at this setting. If switch is at position **9** and output is not yet at 4 mA or lower, leave at setting 9.

5. Turn **ZERO FINE** control slowly clockwise (right) until the milliammeter reads exactly 4 mA. This is the output at 0% full level. Leave **ZERO FINE** control at this setting. If output cannot be adjusted to 4 mA, the zero adjustment range has been exceeded. Consult OMEGA for assistance.

# # #

**Setting The Full Level Output**

1. Change **SPAN COARSE** switch setting from **1** to **6** and **SPAN FINE** control setting from fully counterclockwise to fully clockwise (approximately 30 turns).

2. Manually raise the measured material level up to the desired "full level" position on the level probe. The milliammeter reading should be less than 20 mA. If the reading is higher than 20 mA, the level probe has produced a capacitance change greater than the maximum span of the instrument. This is unlikely, except in cases where the level probe is very long and submerged in a conductive material.

   *NOTE: If the material level cannot be raised up to the desired full level position, refer to the "special case" box on the next page for instructions.*

3. Decrease **SPAN COARSE** switch setting in counterclockwise steps until the milliammeter reads higher than 20 mA. Then turn switch forward (clockwise) one position step. The output should decrease below 20 mA again. Leave **SPAN COARSE** switch at this setting. If switch is at position **1** and output is still below 20 mA, leave at setting 1 and proceed with step 4.

4. Turn **SPAN FINE** control slowly counterclockwise (left)

until the milliammeter reads exactly 20 mA. This is the output at 100% full level. Leave **SPAN FINE** control at this setting. If output cannot be adjusted to 20 mA, the capacitance change produced by the level probe is less than the minimum measurement span. Consult OMEGA for assistance.

The instrument is now calibrated.

SPECIAL CASE FOR SETTING FULL LEVEL OUTPUT

It may not be possible to raise the material level up to the desired "full level" position due to lack of sufficient material. In this case:

A. Bring as much material into the vessel as possible. Then calculate the actual level as a percentage of the total level span and, using the following formula, convert this value to mA on a 4-20 mA scale.

$$mA = (\% \text{ actual level} \times 16) + 4$$

Example: Actual level is 50% of full level. Therefore,
$mA = (50\% \times 16) + 4 = 12\ mA$
Output at this 50% level is 12 mA.

B. Perform steps 3 and 4 exactly as previously described except using the appropriate calculated mA value instead of 20 mA (12 mA for this example).

***NOTE:*** *Calibration using less than a 25% full span level change is not recommended. It may be necessary to recalibrate the full level at a later time when the vessel is full.*

Adjusting Output Signal Damping

Output damping is provided to damp a constantly changing output signal caused by turbulent material level. Turning the **RESP** control clockwise (right) increases the damping from 0.1 to 10 seconds. Turn this control slowly clockwise until any output ripple is no longer evident.

### 3.2.2 With Output In Reverse Acting Mode

The switch and control settings described in Section 3.2.1 are exactly the same except set the **REV/DIR** switch to the **REV** position.

The calibration procedure is exactly the same as in the direct acting mode except that 20 mA is substituted for 4 mA, and 4 mA is substituted for 20 mA wherever referenced.

# SECTION 4 - PRINCIPLE OF OPERATION

See Figure 4-1 for a simplified schematic diagram pertaining to these descriptions:

1. The power supply section (not shown) converts line power to appropriate voltages for circuit operation.
2. The OSCILLATOR section produces the triangle wave signal used to measure the probe impedance and several square wave signals used to synchronize other parts of the circuit.

   A voltage-controlled square wave oscillator operates at a frequency four times that of the measuring signal. Two "flip-flops" divide the oscillator frequency and produce four square waves with a 90° phase difference between each successive signal. One of these square waves is applied through a resistor to a capacitor. The result, a low-voltage triangle wave with low distortion, becomes the SHIELD signal.

   The SHIELD signal is gated with analog switches controlled by two of the square wave signals to a differential

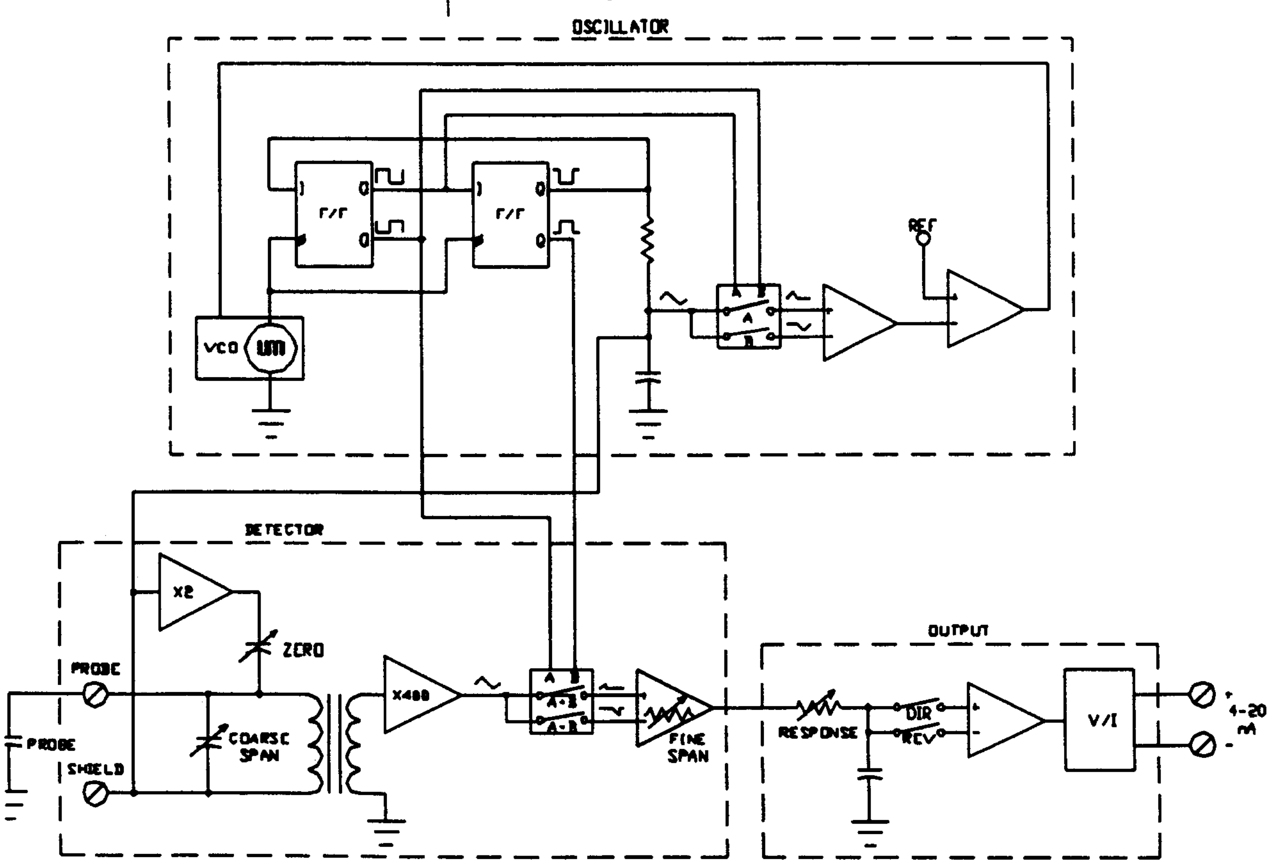



*FIGURE 4-1 Instrument Operations Schematic Diagram*

amplifier which produces an output voltage proportional to the peak-to-peak voltage of the SHIELD signal. This voltage is compared to a reference voltage by another differential amplifier which produces an output voltage that is used to adjust the frequency of the voltage controlled oscillator. If the SHIELD voltage is too low, the amplifier output increases. This increases the period of the signal which allows the capacitor to charge to a higher voltage. The reverse occurs if the voltage is too high. This feedback circuit maintains a constant SHIELD signal voltage and compensates for any circuit drift and for any capacitance at the SHIELD terminal from any cable connected there.

3. In the DETECTOR section, the SHIELD signal voltage is amplified and applied to an adjustable ZERO capacitor which is connected to the PROBE terminal. The probe forms a variable capacitor to ground. A large adjustable SPAN capacitor is connected between the PROBE and SHIELD terminals. Since the impedance of the SPAN capacitor is much lower than that of the ZERO or PROBE capacitors, the voltage on the PROBE terminal is approximately equal to the voltage on the SHIELD terminal. When the ZERO and PROBE capacitors are equal, no current flows through the SPAN capacitor. As the PROBE capacitance increases due to increasing level in the vessel, current through the SPAN capacitor increases. This current produces a very small voltage across the capacitor which is transformer coupled to the input of a high-gain amplifier.

   The output of the amplifier is gated by analog switches to a differential amplifier which produces a voltage proportional to the capacitance difference. The harmonic content of the triangle wave signal and the operation of the analog switches allow the circuit to ignore the effect of probe buildup. The differential amplifier includes a FINE SPAN adjustment which controls its gain.

4. The OUTPUT section includes an adjustment to vary the unit's response time to allow it to produce a steady output signal even when there is turbulence in the vessel. A switch controls whether or not the resulting signal is inverted before being converted to an output current. If the signal is not inverted, the output is direct acting and will increase with rising level. If inverted, the output is reverse acting (decreases with rising level).

# SECTION 5 - SERVICE AND MAINTENANCE

## 5.1 - GENERAL

The electronic chassis assembly is held into the enclosure with two screws in the bottom of the chassis. These are accessible from the sides of the chassis.

Replacement of circuit board components should be performed by a qualified technician. Otherwise, return the entire chassis assembly to the factory after obtaining a return authorization. If possible, include a brief description of the trouble symptoms.

In some applications it may be necessary to clean the level probe periodically.

## 5.2 - TROUBLESHOOTING

The following simple checks can be used to determine if the transmitter is operating properly:

1. Calibrate the transmitter using the procedure in Section 3.2. If calibration is accomplished, the system is operating properly. If not, perform step 2.
2. Remove the transmitter from the level probe. With the unit powered, the **REV/DIR** switch in the **DIR** position and any load(s) disconnected from the output circuit, the transmitter's output should be less than 4 mA. Now short the probe and ground symbol terminals together and the output should increase to more than 20 mA. If these checks are accomplished, the transmitter is probably okay but the level probe may be defective (see step 3).
3. Perform the following checks to find common problems with a level probe:
   - Check that the banana plug on the back of the level probe is installed and not damaged.
   - Check that the probe's mounting gland is sealed together properly and that there is no moisture in the gland which could cause a short circuit.
   - Check that the level probe is not shorted to the mounting gland (resistance should be greater than 1 megohm).
   - If the probe is an insulated type, check for nicks in the insulation and that the weld at the probe tip is intact.

***NOTE:*** *Do not use Teflon tape or any other pipe sealant on the 1/2-inch NPT threaded upper portion of the mounting gland. This connection must provide a good ground.*

4. If the previous steps have determined that the transmitter and level probe are operating properly, the system may be incorrectly applied. For example, a non-insulated level probe will not work in conductive material, or an insulated level probe will not work with conductive material in lined metal or plastic vessels that are not properly grounded. Contact OMEGA for application assistance.

Should service, parts or assistance in troubleshooting or repair be required, please contact the OMEGA Customer Service Department at 1-800-622-2378 or (203)359-1660.

# SECTION 6 - SPARE PARTS AND ACCESSORIES

| | Description | Part Number |
|---|---|---|
| Accessories For Remote Mounting | Threaded Adapter | LV5971 |
| | Explosion-resistant Junction Box (with jack and terminal strip) | LV5972 |
| | Triaxial Interconnect Cable* | LV5974 |
| | *Cable has stripped and tinned wires at each end. It connects transmitter to level probe j-box. Specify length up to 150 feet. | |
| Electronic Chassis Assemblies | DC-Powered Transmitter (18-35 VDC) | 7005-101 |
| | 115 VAC Line-Powered Transmitter (four-wire) | 7005-201 |
| | 230 VAC Line-Powered Transmitter (four-wire) | 7005-401 |
| Fuse | 1/4 Amp Slo-blow Fuse | 99X1F1036 |

# LV5000 General Purpose Level Sensing Elements

- Bare and Insulated Probes for Radio Frequency Capacitive Level Measurement
- Custom Extruded Insulation Minimizes Air Encapsulation and Capacitance Variation
- Captive Sensing Element for Safe Operation in Pressurized Vessels
- Low Cost Probes for Liquid and Granular Materials

The OMEGA LV5000 general purpose sensing elements are used with the LV5900 RF capacitive transmitters for continuous monitoring of levels in tanks. They are used in common applications for many chemically compatible liquids or granular solids which do not leave a conductive coating on the probe surface. General purpose level sensing probes are available with 316SS or Hastelloy C wetted metal parts. The electrode must be coated with TFE Teflon, PVDF (Kynar), or polyethylene for use with conductive (10 microMhos/cm or greater) fluids. (Typical process water, excluding purified, distilled, or deionized water, will be much more conductive than this.) The electrode portion of the standard insulated probe is 316SS, which would not be wetted. The LV5000 General Purpose probes are *not* recommended for use in materials which tend to form a conductive film on the electrode surface. (Use the LV5200 enhanced performance elements in such cases.) Water-based latex paint, fine carbon powder, or fine metallic powders are examples of materials that leave conductive coatings on the probes. An optional sheath can be specified to render a portion of the electrode inactive where the probe will be mounted through a nozzle and fluid contact is possible.

**To Order** *(Specify Model No. plus options for X, Y and Z)*

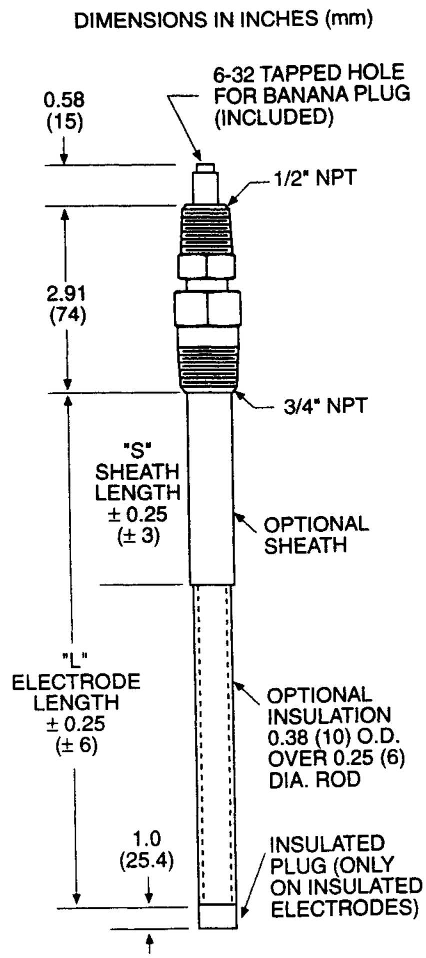
| Model No. | Description |
|---|---|
| LV500X-Y-(LENGTH)-Z* | General purpose, 316SS |
| LV501X-Y-(LENGTH)-Z* | General Purpose, Hastelloy C electrode for insulated element is 316SS unless otherwise specified |

**Insert appropriate ordering suffixes for "X," "Y," and "Z" from the chart below, to complete model number. Specify all lengths in inches. Maximum length is 234 inches.*

**Options**

| Ordering Suffix | Description |
|---|---|
| **X - Insulation Options** | |
| 0 | Bare element- no insulation |
| 1 | TFE Teflon |
| 2 | PVDF(Kynar) |
| 3 | Polyethylene |
| **Y - Ground Wire** | |
| Y0 | No ground wire |
| Y1 | 316SS ground wire |
| Y2 | Hastelloy C ground wire |
| **Z - Sheath** | |
| Z0 | No sheath required |
| Z(#) | Sheath length in inches |

# LV5000 Dimensions




**SPECIFICATIONS**

| | |
|---|---|
| Wetted Materials: | 316SS or Hastelloy C; optionally TFE Teflon, PVDF (Kynar) or Polyethylene |
| Maximum Temperature: | TFE Teflon, 450°F (232°C); PVDF (Kynar), 250°F (121°C); Polyethylene, 160°F (71°C) |
| Maximum Pressure: | TFE Teflon, 1000 PSIG @ 150°F, derated to 0 PSIG @350°F; PVDF (Kynar), 1000 PSIG @ 100°F, derated to 0 PSIG @ 250°F Polyethylene, 1000 PSIG @ 80°F, derated to 0 PSIG @140°F |
| Gland Capacitance: | 25pF (for TFE Teflon) |
| Recommended Maximum Probe Length: | 19.5 feet (use LV5300 cable element for longer lengths) |
| Connection: | 3/4" NPT 316SS or Hastelloy C |
| Electrode Diameter: | Bare, 1/4"; Insulated, 3/8" |

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Kynar is a trademark of Pennwalt Corp.

# LV5100 Heavy Duty Level Sensing Elements

- Bare and Insulated Probes for Radio Frequency Capacitive Level Measurement
- Custom Extruded Insulation Minimizes Air Encapsulation and Capacitance Variation
- Captive Sensing Element for Safe Operation in Pressurized Vessels
- Stronger Version of the General Purpose Probe for Most Liquid and Granular Materials

The OMEGA LV5100 heavy duty sensing elements are used with the LV5900 RF capacitive transmitters for continuous monitoring of levels in tanks. They are used in common applications for many chemically compatible liquids or granular solids which do not leave a conductive coating on the probe surface. Heavy duty level sensing probes are available with 316SS or Hastelloy C wetted metal parts. The electrode can be coated with TFE Teflon or PVDF (Kynar) for use with conductive (10 microMhos/cm or greater) fluids. (Typical process water, excluding purified, distilled, or deionized water, will be much more conductive than this.) The electrode portion of the standard insulated probe is 316SS, which would not be wetted. The LV5100 heavy duty probes are *not* recommended for use in materials which tend to form a conductive film on the electrode surface. (The LV5200 enhanced performance elements can be used in such applications.) Water-based latex paint, fine carbon powder, or fine metallic powders are examples of materials that leave conductive coatings on the probes. An optional sheath can be specified to render a portion of the electrode inactive where the probe will be mounted through a nozzle and fluid contact is possible.

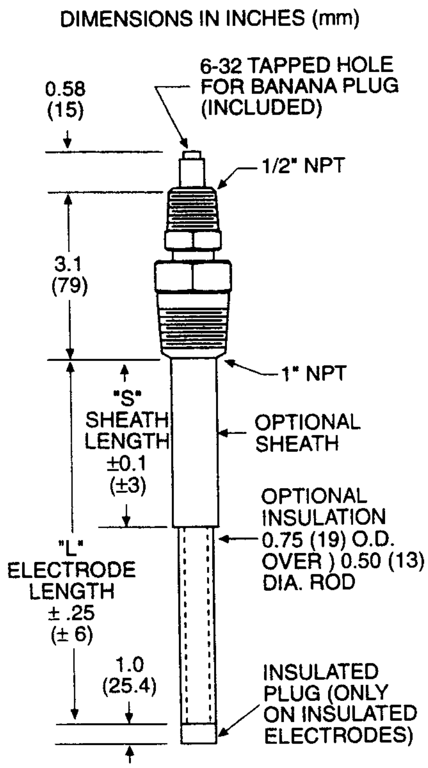
| To Order (Specify [illegible]) | |
|---|---|
| Model No. | [illegible] |
| **LV510X-Y-(LENGTH)-Z*** | General purpose, 316SS |
| **LV511X-Y-(LENGTH)-Z*** | General purpose, Hastelloy C electrode for insulated element is 316SS unless otherwise specified. |

**Insert appropriate ordering suffixes for "X," "Y," and "Z" from the chart below, to complete model number. Specify all lengths in inches. Maximum length is 234 inches.*

### Options

| Ordering Suffix | Description |
|---|---|
| **X - Insulation Options** | |
| **0** | Bare element- no insulation |
| **1** | TFE Teflon |
| **2** | PVDF(Kynar) |
| **Y - Ground Wire** | |
| **Y0** | No ground wire |
| **Y1** | 316SS ground wire |
| **Y2** | Hastelloy C ground wire |
| **Z - Sheath** | |
| **Z0** | No sheath required |
| **Z(#)** | Sheath length in inches |

# LV5100 Dimensions




**SPECIFICATIONS**

| | |
|---|---|
| Wetted Materials: | 316SS or Hastelloy C; optionally TFE Teflon or PVDF (Kynar) |
| Maximum Temperature: | TFE Teflon, 450°F (232°C); PVDF (Kynar), 250°F (121°C) |
| Maximum Pressure: | TFE Teflon, 1000 PSIG @ 150°F, derated to 0 PSIG @350°F; PVDF (Kynar), 1000 PSIG @ 100°F, derated to 0 PSIG @ 250°F |
| Gland Capacitance: | 42pF (for TFE Teflon) |
| Recommended Maximum Probe Length: | 19.5 feet (use LV5300 cable element for longer lengths) |
| Connection: | 1" NPT 316SS or Hastelloy C |
| Electrode Diameter: | Bare, 1/2"; Insulated, 3/4" |

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Kynar is a trademark of Pennwalt Corp.

# LV5200 Enhanced Performance Level Sensing Elements

- Bare and Insulated Probes for Radio Frequency Capacitive Level Measurement
- Custom Extruded Insulation Minimizes Air Encapsulation and Capacitance Variation
- Captive Sensing Element for Safe Operation in Pressurized Vessels
- Thin Wall Insulation for Reduced Conductive Coating Error

The OMEGA LV5200 enhanced performance sensing elements are used with the LV5900 RF capacitive transmitters for continuous monitoring of levels in tanks. They are used in applications for many chemically compatible liquids or granular solids. Enhanced performance level sensing probes are available with 316SS or Hastelloy C connections which should be considered as wetted metal parts. The electrode is coated with a thin coat of PFA Teflon or PVDF (Kynar). The sensing portion inside the standard insulated probe is 316SS, which would not be wetted. The LV5200 probes are most advantageous in materials which tend to form a conductive film on the element surface. Water-based latex paint, fine carbon powder, or fine metallic powders are examples of materials that leave conductive coatings on the probes. An optional sheath can be specified to render a portion of the element inactive where the probe will be mounted through a nozzle or pipe extension.

**To Order** *(Specify Model No.)*

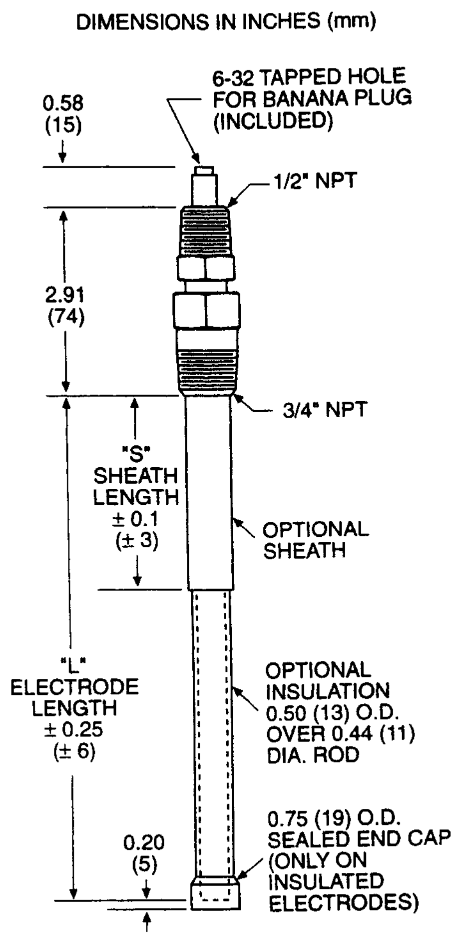
| Model No. | Description |
|---|---|
| LV520X-Y-(LENGTH)-Z* | Enhanced Performance, 316SS |
| LV521X-Y-(LENGTH)-Z* | Enhanced Performance, Hastelloy C electrode for insulated element is 316SS unless otherwise specified |

**Insert appropriate ordering suffixes for "X," "Y," and "Z" from the chart below, to complete model number. Specify all lengths in inches. Maximum length is 138 inches.*

**Options**

| Ordering Suffix | Description |
|---|---|
| **X - Insulation Options** | |
| 0 | Bare element- no insulation |
| 2 | PVDF (Kynar) |
| 4 | PFA Teflon |
| **Y - Ground Wire** | |
| Y0 | No ground wire |
| Y1 | 316SS ground wire |
| Y2 | Hastelloy C ground wire |
| **Z - Sheath** | |
| Z0 | No sheath required |
| Z(#) | Sheath length in inches |

# LV5200 Dimensions




**SPECIFICATIONS**

| | |
|---|---|
| Wetted Materials: | 316SS or Hastelloy C and PFA Teflon or PVDF (Kynar) |
| Maximum Temperature: | PFA Teflon, 450°F (232°C); PVDF (Kynar), 250°F (121°C) |
| Maximum Pressure: | PFA Teflon, 1000 PSIG @ 150°F, derated to 0 PSIG @350°F; PVDF (Kynar), 1000 PSIG @ 100°F, derated to 0 PSIG @ 250°F |
| Gland Capacitance: | 38pF (for PFA Teflon) |
| Recommended Maximum Probe Length: | 11.5 feet (use LV5300 cable element for longer lengths) |
| Connection: | 3/4" NPT 316SS or Hastelloy C |
| Electrode Diameter: | Bare, N/A; Insulated, 7/16" electrode and 1/2" O.D. |

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Kynar is a trademark of Pennwalt Corp.

# LV5300 Flexible Cable Level Sensing Elements

- Insulated and Bare Cables for Radio Frequency Capacitive Level Measurement
- Measures Levels up to 500 Feet Maximum for Most Liquid and Granular Material (2000 feet for LV5603)
- Aircraft Quality Stainless Wire Rope Construction

The OMEGA LV5300 and LV5603 flexible cable sensing elements are used with the LV5900 RF capacitive transmitters for continuous monitoring of levels in tanks. They are used in non-coating fluid applications which require measurements greater than 10 feet in depth. The LV5300 sensing elements are available as bare 316SS wire rope and may be insulated with PFA Teflon, PVDF (Kynar), or polyethylene. The LV5603 is only available with polyethylene insulation. The LV5603 is designed for use in deep well applications, but can also be used as a lower cost alternative in non-coating liquid, granular, and interface applications. The flexible cable elements are *not* recommended for use in materials which tend to form a conductive film on the electrode surface. Water-based latex paint, fine carbon powder, or fine metallic powders are examples of materials that leave conductive coatings on the probes. Termination fittings are machine swaged to exceed the breaking strength of the flexible cable section. Optional spiral-wrapped ground wires are available for use in irregularly shaped vessels. A metal tie-down fitting can be specified (LV5300 only) for granular applications or plastic tie-down for liquids.

**To Order** *(Specify Model No.)*

| Model No. | Description |
|---|---|
| LV530X-Y-(LENGTH)-Z* | Flexible Cable, 316SS |
| LV5603-(LENGTH)* | Flexible Cable, 316SS & Polyethylene |

**Insert appropriate ordering suffixes for "X," "Y," and "Z" from the chart below to complete model number. Specify cable lengths in feet. Maximum length is 5000 feet for LV5300, 5000 feet for LV5603.*

| Ordering Suffix | Description |
|---|---|
| **X - Insulation Options (LV5300 only, except polyethylene)** | |
| 0 | Bare element- no insulation |
| 2 | PVDF(Kynar ) |
| 3 | Polyethylene |
| 4 | PFA Teflon |
| **Y - Ground Wire (model LV5300 only)** | |
| Y0 | No ground wire |
| Y1 | 316SS ground wire |
| Y2 | Hastelloy C ground wire |
| **Z - Tie-Down Fitting (plastic must match insulation)** | |
| — | LV5603 has plastic cylinder termination |
| TSS | 316SS (for granular materials) |
| TPV | PVDF |
| THD | HDPE-high density polyethylene |
| TPF | PFA Teflon |

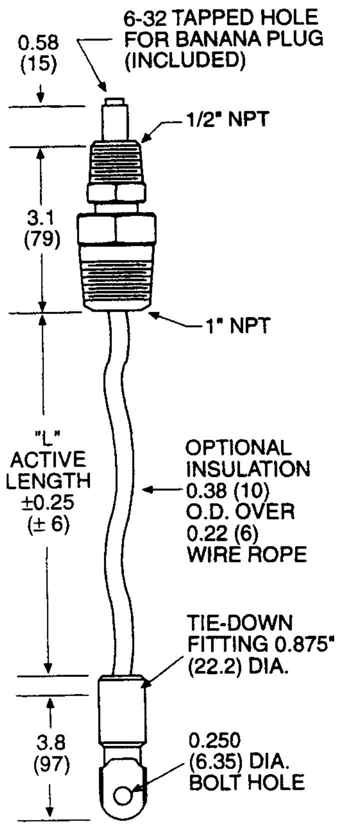
**Accessory Weights (for LV5300)**

| Model No. | Diameter | Weight |
|---|---|---|
| LV53W10225 | 1″ | 2.25 lbs (1 kg) |
| LV53W10550 | 1″ | 5.50 lbs (2.5 kg) |
| LV53W15225 | 1.5″ | 2.25 lbs (1 kg) |
| LV53W15550 | 1.5″ | 5.50 lbs (2.5 kg) |

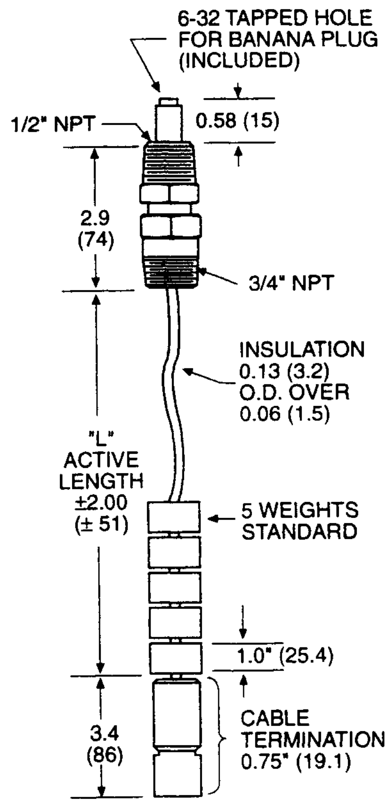
*Note- use 5.50 lbs weight for cables 20 feet or shorter.*

| LV5300 | LV5603 |
|---|---|

DIMENSIONS IN INCHES (mm)




DIMENSIONS IN INCHES (mm)




## SPECIFICATIONS

| | |
|---|---|
| Wetted Materials: | 316SS, optionally: PVDF (Kynar), Polyethylene (low density), or PFA Teflon; (316SS and Polyethylene only for LV5603) |
| Maximum Temperature: | Bare 316SS, PFA Teflon, 350°F (176°C); PVDF (Kynar), 250°F (121°C); Polyethylene, 140°F (60°C) |
| Accessory Weights: | 316SS for LV5300 (to hold down cable) |
| Normal Pressure: | PFA Teflon, 1000 PSIG @ 150°F, derated to 0 PSIG @ 300°F; PVDF (Kynar), 1000 PSIG @ 100°F, derated to 0 PSIG @ 250°F; Polyethylene, 1000 PSIG @ 80°F, derated to 0 PSIG @ 140°F |
| Gland Capacitance: | 25 pF for PFA Teflon; (35pF for LV5603) |
| Cable Length: | Maximum 5000 feet for LV5300; 5000 feet for LV5603 |
| Diameter of Cable: | 7/32" bare, 3/8" insulated; (1/8" insulated for LV5603) |
| Lower Termination: | 316SS for granular applications, PFA Teflon or PVDF (Kynar) for liquid applications; (HDPE only for LV5603) |
| Mounting Connection: | 1" NPT 316 SS; (3/4" NPT for LV5603) |
| Break Strength: | Metal tie-down, 5000 lbs, plastic tie-down, 200 lbs; plastic termination, 200 lbs for LV5603 |

# LV5500 Concentric Shield Level Sensing Elements

- Concentric Shield for Plastic Tanks or Vessels with Irregular Shape
- Shields Enable Calibration Outside of Tank
- Custom Extruded Insulation Minimizes Air Encapsulation and Variation in Capacitance

The OMEGA LV5500 concentric shield sensing elements are used with the LV5900 RF capacitive transmitters for continuous monitoring of levels in tanks. The LV5500 probes are used in clean, low viscosity liquid applications which do not leave a conductive coating on the probe. The concentric shield level sensing probes are constructed with 316SS connections and shields. The metal shield provides a linear ground reference for applications in which non-conductive liquids are contained in irregularly shaped and/or plastic vessels. The electrode inside the shield is insulated with TFE Teflon, PVDF (Kynar), or polyethylene.

Due to the close proximity of the shield to the measuring electrode, these level sensing elements produce a high capacitance change with level variation. The concentric shield also makes it possible to pre-calibrate the electronics outside the main vessel using the same material to be measured.

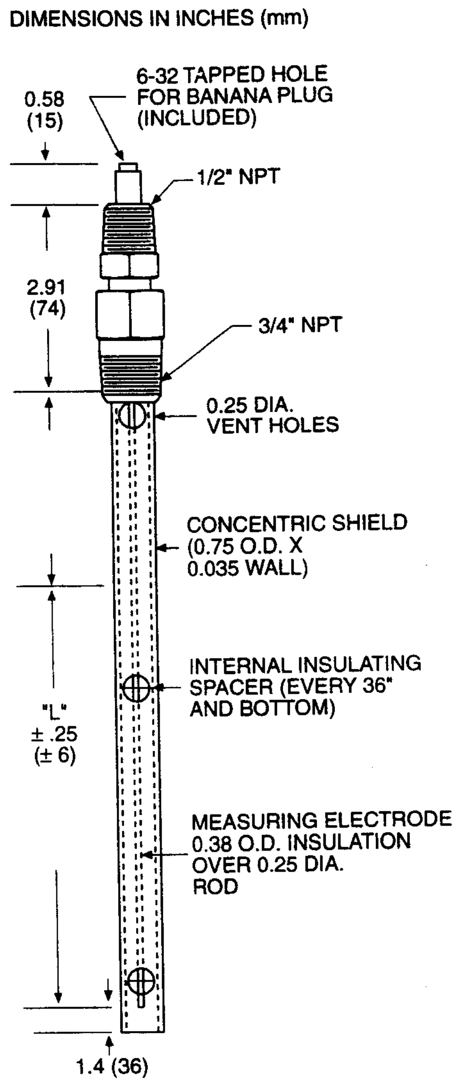
**To Order** *(Specify Model No.)*

| Model No. | Description |
|---|---|
| LV550X-(LENGTH*) | Concentric Shield element |

**Insert appropriate ordering suffix for "X" from the chart below to complete model number. Specify all lengths in inches. Maximum length is 138 inches.*

| Ordering Suffix | Description |
|---|---|
| **X - Insulation Options** | |
| 1 | TFE Teflon |
| 2 | PVDF(Kynar) |
| 3 | Polyethylene |

# LV5500 Dimensions




**SPECIFICATIONS**

| | |
|---|---|
| Wetted Materials: | 316SS and TFE Teflon, PVDF (Kynar), or Polyethylene |
| Maximum Temperature: | TFE Teflon, 450°F (232°C); PVDF (Kynar), 250°F (121°C)<br>Polyethylene 140°F (60°C) |
| Maximum Pressure: | TFE Teflon, 1000 PSIG @ 150°F, derated to 0 PSIG @350°F;<br>PVDF (Kynar), 1000 PSIG @ 100°F, derated to 0 PSIG @ 250°F<br>Polyethylene, 1000 PSIG @ 80°F, derated to 0 PSIG @ 140°F |
| Gland Capacitance: | 25pF (for TFE Teflon) |
| Recommended Maximum Probe Length: | 11.5 feet (use LV5300 cable element for longer lengths) |
| Connection: | 3/4" NPT 316SS |
| Electrode Diameter: | Concentric shield 3/4" O.D.; 3/8" O.D. insulation on 1/4" 316SS rod |

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Kynar is a trademark of Pennwalt Corp.

**OMEGA® APPLICATION NOTE** DOCUMENT #9001

# Interface Level Measurement and Control

**Introduction**

One of the unique capabilities of RF level measuring instrumentation is to indicate and/or control an interface between two immiscible liquids, each having a different dielectric constant.

Oil/water interface measurement is a common application of this type. The LV5900 series of continuous level transmitters provides an analog output proportional to the position of the interface on a vertically-mounted electrode.

It is important to note that a vertically-mounted electrode must be fully submerged at all times to provide correct interface detection. If it isn't, the electrode will be exposed to two interfaces; the first being between air or a gas and the upper phase material, and the second being between the low and high dielectric constant liquids.

The zero is calibrated when the probe is completely submerged in the low dielectric constant liquid. The 100% point is established using the span adjustment when the entire electrode is submerged in the high dielectric constant liquid. In the oil/water example, as the interface rises on the electrode, a greater percentage of it is submerged in the higher dielectric constant liquid. This causes an increase in the capacitance generated and a corresponding increase in the output signal.

To ensure that the measuring section of the electrode is always fully submerged, a metal sheath of sufficient length may be included on the probe. The sheath renders that portion of the electrode insensitive to capacitance change and variation and the top level is ignored. Another common approach is to arrange a control system and a tank overflow so that the upper level remains constant.

**Important Considerations**

1. **Quality of the Interface**—Some materials do not form a distinct interface, but instead form an emulsion layer between the two materials. Calibration of the 0% and 100% points can be made by establishing a desired position in the emulsion layer.
2. **Agitation**—No interface will occur if the material in the vessel is agitated. The use of a stilling well may be required. Allow the material to settle before performing calibrations.
3. **Dielectric Constants**—Usually the two immiscible materials forming an interface will have widely differing dielectric constants. Check Capacitance vs. Dielectric Constant charts for each material to ensure a total capacitance change of at least 10 pF, but not greater than 10,000 pF for transmitter applications.
4. **Grounding**—In plastic vessels, it is necessary to electrically ground the conductive phase.

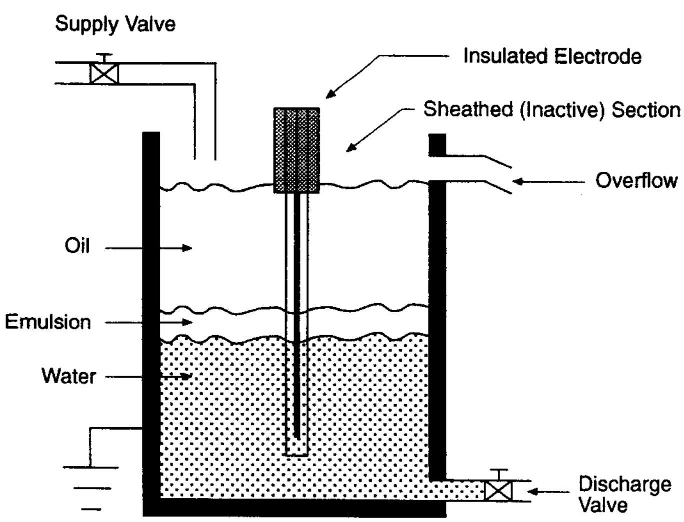



**Figure 1**

**Continuous Level Interface Detection**

# RF Level Measurement In Lined Vessels With Grounded Shell

## Introduction

Storage and process vessels for containing highly corrosive liquids are fabricated of metal, fiberglass or other plastic materials depending on the pressure rating required. The application of RF level measuring instrumentation in these vessels requires some special considerations and techniques for successful results. While there are some similarities between level applications in lined vessels and plastic vessels, the implementation techniques are different.

For corrosion resistance, metal vessels are generally lined with rubber, glass or plastic rather than fabricating the vessel of an expensive, and perhaps exotic metal. Various techniques are employed to line vessels. These include spray or brush-on coatings, heat fusion and sheet or film linings cemented in place with welded plastic seams.

Most, but not all, of the materials stored or processed in these vessels are electrically conductive. Hydrochloric, sulfuric and hydrofluoric acids and caustic in various concentrations are common applications.

## Non-Conductive Materials

In a lined metal vessel (Figure 1), the capacitive measurement path is from the metal electrode through the electrode insulation (CI), then through the measured material (CM) and finally through the liner (CL) to the electrically grounded metal shell of the vessel.

The total capacitance measured between the metal electrode and the grounded metal vessel depends on the individual capacitances of the electrode insulation (CI), the measured material (CM) and the vessel liner (CL). This formula is:

$$C_T = \frac{C_I \times C_M \times C_L}{C_I C_M + C_I C_L + C_M C_L}$$

This formula becomes more complex if one substitutes the dielectric constants of each material into the formula, but the net result will show that the changing capacitance measured will be directly proportional to the changing level of the material in the vessel.

If the vessel is a horizontal cylinder or irregularly shaped, the measured capacitance with respect to level on the sensor will not be linear because of the variable distance between the electrode and the vessel wall. One way to solve this problem is to place a grounded, concentric tube around the measuring sensor. If corrosion problems or the high cost of the tube makes this choice undesirable, an alternate solution is to use another insulated electrode parallel to the measuring sensor. This reference electrode must be grounded (perhaps to the grounded metal vessel) and kept at a constant distance from the measuring sensor using insulated spacers.

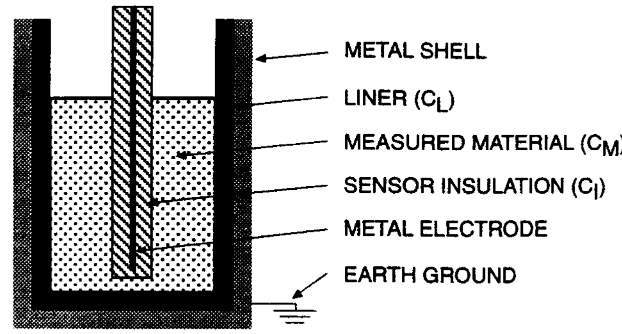



**Figure 1 Capacitive Measurement Path In Lined Metal Vessel**

## Conductive Materials

The total capacitance output of the sensor in a conductive media is still a function of two capacitors in series: sensor insulation (CI) and vessel liner (CL). The measured material (CM) is effectively eliminated from the capacitance equation because the conductive material has virtually no ability to store a charge. The total capacitance of a conductive fluid or solid is approximated by the following equation:

$$C_T = \frac{C_I \times C_L}{C_I + C_L}$$

The capacitance of an electrode varies with the choice of insulation. Table A shows the saturation capacitance for a variety of OMEGA level sensors. Note that saturation capacitance is the highest capacitance generated by an electrode which occurs in an infinitely conductive material. An enhanced performance electrode with PVDF insulation has 950 pF per immersed foot, while a general purpose electrode with TFE insulation has 76 pF per immersed tool.

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 (CL) 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

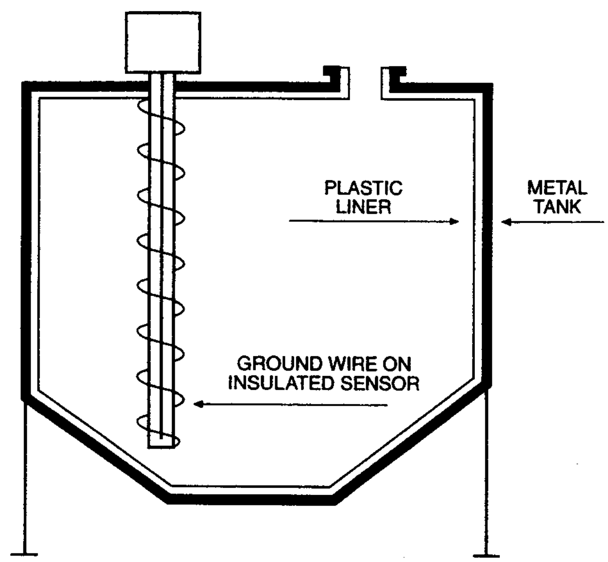
| Measured Material Not Grounded | Measured Material Grounded |
|---|---|
| $C_T = \frac{76 \times 15,000}{15,076} = 75.6\ pF/ft.$ | $C_T = C_I = 76.0\ F/ft.$ |

\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 $C_I$.

The significance of 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.

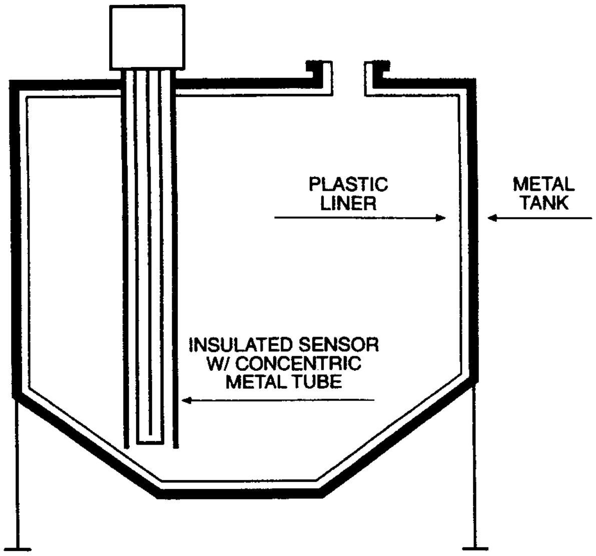
If one is not certain that the material will never get grounded accidentally, ALWAYS INTENTIONALLY GROUND THE MEASURED MATERIAL. This eliminates CL from the measurement and prevents changes in capacitance caused by inadvertent grounding. The following methods of ground are recommended.

### Grounding Methods

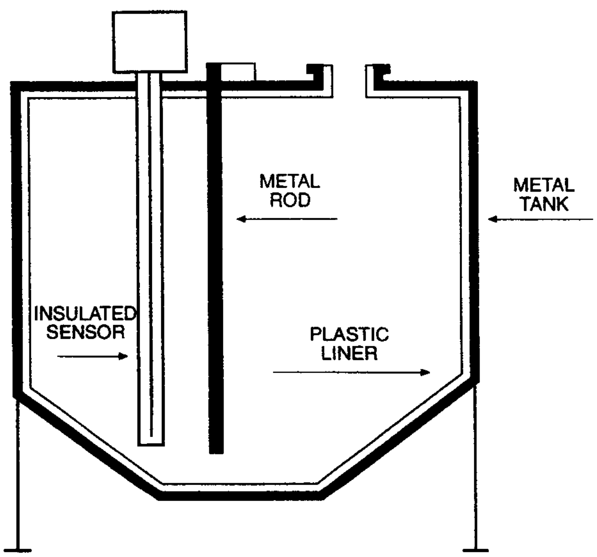



1. *Ground Wire Wrapped Electrode**—This is a popular method especially when an exotic metal must be used for compatibility. The exotic metal wire is less expensive than rod stock or concentric pipe or tube. The measuring electrode is normally mounted in a plastic-faced flange. The small diameter grounded 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.*

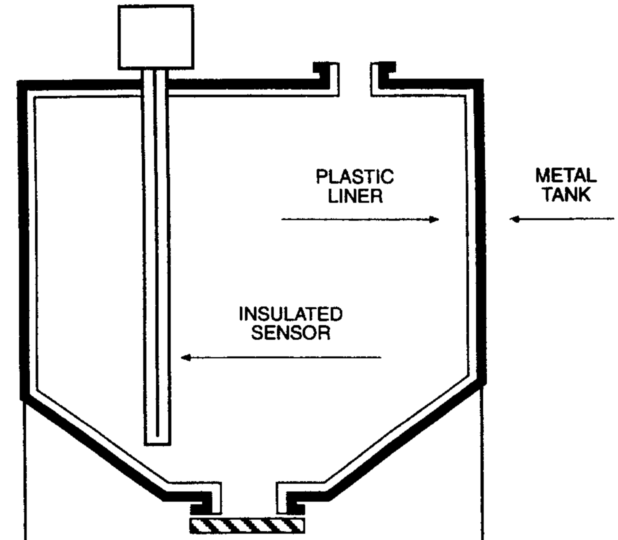



2. *Metal Concentric Tube*—In some applications, a metal concentric tube serves as a grounding element and also as a stilling well. The advantage of the concentric tube is that it requires only one vessel entrance which may be threaded or flanged. However, if the concentric tube must be made of an exotic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

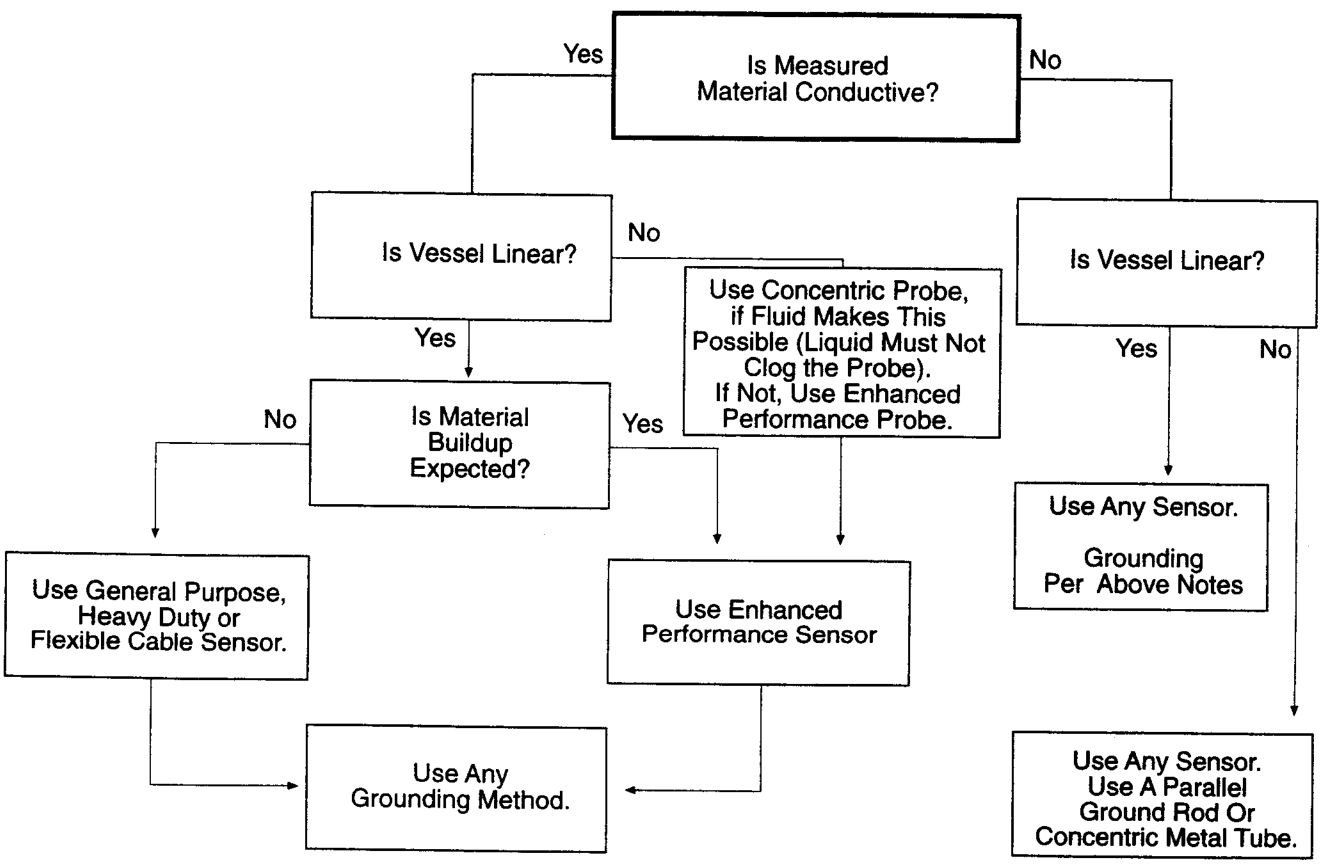
**About Conductivity**

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.

## 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**



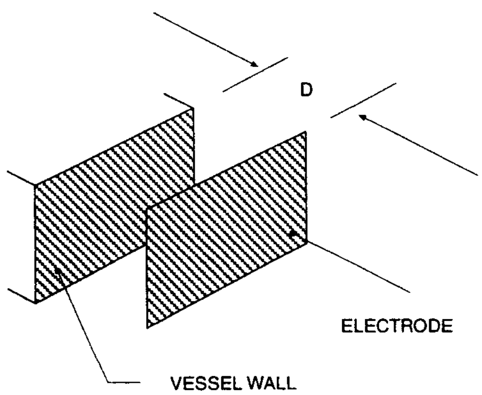
# CAPACITANCE LEVEL MEASUREMENT

## Basic Measuring Principle

A capacitor is formed when a level sensing electrode is installed in a vessel. The metal rod of the electrode acts as one plate of the capacitor and the tank wall (or reference electrode in a non-metallic vessel) acts as the other plate. As level rises, the air or gas normally surrounding the electrode is displaced by material having a different dielectric constant. A change in the value of the capacitor takes place because the dielectric between the plates has changed. RF (radio frequency) capacitance instruments detect this change and convert it into a relay actuation or a proportional output signal. The capacitance relationship is illustrated with the following equation:

$$C = 0.225\,K\left(\frac{A}{D}\right)$$

where:
- C = Capacitance in picoFarads
- K = Dielectric constant of material
- A = Area of plates in square inches
- D = Distance between the plates in inches




The dielectric constant is a numerical value on a scale of 1 to 100 which relates to the ability of the dielectric (material between the plates) to store an electrostatic charge. The dielectric constant of a material is determined in an actual test cell. Values for many materials are published by the National Institute of Standards and Technology.

In actual practice, capacitance change is produced in different ways depending on the material being measured and the level electrode selection. However, the basic principle always applies. If a higher dielectric material replaces a lower one, the total capacitance output of the system will increase. If the electrode is made larger (effectively increasing the surface area) the capacitance output increases; if the distance between measuring electrode and reference decreases, then the capacitance output decreases.

Level measurement can be organized into three basic categories: the measurement of non-conductive materials, conductive materials and proximity or non-contacting measurement. While the following explanations oversimplify the measurement, they provide the basics that must be used to properly specify a capacitance measurement system.

- Non-Conductive Materials—As previously stated, capacitance changes as material comes between the plates of the capacitor. For example, suppose the sensor and the metal wall are measuring the increasing level of a non-conductive hydrocarbon such as gasoline. Figure 1 depicts a typical system.

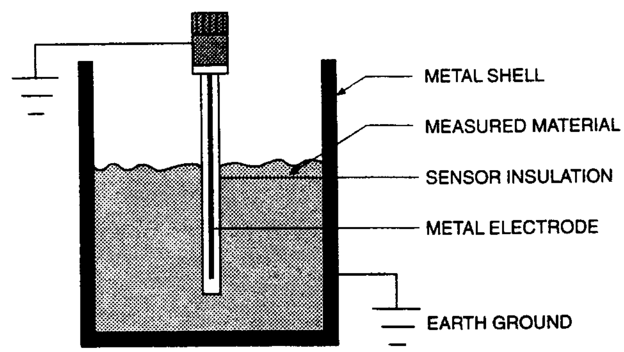



**Figure 1 Capacitive Measurement In Non-Conductive Media**

While the actual capacitive equation is very complex, it can be approximated for the above example as follows:

$$C = \frac{0.225\,(K_{air} \times A_{air})}{D_{air}} + \frac{0.225\,(K_{material} \times A_{material})}{D_{material}}$$

Since the electrode and tank wall are fixed in place, the distance between them will not vary. Similarly, the dielectric of air and of the measured material remain constant (air is 1 and the hydrocarbon is 10). Consequently, the capacitance output of the system example can be reduced to this very basic equation:

$$C = (1 \times A_{air}) + (10 \times A_{material})$$

As this equation demonstrates, the more material in the tank, the higher the capacitance output will be. The capacitance is directly proportional to the level of the measured material.

- Conductive Materials—The same logic for non-conductive materials applies for conductive materials, except that conductive material acts as the ground plate of the capacitor, rather than the tank wall. This changes the distance aspect of the equation, whereby the output would be comparatively higher than for a non-conductive material. However, it still remains fixed; therefore, as level rises on the vertically mounted sensor, the output increases proportionally.

  **NOTE:** A material is considered conductive when it has a conductivity value of greater than 10 microSiemens/cm.

  **WARNING:** The level sensing electrode must be insulated. A non-insulated sensor would be tip sensitive and act like a conductive switch.

- Proximity (non-contacting) Measurements—The level sensing electrode is normally a flat plate mounted parallel to the surface of the material. The material, if conductive, acts as the ground plate of the capacitor. As level rises to the sensor plate, the effective distance between plates is decreased, thus causing an increase in capacitance. In non-conductive materials, the vessel acts as the ground plate and the mass of material between the plates is the variable. In the measurement of non-conductive and conductive materials, the area changes and the distance is fixed. Proximity level measurement is exactly the opposite in that the area is fixed, but distance varies.

  Proximity level measurement does not produce a linear output and can only be used when the level varies by several inches.

Some typical level sensor installations for measuring conductive and non-conductive materials and for proximity level measurement are shown in Figures 2 and 3.

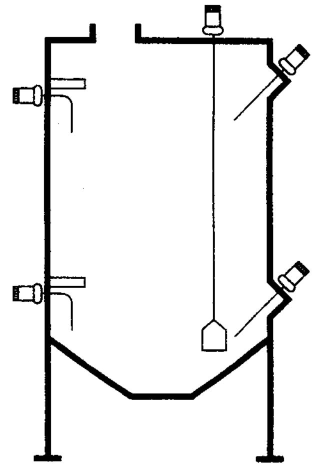


**Figure 2**

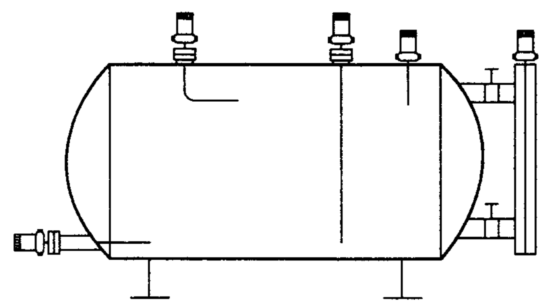


**Figure 3**

### Applications

Applications for RF point level controls and analog transmitters/controllers are widespread. Granular applications range from light powders to heavy aggregates. Applications in liquids, slurries and pastes are commonplace. Capacitance level can also be used to detect the interface between two immiscible materials.

Selecting the proper level sensing electrode and installing it in the proper location are important factors that contribute to the success of any application. A thorough understanding of these factors is required.

- *Electrode Selection*—The electrode is the primary measuring element and must be capable of producing sufficient capacitance change as it becomes submerged in the measured material. Several electrode types are offered, each having specific design characteristics. Capacitance (per foot of submersion) vs. dielectric constant curves are published for each type as installed in various size vessels. For non-conductive materials, these curves are non-linear. Figure 4 shows a typical set of curves. As the size of the tank gets smaller, the capacitance per foot of submersion increases. A conductive material essentially makes the tank be the size of the electrode insulation.

  **Note:** Continuous level transmitter applications require a minimum span of 10.0 pF and a maximum span of 10,000 pF.

  In this case, the saturation capacitance is used. Table A lists basic capacitance values for different electrodes and tank sizes.

### Capacitance Level Probe Selection Guide

The simplest applications are clean, non-coating conductive liquids (such as many water-based liquids) in metallic tanks. An insulated probe must be used, and the fluid is grounded to the probe through the tank. The capacitance change per foot = the saturation capacitance.

Clean, non-coating conductive liquids (such as many water-based liquids) in non-metallic tanks require the use of a concentric probe. The capacitance change per foot = the saturation capacitance. See application note

"RF Level Measurement in Lined Vessels with Grounded Shell" for details on lined or coated metallic tank applications. Clean, non-coating non-conductive liquids (such as many hydrocarbons ) in non-metallic tanks require the use of a concentric probe. The capacitance change per foot depends upon the dielectric constant of the material.

Clean, non-coating non-conductive liquids (such as many hydrocarbons ) in metallic tanks require special consideration. A bare (un-insulated) probe can be used, but one must insure that the probe does not come in contact with any conductive liquid that may contaminate the non-conductive liquid (such as water in oil). If this occurs, the output will be driven to full scale, regardless of the actual level in the tank. Note that an insulated probe can also be used. The probe's metal fitting must be grounded to the metal tank wall, and the distance from the tank wall to the probe must be constant along the entire length of the probe, to provide a linear change in analog output per change in fluid height. If this is not the case (i.e. the tank is "irregular" in shape), or if the tank is greater than 15 ft in diameter, a concentric probe should be used. The capacitance change per foot depends upon the dielectric constant of the material, as well as the tank diameter (tank diameter does NOT effect the concentric probe).

After making a preliminary probe selection based upon the above considerations, it is important to insure that the capacitance of the probe selected meets the following limitations: the capacitance at zero level in the tank is less than 500 pFd, and the maximum capacitance at full span level is more than 10 pFd but less than 10,000 pFd. Also, the zero to span ratio must not exceed 10 to 1. That is, if the zero pf value is 200, the span must be at least 20 pf.

**THIS IS CALCULATED AS FOLLOWS:**

For the LV5100 probe, TFE insulated, in a 24" tank, with a dielectric = 2 (air has a much lower dielectric, so this calculation is very conservative), the pFd per foot is 6 pFd. The maximum length of this probe is 12 ft, so that the maximum probe capacitance in the open air is = (6 x 12) + (42 pFd - gland capacitance) = 114 pFd, which is less than 500 pFd. Note that no probe has greater than 50 pFd gland capacitance.

*** Helpful Hint: 500 pFd can only be exceeded with an LV5300 probe of greater than 25 ft length, or greater than 9 ft length in the LV5102 PVDF insulated heavy duty probe, or greater than 9 ½ ft length in the polyethylene insulated heavy duty probe.

For the LV5100 probe, TFE insulated, in a 24" tank, with a dielectric = 2 (this is a typical value for hydrocarbons) the pFd per foot is 6 pFd. The maximum length of this probe is 12 ft, so that the maximum span capacitance is = (6 x 12) + (0 pFd - gland capacitance is not added to the span) = 72 pFd, which is greater than 10 pFd and less than 10,000 pFd. Note that if the probe were only 1 ft long, that the maximum span capacitance would be only 6 pFd, which is less than the required 10 pFd.

*** Helpful Hint: 10,000 pFd can only be exceeded with an LV5300 probe of greater than 39 ft length, or greater than 10 ft length in the LV5202 or LV5212 PVDF insulated enhanced performance probe with a conductive liquid.

*** Helpful Hint: To have less than 10 pFd span, one must have a span of less than 1 ft for non-conductive liquid with dielectric less than 20 and in a tank greater than 1" diameter.

*** Note that the "Saturation Capacitance" values should be used when the liquid is conductive (i.e. above 20 microsiemens/cm ), such as water-based fluids that are not ultra-pure or distilled or deionized.

**Field Calibration Required:**

Capacitive level transmitters must always be calibrated for zero and span in the field. The concentric probe can be tested in a bucket or small tank of the liquid to be measured; all other probes must be calibrated after final installation by changing the material level and adjusting the zero and span pots.

**Unlined Plastic Tanks:**

Due to the low gains in large tanks, concentric probes are recommended for unlined plastic tanks to minimize this effect and to provide a ground reference.

**Large Diameter Metal Tanks for Low Dielectric Fluids (such as Hydrocarbons)**

Due to the low gains in large tanks, concentric probes are recommended for metal tanks greater than 20 foot diameter used to measure low dielectric fluids (such as hyrdrocarbons). Also, if concentric probe is impractical, mount closer to tank wall if possible.

- *Electrode Location*—Mounting positions should be carefully considered. They must be clear of the inflow of material as impingement during a filling cycle can cause serious fluctuations in the capacitance generated. Side mounted electrodes with point level controls are typically mounted at a downward angle to allow the measured material to drain or fall from the electrode surface.

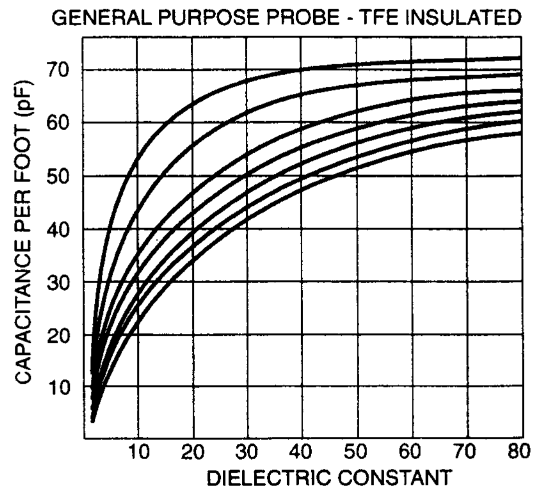



**Figure 4**

Electrodes mounted in nozzles should contain a metal "sheath" extending a few inches past the nozzle length. The sheath renders that part of the electrode insensitive to capacitance change, and therefore, ignores the material which may build up in the nozzle.

**WARNING:** Vertically mounted electrodes must be clear of agitators and other obstructions and far enough from the vessel wall to prevent "bridging" of material between the electrode and the vessel wall.

**NOTE:** In addition to the electrode selection and location factors, there are other considerations which can have a significant impact on the measurement.

### Continuous Level Measurement

Various methods are used to minimize the coating error. These include proper electrode selection, higher frequency measurements, phase shifting and conductive component subtraction circuits.

Coating error is illustrated by the diagram shown in Figure 5. The submerged portion of the electrode generates nearly a pure capacitive susceptance. Since the electrode is insulated, a conductive component is virtually non-existent. However, the upper section of the electrode, coated with conductive material, generates an error signal consisting of a capacitive susceptance and a conductive component. The result is an admittance component which is 45° out of phase with the main level signal. A study of transmission line theory is required to prove this phenomenon. An equivalent circuit for the coated section is shown as a ladder network producing the phase shifted error signal.

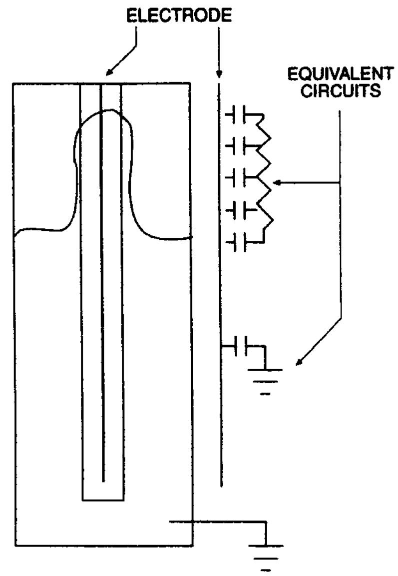



**Figure 5**

## Special Considerations

1. *Temperature*—The dielectric constant of some materials varies with temperature which affects the capacitance measured by the electrode. Generally, materials with a higher dielectric constant are less affected by temperature variation. The temperature effect is usually given in the tables of dielectric constants.

**WARNING:** The effect of changing temperature and changing dielectric can not be quantified; if temperature or dielectric constant change, it is recommended that the level transmitter be calibrated at each temperature and dielectric constant value to quantify the effect of the changes.

2. *Moisture Content*—The dielectric constant of granular materials changes with changing moisture content. This variation can cause significant measurement errors, so each application must be carefully examined. Accuracy requirements determine the amount of moisture change that is tolerable.

**WARNING:** The effect of changing moisture content can not be quantified; if moisture content changes, it is recommended that the level transmitter be calibrated at each moisture level value to quantify the effect of the changes. In addition, the LV5000 series level transmitter should NOT be used with hygroscopic materials (i.e. those materials that absorb moisture from the atmosphere).

3. *Static Change*—Air-conveyed, non-conductive granular materials such as nylon pellets build up a static charge on the electrode which can damage the electronic components in the measuring instruments.

**WARNING:** The LV5000 series level transmitter should NOT be used with materials that could build up static charges.

4. *Composition*—The dielectric constant of the measured material must remain constant throughout its volume. Mixing materials with different dielectric constants in varying ratios will change the overall dielectric constant and the resultant capacitance generated. Solutions having a high dielectric constant are less affected due to the saturation capacitance of the electrode system. See capacitance vs. dielectric constant curve in Figure 4.

**WARNING:** The LV5000 series level transmitter should NOT be used with materials of varying compositions.

5. *Conductivity*—Large variations in the conductivity of the measured material can introduce measurement error. The proper electrode selection can minimize this effect. A thick wall electrode insulation is recommended in this case.

**WARNING:** The effect of changing conductivity can not be quantified; if conductivity changes, it is recommended that the level transmitter be calibrated at each conductivity value to quantify the effect of the changes.

6. *Material Buildup*—The most devastating effect on the accuracy of RF capacitive measurements is caused by the buildup of conductive material on the electrode surface. Non-conductive buildup is not as serious since it only represents a small part of the total capacitance. Latex, carbon black, and fine metal powders are examples of materials that produce conductive coatings.

One means of canceling the error signal is to measure the conductive component (c) shown in Figure 6, Method A. Since the 45° relationship exists, the capacitive error component (e) is the same magnitude and can be subtracted from the total output signal, thereby effectively canceling the error signal.

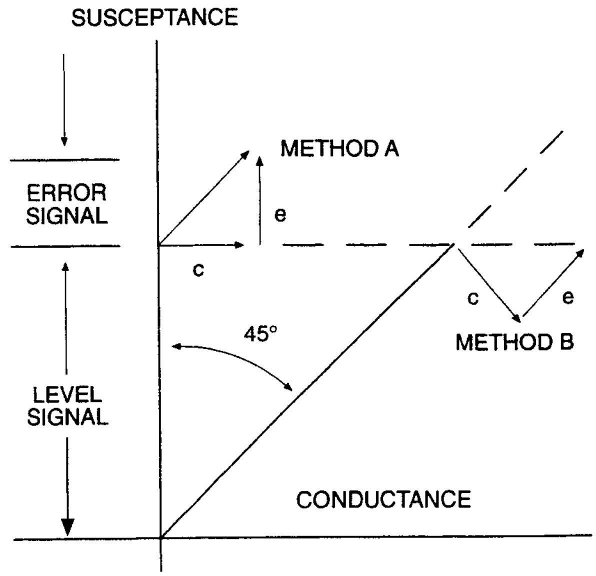
Another cancellation method is to introduce a 45° phase shift to the entire measurement as shown in Figure 7, Method B. This automatically cancels the coating error portion because the conductance component (c) still has the same magnitude as the error component (e), resulting in the appropriate level signal. Instruments which incorporate these techniques are known as "admittance" types.

The coating error can also be reduced by increasing the capacitive susceptance. This is accomplished by increasing the frequency of measurement and/or decreasing the electrode insulation wall thickness.

It should be noted that any of these techniques cannot perfectly cancel the coating effect, but each tends to reduce the error.

**WARNING:** For all of the preceding reasons, RF continuous level instrumentation is not used in inventory control applications.

These are process control devices which require careful evaluation of the listed considerations to provide satisfactory results.




**Admittance Vector Diagram**
**Figure 6**

Table A—Capacitance Values (pF per foot)

| Type of Sensor | Non-Conductive Materials/Tank Diameter: Dielectric = 2, 1″ | Dielectric = 2, 24″ | Dielectric = 2, 96″ | Dielectric =20, 1″ | Dielectric =20, 24″ | Dielectric =20, 96″ | Dielectric = 80, 1″ | Dielectric = 80, 24″ | Dielectric = 80, 96″ | Conductive Material (Saturation Capacitance) |
|---|---|---|---|---|---|---|---|---|---|---|
| General Purpose (LV5000 Series): | | | | | | | | | | |
| TFE Teflon Insulated | 15 pF | 4 pF | 2 pF | 63 pF | 39 pF | 34 pF | 73 pF | 62 pF | 58 pF | 76 pF |
| Polyethylene Insulated | 16 pF | 6 pF | 3 pF | 123 pF | 57 pF | 46 pF | 167 pF | 120 pF | 117 pF | 189 pF |
| PVDF Insulated | 18 pF | 7 pF | 4 pF | 178 pF | 68 pF | 50 pF | 280 pF | 169 pF | 142 pF | 350 pF |
| Heavy Duty (LV5100 Series): | | | | | | | | | | |
| TFE Insulated | 35 pF | 6 pF | 4 pF | 74 pF | 44 pF | 36 pF | 78 pF | 66 pF | 62 pF | 79 pF |
| Polyethylene Insulated | 48 pF | 5 pF | 3 pF | 172 pF | 66 pF | 52 pF | 190 pF | 131 pF | 116 pF | 198 pF |
| PVDF Insulated | 52 pF | 8 pF | 5 pF | 282 pF | 78 pF | 58 pF | 340 pF | 190 pF | 158 pF | 365 pF |
| Enhanced Performance (LV5200 Series): | | | | | | | | | | |
| PFA Teflon Insulated | 23 pF | 5 pF | 3 pF | 147 pF | 160 pF | 48 pF | 187 pF | 128 pF | 114 pF | 207 pF |
| Polyethylene Insulated | 22 pF | 8 pF | 5 pF | 260 pF | 78 pF | 58 pF | 410 pF | 210 pF | 165 pF | 518 pF |
| PVDF Insulated | 25 pF | 10 pF | 8 pF | 330 pF | 80 pF | 60 pF | 640 pF | 260 pF | 205 pF | 950 pF |
| Flexible Cable (LV5300 Series): | | | | | | | | | | |
| PFA Teflon Insulated | 14 pF | 5 pF | 3 pF | 50 pF | 34 pF | 30 pF | 57 pF | 49 pF | 30 pF | 58 pF |
| Polyethylene Insulated | 17 pF | 5 pF | 3 pF | 103 pF | 52 pF | 43 pF | 132 pF | 101 pF | 91 pF | 146 pF |
| PVDF Insulated | 18 pF | 5 pF | 3 pF | 154 pF | 62 pF | 48 pF | 222 pF | 145 pF | 128 pF | 254 pF |
| Concentric (LV 5500 Series) | | | | | | | | | | |
| Teflon | | 25 | | | 67 | | | 75 | | 76 |
| Polyethylene | | 25 | | | 142 | | | 175 | | 189 |
| Kynar | | 35 | | | 220 | | | 305 | | 350 |

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OMEGA ENGINEERING, INC. warrants this unit to be free of defects in materials and workmanship for a period of **13 months** from date of purchase. OMEGA's WARRANTY adds an additional one (1) month grace period to the normal **one (1) year product warranty** to cover handling and shipping time. This ensures that OMEGA's customers receive maximum coverage on each product.

If the unit malfunctions, it must be returned to the factory for evaluation. OMEGA's Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective, it will be repaired or replaced at no charge. OMEGA's WARRANTY does not apply to defects resulting from any action of the purchaser, including but not limited to mishandling, improper interfacing, operation outside of design limits, improper repair, or unauthorized modification. This WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of having been damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear are not warranted, including but not limited to contact points, fuses, and triacs.

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# RETURN REQUESTS/INQUIRIES

Direct all warranty and repair requests/inquiries to the OMEGA Customer Service Department. BEFORE RETURNING ANY PRODUCT(S) TO OMEGA, PURCHASER MUST OBTAIN AN AUTHORIZED RETURN (AR) NUMBER FROM OMEGA'S CUSTOMER SERVICE DEPARTMENT (IN ORDER TO AVOID PROCESSING DELAYS). The assigned AR number should then be marked on the outside of the return package and on any correspondence.

The purchaser is responsible for shipping charges, freight, insurance and proper packaging to prevent breakage in transit.

FOR WARRANTY RETURNS, please have the following information available BEFORE contacting OMEGA:

1. Purchase Order number under which the product was PURCHASED,
2. Model and serial number of the product under warranty, and
3. Repair instructions and/or specific problems relative to the product.

FOR NON-WARRANTY REPAIRS, consult OMEGA for current repair charges. Have the following information available BEFORE contacting OMEGA:

1. Purchase Order number to cover the COST of the repair,
2. Model and serial number of the product, and
3. Repair instructions and/or specific problems relative to the product.

OMEGA's policy is to make running changes, not model changes, whenever an improvement is possible. This affords our customers the latest in technology and engineering.

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