Installation and Operating Instructions

Series 508-2X
Level Transmitter
using 408-6200
Cote-Shield™ Electronics
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Series 508-2X
Level Transmitter
using 408-6200
Cote-Shield™ Electronics
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1.0 Introduction

The instructions in this manual are for the Drexelbrook 508-2X-XX Series transmitter for level measurement in liquids, slurries, interfaces and granulars.

1.1 System Description

Each Drexelbrook 508-2X-XX transmitter consists of a 408-6200 Series two-wire electronic unit, a 700 Series sensing element (probe), and a 380 Series connecting cable.

The transmitter model numbers indicate the application where they most often will be used:

- 508-25-X: For conducting liquids
- 508-26-X: For liquid/liquid interfaces
- 508-27-X: For insulating liquids
- 508-29-X: For granular solids

The final digits in the transmitter model number refer to the type of 700 Series sensing element used. A 508-29-1 transmitter uses a 700-205-78 type sensing element for measuring level in granular solids.

In the two-wire transmitter, the current supplied to the electronic unit from an external power supply is the same current used for the transmitter output signal. Line powered, 115 or 230 VAC 50/60 Hz transmitters are also available. See Figure 1-1.

1.2 Models Available

1.2.1 Electronic Chassis

The following is a partial list of the various 408-6200 Series chassis models available:

- 408-6200-1 — Basic electronic unit intended for use with insulating materials, interfaces, and semi-conducting granulars. Standard frequency 100 KHz.
- 408-6230-1 — Basic electronic unit (408-6200) modified for use with conductive materials and certain insulating granulars.
- 408-6250-1 — High-sensitivity unit for use with proximity applications and short spans in insulating materials.
- 408-62X2-1 — Time delay option added.
- 408-62X0-11 — Low-frequency unit
- 408-62X0-21 — High-frequency unit.
- 408-62X0-31 — Very-low-frequency unit.

1.2.2 Housings

The 408-6200 Series electronic units are available in either standard weatherproof, Nema 4, or explosionproof housings. A “1” in the last position of instrument number indicates chassis only, no housing. Example, 408-62XX-X1 means chassis only. The standard housings meet the following Nema classifications:

- 1 General Purpose
- 2 Drip Tight
- 3 Weather Resistant
- 5 Dust Tight
- 12 Industrial use: oil and dust tight

For typical dimensions of the standard housing, see Figure 1-2. Larger housings are also available when accessory items are to be packaged together with the electronic chassis. See Figure 1-3.
INTRODUCTION

The explosionproof housing is suitable for Class I Groups C and D, Class II Groups E, F and G (Div. 1 and 2). For dimensions of the explosionproof case, see Figure 1-4.

1.2.3 Sensing Elements

The following sensing elements are most often recommended with a 508-2X-XX transmitter according to the application requirements. See Section 1.3.2 for detailed specifications. This listing does not include all of the sensing elements available with the 508-2X-XX series transmitters. For identification, the last digits of the sensing element model number are stamped into the mounting gland. If you have additional questions about sensing elements, contact the factory or your local representative.

700-1-22—Rigid sensing element for waterlike conducting liquids.
700-1-24—Concentric shield sensing element for waterlike insulating liquids.
700-1-34—Caged sensing element for thick, insulating liquids.
700-2-24—Rigid sensing element for low viscosity conducting liquids.
700-2-27—Rigid sensing element for interface measurements which include ketones and esters.
700-2-37—Rigid sensing element with a lower resistivity limit for interface measurements and thick conducting liquids.
700-2-57—Heavy-duty, rigid sensing element for most conducting liquid and interface measurements.
700-5-14—Flexible sensing element for longer insertion lengths in waterlike conducting liquids.
700-5-18—Flexible sensing element for agitated conducting liquids and for granulars.
700-5-19—Heavy-duty, flexible sensing element for highly abrasive mineral granulars.
700-202-23—Rigid 3-terminal sensing element for short range spans in insulating liquids and granulars.
700-205-78—Flexible sensing element with slack adjuster for insulating liquids and granulars.
1.2.4. Connecting Cables

Typically, the electronic unit and sensing element are connected by a three-terminal coaxial cable. Drexelbrook cables are available in:

- **General Purpose**: 380-XXX-12
- **High Temperature**: 360-XXX-11
- **Composite**: 380-XXX-18 (first 10 feet high temp.)

The XXX in the model number indicates the length of the cable in feet. 25 feet is standard, but cut lengths up to 100 feet are available. Cable can also be purchased in bulk lengths with termination kits. Contact factory for maximum recommended lengths for your application.

The high-frequency electronic units (408-62X-21) use a two-terminal cable, together with a tuning assembly for the specific cable length.

1.3 Technical Specifications

1.3.1 Electronic Unit

- **A.** Power requirement: 24 to 100 VDC (For intrinsic safety, see “Q” below.)
- **B.** Input range: 408-6200: 8.0 to 40,000 pF; 408-6230: 12 to 40,000 pF; 408-6250: 5 to 1200 pF.
- **C.** Output range: 4-20 mA (optional 10-50 mA).
- **D.** Linearity: ±0.5%.
- **E.** Load resistance: \( V_s + 13^2 \) \( \Omega \) (i.e. max 550 \( \Omega \) @ 24 VDC). 0.02
- **F.** Temperature effect: ±0.5% per 30°F or ±0.15 pF whichever is larger.
- **G.** Supply voltage effect: 0.5% max. per 10 volt change of dc power supply.
- **H.** Effect of load resistance: 0.2% or less for full resistance range at 24 VDC supply.
- **I.** Response to Step Change: 20 milliseconds std. (to 90% of final value); 0-30 seconds available in time delay units.
- **J.** Fail-Safe: Field selectable. Low-level Fail-Safe (LLFS) std. Also called direct acting because current increases as the level increases. High-Level Fail-Safe (HLFS). Also called reverse acting because current decreases as level increases.

Note: THERE ARE NO DEVICES THAT ARE ABSOLUTELY "fail-safe". "Fail-safe" means that in the event of the most probable failures, the instruments will fail safely. "Most probable failures" means such things as loss of power and most transistor and component failures. If your application needs absolute fail-safe, a backup instrument should be installed.

- **K.** Ambient temperature: \(-40^\circ\) to \(+140^\circ\)F \((-40^\circ\) to \(60^\circ\)C).
- **M.** Lowest permitted resistance (sensing element to ground): 100KΩ.

1. Sensing Element coating effect: Max error for 2000 ohms-cm. product buildup of 1/18" thick on typical sensing element.
2. 408-6200-1—1.5"
3. 408-6230-1—0.7"
4. (error is 0" when coating is longer than 2.2"). Consult factory for other models.

- **O.** Intrinsic Safety: Sensing element and cable. Intrinsically safe for Class I Groups A,B, C and D; Class II Groups E, F and G (Div. 1 and 2).

Electronics and signal wires: Intrinsically safe for Class I Groups C and D, Class II Groups E, F and G (Div. 1) when powered by an intrinsically safe power supply.

Non-incentive for Class I Groups A, B, C and D; Class II Groups E, F and G (Div. 2)

*Where \( V_s \) = power supply voltage. Use .05 for 10-50 mA output.
### 1.3.2. Sensing Elements

<table>
<thead>
<tr>
<th>Mod. #</th>
<th>Std. Mat. of Construction</th>
<th>OD &amp; Mtg.</th>
<th>Temp. &amp; Press. Limits</th>
<th>Max Rec. Insertion Length</th>
<th>Sensing Element Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>700-1-22</td>
<td>TFE covered rod</td>
<td>¾&quot; OD ¾&quot; NPT</td>
<td>100°F @ 1000 psi 300°F @ 500 psi</td>
<td>20 ft</td>
<td>2-term. rigid</td>
</tr>
<tr>
<td>700-1-24</td>
<td>TFE covered rod w/CS concentric shield</td>
<td>Concentric shield 1.66&quot; OD 1½&quot; NPT</td>
<td>100°F @ 1000 psi 300°F @ 500 psi</td>
<td>20 ft</td>
<td>2-term. rigid</td>
</tr>
<tr>
<td>700-1-34</td>
<td>TFE covered rod w/CS cage</td>
<td>Cage 4.026&quot; OD 4&quot; 159# flange</td>
<td>100°F @ 1000 psi 300°F @ 500 psi</td>
<td>19 ft</td>
<td>2-term. rigid</td>
</tr>
<tr>
<td>700-2-24</td>
<td>TFE covered rod</td>
<td>¾&quot; OD ¾&quot; NPT</td>
<td>100°F @ 1000 psi 450°F @ 500 psi</td>
<td>14 ft</td>
<td>2-term. rigid</td>
</tr>
<tr>
<td>700-2-27</td>
<td>TFE covered rod</td>
<td>.54&quot; OD ¾&quot; NPT</td>
<td>100°F @ 1000 psi 300°F @ 500 psi</td>
<td>12 ft</td>
<td>2-term. rigid</td>
</tr>
<tr>
<td>700-2-37</td>
<td>* &quot;X&quot; covered rod</td>
<td>Rod .54&quot; OD ¾&quot; NPT</td>
<td>100°F @ 1000 psi 250°F @ 500 psi</td>
<td>13 ft</td>
<td>2-term. rigid</td>
</tr>
<tr>
<td>700-2-57</td>
<td>* &quot;X&quot; covered rod</td>
<td>Rod .84&quot; OD 1&quot; NPT</td>
<td>100°F @ 1000 psi 250°F @ 500 psi</td>
<td>20 ft</td>
<td>2-term. rigid</td>
</tr>
<tr>
<td>700-5-14</td>
<td>TFE covered cable</td>
<td>Cable ¼&quot; OD ¼&quot; NPT</td>
<td>250°F @ 50 psi</td>
<td>400 ft</td>
<td>2-term. flexible</td>
</tr>
<tr>
<td>700-5-18</td>
<td>* &quot;X&quot; covered cable</td>
<td>Cable 5/16&quot; OD ¼&quot; NPT</td>
<td>100°F @ 1000 psi 250°F @ 500 psi</td>
<td>200 ft</td>
<td>2-term. flexible</td>
</tr>
<tr>
<td>700-5-19</td>
<td>Urethane covered cable</td>
<td>Cable ¾&quot; OD 2&quot; NPT</td>
<td>150°F @ 50 psi</td>
<td>200 ft</td>
<td>2-term. flexible</td>
</tr>
<tr>
<td>700-202-23</td>
<td>Bare 304 SS rod</td>
<td>Rod ⅝&quot; OD 1½&quot; NPT</td>
<td>100°F @ 1000 psi 450°F @ 200 psi</td>
<td>10 ft</td>
<td>3-term. rigid</td>
</tr>
<tr>
<td>700-205-78</td>
<td>* &quot;X&quot; covered cable</td>
<td>Cable 5/16&quot; OD 1&quot; NPT</td>
<td>250°F @ 5 psi</td>
<td>200 ft</td>
<td>3-term. flexible</td>
</tr>
</tbody>
</table>

### 1.3.3 Three-Terminal Cable

**A. General Purpose 380-XXX-12: .51" OD at largest point, 160°F temp limit.**

**B. Composite Cable (first 10 ft. high temp) 380-XXX'1B...62" OD at largest point. 450°F temp limit for first 10 ft. 160°F temp limit for remainder.**

**C. High Temp. Cable 380-XXX-11: .51" OD at largest point, 450°F temp limit.**

*"X" is a fluorocarbon-type insulation.*
2.0 Theory of Operation

2.1 The Electronic Unit

The theory of operation for the Cote-Shield (TM) electronic unit is similar to the theory of a capacitance electronic unit, but with two very important circuit additions. These additions followed an important discovery about the electrical nature of a conductive coating which will be discussed in the paragraph that follows.

Figure 2-1 shows a block diagram of a three-terminal Cote-Shield (TM) transmitter with the critical circuits shown in heavy outline.

These are the OSCILLATOR BUFFER and the CHOPPER DRIVE circuits. The need for these circuits is determined by the electrical nature of the signal produced by a sensing element (probe) with a conductive coating above the level.

Figure 2-2 shows a vessel filled with a highly conductive material. Since the material is conductive, the ground is at the outside surface of the probe insulation in the bulk liquid, and the electronic unit sees a pure capacitance. In this case, either a capacitance or a Cote-Shield (more technically an admittance) transmitter can adequately measure the level.

As the vessel is drained, the picture changes. What was before a pure capacitance circuit now contains a resistive element, because the resistance in the coating is much higher than in the bulk liquid.

When resistance enters the sensing element circuit, energy is consumed in the resistance of the coating and draws down the oscillator voltage. This results in output error. To prevent this problem, a buffer amplifier is placed between the oscillator and bridge circuits so that the loss in power does not affect the oscillator voltage. With a capacitance instrument, the output would indicate that the level was still near the top of the coating, because there would still be the same amount of sensing element connected to ground. See Figure 2-2.
The coated portion of the sensing element looks like an electrical transmission line made up of an infinite number of tiny capacitive and resistive elements. Mathematically, it can be shown that if the coating is long enough, the resistive and capacitive parts of the coating have equal impedances. To benefit from this information, a CHOPPER DRIVE circuit was added. This is the circuit that makes the major difference between a CAPACITANCE transmitter and an ADMITTANCE transmitter. This circuit, together with the chopper or synchronous detector, permits separate measurement of resistance and capacitance. The total capacitance is measured by adding the capacitance of the level plus the capacitance of the coating and subtracting an amount equal to the coating resistance. Since the resistive and capacitive current in the coating are equal, only the capacitance due to the actual level is measured, and the instrument, in effect, has "ignored" the coating. See Figure 2-2A.

FIG. 2-2A
SCHEMATIC OF A CONDUCTIVE COATING

The coating must be electrically "long" for this measurement to work perfectly. How long will depend on the thickness of the coating, the capacitance of the sensing element, the sensing element diameter, and the frequency at which the measurement is made. Generally, a coating of several inches to one foot is long enough not to produce an error. Shorter coatings have some error, but only a fraction of the length of the coating. For any one set of parameters, the coating error is in inches, not percent. A set of conditions that produces a coating error of one inch will always produce an error of one inch, regardless of the sensing element length or calibrated span.

By the time this instrument was developed, the three-terminal sensing element bridge circuit had already been in use for several years in the on/off (Cote-Shield) control. By replacing the older balanced bridge with a three-terminal measuring circuit, the two-wire instrument eliminates the need for a compensate cable and generally permits longer distances between the sensing element and the transmitter. A further improvement in the bridge circuit allows spans as high as 40,000 pF instead of the 4000 pF allowed in the older models. This span increase permits measurements in larger vessels and makes it possible to use sensing elements with higher capacitance in order to improve the instrument's ability to reject the effects of coatings. A great advantage with this unit is that, because of the two-wire transmission, it can be made intrinsically safe. This often removes conduit and explosion-proof requirements, and eliminates safety hazards to the instrument mechanic.

All of the above circuitry is fed from a conventional two-wire 4-20 mA power source where the first 4 mA runs the circuitry and the current from 4-20 mA is the output signal.

2.2 Sensing Elements

The necessary change of input capacitance is provided by a sensing element or "probe", which is mounted in or near the material being measured.

Sensing elements are available in many forms, depending chiefly on the application factors of temperature, pressure, insertion length, and the characteristics of the product being measured; such as viscosity, coating, corrosion, conductivity and dielectric constant. When these properties are known, the factory will select the correct sensing element for the application.

Sensing elements are of two general types—immersion and proximity.

Immersion type sensing elements can be divided into two general categories, "insulated" and " uninsulated".

Uninsulated or "bare" immersion sensing elements have a bare metal probe to sense the product. These are commonly used when the product being measured is nonconducting and not highly corrosive. See Figure 2-3.

FIG. 2-3
BARE SENSING ELEMENT

Insulated immersion sensing elements have the probe covered in an insulating material such as teflon or glass. Insulated sensing elements may be used in applications measuring conductive or nonconductive products. See Figure 2-4.

Proximity-type sensing elements are used for short spans when it is necessary or desirable that the material being measured does not come in contact with the sensing element. See Figure 2-5.
For long insertion lengths or where head clearance is a problem, flexible cable probes are also available in both insulated and bare metal models.

2.3 Connecting Cables

The Drexelbrook 508-2X-XX series transmitters typically use a three-terminal coaxial cable to connect the sensing element to the electronic unit. The center wire of the cable carries the change in capacitance signal from the probe to the electronic unit, while the coaxial shield is driven at guard potential (sometimes called Cote-Shield [TM]). The purpose of the shield is to eliminate any capacitance from the center wire to ground. As a result, the cable capacitance does not interfere with the capacitance signals from the probe. There is no need for the electronic unit to “zero out” the cable capacitance in order to get a reliable reading. The shield also prevents output errors due to changes in cable capacitance caused by temperature. See Figure 2-6.
3.0 Installation

3.1 Unpacking

Carefully remove the contents of the carton and check each item against the packing list before destroying any packing material. If there is any shortage or damage, report it immediately to the factory.

3.2 Mounting the Electronics

The 408-6200 Series transmitter was designed for field mounting, but it should be mounted in a location as free as possible from vibration, corrosive atmospheres, and any possibility of mechanical damage. For convenience at start-up, mount the instrument in a reasonably accessible location. Ambient temperatures should be between -40°F and 140°F (-40° and 60°C). See Figure 3-1.

![Figure 3-1: Typical Mounting Dimensions](image)

3.3 Mounting the Sensing Element

The mounting location for the sensing element (probe) is often determined by the placement of nozzles or openings in the vessel. The sensing element should not be placed in a fill stream. When there is no suitable location inside a vessel, an external side arm or float cage can be considered.

The following sensing element mounting and installation instructions should be followed so that the equipment will operate properly and accurately:

- **A.** In applications requiring an insulated sensing element, use particular care during installation. There is always the danger of puncturing the insulating sheath, especially with the thin-walled, high capacitance probes.

- **B.** Sensing elements should be mounted in such a manner that they are not in the direct steam of a filling nozzle or chute. If this is not possible, a deflecting baffle should be installed between the probe and the fill.

- **C.** Do not take a sensing element apart or loosen the packing glands.

- **D.** Tighten the sensing element with the wrench flats nearest the mounting threads.

- **E.** If waves caused by agitation cause the output to be unsteady, consult the factory for the correct solution of the problem.

3.4 Wiring the Electronic Unit

The signal connections are made to the terminal strip(s) on the chassis. Due to the low power consumption of the instrument, the wiring need only be light gauge. See Figure 3-2 for proper connections.

![Figure 3-2: Power/Signal Connections](image)

The cable from the sensing element is also connected to the terminal strip on the instrument chassis. See Figure 3-3. The cable connections are center wire (CW), ground (gnd), and shield (SH).

Only coaxial cables supplied by Drexelbrook Engineering Company should be used to connect the transmitter to the sensing element. Use of other cables can result in unstable calibration.

**Caution:** Before using Intrinsic Safety Barriers, read the manufacturers instructions for barrier operation. Barriers supplied by Drexelbrook Engineering Company, and prewired to the power supply, have already been tested for proper operation. See Figure 3-4.
The 408-6200 has a built-in current limiter which holds the signal current to a maximum of 35 mA. Check to make sure that the barriers being used will limit current to less than 35 mA. Make sure that the voltage applied will not exceed the barrier voltage rating. (See Section 5.5)

### 3.5 Sensing Element Connections

The cable connections to the sensing element are shown in Figures 3-5A and 3-5B. Do not connect the cable to the sensing element until after the sensor has been installed in the vessel and the conduit housing has been screwed on securely. If your probe does not have a shield connection, be sure to clip and/or tape the shield wire at the probe end of the cable. For high frequency, two-terminal cable connections, see Figure 3-5C.
If spark protection is supplied, use the following instructions for installing the spark protector in the sensing element conduit: (See Figure 3-6.)

A. Attach the mounting link on the spark protector to the probe center connection screw.
B. Connect the green wire from the spark protector to the ground screw.
C. Feed the cable into the conduit.
D. Connect the cable center wire (CW) to the spark protector and the ground wire (gnd) to the ground screw as shown.
E. Connect the shield wire to the Cote-Shield terminal (SH).*

*For sensing elements that do not have shield connections, clip the shield wire as shown in Figure 3-6.
4.0 Calibration

4.1 Controls and Adjustments

4.1.1 Zero and Span Controls

There are four main controls on the chassis front panel. They are the Step Zero, Fine Zero, Step Span and Fine Span controls. See Figure 4-1.

The Step Zero and Fine Zero controls work together to provide continuous adjustment of the minimum current point. Each Step Zero position advances the minimum current point approximately 60 pF, while the Fine Zero provides continuous adjustment between each step.

See Figure 4-2. After calibration is complete, the time delay can be added, without affecting the calibration, by turning the control knob clockwise. Occasionally, when the time delay is first turned on, there is a temporary upset in the transmitter output until the circuit settles out.

4.1.3 Below-Chassis Adjustments

There are two adjustments below the chassis that are set by the factory and normally do not need to be changed. However, if necessary, they may be reset by field personnel. They are the fail-safe selector and a modification procedure for changing the 408-6200-XX to a 408-6230-XX.

A. Fail-Safe Selector

The fail-safe selector determines whether increasing or decreasing level will cause the output current to increase. It is a movable link located on a P.C. board on the right side of the chassis. See Figure 4-3.

The instrument is supplied as low-level fail-safe unless otherwise specified. However, it may be changed in the field, after which it must be recalibrated.
To change the fail-safe of the instrument, take the chassis out of the housing by removing the four holddown screws and lifting up. See Figure 4-4. To change the fail-safe link, loosen the fail-safe screw that the link is attached to and swing the link to the other fail-safe screw. When the link is in place, tighten down both screws. Do not force. See Figure 4-3.

FIG. 4-4
ELECTRONIC UNIT
IN TYPICAL HOUSING

Low-Level Fail-Safe is also called DIRECT ACTING. This is the most commonly used fail-safe position FOR CONTINUOUS INSTRUMENTS. Output CURRENT INCREASES as the LEVEL INCREASES. (Exception being inverted interface, see Section 4.3.3). In the event of most probable failures, the output current will drop and indicate LOW LEVEL.

High-Level Fail-Safe is called REVERSE ACTING. Output CURRENT INCREASES as the LEVEL DECREASES. In the event of most probable failures, output current will drop indicating HIGH LEVEL.

B. 408-6230-XX Modification Procedure
The following procedure can be used to modify a basic 408-6200 electronic unit to a 408-6230 electronic unit. See Figure 4-5. It should only be used when the application makes it necessary. Consult factory.

FIG. 4-5
MODIFICATION PROCEDURE
FOR 408-6230

a. Locate the jumper on the Oscillator P.C. Board toward the middle of the board.
b. Un solder the end of this jumper which is presently on the land connected to C7. c. Solder the free end of the jumper to the land joining R12.
d. To convert 408-6230 unit to a 408-6200 unit, follow the preceding instructions in reverse.

4.2 Start-Up
Before applying power to the instrument, be sure that the input power will be from 13 to 100 VDC. Check all wiring connections, observing polarity of the output loop.

Caution: Explosionproof Units in Hazardous Areas: Before the explosionproof housing cover is removed to calibrate the instrument, the area must be checked and known to be nonhazardous. When calibration is complete, the housing cover must be replaced. Each lead from the explosionproof case must be equipped with an approved seal fitting.

4.3 Calibration Procedures
Note: If your transmitter has been precalibrated at the factory, do not recalibrate.

The calibration instructions for the 408-6200 Series transmitter are divided into three major application categories with different methods in each category.
The three calibration categories are immersion applications, proximity applications, and interface applications.

### 4.3.1 Immersion Applications (See Figure 4-6)

A. **Immersion - Low-Level Fail-Safe** (Output rises as material rises)
   Calibrating the instrument in an immersion application for low-level fail-safe is the most commonly used method.

   a. With fail-safe link in low-level position, (see Section 4.1.3), set Fine Span to extreme counterclockwise position. Do not force. See Figure 4-7.

   b. Set Step Span to Position #1.

   c. With the vessel empty (or probe uncovered), adjust the Step and Fine Zero controls until the output is minimum (4 mA).

   d. Fill the vessel (or raise the level as much as possible). Output current will now exceed full scale current.

   e. Turn the Step Span control clockwise until the output is less than full scale. (If current did not exceed full scale in Step d., then leave Step Span in Position #1.)

   f. Turn the Fine Span control clockwise until the output is full scale (20 mA) or actual level.

Calibration is now complete. Record the capacitance values that produce 4 mA and 20 mA outputs.
B. Immersion—High-Level Fail-Safe. (Output fails as material rises.)

a. Set the Fail-Safe link in the HLFS position (See Section 4.1.3) and set the Fine Span control to extreme counterclockwise position. Do not force. See Figure 4-7.

b. Set the Step Span to Position #1.

c. With the vessel full, set the Step and Fine Zero controls until the output is minimum (4 mA).

d. For this calibration procedure, a compensation capacitor is usually required to obtain the minimum 4 mA output. It will be added by the factory when the application is known. If needed and not supplied, add - in 100 pF steps - an NPO capacitor across Terminals 6 and 9 until the minimum output can be obtained. See Figure 4-7A.

e. Empty the vessel. Output current will now exceed full scale current.

f. Turn the Step Span control clockwise until the output is less than full scale. (If current did not exceed full scale in Step D, then leave Step Span in Position #1.)

g. Turn the Fine Span control clockwise until the output is full scale (20 mA) or actual level.

Calibration is now complete.

FIG. 4-7A
NPO CAPACITOR CONNECTIONS

4.3.2 Proximity Applications

In applications where the product being measured is an insulator, it may be necessary to install a ground plate just below the product lower level. This ground plate should be at least as large as the sensing plate and electrically connected to ground. The ground plate need not be a solid plate. It could be a series of rods, spaced apart, enclosing the same areas as a plate. Consult factory.

There are two different methods for calibrating your instrument for a proximity application. See Figure 4-8. Set the instrument for either low-level or high-level fail-safe.

FIG. 4-8
PROXIMITY APPLICATION

A. Proximity—Low-Level Fail-Safe. (Output rises as material rises.)

a. Be sure fail-safe link is in LLFS position. See Section 4.1.3.

b. Set Fine Span control to extreme counterclockwise position. Do not force. See Figure 4-7.

c. Set Step Span to Position #1.

d. With the material at the lower operating level, adjust the Step and Fine Zero controls until output is minimum (4 mA).

e. Raise the material to the upper operating level, but not touching the probe plate. Output current will now exceed full scale current.

f. Turn the Step Span control clockwise until the output is less than full scale. (If current did not exceed full scale in Step e, leave Step Span in Position #1).^*

g. Turn the Fine Span control clockwise until the output is full scale (20 mA) or actual level.^

Calibration is now complete.

*If output is less than full scale, a higher sensitivity instrument may be required. Consult factory.
B. Proximity—High-Level Fail-Safe. (Output fails as material rises.)

a. Be sure Fail-Safe link is in HLFS position. See Section 4.1.3.
b. Set Fine Span control to extreme counterclockwise position. Do not force. See Figure 4-7.
c. Set Step Span to Position #1.
d. With the material at the upper operating level (but lower than the probe plate), adjust the Step and Fine Zero controls until the output is minimum (4 mA).
e. Lower the material to the lower operating level. Output current will exceed full scale.
f. Turn the Step Span control clockwise until the output is less than full scale. (If current did not exceed full scale in Step e, leave Step Span in Position #1).*
g. Turn the Fine Span control clockwise until the level is full scale (20 mA) or actual level.*

Calibration is now complete.

4.3.3 Interface Applications

All level control applications are actually interface measurements. The most common being the interface of air and product. The term interface generally refers to the interface of two immiscible liquids (liquids that don't mix).

For the purpose of level control, two types of interface are considered. The first and more common is called normal interface. An interface is considered “normal” when the lower product has the higher conductivity (i.e. oil and water). The other type of interface is called inverted interface. In an inverted interface, the upper-phase product has the higher conductivity, indicating the insulating phase is heavier than water.

There are four separate methods for calibration in interface applications. (See Figure 4-9.) They are normal interface in either high- or low-level fail-safe, and inverted interface in high- and low-level fail-safe.

A. Normal Interface - Low-Level Fail-Safe

a. Set fail-safe link to LLFS position (see Section 4.1.3) and set Fine Span to extreme counterclockwise position. Do not force. See Figure 4-7.
b. Set Step Span to Position #1.
c. Lower the level until the probe is covered with only the upper phase, insulating material. Set the Step and Fine Zero controls until the output is minimum (4 mA).
d. For this calibration procedure, a compensation capacitor may be required to obtain the minimum 4 mA output. It will be added by the factory when the application is known. If needed and not supplied, add in 100 pF steps - an NPO capacitor across Terminals 6 and 9 until the minimum output can be obtained. See Figure 4-7A.
e. Raise the interface until most of the lower, waterlike phase of material is covering the probe. Output current will now normally exceed full scale.
f. Turn the Step Span control clockwise until the output is less than full scale. (If current did not exceed full scale in Step e, then leave Step Span in Position #1).
g. Turn the Fine Span control clockwise until the output is equal to the actual interface level on the probe.

Calibration is now complete.

*If output is less than full scale, a higher sensitivity instrument may be required. Consult factory.
B. Normal Interface - High-Level Fail-Safe
   a. Set the fail-safe link to the HLFS position (see Section 4.1.3) and set the Fine Span control to the extreme counterclockwise position. Do not force. See Figure 4-7.
   b. Set the Step Span to Position #1.
   c. Raise the level until the lower phase, conducting material is covering the probe. Adjust the Step and Fine Zero controls until the output is minimum (4 mA).
   d. If 4 mA cannot be obtained, add a padding capacitor equal to or less than 1/3 the full scale capacity of the probe in the upper phase. This capacitor will be added across Terminals 6 and 9 by the factory when the application is known. If not supplied, contact the factory for capacitors of proper value. See Figure 4-7A.
   e. Lower the interface until only the upper phase, insulating material is covering the probe. Output current will now normally exceed full scale.
   f. Turn the Step Span control clockwise until the output is less than full scale. (If current did not exceed full scale in Step e, then leave Step Span in Position #1).
   g. Turn the Fine Step control clockwise until the output is equal to the amount of the upper phase material covering the probe.

Calibration is now complete.

C. Inverted Interface - Low-Level Fail-Safe
   a. Move fail-safe link to High-Level Fail-Safe position, not Low-Level. See Section 4.1.3.
   b. Set the Step Span control to Position #1 and Fine Span in the full counterclockwise position. Do not force. See Figure 4-7.
   c. Lower the level until the probe is covered with only the conducting, upper phase material.
   d. Set the Step and Fine Zero controls until output is minimum (4 mA).
   e. If 4 mA cannot be obtained, add a padding capacitor equal to or less than 1/3 the full scale capacity of the probe in the upper phase. This capacitor will be added across Terminals 6 and 9 by the factory when the application is known. If not supplied, contact the factory for the proper value capacitors. See Figure 4-7A.
   f. Raise the interface until most of the lower insulating phase of the material is covering the probe. Output current will now normally exceed full scale current.
   g. Turn the Step Span control clockwise until the output is less than full scale. (If output current did not exceed full scale in Step f, then leave Step Span in Position #1).
   h. Turn the Fine Span control clockwise until the output is equal to level of lower phase material covering the probe.

Calibration is now complete.

D. Inverted Interface - High-Level Fail-Safe
   a. Set fail-safe link to Low-Level Fail-Safe position, not High-Level. See Section 4.1.3.
   b. Set the Step Span control to Position #1, and the Fine Span in the full counterclockwise position. Do not force. See Figure 4-7.
   c. Raise the interface to the desired upper level.
   d. Adjust the Step and Fine Zero controls until the current output is minimum (4 mA).
   e. If 4 mA cannot be obtained, add a padding capacitor equal to or less than 1/3 the full scale capacity of the probe in the lower phase. This capacitor will be added across Terminals 6 and 9 by the factory when the application is known. If not supplied, contact the factory for capacitors of proper value. See Figure 4-7A.
   f. Lower the interface to the desired lower level. Output current will now normally exceed full scale.
   g. Turn the Step Span control clockwise until the output is less than full scale. (If output current did not exceed full scale in Step f, then leave Step Span in Position #1).
   h. Turn the Fine Span control clockwise until the output is full scale (20 mA) or actual level.

Calibration is now complete.

4.4 Secondary Calibration Standard

In some applications, it is difficult or even impossible to completely fill or empty a vessel. In such a case, it is desirable to have a secondary calibration standard such as the Drexelbrook Model 401-6-8, which can be used to simulate the capacitance of an empty vessel. The following procedure permits recalibration of an instrument without the necessity of emptying the vessel.
4.4.1 Recording Calibration Data

In order to establish the zero, or empty vessel calibration, start by setting up the instrument as described under Calibration. After initial calibration, do the following: (Also, see instruction manual for calibration standard.)

A. Disconnect the coax center wire from the probe rod in the probe conduit. (Be sure that it does not short to anything.)

B. Connect the calibration standard to the instrument in parallel with existing cable, ground to Terminal 7, center wire to 9, and shield to Terminal 8. See Figure 4-10.

C. Adjust the calibration standard until the instrument indicates minimum current (4 mA).

D. Record the value read on the calibration standard and its serial number for later use. Recording the value on the inside of the instrument door is also suggested.

E. Adjust the calibration standard until the instrument indicates maximum current (20 mA).

F. Record the capacitance value as in Step D.

G. Disconnect the calibration standard from the instrument terminals and reconnect the probe.

4.4.2 Recalibration

Whenever it is subsequently desired to check or reset the calibration, or replace the instrument, the calibration capacitor set to the value recorded above may be substituted for the probe. This is done as follows:

A. Disconnect the coax center wire from the probe in the probe conduit.

B. Connect the calibration standard in parallel with the existing cable. See Figure 4-10.

C. Set the calibration standard to the recorded values.

D. If necessary, adjust the zero controls for the minimum current calibration and the span controls for the maximum current calibration.

E. Disconnect the calibration standard and reconnect the coax center lead to probe.

Unit is again ready for operation.

When replacing a malfunctioning electronic unit, the replacement chassis can be calibrated on the bench by the preceding method and then installed in the field.
5.0 Accessories
The following Drexelbrook accessories are available for use with the 508-2X-XX Series transmitters.

5.1 RFI Filters
Radio Frequency Interference (RFI) filters are designed to protect Drexelbrook RF level transmitters from the interference of outside radio transmissions...mainly walkie-talkies. Without this protection, those interfering transmissions can cause the transmitter output to be in error. For complete protection up to 460 MHz, all electrical lines to and from the transmitter housing must be filtered. Each filter should be close-coupled to the housing, and the housing should be earth-grounded. See Figure 5-1. To be effective, the housing door must be closed.
Drexelbrook RFI filters are available for both weatherproof and explosionproof units.

![RFI Protection Diagram](image)

5.2 Setcon (TM)
Setcon is a Drexelbrook trade name for a current-operated setpoint relay. It is used with continuous instruments to provide an on-off output at a specific position along the transmitters 0-100% range. Setcons are available in double pole, double throw relay output models. Field adjustable to either high- or low-level fail-safe. The relay contacts can be used to operate an alarm, solenoid valve, or other device.

![Setcon Diagram](image)

The Setcon's standard differential, or deadband, is approximately .5% of the 0-100% setpoint range. There is an adjustable differential model with a deadband range of 0-100%, as well as a setpoint range of 0-100% of full scale.
Setcons are available in weatherproof and explosionproof housings or chassis only for mounting in various prewired case option packages. See Figure 5-2 and Setcon instruction manual.

![Setcon Housing Diagram](image)
5.3 Power Supplies

Drexelbrook power supplies are available in 24 VDC or 45 VDC models. See Figure 5-3. The power supply takes a typical 115 VAC input and converts it to the 24 VDC (or 45 VDC).

![TOP VIEW]

Fig. 5-3
Typical Power Supply

The Drexelbrook 24 VDC model has an auto-restart feature. The auto-restart power supply will shut itself off when an excessive current fault occurs. It then tries every few seconds to turn back on until the fault is cleared. This feature is particularly useful when feeding SCR-type intrinsic safety barriers.

The maximum current available with the Drexelbrook 24 VDC supply will run two transmitter loops.

Power supplies are available in weatherproof and explosionproof housings, chassis only, or included in line-powered transmitters.

5.4 Meters

The standard Drexelbrook analog meter is a 5" horizontal, taut-band, type with 0-1 mA movement. See Figure 5-4. There is a 10 mA shunt on the back of the meter that can be changed to convert it to 0-50 mA input. In addition to the 4-20 mA scale a 0-100% scale. These meters can be purchased as meter only and in either weatherproof or explosionproof housings, or included in indicating transmitter housings.

Special linear, nonlinear, and vertical scales are also available in the analog meters.

![FIG. 5-4]

Typical Analog Meter

*240 VAC power supplies are also available.
The standard Drexelbrook digital meter is a 3.5-digit, .5-inch high liquid crystal display. It is powered directly from the 4-20 mA two-wire loop current. They can be purchased as meter only, in either weatherproof, Nema 4, or explosionproof housings, or included in indicating transmitter housings.

The digital meters can be calibrated to show percent of level, current, or Engineering Units. See Figure 5-4A.

5.5 Intrinsic Safety Barriers - Installation with Drexelbrook Continuous Instruments

A typical installation of a single intrinsic safety barrier is shown in Figure 1. A single barrier installation is usually rated for operation at 24-28V with a maximum of 80mA. The barrier will typically start limiting the current at 26mA. Drexelbrook recommends that a current-limiting, rather than a trip type barrier be used in the installation. The reason for this approach is that a trip-type barrier must be reset by breaking the loop power to reset the barrier. The inadvertent tripping often occurs during calibration. This condition does not occur with a current-limiting style barrier.

5.5.1 Single-Barrier Installations (Figure 1)

When using barriers, an important consideration is the overall loop resistance. Using a standard 24 Vdc power supply, the maximum loop resistance is 1200 ohms. Each 50 ohms in a loop uses 1 Vdc. A typical Drexelbrook transmitter requires a minimum of 13 Vdc, leaving 11 volts for the loop and a maximum load in the loop of 550 ohms. All of the loop resistance must be totaled to determine the remaining resistance that can be used by a barrier. Usually a “positive” barrier in a loop has a resistance of between 200 and 250 ohms, leaving only approximately 300 ohms for other items in the loop.

5.5.2 2-Barrier Installations (Figure 2)

In certain instances it is required that two barriers be used in an installation, usually when the signal is being fed to a microprocessor input card. A two-barrier installation requires that the loop be floating relative to ground. When this condition exists, it is very important that the loop resistance is checked to be sure that sufficient voltage is available for correct transmitter operation. As shown in Figure 2, if two barriers are used, each having an internal resistance of 250 ohms, there would be only 50 ohms available for all other devices. To gain additional resistance, change the return (negative leg) barrier to a lower voltage type, e.g. rating of +6V. Normally the barriers have a resistance of approximately 12.5 ohms + 2V. By lowering the voltage type, the overall effective resistance would be 362.5 ohms, which allows an additional 187.5 ohms in the loop.
6.0 Troubleshooting

6.1 Introduction

The 408-6200 Series instruments are designed to give years of unattended service. No periodic or scheduled maintenance is required.

A spare chassis is recommended for every 10 units so that, in case of a failed unit, a critical application will not be held up while the unit is returned to the factory for repair.

If a difficulty occurs when operating your measurement system, mentally divide the system into its component parts and test each part individually for proper operation.

These troubleshooting procedures should be followed in checking out your system. If attempts to locate the difficulty fail, notify your local factory representative or call the factory direct and ask for the service department.

6.2 Testing the 408-6200 Series Electronic Unit

6.2.1 Operation Check

A. Remove the sensing element and signal wires from the transmitter.
B. Be sure Fail-Safe link is in low-level fail-safe position. See Figure 6-1.

C. With pencil, mark the positions of all controls on the faceplate in order to return to them.
D. Put the Step Span in Position #1 and the Fine Span in the full clockwise position. Put the Step Zero in Position #1 (most sensitive position). See Figure 6-2.
E. Observing polarities, connect a DC milliammeter and DC power supply (13 to 100 volts) in series, and complete the loop by connecting Terminals 1 and 2. See Figure 6-3.

F. Adjust the Fine Zero until the meter reads 0% (4 mA).
G. Turn the Fine Zero one clockwise turn further. The output should read 70% or greater for 408-6200 Series, 100% or greater for 408-6250 Series, and 40% or greater for 408-6230 Series.

If so, the instrument is probably working correctly. Each turn of the Fine Span changes the input a known amount. This checks the operation and gain of the transmitter.
H. If the difficulty has not been located at this point, proceed to the output checkout procedure.

6.2.2 Drift Check

If the output of a transmitter seems to be drifting, it is important to determine whether the drift is in the transmitter or in the probe. (A properly connected cable never drifts.)

A. Remove the sensing element cable from the transmitter.
B. Without disturbing the dial settings, connect a capacitance standard or an NPO capacitor* across the probe to ground input. Adjust the capacitance standard or select a capacitor value that will bring the unit on scale.

*The capacitor should remain stable with changes in temperature.
C. Observe the reading over a 24-hour period to see if it is stable.

D. If the reading is stable, the sensing element or the application must be the source of the drift. If the reading drifted, return the instrument for repair. Be sure to mark on the tag that the problem is drift. (List the capacitor size and mA deviation.)

6.3 Checking the Two-Wire System Loop. See Figure 6-4.

A. With probe disconnected, disconnect the power from Terminals 1 and 2 and measure the open circuit voltage from the power supply. Voltage should be between 24 and 100 VDC.

B. Connect the signal wires to Terminals 1 and 2. Turn the Step Span and Step Zero to Position #1. Put Fine Span control completely clockwise and adjust the Fine Zero until 20 mA flows.

C. Measure the voltage between Terminals 1 and 2. Voltage should be between 13 and 100 VDC. If there is less than the minimum 13 volts required, the loop has too much resistance or not enough power supply voltage.

D. If, in Step C above, the voltage is less than 13 VDC, disconnect the power supply and signal wires to the unit. Short the wires that were removed from the power supply (+) and (-) terminals.

E. Measure the resistance between the two wires that were just removed from Terminals 1 and 2 of the electronic unit. The graph below will tell you when the resistance is too large. See Figure 6-5.

FIG. 6-3
POWER/SIGNAL WIRING

FIG. 6-4
LOOP CHECK
6.4 Checking the Sensing Element

A. With an analog ohmmeter*, check the resistance of the probe-to-ground with level below the probe. See Figure 6-6.

Resistance should be infinite. Resistance less than 1 megohm indicates excessive leakage, probably due to product or condensation in the conduit, around the gland/packing nut area.

(Consult factory.)

B. Check the resistance of the probe-to-ground with level above the probe. See Figure 6-7. Resistance readings less than 1 megohm indicate either defects in the probe insulation or, if a bare probe, that the material is conductive and an insulated probe may be required. (Consult factory.)

C. Coating error is characterized by high output with falling level, and a sharp drop to 0% when the material goes below the tip of the probe. To verify a coating problem, wipe the coating off the probe and recheck instrument operation. If the instrument reads correctly after cleaning, consult the factory for the best solution to the problem.

* A digital ohmmeter may produce erroneous readings.
6.5 Checking the Sensing Element Cable.

1. Disconnect cable at both ends. Be sure all terminals are standing clear.

2. Measure resistance from center wire to cote-shield. Resistance should be infinity (open circuit).

3. Short probe & ground terminals together at one end.

4. Measure resistance from probe to ground terminals at other end. Resistance should be near zero ohms (short circuit).

5. Repeat step 2 for cote-shield and ground terminals.
### 6.6 List of Some Possible Problems and Causes

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>POSSIBLE CAUSE</th>
<th>CHECKOUT</th>
</tr>
</thead>
</table>
| 1. Transmitter reads 20 mA or greater even when vessel is not full. | a. Transmitter malfunction  
b. Water in probe conduit  
c. Short in cable  
d. Cut in probe insulation  
e. Calibration is wrong | a. Sec. 6.2.1  
b. Sec. 6.4  
c. Sec. 6.5  
d. Sec. 6.4  
e. Sec. 4.3 |
| 2. Transmitter never reaches 20 mA even though the vessel is full, or the output reading is nonlinear at the upper end of the scale. | a. Load resistance too high  
b. Calibration is wrong  
c. Transmitter malfunction | a. Sec. 6.3  
b. Sec. 4.3  
c. Sec. 6.2.1 |
| 3. Transmitter is drifting. | a. Moisture in probe gland  
b. Water in probe conduit  
c. Transmitter malfunction  
d. Water in cable  
e. Cut in probe insulation  
f. Calibration is wrong | a. Sec. 6.4  
b. Sec. 6.4  
c. Sec. 6.2.2  
d. Sec. 6.5  
e. Sec. 6.4  
f. Sec. 4.3 |
| 4. Transmitter is erratic. Output reading jumps any where from 10% to 100%. | a. Radio frequency interference  
b. Cut in probe insulation  
b. Sec. 6.4  
c. Sec. 4.1.2 |
| 5. Transmitter was shipped precalibrated but is not reading correct level. | a. Wrong precalibration information supplied to factory  
b. Nozzle or pipe around probe is 6” or less in diameter  
c. Accuracy being checked by measuring outage as a % of full tank | a. Verify precal. info.  
b. Need to include info on nozzle for precal.  
c. Note: The zero point is at end of probe; not bottom of tank. |
| 6. Probe installed in stilling well, and readings are incorrect. | a. Probe touching stilling well  
b. Reading lower than actual level: Air trapped in stilling well  
c. Calibration is wrong | a. Adjust mounting.  
b. Put holes in stilling well to allow air to escape.  
c. Sec. 4.3 |
| 7. As level increases, output reading decreases | a. Fail-safe in HLFS position  
b. Transmitter malfunction | a. Sec. 4.1.3  
b. Sec. 6.2.1 |
### Troubleshooting

| 8. Transmitter reading | a. Conductive buildup on probe | a. Sec. 6.4 Consult Factory.  
b. Calibration is wrong | b. Sec. 4.3 |
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>9. Erratic or incorrect readings</td>
<td>a. Ungrounded conducting liquid in a fiberglass vessel</td>
<td>a. Instrument may need a ground ref. Consult factory.</td>
<td></td>
</tr>
<tr>
<td>10. Output current reading less than 2 mA</td>
<td>a. Wiring short from shield-to-ground, probably in probe head</td>
<td>a. Sec. 3.5</td>
<td></td>
</tr>
</tbody>
</table>

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#### 6.7 Factory and Field Service Assistance

##### 6.7.1 Telephone Assistance

If you are having difficulty with your Drexelbrook equipment, and attempts to locate the problem have failed, notify your local Drexelbrook representative, or call toll-free for the service department, 1-800-527-6297. Drexelbrook Engineering Company is located at 205 Keith Valley Road, Horsham, Pa. 19044. The factory telephone number is (215) 674-1234. To help us solve your problem quickly, please have as much of the following information as possible when you call:

- **Instrument Model#**
- **Probe Model #**
- **P. O. #**
- **& Date**
- **Cable Length**
- **Application**
- **Material being measured**
- **Temperature**
- **Pressure**
- **Agitation**
- **Brief description of the problem**
- **Checkout procedures that failed**
- **Do not return equipment without first contacting the factory for a return authorization number.**
- **Any equipment being returned must include the following information:**
- **Reason for return**

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#### Return Authorization #

- **Original P.O. #**
- **Drexelbrook order #**
- **Your company contact**

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**"Ship To" address**

To keep the paperwork in order, *please* include a purchase order with returned equipment even though it may be coming back for warranty repair. You will not be charged if covered under warranty. Please return your equipment with freight charges prepaid. We regret that we cannot accept collect shipments.

Drexelbrook usually has a stock of reconditioned exchange units available for faster turnaround of a repair order. If you prefer your own unit repaired rather than exchanged, please mark clearly on the return unit, "Do Not Exchange".

Spare instruments are generally in factory stock. If the application is critical, a spare chassis should be kept on hand.

##### 6.7.2 Field Service

Trained field servicemen are available on a time-plus-expense basis to assist in start-ups, diagnosing difficult application problems, or in-plant training of personnel.

Periodically, Drexelbrook instrument training seminars for customers are held at the factory. Contact the service department for further details on any of the above.