Rosemount 2151N Analog Pressure Transmitter

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Rosemount 2151N Analog Pressure Transmitter

⚠ CAUTION

The product described in this document is NOT designed for nuclear-qualified applications. Using non-nuclear qualified products in applications that require nuclear-qualified hardware or products may cause inaccurate readings.

For information on Rosemount nuclear-qualified products, contact your local Emerson™ Sales Representative.

⚠ WARNING

Read this manual before working with the product. For personal and system safety, and for optimum product performance, make sure you thoroughly understand the contents before installing, using, or maintaining this product.

For Assistance:

Within the United States, contact Rosemount Nuclear Instruments, Inc. (Rosemount Nuclear) at 1-952-949-5200.

Outside the United States, contact the nearest Rosemount representative.

Customer Feedback:

Your feedback is important to us, please send comments or suggestions to:
Chan.RNII-CustomerFeedback@Emerson.com

CE *Rosemount Nuclear satisfies all obligations coming from legislation to harmonize product requirements in the European Union*

Rosemount Nuclear Instruments, Inc. Warranty and Limitations of Remedy

The warranty and limitations of remedy applicable to this Rosemount product can be found in Emerson Terms & Conditions of Sale on the reverse side of the current Rosemount quotation and customer acknowledgment forms.

RETURN OF MATERIAL
Authorization for return is required from Rosemount Nuclear prior to shipment. Contact Rosemount Nuclear (1-952-949-5200) for details on obtaining Return Material Authorization (RMA). **Rosemount Nuclear will not accept any returned material without a Return Material Authorization**. Material returned without authorization is subject to return to customer. Material returned for repair, whether in or out of warranty, should be shipped prepaid to: Rosemount Nuclear Instruments, Inc. 8200 Market Blvd. Chanhassen, MN 55317 USA

Revision Status

Changes from August 2019 (Rev AC) to December 2023 (Rev AD)

Page (Old)	Page (New)	Changes
Cover, throughout	Cover, throughout	Document revision changed from August 2019 to December 2023, Rev AC to Rev AD.
1	1	Update Figure 1-1.
9	9	Update Figure 2-3.
11	11	Update Table 2-1.
12	12	Update Figure 2-4.
13	13	Update Figure 2-5.
21	21	Update Calibration Considerations with optional output damping.
22	22	Update Figure 3-2.
30,31	30,31	Update Figure 3-8.
31	31	Add Damping Adjustment section.

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Operation

SECTION 5
Maintenance and Troubleshooting

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SECTION 1: Introduction

USING THIS MANUAL

This manual is designed to assist in installing, operating and maintaining the Rosemount 2151N Pressure Transmitter. The manual is organized into the following sections:

Section 2: Installation
Provides general, mechanical, and electrical installation considerations.

Section 3: Calibration
Provides transmitter calibration procedures.

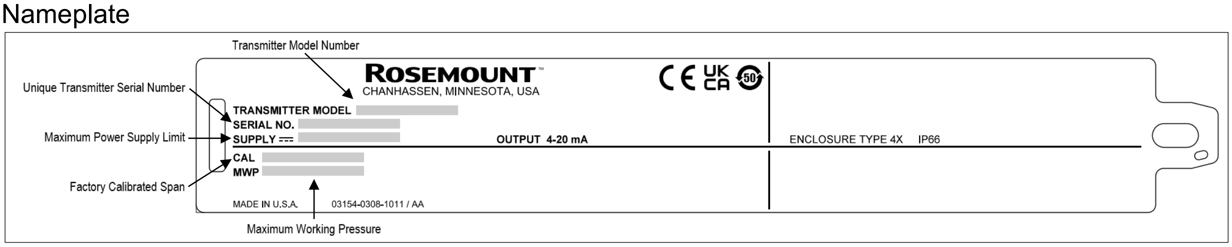
Section 4: Operation
Provides a description of how the transmitter operates.

Section 5: Maintenance and Troubleshooting
Provides basic hardware troubleshooting considerations including disassembly and reassembly procedures, and post assembly tests.

NOTE
Refer to Rosemount Product Data Sheet-00813-0000-4851 for performance specifications, ordering information, and dimensional drawings.

Figure 1-1 shows the standard transmitter nameplate and where transmitter information is stamped onto the nameplate. Nameplate material is stainless steel.

Figure 1-1 – Standard Transmitter Nameplate



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SECTION 2: Installation

OVERVIEW

This section contains the following installation considerations:

- General Considerations
- Mechanical Considerations
  - → Process Connections
  - → Impulse Piping
  - → Mounting Configurations
  - → Conduit Connections
  - → Electronics Housing
- Electrical Considerations
  - → Signal Integrity
  - → Wiring Connections
- Installation Procedures
  - → Mechanical – Transmitter
  - → Mechanical – Conduit
  - → Electrical

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operation. Refer to the following safety messages before performing an operation preceded by this symbol: ⚠

⚠ WARNING

Explosions can result in death or injury.

- Do not remove the transmitter covers in explosive environments when the circuit is live.

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⚠ WARNING

Electrical shock can result in death or serious injury.
- Avoid contact with the leads and terminals.

Process leaks could result in death or serious injury.
- Install and tighten all four flange bolts before applying pressure.
- Do not attempt to loosen or remove flange bolts while the transmitter is in service.

Replacement equipment or spare parts not approved by Rosemount Nuclear for use could reduce the pressure retaining capabilities of the transmitter and may render the instrument dangerous.
- Use only components supplied with the Rosemount 2151N transmitter or designated by Rosemount Nuclear as spare parts for the 2151N.

Improper assembly of mounting bracket to process flange can damage sensor module.
- For safe assembly of bracket to transmitter process flange, bolts must break back plane of flange web (i.e. bolt hole), but must not contact module housing. Use only the approved bolts supplied with the bracket.

GENERAL CONSIDERATIONS

Measurement performance depends upon proper installation of the transmitter, and its associated impulse piping and valves. Mount the transmitter close to the process and use minimum piping to achieve best performance. For flow measurement, proper installation of the primary element is also critical to performance. Also, consider the need for easy access, personnel safety, practical field calibration, and a suitable transmitter environment. Install the transmitter to minimize vibration, shock, and temperature fluctuation.

Remove orange plugs from the transmitter conduit and process connection openings. The orange plugs are used to keep the housing free of debris during shipping. They are not meant to be in the conduit openings when the transmitter is installed and in use.

MECHANICAL CONSIDERATIONS

This section contains information you should consider when preparing to mount the transmitter. Read this section carefully before proceeding to the mechanical installation procedure.

⚠ WARNING

Do not attempt to loosen or remove flange bolts while the transmitter is in service.

Mount the Rosemount 2151N transmitter to a rigid support (i.e. one with a fundamental mechanical resonant frequency of 40 Hz or greater). A stainless steel bracket is available for the coplanar flange, and a painted carbon steel bracket is available for the traditional flange.

Refer to **Figure 2-4** for typical mounting configurations for both the coplanar and traditional flange options.

For maximum accuracy, zero the transmitter after installation to cancel any zero shift that may occur due to liquid head effect caused by mounting position.

NOTE
The transmitter is calibrated in an upright position at the factory. Mounting the transmitter in another position may cause the zero point to shift by an amount equivalent to the internal liquid head within the sensor module induced by the varied mounting position. For maximum accuracy, zero the transmitter to cancel this effect per **Section 3: Calibration**.

Mount the process flanges with sufficient clearance for process connections. For safety reasons, place the drain/vent valves so the process fluid is directed away from possible human contact when the vents are used. Also, consider that access to the vent/drain valve(s) and process connection(s) may be required for plant specific operations (i.e. calibration, draining, etc.).

Process Connections and Interfaces

Process tubing must be installed to prevent any added mechanical stress on the transmitter. Use stress-relief loops in the process tubing or separately support the process tubing close to the transmitter.

Connections on the transmitter flange are 1/4-18 NPT. Use your plant-approved thread sealant when making threaded connections.

If drain/vent valves are opened to bleed process lines, torque drain/vent valve stems to the value in **Table 5-2** in **Section 5: Maintenance and Troubleshooting** when closing.

Impulse Piping

The piping between the process and the transmitter must accurately transfer the pressure to obtain accurate measurements. There are five possible sources of error: pressure transfer (such as obstruction), leaks, friction loss (particularly if purging is used), trapped gas in a liquid line or liquid in a gas line, and density variations between the legs.

The best location for the transmitter in relation to the process pipe depends on the process itself. Use the following guidelines to determine transmitter location and placement of impulse piping:

- Keep impulse piping as short as possible.
- For liquid service, slope the impulse piping at least 1 inch per foot (8 cm per meter) upward from the transmitter toward the process tap (see **Figure 2-1** for details).
- For gas service, slope the impulse piping at least 1 inch per foot (8 cm per meter) downward from the transmitter toward the process tap (see **Figure 2-1** for details).
- Avoid high points in liquid lines and low points in gas lines.
- Make sure both impulse legs are the same temperature.
- Use impulse piping of large enough diameter to avoid friction effects and blockage.
- Vent all gas from liquid piping legs and internal to transmitter process flange.
- Drain all liquid from gas piping legs and internal to transmitter process flange.
- When using a sealing fluid, fill both piping legs to the same level.
- When purging, make the purge connection close to the process taps and purge through equal lengths of the same size pipe – avoid purging through the transmitter.
- Keep corrosive or hot process material out of direct contact with the transmitter.
- Prevent sediment deposits in the impulse piping.
- Keep the liquid balanced on both legs of the impulse piping.
- Avoid conditions that might allow process fluid to freeze within the process flange.
- Make sure the impulse piping is of adequate strength to be compatible with anticipated pressure.

Mounting Configuration

Refer to **Figure 2-1** for examples of the following mounting configurations:

Liquid Flow Measurement

- Place taps to the side of the line to prevent sediment deposits on the process isolators.
- Mount the transmitter beside or below the taps so gases vent into the process lines.

Gas Flow Measurement

- Place taps in the top or side of the line.
- Mount the transmitter beside or above the taps to drain liquid into the process line.

Steam Flow Measurement

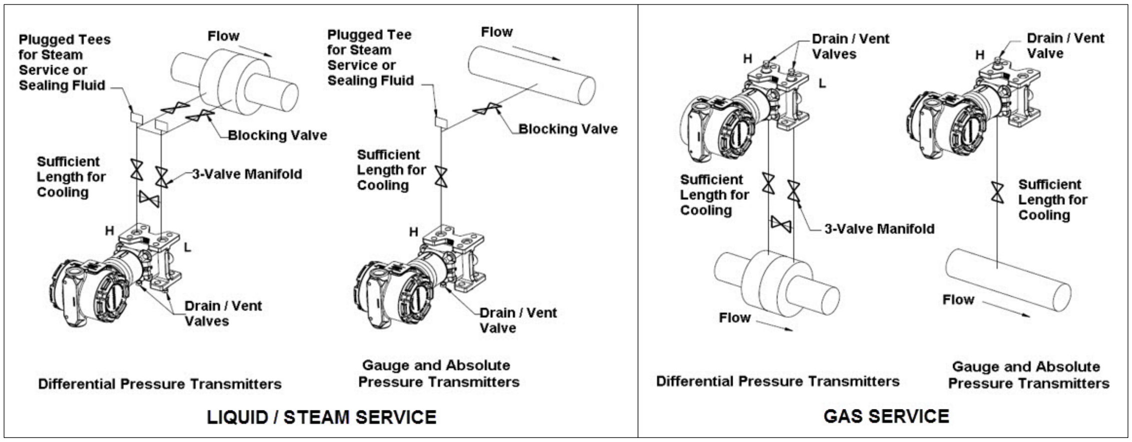
- Place taps to the side of the line.
- Mount the transmitter below the taps to ensure that impulse piping will remain filled with condensate.
- Fill impulse lines with water to prevent steam from contacting the transmitter directly and to ensure accurate measurement start-up. Condensate chambers are not typically necessary since the volumetric displacement of the transmitter is negligible.

NOTE
For steam service, do not blow down impulse piping through the transmitter. Flush the lines with the transmitter isolated and refill the lines with water before resuming measurement.

NOTE
The mounting configurations described above and depicted in **Figure 2-1** are based on general industry "best practice" recommendations. Where applicable, specific plant approved installation practices should be used.

NOTE
In steam or other elevated temperature services, it is important that temperatures at the process flanges not exceed 250°F (121°C). In vacuum service, these limits are reduced to 220°F (104°C).

Figure 2-1 – Transmitter Installation
Examples (liquid, gas or steam)



Please note that transmitters depicted in Figure 2-1 are intended for reference only.

Conduit Connections

The conduit connections to the transmitter are threaded. Options available are 1/2-14 NPT, M20 x 1.5, and PG 13.5. Two conduits are available on the transmitter housings for convenient installation. Close off the unused conduit with the compatible thread type stainless steel plug provide with the transmitter. Use your plant-approved thread sealant on the conduit connection threads and install the plug per the torque values in **Table 5-2** in **Section 5: Maintenance and Troubleshooting**.

NOTE
A Swagelok® rotatable two-piece 90 degree elbow is available. Please contact Rosemount Nuclear for ordering information.

Electronics Housing

The standard transmitter orientation is shown in dimensional drawings found in this manual (see **Figure 2-5**). Use the following procedure to rotate the electronics housing for improved field access to wiring or the zero/span screws:

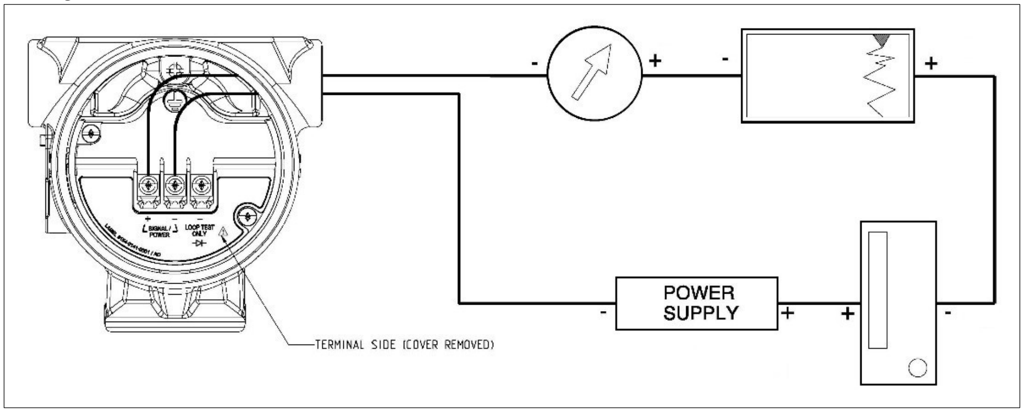
1. Loosen the housing rotation set screws.
2. First rotate the housing clockwise to the desired location. If the desired location cannot be achieved due to thread limit, rotate the housing counter clockwise to the desired location (up to 360° from thread limit).
3. Retighten the housing rotation set screws.

ELECTRICAL CONSIDERATIONS

This section contains information you should consider when preparing to make electrical connections to the transmitter. Read this section carefully before proceeding to the electrical installation procedure.

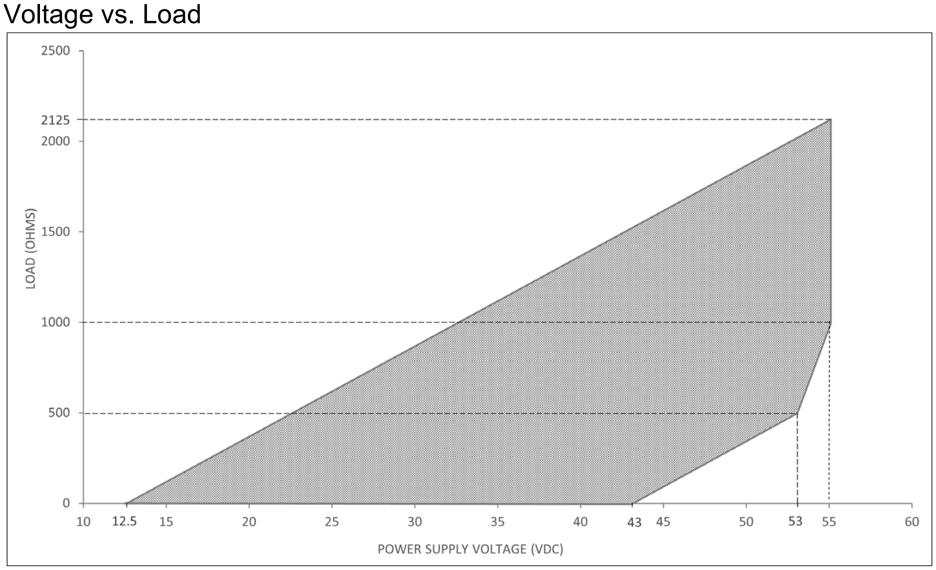
Rosemount 2151N transmitters provide a 4-20 mA signal when connected to a suitable dc power source. **Figure 2-2** illustrates a typical signal loop consisting of a transmitter, power supply, and various receivers (controller, indicator, computer).

Figure 2-2 – Typical Transmitter Wiring Connection



The power supply versus load limit relationship is shown in **Figure 2-3**. The loop load is the sum of the resistance of the signal leads and the load resistance of the receivers. Any power supply ripple appears in the output signal.

Figure 2-3 – Transmitter Supply Voltage vs. Load



Signal Integrity

Signal wiring need not be shielded, but twisted pairs yield the best results. Shielded cable should be used for best results in electrically noisy environments. Do not run signal wiring in conduit or open trays with AC power wiring, or near heavy electrical equipment.

For installations with EMC performance requirements, consult the applicable EMC test reports for additional details regarding recommended practices for electrical wiring per various national and international codes and regulations.

The capacitance sensing element uses alternating current to generate a capacitance signal. This alternating current is developed in an oscillator circuit with a nominal frequency of 110 kHz +/- 11 kHz. This 110 kHz signal is capacitively-coupled to the transmitter case ground through the sensing element. Because of this coupling, a voltage may be imposed across the load, depending on choice of grounding.

This impressed voltage, which is seen as high frequency noise, has no effect on most instruments. Computers with short sampling times in a circuit where the negative transmitter terminal is grounded can detect a significant noise signal. Filter this signal out by using a large capacitor (1 uf) or a 110 kHz LC filter across the load. Signal loops grounded at any other point are negligibly affected by this noise and do not need filtering.

Signal wiring may be ungrounded (floating) or grounded at any one point in the signal loop.

The transmitter case may be grounded or ungrounded. Grounding should be completed in accordance with national and local electrical codes. Transmitter case can be grounded using either the internal or external ground connection.

- Internal Ground Connection: The Internal Ground Connection screw is inside the terminal side of the electronics housing (see **Figure 2-7**). The screw is identified by a ground symbol (⏚), and is standard on 2151N transmitters.

- External Ground Assembly: The External Ground location is indicated by the ground symbol (⏚) on the module (see **Figure 2-5**). An External Ground Assembly kit can be ordered as an option on the 2151N transmitter. This kit can also be ordered as a spare part. Please contact Rosemount Nuclear for ordering information.

Wiring Connections

The transmitter terminal block and ground screw terminals are designed to accommodate wire sizes from 24 AWG to 14 AWG. The screw terminals are also compatible with stud size #6 (M3.5) or #8 (M4) crimp terminals. Crimped connections shall be performed in accordance with manufacturers' recommendations with proper tooling.

INSTALLATION PROCEDURES

Installation consists of mounting the transmitter and conduit/connector, and making electrical and process connections. The procedures for each operation follow.

Mechanical – Transmitter

⚠ WARNING

Improper assembly of mounting bracket to transmitter process flange can damage sensor module.

For safe assembly of bracket to flange, bolts must break back plane of flange web (i.e. bolt hole), but must not contact module housing. Use only the approved bolts supplied with the bracket.

1. Attach the mounting bracket to the mounting location as follows:

   Coplanar and Traditional Flange Panel Mount
   Mount the bracket to a panel or other flat surface (for illustration see **Figure 2-4**). Please note that the bolts required for this step are customer supplied hardware. Based on tests performed by Rosemount, the bolts listed in **Table 2-1** are recommended for the bracket-to-customer interface. Torque each bolt to the value shown in **Table 5-2** in **Section 5: Maintenance and Troubleshooting**.

2. Attach the transmitter to the mounting bracket (for illustration see **Figure 2-4**). Use the four bolts with washers supplied with the transmitter (3/8-16 x 1 1/2-inch bolts for coplanar flange; 7/16-20 x 5/8-inch bolts for traditional flange). Torque each bolt to the value shown in **Table 5-2** in **Section 5: Maintenance and Troubleshooting**.

Table 2-1 – Recommended Bolts for Bracket-to-Customer Interface

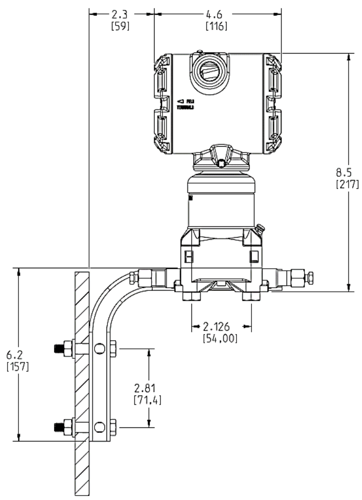
Bracket Code (1)	Bracket Type	Recommended Bolt for Bracket-to-Customer Interface(2)
0	No Bracket Supplied	N/A
1	SST Bracket for Coplanar Flange	5/16-18 Grade 5(3)
2	Painted CS Bracket for Traditional Flange	5/16-18 Grade 5(3)

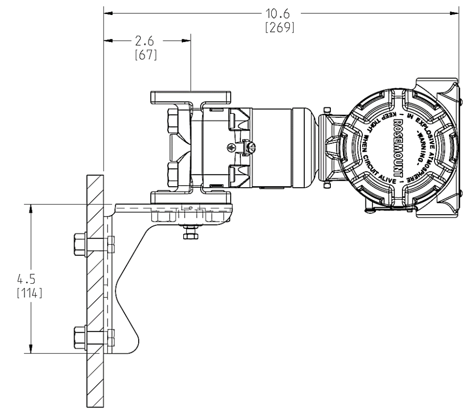
(1) The Bracket Code can be found in the 14th position of the 2151N model string.
(2) Bracket-to-customer interface hardware is not supplied by Rosemount Nuclear.
(3) Grade 2 bolt is also acceptable for use.

Figure 2-4 – Typical Mounting Configuration

Stainless Steel Panel Mounting Bracket for Coplanar Flange	Carbon Steel Panel Mounting Bracket for Traditional Flange

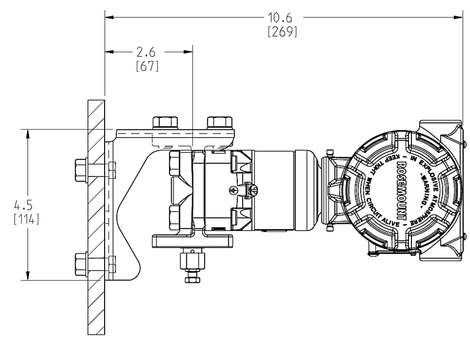
Mounted Outside Bracket – Side View



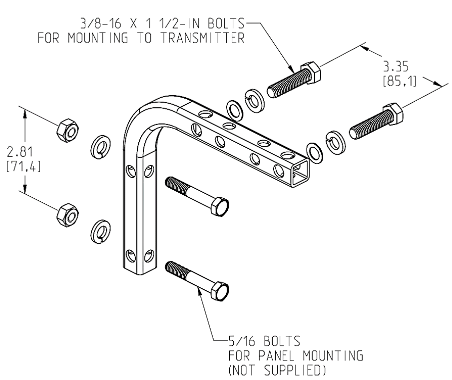


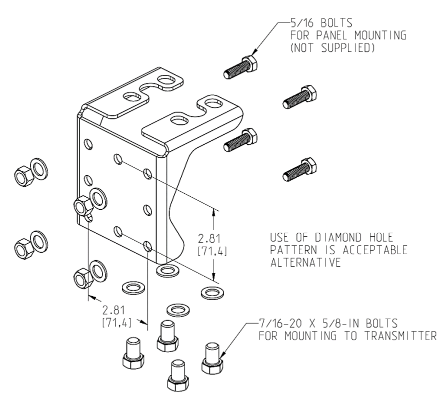
Mounted Inside Bracket – Side View

Not Applicable



Mounting Bracket Detail

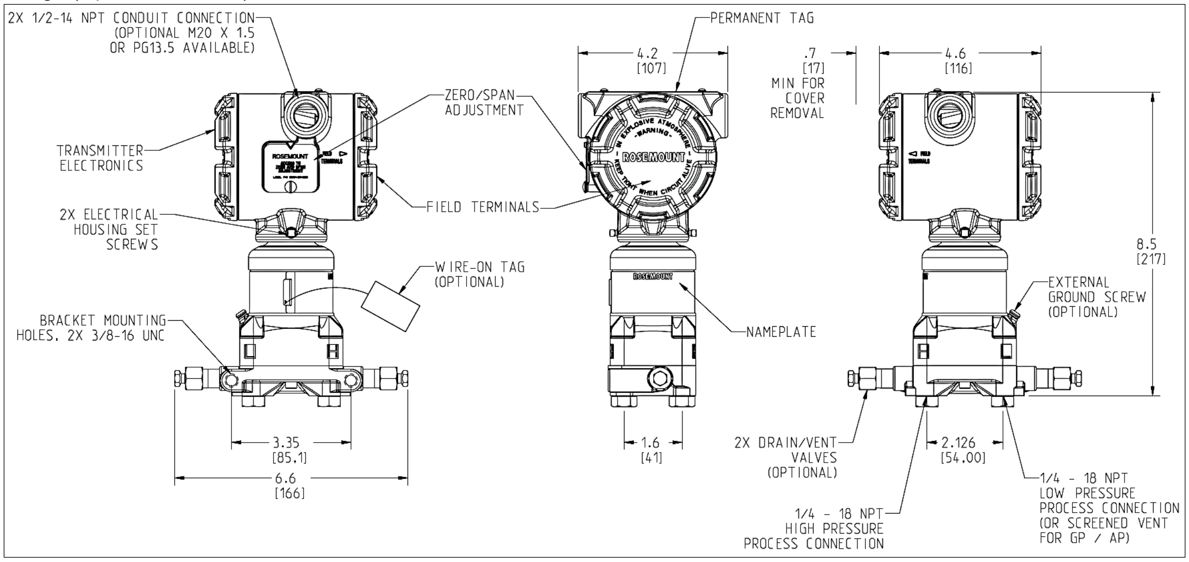




NOTE: All dimensions are nominal in inches [millimeters]

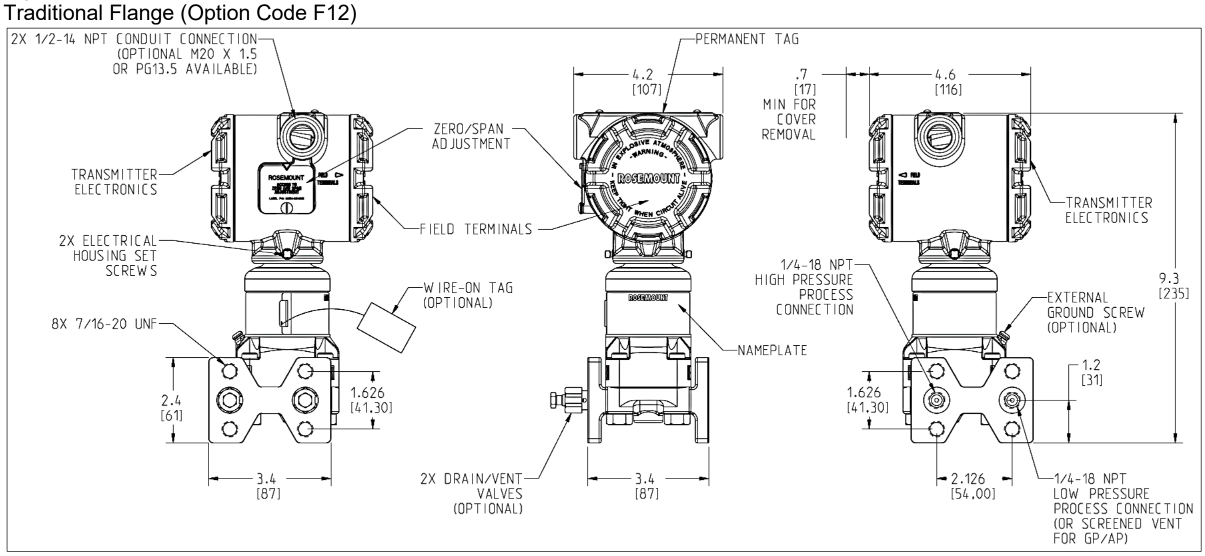
Figure 2-5 – Transmitter Dimensional Drawings

Figure 2-5a – Rosemount 2151N with Coplanar Flange (Option Code E12)



NOTE: All dimensions are nominal in inches [millimeters]

Figure 2-5b – Rosemount 2151N with Traditional Flange (Option Code F12)



NOTE: All dimensions are nominal in inches [millimeters]

Mechanical – Conduit Connections

⚠ CAUTION

Be careful not to damage the set screw interface between the sensor module and the electronics housing when making conduit connections.

NOTE

Install the conduit seal in accordance with the manufacturer's instructions or use the following procedure:

1. Seal conduit threads with your plant-approved thread sealant.
2. Install conduit/connector to the manufacturers' recommended thread engagement or torque level. For electrical connectors, refer to the appropriate manufacturers' installation manuals. Hold the electronics housing securely to avoid damaging the set screw interface between the sensor module and the electronics housing during conduit installation.
3. Provide separate support for the conduit if necessary.

Electrical

⚠ CAUTION

Do not connect signal leads to the 'TEST' terminals.

⚠ WARNING

Electrical shock can result in death or serious injury. Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

1. Remove the cover from the terminal side of the transmitter.
2. Connect the power leads to the 'SIGNAL' terminals on the transmitter terminal block (see **Figure 2-6**). Avoid contact with the leads and terminals. Do not connect the powered signal wiring to the test terminals, power could damage the test diode. Torque the terminal screws to the value shown in **Table 5-2** in **Section 5: Maintenance and Troubleshooting** or hand-tight. Signal wiring supplies all power to the transmitter. If a 3-wire connector is utilized or loop grounding is required, use the ground screw shown in **Figure 2-7**.
3. Recheck connections for proper polarity. Position excess wiring inside the housing so it cannot be damaged during cover installation.
4. Carefully replace cover. Take care that electrical wires do not interfere with cover installation or wire damage could occur.

NOTE

Housing covers are pre-lubricated and do not require additional lubrication.

5. Tighten until cover and housing are fully engaged metal-to-metal (see **Figure 2-8**). Once metal-to-metal contact has been made, it is not necessary to tighten the cover any further.
6. Visually inspect both covers to ensure they are installed metal-to-metal. Visual inspection is sufficient to ensure metal-to-metal contact; however, a gap gauge may be used for verification if desired. When metal-to-metal contact has been made, the acceptable gap between cover and housing will be less than 0.010 inch (see **Figures 2-9** and **2-10**).

NOTE
Replace the cover O-rings per the steps outlined in **Electronics Housing Reassembly** section if either cover was installed metal-to-metal and then removed.

Figure 2-6 – Terminal Block Assembly

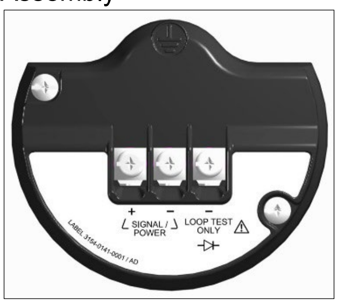


Figure 2-7 – Internal Ground Screw Location

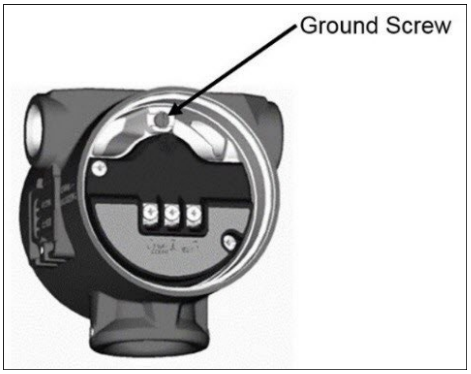


Figure 2-8 – Electronics Housing Covers Installed Metal-to-Metal

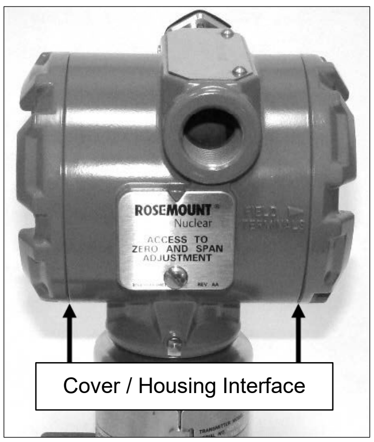
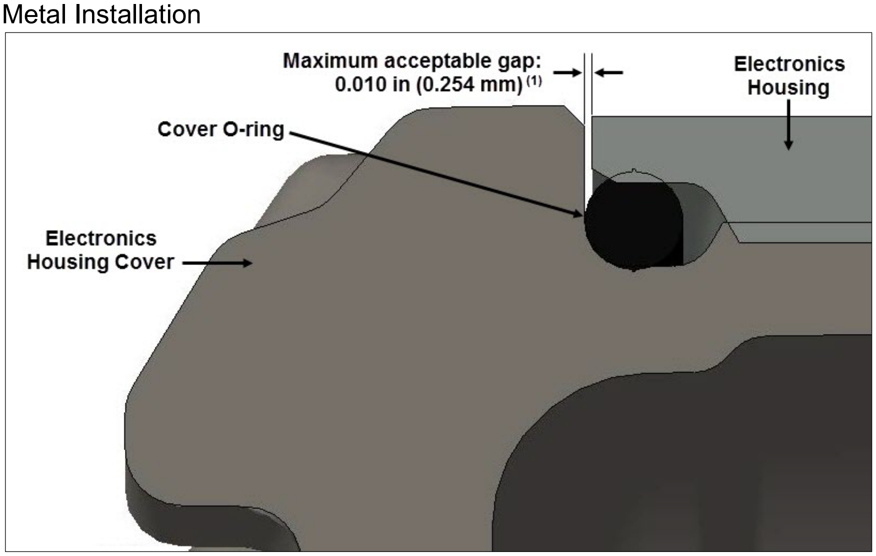


Figure 2-9 – Inspection of Metal-to-Metal Installation



(1) If the gap exceeds acceptable limit, it will be possible to insert a 0.010 inch gap gauge at least 0.100 in (2.54 mm).

Figure 2-10 – Acceptable vs. Unacceptable Gap Between Cover and Housing

Figure 2-10a – Acceptable Gap Between Cover and Housing

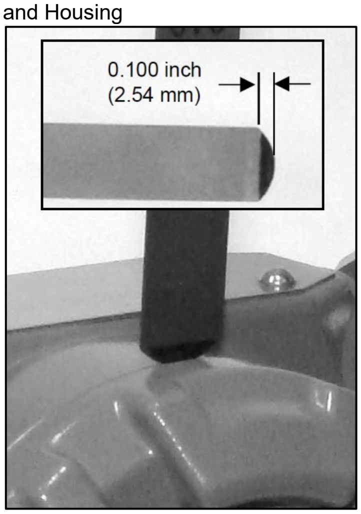
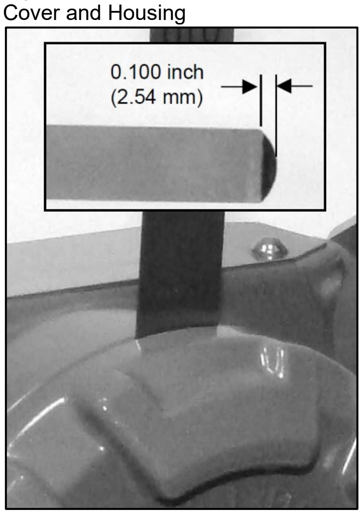


Figure 2-10b – Unacceptable Gap Between Cover and Housing



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SECTION 3: Calibration

OVERVIEW

This section contains the following transmitter calibration information:

- Calibration Overview
  - → Calibration Considerations
  - → Definitions
  - → Span Adjustment Range
  - → Zero Adjustment Range
- Calibration Procedures
  - → Span and Zero Adjustment
    - ▪ Zero Based Calibration Procedure (LRV is Zero)
    - ▪ Elevated or Suppressed Zero Calibration Procedure
    - ▪ Coarse Zero Select Jumper Position Selection Procedure
- Damping Adjustment
- Correction for High Static Line Pressure
  - → High Static Pressure Span Effect on Range Codes 1, 2 and 3 DP Transmitters
  - → High Static Pressure Span Correction for Range Codes 4 and 5 DP Transmitters
  - → High Static Line Pressure Zero Correction for DP Transmitters (All Ranges)
- Linearity

SAFETY MESSAGES

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- Do not remove the transmitter covers in explosive environments when the circuit is live.

⚠ WARNING

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals when the circuit is live.

⚠ WARNING

Process leaks could result in death or serious injury.

- Install and tighten all four flange bolts before applying pressure.
- Do not attempt to loosen or remove flange bolts while the transmitter is in service.

⚠ WARNING

Replacement equipment or spare parts not approved by Rosemount Nuclear for use could reduce the pressure retaining capabilities of the transmitter and may render the instrument dangerous.

- Use only components supplied with the 2151N transmitter or designated by Rosemount Nuclear as spare parts for the 2151N.

NOTE
The pressure unit "inches H_2O at 68ºF (20ºC)" is used throughout this section. For ease of reading this pressure unit will be abbreviated to "inH_2O".

CALIBRATION OVERVIEW

Calibration Considerations

Review this section to become familiar with the fundamentals of calibrating the Rosemount 2151N transmitter. Contact Rosemount Nuclear with questions regarding calibrations that are not explained in this manual.

Rosemount 2151N transmitters are factory calibrated to the range shown on the nameplate (see **Figure 1-1**). This range may be changed within the limits of the transmitter. Zero may also be adjusted to elevate (for all models except absolute pressure reference) or suppress (for all models). Calibrations that have a lower range value below zero are termed zero elevated while calibrations that have a lower range value above zero are termed zero suppressed.

NOTE
Transmitters are factory calibrated at ambient temperature and pressure to the customer's specified range. If calibration is not specified, transmitters are calibrated 0 to Upper Range Limit (URL).

The zero and span are adjusted during calibration using zero and span adjustment screws. The adjustment screws are accessible externally and are located behind the access cover plate on the side of the electronics housing (see **Figure 3-1**). Transmitter output increases with clockwise rotation of the adjustment screws. For normal calibration adjustments, the zero adjustment screw has negligible effect on the span and the span adjustment has negligible effect on the zero.

For large amounts of zero adjustment, a coarse zero select jumper is provided. The jumper is located on the electronics assembly, accessible within the electronics housing as shown in **Figures 3-1** and **3-2**. Models ordered with optional output damping will have a damping adjustment potentiometer located on the amplifier board (see Figure 3-2).

Procedures for calibration, including setting the coarse zero select jumper and optional damping adjustment, are provided later in this section.

Definitions

The following definitions and descriptions are provided to aid in calibration:

DP
Differential pressure between the high pressure “H” and low pressure “L” process inputs, as marked on the transmitter module.

Upper Range Limit (URL)
The highest pressure the transmitter can be adjusted to measure, specified in the model ordering information by pressure range code.

Upper Range Value (URV)
The highest pressure the transmitter is adjusted to measure. This pressure corresponds to the 20mA output point.

Lower Range Value (LRV)
The lowest pressure the transmitter is adjusted to measure. This pressure corresponds to the 4mA output point.

Span = |URV - LRV|

Zero Based Calibration
Calibration where the LRV is zero (see **Figure 3-3**)

Elevated Zero Calibration
Calibration where the LRV is less than zero (i.e. the LRV is achieved when a positive pressure is applied to the low pressure side of the DP cell or a vacuum is applied to the high pressure side of the DP cell – see **Figure 3-3**).

Suppressed Zero Calibration
Calibration where the LRV is greater than zero (i.e. the LRV is achieved when a positive pressure is applied to the high pressure side of the DP cell or a vacuum is applied to the low pressure side of the DP cell – see **Figure 3-3**).

% Zero Offset
= (LRV/URL) X 100
Note: % Zero Offset is used when making coarse zero adjustments and replaces the traditional % Zero Elevation and % Zero Suppression terms. This concept is used due to the limited interaction between zero and span adjustments on the 2151N pressure transmitter.

Sign Convention
Positive numbers indicate positive pressure is applied to the high pressure side of the DP cell or a vacuum is applied to the low pressure side of the DP cell. The high pressure side is indicated on the sensor module by an “H”.

Negative numbers indicate positive pressure is applied to the low pressure side of the DP cell or a vacuum is applied to the high pressure side of the DP cell. The low pressure side is indicated on the sensor module by an “L”.

Figure 3-1 – Zero and Span

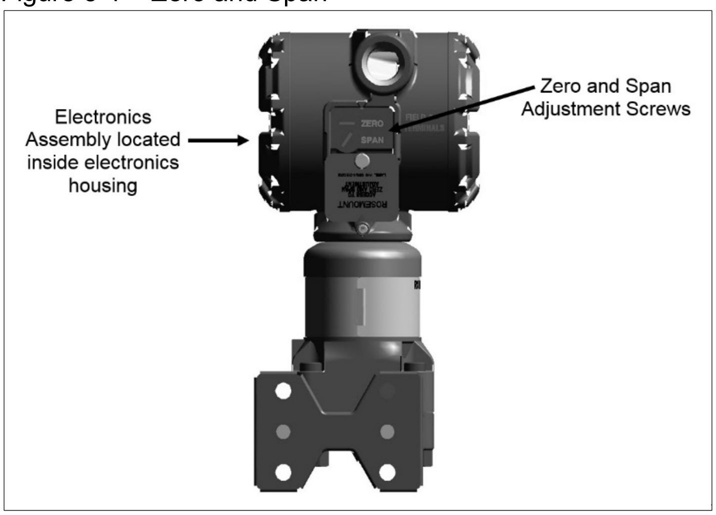
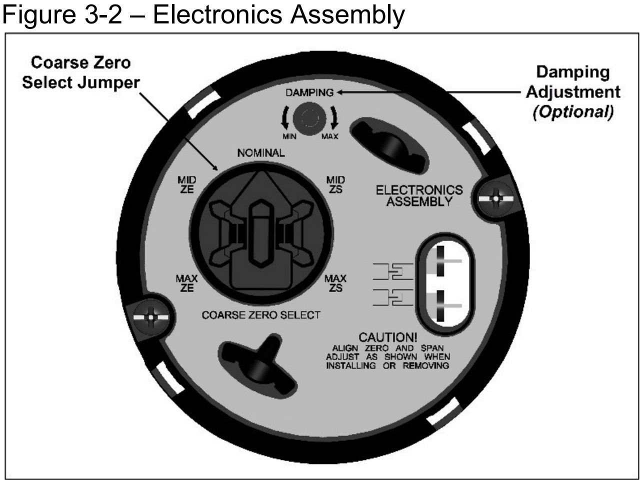


Figure 3-2 – Electronics Assembly



Span Adjustment Range

For transmitter ranges 2 to 6, the span is continuously adjustable to allow calibration anywhere between the transmitter URL and 1/10 of URL. For example, the span on a Range 2 transmitter can be continuously adjusted between 25 and 250 inH_2O (6,22 kPa and 62,2 kPa).

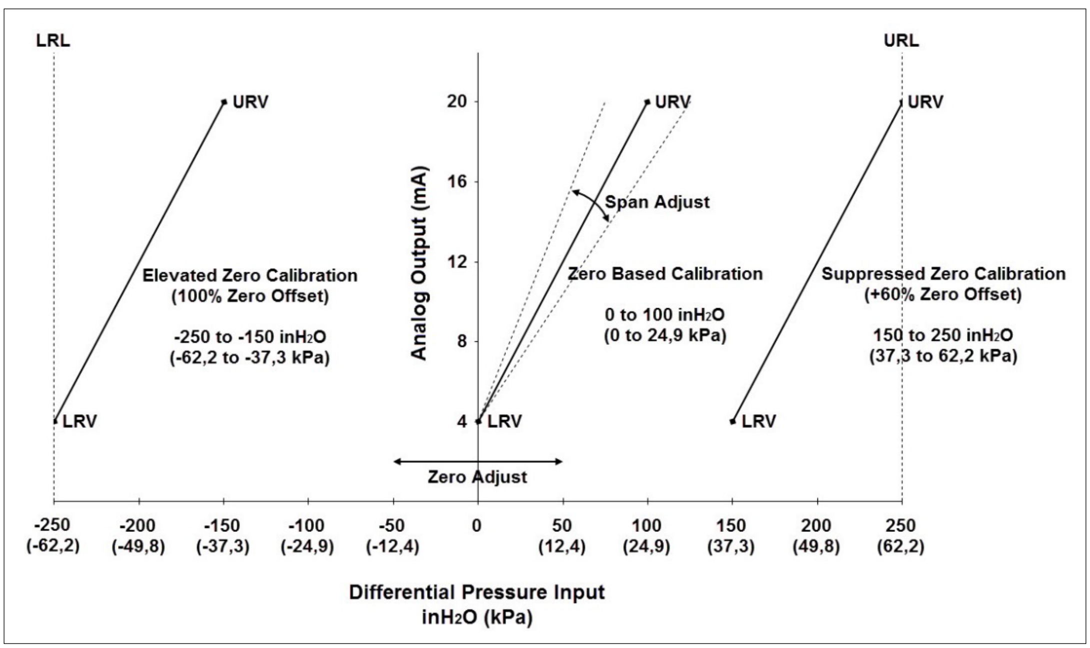
For Range 1 transmitters, the span is continuously adjustable to allow calibration anywhere between the transmitter URL and 1/5 of URL. For example, the span on a Range 1 transmitter can be continuously adjusted between 5 and 25 inH_2O (1,25 kPa and 6,22 kPa).

Zero Adjustment Range

The transmitter zero can be adjusted to achieve a maximum 90% Zero Offset for suppressed zero calibrations and -100% Zero Offset for elevated zero calibrations. To achieve these levels of zero elevation and zero suppression, the 2151N is equipped with a coarse zero select jumper located on the Electronics Assembly in the electronics housing (see **Figure 3-2**).

A graphical representation of three calibrations is shown in **Figure 3-3**. Instructions for setting the coarse zero select jumper are provided in the **Calibration Procedures** section. The zero may be elevated or suppressed with the limitation that no applied pressure within the calibrated range exceeds the URL or LRL. During zero elevation, the transmitter may be calibrated to cross zero, ex. -75 to 75 inH_2O (-18,6 kPa to 18,6 kPa).

Figure 3-3 – Graphical Representation of Elevated Zero, Zero Based, and Suppressed Zero Calibrations for a Range 2 Transmitter



CALIBRATION PROCEDURES

The following calibration procedures describe the recommended steps necessary to calibrate the Rosemount 2151N pressure transmitter.

Span and Zero Adjustment

⚠ CAUTION

The 2151N pressure transmitter contains electronic circuit boards which may be static sensitive.

NOTE
Electronics housing covers do not need to be removed to access the zero and span adjustment screws.

NOTE
The pressure unit "inches H_2O at 68ºF (20ºC)" is used throughout this section. For ease of reading this pressure unit will be abbreviated to "inH_2O".

Zero Based Calibration Procedure (LRV is zero)

The adjustment screws are accessible externally and are located behind the access cover plate on the side of the electronics housing (see **Figure 3-1**). The transmitter output increases with clockwise rotation of the adjustment screw. The coarse zero select jumper is in the Nominal position for all zero based calibrations.

1. Apply a pressure equal to the LRV to the high side pressure connection and turn Zero adjustment until output reads 4 mA.
2. Apply a pressure equal to the URV to the high side process connection and turn Span adjustment until output reads 20 mA.
3. Check to assure desired outputs are achieved and repeat steps 1 and 2 if necessary.

Figure 3-4 contains an example of calibrating a transmitter with a zero based calibration. **Figure 3-4a** uses English Units (inH2O) while **Figure 3-4b** uses SI Units (kPa).

Figure 3-4 – Zero Based Calibration Example

Figure 3-4a – Example for Zero Based Calibration (English Units)

Range 2 for a calibration of 0 to 100 inH_2O (100 inH_2O span)

1. Adjust the zero: With 0 inH_2O applied to the transmitter, turn the Zero adjustment until the transmitter reads 4 mA.
2. Adjust the span: Apply 100 inH_2O to the transmitter high side connection. Turn the Span adjustment until the transmitter output reads 20 mA.
3. Check to assure desired outputs are achieved and repeat steps 1 and 2 if necessary.

Figure 3-4b – Example for Zero Based Calibration (SI Units)

Range 2 for a calibration of 0 to 24,9 kPa (24,9 kPa span)

1. Adjust the zero: With 0 kPa applied to the transmitter, turn the Zero adjustment until the transmitter reads 4 mA.
2. Adjust the span: Apply 24,9 kPa to the transmitter high side connection. Turn the Span adjustment until the transmitter output reads 20 mA.
3. Check to assure desired outputs are achieved and repeat steps 1 and 2 if necessary.

Elevated or Suppressed Zero Calibration Procedure

The easiest way to calibrate a 2151N pressure transmitter with an elevated or suppressed zero is to perform a zero-based calibration and then elevate or suppress the zero by adjusting the zero adjustment screw and, if necessary, the coarse zero select Jumper.

NOTE
For large amounts of elevation or suppression, it may be necessary to reposition the coarse zero select jumper. Procedures for re-positioning the jumper are described in the **Coarse Zero Select Jumper Position Selection Procedure**.

Figures 3-5 and **3-6** contain examples of calibrating a transmitter with an Elevated Zero and Suppressed Zero calibration respectively. **Figures 3-5a** and **3-6a** use English units (inH2O) while **Figures 3-5b** and **3-6b** use SI units (kPa).

Figure 3-5 – Elevated Zero Calibration Example

Figure 3-5a – Example for Elevated Zero Calibration (English Units)

Range 2 with Zero Elevation for a calibration of –120 to –20 inH_2O (100 inH_2O span)

1. Calibrate the transmitter to 0 to 100 inH_2O as described in the **Zero Based Calibration Procedure**.
2. Consult **Figure 3-8b** to help determine typical coarse zero select jumper position. If necessary, reposition jumper using the **Coarse Zero Select Jumper Position Selection Procedure**.

   For this example:
   % Zero Offset = (-120 inH_2O /250 inH_2O)*100 = -48%
   Position the jumper to the MID ZE position.

3. Apply -120 inH_2O to the high side process connection (as marked on the transmitter sensor module) and adjust the zero until the transmitter output reads 4mA. DO NOT USE THE SPAN ADJUSTMENT.

NOTE
Applying 120 inH_2O to the low side process connection (as marked on the transmitter module) will give the same result.

4. Apply -20 inH_2O to the high side process connection (as marked on the transmitter sensor module). Verify the output reads 20mA. If necessary, adjust the span. Recheck the zero after any span adjustment.

NOTE
Applying 20 inH_2O to the low side process connection (as marked on the transmitter module) will give the same result.

Figure 3-5b – Example for Elevated Zero Calibration (SI Units)

Range 2 with Zero Elevation for a calibration of –29,9 to –5,0 kPa (24,9 kPa span)

1. Calibrate the transmitter to 0 to 24,9 kPa as described in the **Zero Based Calibration Procedure**.
2. Consult **Figure 3-8b** to help determine typical coarse zero select jumper position. If necessary, reposition jumper using the **Coarse Zero Select Jumper Position Selection Procedure**.

   For this example:
   % Zero Offset = (-29,9 kPa /62,2 kPa)*100 = -48%
   Position the jumper to the MID ZE position.

3. Apply -29,9 kPa to the high side process connection (as marked on the transmitter sensor module) and adjust the zero until the transmitter output reads 4mA. DO NOT USE THE SPAN ADJUSTMENT.

NOTE
Applying 29,9 kPa to the low side process connection (as marked on the transmitter module) will give the same result.

4. Apply -5,0 kPa to the high side process connection (as marked on the transmitter sensor module). Verify the output reads 20 mA. If necessary, adjust the span. Recheck the zero after any span adjustment.

NOTE
Applying 5,0 kPa to the low side process connection (as marked on the transmitter module) will give the same result.

Figure 3-6 – Suppressed Zero Calibration Example

Figure 3-6a – Example for Suppressed Zero Calibration (English Units)

Range 2 with Zero Suppression for a calibration of 20 to 120 inH_2O (100 inH_2O span)

1. Calibrate the transmitter to 0 to 100 inH_2O as described in the **Zero Based Calibration Procedure**.
2. Consult **Figure 3-8b** to help determine typical coarse zero select jumper position. If necessary, reposition jumper using the **Coarse Zero Select Jumper Position Selection Procedure**.

   For this example:
   % Zero Offset = (20 inH_2O /250 inH_2O)*100 = 8%
   Position the jumper to the NOMINAL position.

3. Apply 20 inH_2O to the high side process connection, and adjust the zero until the transmitter output reads 4 mA. DO NOT USE THE SPAN ADJUSTMENT.
4. Apply 120 inH_2O to the high side process connection. Verify the output reads 20 mA. If necessary, adjust the span. Recheck the zero after any span adjustment.

Figure 3-6b – Example for Suppressed Zero Calibration (SI Units)

Range 2 with Zero Suppression for a calibration of 5,0 to 29,9 kPa (24,9 kPa span)

1. Calibrate the transmitter to 0 to 24,9 kPa as described in the **Zero Based Calibration Procedure**.
2. Consult **Figure 3-8b** to help determine typical coarse zero select jumper position. If necessary, reposition jumper using the **Coarse Zero Select Jumper Position Selection Procedure**.

   For this example:
   % Zero Offset = (5,0 kPa /62,2 kPa)*100 = 8%
   Position the jumper to the NOMINAL position.

3. Apply 5,0 kPa to the high side process connection, and adjust the zero until the transmitter output reads 4 mA. DO NOT USE THE SPAN ADJUSTMENT.
4. Apply 29,9 kPa to the high side process connection. Verify the output reads 20 mA. If necessary, adjust the span. Recheck the zero after any span adjustment.

Coarse Zero Select Jumper Position Selection Procedure

The coarse zero select jumper (see **Figure 3-2**) is shipped from the factory in either the Nominal position or the position required to obtain the calibration specified when ordered. Changes to the factory calibration may require repositioning of the jumper. To do this, follow the procedure below:

1. Calculate the % zero offset using the following formula:

   % Zero Offset = (LRV/URL) X 100
   Where:
   LRV = Lower Range Value of desired calibration
   URL = Transmitter Upper Range Limit

2. Consult **Figures 3-8a** or **3-8b** to determine typical jumper position.
3. If the jumper requires re-positioning, remove the electronics housing cover opposite the “Field Terminals” label. Remove the jumper by squeezing the sides and pulling out. Reposition the jumper with the arrow pointing to the typical position and carefully push in. Ensure both jumper clips are fully engaged and return to applicable calibration procedure.

If no change is required, return to applicable calibration procedure.

NOTE
Typical jumper positions indicated in **Figures 3-8a** and **3-8b** are approximate. Position jumper as needed to achieve the desired calibration.

Figure 3-7 contains an example of determining the typical position of the coarse zero select jumper. **Figure 3-7a** uses English Units (inH_2O) while **Figure 3-7b** uses SI Units (kPa).

Figure 3-7 – Coarse Zero Select Jumper Adjustment Example

Figure 3-7a – Example for Coarse Zero Select Jumper Adjustment (English Units)

Range 2 for a calibration of -175 to -125 inH_2O

LRV = -175 inH_2O
% Zero Offset = (-175 inH_2O /250 inH_2O)*100 = -70%

Per **Figure 3-8b**, the typical jumper position is MAX ZE.

Figure 3-7b – Example for Coarse Zero Select Jumper Adjustment (SI Units)

Range 2 for a calibration of –43,6 to –31,1 kPa

LRV = -43,6 kPa
% Zero Offset = (-43,6 kPa /62,2 kPa)*100 = -70%

Per **Figure 3-8b**, the typical jumper position is MAX ZE.

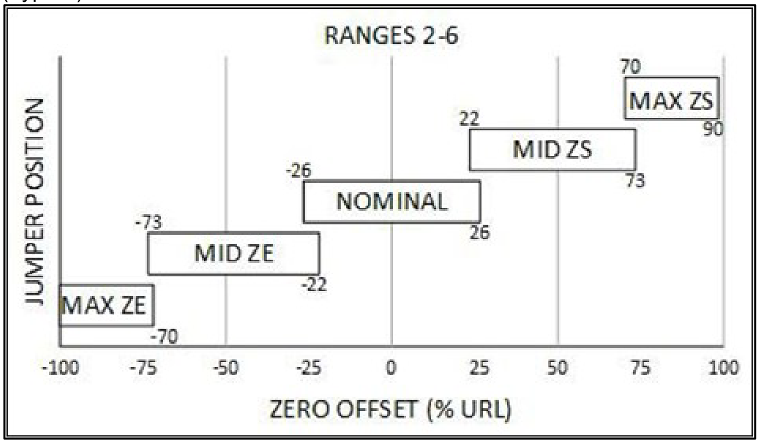
NOTE
If you remove either cover during the above procedures, follow the instructions in **Section 5: Maintenance and Troubleshooting** to reinstall the cover.

Figure 3-8 – Coarse Zero Select Jumper Position (Typical)

Figure 3-8a – Range 1 Jumper Position (Typical)

% Zero Offset values and jumper positions indicated are approximations. Select jumper position as needed to achieve the desired calibration.

Figure 3-8b – Ranges 2-6 Jumper Position (Typical)



% Zero Offset values and jumper positions indicated are approximations. Select jumper position as needed to achieve the desired calibration.

Damping Adjustment

The 2151N amplifier boards with Adjustable Damping are designed to permit damping of rapid pulsations in the pressure source through adjustment of the single turn damping adjustment potentiometer (see **Figure 3-2**). When adjusted to the maximum position (clockwise stop), time-constant values of at least 1.20 seconds are available for 2151N transmitters. Transmitters with the electronics damping option are calibrated and shipped with the adjustment set at the counterclockwise stop (unless a customer specifies time response setting), giving the minimum time constant.

Damping adjustment should be made with the transmitter calibrated to the intended application calibration. To adjust the damping, turn the damping adjustment potentiometer until the desired time constant is obtained. It is best to set the damping to the shortest possible time constant. Since transmitter calibration is not affected by the damping setting, damping may be adjusted with the transmitter installed on the process.

CAUTION

The damping adjustment potentiometer has positive stops at both ends. Forcing the potentiometer beyond the stops may cause permanent damage and require electronics assembly replacement.

NOTE

If you remove either electronics housing cover during the above procedures, follow the instructions in **Section 5: Maintenance and Troubleshooting** to reinstall the cover.

Correction for High Static Line Pressure [1]

High Static Line Pressure Span Effect on Range Codes 1, 2, and 3 DP Transmitters

Rosemount 2151N Range 1, 2, and 3 differential pressure transmitters do not require correction for high static pressure span effect. The correction for these ranges occurs within the sensor; however, an associated residual uncertainty remains. This uncertainty is stated as the high static line pressure span effect found in Product Data Sheet 00813-0000-4851.

High Static Line Pressure Span Correction for Range Code 4 and 5 DP Transmitters

Rosemount 2151N Range 4 and 5 pressure transmitters experience a systematic span shift when operated at high static line pressure. It is linear and correctable during calibration.

The correction factor for span shift caused by the application of static line pressure is shown in **Table 3-1**.

Table 3-1 – Range 4 and 5 Correction Factors

Range 4 and 5 Span Correction Factor % Input Reading per 1000 psi (6,90 MPa)	
Range 4	1.00%
Range 5	1.25%

Correction factors have an uncertainty of ±0.4% of input reading per 1000 psi (6,90 MPa).

The following illustrates two methods of correcting for the high static pressure span shift. Examples follow each method.

Method 1 for High Static Line Pressure, Ranges 4 and 5

Adjust transmitter output while leaving the input pressure at desired in service differential pressures. Use one of the following formula sets (depending on the pressure units being used to calibrate):

If using English Units (psi):
Corrected output reading at LRV =
4 mA + ((S X P/1000 X LRV)/Span) X 16 mA
Corrected output reading at URV =
20 mA + ((S X P/1000 X URV)/Span) X 16 mA

If using SI Units (MPa):
Corrected output reading at LRV =
4 mA + ((S X P/6,90 X LRV)/Span) X 16 mA
Corrected output reading at URV =
20 mA + ((S X P/6,90 X URV)/Span) X 16 mA

Where:
S = Value from **Table 3-1** divided by 100
LRV = Lower Range Value
URV = Upper Range Value
P = Static Line Pressure
Span = Calibrated Span

(1) For Rosemount 2151N pressure transmitters with Standard Option Code "P4", correction for High Static Line Pressure (HSLP) at customer specified line pressure (with no residual HSLP uncertainty) may have been performed at the factory. Please contact Rosemount Nuclear for details.

NOTE
For corrections where the calculated output adjustment exceeds the output high or low adjustment limits, the pressure input adjust procedure described in **Method 2** (see pg. 34) is recommended.

Figure 3-9 outlines examples of calculating a High Static Line Pressure Span Correction using **Method 1**. **Figure 3-9a** uses English units (psi) while **Figure 3-9b** uses SI units (MPa).

Figure 3-9 – High Static Line Pressure Span Correction using Method 1 Example

Figure 3-9a – Example for High Static Line Pressure Span Correction using Method 1 (English Units)

Range 4 for a calibration of –10 to 45 psi corrected for 1,500 psi static line pressure:

1. Calculate the corrected output reading at LRV

   = 4 mA + ((0.01 X 1500 psi/1000 psi X (-10 psi))/55 psi) X 16 mA
   = 3.956 mA

2. Calculate the corrected output reading at URV

   = 20 mA + ((0.01 X 1500 psi/1000 psi X 45 psi)/55 psi) X 16 mA
   = 20.196 mA

3. At atmospheric static line pressure, apply 10 psi to the low side process connection (-10 psi), and adjust the zero until the transmitter output reads 3.956 mA.
4. Remaining at atmospheric static line pressure, apply 45 psi to the <u>high</u> side process connection and adjust the span until the transmitter output reads 20.196 mA.
5. Check to assure desired outputs are achieved and repeat steps 3 and 4 if necessary.

When the transmitter is exposed to 1,500 psi static line pressure, within specified uncertainties, the output will be 4 mA at -10 psi and 20 mA at 45 psi.

Figure 3-9b – Example for High Static Line Pressure Span Correction using Method 1 (SI Units)

Range 4 for a calibration of –0,07 to 0,31 MPa corrected for 10,34 MPa static line pressure:

1. Calculate the corrected output reading at LRV

   = 4 mA + ((0,01 X 10,34 MPa/6,90 MPa X (-0,07 MPa))/0,38 MPa) X 16 mA
   = 3,956 mA

2. Calculate the corrected output reading at URV

   = 20 mA + ((0,01 X 10,34 MPa/6,90 MPa X 0,31 MPa)/0,38 MPa) X 16 mA
   = 20,196 mA

3. At atmospheric static line pressure, apply 0,07 MPa to the low side process connection (-0,07 MPa), and adjust the zero until the transmitter output reads 3,956 mA.
4. Remaining at atmospheric static line pressure, apply 0,31 MPa to the high side process connection and adjust the span until the transmitter output reads 20,196 mA.
5. Check to assure desired outputs are achieved and repeat steps 3 and 4 if necessary.

When the transmitter is exposed to 10,34 MPa static line pressure, within specified uncertainties, the output will be 4 mA at -0,07 MPa and 20 mA at 0,31 MPa.

Method 2 for High Static Line Pressure, Ranges 4 and 5

Adjust transmitter pressure input while leaving the output at 4 mA and 20 mA. Use one of the following formula sets (depending on the pressure units being used to calibrate):

If using English Units (psi):
Corrected LRV pressure input =
Desired LRV – ((S X LRV) X (P/1000))
Corrected URV pressure input =
Desired URV – ((S X URV) X (P/1000))

If using SI Units (MPa):
Corrected LRV pressure input =
Desired LRV – ((S X LRV) X (P/6,90))
Corrected URV pressure input =
Desired URV – ((S X URV) X (P/6,90))

Where:
S = Value from **Table 3-1** divided by 100
LRV = Lower Range Value
URV = Upper Range Value
P = Static Line Pressure
Span = Calibrated Span

Figures 3-10 and **3-11** outline two examples of calculating a High Static Line Pressure Span Correction using Method 2.

"Example 1" in **Figure 3-10** contains a calculation for a Zero Based Calibration Range. **Figure 3-10a** uses English units (psi) for the calculation while **Figure 3-10b** uses SI units (MPa)

"Example 2" in **Figure 3-11** demonstrates the calculation for a Zero Elevated Calibration Range. "Example 2" can also be followed for Zero Suppressed Calibration Ranges. **Figure 3-11a** uses English units (psi) while **Figure 3-11b** uses SI units (MPa).

Figure 3-10 – High Static Line Pressure Span Correction using Method 2; Example 1

Figure 3-10a – Example 1 for High Static Line Pressure Span Correction using Method 2 (English Units)

Range 4 for a calibration of 0 to 45 psi corrected for 1,500 psi static line pressure

1. In this example LRV is 0 psid. Zero differential pressure points require no span correction.
2. Calculate the corrected URV pressure input

   = 45 psi – ((0.01 X 45 psi) X (1500 psi/1000 psi))
   = 44.325 psi

3. At atmospheric static line pressure, with zero differential pressure applied, adjust the zero until the transmitter output reads 4 mA.
4. Remaining at atmospheric static line pressure, apply 44.325 psi to the high side process connection and adjust the span until the transmitter output reads 20 mA.
5. Check to assure desired outputs are achieved and repeat steps 3 and 4 if necessary.

When the transmitter is exposed to 1,500 psi static line pressure, within specified uncertainties, the output will be 4 mA at 0 psi and 20 mA at 45 psi.

Figure 3-10b – Example 1 for High Static Line Pressure Span Correction using Method 2 (SI Units)

Range 4 for a calibration of 0 to 0,31 MPa corrected for 10,34 MPa static line pressure

1. In this example LRV is 0 MPa. Zero differential pressure points require no span correction.
2. Calculate the corrected URV pressure input

   = 0,31 MPa – ((0,01 X 0,31 MPa) X (10,34 MPa/6,90 MPa))
   = 0,305 MPa

3. At atmospheric static line pressure, with zero differential pressure applied, adjust the zero until the transmitter output reads 4 mA.
4. Remaining at atmospheric static line pressure, apply 0,305 MPa to the high side process connection and adjust the span until the transmitter output reads 20 mA.
5. Check to assure desired outputs are achieved and repeat steps 3 and 4 if necessary.

When the transmitter is exposed to 10,34 MPa static line pressure, within specified uncertainties, the output will be 4 mA at 0 MPa and 20 mA at 0,305 MPa.

Figure 3-11 – High Static Line Pressure Span Correction using Method 2; Example 2

Figure 3-11a – Example 2 for High Static Line Pressure Span Correction using Method 2 (English Units)

Range 5 for a calibration of –250 to 750 psi corrected for 1,500 psi static line pressure

1. Calculate the corrected LRV pressure input

   = -250 psi – ((0.0125 X -250 psi) X (1500 psi/1000 psi))
   = -245.31 psi

2. Calculate the corrected URV pressure input

   = 750 psi – ((0.0125 X 750 psi) X (1500 psi/1000 psi))
   = 735.94 psi

3. At atmospheric static line pressure, apply 245.31 psi to the low side process connection (-245.31 psi) and adjust the zero until the transmitter output reads 4 mA.
4. Remaining at atmospheric static line pressure, apply 735.94 psi to the high side process connection and adjust the span until the transmitter output reads 20 mA.
5. Check to assure desired outputs are achieved and repeat steps 3 and 4 if necessary.

When the transmitter is exposed to 1,500 psi static line pressure, within specified uncertainties, the output will be 4 mA at -250 psi and 20 mA at 750 psi.

Figure 3-11b – Example 2 for High Static Line Pressure Span Correction using Method 2 (SI Units)

Range 5 for a calibration of –1,72 to 5,17 MPa corrected for 10,34 MPa static line pressure

1. Calculate the corrected LRV pressure input

   = -1,72 MPa – ((0,0125 X -1,72 MPa) X (10,34 MPa/6,90 MPa))
   = -1,69 MPa

2. Calculate the corrected URV pressure input

   = 5,17 MPa – ((0,0125 X 5,17 MPa) X (10,34 MPa/6,90 MPa))
   = 5,07 MPa

3. At atmospheric static line pressure, apply 1,69 MPa to the low side process connection (-1,69 MPa) and adjust the zero until the transmitter output reads 4 mA.
4. Remaining at atmospheric static line pressure, apply 5,07 MPa to the high side process connection and adjust the span until the transmitter output reads 20 mA.
5. Check to assure desired outputs are achieved and repeat steps 3 and 4 if necessary.

When the transmitter is exposed to 10,34 MPa static line pressure, within specified uncertainties, the output will be 4 mA at -1,72 MPa and 20 mA at 5,17 MPa.

High Static Line Pressure Zero Correction for DP Transmitters (All Ranges)

Zero shift with static pressure is not systematic. However, the effect can be eliminated during calibration. To trim out the zero error at high static line pressure, perform the following:

- If the calibrated range includes zero differential pressure (zero-based or zero crossing):
  a. Calibrate the pressure transmitter according to the preceding sections.
  b. Apply atmospheric line pressure to high and low sides (zero differential pressure).
  c. Record the output reading.
  d. Apply the intended line pressure to high and low sides (zero differential pressure).
  e. Adjust the zero to match the reading obtained in step c.

- If the calibrated range does not include zero differential pressure (certain zero elevated or zero suppressed calibrations):
  a. Calibrate the pressure transmitter to the intended span using the **Zero Based Calibration Procedure**.
  b. Apply atmospheric line pressure to high and low sides (zero differential pressure).
  c. Record the output reading.

d. Apply the intended line pressure to high and low sides (zero differential pressure).
e. Record the output reading.
f. Subtract the reading in step e from the reading in step c. *Note the sign associated with the calculated value, as the sign is maintained for the adjustment in step i*.
g. Calibrate the transmitter to the desired calibration using the **Elevated or Suppressed Zero Calibration Procedure**.
h. For range codes 4 and 5 only, correct for static pressure span effect as described in **Static Pressure Span Correction for Range Code 4 and 5 DP Transmitters**.
i. Apply pressure equal to the LRV (zero line pressure), adjust the zero by the amount calculated in step f.

Figure 3-12 outlines an example of a Zero Correction for High Static Line Pressure for a transmitter with a non-zero based calibration.

Figure 3-12 – High Static Line Pressure Zero Correction Example

If -0.007 mA was calculated in step f and the LRV reads 4.002 mA, adjust the zero until the LRV reads 3.995 mA. DO NOT ADJUST THE SPAN. When static pressure is applied, the output should read 4.002 mA.

Linearity

Linearity is factory optimized and requires no field adjustment.

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SECTION 4: Operation

OVERVIEW

This section provides a brief description of basic 2151N pressure transmitter operations in the following order:

- Transmitter Theory of Operation
- The Sensor Cell
- Demodulator
- Oscillator
- Voltage Regulator
- Current Control
- Current Limit
- Reverse Polarity Protection

TRANSMITTER THEORY OF OPERATION

The block diagram in **Figure 4-1** illustrates the operation of the 2151N pressure transmitter.

The 2151N pressure transmitter has a variable capacitance sensor (see **Figure 4-2**). Differential capacitance between the sensing diaphragm and the capacitor plates is converted electronically to a 2-wire, 4-20 mA dc signal based on the following formulas:

$$P = k_1 \left(\frac{C_2 - C_1}{C_1 + C_2} \right)$$

Where:

P	is the process pressure.
k_1	is a constant.
C_1	is the capacitance between the high-pressure side and the sensing diaphragm.
C_2	is the capacitance between the low-pressure side and the sensing diaphragm.

$$fV_{p-p} = \frac{I_{ref}}{C_1 + C_2}$$

Where:

I_{ref}	is the reference current.
V_{p-p}	is the peak to peak oscillation voltage.
f	is the oscillation frequency.

$$I_{diff} = fV_{p-p}(C_2 - C_1)$$

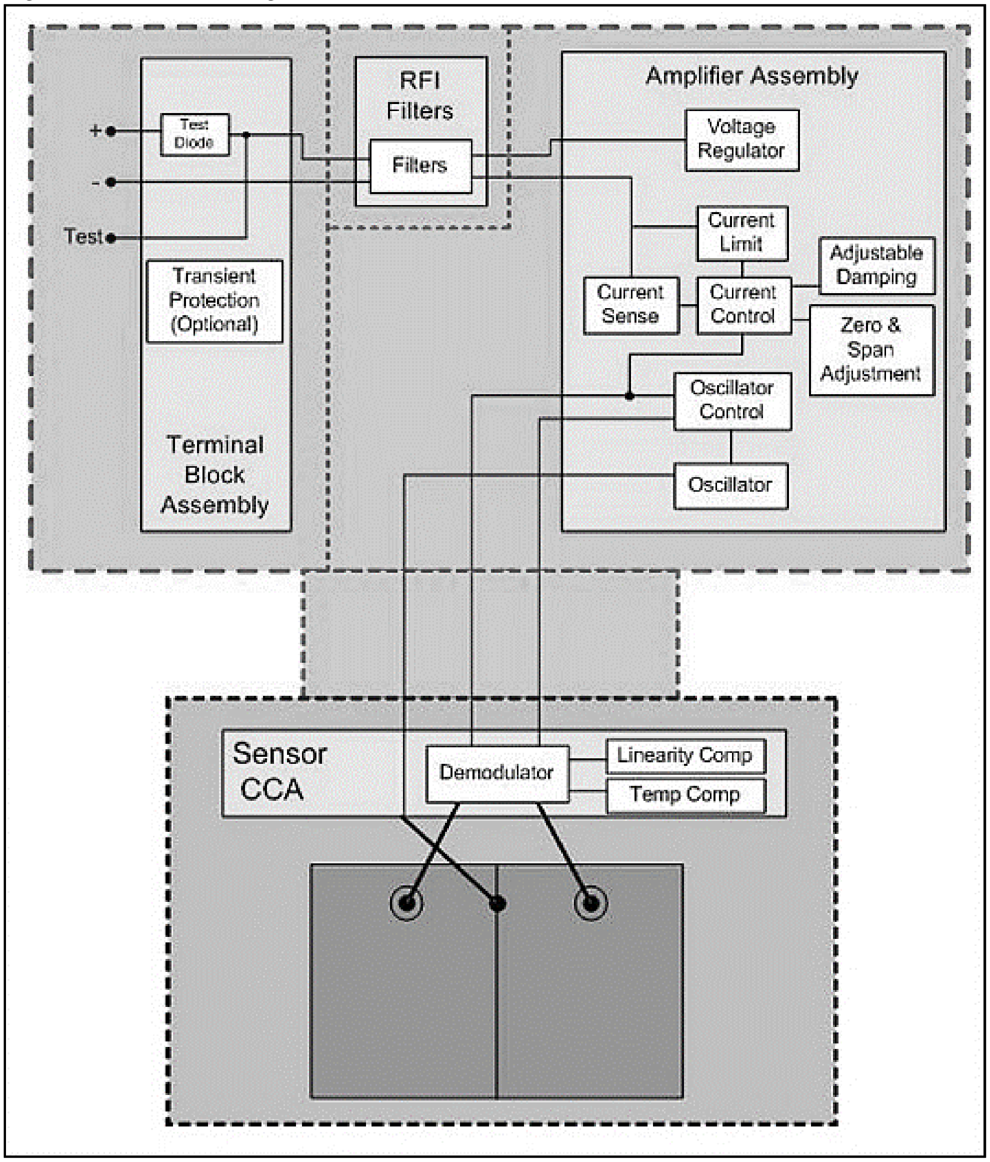
Where:

I_{diff}	is the difference in current between C_1 and C_2.

Therefore:

$$P = constant\ x\ I_{diff} = I_{ref} \left(\frac{C_2 - C_1}{C_2 + C_1} \right)$$

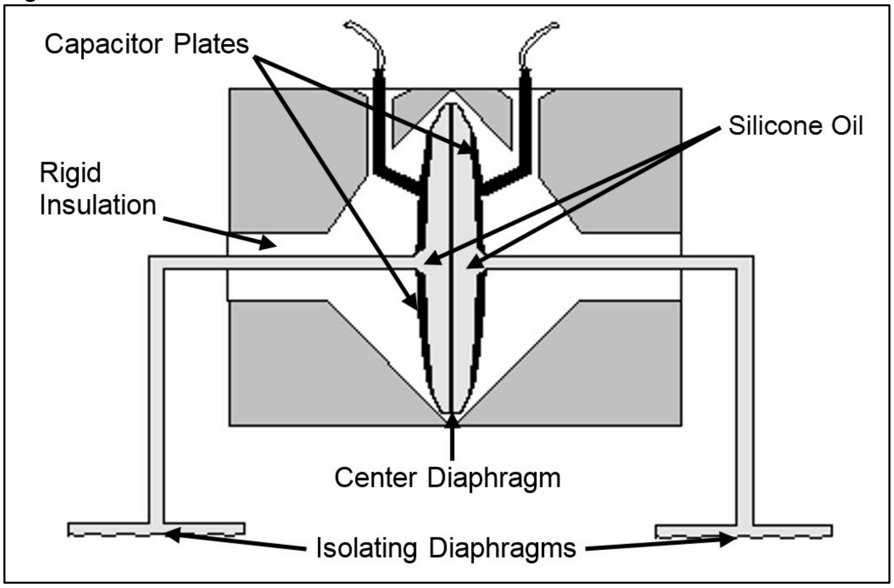
Figure 4-1 – Block Diagram



THE SENSOR CELL

Process pressure is transmitted through an isolating diaphragm and silicone oil fill fluid to a sensing diaphragm in the center of the Sensor. The reference pressure is transmitted in a like manner to the other side of the sensing diaphragm. The capacitance plates on both sides of the sensing diaphragm detect the position of the sensing diaphragm. The capacitance between the sensing diaphragm and either capacitor plate ranges from 40 pf to 80 pf depending on input pressure. An oscillator drives the sensor current through the transformer windings at roughly 110 kHz and 20 V_{p-p}.

Figure 4-2 – The Sensor Cell



DEMODULATOR

The demodulator consists of a diode bridge that rectifies the ac signal from the sensor cell to a dc signal. The oscillator driving current, I_{ref} (the sum of the dc currents through two transformer windings), is kept constant by an integrated circuit operational amplifier (op amp). The output of the demodulator is a current directly proportional to pressure, i.e.,

$$I_{diff} = fV_{p-p}(C_2 - C_1)$$

The diode bridge and temperature compensation circuits are located inside the sensor module.

OSCILLATOR

The oscillator frequency is determined by the capacitance of the sensing element and the inductance of the transformer windings. The sensing element capacitance is variable. Therefore, the frequency is variable about a nominal value of 110 kHz. An operational amplifier acts as a feedback control circuit and controls the oscillator drive voltage such that:

$$fV_{p-p} = \frac{I_{ref}}{C_1 + C_2}$$

VOLTAGE REGULATOR

The transmitter uses a zener diode, transistors, associated resistors and capacitors to provide a constant reference voltage of 3.2 Vdc and a regulated voltage of 7.4 Vdc for the oscillator and amplifiers.

CURRENT CONTROL

The current control amplifier consists of two operational amplifiers, two transistors, and associated components. The first amplifier provides an adjustable gain output proportional to the sum of the differential sensor current and a zero adjustment current. This output is supplied to the second amplifier, which controls the current in the 4-20 mA loop proportionally.

CURRENT LIMIT

The current limiter prevents output current from exceeding 30 mA nominal in an overpressure condition. Conversely, minimum output is limited to 3 mA nominal. Both the minimum and maximum current limits may vary slightly depending upon sensor pressure range code and associated calibration.

REVERSE POLARITY PROTECTION

A diode provides reverse polarity protection.

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SECTION 5: Maintenance & Troubleshooting

OVERVIEW

This section outlines techniques for checking out the components, a method for disassembly and reassembly, and a troubleshooting guide.

- General Considerations
- Test Terminal
- Electronics Assembly Checkout
- Sensor Module Checkout
- Disassembly Procedure
  - → Process Flange Removal
  - → Electronics Housing Disassembly
- Reassembly Procedure
  - → Electronics Housing Reassembly
  - → Process Flange Reassembly
- Post Assembly Tests

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operation(s). Refer to the following safety messages before performing an operation preceded by this symbol ⚠

⚠ WARNING
Explosions can result in death or injury. • Do not remove the transmitter covers in explosive environments when the circuit is live.

⚠ WARNING
Electrical shock can result in death or serious injury. • Avoid contact with the leads and terminals when the circuit is live.

EMERSON™

⚠ WARNING

Process leaks could result in death or serious injury.

- Install and tighten all four flange bolts before applying pressure.
- Do not attempt to loosen or remove flange bolts while the transmitter is in service.

⚠ WARNING

Residual process fluid may remain after disassembly of process flanges. If this fluid is potentially contaminated, take appropriate safety measures.

⚠ WARNING

Replacement equipment or spare parts not approved by Rosemount Nuclear for use could reduce the pressure retaining capabilities of the transmitter and may render the instrument dangerous.

- Use only components supplied with the 2151N transmitter or designated by Rosemount Nuclear as spare parts for the 2151N.

NOTE
Maintenance of traceability of any replacement parts is the responsibility of the user.

GENERAL CONSIDERATIONS

The Rosemount 2151N transmitter has no moving parts and require a minimum of scheduled maintenance. Calibration procedures for range adjustments are outlined in **Section 3: Calibration**. A calibration check should be conducted after inadvertent exposure to overpressure, unless your plant considers this factor separately in the plant error analysis.

NOTE
Transmitters are factory calibrated at ambient temperature and pressure to the customer's specified range. If calibration is not specified, transmitters are calibrated 0 to Upper Range Limit (URL).

Test terminals are available for in-process checks. For further checks, the transmitter can be divided into two active physical components: the sensor module and the electronics assembly.

An exploded view drawing of the transmitter is provided in **Figure 5-1**. In the following procedures, numbers in parentheses refer to item numbers in the exploded view.

Figure 5-1 – Parts Drawing, Exploded View (Rosemount 2151N with Coplanar Flange Shown)

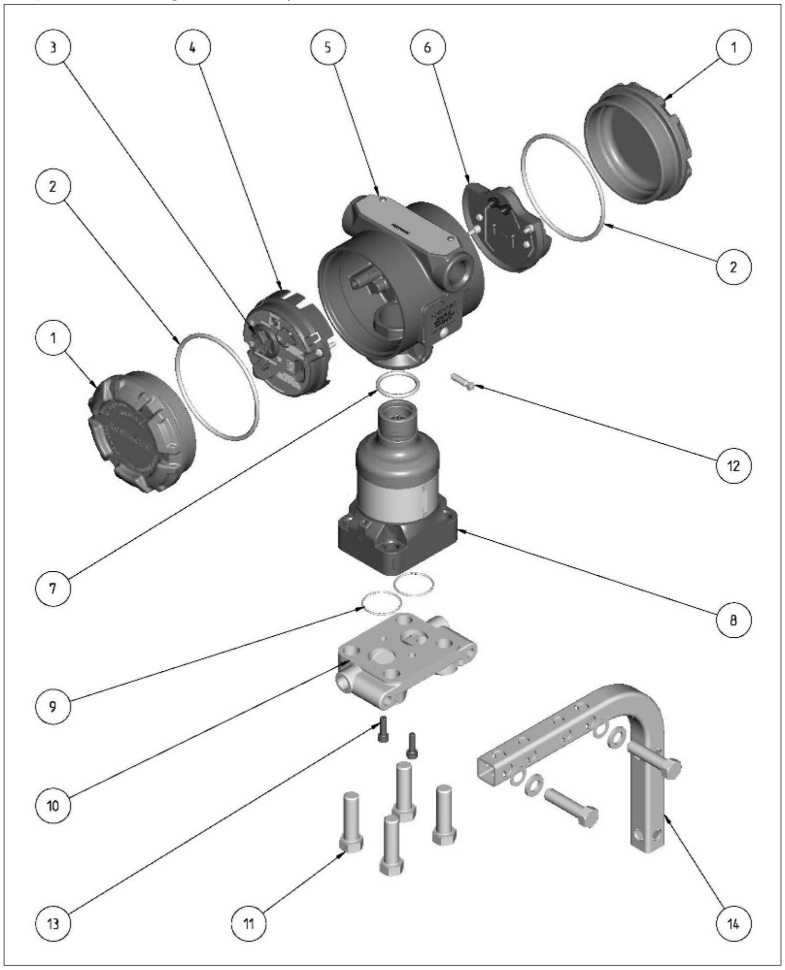


Table 5-1 – 2151N Parts List

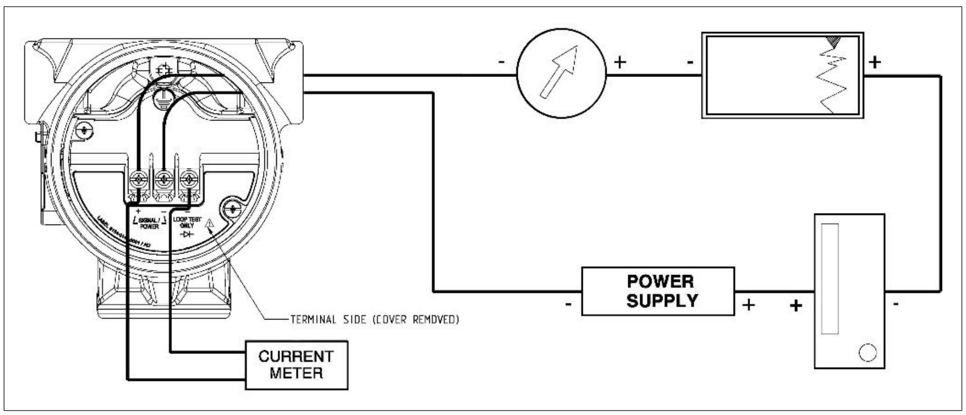
ITEM NO.	DESCRIPTION	ITEM NO.	DESCRIPTION
1	Electronics Cover	8	Sensor Module
2	Cover O-ring	9	Process Seals
3	Coarse Zero Select Jumper	10	Process Flange
4	Electronics Assembly	11	Flange Bolts
5	Electronics Housing Assembly	12	Electronics Housing Set Screws
6	Terminal Block Assembly	13	Flange Cap Screws
7	Header O-ring	14	Mounting Bracket and Hardware (Optional)

TEST TERMINAL

A test terminal is provided to allow connection of a current meter without impacting the powered signal loop. As shown in **Figure 5-2**, the current meter is connected from the positive signal terminal to the loop test terminal. Proper function of the test terminal requires that the internal resistance of the current meter be no more than 10 ohms.

> ⚠ **WARNING**
>
> Incorrect wiring of the test terminal may result in damage to the transmitter.

Figure 5-2 – Connection of Current Meter to Test Terminals



ELECTRONICS ASSEMBLY CHECKOUT

NOTE
Numbers in parentheses refer to item numbers in **Figure 5-1**.

NOTE
2151N transmitters contain electronic circuit boards which may be static sensitive. Therefore, observe proper ESD precautions/techniques whenever the electronics assemblies are handled and/or uncovered.

The electronics assembly (4) is not field-repairable and must be replaced if defective.

To check the electronics assembly for a malfunction, substitute a spare assembly into the transmitter using the procedures in this section.

To remove the existing electronics assembly, refer to the steps outlined in the **Electrical Housing Disassembly** section.

To install the new electronics assembly, refer to the steps outlined in **Electrical Housing Reassembly** section.

If this procedure reveals a malfunctioning assembly, return the defective assembly to Rosemount Nuclear for replacement.

SENSOR MODULE CHECKOUT

NOTE
Numbers in parentheses refer to item numbers in **Figure 5-1**.

The sensor module (8) is not field-repairable and must be replaced if defective. If no visible defect such as a punctured isolating diaphragm or loss of fill fluid is observed, check the sensing module in the following manner:

1. Remove the electronics assembly (4) from the transmitter per the steps outlined in **Electrical Housing Disassembly** section. This will allow access to the sensor module pins located at the top of the sensor module.

   Refer to **Figure 5-3** for the following steps.

   Diode Check
   Using a digital multimeter with diode test functionality, measure the voltage drop of the sensor diodes between the following sensor module pins (the positive (+) lead should be connected to the first sensor module pin listed):

   A. Pin #3 and Pin #5
   (Should measure approximately 1.2 volts)
   B. Pin #4 and Pin #3
   (Should measure approximately 1.2 volts)
   C. Pin #4 and Pin #5
   (Should measure approximately 2.4 volts)

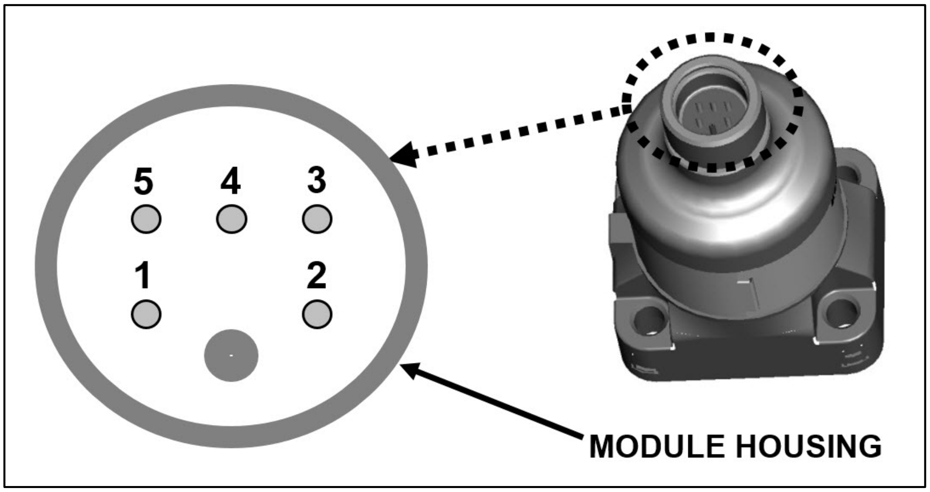
NOTE
Results obtained using the above procedure may vary depending on the specific meter that is used for testing (manufacturer, model, type, etc.). Please contact Rosemount Nuclear with any questions regarding test procedure and/or results.

   Resistance Check
   Using a low-voltage ohmmeter, check resistance between the following sensor module pins:

   A. Pin #1 and all other Pins
   (All measurements should be >10 mega ohms)
   B. Pin #2 and Pin #5
   (Should measure between 15 kilo ohms and 38 kilo ohms)
   C. All Pins and the module housing
   (All measurements between pins and module housing should be >10 mega ohms)

NOTE
The **Sensor Module Checkout** procedure does not completely test the sensor module. If electronics assembly replacement does not correct the abnormal condition and no other problems are obvious, replace the sensor module.

Figure 5-3 – Sensor Module Pin Connection



DISSASSEMBLY PROCEDURE

NOTE
Before removing the transmitter from service:

- Follow all plant safety rules and procedures.
- Isolate and vent the process from the transmitter before removing the transmitter from service.
- Remove all electrical leads and conduit.

⚠ WARNING
Residual process fluid may remain after disassembly of process flanges. If this fluid is potentially contaminated, take appropriate safety measures.

NOTE
Numbers in parentheses refer to item numbers in **Figure 5-1**.

NOTE
2151N transmitters contain electronic circuit boards which may be static sensitive. Therefore, observe proper ESD precautions/techniques whenever the electronics assemblies are handled and/or uncovered.

NOTE
Special testing and part replacement are required for reassembly. Read the **Process Flange Reassembly** procedure (see pg. 59) before attempting disassembly.

Process Flange Removal

1. Remove the transmitter from service before disassembling flanges.
2. Remove the two flange cap screws (13).
3. Detach process flange (10) by removing the four large bolts (11). TAKE CARE NOT TO SCRATCH OR PUNCTURE THE ISOLATING DIAPHRAGMS. Identify the orientation of flange with respect to sensor module for reassembly.
4. Carefully remove the O-rings (C-ring for AP transmitters) (9). DO NOT REUSE O-RINGS (C-RING). TAKE CARE NOT TO SCRATCH THE SEALING SURFACES ON THE PROCESS FLANGE AND SENSOR MODULE.

Electronics Housing Disassembly

⚠ WARNING
Remove power from the transmitter before removing either the terminal side or circuit side cover (1).

Electronics Assembly Removal

1. The electronics assembly (4) is accessible by unscrewing the cover (1) on the electronics side. This compartment is not specifically identified by notes on the housing (5), but is located opposite of the side marked “FIELD TERMINALS.”
2. Before removing the electronics assembly, align the zero and span adjustment screws so that their slots are perpendicular to the board, as shown in **Figure 5-4**.
3. Unscrew the two 6-32 captive screws holding the electronics assembly to the housing and pull the electronics assembly from the housing (see **Figure 5-4**).
4. Unclip and disconnect the connector plug from the top of the sensor module (8) to completely remove the electronics assembly (see **Figure 5-5**). To remove connector plug, apply even pressure to both clips and pull the connector body up from the sensor module. DO NOT PULL ON THE CABLE WIRES.

Terminal Block Removal

1. The signal terminals and test terminals are accessible by unscrewing the cover (1) on the terminal side. This compartment is identified by the “FIELD TERMINALS” notes on the sides of the electronics housing (5).
2. The terminal block assembly (6) is removed by removing the two 6-32 screws and pulling the terminal block assembly out of the housing (see **Figure 5-6**).

Figure 5-4 – Location of Zero and Span Adjustment Screws and Electronics Assembly Captive Screws

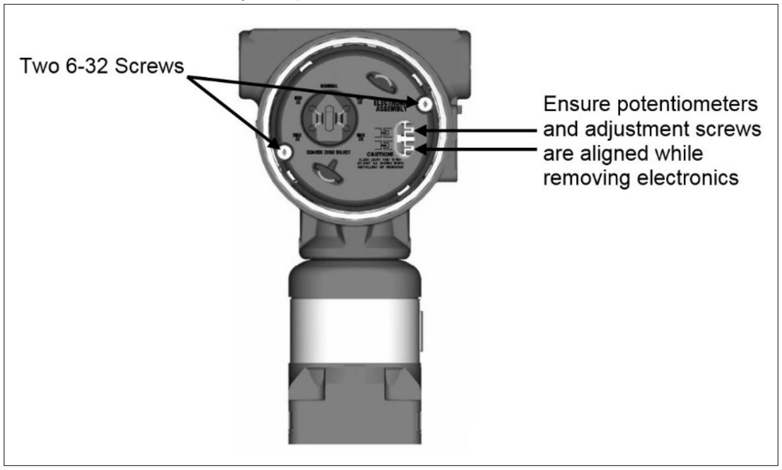


Figure 5-5 – Removing Electronics Assembly

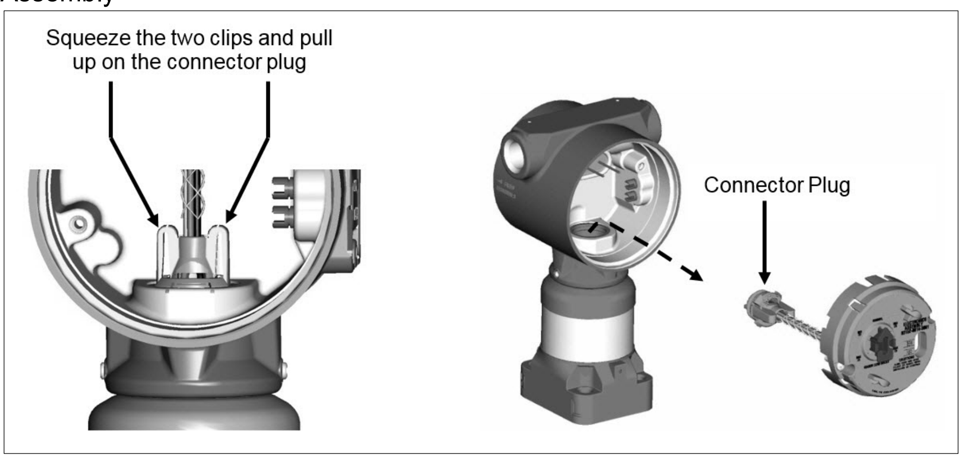
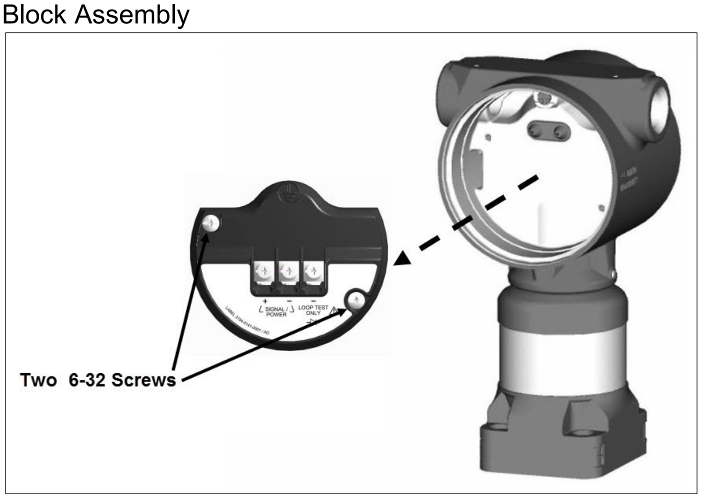


Figure 5-6 – Removing Terminal Block Assembly



REASSEMBLY PROCEDURE

NOTE
Numbers in parentheses refer to item numbers in **Figure 5-1**.

NOTE
2151N transmitters contain electronic circuit boards which may be static sensitive. Therefore, observe proper ESD precautions/techniques whenever the electronics assemblies are handled and/or exposed.

Electronics Housing Reassembly

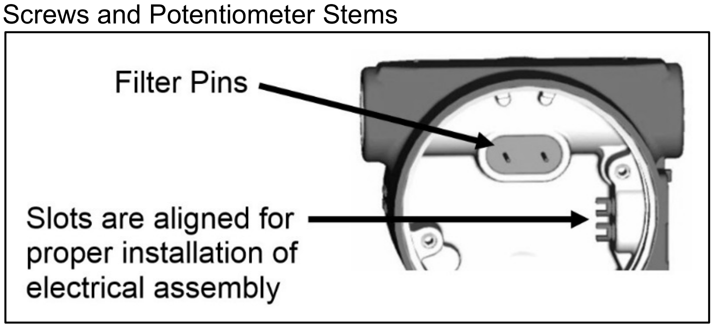
Preliminary

1. Replace the cover o-rings (2) whenever removing an electronics housing cover (1). Check the cover o-ring grooves for cleanliness. If chips or dirt are present, clean the seat and mating portion of the cover with alcohol. Lubricate replacement o-ring(s) with your plant-approved lubricant.
2. Ensure filter pins are clean. If necessary, clean with alcohol.

Electronics Assembly Installation

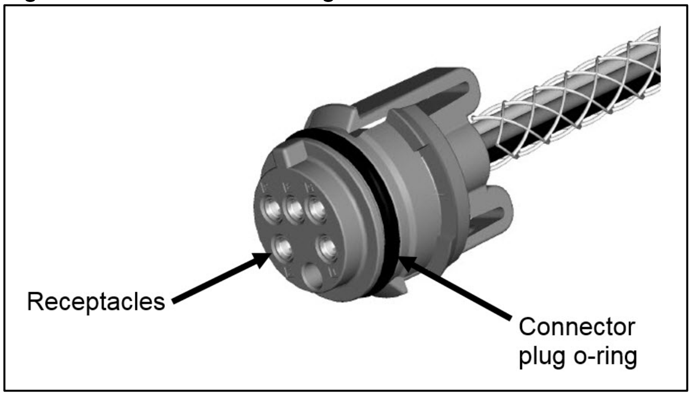
1. Align the zero and span adjustment screws with the potentiometer stems on the board in the electronics assembly (4) as shown in **Figure 5-7**.

Figure 5-7 – Alignment of Adjustment Screws and Potentiometer Stems



2. Verify connector plug o-ring is in place as shown in **Figure 5-8**. If connector plug o-ring is missing, please contact Rosemount Nuclear for assistance.
3. Apply a small amount of your plant-approved lubricant to exposed surface of the connector plug o-ring.

Figure 5-8 – Connector Plug



NOTE
Use caution when applying lubricant to the exposed surface of the connector plug o-ring to avoid getting lubricant on the receptacles at the end of the connector plug.

4. Push the connector plug down over the pins on the top of the sensor module (8) (see **Figure 5-9**). Ensure that the two clips on the connector plug are fully engaged under the lip of the sensor module (see **Figure 5-10**).

Figure 5-9 – Mating of Connector Plug to Sensor Module Pins

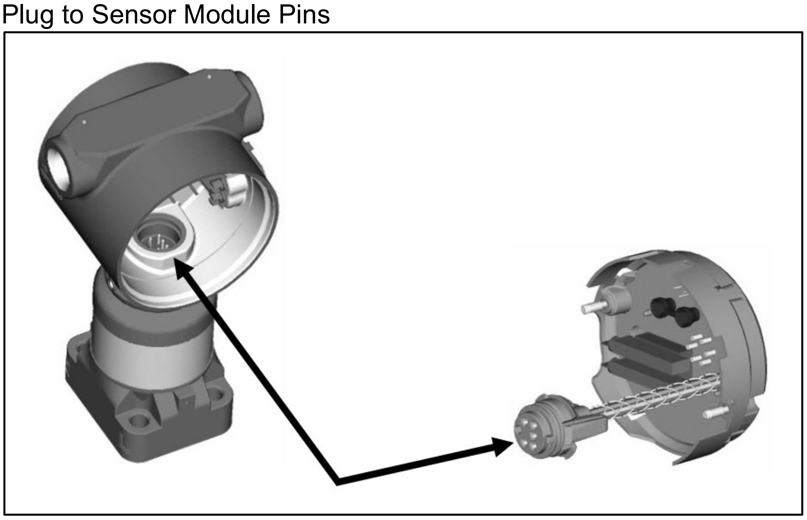
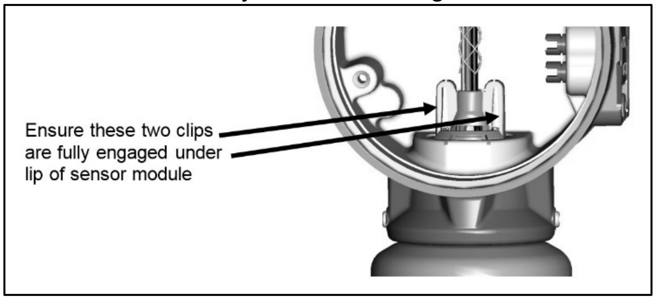
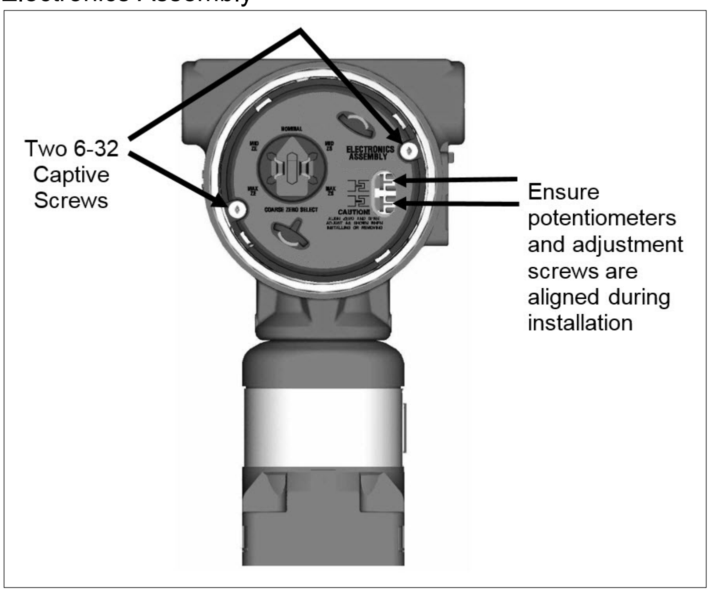


Figure 5-10 – Installation of
Electronics Assembly Connector Plug



5. Push the electronics assembly (4) into the electronics housing (5) and fasten with the two 6-32 captive screws. Torque each captive screw to 7in-lb ±1 in-lb (0.8 N-m ±0.1 N-m), or hand-tight (see **Figure 5-11**).

Figure 5-11 – Installation of
Electronics Assembly



Terminal Block Assembly

1. Install the terminal block assembly (6) into the “FIELD TERMINALS” side of the electronics housing (5) and torque the two 6-32 screws to 7in-lb ± 1 in-lb (0.8 N-m ±0.1 N-m), or hand-tight.

Electronics Housing Cover Installation

1. Inspect the housing (5) and cover (1) threads for cleanliness. If chips or dirt are present, clean the o-ring seat and mating threads on the housing and cover with a soft brush.
2. Carefully replace each cover, ensuring that each contains a cover o-ring (2) (See **Preliminary** Section above). Take care that electrical wires do not interfere with cover installation or wire damage could occur.

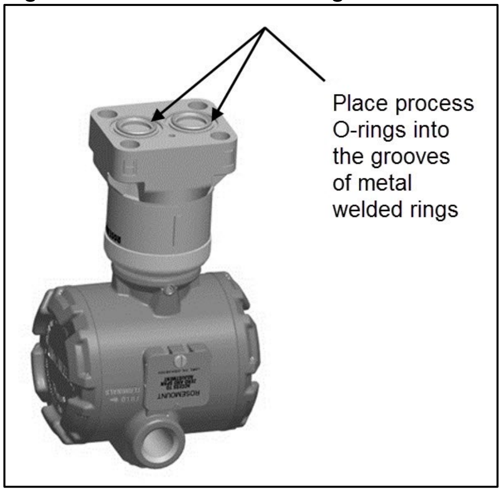
NOTE
Housing covers are pre-lubricated and do not require additional lubrication.

3. Tighten cover until it makes metal-to-metal contact with the housing (see **Figure 2-8** in **Section 2: Installation**). Once metal-to-metal contact has been made, it is not necessary to tighten the cover any further.
4. Visually inspect both covers to ensure they are installed metal-to-metal. Visual inspection is sufficient to ensure metal-to-metal contact; however, a gap gauge may be used for verification if desired. When metal-to-metal contact has been made, the acceptable gap between cover and housing will be less than 0.010 inch (see **Figures 2-9** and **2-10**).

Process Flange Reassembly

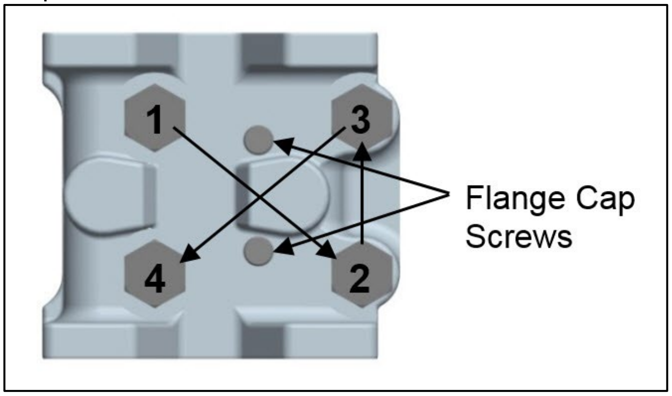
1. Replace the process O-rings (C-ring for AP transmitters) (9) with new O-rings (C-ring) if the flange (10) was removed. Carefully place one O-ring (C-ring) in each of the two weld rings located on the isolating diaphragms of the sensor module (8) as shown in **Figure 5-12**.
2. Carefully place the process flange on the sensor module. Take care not to disturb the O-rings (C-ring) or damage the isolating diaphragms.

Figure 5-12 – Process O-rings



3. With the process flange sitting securely on the sensor module, install two flange cap screws (13) into the flange location shown in **Figure 5-13**. Install the cap screws finger tight.
4. Place the four bolts (11) through the process flange and screw them on finger-tight.
5. Using a hand torque wrench, evenly seat the flange onto the sensor module by following steps 6 through 9 (see **Figure 5-13** to identify the bolts).
6. Alternately tighten the four bolts in the sequence shown in **Figure 5-13** to 150 in-lb ±15 in-lb (16.9 N-m ± 1.7 N-m)
7. Repeat step 6.
8. Repeat step 6 at 300 in-lb ± 25 in-lb (33.9 N-m ± 2.8 N-m)
9. Repeat step 8.
10. Torque the two cap screws in the flange to 33 in-lb ± 1.7 in-lb (3.7 N-m ± 0.2 N-m). NOTE: Cap screws must be torqued after bolts, or they will loosen.

Figure 5-13 – Flange Bolt Torqueing Sequence



POST ASSEMBLY TESTS

1. Conduct hydrostatic testing to 150% of maximum working pressure or 2,000 psi (13.79 MPa), whichever is greater. Conduct the testing for a duration of ten minutes minimum, and visually verify that there is no water leakage from the transmitter, including the flange/process connection interface and the flange/sensor module interface.
2. Calibrate the transmitter per **Section 3: Calibration** in this manual.

Table 5-2 – Torque References

ITEM(S) TO BE TORQUED	TORQUE VALUE	TOLERANCE
Traditional Flange Bracket to Mounting Surface Bolts	19 ft-lb (26 N-m)	±1 ft-lb (1.4 N-m)
Coplanar Flange Bracket to Mounting Surface Bolts	19 ft-lb (26 N-m)	±1 ft-lb (1.4 N-m)
Traditional Flange Transmitter to Bracket Bolts	21 ft-lb (29 N-m)	±1 ft-lb (1.4 N-m)
Coplanar Flange Transmitter to Bracket Bolts	21 ft-lb (29 N-m)	±1 ft-lb (1.4 N-m)
Flange Bolts	See **Process Flange Reassembly** section	See **Process Flange Reassembly** section
Drain/Vent Valve-Stems	7.5 ft-lb (10 N-m)	±0.5 ft-lb (0.7 N-m)
Drain/Vent Valve Seats	200 in-lb (22.6 N-m)	± 1 ft-lb (1.4 N-m)
Screen Plug	50 in-lb (5.7 N-m)	±1 in-lb (0.1 N-m)
Covers	See **Electrical** in **Section 2: Installation**	See **Electrical** in **Section 2: Installation**
Conduit Plug	200 in-lb (22.6 N-m)	±1 ft-lb (1.4 N-m)
Conduit Seal Fitting	See Manufacturer's instructions	See Manufacturer's instructions
Electrical Connector	See Manufacturer's instructions	See Manufacturer's instructions
Terminal Block Mounting Screws	7 in-lb (0.8 N-m)	±1 in-lb (0.1 N-m)
Electronics Assembly Mounting Screws	7 in-lb (0.8 N-m)	±1 in-lb (0.1 N-m)
Internal Ground Screw	7 in-lb (0.8 N-m)	±1 in-lb (0.1 N-m)
External Ground Screw	8.9 in-lb (1.0 N-m)	±1 in-lb (0.1 N-m)
Terminal Screw	7 in-lb (0.8 N-m)	±1 in-lb (0.1 N-m)

Table 5-3 – Troubleshooting

SYMPTOM	POTENTIAL SOURCE	CORRECTIVE ACTION
High Output	Primary Element	Check for restrictions at primary element, improper installation or poor condition. Note any changes in process fluid properties that may affect output.
	Impulse Piping	• Check for leaks or blockage. • Ensure blocking valves are fully open. • Check for entrapped gas in liquid lines, or liquid in dry lines. • Ensure that density of fluid in impulse line is unchanged. • Check for sediment in transmitter process flanges.
	Transmitter Electronics	Make sure that filter pins and the sensor module connections are clean. If the electronics are still suspect, substitute new electronics.
	Transmitter Electronics Failure	Determine faulty circuit board by trying spare electronics assembly or terminal block assembly. Replace faulty assembly.
	Sensor Module	NOTE: See **Sensor Module Checkout** section. The sensing element is not field repairable and must be replaced if found to be defective. See **Disassembly Procedure** for instructions on disassembly. Check for obvious defects (i.e. punctured isolating diaphragm, etc.) and contact Rosemount Nuclear.
	Power Supply	Check the power supply output voltage at the transmitter.
Low Output or No Output	Primary Element	Check the installation and condition of primary element. Note any changes in process fluid properties that may affect output.
	Loop Wiring	**CAUTION** Do not use more than 55 volts to check the loop, or damage to the transmitter electronics may result. • Check for inadequate voltage to the transmitter. • Check the milliamp rating of the power supply against the total current being drawn for all transmitters being powered. • Check for intermittent shorts, open circuits, or multiple grounds. • Check for proper polarity at the signal terminal. • Check loop impedance. • Check wire insulation to detect possible shorts to ground.
	Impulse Piping	• Ensure that the pressure connection is correct. • Check for leaks or blockage. • Check for entrapped gas in liquid lines, or liquid in dry lines. • Check for sediment in transmitter process flanges. • Ensure that blocking valves are fully open and that bypass valves are tightly closed. • Ensure that density of fluid in the impulse line is unchanged.
	Transmitter Electronics Connections	• Ensure that calibration adjustments are in allowable range. • Check for short in sensor leads. • Make sure filter pins are clean, and check the sensor module connections. • If the electronics are still suspect, substitute new electronics.

Continued on Next Page

SYMPTOM	POTENTIAL SOURCE	CORRECTIVE ACTION
Low Output or No Output	Test Diode Failures	Replace terminal block.
	Transmitter Electronics Failure	Determine faulty circuit board by trying spare electronics assembly or terminal block assembly. Replace faulty assembly.
	Sensor Module	NOTE: See **Sensor Module Checkout** section. The sensing element is not field repairable and must be replaced if found to be defective. See **Disassembly Procedure** for instructions on disassembly. Check for obvious defects (i.e. punctured isolating diaphragm, etc.) and contact Rosemount Nuclear.
	Power Supply	Check the power supply output voltage at the transmitter.
Erratic Output	Impulse Piping and Process Connections	Check for entrapped gas in liquid lines, or liquid in dry lines.
	Transmitter Electronics	• Check for intermittent shorts or open circuits. • Make sure the pins on the jumper, the pins on the filters, and the pins on the sensor module are clean
	Transmitter Electronic Failure	Determine faulty circuit board by trying spare electronics assembly or terminal block assembly. Replace faulty assembly.
	Power Supply	Check power supply output voltage.

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