

# Rosemount 3159 Nuclear Qualified Remote Diaphragm Seal

*FOR USE ON ROSEMOUNT 3152, 3153, AND 3154 TRANSMITTERS*

- Qualified per:
  - IEEE Std 323™-1974/1983/2003
  - IEEE Std 344™-1975/1987/2004
- 112 Mrad (1.12 MGy) TID Gamma Radiation
- 8.5g ZPA Seismic
- Mild and Harsh Steam/Temperature



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# Rosemount 3159

## Introduction

Rosemount has combined nuclear qualified pressure transmitters with remote diaphragm seals to provide the nuclear power industry with a proven design for safety-related applications. The 3159 Remote Diaphragm Seal was qualified per IEEE Std 323™-1974/1983/2003 and IEEE Std 344™-1975/1987/2004 with radiation exposure up to 112 Mrads TID gamma radiation, seismic levels to 8.5g ZPA, and for steam pressure/temperature performance. Stringent quality control during the manufacturing process includes traceability of pressure-retaining parts, special nuclear cleaning, and hydrostatic testing.

### Product Description

Rosemount offers the 3159 Remote Diaphragm Seal on Rosemount 3150 Series Pressure Transmitters to encompass both boiling water and pressurized water reactor applications. Rosemount

Nuclear Instruments, Inc. provides pressure transmitters in combination with the 3159 Remote Diaphragm Seal in order to accurately measure process pressure or liquid level while preventing the process fluid from contacting the transmitter isolating diaphragm.

### Operation

Process pressure sensed by the remote seal isolator diaphragm is transmitted through a filled capillary system to the transmitter's isolating diaphragm. The transmitted pressure displaces the sensing diaphragm in the center of the transmitter's sensor, creating a differential capacitance between the sensing diaphragm and the capacitor plates. The differential capacitance is converted to a 2-wire, 4-20 mA signal.

Figure 1 – 3159 Remote Diaphragm Seal / Lower Housing Assembly

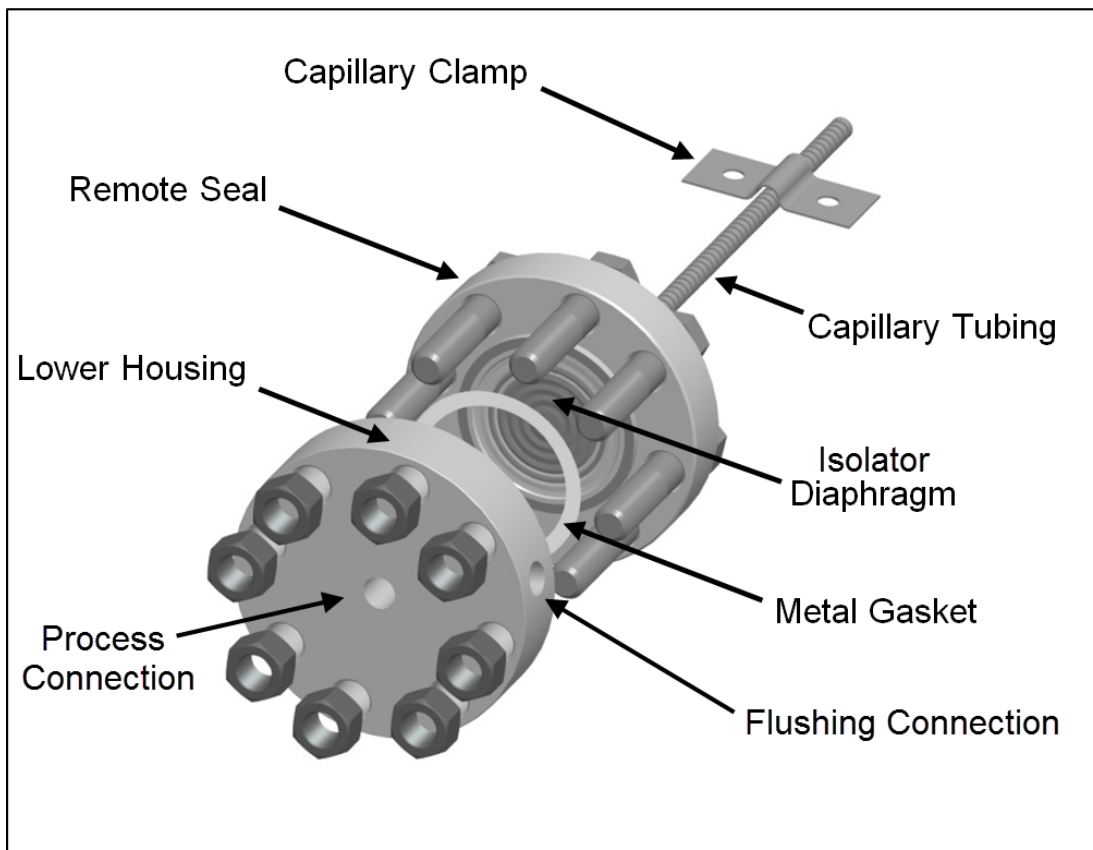
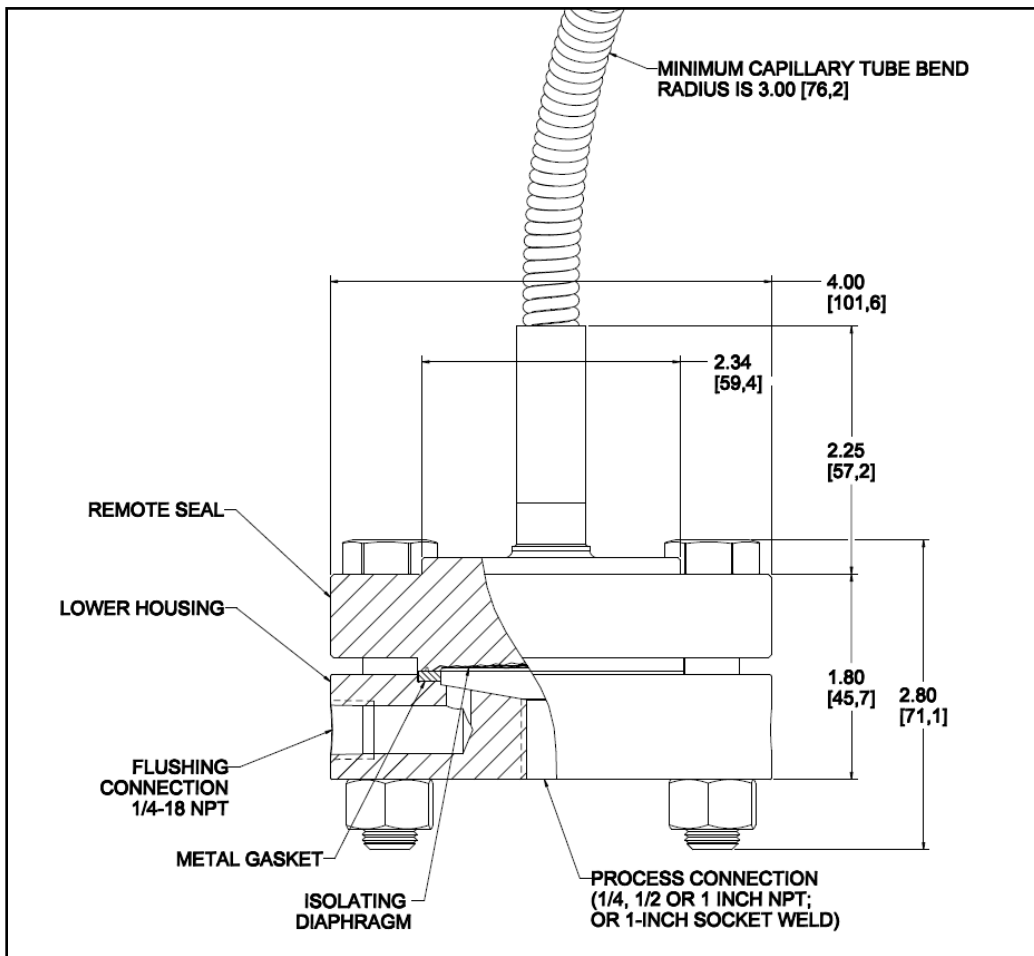


Figure 2 – 3159 Remote Diaphragm Assembly Dimensions



Note: All dimensions are nominal in inches (millimeters)

### SPECIFICATIONS

#### Nuclear Specifications

The accuracy of the remote seal system in a design basis event (DBE) is expressed as the algebraic sum of the transmitter accuracy plus the remote seal accuracy. If the transmitter and remote seal assemblies are subjected to different accident conditions, the pertinent transmitter specifications should be combined with the pertinent remote seal specifications.

#### TRANSMITTER

Refer to appropriate product data sheets for transmitter specifications.

Base Model	Product Data Sheet
3152N	00813-0100-4852
3153N	00813-0100-4853
3154N	00813-0100-4854

#### REMOTE SEAL AND CAPILLARY

Remote seal assemblies are qualified according to IEEE Std 323™-1974/1983/2003 and IEEE Std 344™-1975/1987/2004 as documented in Rosemount report D2013009.

#### Seismic

When exposed to a disturbance defined by the required response spectrum with a ZPA of 8.5 g (see Figure 3), accuracies are as shown in the following table:

Fill Fluid	Triaxial Random Multifrequency 8.5g ZPA	
	During	After
Distilled Water	±13.00 inH <sub>2</sub> O	Within transmitter reference accuracy
DC704	±2.00 inH <sub>2</sub> O	
PMX-200	±1.25 inH <sub>2</sub> O	

#### Radiation <sup>(1)</sup>

When exposed to a Total Integrated Dose (TID) of 6.5 Mrads (65 kGy) for mild environments and 112 Mrads (1.12 MGy) for harsh environments, accuracies are as shown in the following tables:

(1) PMX-200 fill fluid qualified for mild environment only.

Mild Environment:

Test Type	Mild Environment (All Fill Fluids)	
	Dose Rate	TID
Normal	0.1 Mrad / hr	1 Mrad
Accident	0.4 Mrad / hr	5.5 Mrad
Total	-	6.5 Mrad

Fill Fluid	Remote Seal Accuracy	
	Normal	Accident
All	Within transmitter accuracy	Within transmitter accuracy

Harsh Environment:

Test Type	Harsh Environment (Distilled Water & DC704 Only)	
	Dose Rate	TID
Normal	0.1 Mrad / hr	2 Mrad
Accident	2 Mrad / hr	4 Mrad
	1.5 Mrad / hr	6 Mrad
	1 Mrad / hr	100 Mrad
Total	-	112 Mrad

Fill Fluid	Remote Seal Accuracy	
	Normal	Accident
Distilled Water	Within transmitter accuracy	Within transmitter accuracy
DC704	Within transmitter accuracy	±0.35 inH <sub>2</sub> O per 5 ft of capillary

**Steam Pressure/Temperature and Post DBE Operation** <sup>(1)(2)(3)(4)</sup>

Remote seal accuracy during and after exposure to steam in the following environments can be extrapolated from the following tables:

**Mild Environment:**

Exposure to steam for 68 hours, concurrent with chemical spray for the first 48 hours, at the following temperatures and pressures (see Figure 4):

290°F (143.3°C), 43 psig (296 kPa) for 2 hours  
275°F (135.0°C), 31 psig (213 kPa) for 54 hours,  
140°F (60.0°C), 31 psig (213 kPa) for 12 hours.

Chemical spray consisted of boron water for first 24 hours followed by a solution of boric acid, sodium thiosulfate, and sodium hydroxide for an additional 24 hours (see Figure 4).

**Harsh Environment:**

Exposure to steam for 293 hours, concurrent with chemical spray for the first 24 hours, at the following temperatures and pressures (see Figure 5):

435°F (224.0°C), 95 psig (655 kPa) for 2 minutes,  
365°F (185.0°C), 95 psig (655 kPa) for 6 minutes,  
320°F (160.0°C), 75 psig (517 kPa) for 8 hours,  
265°F (129.4°C), 24 psig (165 kPa) for 56 hours,  
212°F (100.0°C), 0 psig (0 kPa) for 216 hours,  
140°F (60.0°C), 0 psig (0 kPa) for 13 hours.

Chemical spray consisted of boric acid, sodium thiosulfate, and sodium hydroxide (see Figure 5).

- (1) *PMX-200 fill fluid qualified for mild environment only.*
- (2) *For distilled water at temperatures above 180°F (82.2°C), static pressure must be sufficient to prevent fill fluid from dropping below the vapor pressure limit.*
- (3) *Specifications are applicable for capillary lengths from 5 to 60 feet. Consult factory for lengths longer than 60 feet.*
- (4) *Specification may be linearly interpolated down to 50°F (27.8°C) temperature interval.*

**Accuracy After Initial Temperature Ramp:**

**Distilled Water:**

Seal Type	Accuracy After Initial Ramp (per 100 °F (55.6 °C) Temperature shift)
1 sided	±(2.0 inH <sub>2</sub> O for first 5 ft + 1.4 inH <sub>2</sub> O for each additional 5 ft of capillary)
2 sided	±(1.3 inH <sub>2</sub> O for first 5 ft + 0.5 inH <sub>2</sub> O for each additional 5 ft of capillary)

**DC704:**

Seal Type	Accuracy After Initial Ramp (per 100 °F (55.6 °C) Temperature shift)
1 sided	±(5.3 inH <sub>2</sub> O/ for first 5 ft + 2.6 inH <sub>2</sub> O for each additional 5 ft of capillary)
2 sided	±(1.4 inH <sub>2</sub> O for first 5 ft + 0.7 inH <sub>2</sub> O for each additional 5 ft of capillary)

**PMX-200 (mild environment only):**

Seal Type	Accuracy After Initial Ramp (per 100 °F (55.6 °C) Temperature shift)
1 sided	±(6.0 inH <sub>2</sub> O for first 5 ft + 3.0 inH <sub>2</sub> O for each additional 5 ft of capillary)
2 sided	±(1.5 inH <sub>2</sub> O for first 5 ft + 1.0 inH <sub>2</sub> O for each additional 5 ft of capillary)

**Accuracy During Initial Temperature Ramp:**

Remote seal accuracy during the initial temperature ramp portion for both the mild environment test profile (Time = 0 - 180 seconds on Figure 4) and the harsh environment test profile (Time = 0 - 60 seconds on Figure 5).

**Distilled Water:**

Seal Type	Accuracy During Initial Ramp (per 100 °F (55.6 °C) Temperature shift)
1 sided	±(3.4 inH <sub>2</sub> O for first 5 ft + 2.38 inH <sub>2</sub> O for each additional 5 ft of capillary)
2 sided	±(1.3 inH <sub>2</sub> O for first 5 ft + 0.5 inH <sub>2</sub> O for each additional 5 ft of capillary)

**DC704:**

Seal Type	Accuracy During Initial Ramp (per 100 °F (55.6 °C) Temperature shift)
1 sided	±(18.5 inH <sub>2</sub> O for first 5 ft + 9.1 inH <sub>2</sub> O for each additional 5 ft of capillary)
2 sided	±(5.3 inH <sub>2</sub> O for first 5 ft + 2.6 inH <sub>2</sub> O for each additional 5 ft of capillary)

**PMX-200 (mild environment only):**

Seal Type	Accuracy During Initial Ramp (per 100 °F (55.6 °C) Temperature shift)
1 sided	±(27.6 inH <sub>2</sub> O for first 5 ft + 13.8 inH <sub>2</sub> O for each additional 5 ft of capillary)
2 sided	±(6.0 inH <sub>2</sub> O for first 5 ft + 3.0 inH <sub>2</sub> O for each additional 5 ft of capillary)

## Nuclear Cleaning

Process wetted surfaces cleaned to <1ppm chloride content.

## Hydrostatic Testing

To 150% of maximum working pressure or 2000 psig (13.79 MPa), whichever is greater (subject to a limitation of 5000 psig (34.48 MPa)).

## Traceability

Per 10CFR50 Appendix B, NQA-1, and ISO 9001:2008; chemical and physical certification of pressure retaining parts and process-wetted materials.

## Qualified Life

Remote seal qualified life is equivalent to transmitter qualified life (see the appropriate product data sheet for transmitter qualified life).

Figure 3 – Seismic Required Response Spectra (RRS)

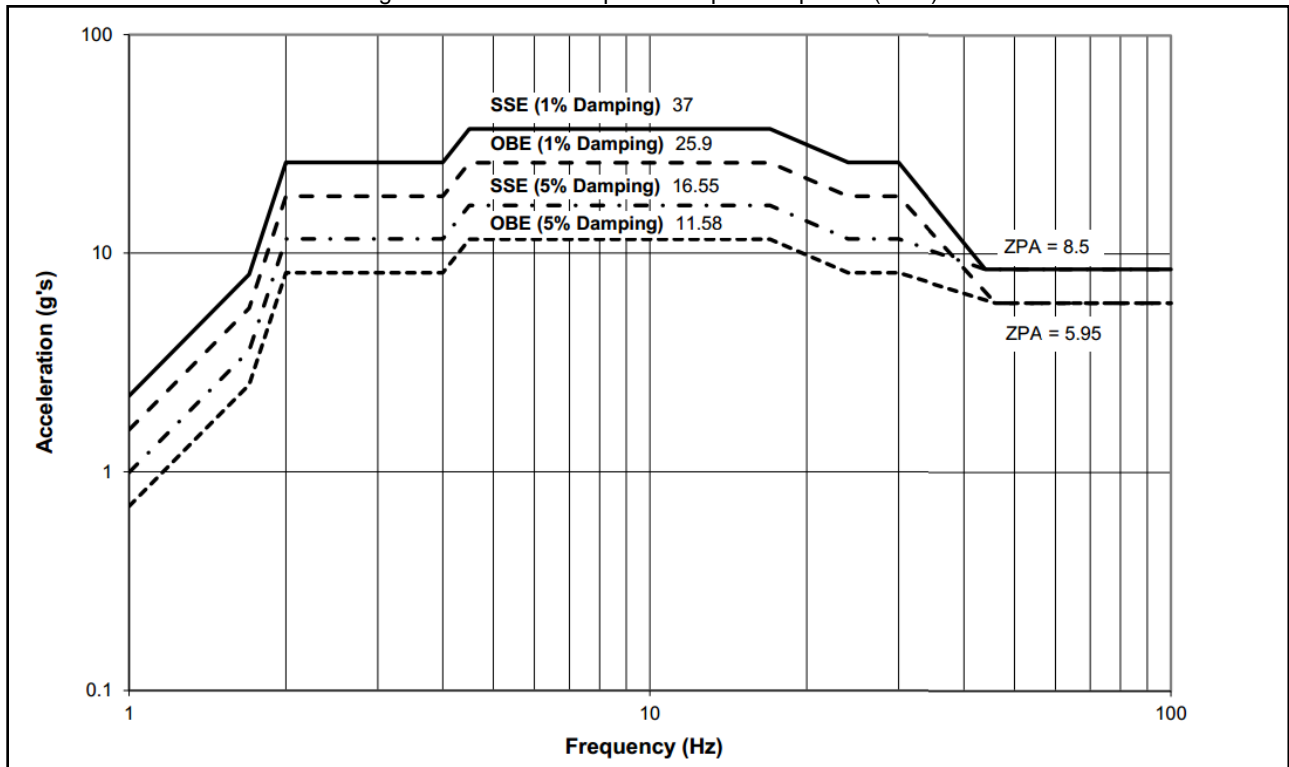


Figure 4 – Mild Steam Pressure/Temperature Profile

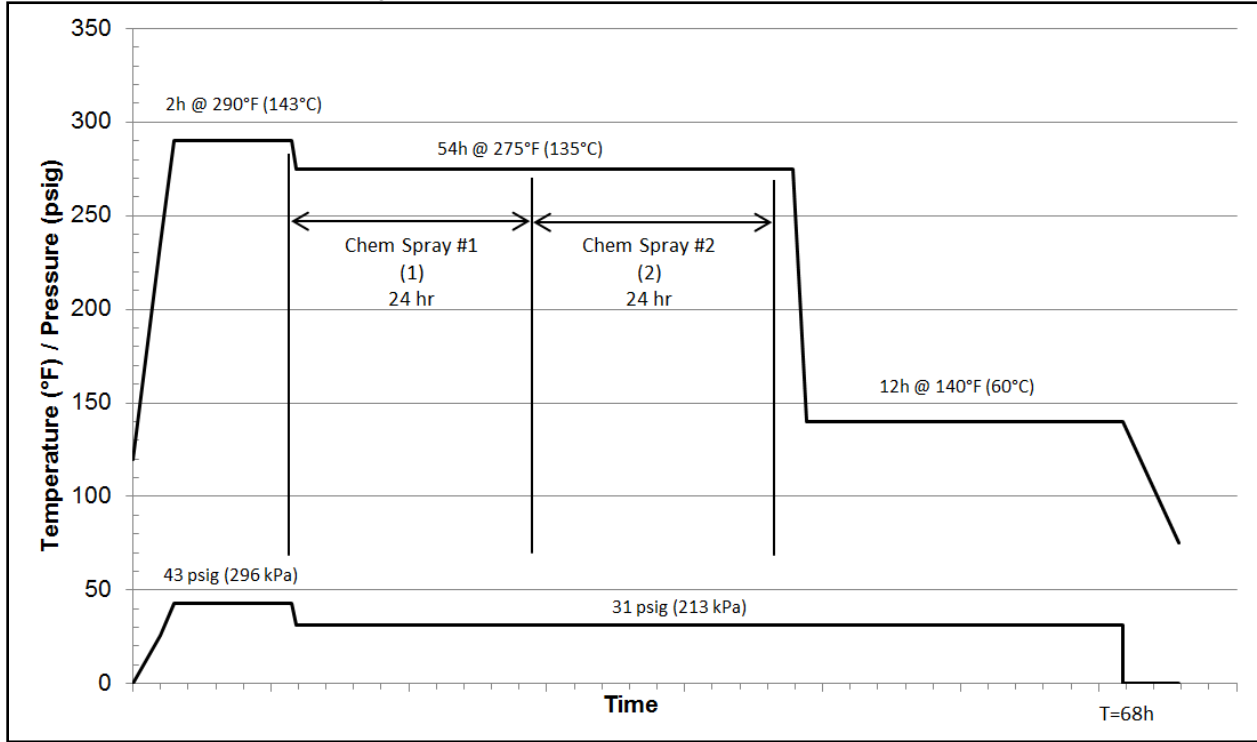
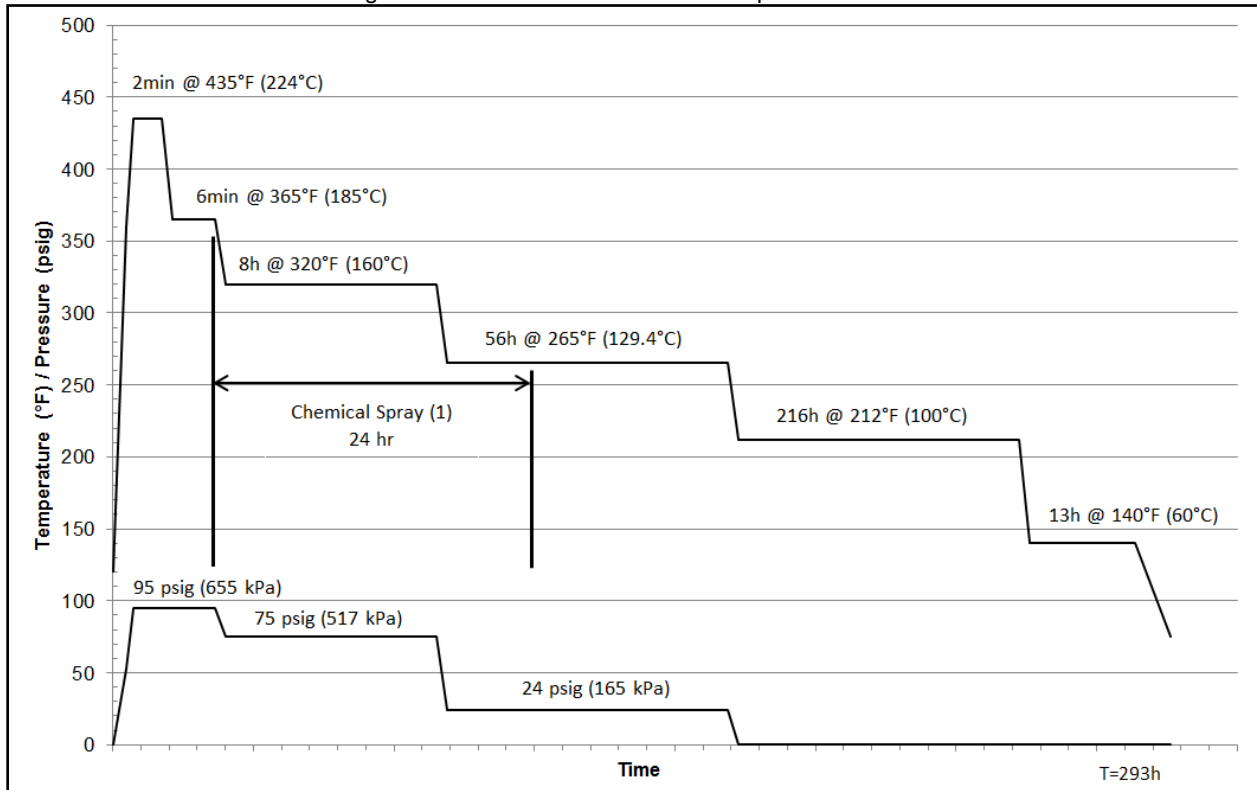


Figure 5 – Harsh Steam Pressure/Temperature Profile



## Performance Specifications

Based on zero-based calibration spans under reference conditions. The accuracy of the remote seal system is expressed as the algebraic sum of the transmitter accuracy plus the remote seal accuracy. If the transmitter and remote seal assemblies are subjected to different conditions, the pertinent transmitter specifications should be combined with the pertinent remote seal specifications.

### TRANSMITTER

Refer to the appropriate product data sheets for transmitter specifications.

### REMOTE SEAL AND CAPILLARY

#### Temperature Effect of Seal and Capillary<sup>(1)(2)</sup>

##### Distilled Water:

Seal Type	Temperature Effect (per 100 °F (55.6 °C) Temperature shift)
1 sided	±(2.0 inH <sub>2</sub> O for first 5 ft + 1.4 inH <sub>2</sub> O for each additional 5 ft of capillary)
2 sided	±(1.3 inH <sub>2</sub> O for first 5 ft + 0.5 inH <sub>2</sub> O for each additional 5 ft of capillary)

##### DC704:

Seal Type	Temperature Effect (per 100 °F (55.6 °C) Temperature shift)
1 sided	±(5.3 inH <sub>2</sub> O/ for first 5 ft + 2.6 inH <sub>2</sub> O for each additional 5 ft of capillary)
2 sided	±(1.4 inH <sub>2</sub> O for first 5 ft + 0.7 inH <sub>2</sub> O for each additional 5 ft of capillary)

##### PMX-200:

Seal Type	Temperature Effect (per 100 °F (55.6 °C) Temperature shift)
1 sided	±(6.0 inH <sub>2</sub> O for first 5 ft + 3.0 inH <sub>2</sub> O for each additional 5 ft of capillary)
2 sided	±(1.5 inH <sub>2</sub> O for first 5 ft + 1.0 inH <sub>2</sub> O for each additional 5 ft of capillary)

- (1) Temperature effects specification may be linearly interpolated down to 50°F (27.8°C) temperature interval.
- (2) Temperature effects specification is applicable for capillary lengths from 5 to 60 feet. Consult factory for lengths longer than 60 feet.

## Mounting Position Effect

Dependent on the elevation of the seal(s) with respect to transmitter. See Rosemount 3159 Reference Manual (00809-0100-4859) for additional details.

## Response Time of Seal and Capillary<sup>(1)</sup>

Time constant (63.2%) at 100°F (37.8°C)

### Distilled Water:

Range Code	Maximum Time Response
1	0.27 sec per 5 ft of capillary
2	0.09 sec per 5 ft of capillary
3	0.06 sec per 5 ft of capillary
4-6	0.02 sec per 5 ft of capillary

### DC704:

Range Code	Fixed Time Response
1	2.5 sec per 5 ft of capillary
2	0.80 sec per 5 ft of capillary
3	0.53 sec per 5 ft of capillary
4-6	0.11 sec per 5 ft of capillary

### PMX-200:

Range Code	Fixed Time Response
1	2.9 sec per 5 ft of capillary
2	0.90 sec per 5 ft of capillary
3	0.63 sec per 5 ft of capillary
4-6	0.13 sec per 5 ft of capillary

- (1) Time response specification is based on total capillary length (high side capillary length + low side capillary length).



**Functional Specifications**

**Service**

Liquid, gas, vapor

**Transmitter Output**

4-20 mA

**Temperature Limits of Seal and Capillary**

Normal Operating Limits <sup>(1) (2)</sup>

Fill Fluid	Temperature Limits
Distilled Water	40°F to 180°F (4.4°C to 82.2°C)
Silicone Oil	40°F to 270°F (4.4°C to 132.2°C)

- (1) Upper temperature limit is for capillary systems mounted away from the transmitter. Refer to the appropriate product data sheets for transmitter temperature limits.
- (2) For distilled water at temperatures above 180°F (82.2°C), static pressure must be sufficient to prevent fill fluid from dropping below the vapor pressure limit.

**Qualified Storage Limits**

Fill Fluid	Temperature Limits
Distilled Water	40°F to 180°F (4.4°C to 82.2°C)
Silicone Oil	-40°F to 180°F (-40.0°C to 82.2°C)

**Humidity Limits**

0 to 100% relative humidity

**Maximum Working Pressure**

Larger of Static Line Pressure Limit or Upper Range Limit (URL). Bolting option B1 limited to 2500 psig (17.24 MPa).

**Transmitter Pressure Ranges**

Adjustable within the range shown; Upper Range Limit (URL) is the highest pressure shown.

Range Code	Pressure Range
1	0-5 to 0-25 inH <sub>2</sub> O (0-1.25 kPa to 0-6.23 kPa)
2	0-25 to 0-250 inH <sub>2</sub> O (0-6.23 kPa to 0-62.3 kPa)
3	0-100 to 0-1000 inH <sub>2</sub> O (0-24.9 kPa to 0-249 kPa)
4	0-30 to 0-300 psi (0-206.8 kPa to 0-2068 kPa)
5	0-200 to 0-2000 psi (0-1379 kPa to 0-13.79 MPa)
6 <sup>(1)</sup>	0-400 to 0-4000 psi (0-2758 kPa to 0-27.58 MPa)

(1) Range 6 offered for gage and absolute pressure transmitter models only.

**Static Line Pressure Limits (Differential only)**

Range Code	Static Line Pressure Limit
1	0.5 psia to 2000 psig (3.45 kPa to 13.79 MPa)
2-5 <sup>(1)</sup>	0.5 psia to 3626 psig (3.45 kPa to 25.00 MPa)

(1) B1 option limited to 2500 psig (17.89 MPa).

**Overpressure Limits**

Range Code	Overpressure Limit
1	2000 psig (13.79 MPa)
2-5	3626 psig (25.00 MPa)
6	5000 psig (34.48 MPa)

**Burst Pressure**

Minimum burst pressure is 5000 psig (34.48 MPa).

# Rosemount 3159

## Physical Specifications

### Materials of Construction

*Numbers in parentheses indicate where part is located in Figure 6*

#### Remote Seal Components:

**Isolator Diaphragm (5)**  
316L SST

**Remote Seal Body (5)**  
316L SST

**Lower Housing (4)**  
316L SST

**Bolts/Nuts (3/6)**  
316 SST

**Metal Gasket (2)**  
Monel 400

#### Capillary Components:

**Capillary Tubing (1)**  
316L SST

**Protective Armored Sleeve (1)**  
304 SST

**Capillary Fitting (5)**  
316L SST

#### Transmitter Interface:

**Transmitter Process Flange (7)**  
316L SST

#### Accessories:

**Capillary Clamps (optional)**  
316 SST

## Process Connections

1/4, 1/2, or 1 inch NPT; or 1-inch socket weld

## Flushing Connection(s)

1/4 -18 NPT

## Seal and Capillary Fill Fluid

Distilled Water  
DC704 Silicone Oil  
PMX-200 Silicone Oil

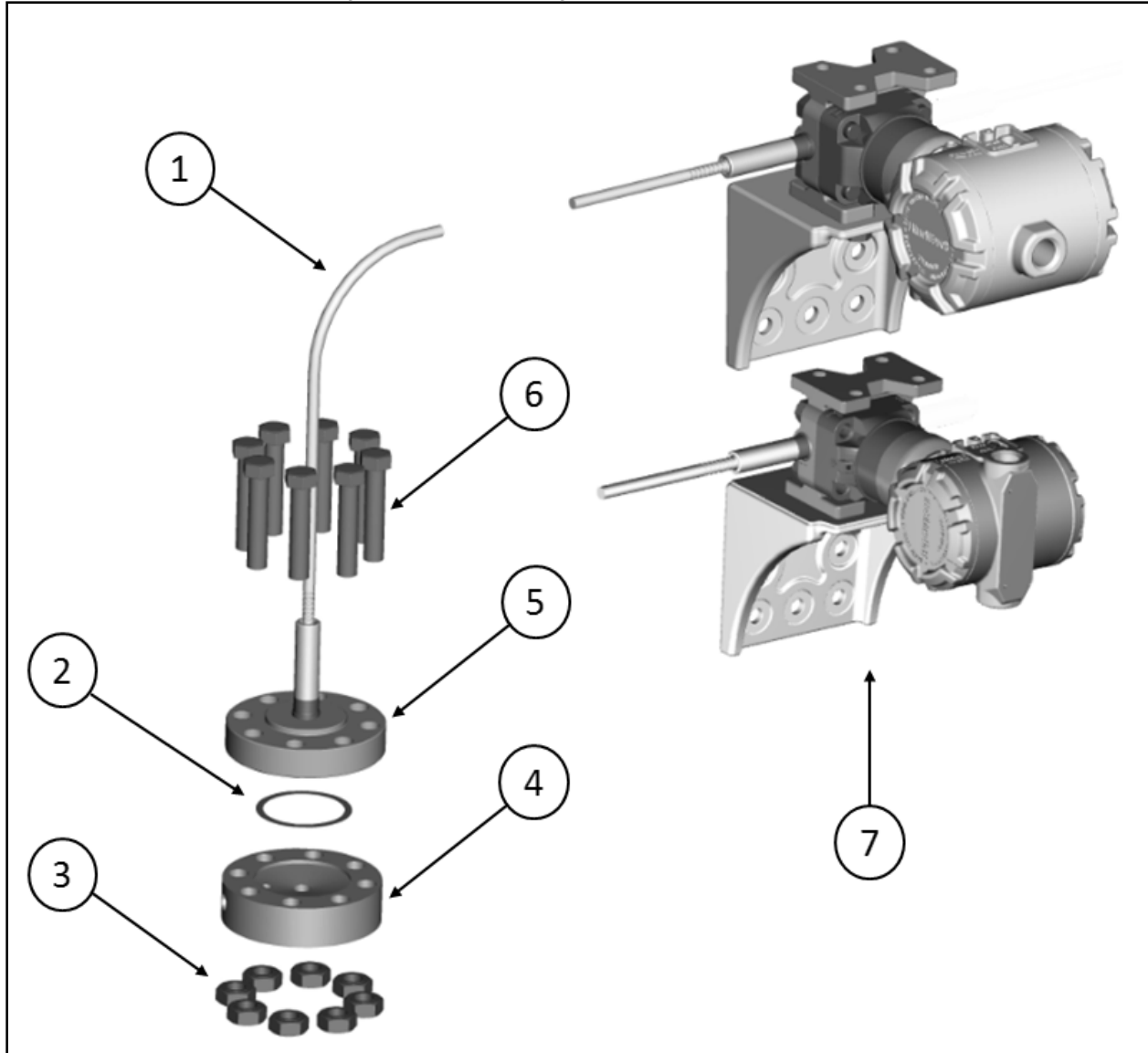
## Weight

Seal: 7.7 lbs (3.50 kg)  
Capillary: 1 oz/ft (93.5 g/m) of capillary

## Specific Gravity of Fill Fluid at 77°F (25°C)

Fill Fluid	Specific Gravity at 77°F (25°C)
Distilled Water	1.00
DC704	1.07
PMX-200	0.93

Figure 6 – Parts Drawing and Table, Exploded View



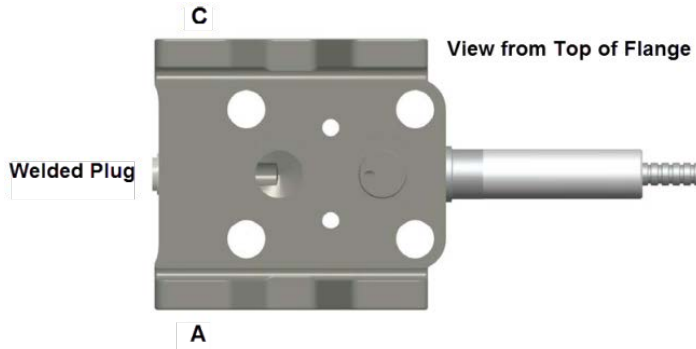
ITEM #	DESCRIPTION
1	Capillary Tube
2	Metal Gasket
3	Remote Seal Nuts
4	Lower Housing
5	Remote Diaphragm Seal
6	Remote Seal Bolts
7	315X Series Pressure Transmitter (Typical, specified separately)

## ROSEMOUNT 3159 REMOTE SEAL ORDERING INFORMATION

Model	Type
3159	Rosemount 3159 Remote Diaphragm Seal
Code	Seal Mounting Location
H	Single Seal Mounted on High Pressure Side of Transmitter
L	Single Seal Mounted on Low Pressure Side of Transmitter
B	Same Seal on Both High and Low Pressure Sides of Transmitter
Code	Capillary Length <sup>(1)(2)(7)</sup>
005	5 ft (1.52 m)
010	10 ft (3.05 m)
015	15 ft (4.57 m)
020	20 ft (6.10 m)
025	25 ft (7.62 m)
030	30 ft (9.14 m)
035	35 ft (10.67 m)
040	40 ft (12.19 m)
045	45 ft (13.72 m)
050	50 ft (15.24 m)
055	55 ft (16.76 m)
060	60 ft (18.29 m)
Code	Process Connection <sup>(3)</sup>
P1	1/4 -in NPT Process Connection, One Flushing Connection
P2	1/2 -in NPT Process Connection, One Flushing Connection
P3	1-in NPT Process Connection, One Flushing Connection
P4	1-in Socket Weld Connection, One Flushing Connection
P5	1/4 -in NPT Process Connection, Two Flushing Connections
P6	1/2 -in NPT Process Connection, Two Flushing Connections
P7	1-in NPT Process Connection, Two Flushing Connections
P8	1-in Socket Weld Connection, Two Flushing Connections
Code	Remote Seal Bolting <sup>(4)</sup>
B1	Low Pressure (Standard bolts/nuts)
B2	High Pressure (Grade 8 bolts/nuts)
Code	Fill Fluid
F1	Distilled Water <sup>(5)(6)</sup>
F2	DC704 Silicone Oil <sup>(7)</sup>
F3	PMX-200 Silicone Oil <sup>(7)</sup>

*Continued on Next Page*

Code	Flange Configuration
K00	Default Value- Required for Absolute, Gauge and 2-Sided Differential Pressure Measurement.
KAC	"A" & "C" Must be Specified for a One Sided Differential Transmitter per Option Values Shown in Figure 7



Option value	Description
1	1/4-18 NPT
2	Welded 3/8-inch Swagelok
3	Welded vent/drain valve
4	Welded 1/4-inch Swagelok

Figure 7

Code	Standard Options
V4	Threaded Drain / Vent Valve(s) (1/4-18 NPT) – Unassembled (Provided separately in package) <sup>(3)(8)</sup>
W2	Wire-on Tag

**Typical Model Number:** 3159 H 015 P1 B1 F1 K00

- (1) Maximum capillary length for transmitter range code 1 is 25 ft (7.62 m).
- (2) For capillary lengths greater than 60 ft (18.29 m), consult factory.
- (3) Customer assumes responsibility for qualifying Interfaces on these options. Contact Rosemount Nuclear Instruments, Inc. for details.
- (4) Maximum working pressure for B1 option is 2500 psi (17.24 MPa).
- (5) For distilled water (Code F1) at temperatures above 180°F (82.2°C), static pressure at process connection must be sufficient to prevent fill fluid anywhere in the system from dropping below the vapor pressure limit.
- (6) Distilled water (Code F1) is not available with absolute pressure measurement type transmitters.
- (7) For silicone oils (Codes F2 and F3), it is recommended to keep capillary lengths as short as possible in order to minimize ambient temperature and time response effects.
- (8) Quantity is one for each 1/4-18 NPT flushing connection or transmitter flange process connection.



## REVISIONS

### Changes from Rev AB to Rev AC

Page (Old)	Page (New)	Changes
Throughout	Throughout	Update document revision and implementation date
8	8	Update temperature effects specification for single sided, distilled water filled remote diaphragm seal configurations.
13	13	Add option code "V4" for threaded drain/vent valves into ordering table.

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requirements in the European Union.*