MEASUREMENT AND CONTROL

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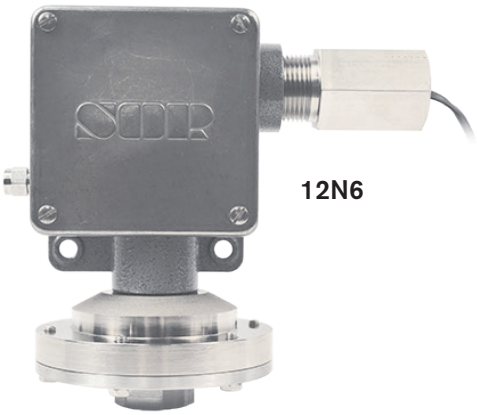
# Switches for the Nuclear Power Industry

## SOR® Pressure, Vacuum and Temperature Switches

are qualified by a combination of testing and analysis per IEEE-323-1974 & 1983 and IEEE-344-1975 & 1987. See SOR Test Report 9058-102 and other applicable reports on page four for qualification testing and explanations. (Note: for nuclear qualified differential pressure switches, see SOR catalog 1291.)

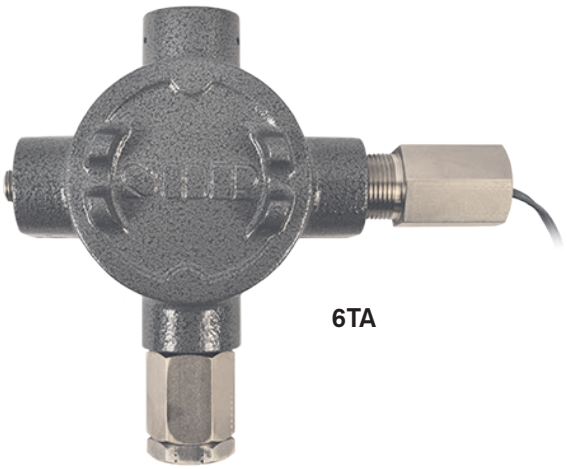
**Qualification testing included**

- Thermal Aging
- Irradiation
- Mechanical/Electrical Cycling
- Sine Beat
- Random Multifrequency
- LOCA
- HELB



**12N6**

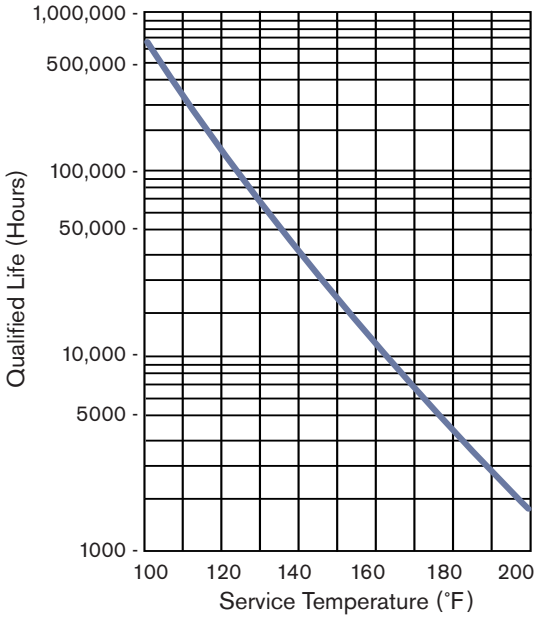
**9RT**



**6TA**

SOR maintains a quality system dedicated to compliance with the applicable elements of 10CFR50, Appendix B, ANSI N45.2 and NQA-1, including the reporting requirements of 10CFR21. The products in this catalog are manufactured under this dedicated system which is audited by the Nuclear Procurement Issues Committee (NUPIC), Nuclear Industry Assessment Committee (NIAC) and Canadian TSSA N285.0.

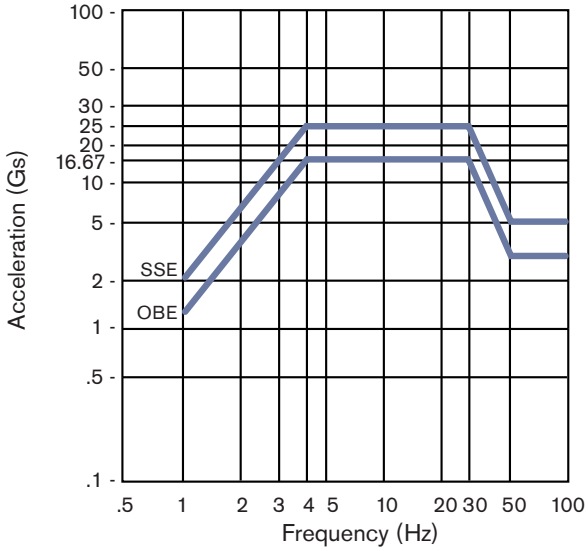
**Figure 1: AGING**




This graph is based on the Arrhenius equation and may be used as a general guideline in determining the qualified life if the service temperature is greater than or less than 120°F.

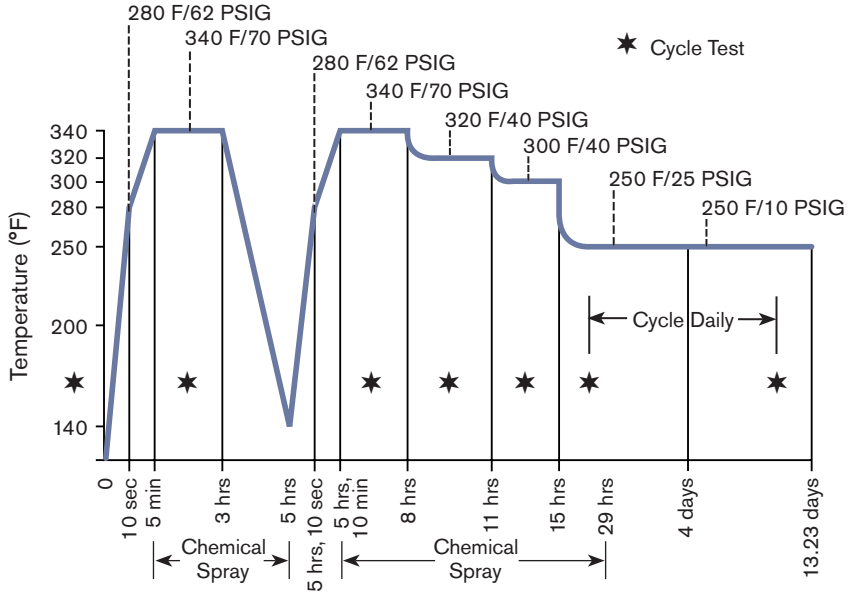
**Figure 2: SEISMIC**

100% RRS Curves at 1% Damping



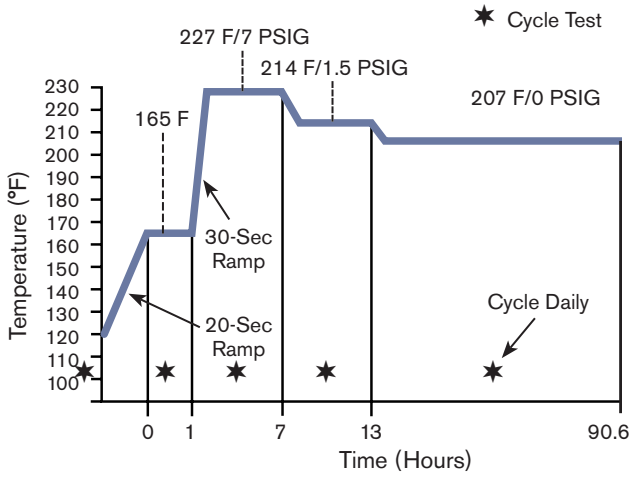

This is the RRS (Required Response Spectrum) at 1% damping to which all switches were seismically tested. All TRS (Test Response Spectrum) plots are contained in test report 9058-102. Seismic damping analysis to 0.5%, 2%, 3%, 4%, and 5% are also available upon request.

**Figure 3: LOCA**



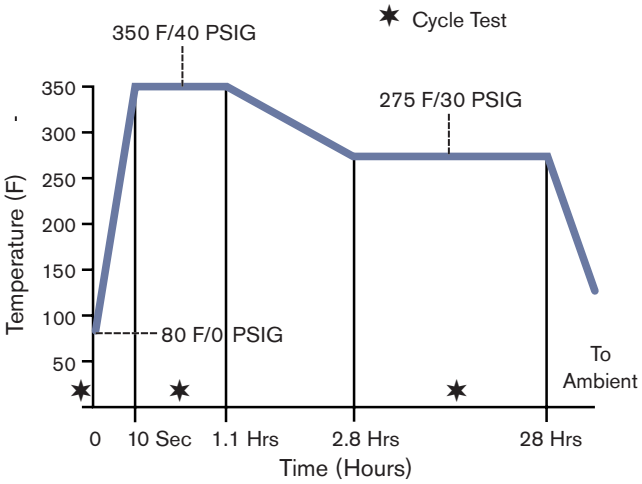

This graph shows the combined environmental conditions to which certain switches were subjected at end-of-life conditions to simulate a LOCA (Loss Of Coolant Accident). The two thermodynamic transients were generated by injecting superheated steam into the autoclave in a controlled manner. The chemical spray consisted of 0.28 molar boric acid and 0.064 molar sodium thiosulfate buffered to pH 10.5 with sodium hydroxide.

**Figure 4: HELB 1**




This graph shows the combined environmental conditions to which certain switches were subjected at end-of-life conditions to simulate a HELB (High Energy Line Break). The HELB 1 profile shown here was generated by injecting superheated steam into the autoclave in a controlled manner.

**Figure 5: HELB 2**




This graph shows the combined environmental conditions to which certain switches were subjected at end-of-life conditions to simulate a second more severe HELB (High Energy Line Break). The HELB 2 profile shown here was generated by injecting superheated steam into the autoclave in a controlled manner.

## Test Program Explanation

- **Thermal Aging** to simulate a 20-year life at a service temperature of 120°F (see Figure 1). Switches were subjected to accelerated thermal aging according to the Arrhenius model and based on the lowest activation energy of all of the safety related, non-metallic materials of construction.

- **Irradiation** to levels as high as 200 megarads. Switches were subjected to various amounts of gamma irradiation (see test report) to simulate that amount of radiation the switch might be exposed to during its' qualified life, plus the amount of radiation it might see during an accident plus margin.

- **Mechanical/Electrical Cycling** to 30,000 cycles at full-scale pressure/temperature and rated electrical load. Pressure and vacuum switches were cycled either pneumatically or hydraulically from the low end to the high end of the adjustable range. Temperature switch sensors were thermally cycled from 20°F below set point to 20°F above set point. All cycling was conducted with full rated voltage and current applied to the switch contacts.

- **Sine Beat** testing at 1-50 Hz, 4.5g on line-mount temperature switches. This test was performed to age the switch and determine its response to these conditions. Only the direct mount temperature switch was chosen for this test as it is the only switch that may be line mounted.

- **Random Multifrequency** testing including five OBEs (Operating Basis Earthquake) and one SSE (safe shutdown earthquake) in each of four orientations (see Figure 2). This test was performed to age the switch and determine its' response to these conditions.

- **LOCA** (Loss Of Coolant Accident) testing on selected models (see Figure 3). This test simulated LOCA conditions and established the switch's response/condition before during and after the test.
- **HELB** (High Energy Line Break) testing to two different profiles on selected models (see Figures 4 and 5). This test simulated two different HELB conditions and established the switch's response/condition before during and after the test.

The above testing brought the switches to end-of-life conditions as required by the IEEE standards and then subjected them to accident conditions. Please note that none of the qualification levels were established based on a specific application. Rather, they were chosen generically with the intent to be suitable for the majority of possible applications in nuclear power stations. It is the responsibility of the end user to establish if the qualification levels are suitable for the intended use.

## Specifications

**Repeatability** The ability of a pressure/temperature switch to successively operate at a set point that is approached from a starting point in the same direction, and returns to the starting point over three consecutive cycles, to establish a profile. The closeness of the measured set point values is normally expressed as a percentage of span. Repeatability on SOR qualified switches will be +/-1% of span per ISA/ANSI S51.1.

**Drift** Maximum Annual Drift for all qualified models (except #9 & #29 pistons with U8 diaphragm) is 2.5% of span. The Maximum Annual Drift for #9 & #29 pistons with U8 diaphragms is 4.0% of span.

## Temperature Influence Formulas

### for Pressure and Vacuum Switches

The formulas given below represent a general guideline for the expected influence of temperatures on the set points of the pressure and vacuum switches in this catalog.

| Housing | |
|---|---|
| | **Sealed** - △SP = [0.027 (psi/°F) - (SP x 0.0003 / °F)] x (Tf - Ti) |
| | **Vented** - △SP = - (SP x 0.0003 / °F) x (Tf - Ti) |

Where: △SP = The change in the set point in (psi) from the intial value.
SP = The initial set point in (psi).
TI = The initial ambient temperature in °F
Tf = The final ambient temperature in °F

## Test Reports

### for SOR Pressure, Vacuum and Temperature Switches

| | |
|---|---|
| 9058-102 | Qualification Test Report. |
| 9058-103 | DC rating on "W" switch element. |
| 9058-105 | "U1" diaphragm option for improved long-term drift and dead band. *Affects qualification levels. Contact SOR.* |
| 9058-106 | Over temperature test for direct-mount temperature switches. |
| 9058-107 | Temperature switch with 25' capillary. |
| 9058-108 | #9 piston with 30mPa overrange pressure. |
| 9058-110 | #4 piston with vacuum protection plate. |
| 8923-306 | Switch without "JJ" conduit seal. *Affects qualification levels. Contact SOR.* |
| 8923-340 | N6 housing modifications. |
| 8923-343 | Direct-mount temperature switch with 3-inch sensing bulb. |
| 8923-347 | Direct-mount temperature switch with conduit in top hub of TA housing. |
| 8923-437 | #54 vacuum switch with Monel-wetted parts. |

**Contact SOR for additional modifications and test reports.*

## Model Number System

# 12N6-B45-U8-C2A-JJTTNQ

| Piston (Designator 1) | Housing (Designator 2) | Switching Element (Designator 3) | Range Spring (Designator 4) | Diaphragm (Designator 5) | Pressure Port (Designator 6) | Accessories (Designator 7) |
|---|---|---|---|---|---|---|
| 12 | N6 | B | 45 | U8 | C2A | JJTTNQ |

To specify a

**Pressure Switch, begin with Step 1a.**

**Vacuum Switch, begin with Step 1b.**

**Temperature Switch, begin with Step 1c.**

Use the sample model number above each table to position selected designators within the model number.

## Step 1a: Pressure Switch

**12**N6-B**45**-U8-C2A-JJTTNQ

Place designators in positions 1 and 4.

| Piston (Designator 1) | Spring (Designator 4) | Adjustable Range | | Overrange* | |
|---|---|---|---|---|---|
| | | psi | bar [mbar] | psi | bar |
| 12 | 4 | 0.5 to 6.0 | [35 to 415] | 200 | 14 |
| 12 | 5 | 0.75 to 12 | [50 to 830] | | |
| 12 | 45 | 1 to 16 | [70 to 1100] | | |
| 4 | 4 | 2 to 25 | 0.14 to 1.7 | 750 | 50 |
| 4 | 5 | 3 to 50 | 0.2 to 3.5 | | |
| 4 | 45 | 4 to 75 | 0.3 to 5 | | |
| 6 | 2 | 7 to 30 | 0.5 to 2 | 1500 | 100 |
| 6 | 3 | 12 to 100 | 0.8 to 7 | | |
| 6 | 5 | 20 to 180 | 1.4 to 12 | | |
| 6 | 45 | 25 to 275 | 1.7 to 19 | | |
| 5 | 3 | 25 to 240 | 1.7 to 16 | | |
| 5 | 5 | 35 to 375 | 2.4 to 26 | | |
| 5 | 45 | 45 to 550 | 3.1 to 38 | | |
| 29 | 45 | 150 to 1350 | 10 to 93 | 2500 | 170 |
| 9 | 4 | 100 to 500 | 7 to 35 | | |
| 9 | 5 | 200 to 1000 | 14 to 70 | | |
| 9 | 45 | 200 to 1750 | 14 to 120 | | |

**The maximum input pressure/temperature that can be continuously applied to the switch without causing a permanent change of set point, leakage or material failure.*

## Step 1b: Vacuum Switch

**54**N6-B**118**-M9-C2A-JJTTNQ

Place designators in positions 1 and 4.

| Piston (Designator 1) | Spring (Designator 4) | Adjustable Range (Vacuum - 0 - Pressure) | | Overrange | |
|---|---|---|---|---|---|
| | | in. Hg | mbar | psi | bar |
| 54 | 118 | 30 - 0 - 1 | 1000 - 0 - 35 | 750 | 50 |

## Step 1c: Temperature Switch

201N6-B125-U9-C7A-JJTTNQ

Place designators in positions 1 and 4.

| Probe (Designator 1) | Range (Designator 4) | Mounting Type | Capillary Length | | Adjustable Range | | Overrange Temperature | | Max Process Pressure | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ft. | m | °F | °C | °F | °C | psi | bar |
| 201 | 125 | Direct | - | - | 40 to 225 | 5 to 107 | 360 | 182 | 2300 | 158 |
| 203 | 125 | Remote | 6 | 1.8 | | | | | | |
| 205 | 125 | Remote | 10 | 3.0 | | | | | | |
| 207 | 125 | Remote | 15 | 4.5 | | | | | | |
| 209 | 125 | Remote | 20 | 6.0 | | | | | | |
| 201 | 115 | Direct | - | - | 150 to 375 | 66 to 190 | 520 | 270 | | |
| 203 | 115 | Remote | 6 | 1.8 | | | | | | |
| 205 | 115 | Remote | 10 | 3.0 | | | | | | |
| 207 | 115 | Remote | 15 | 4.5 | | | | | | |
| 209 | 115 | Remote | 20 | 6.0 | | | | | | |

## Step 2: Select Housing

12N6-B45-U8-C2A-JJTTNQ

Replace N6 in the sample model number with the appropriate housing designator.

| Housing (Designator 2) | Specifications |
|---|---|
| RT | 33 mega rad<br>See figures 4 and 5 (page 3) for DBE profile.<br>Material: 316SS (CF8M) |
| N6 | 33 mega rad<br>See figures 4 and 5 (page 3) for DBE profile.<br>Material: carbon steel |
| TA | 200 mega rad<br>See figure 3 (page 2) for DBE profile.<br>Material: ductile iron.<br>*Temperature switches in the TA housing are qualified for 33 M rad and HELB only.* |

## Step 3: Select Switching Element

12N6-B45-U8-C2A-JJTTNQ

Replace B in the sample model number with the appropriate switching element designator.

| Switch (Designator 3) | AC Rating | | DC Rating Resistive | | Contact Form |
|---|---|---|---|---|---|
| | Volts | Amps | Volts | Amps | |
| B | 250 | 5 | 125 | 0.3 | SPDT |
| Y* | 250 | 5 | - | - | SPDT |
| W* | 250 | 5 | - | - | SPDT |
| BB | 250 | 5 | 125 | 0.3 | DPDT |

**DC rating is optional. Contact SOR.*

## Step 4: Select Diaphragm System

Replace U8 in the sample model number with the appropriate diaphragm system designator.

12N6-B45-**U8**-C2A-JJTTNQ

*NOTE: If the designator 1 (chosen in step 1) does not appear under Compatible Designators, the line item is not available.*

| Diaphragm (Designator 5) | Diaphragm Material | Diaphragm System | | Compatible Designators (Designator 1) |
|---|---|---|---|---|
| | | Welded | O-Ring | |
| U8 | 316SS | Yes | None | 12, 4, 5, 6*** |
| M4* | | No | Viton | 54 |
| M9 | | No | EPR | 54 |
| U9* | | Yes | None | 201, 203, 205, 207, 209 |
| U1** | | Yes | None | 9, 29**** |

* *M4 and U9 diaphragm systems are qualified for 33 M rad and HELB only.*
** *Reduced drift and dead band. Affects qualification levels. Consult SOR.*
*** *Designators 9 and 29 are also available. Consult SOR.*
**** *Designators 5 and 6 are also available. Consult SOR.*

## Step 5: Select Process Connection

Replace C2A in the sample model number with the appropriate process connection designator.

12N6-B45-U8-**C2A**-JJTTNQ

*NOTE: If the designator 1 (chosen in step 1) does not appear under Compatible Designators, the line item is not available.*

| Process Connection (Designator 6) | Connection Material | Connection Size/Type | | Compatible Designators (Designator 1) |
|---|---|---|---|---|
| C1A | 316SS | 1/4 | NPT(F) | 12, 4, 5, 6, 9, 29, 54 |
| C2A | | 1/2 | NPT(F) | |
| C7A | | 1/2 | NPT(M) | 201, 203, 205, 207, 209 |

## Step 6: Select Accessories

12N6-B45-U8-C2A-**JJTTNQ**

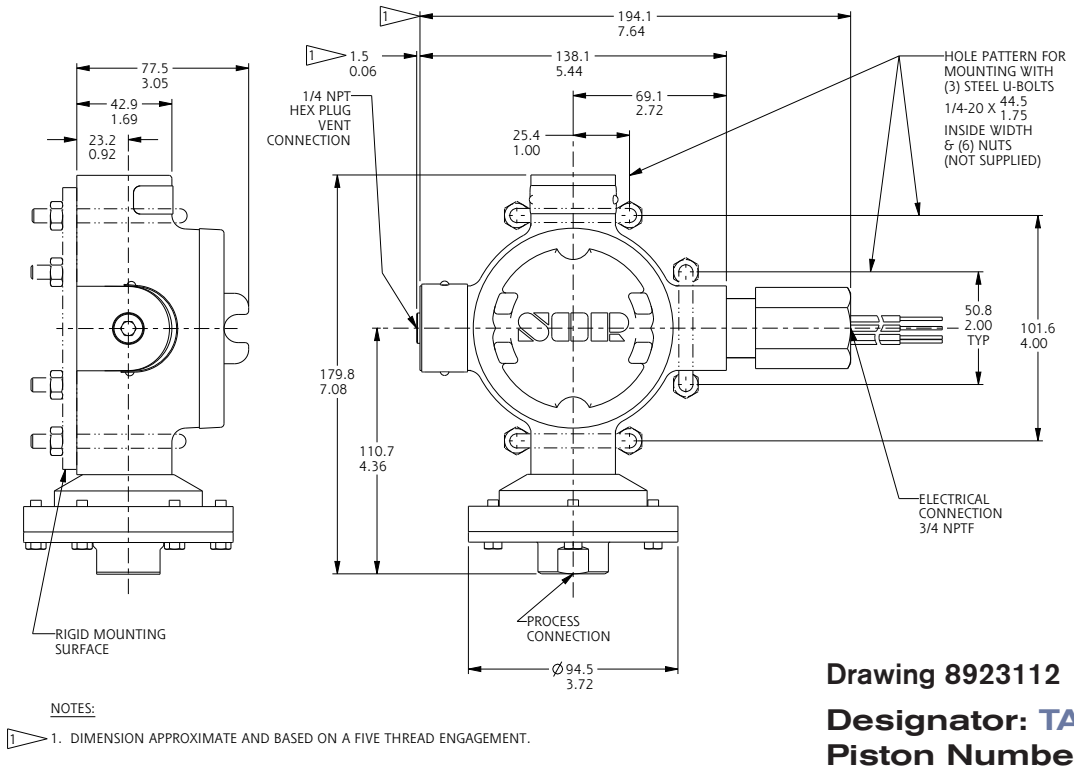
| Accessories (Designator 7) | Description |
|---|---|
| JJ | Conduit seal with 17 ft. lead wire length. *Optional.* *This designator must be used for HELB and LOCA applications.* |
| RR | Stainless steel tag attached with stainless steel wire to housing. |
| TT | Oversized nameplate for tagging information. *Required designator.* |
| NQ | Nuclear-qualified model. *Required designator.* |

## Approximate Weights

| Designator | Piston | Weight (lbs) | Kilograms |
|---|---|---|---|
| TA | No. 12 | 8.81 | 4.00 |
| | No. 4, 54 | 7.19 | 3.26 |
| | No. 5, 6, 9, 29 | 6.75 | 3.06 |
| RT | No. 12 | 7.13 | 3.23 |
| | No. 4, 54 | 5.50 | 2.49 |
| | No. 5, 6, 9, 29 | 5.06 | 2.30 |
| N6 | No. 12 | 5.63 | 2.55 |
| | No. 4, 54 | 3.94 | 1.79 |
| | No. 5, 6, 9, 29 | 3.56 | 1.62 |

Includes weight of "JJ" conduit seal.
Excludes weight of external wire leads.

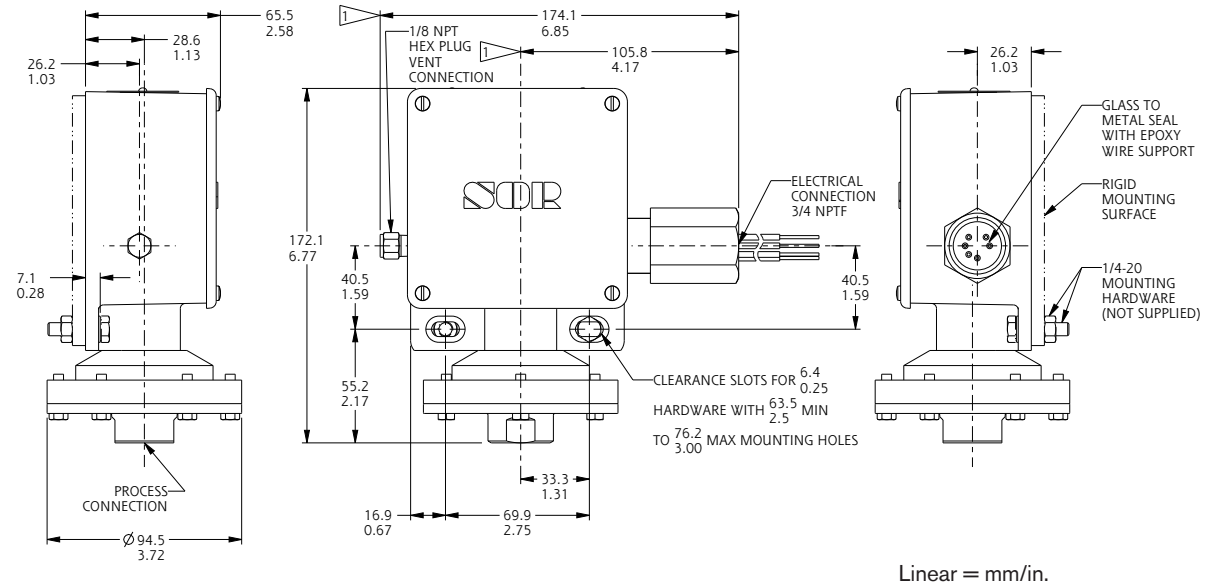
## Dimensions




**Drawing 8923112**

**Designator: TA**
**Piston Number 12**

Dimensions in this catalog are for reference only. They may be changed without notice. Contact the factory for certified drawings for a particular model number.

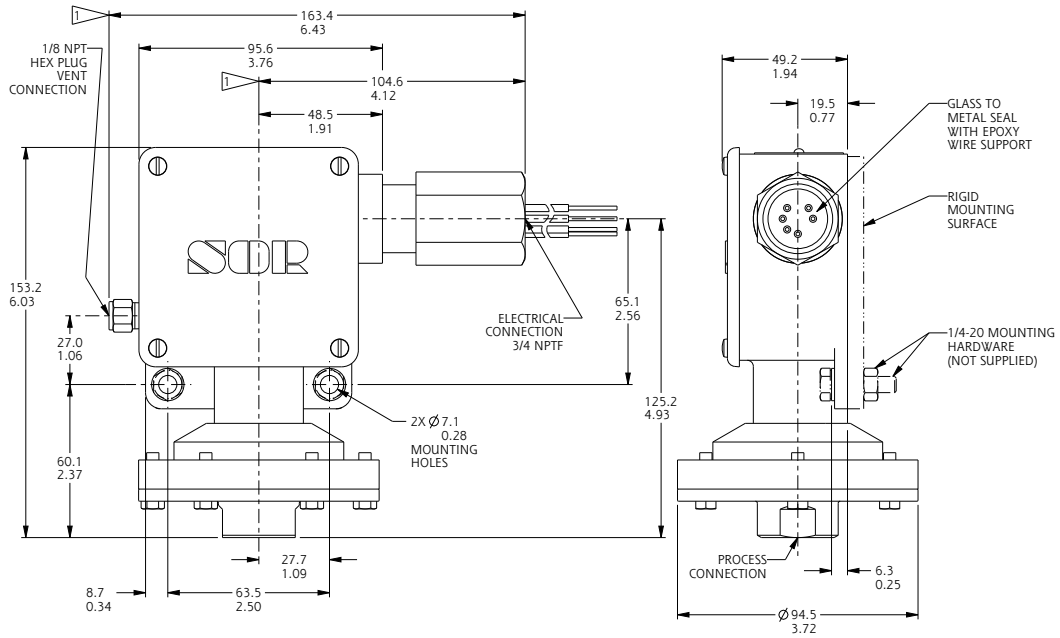



Linear = mm/in.

**Drawing 8923118**
**Designator: RT**
**Piston Number 12**

NOTES:

1. 1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

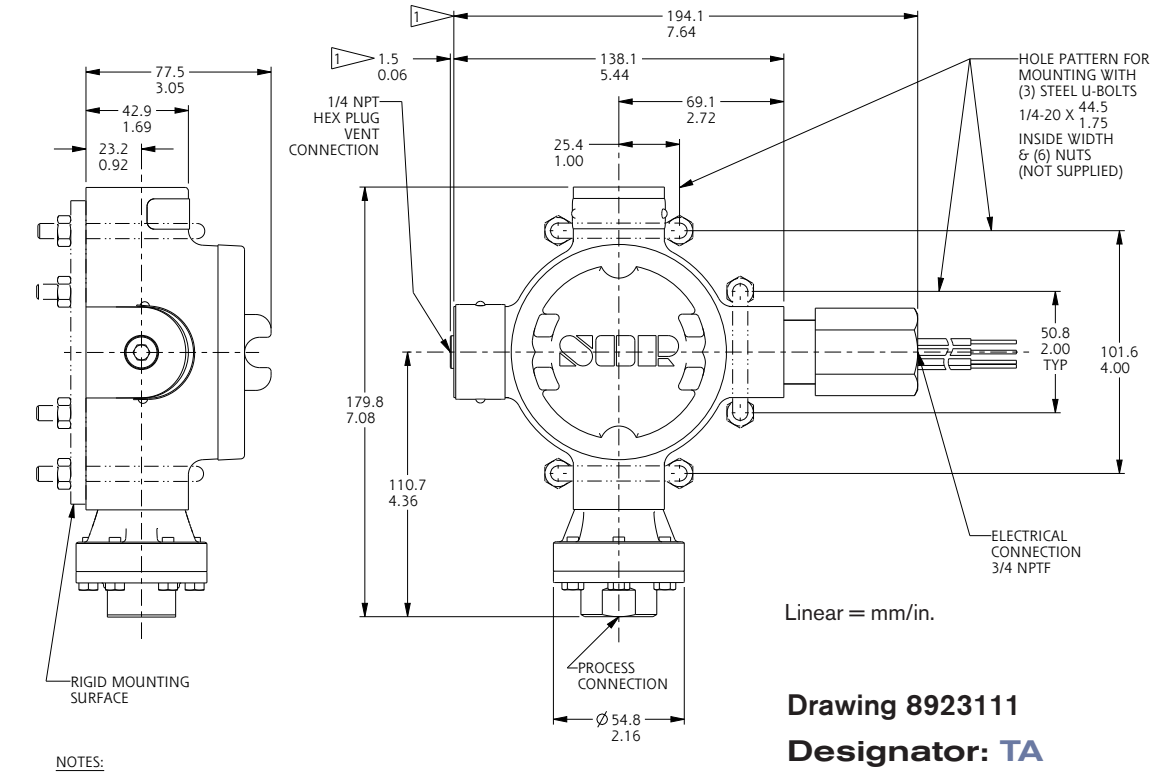



NOTES:

1. 1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

**Drawing 8923115**
**Designator: N6**
**Piston Number 12**

Dimensions in this catalog are for reference only. They may be changed without notice. Contact the factory for certified drawings for a particular model number.




Linear = mm/in.

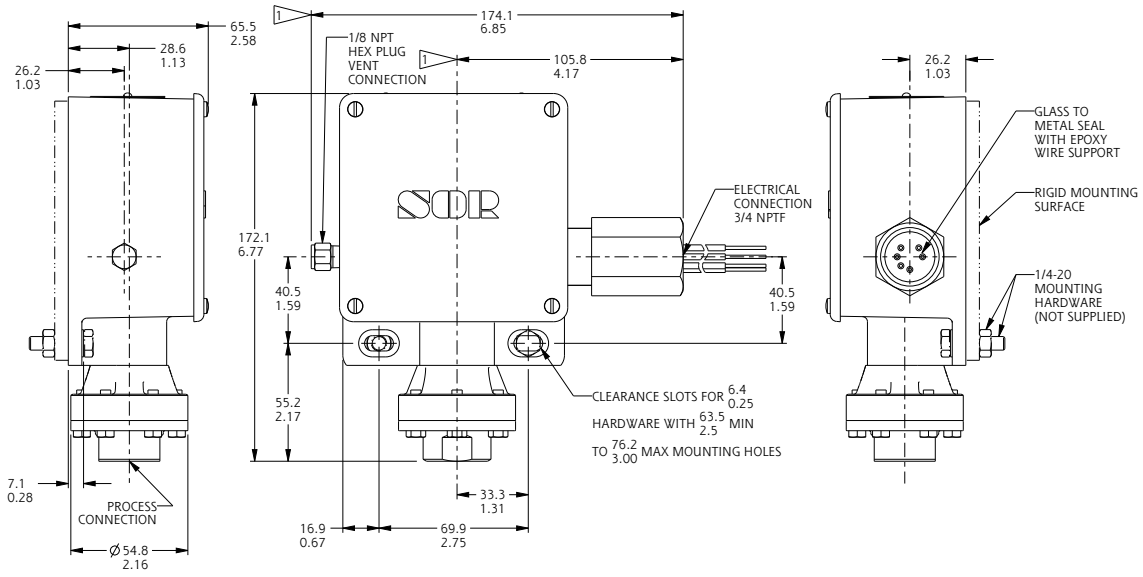
NOTES:

1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

**Drawing 8923111**

**Designator: TA**

**Piston Numbers 4, 54**




NOTES:

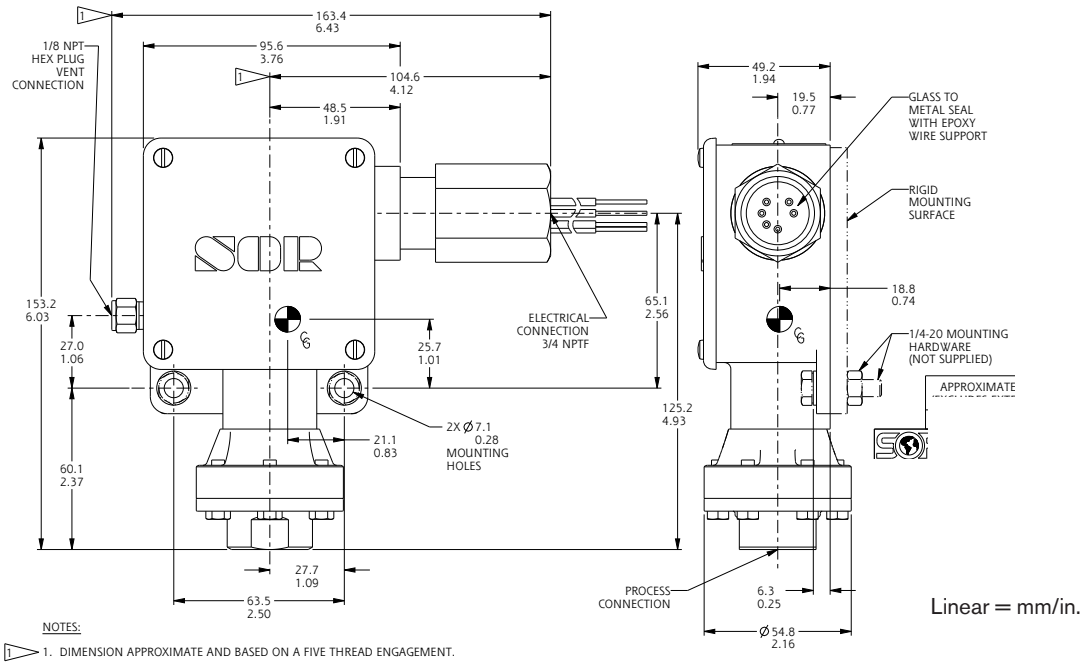
1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

**Drawing 8923117**

**Designator: RT**

**Piston Numbers 4, 54**

Dimensions in this catalog are for reference only. They may be changed without notice. Contact the factory for certified drawings for a particular model number.



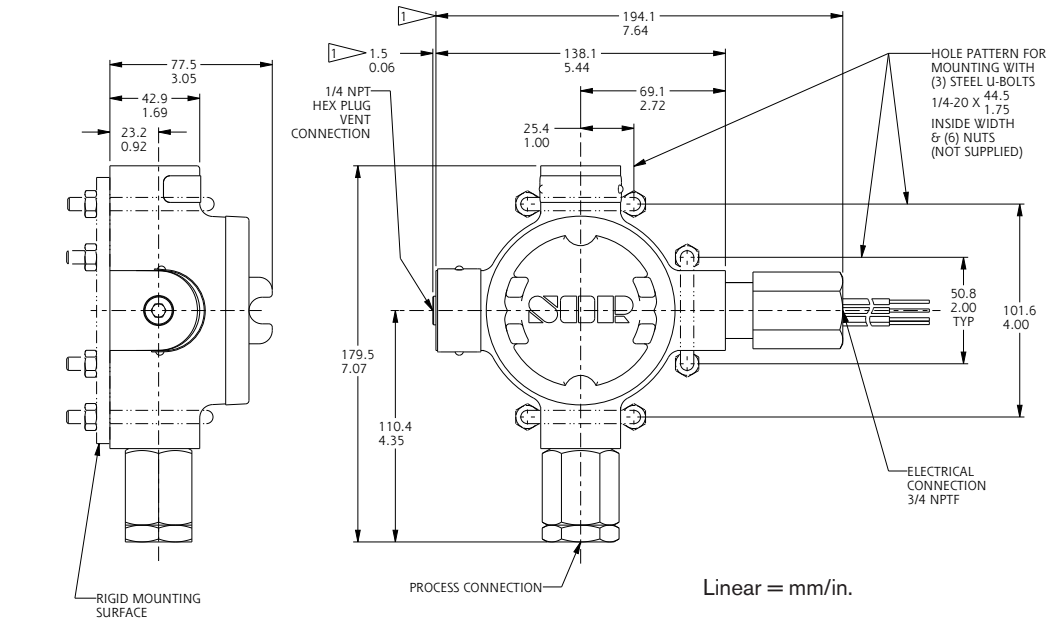

NOTES:

1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

**Drawing 8923114**

**Designator: N6**

**Piston Numbers 4, 54**




NOTES:

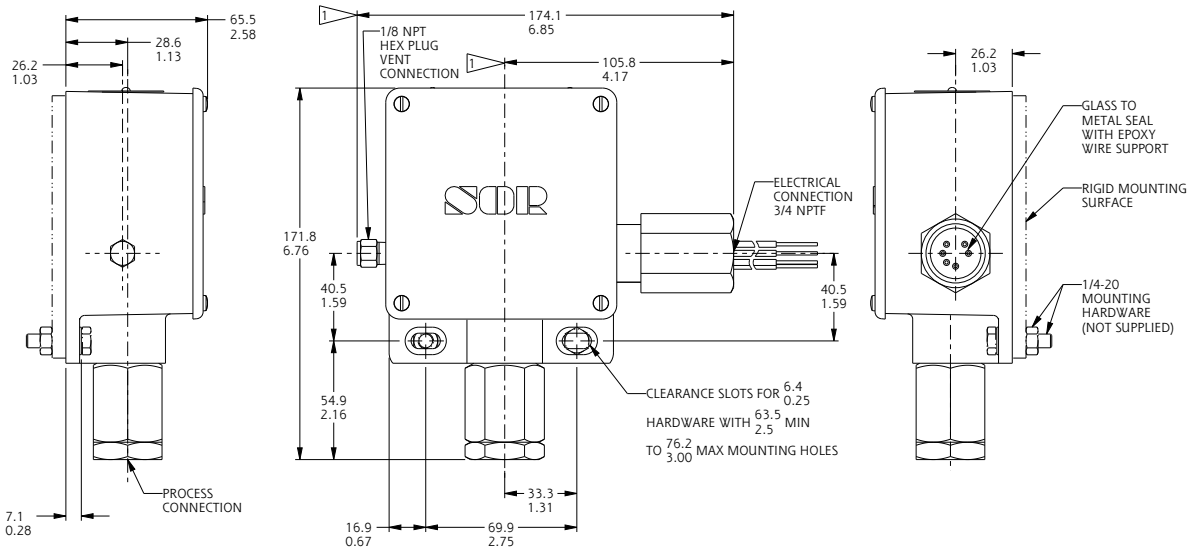
1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

**Drawing 8923110**

**Designator: TA**

**Piston Numbers 5, 6, 9, 29**

Dimensions in this catalog are for reference only. They may be changed without notice. Contact the factory for certified drawings for a particular model number.




Linear = mm/in.

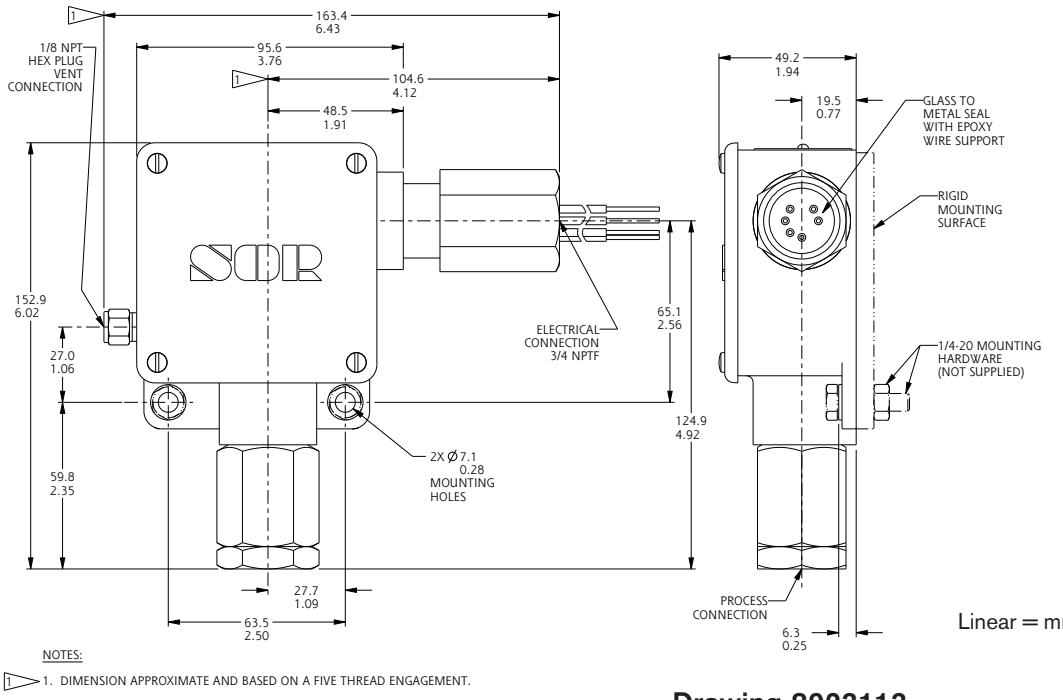
NOTES:

1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

**Drawing 8923116**

**Designator: RT**

**Piston Numbers 5, 6, 9, 29**




Linear = mm/in.

NOTES:

1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

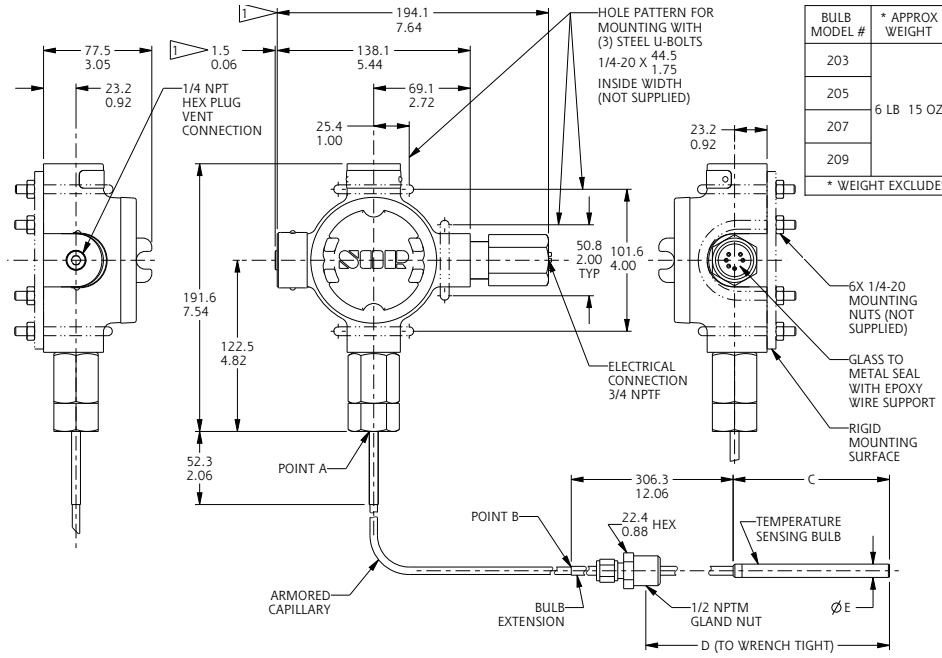
**Drawing 8923113**

**Designator: N6**

**Piston Numbers 5, 6, 9, 29**

Dimensions in this catalog are for reference only. They may be changed without notice. Contact the factory for certified drawings for a particular model number.

## Dimensions




| BULB MODEL # | * APPROX WEIGHT | LENGTH A-B | LENGTH C | LENGTH D | ØE |
|---|---|---|---|---|---|
| 203 | 6 LB 15 OZ | 1829 72 | 112.0 4.41 | 125.7 4.95 TO 381.8 15.03 | 9.7 0.38 |
| 205 | | 3048 120 | 124.7 4.91 | 138.4 5.45 TO 394.5 15.53 | |
| 207 | | 4572 180 | 162.8 6.41 | 176.5 6.95 TO 432.6 17.03 | |
| 209 | | 6096 240 | 194.6 7.66 | 208.3 8.20 TO 464.3 18.28 | |

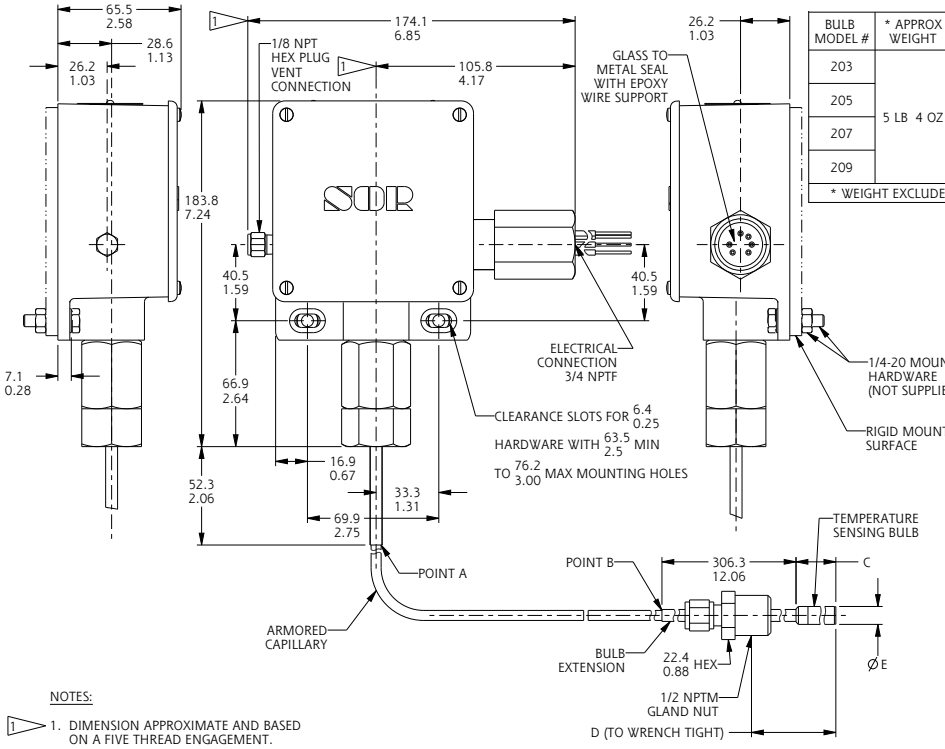
* WEIGHT EXCLUDES CAPILLARY, BULB AND EXTERNAL WIRE LEADS

NOTES:

1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

### Drawing 8923124

### Designator: TA Remote Temperature Switch




| BULB MODEL # | * APPROX WEIGHT | LENGTH A-B | LENGTH C | LENGTH D | ØE |
|---|---|---|---|---|---|
| 203 | 5 LB 4 OZ | 1829 72 | 112.0 4.41 | 125.7 4.95 TO 381.8 15.03 | 9.7 0.38 |
| 205 | | 3048 120 | 124.7 4.91 | 138.4 5.45 TO 394.5 15.53 | |
| 207 | | 4572 180 | 162.8 6.41 | 176.5 6.95 TO 432.6 17.03 | |
| 209 | | 6096 240 | 194.6 7.66 | 208.3 8.20 TO 464.3 18.28 | |

* WEIGHT EXCLUDES CAPILLARY, BULB AND EXTERNAL WIRE LEADS

NOTES:

1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

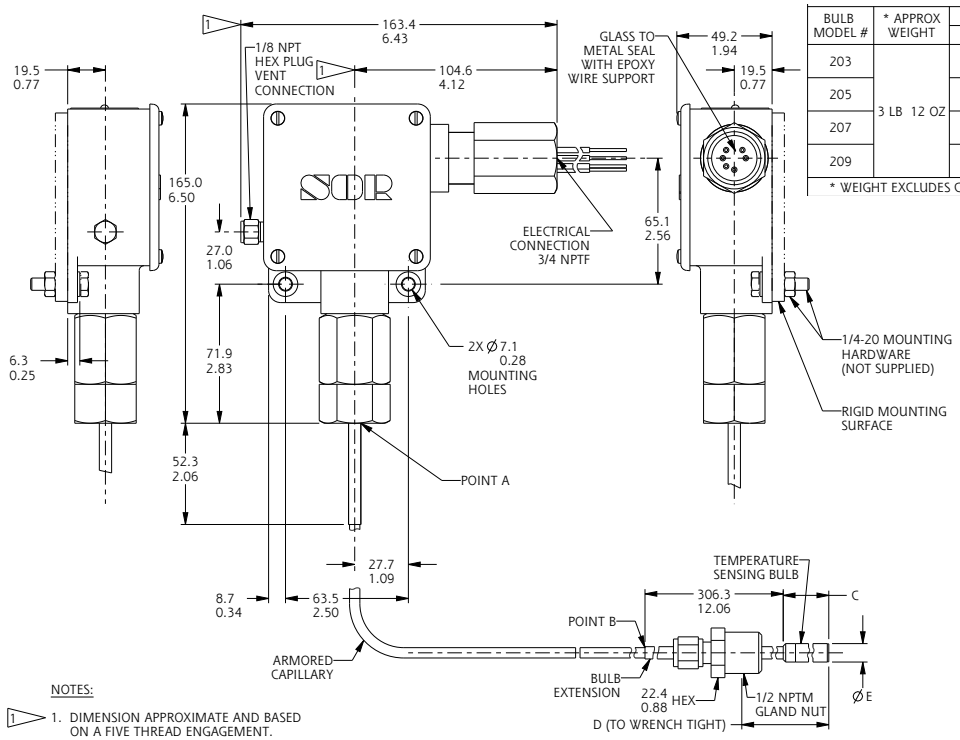
Linear = mm/in.

### Drawing 8923126

### Designator: RT Remote Temperature Switch

Dimensions in this catalog are for reference only. They may be changed without notice. Contact the factory for certified drawings for a particular model number.

## Dimensions

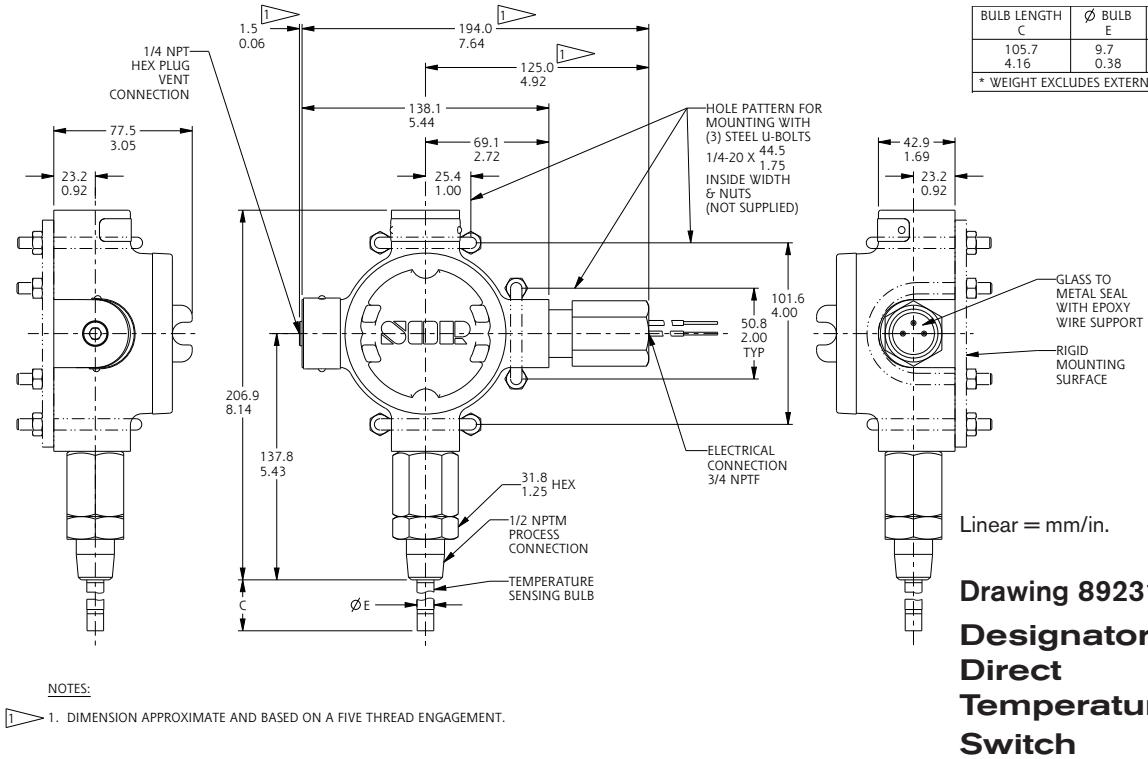



| BULB MODEL # | * APPROX WEIGHT | LENGTH A-B | LENGTH C | LENGTH D | Ø E |
|---|---|---|---|---|---|
| 203 | 3 LB 12 OZ | 1829 72 | 112.0 4.41 | 125.7 4.95 TO 381.8 15.03 | 9.5 0.38 |
| 205 | | 3048 120 | 124.7 4.91 | 138.4 5.45 TO 394.5 15.53 | |
| 207 | | 4572 180 | 162.8 6.41 | 176.5 6.95 TO 432.6 17.03 | |
| 209 | | 6096 240 | 194.6 7.66 | 208.3 8.20 TO 464.3 18.28 | |

* WEIGHT EXCLUDES CAPILLARY, BULB AND EXTERNAL WIRE LEADS

### Drawing 8923122

### Designator: N6 Remote Temperature Switch




| BULB LENGTH C | Ø BULB E | * APPROX WEIGHT |
|---|---|---|
| 105.7 4.16 | 9.7 0.38 | 7 LB 1 OZ |

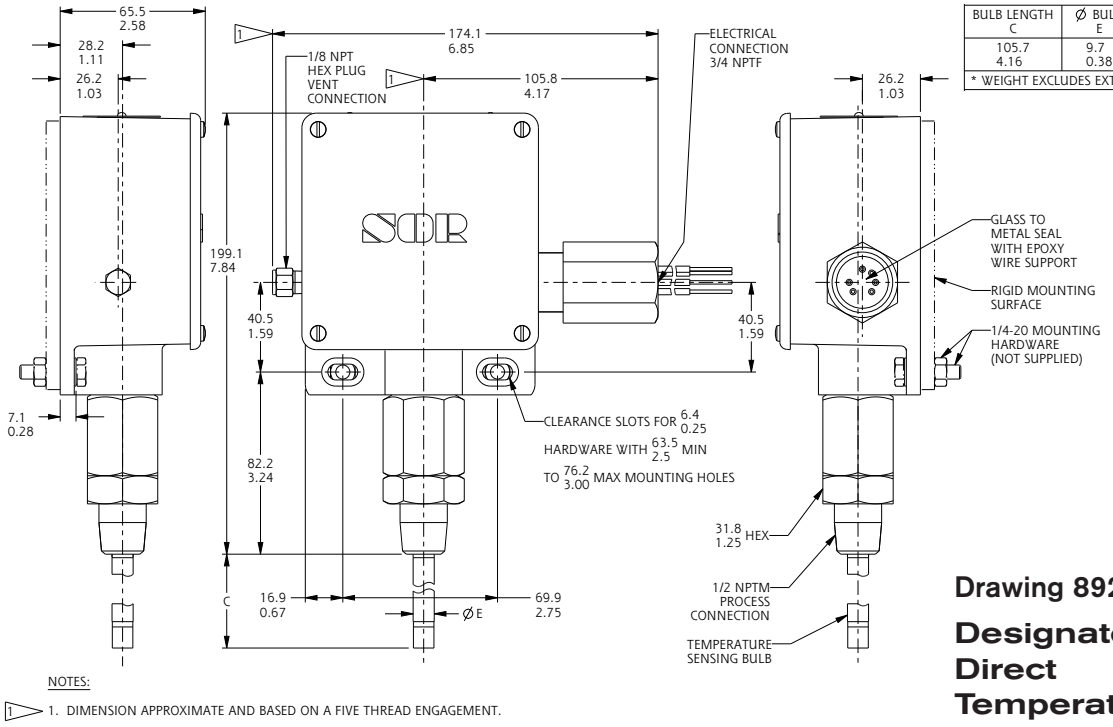
* WEIGHT EXCLUDES EXTERNAL WIRE LEADS

Linear = mm/in.

### Drawing 8923123

### Designator: TA Direct Temperature Switch

Dimensions in this catalog are for reference only. They may be changed without notice. Contact the factory for certified drawings for a particular model number.




| BULB LENGTH C | Ø BULB E | * APPROX WEIGHT |
|---|---|---|
| 105.7 4.16 | 9.7 0.38 | 5 LB 6 OZ |

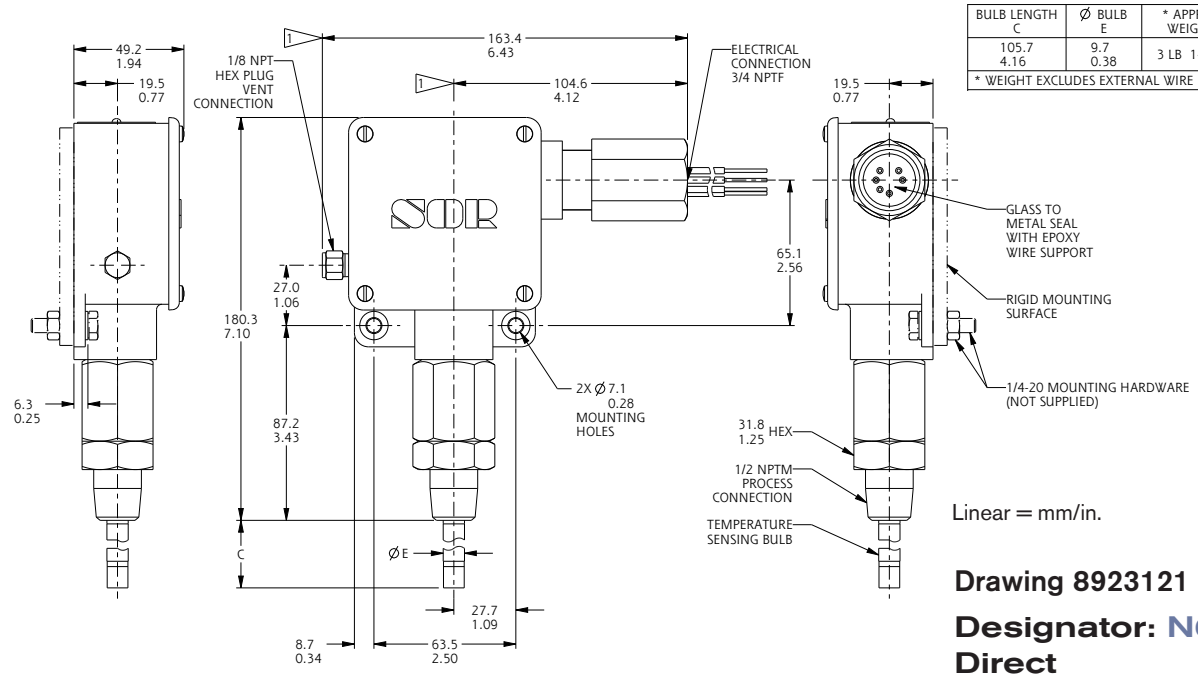
* WEIGHT EXCLUDES EXTERNAL WIRE LEADS

NOTES:

1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

**Drawing 8923125**

**Designator: RT**
**Direct Temperature Switch**




| BULB LENGTH C | Ø BULB E | * APPROX WEIGHT |
|---|---|---|
| 105.7 4.16 | 9.7 0.38 | 3 LB 14 OZ |

* WEIGHT EXCLUDES EXTERNAL WIRE LEADS

Linear = mm/in.

NOTES:

1. DIMENSION APPROXIMATE AND BASED ON A FIVE THREAD ENGAGEMENT.

**Drawing 8923121**

**Designator: N6**
**Direct Temperature Switch**

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