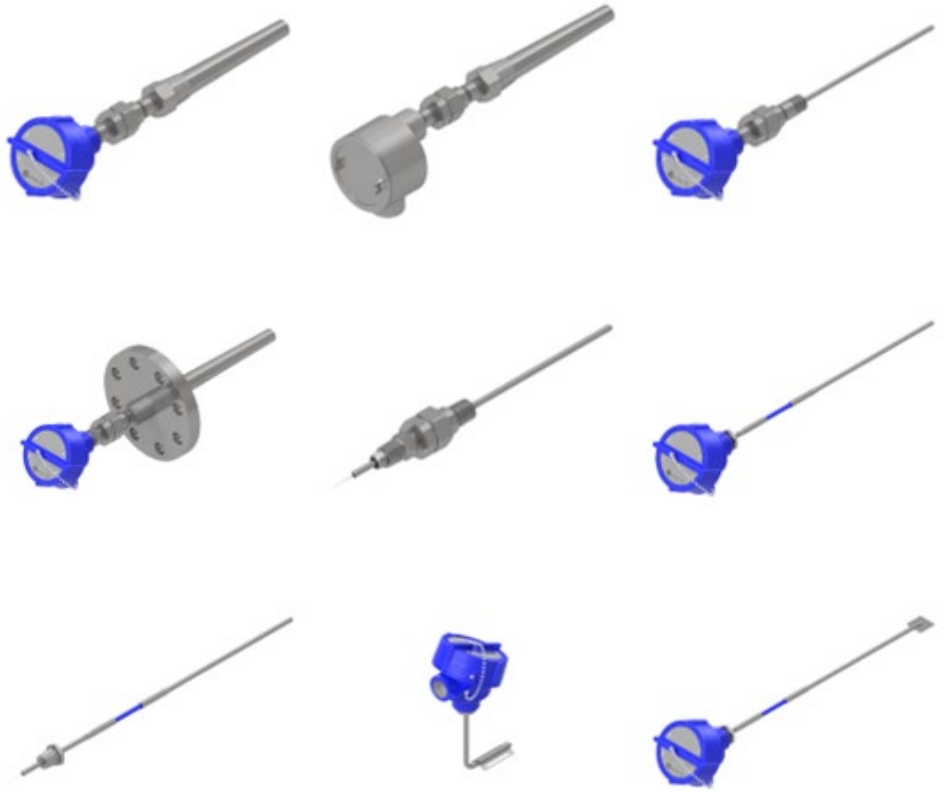
Aircom Instrumentation Ltd.

Installation, Operation, and Maintenance Information: Temperature Sensor Assemblies with Connection Head Enclosures

Model Series Thermocouples, RTDs, and Thermowells:

TC8, TC9, TC10, TC11, TC14, TC15, TC16, TC17, RT6, RT7, RT9, RT11, RT14, RT15, RT16, RT17, SM2, SM4, HT2, HT3, WPT, MG1, MG2, MG3, S22, S24, S26, S32, S34, SL22, SL24, SL26, SL32, SL34, TW52, TW72, SW22, SW24, SW26, SW32, SW34, WF22, WF24, WF26, WF32, WF34, B24, BL24, F22, F24, F26, F32, F34, FS22, and VST



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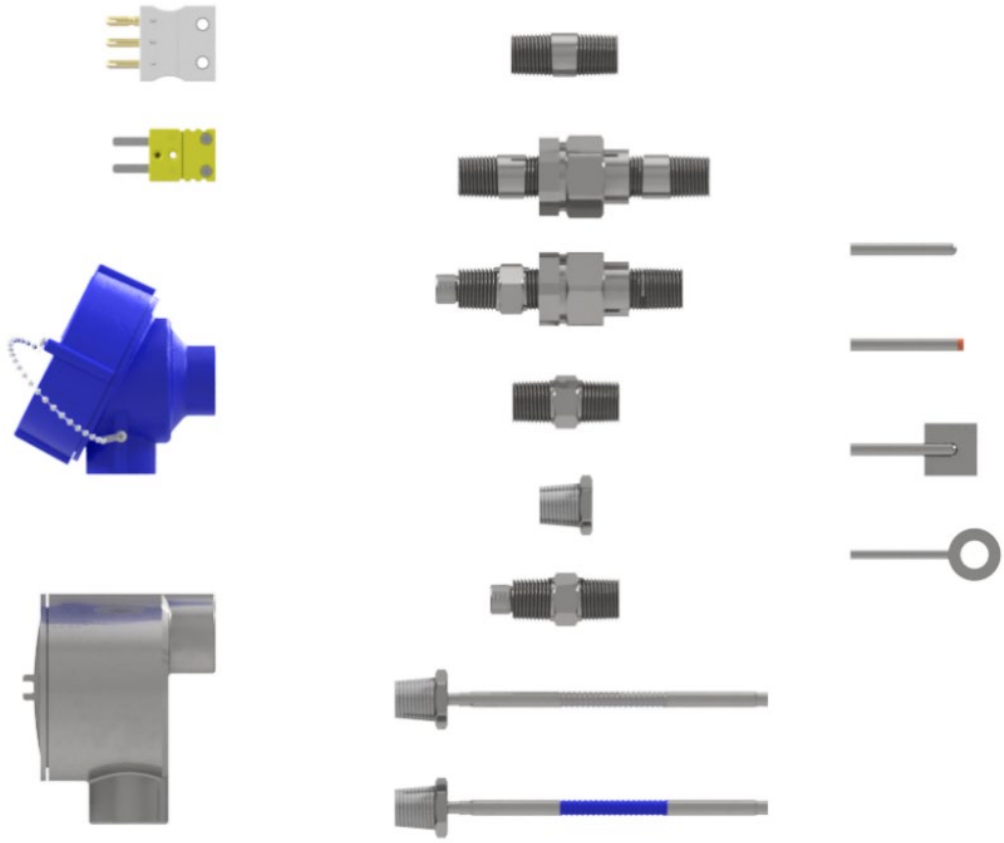

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Revision Table

Revision	Date (YYYY-MM-DD)	By
1	2021-06-02	BSG

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1 Intended Use and Scope

The temperature sensor assembly devices in this document are used for the collection of industrial temperature measurements. The signals may or may not be converted during transmission from the sensor element to the acquisition system. Aircom is not liable for damages caused by improper use or misapplication of these devices.

This document and any supplemental documents provided by Aircom are intended to help the end-user with their temperature sensor assemblies. This document does not cover all aspects of the use of temperature sensor assemblies, it gives a general overview of common practices. Included in this document is information on safety warnings, important notices, installation, pre-commissioning, commissioning, operation, and maintenance, as well as links to other relevant information. This document covers both Resistance Temperature Detector (RTD) and thermocouple assemblies with and without thermowells.

2 Important Notices and Warnings

Ensure all installation, operation, and maintenance information, safety warnings and notices are reviewed before using these temperature sensor assemblies.

2.1 Selection

Before using these temperature sensor assemblies, it is important to ensure that the correct assembly was selected for the specific application, that the assembly was correctly installed, and is correctly operated and maintained. The following information will help as guidelines to ensuring expected temperature sensor assembly performance.

2.2 Notices

The following information provided in this document is based on common practice in industry for specific conditions. This information does not cover all scenarios and applications and Aircom does not guarantee this information will lead to the desired results and assumes no liability for the resulting outcomes. Aircom's personnel are available to help with temperature sensor assembly selection for various applications, however, the end-user is ultimately responsible for ensuring the suitability of the products being used and how they are used in their specific applications. Aircom is not responsible for any damages caused due to non-conformance with the information provided in this document, or the improper use of the devices in this document.

2.3 Safety Warnings

The devices in this document may be connected to sources that are pressurized, electrified, and may contain hazardous mediums, products, fluids, atmospheres, or materials that may be at harmful levels. Ensure that all personnel involved in the installation, operation, and maintenance of these devices take care when around these devices, while handling them, and use appropriate protection for the task being performed. Follow all safety instructions, be aware of the dangers, and heed all warnings in this

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document and according to the local jurisdiction and site requirements. Do not install damaged devices, and ensure all damaged devices are properly tagged/labeled as defective and are taken out of service.

2.4 Definitions, Terms, Abbreviation, and Units

The following are the definitions, terms, and abbreviation used specifically in this document and are based on general industry terminology.

Table 1: Definitions and terms.

Definition/Term	Description
⚠ **DANGER:**	Means if the danger is not avoided, it will cause death or serious injury.
⚠ **WARNING:**	Means if the warning is not heeded, it can cause death or serious injury.
⚠ **CAUTION:**	Means if the precaution is not taken, it may cause minor or moderate injury.
NOTICE:	Important information that can affect the functionality of the system.
Types of Hazards:	- ⚡ Electric Hazard - 💥 Explosive Hazard - 🔥 Fire Hazard
Conduit Connection:	This is the field wiring entry point on the head. Theses are typically threaded connections on the connection head enclosure that connect to the conduits/conduit fittings, or field wiring/cable.
Connection Head Enclosure, Connection Head, or Head:	This is the enclosure where the lead wires and sensor wires are connected/terminated (*e.g.*, to a terminal block, wire splices, DIN rail connectors, or transmitter, *etc.*).
Head Connection:	This is the sensor entry point on the head. These are typically a threaded connection on the connection head enclosure that connects to the connection extension fittings between the connection head and the process instrument connection (*e.g.,* thermowell, fixed fitting probe, *etc.*).
Connection Extension:	This is where the sensor passes from the head to the process connection. These are the threaded fittings that connect the connection head enclosure to the process instrument connection (*e.g.*, nipple-union-nipple, nipple, *etc.*).
Process Instrument Connection:	This is where the sensor enters the process directly, or the process connection. This is typically a threaded connection connecting the connection extension to the process connection.
Process Connection:	This is where the sensor or thermowell is connected directly to the process and is in contact with the medium. This connection varies and typically is threaded, flanged, or welded (in some cases it may be clamped, or use other special connection methods).
Nozzle:	General term for different types of process connections that the thermowell or fixed fitting probe will be connected to (*e.g.*, flange, coupling, threadolet, sockolet, *etc.*).
Medium:	Any substance used in the process (*e.g.*, fluids (liquids/gases), bulk solids, *etc.*).
Aircom:	Aircom Instrumentation Ltd.
T-Code:	Temperature Code.
DIN Rail Connector:	Rail mounted wire connection tension clamp

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Definition/Term	Description
CSA B51:	CSA B51 Boiler, pressure vessel, and pressure piping code
ASME B1.20.1:	ASME B1.20.1 Pipe Threads, General Purpose (Inch)
ASME B16.5:	ASME B16.5 Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24 Metric/Inch Standard
ASME B16.11:	ASME B16.11 Forged Fittings, Socket-Welding and Threaded
ASME PCC-1:	ASME PCC-1 Guidelines for Pressure Boundary Bolted Flange Joint Assembly
ASME PTC 19.3:	ASME PTC 19.3 Part 3 Temperature Measurement Instruments and Apparatus Supplement to ASME Performance Test Codes
ASME PTC 19.3 TW:	ASME PTC 19.3 TW Thermowells Performance Test Codes
ASME B31.1:	ASME B31.1 Power Piping ASME Code for Pressure Piping, B31
ASME B31.3:	ASME B31.3 Process Piping ASME Code for Pressure Piping, B31
ASME VIII-1:	ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Rules for Construction of Pressure Vessels
***e.g.*:**	**e**xempli **g**ratia (“for example”)
***etc.*:**	**et c**etera (“and the rest”)

Table 2: Abbreviations.

Abbreviation	Description
IOM:	**I**nstallation, **O**peration, and **M**aintenance
MRB:	**M**anufacturer’s **R**ecord **B**ook (Databook)
MTR:	**M**aterial **T**est **R**eport (Mill Test Report/Certificate)
ITP:	**I**nspection **T**est **P**lan
PWHT:	**P**ost **W**eld **H**eat **T**reatment
NDE:	**N**on-**D**estructive **E**xamination
CSA:	**C**anadian **S**tandards **A**ssociation
CEC:	**C**anadian **E**lectrical **C**ode
NEC:	**N**ational **E**lectrical **C**ode (US)
SELV:	**S**afety **E**xtra-**L**ow **V**oltage
RTD:	**R**esistance **T**emperature **D**etector
MI:	**M**ineral **I**nsulated (Cable)
NI:	**N**on-**I**ncendive (*e.g.,* Field Wiring)
NPS:	**N**ominal **P**ipe **S**ize
NPT:	**N**ational (American Standard) **P**ipe **T**aper (Thread)
NPTF:	**N**ational (American Standard) **P**ipe **T**aper **F**uel (Thread)
BSP:	**B**ritish **S**tandard **P**ipe (Thread)
BSPP:	**B**ritish **S**tandard **P**arallel **P**ipe (Thread)
BSPT:	**B**ritish **S**tandard **P**ipe **T**aper (Thread)
UN:	**U**nified **N**ational (Thread)
UNF:	**U**nified **N**ational **F**ine (Thread)
PTFE:	**P**oly**t**etra**f**luoro**e**thylene (*e.g.*, Teflon ™)
PVC:	**P**oly**v**inyl **C**hloride
AWG:	**A**merican **W**ire **G**auge
ASME:	**A**merican **S**ociety of **M**echanical **E**ngineers

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Abbreviation	Description
PTC:	Performance **T**est **C**ode
TW:	**T**hermo**w**ell
DIN:	**D**eutsches **I**nstitut fur **N**ormung (German Institute for Standardization)
EN:	**E**uropean **S**tandard
SI:	Le **S**ystème **I**nternational d'Unités (The International System of Units)
EMI:	**E**lectro**m**agnetic **I**nterference
RFI:	**R**adio **F**requency **I**nterference
I/O:	**I**nput/**O**utput
RH:	**R**elative **H**umidity
N/A:	**N**ot **A**pplicable
US:	**U**nited **S**tates of **A**merica (also USA)

Table 3: Units used in document.

Document Unit Type	Metric	Imperial
Pressure	kPa (kilopascal) 1 kPa = 1 x 10^3 Pa	psi (pounds-force per square inch) [lb_f/in^2]
Temperature	°C (degree Celsius) 0°C = +273.15 K	°F (degree Fahrenheit) +32°F = +491.67°R
Voltage	Vdc (volts direct current)	
Current	A (ampere) / mA (milliampere)	
Distance | Length	m (meter) / mm (millimeter)	’ (foot) / ” (inch) [ft] / [in]

3 Assemblies Information and Specifications

Aircom’s temperature sensor assemblies are built to measure temperatures in a variety of applications including industrial processes with CSA hazardous location approvals on various models in Canada and the US. Aircom temperature sensor assemblies consist of a sensor element (RTD, or Thermocouple), a connection head enclosure, a terminal block, or optional wire splice connectors, DIN rail connectors or a transmitter, connection extension fitting(s), and a thermowell or fixed fitting probe. There are options to have the sheath as spring-loaded or fixed. These assemblies should be shipped, handled, and stored with care to avoid damage that could affect their functionality. Temperature sensor assembly design, selection, and construction should take the following factors into considerations which include but are not limited to construction, response time, tolerance (accuracy/precision), immersion length, temperature (minimum/maximum), pressure (minimum/maximum), compatibility (physical and chemical), applied forces (fluid flow, cycling, *etc.*), vibration, and thermal effects (ambient temperature, low/high-temperatures, thermal equilibrium, thermal cycling, passive/forced heating/cooling, intermediate temperature material property changes, *etc.*).

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3.1 Sizes and Models

The typical sizes of the temperature sensor assembly components are as follows; other sizes are available when requested.

Table 4: Typical component sizes.

Component	Size Ranges
Connection Head Enclosure Nozzles	NPT Thread: ½", ¾", 1", 1-¼", 1-½", 2" (Reducer bushings also available)
Terminal Blocks, Wire Splice Connectors, and DIN Rail Connectors	Number of Terminals/Connections: up to 8
Connection Extension Fittings (Conduit, Nipples, Unions, Bushings, *etc.*)	NPT Thread: ½" (typically) Length: 0.00 mm to 6.1 m (0.0" to 241.5")
Sensor Probe Sheaths	Outer Diameter: 1.6 mm to 12.7 mm (1/16" to ½") Length: 6.35 mm to 12.192 m (¼" to 480") Minimum Wall Thickness: 0.10 mm (0.004")
Lead Wires	Diameter: 8 AWG to 30 AWG
Threaded & Flanged Thermowells	Length: 50.8 mm to 4.3 m (2.00" to 169.75") NPT Thread: ⅛" to 2" Minimum Tip Thickness: 6.4 mm (¼") Minimum Wall Thickness: 3.0 mm (0.12") *Flange Class: 150# to 2,500# NPS Flanges: ≥ 1" (typically 1" to 10") (Reducing flanges also available)
Fixed Fitting Probes	NPT Thread: ½" (typically) Probe Outer Diameter: 1.6 mm to 12.7 mm (" to ½") Probe Length: 6.35 mm to 12.192 m (¼" to 480")
**Flex-Armour Sheath (Flex-Cable) Probes	NPT Thread: ½", ¾" Outer Diameter: 3.2 mm to 9.5 mm (⅛" to ⅜") Probe Outer Diameter: 1.6 mm to 12.7 mm (1/16" to ½") Probe Length: 6.35 mm to 12.192 m (¼" to 480") Flex-Cable Length: 25.4 mm to 6.1 m (1" to 241.5")

*Notes: These are the common sizes of components if other sizes are required contact Aircom ("**Contact Information and Technical Assistance**").*

**Various styles of flanges are available (some styles include ported flanges, raised faced flanges, high-hub flanges, etc.).*

***Can be provided with or without a polyurethane, Teflon, or polyvinyl chloride (PVC) coating.*

Refer to the catalogue pages for the configuration and technical specifications of the temperature sensor assemblies. The following information in this document is general to all temperature sensor assemblies unless otherwise specified. Customizations and alternate options for most components are available upon request including but not limited to connection head enclosures, transmitters, extension connections, and thermowells.

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This document covers the model series thermocouple, and RTD temperature sensor assemblies as follows:

- The TC9, TC14, RT9, and RT14 are CSA rated as Class I, Division 1, Groups A, B, C, D; Class I, Zone 1, Groups IIC, IIB plus hydrogen, IIB; Class II, Division 1, Groups E, F, G; Zone 20; Class III; T6…T1; (explosion proof) assemblies that include a sensor probe, thermowell or fixed fitting probe, connection extension fittings, connection head enclosure, and a terminal block, wire splice connectors, DIN rail connectors or transmitter.
- The TC8, TC10, TC17, RT6, RT7, and RT17 are CSA rated as Class I, Division 1, Groups B, C, D; Class I, Zone 1, Groups IIB plus hydrogen, IIB; Class II, Division 1, Groups E, F, G; Zone 20; Class III; T6…T1; (explosion proof) assemblies that include a sensor probe, thermowell or fixed fitting probe, connection extension fittings, connection head enclosure, and a terminal block, wire splice connectors, DIN rail connectors or transmitter.
- The TC16, and RT16 are CSA rated as Class I, Division 1, Groups C, D; Class I, Zone 1, Group IIB; Class II, Division 1, Groups E, F, G; Zone 20; Class III; T6…T1; (explosion proof) assemblies that include a sensor probe, thermowell or fixed fitting probe, connection extension fittings, connection head enclosure, and a terminal block, wire splice connectors, DIN rail connectors or transmitter.
- The TC11, TC15, RT11, RT15, SM2, SM4, HT2, and HT3 are CSA rated as Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC (US only); T6…T1; (non-incendive) assemblies include a sensor probe with a fixed fitting probe with or without flex-armour cable, and a connection head enclosure. The assemblies also include either a terminal block, wire splice connectors, DIN rail connectors, or may be provided with a transmitter only when installed outside of the hazardous zone or as per the control drawing and with non-incendive field wiring. The assemblies may also be provided with optional connection extension fittings, and/or a thermowell.

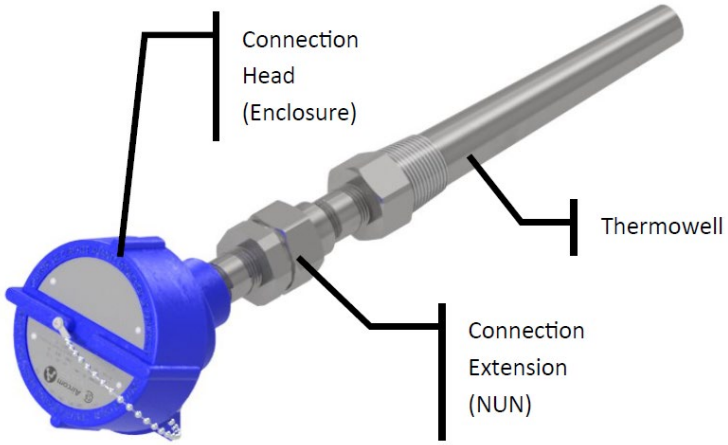

Figure 1: Components of a temperature sensor assembly with a thermowell.

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Figure 2: Temperature sensor assembly with a welded fixed fitting probe (Style F).

3.1.1.1 Quick Weblinks

- ***Overview of Products and Services***
  - ***RTD Sensor Probes and Assemblies***
  - ***Thermocouple Sensor Probes and Assemblies***
  - ***Thermowells and Protection Tubes***
- ***Aircom - Home***
  - ***About Aircom***
  - ***Innovation at Work***
  - ***News & Resources***
  - ***Contact Information***

3.2 Equipment Ratings

Temperature sensor assemblies' ratings shall be based on local jurisdictional requirements, regulation, bylaws, codes, and standards. The following ratings may vary depending on the installation location, and configuration of the assembly.

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Table 5: Temperature sensor assemblies supply, I/O connections, and operating environmental conditions.

Item	Description
Operation Conditions:	Continuous operation in extended environmental conditions
Electrical Rating:	30 Vdc, 1.0 A maximum
Enclosure Rating:	for indoor use, unless marked with an enclosure rating (*e.g.*, 4, 4X, none, *etc.*)
Maximum Altitude:	2,000 meters (6,561 feet)
Maximum Relative Humidity:	80% for temperatures up to +31°C (+87°F), decreasing linearly to 50% RH at +40°C (+104°F)
Equipment Class:	I
Overvoltage Category:	II
Pollution Degree:	2
Intended Supply:	Class 2, SELV (Safety Extra Low Voltage), or equivalent

Note: Temperature sensor assemblies are intended to be connected to control/monitoring systems, consult the specific equipment documents for the I/O requirements.

Table 6: Temperature code ratings based on ambient and process conditions limits.

*Minimum Connection Extension (Nipple) Length	Rated Ambient Temperature Range	Rated Process Temperature Range	**T-Code
None (Style F probe) / zero clearance nipple	-50°C to +50°C (-58°F to +122°F)	-50°C to +50°C (-58°F to +122°F)	T6 (+85°C) (+185°F)
Short (1-inch)	-50°C to +50°C (-58°F to +122°F)	-50°C to +200°C (-58°F to +392°F)	T4A (+120°C) (+248°F)
Long (3-inch)	-50°C to +50°C (-58°F to +122°F)	-50°C to +230°C (-58°F to +446°F)	T3C (+160°C) (+320°F)
Extra-Long (8-inch)	-50°C to +50°C (-58°F to +122°F)	-50°C to +450°C (-58°F to +842°F)	T2 (+300°C) (+572°F)

Note: Surface temperatures not exceeding 100°C (T5) may not be marked on products.
Pressure components may have different temperature ratings based on the design code or standard used.
**The minimum connection extension length is the minimum length not in contact with the process at its maximum temperature.*
**This also applies to the flex-armor extension, probe tubing/MI cable extension, or other styles of extensions (when adding an additional 1.5" to the nipple length to account for not having the thermowell hex fitting length).*
***The maximum surface temperature at the maximum rated ambient temperature and the maximum rated process temperature.*

Table 7: CSA maximum ambient working pressure.

Style	Maximum Working Pressure (Process Gauge-Pressure)
**Threaded Thermowell	Up to 48,260 kPa @ 20°C (7,000 psi @ 68°F)
*Flanged Thermowell	Up to 43,090 kPa @ 38°C (6,250 psi @ 100°F)
**Style F – Welded Probe	Up to 34,400 kPa @ 20°C (5,000 psi @ 68°F)
**Style G – Flex-Assembly Probe	Up to 34,400 kPa @ 20°C (5,000 psi @ 68°F)

*Notes: *Flanged Thermowell pressure ratings are based on their Class from ASME B16.5 (e.g.*, 150# to 2,500#).
**Pressure ratings may be limited depending on the fitting type, materials selected, and the design code or standard used.
The pressure values in this table are based on CSA and CRN rated values, for specific ratings contact Aircom *("*Contact Information and Technical Assistance*").*

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Table 8: Typical component material options.

*Component	Material Options	**Materials Assembly Temperature Ratings Ranges	Assembly Enclosure Ratings
Connection Head Enclosures	Aluminum	-50°C to +125°C (-58°F to +257°F)	Type 4
	Epoxy Coated Aluminum	-50°C to +85°C (-58°F to +185°F)	Type 4/4X
	Stainless Steel	-50°C to +125°C (-58°F to +257°F)	Type 4/4X
	Cast Iron	-25°C to +120°C (-13°F to +248°F)	Type 4
Extension Connections	Stainless Steel	-50°C to +450°C (-58°F to +842°F)	Type 4/4X
	Galvanized Steel	*-45°C to* +450°C (-49°F to +842°F)	None
Lead Wires	Teflon	*Up to +260°C* (Up to +500°F)	Not Applicable
	****Fiberglass	*Up to +450°C* (Up to +842°F)	Not Applicable
***Thermowells & Sensor Probes**	300 Series Stainless Steel	-50°C to +450°C (-58°F to +842°F)	Type 4
	302, 303, 304, 305, 309, & 316	-50°C to +450°C (-58°F to +842°F)	Type 4/4X
	310 Series	-48°C to +450°C (-54°F to +842°F)	Type 4
	400 Series Stainless Steel	-50°C to +450°C (-58°F to +842°F)	Type 4
	Duplex Stainless Steel	-50°C to +316°C (-58°F to +600°F)	Type 4
	Inconel	-50°C to +450°C (-58°F to +842°F)	None
	Incoloy	-50°C to +450°C (-58°F to +842°F)	None
	Monel	-50°C to +450°C (-58°F to +842°F)	None
	Hastelloy	-50°C to +450°C (-58°F to +842°F)	None
	Hastelloy B2	-50°C to +427°C (-58°F to +800°F)	None
	Hastelloy C-22	-50°C to +427°C (-58°F to +800°F)	None
	Nickel 200	-50°C to +316°C (-58°F to +600°F)	None

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*Component	Material Options	**Materials Assembly Temperature Ratings Ranges	Assembly Enclosure Ratings
***Thermowells & Sensor Probes	Alloy 20	-50°C to +427°C (-58°F to +800°F)	None
	Super Ferritic 446	*-8°C to* +371°C (-17°F to +699°F)	None
	Titanium TI2	-50°C to +316°C (-58°F to +600°F)	None
	5 Chrome, 9 Chrome	-29°C to +450°C (-20°F to +842°F)	Type 4
	Aluminum	-50°C to +50°C (-58°F to +122°F)	Type 4
	Copper	-50°C to +50°C (-58°F to +122°F)	Type 4
	Brass (80% Cu)	-50°C to +50°C (-58°F to +122°F)	None
	Carbon Steel	-45°C to +450°C (-49°F to +842°F)	None

*Note: *Additional material options are available upon request (e.g., aluminum, copper, brass, etc.), and for specific grades contact Aircom ("Contact Information and Technical Assistance").*

***These temperature ratings may be lower than the range stated depending on the component selected, contact Aircom to confirm the rating ("Contact Information and Technical Assistance").*

***Temperature ratings of individual components may vary (be higher or lower) depending on the materials selected, and the design code or standard used. Sensor probe tips can be manufactured with a copper tip (tip sensitive).

****Fiberglass lead wires are rated up to +510°C.

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3.3 CSA Canada and US Certifications

Consult Aircom to confirm the exact certification based on the configuration selected.

Table 9: CSA certifications.

Item	Description
Master Contract:	163846
Certificate:	1526478
Hazardous Location Designations:	*Class I, Division 1, Groups A, B, C, D; Class II, Division 1, Groups E, F, G; Class III; T6…T1 Class I, Zone 1, Groups IIC, IIB plus hydrogen, IIB, Zone 20 *Class I, Division 1, Groups B, C, D; Class II, Division 1, Groups E, F, G; Class III; T6…T1 Class I, Zone 1, Groups IIB plus hydrogen, IIB, Zone 20 *Class I, Division 1, Groups C, D; Class II, Division 1, Groups E, F, G; Class III; T6…T1 Class I, Zone 1, Groups IIB, Zone 20 **Class I, Division 2, Groups A, B, C, D; T6…T1, (NI) Class I, Zone 2, Group IIC, (US only)

*Notes: *Canada only when SNUN, or STXUN is selected (for stainless steel unions).*
***Non-Incendive when installed per control drawing and using non-incendive field wiring.*

4 Personnel Qualifications

The installation, pre-commissioning, commissioning, operation, and maintenance of temperature sensor assemblies should only be done by qualified and authorized personnel. These personnel (installers, technician, operators, users, *etc.*) must follow local jurisdictional and plant specific requirements, specifications, acts, regulations, codes, standards, bylaws, approval processes, and safe practices. The personnel must review and understand all relevant specifications, datasheets, manuals, instructions, drawings, and other pertinent documentation before acting, including the information in this document. These documents may include but is not limited to installation details, functional testing requirements, repairs, replacement, operation, maintenance, and troubleshooting for pressure retaining and electrical devices as required for the specific industry, country, and region where being used.

5 Shipping, Handling, Storage, and Disposal

Aircom temperature sensor assembly consider applicable regulation as specified in any provided procurement documents from the end-user/purchaser and is built and verified to be fully functional and free of defects before leaving the factory. Verify that the temperature sensor assembly has not been damaged from shipping, handling, or storage before installing. Ensure the assembly is complete and has no missing components.

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Ensure that any prolonged storage is done in a protected, dry, and warm indoors location. For components that are prone to rusting (*e.g.*, uncoated carbon steel, *etc.*) ensure measures are taken to prevent excessive corrosion.

Temperature sensor assemblies are intended to be replaced at the end of their useful life. When disposing of the device, ensure local regulations and good practices are followed.

6 Installation

NOTICE:

- Thermowells conforming to ASME PTC 19.3 TW are limited to an insertion length from 63.5 mm to 609.6 mm (2.5” to 24”). Going outside of this range does not conform to the standard and requires a custom engineered solution.

6.1 Preparations

Review all relevant plant schematics, drawings (including control drawings), and documents to understand how the temperature sensor assembly integrates with the facility’s systems. Review all applicable acts, regulations, codes, standards, bylaws, and jurisdictional requirements (*e.g.*, local electrical codes, CEC, NEC, *etc.*).

Verify the temperature sensor assembly ratings are appropriate for the installation location (minimum/maximum ambient temperature, minimum/maximum process temperature and pressure, area classification, materials compatibility, *etc.*).

If equipped with, test the spring range of the spring-loaded temperature sensor assembly, typically it has a range of 12 mm (½”).

Locate the process connection (port) where the temperature sensor assembly will be mounted.

⚠ DANGER:

- Ensure the process connection nozzle is isolated from all hazardous sources before installing the thermowell.
- Ensure all ⚡ electrical sources are isolated from all hazardous atmospheres before installing the temperature sensor assembly.
- Hazardous areas/locations may have 🔥 flammable/ignitable, or 💥 explosive materials present (*e.g.*, gases, vapours, dust, fibres, *etc.*).

⚠ WARNING:

- Do not exceed the temperature/pressure ratings of the process connection fitting (*e.g.,* thermowell, fixed fitting probe, *etc.*).
- Do not exceed the rated temperatures of the temperature sensor assembly components.

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⚠ CAUTION:

• Keep covers closed and sealed when there is a hazardous atmosphere.
• For Class I, Division 1, and Class II, Division 1 rated devices:
  ○ Open circuit before removing cover.
  ○ Keep covers tight while circuits are alive.

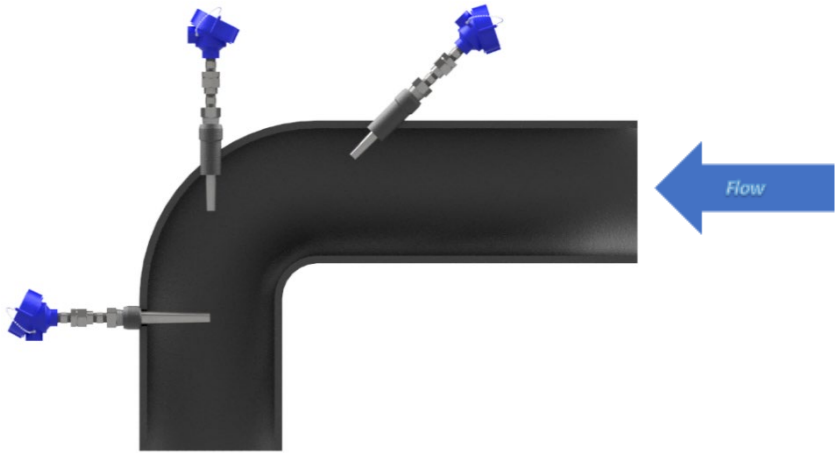

Figure 3: Acceptable thermowell orientations per ASME PTC 19.3 TW.

Before installing the temperature sensor assembly, isolate the installation location from any hazardous conditions including but not limited to process conditions and mediums (process fluids, dust, flyings, bulk solids, materials, pressure, temperature, *etc.*), and disconnect and isolate from electrical power.

6.2 Installation

Temperature sensor assemblies are installed by mounting the thermowell to the process connection nozzle (*e.g.*, to piping, pressure vessels, furnaces, autoclaves, *etc.*), and then connecting the wiring inside the connection head enclosure, with appropriate methods for the hazardous area location rating. Thermowells can be mounted in various ways including threaded, flanged, socket-welded, direct welded, and others.

Install the device before the process and equipment are filled with the process medium and put into operation.

When thermowell materials do not match each-other, or the process connection it can cause bi-metallic/galvanic corrosion to occur, ensure this factor is taken into consideration when selecting materials.

Insulation may be required for various reasons including but not limited to personnel safety, system performance/efficiency, and measurement accuracy. Insulation can affect the performance of the sensor assembly by isolating the externally exposed components from atmospheric conditions that may factor into the thermal equilibrium and transient thermal effects of the installation.

For Class I, Division 1 Rated Devices a seal shall be installed within 50 mm (2 in) of the connection head enclosure.

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6.2.1 Installation of Threaded Process Connections

⚠ WARNING:

- Do not over tighten the threads on the assembly.
- Do not use if any threads are damaged or striped.
- Do not install without the required seal (*e.g.*, PTFE tape, seal weld, *etc.*).

⚠ CAUTION:

- Using dissimilar metals for the thermowell and the process connection nozzle may lead to various issues including but not limited to corrosion issues (*e.g.*, galvanic corrosion, *etc.*), differential thermal expansion issues, and potential damage to the weaker thread when installing/removing the thermowell.

NOTICE:

- There are many types of threads that may be used, ensure the thermowell thread type matches the process connection nozzle thread type (*e.g.*, NPT/NPTF, BSP/BSPP, BSPT, UN/UNF, straight, metric (tapered, parallel), *etc.*) and that the correct type is being used for the application.
    - Aircom standard thread is NPT (per ASME B1.20.1).
- If the materials of the thermowell threads is different from the process connection nozzle threads, then the rating of the assembled parts will need to be verified and the weaker material may reduce the combinations pressure rating.
- Seal welded threads do not use thread sealants (*e.g.*, no PTFE tape, *etc.*)

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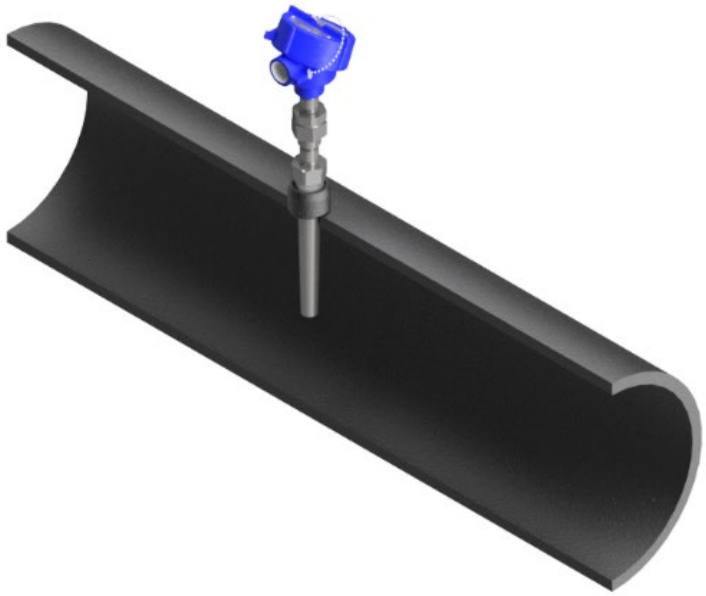

Figure 4: Threaded temperature sensor assembly.

Ensure the following items are checked/verified:

- The thermowell thread size matches the process connection thread size (*e.g.*, ½" NPT, ¾" NPT, *etc.*).
- Any combination of dissimilar materials/metals meets the systems ratings.
- Install the thermowell into the process connection nozzle with the following steps:

Installation Steps:

1. If applicable, apply the specified thread sealant (*e.g.*, PTFE tape, *etc.*).
2. Thread the thermowell into the process connection nozzle hand-tight first.
3. Tighten the threads to the specified torque using appropriate tools (*e.g.*, a torque wrench, *etc.*).
4. If applicable, seal weld the thermowell using the specified weld procedures.

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6.2.2 Installation of Flanged Process Connections

NOTICE:

- There are many types of gaskets used with flanges, ensure the correct gasket is selected for the specific application the flange is being used in.
- Ensure the correct flange bolt orientation is selected if there are any features of the assembly that require a specific orientation (*e.g.*, Aircom standard and the most common is straddled/two-hole, and an alternate option is one-hole).
- A re-torque of the nuts/bolts at the operating temperature may be required, confirm this ahead of time (bolt stretch is affected by the torque applied to the bolt/nut).
- There are multiple types of flanges (*e.g.*, blind, high-hub, lap-joint/Van Stone, *etc.*), ensure the correct type is being used for the application.
- For more information on bolted flange joint assemblies refer to ASME PCC-1.

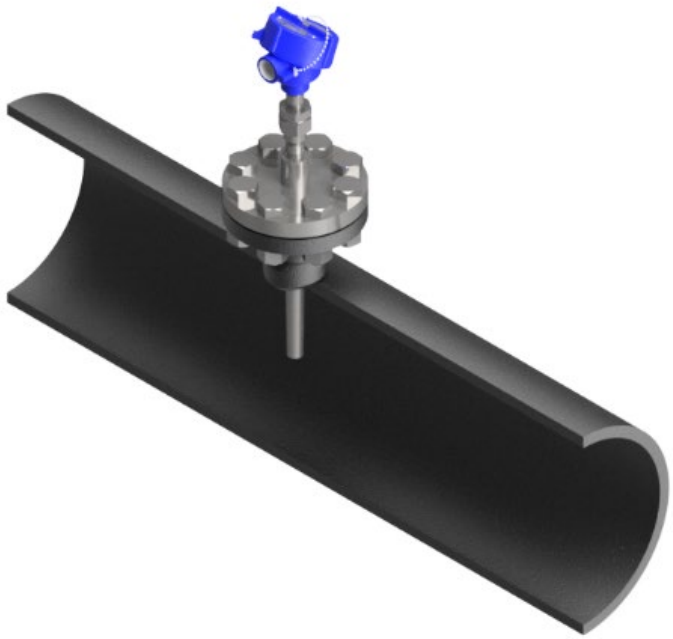

Figure 5: Flanged temperature sensor assembly.

Installation Steps:

1. Place the specified gasket on the flanged nozzle with the holes lined up.
2. Insert the thermowell into the flanged nozzle with the holes lined up, being careful not to damage the gasket and ensuring the gasket alignment is maintained for a good seal.
3. Insert the bolts into the holes and apply the mounting hardware hand tight (*e.g.*, washers, nuts, *etc.*) as specified.
4. Tighten the nuts/bolts to the specified torque and in the specified order to provide a good seal and ensuring proper bolt stretch (the pattern of tightening affects the sealing of the gasket).

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6.2.3 Installation of Welded Process Connections

NOTICE:

- There are multiple types of welded thermowells (*e.g.*, direct welded, socket welded, *etc.*), ensure the correct type is being used for the application.

⚠ WARNING:

- Ensure only qualified welders following qualified welding procedures install the thermowell into the process connection.
- For socket weld fittings ensure the correct size weld gap (clearance) is used between the thermowell and the process connection fitting (*e.g.*, from ASME B16.11 1.5 mm (0.06”), *etc.*).

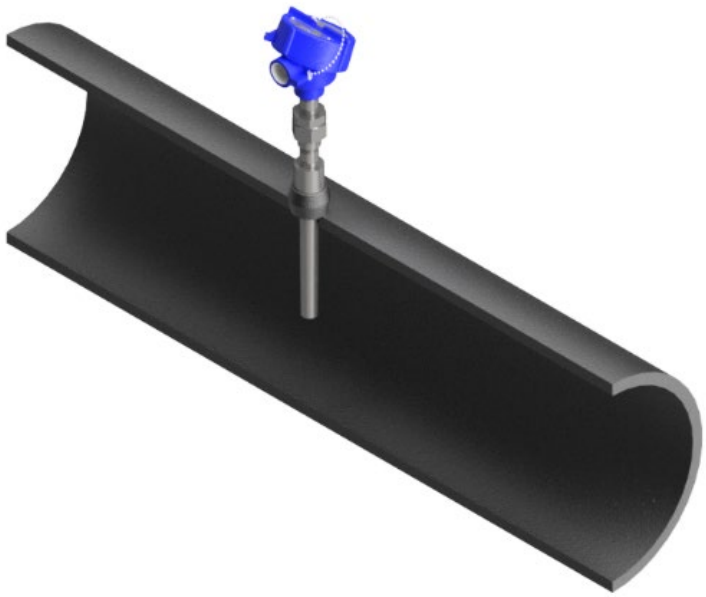

Figure 6: Welded temperature sensor assembly.

Installation Steps:

1. Line-up and note the desired orientation of the assembly before welding.
2. Remove the thermowell from the temperature sensor assembly.
3. Re-line-up the thermowell in the process connection according to the type of fitting connection (*e.g.*, weld gap for socket welds, *etc.*).
4. Weld the thermowell in place using the specified weld procedures, ensuring a clearance for socket fittings.
5. Allow the thermowell to cool before re-attaching the rest of the temperature sensor assembly.
6. Re-insert the rest of the temperature sensor assembly into the thermowell, ensuring good contact of the tip of the sensor with the inside tip of the thermowell (*e.g.*, spring compressed for a spring-loaded assembly, *etc.*).

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6.2.4 Installation of Temperature Sensor Assembly Without a Thermowell

NOTICE:

- Temperature sensor assemblies may be provided as spring-loaded, or fixed construction, ensure the correct type is selected for the application.

⚠ WARNING:

- There are many types of threads that may be used, ensure the thermowell instrumentation thread type or process connection nozzle thread type matches the connection extension thread type (*e.g.*, NPT/NPTF, BSP/BSPP, BSPT, UN/UNF, straight, metric (tapered, parallel), *etc.*) and that the correct type is being used for the application.

Temperature sensor assemblies may be provided without a thermowell as Style F with a fixed fitting probe, Style G flexible assembly probe, or as a replacement kit without a thermowell to be installed into an existing approved thermowell in the field.

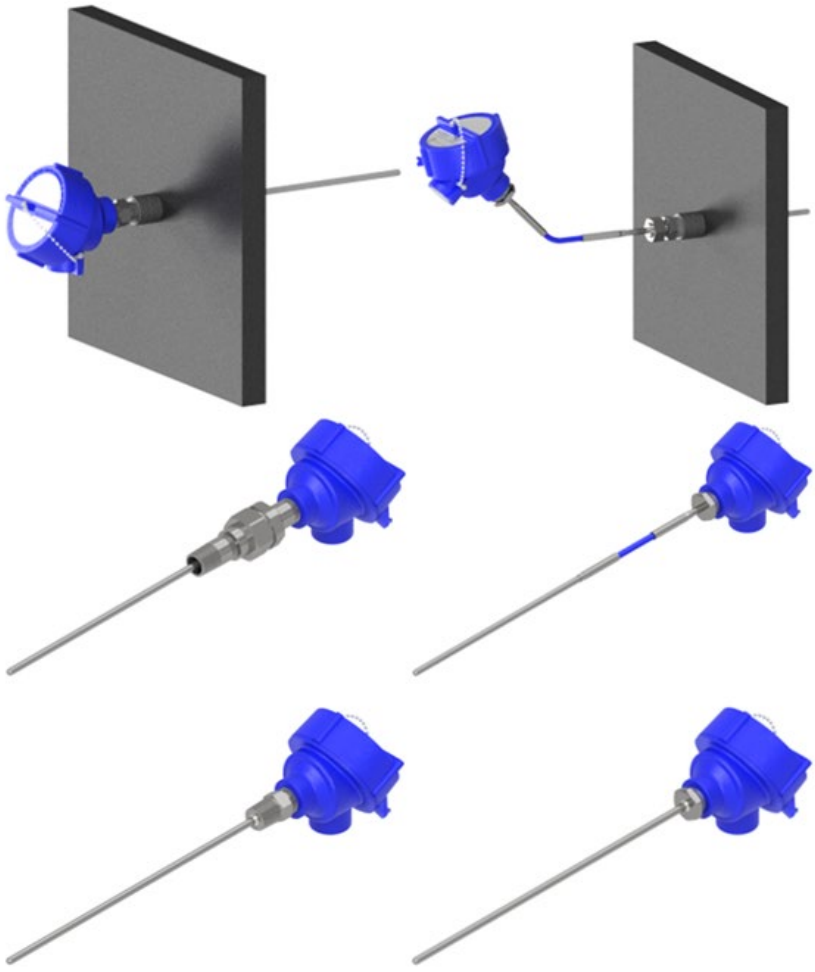

Figure 7: Temperature sensor assemblies without thermowells.

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Installation Steps:

1. If applicable, apply the specified thread sealant (*e.g.*, PTFE tape, *etc.*).
2. As applicable, thread the connection extension into the thermowell instrumentation connection hand-tight first, thread the fixed fitting probe, Style F, into process connection nozzle hand-tight first, or insert the flexible assembly probe, Style G, into the process connection (*e.g.*, if a compression fitting line up fitting with the correct location on the probe tubing and tighten the threads on the fitting hand-tight first, *etc.*).
3. Tighten the threads to the specified torque using appropriate tools (*e.g.*, a torque wrench, number of turns, *etc.*).
4. If applicable, install any cable clamps as specified.
5. If applicable, install additional components as specified (*e.g.,* adding insulation, *etc.*).

6.2.5 Surface Mounts

Aircom has various surface mount options and creates custom surface mount sensors for application specific installations. Some of these options include weld pads (curved or flat), surface pads (curved or flat), washer/bolt-on, heat trace, magnet, pipe shoe riser, and pipe saddle riser.

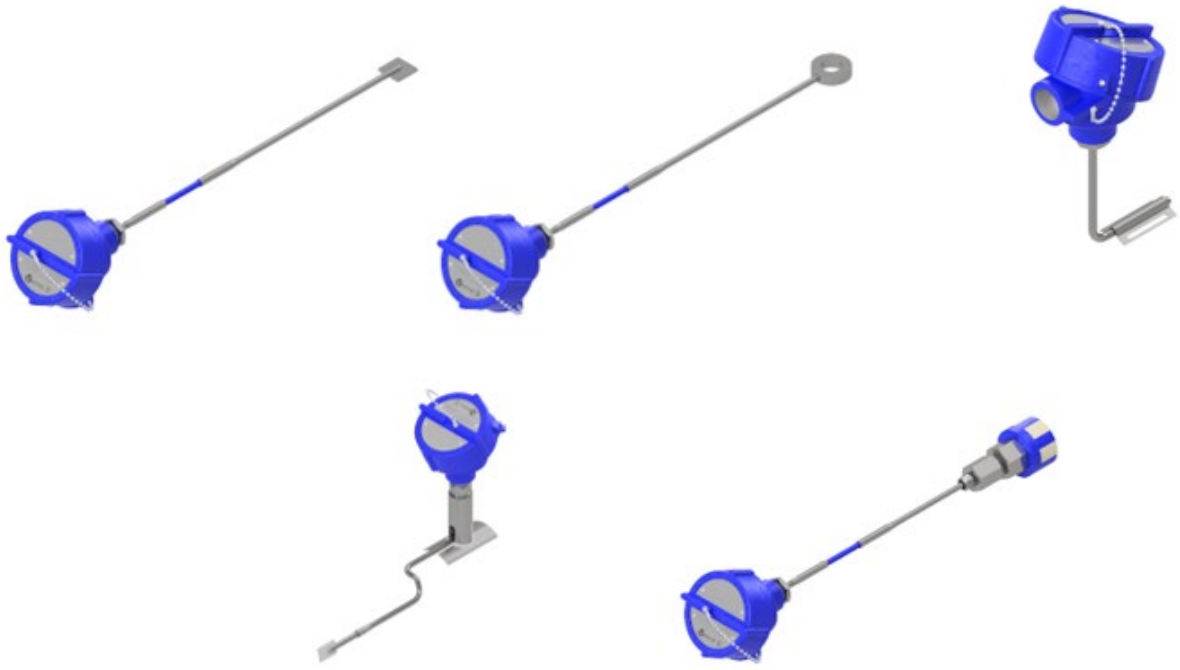

Figure 8: Typical surface mount styles.

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Heat Trace/Clamp-On (HT2/HT3)

NOTICE:
• Heat Trace/Clamp-On assemblies are provided with a slotted bracket for strapping the sensor to the surface. For other configurations consult the Aircom factory ("***Contact Information and Technical Assistance***"). • Cable clamps are good practice when securing MI cable, or flex-armor cable during installation.

Figure 9: Heat trace assembly.

Installation Steps:

1. Line-up and note the desired orientation of the assembly on the surface before securing it in place.
2. Clean and prepare the surface before securing the assembly in place.
3. Re-line-up the assembly on the surface.
4. Secure the assembly in place as specified, ensuring any necessary clearances (*e.g.,* using band clamps, *etc.*).
5. If applicable, install any cable clamps as specified.
6. If applicable, install additional components as specified (*e.g.,* adding insulation, *etc.*).

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6.2.5.1 Pipe Shoe Riser (SM2)

NOTICE:
• Pipe Shoe Riser assemblies may be provided as flat or curved to match your surface. For other configurations consult the Aircom factory ("***Contact Information and Technical Assistance***"). • Standard spring-loaded Pipe Saddle Risers (SM1) are not hazardous location approved; custom designs can be provided with hazardous location approval.

Figure 10: Pipe shoe riser assembly.

Installation Steps:

1. Clean and prepare the surface before securing the assembly in place.
2. Line-up and note the desired orientation of the assembly on the surface before securing it in place.
3. Secure the assembly in place as specified, ensuring any necessary clearances (e.g., using band clamps, *etc.*).
4. If applicable, install any brackets, or cable clamps as specified.
5. If applicable, install additional components as specified (e.g., adding insulation, *etc.*).

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6.2.5.2 Surface Pad (SM3/SM4)

NOTICE:
• Surface pads may be provided as flat or curved to match your surface. For other configurations consult the Aircom factory ("***Contact Information and Technical Assistance***"). • Surface Pads (SM3) are not hazardous location approved when provided without a connection head enclosure.

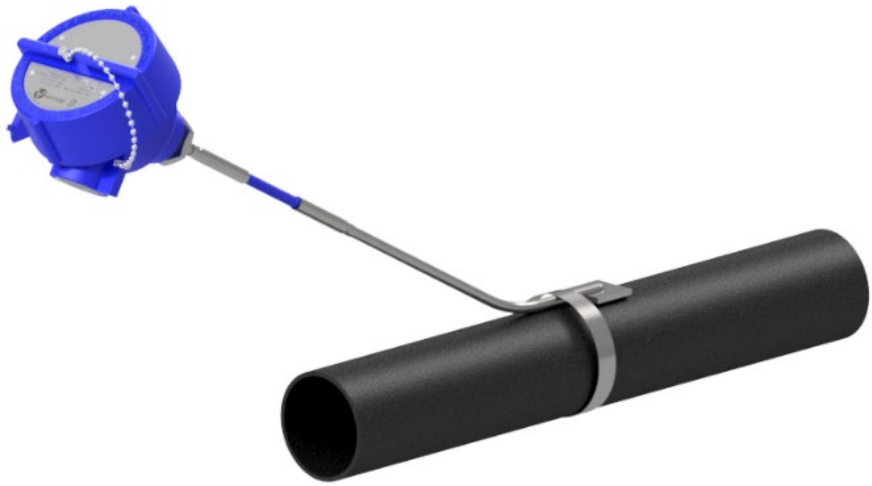

Figure 11: Surface pad assembly.

Installation Steps:

1. Line-up and note the desired orientation of the assembly on the surface before securing it in place.
2. Clean and prepare the surface before securing the surface pad in place.
3. Re-line-up the surface pad on the surface.
4. Secure the pad in place as specified, ensuring any necessary clearances (*e.g.,* using band clamps, *etc.*).
5. If applicable, install any cable clamps as specified.
6. If applicable, install additional components as specified (*e.g.,* adding insulation, *etc.*).

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Weld Pad (WPT)

NOTICE:

- If too much heat input is used when welding on a weld pad it can cause distortion of the pad and/or the surface it is being welded to. Use good welding practices to minimize distortion (*e.g.,* alternating stitch welds, using small diameter weld rods, *etc.*).
- Weld pads may be provided as flat or curved to match your surface. For other configurations consult the Aircom factory ("***Contact Information and Technical Assistance***").
- Standard Weld Pad assemblies (WPT) are not hazardous location approved, custom designs can be provided with hazardous location approval (*e.g.,* when provided with a connection head enclosure, *etc.*).

⚠ WARNING:

- Ensure only qualified welders following qualified welding procedures install the weld pad onto the surface.

Figure 12: Weld pad assembly.

Installation Steps:

1. Line-up and note the desired orientation of the assembly on the surface before welding.
2. Clean and prepare the surface before starting to weld.
3. Re-line-up the weld pad on the surface.
4. Weld the pad in place using the specified weld procedures, ensuring any necessary clearances.
5. If applicable, weld on any cable clamps using the specified weld procedures.
6. Allow time for the weld pad to cool before performing any additional work on the weld pad (*e.g.,* adding a shroud, insulating, *etc.*).

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6.2.5.3 Magnet (MG1, MG2, & MG3)

NOTICE:

- Magnet assemblies are typically provided with 22 kg, 34 kg, or 68 kg (50 lb, 75 lb, or 150 lb) pull force (hanging weight). For other configurations consult the Aircom factory ("***Contact Information and Technical Assistance***").
- Standard Magnet assemblies (MG1, MG2, and MG3) are not hazardous location approved, custom designs can be provided with hazardous location approval (*e.g.,* when provided with a connection head enclosure, *etc.*).

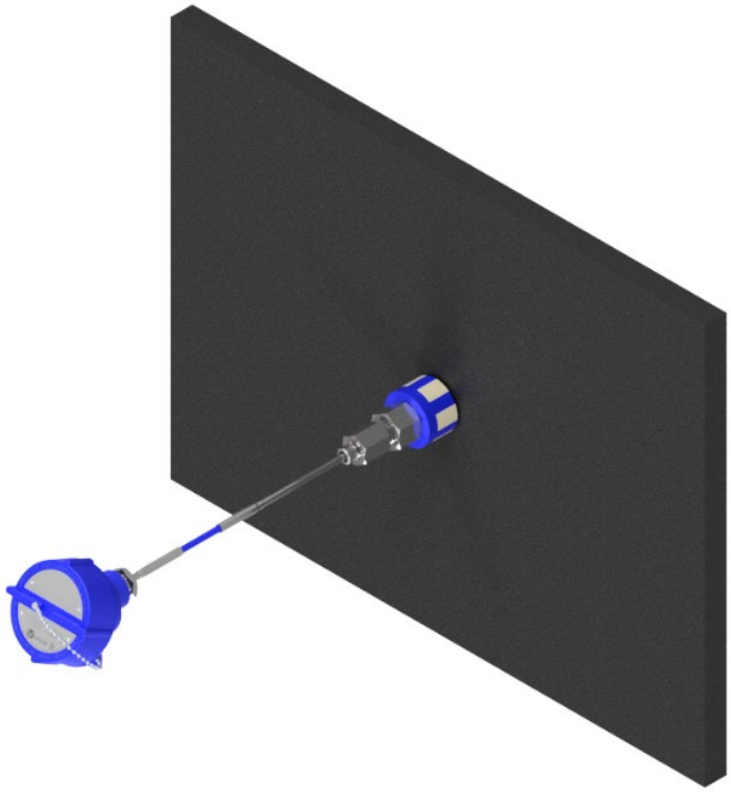

Figure 13: Magnet assembly.

Installation Steps:

1. Clean and prepare the surface before placing the assembly in place.
2. Line-up, note, and place the assembly in the desired location and orientation on the surface.
3. If applicable, install any brackets, or cable clamps as specified.
4. If applicable, install additional components as specified (*e.g.,* adding insulation, *etc.*).

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6.2.5.4 Washer/Bolt-On

NOTICE:
• Washer/Bolt-On assemblies may be provided as flat or curved to match your surface. For other configurations consult the Aircom factory ("***Contact Information and Technical Assistance***"). • Standard Washer/Bolt-On assemblies are not hazardous location approved, custom designs can be provided with hazardous location approval (*e.g.,* when provided with a connection head enclosure, *etc.*).

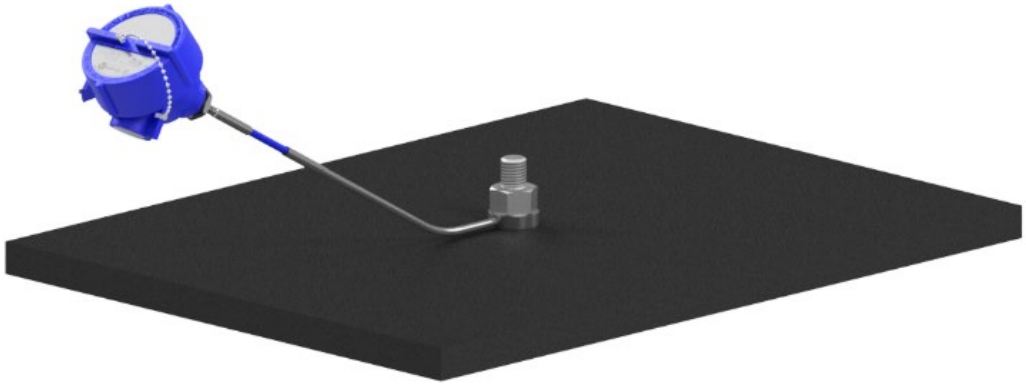

Figure 14: Washer assembly.

Installation Steps:

1. Line-up and note the desired orientation of the assembly on the surface before securing it in place.
2. Clean and prepare the surface before securing the assembly in place.
3. Re-line-up the assembly on the surface.
4. If applicable, apply the specified thread-lock to the threads (*e.g.*, Loctite, *etc.*).
5. Install the fastener assembly hand-tight first (*e.g.,* washer and bolt, *etc.*).
6. Tighten the threads to the specified torque using appropriate tools (*e.g.*, a torque wrench, *etc.*).
7. If applicable, install any cable clamps as specified.
8. If applicable, install additional components as specified (*e.g.,* adding insulation, *etc.*).

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6.2.6 Installation of Wiring (Cable, Conduit, and Connections)

⚠ DANGER:

- For hazardous locations threaded connections will require a specific number of threads to be engaged (typically at least five (5) full threads), ensure that all specified threads are engaged when installing.
- Risk of ⚡ electric shock.
- Risk of 🔥 fire and/or 💥 explosion.
- For Non-Incendive Class I, Division 2 rated devices:
  - Follow the control drawings for the specific transmitter module and use Non-Incendive field wiring.
  - Refer to the specific transmitter module documents for calculating the allowed capacitance and inductance values for the NI field wiring circuit, the hazardous/classified locations in which the apparatus may be located, and the permissible connections to simple apparatus.

NOTICE:

- If the connection head enclosure needs to line up with rigid conduit (instead of flexible cable/conduit) consider using a union fitting to be able to adjust the orientation of the connection head enclosure conduit connection.
- If the assembly is provided with a transmitter, then review the transmitter documentation before installation and follow the installation instruction for the application as required. Documents may include but are not limited to the catalogue, datasheet, IOM manual, quick/installation instructions, specifications, drawings, control drawings, wiring diagrams, hazardous location drawings, *etc.*
- The sensor wires should already be securely connected to the terminals inside the connection head enclosure.
- For RTD extension wires the number of leads in the connection head enclosure shall be matched by the same quantity from the extension wire(s) (RTD extension wire can be copper wire).
- Thermocouple extension wire shall be the same type/calibration as the thermocouple, match the number of leads in the connection head with the quantity from the extension wire(s).
- Temperature transmitters typically require two (2) wires to connect, see the temperature transmitter documentation before connecting (transmitter extension wire can be copper wire).
- It is common for the wire outer insulation jacket to be striped 38 mm to 50 mm (1.5” to 2.0”), and the individual conductors to be striped 6 mm (0.25”) for installation into the wire terminals/connectors.
- Take care not to cut, excessively bend, or damage the conductor wires when striping and handling them. This can lead to stress concentration points that can lead to breakage and interruption of the temperature communication signal during operation.
- The connection of a grounding wire to the grounding location (*e.g.*, screw, lugs, *etc.*) may be required by the local jurisdiction, codes, or specifications.

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Installation Steps:

1. If applicable, loosen the connection extension union fitting to line up the connection head conduit connection with the conduit fitting, then tighten the union fitting to lock it into place and maintain alignment.
2. When safe to do so, open the connection head enclosure cap.
3. Connect the flexible cable/conduit/wiring fitting to the specified connection head enclosure nozzle/port using the required torque.
4. Run/pull the specified extension-wiring (*e.g.*, copper, RTD, or thermocouple) through the flex-cable/conduit into the connection head enclosure.
5. Connect the extension wire to the correct terminals, see the applicable wiring diagram(s) (RTD, or thermocouple) and any drawing(s) for the applicable connection type (*e.g.*, terminal block, wire connectors, temperature transmitter, *etc.*).
6. If applicable, connect the ground wire (typically to the green ground screw) to the connection head enclosure grounding screw.
7. If applicable, apply seals to the connecting conduit, cable, or wiring (*e.g.,* Class I, Division 1 conduit within 50 mm (2")).
8. Clean the inside of the connection head enclosure, ensuring that there is no moisture, dust, fibres, or other contaminants inside of the connection head enclosure.
9. Close the connection head enclosure cap securely.

6.2.6.1 RTD Wiring Diagrams

The following RTD wiring diagrams are some of the typical configuration Aircom provides. If you require other configurations, please contact Aircom ("***Contact Information and Technical Assistance***").

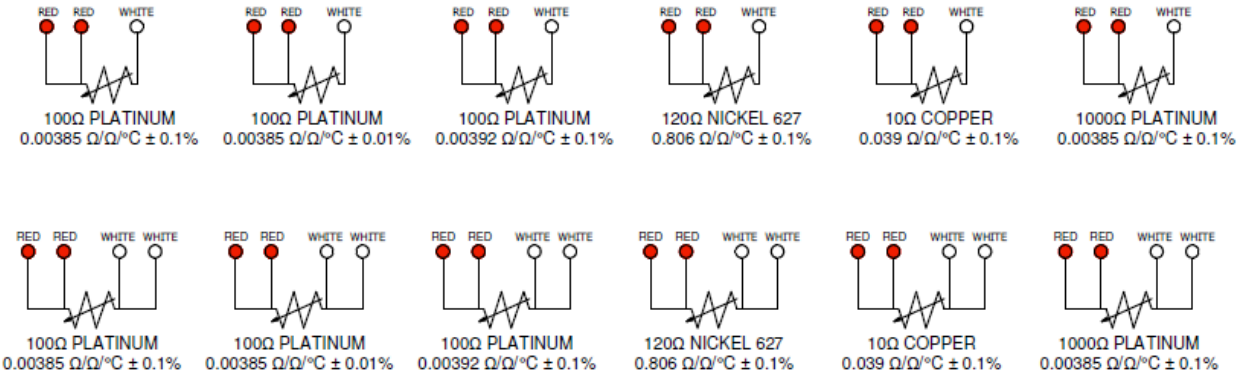

Figure 15: RTD wiring diagrams.

6.2.6.2 Thermocouple Wiring Diagram

The following thermocouple wiring diagrams are some of the typical configuration Aircom provides. If you require other configurations, please contact Aircom ("***Contact Information and Technical Assistance***").

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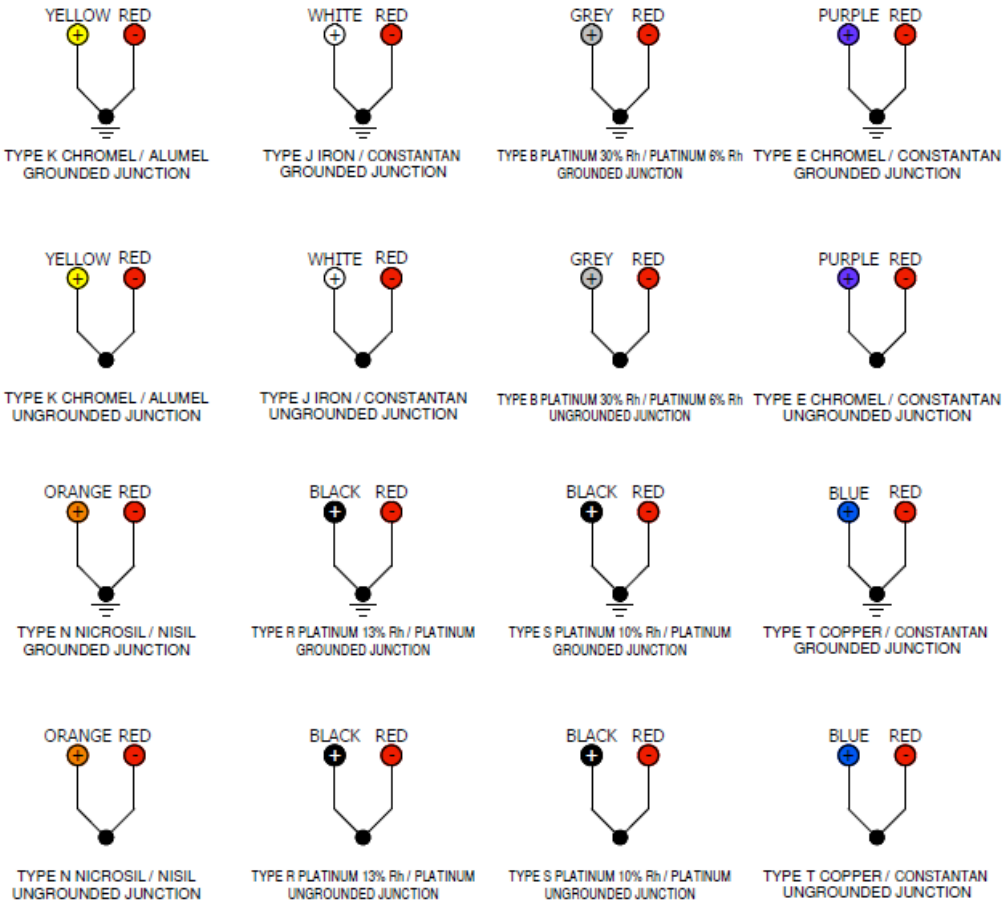

Figure 16: Thermocouple wiring diagrams.

6.3 Pre-Commissioning

NOTICE:
• A hydro-test can be requested from the factory before the assembly is shipped to site.

Before applying power, pressure, temperature, or any other process conditions, verify that the process and instrument connections are securely fastened and sealed as required. Verify all wiring is connected to the correct location and all conduit is installed according to local code requirements for the appropriate area classification. If applicable, leak test the pressure fitting(s) to ensure all seals are good.

6.4 Commissioning

When safe to do so, get qualified personnel to apply power to the temperature sensor assembly and verify the correct operation. Perform any performance checks and any necessary configuration, verification, and/or calibration.

6.5 Normal Operation

Once properly installed and powered the temperature sensor assembly will operate based on the controls/data collection system it is attached to. Normal operation should maintain the temperature

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sensor assembly within its operational limits of temperature, pressure, and power. The device shall be powered by Class 2, SELV, or an equivalent power source, and is Equipment Class I, Overvoltage Category II, and Pollution Degree 2.

6.6 Start-Up, and Shut Down

Gradually starting-up and shutting-down can limit stresses developed in system components. Gradual heating and cooling, and gradual pressurization and depressurization can extend the life of fittings exposed to elevated temperatures and pressures, respectively.

6.7 Emergency Shut Down

Temperature sensor assemblies may be connected to emergency shut down system. It is good practice to do a pre-test of the emergency shut-down system before starting normal operation.

6.8 Inspection, Maintenance, Cleaning, Replacement, and Re-Use

⚠ DANGER:

- Re-use of a thermowell in another service may cause contamination and/or an explosion (*e.g.*, moving an oil/hydrocarbon service thermowell to an oxidizing service (some cleaning methods may not be effective enough to eliminate the hazards), *etc.*).
- Re-use of a thermowell from one installation to a subsequent installation may lead to early failure from previous cycles of variable flow conditions (*e.g.*, pulsation, vibration, *etc.*) weakening the thermowell for other types of loading.
- Re-use of a thermowell that was installed in a corrosive environment may lead to early failure in the further installations.

Periodically verify/ inspect there is no damage to the temperature sensor assembly and flexible cable/conduit/wiring connected to it.

Periodically cleaning the temperature sensor assembly can improve performance of the device.

Good practice is to select materials resistant to chemical attacks, corrosion (*e.g.,* oxidization like “green rot”, sulphidization, *etc.*), and erosion. When corrosion and erosion can not be prevented it is good practice to monitor the wear components in the system.

Thermal cycling can lead to physical changes to the properties of the temperature sensor assembly including but not limited to physical property changes such as geometry/volume (*e.g.*, length, diameter, *etc.*), grain-structure, and phase-changes. Changes in the physical properties can affect the electrical properties of the sensor (*e.g.,* resistance, temperature coefficient of resistance, *etc.*).

The cycles of applied loads can affect the fatigue life of the thermowell, special design consideration should be taken for severe cyclic service. It is good practice on critical applications to monitor the number of cycles the system has experienced.

Various types of vibration can cause issues with temperature sensor assemblies including but not limited to system vibrations (*e.g.,* the piping system vibrating from fluid flow, *etc.*), fluid thermowell interaction vibrations (*e.g.,* vortex induced vibrations from vortex shedding, *etc.*), and parasitic vibration (*e.g.,* vibration of the sensor probe inside of the thermowell, *etc.*). Any chattering or unusual noise coming

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from the temperature sensor assembly is not normal and should be addressed promptly. It is good practice on critical applications to perform vibration monitoring of the system.

When a thermowell is in good condition the rest of the temperature sensor assembly may be replaced, or removed for calibration, verification, or other maintenance when safe to do so (*e.g.*, when the hazardous atmosphere around the sensor is eliminated, *etc.*).

The temperature sensor assembly is not intended to be repaired or re-used. If there are issues with the device that can not be verified in the field, send the device back to Aircom (as specified in the "***Contact Information and Technical Assistance***" section, and the "***Returns***" section).

6.8.1 Accessories and Spare Parts

⚠ WARNING:

- Aircom instrumentation temperature sensor assemblies are only certified for use in hazardous locations when they are installed in a hazardous location/area certified fitting (*e.g.,* an Aircom CSA approved thermowell, an Aircom CSA approved welded fixed fitting probe, an Aircom CSA approved welded fixed fitting with flex-armor probe, *etc.*).

Partial assemblies and field replacement kits are available to complete assemblies that use certified thermowells and interconnecting components in the field.

CSA approved hazardous location field replacement kits are either full assemblies, or partial assemblies each consisting of a connection head enclosure with or without probes, connection extension (interconnecting components), or thermowells/test-wells. The assemblies must be fully assembled at the Aircom factory, or in the field including the connection head enclosure, connection extension fittings and thermowell, or the connection head enclosure connected directly to the fixed fitting probe with optional connection extensions fittings.

6.9 Contact Information and Technical Assistance

For Technical Assistance contact Aircom Instrumentation Ltd. at:

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Fax: ***780-434-6911***
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Website: ***www.aircominstrumentation.com***

6.10 Troubleshooting

To troubleshoot issues with the temperature sensor assembly, use the following information and "***Table 10: Temperature sensor troubleshooting potential causes and solutions.***" that includes some of the common issues that may occur. If the issues are found when operating the device and they can not be verified in the field, send the device back to Aircom at the address in the "***Contact Information and Technical Assistance***" section and as per the *"**Returns**"* section and it will be inspected/examined to confirm the type and location of the issue(s) in order to be able to help understand what has caused the issue and how to prevent it in the future.

6.10.1 General

For most temperature sensor assemblies, the following items should be considered when troubleshooting:

- Exceeding the maximum design pressure.
- Going below the minimum design pressure (*e.g.,* vacuum pressure).
- Exceeding the maximum design temperature.
- Going below the minimum design temperature.
- Excessive temperature cycling, and large temperature gradients.
- Excessive vibration of the temperature sensor assembly.
- Noise, interference, grounding of the measurement signal (*e.g.,* radio-frequency interference (RFI), electromagnetic interference (EMI), static electricity, grounded in multiple locations, induction (high and low power wires close together), *etc.*).
- Corrosion of lead wires, connections, sheath, or sensor element/junction.
- Mechanical stress or thermal stress/strain of the sensor element/junction, or lead wire junction.
- For MI cable moisture contamination of the insulation can lead to short circuiting of the sensor probe.
- If you are getting an unexpected temperature reading it may be due to insertion depth into a developed flow in piping, ducting, or other flowing cross-sections. A general rule of thumb for getting an average temperature from a single point measurement, based on an average velocity, is a one-third, or two-thirds (1/3rd or 2/3rd) insertion. This can vary based on the layout of the piping and the medium being transported.
- There are several factors that contribute to temperature sensor drift including but not limited to oxidation, material/metallurgical changes, aging, interaction, and contamination.

6.10.1.1 RTDs

Additionally, specific to RTDs, the following items should be considered when troubleshooting:

- Large temperature gradient along wires, or between terminals of connection leads.
- Physical shock to the RTD element.
- Excessive lead wire resistance (*e.g.,* large length, small diameter, material selected, *etc.*).
- Changes in insulation resistance (*e.g.,* moisture ingress, *etc.*).
- Self heating of wires (*e.g.,* long wire lengths, *etc.*).
- Selection of wiring (*e.g.,* 2-wire, 3-wire, 4-wire, *etc.*).

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- Selection of element tolerance/accuracy (*e.g.,* class of element like Class A, Class B, Class 1/3 B, Class 1/10 B, *etc.*).

Thermocouples

Additionally, specific to thermocouples, the following items should be considered when troubleshooting:

- Ground loop errors of a grounded thermocouple junction.
- Reversed polarity of the thermocouple wires.
- Reference junctions/cold junction temperature not controlled or not compensated for.
- Selection of thermocouple wire type (*e.g.,* using special-limits wire (tolerance/accuracy), type K, type N, type E, type J, type R, type S, type B, type T, cryogenic (low-temperature), high-temperature, *etc.*).
- Selection of thermocouple junction type (*e.g.,* ungrounded tip, grounded tip, exposed tip, tip sensitive, *etc.*).

6.10.1.2 Possible Causes and Potential Solutions

The following includes some of the common issues that may occur. If you are unable to verify the issue(s), please contact Aircom ("***Contact Information and Technical Assistance***") with all relevant available details including the temperature sensor assembly configuration, serial number, and installation and operation details when the issues are present.

It is good practice to troubleshoot the whole temperature sensor system isolating each device/component individually going from the temperature sensor assembly (sensor probe, fittings, and connection head enclosure) to the transmitter, if applicable, to the wire/cable runs all the way back to the controls/monitoring systems. Isolating each device/component can help narrow down the potential causes and narrow in on the location of the root cause of the failure.

Table 10: Temperature sensor troubleshooting potential causes and solutions.

Identified Issue(s)	*Possible Cause(s)	*Potential Solution(s)
No response from device.	Incorrect supply voltage.	Apply the correct voltage.
	Break in cables or contacts (*e.g.*, broken/frayed cable, loose contact, *etc.*).	Check cables and contacts for continuity and proper connection and correct as necessary (*e.g.*, tighten contact, replace broken cables or contacts, *etc.*).
Current failure.	Electronic unit is damaged/faulty/defective.	Replace device(s).
	Damaged/faulty sensor.	
	Device is incorrectly programmed (*e.g.*, incorrect scale, *etc.*).	Fix programming (*e.g.*, change scale, *etc.*).

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Identified Issue(s)	*Possible Cause(s)	*Potential Solution(s)
Incorrect/inaccurate indication (measurement reading) value.	Installation is incorrect (*e.g.*, incorrect orientation, lack of insulation, poor contact, *etc.*).	Modify/correct installation (*e.g.*, change orientation, add insulation, fix/adjust contact with surface, add signal isolators for ground loop errors, *etc.*).
	Offset set incorrectly.	Change the offset.
	Device is incorrectly programmed (*e.g.*, incorrect scale, incorrect sensor type selected, *etc.*).	Change the programming (*e.g.*, change scale, select correct sensor type, *etc.*).
Temperature indication (measurement reading) too high.	RTD lead wire resistance too high or not compensated for.	If possible, modify the lead wires (*e.g.,* increase RTD lead wire gauge/size, reduce lead wire length, compensate for the lead wires, install a transmitter in the connection head enclosure, change to a 3-wire or a 4-wire circuit, *etc.*).
	Self heating due to measuring the current too high.	Change to a smaller measuring current (*e.g.,* 1 mA, *etc.*).
Temperature indication (measurement reading) changes with ambient temperature change.	A large temperature gradient/change of the lead wires in a 2-wire circuit.	Change to a compensating circuit (*e.g.,* 3-wire for ambient effects, 4-wire for lead wire resistance as well, *etc.*).
Temperature indication (measurement reading) too low (error increasing) with increasing temperature.	A decrease in insulation resistance changing the flow path of current.	Verify the correct insulation resistance was selected for the application or replace sensor probe if damaged/defective.
Indication (measurement reading) not matching the IEC / DIN EN 60751 table values.	Parasitic and/or galvanic electromagnetic interference. Terminal connection corrosion. Temperature gradient between terminal connections. Moisture, contamination, and/or lead wire material properties out of specifications range.	Inspect and clean up or replace installation of lead wires. Thermally isolate the connection head enclosure from the surrounding environment (*e.g.,* insulate the connection head enclosure, *etc.*).
Indication (measurement reading) drifting (changing over time) for a stable process.	Thermal aging/drifting of temperature sensor materials.	Regular recalibration and/or regular replacement. Investigate and implement alternate designs (*e.g.,* high-temperature designs, alternate materials, alternate sensor element types, *etc.*).

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Identified Issue(s)	*Possible Cause(s)	*Potential Solution(s)
Not reaching /matching expected temperature value(s).	Thermal equilibrium/balance of the temperature sensor assembly system installation. Response time of temperature sensor assembly does not match process fluctuations speed. Accuracy changing due to high temperature effects (*e.g.,* above 300°C the accuracy of a Class A RTD reduces, *etc.*).	Isolating the temperature sensor assembly from system conditions (*e.g.,* thermal insulation of exposed surface, heat tracing, *etc.*). Modify in the installation location (*e.g.,* change the insertion length, *etc.*). Changing the sensor element tip type (*e.g.,* tip sensitive, *etc.*)
Leaking Fitting/Flange.	Gasket or thread sealant not seated properly, or incorrect type of seal.	Replace the seal (*e.g.,* re-seat the gasket, re-apply the thread sealant, or change the seal type, *etc.*).
	Improperly threaded (*e.g.,* too loose, too tight, threads not matching, *etc.*).	Adjust the thread engagement or change the fitting/flange to match the process connection fitting/flange.
	Damaged components (*e.g.,* cracked component, corrosion, *etc.*).	Replace damaged components.
Vibration (noise, chatter) of temperature sensor assembly.	Sensor loose inside assembly.	Adjust the contact of the sensor inside the assembly (*e.g.,* adjust the spring-loaded fitting, *etc.*).
	Natural frequency of the temperature sensor assembly or the piping system reached.	Change the dampening of the sensor or the piping system (*e.g.,* adjust the dampening factors such as the mass, spring or acceleration of the assembly or system, *etc.*).

Notes: The temperature sensor assembly possible causes and potential solutions identified in this table are for consideration only and are not recommendations. Consult the responsible parties that designed, implemented, and fully understand the system the temperature sensor assemblies are installed in. Aircom is not responsible for any actions taken to remedy issues based on the information in this table. Reference ASME PTC 19.3 for additional temperature measurement assistance.

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6.11 Returns

⚠ CAUTION:
• If the device has been exposed to a hazardous environment it may have substances that have penetrated crevices, cracks, pores, or diffused into the device, ensure that the device is handled with care after service to avoid health issues.

Ensure the device is safe when returning it to Aircom by removing all hazards before shipping following site procedures and the following procedures. Ensure the device components are safely secured and protected from shipping damage as to not affect any investigations/examinations, or restocking (*e.g.*, provide padding and supports, using desiccants, *etc.*).

- Remove all hazardous to health materials from the components being shipped (*e.g.*, flammables, toxic mediums, caustic mediums, carcinogenic mediums, irritants, acids, explosive materials, reactive materials, *etc.*).
- If applicable, provide the MSDS for any materials, residues, or other substances that may still be present.
- Remove or protect any sharp edges or surfaces.

Do not return any devices or device components that are hazardous and cannot be made safe.

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7 Appendices

The following appendices include placeholders for useful project information and some helpful temperature sensor assembly information.

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7.1 Appendix I: Catalogue Information

If applicable, this is a placeholder for the temperature sensor assembly catalogue information.

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7.2 Appendix II: Datasheets

If applicable, this is a placeholder for the temperature sensor assembly datasheets used for the design and selection of the components.

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7.3 Appendix III: Drawings

If applicable, this is a placeholder for the temperature sensor assembly drawings.

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7.4 Appendix IV: Transmitter Documents

If applicable, this is a placeholder for the transmitter documents for the temperature sensor assembly.

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7.5 Appendix V: Certificates

If applicable, this is a placeholder for any certificates for the temperature sensor assembly.

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7.6 Appendix VI: Manufacturer's Record Book

If applicable, this is a place holder for an MRB (also know as a manufacturer's databook) for the construction and quality information for the temperature sensor assembly including but not limited to MTRs, travelers, traceability records, NDE records, coating records, PWHT records, certificates of compliance, and ITPs.

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7.7 Appendix VII: Quick Reference Information and Weblinks

The following information and links are provided to help with selection and application of temperature sensor assemblies. Visit www.aircominstrumentation.com if not accessing this document directly from a computer.

7.7.1 RTD Technical Information

The following material is general RTD information to assist and reference in the application of RTD's to your process requirements.

- **RTD Overview and Tolerance**
- **Resistance Table 100Ω Pt 385**
- **RTD Wiring Configuration**

7.7.2 Thermocouple Technical Information

The following material is general thermocouple information to assist and reference in the application of thermocouples to your process requirements.

- **Thermocouple Overview and Temperature Reference Chart**
- **Thermocouple Tolerance**
- **Thermocouple Junctions and Response Time**

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7.8 Area Classification Reference Information

The following information is general information applicable to temperature sensor assemblies that are used in hazardous locations.

Table 11: CSA temperature classification (T-Code) maximum surface temperatures.

Maximum Surface Temperature [°C]	Maximum Surface Temperature [°F]	Divisions T-Code	Zones T-Code
+450	+842	T1	T1
+300	+572	T2	T2
+280	+536	T2A	—
+260	+500	T2B	—
+230	+446	T2C	—
+215	+419	T2D	—
+200	+392	T3	T3
+180	+356	T3A	—
+165	+329	T3B	—
+160	+320	T3C	—
+135	+275	T4	T4
+120	+248	T4A	—
+100	+212	T5	T5
+85	+185	T6	T6

Note: The maximum surface temperature is not the same as the maximum process temperature.

Table 12: Aircom CSA division and zone equivalents.

Division	Equivalent Zone
Class I, Division 1, Group A	Class I, Zone 1, Group IIC
Class I, Division 1, Group B	Class I, Zone 1, Group IIB plus hydrogen
Class I, Division 1, Group C	Class I, Zone 1, Group IIB
Class II, Division 1	Zone 20
Class I, Division 2, Groups A	Class I, Zone 2, Group IIC (US only)

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