Honeywell

STT 3000 Series STT 800

STT 800 Temperature Probe Assemblies

STT 800 User Manual

34-TT-25-02
Revision: 1
May 2012

Honeywell Process Solutions

Notices and Trademarks

Honeywell Process Solutions

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About This Document

This document describes preparation, operation and maintenance of the STT800 Series temperature Probe Assemblies. Mounting, installation and wiring are covered in other documents.

Revision Information

Document Name	Document ID	Revision Number	Publication Date
STT 800 Temperature Probe Assemblies User Manual	34-TT-25-02	1	May 2012

References

The following list identifies all documents that may be sources of reference for material discussed in this publication.

Document Title	
STT 800 Specification	34-TT-03-08

Support and contact info

For Europe, Asia Pascific, North & South America contact details see back page for global contacts list.

World Wide Web

Honeywell Solution Support Online:

Honeywell Organization	WWW Address (URL)
Corporate	**www.honeywellprocess.com**
Honeywell Process Solutions	**www.honeywellprocess.com/temperature-transmitters-and-sensors**

Training Classes

Honeywell Automation College: http://www.automationcollege.com

Telephone & Email

Contact us by telephone at the numbers listed below.

Area	Organization	Phone Number	
United States and Canada	Honeywell Inc.	1-800-343-0228 1-800-423-9883	Customer service Global Technical Support
Global Email support:	Honeywell Process Solutions	**ask-ssc@honeywell.com**	

Symbol Definitions

The following table lists those symbols used in this document to denote certain conditions.

Symbol	Definition
	**ATTENTION:** Identifies information that requires special consideration.
	**TIP:** Identifies advice or hints for the user, often in terms of performing a task.
CAUTION	Indicates a situation which, if not avoided, may result in equipment or work (data) on the system being damaged or lost, or may result in the inability to properly operate the process.
	**CAUTION**: Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices. **CAUTION** symbol on the equipment refers the user to the product manual for additional information. The symbol appears next to required information in the manual.
	**WARNING**: Indicates a potentially hazardous situation, which, if not avoided, could result in serious injury or death. **WARNING** symbol on the equipment refers the user to the product manual for additional information. The symbol appears next to required information in the manual.
	**WARNING, Risk of electrical shock**: Potential shock hazard where HAZARDOUS LIVE voltages greater than 30 Vrms, 42.4 Vpeak, or 60 VDC may be accessible.
	**ESD HAZARD:** Danger of an electro-static discharge to which equipment may be sensitive. Observe precautions for handling electrostatic sensitive devices.
	**Protective Earth (PE) terminal**: Provided for connection of the protective earth (green or green/yellow) supply system conductor.
	**Functional earth terminal**: Used for non-safety purposes such as noise immunity improvement. NOTE: This connection shall be bonded to Protective Earth at the source of supply in accordance with national local electrical code requirements.
	**Earth Ground**: **Functional earth connection.** NOTE: This connection shall be bonded to Protective Earth at the source of supply in accordance with national and local electrical code requirements.
	**Chassis Ground**: Identifies a connection to the chassis or frame of the equipment shall be bonded to Protective Earth at the source of supply in accordance with national and local electrical code requirements.

continued

Symbol	Description
	The Factory Mutual® Approval mark means the equipment has been rigorously tested and certified to be reliable.
	The Canadian Standards mark means the equipment has been tested and meets applicable standards for safety and/or performance.
	The Ex mark means the equipment complies with the requirements of the European standards that are harmonised with the 94/9/EC Directive (ATEX Directive, named after the French "ATmosphere EXplosible").

Contents

Tables

Figures

1. Introduction

1.1 Purpose

This manual describes the Honeywell STT800 Series Temperature Probe Assemblies function, operation and maintenance.

1.2 Scope

The manual includes:

- Details of topics that relate uniquely to the Honeywell STT800 Series Temperature Probe Assemblies,

1.3 STT800 overview

Honeywell's STT 3000 family of microprocessor based smart temperature transmitters includes STT 170, STT250, STT350 and STT800 series of products.

While the STT 170, STT250 and STT350 are standalone temperature transmitters, STT800 series are integrated probe assemblies based on variety of temperature elements; thermowells; connection heads and terminal blocks for connection to remote mounted transmitters.

Choose the unit to meet your application needs:

- STT820: Rigid Probe assembly without thermowell
- STT830: Threaded and socket weld assembly with thermowell and extension
- STT840: Drilled Flanged assembly with thermowell and extension.

1.4 About the transmitter

The STT800 series integrated temperature probe assemblies cater to tough industrial applications and are available with variety of process connection options.

The integrated temperature probe assemblies are ready for installation when they are calibrated and shipped from the factory. They can be ordered with variety of RTD and Thermocouple elements and wells.

Ready to install temperature point resulting in lower engineering, procurement , installation and commissioning cost

- Choice of STT 3000 temperature transmitters with connection head, extension, sensor and thermowell are available with easy to order model number
- Custom calibration for transmitter and element
- Probe with transmitter calibration option
- Variety of communication protocols Analog, DE, HART, FF

2. Specifications

2.1 Specifications of Connection Heads

Connection Heads are part of the STT 800 integrated temperature probe assemblies meant for housing the sensor terminals and/or transmitters. STT 800 integrated temperature probe assemblies are available with both head mounted and field mounted housings.

Figure 2-1 Series STT820 Assembly - Typical

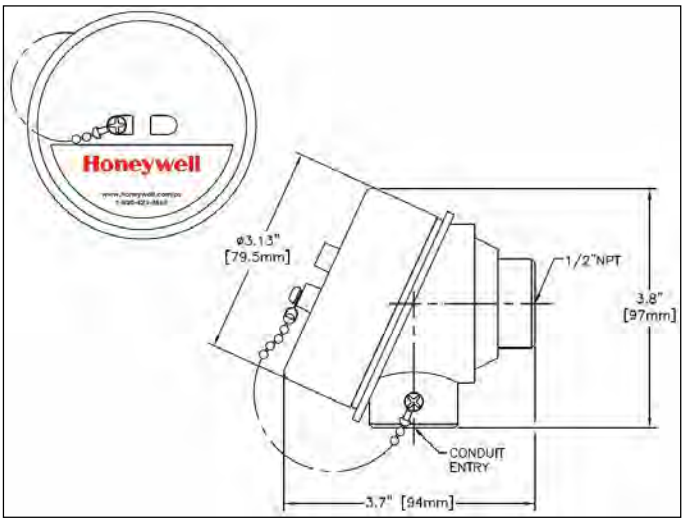
Figure 2-2 Series STT830 Assembly - Typical

Figure 2-3 Series STT840 Assembly - Typical

2.2 Housings

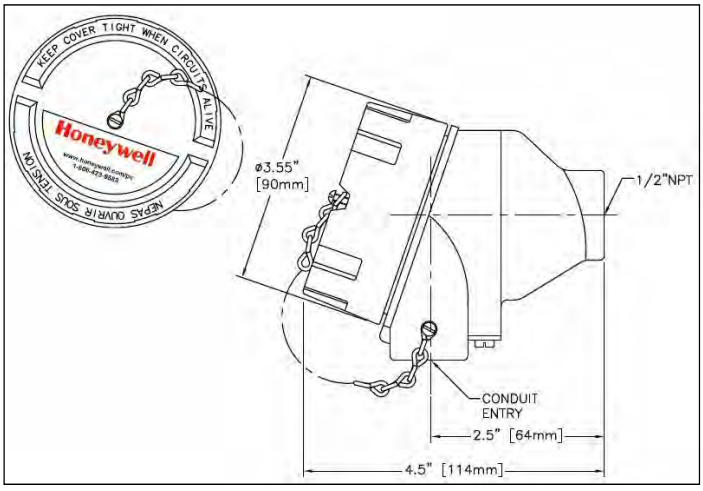
General Purpose Aluminum Housings:

- Dimensions according to DIN form **B**
- Protection grade: **IP66 (NEMA-4)**
- Max. temperature: **121˚ C (250˚ F)**
- Material: **aluminum**
- Conduit Entry: **½" NPT or ¾" NPT or M20 x 1.5**
- Thermowell Entry: **½" NPT**
- Body Color: **Gray**
- Cap Color: **Gray**
- Weight: **.8lbs (360g**)
- Captive Chain: **Stainless Steel Ball Type**



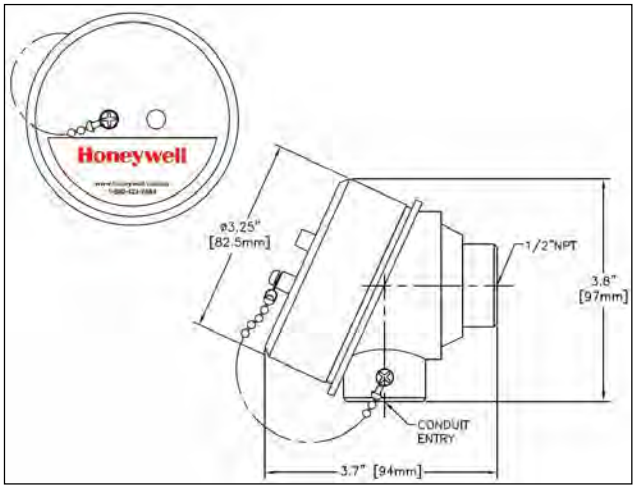
Explosion Proof Aluminum Housings:

- Dimensions according to DIN form **B**
- Protection grade: **IP66 (NEMA-4)**
- Class 1 Div 1, **Groups B, C & D**
- Class 2, Div. 1 **Groups E, F & G**
- Max. temperature: **121˚ C (250˚ F)**
- Material: **aluminum**
- Conduit Entry: **½" NPT, ¾" NPT or M20 x 1.5**
- Thermowell Entry: **½" NPT**
- Body Color: **Gray**
- Cap Color: **Gray**
- Weight: **.8lbs (360g)**
- Captive Chain: **Stainless Steel Link Type**



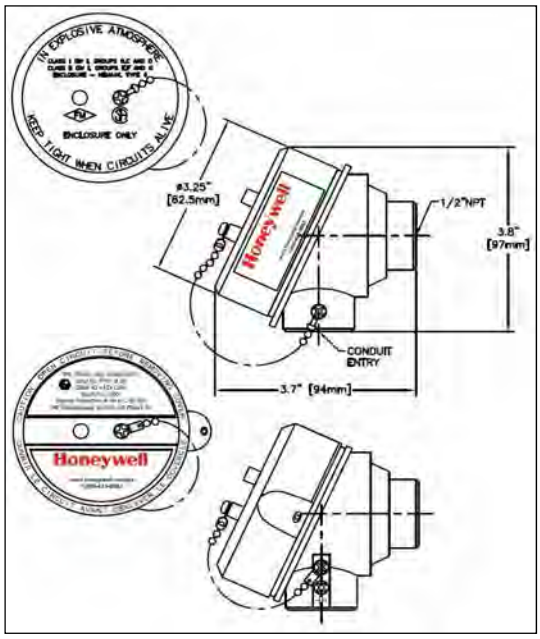
General Purpose Stainless Steel Housings:

- Dimensions according to DIN form **B**
- Protection grade: **IP66 (NEMA-4, -4X)**
- Max. temperature: **121˚ C (250˚F)**
- Material: **316 Stainless Steel**
- Conduit Entry: **½" NPT, ¾" NPT or M20 x 1.5**
- Thermowell Entry: **½" NPT**
- Body Finish: **Electro Polish**
- Cap Finish: **Electro Polish**
- Weight: **1.8Lbs (800g)**
- Captive Chain: **Stainless Steel Ball Type**



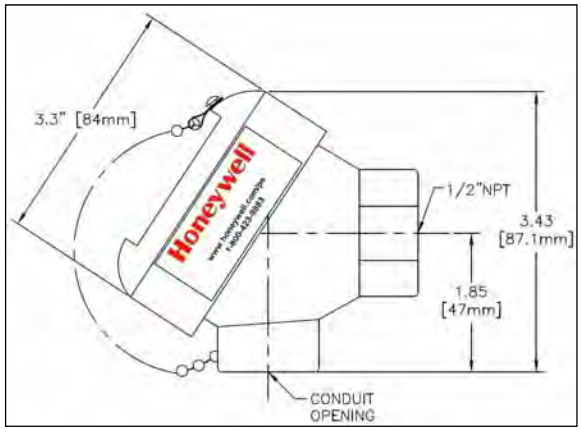
Explosion Proof Stainless Steel Housings:

- Dimensions according to DIN form **B**
- Protection grade: **IP66 (NEMA-4, -4X)**
- Class 1 Div 1, **Groups B, C & D**
- Class 2, Div. 1 **Groups E, F & G**
- Max. temperature: **121˚ C (250˚F)**
- Material: **316 Stainless Steel**
- Conduit Entry: **½" NPT, ¾" NPT or M20 x 1.5**
- Thermowell Entry: **½" NPT**
- Body Finish: **Electro Polish**
- Cap Finish: **Electro Polish**
- Weight: **1.8Lbs (800g)**
- Captive Chain: **Stainless Steel Ball Type**



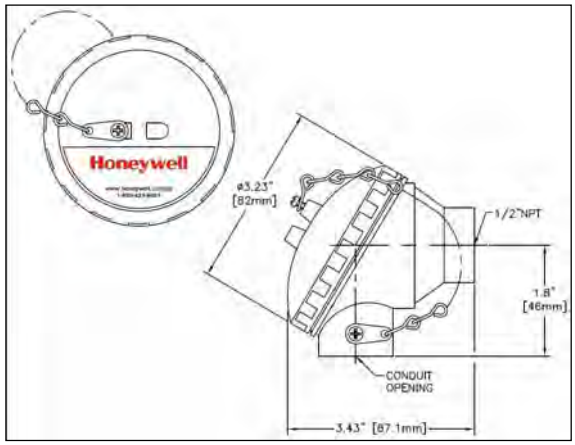
General Purpose Cast Iron Housings:

- Dimensions according to DIN form **B**
- Protection grade: **IP68 (NEMA-4, -4X)**
- Max. temperature: **121˚ C (250˚F)**
- Material: **Cast Iron**
- Conduit Entry: **½" NPT, ¾"NPT or M20 x 1.5**
- Thermowell Entry: **½" NPT**
- Body Finish: **Cast Iron with a High Temperature Black Paint**
- Cap Finish: **Cast Iron with a High Temperature Black Paint**
- Weight: **2Lbs (900g)**
- Captive Chain: **Stainless Steel Ball Type**



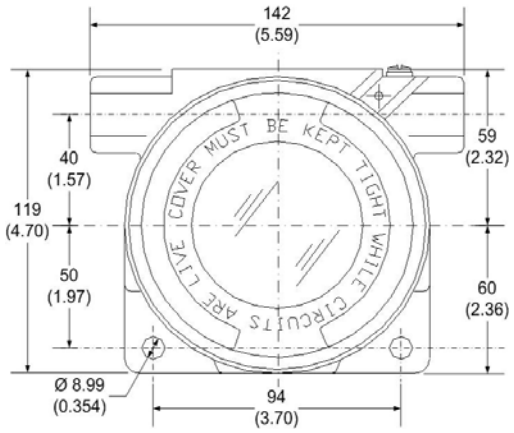
General Purpose Polypropylene Housings:

- Dimensions according to DIN form **B**
- Protection grade: **FDA Approved Polypropylene**
- Max. temperature: **92˚ C (198˚F)**
- Material: **White Polypropylene**
- Conduit Entry: **½" NPT, ¾"NPT or M20 x 1.5**
- Thermowell Entry: **½" NPT**
- Weight : 6**oz (170g)**
- Captive Chain: **Stainless Steel Link Type**



Explosion Proof Aluminum & Stainless Steel housing EPE / STE:

- Protection grade: IP66/67 (NEMA-4, -4X)
- Class 1 Div 1, Groups B, C & D
- Class 2, Div. 1 Groups E, F & G
- Max. temperature: 121˚ C (250˚F)
- Material: Aluminum Alloy 360 / 316 Stainless Steel
- Conduit Entry: ½" NPT
- Thermowell Entry: ½" NPT
- Aluminum Body Finish: Beige Epoxy
- Aluminum Cap Finish: Beige Epoxy
- Weight: 3.05 Lbs (1.38 kg)



2.3 Extension

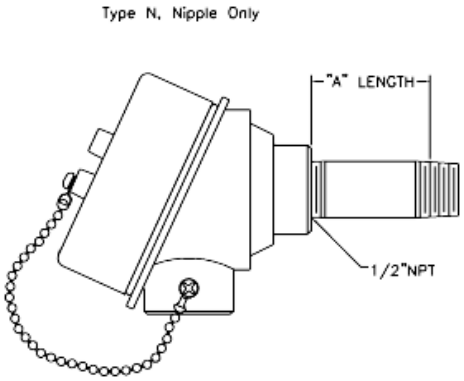
To complete the connection between the thermowell and the head a nipple or nipple / union / nipple combination is used.

The most economical would be a pipe nipple. A nipple / union / nipple combination allows for rotating the connection head 360°. Hex nipples provide for wrench adjustment. Extensions are available in carbon steel or stainless steel for corrosion protection. Extension lengths can be 1, 2, 5, 7 or 9" with the longer lengths to extend the head beyond insulation or firebrick.

Extension Specifications:

Nipple Extension Only

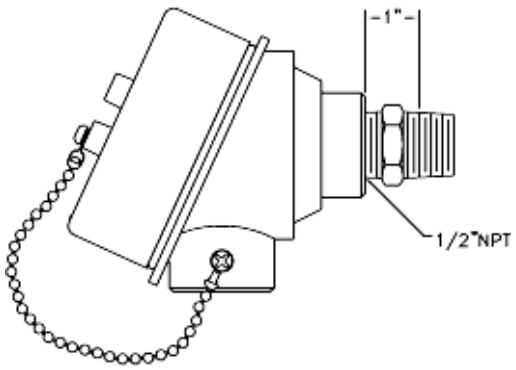
- Most economical
- Provides for minimal space between head and thermowell
- Nipple size: ½"NPT by Schedule 40
- Available materials: Carbon Steel or 304 Grade Stainless Steel
- Standard "A" Length: 2" and 5"
- Available in longer lengths, 316 Stainless Steel and/or Schedule 80



Hex Nipple Extension

- Machined from solid bar stock
- Best suited for wiring the transmitter
- Hex allows for easy dis-assembly
- Standard “A” length of 1”
- Standard 316 Grade Stainless Steel

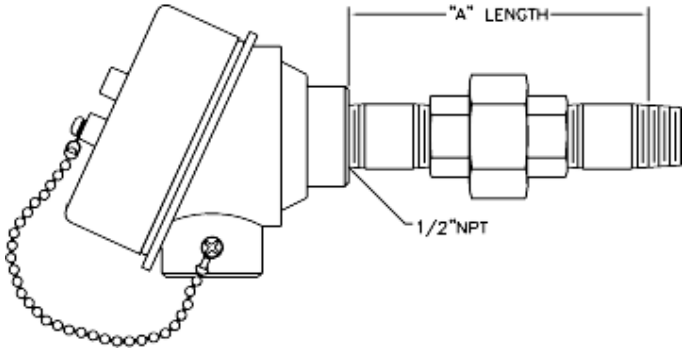
Type H02S, Hex Nipple Only



Nipple/Union/Nipple Extension

- Union provides the means for positioning for conduit cable connection
- Nipple size: ½”NPT by Schedule 40
- Union size: ½”NPT by 150#
- Available nipple materials: Carbon Steel or 304 Grade Stainless Steel
- Available union materials: Galvanized Steel or 304 Grade Stainless Steel
- Standard “A” Length: 5”, 7” and 9”
- Available in other lengths, 316 Stainless Steel or Schedule 80 nipples and 3000# rated unions

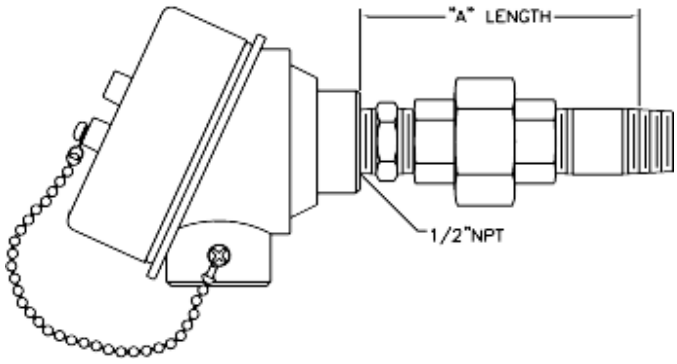
Type U, Nipple–Union–Nipple



Hex Nipple/Union/Nipple Extension

- Union provides the means for positioning for conduit cable connection
- Best suited for wiring the transmitter
- Hex nipple provide for additional wrench tightening
- Union provides the means for positioning for conduit cable connection
- Nipple size: ½”NPT by Schedule 40
- Union size: ½”NPT by 150#
- Hex nipple: 316 Grade Stainless Steel
- Available nipple materials: Carbon Steel or 304 Grade Stainless Steel
- Available union materials: Galvanized Steel or 304 Grade Stainless Steel
- Standard “A” Length: 5”, 7” and 9”
- Available in other lengths, 316 Stainless Steel or Schedule 80 nipples and 3000# rated unions

Type H, Hex Nipple–Union–Nipple

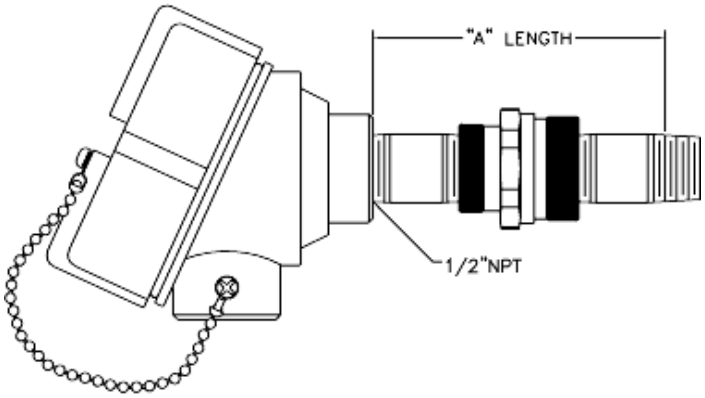


Nipple/Explosion Proof Union/Nipple Extension

- Same benefits as the standard Nipple/Union/Nipple extension except with explosion proof union rated:
- Class 1, Division 1 and 2, Groups A, B, C and D
- Class 2, Division 1 and 2, Groups E, F and G
- Class 3

Recommended when supplied with explosion proof connection heads.

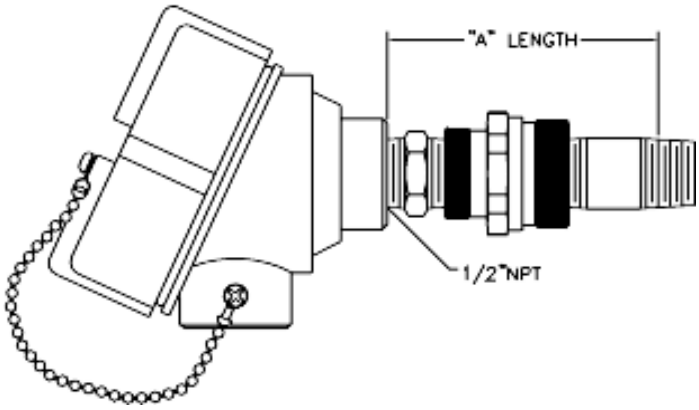
Type E, Nipple–Explosion Proof Union–Nipple



Hex Nipple/Explosion Proof Union/Nipple Extension

- Same benefits as the standard Hex Nipple/Union/Nipple extension except with explosion proof union rated:
- Class 1, Division 1 and 2, Groups A, B, C and D
- Class 2, Division 1 and 2, Groups E, F and G
- Class 3
- Recommended when supplied with explosion proof connection heads.

Type X, Hex Nipple–Explosion Proof Union–Nipple



2.4 Thermowells:

Thermowells are generally incorporated into the process three ways, threaded, welded or a flanged connection. For smaller diameters where the well is not required to be removed on a regular basis and corrosion is not a serious problem, threaded process connections are preferred. By threading into a coupling, thread-o-let or TEE, the well has attached directly to the vessel or run pipe.

For installations where the well needs to be removed more frequently due to corrosion or other requirements, a flange connection is used. The flange connection will bolt to a mating flange mounted to the process. Flange connections are more appropriate for high-pressure applications and larger pipe sizes.

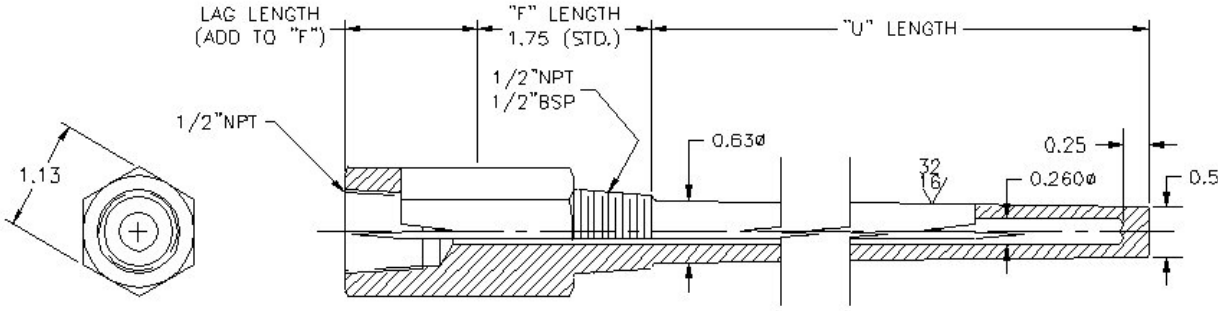
For applications where access is not required, a socket well can be used. These provide a high quality connection, but obviously cannot be removed without significant effort. Welded connections are also preferred for high pressure, high temperature steam lines.

Flanges are ANSI (American National Standards Institute) and Threads are NPT (National Pipe Threads).

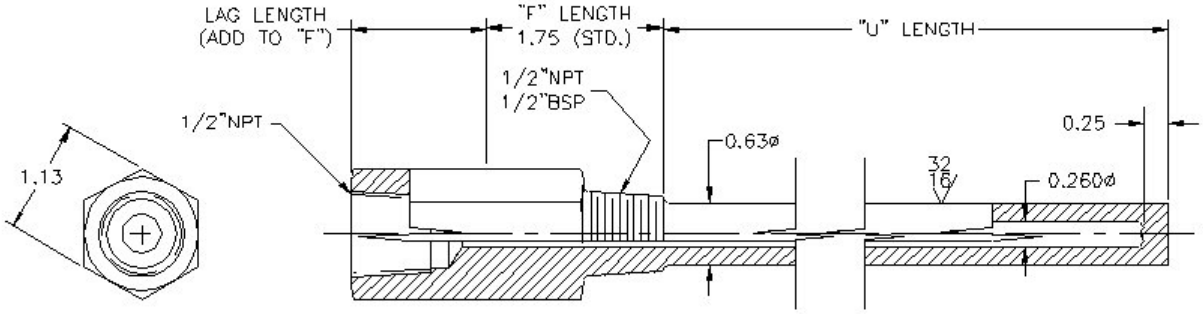
Threaded and Socket thermowells

- Selection A (1/2”NPT Process Connection)
- Selection B (1/2”BSP Process Connection)

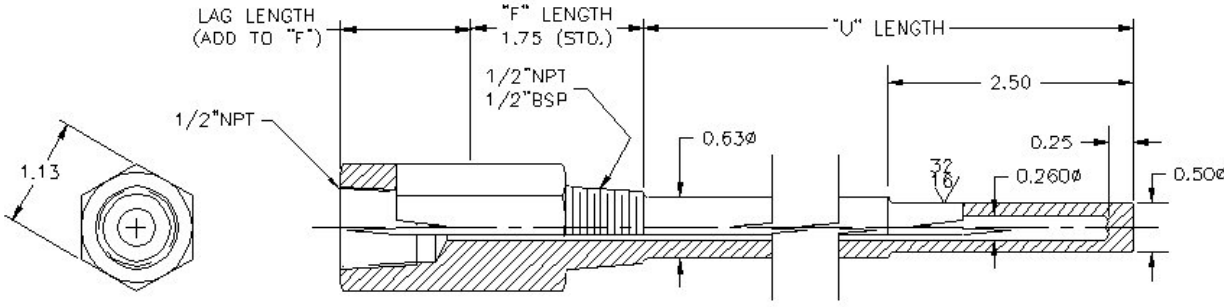
T Tapered Design



S Straight Design

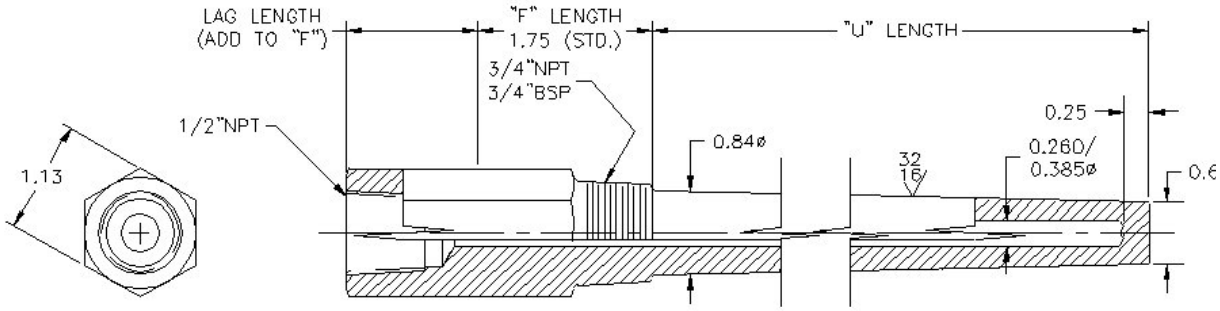


P Stepped Design

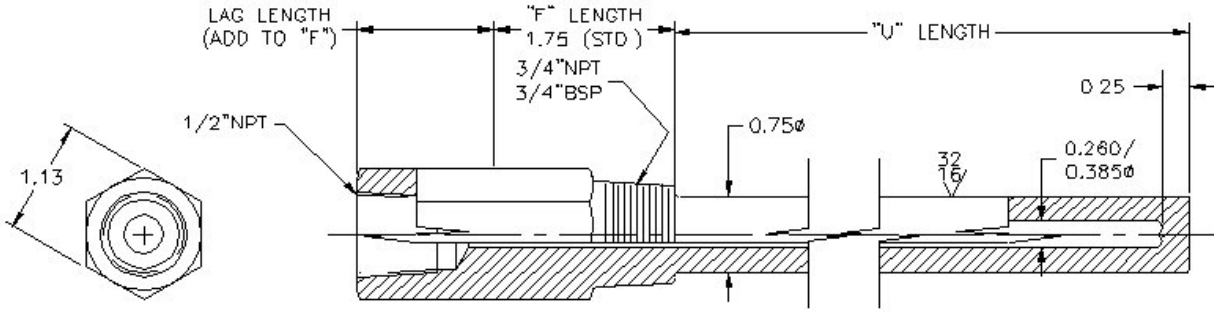


- Selection C (3/4”NPT Process Connection, .260Ø Bore)
- Selection D (3/4”NPT Process Connection, .385Ø Bore)
- Selection E (3/4”BSP Process Connection, .260Ø Bore)
- Selection F (3/4”BSP Process Connection, .385Ø Bore)

T Tapered Design



S Straight Design



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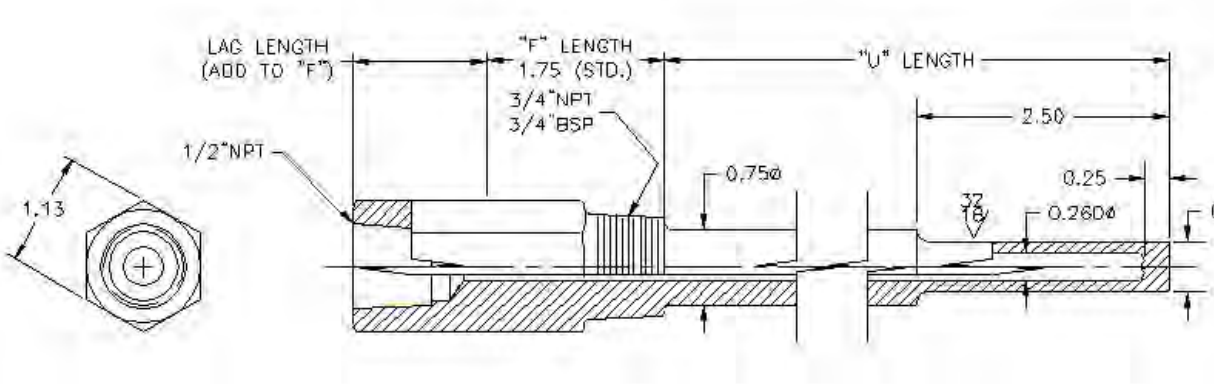
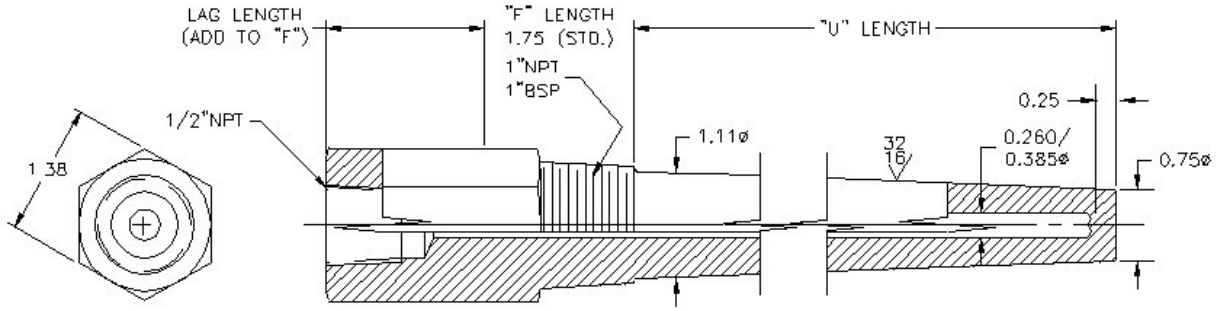
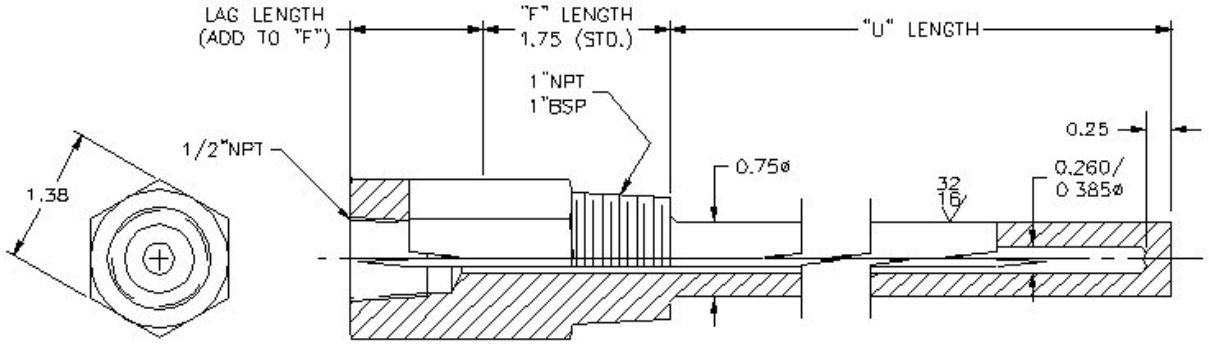


- Selection G (1”NPT Process Connection, .260Ø Bore)
- Selection H (1”NPT Process Connection, .385Ø Bore)
- Selection J (1”BSP Process Connection, .260Ø Bore)
- Selection K (1”BSP Process Connection, .385Ø Bore)

T Tapered Design



S Straight Design



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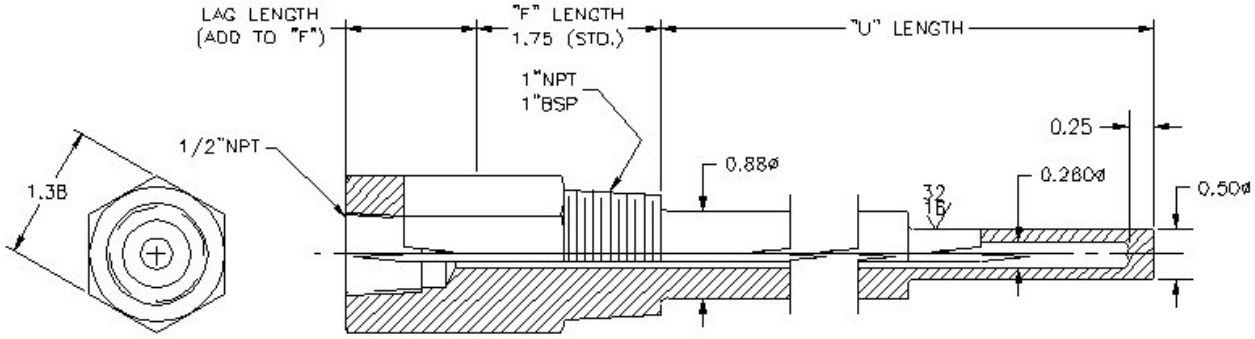
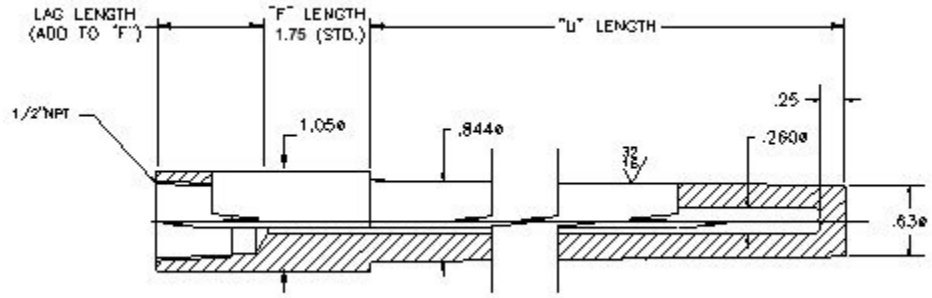


- Selection M (3/4”NPS Socket Weld Process Connection)



- Selection N (1”NPS Socket Weld Process Connection)

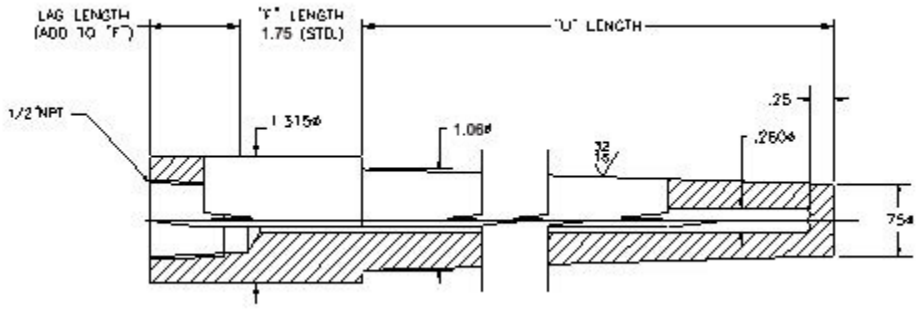
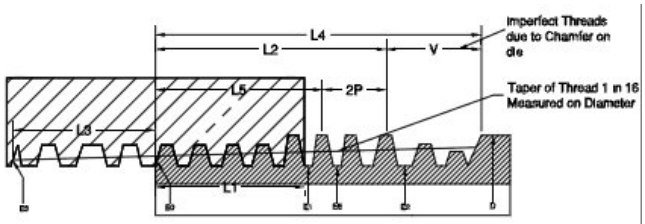


Table 2-1 NPT Dimensions

Basic NPT Dimensions



For all dimensions, see corresponding reference letter in table.
Angle between sides of thread is 60 degrees. Taper of thread, on diameter, is 3/4 inch per foot. Angle of taper with center line is 1°47'.
The basic maximum thread height, h, of the truncated thread is 0.8 x pitch of thread. The crest and root are truncated a minumum of 0.033 x pitch for all pitches.

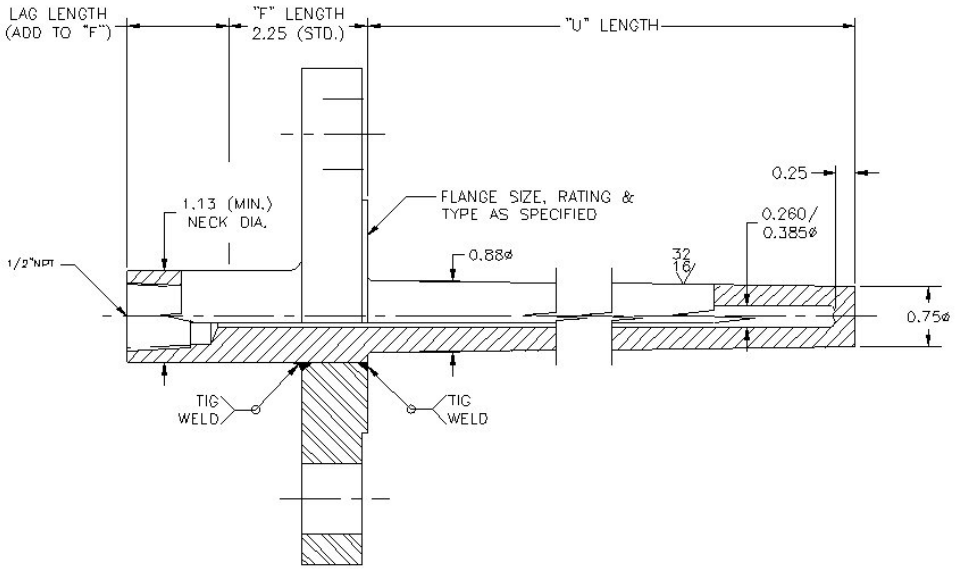
Nominal Pipe Size	Outside Dia. of Pipe, D	Threads per Inch, n	Pitch of Thread, P	Pitch Diameter at Beginning of External Thread, E0	Handtight Engagement		Effective Thread, External	
					Length, L1	Dia., E1	Length, L2	Dia., E2
					In.		In.	
1/16	0.3125	27	0.03704	0.27118	0.160	0.28118	0.2611	0.28750
1/8	0.405	27	0.03704	0.36351	0.1615	0.37360	0.2639	0.38000
1/4	0.540	18	0.05556	0.47739	0.2278	0.49163	0.4018	0.50250
3/8	0.675	18	0.05556	0.61201	0.240	0.62701	0.4078	0.63750
1/2	0.840	14	0.07143	0.75843	0.320	0.77843	0.5337	0.79179
3/4	1.050	14	0.07143	0.96768	0.339	0.98887	0.5457	1.00179
1	1.315	11 1/2	0.08696	1.21363	0.400	1.23863	0.6828	1.25630
1 1/4	1.660	11 1/2	0.08696	1.55713	0.420	1.58338	0.7068	1.60130
1 1/2	1.900	11 1/2	0.08696	1.79609	0.420	1.82234	0.7235	1.84130
2	2.375	11 1/2	0.08696	2.26902	0.436	2.29627	0.7565	2.31630
2 1/2	2.875	8	0.12500	2.71953	0.682	2.76216	1.1375	2.79062
3	3.500	8	0.12500	3.34062	0.766	3.38850	1.2000	3.41562
3 1/2	4.000	8	0.12500	3.83750	0.821	3.88881	1.2500	3.91562
4	4.500	8	0.12500	4.33438	0.844	4.38712	1.3000	4.41562

Nominal Pipe Size	Wrench Makeup Length for Internal Thread		Vanish Thread, (3.47 thds.), V	Overall Length External Thread, L4	Nominal Perfect External Threads		Height of Thread, l1	Basic Minor Dia. at Small End of Pipe, K0
	Length, L3	Dia., E3			Length, L5	Dia., E5		
1/16	0.1111	0.26424	0.1285	0.3896	0.1870	0.28287	0.02963	0.2416
1/8	0.1111	0.35656	0.1285	0.3924	0.1898	0.37537	0.02963	0.3339
1/4	0.1667	0.46697	0.1928	0.5946	0.2907	0.49556	0.04444	0.4329
3/8	0.1667	0.60160	0.1928	0.6006	0.2967	0.63056	0.04444	0.5676
1/2	0.2143	0.74504	0.2478	0.7815	0.3909	0.78286	0.05714	0.7013
3/4	0.2143	0.95429	0.2478	0.7935	0.4029	0.99286	0.05714	0.9105
1	0.2609	1.19733	0.3017	0.9845	0.5089	1.24543	0.06957	1.1441
1 1/4	0.2609	1.54083	0.3017	1.0085	0.5329	1.59043	0.06957	1.4876
1 1/2	0.2609	1.77978	0.3017	1.0252	0.5496	1.83043	0.06957	1.7265
2	0.2609	2.25272	0.3017	1.0582	0.5826	2.30543	0.06957	2.1995
2 1/2	0.2500	2.70391	0.4337	1.5712	0.8875	2.77500	0.10000	2.6195
3	0.2500	3.32500	0.4337	1.6337	0.9500	3.40000	0.10000	3.2406
3 1/2	0.2500	3.82188	0.4337	1.6837	1.0000	3.90000	0.10000	3.7375
4	0.2500	4.31875	0.4337	1.7337	1.0500	4.40000	0.10000	4.2344

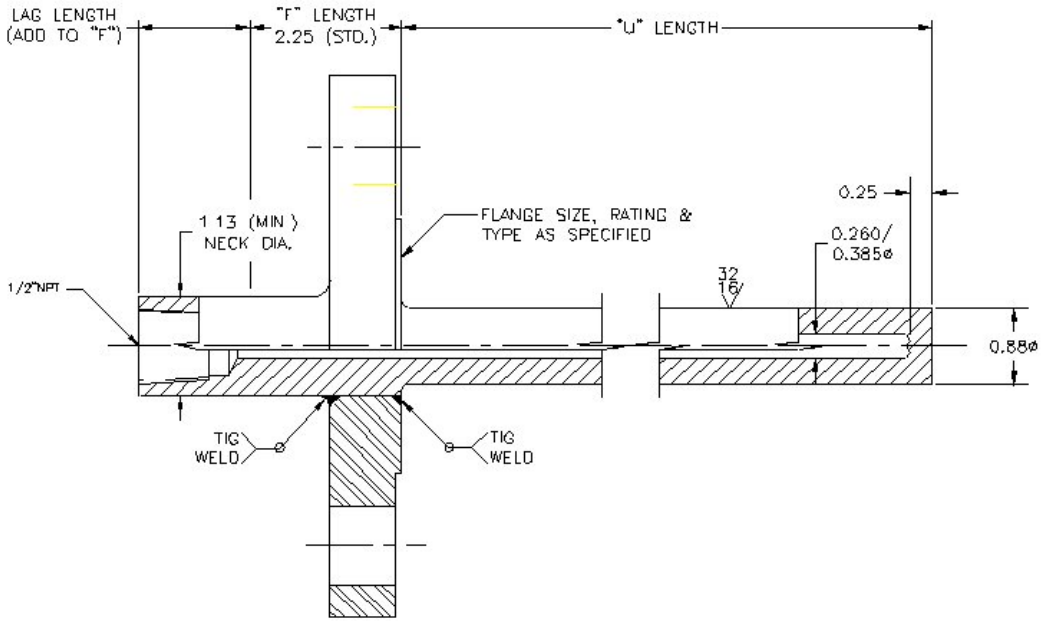
All dimensions given in inches. Increase in diameter per thread is equal to 0.0625/n.
The basic dimensions of the ANSI standard taper pipe thread are given in inches to four or five decimal places. While this implies a greater degree of precision than is ordinarily attained, these dimensions are the basis of gage dimensions and are so expressed for the purpose of eliminating errors in computations.

Flanged Thermowells:

- Selection A (.260Ø Bore, Tapered Design)
- Selection B (.385Ø Bore Tapered Design)



- Selection C (.260Ø Bore, Straight Design)
- Selection D (.385Ø Bore Straight Design)



- Selection E (.260Ø Bore, Stepped Design)

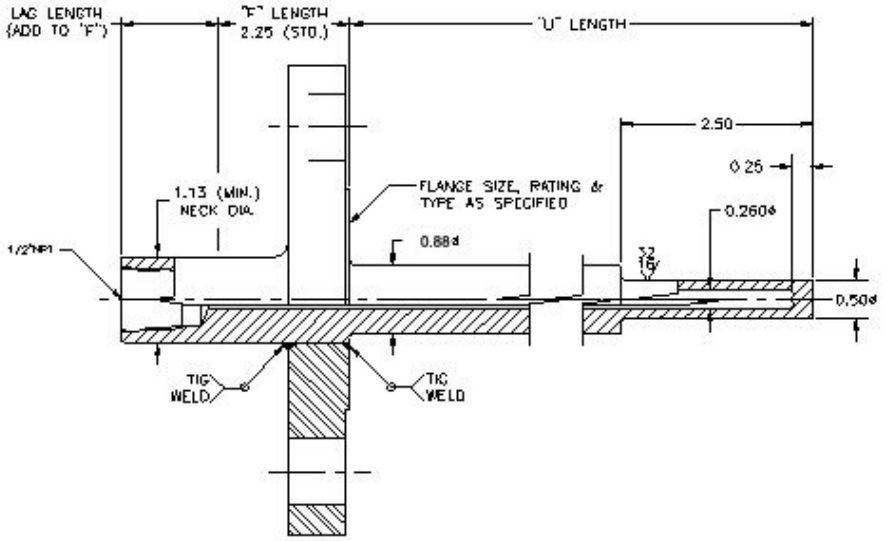
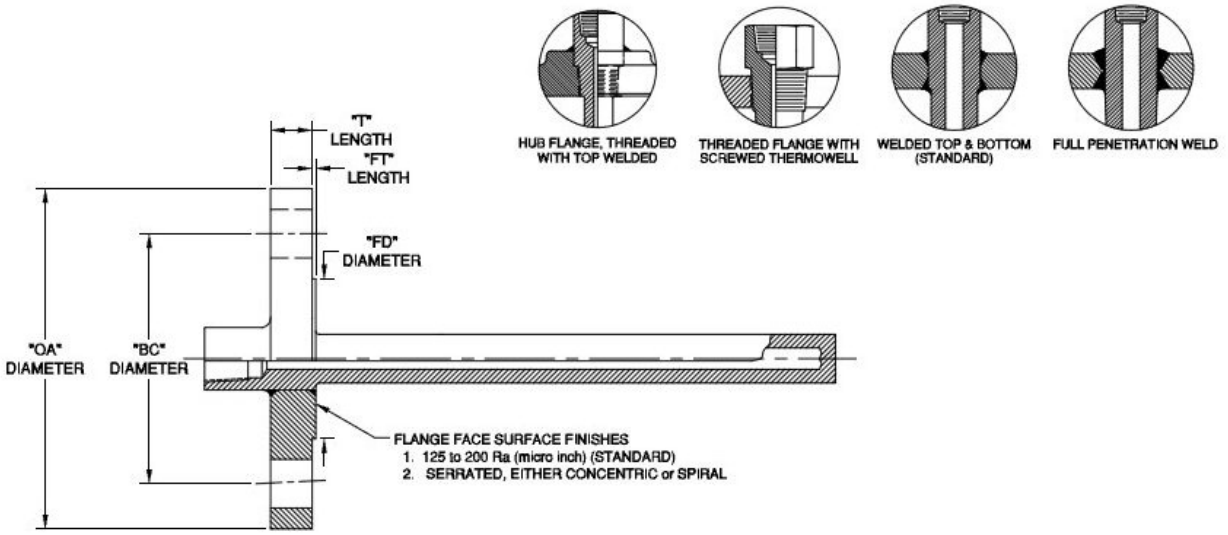


Table 2-2 Flange Information



Class 150 Forged Flanges

Nom. Pipe Size	No./Dia. of Holes (1)	BC	OA	FD	T
1/2	4-0.62	2.38	3.5	1.38	.38
3/4	4-0.62	2.75	3.88	1.69	.44
1	4-0.62	3.12	4.25	2	.50
1 1/4	4-0.62	3.5	4.62	2.5	.56
1 1/2	4-0.62	3.88	5	2.88	.62
2	4-0.75	4.75	6	3.62	.69
2 1/2	4-0.75	5.5	7	4.12	.82
3	4-0.75	6	7.5	5	.88
3 1/2	8-0.75	7	8.5	5.5	.88
4	8-0.75	7.5	9	6.19	.88

1. Bolt hole diameter 1/8 in. larger than bolt diameter
2. "FT" length equal to 1/16 in.
3. Exracted from ANSI B16.5, see complete standard for critical applications.

Class 300 Forged Flanges

Nom. Pipe Size	No./Dia. of Holes (1)	BC	OA	FD	T
1/2	4-0.62	2.62	3.75	1.38	.50
3/4	4-0.75	3.25	4.62	1.69	.56
1	4-0.75	3.5	4.88	2	.63
1 1/4	4-0.75	3.88	5.25	2.5	.69
1 1/2	4-0.88	4.5	6.12	2.88	.75
2	8-0.75	5	6.5	3.62	.82
2 1/2	8-0.88	5.88	7.5	4.12	.94
3	8-0.88	6.62	8.25	5	1.06
3 1/2	8-0.88	7.25	9	5.5	1.13
4	8-0.88	7.88	10	6.19	1.19

1. Bolt hole diameter 1/8 in. larger than bolt diameter
2. "FT" length equal to 1/16 in.
3. Exracted from ANSI B16.5, see complete standard for critical applications.

Flange Information

Class 600 Forged Flanges

Nom. Pipe Size	No./Dia. of Holes (1)	BC	OA	FD	T
1/2	4-0.62	2.62	3.75	1.38	0.56
3/4	4-0.75	3.25	4.62	1.69	0.62
1	4-0.75	3.5	4.88	2	0.69
1 1/4	4-0.75	3.88	5.25	2.5	0.81
1 1/2	4-0.88	4.5	6.12	2.88	0.88
2	8-0.75	5	6.5	3.62	1
2 1/2	8-0.88	5.88	7.5	4.12	1.12
3	8-0.88	6.62	8.25	5	1.25
3 1/2	8-1.00	7.25	9	5.5	1.38
4	8-1.00	8.5	10.75	6.19	1.5

1. Bolt hole diameter 1/8 in. larger than bolt diameter
2. "FT" length equal to 1/4 in.
3. Exracted from ANSI B16.5, see complete standard for critical applications.

Class 900 Forged Flanges

Nom. Pipe Size	No./Dia. of Holes (1)	BC	OA	FD	T
1/2	4-0.88	3.25	4.75	1.38	0.88
3/4	4-0.88	3.50	5.13	1.69	1.00
1	4-1.00	4.00	5.88	2.00	1.13
1 1/4	4-1.00	4.38	6.25	2.50	1.13
1 1/2	4-1.13	4.88	7.00	2.88	1.25
2	8-1.00	6.50	8.50	3.63	1.50
2 1/2	8-1.13	7.50	9.63	4.13	1.63
3	8-1.00	7.50	9.50	5.00	1.50
4	8-1.25	9.25	11.50	6.19	1.75

1. Bolt hole diameter 1/8 in. larger than bolt diameter
2. "FT" length equal to 1/4 in.
3. Exracted from ANSI B16.5, see complete standard for critical applications.

Class 1500 Forged Flanges

Nom. Pipe Size	No./Dia. of Holes (1)	BC	OA	FD	T
1/2	4-.088	3.25	4.75	1.38	0.88
3/4	4-0.88	3.50	5.13	1.69	1.00
1	4-1.00	4.00	5.88	2.00	1.13
1 1/4	4-1.00	4.38	6.25	2.50	1.13
1 1/2	4-1.13	4.88	7.00	2.88	1.25
2	8-1.00	6.50	8.50	3.63	1.50
2 1/2	8-1.13	7.50	9.63	4.13	1.63
3	8-1.25	8.00	10.50	5.00	1.88
4	8-1.38	9.50	12.25	6.19	2.13

1. Bolt hole diameter 1/8 in. larger than bolt diameter
2. "FT" length equal to 1/4 in.
3. Exracted from ANSI B16.5, see complete standard for critical applications.

Class 2500 Forged Flanges

Nom. Pipe Size	No./Dia. of Holes (1)	BC	OA	FD	T
1/2	4-0.88	3.50	5.25	1.38	1.19
3/4	4-0.88	3.75	5.50	1.69	1.25
1	4-1.00	4.25	6.25	2.00	1.38
1 1/4	4-1.13	5.13	7.25	2.50	1.50
1 1/2	4-1.25	5.75	8.00	2.88	1.75
2	8-1.13	6.75	9.25	3.63	2.00
2 1/2	8-1.25	7.75	10.50	4.13	2.25
3	8-1.38	9.00	12.00	5.00	2.63
4	8-1.63	10.75	14.00	6.19	3.00

1. Bolt hole diameter 1/8 in. larger than bolt diameter
2. "FT" length equal to 1/4 in.
3. Exracted from ANSI B16.5, see complete standard for critical applications.

2.5 Assembly Options

Selection PTI & PT2, Hydrostatic Testing (PT1 only on Socket wells)

Hydrostatic testing is a diagnostic technique to check for leaks or defects by means of slowly increasing water pressure in a line or chamber to a pre-determined setting. A visual inspection is performed to determine if any leakage exists or if the pressure set point reduces. Thermowells are mostly internally pressure tested, flanged and threaded thermowells may be externally tested. Testing pressure is recommended at the process maximum pressure or at 1.5 times the pressure rating in accordance with ANSI B16.5.

Selection FPW, Full Penetration Weld (Flanged Thermowells)

The most secure method of connecting the flange to the well is with a full penetration weld. In this, the flange is over bored to allow the well material to make full contact for the entire length of the connection. With a full penetration welded connection, the integrity of the connection is excellent. While this is much more costly in initial procurement cost, it can save significant long-term cost in the life and performance of the thermowell. Again, proper welding procedures are critical.

Selection HT1, NACE Certificate

Certification of material to the maximum hardness guidelines for sour service is found in NACE MR0175.

Selection XGN Oxygen Cleaning in accordance with ASTM G 93 - 96

Adequate contamination control in oxygen systems is imperative to minimize hazards and component failures because of contamination. This method of cleaning for service in oxygen environments eliminates contamination problems encountered in the use of enriched air, mixtures of oxygen with other gases, or any other oxidizing gas that may be solved by the same cleaning procedures. This is applicable to metallic materials thereby preventing ignition by a variety of mechanisms such as particle impact, mechanical or pneumatic impact.

Selection CLN Chlorine Cleaning in accordance with ASTM G 93 - 96

To assure that dry chlorine systems have protection from the intrusion of moisture the Chlorine Institute, Inc. has provided pamphlets to support the chlor-alkali industry and serve the public with human health and environmental protection in the distribution and use of chlorine.

Selection FRQ Frequency Calculation

Thermowells must be carefully selected for processes where significant velocity is present. By penetrating the process flow, the thermowell is subject to the stress and friction of the flow. This may set up a natural vibration in the well. If this is not done correctly, the vibration will be such that the well will shear off in the process. This can be especially troublesome in high velocity steam lines. As the engineer needs to have the well deep enough into the process to accurately measure the temperature, the selection of the length and diameter of the well needs to be checked against the process to ensure that they are compatible. This is done through a calculation known as a Murdock. This calculation will determine whether a thermowell will be acceptable for the proposed process. The Von Karman Trail refers to the turbulent wake, which is formed as fluid flows past the thermowell. A vibration frequency is determined by the diameter of the thermowell and the fluid velocity. Should this frequency equal the natural frequency of the thermowell it will cause the thermowell to vibrate to the point where it will break off? Therefore, it is important that the thermowell is designed to insure the natural frequency of the thermowell always exceeds the potential wake frequency.

Selection TMC Thermowell Material Certificate

The bar stock and flange supplier certifications are traceable to the lot, batch, or heat number lot in accordance with the applicable specification. A Mill Test Report or MTR is documentation that shows the chemical makeup and physical strength/properties of materials (bar stock, flanges) used in fabrication of thermowells required to meet ASME and ASTM grades. The MTR shows the percentage of alloy used through chemical analysis and mechanical tests of a sample piece to represent the whole batch of a run of material. The MTR proves that the material received meets the grade required. The company that does the testing from the mill itself issues this or by an outside company who tests for the mill. The MTR's include approval as define in EN 10204 3.1B assuring the manufacturer's authorized representation is independent of manufacturing.

Selection AP2, AP3 & AP4 Probe Calibration Data Certificate

Probe calibration provided at two, three or four temperature points. A comparison method to NIST standard PRT (Primary Reference Thermometer) is used. This allows for maintaining a calibration uncertainty of as low as .03º C. Calibration testing is available at any temperature between -35º C and 1250º C as well as cryogenic temperature of -195.6º C. Detailed calibration report is submitted with shipment showing test results. Temperature points are required at time of order.

Selection SP1 & SP2 Upgrade to Special Limits (Thermocouples)

For improved probe accuracy of approximately ½ the calibration error of the standard, we select and check calibration that are set factory temperature points. Recommend when using options AP2, AP3 & AP4.

Selection CL1 & CL2 Upgrade to Grade A (RTD's)

Platinum RTD's typically are provided in grades (or class) or tolerance. Grade A has an ice point tolerance of ±0.06% at ice point and grade B ±0.12% at ice point. The ASTM standard is slightly better than the DIN at ±0.05% and ±0.10%. Recommend when using options AP2, AP3 & AP4.

Selection TC1 & TC2 Transmitter with Probe System Calibration

All temperature sensors (thermocouple or RTD) have inherent errors. A properly designed, manufactured and calibrated Class A RTD probe has an allowable error of 0.13 ºC at ice point, at 500 ºC the max. allowable error is 0.98 ºC (per ASTM E1137-5). If a transmitter is calibrated using a calibration standard with a typical accuracy of .01 to .02 ºC and then attached to an RTD probe, the error of that RTD probe is transferred directly to the transmitter output. From the start you may see an error of close to 1 ºC at the higher temperatures.

Using our system calibration, the transmitter is calibrated at the customers selected zero and span points using the actual sensor as the input rather than a standard. This means the transmitter calibration eliminates the probes inherent error. This allows the system accuracy to exceed from what it would normally achieve when calibrating the probe and transmitter separately.

Platinum RTD's typically are provided in grades (or class) or tolerance. Grade A has an ice point tolerance of ±0.06% at ice point and grade B ±0.12% at ice point. The ASTM standard is slightly better, in this application, than the DIN at ±0.05% and ±0.10%. Recommend when using options AP2, AP3 & AP4.

Selection CRN Canadian Register Number

The Canadian Registration Number (CRN) is a number issued by each province or territory of Canada to the design of a boiler, pressure vessel or fitting. Fitting being the thermowell has been accepted and registered for use in that province or territory. Numeric digits following the decimal point within the CRN represent the province or territory.

2.6 Sensors

Thermocouple and RTD's (Resistance Temperature Detectors) are the most common temperature sensors employed by the process manufacturers.

Resistance Temperature Detector (RTD) elements are normally constructed of platinum, copper, nickel or nickel/iron. They operate as a positive temperature coefficient device when an excitation voltage is applied to convert changes in temperature to voltage signals by the measurement of resistance. The metals have the properties necessary for use in RTD elements due to their resistance to temperature characteristics that increase in resistance as temperature increases and, conversely, decrease in resistance as temperature decreases. These metals are best suited for RTD applications because of their linear resistance-temperature characteristics, their high coefficient of resistance, and their ability to withstand repeated temperature cycles. The change in electrical resistance to temperature for a material is termed the "temperature coefficient of resistance".

Wire wound design uses helical coil of very small platinum sensing wire of known alpha value. This coil is then slid into a ceramic insulator. Larger extension leads are spot welded to the ends of the platinum wire and cemented in place. Another construction is an outer winding of the platinum wire around a center mandrel, usually made of ceramic. This winding is coated with glass as a means of securing the windings. Wire wound elements are available in a number of materials and suitable for a wider temperature range.

Thin film sensing elements are manufactured with a thin layer of platinum deposited on to a ceramic substrate. The platinum film is laser cut or chemical etched to achieve the desired resistance path. The element is then coated with a thin layer of glass for protection. Lead wires are welded to the platinum with epoxy applied to hold the lead wires in place. Thin film elements are lower in cost than wire wound and faster in response time. RTD's are available in two, three and four wire configuration. Selection of the lead wire configuration is usually based on the instrumentation, desired accuracy and stability.

Two wire RTD: One lead wire is attached to each side of the element. This is the least accurate due to the inability to compensate for lead length resistance.

Three wire RTD: This is the most commonly used configuration. By adding a third lead to one end of the sensing element instrumentation can detect and compensate for lead resistance.

Four wire RTD: four wires provide for the most accurate method of RTD measurement. A constant current is carried through two leads with the remaining two used to measure the voltage drop.

Duplex RTD: RTD's are available in duplex construction in any of the wire configurations. With wire wound bulbs, two sets of windings are used. In thin film, two elements are set in place side-by-side. The second element may be used as a spare, testing purposes or connection to a second instrument.

R - Low Temperature

Low temperature is recommended for uses up to -58 to +500°F.

The Standard RTD employs a thin film element. The element is calibrated to ASTM E 1137 Grade B. Internal lead wires are nickel clad copper, insulated with Teflon. Film elements are sometimes better suited for high vibration applications.

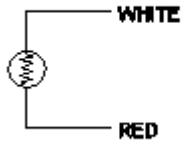
H – High Temperature

High temperature is recommended for uses up to -292 to +932°F.

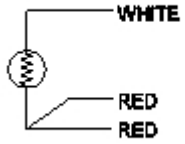
It is made utilizing MgO insulated, metal sheathed cable. Internal lead wires are made from nickel-plated copper wires. This provides the minimum lead wire resistance change with temperature. H type RTD's employ a Ceramic wire wound element

RTD’s are considered ungrounded.

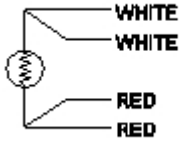
- **Type R1 or H1**
  - Construction: Single, 2-wire
  - Resistance @ 0ºC: 100 OHMS
  - Temperature Coefficient of Resistance: .00385
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”



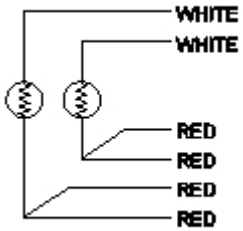
- **Type R2 or H2**
  - Construction: Single, 3-wire
  - Resistance @ 0ºC: 100 OHMS
  - Temperature Coefficient of Resistance: .00385
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”



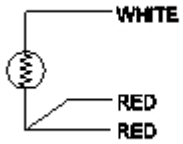
- **Type R3 or H3**
  - Construction: Single, 4-wire
  - Resistance @ 0ºC: 100 OHMS
  - Temperature Coefficient of Resistance: .00385
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”



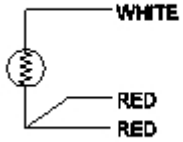
- **Type R4 or H4**
  - Construction: Duplex, 3-wire
  - Resistance @ 0ºC: 100 OHMS
  - Temperature Coefficient of Resistance: .00385
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”



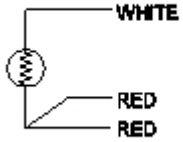
- **Type R5 or H5**
  - Construction: Single, 3-wire
  - Resistance @ 0ºC: 200 OHMS
  - Temperature Coefficient of Resistance: .00385
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”



- **Type R6 or H6**
  - Construction: Single, 3-wire
  - Resistance @ 0ºC: 500 OHMS
  - Temperature Coefficient of Resistance: .00385
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”



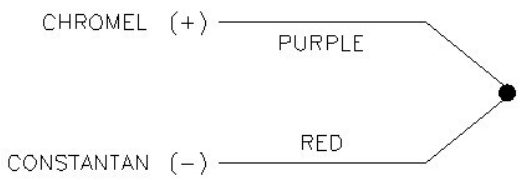
- **Type R7 or H7**
  - Construction: Single, 3-wire
  - Resistance @ 0ºC: 1000 OHMS
  - Temperature Coefficient of Resistance: .00385
  - Insulation Teflon(FEP)
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”



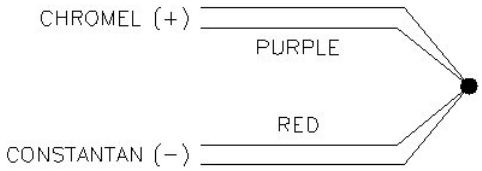
Lead Wire provides for termination from the sheath solid wire to flexible lead wire with Teflon insulation. Lead wires are attached by soldering and the area is sealed with epoxy to provide a durable moisture seal. Lead wires terminate to bare ends for connection to terminal block or transmitters.

2.7 Thermocouples

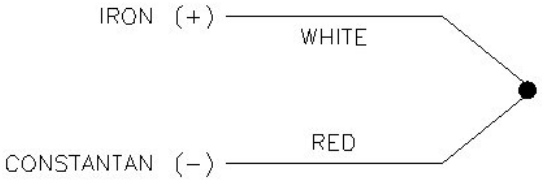
- **Type T1**
  - Construction: Single
  - Calibration: Type E, Chromel – Constantan
  - Conductor Size: 18 Ga.
  - Insulation: Hard Packed MgO
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼"
  - Recommended Temperature Range: -328 to +1600º F



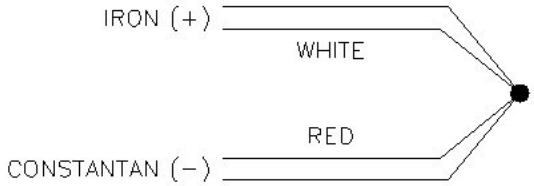
- **Type T2**
  - Construction: Duplex
  - Calibration: Type E, Chromel – Constantan
  - Conductor Size: 18 Ga.
  - Insulation: Hard Packed MgO
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼"
  - Recommended Temperature Range: -328 to +1600º F



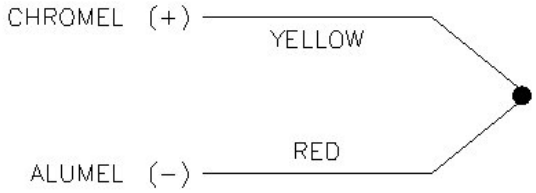
- **Type T3**
  - Construction: Single
  - Calibration: Type J, Iron - Constantan
  - Conductor Size: 18 Ga.
  - Insulation: Hard Packed MgO
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼"
  - Recommended Temperature Range: -32 to +1400º F



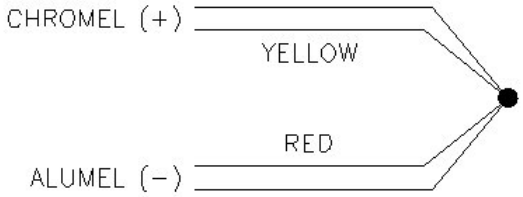
- **Type T4**
  - Construction: Duplex
  - Calibration: Type J, Iron - Constantan
  - Conductor Size: 18 Ga.
  - Insulation: Hard Packed MgO
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”
  - Recommended Temperature Range: -32 to +1400º F



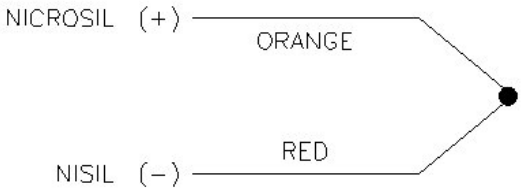
- **Type T5**
  - Construction: Single
  - Calibration: Type K, Chromel - Alumel
  - Conductor Size: 18 Ga.
  - Insulation: Hard Packed MgO
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”
  - Recommended Temperature Range: -328 to +2300º F



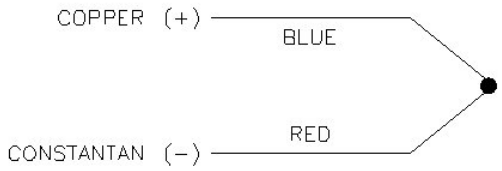
- **Type T6**
  - Construction: Duplex
  - Calibration: Type K, Chromel - Alumel
  - Conductor Size: 18 Ga.
  - Insulation: Hard Packed MgO
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”
  - Recommended Temperature Range: -328 to +2300º F



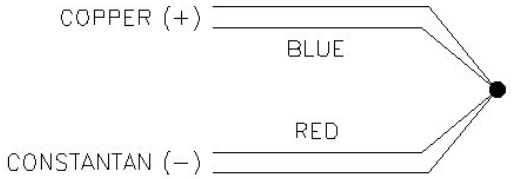
- **Type T7**
  - Construction: Single
  - Calibration: Type N, Nicrosil - Nisil
  - Conductor Size: 18 Ga.
  - Insulation: Hard Packed MgO
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”
  - Recommended Temperature Range: -328 to +2300º F



- **Type T1**
  - Construction: Single
  - Calibration: Type T, Copper – Constantan
  - Conductor Size: 18 Ga.
  - Insulation: Hard Packed MgO
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”
  - Recommended Temperature Range: -328 to +700º F



- **Type T2**
  - Construction: Duplex
  - Calibration: Type T, Copper – Constantan
  - Conductor Size: 18 Ga.
  - Insulation: Hard Packed MgO
  - Sheath Material: 316 Stainless Steel
  - Sheath Diameter: ¼”
  - Recommended Temperature Range: -328 to +700º F



Type E: CHROMEL (+) vs Constantan (-) has the highest EMF output of any standardized metallic thermocouple. If used unprotected, Type E wires are NOT subject to corrosion at sub-zero temperatures. They can be used in inert, oxidizing or reducing atmospheres. Because they cover a wide range with a single calibration curve, Type E thermocouples are preferred for computer applications.

Type J: Iron (+) vs Constantan (-), is the most commonly used calibration. It is suitable for use in a vacuum, inert, oxidizing)with the iron leg protected) or reducing atmosphere. If unprotected the iron wire may be attacked by ammonia, nitrogen and hydrogen atmospheres. In sub zero temperatures the iron wire may rust or become brittle. Type J should not be used in sulfurous atmospheres above 540°C.

Type K: Chromel (+) vs Alumel (-) is generally used to measure high temperatures up to 2300°F. It should not be used for accurate temperature measurement below 900°F or after prolonged exposure above 1400°F. If unprotected, it can be used only in inert or oxidizing atmospheres. It has a short life in alternately oxidizing and reducing atmospheres and in reducing atmospheres, particularly in the 1500 to 1850°F range.

Type N: Nicrosil (+) vs Nisil(-), was developed for oxidation resistance and EMF stability superior to those of Type K thermocouples at elevated temperatures. These couples have shown to have a longer life, than Type K thermocouples, in both laboratories and industrial applications

Type T: Copper (+) vs. Constantan (-), is commonly used for sub-zero to 700°F temperature. It is preferred to Type J for sub-zero applications because of copper's higher moisture resistance as compared to iron. If unprotected, it will still function in a vacuum, inert, oxidizing or reducing atmosphere.

Grounded Measuring Junction – G (Not permitted with ATEX certification)

In this construction, the measuring junction is completely sealed from contaminants and becomes an integral part of sheath at the tip of the thermocouple. Response time approaches that of an exposed loop thermocouple and in addition, the junction conductors are completely protected in a pressure tight seal protecting it from harsh environmental conditions and mechanical damage. Grounded junctions should not used when ground loops or other electrical interference is likely.

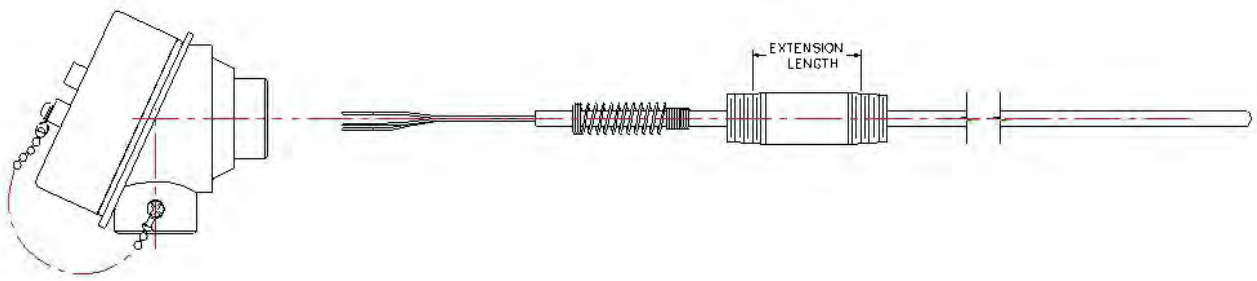
Dual grounded junction thermocouples furnish two measuring circuits for simultaneous control and indication (or recording) of a single point with two instruments. Thus prevents the signal loading effect common to instrumentation of low or combination low and high impedance.

Ungrounded Measuring Junction - U

In this construction, the thermocouple conductors are welded together to form the junction, which is insulated from the external sheath with magnesium oxide. The response time for an insulated junction is slightly longer than for a grounded junction thermocouple of the same outside diameter. This feature is advantageous in applications where thermocouples are used in conductive solutions, or when used for differential, averaging (parallel) or additive (series) applications, or wherever isolation of the measuring circuitry is required. The strain due to differential expansion between wires and sheath may reduce.

Same as the single ungrounded junction the dual ungrounded junction thermocouples furnish two measuring circuits for simultaneous control and indication (or recording) of a single point with two instruments. Thus preventing the signal loading effect is common to instrumentation of low or combination low and high impedance.

Lead Wire provides for termination from the sheath solid wire to flexible lead wire with PVC insulation. Lead wires are attached by welding or soldering and the area is than sealed with epoxy to provide a durable moisture seal. Thermocouple lead wires utilize the same alloys as the thermocouple calibration. Lead wires terminate to bare ends for connection to terminal block or transmitters.



2.8 Integral Meters

Honeywell's Series STT800 integrated temperature probe assemblies can be supplied with local or remote indication as an option. An Analog, (ME), Engineering Unit (EU) or a Smart Meter (SM) can be mounted integral to the transmitter inside the field mount housing. Order an integral meter as part of the model number; Table II _ _ M, _ _ E and _ _ S, respectively. Order a remote meter as model RMA300. The analog meter (ME) is a 4-20mA moving coil type and displays the temperature in 0 to 100% span.

The EU meter displays temperature in engineering units with the STT25H, STT25T and STT25S HART units. Refer to 34-ST-25-08D for more details. The Smart Meter accepts 4-20mA or DE protocol and displays temperature on a LCD in engineering units or 0 to 100% span.

The remote digital meter (DM) reads DE protocol and displays temperature on a LCD in 0 to 100% span. Refer to 34-ST-25-07A for details. Smart Meter and Fieldbus Meter are available with STT350 and STT35F Respectively in the field mounted housing.

The EU meter is available with STT170 transmitters in the field-mounted housing without hazardous location certifications.

2.9 Approvals

ATEX

ATEX	Certificate No.*	LCIE 05 ATEX 6105 X	
	Type of Protection	II 2 GD Ex d IIC T6	
		Ex tD A21 T85 IP6X	
		Ta= -20°C to +60°C	
	Suitable Locations	Group II	Explosive gas atmoshere (Group I for mines susceptible to firedamp).
		Category 2	Explosive gas atmoshere,quivialent to Zone 1, explosion likely to accur.
		GD	Type of explosive atmoshere, G (gas, vapor, mist), D**(combustable dust)
		Ex	Product is explosive protected for a flammable/hazardous environment.
		d	Flame-proof protection method.
		IIC	Certified for gases falling into Hydrogen & Acetylene (also includes propane & ethylene gases).***
		T6	Temperature class, 85°C
		Ta= -20°C to +60°C	Normal atmosheric temperature range.****
		tD	Dust protected by enclosure.
		A21	Approved for dusts in Zone 21.
		T85°C	Maximum permissable surface temperature by thermal rise with a dust blanket on the product.
		IP6X	IP Protection, no ingress of dust

**Asssemblies with EPE or STE housings not certified in dust atmosheres.

***Also suitable for groups IIA & IIB

****See table below to determine surface temperature based on transmitter selected.

STT171, STT173, STT17H	T6(Ta= -40°C to +60°C)	T5(Ta= -40°C to +85°C)
STT17F	T6(Ta ≤ 60°C)	T5(Ta ≤ 75°C)
STT25	T6(Ta= -50°C to +80°C)	T5(Ta= -50°C to +85°C)
STT350, STT35F	T6(Ta= -50°C to +80°C)	T5(Ta= -50°C to +85°C)

*The temperature probe and head-mount housings are supplied and certified by Thermo Electric Company, Inc., 1193 Dermott Drive, West Chester PA, 19380. Honeywell International Inc. supplies the temperature transmitter module.

FM

FM	Certificate No.*	3036581	
	Type of Protection	Class I, Division 1 & 2, Groups A**, B, C, D	
		Class II, Division 1 & 2, Groups E, F, G	
		Class III	
		Type-4 or 4X	
		Class I Zone 1 IIC	
		T6(Ta= -50°C to +80°C)	
		IP66	
	Suitable Locations	Class I	Flammable gases or vapors
		Division 1	Locations where continuous or intermittenting hazarduous conditions exist.
		Division 2	Locations where under abnormal continuous or intermittenting hazarduous conditions may exist.
		Groups A, B, C, D	Gas & vapor groups (A=Acetylene, B=Hydogen, C=Ethylene, D=Propene)
		Class II	Combustible Dusts
		Division 1***	Locations where continuous or intermittenting hazarduous conditions exist.
		Division 2***	Locations where under abnormal continuous or intermittenting hazarduous conditions may exist.
		Groups E, F, G	Gas & vapors (E=Metallic, F=Carbonaceous, G=organic)
		Class III	Combustible fibers & flyings
		Type-4	Complies with requirements of NEMA-250 indoor or outdoor potection due to ingress of water
		Type-4X****	Provides additional protection against corrosion.
		Class I	Flammable Liquids gases or vapors
		Zone 1	Locations in which ignitible flammable gases or vapors are likely ot exist under normal conditions.
		IIC	Certified for gases falling into Hydrogen & Acetylene (also includes propane & ethylene gases).*****
		T6	Temperature class, 85°C
		Ta= -50°C to +80°C	Normal atmosheric temperature range.******
		IP66	IP Protection, no ingress of dust and water (powerful jetting)

** Class A not available with EPE &STE housing with window.

*** Area division depends on quantity of dust present except groupl E which is division 1 only.

****Available only when supplied with stainless steel extensions & thermowells.

*****Also suitable for groups IIA & IIB

******See table below to determine surface temperature based on transmitter selected.

STT171, STT173, STT17H	T6(Ta= -40°C to +60°C)	T5(Ta= -40°C to +85°C)	
STT17F	T6(Ta= -40°C to +45°C)	T5(Ta= -40°C to +60°C)	T4(Ta= -40°C to +85°C)
STT25	T6(Ta= -40°C to +60°C)	T5(Ta= -40°C to +65°C)	T4(Ta= -50°C to +85°C)
STT350	T3(Ta= -40°C to +85°C)		
STT35F	T6(Ta= -40°C to +60°C)	T5(Ta= -40°C to +65°C)	T4(Ta= -40°C to +85°C)

*The temperature probe and head-mount housings are supplied and certified by Thermo Electric Company, Inc., 1193 McDermott Drive, West Chester PA, 19380. Honeywell International Inc. supplies the temperature transmitter module.

CSA

FM	Certificate No.*	1896285	
	Type of Protection	Class I, Division 1 & 2, Groups B, C, D	
		Class II, Division 1 & 2, Groups E, F, G	
		Class III	
		Type-4 or 4X	
		Class I Zone 1 IIC	
		T6(Ta= -40°C to +85°C)	
		IP66	
	Suitable Locations	Class I	Flammable gases or vapors
		Division 1	Locations where continuous or intermittenting hazarduous conditions exist.
		Division 2	Locations where under abnormal continuous or intermittenting hazarduous conditions may exist.
		Groups B, C, D	Gas & vapor groups (B=Hydogen, C=Ethylene, D=Propene)
		Class II	Combustible Dusts
		Division 1***	Locations where continuous or intermittenting hazarduous conditions exist.
		Division 2***	Locations where under abnormal continuous or intermittenting hazarduous conditions may exist.
		Groups E, F, G	Gas & vapors (E=Metallic, F=Carbonaceous, G=organic)
		Class III	Combustible fibers & flyings
		Type-4	Complies with requirements of NEMA-250 indoor or outdoor potection due to ingress of water
		Type-4X****	Provides additional protection against corrosion.
		Class I	Flammable Liquids gases or vapors
		Zone 1	Locations in which ignitible flammable gases or vapors are likely ot exist under normal conditions.
		EX d IIC	Certified for gases falling into Hydrogen & Acetylene (also includes propane & ethylene gases).*****
		T6	Temperature class, 85°C
		Ta= -40°C to +85°C	Normal atmosheric temperature range.******
		IP66	IP Protection, no ingress of dust and water (powerful jetting)

** Area division depends on quantity of dust present except groupl E which is division 1 only.

***Available only when supplied with stainless steel extensions & thermowells.

****Also suitable for groups IIA & IIB

*****See table below to determine surface temperature based on transmitter selected.

****** STT350 not certified for zone

STT171, STT173, STT17H	T6(Ta= -40°C to +60°C)	T4(Ta= -40°C to +85°C)	
STT17F	T6(Ta= -40°C to +85°C)	T5(Ta= -40°C to +85°C)	T4(Ta= -40°C to +85°C)
STT25	T4(Ta= -40°C to +60°C)		
STT350	T4(Ta= -40°C to +85°C)		
STT35F	T4(Ta= -40°C to +85°C)		

*The temperature probe and head-mount housings are supplied and certified by Thermo Electric Company, Inc., 1193 McDermott Drive, West Chester PA, 19380. Honeywell International Inc. supplies the temperature transmitter module.

For the detailed specifications of Honeywell STT 3000 range of temperature transmitters, refer to

34-TT-03-07	STT170	Specification
EN0I – 6031	STT250	Specifications of STT25M, STT25D, STT25H, and STT25S Smart temperature transmitters
EN0I – 6091	STT250	Specifications of STT25T Dual Input Smart temperature transmitters
EN0I – 6083	STT35F	Specification
EN0I – 5222	STT350	Specification

The range of thermowells available as a total thermal solution covers almost every possible requirement:

STT820 Series	34-44-16-08	Rigid Probe Assemblies.
STT830 Series	34-44-16-09	Threaded and Socket Weld Thermowell Assemblies.
STT840 Series	34-44-16-10	Drilled Flanged Thermowell Assemblies.

3. Tables and Charts

3.1 General Tables and Charts

Table 3-1 Temperature Conversion Table

°F		°C	°F		°C	°F		°C	°F		°C	°F		°C	°F		°C
	-292	-180.00	-256.0	-160	-106.67	-18.4	-28	-33.33	219.2	104	40.00	456.8	236	113.33	694.4	368	186.67
	-290	-178.89	-252.4	-158	-105.56	-14.8	-26	-32.22	222.8	106	41.11	460.4	238	114.44	698.0	370	187.78
	-288	-177.78	-248.8	-156	-104.44	-11.2	-24	-31.11	226.4	108	42.22	464.0	240	115.56	701.6	372	188.89
	-286	-176.67	-245.2	-154	-103.33	-7.6	-22	-30.00	230.0	110	43.33	467.6	242	116.67	705.2	374	190.00
	-284	-175.56	-241.6	-152	-102.22	-4.0	-20	-28.89	233.6	112	44.44	471.2	244	117.78	708.8	376	191.11
	-282	-174.44	-238.0	-150	-101.11	-0.4	-18	-27.78	237.2	114	45.56	474.8	246	118.89	712.4	378	192.22
	-280	-173.33	-234.4	-148	-100.00	3.2	-16	-26.67	240.8	116	46.67	478.4	248	120.00	716.0	380	193.33
	-278	-172.22	-230.8	-146	-98.89	6.8	-14	-25.56	244.4	118	47.78	482.0	250	121.11	719.6	382	194.44
	-276	-171.11	-227.2	-144	-97.78	10.4	-12	-24.44	248.0	120	48.89	485.6	252	122.22	723.2	384	195.56
	-274	-170.00	-223.6	-142	-96.67	14.0	-10	-23.33	251.6	122	50.00	489.2	254	123.33	726.8	386	196.67
-457.6	-272	-168.89	-220.0	-140	-95.56	17.6	-8	-22.22	255.2	124	51.11	492.8	256	124.44	730.4	388	197.78
-454.0	-270	-167.78	-216.4	-138	-94.44	21.2	-6	-21.11	258.8	126	52.22	496.4	258	125.56	734.0	390	198.89
-450.4	-268	-166.67	-212.8	-136	-93.33	24.8	-4	-20.00	262.4	128	53.33	500.0	260	126.67	737.6	392	200.00
-446.8	-266	-165.56	-209.2	-134	-92.22	28.4	-2	-18.89	266.0	130	54.44	503.6	262	127.78	741.2	394	201.11
-443.2	-264	-164.44	-205.6	-132	-91.11	32.0	0	-17.78	269.6	132	55.56	507.2	264	128.89	744.8	396	202.22
-439.6	-262	-163.33	-202.0	-130	-90.00	35.6	2	-16.67	273.2	134	56.67	510.8	266	130.00	748.4	398	203.33
-436.0	-260	-162.22	-198.4	-128	-88.89	39.2	4	-15.56	276.8	136	57.78	514.4	268	131.11	752.0	400	204.44
-432.4	-258	-161.11	-194.8	-126	-87.78	42.8	6	-14.44	280.4	138	58.89	518.0	270	132.22	755.6	402	205.56
-428.8	-256	-160.00	-191.2	-124	-86.67	46.4	8	-13.33	284.0	140	60.00	521.6	272	133.33	759.2	404	206.67
-425.2	-254	-158.89	-187.6	-122	-85.56	50.0	10	-12.22	287.6	142	61.11	525.2	274	134.44	762.8	406	207.78
-421.6	-252	-157.78	-184.0	-120	-84.44	53.6	12	-11.11	291.2	144	62.22	528.8	276	135.56	766.4	408	208.89
-418.0	-250	-156.67	-180.4	-118	-83.33	57.2	14	-10.00	294.8	146	63.33	532.4	278	136.67	770.0	410	210.00
-414.4	-248	-155.56	-176.8	-116	-82.22	60.8	16	-8.89	298.4	148	64.44	536.0	280	137.78	773.6	412	211.11
-410.8	-246	-154.44	-173.2	-114	-81.11	64.4	18	-7.78	302.0	150	65.56	539.6	282	138.89	777.2	414	212.22
-407.2	-244	-153.33	-169.6	-112	-80.00	68.0	20	-6.67	305.6	152	66.67	543.2	284	140.00	780.8	416	213.33
-403.6	-242	-152.22	-166.0	-110	-78.89	71.6	22	-5.56	309.2	154	67.78	546.8	286	141.11	784.4	418	214.44
-400.0	-240	-151.11	-162.4	-108	-77.78	75.2	24	-4.44	312.8	156	68.89	550.4	288	142.22	788.0	420	215.56
-396.4	-238	-150.00	-158.8	-106	-76.67	78.8	26	-3.33	316.4	158	70.00	554.0	290	143.33	791.6	422	216.67
-392.8	-236	-148.89	-155.2	-104	-75.56	82.4	28	-2.22	320.0	160	71.11	557.6	292	144.44	795.2	424	217.78
-389.2	-234	-147.78	-151.6	-102	-74.44	86.0	30	-1.11	323.6	162	72.22	561.2	294	145.56	798.8	426	218.89
-385.6	-232	-146.67	-148.0	-100	-73.33	89.6	32	0.00	327.2	164	73.33	564.8	296	146.67	802.4	428	220.00
-382.0	-230	-145.56	-144.4	-98	-72.22	93.2	34	1.11	330.8	166	74.44	568.4	298	147.78	806.0	430	221.11
-378.4	-228	-144.44	-140.8	-96	-71.11	96.8	36	2.22	334.4	168	75.56	572.0	300	148.89	809.6	432	222.22
-374.8	-226	-143.33	-137.2	-94	-70.00	100.4	38	3.33	338.0	170	76.67	575.6	302	150.00	813.2	434	223.33
-371.2	-224	-142.22	-133.6	-92	-68.89	104.0	40	4.44	341.6	172	77.78	579.2	304	151.11	816.8	436	224.44
-367.6	-222	-141.11	-130.0	-90	-67.78	107.6	42	5.56	345.2	174	78.89	582.8	306	152.22	820.4	438	225.56
-364.0	-220	-140.00	-126.4	-88	-66.67	111.2	44	6.67	348.8	176	80.00	586.4	308	153.33	824.0	440	226.67
-360.4	-218	-138.89	-122.8	-86	-65.56	114.8	46	7.78	352.4	178	81.11	590.0	310	154.44	827.6	442	227.78
-356.8	-216	-137.78	-119.2	-84	-64.44	118.4	48	8.89	356.0	180	82.22	593.6	312	155.56	831.2	444	228.89
-353.2	-214	-136.67	-115.6	-82	-63.33	122.0	50	10.00	359.6	182	83.33	597.2	314	156.67	834.8	446	230.00
-349.6	-212	-135.56	-112.0	-80	-62.22	125.6	52	11.11	363.2	184	84.44	600.8	316	157.78	838.4	448	231.11
-346.0	-210	-134.44	-108.4	-78	-61.11	129.2	54	12.22	366.8	186	85.56	604.4	318	158.89	842.0	450	232.22
-342.4	-208	-133.33	-104.8	-76	-60.00	132.8	56	13.33	370.4	188	86.67	608.0	320	160.00	845.6	452	233.33
-338.8	-206	-132.22	-101.2	-74	-58.89	136.4	58	14.44	374.0	190	87.78	611.6	322	161.11	849.2	454	234.44
-335.2	-204	-131.11	-97.6	-72	-57.78	140.0	60	15.56	377.6	192	88.89	615.2	324	162.22	852.8	456	235.56
-331.6	-202	-130.00	-94.0	-70	-56.67	143.6	62	16.67	381.2	194	90.00	618.8	326	163.33	856.4	458	236.67
-328.0	-200	-128.89	-90.4	-68	-55.56	147.2	64	17.78	384.8	196	91.11	622.4	328	164.44	860.0	460	237.78
-324.4	-198	-127.78	-86.8	-66	-54.44	150.8	66	18.89	388.4	198	92.22	626.0	330	165.56	863.6	462	238.89
-320.8	-196	-126.67	-83.2	-64	-53.33	154.4	68	20.00	392.0	200	93.33	629.6	332	166.67	867.2	464	240.00
-317.2	-194	-125.56	-79.6	-62	-52.22	158.0	70	21.11	395.6	202	94.44	633.2	334	167.78	870.8	466	241.11
-313.6	-192	-124.44	-76.0	-60	-51.11	161.6	72	22.22	399.2	204	95.56	636.8	336	168.89	874.4	468	242.22
-310.0	-190	-123.33	-72.4	-58	-50.00	165.2	74	23.33	402.8	206	96.67	640.4	338	170.00	878.0	470	243.33
-306.4	-188	-122.22	-68.8	-56	-48.89	168.8	76	24.44	406.4	208	97.78	644.0	340	171.11	881.6	472	244.44
-302.8	-186	-121.11	-65.2	-54	-47.78	172.4	78	25.56	410.0	210	98.89	647.6	342	172.22	885.2	474	245.56
-299.2	-184	-120.00	-61.6	-52	-46.67	176.0	80	26.67	413.6	212	100.00	651.2	344	173.33	888.8	476	246.67
-295.6	-182	-118.89	-58.0	-50	-45.56	179.6	82	27.78	417.2	214	101.11	654.8	346	174.44	892.4	478	247.78
-292.0	-180	-117.78	-54.4	-48	-44.44	183.2	84	28.89	420.8	216	102.22	658.4	348	175.56	896.0	480	248.89
-288.4	-178	-116.67	-50.8	-46	-43.33	186.8	86	30.00	424.4	218	103.33	662.0	350	176.67	899.6	482	250.00
-284.8	-176	-115.56	-47.2	-44	-42.22	190.4	88	31.11	428.0	220	104.44	665.6	352	177.78	903.2	484	251.11
-281.2	-174	-114.44	-43.6	-42	-41.11	194.0	90	32.22	431.6	222	105.56	669.2	354	178.89	906.8	486	252.22
-277.6	-172	-113.33	-40.0	-40	-40.00	197.6	92	33.33	435.2	224	106.67	672.8	356	180.00	910.4	488	253.33
-274.0	-170	-112.22	-36.4	-38	-38.89	201.2	94	34.44	438.8	226	107.78	676.4	358	181.11	914.0	490	254.44
-270.4	-168	-111.11	-32.8	-36	-37.78	204.8	96	35.56	442.4	228	108.89	680.0	360	182.22	917.6	492	255.56
-266.8	-166	-110.00	-29.2	-34	-36.67	208.4	98	36.67	446.0	230	110.00	683.6	362	183.33	921.2	494	256.67
-263.2	-164	-108.89	-25.6	-32	-35.56	212.0	100	37.78	449.6	232	111.11	687.2	364	184.44	924.8	496	257.78
-259.6	-162	-107.78	-22.0	-30	-34.44	215.6	102	38.89	453.2	234	112.22	690.8	366	185.56	928.4	498	258.89

Temperature Conversion Table (continued)

°F		°C	°F		°C	°F		°C	°F		°C	°F		°C	°F		°C
932.0	500	260.00	1742.0	950	510.00	2912.0	1600	871.11	4082.0	2250	1232.22	5252.0	2900	1593.33	6422.0	3550	1954.44
935.6	502	261.11	1760.0	960	515.56	2930.0	1610	876.67	4100.0	2260	1237.78	5270.0	2910	1598.89	6440.0	3560	1960.00
939.2	504	262.22	1778.0	970	521.11	2948.0	1620	882.22	4118.0	2270	1243.33	5288.0	2920	1604.44	6458.0	3570	1965.56
942.8	506	263.33	1796.0	980	526.67	2966.0	1630	887.78	4136.0	2280	1248.89	5306.0	2930	1610.00	6476.0	3580	1971.11
946.4	508	264.44	1814.0	990	532.22	2984.0	1640	893.33	4154.0	2290	1254.44	5324.0	2940	1615.56	6494.0	3590	1976.67
950.0	510	265.56	1832.0	1000	537.78	3002.0	1650	898.89	4172.0	2300	1260.00	5342.0	2950	1621.11	6512.0	3600	1982.22
953.6	512	266.67	1850.0	1010	543.33	3020.0	1660	904.44	4190.0	2310	1265.56	5360.0	2960	1626.67	6530.0	3610	1987.78
957.2	514	267.78	1868.0	1020	548.89	3038.0	1670	910.00	4208.0	2320	1271.11	5378.0	2970	1632.22	6548.0	3620	1993.33
960.8	516	268.89	1886.0	1030	554.44	3056.0	1680	915.56	4226.0	2330	1276.67	5396.0	2980	1637.78	6566.0	3630	1998.89
964.4	518	270.00	1904.0	1040	560.00	3074.0	1690	921.11	4244.0	2340	1282.22	5414.0	2990	1643.33	6584.0	3640	2004.44
968.0	520	271.11	1922.0	1050	565.56	3092.0	1700	926.67	4262.0	2350	1287.78	5432.0	3000	1648.89	6602.0	3650	2010.00
971.6	522	272.22	1940.0	1060	571.11	3110.0	1710	932.22	4280.0	2360	1293.33	5450.0	3010	1654.44	6620.0	3660	2015.56
975.2	524	273.33	1958.0	1070	576.67	3128.0	1720	937.78	4298.0	2370	1298.89	5468.0	3020	1660.00	6638.0	3670	2021.11
978.8	526	274.44	1976.0	1080	582.22	3146.0	1730	943.33	4316.0	2380	1304.44	5486.0	3030	1665.56	6656.0	3680	2026.67
982.4	528	275.56	1994.0	1090	587.78	3164.0	1740	948.89	4334.0	2390	1310.00	5504.0	3040	1671.11	6674.0	3690	2032.22
986.0	530	276.67	2012.0	1100	593.33	3182.0	1750	954.44	4352.0	2400	1315.56	5522.0	3050	1676.67	6692.0	3700	2037.78
989.6	532	277.78	2030.0	1110	598.89	3200.0	1760	960.00	4370.0	2410	1321.11	5540.0	3060	1682.22	6710.0	3710	2043.33
993.2	534	278.89	2048.0	1120	604.44	3218.0	1770	965.56	4388.0	2420	1326.67	5558.0	3070	1687.78	6728.0	3720	2048.89
996.8	536	280.00	2066.0	1130	610.00	3236.0	1780	971.11	4406.0	2430	1332.22	5576.0	3080	1693.33	6746.0	3730	2054.44
1000.4	538	281.11	2084.0	1140	615.56	3254.0	1790	976.67	4424.0	2440	1337.78	5594.0	3090	1698.89	6764.0	3740	2060.00
1004.0	540	282.22	2102.0	1150	621.11	3272.0	1800	982.22	4442.0	2450	1343.33	5612.0	3100	1704.44	6782.0	3750	2065.56
1007.6	542	283.33	2120.0	1160	626.67	3290.0	1810	987.78	4460.0	2460	1348.89	5630.0	3110	1710.00	6800.0	3760	2071.11
1011.2	544	284.44	2138.0	1170	632.22	3308.0	1820	993.33	4478.0	2470	1354.44	5648.0	3120	1715.56	6818.0	3770	2076.67
1014.8	546	285.56	2156.0	1180	637.78	3326.0	1830	998.89	4496.0	2480	1360.00	5666.0	3130	1721.11	6836.0	3780	2082.22
1018.4	548	286.67	2174.0	1190	643.33	3344.0	1840	1004.44	4514.0	2490	1365.56	5684.0	3140	1726.67	6854.0	3790	2087.78
1022.0	550	287.78	2192.0	1200	648.89	3362.0	1850	1010.00	4532.0	2500	1371.11	5702.0	3150	1732.22	6872.0	3800	2093.33
1040.0	560	293.33	2210.0	1210	654.44	3380.0	1860	1015.56	4550.0	2510	1376.67	5720.0	3160	1737.78	6890.0	3810	2098.89
1058.0	570	298.89	2228.0	1220	660.00	3398.0	1870	1021.11	4568.0	2520	1382.22	5738.0	3170	1743.33	6908.0	3820	2104.44
1076.0	580	304.44	2246.0	1230	665.56	3416.0	1880	1026.67	4586.0	2530	1387.78	5756.0	3180	1748.89	6926.0	3830	2110.00
1094.0	590	310.00	2264.0	1240	671.11	3434.0	1890	1032.22	4604.0	2540	1393.33	5774.0	3190	1754.44	6944.0	3840	2115.56
1112.0	600	315.56	2282.0	1250	676.67	3452.0	1900	1037.78	4622.0	2550	1398.89	5792.0	3200	1760.00	6962.0	3850	2121.11
1130.0	610	321.11	2300.0	1260	682.22	3470.0	1910	1043.33	4640.0	2560	1404.44	5810.0	3210	1765.56	6980.0	3860	2126.67
1148.0	620	326.67	2318.0	1270	687.78	3488.0	1920	1048.89	4658.0	2570	1410.00	5828.0	3220	1771.11	6998.0	3870	2132.22
1166.0	630	332.22	2336.0	1280	693.33	3506.0	1930	1054.44	4676.0	2580	1415.56	5846.0	3230	1776.67	7016.0	3880	2137.78
1184.0	640	337.78	2354.0	1290	698.89	3524.0	1940	1060.00	4694.0	2590	1421.11	5864.0	3240	1782.22	7034.0	3890	2143.33
1202.0	650	343.33	2372.0	1300	704.44	3542.0	1950	1065.56	4712.0	2600	1426.67	5882.0	3250	1787.78	7052.0	3900	2148.89
1220.0	660	348.89	2390.0	1310	710.00	3560.0	1960	1071.11	4730.0	2610	1432.22	5900.0	3260	1793.33	7070.0	3910	2154.44
1238.0	670	354.44	2408.0	1320	715.56	3578.0	1970	1076.67	4748.0	2620	1437.78	5918.0	3270	1798.89	7088.0	3920	2160.00
1256.0	680	360.00	2426.0	1330	721.11	3596.0	1980	1082.22	4766.0	2630	1443.33	5936.0	3280	1804.44	7106.0	3930	2165.56
1274.0	690	365.56	2444.0	1340	726.67	3614.0	1990	1087.78	4784.0	2640	1448.89	5954.0	3290	1810.00	7124.0	3940	2171.11
1292.0	700	371.11	2462.0	1350	732.22	3632.0	2000	1093.33	4802.0	2650	1454.44	5972.0	3300	1815.56	7142.0	3950	2176.67
1310.0	710	376.67	2480.0	1360	737.78	3650.0	2010	1098.89	4820.0	2660	1460.00	5990.0	3310	1821.11	7160.0	3960	2182.22
1328.0	720	382.22	2498.0	1370	743.33	3668.0	2020	1104.44	4838.0	2670	1465.56	6008.0	3320	1826.67	7178.0	3970	2187.78
1346.0	730	387.78	2516.0	1380	748.89	3686.0	2030	1110.00	4856.0	2680	1471.11	6026.0	3330	1832.22	7196.0	3980	2193.33
1364.0	740	393.33	2534.0	1390	754.44	3704.0	2040	1115.56	4874.0	2690	1476.67	6044.0	3340	1837.78	7214.0	3990	2198.89
1382.0	750	398.89	2552.0	1400	760.00	3722.0	2050	1121.11	4892.0	2700	1482.22	6062.0	3350	1843.33	7232.0	4000	2204.44
1400.0	760	404.44	2570.0	1410	765.56	3740.0	2060	1126.67	4910.0	2710	1487.78	6080.0	3360	1848.89	7250.0	4010	2210.00
1418.0	770	410.00	2588.0	1420	771.11	3758.0	2070	1132.22	4928.0	2720	1493.33	6098.0	3370	1854.44	7268.0	4020	2215.56
1436.0	780	415.56	2606.0	1430	776.67	3776.0	2080	1137.78	4946.0	2730	1498.89	6116.0	3380	1860.00	7286.0	4030	2221.11
1454.0	790	421.11	2624.0	1440	782.22	3794.0	2090	1143.33	4964.0	2740	1504.44	6134.0	3390	1865.56	7304.0	4040	2226.67
1472.0	800	426.67	2642.0	1450	787.78	3812.0	2100	1148.89	4982.0	2750	1510.00	6152.0	3400	1871.11	7322.0	4050	2232.22
1490.0	810	432.22	2660.0	1460	793.33	3830.0	2110	1154.44	5000.0	2760	1515.56	6170.0	3410	1876.67	7340.0	4060	2237.78
1508.0	820	437.78	2678.0	1470	798.89	3848.0	2120	1160.00	5018.0	2770	1521.11	6188.0	3420	1882.22	7358.0	4070	2243.33
1526.0	830	443.33	2696.0	1480	804.44	3866.0	2130	1165.56	5036.0	2780	1526.67	6206.0	3430	1887.78	7376.0	4080	2248.89
1544.0	840	448.89	2714.0	1490	810.00	3884.0	2140	1171.11	5054.0	2790	1532.22	6224.0	3440	1893.33	7394.0	4090	2254.44
1562.0	850	454.44	2732.0	1500	815.56	3902.0	2150	1176.67	5072.0	2800	1537.78	6242.0	3450	1898.89	7412.0	4100	2260.00
1580.0	860	460.00	2750.0	1510	821.11	3920.0	2160	1182.22	5090.0	2810	1543.33	6260.0	3460	1904.44	7430.0	4110	2265.56
1598.0	870	465.56	2768.0	1520	826.67	3938.0	2170	1187.78	5108.0	2820	1548.89	6278.0	3470	1910.00	7448.0	4120	2271.11
1616.0	880	471.11	2786.0	1530	832.22	3956.0	2180	1193.33	5126.0	2830	1554.44	6296.0	3480	1915.56	7466.0	4130	2276.67
1634.0	890	476.67	2804.0	1540	837.78	3974.0	2190	1198.89	5144.0	2840	1560.00	6314.0	3490	1921.11	7484.0	4140	2282.22
1652.0	900	482.22	2822.0	1550	843.33	3992.0	2200	1204.44	5162.0	2850	1565.56	6332.0	3500	1926.67	7502.0	4150	2287.78
1670.0	910	487.78	2840.0	1560	848.89	4010.0	2210	1210.00	5180.0	2860	1571.11	6350.0	3510	1932.22	7520.0	4160	2293.33
1688.0	920	493.33	2858.0	1570	854.44	4028.0	2220	1215.56	5198.0	2870	1576.67	6368.0	3520	1937.78	7538.0	4170	2298.89
1706.0	930	498.89	2876.0	1580	860.00	4046.0	2230	1221.11	5216.0	2880	1582.22	6386.0	3530	1943.33	7556.0	4180	2304.44
1724.0	940	504.44	2894.0	1590	865.56	4064.0	2240	1226.67	5234.0	2890	1587.78	6404.0	3540	1948.89	7574.0	4190	2310.00

3.2 TC Tables and Charts

Table 3-2 Thermocouple Concept

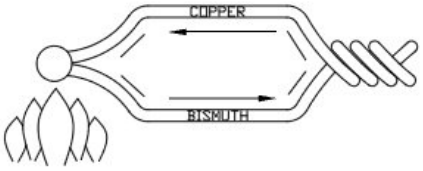
BASIC THERMOCOUPLE CONCEPT

Of all the primary measuring sensors, the thermocouple is perhaps the easiest to visualize. A thermocouple consists essentially of a pair of dissimilar conductors welded or fused together at one end to form the "hot" or measuring junction with the free ends available for connection to the "cold" or reference junction.

A temperature difference between the measuring and reference junctions must exist for this device to function as a thermocouple. When this occurs, small electromotive forces (emf's) are generated. These emf's originate at the "hot" junction as well as whenever there is a temperature gradient between parts of the same wire.

DISCOVERY OF THE THERMOCOUPLE

In early 1820, Thomas Seebeck searched experimentally for a relation between electricity and heat. In 1821, he joined two wires of dissimilar metals to form a loop or circuit. Connecting the ends of the wires to each other formed two junctions. He then accidentally discovered that if he heated one junction to a high temperature, and the other junction remained at a cooler temperature a magnetic field was observed around the circuit of different temperatures. This became known as the Seebeck Effect. It remains true of any pair of metals.

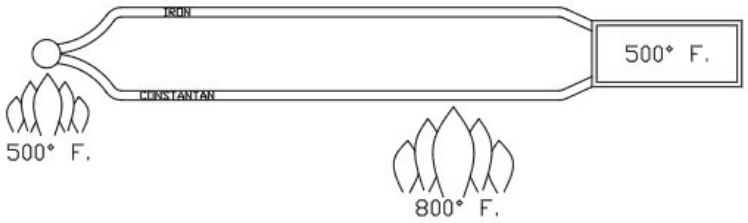


In 1834, French physicist Jean Peltier discovered that when electrical current is sent though a circuit made of dissimilar conducting materials that heat is absorbed at one junction and given up at the other, known as the Peltier Effect.

In 1851 W. Thompson (later Lord Kelvin) succeeded in showing that in certain homogeneous materials heat is absorbed when an electric current flows from colder to hotter parts of the metal and that the reverse is true when the current flows in the opposite direction. This is called the Thompson effect.

STATEMENT of LAWS

Many investigations of thermoelectric circuits have been made and have resulted in the establishment of several basic precepts. These precepts, while stated in many different ways, can be reduced to three fundamental laws.



LAW OF HOMOGENEOUS METALS

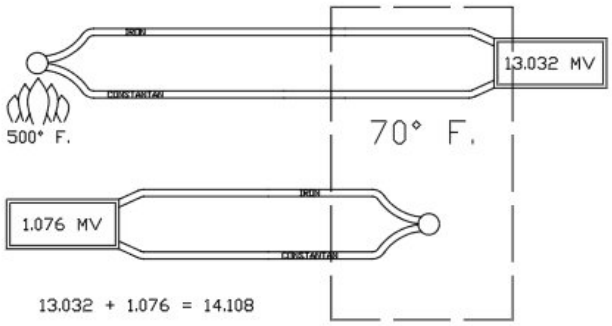
A thermoelectric current cannot be sustained in a circuit of a single homogeneous material, however varying in cross-section, by the application of heat alone.

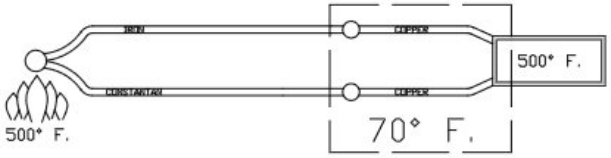
What it means: use thermocouple extension wire and connectors.

LAW OF INTERMEDIATE TEMPERATURES

The law states that the sum of the EMF's generated by two thermocouples, one with its junction at 32° F. and some reference temperature and the other with its junction at the same reference temperature and the measured temperature is equivalent to that EMF produced by a single thermocouple with its junction at 32° F.

What it means: cold junction compensation is easily controlled by instrumentation





LAW OF INTERMEDIATE METALS

Insertion of an intermediate metal into a thermocouple circuit will not affect the EMF voltage output as long as the two junctions are at the same temperatures.

What it means: standard copper or brass terminal blocks inside connection heads and junction boxes will have no adverse effect on accuracy.

The three fundamental laws combined and stated as follows: the algebraic sum of the thermoelectric EMF's generate in any given circuit containing any number of dissimilar homogenous metals is a function only of the temperature of the junction. If all but one of the junctions in such a circuit are maintained at some reference temperature, the EMF generated depends only on the temperature of that one junction and can be used as a measure of its temperature.

Thermocouple Concept

BASE METAL THERMOCOUPLES

Type J: Iron (+) vs Constantan (-), is the most commonly used calibration. It is suitable for use in a vacuum, inert, oxidizing with the iron leg protected or reducing atmosphere. If unprotected the iron wire may be attacked by ammonia, nitrogen and hydrogen atmospheres. In sub zero temperatures the iron wire may rust or become brittle. Type J should not be used in sulfurous atmospheres above 540°C.

Type T: Copper (+) vs Constantan (-), is commonly used for sub-zero to 700°F temperature. Preferred to Type J for sub-zero applications because of Copper's higher moisture resistance, as compared to iron. If unprotected, it will still function in a vacuum, inert, oxidizing or reducing atmosphere.

Type K: Chromel (+) vs Alumel (-) is generally used to measure high temperature to 2300°F. It should not be used for accurate temperature measurements below 900°F or after prolonged exposure above 1400°F. If unprotected it can be used only in inert or oxidizing atmospheres. It has a short life in alternately oxidizing and reducing atmospheres and in reducing atmospheres, particularly in the 1500 to 1850°F range.

Type E: CHROMEL (+) vs Constantan (-) has the highest EMF output of any standardized metallic thermocouple. If used unprotected, Type E wires are NOT subject to corrosion at sub-zero temperatures. They can be used in inert, oxidizing or reducing atmospheres. Because they cover a wide range with a single calibration curve, Type E thermocouples are preferred for computer applications.

Type N: Nicrosil (+) vs Nisil(-), was developed for oxidation resistance and EMF stability superior to those of Type K thermocouples at elevated temperatures. These couples have been shown to have a longer life, than Type K thermocouples, in both laboratories and industrial applications.

NOBLE METAL THERMOCOUPLES

Type S: Platinum-10% Rhodium (+) vs. Platinum (-). The Type S thermocouple is widely used in industrial laboratories as a standard for calibration of base metal thermocouples and other temperature sensing instruments.

Type R: Platinum-13% Rhodium (+) vs. Platinum (-). These thermoelements should always be protected from contamination by reduced oxides, metallic vapors or other oxides at high temperatures. Platinum protective sheaths are used at temperatures which preclude the use of base metal sheaths. Insulation should be silica free to prevent contamination. Type S is frequently used for calibration and checking. Type R has a slightly greater sensitivity and consequently is used more frequently in industrial applications.

Type B: Platinum-30% Rhodium (+) vs. Platinum-6% Rhodium (-). For use between 1000 and 3175°F. Intended to prevent the problems experienced with Types S and R such as: (1) weakening of the pure platinum leg due to excessive grain growth and (2) calibration shift due to the pure platinum wire picking up rhodium volatilized from the alloy wire at 1500°C. The flatness of the temperature-millivolt curve at normal reference junction ambient temperature permits the use of copper extension wire.

REFRACTORY THERMOCOUPLES

These thermoelements possesses excellent stability at temperatures in the 3000°F to 4000°F range. For use at high temperatures a protective atmosphere must be provided such as hydrogen, inert gas or vacuum. They are extremely sensitive to mechanical damage and should be handled carefully to prevent breakage.

Type W: Tungsten (+) vs. Tungsten-26% Rhenium (-). Also identified as letter code type G. This was an early stage thermocouple capable of measuring high temperature with reasonable accuracy. However, one serious drawback was the positive leg became embrittled. Extension lead wire used is an alloy type 200/226.

Type W5: Tungsten-5% Rhenium (+) vs. Tungsten-26% Rhenium (-). Also identified as letter code type C. Adding 5% rhenium to the positive leg improved the ductility and produces a higher EMF output Extension lead wire used is an alloy type 405/426.

Type W3: Tungsten-3% Rhenium (+) vs. Tungsten-25% Rhenium (-). Also identified as letter code type D. The W3 provides the same ductility as the W5 with the highest EMF output of all three. Extension lead wire used is an alloy type 203/225.

Table 3-3 Thermocouple Colour Codes

TYPE (Letter)	Conductor Material	POLARITY	U.S.A.	FRANCE	U.K.	GERMANY	JAPAN	IEC
J	Iron	+	Jacket: Black (+): White (-): Red	Jacket: Black (+): Yellow (-): Black	Jacket: Black (+): Yellow (-): Blue	Jacket: Blue (+): Red (-): Blue	Jacket: Yellow (+): Red (-): White	Jacket: Black (+): Black (-): White
	Constantan	−						
K	Chromel	+	Jacket: Yellow (+): Yellow (-): Red	Jacket: Yellow (+): Yellow (-): Purple	Jacket: Red (+): Brown (-): Blue	Jacket: Green (+): Red (-): Green	Jacket: Blue (+): Red (-): White	Jacket: Green (+): Green (-): White
	Alumel	−						
T	Copper	+	Jacket: Blue (+): Blue (-): Red	Jacket: Blue (+): Yellow (-): Blue	Jacket: Blue (+): White (-): Blue	Jacket: Brown (+): Red (-): Brown	Jacket: Brown (+): Red (-): White	Jacket: Brown (+): Brown (-): White
	Constantan	−						
E	Chromel	+	Jacket: Purple (+): Purple (-): Red	Jacket: Red (+): Yellow (-): Brown	Jacket: Brown (+): Brown (-): Blue	Jacket: Black (+): Red (-): Black	Jacket: Purple (+): Red (-): White	Jacket: Purple (+): Purple (-): White
	Constantan	−						
N	Nicrosil	+	Jacket: Orange (+): Orange (-): Red	Not Established	Jacket: Orange (+): Orange (-): Blue	Not Established	Not Established	Jacket: Pink (+): Pink (-): White
	NISIL	−						
R	Platinum 13% Rhodium	+	Jacket: Green (+): Black (-): Red	Jacket: Green (+): Yellow (-): Green	Jacket: Green (+): White (-): Blue	Jacket: White (+): Red (-): White	Jacket: Black (+): Red (-): White	Jacket: Orange (+): Orange (-): White
	Platinum	−						
S	Platinum 10% Rhodium	+	Jacket: Green (+): Black (-): Red	Jacket: Green (+): Yellow (-): Green	Jacket: Green (+): White (-): Blue	Jacket: White (+): Red (-): White	Jacket: Black (+): Red (-): White	Jacket: Orange (+): Orange (-): White
	Platinum	−						
B	Platinum 30% Rhodium	+	Jacket: Grey (+): Grey (-): Red	Not Established	Not Established	Jacket: Grey (+): Red (-): Grey	Jacket: Grey (+): Red (-): Grey	Not Established
	Platinum 6% Rhodium	−						

THERMOCOUPLE CONNECTOR COLOR CODE			
TYPE	ANSI	IEC	DIN
K	Yellow	Green	Green
J	Black	Black	N/A
L	N/A	N/A	Blue
T	Blue	Brown	Brown

THERMOCOUPLE CONNECTOR COLOR CODE			
TYPE	ANSI	IEC	DIN
R	Green	Orange	White
E	Purple	Purple	N/A
N	Orange	Pink	N/A
S	Green	Orange	White
B	Grey	Grey	Grey

(1) ISA color codes shown is for thermocouple extension grade wire. Thermocouple grade wire has a brown jacket in all calibrations.
(2) Compensating extension wire and connector pins (copper/alloy II) used with both R and S thermocouples.
(3) Compensating extension wire and connector pins (copper/copper) used with B thermocouples. Connector body is usually supplied white.

Table 3-4 Thermocouple Calibration

INITIAL CALIBRATION TOLERANCE Per ANSI MC96.1-1982 and ASTM E230
Reference Junction 0° C (32°F)

Thermocouple Type		Temperature Range		Standard Tolerance		Special Tolerance	
Standard	Special	°C	°F	°C(whichever is greater)	°F(whichever is greater)	°C(whichever is greater)	°F(whichever is greater)
J	JJ	0 to 760	32 to 1400	±2.2°C or ±0.75%	±4.0°F or ±0.75%	±1.1°C or ±0.4%	±2.0°F or ±0.4%
K and N	KK and NN	-200 to 0	-328 to 32	±2.2°C or ±2.0%	±4.0°F or ±2.0%		
		0 to 1260	32 to 2300	±2.2°C or ±0.75%	±4.0°F or ±0.75%	±1.1°C or ±0.4%	±2.0°F or ±0.4%
E	EE	-200 to 0	-328 to 32	±1.7°C or ±1.0%	±3.0°F or ±1.0%	±1.0°C or ±0.5%	±1.8°F or ±0.5%
		0 to 870	32 to 1600	±1.7°C or ±0.5%	±3.0°F or ±0.5%	±1.0°C or ±0.4%	±1.8°F or ±0.4%
T	TT	-200 to 0	-328 to 32	±1.0°C or ±1.5%	±1.8°F or ±1.5%	±0.5°C or ±0.8%	±0.9°F or ±0.8%
		0 to 370	32 to 700	±1.0°C or ±0.75%	±1.8°F or ±0.75%	±0.5°C or ±0.4%	±0.9°F or ±0.4%
R and S	RR and SS	0 to 1400	32 to 2700	±1.5°C or ±0.25%	±2.7°F or ±0.25%	±0.6°C or ±0.1%	±1.1°F or ±0.1%
B	BB	870 to 1700	1600 to 3100	±0.5%	0.5%	±0.25%	0.25%

Tolerances shown do not include system or installation error. Certain characteristics of thermocouple materials, including the EMF versus temperature relationship may change with time in use; consequently results and performance obtained at time of manufacture may not necessarily apply throughout an extended period of use. The magnitude of such changes will depend on such factors as size, temperature, temperature time of exposure and environment. Tolerances for temperatures below 0° C(32° F) may not fall within tolerance above zero. Temperature range should be specified when requesting thermocouples for sub zero applications.

PROPERTIES of THERMOCOUPLES

Type	Conductor		Composition	Conductor Identification	Melting Point	Recommended Service	Maximum Temperature
J	JP	Iron	Fe	Magnetic, May Have Copper Coating	2725° F(1496° C)	Oxidizing or Reducing	1400° F (760° C)
	JN	Constantan	55%CU, 44%Ni, 1%Mn	Non-Magnetic	2336° F(1280° C)		
K	KP	Chromel*	89.1%Ni, 10%Cr, 0.5%Si, 0.4%Fe	Non-Magnetic	2606° F(1430° C)	Oxidizing	2300° F (1260° C)
	KN	Alumel*	95%Ni, 5%MnAlSi	Magnetic	2552° F(1400° C)		
T	TP	Copper	Cu	Non-Magnetic, Copper Color	1981° F(1083° C)	Oxidizing or Reducing	700° F (370° C)
	TN	Constantan	55%CU, 44%Ni, 1%Mn	Non-Magnetic, Silver in Color	2336° F(1280° C)		
E	EP	Chromel*	89.1%Ni, 10%Cr, 0.5%Si, 0.4%Fe	Non-Magnetic	2606° F(1430° C)	Oxidizing	1600° F (870° C)
	EN	Constantan	55%CU, 44%Ni, 1%Mn	Non-Magnetic, Slightly Softer	2336° F(1280° C)		
N	NP	Nicrosil	84.6%Ni, 14%Cr, 1.4%Si	Non-Magnetic	2541° F(1394° C)	Oxidizing	2300° F (1260° C)
	NN	Nisil	95.6%Ni, 4.4%Si	Slightly Magnetic	2446° F(1341° C)		
R	RP	Platinum 13%Rhodium	87%Platinum 13%Rhodium		3380° F(1860° C)	Oxidizing or Inert	2700° F (1480° C)
	RN	Platinum	Platinum	Slightly Softer than the Positive Leg	3216° F(1769° C)		
S	SP	Platinum 10%Rhodium	90%Platinum 10%Rhodium		3362° F(1850° C)	Oxidizing or Inert	2700° F (1480° C)
	SN	Platinum	Platinum	Slightly Softer than the Positive Leg	3216° F(1769° C)		
B	BP	Platinum 30%Rhodium	70%Platinum 30%Rhodium		3501° F(1927° C)	Oxidizing Vacuum or Inert	3100° F (1700° C)
	BN	Platinum 6%Rhodium	94%Platinum 6%Rhodium	Slightly Softer than the Positive Leg	3319° F(1826° C)		

*Trademark of now defunct Hoskins Manufacturing Co.

REFRACTORY THERMOCOUPLES (Tungsten-Rhenium)

Type	Conductor		Temperature Range	Initial Calibration Tolerance	Melting Point	Operating Conditions
W	+	Tungsten	0 to 426°C (32 to 800°F)	±4.4°C or ±8.0°F	3410° C(6170° F)	Use in dry hydrogen, inert or vacuum atmospheres at temperatures up to 2760° F(1515° C) depending on insulation and sheath. W type most brittle when heated to 2200° F(1200° C). W_3 produces the highest EMF output above 2100° F(1149° C).
	—	Tungsten 26% Rhenium	426 to 2315°C (800 to 4200°F)	±1% of actual temperature	3120° C(5648° F)	
W_3	+	Tungsten 3% Rhenium	0 to 426°C (32 to 800°F)	±4.4°C or ±8.0°F	3360° C(6080° F)	
	—	Tungsten 25% Rhenium	426 to 2315°C (800 to 4200°F)	±1% of actual temperature	3120° C(5648° F)	
W_5	+	Tungsten 5% Rhenium	0 to 426°C (32 to 800°F)	±4.4°C or ±8.0°F	3350° C(6062° F)	
	—	Tungsten 26% Rhenium	426 to 2315°C (800 to 4200°F)	±1% of actual temperature	3120° C(5648° F)	

Trademark of now defunct Hoskins Manufacturing Co.
W_3 & W_5 reference tables per ASTM E 988. Type letter symbols not assigned by ASTM.

NON-STANDARD THERMOCOUPLES

Type	Conductor		Temperature Range	Recommended Service	Development
19/20	20	(+) 82%Ni - 18%Mo	32 to 2300° F (0 to 1260° C)	Hydrogen or Reducing	The type 19/20 sometimes referred to as Nickel/Nickel Moly, was developed by General Electric Research Lab for special high temperature applications.
	19	(-) 99%Ni - 1%Co			
Platinel I	+	83%Pd-14%Pt-3%Au	32 to 2480° F (0 to 1360° C)	Hydrogen, Inert or Oxidizing	Trademark of Engelhard Corporation, an all-noble metal combination demonstrates good corrosion resistance and stability at high temperatures with platinel II offering better fatigue properties. Platinel thermocouples EMF characteristics allows matching to type K extension leadwire and connectors.
	—	65%Au - 35%Pd			
Platinel II	+	55%Pd-31%Pt-14%Au	32 to 2480° F (0 to 1360° C)	Hydrogen, Inert or Oxidizing	
	—	65%Au - 35%Pd			
Iridium/Rh. vs Iridium	+	60%Iridium-40%Rh.	32 to 3812° F (0 to 2100° C)	Hydrogen or Vacuum	Generally used as for service at temperatures above the type R, S and B range. Iridium TC's also available in 50%Ir - 50%Rh. vs Ir, and 40%Ir.-60%Rh. vs Ir.
	—	Iridium			

Table 3-5 Thermocouple Millivolt Tables A-G

Thermocouple Millivolt Table A

Temperature (°F)	Type J	Type K	Type T	Type E	Type N	Type R	Type S	Type B	Type W	Type W3	Type W5
1600	50.060	36.166		66.559	31.242	8.837	8.127	3.717	11.725	15.624	15.851
1610	50.411	36.390		66.989	31.459	8.908	8.189	3.763			
1620	50.762	36.613		67.418	31.677	8.978	8.250	3.809	11.952	15.850	16.062
1630	51.112	36.836		67.846	31.894	9.049	8.312	3.855			
1640	51.460	37.059		68.274	32.111	9.120	8.375	3.901	12.179	16.076	16.271
1650	51.808	37.281		68.701	32.328	9.191	8.437	3.948			
1660	52.154	37.504		69.128	32.545	9.262	8.499	3.994	12.407	16.302	16.481
1670	52.500	37.725		69.554	32.761	9.333	8.562	4.041			
1680	52.844	37.947		69.979	32.978	9.404	8.624	4.089	12.635	16.527	16.689
1690	53.188	38.168		70.404	33.195	9.476	8.687	4.136			
1700		38.389		70.828	33.411	9.547	8.749	4.184	12.864	16.752	16.898
1710		38.610		71.252	33.627	9.619	8.812	4.232			
1720		38.830		71.675	33.844	9.691	8.875	4.280	13.094	16.976	17.105
1730		39.050		72.097	34.060	9.763	8.938	4.328			
1740		39.270		72.518	34.276	9.835	9.001	4.377	13.324	17.200	17.312
1750		39.489		72.939	34.491	9.908	9.065	4.426			
1760		39.708		73.360	34.707	9.980	9.128	4.475	13.555	17.424	17.519
1770		39.927		73.780	34.923	10.053	9.192	4.524			
1780		40.145		74.199	35.138	10.126	9.255	4.574	13.786	17.647	17.725
1790		40.363		74.618	35.353	10.198	9.319	4.623			
1800		40.581		75.036	35.568	10.271	9.382	4.673	14.018	17.870	17.930
1810		40.798		75.454	35.783	10.345	9.446	4.723			
1820		41.015		75.872	35.998	10.418	9.510	4.774	14.250	18.093	18.134
1830		41.232		76.289	36.213	10.491	9.574	4.824			
1840		41.449			36.427	10.565	9.638	4.875	14.482	18.315	18.339
1850		41.665			36.641	10.638	9.703	4.926			
1860		41.881			36.855	10.712	9.767	4.977	14.715	18.537	18.542
1870		42.096			37.069	10.786	9.831	5.028			
1880		42.311			37.283	10.860	9.896	5.080	14.948	18.758	18.745
1890		42.526			37.497	10.934	9.961	5.132			
1900		42.741			37.710	11.009	10.025	5.184	15.182	18.979	18.947
1910		42.955			37.923	11.083	10.090	5.236			
1920		43.169			38.136	11.158	10.155	5.288	15.415	19.199	19.148
1930		43.382			38.349	11.233	10.220	5.341			
1940		43.595			38.562	11.307	10.285	5.394	15.649	19.419	19.349
1950		43.808			38.774	11.382	10.350	5.447			
1960		44.020			38.986	11.457	10.416	5.500	15.884	19.638	19.549
1970		44.232			39.198	11.533	10.481	5.553			
1980		44.444			39.410	11.608	10.547	5.607	16.118	19.857	19.748
1990		44.655			39.622	11.683	10.612	5.661			
2000		44.866			39.833	11.759	10.678	5.715	16.353	20.075	19.947
2010		45.077			40.044	11.834	10.743	5.769			
2020		45.287			40.255	11.910	10.809	5.823	16.587	20.293	20.145
2030		45.497			40.466	11.986	10.875	5.878			
2040		45.706			40.677	12.062	10.941	5.932	16.822	20.510	20.343
2050		45.915			40.887	12.138	11.007	5.987			
2060		46.124			41.097	12.214	11.073	6.042	17.057	20.726	20.539
2070		46.332			41.307	12.291	11.139	6.098			
2080		46.540			41.516	12.367	11.205	6.153	17.292	20.943	20.735
2090		46.747			41.725	12.443	11.272	6.209			
2100		46.954			41.935	12.520	11.338	6.264	17.527	21.158	20.930
2110		47.161			42.143	12.597	11.404	6.320			
2120		47.367			42.352	12.673	11.471	6.377	17.762	21.373	21.125
2130		47.573			42.560	12.750	11.537	6.433			
2140		47.778			42.768	12.827	11.604	6.490	17.997	21.588	21.319
2150		47.983			42.976	12.904	11.670	6.546			
2160		48.187			43.184	12.981	11.737	6.603	18.232	21.802	21.512
2170		48.391			43.391	13.058	11.804	6.660			
2180		48.595			43.598	13.135	11.870	6.718	18.467	22.015	21.704
2190		48.798			43.805	13.213	11.937	6.775			
2200		49.000			44.012	13.290	12.004	6.833	18.701	22.228	21.896
2210		49.202			44.218	13.367	12.071	6.890			
2220		49.404			44.424	13.445	12.138	6.948	18.936	22.440	22.087
2230		49.605			44.629	13.522	12.205	7.006			
2240		49.806			44.835	13.600	12.272	7.065	19.170	22.651	22.277

Thermocouple Millivolt Table B

Temperature (°F)	Type J	Type K	Type T	Type E	Type N	Type R	Type S	Type B	Type W	Type W3	Type W5
2250		50.006			45.040	13.677	12.339	7.123			
2260		50.206			45.245	13.755	12.406	7.182	19.405	22.863	22.466
2270		50.405			45.449	13.833	12.473	7.240			
2280		50.604			45.653	13.911	12.540	7.299	19.639	23.073	22.655
2290		50.802			45.857	13.989	12.607	7.358			
2300		51.000			46.060	14.066	12.675	7.417	19.873	23.283	22.843
2310		51.198			46.263	14.144	12.742	7.477			
2320		51.395			46.466	14.222	12.809	7.536	20.106	23.492	23.030
2330		51.591			46.668	14.300	12.876	7.596			
2340		51.787			46.870	14.379	12.944	7.656	20.340	23.701	23.217
2350		51.982			47.071	14.457	13.011	7.716			
2360		52.177			47.272	14.535	13.078	7.776	20.573	23.909	23.403
2370		52.371			47.473	14.613	13.146	7.836			
2380		52.565				14.691	13.213	7.897	20.806	24.116	23.588
2390		52.759				14.770	13.280	7.957			
2400		52.952				14.848	13.348	8.018	21.038	24.323	23.772
2410		53.144				14.926	13.415	8.079			
2420		53.336				15.005	13.483	8.140	21.270	24.529	23.956
2430		53.528				15.083	13.550	8.201			
2440		53.719				15.161	13.617	8.262	21.502	24.735	24.138
2450		53.910				15.240	13.685	8.323			
2460		54.100				15.318	13.752	8.385	21.734	24.940	24.320
2470		54.289				15.397	13.820	8.446			
2480		54.479				15.475	13.887	8.508	21.965	25.145	24.502
2490		54.668				15.553	13.955	8.570			
2500		54.856				15.632	14.022	8.632	22.195	25.348	24.682
2510						15.710	14.089	8.694			
2520						15.789	14.157	8.756	22.425	25.551	24.862
2530						15.867	14.224	8.819			
2540						15.946	14.292	8.881	22.655	25.754	25.041
2550						16.024	14.359	8.944			
2560						16.103	14.426	9.006	22.884	25.956	25.219
2570						16.181	14.494	9.069			
2580						16.260	14.561	9.132	23.113	26.157	25.397
2590						16.338	14.629	9.195			
2600						16.417	14.696	9.258	23.341	26.358	25.574
2610						16.495	14.763	9.321			
2620						16.574	14.830	9.385	23.569	26.558	25.750
2630						16.652	14.898	9.448			
2640						16.731	14.965	9.511	23.796	26.757	25.925
2650						16.809	15.032	9.575			
2660						16.887	15.099	9.639	24.023	26.956	26.100
2670						16.966	15.166	9.702			
2680						17.044	15.233	9.766	24.249	27.154	26.274
2690						17.122	15.300	9.830			
2700						17.200	15.367	9.894	24.474	27.352	26.447
2710						17.279	15.434	9.958			
2720						17.357	15.501	10.022	24.699	27.548	26.619
2730						17.435	15.568	10.086			
2740						17.513	15.635	10.150	24.923	27.745	26.791
2750						17.591	15.702	10.215			
2760						17.669	15.769	10.279	25.146	27.940	26.962
2770						17.747	15.835	10.344			
2780						17.825	15.902	10.408	25.369	28.135	27.132
2790						17.903	15.969	10.473			
2800						17.981	16.035	10.537	25.591	28.329	27.301
2810						18.059	16.102	10.602			
2820						18.137	16.168	10.666	25.812	28.523	27.470
2830						18.214	16.235	10.731			
2840						18.292	16.301	10.796	26.033	28.715	27.637
2850						18.369	16.367	10.861			
2860						18.447	16.434	10.925	26.253	28.908	27.805
2870						18.524	16.500	10.990			
2880						18.602	16.566	11.055	26.472	29.099	27.971
2890						18.679	16.632	11.120			

Thermocouple Millivolt Table C

Temperature (°F)	Type J	Type K	Type T	Type E	Type N	Type R	Type S	Type B	Type W	Type W3	Type W5
2900						18.756	16.698	11.185	26.690	29.290	28.137
2910						18.834	16.764	11.250			
2920						18.911	16.829	11.315	26.907	29.480	28.301
2930						18.988	16.895	11.380			
2940						19.065	16.961	11.445	27.124	29.669	28.466
2950						19.141	17.026	11.510			
2960						19.218	17.092	11.575	27.340	29.858	28.629
2970						19.295	17.157	11.640			
2980						19.372	17.223	11.705	27.555	30.046	28.791
2990						19.448	17.288	11.770			
3000						19.525	17.353	11.835	27.769	30.233	28.953
3010						19.601	17.418	11.900			
3020						19.677	17.483	11.965	27.983	30.419	29.114
3030						19.753	17.548	12.030			
3040						19.829	17.613	12.095	28.195	30.605	29.275
3050						19.905	17.678	12.160			
3060						19.981	17.742	12.225	28.407	30.790	29.434
3070						20.056	17.807	12.290			
3080						20.132	17.871	12.355	28.618	30.974	29.593
3090						20.207	17.935	12.420			
3100						20.281	17.998	12.484	28.827	31.158	29.751
3110						20.356	18.061	12.549			
3120						20.430	18.124	12.614	29.036	31.340	29.908
3130						20.503	18.187	12.679			
3140						20.576	18.248	12.743	29.244	31.522	30.065
3150						20.649	18.310	12.808			
3160						20.721	18.371	12.872	29.451	31.703	30.221
3170						20.792	18.431	12.937			
3180						20.863	18.491	13.001	29.657	31.884	30.376
3190						20.933	18.551	13.066			
3200						21.003	18.609	13.130	29.862	32.063	30.530
3210						21.071	18.667	13.194			
3220								13.259	30.068	32.242	30.683
3230								13.323			
3240								13.387	30.269	32.420	30.836
3250								13.451			
3260								13.515	30.471	32.596	30.988
3270								13.579			
3280								13.642	30.672	32.772	31.139
3290								13.706			
3300								13.769	30.871	32.948	31.289
3310											
3320									31.070	33.122	31.438
3330											
3340									31.268	33.295	31.587
3350											
3360									31.464	33.467	31.735
3370											
3380									31.660	33.639	31.882
3390											
3400									31.854	33.809	32.028
3410											
3420									32.047	33.979	32.173
3430											
3440									32.240	34.147	32.318
3450											
3460									32.430	34.314	32.461
3470											
3480									32.620	34.481	32.604
3490											
3500									32.809	34.646	32.746
3510											
3520									32.996	34.810	32.887
3530											
3540									33.182	34.973	33.027

Thermocouple Millivolt Table D

Temperature (°F)	Type J	Type K	Type T	Type E	Type N	Type R	Type S	Type B	Type W	Type W3	Type W5
3550											
3560									33.367	35.135	33.166
3570											
3580									33.551	35.295	33.305
3590											
3600									33.733	35.455	33.442
3610											
3620									33.914	35.613	33.579
3630											
3640									34.094	35.770	33.714
3650											
3660									34.273	35.926	33.849
3670											
3680									34.450	36.080	33.982
3690											
3700									34.626	36.233	34.115
3710											
3720									34.801	36.384	34.247
3730											
3740									34.974	36.535	34.378
3750											
3760									35.146	36.683	34.507
3770											
3780									35.317	36.831	34.636
3790											
3800									35.486	36.976	34.763
3810											
3820									35.654	37.120	34.890
3830											
3840									35.821	37.263	35.015
3850											
3860									35.986	37.404	35.140
3870											
3880									36.150	37.543	35.263
3890											
3900									36.312	37.681	35.385
3910											
3920									36.473	37.816	35.506
3930											
3940									36.632	37.950	35.626
3950											
3960									36.790	38.082	35.744
3970											
3980									36.946	38.213	35.862
3990											
4000									37.101	38.341	35.978
4010											
4020									37.853	38.467	36.093
4030											
4040									37.998	38.591	36.206
4050											
4060									38.142	38.714	36.319
4070											
4080									38.285	38.834	36.430
4090											
4110									38.425	38.951	36.539
4120											
4130									38.564	39.067	36.647
4140											
4150										39.180	36.754
4160											
4170										39.291	.XXXX
4180											
4190										39.400	.XXXX
4200											

Thermocouple Millivolt Table E

Temperature (°F)	Type J	Type K	Type T	Type E	Type N	Type R	Type S	Type B	Type W	Type W3	Type W5
-340	-8.030	-5.989	-5.705	-8.986	-4.054						
-330	-7.915	-5.908	-5.620	-8.852	-4.001						
-320	-7.791	-5.822	-5.532	-8.710	-3.945						
-310	-7.659	-5.730	-5.439	-8.561	-3.884						
-300	-7.519	-5.632	-5.341	-8.404	-3.820						
-290	-7.373	-5.529	-5.240	-8.240	-3.752						
-280	-7.219	-5.421	-5.135	-8.069	-3.679						
-270	-7.058	-5.308	-5.025	-7.891	-3.604						
-260	-6.890	-5.190	-4.912	-7.707	-3.524						
-250	-6.716	-5.067	-4.794	-7.516	-3.441						
-240	-6.536	-4.939	-4.673	-7.319	-3.354						
-230	-6.351	-4.806	-4.548	-7.116	-3.264						
-220	-6.159	-4.669	-4.419	-6.907	-3.171						
-210	-5.962	-4.527	-4.286	-6.692	-3.074						
-200	-5.760	-4.381	-4.149	-6.472	-2.974						
-190	-5.553	-4.246	-4.009	-6.246	-2.871						
-180	-5.341	-4.091	-3.865	-6.014	-2.765						
-170	-5.125	-3.933	-3.717	-5.777	-2.658						
-160	-4.903	-3.771	-3.565	-5.535	-2.544						
-150	-4.678	-3.604	-3.410	-5.287	-2.430						
-140	-4.449	-3.434	-3.251	-5.035	-2.313						
-130	-4.215	-3.260	-3.089	-4.777	-2.193						
-120	-3.978	-3.083	-2.923	-4.515	-2.072						
-110	-3.737	-2.902	-2.754	-4.248	-1.947						
-100	-3.493	-2.718	-2.581	-3.976	-1.821						
-90	-3.245	-2.530	-2.405	-3.700	-1.692						
-80	-2.994	-2.339	-2.225	-3.420	-1.562						
-70	-2.740	-2.146	-2.043	-3.135	-1.430						
-60	-2.483	-1.949	-1.857	-2.846	-1.296						
-50	-2.223	-1.749	-1.667	-2.552	-1.160	-0.210	-0.218				
-40	-1.961	-1.547	-1.475	-2.255	-1.023	-0.188	-0.194				
-30	-1.695	-1.343	-1.279	-1.953	-0.884	-0.165	-0.170				
-20	-1.428	-1.135	-1.081	-1.648	-0.744	-0.141	-0.145				
-10	-1.158	-0.926	-0.879	-1.339	-0.603	-0.116	-0.119				
0	-0.886	-0.714	-0.675	-1.026	-0.461	-0.090	-0.092				
0	-0.886	-0.692	-0.675	-1.026	-0.461	-0.090	-0.092				
10	-0.611	-0.478	-0.467	-0.709	-0.318	-0.063	-0.064				
20	-0.334	-0.044	-0.256	-0.389	-0.174	-0.035	-0.035				
30	-0.056	0.176	-0.043	-0.065	-0.029	-0.006	-0.006				
40	0.225	0.397	0.173	0.262	0.116	0.024	0.024	-0.001			
50	0.507	0.397	0.391	0.591	0.261	0.054	0.055	-0.002			
60	0.791	0.619	0.611	0.924	0.407	0.086	0.087	-0.002			
70	1.076	0.843	0.834	1.259	0.555	0.118	0.119	-0.003			
80	1.364	1.068	1.060	1.597	0.703	0.151	0.153	-0.002			
90	1.652	1.294	1.288	1.938	0.853	0.184	0.186	-0.002			
100	1.942	1.521	1.519	2.281	1.004	0.218	0.221	-0.001	0.079	0.390	0.522
110	2.234	1.749	1.752	2.628	1.156	0.254	0.256	0.000			
120	2.527	1.977	1.988	2.977	1.309	0.289	0.292	0.002	0.113	0.515	0.682
130	2.821	2.207	2.227	3.330	1.463	0.326	0.328	0.004			
140	3.116	2.436	2.468	3.685	1.619	0.363	0.365	0.006	0.153	0.644	0.845
150	3.412	2.667	2.712	4.042	1.776	0.400	0.402	0.009			
160	3.709	2.897	2.958	4.403	1.934	0.439	0.440	0.012	0.197	0.778	1.010
170	4.007	3.128	3.207	4.766	2.093	0.478	0.479	0.015			
180	4.306	3.359	3.459	5.131	2.253	0.517	0.518	0.019	0.246	0.916	1.178
190	4.606	3.590	3.712	5.500	2.415	0.557	0.557	0.023			
200	4.907	3.820	3.968	5.871	2.577	0.598	0.597	0.027	0.299	1.058	1.348
210	5.209	4.050	4.227	6.244	2.741	0.639	0.638	0.032			
220	5.511	4.280	4.487	6.620	2.906	0.681	0.679	0.037	0.357	1.204	1.520
230	5.814	4.509	4.750	6.998	3.072	0.723	0.720	0.043			
240	6.117	4.738	5.015	7.379	3.240	0.766	0.762	0.049	0.420	1.354	1.695
250	6.421	4.965	5.282	7.762	3.408	0.809	0.804	0.055			
260	6.726	5.192	5.551	8.147	3.578	0.853	0.847	0.061	0.487	1.507	1.872
270	7.031	5.419	5.823	8.535	3.748	0.897	0.889	0.068			
280	7.336	5.644	6.096	8.924	3.920	0.941	0.933	0.075	0.559	1.664	2.051
290	7.642	5.869	6.371	9.316	4.093	0.986	0.977	0.083			

Thermocouple Millivolt Table F

Temperature (°F)	Type J	Type K	Type T	Type E	Type N	Type R	Type S	Type B	Type W	Type W3	Type W5
300	7.949	6.094	6.648	9.710	4.267	1.032	1.021	0.090	0.634	1.824	2.232
310	8.255	6.317	6.928	10.106	4.442	1.078	1.065	0.099			
320	8.562	6.540	7.209	10.504	4.618	1.124	1.110	0.107	0.714	1.988	2.415
330	8.869	6.763	7.492	10.903	4.795	1.171	1.155	0.116			
340	9.177	6.985	7.777	11.305	4.973	1.218	1.200	0.125	0.799	2.154	2.600
350	9.485	7.207	8.064	11.708	5.152	1.265	1.246	0.135			
360	9.793	7.429	8.352	12.113	5.332	1.313	1.292	0.145	0.887	2.324	2.786
370	10.101	7.650	8.643	12.520	5.512	1.361	1.338	0.155			
380	10.409	7.872	8.935	12.929	5.694	1.410	1.385	0.165	0.979	2.497	2.975
390	10.717	8.094	9.229	13.339	5.877	1.459	1.431	0.176			
400	11.025	8.316	9.525	13.751	6.060	1.508	1.478	0.187	1.075	2.673	3.165
410	11.334	8.539	9.882	14.164	6.245	1.558	1.526	0.199			
420	11.642	8.761	10.122	14.579	6.430	1.607	1.573	0.211	1.175	2.851	3.357
430	11.951	8.985	10.423	14.995	6.616	1.658	1.621	0.223			
440	12.260	9.208	10.725	15.413	6.803	1.708	1.669	0.235	1.279	3.032	3.551
450	12.568	9.432	11.029	15.831	6.991	1.759	1.718	0.248			
460	12.877	9.657	11.335	16.252	7.179	1.810	1.766	0.261	1.387	3.216	3.746
470	13.185	9.882	11.643	16.673	7.369	1.861	1.815	0.275			
480	13.494	10.108	11.951	17.096	7.559	1.913	1.864	0.288	1.498	3.402	3.942
490	13.802	10.334	12.262	17.520	7.750	1.965	1.913	0.303			
500	14.110	10.561	12.574	17.945	7.941	2.017	1.962	0.317	1.613	3.590	4.140
510	14.418	10.789	12.887	18.371	8.134	2.070	2.012	0.332			
520	14.727	11.017	13.202	18.798	8.327	2.122	2.062	0.347	1.731	3.781	4.339
530	15.035	11.245	13.518	19.227	8.520	2.175	2.111	0.362			
540	15.343	11.474	13.836	19.656	8.715	2.229	2.162	0.378	1.853	3.973	4.540
550	15.650	11.703	14.155	20.086	8.910	2.282	2.212	0.394			
560	15.958	11.933	14.476	20.517	9.105	2.336	2.262	0.411	1.978	4.168	4.742
570	16.266	12.163	14.797	20.950	9.302	2.390	2.313	0.427			
580	16.573	12.393	15.121	21.383	9.499	2.444	2.364	0.444	2.106	4.365	4.945
590	16.881	12.624	15.445	21.817	9.696	2.498	2.415	0.462			
600	17.188	12.855	15.771	22.252	9.895	2.553	2.466	0.479	2.238	4.564	5.149
610	17.495	13.086	16.098	22.687	10.093	2.608	2.517	0.497			
620	17.802	13.318	16.426	23.124	10.293	2.663	2.568	0.516	2.373	4.765	5.354
630	18.109	13.549	16.756	23.561	10.493	2.718	2.620	0.534			
640	18.416	13.782	17.086	23.999	10.693	2.773	2.672	0.553	2.511	4.967	5.560
650	18.722	14.014	17.418	24.437	10.894	2.829	2.723	0.572			
660	19.029	14.247	17.752	24.876	11.096	2.885	2.775	0.592	2.652	5.171	5.757
670	19.336	14.479	18.086	25.316	11.298	2.941	2.827	0.612			
680	19.642	14.713	18.422	25.757	11.501	2.997	2.880	0.632	2.796	5.337	5.975
690	19.949	14.946	18.759	26.198	11.704	3.054	2.932	0.653			
700	20.255	15.179	19.097	26.640	11.907	3.110	2.985	0.673	2.943	5.584	6.184
710	20.561	15.413	19.437	27.082	12.111	3.167	3.037	0.694			
720	20.868	15.647	19.777	27.525	12.316	3.224	3.090	0.716	3.093	5.793	6.394
730	21.174	15.881	20.118	27.969	12.521	3.281	3.143	0.738			
740	21.480	16.116	20.460	28.413	12.726	3.339	3.196	0.760	3.246	6.003	6.604
750	21.787	16.350	20.803	28.857	12.932	3.396	3.249	0.782			
760	22.093	16.585		29.302	13.139	3.454	3.302	0.805	3.401	6.214	6.815
770	22.400	16.820		29.747	13.346	3.512	3.355	0.828			
780	22.706	17.055		30.193	13.553	3.570	3.409	0.851	3.559	6.427	7.027
790	23.013	17.290		30.639	13.760	3.628	3.462	0.875			
800	23.320	17.526		31.086	13.969	3.686	3.516	0.898	3.720	6.640	7.240
810	23.627	17.761		31.533	14.177	3.745	3.570	0.923			
820	23.934	17.997		31.980	14.386	3.803	3.623	0.947	3.884	6.855	7.453
830	24.241	18.233		32.427	14.595	3.862	3.677	0.972			
840	24.549	18.469		32.875	14.804	3.921	3.731	0.997	4.049	7.071	7.667
850	24.856	18.705		33.323	15.014	3.980	3.786	1.022			
860	25.164	18.941		33.772	15.225	4.040	3.840	1.048	4.216	7.288	7.881
870	25.473	19.177		34.220	15.435	4.099	3.894	1.074			
880	25.781	19.414		34.669	15.646	4.159	3.949	1.100	4.389	7.506	8.095
890	26.090	19.650		35.118	15.857	4.219	4.003	1.127			
900	26.400	19.887		35.567	16.069	4.279	4.058	1.154	4.562	7.725	8.310
910	26.710	20.123		36.016	16.281	4.339	4.113	1.181			
920	27.020	20.360		36.466	16.493	4.399	4.167	1.208	4.737	7.945	8.526
930	27.330	20.597		36.915	16.705	4.459	4.222	1.236			
940	27.642	20.834		37.365	16.918	4.520	4.277	1.264	4.915	8.165	8.741

Thermocouple Millivolt Table G

Temperature (°F)	Type J	Type K	Type T	Type E	Type N	Type R	Type S	Type B	Type W	Type W3	Type W5
950	27.953	21.071		37.815	17.131	4.580	4.332	1.293			
960	28.266	21.308		38.265	17.344	4.641	4.388	1.321	5.095	8.386	8.957
970	28.579	21.544		38.714	17.558	4.702	4.443	1.350			
980	28.892	21.781		39.164	17.772	4.763	4.498	1.379	5.277	8.606	9.174
990	29.206	22.018		39.614	17.986	4.824	4.554	1.409			
1000	29.521	22.255		40.064	18.200	4.886	4.610	1.439	5.461	8.830	9.390
1010	29.836	22.492		40.513	18.414	4.947	4.665	1.469			
1020	30.153	22.729		40.963	18.629	5.009	4.721	1.499	5.647	9.053	9.607
1030	30.470	22.966		41.412	18.844	5.071	4.777	1.530			
1040	30.788	23.203		41.862	19.059	5.133	4.833	1.561	5.836	9.277	9.824
1050	31.106	23.439		42.311	19.274	5.195	4.889	1.592			
1060	31.426	23.676		42.760	19.490	5.257	4.945	1.624	6.026	9.501	10.041
1070	31.746	23.913		43.209	19.705	5.320	5.001	1.655			
1080	32.068	24.149		43.658	19.921	5.382	5.058	1.687	6.218	9.726	10.258
1090	32.390	24.386		44.107	20.137	5.445	5.114	1.720			
1100	32.713	24.622		44.555	20.353	5.508	5.171	1.752	6.412	9.951	10.475
1110	33.037	24.858		45.004	20.570	5.571	5.227	1.785			
1120	33.363	25.094		45.452	20.786	5.634	5.284	1.818	6.607	10.176	10.693
1130	33.689	25.330		45.900	21.003	5.697	5.341	1.852			
1140	34.016	25.566		46.347	21.220	5.761	5.398	1.886	6.805	10.402	10.910
1150	34.345	25.802		46.794	21.437	5.824	5.455	1.920			
1160	34.674	26.037		47.241	21.654	5.888	5.512	1.954	7.004	10.628	11.127
1170	35.005	26.273		47.688	21.871	5.952	5.569	1.988			
1180	35.337	26.508		48.135	22.088	6.016	5.627	2.023	7.205	10.854	11.344
1190	35.670	26.743		48.581	22.305	6.080	5.684	2.058			
1200	36.004	26.978		49.027	22.523	6.144	5.741	2.094	7.407	11.080	11.561
1210	36.339	27.213		49.472	22.740	6.209	5.799	2.129			
1220	36.675	27.447		49.917	22.958	6.273	5.857	2.165	7.611	11.307	11.778
1230	37.013	27.681		50.362	23.176	6.338	5.915	2.201			
1240	37.352	27.915		50.807	23.393	6.403	5.972	2.237	7.816	11.534	11.995
1250	37.692	28.149		51.251	23.611	6.468	6.030	2.274			
1260	38.033	28.383		51.695	23.829	6.533	6.089	2.311	8.023	11.761	12.212
1270	38.375	28.616		52.138	24.047	6.598	6.147	2.348			
1280	38.718	28.849		52.581	24.265	6.664	6.205	2.385	8.232	11.988	12.429
1290	39.063	29.082		53.024	24.483	6.730	6.264	2.423			
1300	39.408	29.315		53.466	24.701	6.795	6.322	2.461	8.441	12.215	12.645
1310	39.755	29.548		53.908	24.919	6.861	6.381	2.499			
1320	40.103	29.780		54.350	25.137	6.927	6.439	2.538	8.652	12.443	12.861
1330	40.452	30.012		54.791	25.356	6.994	6.498	2.576			
1340	40.801	30.243		55.232	25.574	7.060	6.557	2.615	8.865	12.670	13.077
1350	41.152	30.475		55.673	25.792	7.126	6.616	2.654			
1360	41.504	30.706		56.113	26.010	7.193	6.675	2.694	9.078	12.897	13.292
1370	41.856	30.937		56.553	26.229	7.260	6.735	2.734			
1380	42.210	31.167		56.992	26.447	7.327	6.794	2.774	9.293	13.125	13.508
1390	42.564	31.398		57.431	26.665	7.394	6.853	2.814			
1400	42.919	31.628		57.870	26.883	7.461	6.913	2.854	9.509	13.352	13.723
1410	43.274	31.857		58.308	27.102	7.529	6.973	2.895			
1420	43.631	32.087		58.746	27.320	7.596	7.032	2.936	9.726	13.579	13.937
1430	43.988	32.316		59.184	27.538	7.664	7.092	2.978			
1440	44.346	32.545		59.621	27.756	7.732	7.152	3.019	9.945	13.807	14.152
1450	44.705	32.774		60.058	27.975	7.800	7.212	3.061			
1460	45.064	33.002		60.494	28.193	7.868	7.273	3.103	10.164	14.034	14.366
1470	45.423	33.230		60.930	28.411	7.936	7.333	3.145			
1480	45.782	33.458		61.366	28.629	8.005	7.393	3.188	10.384	14.262	14.579
1490	46.141	33.685		61.801	28.847	8.073	7.454	3.230			
1500	46.500	33.912		62.236	29.065	8.142	7.514	3.273	10.606	14.489	14.792
1510	46.858	34.139		62.670	29.283	8.211	7.575	3.317			
1520	47.216	34.365		63.104	29.501	8.280	7.636	3.360	10.828	14.717	15.005
1530	47.574	34.591		63.538	29.719	8.349	7.697	3.404			
1540	47.931	34.817		63.971	29.937	8.418	7.758	3.448	11.051	14.944	15.217
1550	48.288	35.043		64.403	30.154	8.488	7.819	3.492			
1560	48.644	35.268		64.835	30.372	8.557	7.881	3.537	11.275	15.171	15.429
1570	48.999	35.493		65.267	30.590	8.627	7.942	3.581			
1580	49.353	35.718		65.698	30.807	8.697	8.003	3.626	11.500	15.398	15.640
1590	49.707	35.942		66.129	31.025	8.767	8.065	3.672			

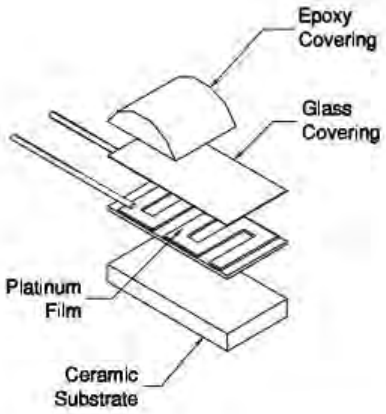
3.3 RTD Tables and Charts

Table 3-6 RTD Circuitry

Resistance Temperature Detector (RTD) elements are normally constructed of platinum, copper, nickel or nickel/iron. They operate as a positive temperature coefficient device when an excitation voltage is applied to convert changes in temperature to voltage signals by the measurement of resistance. The metals have the properties necessary for use in RTD elements due to their resistance to temperature characteristics that increase in resistance as temperature increases and, conversely, decrease in resistance as temperature decreases. These metals are best suited for RTD applications because of their linear resistance-temperature characteristics, their high coefficient of resistance, and their ability to withstand repeated temperature cycles. The change in electrical resistance to temperature for a material is termed the " temperature coefficient of resistance"

Thermo Electric uses two types of RTD, the wire wound and the thin film.

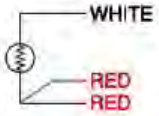
Wire wound design uses helical coil of very small platinum sensing wire of known alpha value. This coil is then slid into a ceramic insulator. Larger extension leads are spot welded to the ends of the platinum wire and cemented in place. Another construction is an outer winding of the platinum around a center mandrel usually made of ceramic. This winding is then coated with glass as a means of securing the windings. Wire wound elements are available in a number of materials and suitable for a wider temperature range.



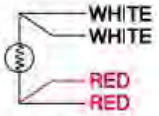
Thin film sensing elements are manufactured with a thin layer of platinum deposited on to a ceramic substrate. The platinum film is laser cut or chemical etched to achieve the desired resistance path. The element is then coated with a thin layer of glass for protection.
Lead wires are welded to the platinum with epoxy applied to hold the lead wires in place. Thin film elements are lower in cost than wire wound and faster in response time.

RTD's are available in two, three and four wire configuration. Selection of the lead wire configuration is usually based on the instrumentation, desired accuracy and stability.

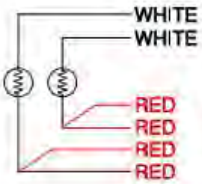
Two wire RTD: One lead wire is attached to each side of the element. This is the least accurate due to the inability to compensate for lead length resistance.



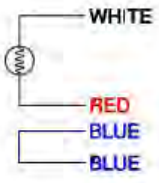
Three wire RTD: This is the most commonly used configuration. By adding a third lead to one end of the sensing element instrumentation can detect and compensate for lead resistance.



Four wire RTD: Four wire provide for the most accurate method of RTD measurement. A constant current is carried through two leads with the remaining two used to measure the voltage drop.



Duplex RTD: RTD's are available in duplex construction in any of the wire configurations. With wire wound bulbs two sets of windings are used. In thin film, two elements are set in place side-by-side. The second element may be used as a spare, testing purposes or connection to a second instrument. In most of Thermo Electric ordering codes a "D" is added to the prefix to denote duplex construction.



Compensating Loop RTD: A compensating loop is an extra pair of lead wires that have the same resistance as the actual lead wires but which are not connected to the RTD element. Its purpose is to correct for lead wire resistance errors when making temperature measurement.

RTD Circuitry

Temperature Coefficient and Sensitivity of RTD's

The best RTD for a given application meets the temperature range required and delivers the performance and cost requirements expected. All RTDs are specified by both a base resistance and the Temperature Coefficient of Resistance (TCR) or Alpha, expressed as Ω/Ω/°C. The base resistance is usually the ice point, the most common exception is Copper which is specified as 10 Ω at 25°C. The TCR is the RTD's Resistance change from 0 too 100°C, divided by the resistance at 0°C, divided by 100°C. The following is the formula used to calculate TCR.

$$TCR\ (\Omega/\Omega/°C) = \frac{R100°C - R0°C}{R0°C \times R100°C}$$

$$R = 200\ ft. \times 0.0103\ \Omega/ft. = 2.06\Omega$$

Approximate Error

$$E = \frac{2.06\Omega}{0.385\ \Omega/°C} = 5.35°C$$

The most common and important use of TCR is in specifying the curves for Platinum RTDs. It is important that the TCR be matched properly when replacing RTDs or connecting them to instrumentation or erroneous readings will result . The most popular RTD used in most applications is a 100 U+03A9 with a TCR of 0.00385. Sensitivity of an RTD is the value of the TCR multiplied by R0°C and is therefore a function of the base resistance and TCR. Sensitivity is expressed as Ω/°C. Since an RTD is a resistance type sensor any variable that can alter the resistance between the RTD and the control instrument will add to the reading. Therefore, the length of the lead wires can alter the readings. Since, the copper in lead wire changes resistance with changing ambient temperatures, the resistance is not constant. Lead wire error can be calculated by multiplying the total length of the lead wire, in feet, by the resistance value per foot of the wire gauge used at a given temperature. This figure is then divided by the sensitivity value to obtain an error figure. Lead wire errors can be significant when using small gauge wires or elements with low sensitivity. Example: A two wire 100 Ω Platinum RTD has a sensitivity value of 0.385 W°C. Leadwires are 100 feet, 20 gauge copper wire with a resistance value of 0.0103

Available RTD Elements

The most commonly used element material is the standard platinum with a resistance of 100 ohms at 0°C and a temperature coefficient of resistance of 0.00385 ohms/ohms/°C. Other types of RTDs are available from Thermo Electric. Below is a listing for some of the other element types that we supply.

ELEMENT MATERIAL	NOMINAL RESISTANCE	TEMPERATURE COEFFICIENT OHMS/OHM/° C	RELATED STANDARDS
PLATINUM	50 Ohms @ 0° C	0.003916	JIS C1604-1997, US STANDARD*
PLATINUM	98.129 Ohms @ 0° C	0.003923	SAMA RC21-4-1966
PLATINUM	100 Ohms @ 0° C	0.00385	ASTM-1137, IEC-60751, DIN 43760, ITS-90 BS EN 60751:1998(Replaces BS 1904:1984)
PLATINUM	100 Ohms @ 0° C	0.003916	JIS C1604-1997, US STANDARD*
PLATINUM	100 Ohms @ 0° C	0.003902	US STANDARD*
PLATINUM	130 Ohms @ 0° C	0.003900	BS 2G 148 (British Aircraft Industry)
PLATINUM	200 Ohms @ 0° C	0.00385	DIN 43760
PLATINUM	500 Ohms @ 0° C	0.00385	DIN 43760
PLATINUM	1000 Ohms @ 0° C	0.00385	DIN 43760
NICKEL	100 Ohms @ 0° C	0.00617	DIN 43760
NICKEL	120 Ohms @ 0° C	0.00672	Edison No. 7
NICKEL/IRON	604 Ohms @ 0° C	0.00518	N/A
COPPER	10 Ohms @ 25° C	0.00427	Edison No. 15

*No document exists for US Standard.

RTD Circuitry

RTD Stability: Stability is a RTD ability to maintain its specified resistance to temperature characteristic over long periods of time while being operated within its specified temperature limits. Often refered to as long term stability is the ability of the element to maintain its initial accuracy over an extended period of time. Most RTD's are stable to less than 0.05°C per year. However, stability is also affected by the environment, vibration, thermal shock and mechanical abuse it may be subject to.

RTD Interchangeability: Interchangeability is the measure of the variable based on tolerance and temperature coefficient from element to element. RTD's allow for easier interchangeability since their original variation is much lower than that of thermocouples.

Insulation Resistance: RTD's are insulated with MgO or insulated lead wire which is then sealed in a stainless steel tube. To prevent a shunting effect between the sensing element and the tube, care must be taken to assure no contamination or moisture absorption is present to cause any potential problems.

Repeatability: Repeatability of the element is defined as the relationship of the original resistance at 0°C and any different resistance at 0°C after being subjected to the following test. The sensor shall be brought slowly to the upper limits of its temperature range and then exposed to air at room temperature. It shall then be brought slowly to its lower limit, and exposed to air at room temperature. This procedure is repeated ten times. The resistance of 0°C is then measured and the difference from the pretesting resistance at 0°C is noted. For a typical platinum probe, the resistance should not change more than 0.3°C for a 0.12 % sensor or 0.15°C for a 0.06% sensor. The 0.12% and 0.06% are original resistance tolerances at 0°C of the element.

Self Heating: To measure resistance, it is necessary to pass a current through the element. The voltage drop across fine wire of a wire wound or thin coating of a thin film will tend to heat the element, this is known as Joule heating. To prevent this self heating RTD's are specified to have a current applied of 1 mA or less. (Self Heating: 0.01 °C/mW in still liquid)

Vibration: Damage to the weld joints caused by excessive vibration can cause erratic readings or complete failure. All styles of Thermo Electric RTD's were tested and passed in accordance with IEC 60751 over a frequency range of 10 to 500Hz with a forcing acceleration of 20m/s² to 30m/s² peak-to-peak.

Response Time: Thermal response time is the time necessary for an RTD to reach 63.2 % step change of temperature and reach the resistance corresponding to some specified fraction of the total temperature change. Table to the right shows typical performance of the time constant in moving water at 3FT/sec.

SHEATH DIAMETER	TIME
.125" (3.2mm)	1.5 seconds
.188" (4.8mm)	3.0 seconds
.25" (6.4mm)	3.0 seconds

Callendar Van Dusen Founded by British physicist Hugh Longbourne Callendar, and refined by M. S. Van Dusen. The Callendar-Van Dusen equation is an equation that describes the relationship between resistance (R) and temperature (t) of platinum. The Callendar Van Dusen equation analytically addresses the tolerance and accuracy of a platinum RTD at any point within its operation temperature range independent of alpha and ice point resistance.

ACCURACY	ASTM E1137	DIN EN 60751
CLASS B	± .10% @ 0°C (32°F)	± .12% @ 0°C (32°F)
CLASS A	± .05% @ 0°C (32°F)	± .06% @ 0°C (32°F)

Accuracy: Platinum RTD's typically are provided in grades (or class) of tolerance. Grade A has an ice point tolerance of ±0.06 % at ice point and grade B ±0.12 % at ice point. The ASTM standard is slightly better than the DIN at ±0.05 % and 0.10%. The accuracy will decrease with temperature. Thermo Electric RTD's conform to standard ASTM grade B accuracy and ASTM grade A accuracy when selected in ordering code.

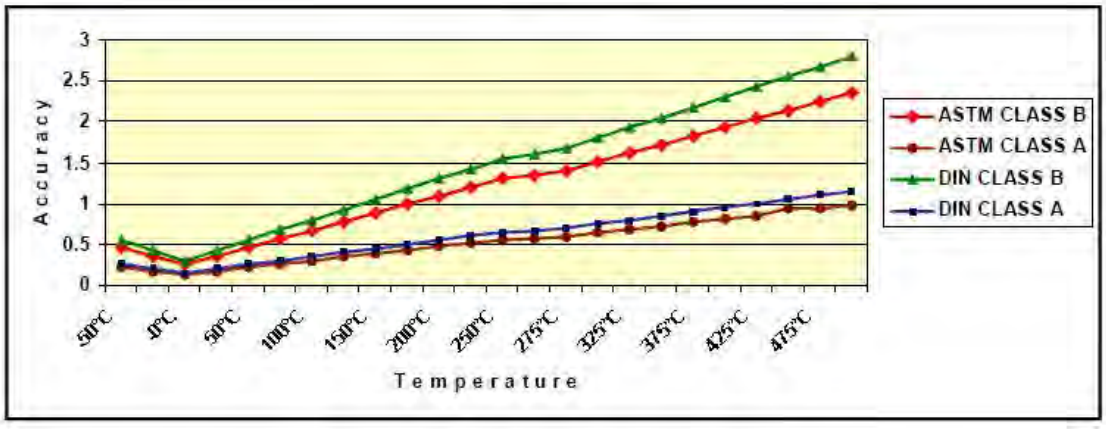


Table 3-7 RTD tables A-F

RTD table A

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
-180	27.10	25.80	25.80	1.884	
-179	27.52	26.24	26.23	1.925	
-178	27.95	26.67	26.67	1.967	
-177	28.37	27.10	27.10	2.008	
-176	28.80	27.53	27.53	2.049	
-175	29.22	27.97	27.96	2.090	
-174	29.64	28.40	28.39	2.131	
-173	30.07	28.83	28.82	2.172	
-172	30.49	29.26	29.25	2.213	
-171	30.91	29.69	29.68	2.254	
-170	31.34	30.12	30.11	2.295	
-169	31.76	30.56	30.54	2.336	
-168	32.18	30.99	30.97	2.377	
-167	32.60	31.42	31.40	2.418	
-166	33.02	31.85	31.83	2.459	
-165	33.44	32.28	32.26	2.500	
-164	33.86	32.70	32.69	2.541	
-163	34.28	33.13	33.11	2.582	
-162	34.70	33.56	33.54	2.623	
-161	35.12	33.99	33.97	2.664	
-160	35.54	34.42	34.39	2.705	
-159	35.96	34.85	34.82	2.746	
-158	36.38	35.27	35.25	2.786	
-157	36.80	35.70	35.67	2.827	
-156	37.22	36.13	36.10	2.868	
-155	37.64	36.55	36.52	2.909	
-154	38.05	36.98	36.95	2.950	
-153	38.47	37.41	37.37	2.990	
-152	38.89	37.83	37.80	3.031	
-151	39.31	38.26	38.22	3.072	
-150	39.72	38.68	38.65	3.113	
-149	40.14	39.10	39.07	3.153	
-148	40.56	39.53	39.49	3.194	
-147	40.97	39.95	39.92	3.235	
-146	41.39	40.38	40.34	3.275	
-145	41.80	40.80	40.76	3.316	
-144	42.22	41.22	41.19	3.356	
-143	42.63	41.64	41.61	3.397	
-142	43.05	42.07	42.03	3.438	
-141	43.46	42.49	42.45	3.478	
-140	43.88	42.91	42.87	3.519	
-139	44.29	43.33	43.29	3.559	
-138	44.70	43.75	43.72	3.600	
-137	45.12	44.17	44.14	3.640	
-136	45.53	44.59	44.56	3.681	
-135	45.94	45.01	44.98	3.721	
-134	46.36	45.43	45.40	3.762	
-133	46.77	45.85	45.82	3.802	
-132	47.18	46.27	46.24	3.843	
-131	47.59	46.69	46.66	3.883	
-130	48.00	47.11	47.07	3.923	
-129	48.42	47.53	47.49	3.964	
-128	48.83	47.95	47.91	4.004	
-127	49.24	48.37	48.33	4.045	
-126	49.65	48.78	48.75	4.085	
-125	50.06	49.20	49.17	4.125	
-124	50.47	49.62	49.58	4.165	
-123	50.88	50.04	50.00	4.206	
-122	51.29	50.45	50.42	4.246	
-121	51.70	50.87	50.84	4.286	
-120	52.11	51.29	51.25	4.327	
-119	52.52	51.70	51.67	4.367	
-118	52.93	52.12	52.09	4.407	
-117	53.34	52.53	52.50	4.447	
-116	53.75	52.95	52.92	4.487	
-115	54.15	53.36	53.33	4.527	
-114	54.56	53.78	53.75	4.568	
-113	54.97	54.19	54.16	4.608	
-112	55.38	54.61	54.58	4.648	
-111	55.79	55.02	54.99	4.688	
-110	56.19	55.44	55.41	4.728	
-109	56.60	55.85	55.82	4.768	
-108	57.01	56.26	56.24	4.808	
-107	57.41	56.68	56.65	4.848	
-106	57.82	57.09	57.06	4.888	

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
-105	58.23	57.50	57.48	4.928	
-104	58.63	57.92	57.89	4.968	
-103	59.04	58.33	58.30	5.008	
-102	59.44	58.74	58.72	5.048	
-101	59.85	59.16	59.13	5.088	
-100	60.26	59.57	59.54	5.128	
-99	60.66	59.98	59.96	5.168	
-98	61.07	60.39	60.37	5.208	
-97	61.47	60.80	60.78	5.248	
-96	61.88	61.21	61.19	5.288	
-95	62.28	61.63	61.60	5.327	
-94	62.68	62.04	62.01	5.367	
-93	63.09	62.45	62.43	5.407	
-92	63.49	62.86	62.84	5.447	
-91	63.90	63.27	63.25	5.487	
-90	64.30	63.68	63.66	5.526	
-89	64.70	64.09	64.07	5.566	
-88	65.11	64.50	64.48	5.606	
-87	65.51	64.91	64.89	5.646	
-86	65.91	65.32	65.30	5.685	
-85	66.31	65.73	65.71	5.725	
-84	66.72	66.14	66.12	5.765	
-83	67.12	66.55	66.53	5.804	
-82	67.52	66.96	66.94	5.844	
-81	67.92	67.36	67.35	5.884	
-80	68.33	67.77	67.76	5.923	66.60
-79	68.73	68.18	68.17	5.963	67.25
-78	69.13	68.59	68.57	6.002	67.90
-77	69.53	69.00	68.98	6.042	68.55
-76	69.93	69.41	69.39	6.081	69.20
-75	70.33	69.81	69.80	6.121	69.85
-74	70.73	70.22	70.21	6.160	70.50
-73	71.13	70.63	70.61	6.200	71.15
-72	71.53	71.04	71.02	6.239	71.80
-71	71.93	71.44	71.43	6.279	72.45
-70	72.33	71.85	71.84	6.318	73.10
-69	72.72	72.26	72.24	6.358	73.75
-68	73.13	72.66	72.65	6.397	74.41
-67	73.53	73.07	73.06	6.437	75.06
-66	73.93	73.43	73.47	6.476	75.71
-65	74.33	73.88	73.87	6.515	76.36
-64	74.73	74.29	74.28	6.555	77.01
-63	75.13	74.70	74.68	6.594	77.66
-62	75.53	75.10	75.09	6.633	78.31
-61	75.93	75.51	75.50	6.673	78.97
-60	76.33	75.91	75.90	6.712	79.62
-59	76.73	76.32	76.31	6.751	80.27
-58	77.12	76.72	76.71	6.791	80.93
-57	77.52	77.13	77.12	6.830	81.58
-56	77.92	77.53	77.52	6.869	82.23
-55	78.32	77.94	77.93	6.908	82.89
-54	78.72	78.34	78.33	6.947	83.54
-53	79.11	78.75	78.74	6.987	84.20
-52	79.51	79.15	79.14	7.026	84.85
-51	79.91	79.56	79.55	7.065	85.51
-50	80.31	79.96	79.95	7.104	86.16
-49	80.70	80.36	80.36	7.143	86.32
-48	81.10	80.77	80.76	7.181	87.48
-47	81.50	81.17	81.16	7.220	88.14
-46	81.89	81.58	81.57	7.259	88.79
-45	82.29	81.98	81.97	7.297	89.45
-44	82.69	82.38	82.38	7.336	90.11
-43	83.08	82.79	82.78	7.374	90.77
-42	83.48	83.19	83.18	7.413	91.43
-41	83.87	83.59	83.58	7.452	92.09
-40	84.27	83.99	83.99	7.490	92.76
-39	84.67	84.40	84.39	7.529	93.42
-38	85.06	84.80	84.79	7.568	94.08
-37	85.46	85.20	85.20	7.606	94.74
-36	85.85	85.60	85.60	7.645	95.41
-35	86.25	86.01	86.00	7.683	96.07
-34	86.64	86.41	86.40	7.722	96.74
-33	87.04	86.81	86.80	7.761	97.41
-32	87.43	87.21	87.21	7.799	98.07
-31	87.83	87.61	87.61	7.838	98.74

RTD table B

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
-30	88.22	88.01	88.01	7.876	99.41
-29	88.62	88.42	88.41	7.915	100.08
-28	89.01	88.82	88.81	7.954	100.75
-27	89.40	89.22	89.21	7.992	101.42
-26	89.80	89.62	89.61	8.031	102.09
-25	90.19	90.02	90.02	8.070	102.77
-24	90.59	90.42	90.42	8.108	103.44
-23	90.98	90.82	90.82	8.147	104.12
-22	91.37	91.22	91.22	8.185	104.79
-21	91.77	91.62	91.62	8.224	105.47
-20	92.16	92.02	92.02	8.263	106.15
-19	92.55	92.42	92.42	8.301	106.83
-18	92.95	92.82	92.82	8.340	107.51
-17	93.34	93.22	93.22	8.378	108.19
-16	93.73	93.62	93.62	8.417	108.88
-15	94.12	94.02	94.02	8.456	109.56
-14	94.52	94.42	94.42	8.494	110.25
-13	94.91	94.82	94.82	8.533	110.93
-12	95.30	95.22	95.22	8.572	111.62
-11	95.69	95.62	95.62	8.610	112.31
-10	96.09	96.02	96.02	8.649	113.00
-9	96.48	96.42	96.41	8.687	113.70
-8	96.87	96.81	96.81	8.726	114.39
-7	97.26	97.21	97.21	8.765	115.09
-6	97.65	97.61	97.61	8.803	115.78
-5	98.04	98.01	98.01	8.842	116.48
-4	98.44	98.41	98.41	8.881	117.18
-3	98.83	98.81	98.81	8.919	117.88
-2	99.22	99.20	99.20	8.958	118.59
-1	99.61	99.60	99.60	8.996	119.29
0	100.00	100.00	100.00	9.035	120.00
1	100.39	100.40	100.40	9.074	120.71
2	100.78	100.80	100.80	9.112	121.42
3	101.17	101.19	101.19	9.151	122.13
4	101.56	101.59	101.59	9.189	122.85
5	101.95	101.99	101.99	9.228	123.56
6	102.34	102.38	102.39	9.267	124.28
7	102.73	102.78	102.78	9.305	125.00
8	103.12	103.18	103.18	9.344	125.72
9	103.51	103.57	103.58	9.383	126.44
10	103.90	103.97	103.97	9.421	127.17
11	104.29	104.37	104.37	9.460	127.89
12	104.68	104.76	104.77	9.498	128.62
13	105.07	105.16	105.16	9.537	129.35
14	105.46	105.56	105.56	9.576	130.09
15	105.85	105.95	105.95	9.614	130.82
16	106.24	106.35	106.35	9.653	131.56
17	106.63	106.74	106.75	9.692	132.29
18	107.02	107.14	107.14	9.730	133.03
19	107.40	107.53	107.54	9.769	133.77
20	107.79	107.93	107.93	9.807	134.52
21	108.18	108.32	108.33	9.846	135.26
22	108.57	108.72	108.72	9.885	136.01
23	108.96	109.11	109.12	9.923	136.76
24	109.35	109.51	109.52	9.962	137.51
25	109.73	109.90	109.91	10.000	138.26
26	110.12	110.30	110.30	10.039	139.02
27	110.51	110.69	110.70	10.078	139.78
28	110.90	111.09	111.09	10.116	140.54
29	111.29	111.48	111.49	10.115	141.30
30	111.67	111.88	111.88	10.194	142.06
31	112.06	112.27	112.28	10.232	142.82
32	112.45	112.66	112.67	10.271	143.59
33	112.83	113.06	113.07	10.309	144.36
34	113.22	113.45	113.46	10.348	145.13
35	113.61	113.84	113.85	10.387	145.90
36	114.00	114.24	114.25	10.425	146.68
37	114.38	114.63	114.64	10.464	147.46
38	114.77	115.02	115.03	10.502	148.24
39	115.15	115.42	115.43	10.541	149.02
40	115.54	115.81	115.82	10.580	149.80
41	115.93	116.20	116.21	10.618	150.59
42	116.31	116.59	116.61	10.657	151.37
43	116.70	116.99	117.00	10.696	152.16
44	117.08	117.38	117.39	10.734	152.95

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
45	117.47	117.77	117.79	10.773	153.75
46	117.86	118.16	188.18	10.811	154.54
47	118.24	118.56	118.57	10.850	155.34
48	118.63	118.95	118.96	10.889	156.14
49	119.01	119.34	119.35	10.927	156.94
50	119.40	119.73	119.75	10.966	157.75
51	119.78	120.12	120.14	11.005	158.55
52	120.17	120.51	120.53	11.043	159.36
53	120.55	120.91	120.92	11.082	160.17
54	120.94	121.30	121.31	11.120	160.98
55	121.32	121.69	121.71	11.159	161.80
56	121.71	122.08	122.10	11.198	162.61
57	122.09	122.47	122.49	11.236	163.43
58	122.47	122.86	122.88	11.275	164.25
59	122.86	123.25	123.27	11.313	165.07
60	123.24	123.64	123.66	11.352	165.90
61	123.63	124.03	124.05	11.391	166.73
62	124.01	124.42	124.44	11.429	167.56
63	124.39	124.81	124.83	11.468	168.39
64	124.78	125.20	125.22	11.507	169.22
65	125.16	125.59	125.61	11.545	170.06
66	125.54	125.98	126.00	11.584	170.90
67	125.93	126.37	126.39	11.622	171.74
68	126.31	126.76	126.78	11.661	172.58
69	126.69	127.15	127.17	11.700	173.42
70	127.08	127.54	127.56	11.738	174.27
71	127.46	127.93	127.95	11.777	175.12
72	127.84	128.32	128.34	11.816	175.97
73	128.22	128.71	128.73	11.854	176.82
74	128.61	129.09	129.12	11.893	177.68
75	128.99	129.48	129.51	11.931	178.53
76	129.37	129.87	129.90	11.970	179.39
77	129.75	130.26	130.29	12.009	180.25
78	130.13	130.65	130.68	12.047	181.12
79	130.52	131.04	131.07	12.086	181.98
80	130.90	131.42	131.45	12.124	182.85
81	131.28	131.81	131.84	12.163	183.72
82	131.66	132.20	132.23	12.202	184.59
83	132.04	132.59	132.62	12.240	185.46
84	132.42	132.98	133.01	12.279	186.34
85	132.80	133.36	133.39	12.318	187.22
86	133.18	133.75	133.78	12.356	188.10
87	133.57	134.14	134.17	12.395	188.98
88	133.95	134.52	134.56	12.433	189.87
89	134.33	134.91	134.95	12.472	190.75
90	134.71	135.30	135.33	12.511	191.64
91	135.09	135.68	135.72	12.549	192.53
92	135.47	136.07	136.11	12.588	193.42
93	135.85	136.46	136.49	12.627	194.32
94	136.23	136.84	136.88	12.665	195.21
95	136.61	137.23	137.27	12.704	196.11
96	136.99	137.62	137.65	12.742	197.01
97	137.37	138.00	138.04	12.781	197.92
98	137.75	138.39	138.43	12.820	198.82
99	138.13	138.77	138.81	12.858	199.73
100	138.51	139.16	139.20	12.897	200.64
101	138.88	139.55	139.59	12.935	201.55
102	139.26	139.93	139.97	12.974	202.47
103	139.64	140.32	140.36	13.013	203.38
104	140.02	140.70	140.74	13.051	204.30
105	140.40	141.09	141.13	13.090	205.22
106	140.78	141.47	141.51	13.129	206.14
107	141.16	141.86	141.90	13.167	207.07
108	141.54	142.24	142.29	13.206	207.99
109	141.91	142.63	142.67	13.244	208.92
110	142.29	143.01	143.06	13.283	209.85
111	142.67	143.39	143.44	13.322	210.79
112	143.05	143.78	143.83	13.360	211.72
113	143.43	144.16	144.21	13.399	212.66
114	143.80	144.55	144.59	13.437	213.60
115	144.18	144.93	144.98	13.476	214.54
116	144.56	145.31	145.36	13.515	215.49
117	144.94	145.70	145.75	13.553	216.43
118	145.31	146.08	146.13	13.592	217.38
119	145.69	146.46	146.52	13.631	218.34

RTD table C

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
120	146.07	146.85	146.90	13.669	219.29
121	146.44	147.23	147.28	13.708	220.25
122	146.82	147.61	147.67	13.746	221.20
123	147.20	148.00	148.05	13.785	222.16
124	147.57	148.38	148.43	13.824	223.13
125	147.95	148.76	148.82	13.862	224.09
126	148.33	149.15	149.20	13.901	225.06
127	148.70	149.53	149.58	13.940	226.03
128	149.08	149.91	149.97	13.978	227.00
129	149.46	150.29	150.35	14.017	227.97
130	149.83	150.67	150.73	14.055	228.95
131	150.21	151.06	151.11	14.094	229.93
132	150.58	151.44	151.50	14.133	230.91
133	150.96	151.82	151.88	14.171	231.89
134	151.33	152.20	152.26	14.210	232.88
135	151.71	152.58	152.64	14.248	233.86
136	152.08	152.96	153.02	14.287	234.85
137	152.46	153.35	153.41	14.326	235.85
138	152.83	153.73	153.79	14.364	236.84
139	153.21	154.11	154.17	14.403	237.84
140	153.58	154.49	154.55	14.442	238.84
141	153.96	154.87	154.93	14.480	239.84
142	154.33	155.25	155.31	14.519	240.84
143	154.71	155.63	155.70	14.557	241.85
144	155.08	156.01	156.08	14.596	242.85
145	155.46	156.39	156.46	14.635	243.86
146	155.83	156.77	156.84	14.673	244.88
147	156.20	157.15	157.22	14.712	245.89
148	156.58	157.53	157.60	14.751	246.91
149	156.95	157.91	157.98	14.789	247.93
150	157.33	158.29	158.36	14.828	248.95
151	157.70	158.67	158.74	14.867	249.97
152	158.07	159.05	159.12	14.906	251.00
153	158.45	159.43	159.50	14.945	252.03
154	158.82	159.81	159.88	14.984	253.06
155	159.19	160.19	160.26	15.022	254.09
156	159.56	160.57	160.64	15.061	255.13
157	159.94	160.95	161.02	15.100	256.17
158	160.31	161.33	161.40	15.139	257.21
159	160.68	161.70	161.78	15.178	258.25
160	161.05	162.08	162.16	15.217	259.30
161	161.43	162.46	162.54	15.256	260.34
162	161.80	162.84	162.91	15.295	261.39
163	162.17	163.22	163.29	15.334	262.45
164	162.54	163.60	163.67	15.373	263.50
165	162.91	163.97	164.05	15.412	264.56
166	163.29	164.35	164.43	15.451	265.62
167	163.66	164.73	164.81	15.490	266.69
168	164.03	165.11	165.19	15.529	267.75
169	164.40	165.48	165.56	15.568	268.82
170	164.77	165.86	165.94	15.607	269.89
171	165.14	166.24	166.32	15.646	270.97
172	165.51	166.62	166.70	15.685	272.05
173	165.89	166.99	167.07	15.724	273.13
174	166.26	167.37	167.45	15.763	274.21
175	166.63	167.75	167.83	15.802	275.30
176	167.00	168.12	168.21	15.840	276.38
177	167.37	168.50	168.58	15.879	277.48
178	167.74	168.88	168.96	15.918	278.57
179	168.11	169.25	169.34	15.957	279.67
180	168.48	169.63	169.71	15.996	280.77
181	168.85	170.00	170.09	16.035	281.87
182	169.22	170.38	170.47	16.074	282.98
183	169.59	170.76	170.84	16.113	284.09
184	169.96	171.13	171.22	16.152	285.20
185	170.33	171.51	171.60	16.191	286.32
186	170.70	171.88	171.97	16.230	287.44
187	171.07	172.26	172.35	16.269	288.56
188	171.43	172.63	172.73	16.308	289.69
189	171.80	173.01	173.10	16.347	290.82
190	172.17	173.38	173.48	16.386	291.95
191	172.54	173.76	173.85	16.425	293.08
192	172.91	174.13	174.23	16.464	294.22
193	173.28	174.51	174.60	16.503	295.37
194	173.65	174.88	174.98	16.542	296.51

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
195	174.02	175.26	175.35	16.581	297.66
196	174.38	175.63	175.73	16.620	298.81
197	174.75	176.01	176.10	16.659	299.97
198	175.12	176.38	176.48	16.698	301.13
199	175.49	176.75	176.85	16.737	302.29
200	175.86	177.13	177.23	16.776	303.45
201	176.22	177.50	177.60	16.815	304.62
202	176.59	177.88	177.97	16.854	305.80
203	176.96	178.25	178.35	16.893	306.97
204	177.33	178.62	178.72	16.932	308.15
205	177.69	179.00	179.10	16.971	309.34
206	178.06	179.37	179.47	17.010	310.52
207	178.43	179.74	179.84	17.049	311.72
208	178.79	180.12	180.22	17.088	312.91
209	179.16	180.49	180.59	17.127	314.11
210	179.53	180.86	180.96	17.166	315.31
211	179.89	181.23	181.34	17.205	316.52
212	180.26	181.61	181.71	17.244	317.73
213	180.63	181.98	182.08	17.283	318.94
214	180.99	182.35	182.46	17.322	320.16
215	181.36	182.72	182.83	17.360	321.28
216	181.72	183.09	183.20	17.399	322.60
217	182.09	183.47	183.57	17.438	323.83
218	182.46	183.84	183.95	17.477	325.06
219	182.82	184.21	184.32	17.516	326.30
220	183.19	184.58	184.69	177.555	327.54
221	183.55	184.95	185.06	17.594	328.78
222	183.92	185.32	185.43	17.633	330.03
223	184.28	185.70	185.81	17.672	331.28
224	184.65	186.07	186.18	17.711	332.53
225	185.01	186.44	186.55	17.750	333.79
226	185.38	186.81	186.92	17.789	335.05
227	185.74	187.18	187.29	17.828	336.32
228	186.11	187.55	187.66	17.867	337.59
229	186.47	187.92	188.03	17.906	338.87
230	186.84	188.29	188.41	17.945	340.14
231	187.20	188.66	188.78	17.984	341.43
232	187.56	189.03	189.15	18.023	342.71
233	187.93	189.40	189.52	18.062	344.00
234	188.29	189.77	189.89	18.101	345.29
235	188.66	190.14	190.26	18.140	346.59
236	189.02	190.51	190.63	18.179	347.89
237	189.38	190.88	191.00	18.218	349.20
238	189.75	191.25	191.37	18.257	350.51
239	190.11	191.62	191.74	18.296	351.82
240	190.47	191.99	192.11	18.335	353.14
241	190.84	192.36	192.48	18.374	354.46
242	191.20	192.73	192.85	18.413	355.79
243	191.56	193.09	193.22	18.452	357.12
244	191.92	193.46	193.59	18.491	358.45
245	192.29	193.83	193.96	18.530	359.79
246	192.65	194.20	194.32	18.569	361.13
247	193.01	194.57	194.69	18.609	362.47
248	193.37	194.94	195.06	18.648	363.82
249	193.74	195.31	195.43	18.687	365.17
250	194.10	195.67	195.80	18.726	366.53
251	194.46	196.04	196.17	18.765	367.89
252	194.82	196.41	196.54	18.804	369.26
253	195.18	196.78	196.90	18.843	370.62
254	195.55	197.14	197.27	18.882	372.00
255	195.91	197.51	197.64	18.921	373.37
256	196.27	197.88	198.01	18.960	374.75
257	196.63	198.25	198.38	18.999	376.14
258	196.99	198.61	198.74	19.038	377.52
259	197.35	198.98	199.11	19.077	378.91
260	197.71	199.35	199.48	19.116	380.31
261	198.07	199.71	199.85		
262	198.43	200.08	200.21		
263	198.79	200.45	200.58		
264	199.15	200.81	200.95		
265	199.51	201.18	201.31		
266	199.87	201.55	201.68		
267	200.23	201.91	202.05		
268	200.59	202.28	202.41		
269	200.95	202.64	202.78		

RTD table D

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
270	201.31	203.01	203.15		
271	201.67	203.38	203.51		
272	202.03	203.74	203.88		
273	202.39	204.11	204.24		
274	202.75	204.47	204.61		
275	203.11	204.84	204.98		
276	203.47	205.20	205.34		
277	203.83	205.57	205.71		
278	204.19	205.93	206.07		
279	204.55	206.30	206.44		
280	204.90	206.66	206.80		
281	205.26	207.02	207.17		
282	205.62	207.39	207.53		
283	205.98	207.75	207.90		
284	206.34	208.12	208.26		
285	206.70	208.48	208.63		
286	207.05	208.85	208.99		
287	207.41	209.21	209.35		
288	207.77	209.57	209.72		
289	208.13	209.94	210.08		
290	208.48	210.30	210.45		
291	208.84	210.66	210.81		
292	209.20	211.03	211.17		
293	209.56	211.39	211.54		
294	209.91	211.75	211.90		
295	210.27	212.11	212.26		
296	210.63	212.48	212.63		
297	210.98	212.84	212.99		
298	211.34	213.20	213.35		
299	211.70	213.56	213.72		
300	212.05	213.93	214.08		
301	212.41	214.29	214.44		
302	212.76	214.65	214.80		
303	213.12	215.01	215.17		
304	213.48	215.37	215.53		
305	213.83	215.74	215.89		
306	214.19	216.10	216.25		
307	214.54	216.46	216.61		
308	214.90	216.82	216.98		
309	215.25	217.18	217.34		
310	215.61	217.54	217.70		
311	215.96	217.90	218.06		
312	216.32	218.26	218.42		
313	216.67	218.63	218.78		
314	217.03	218.99	219.14		
315	217.38	219.35	219.51		
316	217.74	219.71	219.87		
317	218.09	220.07	220.23		
318	218.44	220.43	220.59		
319	218.80	220.79	220.95		
320	219.15	221.15	221.31		
321	219.51	221.51	221.67		
322	219.86	221.87	222.03		
323	220.21	222.23	222.39		
324	220.57	222.59	222.75		
325	220.92	222.94	223.11		
326	221.27	223.30	223.47		
327	221.63	223.66	223.83		
328	221.98	224.02	224.19		
329	222.33	224.38	224.55		
330	222.68	224.74	224.91		
331	223.04	225.10	225.26		
332	223.39	225.46	225.62		
333	223.74	225.81	225.98		
334	224.09	226.17	226.34		
335	224.45	226.53	226.70		
336	224.80	226.89	227.06		
337	225.15	227.25	227.42		
338	225.50	227.61	227.78		
339	225.85	227.96	228.13		
340	226.21	228.32	228.49		
341	226.56	228.68	228.85		
342	226.91	229.04	229.21		
343	227.26	229.39	229.56		
344	227.61	229.75	229.92		

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
345	227.96	230.11	230.28		
346	228.31	230.46	230.64		
347	228.66	230.82	230.99		
348	229.02	231.18	231.35		
349	229.37	231.53	231.71		
350	229.72	231.89	232.07		
351	230.07	232.25	232.42		
352	230.42	232.60	232.78		
353	230.77	232.96	233.13		
354	231.12	233.31	233.49		
355	231.47	233.67	233.85		
356	231.82	234.03	234.20		
357	232.17	234.38	234.56		
358	232.52	234.74	234.92		
359	232.87	235.09	235.27		
360	233.21	235.45	235.63		
361	233.56	235.80	235.98		
362	233.91	236.16	236.34		
363	234.26	236.51	236.69		
364	234.61	236.87	237.05		
365	234.96	237.22	237.40		
366	235.31	237.58	237.76		
367	235.66	237.93	238.11		
368	236.00	238.28	238.47		
369	236.35	238.64	238.82		
370	236.70	238.99	239.18		
371	237.05	239.35	239.53		
372	237.40	239.70	239.89		
373	237.74	240.05	240.24		
374	238.09	240.41	240.59		
375	238.44	240.76	240.95		
376	238.79	241.11	241.30		
377	239.13	241.47	241.66		
378	239.48	241.82	242.01		
379	239.83	242.17	242.36		
380	240.18	242.53	242.72		
381	240.52	242.88	243.07		
382	240.87	243.23	243.42		
383	241.22	243.58	243.78		
384	241.56	243.94	244.13		
385	241.91	244.29	244.48		
386	242.26	244.64	244.83		
387	242.60	244.99	245.19		
238	242.95	245.35	245.54		
389	243.29	245.70	245.89		
390	243.64	246.05	246.24		
391	243.99	246.40	246.59		
392	244.33	246.75	246.95		
393	244.68	247.10	247.30		
394	245.02	247.46	247.65		
395	245.37	247.81	248.00		
396	245.71	248.16	248.35		
397	246.06	248.51	248.70		
398	246.40	248.86	249.06		
399	246.75	249.21	249.41		
400	247.09	249.56	249.76		
401	247.44	249.91	250.11		
402	247.78	250.26	250.46		
403	248.13	250.61	250.81		
404	248.47	250.96	251.16		
405	248.81	251.31	251.51		
406	249.16	251.66	251.86		
407	249.50	252.01	252.21		
408	249.85	252.36	252.56		
409	250.19	252.71	252.91		
410	250.53	253.06	253.26		
411	250.88	253.41	253.61		
412	251.22	253.76	253.96		
413	251.56	254.11	254.31		
414	251.91	254.46	254.66		
415	252.25	254.80	255.01		
416	252.59	255.15	255.36		
417	252.93	255.50	255.71		
418	253.28	255.85	256.06		
419	253.62	256.20	256.40		

RTD table E

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
420	253.96	256.55	256.75		
421	254.30	256.89	257.10		
422	254.65	257.24	257.45		
423	254.99	257.59	257.80		
424	255.33	257.94	258.15		
425	255.67	258.29	258.49		
426	256.01	258.63	258.84		
427	256.35	258.98	259.19		
428	256.70	259.33	259.54		
429	257.04	259.67	259.89		
430	257.38	260.02	260.23		
431	257.72	260.37	260.58		
432	258.06	260.72	260.93		
433	258.40	261.06	261.27		
434	258.74	261.41	261.62		
435	259.08	261.75	261.97		
436	259.42	262.10	262.31		
437	259.76	262.45	262.66		
438	260.10	262.79	263.01		
439	260.44	263.14	263.35		
440	260.78	263.49	263.70		
441	261.12	263.83	264.05		
442	261.46	264.18	264.39		
443	261.80	264.52	264.74		
444	262.14	264.87	265.08		
445	262.48	265.21	265.43		
446	262.82	265.56	265.78		
447	263.16	265.90	266.12		
448	263.50	266.25	266.47		
449	263.84	266.59	266.81		
450	264.18	266.94	267.16		
451	264.52	267.28	267.50		
452	264.86	267.63	267.85		
453	265.20	267.97	268.19		
454	265.53	268.31	268.54		
455	265.87	268.66	268.88		
456	266.21	269.00	269.23		
457	266.55	269.35	269.57		
458	266.89	269.69	269.91		
459	267.22	270.03	270.26		
460	267.56	270.38	270.60		
461	267.90	270.72	270.95		
462	268.24	271.06	271.29		
463	268.57	271.41	271.63		
464	268.91	271.75	271.98		
465	269.25	272.09	272.32		
466	269.59	272.44	272.66		
467	269.92	272.78	273.01		
468	270.26	273.12	273.35		
469	270.60	273.46	273.69		
470	270.93	273.80	274.03		
471	271.27	274.15	274.38		
472	271.61	274.49	274.72		
473	271.94	274.83	275.06		
474	272.28	275.17	275.40		
475	272.61	275.51	275.75		
476	272.95	275.86	276.09		
477	273.29	276.20	276.43		
478	273.62	276.54	276.77		
479	273.96	276.88	277.11		
480	274.29	277.22	277.46		
481	274.63	277.56	277.80		
482	274.96	277.90	278.14		
483	275.30	278.24	278.48		
484	275.63	278.58	278.82		
485	275.97	278.92	279.16		
486	276.30	279.26	279.50		
487	276.64	279.61	279.84		
488	276.97	279.95	280.18		
489	277.31	280.29	280.52		
490	277.64	280.63	280.87		
491	277.98	280.96	281.21		
492	278.31	281.30	281.55		
493	278.64	281.64	281.89		
494	278.98	281.98	282.23		

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
495	279.31	282.32	282.57		
496	279.64	282.66	282.91		
497	279.98	283.00	283.24		
498	280.31	283.34	283.58		
499	280.64	283.68	283.92		
500	280.98	284.02	284.26		
501	281.31	284.36	284.60		
502	281.64	284.69	284.94		
503	281.98	285.03	285.28		
504	282.31	285.37	285.62		
505	282.64	285.71	285.96		
506	282.97	286.05	286.30		
507	283.31	286.39	286.63		
508	283.64	286.72	286.97		
509	283.97	287.06	287.31		
510	284.30	287.40	287.65		
511	284.63	287.74	287.99		
512	284.97	288.07	288.32		
513	285.30	288.41	288.66		
514	285.63	288.75	289.00		
515	285.96	289.08	289.34		
516	286.29	289.42	289.67		
517	286.62	289.76	290.01		
518	286.95	290.09	290.35		
519	287.29	290.43	290.69		
520	287.62	290.77	291.02		
521	287.95	291.10	291.36		
522	288.28	291.44	291.70		
523	288.61	291.77	292.03		
524	288.94	292.11	292.37		
525	289.27	292.45	292.71		
526	289.60	292.78	293.04		
527	289.93	293.12	293.38		
528	290.26	293.45	293.71		
529	290.59	293.79	294.05		
530	290.92	294.12	294.39		
531	291.25	294.46	294.72		
532	291.58	294.79	295.06		
533	291.91	295.13	295.39		
534	292.24	295.46	295.73		
535	292.56	295.80	296.06		
536	292.89	296.13	296.40		
537	293.22	296.46	296.73		
538	293.55	296.80	297.07		
539	293.88	297.13	297.40		
540	294.21	297.47	297.74		
541	294.54	297.80	298.07		
542	294.86	298.13	298.41		
543	295.19	298.47	298.74		
544	295.52	298.80	299.07		
545	295.85	299.13	299.41		
546	296.18	299.47	299.74		
547	296.50	299.80	300.07		
548	296.83	300.13	300.41		
549	297.16	300.47	300.74		
550	297.49	300.80	301.08		
551	297.81	301.13	301.41		
552	298.14	301.46	301.74		
553	298.47	301.80	302.07		
554	298.80	302.13	302.41		
555	299.12	302.46	302.74		
556	299.45	302.79	303.07		
557	299.78	303.12	303.41		
558	300.10	303.46	303.74		
559	300.43	303.79	304.07		
560	300.75	304.12	304.40		
561	301.08	304.45	304.73		
562	301.41	304.78	305.07		
563	301.73	305.11	305.40		
564	302.06	305.44	305.73		
565	302.38	305.77	306.06		
566	302.71	306.11	306.39		
567	303.03	306.44	306.72		
568	303.36	306.77	307.06		
569	303.69	307.10	307.39		

RTD table F

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
570	304.01	307.43	307.72		
571	304.34	307.76	308.05		
572	304.66	308.09	308.38		
573	304.98	308.42	308.71		
574	305.31	308.75	309.04		
575	305.63	309.08	309.37		
576	305.96	309.41	309.70		
577	306.28	309.74	310.03		
578	306.61	310.06	310.36		
579	306.93	310.39	310.69		
580	307.25	310.72	311.02		
581	307.58	311.05	311.35		
582	307.90	311.38	311.68		
583	308.23	311.71	312.01		
584	308.55	312.04	312.34		
585	308.87	312.37	312.67		
586	309.20	312.69	313.00		
587	309.52	313.02	313.33		
588	309.84	313.35	313.66		
589	310.16	313.68	313.99		
590	310.49	314.01	314.31		
591	310.81	314.33	314.64		
592	311.13	314.66	314.97		
593	311.45	314.99	315.30		
594	311.78	315.32	315.63		
595	312.10	315.64	315.96		
596	312.42	315.97	316.28		
597	312.74	316.30	316.61		
598	313.06	316.62	316.94		
599	313.39	316.95	317.27		
600	313.71	317.28	317.59		
601	314.03	317.60	317.92		
602	314.35	317.93	318.25		
603	314.67	318.26	318.58		
604	314.99	318.58	318.90		
605	315.31	318.91	319.23		
606	315.64	319.23	319.56		
607	315.96	319.56	319.88		
608	316.28	319.89	320.21		
609	316.60	320.21	320.54		
610	316.92	320.54	320.86		

Temperature (°C)	Platinum 100 OHMs 0.00385TRC	Platinum 100 OHMs 0.003916TRC	Platinum 95.129 OHMs 0.003923TRC	Copper 10 OHMs 0.00427TRC	Nickel 120 OHMs 0.00672TRC
611	317.24	320.86	321.19		
612	317.56	321.19	321.52		
613	317.88	321.51	321.84		
614	318.20	321.84	322.17		
615	318.52	322.16	322.49		
616	318.84	322.49	322.82		
617	319.16	322.81	323.14		
618	319.48	323.13	323.47		
619	319.80	323.46	323.79		
620	320.12	323.78	324.12		
621	320.43	324.11	324.44		
622	320.75	324.43	324.77		
623	321.07	324.75	325.09		
624	321.39	325.08	325.42		
625	321.71	325.40	325.74		
626	322.03	325.72	326.07		
627	322.35	326.05	326.39		
628	322.67	326.37	326.72		
629	322.98	326.69	327.04		
630	323.30		327.36		
631	323.62		327.69		
632	323.94		328.01		
633	324.26		328.34		
634	324.57		328.66		
635	324.89		328.98		
636	325.21		329.31		
637	325.53		329.63		
638	325.84		329.95		
639	326.16		330.28		
640	326.48		330.60		
641	326.79		330.92		
642	327.11		331.24		
643	327.43		331.57		
644	327.74		331.89		
645	328.06		332.21		
646	328.38		332.53		
647	328.69		332.85		
648	329.01		333.18		
649	329.32		333.50		
650	329.64		333.82		

ELEMENT MATERIAL	NOMINAL RESISTANCE	TEMPERATURE COEFFICIENT OHMS/OHM/° C	RELATED STANDARDS
PLATINUM	50 Ohms @ 0° C	0.003916	JIS C1604-1997, US STANDARD*
PLATINUM	98.129 Ohms @ 0° C	0.003923	SAMA RC21-4-1966
PLATINUM	100 Ohms @ 0° C	0.00385	ASTM-1137, IEC-60751, DIN 43760, ITS-90 BS EN 60751:1998(Replaces BS 1904:1984)
PLATINUM	100 Ohms @ 0° C	0.003916	JIS C1604-1997, US STANDARD*
PLATINUM	100 Ohms @ 0° C	0.003902	US STANDARD*
PLATINUM	130 Ohms @ 0° C	0.003900	BS 2G 148 (British Aircraft Industry)
PLATINUM	200 Ohms @ 0° C	0.00385	DIN 43760
PLATINUM	500 Ohms @ 0° C	0.00385	DIN 43760
PLATINUM	1000 Ohms @ 0° C	0.00385	DIN 43760
NICKEL	100 Ohms @ 0° C	0.00617	DIN 43760
NICKEL	120 Ohms @ 0° C	0.00672	Edison No. 7
NICKEL/IRON	604 Ohms @ 0° C	0.00518	N/A
COPPER	10 Ohms @ 25° C	0.00427	Edison No. 15

*No document exists for US Standard.

3.4 Thermowell Tables and Charts

Table 3-8 Thermowell Selection Guide

Thermowells are critical accessories for the successful operation of temperature sensors in industrial processes. They protect the sensing element and insure that the temperature of the process is passed to the sensor. Unfortunately, many users look at thermowells as a commodity product and do not realize the wide range of performance they supply. An improperly specified thermowell could result in:
1. A catastrophic failure due to poor welding practices that compromises the process.
2. Poor compatibility with the temperature and media of the process leading to premature failure.
3. Inadequate temperature transfer to the sensor, thus providing an inaccurate signal.
4. Incompatibility with the process velocity leading to catastrophic failure due to vibration.
The specifying engineer can eliminate the possibility of these problems by working with a quality manufacturer who can ensure that the thermowell is the right selection for the application.

Heat Transfer

A very important role of the thermowell is to transfer heat from the process to the sensor. For this reason, quality manufacturers follow a number of guidelines to improve the heat transfer qualities of the well. First is the bore diameter, which is the drilled out portion of the well where the sensor is inserted. For thermocouples, it is recommended to use a .385 inch diameter bore. This allows ample room for the sensing element to be inserted into the well and makes removal easy. Because thermocouples are tip sensitive, the sensor to well contact is critical in the tip of the thermowell. For this reason, most industrial thermocouple sensors are spring loaded to insure contact with the thermowell. For RTD's the recommended bore is .260 inches of diameter. This provides a closer relationship with the normally .250 inches diameter element. Because RTD's are stem sensitive, it is important that the well be close to the side of the sensing element. This improves the transfer of heat directly to the RTD element within the probe. Improved heat transfer provides better accuracy and better response time, which are normally weaknesses of RTD's. Thermowell profile is another means of insuring that the thermowell is capable of transferring the process temperature. Most thermowells have a tapered construction where the tip is of a smaller diameter than the base of the stem. This aids in the transfer of heat. A variation on the tapered well is the stepped down well, where the tip is significantly reduced in diameter for a specified length. This improves the heat transfer to the sensing element even more. It will help make the sensor more sensitive to changes in the process temperature. This is more commonly used for RTD's where stem sensitivity is important for accurate temperature measurement.

Process Connection

Generally, thermowells are either threaded into the process connection or attached using a flanged connection. The guidelines are rather simple. For smaller diameters where the well will not be required to be removed on a regular basis and corrosion is not a serious problem, threaded process connections are preferred. By threading into a welded in fitting, the well is attached directly to the vessel or pipe. To make installation easier, a 1 - 1/8 inch hex is left at the top of the well. This provides a strong place for the installer to grip the well with a wrench. The hex portion can be extended up to 3 inches for easier installation for use under insulation. For installations where the well needs to be removed more frequently due to corrosion or other requirements, a flanged connection is used. The flanged connection will bolt to a mating flange mounted to the process. Flanged connections are more appropriate for high pressure applications and larger pipe sizes. They are normally used up to 3 inches in diameter. For some applications where the process is not corrosive and access is not required, a welded connection for the thermowell may be used. These provide a high quality connection, but obviously cannot be removed without significant effort. Welded connections are also preferred for very high temperature and pressure applications, especially steam lines.

Flanged Well Construction

When a flanged thermowell is made, a blind (blank) flange is machined to provide a hole to pass the thermowell stem through. This stem must then be adequately attached to the flange to insure that it can withstand the pressure, temperature, shock and corrosion of the process. The normal method used to attach the flange to the stem is a seal weld at both the top and bottom of the flange. The seal weld requires good welding procedures to insure that the welds are strong and void free. If a seal weld should fail, it is possible for the stem to travel downstream in the process and damage any equipment in the line, such as pumps or compressors. Some users will use a lower quality material for the flange and a higher quality material for the stem. This is based on the fact that most of the flange is not normally in contact with the process. While this saves money on the initial purchase, if the welds of dissimilar metals are not done with certified welding procedures, the weld between the flange and stem may lack integrity. When high alloy wells are used on some processes, the flange may be of a lower alloy with a built up surface of the high alloy on the raised face. For example, a hastelloy well may have a hastelloy stem and a stainless flange with a hasteloy overlay on the raised face, which can be considered part of the wetted surface of the well. This again is a cost saver, but could lead to weld and well failures if not done by certified procedures. Another option is to have a flange stem connection that is both threaded and welded. This provides an additional security for the connection should the seal weld fail. One major process licenser specifies this connection for all thermowells. The most secure method of connecting the flange to the well is with a full penetration weld. In this, the flange is overbored to allow the well material to make full contact for the entire length of the connection. With a full penetration welded connection, the integrity of the connection is excellent. While this is much more costly in initial procurement cost, it can save significant long term cost in the life and performance of the thermowell. Again, proper welding procedures are critical.

Table 3-9 Thermowell Material Selection

Process Fluid	Concentration	Temperature	Well Material
Acetate Solvents	Pure		Monel 400 or Nickel 200
Acetic Acid	to 50%	212°F	316 Stn. Stl.
Acetic Acid	to 99%	212°F	Hastelloy C276
Acetic Anhydride	All Conc.		Hastelloy C276
Acetone	All Conc.	212°F	Hastelloy C276 or Monel 400
Acetylene			304 Stn. Stl.
Alcohol, Ethyl	All Conc.	70°F to [illegible]	316 Stn. Stl.
Aluminum		Molten	Cast Iron
Aluminum Acetate	Saturated		304 Stn. Stl.
Aluminum Sulphate	to 25%	212°F	304 Stn. Stl.
Aluminum Sulphate	to 50%	212°F	Hastelloy C276
Ammonia	All Conc.	70°F	304 Stn. Stl.
Ammonium Chloride	All Conc.	70°F	316 Stn. Stl.
Ammonium Fluoride	to 25%	150°F	Hastelloy C276
Ammonium Nitrate	All Conc.	212°F	304 Stn. Stl.
Ammonium Phosphate	to 25%	212°F	304 Stn. Stl.
Ammonium Sulphate	All Conc.	212°F	Hastelloy C276
Amyl Acetate	All Conc.	300°F	Monel 400
Aniline	All Conc.	400°F	304 Stn. Stl.
Asphalt		250°F	C1018 Steel
Barium Carbonate		70°F	304 Stn. Stl.
Barium Chloride	to 25%	212°F	Hastelloy C276
Barium Hydroxide	to 50%	212°F	316 Stn. Stl.
Barium Sulphide			304 Stn. Stl.
Baroacic Acid	5%		304 Stn. Stl.
Beer		70°F	304 Stn. Stl.
Benzaldehyde			304 Stn. Stl.
Benzene, Benzol		212°F	304 Stn. Stl.
Benzoic Acid	All Conc.	212°F	316 Stn. Stl.
Black Liquor			Hastelloy C276
Bleaching Powder	15%	70°F	Monel 400
Bordeaux Mixture	All Conc.	212°F	304 Stn. Stl.
Boric Acid	All Conc.	400°F	316 Stn. Stl.
Bromine	Wet	70°F	Tantalum
Bromine	Dry	70°F	Tantalum
Butane		400°F	Carbon Steel
Butyl Alcohol			Copper
Butylacetate			Monel 400
Butylenes			Carbon Steel
Butyric Acid		70°F	304 Stn. Stl.
Butyric Acid		212°F	Hastelloy C276
Calcium Bicarbonate			304 Stn. Stl.
Calcium Chlorate	30%	212°F	304 Stn. Stl.
Calcium Fluoride			304 Stn. Stl.
Calcium Hydroxide	20%	212°F	304 Stn. Stl.
Calcium Hydroxide	50%	212°F	Hastelloy C276
Calcium Hypochlorite	15%	70°F	Monel 400
Carbolic Acid	All Conc.	212°F	316 Stn. Stl.
Carbon Dioxide	Dry		Carbon Steel
Carbon Dioxide	Wet		Carbon Steel
Carbon Tetrachloride	All Conc.	70°F	Monel 400
Carbonic Acid		212°F	304 Stn. Stl.

Process Fluid	Concentration	Temperature	Well Material
Chloracetic Acid	All Conc.	300°F	Hastelloy C276
Chlorex Caustic			316 Stn. Stl.
Chlorine Gas	Dry	70°F	C.Stl.
Chlorine Gas	Moist	70°F	Hastelloy C276
Chloroform	Dry	212°F	Monel 400
Chromic Acid	5%	70°F	304 Stn. Stl.
Chromic Acid	50%	212°F	Hastelloy C276
Cider	All Conc.	300°F	304 Stn. Stl.
Citric Acid	15%	70°F	304 Stn. Stl.
Citric Acid	All Conc.	212°F	Hastelloy C276
Coal Tar		Hot	304 Stn. Stl.
Coke Oven Gas		70°F	Alumiun
Copper Nitrate	All Conc.	300°F	316 Stn. Stl.
Copper Sulphate	All Conc.	300°F	316 Stn. Stl.
Corn Oils		212°F	316 Stn. Stl.
Cottenseed Oil			Carbon Steel
Creosols		212°F	304 Stn. Stl.
Cyanogen Gas			304 Stn. Stl.
Dowtherm			Carbon Steel
Epson Salt			304 Stn. Stl.
Ether		70°F	304 Stn. Stl.
Ethyl Acetate			Monel 400
Ethyl Chloride		70°F	304 Stn. Stl.
Ethyl Sulphate		70°F	Monel 400
Ethylene Glycol	All Conc.	212°F	304 Stn. Stl.
Ethylene Oxide		70°F	Carbon Steel
Ferric Chloride	1%	70°F	316 Stn. Stl.
Ferric Chloride		212°F	Tantalum
Ferric Nitrate		212°F	Tantalum
Ferric Sulphate	All Conc.	300°F	Tantalum
Fluorine		212°F	Hastelloy C276
Fluosilicic Acid		70°F	Carp.20
Formaldehyde	40%	212°F	316 Stn. Stl.
Formic Acid	All Conc.	300°F	316 Stn. Stl.
Furfural		400°F	316 Stn. Stl.
Galic Acid	5%	150°F	Monel 400
Gasoline		70°F	304 Stn. Stl.
Glucose		70°F	304 Stn. Stl.
Glycerine		212°F	304 Stn. Stl.
Glycerol		70°F	304 Stn. Stl.
Hydrobromic Acid	All Conc.	212°F	Hastelloy B
Hydrochloric Acid	All Conc.	212°F	Tantalum
Hydrocyanic Acid	All Conc.	212°F	304 Stn. Stl.
Hydrofluoric Acid	60%	212°F	Hastelloy C276
Hydrogen Chloride	Dry	500°F	304 Stn. Stl.
Hydrogen Peroxide		212°F	304 Stn. Stl.
Hydrogen Sulphide	Dry	212°F	316 Stn. Stl.
Iodine		70°F	Hastelloy C276
Kerosene		300°F	304 Stn. Stl.
Lacquer		212°F	316 Stn. Stl.
Lactic Acid	5%	150°F	316 Stn. Stl.
Lactic Acid	10%	212°F	Tantalum

Thermowell Material Selection (continued)

Process Fluid	Concentration	Temperature	Well Material
Latex		212°F	Carbon Steel
Lime Sulphur			PVC
Linseed Oil		70°F	304 Stn. Stl.
Magnesium Carbonate		150°F	304 Stn. Stl.
Magnesium Chloride	5%	70°F	Monel 400
Magnesium Chloride	5%	212°F	Nickel 200
Magnesium Hydroxide	All Conc.	70°F	304 Stn. Stl.
Magnesium Nitrate		150°F	304 Stn. Stl.
Magnesium Oxide	All Conc.	70°F	304 Stn. Stl.
Magnesium Sulphate	40%	212°F	304 Stn. Stl.
Mailic Acid		212°F	316 Stn. Stl.
Mercuric Chloride	10%	70°F	Hastelloy C276
Mercury	100%	660°F	Carbon Steel
Methane		70°F	Carbon Steel
Methyl Chloride	Dry	70°F	Carbon Steel
Methylene Chloride	All Conc.	212°F	304 Stn. Stl.
Milk		175°F	304 Stn. Stl.
Molasses		300°F	304 Stn. Stl.
Muriatic Acid		70°F	Tantalum
Naphta		70°F	304 Stn. Stl.
Natural Gas		70°F	304 Stn. Stl.
Neon		70°F	304 Stn. Stl.
Nickel Chloride		70°F	304 Stn. Stl.
Nickel Sulphate		212°F	304 Stn. Stl.
Nitric Acid	40%	180°F	347 Stn. Stl.
Nitric Acid	All Conc.	370°F	Tantalum
Nitrobenzene		70°F	304 Stn. Stl.
Nitrous Acid		70°F	304 Stn. Stl.
Oleic Acid	All Conc.	400°F	316 Stn. Stl.
Oleum		70°F	316 Stn. Stl.
Oxalic Acid	5%	70°F	304 Stn. Stl.
Oxalic Acid	10%	212°F	Monel 400
Oxygen	Liquid		304 Stn. Stl.
Oxygen		70°F	Carbon Steel
Palmitic Acid	All Conc.	400°F	316 Stn. Stl.
Pentane			304 Stn. Stl.
Petroleum Ether			304 Stn. Stl.
Phenol	All Conc.	212°F	316 Stn. Stl.
Phosphoric Acid	10%	70°F	316 Stn. Stl.
Phosphoric Acid	85%	212°F	Hastelloy C276
Picric Acid		70°F	304 Stn. Stl.
Pot. Permanganate	5%	70°F	304 Stn. Stl.
Potassium Bromide		70°F	316 Stn. Stl.
Potassium Carbonate	20%	212°F	316 Stn. Stl.
Potassium Chlorate		70°F	304 Stn. Stl.
Potassium Chloride	20%	70°F	316 Stn. Stl.
Potassium Chloride	20%	212°F	Monel 400
Potassium Hydroxide	30%	212°F	316 Stn. Stl.
Potasstium Nitrate	40%	212°F	316 Stn. Stl.
Potassium Nitrite	20%	70°F	316 Stn. Stl.
Potassium Sulphate	30%	212°F	316 Stn. Stl.
Potassium Sulphide	10%	212°F	304 Stn. Stl.

Process Fluid	Concentration	Temperature	Well Material
Potassium Sulphite	30%	212°F	304 Stn. Stl.
Propane		300°F	Carbon Steel
Pyrogallic Acid			304 Stn. Stl.
Quinine Bisulphate	Dry		316 Stn. Stl.
Quinine Sulphate	Dry		304 Stn. Stl.
Salommoniac		70°F	Monel 400
Sea Water		70°F	Monel 400
Shellac			304 Stn. Stl.
Silver Chloride		70°F	Carp. 20
Silver Nitrate		212°F	304 Stn. Stl.
Sodium Bicarbonate	All Conc.	150°F	316 Stn. Stl.
Sodium Bisulphate	20%	212°F	Hastelloy B
Sodium Bisulphite	20%	212°F	Hastelloy C276
Sodium Carbonate	20%	212°F	316 Stn. Stl.
Sodium Chloride	30%	70°F	316 Stn. Stl.
Sodium Chloride	30%	212°F	Monel 400
Sodium Chromate	All Conc.	212°F	316 Stn. Stl.
Sodium Fluoride	5%	70°F	Hastelloy B
Sodium Hydroxide	30%	212°F	316 Stn. Stl.
Sodium Hypochlorite			Tantalum
Sodium Nitrate	40%	212°F	304 Stn. Stl.
Sodium Nitrate	20%	70°F	304 Stn. Stl.
Sodium Peroxide	Fused		304 Stn. Stl.
Sodium Phosphate	10%	212°F	Carbon Steel
Sodium Silicate	10%	212°F	Carbon Steel
Sodium Sulphate	30%	212°F	316 Stn. Stl.
Sodium Sulphide	10%	212°F	316 Stn. Stl.
Sodium Sulphite	30%	212°F	304 Stn. Stl.
Stearic Acid			316 Stn. Stl.
Sulphur		Molten	304 Stn. Stl.
Sulphur	Wet		316 Stn. Stl.
Sulphur Dioxide		500°F	316 Stn. Stl.
Sulphur Trioxide	Dry	500°F	316 Stn. Stl.
Sulphuric Acid	Fuming	365°F	Carp. 20
Sulphuric Acid	All Conc.	212°F	Hastelloy B
Sulphurous Acid	20%	70°F	316 Stn. Stl.
Tar			Carbon Steel
Tartaric Acid		70°F	304 Stn. Stl.
Tartaric Acid		150°F	316 Stn. Stl.
Tin		Molten	Cast Iron
Tinan. Tetrachloride	All Conc.	70°F	316 Stn. Stl.
Toluene			304 Stn. Stl.
Trichloracetic Acid	All Conc.	70°F	HastelloyB
Trichlorethylene	Dry	300°F	Monel 400
Turpentine		70°F	316 Stn. Stl.
Vegetable Oils			304 Stn. Stl.
Vinegar			304 Stn. Stl.
Whiskey, Wine			304 Stn. Stl.
Xylene			Copper
Zinc		Molten	Cast Iron
Zinc Chloride	All Conc.	212°F	Hastelloy B
Zinc Sulphate	All Conc.	212°F	316 Stn. Stl.

4. Ordering Information

Refer to Section 2 Specifications for information on types of Connection Heads, Housings, Extensions and Thermowells and use to the Model Selection Guide to compile a part number to your exacting requirements.

4.1 Model Selection Guide

Document part number:

STT820: 34-44-16-08

STT830: 34-44-16-09

STT840: 34-44-16-10

Model Selection Guides are subject to change and are inserted into the specifications as guidance only.
Prior to specifying or ordering a model check for the latest revision Model Selection Guides which are published at:

https://www.honeywellprocess.com/en-US/explore/products/instrumentation/temperature-transmitters-and-sensors/Pages/STT-800-Temperature-Probes-Asemblies.aspx

5. Installation and Maintenance

5.1 Disclaimer

CAUTION: CHECK AND OBSERVE ALL APPROPRIATE SAFETY RULES AND REGULATIONS PRIOR TO PERFORMING ANY WORK INVOLVING THE INSTALLATION OF THESE PRODUCTS.

Due to the multitude of ways in which Thermocouple and RTD Assemblies are installed, it is not practical for one set of instructions to cover every installation or every detail that may be required. The instructions and recommendations contained in this manual are provided as an aid to those attempting to work with these units. These instructions are not intended to cover every installation, this is not to be considered an authoritative guide on the installation and maintenance of these assemblies . All specific questions concerning the installation, care and maintenance of these assemblies should be directed to the supplier, manufacturer, or fabricator as they occur.

5.2 Installation Instructions

Installation Instruction Diagrams

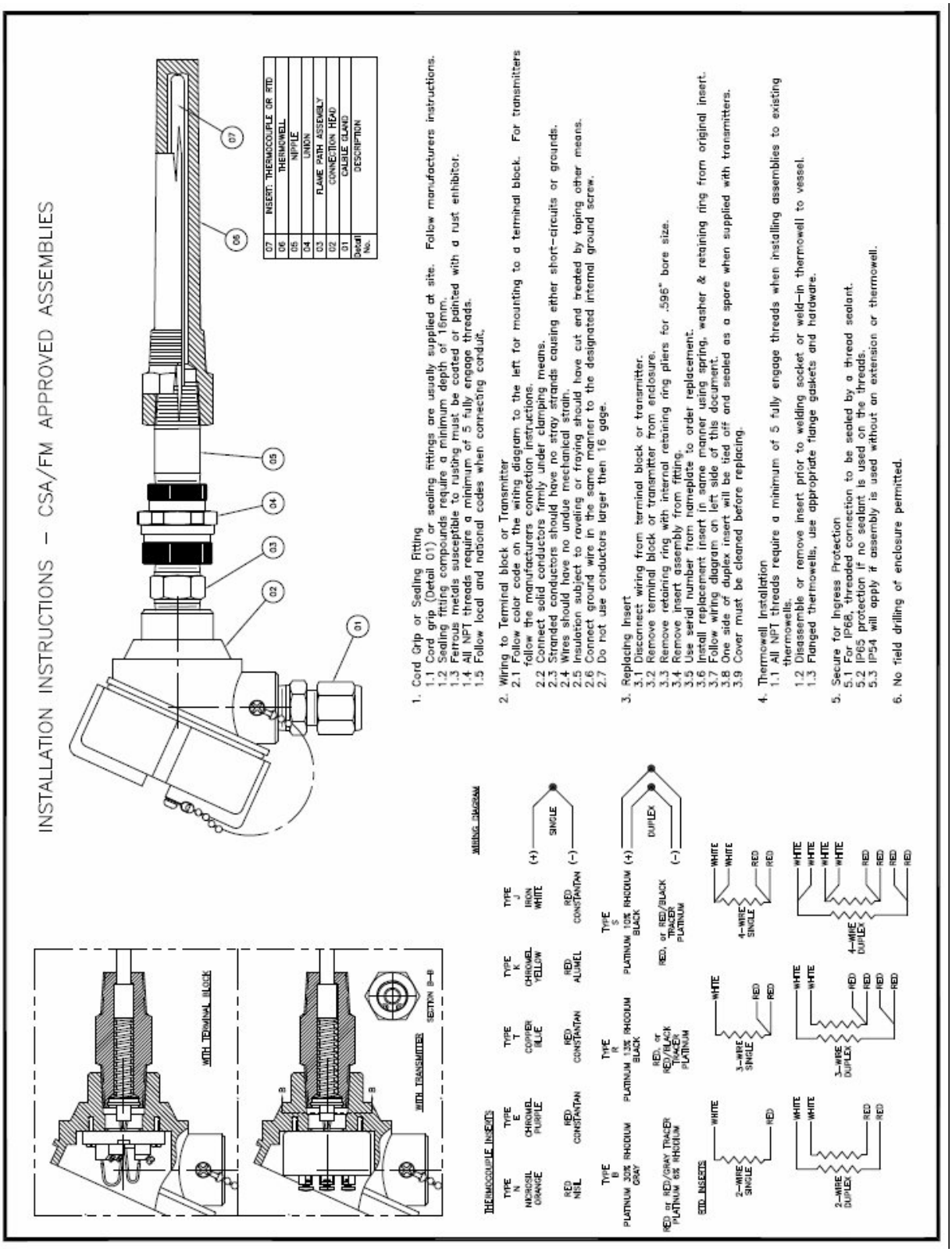


Figure 5-1 CSA/FM Installation Instructions Series STT830/840 Connection Head

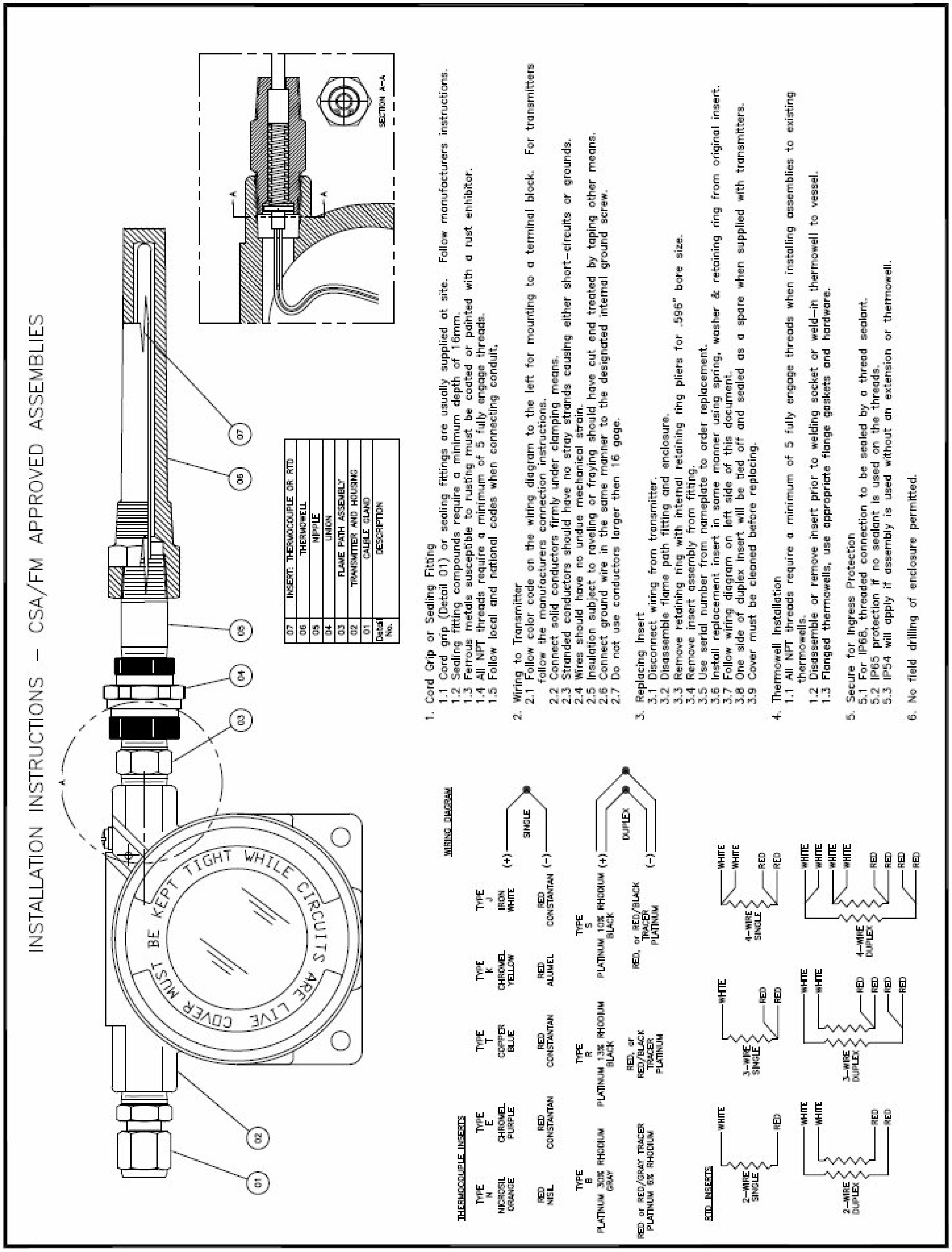


Figure 5-2 CSA/FM Installation Instructions Series STT830/840 EPE/STE housing and transmitter

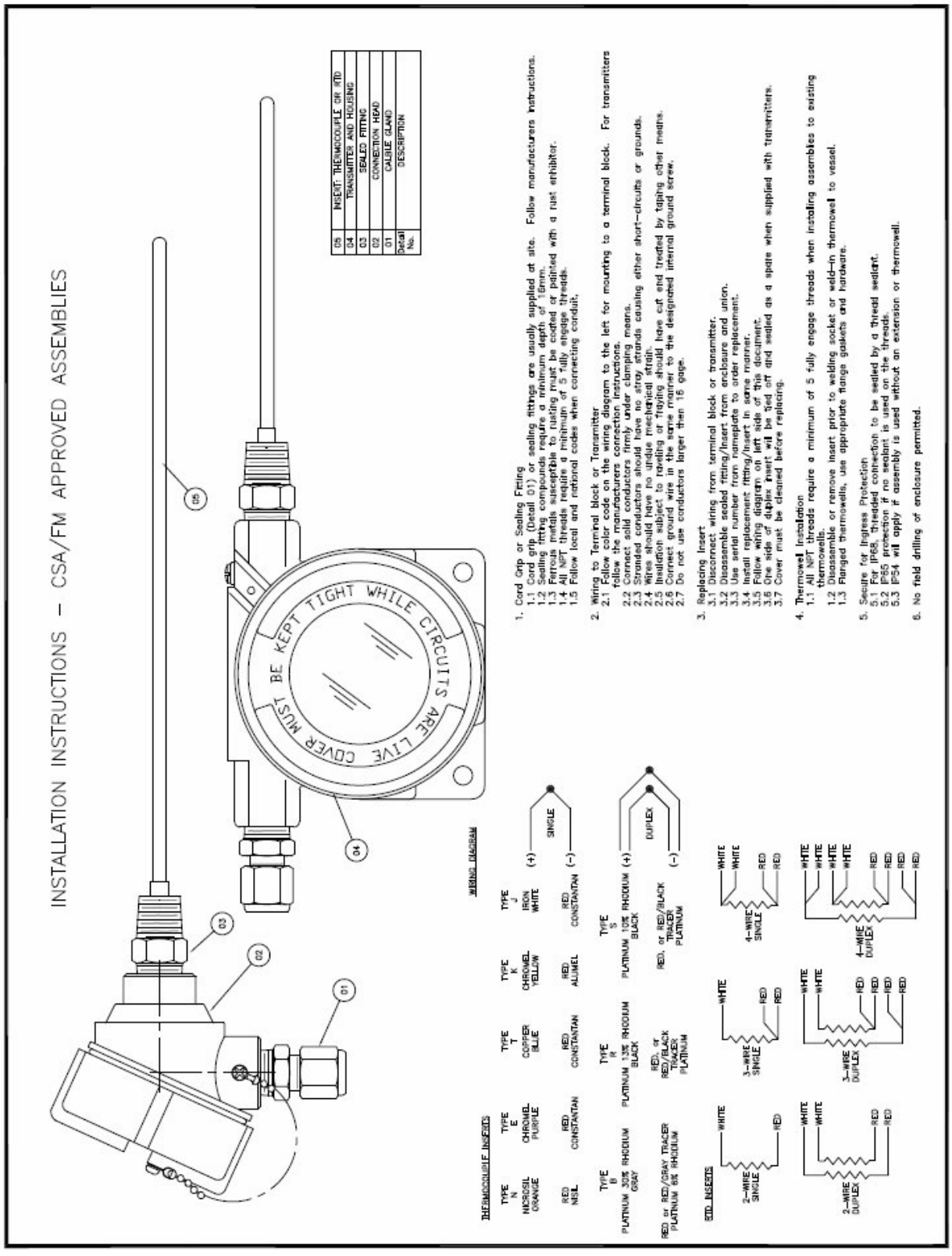


Figure 5-3 CSA/FM Installation Instructions Series STT820

Wiring Instructions to Terminal Block

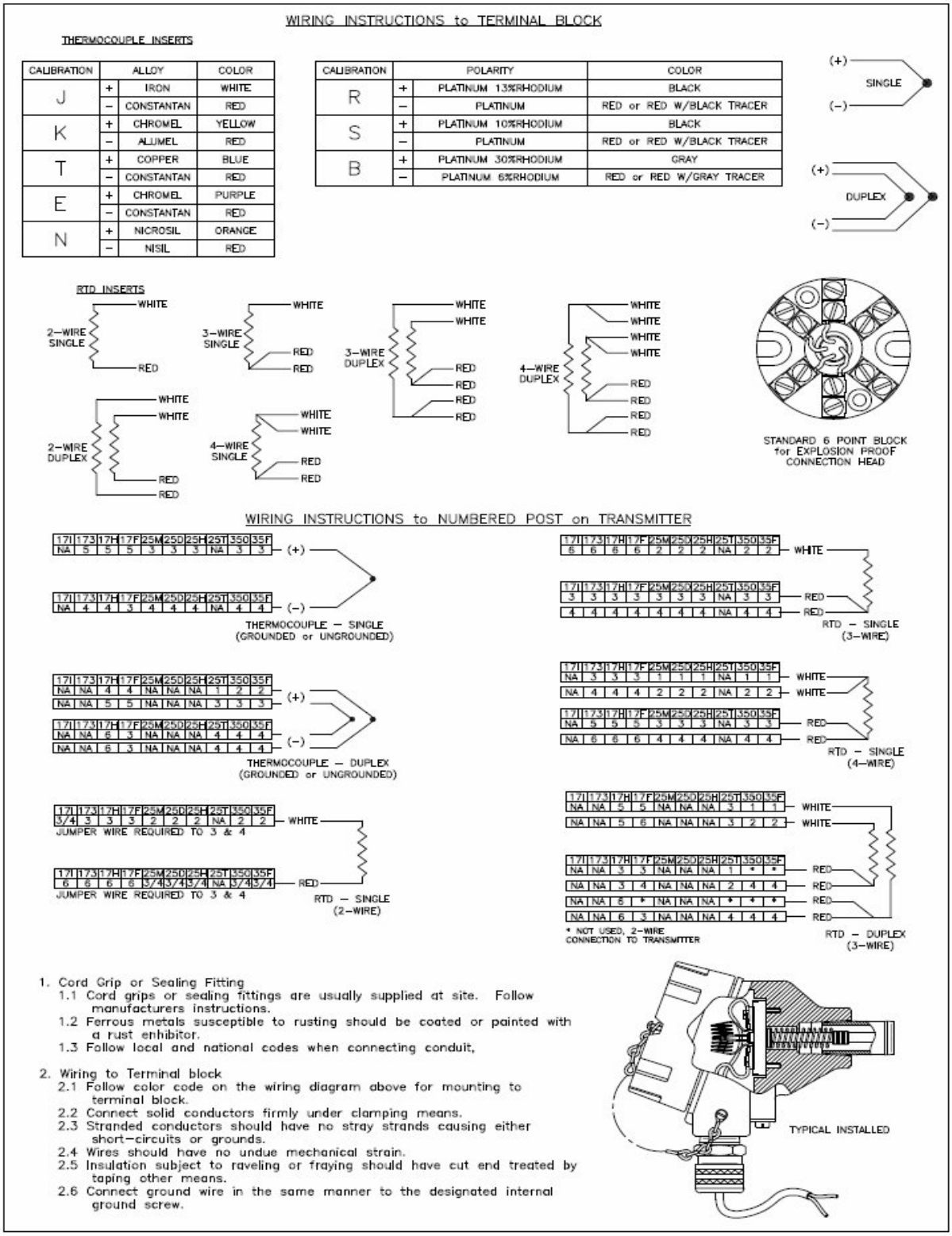


Figure 5-4 Teminal Block Wiring Instructions

Sales and Service

For application assistance, current specifications, pricing, or name of the nearest Authorized Distributor, contact one of the offices below.

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