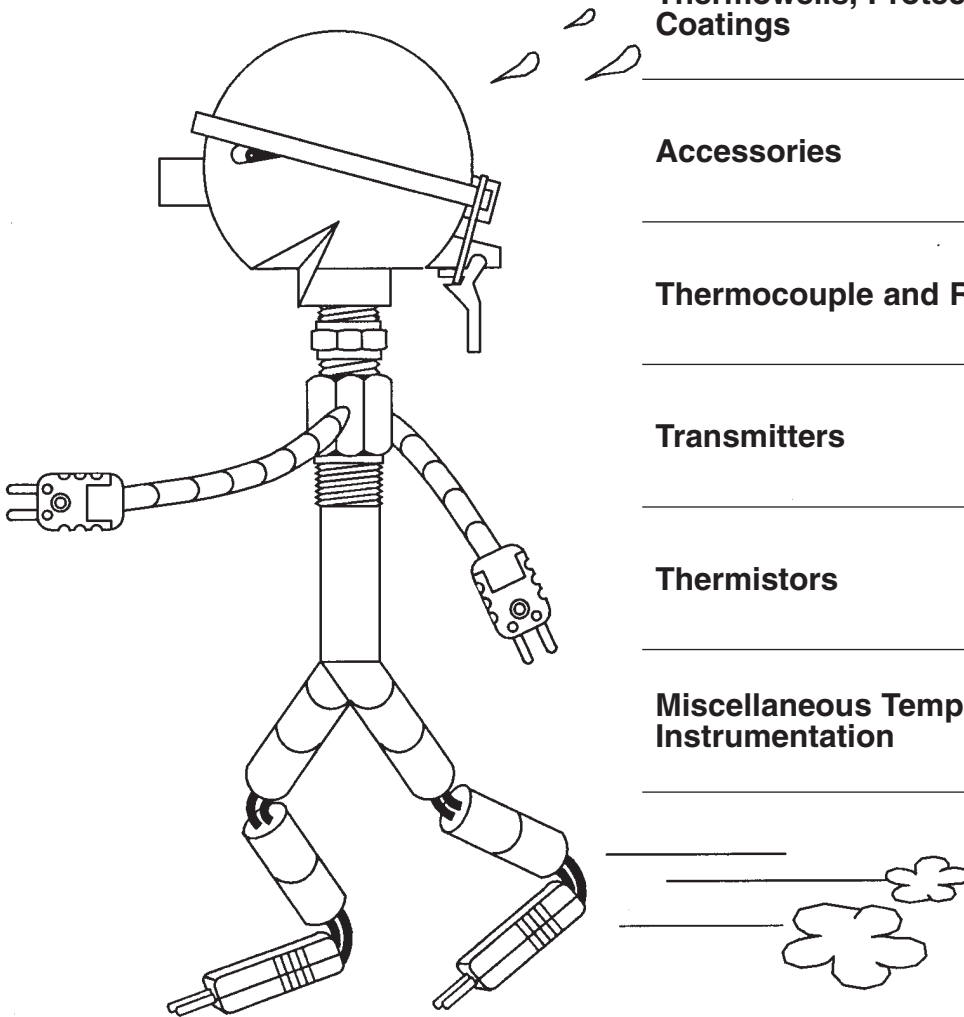


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JMS Southeast, Inc.
Temperature Measurement



Miniature and Industrial Thermocouples



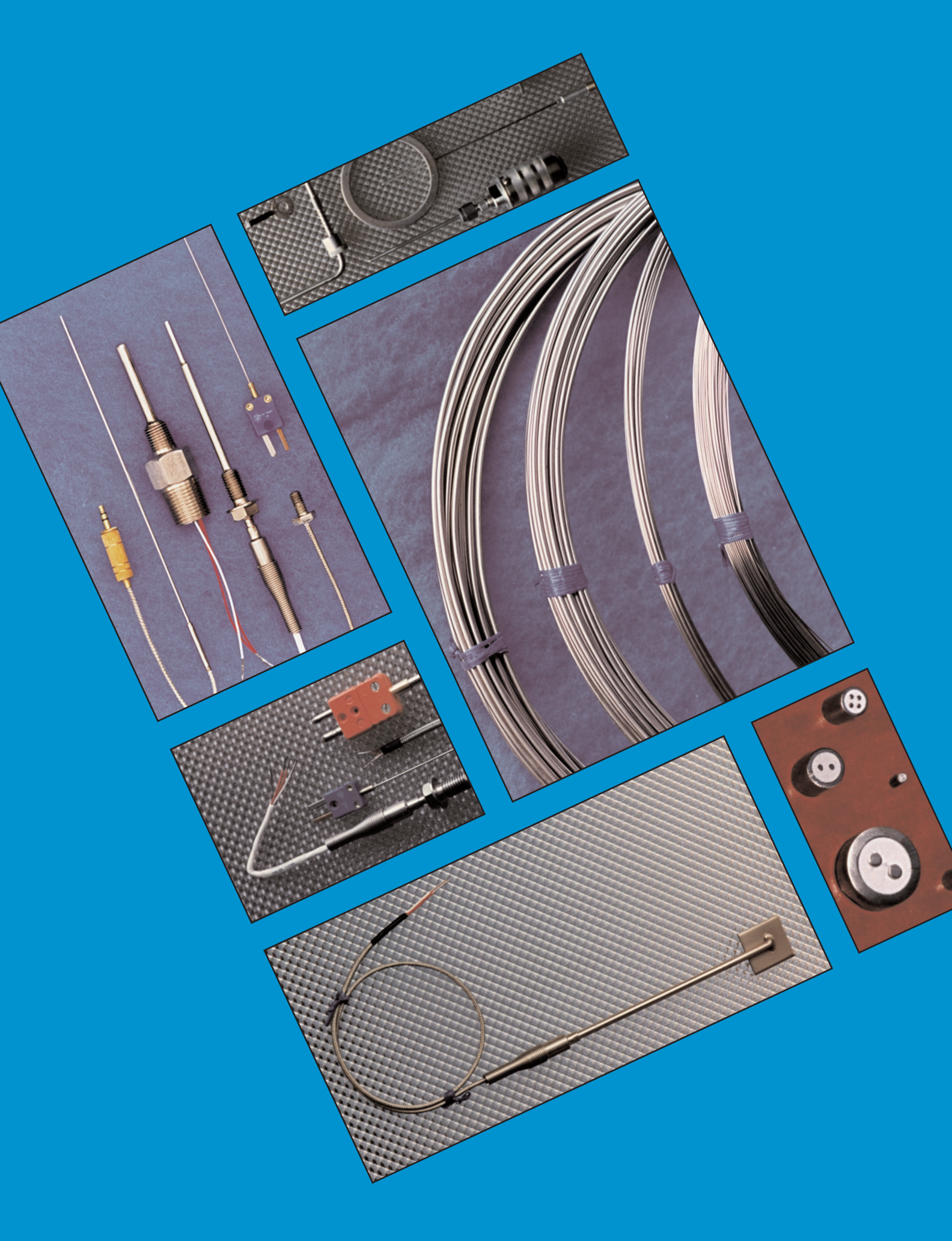


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Note: All thermocouples may be coated for abrasion resistance or resistance to chemical attack. See pages 5-35 through 5-39.

MINIATURE AND INDUSTRIAL THERMOCOUPLES

#1	SERIES [6, 7]	
1	Thermocouple	
#2	TYPE [8, 9, 10]	
—	J, T, K, E, N, X (Other, specify)	
#3	LIMITS OF ERROR [9]	ELEMENT CONSTRUCTION
1	Standard	Single
2	Standard	Dual
3	Special	Single
4	Special	Dual
X	Other, specify	
Note: For hollow tube sensors see pages 2-1 and 2-2.		
#4	OUTSIDE DIAMETER [11]	CONDUCTOR SIZE (FOR BASE METALS ONLY) SINGLE (awg) DUAL (awg)
*A	3/8"	13 16
B	1/4"	16 18
C	3/16"	19 20
D	1/8"	22 24
E	1/16"	28 30
*F	1/25"	32 34
X	Other, specify	
Z	N/A	
Note: JMS now offers sheath as small as .010 in diameter		
#5	SHEATH MATERIAL [11]	MAX °F [2-8, 4-17]
H	304 Stainless Steel	1650
J	310 Stainless Steel	2100
V	STABALOY	2220
K	316 Stainless Steel	1650
M	Inconel 600	2100
C	Teflon coated SS	400
X	Other, specify	
#6	MEASURING JUNCTION [12, 13, 15]	
G	Grounded	*P Reduced tip, grounded
U	Ungrounded	*Y Reduced tip, ungrounded
E	Exposed (Isolated on dual)	*R Gas/Air, exposed
I	Isolated	*S Gas/Air, grounded
*J	Pointed tip, grounded	*T Gas/Air, ungrounded
*K	Pointed tip, ungrounded	*V Enlarged tip, grounded
*L	Weld pad, grounded	*W Enlarged tip, ungrounded
*M	Weld pad, ungrounded	*X Other, specify
*N	Weld pad, removable grounded	
*O	Weld pad, removable ungrounded	
*Note: When selecting these options, a description must be provided		
#7	LENGTH (See sketches on Pg. 1-1, 2, 3 & 4 for lengths)	
—	Length in inches	
Note: If sensors requires a bend from the factory use page 2-1 to order.		
#8	STANDARD INDUSTRIAL ATTACHING DEVICE [1-3, 6- 13]	
W	Fixed NPT ss fitting - double threaded	
S	Spring loaded NPT ss fitting -double threaded	
C	Spring loaded NPT ss w/ oil ring - double threaded	
D	Spring loaded ss fitting - single threaded	
B	Bayonet spring loaded assembly for thermowells and heads	
*E	Adjustable spring over .250", .188", .125" sheath	
F	Reverse mounted steel plug fixed for attaching head	
G	Fixed stainless steel to sheath (See drawing to left)	
*H	Compression fitting ss w/ ss ferrule	
*I	Compression fitting ss w/ teflon ferrule	
*J	Compression fitting ss w/ lava ferrule	
*K	Compression fitting ss w/ nylon ferrule	
*L	Compression fitting brass w/ brass ferrule	
N4	4" Nipple-Union-Nipple (NUN4G1)	
N6	6" Nipple-Union-Nipple (NUN6G1)	
S4	4" Spring-Loaded-Union-Nipple (NU4G1)	
S6	6" Spring-Loaded-Union-Nipple (NU6G1)	
X	Other, specify or if more than 1 is needed	
Z	Not applicable (no fitting required)	
* Length is calculated without consideration of these attaching device. (See dwg on pg. 1-2)		

[] BRACKETS INDICATE PAGE NUMBERS ON WEB OR FULL CATALOG FOR ADDITIONAL TECHNICAL INFORMATION
WWW.JMS-SE.COM

Immersion for Symbol #8-E Spring

Immersion for Symbol #8-G&D Fitting

For materials other than SS, (ex: brass, carbon steel, etc.) Use X + material + letter designation

(SEE PAGE 1-3) FOR MORE NIPPLE OPTIONS.

MINIATURE AND INDUSTRIAL THERMOCOUPLES

#9	PROCESS NPT [3]			
L M P O X Z	1/8" 1/4" 1/2" (Standard w/ symbols W, S, C, and N in symbol #8) 3/4" Other, specify N/A			
#10	LEAD WIRE TYPE & LENGTH IN INCHES [SEE SECTION 7]			
Z 1 2 3 4 5 7 X	No lead wires Glass braid PVC Teflon Hi-temp glass braid Kapton Bare wire Other, specify	8 PVC coil cord - Standard when using symbol #8-B and #13-R	Note: For non-stock stranded wire, add "S" before symbol designation in this column. 24 awg or smaller may be used to accommodate some smaller diameters and flex armor extensions.	
#11	ARMOR OR HEAT SHRINK [7-7] [16]			
A B C D F G H	3/16" ID SS flex armor 3/16" ID SS flex armor PVC coated white 3/16" ID SS flex armor PVC coated black 1/8" ID SS flex armor SS overbraid Heat shrink / sleeving Jacket to match primary insulation	J X Z	Aluminum mylar shielded and jacketed to match primary insulation Other, specify N/A Note: Bell Springs are used for most wire extensions at transition. A special armor adapter is used when armor is longer than 60".	
#12	TYPE OF TRANSITION [16]			
H S T R X Z	Heat shrink Size on size 3/8" OD (Standard) 1/4" OD Other, specify No transition	Note: For high humidity / moisture environments, ≤ 500°F put a "2" after your selection. * For high temperature at the transition area use an X + type of transition and maximum temperature. >500°F		
#13	COLD END TERMINATION [SEE SECTION 7] PICK AS MANY AS APPLICABLE			
A B C D E F G I K L M N O	Bare ends Miniature plug Standard plug Miniature jack Standard jack High temperature plug (< 800° F) High Temperature jack (< 800° F) Explosion proof Nema 7 head (6I / 6PT) Spade lugs (6SL) Aluminum head w/ hinged cover (6L / 6B4) Aluminum head w/ screw cover & chain (6M / 6B4) Cast iron head w/ screw cover (6N / 6B4) Open terminal block (6M)	Note: For any other cold end termination, use symbol X and describe using appropriate part numbers from section 6 in place of symbol #13.	Q R W* 8H 8N 8S 8I 8E 8D X	Black nylon Nema 4 head (6Q / 6B4) High dome head (6R) Microphone style connector (6DA) -Male Isolated Transmitter Non Isolated Transmitter AI-1500 TempIR with Hart Protocol Intrinsically Safe TempIR TempIR/ Hart/ Intrinsically Safe Other, specify
		*Use double symbol here for matching female connectors. i.e. B/BB (male with matching female).		
#14	OPTIONS USE ONLY IF APPLICABLE [INTRODUCTION]			
1 2 3 4	Stainless steel tag Plastic tag Paper tag Electroetch on probe Note: You must always specify information required on tag	5 6 7 8 9 Z	TAGGING CALIBRATION	Calibrate at specified point(s). Corrections data will be provided for each point. Calibrate specified temperature range. Corrections data will be provided for all temperatures within the range. Note: You must specify increments & range Ex. 0 to 300°F, 0.1° increments CE Marking [Page XV] Guide 17025 calibration BAR CODE N/A

LEADWIRE

Immersion is overall length of tube for non-fixed attaching devices

L

Z

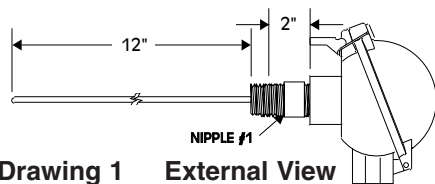
G

Z

L

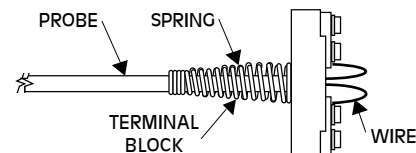
1

NIPPLE-UNION-NIPPLE EXTENSION ASSEMBLIES

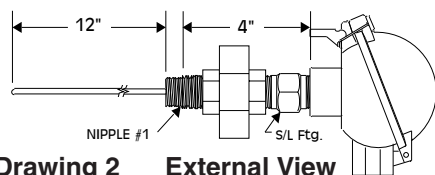


Drawing 1 External View

Drawing 1 - Nipple Only
Minimum Nipple L=1"
Ex. Part#: 1J1BHG12"EXZZZL
X = N2"G1

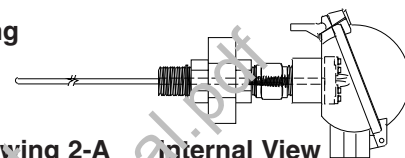


Direct Mounted Spring on Terminal Block

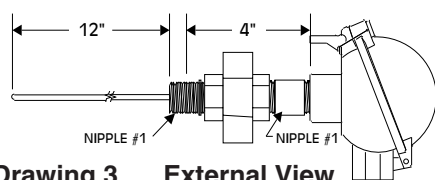


Drawing 2 External View

**Drawing 2 - Nipple-Union with
Machined 1/2" x 1/2" Spring Loaded Fitting**
Minimum NU L=4" (includes S/L fitting)
Ex. Part#: 1J1BHG12"SXZZZL
X = NU4"G1

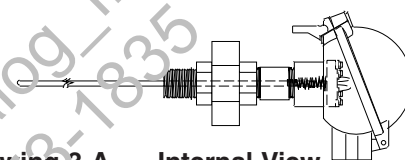


Drawing 2-A Internal View



Drawing 3 External View

**Drawing 3 - Nipple-Union-Nipple with
Spring Against Terminal Block**
Minimum NUN L=4"
EX. Part#: 1J1BHG12"EXZZZL
X = NUN4"G1



Drawing 3-A Internal View

An extension assembly may be needed to provide extra length for your sensor in order to extend your sensor head through insulation, or away from the heat of the process. This extension can include a pipe nipple only or a nipple-union-nipple or a nipple-union with a spring-loaded fitting.

Standard nipples and unions are 1/2" NPT and are available in galvanized or stainless steel. The union joins two nipples in an extension assembly and has a standard pressure rating of 150 pounds.

When a nipple-union-nipple or nipple only assembly is used and spring loading of the thermocouple element is required, there are two different methods of spring loading the sensor. The preferred method is to use the machined 1/2" by 1/2" NPT spring-loaded stainless steel fitting as one of the nipples (see symbol #8, S page 1-1). With this design, the probe is secured within the fitting and is mounted to the head in a rigid manner (see drawing #2 above). The appropriate part number for this assembly would be selected from symbols #8 and #9 from page 1-1 and 1-2, in addition to the symbols on this page. A cheaper method is a spring, mounted over the probe and loaded against the bottom of the terminal block in the head. With this method the probe is not supported within the nipple-union-nipple. It is secured only by the wires into the terminal block. (See drawings 1 & 3 above). We do not recommend that you use this method of spring loading if your probe is mounted horizontally.

When specifying this sensor extension, the nipple-union-nipple length tolerance is $\pm 1/4"$.

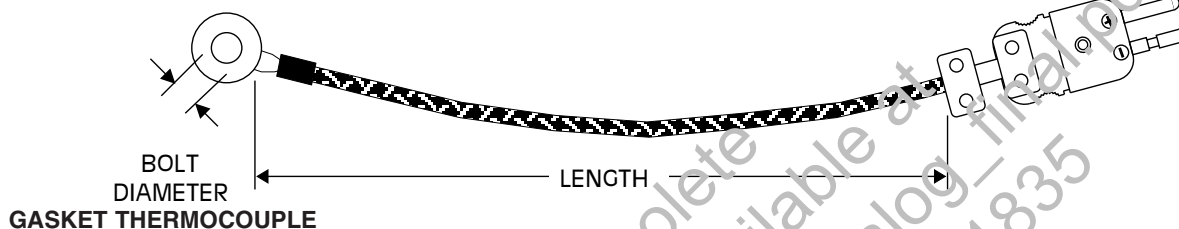
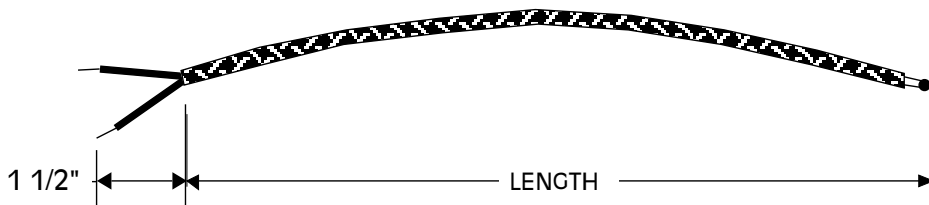
#1	EXTENSION ASSEMBLY		
N	Nipple Only (Dwg #1)		
NU	Nipple-Union (Dwg #2)		
NUN	Nipple-Union-Nipple (Dwg #3)		
	#2	LENGTH	
	--"	Specify length in inches	
	#3	MATERIAL	
	G	Galvanized Steel	
	H	304 Stainless Steel	
	C	Black Steel	
	#4	PRESSURE RATING	
	1	#150	- A351 spec (Standard)
	2	#3000	- A182 spec
	3	#6000	- A182 spec
	X	Other, specify	
		} ASTM	
NUN	6"	G	1

BEADED THERMOCOUPLES

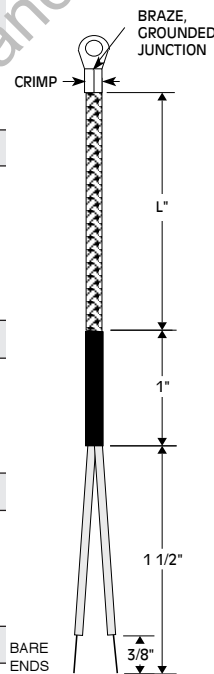
#1	SERIES									
1B	Beaded Thermocouple									
	#2	SERIES								
	B	Welded bead only								
	T	Twisted and welded bead								
	#3	INSULATOR TYPE AND LENGTH (L)								
	A	1 inch - Round								
	D	3 inch - Round								
	F	One piece construction - Round								
	G	1 inch - Oval								
	H	3 inch - Oval								
	X	Other, specify in description								
	Note: Oval insulators are recommended for lengths beyond 100".									
	#4	COLD END INSULATION								
	1	Fiberglass sleeve (Standard)								
	2	Heat shrink								
	3	Mullite fish spine beads (includes tangs)								
	Z	Bare ends								
	X	Other, specify								
	#5	INSULATOR MATERIAL								
	A	Alumina (Standard for noble metals)								
	M	Mullite (Standard for base metals)								
	#6	WIRE GAUGE								
	SINGLE ELEMENT	O.D. OF 1" OR 3" OVAL INSULATORS								
	8	8 (Standard oval) 5/16" x 7/16"								
	14	14 (Standard oval) 3/16" x 1/4"								
	20	20 3/16"								
	24	24 3/16"								
	26	26 3/16"								
	30	30 3/16"								
	X	Other, specify								
	DUAL ELEMENT	O.D. OF 1" OR 3" ROUND INSULATORS								
	D08	8 7/16"								
	D14	14 1/4"								
	D20	20 3/16"								
	D24	24 3/16"								
	D26	26 3/16"								
	D30	30 3/16"								
	D X	Other, specify								
	#7	TYPE								
	-	J, K, E, S, R, B, N, X (Other, specify)								
	#8	LEAD LENGTH IN INCHES								
	-"	Specify length of thermocouple leads in inches. (See drawings) (2" Recommended for replacement elements)								
	#9	OPTIONS USE ONLY IF APPLICABLE [INTRODUCTION]								
	TAGGING	1 Stainless steel tag 2 Plastic tag 3 Paper tag				CALIBRATION				
						4 Calibrate at specified point(s). Corrections data will be provided for each point. 5 Calibrate specified temperature range. Corrections data will be provided for all temperatures within the range.				
						Note: You must specify increments & range Ex. 0 to 300°F, 0.1° increments.				
	Insulator Tolerances Ø: ± 6% or .005" whichever is greater. Length: ± .063".									
	Noble metal thermocouples are normally 24 gauge wires. To specify ceramic or metal protection tubes for above assemblies, see "Thermowells and Protection Tubes Section".									
	Oval Insulators will be used for any bent beaded thermocouple.									
1B	B	A (18)	Z	A	24	R	3"	3		

WIRE, GASKET, AND LUG THERMOCOUPLES

WIRE THERMOCOUPLE



#1	DESCRIPTION	
1D	Wire and Gasket thermocouples	
	#2	TYPE OF THERMOCOUPLE
	G	Wire thermocouple
	H	Gasket thermocouple
	L	Ring Terminal thermocouple
	S	Spade Lug thermocouple
	#3	TYPE
	J	Iron/Constantan
	T	Copper/Constantan
	K	Chromel/Alumel
	E	Chromel/Constantan
	N	Nicrosil/Nisil
	X	Other, specify
	#4	GASKET MATERIAL
	C	Copper (Standard)
	P	Spark plug washer (1 cycle automotive)
	S	Stainless steel
	X	Other, specify
	Z	N/A
	#5	BOLT DIAMETER
	A	#10
	B	#12
	C	1/4"
	X	Other, specify
	Z	N/A
	#6	WIRE INSULATION
	1	Glass braid
	3	FEP teflon
	4	Hi-temp glass braid
	5	Kapton
	8	Glass braid / stainless steel overbraid
	X	Other, specify
	#7	DESCRIPTION
	--"	Length in inches
	#8	COLD END TERMINATION
	A	Bare ends (Heat shrink used with braided insulation)
	B	Miniature plug
	C	Standard plug
	X	Other, specify (See page 1-2 or section 6 for options)



RING TERMINAL THERMOCOUPLE

THERMOCOUPLES

Thermocouples operate on the principle that when two dissimilar metals are joined at both ends and one of the ends is at a different temperature, a measurable and repeatable EMF is produced.

The preferred design for JMS thermocouples is mineral insulated sheath. The high purity, hard packed magnesium oxide provides excellent insulation of the positive and negative wire conductors in relation to each other and to the outer metal material. Among the outstanding features of sheath are: (A) flexibility to bend or form to a radius = to 2x sheath diameter, (B) its rigidity to maintain size and shape after bending or straightening, (C) vibration nor shock has little effect on the sensor, (D) sheath withstands pressures upwards to 50,000 psi, and (E) sheath may be used in applications where temperatures may range from -400° to 3000°F depending on requirements and selection of materials.

COMPONENTS OF THERMOCOUPLES

HOT END

Outside Diameter

Thermocouples range in outside diameters from .010" to .500". A general rule of thumb is the smaller the diameter, the quicker the response time. For additional information see page 1-13.

Sheath Material

JMS offers thermocouples in a wide variety of sheath materials, with 304 and 316 stainless steel being the most popular. Both temperature and environment should be taken into consideration when selecting your sheath material. See pages 1-1, 1-11 and 4-17 for temperature ratings of various materials. See page 2-8 for insulation characteristics.

Measuring Junction

The measuring junction is the sensitive portion of the thermocouple. Grounded junctions are the most frequently requested junctions. For a complete description of measuring junctions available and their advantages and disadvantages see page 1-12, 1-13.

TRANSITION AREA

This area is between the points when the sheath or tube ends and the cold end begins. The area includes the **actual transition point** (see pg. 1-16) and any process fitting or connections within these two points. Process connection **fittings** include compression fittings and 1/2" x 1/2" N.P.T. welded or spring loaded fittings. See page 1-2 for full selection of process connections. Metal parts and process connections can either be welded or brazed (silver solder), depending on the wall size of the material to which the parts are being attached.

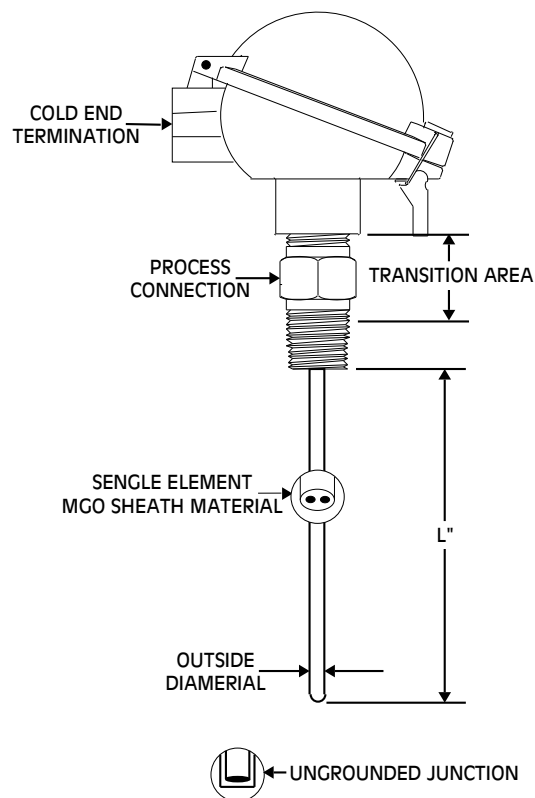
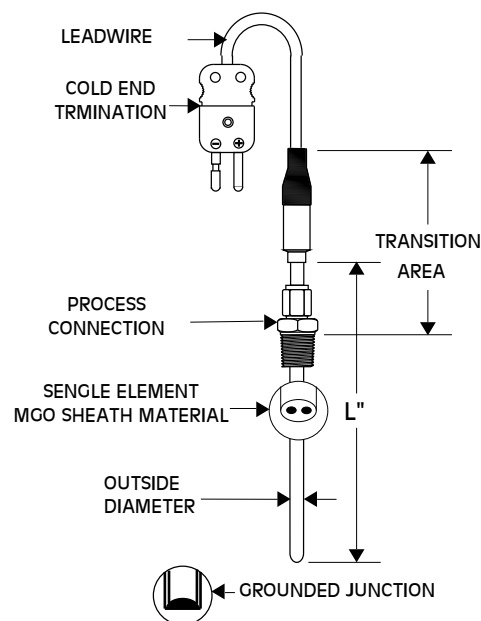
COLD END

Leadwire Insulation

JMS offers a large selection of thermocouple leadwire. Insulations include fiberglass, PVC, teflon, kapton, high temperature fiberglass, and fiberglass with stainless steel overbraid or flexible armor. Additional information can be found in the "Thermocouple and RTD Wire" section. (Section 7)

Cold End Termination

This may be in the form of wires, plugs, or terminal heads. A partial list is given on page 1-2. See section 6.



4, one hour sessions training video.
\$1200.00 - Call for information.

THERMOCOUPLE GENERAL INFORMATION

Thermocouples consist of two dissimilar metals and provide a means of sensing temperature in a variety of processes. Temperature is the most widely measured process variable and its measurement is critical in many manufacturing processes. We at JMS manufacture temperature probes of exceptional quality to assure this measurement is accurate.

Thermocouples can be constructed in a variety of ways from flexible wires smaller than a human hair to rugged sheath one half inch in diameter. They can measure temperatures from -454°F to 4200°F.

Thermocouples are low-impedance devices that work by producing electro-motive forces and these EMF's are correlated to a temperature based on a curve specified for that particular thermocouple calibration. The EMF produced occurs due to temperature gradients along the wire and not at the junction. This phenomenon can be explained in three scientific theories called the Seebeck effect, the Peltier effect, and the Thompson effect.

Three laws of thermoelectric circuits that explain thermocouple behavior are **The Law of Intermediate Metals** which explains that a circuit's EMFs are algebraically additive unless the circuit is at a uniform temperature, **The Law of Homogeneous Metals** which indicates an EMF cannot be created unless another type of metal exists in the circuit and a temperature gradient exists.

The third law is the **The Law of Intermediate Temperatures**. If two dissimilar homogeneous metals produce a thermal EMF of X; it will remain at that number if a third material is introduced into the circuit, if both ends of that third material are at the same temperature.

The millivolt signal produced by the thermocouple is a very, very, very low level signal. Thus, transmitting this signal over a long distance may be difficult if any extraneous "noise" is introduced into the system. This noise may cause errors in the EMF signal. Shielded lead wire should be used in areas with excessive "noise" to help eliminate the problem.

The lead wire that extends from the thermocouple must match the calibration of the thermocouple. This lead wire continues to transmit the signal from the thermocouple to the instrument, and as long as it is one homogeneous metal, it does not produce an EMF along that length even if it does experience temperature gradients.

The output of a thermocouple depends on the magnitude of the temperature difference between the measuring junction and the reference junction. The reference junction is the cold end to which the thermocouple is connected. While the hot measuring junction is stable at a given temperature, the output of the point at which the reference junction is made must be compensated for in the instrumentation. This is accomplished through "cold junction Compensation." The temperature of the cold junction is measured and calculated into the overall EMF signal to obtain the accurate hot junction temperature, or the temperature of the process.²

²Benedict, R.P. Fundamentals of Temperature, Pressure and flow Measurement, Second Edition, Wiley, New York (1977).

THERMOCOUPLE POINTS

1. A thermocouple produces an EMF based on the composition of the two dissimilar metals only, irregardless of the dimension or length of the conductors.
2. No voltage is produced at the thermocouple junction, only in those portions of the sensor that are in a temperature gradient.

JMS has access to several papers on noise and its effect on instruments. Call us and we will mail or fax you a copy.

4, one hour sessions training video.
\$1200.00 - Call for information.

THERMOCOUPLE TYPE INFORMATION

JMS offers thermocouples and wire in the following types. Listed below are suggested criteria to consider in selecting the desired type for your application. Contact JMS Southeast if additional information is required.

(J)—Iron vs Constantan (Most Common)

May be used in vacuum, oxidizing, reducing, and inert atmospheres. Heavier gauge wire is recommended for long term life above 1000°F since the iron element oxidizes rapidly at these temperatures.

(T)—Copper vs Constantan (Most Common Cold)

May be used in vacuum, oxidizing, reducing, and inert atmospheres. It is resistant to corrosion in most atmospheres. High stability at sub-zero temperatures and its limits of error are guaranteed at cryogenic temperatures.

(K)—Chromel vs Alumel (Most Common Real Hot)

Recommended for continuous use in oxidizing or inert atmospheres up to 2300°F (1260°C), especially above 1000°F. Cycling above and below 1800°F (1000°C), is not recommended due to EMF alteration from hysteresis effects. Should not be used in sulfurous or alternating reducing and oxidizing atmospheres unless protected with protection tubes. Fairly reliable and accurate at high temperatures.

(E)—Chromel vs Constantan

May be used in oxidizing or inert atmospheres, but not recommended for alternating oxidizing or inert atmospheres. Not subject to corrosion under most atmospheric conditions. Has the highest EMF produced per degree than any other standard thermocouple and must be protected from sulfurous atmospheres.

(S,R)—Platinum vs Platinum Rhodium (Most Common Real, Real Hot)

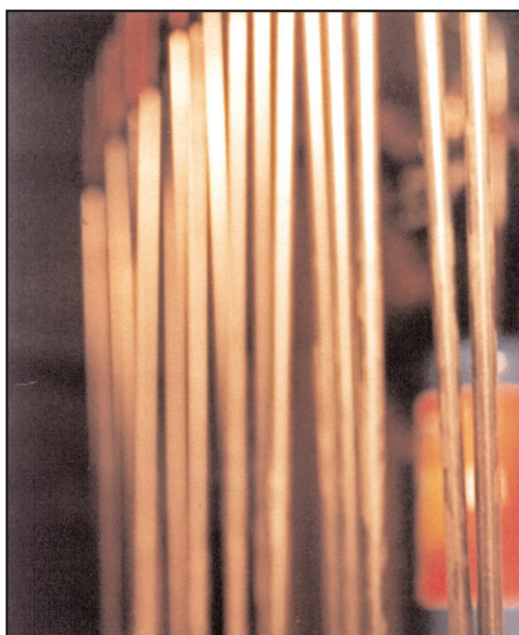
Recommended for use in oxidizing or inert atmospheres. Reducing atmospheres may cause excessive grain growth and drifts in calibration.

(N)—Nicrosil vs Nisil (New ... Better Than “K”)

May be used in oxidizing, dry reducing, or inert atmospheres. Must be protected in sulfurous atmospheres. Very reliable and accurate at high temperatures. Can replace Type K thermocouples in many application.

(C)—Tungsten 5% Rhenium vs Tungsten 26% Rhenium

Recommended for use in vacuum, high purity hydrogen, or pure inert atmospheres. May be used at very high temperatures (2316°C), however, is inherently brittle.



THERMOCOUPLE TYPE INFORMATION

	ANSI T/C TYPE	NAMES	CONDUCTOR IDENTIFICATION	ASTM COLOR CODING	MAGNETIC	IEC COLOR CODING
Not ANSI	J	Iron Constantan	+ -	white red	yes no	white black
	T	Copper Constantan	+ -	blue red	no no	white brown
	K	Chromel Alumel	+ -	yellow red	no yes	white green
	E	Chromel Constantan	+ -	purple red	no no	white violet
	P	Platinel	N/A	N/A	N/A	N/A
	S	Platinum 10% Rhodium Pure platinum	+ -	black red	no no	white orange
	R	Platinum 13% Rhodium Pure platinum	+ -	black red	no no	white orange
	B	Platinum 30% Rhodium Platinum 6% Rhodium	+ -	grey red	no no	white grey
Not ANSI	N	Nicrosil Nisil	+ -	orange red	no slightly	white pink
	C	Tungsten 5% Rhenium Tungsten 26% Rhenium	+ -	white red	no no	N/A

See Section 7 for wire insulation color codes.

ANSI THERMOCOUPLE TYPE	TEMP. RANGE		LIMITS OF ERROR			
	(°C)	(°F)	STANDARD °C	°F	SPECIAL °C	°F
J	0 to 760	32 to 1400	±2.2 or ±0.75%	See Note	±1.1 or 0.4%	See Note
T	0 to 370	32 to 700	±1 or ±0.75%		±0.5 or 0.4%	
K	0 to 1260	32 to 2300	±2.2 or ±0.75%		±1.1 or ±0.4%	
E	0 to 870	32 to 1600	±1.7 or ±0.5%		±1 or ±0.4%	
S	0 to 1480	32 to 2700	±1.5 or ±0.25%		±0.6 or ±0.1%	
R	0 to 1480	32 to 2700	±1.5 or ±0.25%		±0.6 or ±0.1%	
N	0 to 1246	32 to 2300	±2.2 or ±0.75%		±1.1 or ±0.4%	
B	870 to 1700	1600 to 3100	±0.5%		±0.25%	
T ^A	-200 to 0	-328 to 32	±1 or ±1.5%		B	
E ^A	-200 to 0	-328 to 32	±1.7 or ±1%		B	
K ^A	-200 to 0	-328 to 32	±2.2 or ±2		B	

^A Thermocouple and thermocouple materials are normally supplied to meet the tolerances specified in the table for temperatures above 0°C. The same materials, however, may not fall within the tolerances given for temperatures below 0°C in the section of the table. If materials are required to meet the tolerances stated for temperatures below 0°C the purchase order must so state. Selection of materials usually will be required.

^B Special tolerances for temperatures below 0°C are difficult to justify due to limited available information.

Note: The °F tolerance is 1.8 times larger than the °C tolerance at the equivalent °C temperature.

THERMOCOUPLE-MILLIVOLT GRAPH

T=Copper vs. Constantan

E=Chromel vs. Constantan

J=Iron vs. Constantan

K=Chromel vs. Alumel

W=Tungsten vs. Tungsten 26% Rhenium (also known as Type G)

C=Tungsten 5% Rhenium vs. Tungsten 26% Rhenium (also known as Type W5)

R=Platinum vs. Platinum 13% Rhodium

S=Platinum vs. Platinum 10% Rhodium

B=Platinum 6% Rhodium vs. Platinum 30% Rhodium

N=Nicrosil vs. Nisil

P=Platinel

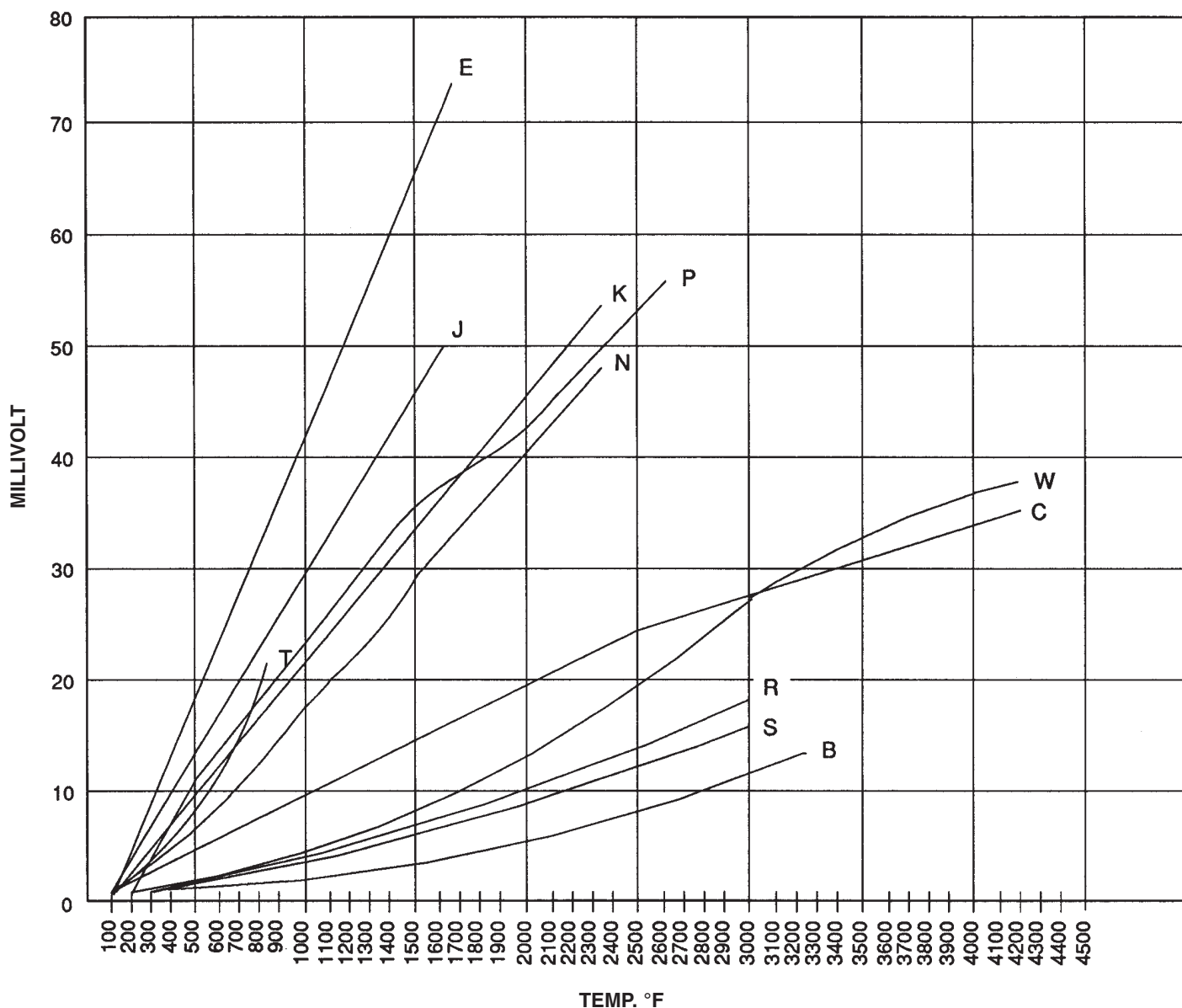
Selection of the optimum type of thermocouple and auxiliary components for a pyrometric system is necessarily based on a number of variables or factors of the appli-

cation. The temperature range, EMF output, accuracy required, resistance to atmospheric conditions, pressure and shock are typical thermocouple systems for a given application.

The following technical information is intended to serve only as a guide for thermocouple selection. Any recommendation stated is based on past practices and experience, and no guarantees, implied or otherwise, are made as to optimum operation conditions.

Although some of these materials will operate at higher temperatures than shown on the chart, they represent what is generally conceded as the maximum reliable operating temperature.

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ELEMENT CONSTRUCTION

JMS Southeast offers the choice of single, dual, or triple element thermocouples. A single element thermocouple is used when a single signal is required. If two inputs are required, we offer dual element sensors. Dual isolated elements are frequently used for two different monitoring systems such as a recorder and controller. Although not as commonly used as single or dual elements, JMS also manufactures triple element sensors for applications that require three inputs. It is possible to parallel outputs from a thermocouple to any number of instruments, but this is not a recommended practice. The use of dual or triple elements should also specify isolated junctions. See page 1-1.

SUGGESTED UPPER LIMIT FOR OUTSIDE DIAMETER (SINGLE ELEMENT) °C (°F)						
Sheath		Thermocouple Type				
In.	mm	T	J	E	K	N
1/25"	1.0	260° (500°)	260° (500°)	300° (570°)	700° (1290°)	700° (1290°)
1/16"	1.6	260° (500°)	440° (825°)	510° (950°)	920° (1690°)	920° (1690°)
1/8"	3.2	315° (600°)	520° (970°)	650° (1200°)	1070° (1960°)	1070° (1960°)
3/16"	4.8	370° (700°)	620° (1150°)	730° (1350°)	1150° (2100°)	1150° (2100°)
1/4"	6.3	370° (700°)	720° (1330°)	820° (1510°)	1150° (2100°)	1150° (2100°)
3/8"	9.5	370° (700°)	720° (1330°)	820° (1510°)	1150° (2100°)	1150° (2100°)

TEMPERATURE INFORMATION FOR SHEATH MATERIAL				
MATERIAL SYMBOL	SHEATH MATERIAL	MELTING POINT (°F)	MAX. TEMP. IN AIR (°F)	ATMOSPHERE*
H	304SS	2550	1650	ORNV
J	310SS	2550	2100	ORNV
L	316LSS	2550	1650	ORNV
O	446SS	2700	2100	ORNV
M	Inconel 600	2500	2100	ONV
P	Inconel 702	2620	1500	ONV
Q	Platinum	3216	3000	ON
R	Molybdenum	4750	1000	VNR
S	Tantalum	5440	750	V
T	Titanium	3300	600	V
V	STABALLOY	2552	2220	ORNV

*KEY

O=Oxidizing R=Reducing N=Neutral V=Vacuum

NEW!

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For high temperature applications 1000°F to 2300°F, new proprietary materials have been developed to perform better than the alloys used in the past.

V = STABALLOY: "...can be used at ultra high temperatures for prolonged periods with little degradation to the thermocouple wires."

MEASURING JUNCTION



GROUNDING JUNCTION

The **grounded** thermocouple junction is an integral part of the thermocouple sheath tip.

Advantages:

- fast response time in relation to ungrounded and isolated junctions.
- protects the wires from environmental chemicals and corrosives.
- prolongs the operational life of the thermocouple. Longer lifespan than the exposed junction thermocouple.
- it is recommended for high pressure applications.
- it is the least expensive construction.

Disadvantages:

- thermal expansion of sheath material may differ from element to cause mechanical stress and work hardening of metals.
- ground loops may cause interference with instruments.
- faults in insulation are more difficult to detect.



UNGROUNDING JUNCTION

The **ungrounded** thermocouple junction is electrically insulated and electrically isolated from the outer sheath material. In a dual ungrounded thermocouple, one common junction is electrically insulated from the outside sheath.

Advantages:

- the thermocouple junction is isolated from the ground.
- defects in the MgO insulation can be detected by measuring resistance from loop to sheath.
- long term drift under cycling conditions is minimized.

Disadvantages:

- response time is usually slower than grounded thermocouples.
- more expensive than grounded thermocouples.

Dual exposed junctions are common, except for 8 awg



EXPOSED JUNCTION

The **exposed** thermocouple junction extends beyond the protective metallic sheath.

Advantages:

- recommended for measurement of noncorrosive static gas, or air.
- very fast response time, faster than grounded junction.

Disadvantages:

- cannot be used in an environment with a high percentage of solids, high pressure, or flowing material since the junction is exposed to this environment.

Isolated thermocouple junctions are used in a dual or triple thermocouple when the junctions are isolated from the outer sheath material as well as from each other.

Advantages:

- the elements are insulated from ground.
- performs better than ungrounded or grounded junctions in a thermal cycling environment.

Disadvantages:

- slower response time than a grounded dual thermocouple.

*For tip sensitivity information, see page 3-8.



ISOLATED JUNCTION

MEASURING JUNCTION TYPICAL RESPONSE TIME

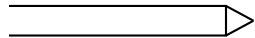
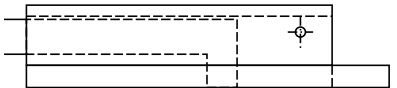
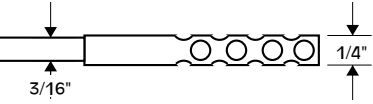
SHEATH O.D.	MEASURING JUNCTION	*RESPONSE
.040 (1/25")	Grounded	.07
	Ungrounded / Isolated	.11
.063 (1/16")	Grounded	.09
	Ungrounded / Isolated	.28
.125 (1/8")	Grounded	.34
	Ungrounded / Isolated	1.6
.188 (3/16")	Grounded	.7
	Ungrounded / Isolated	2.6
.250 (1/4")	Grounded	1.7
	Ungrounded / Isolated	4.5
	Exposed	.09

*Response time in seconds. The above table is the average of several thermocouples tested in each category. Tests were performed during a step change from room temperature to boiling water. The above indicates time required to show 63.2% of a temperature change. No process we know of matches these conditions. Please use this data as a means of comparing sheath size and junction only. Actual response time in your process can be simulated by our laboratory. Please call us for help.

SPECIAL JUNCTIONS

To specify the following special junctions in the thermocouple part number, you may use the appropriate symbol below in place of symbol #6 on page 1-1.

SYMBOL SPECIAL JUNCTIONS

J	Pointed tip grounded	
K	Pointed tip ungrounded	
	See page 1-15	
L	Weld pad grounded (standard pad size 1" x 1" x 1/8" thick)	EG: 1N1DVX... X=L 2" TUBE If curved, use X in symbol #6 and specify pipe / tube diameter and whether the sensor is mounted parallel or perpendicular to the tube on which it is to be mounted. 
M	Weld pad ungrounded (standard pad size 1" x 1" x 1/8" thick)	
	See page 1-14	
N	Weld pad, removable grounded (standard pad size 1" x 2 1/4" x 1/8" thick)	
O	Weld pad, removable ungrounded (standard pad size 1" x 2 1/4" x 1/8" thick)	Specify Pipe / Tube Diameter 
	See page 1-14	
P	Reduced tip grounded (specify overall length, reduced tip length and outside diameters in description)	
Q	Reduced tip ungrounded (specify overall length, reduced tip length and outside diameters in description)	
	See page 1-15	
R	See page 1-15	
S	Gas/Air exposed	
T	Gas/Air grounded	
F	Ultra fast response (40 awg kapton wire) TC only.	
V	Enlarged tip grounded (specify overall length, enlarged tip length and outside diameters in description)	
W	Enlarged tip ungrounded (specify overall length, enlarged tip length and outside diameters in description)	
	See page 1-15	

TUBE-SKIN SENSORS

Tube skin sensors are designed for measuring the temperature of tube walls in chemical power and petroleum industries. Power houses use this type of thermocouple on boiler and superheater requirements. The measurements are used to determine the fatigue of the tube material. For tube skin thermocouples, JMS Southeast uses sheath material which allows for proper insulation, expansion loops, and easy installation. The weld pad should match the tube material and may be used in upper temperature ranges to 2100°F. The standard weld pad dimensions are 1" x 1" x 1/8" thickness. The removable weld pad dimensions are 1" x 2 1/4" x 1/8" thickness. The pads can be curved to fit the radius of your pipe.

On installation, we recommend attaching weld pads to a surface for good thermal conduction. Avoid any currents or still places of flow in your process.

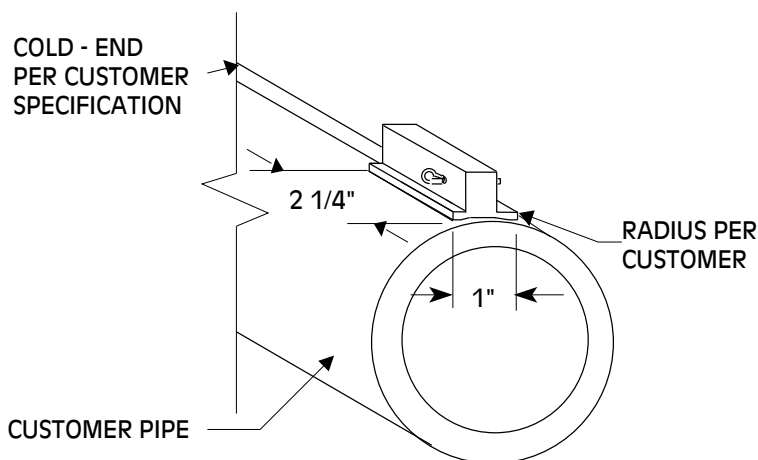
When mounting the tube skin through a furnace wall, insert the probe and mount it into the wall with a compression fitting, then slide another compression fitting onto the probe to secure the head to the cold end.

If this type of mounting is required, the extra compression fitting should be ordered as an accessory piece. The unit will be shipped with the head disassembled.

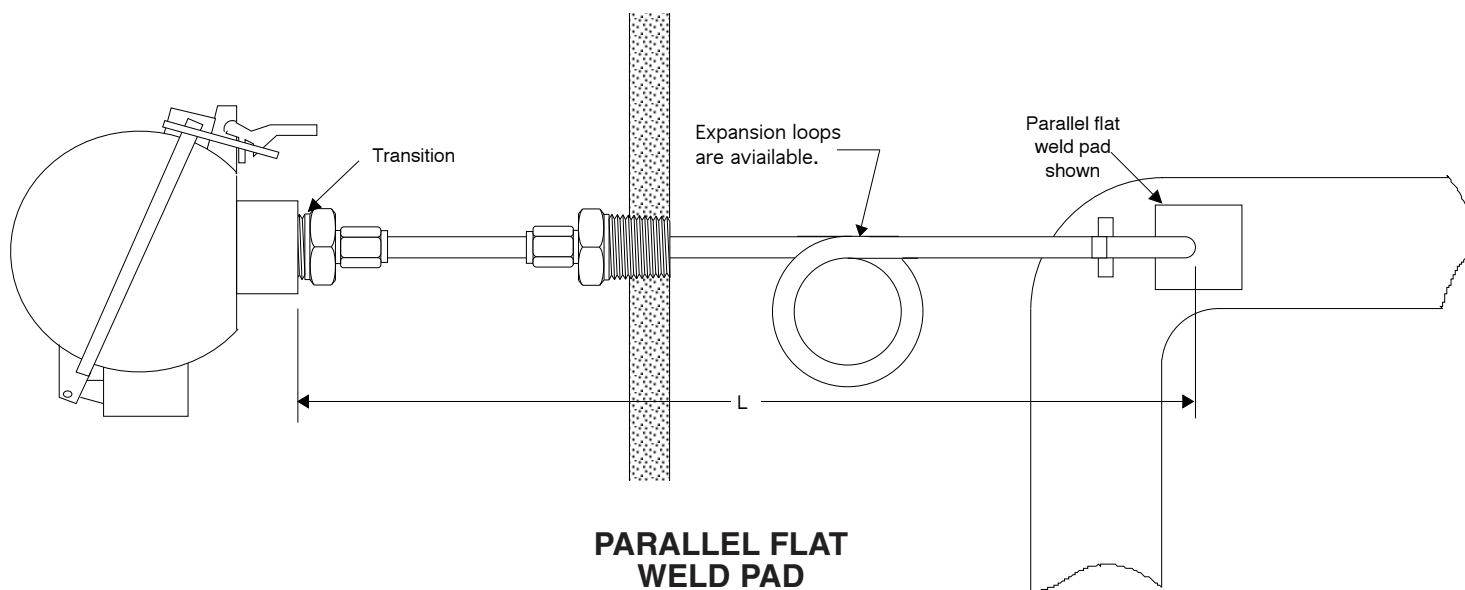
Any other mounting configuration can be specified by a drawing or in the part number description. These fitting options are listed in the ordering symbols below.

Note: Proprietary designs are available for removable tubeskin thermocouples. Call for assistance.

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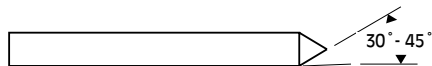


REMOVABLE WELD PAD



SPECIAL JUNCTIONS

POINTED TIP

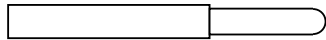


The pointed tip sensor actually acts like a “needle”, and can be inserted into an item to measure its temperature. The angle of the point is approximately 30° - 45°. This type of probe is most commonly used in the food processing and pharmaceutical industries.

This sensor can be manufactured in Types J, K, T, E, and N thermocouple calibration. Any cold end details can be selected from those listed on page 1-2.

The conical point on this sensor is designed to penetrate into soft and semi-frozen objects. It is made from rugged stainless steel and can be manufactured with a durable plastic handle for hand held penetration and measurement, if needed.

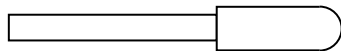
REDUCED TIP



The reduced tip sensor is used to yield a quicker response time. The smaller diameter probe at the tip provides less mass at the sensing end, thus a faster response time.

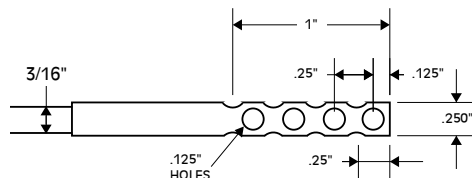
Specify desired diameter needs, large and reduced, and the lengths of both: i.e., X=Reduced tip, 1/4" x 5", 1/8" x 1". This sensor can be used for immersion into air or liquids. Care should be taken to assure high velocity flow and/or pressure does not exist if using a small diameter reduced tip sensor. This sensor can be manufactured in any calibrations. Cold end details can be selected from page 1-2.

ENLARGED TIP



The enlarged tip sensor is usually used for better thermal transfer in an old well. Specify desired diameter needs, reduced and large, and the lengths of both: i.e., X=Enlarged tip, 1/4" x 6", 1/2" x 8". The cold end details can be specified from page 1-2 of the JMS catalog. The standard material used is 316SS.

GAS / AIR TIP



The gas / air section of the probe is made to cover the exposed sensor measuring junction to protect the junction while still allowing air to flow thru the holes. JMS has a standard pattern of hole size and spacing as shown in the drawing above.

This stainless steel cover over the junction acts as a radiant energy shield to protect the measuring junction from radiant heat which may be emitted from a flame or heater in the process. The thermocouple tip is still exposed to air flow for fast measurement. This type of probe can be inserted into duct work, grills, and air vents. For RTD's, a type E sensor (page 3-1) is either exposed (bare) or enclosed in a 1/8" hollow tube for moisture protection. An ultra fast response type is also available.

POTTING COMPOUNDS

JMS Southeast utilizes several potting compounds in the manufacturing of our temperature sensors. Our standard is a moisture impermeable epoxy which is black in color. Its recommended upper temperature limit is 500°F.

The potting compound used in higher temperature applications is a cement which is white in color. It is not as moisture impermeable as the lower temperature epoxy compound, yet it can withstand temperatures to 1750°F. It has a lower mechanical strength than the epoxy compound, but is the recommended choice for high temperature applications. Use an X in symbol #12 to utilize a higher temperature transition. The end of the part # to include the highest temperature (°F) the transition will see + type of transition, ie. X=650T.

Through the JMS Southeast sensor ordering information, we determine the maximum temperature that the potting will be exposed to and select the appropriate potting compound.

JMS provides special hermetic sealing from moisture for those sensors used in high humidity / moisture or total immersion environments. Any moisture penetrating the transition will kill the integrity of the electrical property of the sensor. Our special hermetic sealing will prevent this in any environment. Use a "2" after your selection for symbol #12 on page 1-2.

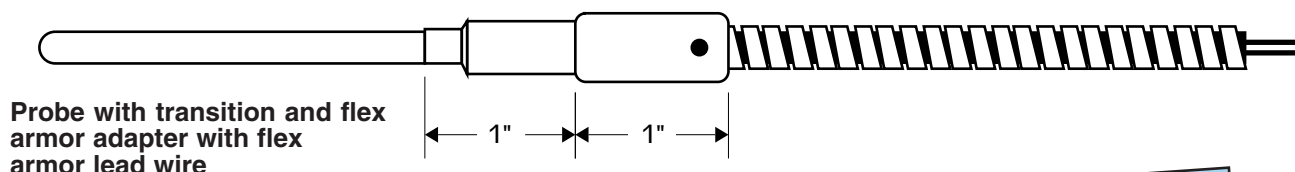
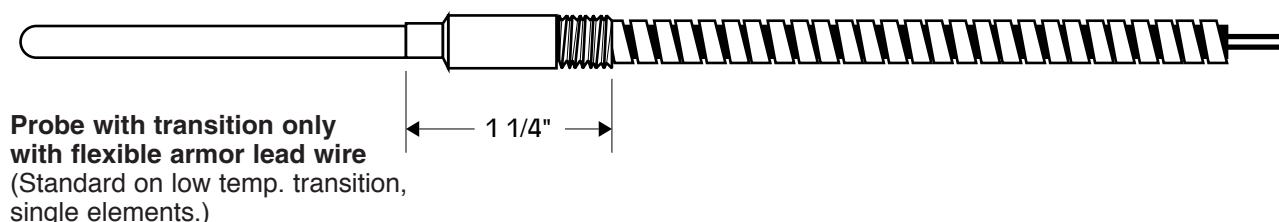
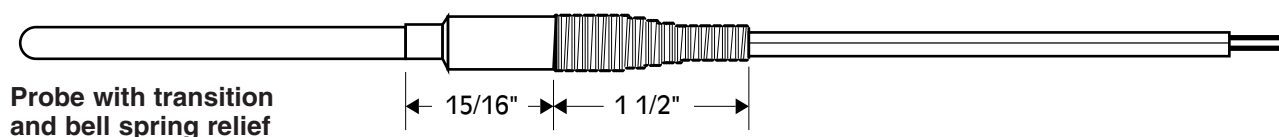
When shipping by air, there is the distinct possibility that the sensor(s) will be exposed to varying pressure, humidity and temperature conditions. This can and does cause some sensors to admit moisture into the insulation. We have experienced a few cases in which the sensor passed the ASTM tests performed here only to fail the same tests after shipping by air. Our recommendation is that you specify special shipping containers in those instances including the use of desiccants, or other moisture prevention devices. Hermetic sealing may be a necessary component as well.

THERMOCOUPLE TRANSITIONS

The transition contains the braze joint that connects the sheathed thermocouple conductors to the lead wire. The stainless steel joint supports and contains the potting compound used to encapsulate the connection.

The standard size of JMS transition is .375 outer diameter by 3/4" long, tapering down and extending over the thermocouple sheath material for 1/4". The outside diameter that tapers down onto the sheath is approximately .055" larger than the thermocouple sheath diameter.

A transition may be used to provide support for lead wire. A bell spring relief may also be used which will extend the rigid length of the probe by approximately 1". The transition and bell spring relief extends the length for a total of approximately 2 1/2".



4, one hour sessions training video.
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THERMOCOUPLE OPERATION AND INSTALLATION INSTRUCTIONS

Thermocouples are installed by means of compression fittings, welded 1/2" x 1/2" NPT fittings, or bayonet fittings.

Follow these instructions for installation of a thermocouple with a 1/2" x 1/2" NPT fitting:

- (1) Insert thermocouple into process hole
- (2) Tighten probe into place by turning probe into threaded connection.

When installing a spring-loaded sensor, the wires should be disconnected from the terminal block to prevent twisting and shorting during installation.

INSTALLATION:

Place thermocouple in area not too close to heating element or direct flame.

When measuring very high temperatures, install thermocouple vertically, if possible, to avoid protection tube element sagging.

Always use thermocouple extension wire to correlate with calibration of thermocouple and instrumentation being used.

Install thermocouple away from AC power lines, preferably more than one foot away.

Do not run thermocouple wires in the same conduit with other electrical wires.

Apply lacquer or silicon resin to screws to prevent effects of vibration and oxidation.

ELECTRICAL:

Make sure the extension wire is clean so a good electrical connection will result at the terminal block. Connect the positive extension wire to the positive thermocouple wire and the negative extension wire to the negative thermocouple wire. Wires are color coded for identification as follows, notice that the negative leg is always red.

THERMOCOUPLE TYPE				EXTENSION WIRES		
	POS.	NEG.	OUTER JACKET	POS.	NEG*	OUTER JACKET
E	purple	red	brown	purple	red	purple
J	white	red	brown	white	red	black
K	yellow	red	brown	yellow	red	yellow
R	N/A	N/A	N/A	black	red	green
S	N/A	N/A	N/A	black	red	green
T	blue	red	brown	blue	red	blue
N	orange	red	brown	orange	red	orange

See Page 1-9 for IEC color codes for primary conductor and color codes. The outer jacket matches the primary conductor unless specified for an intrinsically safe area, in which case all outer jackets are blue.

*A tracer having the color corresponding to the positive extension may be used on the negative wire code. Occasionally, it is necessary to determine thermocouple polarity in the field. The above characteristics are helpful, along with the information on the following page.

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TYPE E-The negative wire has lower resistance in ohms per foot than the positive element for the same size wire.

TYPE J-The positive element is frequently rusty and is magnetic. It has a lower resistance in ohms per foot for the same size wire.

TYPE K-The negative element is slightly magnetic. It has a lower resistance in ohms per foot for the same size positive wire.

TYPE R or S-The negative wire is softer. The positive wire has a lower resistance in ohms per foot for the same size wire.

TYPE T-The negative wire is silver in appearance. The positive wire has a lower resistance in ohms per foot for the same size wire, and is usually copper colored.

TYPE N-The positive leg has a higher resistance in ohms per foot for the same size wire.

Note: When in doubt, twist the wire together, and connect opposite ends to a volt meter. Heat the twisted end with a cigarette lighter. If the volts go up - polarity is correct ...

OPERATION:

The temperature of the connection head should be kept as near room temperature as possible to avoid errors due to the extension wires. The maximum recommended temperature at the terminal block is 400°F.

MAINTENANCE:

The quality and frequency of calibration checks must be determined for each individual application by noting the decalibration rate of each thermocouple at individual installations. Thermocouples will deteriorate due to contamination from their environments. Calibration is usually made by comparison with a working standard. The thermocouple may be removed from its installation and checked in an electric furnace with the working standard; however, check the thermocouple in its installed position and location if possible. See page VI.

Return thermocouples that were removed for tests to the same location and immersion depth for reliable and repeatable readings.

Do not use a thermocouple to measure a very low temperature if it has been used to measure a very high temperature previously.

Make sure protection tubes and thermowells are in good condition when protecting thermocouples with them.

Do not run a single thermocouple to two different instruments. This can result in instrument imbalance. A dual isolated thermocouple should be used instead.

STORAGE:

Store in a clean dry place. Avoid stacking probes in areas of excessive moisture or humidity (ie: dripping, condensation). Special packing with desiccant can be specified. (See page II)



TYPE N THERMOCOUPLE VERSUS TYPE K THERMOCOUPLE IN A BRICK MANUFACTURING FACILITY

The following paper was presented by Barbara Hudson, former General Manager of JMS Southeast, Inc., at the Brick Plant Forum Convention at Clemson University in Clemson, South Carolina.

ABSTRACT:

The brick industry historically has had the option of a Type K thermocouple, which is inaccurate yet inexpensive, versus Type R and S thermocouples which are very expensive yet accurate. This article investigates the Type N thermocouple which has been developed as a substitute for the Type K thermocouple in the 32°F to 2300°F temperature range.

TYPE K VERSUS TYPE R OR S THERMOCOUPLE

Through the years, many changes have occurred in the firing of structural clays including gas, oil, and sawdust combustion. Yet, the temperature measuring methods has remained the same as far as thermocouple configurations are concerned. Throughout history, a Type K thermocouple has been used in an area which was thought of as being "non-critical". The Type R or S thermocouples (platinum-rhodium) have been used in the past in "control" areas. The reasons for these uses include: Type K thermocouples, but are also less stable and less accurate. Type K thermocouples are easily attainable, however, and widely accepted in all industries.

The reasons for the instability in Type K thermocouples are due to some inherent properties in the chromel/alumel material. One problem that occurs with this thermocouple is an effect called short-range ordering. It occurs in a temperature range of about 500°F to 1020°F when nickel and chromium atoms in the chromel leg tend to form an ordered crystalline structure. The ordering produces a different metallurgical structure and if a temperature gradient exists, an erroneous EMF is produced.

Another shortcoming of Type K thermocouples is the hysteresis effect that occurs when a Type K thermocouple is cycled up and down in temperatures above and below 1800°F. The re-ordering of the crystalline structure changes with each cycle. After the first pass above this temperature, the Type K temperature indication will probably be accurate. However, with each additional cycle after this one, the error will increase more and more. The Type K thermocouple also experiences a cumulative drift after a period of time at temperatures above 1650°F. Finally, this thermocouple experiences a physical defect called "green rot" which is caused due to preferential oxidation of the chromel leg.

Even with these problems of instability and lack of longevity in Type K thermocouples, they are widely used and accepted in the brick industry as well as other industries. This is due to the fact that they are inexpensive and the choices have been limited in the past to a thermocouple that could replace Type K at a comparable price.

The platinum-rhodium thermocouples (Type R and S) on the other hand have been used as control thermocouples in the past. They are much more stable than the Type K thermocouples, but much more expensive also. They can be ten times the expense of a Type K thermocouple. Type R or S thermocouples do, however, after a period of time at elevated temperatures, experience a drift due to platinum migration.

In essence, for temperature measurement in a brick kiln, we have a fairly accurate option at a high cost versus an unstable and "short life" option at a reasonable cost. A compromise was needed!

TYPE N THERMOCOUPLES

Noel Burley, from Australia, began extensive research on a type N thermocouple (nasil/nicrosil). The composition of this thermocouple is the following: Nicrosil-Ni-14.2%, Cr-1.4%, Si and Nasil-Ni-4.4%, Si-.1%, Mg. Noel Burley's research showed that the Type N thermocouple exhibited thermal stability above 1650°F, while Type K thermocouples showed a

gradual and cumulative drift. He also showed the Type N thermocouple showed no short-term change due to crystal restructuring that occurred with the Type K thermocouple. Also, the Type N had superior resistance to oxidation (no "green rot") and could replace the Type K throughout its entire range of 32°F-2300°F. Its cost is about the cost of a Type J thermocouple. Due to this information, we decided to experiment with the Type N thermocouple in a brick manufacturing environment.

EXPERIMENTATION:

Frank Todd and Frank Todd, Jr., at Fletcher Brick were kind enough to allow us to do some experimentation in their facility. We were restricted to a short time frame, so we needed accelerated life data on comparisons between a Type K and Type N thermocouple. In communication with Fletcher Brick, a top to bottom and side to side temperature gradient was suspected in their tunnel kiln. They desired better monitoring to attain better control, thus better brick. If they were to go to platinum/rhodium thermocouples as side port monitoring sensors, the thermocouples alone would have cost in excess of \$6,000 not including the data logger needed for data collection. Due to accelerated life data needed, we used 20 gauge thermocouples realizing they would deteriorate quickly. Stage 1 of our experimentation included manufacturing 10 dual thermocouples which consisted of one 20 gauge Type K and one 20 gauge Type N thermocouple in each sensor. These were installed in side ports of the kiln and ran for 30 days. The Type R thermocouples existed in the top center of the kiln as control thermocouples. All monitoring thermocouples were connected to a 40 channel data logger which printed the temperature of all sensors every six hours. This data was converted to actual temperatures for the Type N thermocouples and was compared to the control Type R sensors for kiln changes. After all the data was compiled, the drift was plotted for four Type K thermocouples. The drift of the Type K thermocouple was difficult to predict. All four sensors drifted in non-repeatable and inconsistent patterns.

The Type N readings were graphed and they also failed within the 30 day period as was predicted since 20 gauge wire was used. The drift, however, was more predictable. This was only a preliminary stage of our experimentation. We will continue our work with the 14 gauge Type N versus Type K thermocouples.

CONCLUSION:

In conclusion, Type N thermocouples can be used in all areas of the brick; i.e. traveling thermocouples, air conditioning vents, kiln control, monitoring sensors, and drying sensors.

Research has shown Type N thermocouples have better thermal stability than Type K in the temperature range of 1200°F-1400°F, which is the pre-heat zone where carbon burn-out occurs.

Also better control can be obtained with a Type N thermocouple at the quartz inversion point of 1050°F.

Two or three different types of thermocouples used in a single plant within the Type N temperature range of 32°F-2300°F can be replaced by the Type N thermocouple. This would standardize the plant with one type of thermocouple enabling the use of one type of controller, one type of data logger, etc.

This thermocouple is also ASTM certified. It has been given a color code of orange/red. It is listed in most thermocouple manufacturers catalog. We at JMS Southeast, Inc., will continue doing research with the Type N thermocouple in structural clay firing applications.

REFERENCES:

1. Brick Association of North Carolina (Marion Cochran).
2. The Nicrosil versus Nisil Thermocouple: Properties and Thermoelectric reference Data - NBS Monograph 161.
3. Temperature Sensors Product Information Bulletin (TS-02) by R. Kampion of Leeds and Northrup.

TYPE N THERMOCOUPLE GENERAL INFORMATION

COMPOSITION: Nisil/Nicrosil

Nisil: Ni-4.4 wt%
Si-0.1 wt%
Mg

Nicrosil: Ni-14.2 wt%
Cr-1.4 wt%
Si

	Color Code	Magnetic
Nisil: (N)	Red	No
Nicrosil:(P)	Orange	No

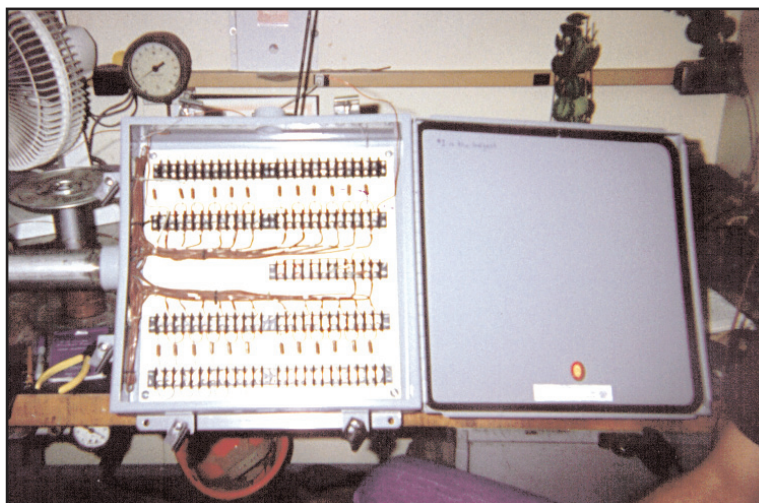
ACCURACY:

32°F to 2300°, $\pm 4^\circ$ or .75% of temperature reading. Can replace Type "K" thermocouples throughout entire range.

Type "N" is available in beaded assemblies or sheath material. Extension wire and other temperature accessories such as meters, controllers, transmitters, etc., are also available.

ADVANTAGES:

1. Superior thermal stability at temperatures over 1650°F, while other thermocouples such as Type "K" exhibit much greater cumulative drift.
2. Superior thermal stability in that no short term change occurs due to the crystal restructuring.
3. Superior resistance to oxidation. (No green rot.)
4. Does not exhibit hysteresis effect as the Type "K" thermocouple does.



ITS-90 Table for type B thermocouple										
°F	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
30			0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001
40	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002
50	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
60	-0.002	-0.002	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
70	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002
80	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
90	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001
100	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000
110	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002
120	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004
130	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006
140	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.009
150	0.009	0.009	0.009	0.010	0.010	0.010	0.011	0.011	0.011	0.012
160	0.012	0.012	0.013	0.013	0.013	0.014	0.014	0.014	0.015	0.015
170	0.015	0.016	0.016	0.016	0.017	0.017	0.017	0.018	0.018	0.019
180	0.019	0.019	0.020	0.020	0.021	0.021	0.021	0.022	0.022	0.023
190	0.023	0.023	0.024	0.024	0.025	0.025	0.026	0.026	0.027	0.027
200	0.027	0.028	0.028	0.029	0.029	0.030	0.030	0.031	0.031	0.032
210	0.032	0.033	0.033	0.034	0.034	0.035	0.035	0.036	0.036	0.037
220	0.037	0.038	0.038	0.039	0.039	0.040	0.041	0.041	0.042	0.042
230	0.043	0.043	0.044	0.044	0.045	0.046	0.046	0.047	0.047	0.048
240	0.049	0.049	0.050	0.050	0.051	0.052	0.052	0.053	0.053	0.054
250	0.055	0.055	0.056	0.057	0.057	0.058	0.059	0.059	0.060	0.060
260	0.061	0.062	0.062	0.063	0.064	0.065	0.065	0.066	0.067	0.067
270	0.068	0.069	0.069	0.070	0.071	0.072	0.072	0.073	0.074	0.074
280	0.075	0.076	0.077	0.077	0.078	0.079	0.080	0.080	0.081	0.082
290	0.083	0.083	0.084	0.085	0.086	0.086	0.087	0.088	0.089	0.090
300	0.090	0.091	0.092	0.093	0.094	0.094	0.095	0.096	0.097	0.098
310	0.099	0.099	0.100	0.101	0.102	0.103	0.104	0.105	0.105	0.106
320	0.107	0.108	0.109	0.110	0.111	0.112	0.112	0.113	0.114	0.115
330	0.116	0.117	0.118	0.119	0.120	0.121	0.121	0.122	0.123	0.124
340	0.125	0.126	0.127	0.128	0.129	0.130	0.131	0.132	0.133	0.134
350	0.135	0.136	0.137	0.138	0.139	0.140	0.141	0.142	0.143	0.144
360	0.145	0.146	0.147	0.148	0.149	0.150	0.151	0.152	0.153	0.154
370	0.155	0.156	0.157	0.158	0.159	0.160	0.161	0.162	0.163	0.164
380	0.165	0.166	0.167	0.168	0.170	0.171	0.172	0.173	0.174	0.175
390	0.176	0.177	0.178	0.179	0.180	0.182	0.183	0.184	0.185	0.186
400	0.187	0.188	0.190	0.191	0.192	0.193	0.194	0.195	0.196	0.198
410	0.199	0.200	0.201	0.202	0.203	0.205	0.206	0.207	0.208	0.209
420	0.211	0.212	0.213	0.214	0.215	0.217	0.218	0.219	0.220	0.222
430	0.223	0.224	0.225	0.226	0.228	0.229	0.230	0.231	0.233	0.234
440	0.235	0.236	0.238	0.239	0.240	0.242	0.243	0.244	0.245	0.247
450	0.248	0.249	0.251	0.252	0.253	0.255	0.256	0.257	0.259	0.260
460	0.261	0.263	0.264	0.265	0.267	0.268	0.269	0.271	0.272	0.273
470	0.275	0.276	0.277	0.279	0.280	0.282	0.283	0.284	0.286	0.287
480	0.288	0.290	0.291	0.293	0.294	0.296	0.297	0.298	0.300	0.301
490	0.303	0.304	0.305	0.307	0.308	0.310	0.311	0.313	0.314	0.316
500	0.317	0.319	0.320	0.321	0.323	0.324	0.326	0.327	0.329	0.330
510	0.332	0.333	0.335	0.336	0.338	0.339	0.341	0.342	0.344	0.345
520	0.347	0.348	0.350	0.352	0.353	0.355	0.356	0.358	0.359	0.361
530	0.362	0.364	0.365	0.367	0.369	0.370	0.372	0.373	0.375	0.377
540	0.378	0.380	0.381	0.383	0.384	0.386	0.388	0.389	0.391	0.393
550	0.394	0.396	0.397	0.399	0.401	0.402	0.404	0.406	0.407	0.409
560	0.411	0.412	0.414	0.416	0.417	0.419	0.421	0.422	0.424	0.426
570	0.427	0.429	0.431	0.432	0.434	0.436	0.437	0.439	0.441	0.443
580	0.444	0.446	0.448	0.449	0.451	0.453	0.455	0.456	0.458	0.460
590	0.462	0.463	0.465	0.467	0.469	0.470	0.472	0.474	0.476	0.478
600	0.479	0.481	0.483	0.485	0.486	0.488	0.490	0.492	0.494	0.495
610	0.497	0.499	0.501	0.503	0.505	0.506	0.508	0.510	0.512	0.514
620	0.516	0.517	0.519	0.521	0.523	0.525	0.527	0.529	0.530	0.532
630	0.534	0.536	0.538	0.540	0.542	0.544	0.546	0.547	0.549	0.551
640	0.553	0.555	0.557	0.559	0.561	0.563	0.565	0.567	0.569	0.570

ITS-90 Table for type B thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
650	0.572	0.574	0.576	0.578	0.580	0.582	0.584	0.586	0.588	0.590	0.59
660	0.592	0.594	0.596	0.598	0.600	0.602	0.604	0.606	0.608	0.610	0.61
670	0.612	0.614	0.616	0.618	0.620	0.622	0.624	0.626	0.628	0.630	0.63
680	0.632	0.634	0.636	0.638	0.640	0.642	0.644	0.646	0.648	0.650	0.65
690	0.653	0.655	0.657	0.659	0.661	0.663	0.665	0.667	0.669	0.671	0.67
700	0.673	0.675	0.678	0.680	0.682	0.684	0.686	0.688	0.690	0.692	0.69
710	0.694	0.697	0.699	0.701	0.703	0.705	0.707	0.709	0.712	0.714	0.71
720	0.716	0.718	0.720	0.722	0.725	0.727	0.729	0.731	0.733	0.735	0.73
730	0.738	0.740	0.742	0.744	0.746	0.749	0.751	0.753	0.755	0.757	0.76
740	0.760	0.762	0.764	0.766	0.769	0.771	0.773	0.775	0.778	0.780	0.78
750	0.782	0.784	0.787	0.789	0.791	0.793	0.796	0.798	0.800	0.802	0.80
760	0.805	0.807	0.809	0.812	0.814	0.816	0.818	0.821	0.823	0.825	0.82
770	0.828	0.830	0.832	0.835	0.837	0.839	0.842	0.844	0.846	0.849	0.85
780	0.851	0.853	0.856	0.858	0.860	0.863	0.865	0.867	0.870	0.872	0.87
790	0.875	0.877	0.879	0.882	0.884	0.886	0.889	0.891	0.894	0.896	0.89
800	0.898	0.901	0.903	0.906	0.908	0.910	0.913	0.915	0.918	0.920	0.92
810	0.923	0.925	0.927	0.930	0.932	0.935	0.937	0.940	0.942	0.945	0.94
820	0.947	0.950	0.952	0.955	0.957	0.959	0.962	0.964	0.967	0.969	0.97
830	0.972	0.974	0.977	0.979	0.982	0.984	0.987	0.989	0.992	0.994	0.99
840	0.997	1.000	1.002	1.005	1.007	1.010	1.012	1.015	1.017	1.020	1.02
850	1.022	1.025	1.027	1.030	1.033	1.035	1.038	1.040	1.043	1.045	1.04
860	1.048	1.051	1.053	1.056	1.058	1.061	1.064	1.066	1.069	1.071	1.07
870	1.074	1.077	1.079	1.082	1.085	1.087	1.090	1.092	1.095	1.098	1.10
880	1.100	1.103	1.106	1.108	1.111	1.114	1.116	1.119	1.122	1.124	1.12
890	1.127	1.130	1.132	1.135	1.138	1.140	1.143	1.146	1.148	1.151	1.15
900	1.154	1.157	1.159	1.162	1.165	1.167	1.170	1.173	1.176	1.178	1.18
910	1.181	1.184	1.186	1.189	1.192	1.195	1.197	1.200	1.203	1.206	1.20
920	1.208	1.211	1.214	1.217	1.220	1.222	1.225	1.228	1.231	1.233	1.23
930	1.236	1.239	1.242	1.245	1.247	1.250	1.253	1.256	1.259	1.262	1.26
940	1.264	1.267	1.270	1.273	1.276	1.278	1.281	1.284	1.287	1.290	1.29
950	1.293	1.296	1.298	1.301	1.304	1.307	1.310	1.313	1.316	1.318	1.32
960	1.321	1.324	1.327	1.330	1.333	1.336	1.339	1.342	1.344	1.347	1.35
970	1.350	1.353	1.356	1.359	1.362	1.365	1.368	1.371	1.374	1.377	1.37
980	1.379	1.382	1.385	1.388	1.391	1.394	1.397	1.400	1.403	1.406	1.40
990	1.409	1.412	1.415	1.418	1.421	1.424	1.427	1.430	1.433	1.436	1.43
1000	1.439	1.442	1.445	1.448	1.451	1.454	1.457	1.460	1.463	1.466	1.46
1010	1.469	1.472	1.475	1.478	1.481	1.484	1.487	1.490	1.493	1.496	1.49
1020	1.499	1.502	1.505	1.508	1.511	1.515	1.518	1.521	1.524	1.527	1.53
1030	1.530	1.533	1.536	1.539	1.542	1.545	1.548	1.552	1.555	1.558	1.56
1040	1.561	1.564	1.567	1.570	1.573	1.576	1.580	1.583	1.586	1.589	1.59
1050	1.592	1.595	1.598	1.601	1.605	1.608	1.611	1.614	1.617	1.620	1.62
1060	1.624	1.627	1.630	1.633	1.636	1.639	1.643	1.646	1.649	1.652	1.65
1070	1.655	1.659	1.662	1.665	1.668	1.671	1.675	1.678	1.681	1.684	1.68
1080	1.687	1.691	1.694	1.697	1.700	1.704	1.707	1.710	1.713	1.716	1.72
1090	1.720	1.723	1.726	1.729	1.733	1.736	1.739	1.743	1.746	1.749	1.75
1100	1.752	1.756	1.759	1.762	1.765	1.769	1.772	1.775	1.779	1.782	1.78
1110	1.785	1.789	1.792	1.795	1.798	1.802	1.805	1.808	1.812	1.815	1.81
1120	1.818	1.822	1.825	1.828	1.832	1.835	1.838	1.842	1.845	1.849	1.85
1130	1.852	1.855	1.859	1.862	1.865	1.869	1.872	1.875	1.879	1.882	1.88
1140	1.886	1.889	1.892	1.896	1.899	1.903	1.906	1.909	1.913	1.916	1.92
1150	1.920	1.923	1.926	1.930	1.933	1.937	1.940	1.944	1.947	1.950	1.95
1160	1.954	1.957	1.961	1.964	1.968	1.971	1.975	1.978	1.981	1.985	1.98
1170	1.988	1.992	1.995	1.999	2.002	2.006	2.009	2.013	2.016	2.020	2.02
1180	2.023	2.027	2.030	2.034	2.037	2.041	2.044	2.048	2.051	2.055	2.05
1190	2.058	2.062	2.065	2.069	2.072	2.076	2.079	2.083	2.086	2.090	2.09
1200	2.094	2.097	2.101	2.104	2.108	2.111	2.115	2.118	2.122	2.126	2.12
1210	2.129	2.133	2.136	2.140	2.143	2.147	2.151	2.154	2.158	2.161	2.16
1220	2.165	2.169	2.172	2.176	2.179	2.183	2.187	2.190	2.194	2.197	2.20
1230	2.201	2.205	2.208	2.212	2.216	2.219	2.223	2.226	2.230	2.234	2.23
1240	2.237	2.241	2.245	2.248	2.252	2.256	2.259	2.263	2.267	2.270	2.27
1250	2.274	2.278	2.281	2.285	2.289	2.292	2.296	2.300	2.303	2.307	2.31
1260	2.311	2.315	2.318	2.322	2.326	2.329	2.333	2.337	2.341	2.344	2.34
1270	2.348	2.352	2.355	2.359	2.363	2.367	2.370	2.374	2.378	2.382	2.38
1280	2.385	2.389	2.393	2.397	2.400	2.404	2.408	2.412	2.416	2.419	2.42
1290	2.423	2.427	2.431	2.434	2.438	2.442	2.446	2.450	2.453	2.457	2.46
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type B thermocouple										
°F	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
1300	2.461	2.465	2.469	2.472	2.476	2.480	2.484	2.488	2.492	2.495
1310	2.499	2.503	2.507	2.511	2.515	2.518	2.522	2.526	2.530	2.534
1320	2.538	2.541	2.545	2.549	2.553	2.557	2.561	2.565	2.569	2.572
1330	2.576	2.580	2.584	2.588	2.592	2.596	2.600	2.604	2.607	2.611
1340	2.615	2.619	2.623	2.627	2.631	2.635	2.639	2.643	2.647	2.651
1350	2.654	2.658	2.662	2.666	2.670	2.674	2.678	2.682	2.686	2.690
1360	2.694	2.698	2.702	2.706	2.710	2.714	2.718	2.722	2.726	2.730
1370	2.734	2.738	2.742	2.746	2.750	2.754	2.758	2.762	2.766	2.770
1380	2.774	2.778	2.782	2.786	2.790	2.794	2.798	2.802	2.806	2.810
1390	2.814	2.818	2.822	2.826	2.830	2.834	2.838	2.842	2.846	2.850
1400	2.854	2.858	2.863	2.867	2.871	2.875	2.879	2.883	2.887	2.891
1410	2.895	2.899	2.903	2.908	2.912	2.916	2.920	2.924	2.928	2.932
1420	2.936	2.940	2.944	2.949	2.953	2.957	2.961	2.965	2.969	2.973
1430	2.978	2.982	2.986	2.990	2.994	2.998	3.002	3.007	3.011	3.015
1440	3.019	3.023	3.027	3.032	3.036	3.040	3.044	3.048	3.052	3.057
1450	3.061	3.065	3.069	3.073	3.078	3.082	3.086	3.090	3.094	3.099
1460	3.103	3.107	3.111	3.116	3.120	3.124	3.128	3.132	3.137	3.141
1470	3.145	3.149	3.154	3.158	3.162	3.166	3.171	3.175	3.179	3.183
1480	3.188	3.192	3.196	3.200	3.205	3.209	3.213	3.218	3.222	3.226
1490	3.230	3.235	3.239	3.243	3.248	3.252	3.256	3.261	3.265	3.269
1500	3.273	3.278	3.282	3.286	3.291	3.295	3.299	3.304	3.308	3.312
1510	3.317	3.321	3.325	3.330	3.334	3.338	3.343	3.347	3.352	3.356
1520	3.360	3.365	3.369	3.373	3.378	3.382	3.386	3.391	3.395	3.400
1530	3.404	3.408	3.413	3.417	3.422	3.426	3.430	3.435	3.439	3.444
1540	3.448	3.452	3.457	3.461	3.466	3.470	3.474	3.479	3.483	3.488
1550	3.492	3.497	3.501	3.506	3.510	3.514	3.519	3.523	3.528	3.532
1560	3.537	3.541	3.546	3.550	3.555	3.559	3.563	3.568	3.572	3.577
1570	3.581	3.586	3.590	3.595	3.599	3.604	3.608	3.613	3.617	3.622
1580	3.626	3.631	3.635	3.640	3.644	3.649	3.653	3.658	3.662	3.667
1590	3.672	3.676	3.681	3.685	3.690	3.694	3.699	3.703	3.708	3.712
1600	3.717	3.722	3.726	3.731	3.735	3.740	3.744	3.749	3.753	3.758
1610	3.763	3.767	3.772	3.776	3.781	3.786	3.790	3.795	3.799	3.804
1620	3.809	3.813	3.818	3.822	3.827	3.832	3.836	3.841	3.845	3.850
1630	3.855	3.859	3.864	3.869	3.873	3.878	3.882	3.887	3.892	3.896
1640	3.901	3.906	3.910	3.915	3.920	3.924	3.929	3.934	3.938	3.943
1650	3.948	3.952	3.957	3.962	3.966	3.971	3.976	3.980	3.985	3.990
1660	3.994	3.999	4.004	4.009	4.013	4.018	4.023	4.027	4.032	4.037
1670	4.041	4.046	4.051	4.056	4.060	4.065	4.070	4.075	4.079	4.084
1680	4.089	4.093	4.098	4.103	4.108	4.112	4.117	4.122	4.127	4.131
1690	4.136	4.141	4.146	4.151	4.155	4.160	4.165	4.170	4.174	4.179
1700	4.184	4.189	4.194	4.198	4.203	4.208	4.213	4.217	4.222	4.227
1710	4.232	4.237	4.242	4.246	4.251	4.256	4.261	4.266	4.270	4.275
1720	4.280	4.285	4.290	4.295	4.299	4.304	4.309	4.314	4.319	4.324
1730	4.328	4.333	4.338	4.343	4.348	4.353	4.358	4.362	4.367	4.372
1740	4.377	4.382	4.387	4.392	4.397	4.401	4.406	4.411	4.416	4.421
1750	4.426	4.431	4.436	4.441	4.445	4.450	4.455	4.460	4.465	4.470
1760	4.475	4.480	4.485	4.490	4.495	4.500	4.504	4.509	4.514	4.519
1770	4.524	4.529	4.534	4.539	4.544	4.549	4.554	4.559	4.564	4.569
1780	4.574	4.579	4.584	4.589	4.593	4.598	4.603	4.608	4.613	4.618
1790	4.623	4.628	4.633	4.638	4.643	4.648	4.653	4.658	4.663	4.668
1800	4.673	4.678	4.683	4.688	4.693	4.698	4.703	4.708	4.713	4.718
1810	4.723	4.728	4.733	4.738	4.743	4.748	4.754	4.759	4.764	4.769
1820	4.774	4.779	4.784	4.789	4.794	4.799	4.804	4.809	4.814	4.819
1830	4.824	4.829	4.834	4.839	4.844	4.850	4.855	4.860	4.865	4.870
1840	4.875	4.880	4.885	4.890	4.895	4.900	4.905	4.911	4.916	4.921
1850	4.926	4.931	4.936	4.941	4.946	4.951	4.957	4.962	4.967	4.972
1860	4.977	4.982	4.987	4.992	4.998	5.003	5.008	5.013	5.018	5.023
1870	5.028	5.034	5.039	5.044	5.049	5.054	5.059	5.065	5.070	5.075
1880	5.080	5.085	5.090	5.096	5.101	5.106	5.111	5.116	5.121	5.127
1890	5.132	5.137	5.142	5.147	5.153	5.158	5.163	5.168	5.173	5.179
1900	5.184	5.189	5.194	5.199	5.205	5.210	5.215	5.220	5.225	5.231
1910	5.236	5.241	5.246	5.252	5.257	5.262	5.267	5.273	5.278	5.283
1920	5.288	5.294	5.299	5.304	5.309	5.315	5.320	5.325	5.330	5.336
1930	5.341	5.346	5.351	5.357	5.362	5.367	5.373	5.378	5.383	5.388
1940	5.394	5.399	5.404	5.410	5.415	5.420	5.425	5.431	5.436	5.441
°F	0	1	2	3	4	5	6	7	8	9

ITS-90 Table for type B thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
1950	5.447	5.452	5.457	5.463	5.468	5.473	5.479	5.484	5.489	5.495	5.50
1960	5.500	5.505	5.511	5.516	5.521	5.527	5.532	5.537	5.543	5.548	5.55
1970	5.553	5.559	5.564	5.569	5.575	5.580	5.585	5.591	5.596	5.601	5.60
1980	5.607	5.612	5.618	5.623	5.628	5.634	5.639	5.644	5.650	5.655	5.66
1990	5.661	5.666	5.671	5.677	5.682	5.688	5.693	5.698	5.704	5.709	5.71
2000	5.715	5.720	5.725	5.731	5.736	5.742	5.747	5.752	5.758	5.763	5.76
2010	5.769	5.774	5.780	5.785	5.790	5.796	5.801	5.807	5.812	5.818	5.82
2020	5.823	5.828	5.834	5.839	5.845	5.850	5.856	5.861	5.867	5.872	5.87
2030	5.878	5.883	5.888	5.894	5.899	5.905	5.910	5.916	5.921	5.927	5.93
2040	5.932	5.938	5.943	5.949	5.954	5.960	5.965	5.971	5.976	5.982	5.98
2050	5.987	5.993	5.998	6.004	6.009	6.015	6.020	6.026	6.031	6.037	6.04
2060	6.042	6.048	6.053	6.059	6.064	6.070	6.075	6.081	6.086	6.092	6.09
2070	6.098	6.103	6.109	6.114	6.120	6.125	6.131	6.136	6.142	6.147	6.15
2080	6.153	6.159	6.164	6.170	6.175	6.181	6.186	6.192	6.197	6.203	6.20
2090	6.209	6.214	6.220	6.225	6.231	6.237	6.242	6.248	6.253	6.259	6.26
2100	6.264	6.270	6.276	6.281	6.287	6.292	6.298	6.304	6.309	6.315	6.32
2110	6.320	6.326	6.332	6.337	6.343	6.349	6.354	6.360	6.365	6.371	6.37
2120	6.377	6.382	6.388	6.394	6.399	6.405	6.410	6.416	6.422	6.427	6.43
2130	6.433	6.439	6.444	6.450	6.456	6.461	6.467	6.473	6.478	6.484	6.49
2140	6.490	6.495	6.501	6.507	6.512	6.518	6.524	6.529	6.535	6.541	6.54
2150	6.546	6.552	6.558	6.563	6.569	6.575	6.580	6.586	6.592	6.597	6.60
2160	6.603	6.609	6.615	6.620	6.626	6.632	6.637	6.643	6.649	6.655	6.66
2170	6.660	6.666	6.672	6.677	6.683	6.689	6.695	6.700	6.706	6.712	6.71
2180	6.718	6.723	6.729	6.735	6.740	6.746	6.752	6.758	6.763	6.769	6.77
2190	6.775	6.781	6.786	6.792	6.798	6.804	6.809	6.815	6.821	6.827	6.83
2200	6.833	6.838	6.844	6.850	6.856	6.861	6.867	6.873	6.879	6.884	6.89
2210	6.890	6.896	6.902	6.908	6.913	6.919	6.925	6.931	6.937	6.942	6.94
2220	6.948	6.954	6.960	6.966	6.971	6.977	6.983	6.989	6.995	7.000	7.00
2230	7.006	7.012	7.018	7.024	7.030	7.035	7.041	7.047	7.053	7.059	7.06
2240	7.065	7.070	7.076	7.082	7.088	7.094	7.100	7.105	7.111	7.117	7.12
2250	7.123	7.129	7.135	7.141	7.146	7.152	7.158	7.164	7.170	7.176	7.18
2260	7.182	7.187	7.193	7.199	7.205	7.211	7.217	7.223	7.229	7.234	7.24
2270	7.240	7.246	7.252	7.258	7.264	7.270	7.276	7.281	7.287	7.293	7.29
2280	7.299	7.305	7.311	7.317	7.323	7.329	7.335	7.340	7.346	7.352	7.35
2290	7.358	7.364	7.370	7.376	7.382	7.388	7.394	7.400	7.406	7.412	7.41
2300	7.417	7.423	7.429	7.435	7.441	7.447	7.453	7.459	7.465	7.471	7.47
2310	7.477	7.483	7.489	7.495	7.501	7.507	7.512	7.518	7.524	7.530	7.53
2320	7.536	7.542	7.548	7.554	7.560	7.566	7.572	7.578	7.584	7.590	7.59
2330	7.596	7.602	7.608	7.614	7.620	7.626	7.632	7.638	7.644	7.650	7.65
2340	7.656	7.662	7.668	7.674	7.680	7.686	7.692	7.698	7.704	7.710	7.71
2350	7.716	7.722	7.728	7.734	7.740	7.746	7.752	7.758	7.764	7.770	7.77
2360	7.776	7.782	7.788	7.794	7.800	7.806	7.812	7.818	7.824	7.830	7.83
2370	7.836	7.842	7.848	7.854	7.860	7.866	7.872	7.878	7.884	7.891	7.89
2380	7.897	7.903	7.909	7.915	7.921	7.927	7.933	7.939	7.945	7.951	7.95
2390	7.957	7.963	7.969	7.975	7.981	7.987	7.994	8.000	8.006	8.012	8.01
2400	8.018	8.024	8.030	8.036	8.042	8.048	8.054	8.060	8.066	8.073	8.07
2410	8.079	8.085	8.091	8.097	8.103	8.109	8.115	8.121	8.127	8.134	8.14
2420	8.140	8.146	8.152	8.158	8.164	8.170	8.176	8.182	8.188	8.195	8.20
2430	8.201	8.207	8.213	8.219	8.225	8.231	8.237	8.244	8.250	8.256	8.26
2440	8.262	8.268	8.274	8.280	8.286	8.293	8.299	8.305	8.311	8.317	8.32
2450	8.323	8.329	8.336	8.342	8.348	8.354	8.360	8.366	8.372	8.379	8.38
2460	8.385	8.391	8.397	8.403	8.409	8.416	8.422	8.428	8.434	8.440	8.44
2470	8.446	8.453	8.459	8.465	8.471	8.477	8.483	8.490	8.496	8.502	8.50
2480	8.508	8.514	8.521	8.527	8.533	8.539	8.545	8.551	8.558	8.564	8.57
2490	8.570	8.576	8.582	8.589	8.595	8.601	8.607	8.613	8.620	8.626	8.63
2500	8.632	8.638	8.644	8.651	8.657	8.663	8.669	8.675	8.682	8.688	8.69
2510	8.694	8.700	8.707	8.713	8.719	8.725	8.731	8.738	8.744	8.750	8.75
2520	8.756	8.763	8.769	8.775	8.781	8.787	8.794	8.800	8.806	8.812	8.81
2530	8.819	8.825	8.831	8.837	8.844	8.850	8.856	8.862	8.869	8.875	8.88
2540	8.881	8.887	8.894	8.900	8.906	8.912	8.919	8.925	8.931	8.937	8.94
2550	8.944	8.950	8.956	8.962	8.969	8.975	8.981	8.988	8.994	9.000	9.00
2560	9.006	9.013	9.019	9.025	9.031	9.038	9.044	9.050	9.057	9.063	9.06
2570	9.069	9.075	9.082	9.088	9.094	9.101	9.107	9.113	9.119	9.126	9.13
2580	9.132	9.138	9.145	9.151	9.157	9.164	9.170	9.176	9.182	9.189	9.19
2590	9.195	9.201	9.208	9.214	9.220	9.227	9.233	9.239	9.245	9.252	9.25
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type B thermocouple											
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	-0.00
10	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003	-0.003	-0.00
20	-0.003	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002	-0.002	-0.002	-0.00
30	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	0.00
40	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.002	0.00
50	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.006	0.00
60	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.011	0.01
70	0.011	0.012	0.012	0.013	0.014	0.014	0.015	0.015	0.016	0.017	0.01
80	0.017	0.018	0.019	0.020	0.020	0.021	0.022	0.022	0.023	0.024	0.02
90	0.025	0.026	0.026	0.027	0.028	0.029	0.030	0.031	0.031	0.032	0.03
100	0.033	0.034	0.035	0.036	0.037	0.038	0.039	0.040	0.041	0.042	0.04
110	0.043	0.044	0.045	0.046	0.047	0.048	0.049	0.050	0.051	0.052	0.05
120	0.053	0.055	0.056	0.057	0.058	0.059	0.060	0.062	0.063	0.064	0.06
130	0.065	0.066	0.068	0.069	0.070	0.072	0.073	0.074	0.075	0.077	0.07
140	0.078	0.079	0.081	0.082	0.084	0.085	0.086	0.088	0.089	0.091	0.09
150	0.092	0.094	0.095	0.096	0.098	0.099	0.101	0.102	0.104	0.106	0.10
160	0.107	0.109	0.110	0.112	0.113	0.115	0.117	0.118	0.120	0.122	0.12
170	0.123	0.125	0.127	0.128	0.130	0.132	0.134	0.135	0.137	0.139	0.14
180	0.141	0.142	0.144	0.146	0.148	0.150	0.151	0.153	0.155	0.157	0.15
190	0.159	0.161	0.163	0.165	0.166	0.168	0.170	0.172	0.174	0.176	0.17
200	0.178	0.180	0.182	0.184	0.186	0.188	0.190	0.192	0.195	0.197	0.19
210	0.199	0.201	0.203	0.205	0.207	0.209	0.212	0.214	0.216	0.218	0.22
220	0.220	0.222	0.225	0.227	0.229	0.231	0.234	0.236	0.238	0.241	0.24
230	0.243	0.245	0.248	0.250	0.252	0.255	0.257	0.259	0.262	0.264	0.26
240	0.267	0.269	0.271	0.274	0.276	0.279	0.281	0.284	0.286	0.289	0.29
250	0.291	0.294	0.296	0.299	0.301	0.304	0.307	0.309	0.312	0.314	0.31
260	0.317	0.320	0.322	0.325	0.328	0.330	0.333	0.336	0.338	0.341	0.34
270	0.344	0.347	0.349	0.352	0.355	0.358	0.360	0.363	0.366	0.369	0.37
280	0.372	0.375	0.377	0.380	0.383	0.386	0.389	0.392	0.395	0.398	0.40
290	0.401	0.404	0.407	0.410	0.413	0.416	0.419	0.422	0.425	0.428	0.43
300	0.431	0.434	0.437	0.440	0.443	0.446	0.449	0.452	0.455	0.458	0.46
310	0.462	0.465	0.468	0.471	0.474	0.478	0.481	0.484	0.487	0.490	0.49
320	0.494	0.497	0.500	0.503	0.507	0.510	0.513	0.517	0.520	0.523	0.52
330	0.527	0.530	0.533	0.537	0.540	0.544	0.547	0.550	0.554	0.557	0.56
340	0.561	0.564	0.568	0.571	0.575	0.578	0.582	0.585	0.589	0.592	0.59
350	0.596	0.599	0.603	0.607	0.610	0.614	0.617	0.621	0.625	0.628	0.63
360	0.632	0.636	0.639	0.643	0.647	0.650	0.654	0.658	0.662	0.665	0.66
370	0.669	0.673	0.677	0.680	0.684	0.688	0.692	0.696	0.700	0.703	0.70
380	0.707	0.711	0.715	0.719	0.723	0.727	0.731	0.735	0.738	0.742	0.74
390	0.746	0.750	0.754	0.758	0.762	0.766	0.770	0.774	0.778	0.782	0.78
400	0.787	0.791	0.795	0.799	0.803	0.807	0.811	0.815	0.819	0.824	0.82
410	0.828	0.832	0.836	0.840	0.844	0.849	0.853	0.857	0.861	0.866	0.87
420	0.870	0.874	0.878	0.883	0.887	0.891	0.896	0.900	0.904	0.909	0.91
430	0.913	0.917	0.922	0.926	0.930	0.935	0.939	0.944	0.948	0.953	0.95
440	0.957	0.961	0.966	0.970	0.975	0.979	0.984	0.988	0.993	0.997	1.00
450	1.002	1.007	1.011	1.016	1.020	1.025	1.030	1.034	1.039	1.043	1.04
460	1.048	1.053	1.057	1.062	1.067	1.071	1.076	1.081	1.086	1.090	1.09
3070	12.290	12.296	12.303	12.309	12.316	12.322	12.329	12.335	12.342	12.348	12.35
3080	12.355	12.361	12.368	12.374	12.381	12.387	12.394	12.400	12.407	12.413	12.42
3090	12.420	12.426	12.433	12.439	12.446	12.452	12.458	12.465	12.471	12.478	12.48
3100	12.484	12.491	12.497	12.504	12.510	12.517	12.523	12.530	12.536	12.543	12.54
3110	12.549	12.556	12.562	12.569	12.575	12.582	12.588	12.595	12.601	12.607	12.61
3120	12.614	12.620	12.627	12.633	12.640	12.646	12.653	12.659	12.666	12.672	12.67
3130	12.679	12.685	12.692	12.698	12.704	12.711	12.717	12.724	12.730	12.737	12.74
3140	12.743	12.750	12.756	12.763	12.769	12.776	12.782	12.789	12.795	12.801	12.80
3150	12.808	12.814	12.821	12.827	12.834	12.840	12.847	12.853	12.860	12.866	12.87
3160	12.872	12.879	12.885	12.892	12.898	12.905	12.911	12.918	12.924	12.931	12.93
3170	12.937	12.943	12.950	12.956	12.963	12.969	12.976	12.982	12.989	12.995	13.00
3180	13.001	13.008	13.014	13.021	13.027	13.034	13.040	13.047	13.053	13.059	13.06
3190	13.066	13.072	13.079	13.085	13.092	13.098	13.104	13.111	13.117	13.124	13.13
3200	13.130	13.137	13.143	13.149	13.156	13.162	13.169	13.175	13.182	13.188	13.19
3210	13.194	13.201	13.207	13.214	13.220	13.227	13.233	13.239	13.246	13.252	13.25
3220	13.259	13.265	13.271	13.278	13.284	13.291	13.297	13.304	13.310	13.316	13.32
3230	13.323	13.329	13.336	13.342	13.348	13.355	13.361	13.368	13.374	13.380	13.38
3240	13.387	13.393	13.400	13.406	13.412	13.419	13.425	13.432	13.438	13.444	13.45
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type B thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
3250	13.451	13.457	13.464	13.470	13.476	13.483	13.489	13.496	13.502	13.508	13.51
3260	13.515	13.521	13.527	13.534	13.540	13.547	13.553	13.559	13.566	13.572	13.57
3270	13.579	13.585	13.591	13.598	13.604	13.610	13.617	13.623	13.630	13.636	13.64
3280	13.642	13.649	13.655	13.661	13.668	13.674	13.680	13.687	13.693	13.700	13.70
3290	13.706	13.712	13.719	13.725	13.731	13.738	13.744	13.750	13.757	13.763	13.76
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type B thermocouple											
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	-0.00
10	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003	-0.003	-0.00
20	-0.003	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002	-0.002	-0.002	-0.00
30	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	0.00
40	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.002	0.00
50	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.006	0.00
60	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.011	0.01
70	0.011	0.012	0.012	0.013	0.014	0.014	0.015	0.015	0.016	0.017	0.01
80	0.017	0.018	0.019	0.020	0.020	0.021	0.022	0.022	0.023	0.024	0.02
90	0.025	0.026	0.026	0.027	0.028	0.029	0.030	0.031	0.031	0.032	0.03
100	0.033	0.034	0.035	0.036	0.037	0.038	0.039	0.040	0.041	0.042	0.04
110	0.043	0.044	0.045	0.046	0.047	0.048	0.049	0.050	0.051	0.052	0.05
120	0.053	0.055	0.056	0.057	0.058	0.059	0.060	0.062	0.063	0.064	0.06
130	0.065	0.066	0.068	0.069	0.070	0.072	0.073	0.074	0.075	0.077	0.07
140	0.078	0.079	0.081	0.082	0.084	0.085	0.086	0.088	0.089	0.091	0.09
150	0.092	0.094	0.095	0.096	0.098	0.099	0.101	0.102	0.104	0.106	0.10
160	0.107	0.109	0.110	0.112	0.113	0.115	0.117	0.118	0.120	0.122	0.12
170	0.123	0.125	0.127	0.128	0.130	0.132	0.134	0.135	0.137	0.139	0.14
180	0.141	0.142	0.144	0.146	0.148	0.150	0.151	0.153	0.155	0.157	0.15
190	0.159	0.161	0.163	0.165	0.166	0.168	0.170	0.172	0.174	0.176	0.17
200	0.178	0.180	0.182	0.184	0.186	0.188	0.190	0.192	0.195	0.197	0.19
210	0.199	0.201	0.203	0.205	0.207	0.209	0.212	0.214	0.216	0.218	0.22
220	0.220	0.222	0.225	0.227	0.229	0.231	0.234	0.236	0.238	0.241	0.24
230	0.243	0.245	0.248	0.250	0.252	0.255	0.257	0.259	0.262	0.264	0.26
240	0.267	0.269	0.271	0.274	0.276	0.279	0.281	0.284	0.286	0.289	0.29
250	0.291	0.294	0.296	0.299	0.301	0.304	0.307	0.309	0.312	0.314	0.31
260	0.317	0.320	0.322	0.325	0.328	0.330	0.333	0.336	0.338	0.341	0.34
270	0.344	0.347	0.349	0.352	0.355	0.358	0.360	0.363	0.366	0.369	0.37
280	0.372	0.375	0.377	0.380	0.383	0.386	0.389	0.392	0.395	0.398	0.40
290	0.401	0.404	0.407	0.410	0.413	0.416	0.419	0.422	0.425	0.428	0.43
300	0.431	0.434	0.437	0.440	0.443	0.446	0.449	0.452	0.455	0.458	0.46
310	0.462	0.465	0.468	0.471	0.474	0.478	0.481	0.484	0.487	0.490	0.49
320	0.494	0.497	0.500	0.503	0.507	0.510	0.513	0.517	0.520	0.523	0.52
330	0.527	0.530	0.533	0.537	0.540	0.544	0.547	0.550	0.554	0.557	0.56
340	0.561	0.564	0.568	0.571	0.575	0.578	0.582	0.585	0.589	0.592	0.59
350	0.596	0.599	0.603	0.607	0.610	0.614	0.617	0.621	0.625	0.628	0.63
360	0.632	0.636	0.639	0.643	0.647	0.650	0.654	0.658	0.662	0.665	0.66
370	0.669	0.673	0.677	0.680	0.684	0.688	0.692	0.696	0.700	0.703	0.70
380	0.707	0.711	0.715	0.719	0.723	0.727	0.731	0.735	0.738	0.742	0.74
390	0.746	0.750	0.754	0.758	0.762	0.766	0.770	0.774	0.778	0.782	0.78
400	0.787	0.791	0.795	0.799	0.803	0.807	0.811	0.815	0.819	0.824	0.82
410	0.828	0.832	0.836	0.840	0.844	0.849	0.853	0.857	0.861	0.866	0.87
420	0.870	0.874	0.878	0.883	0.887	0.891	0.896	0.900	0.904	0.909	0.91
430	0.913	0.917	0.922	0.926	0.930	0.935	0.939	0.944	0.948	0.953	0.95
440	0.957	0.961	0.966	0.970	0.975	0.979	0.984	0.988	0.993	0.997	1.00
450	1.002	1.007	1.011	1.016	1.020	1.025	1.030	1.034	1.039	1.043	1.04
460	1.048	1.053	1.057	1.062	1.067	1.071	1.076	1.081	1.086	1.090	1.09
470	1.095	1.100	1.105	1.109	1.114	1.119	1.124	1.129	1.133	1.138	1.14
480	1.143	1.148	1.153	1.158	1.163	1.167	1.172	1.177	1.182	1.187	1.19
490	1.192	1.197	1.202	1.207	1.212	1.217	1.222	1.227	1.232	1.237	1.24
500	1.242	1.247	1.252	1.257	1.262	1.267	1.272	1.277	1.282	1.288	1.29
510	1.293	1.298	1.303	1.308	1.313	1.318	1.324	1.329	1.334	1.339	1.34
520	1.344	1.350	1.355	1.360	1.365	1.371	1.376	1.381	1.387	1.392	1.39
530	1.397	1.402	1.408	1.413	1.418	1.424	1.429	1.435	1.440	1.445	1.45
540	1.451	1.456	1.462	1.467	1.472	1.478	1.483	1.489	1.494	1.500	1.50
550	1.505	1.511	1.516	1.522	1.527	1.533	1.539	1.544	1.550	1.555	1.56
560	1.561	1.566	1.572	1.578	1.583	1.589	1.595	1.600	1.606	1.612	1.61
570	1.617	1.623	1.629	1.634	1.640	1.646	1.652	1.657	1.663	1.669	1.67
580	1.675	1.680	1.686	1.692	1.698	1.704	1.709	1.715	1.721	1.727	1.73
590	1.733	1.739	1.745	1.750	1.756	1.762	1.768	1.774	1.780	1.786	1.79
600	1.792	1.798	1.804	1.810	1.816	1.822	1.828	1.834	1.840	1.846	1.85
610	1.852	1.858	1.864	1.870	1.876	1.882	1.888	1.894	1.901	1.907	1.91
620	1.913	1.919	1.925	1.931	1.937	1.944	1.950	1.956	1.962	1.968	1.97
630	1.975	1.981	1.987	1.993	1.999	2.006	2.012	2.018	2.025	2.031	2.03
640	2.037	2.043	2.050	2.056	2.062	2.069	2.075	2.082	2.088	2.094	2.10
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type B thermocouple											
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
650	2.101	2.107	2.113	2.120	2.126	2.133	2.139	2.146	2.152	2.158	2.164
660	2.165	2.171	2.178	2.184	2.191	2.197	2.204	2.210	2.217	2.224	2.230
670	2.230	2.237	2.243	2.250	2.256	2.263	2.270	2.276	2.283	2.289	2.295
680	2.296	2.303	2.309	2.316	2.323	2.329	2.336	2.343	2.350	2.356	2.363
690	2.363	2.370	2.376	2.383	2.390	2.397	2.403	2.410	2.417	2.424	2.431
700	2.431	2.437	2.444	2.451	2.458	2.465	2.472	2.479	2.485	2.492	2.499
710	2.499	2.506	2.513	2.520	2.527	2.534	2.541	2.548	2.555	2.562	2.569
720	2.569	2.576	2.583	2.590	2.597	2.604	2.611	2.618	2.625	2.632	2.639
730	2.639	2.646	2.653	2.660	2.667	2.674	2.681	2.688	2.696	2.703	2.710
740	2.710	2.717	2.724	2.731	2.738	2.746	2.753	2.760	2.767	2.775	2.782
750	2.782	2.789	2.796	2.803	2.811	2.818	2.825	2.833	2.840	2.847	2.854
760	2.854	2.862	2.869	2.876	2.884	2.891	2.898	2.906	2.913	2.921	2.928
770	2.928	2.935	2.943	2.950	2.958	2.965	2.973	2.980	2.987	2.995	3.002
780	3.002	3.010	3.017	3.025	3.032	3.040	3.047	3.055	3.062	3.070	3.077
790	3.078	3.085	3.093	3.100	3.108	3.116	3.123	3.131	3.138	3.146	3.153
800	3.154	3.161	3.169	3.177	3.184	3.192	3.200	3.207	3.215	3.223	3.231
810	3.230	3.238	3.246	3.254	3.261	3.269	3.277	3.285	3.292	3.300	3.308
820	3.308	3.316	3.324	3.331	3.339	3.347	3.355	3.363	3.371	3.379	3.387
830	3.386	3.394	3.402	3.410	3.418	3.426	3.434	3.442	3.450	3.458	3.466
840	3.466	3.474	3.482	3.490	3.498	3.506	3.514	3.522	3.530	3.538	3.546
850	3.546	3.554	3.562	3.570	3.578	3.586	3.594	3.602	3.610	3.618	3.626
860	3.626	3.634	3.643	3.651	3.659	3.667	3.675	3.683	3.692	3.700	3.707
870	3.708	3.716	3.724	3.732	3.741	3.749	3.757	3.765	3.774	3.782	3.790
880	3.790	3.798	3.807	3.815	3.823	3.832	3.840	3.848	3.857	3.865	3.873
890	3.873	3.882	3.890	3.898	3.907	3.915	3.923	3.932	3.940	3.949	3.957
900	3.957	3.965	3.974	3.982	3.991	3.999	4.008	4.016	4.024	4.033	4.041
910	4.041	4.050	4.058	4.067	4.075	4.084	4.093	4.101	4.110	4.118	4.127
920	4.127	4.135	4.144	4.152	4.161	4.170	4.178	4.187	4.195	4.204	4.212
930	4.213	4.221	4.230	4.239	4.247	4.256	4.265	4.273	4.282	4.291	4.299
940	4.299	4.308	4.317	4.326	4.334	4.343	4.352	4.360	4.369	4.378	4.387
950	4.387	4.396	4.404	4.413	4.422	4.431	4.440	4.448	4.457	4.466	4.474
960	4.475	4.484	4.493	4.501	4.510	4.519	4.528	4.537	4.546	4.555	4.564
970	4.564	4.573	4.582	4.591	4.599	4.608	4.617	4.626	4.635	4.644	4.653
980	4.653	4.662	4.671	4.680	4.689	4.698	4.707	4.716	4.725	4.734	4.743
990	4.743	4.753	4.762	4.771	4.780	4.789	4.798	4.807	4.816	4.825	4.834
1000	4.834	4.843	4.853	4.862	4.871	4.880	4.889	4.898	4.908	4.917	4.926
1010	4.926	4.935	4.944	4.954	4.963	4.972	4.981	4.990	5.000	5.009	5.019
1020	5.018	5.027	5.037	5.046	5.055	5.065	5.074	5.083	5.092	5.102	5.111
1030	5.111	5.120	5.130	5.139	5.148	5.158	5.167	5.176	5.186	5.195	5.205
1040	5.205	5.214	5.223	5.233	5.242	5.252	5.261	5.270	5.280	5.289	5.299
1050	5.299	5.308	5.318	5.327	5.337	5.346	5.356	5.365	5.375	5.384	5.393
1060	5.394	5.403	5.413	5.422	5.432	5.441	5.451	5.460	5.470	5.480	5.489
1070	5.489	5.499	5.508	5.518	5.528	5.537	5.547	5.556	5.566	5.576	5.585
1080	5.585	5.595	5.605	5.614	5.624	5.634	5.643	5.653	5.663	5.672	5.681
1090	5.682	5.692	5.702	5.711	5.721	5.731	5.740	5.750	5.760	5.770	5.780
1100	5.780	5.789	5.799	5.809	5.819	5.828	5.838	5.848	5.858	5.868	5.877
1110	5.878	5.887	5.897	5.907	5.917	5.927	5.937	5.947	5.956	5.966	5.975
1120	5.976	5.986	5.996	6.006	6.016	6.026	6.036	6.046	6.055	6.065	6.075
1130	6.075	6.085	6.095	6.105	6.115	6.125	6.135	6.145	6.155	6.165	6.175
1140	6.175	6.185	6.195	6.205	6.215	6.225	6.235	6.245	6.256	6.266	6.277
1150	6.276	6.286	6.296	6.306	6.316	6.326	6.336	6.346	6.356	6.367	6.377
1160	6.377	6.387	6.397	6.407	6.417	6.427	6.438	6.448	6.458	6.468	6.477
1170	6.478	6.488	6.499	6.509	6.519	6.529	6.539	6.550	6.560	6.570	6.580
1180	6.580	6.591	6.601	6.611	6.621	6.632	6.642	6.652	6.663	6.673	6.683
1190	6.683	6.693	6.704	6.714	6.724	6.735	6.745	6.755	6.766	6.776	6.787
1200	6.786	6.797	6.807	6.818	6.828	6.838	6.849	6.859	6.869	6.880	6.891
1210	6.890	6.901	6.911	6.922	6.932	6.942	6.953	6.963	6.974	6.984	6.995
1220	6.995	7.005	7.016	7.026	7.037	7.047	7.058	7.068	7.079	7.089	7.100
1230	7.100	7.110	7.121	7.131	7.142	7.152	7.163	7.173	7.184	7.194	7.205
1240	7.205	7.216	7.226	7.237	7.247	7.258	7.269	7.279	7.290	7.300	7.311
1250	7.311	7.322	7.332	7.343	7.353	7.364	7.375	7.385	7.396	7.407	7.417
1260	7.417	7.428	7.439	7.449	7.460	7.471	7.482	7.492	7.503	7.514	7.525
1270	7.524	7.535	7.546	7.557	7.567	7.578	7.589	7.600	7.610	7.621	7.632
1280	7.632	7.643	7.653	7.664	7.675	7.686	7.697	7.707	7.718	7.729	7.740
1290	7.740	7.751	7.761	7.772	7.783	7.794	7.805	7.816	7.827	7.837	7.848
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type B thermocouple
 °C 0 1 2 3 4 5 6 7 8 9 10
 Thermoelectric Voltage in mV

1300	7.848	7.859	7.870	7.881	7.892	7.903	7.914	7.924	7.935	7.946	7.95
1310	7.957	7.968	7.979	7.990	8.001	8.012	8.023	8.034	8.045	8.056	8.06
1320	8.066	8.077	8.088	8.099	8.110	8.121	8.132	8.143	8.154	8.165	8.17
1330	8.176	8.187	8.198	8.209	8.220	8.231	8.242	8.253	8.264	8.275	8.28
1340	8.286	8.298	8.309	8.320	8.331	8.342	8.353	8.364	8.375	8.386	8.39

1350	8.397	8.408	8.419	8.430	8.441	8.453	8.464	8.475	8.486	8.497	8.50
1360	8.508	8.519	8.530	8.542	8.553	8.564	8.575	8.586	8.597	8.608	8.62
1370	8.620	8.631	8.642	8.653	8.664	8.675	8.687	8.698	8.709	8.720	8.73
1380	8.731	8.743	8.754	8.765	8.776	8.787	8.799	8.810	8.821	8.832	8.84
1390	8.844	8.855	8.866	8.877	8.889	8.900	8.911	8.922	8.934	8.945	8.95

1400	8.956	8.967	8.979	8.990	9.001	9.013	9.024	9.035	9.047	9.058	9.06
1410	9.069	9.080	9.092	9.103	9.114	9.126	9.137	9.148	9.160	9.171	9.18
1420	9.182	9.194	9.205	9.216	9.228	9.239	9.251	9.262	9.273	9.285	9.29
1430	9.296	9.307	9.319	9.330	9.342	9.353	9.364	9.376	9.387	9.398	9.41
1440	9.410	9.421	9.433	9.444	9.456	9.467	9.478	9.490	9.501	9.513	9.52

1450	9.524	9.536	9.547	9.558	9.570	9.581	9.593	9.604	9.616	9.627	9.63
1460	9.639	9.650	9.662	9.673	9.684	9.696	9.707	9.719	9.730	9.742	9.75
1470	9.753	9.765	9.776	9.788	9.799	9.811	9.822	9.834	9.845	9.857	9.86
1480	9.868	9.880	9.891	9.903	9.914	9.926	9.937	9.949	9.961	9.972	9.98
1490	9.984	9.995	10.007	10.018	10.030	10.041	10.053	10.064	10.076	10.088	10.09

1500	10.099	10.111	10.122	10.134	10.145	10.157	10.168	10.180	10.192	10.203	10.21
1510	10.215	10.226	10.238	10.249	10.261	10.273	10.284	10.296	10.307	10.319	10.33
1520	10.331	10.342	10.354	10.365	10.377	10.389	10.400	10.412	10.423	10.435	10.44
1530	10.447	10.458	10.470	10.482	10.493	10.505	10.516	10.528	10.540	10.551	10.56
1540	10.563	10.575	10.586	10.598	10.609	10.621	10.633	10.644	10.656	10.668	10.67

1550	10.679	10.691	10.703	10.714	10.726	10.738	10.749	10.761	10.773	10.784	10.79
1560	10.796	10.808	10.819	10.831	10.843	10.854	10.866	10.877	10.889	10.901	10.91
1570	10.913	10.924	10.936	10.948	10.959	10.971	10.983	10.994	11.006	11.018	11.02
1580	11.029	11.041	11.053	11.064	11.076	11.088	11.099	11.111	11.123	11.134	11.14
1590	11.146	11.158	11.169	11.181	11.193	11.205	11.216	11.228	11.240	11.251	11.26

1600	11.263	11.275	11.286	11.298	11.310	11.321	11.333	11.345	11.357	11.368	11.38
1610	11.380	11.392	11.403	11.415	11.427	11.438	11.450	11.462	11.474	11.485	11.49
1620	11.497	11.509	11.520	11.532	11.544	11.555	11.567	11.579	11.591	11.602	11.61
1630	11.614	11.626	11.637	11.649	11.661	11.673	11.684	11.696	11.708	11.719	11.73
1640	11.731	11.743	11.754	11.766	11.778	11.790	11.801	11.813	11.825	11.836	11.84

1650	11.848	11.860	11.871	11.883	11.895	11.907	11.918	11.930	11.942	11.953	11.96
1660	11.965	11.977	11.988	12.000	12.012	12.024	12.035	12.047	12.059	12.070	12.08
1670	12.082	12.094	12.105	12.117	12.129	12.141	12.152	12.164	12.176	12.187	12.19
1680	12.199	12.211	12.222	12.234	12.246	12.257	12.269	12.281	12.292	12.304	12.31
1690	12.316	12.327	12.339	12.351	12.363	12.374	12.386	12.398	12.409	12.421	12.43

1700	12.433	12.444	12.456	12.468	12.479	12.491	12.503	12.514	12.526	12.538	12.54
1710	12.549	12.561	12.572	12.584	12.596	12.607	12.619	12.631	12.642	12.654	12.66
1720	12.666	12.677	12.689	12.701	12.712	12.724	12.736	12.747	12.759	12.770	12.78
1730	12.782	12.794	12.805	12.817	12.829	12.840	12.852	12.863	12.875	12.887	12.89
1740	12.898	12.910	12.921	12.933	12.945	12.956	12.968	12.980	12.991	13.003	13.01

1750	13.014	13.026	13.037	13.049	13.061	13.072	13.084	13.095	13.107	13.119	13.13
1760	13.130	13.142	13.153	13.165	13.176	13.188	13.200	13.211	13.223	13.234	13.24
1770	13.246	13.257	13.269	13.280	13.292	13.304	13.315	13.327	13.338	13.350	13.36
1780	13.361	13.373	13.384	13.396	13.407	13.419	13.430	13.442	13.453	13.465	13.47
1790	13.476	13.488	13.499	13.511	13.522	13.534	13.545	13.557	13.568	13.580	13.59

1800	13.591	13.603	13.614	13.626	13.637	13.649	13.660	13.672	13.683	13.694	13.70
1810	13.706	13.717	13.729	13.740	13.752	13.763	13.775	13.786	13.797	13.809	13.82

°C	0	1	2	3	4	5	6	7	8	9	10
0	-1.026	-0.994	-0.963	-0.931	-0.900	-0.868	-0.836	-0.805	-0.773	-0.741	-0.70
10	-0.709	-0.677	-0.645	-0.614	-0.582	-0.550	-0.517	-0.485	-0.453	-0.421	-0.38
20	-0.389	-0.357	-0.324	-0.292	-0.260	-0.227	-0.195	-0.163	-0.130	-0.098	-0.06
30	-0.065	-0.033	0.000	0.033	0.065	0.098	0.131	0.163	0.196	0.229	0.26
40	0.262	0.294	0.327	0.360	0.393	0.426	0.459	0.492	0.525	0.558	0.59
50	0.591	0.624	0.657	0.691	0.724	0.757	0.790	0.824	0.857	0.890	0.92
60	0.924	0.957	0.990	1.024	1.057	1.091	1.124	1.158	1.192	1.225	1.25
70	1.259	1.292	1.326	1.360	1.394	1.427	1.461	1.495	1.529	1.563	1.59
80	1.597	1.631	1.665	1.699	1.733	1.767	1.801	1.835	1.869	1.904	1.93
90	1.938	1.972	2.006	2.041	2.075	2.109	2.144	2.178	2.212	2.247	2.28
100	2.281	2.316	2.351	2.385	2.420	2.454	2.489	2.524	2.558	2.593	2.62
110	2.628	2.663	2.698	2.733	2.767	2.802	2.837	2.872	2.907	2.942	2.97
120	2.977	3.012	3.048	3.083	3.118	3.153	3.188	3.224	3.259	3.294	3.33
130	3.330	3.365	3.400	3.436	3.471	3.507	3.542	3.578	3.613	3.649	3.68
140	3.685	3.720	3.756	3.792	3.827	3.863	3.899	3.935	3.970	4.006	4.04

ITS-90 Table for type E thermocouple
 °F -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0
 Thermoelectric Voltage in mV

-440	-9.830	-9.829	-9.827	-9.825	-9.823	-9.821	-9.819	-9.817	-9.814	-9.812	-9.80
-430	-9.809	-9.806	-9.803	-9.800	-9.797	-9.793	-9.790	-9.786	-9.782	-9.779	-9.77
-420	-9.775	-9.771	-9.766	-9.762	-9.758	-9.753	-9.749	-9.744	-9.739	-9.734	-9.72
-410	-9.729	-9.724	-9.718	-9.713	-9.707	-9.702	-9.696	-9.690	-9.684	-9.678	-9.67
-400	-9.672	-9.666	-9.659	-9.653	-9.646	-9.639	-9.632	-9.625	-9.618	-9.611	-9.60

-390	-9.604	-9.597	-9.589	-9.581	-9.574	-9.566	-9.558	-9.550	-9.542	-9.534	-9.52
-380	-9.525	-9.517	-9.508	-9.500	-9.491	-9.482	-9.473	-9.464	-9.455	-9.446	-9.43
-370	-9.436	-9.427	-9.417	-9.408	-9.398	-9.388	-9.378	-9.368	-9.358	-9.348	-9.33
-360	-9.338	-9.327	-9.317	-9.306	-9.295	-9.285	-9.274	-9.263	-9.252	-9.241	-9.22
-350	-9.229	-9.218	-9.207	-9.195	-9.184	-9.172	-9.160	-9.148	-9.136	-9.124	-9.11

-340	-9.112	-9.100	-9.088	-9.075	-9.063	-9.050	-9.038	-9.025	-9.012	-8.999	-8.98
-330	-8.986	-8.973	-8.960	-8.947	-8.934	-8.920	-8.907	-8.893	-8.880	-8.866	-8.85
-320	-8.852	-8.839	-8.825	-8.811	-8.797	-8.782	-8.768	-8.754	-8.739	-8.725	-8.71
-310	-8.710	-8.696	-8.681	-8.666	-8.652	-8.637	-8.622	-8.607	-8.591	-8.576	-8.56
-300	-8.561	-8.546	-8.530	-8.515	-8.499	-8.483	-8.468	-8.452	-8.436	-8.420	-8.40

-290	-8.404	-8.388	-8.372	-8.356	-8.339	-8.323	-8.307	-8.290	-8.273	-8.257	-8.24
-280	-8.240	-8.223	-8.206	-8.189	-8.173	-8.155	-8.138	-8.121	-8.104	-8.087	-8.06
-270	-8.069	-8.052	-8.034	-8.017	-7.999	-7.981	-7.963	-7.945	-7.928	-7.910	-7.89
-260	-7.891	-7.873	-7.855	-7.837	-7.819	-7.800	-7.782	-7.763	-7.745	-7.726	-7.70
-250	-7.707	-7.688	-7.670	-7.651	-7.632	-7.613	-7.593	-7.574	-7.555	-7.536	-7.51

-240	-7.516	-7.497	-7.478	-7.458	-7.438	-7.419	-7.399	-7.379	-7.359	-7.339	-7.31
-230	-7.319	-7.299	-7.279	-7.259	-7.239	-7.219	-7.198	-7.178	-7.157	-7.137	-7.11
-220	-7.116	-7.096	-7.075	-7.054	-7.033	-7.013	-6.992	-6.971	-6.950	-6.928	-6.90
-210	-6.907	-6.886	-6.865	-6.843	-6.822	-6.801	-6.779	-6.757	-6.736	-6.714	-6.69
-200	-6.692	-6.671	-6.649	-6.627	-6.605	-6.583	-6.561	-6.539	-6.516	-6.494	-6.47

ITS-90 Table for type E thermocouple										
°F	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
150	4.042	4.078	4.114	4.150	4.186	4.222	4.258	4.294	4.330	4.366
160	4.403	4.439	4.475	4.511	4.547	4.584	4.620	4.656	4.693	4.729
170	4.766	4.802	4.839	4.875	4.912	4.948	4.985	5.021	5.058	5.095
180	5.131	5.168	5.205	5.242	5.278	5.315	5.352	5.389	5.426	5.463
190	5.500	5.537	5.574	5.611	5.648	5.685	5.722	5.759	5.796	5.833
200	5.871	5.908	5.945	5.982	6.020	6.057	6.094	6.132	6.169	6.207
210	6.244	6.281	6.319	6.356	6.394	6.432	6.469	6.507	6.544	6.582
220	6.620	6.658	6.695	6.733	6.771	6.809	6.847	6.884	6.922	6.960
230	6.998	7.036	7.074	7.112	7.150	7.188	7.226	7.264	7.302	7.341
240	7.379	7.417	7.455	7.493	7.532	7.570	7.608	7.647	7.685	7.723
250	7.762	7.800	7.839	7.877	7.916	7.954	7.993	8.031	8.070	8.108
260	8.147	8.186	8.224	8.263	8.302	8.340	8.379	8.418	8.457	8.496
270	8.535	8.573	8.612	8.651	8.690	8.729	8.768	8.807	8.846	8.885
280	8.924	8.963	9.002	9.041	9.081	9.120	9.159	9.198	9.237	9.277
290	9.316	9.355	9.395	9.434	9.473	9.513	9.552	9.591	9.631	9.670
300	9.710	9.749	9.789	9.828	9.868	9.907	9.947	9.987	10.026	10.066
310	10.106	10.145	10.185	10.225	10.265	10.304	10.344	10.384	10.424	10.464
320	10.503	10.543	10.583	10.623	10.663	10.703	10.743	10.783	10.823	10.863
330	10.903	10.943	10.983	11.024	11.064	11.104	11.144	11.184	11.224	11.265
340	11.305	11.345	11.385	11.426	11.466	11.506	11.547	11.587	11.627	11.668
350	11.708	11.749	11.789	11.830	11.870	11.911	11.951	11.992	12.032	12.073
360	12.113	12.154	12.195	12.235	12.276	12.317	12.357	12.398	12.439	12.480
370	12.520	12.561	12.602	12.643	12.684	12.724	12.765	12.806	12.847	12.888
380	12.929	12.970	13.011	13.052	13.093	13.134	13.175	13.216	13.257	13.298
390	13.339	13.380	13.421	13.462	13.504	13.545	13.586	13.627	13.668	13.710
400	13.751	13.792	13.833	13.875	13.916	13.957	13.999	14.040	14.081	14.123
410	14.164	14.205	14.247	14.288	14.330	14.371	14.413	14.454	14.496	14.537
420	14.579	14.620	14.662	14.704	14.745	14.787	14.828	14.870	14.912	14.953
430	14.995	15.037	15.078	15.120	15.162	15.204	15.245	15.287	15.329	15.371
440	15.413	15.454	15.496	15.538	15.580	15.622	15.664	15.706	15.748	15.790
450	15.831	15.873	15.915	15.957	15.999	16.041	16.083	16.125	16.168	16.210
460	16.252	16.294	16.336	16.378	16.420	16.462	16.504	16.547	16.589	16.631
470	16.673	16.715	16.758	16.800	16.842	16.884	16.927	16.969	17.011	17.054
480	17.096	17.138	17.181	17.223	17.265	17.308	17.350	17.392	17.435	17.477
490	17.520	17.562	17.605	17.647	17.690	17.732	17.775	17.817	17.860	17.902
500	17.945	17.987	18.030	18.073	18.115	18.158	18.200	18.243	18.286	18.328
510	18.371	18.414	18.456	18.499	18.542	18.585	18.627	18.670	18.713	18.756
520	18.798	18.841	18.884	18.927	18.969	19.012	19.055	19.098	19.141	19.184
530	19.227	19.269	19.312	19.355	19.398	19.441	19.484	19.527	19.570	19.613
540	19.656	19.699	19.742	19.785	19.828	19.871	19.914	19.957	20.000	20.043
550	20.086	20.129	20.172	20.216	20.259	20.302	20.345	20.388	20.431	20.474
560	20.517	20.561	20.604	20.647	20.690	20.733	20.777	20.820	20.863	20.906
570	20.950	20.993	21.036	21.080	21.123	21.166	21.209	21.253	21.296	21.339
580	21.383	21.426	21.470	21.513	21.556	21.600	21.643	21.686	21.730	21.773
590	21.817	21.860	21.904	21.947	21.991	22.034	22.078	22.121	22.165	22.208
600	22.252	22.295	22.339	22.382	22.426	22.469	22.513	22.556	22.600	22.644
610	22.687	22.731	22.774	22.818	22.862	22.905	22.949	22.993	23.036	23.080
620	23.124	23.167	23.211	23.255	23.298	23.342	23.386	23.429	23.473	23.517
630	23.561	23.604	23.648	23.692	23.736	23.780	23.823	23.867	23.911	23.955
640	23.999	24.042	24.086	24.130	24.174	24.218	24.262	24.305	24.349	24.393
650	24.437	24.481	24.525	24.569	24.613	24.657	24.701	24.745	24.789	24.832
660	24.876	24.920	24.964	25.008	25.052	25.096	25.140	25.184	25.228	25.272
670	25.316	25.360	25.404	25.448	25.493	25.537	25.581	25.625	25.669	25.713
680	25.757	25.801	25.845	25.889	25.933	25.977	26.021	26.065	26.109	26.153
690	26.198	26.242	26.286	26.331	26.375	26.419	26.463	26.507	26.552	26.596
700	26.640	26.684	26.728	26.773	26.817	26.861	26.905	26.950	26.994	27.038
710	27.082	27.127	27.171	27.215	27.259	27.304	27.348	27.392	27.437	27.481
720	27.525	27.570	27.614	27.658	27.703	27.747	27.791	27.836	27.880	27.924
730	27.969	28.013	28.057	28.102	28.146	28.191	28.235	28.279	28.324	28.368
740	28.413	28.457	28.501	28.546	28.590	28.635	28.679	28.724	28.768	28.813
750	28.857	28.901	28.946	28.990	29.035	29.079	29.124	29.168	29.213	29.257
760	29.302	29.346	29.391	29.435	29.480	29.525	29.569	29.614	29.658	29.703
770	29.747	29.792	29.836	29.881	29.925	29.970	30.015	30.059	30.104	30.148
780	30.193	30.238	30.282	30.327	30.371	30.416	30.461	30.505	30.550	30.595
790	30.639	30.684	30.728	30.773	30.818	30.862	30.907	30.952	30.996	31.041

°F 0 1 2 3 4 5 6 7 8 9 10

ITS-90 Table for type E thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
800	31.086	31.130	31.175	31.220	31.264	31.309	31.354	31.398	31.443	31.488	31.53
810	31.533	31.577	31.622	31.667	31.711	31.756	31.801	31.846	31.890	31.935	31.98
820	31.980	32.025	32.069	32.114	32.159	32.204	32.248	32.293	32.338	32.383	32.42
830	32.427	32.472	32.517	32.562	32.606	32.651	32.696	32.741	32.786	32.830	32.87
840	32.875	32.920	32.965	33.010	33.054	33.099	33.144	33.189	33.234	33.278	33.32
850	33.323	33.368	33.413	33.458	33.503	33.547	33.592	33.637	33.682	33.727	33.77
860	33.772	33.816	33.861	33.906	33.951	33.996	34.041	34.086	34.130	34.175	34.22
870	34.220	34.265	34.310	34.355	34.400	34.445	34.489	34.534	34.579	34.624	34.66
880	34.669	34.714	34.759	34.804	34.849	34.893	34.938	34.983	35.028	35.073	35.11
890	35.118	35.163	35.208	35.253	35.298	35.343	35.387	35.432	35.477	35.522	35.56
900	35.567	35.612	35.657	35.702	35.747	35.792	35.837	35.882	35.927	35.972	36.01
910	36.016	36.061	36.106	36.151	36.196	36.241	36.286	36.331	36.376	36.421	36.46
920	36.466	36.511	36.556	36.601	36.646	36.691	36.736	36.781	36.826	36.870	36.91
930	36.915	36.960	37.005	37.050	37.095	37.140	37.185	37.230	37.275	37.320	37.36
940	37.365	37.410	37.455	37.500	37.545	37.590	37.635	37.680	37.725	37.770	37.81
950	37.815	37.860	37.905	37.950	37.995	38.040	38.085	38.130	38.175	38.220	38.26
960	38.265	38.309	38.354	38.399	38.444	38.489	38.534	38.579	38.624	38.669	38.71
970	38.714	38.759	38.804	38.849	38.894	38.939	38.984	39.029	39.074	39.119	39.16
980	39.164	39.209	39.254	39.299	39.344	39.389	39.434	39.479	39.524	39.569	39.61
990	39.614	39.659	39.704	39.749	39.794	39.839	39.884	39.929	39.974	40.019	40.06
1000	40.064	40.109	40.154	40.199	40.243	40.288	40.333	40.378	40.423	40.468	40.51
1010	40.513	40.558	40.603	40.648	40.693	40.738	40.783	40.828	40.873	40.918	40.96
1020	40.963	41.008	41.053	41.098	41.143	41.188	41.233	41.278	41.323	41.368	41.41
1030	41.412	41.457	41.502	41.547	41.592	41.637	41.682	41.727	41.772	41.817	41.86
1040	41.862	41.907	41.952	41.997	42.042	42.087	42.132	42.177	42.221	42.266	42.31
1050	42.311	42.356	42.401	42.446	42.491	42.536	42.581	42.626	42.671	42.715	42.76
1060	42.760	42.805	42.850	42.895	42.940	42.985	43.030	43.075	43.120	43.165	43.20
1070	43.209	43.254	43.299	43.344	43.389	43.434	43.479	43.524	43.569	43.613	43.65
1080	43.658	43.703	43.748	43.793	43.838	43.883	43.928	43.972	44.017	44.062	44.10
1090	44.107	44.152	44.197	44.242	44.286	44.331	44.376	44.421	44.466	44.511	44.55
1100	44.555	44.600	44.645	44.690	44.735	44.780	44.824	44.869	44.914	44.959	45.00
1110	45.004	45.049	45.093	45.138	45.183	45.228	45.273	45.317	45.362	45.407	45.45
1120	45.452	45.497	45.541	45.586	45.631	45.676	45.720	45.765	45.810	45.855	45.90
1130	45.900	45.944	45.989	46.034	46.079	46.123	46.168	46.213	46.258	46.302	46.34
1140	46.347	46.392	46.437	46.481	46.526	46.571	46.616	46.660	46.705	46.750	46.79
1150	46.794	46.839	46.884	46.929	46.973	47.018	47.063	47.107	47.152	47.197	47.24
1160	47.241	47.286	47.331	47.375	47.420	47.465	47.509	47.554	47.599	47.643	47.68
1170	47.688	47.733	47.777	47.822	47.867	47.911	47.956	48.001	48.045	48.090	48.13
1180	48.135	48.179	48.224	48.268	48.313	48.358	48.402	48.447	48.492	48.536	48.58
1190	48.581	48.625	48.670	48.715	48.759	48.804	48.848	48.893	48.937	48.982	49.02
1200	49.027	49.071	49.116	49.160	49.205	49.249	49.294	49.338	49.383	49.428	49.47
1210	49.472	49.517	49.561	49.606	49.650	49.695	49.739	49.784	49.828	49.873	49.91
1220	49.917	49.962	50.006	50.051	50.095	50.140	50.184	50.229	50.273	50.318	50.36
1230	50.362	50.407	50.451	50.495	50.540	50.584	50.629	50.673	50.718	50.762	50.80
1240	50.807	50.851	50.895	50.940	50.984	51.029	51.073	51.118	51.162	51.206	51.25
1250	51.251	51.295	51.340	51.384	51.428	51.473	51.517	51.561	51.606	51.650	51.69
1260	51.695	51.739	51.783	51.828	51.872	51.916	51.961	52.005	52.049	52.094	52.13
1270	52.138	52.182	52.227	52.271	52.315	52.360	52.404	52.448	52.493	52.537	52.58
1280	52.581	52.625	52.670	52.714	52.758	52.803	52.847	52.891	52.935	52.980	53.02
1290	53.024	53.068	53.112	53.157	53.201	53.245	53.289	53.334	53.378	53.422	53.46
1300	53.466	53.510	53.555	53.599	53.643	53.687	53.732	53.776	53.820	53.864	53.90
1310	53.908	53.952	53.997	54.041	54.085	54.129	54.173	54.218	54.262	54.306	54.35
1320	54.350	54.394	54.438	54.482	54.527	54.571	54.615	54.659	54.703	54.747	54.79
1330	54.791	54.835	54.879	54.924	54.968	55.012	55.056	55.100	55.144	55.188	55.23
1340	55.232	55.276	55.320	55.364	55.408	55.453	55.497	55.541	55.585	55.629	55.67
1350	55.673	55.717	55.761	55.805	55.849	55.893	55.937	55.981	56.025	56.069	56.11
1360	56.113	56.157	56.201	56.245	56.289	56.333	56.377	56.421	56.465	56.509	56.55
1370	56.553	56.597	56.641	56.685	56.729	56.773	56.816	56.860	56.904	56.948	56.99
1380	56.992	57.036	57.080	57.124	57.168	57.212	57.256	57.300	57.344	57.387	57.43
1390	57.431	57.475	57.519	57.563	57.607	57.651	57.695	57.738	57.782	57.826	57.87
1400	57.870	57.914	57.958	58.002	58.045	58.089	58.133	58.177	58.221	58.265	58.30
1410	58.308	58.352	58.396	58.440	58.484	58.527	58.571	58.615	58.659	58.702	58.74
1420	58.746	58.790	58.834	58.878	58.921	58.965	59.009	59.053	59.096	59.140	59.18
1430	59.184	59.228	59.271	59.315	59.359	59.402	59.446	59.490	59.534	59.577	59.62
1440	59.621	59.665	59.708	59.752	59.796	59.839	59.883	59.927	59.970	60.014	60.05
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type E thermocouple
 °F 0 1 2 3 4 5 6 7 8 9 10
 Thermoelectric Voltage in mV

1450	60.058	60.101	60.145	60.189	60.232	60.276	60.320	60.363	60.407	60.451	60.49
1460	60.494	60.538	60.581	60.625	60.669	60.712	60.756	60.799	60.843	60.887	60.93
1470	60.930	60.974	61.017	61.061	61.105	61.148	61.192	61.235	61.279	61.322	61.36
1480	61.366	61.409	61.453	61.496	61.540	61.583	61.627	61.671	61.714	61.758	61.80
1490	61.801	61.845	61.888	61.932	61.975	62.018	62.062	62.105	62.149	62.192	62.23
1500	62.236	62.279	62.323	62.366	62.410	62.453	62.496	62.540	62.583	62.627	62.67
1510	62.670	62.714	62.757	62.800	62.844	62.887	62.931	62.974	63.017	63.061	63.10
1520	63.104	63.148	63.191	63.234	63.278	63.321	63.364	63.408	63.451	63.494	63.53
1530	63.538	63.581	63.624	63.668	63.711	63.754	63.798	63.841	63.884	63.927	63.97
1540	63.971	64.014	64.057	64.101	64.144	64.187	64.230	64.274	64.317	64.360	64.40
1550	64.403	64.447	64.490	64.533	64.576	64.619	64.663	64.706	64.749	64.792	64.83
1560	64.835	64.879	64.922	64.965	65.008	65.051	65.094	65.138	65.181	65.224	65.26
1570	65.267	65.310	65.353	65.396	65.440	65.483	65.526	65.569	65.612	65.655	65.69
1580	65.698	65.741	65.784	65.827	65.871	65.914	65.957	66.000	66.043	66.086	66.12
1590	66.129	66.172	66.215	66.258	66.301	66.344	66.387	66.430	66.473	66.516	66.55
1600	66.559	66.602	66.645	66.688	66.731	66.774	66.817	66.860	66.903	66.946	66.98
1610	66.989	67.031	67.074	67.117	67.160	67.203	67.246	67.289	67.332	67.375	67.41
1620	67.418	67.460	67.503	67.546	67.589	67.632	67.675	67.718	67.760	67.803	67.84
1630	67.846	67.889	67.932	67.974	68.017	68.060	68.103	68.146	68.188	68.231	68.27
1640	68.274	68.317	68.359	68.402	68.445	68.488	68.530	68.573	68.616	68.659	68.70
1650	68.701	68.744	68.787	68.829	68.872	68.915	68.957	69.000	69.043	69.085	69.12
1660	69.128	69.171	69.213	69.256	69.298	69.341	69.384	69.426	69.469	69.511	69.55
1670	69.554	69.597	69.639	69.682	69.724	69.767	69.809	69.852	69.894	69.937	69.97
1680	69.979	70.022	70.064	70.107	70.149	70.192	70.234	70.277	70.319	70.362	70.40
1690	70.404	70.447	70.489	70.531	70.574	70.616	70.659	70.701	70.744	70.786	70.82
1700	70.828	70.871	70.913	70.955	70.998	71.040	71.082	71.125	71.167	71.209	71.25
1710	71.252	71.294	71.336	71.379	71.421	71.463	71.506	71.548	71.590	71.632	71.67
1720	71.675	71.717	71.759	71.801	71.844	71.886	71.928	71.970	72.012	72.055	72.09
1730	72.097	72.139	72.181	72.223	72.266	72.308	72.350	72.392	72.434	72.476	72.51
1740	72.518	72.561	72.603	72.645	72.687	72.729	72.771	72.813	72.855	72.897	72.93
1750	72.939	72.981	73.023	73.066	73.108	73.150	73.192	73.234	73.276	73.318	73.36
1760	73.360	73.402	73.444	73.486	73.528	73.570	73.612	73.654	73.696	73.738	73.78
1770	73.780	73.821	73.863	73.905	73.947	73.989	74.031	74.073	74.115	74.157	74.19
1780	74.199	74.241	74.283	74.324	74.366	74.408	74.450	74.492	74.534	74.576	74.61
1790	74.618	74.659	74.701	74.743	74.785	74.827	74.869	74.910	74.952	74.994	75.03
1800	75.036	75.078	75.120	75.161	75.203	75.245	75.287	75.329	75.370	75.412	75.45
1810	75.454	75.496	75.538	75.579	75.621	75.663	75.705	75.746	75.788	75.830	75.87
1820	75.872	75.913	75.955	75.997	76.039	76.081	76.122	76.164	76.206	76.248	76.28

°F 0 1 2 3 4 5 6 7 8 9 10

ITS-90 Table for type E thermocouple
 °C -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0
 Thermoelectric Voltage in mV

-260	-9.835	-9.833	-9.831	-9.828	-9.825	-9.821	-9.817	-9.813	-9.808	-9.802	-9.79
-250	-9.797	-9.790	-9.784	-9.777	-9.770	-9.762	-9.754	-9.746	-9.737	-9.728	-9.71
-240	-9.718	-9.709	-9.698	-9.688	-9.677	-9.666	-9.654	-9.642	-9.630	-9.617	-9.60
-230	-9.604	-9.591	-9.577	-9.563	-9.548	-9.534	-9.519	-9.503	-9.487	-9.471	-9.45
-220	-9.455	-9.438	-9.421	-9.404	-9.386	-9.368	-9.350	-9.331	-9.313	-9.293	-9.27
-210	-9.274	-9.254	-9.234	-9.214	-9.193	-9.172	-9.151	-9.129	-9.107	-9.085	-9.06
-200	-9.063	-9.040	-9.017	-8.994	-8.971	-8.947	-8.923	-8.899	-8.874	-8.850	-8.82
-190	-8.825	-8.799	-8.774	-8.748	-8.722	-8.696	-8.669	-8.643	-8.616	-8.588	-8.56
-180	-8.561	-8.533	-8.505	-8.477	-8.449	-8.420	-8.391	-8.362	-8.333	-8.303	-8.27
-170	-8.273	-8.243	-8.213	-8.183	-8.152	-8.121	-8.090	-8.059	-8.027	-7.995	-7.96
-160	-7.963	-7.931	-7.899	-7.866	-7.833	-7.800	-7.767	-7.733	-7.700	-7.666	-7.63
-150	-7.632	-7.597	-7.563	-7.528	-7.493	-7.458	-7.423	-7.387	-7.351	-7.315	-7.27
-140	-7.279	-7.243	-7.206	-7.170	-7.133	-7.096	-7.058	-7.021	-6.983	-6.945	-6.90
-130	-6.907	-6.869	-6.831	-6.792	-6.753	-6.714	-6.675	-6.636	-6.596	-6.556	-6.51
-120	-6.516	-6.476	-6.436	-6.396	-6.355	-6.314	-6.273	-6.232	-6.191	-6.149	-6.10
-110	-6.107	-6.065	-6.023	-5.981	-5.939	-5.896	-5.853	-5.810	-5.767	-5.724	-5.68
-100	-5.681	-5.637	-5.593	-5.549	-5.505	-5.461	-5.417	-5.372	-5.327	-5.282	-5.23
-90	-5.237	-5.192	-5.147	-5.101	-5.055	-5.009	-4.963	-4.917	-4.871	-4.824	-4.77
-80	-4.777	-4.731	-4.684	-4.636	-4.589	-4.542	-4.494	-4.446	-4.398	-4.350	-4.30
-70	-4.302	-4.254	-4.205	-4.156	-4.107	-4.058	-4.009	-3.960	-3.911	-3.861	-3.81
-60	-3.811	-3.761	-3.711	-3.661	-3.611	-3.561	-3.510	-3.459	-3.408	-3.357	-3.30
-50	-3.306	-3.255	-3.204	-3.152	-3.100	-3.048	-2.996	-2.944	-2.892	-2.840	-2.78
-40	-2.787	-2.735	-2.682	-2.629	-2.576	-2.523	-2.469	-2.416	-2.362	-2.309	-2.25
-30	-2.255	-2.201	-2.147	-2.093	-2.038	-1.984	-1.929	-1.874	-1.820	-1.765	-1.70
-20	-1.709	-1.654	-1.599	-1.543	-1.488	-1.432	-1.376	-1.320	-1.264	-1.208	-1.15
-10	-1.152	-1.095	-1.039	-0.982	-0.925	-0.868	-0.811	-0.754	-0.697	-0.639	-0.58
0	-0.582	-0.524	-0.466	-0.408	-0.350	-0.292	-0.234	-0.176	-0.117	-0.059	0.00
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type E thermocouple	0	1	2	3	4	5	6	7	8	9	10
0	0.000	0.059	0.118	0.176	0.235	0.294	0.354	0.413	0.472	0.532	0.59
10	0.591	0.651	0.711	0.770	0.830	0.890	0.950	1.010	1.071	1.131	1.19
20	1.192	1.252	1.313	1.373	1.434	1.495	1.556	1.617	1.678	1.740	1.80
30	1.801	1.862	1.924	1.986	2.047	2.109	2.171	2.233	2.295	2.357	2.42
40	2.420	2.482	2.545	2.607	2.670	2.733	2.795	2.858	2.921	2.984	3.04
50	3.048	3.111	3.174	3.238	3.301	3.365	3.429	3.492	3.556	3.620	3.68
60	3.685	3.749	3.813	3.877	3.942	4.006	4.071	4.136	4.200	4.265	4.33
70	4.330	4.395	4.460	4.526	4.591	4.656	4.722	4.788	4.853	4.919	4.98
80	4.985	5.051	5.117	5.183	5.249	5.315	5.382	5.448	5.514	5.581	5.64
90	5.648	5.714	5.781	5.848	5.915	5.982	6.049	6.117	6.184	6.251	6.31
100	6.319	6.386	6.454	6.522	6.590	6.658	6.725	6.794	6.862	6.930	6.99
110	6.998	7.066	7.135	7.203	7.272	7.341	7.409	7.478	7.547	7.616	7.68
120	7.685	7.754	7.823	7.892	7.962	8.031	8.101	8.170	8.240	8.309	8.37
130	8.379	8.449	8.519	8.589	8.659	8.729	8.799	8.869	8.940	9.010	9.08
140	9.081	9.151	9.222	9.292	9.363	9.434	9.505	9.576	9.647	9.718	9.78
150	9.789	9.860	9.931	10.003	10.074	10.145	10.217	10.288	10.360	10.432	10.50
160	10.503	10.575	10.647	10.719	10.791	10.863	10.935	11.007	11.080	11.152	11.22
170	11.224	11.297	11.369	11.442	11.514	11.587	11.660	11.733	11.805	11.878	11.95
180	11.951	12.024	12.097	12.170	12.243	12.317	12.390	12.463	12.537	12.610	12.68
190	12.684	12.757	12.831	12.904	12.978	13.052	13.126	13.199	13.273	13.347	13.42
200	13.421	13.495	13.569	13.644	13.718	13.792	13.866	13.941	14.015	14.090	14.16
210	14.164	14.239	14.313	14.388	14.463	14.537	14.612	14.687	14.762	14.837	14.91
220	14.912	14.987	15.062	15.137	15.212	15.287	15.362	15.438	15.513	15.588	15.66
230	15.664	15.739	15.815	15.890	15.966	16.041	16.117	16.193	16.269	16.344	16.42
240	16.420	16.496	16.572	16.648	16.724	16.800	16.876	16.952	17.028	17.104	17.18
250	17.181	17.257	17.333	17.409	17.486	17.562	17.639	17.715	17.792	17.868	17.94
260	17.945	18.021	18.098	18.175	18.252	18.328	18.405	18.482	18.559	18.636	18.71
270	18.713	18.790	18.867	18.944	19.021	19.098	19.175	19.252	19.330	19.407	19.48

ITS-90 Table for type E thermocouple										
°C	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
350	24.964	25.044	25.123	25.202	25.281	25.360	25.440	25.519	25.598	25.678
360	25.757	25.836	25.916	25.995	26.075	26.154	26.233	26.313	26.392	26.472
370	26.552	26.631	26.711	26.790	26.870	26.950	27.029	27.109	27.189	27.268
380	27.348	27.428	27.507	27.587	27.667	27.747	27.827	27.907	27.986	28.066
390	28.146	28.226	28.306	28.386	28.466	28.546	28.626	28.706	28.786	28.866
400	28.946	29.026	29.106	29.186	29.266	29.346	29.427	29.507	29.587	29.667
410	29.747	29.827	29.908	29.988	30.068	30.148	30.229	30.309	30.389	30.470
420	30.550	30.630	30.711	30.791	30.871	30.952	31.032	31.112	31.193	31.273
430	31.354	31.434	31.515	31.595	31.676	31.756	31.837	31.917	31.998	32.078
440	32.159	32.239	32.320	32.400	32.481	32.562	32.642	32.723	32.803	32.884
450	32.965	33.045	33.126	33.207	33.287	33.368	33.449	33.529	33.610	33.691
460	33.772	33.852	33.933	34.014	34.095	34.175	34.256	34.337	34.418	34.498
470	34.579	34.660	34.741	34.822	34.902	34.983	35.064	35.145	35.226	35.307
480	35.387	35.468	35.549	35.630	35.711	35.792	35.873	35.954	36.034	36.115
490	36.196	36.277	36.358	36.439	36.520	36.601	36.682	36.763	36.843	36.924
500	37.005	37.086	37.167	37.248	37.329	37.410	37.491	37.572	37.653	37.734
510	37.815	37.896	37.977	38.058	38.139	38.220	38.300	38.381	38.462	38.543
520	38.624	38.705	38.786	38.867	38.948	39.029	39.110	39.191	39.272	39.353
530	39.434	39.515	39.596	39.677	39.758	39.839	39.920	40.001	40.082	40.163
540	40.243	40.324	40.405	40.486	40.567	40.648	40.729	40.810	40.891	40.972
550	41.053	41.134	41.215	41.296	41.377	41.457	41.538	41.619	41.700	41.781
560	41.862	41.943	42.024	42.105	42.185	42.266	42.347	42.428	42.509	42.590
570	42.671	42.751	42.832	42.913	42.994	43.075	43.156	43.236	43.317	43.398
580	43.479	43.560	43.640	43.721	43.802	43.883	43.963	44.044	44.125	44.206
590	44.286	44.367	44.448	44.529	44.609	44.690	44.771	44.851	44.932	45.013
600	45.093	45.174	45.255	45.335	45.416	45.497	45.577	45.658	45.738	45.819
610	45.900	45.980	46.061	46.141	46.222	46.302	46.383	46.463	46.544	46.624
620	46.705	46.785	46.866	46.946	47.027	47.107	47.188	47.268	47.349	47.429
630	47.509	47.590	47.670	47.751	47.831	47.911	47.992	48.072	48.152	48.233
640	48.313	48.393	48.474	48.554	48.634	48.715	48.795	48.875	48.955	49.035
650	49.116	49.196	49.276	49.356	49.436	49.517	49.597	49.677	49.757	49.837
660	49.917	49.997	50.077	50.157	50.238	50.318	50.398	50.478	50.558	50.638
670	50.718	50.798	50.878	50.958	51.038	51.118	51.197	51.277	51.357	51.437
680	51.517	51.597	51.677	51.757	51.837	51.916	51.996	52.076	52.156	52.236
690	52.315	52.395	52.475	52.555	52.634	52.714	52.794	52.873	52.953	53.033
700	53.112	53.192	53.272	53.351	53.431	53.510	53.590	53.670	53.749	53.829
710	53.908	53.988	54.067	54.147	54.226	54.306	54.385	54.465	54.544	54.624
720	54.703	54.782	54.862	54.941	55.021	55.100	55.179	55.259	55.338	55.417
730	55.497	55.576	55.655	55.734	55.814	55.893	55.972	56.051	56.131	56.210
740	56.289	56.368	56.447	56.526	56.606	56.685	56.764	56.843	56.922	57.001
750	57.080	57.159	57.238	57.317	57.396	57.475	57.554	57.633	57.712	57.791
760	57.870	57.949	58.028	58.107	58.186	58.265	58.344	58.423	58.502	58.581
770	58.659	58.738	58.816	58.895	58.974	59.053	59.131	59.210	59.289	59.367
780	59.446	59.525	59.604	59.682	59.761	59.839	59.918	59.997	60.075	60.154
790	60.232	60.311	60.390	60.468	60.547	60.625	60.704	60.782	60.860	60.939
800	61.017	61.096	61.174	61.253	61.331	61.409	61.488	61.566	61.644	61.723
810	61.801	61.879	61.958	62.036	62.114	62.192	62.271	62.349	62.427	62.505
820	62.583	62.662	62.740	62.818	62.896	62.974	63.052	63.130	63.208	63.286
830	63.364	63.442	63.520	63.598	63.676	63.754	63.832	63.910	63.988	64.066
840	64.144	64.222	64.300	64.377	64.455	64.533	64.611	64.689	64.766	64.844
850	64.922	65.000	65.077	65.155	65.233	65.310	65.388	65.465	65.543	65.621
860	65.698	65.776	65.853	65.931	66.008	66.086	66.163	66.241	66.318	66.396
870	66.473	66.550	66.628	66.705	66.782	66.860	66.937	67.014	67.092	67.169
880	67.246	67.323	67.400	67.478	67.555	67.632	67.709	67.786	67.863	67.940
890	68.017	68.094	68.171	68.248	68.325	68.402	68.479	68.556	68.633	68.710
900	68.787	68.863	68.940	69.017	69.094	69.171	69.247	69.324	69.401	69.477
910	69.554	69.631	69.707	69.784	69.860	69.937	70.013	70.090	70.166	70.243
920	70.319	70.396	70.472	70.548	70.625	70.701	70.777	70.854	70.930	71.006
930	71.082	71.159	71.235	71.311	71.387	71.463	71.539	71.615	71.692	71.768
940	71.844	71.920	72.000	72.072	72.147	72.223	72.299	72.375	72.451	72.527
950	72.603	72.678	72.754	72.830	72.906	72.981	73.057	73.133	73.208	73.284
960	73.360	73.435	73.511	73.586	73.662	73.738	73.813	73.889	73.964	74.040
970	74.115	74.190	74.266	74.341	74.417	74.492	74.567	74.643	74.718	74.793
980	74.869	74.944	75.019	75.095	75.170	75.245	75.320	75.395	75.471	75.546
990	75.621	75.696	75.771	75.847	75.922	75.997	76.072	76.147	76.223	76.298
1000	76.373	76.448	76.523	76.598	76.673	76.748	76.823	76.898	76.973	77.048

ITS-90 Table for type J thermocouple											
°F	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Thermoelectric Voltage in mV											
-340					-8.095	-8.085	-8.074	-8.063	-8.052	-8.041	-8.03
-330	-8.030	-8.019	-8.008	-7.996	-7.985	-7.973	-7.962	-7.950	-7.938	-7.927	-7.91
-320	-7.915	-7.903	-7.890	-7.878	-7.866	-7.854	-7.841	-7.829	-7.816	-7.804	-7.79
-310	-7.791	-7.778	-7.765	-7.752	-7.739	-7.726	-7.713	-7.699	-7.686	-7.672	-7.65
-300	-7.659	-7.645	-7.632	-7.618	-7.604	-7.590	-7.576	-7.562	-7.548	-7.534	-7.51
-290	-7.519	-7.505	-7.491	-7.476	-7.462	-7.447	-7.432	-7.417	-7.403	-7.388	-7.37
-280	-7.373	-7.357	-7.342	-7.327	-7.312	-7.296	-7.281	-7.265	-7.250	-7.234	-7.21
-270	-7.219	-7.203	-7.187	-7.171	-7.155	-7.139	-7.123	-7.107	-7.090	-7.074	-7.05
-260	-7.058	-7.041	-7.025	-7.008	-6.991	-6.975	-6.958	-6.941	-6.924	-6.907	-6.89
-250	-6.890	-6.873	-6.856	-6.839	-6.821	-6.804	-6.787	-6.769	-6.752	-6.734	-6.71
-240	-6.716	-6.699	-6.681	-6.663	-6.645	-6.627	-6.609	-6.591	-6.573	-6.555	-6.53
-230	-6.536	-6.518	-6.500	-6.481	-6.463	-6.444	-6.426	-6.407	-6.388	-6.370	-6.35
-220	-6.351	-6.332	-6.313	-6.294	-6.275	-6.256	-6.236	-6.217	-6.198	-6.179	-6.15
-210	-6.159	-6.140	-6.120	-6.101	-6.081	-6.061	-6.042	-6.022	-6.002	-5.982	-5.96
-200	-5.962	-5.942	-5.922	-5.902	-5.882	-5.862	-5.842	-5.821	-5.801	-5.781	-5.76
-190	-5.760	-5.740	-5.719	-5.699	-5.678	-5.657	-5.637	-5.616	-5.595	-5.574	-5.55
-180	-5.553	-5.532	-5.511	-5.490	-5.469	-5.448	-5.426	-5.405	-5.384	-5.363	-5.34
-170	-5.341	-5.320	-5.298	-5.277	-5.255	-5.233	-5.212	-5.190	-5.168	-5.146	-5.12
-160	-5.125	-5.103	-5.081	-5.059	-5.037	-5.015	-4.992	-4.970	-4.948	-4.926	-4.90
-150	-4.903	-4.881	-4.859	-4.836	-4.814	-4.791	-4.769	-4.746	-4.724	-4.701	-4.67
-140	-4.678	-4.655	-4.633	-4.610	-4.587	-4.564	-4.541	-4.518	-4.495	-4.472	-4.44
-130	-4.449	-4.425	-4.402	-4.379	-4.356	-4.332	-4.309	-4.286	-4.262	-4.239	-4.21
-120	-4.215	-4.192	-4.168	-4.144	-4.121	-4.097	-4.073	-4.050	-4.026	-4.002	-3.97
-110	-3.978	-3.954	-3.930	-3.906	-3.882	-3.858	-3.834	-3.810	-3.786	-3.761	-3.73
-100	-3.737	-3.713	-3.688	-3.664	-3.640	-3.615	-3.591	-3.566	-3.542	-3.517	-3.49
-90	-3.493	-3.468	-3.443	-3.419	-3.394	-3.369	-3.344	-3.320	-3.295	-3.270	-3.24
-80	-3.245	-3.220	-3.195	-3.170	-3.145	-3.120	-3.095	-3.070	-3.044	-3.019	-2.99
-70	-2.994	-2.969	-2.943	-2.918	-2.893	-2.867	-2.842	-2.817	-2.791	-2.766	-2.74
-60	-2.740	-2.714	-2.689	-2.663	-2.638	-2.612	-2.586	-2.560	-2.535	-2.509	-2.48
-50	-2.483	-2.457	-2.431	-2.405	-2.379	-2.353	-2.327	-2.301	-2.275	-2.249	-2.22
-40	-2.223	-2.197	-2.171	-2.145	-2.118	-2.092	-2.066	-2.040	-2.013	-1.987	-1.96
-30	-1.961	-1.934	-1.908	-1.881	-1.855	-1.828	-1.802	-1.775	-1.749	-1.722	-1.69
-20	-1.695	-1.669	-1.642	-1.615	-1.589	-1.562	-1.535	-1.508	-1.482	-1.455	-1.42
-10	-1.428	-1.401	-1.374	-1.347	-1.320	-1.293	-1.266	-1.239	-1.212	-1.185	-1.15
0	-1.158	-1.131	-1.104	-1.076	-1.049	-1.022	-0.995	-0.967	-0.940	-0.913	-0.88
°F	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type J thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	-0.886	-0.858	-0.831	-0.803	-0.776	-0.749	-0.721	-0.694	-0.666	-0.639	-0.61
10	-0.611	-0.583	-0.556	-0.528	-0.501	-0.473	-0.445	-0.418	-0.390	-0.362	-0.33
20	-0.334	-0.307	-0.279	-0.251	-0.223	-0.195	-0.168	-0.140	-0.112	-0.084	-0.05
30	-0.056	-0.028	0.000	0.028	0.056	0.084	0.112	0.140	0.168	0.196	0.22
40	0.225	0.253	0.281	0.309	0.337	0.365	0.394	0.422	0.450	0.478	0.50
50	0.507	0.535	0.563	0.592	0.620	0.649	0.677	0.705	0.734	0.762	0.79
60	0.791	0.819	0.848	0.876	0.905	0.933	0.962	0.991	1.019	1.048	1.07
70	1.076	1.105	1.134	1.162	1.191	1.220	1.249	1.277	1.306	1.335	1.36
80	1.364	1.392	1.421	1.450	1.479	1.508	1.537	1.566	1.594	1.623	1.65
90	1.652	1.681	1.710	1.739	1.768	1.797	1.826	1.855	1.884	1.913	1.94
100	1.942	1.972	2.001	2.030	2.059	2.088	2.117	2.146	2.175	2.205	2.23
110	2.234	2.263	2.292	2.322	2.351	2.380	2.409	2.439	2.468	2.497	2.52
120	2.527	2.556	2.585	2.615	2.644	2.673	2.703	2.732	2.762	2.791	2.82
130	2.821	2.850	2.880	2.909	2.938	2.968	2.997	3.027	3.057	3.086	3.11
140	3.116	3.145	3.175	3.204	3.234	3.264	3.293	3.323	3.353	3.382	3.41
150	3.412	3.442	3.471	3.501	3.531	3.560	3.590	3.620	3.650	3.679	3.70
160	3.709	3.739	3.769	3.798	3.828	3.858	3.888	3.918	3.948	3.977	4.00
170	4.007	4.037	4.067	4.097	4.127	4.157	4.187	4.217	4.246	4.276	4.30
180	4.306	4.336	4.366	4.396	4.426	4.456	4.486	4.516	4.546	4.576	4.60
190	4.606	4.636	4.666	4.696	4.726	4.757	4.787	4.817	4.847	4.877	4.90
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type J thermocouple										
°F	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
200	4.907	4.937	4.967	4.997	5.028	5.058	5.088	5.118	5.148	5.178
210	5.209	5.239	5.269	5.299	5.329	5.360	5.390	5.420	5.450	5.480
220	5.511	5.541	5.571	5.602	5.632	5.662	5.692	5.723	5.753	5.783
230	5.814	5.844	5.874	5.905	5.935	5.965	5.996	6.026	6.056	6.087
240	6.117	6.147	6.178	6.208	6.239	6.269	6.299	6.330	6.360	6.391
250	6.421	6.452	6.482	6.512	6.543	6.573	6.604	6.634	6.665	6.695
260	6.726	6.756	6.787	6.817	6.848	6.878	6.909	6.939	6.970	7.000
270	7.031	7.061	7.092	7.122	7.153	7.184	7.214	7.245	7.275	7.306
280	7.336	7.367	7.398	7.428	7.459	7.489	7.520	7.550	7.581	7.612
290	7.642	7.673	7.704	7.734	7.765	7.795	7.826	7.857	7.887	7.918
300	7.949	7.979	8.010	8.041	8.071	8.102	8.133	8.163	8.194	8.225
310	8.255	8.286	8.317	8.347	8.378	8.409	8.439	8.470	8.501	8.532
320	8.562	8.593	8.624	8.654	8.685	8.716	8.747	8.777	8.808	8.839
330	8.869	8.900	8.931	8.962	8.992	9.023	9.054	9.085	9.115	9.146
340	9.177	9.208	9.238	9.269	9.300	9.331	9.362	9.392	9.423	9.454
350	9.485	9.515	9.546	9.577	9.608	9.639	9.669	9.700	9.731	9.762
360	9.793	9.823	9.854	9.885	9.916	9.947	9.977	10.008	10.039	10.070
370	10.101	10.131	10.162	10.193	10.224	10.255	10.285	10.316	10.347	10.378
380	10.409	10.440	10.470	10.501	10.532	10.563	10.594	10.625	10.655	10.686
390	10.717	10.748	10.779	10.810	10.840	10.871	10.902	10.933	10.964	10.995
400	11.025	11.056	11.087	11.118	11.149	11.180	11.211	11.241	11.272	11.303
410	11.334	11.365	11.396	11.426	11.457	11.488	11.519	11.550	11.581	11.612
420	11.642	11.673	11.704	11.735	11.766	11.797	11.828	11.858	11.889	11.920
430	11.951	11.982	12.013	12.044	12.074	12.105	12.136	12.167	12.198	12.229
440	12.260	12.290	12.321	12.352	12.383	12.414	12.445	12.476	12.506	12.537
450	12.568	12.599	12.630	12.661	12.691	12.722	12.753	12.784	12.815	12.846
460	12.877	12.907	12.938	12.969	13.000	13.031	13.062	13.093	13.123	13.154
470	13.185	13.216	13.247	13.278	13.308	13.339	13.370	13.401	13.432	13.463
480	13.494	13.524	13.555	13.586	13.617	13.648	13.679	13.709	13.740	13.771
490	13.802	13.833	13.864	13.894	13.925	13.956	13.987	14.018	14.049	14.079
500	14.110	14.141	14.172	14.203	14.233	14.264	14.295	14.326	14.357	14.388
510	14.418	14.449	14.480	14.511	14.542	14.573	14.603	14.634	14.665	14.696
520	14.727	14.757	14.788	14.819	14.850	14.881	14.911	14.942	14.973	15.004
530	15.035	15.065	15.096	15.127	15.158	15.189	15.219	15.250	15.281	15.312
540	15.343	15.373	15.404	15.435	15.466	15.496	15.527	15.558	15.589	15.620
550	15.650	15.681	15.712	15.743	15.773	15.804	15.835	15.866	15.897	15.927
560	15.958	15.989	16.020	16.050	16.081	16.112	16.143	16.173	16.204	16.235
570	16.266	16.296	16.327	16.358	16.389	16.419	16.450	16.481	16.512	16.542
580	16.573	16.604	16.635	16.665	16.696	16.727	16.758	16.788	16.819	16.850
590	16.881	16.911	16.942	16.973	17.003	17.034	17.065	17.096	17.126	17.157
600	17.188	17.219	17.249	17.280	17.311	17.341	17.372	17.403	17.434	17.464
610	17.495	17.526	17.556	17.587	17.618	17.649	17.679	17.710	17.741	17.771
620	17.802	17.833	17.863	17.894	17.925	17.955	17.986	18.017	18.048	18.078
630	18.109	18.140	18.170	18.201	18.232	18.262	18.293	18.324	18.354	18.385
640	18.416	18.446	18.477	18.508	18.538	18.569	18.600	18.630	18.661	18.692
650	18.722	18.753	18.784	18.814	18.845	18.876	18.906	18.937	18.968	18.998
660	19.029	19.060	19.090	19.121	19.152	19.182	19.213	19.244	19.274	19.305
670	19.336	19.366	19.397	19.428	19.458	19.489	19.520	19.550	19.581	19.612
680	19.642	19.673	19.704	19.734	19.765	19.795	19.826	19.857	19.887	19.918
690	19.949	19.979	20.010	20.041	20.071	20.102	20.132	20.163	20.194	20.224
700	20.255	20.286	20.316	20.347	20.378	20.408	20.439	20.469	20.500	20.531
710	20.561	20.592	20.623	20.653	20.684	20.715	20.745	20.776	20.806	20.837
720	20.868	20.898	20.929	20.960	20.990	21.021	21.052	21.082	21.113	21.143
730	21.174	21.205	21.235	21.266	21.297	21.327	21.358	21.389	21.419	21.450
740	21.480	21.511	21.542	21.572	21.603	21.634	21.664	21.695	21.726	21.756
750	21.787	21.817	21.848	21.879	21.909	21.940	21.971	22.001	22.032	22.063
760	22.093	22.124	22.154	22.185	22.216	22.246	22.277	22.308	22.338	22.369
770	22.400	22.430	22.461	22.492	22.522	22.553	22.584	22.614	22.645	22.676
780	22.706	22.737	22.768	22.798	22.829	22.860	22.890	22.921	22.952	22.982
790	23.013	23.044	23.074	23.105	23.136	23.166	23.197	23.228	23.258	23.289

°F	0	1	2	3	4	5	6	7	8	9
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ITS-90 Table for type J thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
800	23.320	23.350	23.381	23.412	23.442	23.473	23.504	23.535	23.565	23.596	23.627
810	23.627	23.657	23.688	23.719	23.749	23.780	23.811	23.842	23.872	23.903	23.933
820	23.934	23.964	23.995	24.026	24.057	24.087	24.118	24.149	24.180	24.210	24.241
830	24.241	24.272	24.303	24.333	24.364	24.395	24.426	24.456	24.487	24.518	24.548
840	24.549	24.579	24.610	24.641	24.672	24.702	24.733	24.764	24.795	24.826	24.856
850	24.856	24.887	24.918	24.949	24.979	25.010	25.041	25.072	25.103	25.134	25.164
860	25.164	25.195	25.226	25.257	25.288	25.318	25.349	25.380	25.411	25.442	25.473
870	25.473	25.504	25.534	25.565	25.596	25.627	25.658	25.689	25.720	25.750	25.781
880	25.781	25.812	25.843	25.874	25.905	25.936	25.967	25.998	26.028	26.059	26.090
890	26.090	26.121	26.152	26.183	26.214	26.245	26.276	26.307	26.338	26.369	26.400
900	26.400	26.431	26.462	26.493	26.524	26.555	26.586	26.617	26.648	26.679	26.710
910	26.710	26.741	26.772	26.803	26.834	26.865	26.896	26.927	26.958	26.989	27.020
920	27.020	27.051	27.082	27.113	27.144	27.175	27.206	27.237	27.268	27.299	27.330
930	27.330	27.362	27.393	27.424	27.455	27.486	27.517	27.548	27.579	27.610	27.641
940	27.642	27.673	27.704	27.735	27.766	27.797	27.828	27.860	27.891	27.922	27.953
950	27.953	27.985	28.016	28.047	28.078	28.109	28.141	28.172	28.203	28.234	28.265
960	28.266	28.297	28.328	28.359	28.391	28.422	28.453	28.485	28.516	28.547	28.578
970	28.579	28.610	28.641	28.672	28.704	28.735	28.767	28.798	28.829	28.861	28.892
980	28.892	28.923	28.955	28.986	29.018	29.049	29.080	29.112	29.143	29.175	29.206
990	29.206	29.238	29.269	29.301	29.332	29.363	29.395	29.426	29.458	29.489	29.521
1000	29.521	29.552	29.584	29.616	29.647	29.679	29.710	29.742	29.773	29.805	29.836
1010	29.836	29.868	29.900	29.931	29.963	29.995	30.026	30.058	30.089	30.121	30.153
1020	30.153	30.184	30.216	30.248	30.279	30.311	30.343	30.375	30.406	30.438	30.470
1030	30.470	30.502	30.533	30.565	30.597	30.629	30.660	30.692	30.724	30.756	30.788
1040	30.788	30.819	30.851	30.883	30.915	30.947	30.979	31.011	31.043	31.074	31.106
1050	31.106	31.138	31.170	31.202	31.234	31.266	31.298	31.330	31.362	31.394	31.426
1060	31.426	31.458	31.490	31.522	31.554	31.586	31.618	31.650	31.682	31.714	31.746
1070	31.746	31.778	31.811	31.843	31.875	31.907	31.939	31.971	32.003	32.035	32.068
1080	32.068	32.100	32.132	32.164	32.196	32.229	32.261	32.293	32.325	32.358	32.390
1090	32.390	32.422	32.455	32.487	32.519	32.551	32.584	32.616	32.648	32.681	32.713
1100	32.713	32.746	32.778	32.810	32.843	32.875	32.908	32.940	32.973	33.005	33.037
1110	33.037	33.070	33.102	33.135	33.167	33.200	33.232	33.265	33.298	33.330	33.363
1120	33.363	33.395	33.428	33.460	33.493	33.526	33.558	33.591	33.624	33.656	33.689
1130	33.689	33.722	33.754	33.787	33.820	33.853	33.885	33.918	33.951	33.984	34.016
1140	34.016	34.049	34.082	34.115	34.148	34.180	34.213	34.246	34.279	34.312	34.345
1150	34.345	34.378	34.411	34.444	34.477	34.509	34.542	34.575	34.608	34.641	34.674
1160	34.674	34.707	34.740	34.773	34.806	34.840	34.873	34.906	34.939	34.972	35.005
1170	35.005	35.038	35.071	35.104	35.138	35.171	35.204	35.237	35.270	35.304	35.337
1180	35.337	35.370	35.403	35.437	35.470	35.503	35.536	35.570	35.603	35.636	35.670
1190	35.670	35.703	35.736	35.770	35.803	35.837	35.870	35.903	35.937	35.970	36.004
1200	36.004	36.037	36.071	36.104	36.138	36.171	36.205	36.238	36.272	36.305	36.339
1210	36.339	36.373	36.406	36.440	36.473	36.507	36.541	36.574	36.608	36.642	36.676
1220	36.676	36.709	36.743	36.777	36.810	36.844	36.878	36.912	36.945	36.979	37.013
1230	37.013	37.047	37.081	37.114	37.148	37.182	37.216	37.250	37.284	37.318	37.352
1240	37.352	37.386	37.420	37.454	37.488	37.522	37.556	37.590	37.624	37.658	37.692
1250	37.692	37.726	37.760	37.794	37.828	37.862	37.896	37.930	37.964	37.999	38.033
1260	38.033	38.067	38.101	38.135	38.169	38.203	38.238	38.272	38.306	38.341	38.375
1270	38.375	38.409	38.444	38.478	38.512	38.546	38.581	38.615	38.650	38.684	38.718
1280	38.718	38.753	38.787	38.822	38.856	38.890	38.925	38.959	38.994	39.028	39.063
1290	39.063	39.097	39.132	39.166	39.201	39.235	39.270	39.305	39.339	39.374	39.408
1300	39.408	39.443	39.478	39.512	39.547	39.582	39.616	39.651	39.686	39.720	39.755
1310	39.755	39.790	39.825	39.859	39.894	39.929	39.964	39.998	40.033	40.068	40.103
1320	40.103	40.138	40.173	40.207	40.242	40.277	40.312	40.347	40.382	40.417	40.452
1330	40.452	40.487	40.522	40.556	40.591	40.626	40.661	40.696	40.731	40.766	40.801
1340	40.801	40.836	40.872	40.907	40.942	40.977	41.012	41.047	41.082	41.117	41.152
1350	41.152	41.187	41.222	41.258	41.293	41.328	41.363	41.398	41.433	41.469	41.504
1360	41.504	41.539	41.574	41.610	41.645	41.680	41.715	41.751	41.786	41.821	41.856
1370	41.856	41.892	41.927	41.962	41.998	42.033	42.068	42.104	42.139	42.174	42.210
1380	42.210	42.245	42.281	42.316	42.351	42.387	42.422	42.458	42.493	42.528	42.564
1390	42.564	42.599	42.635	42.670	42.706	42.741	42.777	42.812	42.848	42.883	42.919

ITS-90 Table for type J thermocouple										
°F	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
1400	42.919	42.954	42.990	43.025	43.061	43.096	43.132	43.167	43.203	43.239
1410	43.274	43.310	43.346	43.381	43.417	43.452	43.488	43.524	43.559	43.595
1420	43.631	43.667	43.702	43.738	43.774	43.809	43.845	43.881	43.917	43.953
1430	43.988	44.024	44.060	44.096	44.131	44.167	44.203	44.239	44.275	44.310
1440	44.346	44.382	44.418	44.454	44.490	44.525	44.561	44.597	44.633	44.669
1450	44.705	44.741	44.777	44.812	44.848	44.884	44.920	44.956	44.992	45.028
1460	45.064	45.099	45.135	45.171	45.207	45.243	45.279	45.315	45.351	45.387
1470	45.423	45.458	45.494	45.530	45.566	45.602	45.638	45.674	45.710	45.746
1480	45.782	45.818	45.853	45.889	45.925	45.961	45.997	46.033	46.069	46.105
1490	46.141	46.177	46.212	46.248	46.284	46.320	46.356	46.392	46.428	46.464
1500	46.500	46.535	46.571	46.607	46.643	46.679	46.715	46.751	46.786	46.822
1510	46.858	46.894	46.930	46.966	47.001	47.037	47.073	47.109	47.145	47.181
1520	47.216	47.252	47.288	47.324	47.359	47.395	47.431	47.467	47.503	47.538
1530	47.574	47.610	47.646	47.681	47.717	47.753	47.788	47.824	47.860	47.896
1540	47.931	47.967	48.003	48.038	48.074	48.110	48.145	48.181	48.217	48.252
1550	48.288	48.324	48.359	48.395	48.430	48.466	48.502	48.537	48.573	48.608
1560	48.644	48.679	48.715	48.750	48.786	48.822	48.857	48.893	48.928	48.964
1570	48.999	49.034	49.070	49.105	49.141	49.176	49.212	49.247	49.283	49.318
1580	49.353	49.389	49.424	49.460	49.495	49.530	49.566	49.601	49.636	49.672
1590	49.707	49.742	49.778	49.813	49.848	49.883	49.919	49.954	49.989	50.024
1600	50.060	50.095	50.130	50.165	50.200	50.235	50.271	50.306	50.341	50.376
1610	50.411	50.446	50.481	50.517	50.552	50.587	50.622	50.657	50.692	50.727
1620	50.762	50.797	50.832	50.867	50.902	50.937	50.972	51.007	51.042	51.077
1630	51.112	51.147	51.181	51.216	51.251	51.286	51.321	51.356	51.391	51.425
1640	51.460	51.495	51.530	51.565	51.599	51.634	51.669	51.704	51.738	51.773
1650	51.808	51.843	51.877	51.912	51.947	51.981	52.016	52.051	52.085	52.120
1660	52.154	52.189	52.224	52.258	52.293	52.327	52.362	52.396	52.431	52.465
1670	52.500	52.534	52.569	52.603	52.638	52.672	52.707	52.741	52.776	52.810
1680	52.844	52.879	52.913	52.947	52.982	53.016	53.050	53.085	53.119	53.153
1690	53.188	53.222	53.256	53.290	53.325	53.359	53.393	53.427	53.462	53.496
1700	53.530	53.564	53.598	53.632	53.667	53.701	53.735	53.769	53.803	53.837
1710	53.871	53.905	53.939	53.973	54.007	54.041	54.075	54.109	54.143	54.177
1720	54.211	54.245	54.279	54.313	54.347	54.381	54.415	54.449	54.483	54.516
1730	54.550	54.584	54.618	54.652	54.686	54.719	54.753	54.787	54.821	54.855
1740	54.888	54.922	54.956	54.990	55.023	55.057	55.091	55.124	55.158	55.192
1750	55.225	55.259	55.293	55.326	55.360	55.393	55.427	55.461	55.494	55.528
1760	55.561	55.595	55.628	55.662	55.695	55.729	55.762	55.796	55.829	55.863
1770	55.896	55.930	55.963	55.997	56.030	56.063	56.097	56.130	56.164	56.197
1780	56.230	56.264	56.297	56.330	56.364	56.397	56.430	56.464	56.497	56.530
1790	56.564	56.597	56.630	56.663	56.697	56.730	56.763	56.796	56.829	56.863
1800	56.896	56.929	56.962	56.995	57.028	57.062	57.095	57.128	57.161	57.194
1810	57.227	57.260	57.293	57.326	57.360	57.393	57.426	57.459	57.492	57.525
1820	57.558	57.591	57.624	57.657	57.690	57.723	57.756	57.789	57.822	57.855
1830	57.888	57.920	57.953	57.986	58.019	58.052	58.085	58.118	58.151	58.184
1840	58.217	58.249	58.282	58.315	58.348	58.381	58.414	58.446	58.479	58.512
1850	58.545	58.578	58.610	58.643	58.676	58.709	58.741	58.774	58.807	58.840
1860	58.872	58.905	58.938	58.971	59.003	59.036	59.069	59.101	59.134	59.167
1870	59.199	59.232	59.265	59.297	59.330	59.363	59.395	59.428	59.460	59.493
1880	59.526	59.558	59.591	59.623	59.656	59.689	59.721	59.754	59.786	59.819
1890	59.851	59.884	59.916	59.949	59.982	60.014	60.047	60.079	60.112	60.144
1900	60.177	60.209	60.242	60.274	60.307	60.339	60.371	60.404	60.436	60.469
1910	60.501	60.534	60.566	60.599	60.631	60.663	60.696	60.728	60.761	60.793
1920	60.826	60.858	60.890	60.923	60.955	60.987	61.020	61.052	61.085	61.117
1930	61.149	61.182	61.214	61.246	61.279	61.311	61.343	61.376	61.408	61.440
1940	61.473	61.505	61.537	61.570	61.602	61.634	61.667	61.699	61.731	61.763
1950	61.796	61.828	61.860	61.893	61.925	61.957	61.989	62.022	62.054	62.086
1960	62.118	62.151	62.183	62.215	62.247	62.280	62.312	62.344	62.376	62.409
1970	62.441	62.473	62.505	62.537	62.570	62.602	62.634	62.666	62.699	62.731
1980	62.763	62.795	62.827	62.860	62.892	62.924	62.956	62.988	63.020	63.053
1990	63.085	63.117	63.149	63.181	63.214	63.246	63.278	63.310	63.342	63.374
°F	0	1	2	3	4	5	6	7	8	9

ITS-90 Table for type J thermocouple										
°F	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
2000	63.406	63.439	63.471	63.503	63.535	63.567	63.599	63.632	63.664	63.696
2010	63.728	63.760	63.792	63.824	63.856	63.889	63.921	63.953	63.985	64.017
2020	64.049	64.081	64.113	64.146	64.178	64.210	64.242	64.274	64.306	64.338
2030	64.370	64.402	64.435	64.467	64.499	64.531	64.563	64.595	64.627	64.659
2040	64.691	64.723	64.756	64.788	64.820	64.852	64.884	64.916	64.948	64.980
2050	65.012	65.044	65.076	65.109	65.141	65.173	65.205	65.237	65.269	65.301
2060	65.333	65.365	65.397	65.429	65.461	65.493	65.525	65.557	65.590	65.622
2070	65.654	65.686	65.718	65.750	65.782	65.814	65.846	65.878	65.910	65.942
2080	65.974	66.006	66.038	66.070	66.102	66.134	66.166	66.199	66.231	66.263
2090	66.295	66.327	66.359	66.391	66.423	66.455	66.487	66.519	66.551	66.583
2100	66.615	66.647	66.679	66.711	66.743	66.775	66.807	66.839	66.871	66.903
2110	66.935	66.967	66.999	67.031	67.063	67.095	67.127	67.159	67.191	67.223
2120	67.255	67.287	67.319	67.351	67.383	67.415	67.447	67.479	67.511	67.543
2130	67.575	67.607	67.639	67.671	67.703	67.735	67.767	67.799	67.831	67.863
2140	67.895	67.927	67.959	67.991	68.023	68.055	68.087	68.119	68.150	68.182
2150	68.214	68.246	68.278	68.310	68.342	68.374	68.406	68.438	68.470	68.502
2160	68.534	68.566	68.597	68.629	68.661	68.693	68.725	68.757	68.789	68.821
2170	68.853	68.884	68.916	68.948	68.980	69.012	69.044	69.076	69.108	69.139
2180	69.171	69.203	69.235	69.267	69.299	69.330	69.362	69.394	69.426	69.458
2190	69.490	69.521	69.553	69.584	69.615	69.646	69.677	69.708	69.739	69.770

°F	0	1	2	3	4	5	6	7	8	9
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ITS-90 Table for type J thermocouple											
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Thermoelectric Voltage in mV											
-200	-8.095	-8.076	-8.057	-8.037	-8.017	-7.996	-7.976	-7.955	-7.934	-7.912	-7.89
-190	-7.890	-7.868	-7.846	-7.824	-7.801	-7.778	-7.755	-7.731	-7.707	-7.683	-7.65
-180	-7.659	-7.634	-7.610	-7.585	-7.559	-7.534	-7.508	-7.482	-7.456	-7.429	-7.40
-170	-7.403	-7.376	-7.348	-7.321	-7.293	-7.265	-7.237	-7.209	-7.181	-7.152	-7.12
-160	-7.123	-7.094	-7.064	-7.035	-7.005	-6.975	-6.944	-6.914	-6.883	-6.853	-6.82
-150	-6.821	-6.790	-6.759	-6.727	-6.695	-6.663	-6.631	-6.598	-6.566	-6.533	-6.50
-140	-6.500	-6.467	-6.433	-6.400	-6.366	-6.332	-6.298	-6.263	-6.229	-6.194	-6.15
-130	-6.159	-6.124	-6.089	-6.054	-6.018	-5.982	-5.946	-5.910	-5.874	-5.838	-5.80
-120	-5.801	-5.764	-5.727	-5.690	-5.653	-5.616	-5.578	-5.541	-5.503	-5.465	-5.42
-110	-5.426	-5.388	-5.350	-5.311	-5.272	-5.233	-5.194	-5.155	-5.116	-5.076	-5.03
-100	-5.037	-4.997	-4.957	-4.917	-4.877	-4.836	-4.796	-4.755	-4.714	-4.674	-4.63
-90	-4.633	-4.591	-4.550	-4.509	-4.467	-4.425	-4.384	-4.342	-4.300	-4.257	-4.21
-80	-4.215	-4.173	-4.130	-4.088	-4.045	-4.002	-3.959	-3.916	-3.872	-3.829	-3.78
-70	-3.786	-3.742	-3.698	-3.654	-3.610	-3.566	-3.522	-3.478	-3.434	-3.389	-3.34
-60	-3.344	-3.300	-3.255	-3.210	-3.165	-3.120	-3.075	-3.029	-2.984	-2.938	-2.89
-50	-2.893	-2.847	-2.801	-2.755	-2.709	-2.663	-2.617	-2.571	-2.524	-2.478	-2.43
-40	-2.431	-2.385	-2.338	-2.291	-2.244	-2.197	-2.150	-2.103	-2.055	-2.008	-1.96
-30	-1.961	-1.913	-1.865	-1.818	-1.770	-1.722	-1.674	-1.626	-1.578	-1.530	-1.48
-20	-1.482	-1.433	-1.385	-1.336	-1.288	-1.239	-1.190	-1.142	-1.093	-1.044	-0.99
-10	-0.995	-0.946	-0.896	-0.847	-0.798	-0.749	-0.699	-0.650	-0.600	-0.550	-0.50
0	-0.501	-0.451	-0.401	-0.351	-0.301	-0.251	-0.201	-0.151	-0.101	-0.050	0.00
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type J thermocouple											
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	0.000	0.050	0.101	0.151	0.202	0.253	0.303	0.354	0.405	0.456	0.50
10	0.507	0.558	0.609	0.660	0.711	0.762	0.814	0.865	0.916	0.968	1.01
20	1.019	1.071	1.122	1.174	1.226	1.277	1.329	1.381	1.433	1.485	1.53
30	1.537	1.589	1.641	1.693	1.745	1.797	1.849	1.902	1.954	2.006	2.05
40	2.059	2.111	2.164	2.216	2.269	2.322	2.374	2.427	2.480	2.532	2.58
50	2.585	2.638	2.691	2.744	2.797	2.850	2.903	2.956	3.009	3.062	3.11
60	3.116	3.169	3.222	3.275	3.329	3.382	3.436	3.489	3.543	3.596	3.65
70	3.650	3.703	3.757	3.810	3.864	3.918	3.971	4.025	4.079	4.133	4.18
80	4.187	4.240	4.294	4.348	4.402	4.456	4.510	4.564	4.618	4.672	4.72
90	4.726	4.781	4.835	4.889	4.943	4.997	5.052	5.106	5.160	5.215	5.26
100	5.269	5.323	5.378	5.432	5.487	5.541	5.595	5.650	5.705	5.759	5.81
110	5.814	5.868	5.923	5.977	6.032	6.087	6.141	6.196	6.251	6.306	6.36
120	6.360	6.415	6.470	6.525	6.579	6.634	6.689	6.744	6.799	6.854	6.90
130	6.909	6.964	7.019	7.074	7.129	7.184	7.239	7.294	7.349	7.404	7.45
140	7.459	7.514	7.569	7.624	7.679	7.734	7.789	7.844	7.900	7.955	8.01
150	8.010	8.065	8.120	8.175	8.231	8.286	8.341	8.396	8.452	8.507	8.56
160	8.562	8.618	8.673	8.728	8.783	8.839	8.894	8.949	9.005	9.060	9.11
170	9.115	9.171	9.226	9.282	9.337	9.392	9.448	9.503	9.559	9.614	9.66
180	9.669	9.725	9.780	9.836	9.891	9.947	10.002	10.057	10.113	10.168	10.22
190	10.224	10.279	10.335	10.390	10.446	10.501	10.557	10.612	10.668	10.723	10.77
200	10.779	10.834	10.890	10.945	11.001	11.056	11.112	11.167	11.223	11.278	11.33
210	11.334	11.389	11.445	11.501	11.556	11.612	11.667	11.723	11.778	11.834	11.88
220	11.889	11.945	12.000	12.056	12.111	12.167	12.222	12.278	12.334	12.389	12.44
230	12.445	12.500	12.556	12.611	12.667	12.722	12.778	12.833	12.889	12.944	13.00
240	13.000	13.056	13.111	13.167	13.222	13.278	13.333	13.389	13.444	13.500	13.55
250	13.555	13.611	13.666	13.722	13.777	13.833	13.888	13.944	13.999	14.055	14.11
260	14.110	14.166	14.221	14.277	14.332	14.388	14.443	14.499	14.554	14.609	14.66
270	14.665	14.720	14.776	14.831	14.887	14.942	14.998	15.053	15.109	15.164	15.21
280	15.219	15.275	15.330	15.386	15.441	15.496	15.552	15.607	15.663	15.718	15.77
290	15.773	15.829	15.884	15.940	15.995	16.050	16.106	16.161	16.216	16.272	16.32
300	16.327	16.383	16.438	16.493	16.549	16.604	16.659	16.715	16.770	16.825	16.88
310	16.881	16.936	16.991	17.046	17.102	17.157	17.212	17.268	17.323	17.378	17.43
320	17.434	17.489	17.544	17.599	17.655	17.710	17.765	17.820	17.876	17.931	17.98
330	17.986	18.041	18.097	18.152	18.207	18.262	18.318	18.373	18.428	18.483	18.53
340	18.538	18.594	18.649	18.704	18.759	18.814	18.870	18.925	18.980	19.035	19.09

ITS-90 Table for type J thermocouple											
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
350	19.090	19.146	19.201	19.256	19.311	19.366	19.422	19.477	19.532	19.587	19.64
360	19.642	19.697	19.753	19.808	19.863	19.918	19.973	20.028	20.083	20.139	20.19
370	20.194	20.249	20.304	20.359	20.414	20.469	20.525	20.580	20.635	20.690	20.74
380	20.745	20.800	20.855	20.911	20.966	21.021	21.076	21.131	21.186	21.241	21.29
390	21.297	21.352	21.407	21.462	21.517	21.572	21.627	21.683	21.738	21.793	21.84
400	21.848	21.903	21.958	22.014	22.069	22.124	22.179	22.234	22.289	22.345	22.40
410	22.400	22.455	22.510	22.565	22.620	22.676	22.731	22.786	22.841	22.896	22.95
420	22.952	23.007	23.062	23.117	23.172	23.228	23.283	23.338	23.393	23.449	23.50
430	23.504	23.559	23.614	23.670	23.725	23.780	23.835	23.891	23.946	24.001	24.05
440	24.057	24.112	24.167	24.223	24.278	24.333	24.389	24.444	24.499	24.555	24.61
450	24.610	24.665	24.721	24.776	24.832	24.887	24.943	24.998	25.053	25.109	25.16
460	25.164	25.220	25.275	25.331	25.386	25.442	25.497	25.553	25.608	25.664	25.72
470	25.720	25.775	25.831	25.886	25.942	25.998	26.053	26.109	26.165	26.220	26.27
480	26.276	26.332	26.387	26.443	26.499	26.555	26.610	26.666	26.722	26.778	26.83
490	26.834	26.889	26.945	27.001	27.057	27.113	27.169	27.225	27.281	27.337	27.39
500	27.393	27.449	27.505	27.561	27.617	27.673	27.729	27.785	27.841	27.897	27.95
510	27.953	28.010	28.066	28.122	28.178	28.234	28.291	28.347	28.403	28.460	28.51
520	28.516	28.572	28.629	28.685	28.741	28.798	28.854	28.911	28.967	29.024	29.08
530	29.080	29.137	29.194	29.250	29.307	29.363	29.420	29.477	29.534	29.590	29.64
540	29.647	29.704	29.761	29.818	29.874	29.931	29.988	30.045	30.102	30.159	30.21
550	30.216	30.273	30.330	30.387	30.444	30.502	30.559	30.616	30.673	30.730	30.78
560	30.788	30.845	30.902	30.960	31.017	31.074	31.132	31.189	31.247	31.304	31.36
570	31.362	31.419	31.477	31.535	31.592	31.650	31.708	31.766	31.823	31.881	31.93
580	31.939	31.997	32.055	32.113	32.171	32.229	32.287	32.345	32.403	32.461	32.51
590	32.519	32.577	32.636	32.694	32.752	32.810	32.869	32.927	32.985	33.044	33.10
600	33.102	33.161	33.219	33.278	33.337	33.395	33.454	33.513	33.571	33.630	33.68
610	33.689	33.748	33.807	33.866	33.925	33.984	34.043	34.102	34.161	34.220	34.27
620	34.279	34.338	34.397	34.457	34.516	34.575	34.635	34.694	34.754	34.813	34.87
630	34.873	34.932	34.992	35.051	35.111	35.171	35.230	35.290	35.350	35.410	35.47
640	35.470	35.530	35.590	35.650	35.710	35.770	35.830	35.890	35.950	36.010	36.07
650	36.071	36.131	36.191	36.252	36.312	36.373	36.433	36.494	36.554	36.615	36.67
660	36.675	36.736	36.797	36.858	36.918	36.979	37.040	37.101	37.162	37.223	37.28
670	37.284	37.345	37.406	37.467	37.528	37.589	37.651	37.712	37.773	37.835	37.89
680	37.896	37.958	38.019	38.081	38.142	38.204	38.265	38.327	38.389	38.450	38.51
690	38.512	38.574	38.636	38.698	38.760	38.822	38.884	38.946	39.008	39.070	39.13
700	39.132	39.194	39.256	39.318	39.381	39.443	39.505	39.568	39.630	39.693	39.75
710	39.755	39.818	39.880	39.943	40.005	40.068	40.131	40.193	40.256	40.319	40.38
720	40.382	40.445	40.508	40.570	40.633	40.696	40.759	40.822	40.886	40.949	41.01
730	41.012	41.075	41.138	41.201	41.265	41.328	41.391	41.455	41.518	41.581	41.64
740	41.645	41.708	41.772	41.835	41.899	41.962	42.026	42.090	42.153	42.217	42.28
750	42.281	42.344	42.408	42.472	42.536	42.599	42.663	42.727	42.791	42.855	42.91
760	42.919	42.983	43.047	43.111	43.175	43.239	43.303	43.367	43.431	43.495	43.55
770	43.559	43.623	43.688	43.752	43.817	43.881	43.945	44.010	44.074	44.139	44.20
780	44.203	44.267	44.332	44.396	44.461	44.525	44.590	44.655	44.719	44.784	44.84
790	44.848	44.913	44.977	45.042	45.107	45.171	45.236	45.301	45.365	45.430	45.49
800	45.494	45.559	45.624	45.688	45.753	45.818	45.882	45.947	46.011	46.076	46.14
810	46.141	46.205	46.270	46.334	46.399	46.464	46.528	46.593	46.657	46.722	46.78
820	46.786	46.851	46.915	46.980	47.044	47.109	47.173	47.238	47.302	47.367	47.43
830	47.431	47.495	47.560	47.624	47.688	47.753	47.817	47.881	47.946	48.010	48.07
840	48.074	48.138	48.202	48.267	48.331	48.395	48.459	48.523	48.587	48.651	48.71
850	48.715	48.779	48.843	48.907	48.971	49.034	49.098	49.162	49.226	49.290	49.35
860	49.353	49.417	49.481	49.544	49.608	49.672	49.735	49.799	49.862	49.926	49.98
870	49.989	50.052	50.116	50.179	50.243	50.306	50.369	50.432	50.495	50.559	50.62
880	50.622	50.685	50.748	50.811	50.874	50.937	51.000	51.063	51.126	51.188	51.25
890	51.251	51.314	51.377	51.439	51.502	51.565	51.627	51.690	51.752	51.815	51.87
900	51.877	51.940	52.002	52.064	52.127	52.189	52.251	52.314	52.376	52.438	52.50
910	52.500	52.562	52.624	52.686	52.748	52.810	52.872	52.934	52.996	53.057	53.11
920	53.119	53.181	53.243	53.304	53.366	53.427	53.489	53.550	53.612	53.673	53.73
930	53.735	53.796	53.857	53.919	53.980	54.041	54.102	54.164	54.225	54.286	54.34
940	54.347	54.408	54.469	54.530	54.591	54.652	54.713	54.773	54.834	54.895	54.95
950	54.956	55.016	55.077	55.138	55.198	55.259	55.319	55.380	55.440	55.501	55.56
960	55.561	55.622	55.682	55.742	55.803	55.863	55.923	55.983	56.043	56.104	56.16
970	56.164	56.224	56.284	56.344	56.404	56.464	56.524	56.584	56.643	56.703	56.76
980	56.763	56.823	56.883	56.942	57.002	57.062	57.121	57.181	57.240	57.300	57.36
990	57.360	57.419	57.479	57.538	57.597	57.657	57.716	57.776	57.835	57.894	57.95
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type J thermocouple
 °C 0 1 2 3 4 5 6 7 8 9 10
 Thermoelectric Voltage in mV

1000	57.953	58.013	58.072	58.131	58.190	58.249	58.309	58.368	58.427	58.486	58.54
1010	58.545	58.604	58.663	58.722	58.781	58.840	58.899	58.957	59.016	59.075	59.13
1020	59.134	59.193	59.252	59.310	59.369	59.428	59.487	59.545	59.604	59.663	59.72
1030	59.721	59.780	59.838	59.897	59.956	60.014	60.073	60.131	60.190	60.248	60.30
1040	60.307	60.365	60.423	60.482	60.540	60.599	60.657	60.715	60.774	60.832	60.89
1050	60.890	60.949	61.007	61.065	61.123	61.182	61.240	61.298	61.356	61.415	61.47
1060	61.473	61.531	61.589	61.647	61.705	61.763	61.822	61.880	61.938	61.996	62.05
1070	62.054	62.112	62.170	62.228	62.286	62.344	62.402	62.460	62.518	62.576	62.63
1080	62.634	62.692	62.750	62.808	62.866	62.924	62.982	63.040	63.098	63.156	63.21
1090	63.214	63.271	63.329	63.387	63.445	63.503	63.561	63.619	63.677	63.734	63.79
1100	63.792	63.850	63.908	63.966	64.024	64.081	64.139	64.197	64.255	64.313	64.37
1110	64.370	64.428	64.486	64.544	64.602	64.659	64.717	64.775	64.833	64.890	64.94
1120	64.948	65.006	65.064	65.121	65.179	65.237	65.295	65.352	65.410	65.468	65.52
1130	65.525	65.583	65.641	65.699	65.756	65.814	65.872	65.929	65.987	66.045	66.10
1140	66.102	66.160	66.218	66.275	66.333	66.391	66.448	66.506	66.564	66.621	66.67
1150	66.679	66.737	66.794	66.852	66.910	66.967	67.025	67.082	67.140	67.198	67.25
1160	67.255	67.313	67.370	67.428	67.486	67.543	67.601	67.658	67.716	67.773	67.83
1170	67.831	67.888	67.946	68.003	68.061	68.119	68.176	68.234	68.291	68.348	68.40
1180	68.406	68.463	68.521	68.578	68.636	68.693	68.751	68.808	68.865	68.923	68.98
1190	68.980	69.037	69.095	69.152	69.209	69.267	69.324	69.381	69.439	69.496	69.55
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type K thermocouple
 °F -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0
 Thermoelectric Voltage in mV

-440	-6.456	-6.455	-6.454	-6.454	-6.453	-6.452	-6.451	-6.450	-6.449	-6.448	-6.44
-430	-6.446	-6.445	-6.444	-6.443	-6.441	-6.440	-6.438	-6.436	-6.435	-6.433	-6.43
-420	-6.431	-6.429	-6.427	-6.425	-6.423	-6.421	-6.419	-6.416	-6.414	-6.411	-6.40
-410	-6.409	-6.406	-6.404	-6.401	-6.398	-6.395	-6.392	-6.389	-6.386	-6.383	-6.38
-400	-6.380	-6.377	-6.373	-6.370	-6.366	-6.363	-6.359	-6.355	-6.352	-6.348	-6.34
-390	-6.344	-6.340	-6.336	-6.332	-6.328	-6.323	-6.319	-6.315	-6.310	-6.306	-6.30
-380	-6.301	-6.296	-6.292	-6.287	-6.282	-6.277	-6.272	-6.267	-6.262	-6.257	-6.25
-370	-6.251	-6.246	-6.241	-6.235	-6.230	-6.224	-6.218	-6.213	-6.207	-6.201	-6.19
-360	-6.195	-6.189	-6.183	-6.177	-6.171	-6.165	-6.158	-6.152	-6.146	-6.139	-6.13
-350	-6.133	-6.126	-6.119	-6.113	-6.106	-6.099	-6.092	-6.085	-6.078	-6.071	-6.06
-340	-6.064	-6.057	-6.049	-6.042	-6.035	-6.027	-6.020	-6.012	-6.004	-5.997	-5.98
-330	-5.989	-5.981	-5.973	-5.965	-5.957	-5.949	-5.941	-5.933	-5.925	-5.917	-5.90
-320	-5.908	-5.900	-5.891	-5.883	-5.874	-5.866	-5.857	-5.848	-5.840	-5.831	-5.82
-310	-5.822	-5.813	-5.804	-5.795	-5.786	-5.776	-5.767	-5.758	-5.749	-5.739	-5.73
-300	-5.730	-5.720	-5.711	-5.701	-5.691	-5.682	-5.672	-5.662	-5.652	-5.642	-5.63
-290	-5.632	-5.622	-5.612	-5.602	-5.592	-5.581	-5.571	-5.561	-5.550	-5.540	-5.52
-280	-5.529	-5.519	-5.508	-5.497	-5.487	-5.476	-5.465	-5.454	-5.443	-5.432	-5.42
-270	-5.421	-5.410	-5.399	-5.388	-5.377	-5.365	-5.354	-5.343	-5.331	-5.320	-5.30
-260	-5.308	-5.296	-5.285	-5.273	-5.261	-5.250	-5.238	-5.226	-5.214	-5.202	-5.19
-250	-5.190	-5.178	-5.166	-5.153	-5.141	-5.129	-5.117	-5.104	-5.092	-5.079	-5.06
-240	-5.067	-5.054	-5.042	-5.029	-5.016	-5.003	-4.991	-4.978	-4.965	-4.952	-4.93
-230	-4.939	-4.926	-4.913	-4.900	-4.886	-4.873	-4.860	-4.847	-4.833	-4.820	-4.80
-220	-4.806	-4.793	-4.779	-4.766	-4.752	-4.738	-4.724	-4.711	-4.697	-4.683	-4.66
-210	-4.669	-4.655	-4.641	-4.627	-4.613	-4.599	-4.584	-4.570	-4.556	-4.542	-4.52
-200	-4.527	-4.513	-4.498	-4.484	-4.469	-4.455	-4.440	-4.425	-4.411	-4.396	-4.38
-190	-4.381	-4.366	-4.351	-4.336	-4.321	-4.306	-4.291	-4.276	-4.261	-4.246	-4.23
-180	-4.231	-4.215	-4.200	-4.185	-4.169	-4.154	-4.138	-4.123	-4.107	-4.091	-4.07
-170	-4.076	-4.060	-4.044	-4.029	-4.013	-3.997	-3.981	-3.965	-3.949	-3.933	-3.91
-160	-3.917	-3.901	-3.885	-3.869	-3.852	-3.836	-3.820	-3.803	-3.787	-3.771	-3.75
-150	-3.754	-3.738	-3.721	-3.705	-3.688	-3.671	-3.655	-3.638	-3.621	-3.604	-3.58
-140	-3.587	-3.571	-3.554	-3.537	-3.520	-3.503	-3.486	-3.468	-3.451	-3.434	-3.41
-130	-3.417	-3.400	-3.382	-3.365	-3.348	-3.330	-3.313	-3.295	-3.278	-3.260	-3.24
-120	-3.243	-3.225	-3.207	-3.190	-3.172	-3.154	-3.136	-3.119	-3.101	-3.083	-3.06
-110	-3.065	-3.047	-3.029	-3.011	-2.993	-2.975	-2.957	-2.938	-2.920	-2.902	-2.88
-100	-2.884	-2.865	-2.847	-2.829	-2.810	-2.792	-2.773	-2.755	-2.736	-2.718	-2.69
-90	-2.699	-2.680	-2.662	-2.643	-2.624	-2.605	-2.587	-2.568	-2.549	-2.530	-2.51
-80	-2.511	-2.492	-2.473	-2.454	-2.435	-2.416	-2.397	-2.378	-2.359	-2.339	-2.32
-70	-2.320	-2.301	-2.282	-2.262	-2.243	-2.223	-2.204	-2.185	-2.165	-2.146	-2.12
-60	-2.126	-2.106	-2.087	-2.067	-2.048	-2.028	-2.008	-1.988	-1.969	-1.949	-1.92
-50	-1.929	-1.909	-1.889	-1.869	-1.850	-1.830	-1.810	-1.790	-1.770	-1.749	-1.72
-40	-1.729	-1.709	-1.689	-1.669	-1.649	-1.628	-1.608	-1.588	-1.568	-1.547	-1.52
-30	-1.527	-1.507	-1.486	-1.466	-1.445	-1.425	-1.404	-1.384	-1.363	-1.343	-1.32
-20	-1.322	-1.301	-1.281	-1.260	-1.239	-1.218	-1.198	-1.177	-1.156	-1.135	-1.11
-10	-1.114	-1.094	-1.073	-1.052	-1.031	-1.010	-0.989	-0.968	-0.947	-0.926	-0.90
0	-0.905	-0.883	-0.862	-0.841	-0.820	-0.799	-0.778	-0.756	-0.735	-0.714	-0.69

ITS-90 Table for type K thermocouple
 °F -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0

°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	-0.692	-0.671	-0.650	-0.628	-0.607	-0.586	-0.564	-0.543	-0.521	-0.500	-0.47
10	-0.478	-0.457	-0.435	-0.413	-0.392	-0.370	-0.349	-0.327	-0.305	-0.284	-0.26
20	-0.262	-0.240	-0.218	-0.197	-0.175	-0.153	-0.131	-0.109	-0.088	-0.066	-0.04
30	-0.044	-0.022	0.000	0.022	0.044	0.066	0.088	0.110	0.132	0.154	0.17
40	0.176	0.198	0.220	0.242	0.264	0.286	0.308	0.330	0.353	0.375	0.39
50	0.397	0.419	0.441	0.463	0.486	0.508	0.530	0.552	0.575	0.597	0.61
60	0.619	0.642	0.664	0.686	0.709	0.731	0.753	0.776	0.798	0.821	0.84
70	0.843	0.865	0.888	0.910	0.933	0.955	0.978	1.000	1.023	1.045	1.06
80	1.068	1.090	1.113	1.136	1.158	1.181	1.203	1.226	1.249	1.271	1.29
90	1.294	1.316	1.339	1.362	1.384	1.407	1.430	1.453	1.475	1.498	1.52
100	1.521	1.543	1.566	1.589	1.612	1.635	1.657	1.680	1.703	1.726	1.74
110	1.749	1.771	1.794	1.817	1.840	1.863	1.886	1.909	1.931	1.954	1.97
120	1.977	2.000	2.023	2.046	2.069	2.092	2.115	2.138	2.161	2.184	2.20
130	2.207	2.230	2.253	2.276	2.298	2.321	2.344	2.367	2.390	2.413	2.43
140	2.436	2.459	2.483	2.506	2.529	2.552	2.575	2.598	2.621	2.644	2.66
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type K thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
150	2.667	2.690	2.713	2.736	2.759	2.782	2.805	2.828	2.851	2.874	2.897
160	2.897	2.920	2.944	2.967	2.990	3.013	3.036	3.059	3.082	3.105	3.128
170	3.128	3.151	3.174	3.197	3.220	3.244	3.267	3.290	3.313	3.336	3.359
180	3.359	3.382	3.405	3.428	3.451	3.474	3.497	3.520	3.544	3.567	3.590
190	3.590	3.613	3.636	3.659	3.682	3.705	3.728	3.751	3.774	3.797	3.820
200	3.820	3.843	3.866	3.889	3.912	3.935	3.958	3.981	4.004	4.027	4.050
210	4.050	4.073	4.096	4.119	4.142	4.165	4.188	4.211	4.234	4.257	4.280
220	4.280	4.303	4.326	4.349	4.372	4.395	4.417	4.440	4.463	4.486	4.509
230	4.509	4.532	4.555	4.578	4.601	4.623	4.646	4.669	4.692	4.715	4.738
240	4.738	4.760	4.783	4.806	4.829	4.852	4.874	4.897	4.920	4.943	4.966
250	4.965	4.988	5.011	5.034	5.056	5.079	5.102	5.124	5.147	5.170	5.193
260	5.192	5.215	5.238	5.260	5.283	5.306	5.328	5.351	5.374	5.396	5.419
270	5.419	5.441	5.464	5.487	5.509	5.532	5.554	5.577	5.599	5.622	5.645
280	5.644	5.667	5.690	5.712	5.735	5.757	5.779	5.802	5.824	5.847	5.869
290	5.869	5.892	5.914	5.937	5.959	5.982	6.004	6.026	6.049	6.071	6.094
300	6.094	6.116	6.138	6.161	6.183	6.205	6.228	6.250	6.272	6.295	6.318
310	6.317	6.339	6.362	6.384	6.406	6.429	6.451	6.473	6.496	6.518	6.541
320	6.540	6.562	6.585	6.607	6.629	6.652	6.674	6.696	6.718	6.741	6.763
330	6.763	6.785	6.807	6.829	6.852	6.874	6.896	6.918	6.941	6.963	6.985
340	6.985	7.007	7.029	7.052	7.074	7.096	7.118	7.140	7.163	7.185	7.207
350	7.207	7.229	7.251	7.273	7.296	7.318	7.340	7.362	7.384	7.407	7.429
360	7.429	7.451	7.473	7.495	7.517	7.540	7.562	7.584	7.606	7.628	7.650
370	7.650	7.673	7.695	7.717	7.739	7.761	7.783	7.806	7.828	7.850	7.872
380	7.872	7.894	7.917	7.939	7.961	7.983	8.005	8.027	8.050	8.072	8.094
390	8.094	8.116	8.138	8.161	8.183	8.205	8.227	8.250	8.272	8.294	8.316
400	8.316	8.338	8.361	8.383	8.405	8.427	8.450	8.472	8.494	8.516	8.538
410	8.539	8.561	8.583	8.605	8.628	8.650	8.672	8.694	8.717	8.739	8.761
420	8.761	8.784	8.806	8.828	8.851	8.873	8.895	8.918	8.940	8.962	8.985
430	8.985	9.007	9.029	9.052	9.074	9.096	9.119	9.141	9.163	9.186	9.208
440	9.208	9.231	9.253	9.275	9.298	9.320	9.343	9.365	9.388	9.410	9.432
450	9.432	9.455	9.477	9.500	9.522	9.545	9.567	9.590	9.612	9.635	9.657
460	9.657	9.680	9.702	9.725	9.747	9.770	9.792	9.815	9.837	9.860	9.882
470	9.882	9.905	9.927	9.950	9.973	9.995	10.018	10.040	10.063	10.086	10.108
480	10.108	10.131	10.153	10.176	10.199	10.221	10.244	10.267	10.289	10.312	10.334
490	10.334	10.357	10.380	10.402	10.425	10.448	10.471	10.493	10.516	10.539	10.561
500	10.561	10.584	10.607	10.629	10.652	10.675	10.698	10.720	10.743	10.766	10.788
510	10.789	10.811	10.834	10.857	10.880	10.903	10.925	10.948	10.971	10.994	11.017
520	11.017	11.039	11.062	11.085	11.108	11.131	11.154	11.176	11.199	11.222	11.244
530	11.245	11.268	11.291	11.313	11.336	11.359	11.382	11.405	11.428	11.451	11.474
540	11.474	11.497	11.519	11.542	11.565	11.588	11.611	11.634	11.657	11.680	11.703
550	11.703	11.726	11.749	11.772	11.795	11.818	11.841	11.864	11.887	11.910	11.933
560	11.933	11.956	11.978	12.001	12.024	12.047	12.070	12.093	12.116	12.140	12.163
570	12.163	12.186	12.209	12.232	12.255	12.278	12.301	12.324	12.347	12.370	12.393
580	12.393	12.416	12.439	12.462	12.485	12.508	12.531	12.554	12.577	12.600	12.624
590	12.624	12.647	12.670	12.693	12.716	12.739	12.762	12.785	12.808	12.831	12.855
600	12.855	12.878	12.901	12.924	12.947	12.970	12.993	13.016	13.040	13.063	13.086
610	13.086	13.109	13.132	13.155	13.179	13.202	13.225	13.248	13.271	13.294	13.318
620	13.318	13.341	13.364	13.387	13.410	13.433	13.457	13.480	13.503	13.526	13.549
630	13.549	13.573	13.596	13.619	13.642	13.665	13.689	13.712	13.735	13.758	13.782
640	13.782	13.805	13.828	13.851	13.874	13.898	13.921	13.944	13.967	13.991	14.014
650	14.014	14.037	14.060	14.084	14.107	14.130	14.154	14.177	14.200	14.223	14.247
660	14.247	14.270	14.293	14.316	14.340	14.363	14.386	14.410	14.433	14.456	14.479
670	14.479	14.503	14.526	14.549	14.573	14.596	14.619	14.643	14.666	14.689	14.713
680	14.713	14.736	14.759	14.783	14.806	14.829	14.853	14.876	14.899	14.923	14.946
690	14.946	14.969	14.993	15.016	15.039	15.063	15.086	15.109	15.133	15.156	15.179
700	15.179	15.203	15.226	15.250	15.273	15.296	15.320	15.343	15.366	15.390	15.413
710	15.413	15.437	15.460	15.483	15.507	15.530	15.554	15.577	15.600	15.624	15.647
720	15.647	15.671	15.694	15.717	15.741	15.764	15.788	15.811	15.834	15.858	15.881
730	15.881	15.905	15.928	15.952	15.975	15.998	16.022	16.045	16.069	16.092	16.116
740	16.116	16.139	16.163	16.186	16.209	16.233	16.256	16.280	16.303	16.327	16.350
750	16.350	16.374	16.397	16.421	16.444	16.468	16.491	16.514	16.538	16.561	16.585
760	16.585	16.608	16.632	16.655	16.679	16.702	16.726	16.749	16.773	16.796	16.820
770	16.820	16.843	16.867	16.890	16.914	16.937	16.961	16.984	17.008	17.031	17.055
780	17.055	17.078	17.102	17.125	17.149	17.173	17.196	17.220	17.243	17.267	17.290
790	17.290	17.314	17.337	17.361	17.384	17.408	17.431	17.455	17.478	17.502	17.525
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type K thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
800	17.526	17.549	17.573	17.596	17.620	17.643	17.667	17.690	17.714	17.738	17.761
810	17.761	17.785	17.808	17.832	17.855	17.879	17.902	17.926	17.950	17.973	17.997
820	17.997	18.020	18.044	18.068	18.091	18.115	18.138	18.162	18.185	18.209	18.233
830	18.233	18.256	18.280	18.303	18.327	18.351	18.374	18.398	18.421	18.445	18.468
840	18.469	18.492	18.516	18.539	18.563	18.587	18.610	18.634	18.657	18.681	18.704
850	18.705	18.728	18.752	18.776	18.799	18.823	18.846	18.870	18.894	18.917	18.941
860	18.941	18.965	18.988	19.012	19.035	19.059	19.083	19.106	19.130	19.154	19.177
870	19.177	19.201	19.224	19.248	19.272	19.295	19.319	19.343	19.366	19.390	19.414
880	19.414	19.437	19.461	19.485	19.508	19.532	19.556	19.579	19.603	19.626	19.650
890	19.650	19.674	19.697	19.721	19.745	19.768	19.792	19.816	19.839	19.863	19.887
900	19.887	19.910	19.934	19.958	19.981	20.005	20.029	20.052	20.076	20.100	20.123
910	20.123	20.147	20.171	20.194	20.218	20.242	20.265	20.289	20.313	20.336	20.360
920	20.360	20.384	20.407	20.431	20.455	20.479	20.502	20.526	20.550	20.573	20.597
930	20.597	20.621	20.644	20.668	20.692	20.715	20.739	20.763	20.786	20.810	20.834
940	20.834	20.857	20.881	20.905	20.929	20.952	20.976	21.000	21.023	21.047	21.071
950	21.071	21.094	21.118	21.142	21.165	21.189	21.213	21.236	21.260	21.284	21.308
960	21.308	21.331	21.355	21.379	21.402	21.426	21.450	21.473	21.497	21.521	21.544
970	21.544	21.568	21.592	21.616	21.639	21.663	21.687	21.710	21.734	21.758	21.781
980	21.781	21.805	21.829	21.852	21.876	21.900	21.924	21.947	21.971	21.995	22.018
990	22.018	22.042	22.066	22.089	22.113	22.137	22.160	22.184	22.208	22.232	22.255
1000	22.255	22.279	22.303	22.326	22.350	22.374	22.397	22.421	22.445	22.468	22.492
1010	22.492	22.516	22.540	22.563	22.587	22.611	22.634	22.658	22.682	22.705	22.729
1020	22.729	22.753	22.776	22.800	22.824	22.847	22.871	22.895	22.919	22.942	22.966
1030	22.966	22.990	23.013	23.037	23.061	23.084	23.108	23.132	23.155	23.179	23.203
1040	23.203	23.226	23.250	23.274	23.297	23.321	23.345	23.368	23.392	23.416	23.439
1050	23.439	23.463	23.487	23.510	23.534	23.558	23.581	23.605	23.629	23.652	23.676
1060	23.676	23.700	23.723	23.747	23.771	23.794	23.818	23.842	23.865	23.889	23.913
1070	23.913	23.936	23.960	23.984	24.007	24.031	24.055	24.078	24.102	24.126	24.149
1080	24.149	24.173	24.197	24.220	24.244	24.267	24.291	24.315	24.338	24.362	24.386
1090	24.386	24.409	24.433	24.457	24.480	24.504	24.527	24.551	24.575	24.598	24.622
1100	24.622	24.646	24.669	24.693	24.717	24.740	24.764	24.787	24.811	24.835	24.858
1110	24.858	24.882	24.905	24.929	24.953	24.976	25.000	25.024	25.047	25.071	25.095
1120	25.094	25.118	25.142	25.165	25.189	25.212	25.236	25.260	25.283	25.307	25.331
1130	25.330	25.354	25.377	25.401	25.425	25.448	25.472	25.496	25.519	25.543	25.566
1140	25.566	25.590	25.613	25.637	25.660	25.684	25.708	25.731	25.755	25.778	25.802
1150	25.802	25.825	25.849	25.873	25.896	25.920	25.943	25.967	25.990	26.014	26.037
1160	26.037	26.061	26.084	26.108	26.132	26.155	26.179	26.202	26.226	26.249	26.273
1170	26.273	26.296	26.320	26.343	26.367	26.390	26.414	26.437	26.461	26.484	26.508
1180	26.508	26.532	26.555	26.579	26.602	26.626	26.649	26.673	26.696	26.720	26.743
1190	26.743	26.767	26.790	26.814	26.837	26.861	26.884	26.907	26.931	26.954	26.977
1200	26.978	27.001	27.025	27.048	27.072	27.095	27.119	27.142	27.166	27.189	27.212
1210	27.213	27.236	27.259	27.283	27.306	27.330	27.353	27.377	27.400	27.424	27.447
1220	27.447	27.471	27.494	27.517	27.541	27.564	27.588	27.611	27.635	27.658	27.681
1230	27.681	27.705	27.728	27.752	27.775	27.798	27.822	27.845	27.869	27.892	27.915
1240	27.915	27.939	27.962	27.986	28.009	28.032	28.056	28.079	28.103	28.126	28.149
1250	28.149	28.173	28.196	28.219	28.243	28.266	28.289	28.313	28.336	28.360	28.383
1260	28.383	28.406	28.430	28.453	28.476	28.500	28.523	28.546	28.570	28.593	28.616
1270	28.616	28.640	28.663	28.686	28.710	28.733	28.756	28.780	28.803	28.826	28.849
1280	28.849	28.873	28.896	28.919	28.943	28.966	28.989	29.013	29.036	29.059	29.082
1290	29.082	29.106	29.129	29.152	29.176	29.199	29.222	29.245	29.269	29.292	29.315
1300	29.315	29.338	29.362	29.385	29.408	29.431	29.455	29.478	29.501	29.524	29.547
1310	29.548	29.571	29.594	29.617	29.640	29.664	29.687	29.710	29.733	29.757	29.780
1320	29.780	29.803	29.826	29.849	29.873	29.896	29.919	29.942	29.965	29.989	30.012
1330	30.012	30.035	30.058	30.081	30.104	30.128	30.151	30.174	30.197	30.220	30.243
1340	30.243	30.267	30.290	30.313	30.336	30.359	30.382	30.405	30.429	30.452	30.475
1350	30.475	30.498	30.521	30.544	30.567	30.590	30.613	30.637	30.660	30.683	30.706
1360	30.706	30.729	30.752	30.775	30.798	30.821	30.844	30.868	30.891	30.914	30.937
1370	30.937	30.960	30.983	31.006	31.029	31.052	31.075	31.098	31.121	31.144	31.167
1380	31.167	31.190	31.213	31.236	31.260	31.283	31.306	31.329	31.352	31.375	31.398
1390	31.398	31.421	31.444	31.467	31.490	31.513	31.536	31.559	31.582	31.605	31.628
1400	31.628	31.651	31.674	31.697	31.720	31.743	31.766	31.789	31.812	31.834	31.857
1410	31.857	31.880	31.903	31.926	31.949	31.972	31.995	32.018	32.041	32.064	32.087
1420	32.087	32.110	32.133	32.156	32.179	32.202	32.224	32.247	32.270	32.293	32.316
1430	32.316	32.339	32.362	32.385	32.408	32.431	32.453	32.476	32.499	32.522	32.545
1440	32.545	32.568	32.591	32.614	32.636	32.659	32.682	32.705	32.728	32.751	32.774
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type K thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
1450	32.774	32.796	32.819	32.842	32.865	32.888	32.911	32.933	32.956	32.979	33.00
1460	33.002	33.025	33.047	33.070	33.093	33.116	33.139	33.161	33.184	33.207	33.23
1470	33.230	33.253	33.275	33.298	33.321	33.344	33.366	33.389	33.412	33.435	33.45
1480	33.458	33.480	33.503	33.526	33.548	33.571	33.594	33.617	33.639	33.662	33.68
1490	33.685	33.708	33.730	33.753	33.776	33.798	33.821	33.844	33.867	33.889	33.91
1500	33.912	33.935	33.957	33.980	34.003	34.025	34.048	34.071	34.093	34.116	34.13
1510	34.139	34.161	34.184	34.207	34.229	34.252	34.275	34.297	34.320	34.343	34.36
1520	34.365	34.388	34.410	34.433	34.456	34.478	34.501	34.524	34.546	34.569	34.59
1530	34.591	34.614	34.637	34.659	34.682	34.704	34.727	34.750	34.772	34.795	34.81
1540	34.817	34.840	34.862	34.885	34.908	34.930	34.953	34.975	34.998	35.020	35.04
1550	35.043	35.065	35.088	35.110	35.133	35.156	35.178	35.201	35.223	35.246	35.26
1560	35.268	35.291	35.313	35.336	35.358	35.381	35.403	35.426	35.448	35.471	35.49
1570	35.493	35.516	35.538	35.560	35.583	35.605	35.628	35.650	35.673	35.695	35.71
1580	35.718	35.740	35.763	35.785	35.807	35.830	35.852	35.875	35.897	35.920	35.94
1590	35.942	35.964	35.987	36.009	36.032	36.054	36.076	36.099	36.121	36.144	36.16
1600	36.166	36.188	36.211	36.233	36.256	36.278	36.300	36.323	36.345	36.367	36.39
1610	36.390	36.412	36.434	36.457	36.479	36.501	36.524	36.546	36.568	36.591	36.61
1620	36.613	36.635	36.658	36.680	36.702	36.725	36.747	36.769	36.792	36.814	36.83
1630	36.836	36.859	36.881	36.903	36.925	36.948	36.970	36.992	37.014	37.037	37.05
1640	37.059	37.081	37.104	37.126	37.148	37.170	37.193	37.215	37.237	37.259	37.28
1650	37.281	37.304	37.326	37.348	37.370	37.393	37.415	37.437	37.459	37.481	37.50
1660	37.504	37.526	37.548	37.570	37.592	37.615	37.637	37.659	37.681	37.703	37.72
1670	37.725	37.748	37.770	37.792	37.814	37.836	37.858	37.881	37.903	37.925	37.94
1680	37.947	37.969	37.991	38.013	38.036	38.058	38.080	38.102	38.124	38.146	38.16
1690	38.168	38.190	38.212	38.235	38.257	38.279	38.301	38.323	38.345	38.367	38.38
1700	38.389	38.411	38.433	38.455	38.477	38.499	38.522	38.544	38.566	38.588	38.61
1710	38.610	38.632	38.654	38.676	38.698	38.720	38.742	38.764	38.786	38.808	38.83
1720	38.830	38.852	38.874	38.896	38.918	38.940	38.962	38.984	39.006	39.028	39.05
1730	39.050	39.072	39.094	39.116	39.138	39.160	39.182	39.204	39.226	39.248	39.27
1740	39.270	39.292	39.314	39.335	39.357	39.379	39.401	39.423	39.445	39.467	39.48
1750	39.489	39.511	39.533	39.555	39.577	39.599	39.620	39.642	39.664	39.686	39.70
1760	39.708	39.730	39.752	39.774	39.796	39.817	39.839	39.861	39.883	39.905	39.92
1770	39.927	39.949	39.970	39.992	40.014	40.036	40.058	40.080	40.101	40.123	40.14
1780	40.145	40.167	40.189	40.211	40.232	40.254	40.276	40.298	40.320	40.341	40.36
1790	40.363	40.385	40.407	40.429	40.450	40.472	40.494	40.516	40.537	40.559	40.58
1800	40.581	40.603	40.624	40.646	40.668	40.690	40.711	40.733	40.755	40.777	40.79
1810	40.798	40.820	40.842	40.864	40.885	40.907	40.929	40.950	40.972	40.994	41.01
1820	41.015	41.037	41.059	41.081	41.102	41.124	41.146	41.167	41.189	41.211	41.23
1830	41.232	41.254	41.276	41.297	41.319	41.341	41.362	41.384	41.405	41.427	41.44
1840	41.449	41.470	41.492	41.514	41.535	41.557	41.578	41.600	41.622	41.643	41.66
1850	41.665	41.686	41.708	41.730	41.751	41.773	41.794	41.816	41.838	41.859	41.88
1860	41.881	41.902	41.924	41.945	41.967	41.988	42.010	42.032	42.053	42.075	42.09
1870	42.096	42.118	42.139	42.161	42.182	42.204	42.225	42.247	42.268	42.290	42.31
1880	42.311	42.333	42.354	42.376	42.397	42.419	42.440	42.462	42.483	42.505	42.52
1890	42.526	42.548	42.569	42.591	42.612	42.633	42.655	42.676	42.698	42.719	42.74
1900	42.741	42.762	42.783	42.805	42.826	42.848	42.869	42.891	42.912	42.933	42.95
1910	42.955	42.976	42.998	43.019	43.040	43.062	43.083	43.104	43.126	43.147	43.16
1920	43.169	43.190	43.211	43.233	43.254	43.275	43.297	43.318	43.339	43.361	43.38
1930	43.382	43.403	43.425	43.446	43.467	43.489	43.510	43.531	43.552	43.574	43.59
1940	43.595	43.616	43.638	43.659	43.680	43.701	43.723	43.744	43.765	43.787	43.80
1950	43.808	43.829	43.850	43.872	43.893	43.914	43.935	43.957	43.978	43.999	44.02
1960	44.020	44.041	44.063	44.084	44.105	44.126	44.147	44.169	44.190	44.211	44.23
1970	44.232	44.253	44.275	44.296	44.317	44.338	44.359	44.380	44.402	44.423	44.44
1980	44.444	44.465	44.486	44.507	44.528	44.550	44.571	44.592	44.613	44.634	44.65
1990	44.655	44.676	44.697	44.719	44.740	44.761	44.782	44.803	44.824	44.845	44.86
2000	44.866	44.887	44.908	44.929	44.950	44.971	44.992	45.014	45.035	45.056	45.07
2010	45.077	45.098	45.119	45.140	45.161	45.182	45.203	45.224	45.245	45.266	45.28
2020	45.287	45.308	45.329	45.350	45.371	45.392	45.413	45.434	45.455	45.476	45.49
2030	45.497	45.518	45.539	45.560	45.580	45.601	45.622	45.643	45.664	45.685	45.70
2040	45.706	45.727	45.748	45.769	45.790	45.811	45.832	45.852	45.873	45.894	45.91
2050	45.915	45.936	45.957	45.978	45.999	46.019	46.040	46.061	46.082	46.103	46.12
2060	46.124	46.145	46.165	46.186	46.207	46.228	46.249	46.269	46.290	46.311	46.33
2070	46.332	46.353	46.373	46.394	46.415	46.436	46.457	46.477	46.498	46.519	46.54
2080	46.540	46.560	46.581	46.602	46.623	46.643	46.664	46.685	46.706	46.726	46.74
2090	46.747	46.768	46.789	46.809	46.830	46.851	46.871	46.892	46.913	46.933	46.95
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type K thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
2100	46.954	46.975	46.995	47.016	47.037	47.057	47.078	47.099	47.119	47.140	47.16
2110	47.161	47.181	47.202	47.223	47.243	47.264	47.284	47.305	47.326	47.346	47.36
2120	47.367	47.387	47.408	47.429	47.449	47.470	47.490	47.511	47.531	47.552	47.57
2130	47.573	47.593	47.614	47.634	47.655	47.675	47.696	47.716	47.737	47.757	47.77
2140	47.778	47.798	47.819	47.839	47.860	47.880	47.901	47.921	47.942	47.962	47.98
2150	47.983	48.003	48.024	48.044	48.065	48.085	48.105	48.126	48.146	48.167	48.18
2160	48.187	48.208	48.228	48.248	48.269	48.289	48.310	48.330	48.350	48.371	48.39
2170	48.391	48.411	48.432	48.452	48.473	48.493	48.513	48.534	48.554	48.574	48.59
2180	48.595	48.615	48.635	48.656	48.676	48.696	48.717	48.737	48.757	48.777	48.79
2190	48.798	48.818	48.838	48.859	48.879	48.899	48.919	48.940	48.960	48.980	49.00
2200	49.000	49.021	49.041	49.061	49.081	49.101	49.122	49.142	49.162	49.182	49.20
2210	49.202	49.223	49.243	49.263	49.283	49.303	49.323	49.344	49.364	49.384	49.40
2220	49.404	49.424	49.444	49.465	49.485	49.505	49.525	49.545	49.565	49.585	49.60
2230	49.605	49.625	49.645	49.666	49.686	49.706	49.726	49.746	49.766	49.786	49.80
2240	49.806	49.826	49.846	49.866	49.886	49.906	49.926	49.946	49.966	49.986	50.00
2250	50.006	50.026	50.046	50.066	50.086	50.106	50.126	50.146	50.166	50.186	50.20
2260	50.206	50.226	50.246	50.266	50.286	50.306	50.326	50.346	50.366	50.385	50.40
2270	50.405	50.425	50.445	50.465	50.485	50.505	50.525	50.545	50.564	50.584	50.60
2280	50.604	50.624	50.644	50.664	50.684	50.703	50.723	50.743	50.763	50.783	50.80
2290	50.802	50.822	50.842	50.862	50.882	50.901	50.921	50.941	50.961	50.981	51.00
2300	51.000	51.020	51.040	51.060	51.079	51.099	51.119	51.139	51.158	51.178	51.19
2310	51.198	51.217	51.237	51.257	51.276	51.296	51.316	51.336	51.355	51.375	51.39
2320	51.395	51.414	51.434	51.453	51.473	51.493	51.512	51.532	51.552	51.571	51.59
2330	51.591	51.611	51.630	51.650	51.669	51.689	51.708	51.728	51.748	51.767	51.78
2340	51.787	51.806	51.826	51.845	51.865	51.885	51.904	51.924	51.943	51.963	51.98
2350	51.982	52.002	52.021	52.041	52.060	52.080	52.099	52.119	52.138	52.158	52.17
2360	52.177	52.197	52.216	52.235	52.255	52.274	52.294	52.313	52.333	52.352	52.37
2370	52.371	52.391	52.410	52.430	52.449	52.468	52.488	52.507	52.527	52.546	52.56
2380	52.565	52.585	52.604	52.623	52.643	52.662	52.681	52.701	52.720	52.739	52.75
2390	52.759	52.778	52.797	52.817	52.836	52.855	52.875	52.894	52.913	52.932	52.95
2400	52.952	52.971	52.990	53.010	53.029	53.048	53.067	53.087	53.106	53.125	53.14
2410	53.144	53.163	53.183	53.202	53.221	53.240	53.260	53.279	53.298	53.317	53.33
2420	53.336	53.355	53.375	53.394	53.413	53.432	53.451	53.470	53.490	53.509	53.52
2430	53.528	53.547	53.566	53.585	53.604	53.623	53.643	53.662	53.681	53.700	53.71
2440	53.719	53.738	53.757	53.776	53.795	53.814	53.833	53.852	53.871	53.890	53.91
2450	53.910	53.929	53.948	53.967	53.986	54.005	54.024	54.043	54.062	54.081	54.10
2460	54.100	54.119	54.138	54.157	54.176	54.195	54.214	54.233	54.252	54.271	54.28
2470	54.289	54.308	54.327	54.346	54.365	54.384	54.403	54.422	54.441	54.460	54.47
2480	54.479	54.498	54.517	54.536	54.554	54.573	54.592	54.611	54.630	54.649	54.66
2490	54.668	54.687	54.705	54.724	54.743	54.762	54.781	54.800	54.819	54.837	54.85
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type K thermocouple											
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
350	14.293	14.335	14.377	14.419	14.461	14.503	14.545	14.587	14.629	14.671	14.71
360	14.713	14.755	14.797	14.839	14.881	14.923	14.965	15.007	15.049	15.091	15.13
370	15.133	15.175	15.217	15.259	15.301	15.343	15.385	15.427	15.469	15.511	15.55
380	15.554	15.596	15.638	15.680	15.722	15.764	15.806	15.849	15.891	15.933	15.97
390	15.975	16.017	16.059	16.102	16.144	16.186	16.228	16.270	16.313	16.355	16.39
400	16.397	16.439	16.482	16.524	16.566	16.608	16.651	16.693	16.735	16.778	16.82
410	16.820	16.862	16.904	16.947	16.989	17.031	17.074	17.116	17.158	17.201	17.24
420	17.243	17.285	17.328	17.370	17.413	17.455	17.497	17.540	17.582	17.624	17.66
430	17.667	17.709	17.752	17.794	17.837	17.879	17.921	17.964	18.006	18.049	18.09
440	18.091	18.134	18.176	18.218	18.261	18.303	18.346	18.388	18.431	18.473	18.51
450	18.516	18.558	18.601	18.643	18.686	18.728	18.771	18.813	18.856	18.898	18.94
460	18.941	18.983	19.026	19.068	19.111	19.154	19.196	19.239	19.281	19.324	19.36
470	19.366	19.409	19.451	19.494	19.537	19.579	19.622	19.664	19.707	19.750	19.79
480	19.792	19.835	19.877	19.920	19.962	20.005	20.048	20.090	20.133	20.175	20.21
490	20.218	20.261	20.303	20.346	20.389	20.431	20.474	20.516	20.559	20.602	20.64
500	20.644	20.687	20.730	20.772	20.815	20.857	20.900	20.943	20.985	21.028	21.07
510	21.071	21.113	21.156	21.199	21.241	21.284	21.326	21.369	21.412	21.454	21.49
520	21.497	21.540	21.582	21.625	21.668	21.710	21.753	21.796	21.838	21.881	21.92
530	21.924	21.966	22.009	22.052	22.094	22.137	22.179	22.222	22.265	22.307	22.35
540	22.350	22.393	22.435	22.478	22.521	22.563	22.606	22.649	22.691	22.734	22.77
550	22.776	22.819	22.862	22.904	22.947	22.990	23.032	23.075	23.117	23.160	23.20
560	23.203	23.245	23.288	23.331	23.373	23.416	23.458	23.501	23.544	23.586	23.62
570	23.629	23.671	23.714	23.757	23.799	23.842	23.884	23.927	23.970	24.012	24.05
580	24.055	24.097	24.140	24.182	24.225	24.267	24.310	24.353	24.395	24.438	24.48
590	24.480	24.523	24.565	24.608	24.650	24.693	24.735	24.778	24.820	24.863	24.90
600	24.905	24.948	24.990	25.033	25.075	25.118	25.160	25.203	25.245	25.288	25.33
610	25.330	25.373	25.415	25.458	25.500	25.543	25.585	25.627	25.670	25.712	25.75
620	25.755	25.797	25.840	25.882	25.924	25.967	26.009	26.052	26.094	26.136	26.17
630	26.179	26.221	26.263	26.306	26.348	26.390	26.433	26.475	26.517	26.560	26.60
640	26.602	26.644	26.687	26.729	26.771	26.814	26.856	26.898	26.940	26.983	27.02
650	27.025	27.067	27.109	27.152	27.194	27.236	27.278	27.320	27.363	27.405	27.44
660	27.447	27.489	27.531	27.574	27.616	27.658	27.700	27.742	27.784	27.826	27.86
670	27.869	27.911	27.953	27.995	28.037	28.079	28.121	28.163	28.205	28.247	28.28
680	28.289	28.332	28.374	28.416	28.458	28.500	28.542	28.584	28.626	28.668	28.71
690	28.710	28.752	28.794	28.835	28.877	28.919	28.961	29.003	29.045	29.087	29.12
700	29.129	29.171	29.213	29.255	29.297	29.338	29.380	29.422	29.464	29.506	29.54
710	29.548	29.589	29.631	29.673	29.715	29.757	29.798	29.840	29.882	29.924	29.96
720	29.965	30.007	30.049	30.090	30.132	30.174	30.216	30.257	30.299	30.341	30.38
730	30.382	30.424	30.466	30.507	30.549	30.590	30.632	30.674	30.715	30.757	30.79
740	30.798	30.840	30.881	30.923	30.964	31.006	31.047	31.089	31.130	31.172	31.21
750	31.213	31.255	31.296	31.338	31.379	31.421	31.462	31.504	31.545	31.586	31.62
760	31.628	31.669	31.710	31.752	31.793	31.834	31.876	31.917	31.958	32.000	32.04
770	32.041	32.082	32.124	32.165	32.206	32.247	32.289	32.330	32.371	32.412	32.45
780	32.453	32.495	32.536	32.577	32.618	32.659	32.700	32.742	32.783	32.824	32.86
790	32.865	32.906	32.947	32.988	33.029	33.070	33.111	33.152	33.193	33.234	33.27
800	33.275	33.316	33.357	33.398	33.439	33.480	33.521	33.562	33.603	33.644	33.68
810	33.685	33.726	33.767	33.808	33.848	33.889	33.930	33.971	34.012	34.053	34.09
820	34.093	34.134	34.175	34.216	34.257	34.297	34.338	34.379	34.420	34.460	34.50
830	34.501	34.542	34.582	34.623	34.664	34.704	34.745	34.786	34.826	34.867	34.90
840	34.908	34.948	34.989	35.029	35.070	35.110	35.151	35.192	35.232	35.273	35.31
850	35.313	35.354	35.394	35.435	35.475	35.516	35.556	35.596	35.637	35.677	35.71
860	35.718	35.758	35.798	35.839	35.879	35.920	35.960	36.000	36.041	36.081	36.12
870	36.121	36.162	36.202	36.242	36.282	36.323	36.363	36.403	36.443	36.484	36.52
880	36.524	36.564	36.604	36.644	36.685	36.725	36.765	36.805	36.845	36.885	36.92
890	36.925	36.965	37.006	37.046	37.086	37.126	37.166	37.206	37.246	37.286	37.32
900	37.326	37.366	37.406	37.446	37.486	37.526	37.566	37.606	37.646	37.686	37.72
910	37.725	37.765	37.805	37.845	37.885	37.925	37.965	38.005	38.044	38.084	38.12
920	38.124	38.164	38.204	38.243	38.283	38.323	38.363	38.402	38.442	38.482	38.52
930	38.522	38.561	38.601	38.641	38.680	38.720	38.760	38.799	38.839	38.878	38.91
940	38.918	38.958	38.997	39.037	39.076	39.116	39.155	39.195	39.235	39.274	39.31
950	39.314	39.353	39.393	39.432	39.471	39.511	39.550	39.590	39.629	39.669	39.70
960	39.708	39.747	39.787	39.826	39.866	39.905	39.944	39.984	40.023	40.062	40.10
970	40.101	40.141	40.180	40.219	40.259	40.298	40.337	40.376	40.415	40.455	40.49
980	40.494	40.533	40.572	40.611	40.651	40.690	40.729	40.768	40.807	40.846	40.88
990	40.885	40.924	40.963	41.002	41.042	41.081	41.120	41.159	41.198	41.237	41.27
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type K thermocouple										
°C	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
1000	41.276	41.315	41.354	41.393	41.431	41.470	41.509	41.548	41.587	41.626
1010	41.665	41.704	41.743	41.781	41.820	41.859	41.898	41.937	41.976	42.014
1020	42.053	42.092	42.131	42.169	42.208	42.247	42.286	42.324	42.363	42.402
1030	42.440	42.479	42.518	42.556	42.595	42.633	42.672	42.711	42.749	42.788
1040	42.826	42.865	42.903	42.942	42.980	43.019	43.057	43.096	43.134	43.173
1050	43.211	43.250	43.288	43.327	43.365	43.403	43.442	43.480	43.518	43.557
1060	43.595	43.633	43.672	43.710	43.748	43.787	43.825	43.863	43.901	43.940
1070	43.978	44.016	44.054	44.092	44.130	44.169	44.207	44.245	44.283	44.321
1080	44.359	44.397	44.435	44.473	44.512	44.550	44.588	44.626	44.664	44.702
1090	44.740	44.778	44.816	44.853	44.891	44.929	44.967	45.005	45.043	45.081
1100	45.119	45.157	45.194	45.232	45.270	45.308	45.346	45.383	45.421	45.459
1110	45.497	45.534	45.572	45.610	45.647	45.685	45.723	45.760	45.798	45.836
1120	45.873	45.911	45.948	45.986	46.024	46.061	46.099	46.136	46.174	46.211
1130	46.249	46.286	46.324	46.361	46.398	46.436	46.473	46.511	46.548	46.585
1140	46.623	46.660	46.697	46.735	46.772	46.809	46.847	46.884	46.921	46.958
1150	46.995	47.033	47.070	47.107	47.144	47.181	47.218	47.256	47.293	47.330
1160	47.367	47.404	47.441	47.478	47.515	47.552	47.589	47.626	47.663	47.700
1170	47.737	47.774	47.811	47.848	47.884	47.921	47.958	47.995	48.032	48.069
1180	48.105	48.142	48.179	48.216	48.252	48.289	48.326	48.363	48.399	48.436
1190	48.473	48.509	48.546	48.582	48.619	48.656	48.692	48.729	48.765	48.802
1200	48.838	48.875	48.911	48.948	48.984	49.021	49.057	49.093	49.130	49.166
1210	49.202	49.239	49.275	49.311	49.348	49.384	49.420	49.456	49.493	49.529
1220	49.565	49.601	49.637	49.674	49.710	49.746	49.782	49.818	49.854	49.890
1230	49.926	49.962	49.998	50.034	50.070	50.106	50.142	50.178	50.214	50.250
1240	50.286	50.322	50.358	50.393	50.429	50.465	50.501	50.537	50.572	50.608
1250	50.644	50.680	50.715	50.751	50.787	50.822	50.858	50.894	50.929	50.965
1260	51.000	51.036	51.071	51.107	51.142	51.178	51.213	51.249	51.284	51.320
1270	51.355	51.391	51.426	51.461	51.497	51.532	51.567	51.603	51.638	51.673
1280	51.708	51.744	51.779	51.814	51.849	51.885	51.920	51.955	51.990	52.025
1290	52.060	52.095	52.130	52.165	52.200	52.235	52.270	52.305	52.340	52.375
1300	52.410	52.445	52.480	52.515	52.550	52.585	52.620	52.654	52.689	52.724
1310	52.759	52.794	52.828	52.863	52.898	52.932	52.967	53.002	53.037	53.071
1320	53.106	53.140	53.175	53.210	53.244	53.279	53.313	53.348	53.382	53.417
1330	53.451	53.486	53.520	53.555	53.589	53.623	53.658	53.692	53.727	53.761
1340	53.795	53.830	53.864	53.898	53.932	53.967	54.001	54.035	54.069	54.104
1350	54.138	54.172	54.206	54.240	54.274	54.308	54.343	54.377	54.411	54.445
1360	54.479	54.513	54.547	54.581	54.615	54.649	54.683	54.717	54.751	54.785
°C	0	1	2	3	4	5	6	7	8	9
ITS-90 Table for type N thermocouple										
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1
Thermoelectric Voltage in mV										
-260	-4.345	-4.345	-4.344	-4.344	-4.343	-4.342	-4.341	-4.340	-4.339	-4.337
-250	-4.336	-4.334	-4.332	-4.330	-4.328	-4.326	-4.324	-4.321	-4.319	-4.316
-240	-4.313	-4.310	-4.307	-4.304	-4.300	-4.297	-4.293	-4.289	-4.285	-4.281
-230	-4.277	-4.273	-4.268	-4.263	-4.258	-4.254	-4.248	-4.243	-4.238	-4.232
-220	-4.226	-4.221	-4.215	-4.209	-4.202	-4.196	-4.189	-4.183	-4.176	-4.169
-210	-4.162	-4.154	-4.147	-4.140	-4.132	-4.124	-4.116	-4.108	-4.100	-4.091
-200	-4.083	-4.074	-4.066	-4.057	-4.048	-4.038	-4.029	-4.020	-4.010	-3.999
-190	-3.990	-3.980	-3.970	-3.960	-3.950	-3.939	-3.928	-3.918	-3.907	-3.896
-180	-3.884	-3.873	-3.862	-3.850	-3.838	-3.827	-3.815	-3.803	-3.790	-3.778
-170	-3.766	-3.753	-3.740	-3.728	-3.715	-3.702	-3.688	-3.675	-3.662	-3.648
-160	-3.634	-3.621	-3.607	-3.593	-3.578	-3.564	-3.550	-3.535	-3.521	-3.506
-150	-3.491	-3.476	-3.461	-3.446	-3.431	-3.415	-3.400	-3.384	-3.368	-3.352
-140	-3.336	-3.320	-3.304	-3.288	-3.271	-3.255	-3.238	-3.221	-3.205	-3.188
-130	-3.171	-3.153	-3.136	-3.119	-3.101	-3.084	-3.066	-3.048	-3.030	-3.012
-120	-2.994	-2.976	-2.958	-2.939	-2.921	-2.902	-2.883	-2.865	-2.846	-2.827
-110	-2.808	-2.789	-2.769	-2.750	-2.730	-2.711	-2.691	-2.672	-2.652	-2.632
-100	-2.612	-2.592	-2.571	-2.551	-2.531	-2.510	-2.490	-2.469	-2.448	-2.428
-90	-2.407	-2.386	-2.365	-2.344	-2.322	-2.301	-2.280	-2.258	-2.237	-2.215
-80	-2.193	-2.172	-2.150	-2.128	-2.106	-2.084	-2.062	-2.039	-2.017	-1.995
-70	-1.972	-1.950	-1.927	-1.905	-1.882	-1.859	-1.836	-1.813	-1.790	-1.767
-60	-1.744	-1.721	-1.698	-1.674	-1.651	-1.627	-1.604	-1.580	-1.557	-1.533
-50	-1.509	-1.485	-1.462	-1.438	-1.414	-1.390	-1.366	-1.341	-1.317	-1.293
°C	0	1	2	3	4	5	6	7	8	9

ITS-90 Table for type N thermocouple											
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Thermoelectric Voltage in mV											
-40	-1.269	-1.244	-1.220	-1.195	-1.171	-1.146	-1.122	-1.097	-1.072	-1.048	-1.02
-30	-1.023	-0.998	-0.973	-0.948	-0.923	-0.898	-0.873	-0.848	-0.823	-0.798	-0.77
-20	-0.772	-0.747	-0.722	-0.696	-0.671	-0.646	-0.620	-0.595	-0.569	-0.544	-0.51
-10	-0.518	-0.492	-0.467	-0.441	-0.415	-0.390	-0.364	-0.338	-0.312	-0.286	-0.26
0	-0.260	-0.234	-0.209	-0.183	-0.157	-0.131	-0.104	-0.078	-0.052	-0.026	0.00
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type N thermocouple											
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	0.000	0.026	0.052	0.078	0.104	0.130	0.156	0.182	0.208	0.235	0.26
10	0.261	0.287	0.313	0.340	0.366	0.393	0.419	0.446	0.472	0.499	0.52
20	0.525	0.552	0.578	0.605	0.632	0.659	0.685	0.712	0.739	0.766	0.79
30	0.793	0.820	0.847	0.874	0.901	0.928	0.955	0.983	1.010	1.037	1.06
40	1.065	1.092	1.119	1.147	1.174	1.202	1.229	1.257	1.284	1.312	1.34
50	1.340	1.368	1.395	1.423	1.451	1.479	1.507	1.535	1.563	1.591	1.61
60	1.619	1.647	1.675	1.703	1.732	1.760	1.788	1.817	1.845	1.873	1.90
70	1.902	1.930	1.959	1.988	2.016	2.045	2.074	2.102	2.131	2.160	2.18
80	2.189	2.218	2.247	2.276	2.305	2.334	2.363	2.392	2.421	2.450	2.48
90	2.480	2.509	2.538	2.568	2.597	2.626	2.656	2.685	2.715	2.744	2.77
100	2.774	2.804	2.833	2.863	2.893	2.923	2.953	2.983	3.012	3.042	3.07
110	3.072	3.102	3.133	3.163	3.193	3.223	3.253	3.283	3.314	3.344	3.37
120	3.374	3.405	3.435	3.466	3.496	3.527	3.557	3.588	3.619	3.649	3.68
130	3.680	3.711	3.742	3.772	3.803	3.834	3.865	3.896	3.927	3.958	3.98
140	3.989	4.020	4.051	4.083	4.114	4.145	4.176	4.208	4.239	4.270	4.30
150	4.302	4.333	4.365	4.396	4.428	4.459	4.491	4.523	4.554	4.586	4.61
160	4.618	4.650	4.681	4.713	4.745	4.777	4.809	4.841	4.873	4.905	4.93
170	4.937	4.969	5.001	5.033	5.066	5.098	5.130	5.162	5.195	5.227	5.25
180	5.259	5.292	5.324	5.357	5.389	5.422	5.454	5.487	5.520	5.552	5.58
190	5.585	5.618	5.650	5.683	5.716	5.749	5.782	5.815	5.847	5.880	5.91
200	5.913	5.946	5.979	6.013	6.046	6.079	6.112	6.145	6.178	6.211	6.24
210	6.245	6.278	6.311	6.345	6.378	6.411	6.445	6.478	6.512	6.545	6.57
220	6.579	6.612	6.646	6.680	6.713	6.747	6.781	6.814	6.848	6.882	6.91
230	6.916	6.949	6.983	7.017	7.051	7.085	7.119	7.153	7.187	7.221	7.25
240	7.255	7.289	7.323	7.357	7.392	7.426	7.460	7.494	7.528	7.563	7.59
250	7.597	7.631	7.666	7.700	7.734	7.769	7.803	7.838	7.872	7.907	7.94
260	7.941	7.976	8.010	8.045	8.080	8.114	8.149	8.184	8.218	8.253	8.28
270	8.288	8.323	8.358	8.392	8.427	8.462	8.497	8.532	8.567	8.602	8.63
280	8.637	8.672	8.707	8.742	8.777	8.812	8.847	8.882	8.918	8.953	8.98
290	8.988	9.023	9.058	9.094	9.129	9.164	9.200	9.235	9.270	9.306	9.34
300	9.341	9.377	9.412	9.448	9.483	9.519	9.554	9.590	9.625	9.661	9.69
310	9.696	9.732	9.768	9.803	9.839	9.875	9.910	9.946	9.982	10.018	10.05
320	10.054	10.089	10.125	10.161	10.197	10.233	10.269	10.305	10.341	10.377	10.41
330	10.413	10.449	10.485	10.521	10.557	10.593	10.629	10.665	10.701	10.737	10.77
340	10.774	10.810	10.846	10.882	10.918	10.955	10.991	11.027	11.064	11.100	11.13
350	11.136	11.173	11.209	11.245	11.282	11.318	11.355	11.391	11.428	11.464	11.50
360	11.501	11.537	11.574	11.610	11.647	11.683	11.720	11.757	11.793	11.830	11.86
370	11.867	11.903	11.940	11.977	12.013	12.050	12.087	12.124	12.160	12.197	12.23
380	12.234	12.271	12.308	12.345	12.382	12.418	12.455	12.492	12.529	12.566	12.60
390	12.603	12.640	12.677	12.714	12.751	12.788	12.825	12.862	12.899	12.937	12.97
400	12.974	13.011	13.048	13.085	13.122	13.159	13.197	13.234	13.271	13.308	13.34
410	13.346	13.383	13.420	13.457	13.495	13.532	13.569	13.607	13.644	13.682	13.71
420	13.719	13.756	13.794	13.831	13.869	13.906	13.944	13.981	14.019	14.056	14.09
430	14.094	14.131	14.169	14.206	14.244	14.281	14.319	14.356	14.394	14.432	14.46
440	14.469	14.507	14.545	14.582	14.620	14.658	14.695	14.733	14.771	14.809	14.84
450	14.846	14.884	14.922	14.960	14.998	15.035	15.073	15.111	15.149	15.187	15.22
460	15.225	15.262	15.300	15.338	15.376	15.414	15.452	15.490	15.528	15.566	15.60
470	15.604	15.642	15.680	15.718	15.756	15.794	15.832	15.870	15.908	15.946	15.98
480	15.984	16.022	16.060	16.099	16.137	16.175	16.213	16.251	16.289	16.327	16.36
490	16.366	16.404	16.442	16.480	16.518	16.557	16.595	16.633	16.671	16.710	16.74
500	16.748	16.786	16.824	16.863	16.901	16.939	16.978	17.016	17.054	17.093	17.13
510	17.131	17.169	17.208	17.246	17.285	17.323	17.361	17.400	17.438	17.477	17.51
520	17.515	17.554	17.592	17.630	17.669	17.707	17.746	17.784	17.823	17.861	17.90
530	17.900	17.938	17.977	18.016	18.054	18.093	18.131	18.170	18.208	18.247	18.28
540	18.286	18.324	18.363	18.401	18.440	18.479	18.517	18.556	18.595	18.633	18.67
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type N thermocouple										
°C	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
550	18.672	18.711	18.749	18.788	18.827	18.865	18.904	18.943	18.982	19.020
560	19.059	19.098	19.136	19.175	19.214	19.253	19.292	19.330	19.369	19.408
570	19.447	19.485	19.524	19.563	19.602	19.641	19.680	19.718	19.757	19.796
580	19.835	19.874	19.913	19.952	19.990	20.029	20.068	20.107	20.146	20.185
590	20.224	20.263	20.302	20.341	20.379	20.418	20.457	20.496	20.535	20.574
600	20.613	20.652	20.691	20.730	20.769	20.808	20.847	20.886	20.925	20.964
610	21.003	21.042	21.081	21.120	21.159	21.198	21.237	21.276	21.315	21.354
620	21.393	21.432	21.471	21.510	21.549	21.588	21.628	21.667	21.706	21.745
630	21.784	21.823	21.862	21.901	21.940	21.979	22.018	22.058	22.097	22.136
640	22.175	22.214	22.253	22.292	22.331	22.370	22.410	22.449	22.488	22.527
650	22.566	22.605	22.644	22.684	22.723	22.762	22.801	22.840	22.879	22.919
660	22.958	22.997	23.036	23.075	23.115	23.154	23.193	23.232	23.271	23.311
670	23.350	23.389	23.428	23.467	23.507	23.546	23.585	23.624	23.663	23.703
680	23.742	23.781	23.820	23.860	23.899	23.938	23.977	24.016	24.056	24.095
690	24.134	24.173	24.213	24.252	24.291	24.330	24.370	24.409	24.448	24.487
700	24.527	24.566	24.605	24.644	24.684	24.723	24.762	24.801	24.841	24.880
710	24.919	24.959	24.998	25.037	25.076	25.116	25.155	25.194	25.233	25.273
720	25.312	25.351	25.391	25.430	25.469	25.508	25.548	25.587	25.626	25.666
730	25.705	25.744	25.783	25.823	25.862	25.901	25.941	25.980	26.019	26.058
740	26.098	26.137	26.176	26.216	26.255	26.294	26.333	26.373	26.412	26.451
750	26.491	26.530	26.569	26.608	26.648	26.687	26.726	26.766	26.805	26.844
760	26.883	26.923	26.962	27.001	27.041	27.080	27.119	27.158	27.198	27.237
770	27.276	27.316	27.355	27.394	27.433	27.473	27.512	27.551	27.591	27.630
780	27.669	27.708	27.748	27.787	27.826	27.866	27.905	27.944	27.983	28.023
790	28.062	28.101	28.140	28.180	28.219	28.258	28.297	28.337	28.376	28.415
800	28.455	28.494	28.533	28.572	28.612	28.651	28.690	28.729	28.769	28.808
810	28.847	28.886	28.926	28.965	29.004	29.043	29.083	29.122	29.161	29.200
820	29.239	29.279	29.318	29.357	29.396	29.436	29.475	29.514	29.553	29.592
830	29.632	29.671	29.710	29.749	29.789	29.828	29.867	29.906	29.945	29.985
840	30.024	30.063	30.102	30.141	30.181	30.220	30.259	30.298	30.337	30.376
850	30.416	30.455	30.494	30.533	30.572	30.611	30.651	30.690	30.729	30.768
860	30.807	30.846	30.886	30.925	30.964	31.003	31.042	31.081	31.120	31.160
870	31.199	31.238	31.277	31.316	31.355	31.394	31.433	31.473	31.512	31.551
880	31.590	31.629	31.668	31.707	31.746	31.785	31.824	31.863	31.903	31.942
890	31.981	32.020	32.059	32.098	32.137	32.176	32.215	32.254	32.293	32.332
900	32.371	32.410	32.449	32.488	32.527	32.566	32.605	32.644	32.683	32.722
910	32.761	32.800	32.839	32.878	32.917	32.956	32.995	33.034	33.073	33.112
920	33.151	33.190	33.229	33.268	33.307	33.346	33.385	33.424	33.463	33.502
930	33.541	33.580	33.619	33.658	33.697	33.736	33.774	33.813	33.852	33.891
940	33.930	33.969	34.008	34.047	34.086	34.124	34.163	34.202	34.241	34.280
950	34.319	34.358	34.396	34.435	34.474	34.513	34.552	34.591	34.629	34.668
960	34.707	34.746	34.785	34.824	34.863	34.901	34.940	34.979	35.017	35.056
970	35.095	35.134	35.172	35.211	35.250	35.289	35.327	35.366	35.405	35.444
980	35.482	35.521	35.560	35.598	35.637	35.676	35.714	35.753	35.792	35.831
990	35.869	35.908	35.946	35.985	36.024	36.062	36.101	36.140	36.178	36.217
1000	36.256	36.294	36.333	36.371	36.410	36.449	36.487	36.526	36.564	36.603
1010	36.641	36.680	36.718	36.757	36.796	36.834	36.873	36.911	36.950	36.988
1020	37.027	37.065	37.104	37.142	37.181	37.219	37.258	37.296	37.334	37.373
1030	37.411	37.450	37.488	37.527	37.565	37.603	37.642	37.680	37.719	37.757
1040	37.795	37.834	37.872	37.911	37.949	37.987	38.026	38.064	38.102	38.141
1050	38.179	38.217	38.256	38.294	38.332	38.370	38.409	38.447	38.485	38.524
1060	38.562	38.600	38.638	38.677	38.715	38.753	38.791	38.829	38.868	38.906
1070	38.944	38.982	39.020	39.059	39.097	39.135	39.173	39.211	39.249	39.287
1080	39.326	39.364	39.402	39.440	39.478	39.516	39.554	39.592	39.630	39.668
1090	39.706	39.744	39.783	39.821	39.859	39.897	39.935	39.973	40.011	40.049
1100	40.087	40.125	40.163	40.201	40.238	40.276	40.314	40.352	40.390	40.428
1110	40.466	40.504	40.542	40.580	40.618	40.655	40.693	40.731	40.769	40.807
1120	40.845	40.883	40.920	40.958	41.034	41.072	41.109	41.147	41.185	41.223
1130	41.223	41.260	41.298	41.336	41.374	41.411	41.449	41.487	41.525	41.562
1140	41.600	41.638	41.675	41.713	41.751	41.788	41.826	41.864	41.901	41.939
1150	41.976	42.014	42.052	42.089	42.127	42.164	42.202	42.239	42.277	42.314
1160	42.352	42.390	42.427	42.465	42.502	42.540	42.577	42.614	42.652	42.689
1170	42.727	42.764	42.802	42.839	42.877	42.914	42.951	42.989	43.026	43.064
1180	43.101	43.138	43.176	43.213	43.250	43.288	43.325	43.362	43.399	43.437
1190	43.474	43.511	43.549	43.586	43.623	43.660	43.698	43.735	43.772	43.809
1200	43.846	43.884	43.921	43.958	43.995	44.032	44.069	44.106	44.144	44.181
1210	44.218	44.255	44.292	44.329	44.366	44.403	44.440	44.477	44.514	44.551
1220	44.588	44.625	44.662	44.699	44.736	44.773	44.810	44.847	44.884	44.921
1230	44.958	44.995	45.032	45.069	45.105	45.142	45.179	45.216	45.253	45.290
1240	45.326	45.363	45.400	45.437	45.474	45.510	45.547	45.584	45.621	45.657
1250	45.694	45.731	45.767	45.804	45.841	45.877	45.914	45.951	45.987	46.024
1260	46.060	46.097	46.133	46.170	46.207	46.243	46.280	46.316	46.353	46.389
1270	46.425	46.462	46.498	46.535	46.571	46.608	46.644	46.680	46.717	46.753
1280	46.789	46.826	46.862	46.898	46.935	46.971	47.007	47.043	47.079	47.116
1290	47.152	47.188	47.224	47.260	47.296	47.333	47.369	47.405	47.441	47.477

ITS-90 Table for type N thermocouple										
°C	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
1100	40.087	40.125	40.163	40.201	40.238	40.276	40.314	40.352	40.390	40.428
1110	40.466	40.504	40.542	40.580	40.618	40.655	40.693	40.731	40.769	40.807
1120	40.845	40.883	40.920	40.958	40.996	41.034	41.072	41.109	41.147	41.185
1130	41.223	41.260	41.298	41.336	41.374	41.411	41.449	41.487	41.525	41.562
1140	41.600	41.638	41.675	41.713	41.751	41.788	41.826	41.864	41.901	41.939
1150	41.976	42.014	42.052	42.089	42.127	42.164	42.202	42.239	42.277	42.314
1160	42.352	42.390	42.427	42.465	42.502	42.540	42.577	42.614	42.652	42.689
1170	42.727	42.764	42.802	42.839	42.877	42.914	42.951	42.989	43.026	43.064
1180	43.101	43.138	43.176	43.213	43.250	43.288	43.325	43.362	43.399	43.437
1190	43.474	43.511	43.549	43.586	43.623	43.660	43.698	43.735	43.772	43.809
1200	43.846	43.884	43.921	43.958	43.995	44.032	44.069	44.106	44.144	44.181
1210	44.218	44.255	44.292	44.329	44.366	44.403	44.440	44.477	44.514	44.551
1220	44.588	44.625	44.662	44.699	44.736	44.773	44.810	44.847	44.884	44.921
1230	44.958	44.995	45.032	45.069	45.105	45.142	45.179	45.216	45.253	45.290
1240	45.326	45.363	45.400	45.437	45.474	45.510	45.547	45.584	45.621	45.657
1250	45.694	45.731	45.767	45.804	45.841	45.877	45.914	45.951	45.987	46.024
1260	46.060	46.097	46.133	46.170	46.207	46.243	46.280	46.316	46.353	46.389
1270	46.425	46.462	46.498	46.535	46.571	46.608	46.644	46.680	46.717	46.753
1280	46.789	46.826	46.862	46.898	46.935	46.971	47.007	47.043	47.079	47.116
1290	47.152	47.188	47.224	47.260	47.296	47.333	47.369	47.405	47.441	47.4

ITS-90 Table for type N thermocouple											
°F	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Thermoelectric Voltage in mV											
-40	-1.160	-1.146	-1.133	-1.119	-1.105	-1.092	-1.078	-1.064	-1.050	-1.037	-1.02
-30	-1.023	-1.009	-0.995	-0.981	-0.967	-0.954	-0.940	-0.926	-0.912	-0.898	-0.88
-20	-0.884	-0.870	-0.856	-0.842	-0.828	-0.814	-0.800	-0.786	-0.772	-0.758	-0.74
-10	-0.744	-0.730	-0.716	-0.702	-0.688	-0.674	-0.660	-0.646	-0.632	-0.617	-0.60
0	-0.603	-0.589	-0.575	-0.561	-0.546	-0.532	-0.518	-0.504	-0.490	-0.475	-0.46
°F	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type N thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	-0.461	-0.447	-0.433	-0.418	-0.404	-0.390	-0.375	-0.361	-0.347	-0.332	-0.31
10	-0.318	-0.304	-0.289	-0.275	-0.260	-0.246	-0.232	-0.217	-0.203	-0.188	-0.17
20	-0.174	-0.159	-0.145	-0.131	-0.116	-0.102	-0.087	-0.073	-0.058	-0.044	-0.02
30	-0.029	-0.015	0.000	0.014	0.029	0.043	0.058	0.072	0.087	0.101	0.11
40	0.116	0.130	0.145	0.159	0.174	0.188	0.203	0.217	0.232	0.246	0.26
50	0.261	0.275	0.290	0.305	0.319	0.334	0.349	0.363	0.378	0.393	0.40
60	0.407	0.422	0.437	0.451	0.466	0.481	0.496	0.510	0.525	0.540	0.55
70	0.555	0.570	0.584	0.599	0.614	0.629	0.644	0.659	0.674	0.688	0.70
80	0.703	0.718	0.733	0.748	0.763	0.778	0.793	0.808	0.823	0.838	0.85
90	0.853	0.868	0.883	0.898	0.913	0.928	0.943	0.958	0.974	0.989	1.00
100	1.004	1.019	1.034	1.049	1.065	1.080	1.095	1.110	1.125	1.141	1.15
110	1.156	1.171	1.186	1.202	1.217	1.232	1.248	1.263	1.278	1.294	1.30
120	1.309	1.324	1.340	1.355	1.371	1.386	1.402	1.417	1.432	1.448	1.46
130	1.463	1.479	1.494	1.510	1.525	1.541	1.557	1.572	1.588	1.603	1.61
140	1.619	1.635	1.650	1.666	1.682	1.697	1.713	1.729	1.744	1.760	1.77
150	1.776	1.791	1.807	1.823	1.839	1.855	1.870	1.886	1.902	1.918	1.93
160	1.934	1.950	1.965	1.981	1.997	2.013	2.029	2.045	2.061	2.077	2.09
170	2.093	2.109	2.125	2.141	2.157	2.173	2.189	2.205	2.221	2.237	2.25
180	2.253	2.269	2.285	2.301	2.318	2.334	2.350	2.366	2.382	2.398	2.41
190	2.415	2.431	2.447	2.463	2.480	2.496	2.512	2.528	2.545	2.561	2.57
200	2.577	2.594	2.610	2.626	2.643	2.659	2.676	2.692	2.708	2.725	2.74
210	2.741	2.758	2.774	2.791	2.807	2.824	2.840	2.857	2.873	2.890	2.90
220	2.906	2.923	2.939	2.956	2.973	2.989	3.006	3.022	3.039	3.056	3.07
230	3.072	3.089	3.106	3.123	3.139	3.156	3.173	3.189	3.206	3.223	3.24
240	3.240	3.257	3.273	3.290	3.307	3.324	3.341	3.358	3.374	3.391	3.40
250	3.408	3.425	3.442	3.459	3.476	3.493	3.510	3.527	3.544	3.561	3.57
260	3.578	3.595	3.612	3.629	3.646	3.663	3.680	3.697	3.714	3.731	3.74
270	3.748	3.766	3.783	3.800	3.817	3.834	3.851	3.869	3.886	3.903	3.92
280	3.920	3.937	3.955	3.972	3.989	4.007	4.024	4.041	4.058	4.076	4.09
290	4.093	4.110	4.128	4.145	4.162	4.180	4.197	4.215	4.232	4.250	4.26
300	4.267	4.284	4.302	4.319	4.337	4.354	4.372	4.389	4.407	4.424	4.44
310	4.442	4.459	4.477	4.495	4.512	4.530	4.547	4.565	4.583	4.600	4.61
320	4.618	4.635	4.653	4.671	4.688	4.706	4.724	4.742	4.759	4.777	4.79
330	4.795	4.813	4.830	4.848	4.866	4.884	4.901	4.919	4.937	4.955	4.97
340	4.973	4.991	5.008	5.026	5.044	5.062	5.080	5.098	5.116	5.134	5.15
350	5.152	5.170	5.188	5.206	5.224	5.241	5.259	5.277	5.295	5.314	5.33
360	5.332	5.350	5.368	5.386	5.404	5.422	5.440	5.458	5.476	5.494	5.51
370	5.512	5.531	5.549	5.567	5.585	5.603	5.621	5.639	5.658	5.676	5.69
380	5.694	5.712	5.731	5.749	5.767	5.785	5.804	5.822	5.840	5.858	5.87
390	5.877	5.895	5.913	5.932	5.950	5.968	5.987	6.005	6.024	6.042	6.06
400	6.060	6.079	6.097	6.116	6.134	6.152	6.171	6.189	6.208	6.226	6.24
410	6.245	6.263	6.282	6.300	6.319	6.337	6.356	6.374	6.393	6.411	6.43
420	6.430	6.449	6.467	6.486	6.504	6.523	6.542	6.560	6.579	6.597	6.61
430	6.616	6.635	6.653	6.672	6.691	6.710	6.728	6.747	6.766	6.784	6.80
440	6.803	6.822	6.841	6.859	6.878	6.897	6.916	6.934	6.953	6.972	6.99
450	6.991	7.010	7.029	7.047	7.066	7.085	7.104	7.123	7.142	7.161	7.17
460	7.179	7.198	7.217	7.236	7.255	7.274	7.293	7.312	7.331	7.350	7.36
470	7.369	7.388	7.407	7.426	7.445	7.464	7.483	7.502	7.521	7.540	7.55
480	7.559	7.578	7.597	7.616	7.635	7.654	7.673	7.692	7.711	7.731	7.75
490	7.750	7.769	7.788	7.807	7.826	7.845	7.865	7.884	7.903	7.922	7.94
500	7.941	7.960	7.980	7.999	8.018	8.037	8.057	8.076	8.095	8.114	8.13
510	8.134	8.153	8.172	8.191	8.211	8.230	8.249	8.269	8.288	8.307	8.32
520	8.327	8.346	8.365	8.385	8.404	8.423	8.443	8.462	8.482	8.501	8.52
530	8.520	8.540	8.559	8.579	8.598	8.617	8.637	8.656	8.676	8.695	8.71
540	8.715	8.734	8.754	8.773	8.793	8.812	8.832	8.851	8.871	8.890	8.91
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type N thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
550	8.910	8.929	8.949	8.968	8.988	9.008	9.027	9.047	9.066	9.086	9.10
560	9.105	9.125	9.145	9.164	9.184	9.204	9.223	9.243	9.262	9.282	9.30
570	9.302	9.321	9.341	9.361	9.381	9.400	9.420	9.440	9.459	9.479	9.49
580	9.499	9.519	9.538	9.558	9.578	9.598	9.617	9.637	9.657	9.677	9.69
590	9.696	9.716	9.736	9.756	9.776	9.795	9.815	9.835	9.855	9.875	9.89
600	9.895	9.914	9.934	9.954	9.974	9.994	10.014	10.034	10.054	10.073	10.09
610	10.093	10.113	10.133	10.153	10.173	10.193	10.213	10.233	10.253	10.273	10.29
620	10.293	10.313	10.333	10.353	10.373	10.393	10.413	10.433	10.453	10.473	10.49
630	10.493	10.513	10.533	10.553	10.573	10.593	10.613	10.633	10.653	10.673	10.69
640	10.693	10.713	10.733	10.753	10.774	10.794	10.814	10.834	10.854	10.874	10.89
650	10.894	10.914	10.934	10.955	10.975	10.995	11.015	11.035	11.055	11.076	11.09
660	11.096	11.116	11.136	11.156	11.177	11.197	11.217	11.237	11.257	11.278	11.29
670	11.298	11.318	11.338	11.359	11.379	11.399	11.419	11.440	11.460	11.480	11.50
680	11.501	11.521	11.541	11.561	11.582	11.602	11.622	11.643	11.663	11.683	11.70
690	11.704	11.724	11.744	11.765	11.785	11.805	11.826	11.846	11.867	11.887	11.90
700	11.907	11.928	11.948	11.968	11.989	12.009	12.030	12.050	12.071	12.091	12.11
710	12.111	12.132	12.152	12.173	12.193	12.214	12.234	12.255	12.275	12.295	12.31
720	12.316	12.336	12.357	12.377	12.398	12.418	12.439	12.459	12.480	12.500	12.52
730	12.521	12.542	12.562	12.583	12.603	12.624	12.644	12.665	12.685	12.706	12.72
740	12.726	12.747	12.768	12.788	12.809	12.829	12.850	12.871	12.891	12.912	12.93
750	12.932	12.953	12.974	12.994	13.015	13.036	13.056	13.077	13.098	13.118	13.13
760	13.139	13.159	13.180	13.201	13.221	13.242	13.263	13.284	13.304	13.325	13.34
770	13.346	13.366	13.387	13.408	13.428	13.449	13.470	13.491	13.511	13.532	13.55
780	13.553	13.574	13.594	13.615	13.636	13.657	13.677	13.698	13.719	13.740	13.76
790	13.760	13.781	13.802	13.823	13.844	13.864	13.885	13.906	13.927	13.948	13.96
800	13.969	13.989	14.010	14.031	14.052	14.073	14.094	14.114	14.135	14.156	14.17
810	14.177	14.198	14.219	14.240	14.260	14.281	14.302	14.323	14.344	14.365	14.38
820	14.386	14.407	14.428	14.448	14.469	14.490	14.511	14.532	14.553	14.574	14.59
830	14.595	14.616	14.637	14.658	14.679	14.700	14.721	14.742	14.763	14.784	14.80
840	14.804	14.825	14.846	14.867	14.888	14.909	14.930	14.951	14.972	14.993	15.01
850	15.014	15.035	15.056	15.077	15.098	15.119	15.140	15.162	15.183	15.204	15.22
860	15.225	15.246	15.267	15.288	15.309	15.330	15.351	15.372	15.393	15.414	15.43
870	15.435	15.456	15.477	15.498	15.520	15.541	15.562	15.583	15.604	15.625	15.64
880	15.646	15.667	15.688	15.709	15.731	15.752	15.773	15.794	15.815	15.836	15.85
890	15.857	15.878	15.900	15.921	15.942	15.963	15.984	16.005	16.027	16.048	16.06
900	16.069	16.090	16.111	16.132	16.154	16.175	16.196	16.217	16.238	16.260	16.28
910	16.281	16.302	16.323	16.344	16.366	16.387	16.408	16.429	16.450	16.472	16.49
920	16.493	16.514	16.535	16.557	16.578	16.599	16.620	16.642	16.663	16.684	16.70
930	16.705	16.727	16.748	16.769	16.790	16.812	16.833	16.854	16.875	16.897	16.91
940	16.918	16.939	16.961	16.982	17.003	17.025	17.046	17.067	17.088	17.110	17.13
950	17.131	17.152	17.174	17.195	17.216	17.238	17.259	17.280	17.302	17.323	17.34
960	17.344	17.366	17.387	17.408	17.430	17.451	17.472	17.494	17.515	17.536	17.55
970	17.558	17.579	17.601	17.622	17.643	17.665	17.686	17.707	17.729	17.750	17.77
980	17.772	17.793	17.814	17.836	17.857	17.879	17.900	17.921	17.943	17.964	17.98
990	17.986	18.007	18.028	18.050	18.071	18.093	18.114	18.136	18.157	18.178	18.20
1000	18.200	18.221	18.243	18.264	18.286	18.307	18.328	18.350	18.371	18.393	18.41
1010	18.414	18.436	18.457	18.479	18.500	18.522	18.543	18.565	18.586	18.608	18.62
1020	18.629	18.650	18.672	18.693	18.715	18.736	18.758	18.779	18.801	18.822	18.84
1030	18.844	18.865	18.887	18.908	18.930	18.951	18.973	18.994	19.016	19.037	19.05
1040	19.059	19.081	19.102	19.124	19.145	19.167	19.188	19.210	19.231	19.253	19.27
1050	19.274	19.296	19.317	19.339	19.360	19.382	19.404	19.425	19.447	19.468	19.49
1060	19.490	19.511	19.533	19.554	19.576	19.598	19.619	19.641	19.662	19.684	19.70
1070	19.705	19.727	19.749	19.770	19.792	19.813	19.835	19.857	19.878	19.900	19.92
1080	19.921	19.943	19.964	19.986	20.008	20.029	20.051	20.072	20.094	20.116	20.13
1090	20.137	20.159	20.181	20.202	20.224	20.245	20.267	20.289	20.310	20.332	20.35
1100	20.353	20.375	20.397	20.418	20.440	20.462	20.483	20.505	20.527	20.548	20.57
1110	20.570	20.591	20.613	20.635	20.656	20.678	20.700	20.721	20.743	20.765	20.78
1120	20.786	20.808	20.830	20.851	20.873	20.895	20.916	20.938	20.960	20.981	21.00
1130	21.003	21.025	21.046	21.068	21.090	21.111	21.133	21.155	21.176	21.198	21.22
1140	21.220	21.241	21.263	21.285	21.306	21.328	21.350	21.371	21.393	21.415	21.43
1150	21.437	21.458	21.480	21.502	21.523	21.545	21.567	21.588	21.610	21.632	21.65
1160	21.654	21.675	21.697	21.719	21.740	21.762	21.784	21.806	21.827	21.849	21.87
1170	21.871	21.892	21.914	21.936	21.958	21.979	22.001	22.023	22.044	22.066	22.08
1180	22.088	22.110	22.131	22.153	22.175	22.197	22.218	22.240	22.262	22.284	22.30
1190	22.305	22.327	22.349	22.370	22.392	22.414	22.436	22.457	22.479	22.501	22.52
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type N thermocouple										
°F	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
1100	20.353	20.375	20.397	20.418	20.440	20.462	20.483	20.505	20.527	20.548
1110	20.570	20.591	20.613	20.635	20.656	20.678	20.700	20.721	20.743	20.765
1120	20.786	20.808	20.830	20.851	20.873	20.895	20.916	20.938	20.960	20.981
1130	21.003	21.025	21.046	21.068	21.090	21.111	21.133	21.155	21.176	21.198
1140	21.220	21.241	21.263	21.285	21.306	21.328	21.350	21.371	21.393	21.415
1150	21.437	21.458	21.480	21.502	21.523	21.545	21.567	21.588	21.610	21.632
1160	21.654	21.675	21.697	21.719	21.740	21.762	21.784	21.806	21.827	21.849
1170	21.871	21.892	21.914	21.936	21.958	21.979	22.001	22.023	22.044	22.066
1180	22.088	22.110	22.131	22.153	22.175	22.197	22.218	22.240	22.262	22.284
1190	22.305	22.327	22.349	22.370	22.392	22.414	22.436	22.457	22.479	22.501
1200	22.523	22.544	22.566	22.588	22.610	22.631	22.653	22.675	22.697	22.718
1210	22.740	22.762	22.784	22.805	22.827	22.849	22.871	22.893	22.914	22.936
1220	22.958	22.980	23.001	23.023	23.045	23.067	23.088	23.110	23.132	23.154
1230	23.176	23.197	23.219	23.241	23.263	23.284	23.306	23.328	23.350	23.372
1240	23.393	23.415	23.437	23.459	23.480	23.502	23.524	23.546	23.568	23.589
1250	23.611	23.633	23.655	23.676	23.698	23.720	23.742	23.764	23.785	23.807
1260	23.829	23.851	23.873	23.894	23.916	23.938	23.960	23.982	24.003	24.025
1270	24.047	24.069	24.091	24.112	24.134	24.156	24.178	24.200	24.221	24.243
1280	24.265	24.287	24.309	24.330	24.352	24.374	24.396	24.418	24.439	24.461
1290	24.483	24.505	24.527	24.548	24.570	24.592	24.614	24.636	24.658	24.679
1300	24.701	24.723	24.745	24.767	24.788	24.810	24.832	24.854	24.876	24.897
1310	24.919	24.941	24.963	24.985	25.007	25.028	25.050	25.072	25.094	25.116
1320	25.137	25.159	25.181	25.203	25.225	25.247	25.268	25.290	25.312	25.334
1330	25.356	25.377	25.399	25.421	25.443	25.465	25.487	25.508	25.530	25.552
1340	25.574	25.596	25.618	25.639	25.661	25.683	25.705	25.727	25.748	25.770
1350	25.792	25.814	25.836	25.858	25.879	25.901	25.923	25.945	25.967	25.989
1360	26.010	26.032	26.054	26.076	26.098	26.119	26.141	26.163	26.185	26.207
1370	26.229	26.250	26.272	26.294	26.316	26.338	26.360	26.381	26.403	26.425
1380	26.447	26.469	26.491	26.512	26.534	26.556	26.578	26.600	26.622	26.644
1390	26.665	26.687	26.709	26.731	26.752	26.774	26.796	26.818	26.840	26.862
1400	26.883	26.905	26.927	26.949	26.971	26.993	27.014	27.036	27.058	27.080
1410	27.102	27.124	27.145	27.167	27.189	27.211	27.233	27.254	27.276	27.298
1420	27.320	27.342	27.364	27.385	27.407	27.429	27.451	27.473	27.495	27.516
1430	27.538	27.560	27.582	27.604	27.625	27.647	27.669	27.691	27.713	27.735
1440	27.756	27.778	27.800	27.822	27.844	27.866	27.887	27.909	27.931	27.953
1450	27.975	27.996	28.018	28.040	28.062	28.084	28.105	28.127	28.149	28.171
1460	28.193	28.215	28.236	28.258	28.280	28.302	28.324	28.345	28.367	28.389
1470	28.411	28.433	28.455	28.476	28.498	28.520	28.542	28.564	28.585	28.607
1480	28.629	28.651	28.673	28.694	28.716	28.738	28.760	28.782	28.803	28.825
1490	28.847	28.869	28.891	28.912	28.934	28.956	28.978	29.000	29.021	29.043
1500	29.065	29.087	29.109	29.130	29.152	29.174	29.196	29.218	29.239	29.261
1510	29.283	29.305	29.327	29.348	29.370	29.392	29.414	29.436	29.457	29.479
1520	29.501	29.523	29.545	29.566	29.588	29.610	29.632	29.653	29.675	29.697
1530	29.719	29.741	29.762	29.784	29.806	29.828	29.850	29.871	29.893	29.915
1540	29.937	29.958	29.980	30.002	30.024	30.046	30.067	30.089	30.111	30.133
1550	30.154	30.176	30.198	30.220	30.242	30.263	30.285	30.307	30.329	30.350
1560	30.372	30.394	30.416	30.437	30.459	30.481	30.503	30.524	30.546	30.568
1570	30.590	30.611	30.633	30.655	30.677	30.699	30.720	30.742	30.764	30.786
1580	30.807	30.829	30.851	30.873	30.894	30.916	30.938	30.960	30.981	31.003
1590	31.025	31.047	31.068	31.090	31.112	31.133	31.155	31.177	31.199	31.220
1600	31.242	31.264	31.286	31.307	31.329	31.351	31.373	31.394	31.416	31.438
1610	31.459	31.481	31.503	31.525	31.546	31.568	31.590	31.612	31.633	31.655
1620	31.677	31.698	31.720	31.742	31.764	31.785	31.807	31.829	31.850	31.872
1630	31.894	31.916	31.937	31.959	31.981	32.002	32.024	32.046	32.068	32.089
1640	32.111	32.133	32.154	32.176	32.198	32.219	32.241	32.263	32.284	32.306
1650	32.328	32.350	32.371	32.393	32.415	32.436	32.458	32.480	32.501	32.523
1660	32.545	32.566	32.588	32.610	32.631	32.653	32.675	32.696	32.718	32.740
1670	32.761	32.783	32.805	32.826	32.848	32.870	32.891	32.913	32.935	32.956
1680	32.978	33.000	33.021	33.043	33.065	33.086	33.108	33.130	33.151	33.173
1690	33.195	33.216	33.238	33.260	33.281	33.303	33.325	33.346	33.368	33.389
1700	33.411	33.433	33.454	33.476	33.498	33.519	33.541	33.563	33.584	33.606
1710	33.627	33.649	33.671	33.692	33.714	33.736	33.757	33.779	33.800	33.822
1720	33.844	33.865	33.887	33.908	33.930	33.952	33.973	33.995	34.016	34.038
1730	34.060	34.081	34.103	34.124	34.146	34.168	34.189	34.211	34.232	34.254
1740	34.276	34.297	34.319	34.340	34.362	34.384	34.405	34.427	34.448	34.470

ITS-90 Table for type N thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
1700	33.411	33.433	33.454	33.476	33.498	33.519	33.541	33.563	33.584	33.606	33.62
1710	33.627	33.649	33.671	33.692	33.714	33.736	33.757	33.779	33.800	33.822	33.84
1720	33.844	33.865	33.887	33.908	33.930	33.952	33.973	33.995	34.016	34.038	34.06
1730	34.066	34.081	34.103	34.124	34.146	34.168	34.189	34.211	34.232	34.254	34.27
1740	34.276	34.297	34.319	34.340	34.362	34.384	34.405	34.427	34.448	34.470	34.49
1750	34.491	34.513	34.535	34.556	34.578	34.599	34.621	34.642	34.664	34.686	34.70
1760	34.707	34.729	34.750	34.772	34.793	34.815	34.836	34.858	34.879	34.901	34.92
1770	34.923	34.944	34.966	34.987	35.009	35.030	35.052	35.073	35.095	35.116	35.13
1780	35.138	35.160	35.181	35.203	35.224	35.246	35.267	35.289	35.310	35.332	35.35
1790	35.353	35.375	35.396	35.418	35.439	35.461	35.482	35.504	35.525	35.547	35.56
1800	35.568	35.590	35.611	35.633	35.654	35.676	35.697	35.719	35.740	35.762	35.78
1810	35.783	35.805	35.826	35.848	35.869	35.891	35.912	35.934	35.955	35.977	35.99
1820	35.998	36.019	36.041	36.062	36.084	36.105	36.127	36.148	36.170	36.191	36.21
1830	36.213	36.234	36.256	36.277	36.298	36.320	36.341	36.363	36.384	36.406	36.42
1840	36.427	36.449	36.470	36.491	36.513	36.534	36.556	36.577	36.599	36.620	36.64
1850	36.641	36.663	36.684	36.706	36.727	36.748	36.770	36.791	36.813	36.834	36.85
1860	36.855	36.877	36.898	36.920	36.941	36.962	36.984	37.005	37.027	37.048	37.06
1870	37.069	37.091	37.112	37.134	37.155	37.176	37.198	37.219	37.240	37.262	37.28
1880	37.283	37.305	37.326	37.347	37.369	37.390	37.411	37.433	37.454	37.475	37.49
1890	37.497	37.518	37.539	37.561	37.582	37.603	37.625	37.646	37.667	37.689	37.71
1900	37.710	37.731	37.753	37.774	37.795	37.817	37.838	37.859	37.881	37.902	37.92
1910	37.923	37.945	37.966	37.987	38.009	38.030	38.051	38.073	38.094	38.115	38.13
1920	38.136	38.158	38.179	38.200	38.222	38.243	38.264	38.285	38.307	38.328	38.34
1930	38.349	38.370	38.392	38.413	38.434	38.456	38.477	38.498	38.519	38.541	38.56
1940	38.562	38.583	38.604	38.626	38.647	38.668	38.689	38.711	38.732	38.753	38.77
1950	38.774	38.795	38.817	38.838	38.859	38.880	38.902	38.923	38.944	38.965	38.98
1960	38.986	39.008	39.029	39.050	39.071	39.093	39.114	39.135	39.156	39.177	39.19
1970	39.198	39.220	39.241	39.262	39.283	39.304	39.326	39.347	39.368	39.389	39.41
1980	39.410	39.431	39.453	39.474	39.495	39.516	39.537	39.558	39.580	39.601	39.62
1990	39.622	39.643	39.664	39.685	39.706	39.728	39.749	39.770	39.791	39.812	39.83
2000	39.833	39.854	39.875	39.897	39.918	39.939	39.960	39.981	40.002	40.023	40.04
2010	40.044	40.066	40.087	40.108	40.129	40.150	40.171	40.192	40.213	40.234	40.25
2020	40.255	40.276	40.297	40.319	40.340	40.361	40.382	40.403	40.424	40.445	40.46
2030	40.466	40.487	40.508	40.529	40.550	40.571	40.592	40.613	40.634	40.655	40.67
2040	40.677	40.698	40.719	40.740	40.761	40.782	40.803	40.824	40.845	40.866	40.88
2050	40.887	40.908	40.929	40.950	40.971	40.992	41.013	41.034	41.055	41.076	41.09
2060	41.097	41.118	41.139	41.160	41.181	41.202	41.223	41.244	41.265	41.286	41.30
2070	41.307	41.328	41.349	41.370	41.390	41.411	41.432	41.453	41.474	41.495	41.51
2080	41.516	41.537	41.558	41.579	41.600	41.621	41.642	41.663	41.684	41.705	41.72
2090	41.725	41.746	41.767	41.788	41.809	41.830	41.851	41.872	41.893	41.914	41.93
2100	41.935	41.955	41.976	41.997	42.018	42.039	42.060	42.081	42.102	42.123	42.14
2110	42.143	42.164	42.185	42.206	42.227	42.248	42.269	42.289	42.310	42.331	42.35
2120	42.352	42.373	42.394	42.415	42.435	42.456	42.477	42.498	42.519	42.540	42.56
2130	42.560	42.581	42.602	42.623	42.644	42.664	42.685	42.706	42.727	42.748	42.76
2140	42.768	42.789	42.810	42.831	42.852	42.872	42.893	42.914	42.935	42.956	42.97
2150	42.976	42.997	43.018	43.039	43.059	43.080	43.101	43.122	43.142	43.163	43.18
2160	43.184	43.205	43.225	43.246	43.267	43.288	43.308	43.329	43.350	43.370	43.39
2170	43.391	43.412	43.433	43.453	43.474	43.495	43.515	43.536	43.557	43.578	43.59
2180	43.598	43.619	43.640	43.660	43.681	43.702	43.722	43.743	43.764	43.784	43.80
2190	43.805	43.826	43.846	43.867	43.888	43.908	43.929	43.950	43.970	43.991	44.01
2200	44.012	44.032	44.053	44.073	44.094	44.115	44.135	44.156	44.177	44.197	44.21
2210	44.218	44.238	44.259	44.280	44.300	44.321	44.341	44.362	44.383	44.403	44.42
2220	44.424	44.444	44.465	44.485	44.506	44.527	44.547	44.568	44.588	44.609	44.62
2230	44.629	44.650	44.671	44.691	44.712	44.732	44.753	44.773	44.794	44.814	44.83
2240	44.835	44.855	44.876	44.896	44.917	44.937	44.958	44.978	44.999	45.019	45.04
2250	45.040	45.060	45.081	45.101	45.122	45.142	45.163	45.183	45.204	45.224	45.24
2260	45.245	45.265	45.286	45.306	45.326	45.347	45.367	45.388	45.408	45.429	45.44
2270	45.449	45.469	45.490	45.510	45.531	45.551	45.572	45.592	45.612	45.633	45.65
2280	45.653	45.674	45.694	45.714	45.735	45.755	45.775	45.796	45.816	45.837	45.85
2290	45.857	45.877	45.898	45.918	45.938	45.959	45.979	45.999	46.020	46.040	46.06
2300	46.060	46.081	46.101	46.121	46.142	46.162	46.182	46.202	46.223	46.243	46.26
2310	46.263	46.284	46.304	46.324	46.344	46.365	46.385	46.405	46.425	46.446	46.46
2320	46.466	46.486	46.506	46.527	46.547	46.567	46.587	46.608	46.628	46.648	46.66
2330	46.668	46.688	46.709	46.729	46.749	46.769	46.789	46.810	46.830	46.850	46.87
2340	46.870	46.890	46.910	46.931	46.951	46.971	46.991	47.011	47.031	47.051	47.07
2350	47.071	47.092	47.112	47.132	47.152	47.172	47.192	47.212	47.232	47.252	47.27
2360	47.272	47.292	47.312	47.333	47.353	47.373	47.393	47.413	47.433	47.453	47.47
2370	47.473	47.493	47.513								
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type R thermocouple											
°F	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Thermoelectric Voltage in mV											
-40	-0.210	-0.208	-0.205	-0.203	-0.201	-0.199	-0.197	-0.194	-0.192	-0.190	-0.18
-30	-0.188	-0.185	-0.183	-0.181	-0.179	-0.176	-0.174	-0.172	-0.169	-0.167	-0.16
-20	-0.165	-0.162	-0.160	-0.158	-0.155	-0.153	-0.150	-0.148	-0.145	-0.143	-0.14
-10	-0.141	-0.138	-0.136	-0.133	-0.131	-0.128	-0.126	-0.123	-0.121	-0.118	-0.11
0	-0.116	-0.113	-0.110	-0.108	-0.105	-0.103	-0.100	-0.097	-0.095	-0.092	-0.09
°F	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type R thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	-0.090	-0.087	-0.084	-0.082	-0.079	-0.076	-0.073	-0.071	-0.068	-0.065	-0.06
10	-0.063	-0.060	-0.057	-0.054	-0.051	-0.049	-0.046	-0.043	-0.040	-0.037	-0.03
20	-0.035	-0.032	-0.029	-0.026	-0.023	-0.020	-0.017	-0.015	-0.012	-0.009	-0.00
30	-0.006	-0.003	0.000	0.003	0.006	0.009	0.012	0.015	0.018	0.021	0.02
40	0.024	0.027	0.030	0.033	0.036	0.039	0.042	0.045	0.048	0.051	0.05
50	0.054	0.057	0.060	0.064	0.067	0.070	0.073	0.076	0.079	0.082	0.08
60	0.086	0.089	0.092	0.095	0.098	0.102	0.105	0.108	0.111	0.114	0.11
70	0.118	0.121	0.124	0.127	0.131	0.134	0.137	0.141	0.144	0.147	0.15
80	0.151	0.154	0.157	0.161	0.164	0.167	0.171	0.174	0.177	0.181	0.18
90	0.184	0.188	0.191	0.194	0.198	0.201	0.205	0.208	0.212	0.215	0.21
100	0.218	0.222	0.225	0.229	0.232	0.236	0.239	0.243	0.246	0.250	0.25
110	0.254	0.257	0.261	0.264	0.268	0.271	0.275	0.278	0.282	0.286	0.28
120	0.289	0.293	0.296	0.300	0.304	0.307	0.311	0.315	0.318	0.322	0.32
130	0.326	0.329	0.333	0.337	0.340	0.344	0.348	0.352	0.355	0.359	0.36
140	0.363	0.366	0.370	0.374	0.378	0.382	0.385	0.389	0.393	0.397	0.40
150	0.400	0.404	0.408	0.412	0.416	0.420	0.423	0.427	0.431	0.435	0.43
160	0.439	0.443	0.447	0.450	0.454	0.458	0.462	0.466	0.470	0.474	0.47
170	0.478	0.482	0.486	0.489	0.493	0.497	0.501	0.505	0.509	0.513	0.51
180	0.517	0.521	0.525	0.529	0.533	0.537	0.541	0.545	0.549	0.553	0.55
190	0.557	0.561	0.565	0.569	0.573	0.578	0.582	0.586	0.590	0.594	0.59
200	0.598	0.602	0.606	0.610	0.614	0.618	0.623	0.627	0.631	0.635	0.63
210	0.639	0.643	0.647	0.652	0.656	0.660	0.664	0.668	0.672	0.677	0.68
220	0.681	0.685	0.689	0.693	0.698	0.702	0.706	0.710	0.715	0.719	0.72
230	0.723	0.727	0.732	0.736	0.740	0.744	0.749	0.753	0.757	0.761	0.76
240	0.766	0.770	0.774	0.779	0.783	0.787	0.792	0.796	0.800	0.805	0.80
250	0.809	0.813	0.818	0.822	0.826	0.831	0.835	0.839	0.844	0.848	0.85
260	0.853	0.857	0.861	0.866	0.870	0.875	0.879	0.883	0.888	0.892	0.89
270	0.897	0.901	0.906	0.910	0.915	0.919	0.923	0.928	0.932	0.937	0.94
280	0.941	0.946	0.950	0.955	0.959	0.964	0.968	0.973	0.977	0.982	0.98
290	0.986	0.991	0.995	1.000	1.005	1.009	1.014	1.018	1.023	1.027	1.03
300	1.032	1.036	1.041	1.046	1.050	1.055	1.059	1.064	1.069	1.073	1.07
310	1.078	1.082	1.087	1.092	1.096	1.101	1.105	1.110	1.115	1.119	1.12
320	1.124	1.129	1.133	1.138	1.143	1.147	1.152	1.157	1.161	1.166	1.17
330	1.171	1.175	1.180	1.185	1.190	1.194	1.199	1.204	1.208	1.213	1.21
340	1.218	1.223	1.227	1.232	1.237	1.242	1.246	1.251	1.256	1.261	1.26
350	1.265	1.270	1.275	1.280	1.284	1.289	1.294	1.299	1.304	1.308	1.31
360	1.313	1.318	1.323	1.328	1.332	1.337	1.342	1.347	1.352	1.356	1.36
370	1.361	1.366	1.371	1.376	1.381	1.386	1.390	1.395	1.400	1.405	1.41
380	1.410	1.415	1.420	1.425	1.429	1.434	1.439	1.444	1.449	1.454	1.45
390	1.459	1.464	1.469	1.473	1.478	1.483	1.488	1.493	1.498	1.503	1.50
400	1.508	1.513	1.518	1.523	1.528	1.533	1.538	1.543	1.548	1.553	1.55
410	1.558	1.563	1.568	1.572	1.577	1.582	1.587	1.592	1.597	1.602	1.60
420	1.607	1.612	1.617	1.622	1.627	1.632	1.638	1.643	1.648	1.653	1.65
430	1.658	1.663	1.668	1.673	1.678	1.683	1.688	1.693	1.698	1.703	1.70
440	1.708	1.713	1.718	1.723	1.728	1.733	1.739	1.744	1.749	1.754	1.75
450	1.759	1.764	1.769	1.774	1.779	1.784	1.790	1.795	1.800	1.805	1.81
460	1.810	1.815	1.820	1.825	1.831	1.836	1.841	1.846	1.851	1.856	1.86
470	1.861	1.867	1.872	1.877	1.882	1.887	1.892	1.898	1.903	1.908	1.91
480	1.913	1.918	1.923	1.929	1.934	1.939	1.944	1.949	1.955	1.960	1.96
490	1.965	1.970	1.975	1.981	1.986	1.991	1.996	2.002	2.007	2.012	2.01
500	2.017	2.022	2.028	2.033	2.038	2.043	2.049	2.054	2.059	2.064	2.07
510	2.070	2.075	2.080	2.085	2.091	2.096	2.101	2.107	2.112	2.117	2.12
520	2.122	2.128	2.133	2.138	2.144	2.149	2.154	2.159	2.165	2.170	2.17
530	2.175	2.181	2.186	2.191	2.197	2.202	2.207	2.213	2.218	2.223	2.22
540	2.229	2.234	2.239	2.245	2.250	2.255	2.261	2.266	2.271	2.277	2.28
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type R thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
550	2.282	2.287	2.293	2.298	2.304	2.309	2.314	2.320	2.325	2.330	2.33
560	2.336	2.341	2.347	2.352	2.357	2.363	2.368	2.374	2.379	2.384	2.39
570	2.390	2.395	2.401	2.406	2.411	2.417	2.422	2.428	2.433	2.438	2.44
580	2.444	2.449	2.455	2.460	2.466	2.471	2.477	2.482	2.487	2.493	2.49
590	2.498	2.504	2.509	2.515	2.520	2.526	2.531	2.537	2.542	2.547	2.55
600	2.553	2.558	2.564	2.569	2.575	2.580	2.586	2.591	2.597	2.602	2.60
610	2.608	2.613	2.619	2.624	2.630	2.635	2.641	2.646	2.652	2.657	2.66
620	2.663	2.668	2.674	2.679	2.685	2.690	2.696	2.701	2.707	2.713	2.71
630	2.718	2.724	2.729	2.735	2.740	2.746	2.751	2.757	2.762	2.768	2.77
640	2.773	2.779	2.785	2.790	2.796	2.801	2.807	2.812	2.818	2.824	2.82
650	2.829	2.835	2.840	2.846	2.851	2.857	2.863	2.868	2.874	2.879	2.88
660	2.885	2.891	2.896	2.902	2.907	2.913	2.919	2.924	2.930	2.935	2.94
670	2.941	2.947	2.952	2.958	2.964	2.969	2.975	2.980	2.986	2.992	2.99
680	2.997	3.003	3.009	3.014	3.020	3.026	3.031	3.037	3.042	3.048	3.05
690	3.054	3.059	3.065	3.071	3.076	3.082	3.088	3.093	3.099	3.105	3.11
700	3.110	3.116	3.122	3.127	3.133	3.139	3.144	3.150	3.156	3.161	3.16
710	3.167	3.173	3.179	3.184	3.190	3.196	3.201	3.207	3.213	3.218	3.22
720	3.224	3.230	3.236	3.241	3.247	3.253	3.258	3.264	3.270	3.276	3.28
730	3.281	3.287	3.293	3.298	3.304	3.310	3.316	3.321	3.327	3.333	3.33
740	3.339	3.344	3.350	3.356	3.362	3.367	3.373	3.379	3.385	3.390	3.39
750	3.396	3.402	3.408	3.413	3.419	3.425	3.431	3.437	3.442	3.448	3.45
760	3.454	3.460	3.465	3.471	3.477	3.483	3.489	3.494	3.500	3.506	3.51
770	3.512	3.517	3.523	3.529	3.535	3.541	3.546	3.552	3.558	3.564	3.57
780	3.570	3.576	3.581	3.587	3.593	3.599	3.605	3.610	3.616	3.622	3.62
790	3.628	3.634	3.640	3.645	3.651	3.657	3.663	3.669	3.675	3.680	3.68
800	3.686	3.692	3.698	3.704	3.710	3.716	3.721	3.727	3.733	3.739	3.74
810	3.745	3.751	3.757	3.762	3.768	3.774	3.780	3.786	3.792	3.798	3.80
820	3.803	3.809	3.815	3.821	3.827	3.833	3.839	3.845	3.851	3.856	3.86
830	3.862	3.868	3.874	3.880	3.886	3.892	3.898	3.904	3.909	3.915	3.92
840	3.921	3.927	3.933	3.939	3.945	3.951	3.957	3.963	3.969	3.975	3.98
850	3.980	3.986	3.992	3.998	4.004	4.010	4.016	4.022	4.028	4.034	4.04
860	4.040	4.046	4.052	4.058	4.064	4.069	4.075	4.081	4.087	4.093	4.09
870	4.099	4.105	4.111	4.117	4.123	4.129	4.135	4.141	4.147	4.153	4.15
880	4.159	4.165	4.171	4.177	4.183	4.189	4.195	4.201	4.207	4.213	4.21
890	4.219	4.225	4.231	4.237	4.243	4.249	4.255	4.261	4.267	4.273	4.27
900	4.279	4.285	4.291	4.297	4.303	4.309	4.315	4.321	4.327	4.333	4.33
910	4.339	4.345	4.351	4.357	4.363	4.369	4.375	4.381	4.387	4.393	4.39
920	4.399	4.405	4.411	4.417	4.423	4.429	4.435	4.441	4.447	4.453	4.45
930	4.459	4.465	4.471	4.477	4.483	4.489	4.495	4.502	4.508	4.514	4.52
940	4.520	4.526	4.532	4.538	4.544	4.550	4.556	4.562	4.568	4.574	4.58
950	4.580	4.586	4.593	4.599	4.605	4.611	4.617	4.623	4.629	4.635	4.64
960	4.641	4.647	4.653	4.659	4.666	4.672	4.678	4.684	4.690	4.696	4.70
970	4.702	4.708	4.714	4.720	4.727	4.733	4.739	4.745	4.751	4.757	4.76
980	4.763	4.769	4.775	4.782	4.788	4.794	4.800	4.806	4.812	4.818	4.82
990	4.824	4.831	4.837	4.843	4.849	4.855	4.861	4.867	4.874	4.880	4.88
1000	4.886	4.892	4.898	4.904	4.910	4.917	4.923	4.929	4.935	4.941	4.94
1010	4.947	4.954	4.960	4.966	4.972	4.978	4.984	4.991	4.997	5.003	5.00
1020	5.009	5.015	5.021	5.028	5.034	5.040	5.046	5.052	5.059	5.065	5.07
1030	5.071	5.077	5.083	5.090	5.096	5.102	5.108	5.114	5.121	5.127	5.13
1040	5.133	5.139	5.145	5.152	5.158	5.164	5.170	5.176	5.183	5.189	5.19
1050	5.195	5.201	5.207	5.214	5.220	5.226	5.232	5.239	5.245	5.251	5.25
1060	5.257	5.264	5.270	5.276	5.282	5.289	5.295	5.301	5.307	5.313	5.32
1070	5.320	5.326	5.332	5.338	5.345	5.351	5.357	5.364	5.370	5.376	5.38
1080	5.382	5.389	5.395	5.401	5.407	5.414	5.420	5.426	5.432	5.439	5.44
1090	5.445	5.451	5.458	5.464	5.470	5.476	5.483	5.489	5.495	5.502	5.50
1100	5.508	5.514	5.520	5.527	5.533	5.539	5.546	5.552	5.558	5.565	5.57
1110	5.571	5.577	5.583	5.590	5.596	5.602	5.609	5.615	5.621	5.628	5.63
1120	5.634	5.640	5.647	5.653	5.659	5.666	5.672	5.678	5.685	5.691	5.69
1130	5.697	5.704	5.710	5.716	5.723	5.729	5.735	5.742	5.748	5.754	5.76
1140	5.761	5.767	5.773	5.780	5.786	5.792	5.799	5.805	5.812	5.818	5.82
1150	5.824	5.831	5.837	5.843	5.850	5.856	5.862	5.869	5.875	5.882	5.88
1160	5.888	5.894	5.901	5.907	5.913	5.920	5.926	5.933	5.939	5.945	5.95
1170	5.952	5.958	5.965	5.971	5.977	5.984	5.990	5.997	6.003	6.009	6.01
1180	6.016	6.022	6.029	6.035	6.041	6.048	6.054	6.061	6.067	6.074	6.08
1190	6.080	6.086	6.093	6.099	6.106	6.112	6.119	6.125	6.131	6.138	6.14
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type R thermocouple										
°F	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
1200	6.144	6.151	6.157	6.164	6.170	6.176	6.183	6.189	6.196	6.202
1210	6.209	6.215	6.222	6.228	6.235	6.241	6.247	6.254	6.260	6.267
1220	6.273	6.280	6.286	6.293	6.299	6.306	6.312	6.319	6.325	6.332
1230	6.338	6.345	6.351	6.358	6.364	6.370	6.377	6.383	6.390	6.396
1240	6.403	6.409	6.416	6.422	6.429	6.435	6.442	6.448	6.455	6.461
1250	6.468	6.474	6.481	6.488	6.494	6.501	6.507	6.514	6.520	6.527
1260	6.533	6.540	6.546	6.553	6.559	6.566	6.572	6.579	6.585	6.592
1270	6.598	6.605	6.612	6.618	6.625	6.631	6.638	6.644	6.651	6.657
1280	6.664	6.671	6.677	6.684	6.690	6.697	6.703	6.710	6.716	6.723
1290	6.730	6.736	6.743	6.749	6.756	6.762	6.769	6.776	6.782	6.789
1300	6.795	6.802	6.809	6.815	6.822	6.828	6.835	6.841	6.848	6.855
1310	6.861	6.868	6.874	6.881	6.888	6.894	6.901	6.907	6.914	6.921
1320	6.927	6.934	6.941	6.947	6.954	6.960	6.967	6.974	6.980	6.987
1330	6.994	7.000	7.007	7.013	7.020	7.027	7.033	7.040	7.047	7.053
1340	7.060	7.067	7.073	7.080	7.086	7.093	7.100	7.106	7.113	7.120
1350	7.126	7.133	7.140	7.146	7.153	7.160	7.166	7.173	7.180	7.186
1360	7.193	7.200	7.206	7.213	7.220	7.226	7.233	7.240	7.247	7.253
1370	7.260	7.267	7.273	7.280	7.287	7.293	7.300	7.307	7.313	7.320
1380	7.327	7.334	7.340	7.347	7.354	7.360	7.367	7.374	7.381	7.387
1390	7.394	7.401	7.407	7.414	7.421	7.428	7.434	7.441	7.448	7.454
1400	7.461	7.468	7.475	7.481	7.488	7.495	7.502	7.508	7.515	7.522
1410	7.529	7.535	7.542	7.549	7.556	7.562	7.569	7.576	7.583	7.589
1420	7.596	7.603	7.610	7.616	7.623	7.630	7.637	7.644	7.650	7.657
1430	7.664	7.671	7.677	7.684	7.691	7.698	7.705	7.711	7.718	7.725
1440	7.732	7.739	7.745	7.752	7.759	7.766	7.772	7.779	7.786	7.793
1450	7.800	7.807	7.813	7.820	7.827	7.834	7.841	7.847	7.854	7.861
1460	7.868	7.875	7.882	7.888	7.895	7.902	7.909	7.916	7.922	7.929
1470	7.936	7.943	7.950	7.957	7.964	7.970	7.977	7.984	7.991	7.998
1480	8.005	8.011	8.018	8.025	8.032	8.039	8.046	8.053	8.059	8.066
1490	8.073	8.080	8.087	8.094	8.101	8.108	8.114	8.121	8.128	8.135
1500	8.142	8.149	8.156	8.163	8.169	8.176	8.183	8.190	8.197	8.204
1510	8.211	8.218	8.225	8.232	8.238	8.245	8.252	8.259	8.266	8.273
1520	8.280	8.287	8.294	8.301	8.308	8.314	8.321	8.328	8.335	8.342
1530	8.349	8.356	8.363	8.370	8.377	8.384	8.391	8.398	8.405	8.411
1540	8.418	8.425	8.432	8.439	8.446	8.453	8.460	8.467	8.474	8.481
1550	8.488	8.495	8.502	8.509	8.516	8.523	8.530	8.537	8.544	8.551
1560	8.557	8.564	8.571	8.578	8.585	8.592	8.599	8.606	8.613	8.620
1570	8.627	8.634	8.641	8.648	8.655	8.662	8.669	8.676	8.683	8.690
1580	8.697	8.704	8.711	8.718	8.725	8.732	8.739	8.746	8.753	8.760
1590	8.767	8.774	8.781	8.788	8.795	8.802	8.809	8.816	8.823	8.830
1600	8.837	8.844	8.852	8.859	8.866	8.873	8.880	8.887	8.894	8.901
1610	8.908	8.915	8.922	8.929	8.936	8.943	8.950	8.957	8.964	8.971
1620	8.978	8.985	8.992	8.999	9.007	9.014	9.021	9.028	9.035	9.042
1630	9.049	9.056	9.063	9.070	9.077	9.084	9.091	9.098	9.106	9.113
1640	9.120	9.127	9.134	9.141	9.148	9.155	9.162	9.169	9.176	9.184
1650	9.191	9.198	9.205	9.212	9.219	9.226	9.233	9.240	9.248	9.255
1660	9.262	9.269	9.276	9.283	9.290	9.297	9.304	9.312	9.319	9.326
1670	9.333	9.340	9.347	9.354	9.361	9.369	9.376	9.383	9.390	9.397
1680	9.404	9.411	9.419	9.426	9.433	9.440	9.447	9.454	9.461	9.469
1690	9.476	9.483	9.490	9.497	9.504	9.512	9.519	9.526	9.533	9.540
1700	9.547	9.555	9.562	9.569	9.576	9.583	9.590	9.598	9.605	9.612
1710	9.619	9.626	9.634	9.641	9.648	9.655	9.662	9.670	9.677	9.684
1720	9.691	9.698	9.706	9.713	9.720	9.727	9.734	9.742	9.749	9.756
1730	9.763	9.770	9.778	9.785	9.792	9.799	9.806	9.814	9.821	9.828
1740	9.835	9.843	9.850	9.857	9.864	9.872	9.879	9.886	9.893	9.900
1750	9.908	9.915	9.922	9.929	9.937	9.944	9.951	9.958	9.966	9.973
1760	9.980	9.987	9.995	10.002	10.009	10.016	10.024	10.031	10.038	10.046
1770	10.053	10.060	10.067	10.075	10.082	10.089	10.096	10.104	10.111	10.118
1780	10.126	10.133	10.140	10.147	10.155	10.162	10.169	10.177	10.184	10.191
1790	10.198	10.206	10.213	10.220	10.228	10.235	10.242	10.250	10.257	10.264
1800	10.271	10.279	10.286	10.293	10.301	10.308	10.315	10.323	10.330	10.337
1810	10.345	10.352	10.359	10.367	10.374	10.381	10.389	10.396	10.403	10.411
1820	10.418	10.425	10.433	10.440	10.447	10.455	10.462	10.469	10.477	10.484
1830	10.491	10.499	10.506	10.513	10.521	10.528	10.535	10.543	10.550	10.557
1840	10.565	10.572	10.580	10.587	10.594	10.602	10.609	10.616	10.624	10.631
°F	0	1	2	3	4	5	6	7	8	9

ITS-90 Table for type R thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
1850	10.638	10.646	10.653	10.661	10.668	10.675	10.683	10.690	10.698	10.705	10.71
1860	10.712	10.720	10.727	10.734	10.742	10.749	10.757	10.764	10.771	10.779	10.78
1870	10.786	10.794	10.801	10.808	10.816	10.823	10.831	10.838	10.845	10.853	10.86
1880	10.860	10.868	10.875	10.883	10.890	10.897	10.905	10.912	10.920	10.927	10.93
1890	10.934	10.942	10.949	10.957	10.964	10.972	10.979	10.986	10.994	11.001	11.00
1900	11.009	11.016	11.024	11.031	11.039	11.046	11.053	11.061	11.068	11.076	11.08
1910	11.083	11.091	11.098	11.106	11.113	11.121	11.128	11.135	11.143	11.150	11.15
1920	11.158	11.165	11.173	11.180	11.188	11.195	11.203	11.210	11.218	11.225	11.23
1930	11.233	11.240	11.247	11.255	11.262	11.270	11.277	11.285	11.292	11.300	11.30
1940	11.307	11.315	11.322	11.330	11.337	11.345	11.352	11.360	11.367	11.375	11.38
1950	11.382	11.390	11.397	11.405	11.412	11.420	11.427	11.435	11.442	11.450	11.45
1960	11.457	11.465	11.472	11.480	11.487	11.495	11.502	11.510	11.518	11.525	11.53
1970	11.533	11.540	11.548	11.555	11.563	11.570	11.578	11.585	11.593	11.600	11.60
1980	11.608	11.615	11.623	11.631	11.638	11.646	11.653	11.661	11.668	11.676	11.68
1990	11.683	11.691	11.698	11.706	11.714	11.721	11.729	11.736	11.744	11.751	11.75
2000	11.759	11.766	11.774	11.782	11.789	11.797	11.804	11.812	11.819	11.827	11.83
2010	11.834	11.842	11.850	11.857	11.865	11.872	11.880	11.888	11.895	11.903	11.91
2020	11.910	11.918	11.925	11.933	11.941	11.948	11.956	11.963	11.971	11.979	11.98
2030	11.986	11.994	12.001	12.009	12.016	12.024	12.032	12.039	12.047	12.054	12.06
2040	12.062	12.070	12.077	12.085	12.092	12.100	12.108	12.115	12.123	12.131	12.13
2050	12.138	12.146	12.153	12.161	12.169	12.176	12.184	12.191	12.199	12.207	12.21
2060	12.214	12.222	12.230	12.237	12.245	12.252	12.260	12.268	12.275	12.283	12.29
2070	12.291	12.298	12.306	12.313	12.321	12.329	12.336	12.344	12.352	12.359	12.36
2080	12.367	12.375	12.382	12.390	12.397	12.405	12.413	12.420	12.428	12.436	12.44
2090	12.443	12.451	12.459	12.466	12.474	12.482	12.489	12.497	12.505	12.512	12.52
2100	12.520	12.528	12.535	12.543	12.551	12.558	12.566	12.574	12.581	12.589	12.59
2110	12.597	12.604	12.612	12.620	12.627	12.635	12.643	12.650	12.658	12.666	12.67
2120	12.673	12.681	12.689	12.696	12.704	12.712	12.719	12.727	12.735	12.742	12.75
2130	12.750	12.758	12.765	12.773	12.781	12.788	12.796	12.804	12.812	12.819	12.82
2140	12.827	12.835	12.842	12.850	12.858	12.865	12.873	12.881	12.889	12.896	12.90
2150	12.904	12.912	12.919	12.927	12.935	12.942	12.950	12.958	12.966	12.973	12.98
2160	12.981	12.989	12.996	13.004	13.012	13.019	13.027	13.035	13.043	13.050	13.05
2170	13.058	13.066	13.073	13.081	13.089	13.097	13.104	13.112	13.120	13.128	13.13
2180	13.135	13.143	13.151	13.158	13.166	13.174	13.182	13.189	13.197	13.205	13.21
2190	13.213	13.220	13.228	13.236	13.243	13.251	13.259	13.267	13.274	13.282	13.29
2200	13.290	13.298	13.305	13.313	13.321	13.329	13.336	13.344	13.352	13.359	13.36
2210	13.367	13.375	13.383	13.390	13.398	13.406	13.414	13.421	13.429	13.437	13.44
2220	13.445	13.452	13.460	13.468	13.476	13.483	13.491	13.499	13.507	13.514	13.52
2230	13.522	13.530	13.538	13.545	13.553	13.561	13.569	13.577	13.584	13.592	13.60
2240	13.600	13.608	13.615	13.623	13.631	13.639	13.646	13.654	13.662	13.670	13.67
2250	13.677	13.685	13.693	13.701	13.709	13.716	13.724	13.732	13.740	13.747	13.75
2260	13.755	13.763	13.771	13.778	13.786	13.794	13.802	13.810	13.817	13.825	13.83
2270	13.833	13.841	13.848	13.856	13.864	13.872	13.880	13.887	13.895	13.903	13.91
2280	13.911	13.919	13.926	13.934	13.942	13.950	13.957	13.965	13.973	13.981	13.98
2290	13.989	13.996	14.004	14.012	14.020	14.028	14.035	14.043	14.051	14.059	14.06
2300	14.066	14.074	14.082	14.090	14.098	14.105	14.113	14.121	14.129	14.137	14.14
2310	14.144	14.152	14.160	14.168	14.176	14.183	14.191	14.199	14.207	14.215	14.22
2320	14.222	14.230	14.238	14.246	14.254	14.261	14.269	14.277	14.285	14.293	14.30
2330	14.300	14.308	14.316	14.324	14.332	14.340	14.347	14.355	14.363	14.371	14.37
2340	14.379	14.386	14.394	14.402	14.410	14.418	14.425	14.433	14.441	14.449	14.45
2350	14.457	14.465	14.472	14.480	14.488	14.496	14.504	14.511	14.519	14.527	14.53
2360	14.535	14.543	14.551	14.558	14.566	14.574	14.582	14.590	14.597	14.605	14.61
2370	14.613	14.621	14.629	14.637	14.644	14.652	14.660	14.668	14.676	14.683	14.69
2380	14.691	14.699	14.707	14.715	14.723	14.730	14.738	14.746	14.754	14.762	14.77
2390	14.770	14.777	14.785	14.793	14.801	14.809	14.817	14.824	14.832	14.840	14.84
2400	14.848	14.856	14.864	14.871	14.879	14.887	14.895	14.903	14.911	14.918	14.92
2410	14.926	14.934	14.942	14.950	14.958	14.965	14.973	14.981	14.989	14.997	15.00
2420	15.005	15.012	15.020	15.028	15.036	15.044	15.052	15.059	15.067	15.075	15.08
2430	15.083	15.091	15.099	15.106	15.114	15.122	15.130	15.138	15.146	15.153	15.16
2440	15.161	15.169	15.177	15.185	15.193	15.200	15.208	15.216	15.224	15.232	15.24
2450	15.240	15.248	15.255	15.263	15.271	15.279	15.287	15.295	15.302	15.310	15.31
2460	15.318	15.326	15.334	15.342	15.349	15.357	15.365	15.373	15.381	15.389	15.39
2470	15.397	15.404	15.412	15.420	15.428	15.436	15.444	15.451	15.459	15.467	15.47
2480	15.475	15.483	15.491	15.499	15.506	15.514	15.522	15.530	15.538	15.546	15.55
2490	15.553	15.561	15.569	15.577	15.585	15.593	15.601	15.608	15.616	15.624	15.63
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type R thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
2500	15.632	15.640	15.648	15.655	15.663	15.671	15.679	15.687	15.695	15.703	15.71
2510	15.710	15.718	15.726	15.734	15.742	15.750	15.758	15.765	15.773	15.781	15.78
2520	15.789	15.797	15.805	15.812	15.820	15.828	15.836	15.844	15.852	15.860	15.86
2530	15.867	15.875	15.883	15.891	15.899	15.907	15.915	15.922	15.930	15.938	15.94
2540	15.946	15.954	15.962	15.969	15.977	15.985	15.993	16.001	16.009	16.017	16.02
2550	16.024	16.032	16.040	16.048	16.056	16.064	16.071	16.079	16.087	16.095	16.10
2560	16.103	16.111	16.119	16.126	16.134	16.142	16.150	16.158	16.166	16.174	16.18
2570	16.181	16.189	16.197	16.205	16.213	16.221	16.228	16.236	16.244	16.252	16.26
2580	16.260	16.268	16.276	16.283	16.291	16.299	16.307	16.315	16.323	16.330	16.33
2590	16.338	16.346	16.354	16.362	16.370	16.378	16.385	16.393	16.401	16.409	16.41
2600	16.417	16.425	16.432	16.440	16.448	16.456	16.464	16.472	16.480	16.487	16.49
2610	16.495	16.503	16.511	16.519	16.527	16.534	16.542	16.550	16.558	16.566	16.57
2620	16.574	16.582	16.589	16.597	16.605	16.613	16.621	16.629	16.636	16.644	16.65
2630	16.652	16.660	16.668	16.676	16.683	16.691	16.699	16.707	16.715	16.723	16.73
2640	16.731	16.738	16.746	16.754	16.762	16.770	16.778	16.785	16.793	16.801	16.80
2650	16.809	16.817	16.825	16.832	16.840	16.848	16.856	16.864	16.872	16.879	16.88
2660	16.887	16.895	16.903	16.911	16.919	16.926	16.934	16.942	16.950	16.958	16.96
2670	16.966	16.973	16.981	16.989	16.997	17.005	17.013	17.020	17.028	17.036	17.04
2680	17.044	17.052	17.060	17.067	17.075	17.083	17.091	17.099	17.107	17.114	17.12
2690	17.122	17.130	17.138	17.146	17.154	17.161	17.169	17.177	17.185	17.193	17.20
2700	17.200	17.208	17.216	17.224	17.232	17.240	17.247	17.255	17.263	17.271	17.27
2710	17.279	17.286	17.294	17.302	17.310	17.318	17.326	17.333	17.341	17.349	17.35
2720	17.357	17.365	17.373	17.380	17.388	17.396	17.404	17.412	17.419	17.427	17.43
2730	17.435	17.443	17.451	17.458	17.466	17.474	17.482	17.490	17.498	17.505	17.51
2740	17.513	17.521	17.529	17.537	17.544	17.552	17.560	17.568	17.576	17.583	17.59
2750	17.591	17.599	17.607	17.615	17.622	17.630	17.638	17.646	17.654	17.661	17.66
2760	17.669	17.677	17.685	17.693	17.700	17.708	17.716	17.724	17.732	17.739	17.74
2770	17.747	17.755	17.763	17.771	17.778	17.786	17.794	17.802	17.810	17.817	17.82
2780	17.825	17.833	17.841	17.849	17.856	17.864	17.872	17.880	17.888	17.895	17.90
2790	17.903	17.911	17.919	17.926	17.934	17.942	17.950	17.958	17.965	17.973	17.98
2800	17.981	17.989	17.997	18.004	18.012	18.020	18.028	18.035	18.043	18.051	18.05
2810	18.059	18.067	18.074	18.082	18.090	18.098	18.105	18.113	18.121	18.129	18.13
2820	18.137	18.144	18.152	18.160	18.168	18.175	18.183	18.191	18.199	18.206	18.21
2830	18.214	18.222	18.230	18.238	18.245	18.253	18.261	18.269	18.276	18.284	18.29
2840	18.292	18.300	18.307	18.315	18.323	18.331	18.338	18.346	18.354	18.362	18.36
2850	18.369	18.377	18.385	18.393	18.400	18.408	18.416	18.424	18.431	18.439	18.44
2860	18.447	18.455	18.462	18.470	18.478	18.486	18.493	18.501	18.509	18.517	18.52
2870	18.524	18.532	18.540	18.548	18.555	18.563	18.571	18.579	18.586	18.594	18.60
2880	18.602	18.610	18.617	18.625	18.633	18.640	18.648	18.656	18.664	18.671	18.67
2890	18.679	18.687	18.695	18.702	18.710	18.718	18.725	18.733	18.741	18.749	18.75
2900	18.756	18.764	18.772	18.779	18.787	18.795	18.803	18.810	18.818	18.826	18.83
2910	18.834	18.841	18.849	18.857	18.864	18.872	18.880	18.887	18.895	18.903	18.91
2920	18.911	18.918	18.926	18.934	18.941	18.949	18.957	18.965	18.972	18.980	18.98
2930	18.988	18.995	19.003	19.011	19.018	19.026	19.034	19.042	19.049	19.057	19.06
2940	19.065	19.072	19.080	19.088	19.095	19.103	19.111	19.118	19.126	19.134	19.14
2950	19.141	19.149	19.157	19.165	19.172	19.180	19.188	19.195	19.203	19.211	19.21
2960	19.218	19.226	19.234	19.241	19.249	19.257	19.264	19.272	19.280	19.287	19.29
2970	19.295	19.303	19.310	19.318	19.326	19.333	19.341	19.348	19.356	19.364	19.37
2980	19.372	19.379	19.387	19.395	19.402	19.410	19.418	19.425	19.433	19.440	19.44
2990	19.448	19.456	19.463	19.471	19.479	19.486	19.494	19.502	19.509	19.517	19.52
3000	19.525	19.532	19.540	19.547	19.555	19.563	19.570	19.578	19.586	19.593	19.60
3010	19.601	19.609	19.616	19.624	19.631	19.639	19.647	19.654	19.662	19.670	19.67
3020	19.677	19.685	19.692	19.700	19.708	19.715	19.723	19.730	19.738	19.746	19.75
3030	19.753	19.761	19.769	19.776	19.784	19.791	19.799	19.807	19.814	19.822	19.82
3040	19.829	19.837	19.845	19.852	19.860	19.867	19.875	19.882	19.890	19.898	19.90
3050	19.905	19.913	19.920	19.928	19.936	19.943	19.951	19.958	19.966	19.973	19.98
3060	19.981	19.989	19.996	20.004	20.011	20.019	20.026	20.034	20.041	20.049	20.05
3070	20.056	20.064	20.072	20.079	20.087	20.094	20.102	20.109	20.117	20.124	20.13
3080	20.132	20.139	20.147	20.154	20.162	20.169	20.177	20.184	20.192	20.199	20.20
3090	20.207	20.214	20.222	20.229	20.237	20.244	20.252	20.259	20.266	20.274	20.28
3100	20.281	20.289	20.296	20.304	20.311	20.319	20.326	20.333	20.341	20.348	20.35
3110	20.356	20.363	20.371	20.378	20.385	20.393	20.400	20.407	20.415	20.422	20.43
3120	20.430	20.437	20.444	20.452	20.459	20.466	20.474	20.481	20.488	20.496	20.50
3130	20.503	20.510	20.518	20.525	20.532	20.540	20.547	20.554	20.562	20.569	20.57
3140	20.576	20.583	20.591	20.598	20.605	20.612	20.620	20.627	20.634	20.641	20.64
°F	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type R thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
3150	20.649	20.656	20.663	20.670	20.678	20.685	20.692	20.699	20.706	20.714	20.72
3160	20.721	20.728	20.735	20.742	20.749	20.756	20.764	20.771	20.778	20.785	20.79
3170	20.792	20.799	20.806	20.813	20.821	20.828	20.835	20.842	20.849	20.856	20.86
3180	20.863	20.870	20.877	20.884	20.891	20.898	20.905	20.912	20.919	20.926	20.93
3190	20.933	20.940	20.947	20.954	20.961	20.968	20.975	20.982	20.989	20.996	21.00
3200	21.003	21.010	21.016	21.023	21.030	21.037	21.044	21.051	21.058	21.065	21.07
3210	21.071	21.078	21.085	21.092	21.099						
°F	0	1	2	3	4	5	6	7	8	9	10
ITS-90 Table for type R thermocouple											
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Thermoelectric Voltage in mV											
-40	-0.226	-0.223	-0.219	-0.215	-0.211	-0.208	-0.204	-0.200	-0.196	-0.192	-0.18
-30	-0.188	-0.184	-0.180	-0.175	-0.171	-0.167	-0.163	-0.158	-0.154	-0.150	-0.14
-20	-0.145	-0.141	-0.137	-0.132	-0.128	-0.123	-0.119	-0.114	-0.109	-0.105	-0.10
-10	-0.100	-0.095	-0.091	-0.086	-0.081	-0.076	-0.071	-0.066	-0.061	-0.056	-0.05
0	-0.051	-0.046	-0.041	-0.036	-0.031	-0.026	-0.021	-0.016	-0.011	-0.005	0.00
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type R thermocouple											
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	0.000	0.005	0.011	0.016	0.021	0.027	0.032	0.038	0.043	0.049	0.05
10	0.054	0.060	0.065	0.071	0.077	0.082	0.088	0.094	0.100	0.105	0.11
20	0.111	0.117	0.123	0.129	0.135	0.141	0.147	0.153	0.159	0.165	0.17
30	0.171	0.177	0.183	0.189	0.195	0.201	0.207	0.214	0.220	0.226	0.23
40	0.232	0.239	0.245	0.251	0.258	0.264	0.271	0.277	0.284	0.290	0.29
50	0.296	0.303	0.310	0.316	0.323	0.329	0.336	0.343	0.349	0.356	0.36
60	0.363	0.369	0.376	0.383	0.390	0.397	0.403	0.410	0.417	0.424	0.43
70	0.431	0.438	0.445	0.452	0.459	0.466	0.473	0.480	0.487	0.494	0.50
80	0.501	0.508	0.516	0.523	0.530	0.537	0.544	0.552	0.559	0.566	0.57
90	0.573	0.581	0.588	0.595	0.603	0.610	0.618	0.625	0.632	0.640	0.64
100	0.647	0.655	0.662	0.670	0.677	0.685	0.693	0.700	0.708	0.715	0.72
110	0.723	0.731	0.738	0.746	0.754	0.761	0.769	0.777	0.785	0.792	0.80
120	0.800	0.808	0.816	0.824	0.832	0.839	0.847	0.855	0.863	0.871	0.87
130	0.879	0.887	0.895	0.903	0.911	0.919	0.927	0.935	0.943	0.951	0.95
140	0.959	0.967	0.976	0.984	0.992	1.000	1.008	1.016	1.025	1.033	1.04
150	1.041	1.049	1.058	1.066	1.074	1.082	1.091	1.099	1.107	1.116	1.12
160	1.124	1.132	1.141	1.149	1.158	1.166	1.175	1.183	1.191	1.200	1.20
170	1.208	1.217	1.225	1.234	1.242	1.251	1.260	1.268	1.277	1.285	1.29
180	1.294	1.303	1.311	1.320	1.329	1.337	1.346	1.355	1.363	1.372	1.38
190	1.381	1.389	1.398	1.407	1.416	1.425	1.433	1.442	1.451	1.460	1.46
200	1.469	1.477	1.486	1.495	1.504	1.513	1.522	1.531	1.540	1.549	1.55
210	1.558	1.567	1.575	1.584	1.593	1.602	1.611	1.620	1.629	1.639	1.64
220	1.648	1.657	1.666	1.675	1.684	1.693	1.702	1.711	1.720	1.729	1.73
230	1.739	1.748	1.757	1.766	1.775	1.784	1.794	1.803	1.812	1.821	1.83
240	1.831	1.840	1.849	1.858	1.868	1.877	1.886	1.895	1.905	1.914	1.92
250	1.923	1.933	1.942	1.951	1.961	1.970	1.980	1.989	1.998	2.008	2.01
260	2.017	2.027	2.036	2.046	2.055	2.064	2.074	2.083	2.093	2.102	2.11
270	2.112	2.121	2.131	2.140	2.150	2.159	2.169	2.179	2.188	2.198	2.20
280	2.207	2.217	2.226	2.236	2.246	2.255	2.265	2.275	2.284	2.294	2.30
290	2.304	2.313	2.323	2.333	2.342	2.352	2.362	2.371	2.381	2.391	2.40
300	2.401	2.410	2.420	2.430	2.440	2.449	2.459	2.469	2.479	2.488	2.49
310	2.498	2.508	2.518	2.528	2.538	2.547	2.557	2.567	2.577	2.587	2.59
320	2.597	2.607	2.617	2.626	2.636	2.646	2.656	2.666	2.676	2.686	2.69
330	2.696	2.706	2.716	2.726	2.736	2.746	2.756	2.766	2.776	2.786	2.79
340	2.796	2.806	2.816	2.826	2.836	2.846	2.856	2.866	2.876	2.886	2.89
350	2.896	2.906	2.916	2.926	2.937	2.947	2.957	2.967	2.977	2.987	2.99
360	2.997	3.007	3.018	3.028	3.038	3.048	3.058	3.068	3.079	3.089	3.09
370	3.099	3.109	3.119	3.130	3.140	3.150	3.160	3.171	3.181	3.191	3.20
380	3.201	3.212	3.222	3.232	3.242	3.253	3.263	3.273	3.284	3.294	3.30
390	3.304	3.315	3.325	3.335	3.346	3.356	3.366	3.377	3.387	3.397	3.40
°C	0	1	2	3	4	5	6	7	8	9	10

°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type R thermocouple	0	1	2	3	4	5	6	7	8	9	10
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
400	3.408	3.418	3.428	3.439	3.449	3.460	3.470	3.480	3.491	3.501	3.51
410	3.512	3.522	3.533	3.543	3.553	3.564	3.574	3.585	3.595	3.606	3.61
420	3.616	3.627	3.637	3.648	3.658	3.669	3.679	3.690	3.700	3.711	3.72
430	3.721	3.732	3.742	3.753	3.764	3.774	3.785	3.795	3.806	3.816	3.82
440	3.827	3.838	3.848	3.859	3.869	3.880	3.891	3.901	3.912	3.922	3.93
450	3.933	3.944	3.954	3.965	3.976	3.986	3.997	4.008	4.018	4.029	4.04
460	4.040	4.050	4.061	4.072	4.083	4.093	4.104	4.115	4.125	4.136	4.14
470	4.147	4.158	4.168	4.179	4.190	4.201	4.211	4.222	4.233	4.244	4.25
480	4.255	4.265	4.276	4.287	4.298	4.309	4.319	4.330	4.341	4.352	4.36
490	4.363	4.373	4.384	4.395	4.406	4.417	4.428	4.439	4.449	4.460	4.47
500	4.471	4.482	4.493	4.504	4.515	4.526	4.537	4.548	4.558	4.569	4.58
510	4.580	4.591	4.602	4.613	4.624	4.635	4.646	4.657	4.668	4.679	4.69
520	4.690	4.701	4.712	4.723	4.734	4.745	4.756	4.767	4.778	4.789	4.80
530	4.800	4.811	4.822	4.833	4.844	4.855	4.866	4.877	4.888	4.899	4.91
540	4.910	4.922	4.933	4.944	4.955	4.966	4.977	4.988	4.999	5.010	5.02
550	5.021	5.033	5.044	5.055	5.066	5.077	5.088	5.099	5.111	5.122	5.13
560	5.133	5.144	5.155	5.166	5.178	5.189	5.200	5.211	5.222	5.234	5.24
570	5.245	5.256	5.267	5.279	5.290	5.301	5.312	5.323	5.335	5.346	5.35
580	5.357	5.369	5.380	5.391	5.402	5.414	5.425	5.436	5.448	5.459	5.47
590	5.470	5.481	5.493	5.504	5.515	5.527	5.538	5.549	5.561	5.572	5.58
600	5.583	5.595	5.606	5.618	5.629	5.640	5.652	5.663	5.674	5.686	5.69
610	5.697	5.709	5.720	5.731	5.743	5.754	5.766	5.777	5.789	5.800	5.81
620	5.812	5.823	5.834	5.846	5.857	5.869	5.880	5.892	5.903	5.915	5.92
630	5.926	5.938	5.949	5.961	5.972	5.984	5.995	6.007	6.018	6.030	6.04
640	6.041	6.053	6.065	6.076	6.088	6.099	6.111	6.122	6.134	6.146	6.15
650	6.157	6.169	6.180	6.192	6.204	6.215	6.227	6.238	6.250	6.262	6.27
660	6.273	6.285	6.297	6.308	6.320	6.332	6.343	6.355	6.367	6.378	6.39
670	6.390	6.402	6.413	6.425	6.437	6.448	6.460	6.472	6.484	6.495	6.50
680	6.507	6.519	6.531	6.542	6.554	6.566	6.578	6.589	6.601	6.613	6.62
690	6.625	6.636	6.648	6.660	6.672	6.684	6.695	6.707	6.719	6.731	6.74
700	6.743	6.755	6.766	6.778	6.790	6.802	6.814	6.826	6.838	6.849	6.86
710	6.861	6.873	6.885	6.897	6.909	6.921	6.933	6.945	6.956	6.968	6.98
720	6.980	6.992	7.004	7.016	7.028	7.040	7.052	7.064	7.076	7.088	7.10
730	7.100	7.112	7.124	7.136	7.148	7.160	7.172	7.184	7.196	7.208	7.22
740	7.220	7.232	7.244	7.256	7.268	7.280	7.292	7.304	7.316	7.328	7.34
750	7.340	7.352	7.364	7.376	7.389	7.401	7.413	7.425	7.437	7.449	7.46
760	7.461	7.473	7.485	7.498	7.510	7.522	7.534	7.546	7.558	7.570	7.58
770	7.583	7.595	7.607	7.619	7.631	7.644	7.656	7.668	7.680	7.692	7.70
780	7.705	7.717	7.729	7.741	7.753	7.766	7.778	7.790	7.802	7.815	7.82
790	7.827	7.839	7.851	7.864	7.876	7.888	7.901	7.913	7.925	7.938	7.95
800	7.950	7.962	7.974	7.987	7.999	8.011	8.024	8.036	8.048	8.061	8.07
810	8.073	8.086	8.098	8.110	8.123	8.135	8.147	8.160	8.172	8.185	8.19
820	8.197	8.209	8.222	8.234	8.247	8.259	8.272	8.284	8.296	8.309	8.32
830	8.321	8.334	8.346	8.359	8.371	8.384	8.396	8.409	8.421	8.434	8.44
840	8.446	8.459	8.471	8.484	8.496	8.509	8.521	8.534	8.546	8.559	8.57
850	8.571	8.584	8.597	8.609	8.622	8.634	8.647	8.659	8.672	8.685	8.69
860	8.697	8.710	8.722	8.735	8.748	8.760	8.773	8.785	8.798	8.811	8.82
870	8.823	8.836	8.849	8.861	8.874	8.887	8.899	8.912	8.925	8.937	8.95
880	8.950	8.963	8.975	8.988	9.001	9.014	9.026	9.039	9.052	9.065	9.07
890	9.077	9.090	9.103	9.115	9.128	9.141	9.154	9.167	9.179	9.192	9.20
900	9.205	9.218	9.230	9.243	9.256	9.269	9.282	9.294	9.307	9.320	9.33
910	9.333	9.346	9.359	9.371	9.384	9.397	9.410	9.423	9.436	9.449	9.46
920	9.461	9.474	9.487	9.500	9.513	9.526	9.539	9.552	9.565	9.578	9.59
930	9.590	9.603	9.616	9.629	9.642	9.655	9.668	9.681	9.694	9.707	9.72
940	9.720	9.733	9.746	9.759	9.772	9.785	9.798	9.811	9.824	9.837	9.85
950	9.850	9.863	9.876	9.889	9.902	9.915	9.928	9.941	9.954	9.967	9.98
960	9.980	9.993	10.006	10.019	10.032	10.046	10.059	10.072	10.085	10.098	10.11
970	10.111	10.124	10.137	10.150	10.163	10.177	10.190	10.203	10.216	10.229	10.24
980	10.242	10.255	10.268	10.282	10.295	10.308	10.321	10.334	10.347	10.361	10.37
990	10.374	10.387	10.400	10.413	10.427	10.440	10.453	10.466	10.480	10.493	10.50
°C	0	1	2	3	4	5	6	7	8	9	10

	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type R thermocouple	0	1	2	3	4	5	6	7	8	9	10
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
1000	10.506	10.519	10.532	10.546	10.559	10.572	10.585	10.599	10.612	10.625	10.63
1010	10.638	10.652	10.665	10.678	10.692	10.705	10.718	10.731	10.745	10.758	10.77
1020	10.771	10.785	10.798	10.811	10.825	10.838	10.851	10.865	10.878	10.891	10.90
1030	10.905	10.918	10.932	10.945	10.958	10.972	10.985	10.998	11.012	11.025	11.03
1040	11.039	11.052	11.065	11.079	11.092	11.106	11.119	11.132	11.146	11.159	11.17
1050	11.173	11.186	11.200	11.213	11.227	11.240	11.253	11.267	11.280	11.294	11.30
1060	11.307	11.321	11.334	11.348	11.361	11.375	11.388	11.402	11.415	11.429	11.44
1070	11.442	11.456	11.469	11.483	11.496	11.510	11.524	11.537	11.551	11.564	11.57
1080	11.578	11.591	11.605	11.618	11.632	11.646	11.659	11.673	11.686	11.700	11.71
1090	11.714	11.727	11.741	11.754	11.768	11.782	11.795	11.809	11.822	11.836	11.85
1100	11.850	11.863	11.877	11.891	11.904	11.918	11.931	11.945	11.959	11.972	11.98
1110	11.986	12.000	12.013	12.027	12.041	12.054	12.068	12.082	12.096	12.109	12.12
1120	12.123	12.137	12.150	12.164	12.178	12.191	12.205	12.219	12.233	12.246	12.26
1130	12.260	12.274	12.288	12.301	12.315	12.329	12.342	12.356	12.370	12.384	12.39
1140	12.397	12.411	12.425	12.439	12.453	12.466	12.480	12.494	12.508	12.521	12.53
1150	12.535	12.549	12.563	12.577	12.590	12.604	12.618	12.632	12.646	12.659	12.67
1160	12.673	12.687	12.701	12.715	12.729	12.742	12.756	12.770	12.784	12.798	12.81
1170	12.812	12.825	12.839	12.853	12.867	12.881	12.895	12.909	12.922	12.936	12.95
1180	12.950	12.964	12.978	12.992	13.006	13.019	13.033	13.047	13.061	13.075	13.08
1190	13.089	13.103	13.117	13.131	13.145	13.158	13.172	13.186	13.200	13.214	13.22
1200	13.228	13.242	13.256	13.270	13.284	13.298	13.311	13.325	13.339	13.353	13.36
1210	13.367	13.381	13.395	13.409	13.423	13.437	13.451	13.465	13.479	13.493	13.50
1220	13.507	13.521	13.535	13.549	13.563	13.577	13.590	13.604	13.618	13.632	13.64
1230	13.646	13.660	13.674	13.688	13.702	13.716	13.730	13.744	13.758	13.772	13.78
1240	13.786	13.800	13.814	13.828	13.842	13.856	13.870	13.884	13.898	13.912	13.92
°C	0	1	2	3	4	5	6	7	8	9	10
ITS-90 Table for type S thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
550	2.212	2.217	2.222	2.227	2.232	2.237	2.242	2.247	2.252	2.257	2.26
560	2.262	2.267	2.272	2.277	2.283	2.288	2.293	2.298	2.303	2.308	2.31
570	2.313	2.318	2.323	2.328	2.333	2.338	2.343	2.348	2.354	2.359	2.36
580	2.364	2.369	2.374	2.379	2.384	2.389	2.394	2.399	2.404	2.410	2.41
590	2.415	2.420	2.425	2.430	2.435	2.440	2.445	2.450	2.455	2.461	2.46
600	2.466	2.471	2.476	2.481	2.486	2.491	2.496	2.502	2.507	2.512	2.51
610	2.517	2.522	2.527	2.532	2.537	2.543	2.548	2.553	2.558	2.563	2.56
620	2.568	2.574	2.579	2.584	2.589	2.594	2.599	2.604	2.610	2.615	2.62
630	2.620	2.625	2.630	2.635	2.641	2.646	2.651	2.656	2.661	2.666	2.67
640	2.672	2.677	2.682	2.687	2.692	2.697	2.703	2.708	2.713	2.718	2.72
650	2.723	2.729	2.734	2.739	2.744	2.749	2.755	2.760	2.765	2.770	2.77
660	2.775	2.781	2.786	2.791	2.796	2.801	2.807	2.812	2.817	2.822	2.82
670	2.827	2.833	2.838	2.843	2.848	2.854	2.859	2.864	2.869	2.874	2.88
680	2.880	2.885	2.890	2.895	2.901	2.906	2.911	2.916	2.922	2.927	2.93
690	2.932	2.937	2.943	2.948	2.953	2.958	2.964	2.969	2.974	2.979	2.98
700	2.985	2.990	2.995	3.000	3.006	3.011	3.016	3.021	3.027	3.032	3.03
710	3.037	3.042	3.048	3.053	3.058	3.063	3.069	3.074	3.079	3.085	3.09
720	3.090	3.095	3.100	3.106	3.111	3.116	3.122	3.127	3.132	3.137	3.14
730	3.143	3.148	3.153	3.159	3.164	3.169	3.174	3.180	3.185	3.190	3.19
740	3.196	3.201	3.206	3.212	3.217	3.222	3.227	3.233	3.238	3.243	3.24
750	3.249	3.254	3.259	3.265	3.270	3.275	3.281	3.286	3.291	3.297	3.30
760	3.302	3.307	3.313	3.318	3.323	3.329	3.334	3.339	3.345	3.350	3.35
770	3.355	3.361	3.366	3.371	3.377	3.382	3.387	3.393	3.398	3.403	3.40
780	3.409	3.414	3.419	3.425	3.430	3.435	3.441	3.446	3.451	3.457	3.46
790	3.462	3.468	3.473	3.478	3.484	3.489	3.494	3.500	3.505	3.510	3.51
800	3.516	3.521	3.527	3.532	3.537	3.543	3.548	3.553	3.559	3.564	3.57
810	3.570	3.575	3.580	3.586	3.591	3.596	3.602	3.607	3.613	3.618	3.62
820	3.623	3.629	3.634	3.640	3.645	3.650	3.656	3.661	3.667	3.672	3.67
830	3.677	3.683	3.688	3.694	3.699	3.704	3.710	3.715	3.721	3.726	3.73
840	3.731	3.737	3.742	3.748	3.753	3.758	3.764	3.769	3.775	3.780	3.78
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type S thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
850	3.786	3.791	3.796	3.802	3.807	3.813	3.818	3.823	3.829	3.834	3.84
860	3.840	3.845	3.851	3.856	3.862	3.867	3.872	3.878	3.883	3.889	3.89
870	3.894	3.900	3.905	3.910	3.916	3.921	3.927	3.932	3.938	3.943	3.94
880	3.949	3.954	3.959	3.965	3.970	3.976	3.981	3.987	3.992	3.998	4.00
890	4.003	4.009	4.014	4.020	4.025	4.030	4.036	4.041	4.047	4.052	4.05
900	4.058	4.063	4.069	4.074	4.080	4.085	4.091	4.096	4.102	4.107	4.11
910	4.113	4.118	4.123	4.129	4.134	4.140	4.145	4.151	4.156	4.162	4.16
920	4.167	4.173	4.178	4.184	4.189	4.195	4.200	4.206	4.211	4.217	4.22
930	4.222	4.228	4.233	4.239	4.244	4.250	4.255	4.261	4.266	4.272	4.27
940	4.277	4.283	4.288	4.294	4.299	4.305	4.310	4.316	4.321	4.327	4.33
950	4.332	4.338	4.343	4.349	4.355	4.360	4.366	4.371	4.377	4.382	4.38
960	4.388	4.393	4.399	4.404	4.410	4.415	4.421	4.426	4.432	4.437	4.44
970	4.443	4.449	4.454	4.460	4.465	4.471	4.476	4.482	4.487	4.493	4.49
980	4.498	4.504	4.510	4.515	4.521	4.526	4.532	4.537	4.543	4.548	4.55
990	4.554	4.559	4.565	4.571	4.576	4.582	4.587	4.593	4.598	4.604	4.61
1000	4.610	4.615	4.621	4.626	4.632	4.637	4.643	4.648	4.654	4.660	4.66
1010	4.665	4.671	4.676	4.682	4.688	4.693	4.699	4.704	4.710	4.715	4.72
1720	20.488	20.502	20.515	20.528	20.541	20.554	20.567	20.581	20.594	20.607	20.62
1730	20.620	20.633	20.646	20.659	20.672	20.685	20.698	20.711	20.724	20.736	20.74
1740	20.749	20.762	20.775	20.788	20.801	20.813	20.826	20.839	20.852	20.864	20.87
1750	20.877	20.890	20.902	20.915	20.928	20.940	20.953	20.965	20.978	20.990	21.00
1760	21.003	21.015	21.027	21.040	21.052	21.065	21.077	21.089	21.101		
°C	0	1	2	3	4	5	6	7	8	9	10
ITS-90 Table for type S thermocouple											
°F	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Thermoelectric Voltage in mV											
-50			-0.236	-0.233	-0.231	-0.229	-0.227	-0.224	-0.222	-0.220	-0.21
-40	-0.218	-0.215	-0.213	-0.211	-0.208	-0.206	-0.204	-0.201	-0.199	-0.197	-0.19
-30	-0.194	-0.192	-0.190	-0.187	-0.185	-0.182	-0.180	-0.178	-0.175	-0.173	-0.17
-20	-0.170	-0.168	-0.165	-0.163	-0.160	-0.158	-0.155	-0.153	-0.150	-0.148	-0.14
-10	-0.145	-0.142	-0.140	-0.137	-0.135	-0.132	-0.129	-0.127	-0.124	-0.122	-0.11
0	-0.119	-0.116	-0.114	-0.111	-0.108	-0.106	-0.103	-0.100	-0.097	-0.095	-0.09
°F	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type S thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	-0.092	-0.089	-0.086	-0.084	-0.081	-0.078	-0.075	-0.073	-0.070	-0.067	-0.06
10	-0.064	-0.061	-0.058	-0.056	-0.053	-0.050	-0.047	-0.044	-0.041	-0.038	-0.03
20	-0.035	-0.033	-0.030	-0.027	-0.024	-0.021	-0.018	-0.015	-0.012	-0.009	-0.00
30	-0.006	-0.003	0.000	0.003	0.006	0.009	0.012	0.015	0.018	0.021	0.02
40	0.024	0.027	0.030	0.033	0.037	0.040	0.043	0.046	0.049	0.052	0.05
50	0.055	0.058	0.062	0.065	0.068	0.071	0.074	0.077	0.081	0.084	0.08
60	0.087	0.090	0.093	0.097	0.100	0.103	0.106	0.110	0.113	0.116	0.11
70	0.119	0.123	0.126	0.129	0.133	0.136	0.139	0.143	0.146	0.149	0.15
80	0.153	0.156	0.159	0.163	0.166	0.169	0.173	0.176	0.180	0.183	0.18
90	0.186	0.190	0.193	0.197	0.200	0.204	0.207	0.210	0.214	0.217	0.22
100	0.221	0.224	0.228	0.231	0.235	0.238	0.242	0.245	0.249	0.252	0.25
110	0.256	0.260	0.263	0.267	0.270	0.274	0.277	0.281	0.285	0.288	0.29
120	0.292	0.295	0.299	0.303	0.306	0.310	0.313	0.317	0.321	0.324	0.32
130	0.328	0.332	0.335	0.339	0.343	0.346	0.350	0.354	0.357	0.361	0.36
140	0.365	0.369	0.372	0.376	0.380	0.384	0.387	0.391	0.395	0.399	0.40
150	0.402	0.406	0.410	0.414	0.417	0.421	0.425	0.429	0.433	0.436	0.44
160	0.440	0.444	0.448	0.452	0.456	0.459	0.463	0.467	0.471	0.475	0.47
170	0.479	0.483	0.487	0.490	0.494	0.498	0.502	0.506	0.510	0.514	0.51
180	0.518	0.522	0.526	0.530	0.534	0.538	0.541	0.545	0.549	0.553	0.55
190	0.557	0.561	0.565	0.569	0.573	0.577	0.581	0.585	0.589	0.593	0.59
200	0.597	0.601	0.605	0.609	0.613	0.617	0.622	0.626	0.630	0.634	0.63
210	0.638	0.642	0.646	0.650	0.654	0.658	0.662	0.666	0.670	0.675	0.67
220	0.679	0.683	0.687	0.691	0.695	0.699	0.703	0.708	0.712	0.716	0.72
230	0.720	0.724	0.728	0.732	0.737	0.741	0.745	0.749	0.753	0.758	0.76
240	0.762	0.766	0.770	0.774	0.779	0.783	0.787	0.791	0.795	0.800	0.80
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type S thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
150	0.402	0.406	0.410	0.414	0.417	0.421	0.425	0.429	0.433	0.436	0.44
160	0.440	0.444	0.448	0.452	0.456	0.459	0.463	0.467	0.471	0.475	0.47
170	0.479	0.483	0.487	0.490	0.494	0.498	0.502	0.506	0.510	0.514	0.51
180	0.518	0.522	0.526	0.530	0.534	0.538	0.541	0.545	0.549	0.553	0.55
190	0.557	0.561	0.565	0.569	0.573	0.577	0.581	0.585	0.589	0.593	0.59
200	0.597	0.601	0.605	0.609	0.613	0.617	0.622	0.626	0.630	0.634	0.63
210	0.638	0.642	0.646	0.650	0.654	0.658	0.662	0.666	0.670	0.675	0.67
220	0.679	0.683	0.687	0.691	0.695	0.699	0.703	0.708	0.712	0.716	0.72
230	0.720	0.724	0.728	0.732	0.737	0.741	0.745	0.749	0.753	0.758	0.76
240	0.762	0.766	0.770	0.774	0.779	0.783	0.787	0.791	0.795	0.800	0.80
250	0.804	0.808	0.812	0.817	0.821	0.825	0.829	0.834	0.838	0.842	0.84
260	0.847	0.851	0.855	0.859	0.864	0.868	0.872	0.877	0.881	0.885	0.88
270	0.889	0.894	0.898	0.902	0.907	0.911	0.915	0.920	0.924	0.928	0.93
280	0.933	0.937	0.942	0.946	0.950	0.955	0.959	0.963	0.968	0.972	0.97
290	0.977	0.981	0.985	0.990	0.994	0.998	1.003	1.007	1.012	1.016	1.02
300	1.021	1.025	1.029	1.034	1.038	1.043	1.047	1.052	1.056	1.061	1.06
310	1.065	1.069	1.074	1.078	1.083	1.087	1.092	1.096	1.101	1.105	1.11
320	1.110	1.114	1.119	1.123	1.128	1.132	1.137	1.141	1.146	1.150	1.15
330	1.155	1.159	1.164	1.168	1.173	1.177	1.182	1.186	1.191	1.196	1.20
340	1.200	1.205	1.209	1.214	1.218	1.223	1.227	1.232	1.237	1.241	1.24
350	1.246	1.250	1.255	1.260	1.264	1.269	1.273	1.278	1.283	1.287	1.29
360	1.292	1.296	1.301	1.306	1.310	1.315	1.319	1.324	1.329	1.333	1.33
370	1.338	1.343	1.347	1.352	1.357	1.361	1.366	1.371	1.375	1.380	1.38
380	1.385	1.389	1.394	1.399	1.403	1.408	1.413	1.417	1.422	1.427	1.43
390	1.431	1.436	1.441	1.445	1.450	1.455	1.460	1.464	1.469	1.474	1.47
400	1.478	1.483	1.488	1.493	1.497	1.502	1.507	1.512	1.516	1.521	1.52
410	1.526	1.531	1.535	1.540	1.545	1.550	1.554	1.559	1.564	1.569	1.57
420	1.573	1.578	1.583	1.588	1.592	1.597	1.602	1.607	1.612	1.616	1.62
430	1.621	1.626	1.631	1.636	1.640	1.645	1.650	1.655	1.660	1.664	1.66
440	1.669	1.674	1.679	1.684	1.689	1.693	1.698	1.703	1.708	1.713	1.71
450	1.718	1.722	1.727	1.732	1.737	1.742	1.747	1.752	1.756	1.761	1.76
460	1.766	1.771	1.776	1.781	1.786	1.790	1.795	1.800	1.805	1.810	1.81
470	1.815	1.820	1.825	1.829	1.834	1.839	1.844	1.849	1.854	1.859	1.86
480	1.864	1.869	1.874	1.878	1.883	1.888	1.893	1.898	1.903	1.908	1.91
490	1.913	1.918	1.923	1.928	1.933	1.938	1.942	1.947	1.952	1.957	1.96
500	1.962	1.967	1.972	1.977	1.982	1.987	1.992	1.997	2.002	2.007	2.01
510	2.012	2.017	2.022	2.027	2.032	2.037	2.042	2.047	2.052	2.057	2.06
520	2.062	2.067	2.072	2.076	2.081	2.086	2.091	2.096	2.101	2.106	2.11
530	2.111	2.116	2.121	2.126	2.131	2.136	2.141	2.147	2.152	2.157	2.16
540	2.162	2.167	2.172	2.177	2.182	2.187	2.192	2.197	2.202	2.207	2.21
550	2.212	2.217	2.222	2.227	2.232	2.237	2.242	2.247	2.252	2.257	2.26
560	2.262	2.267	2.272	2.277	2.283	2.288	2.293	2.298	2.303	2.308	2.31
570	2.313	2.318	2.323	2.328	2.333	2.338	2.343	2.348	2.354	2.359	2.36
580	2.364	2.369	2.374	2.379	2.384	2.389	2.394	2.399	2.404	2.410	2.41
590	2.415	2.420	2.425	2.430	2.435	2.440	2.445	2.450	2.455	2.461	2.46
600	2.466	2.471	2.476	2.481	2.486	2.491	2.496	2.502	2.507	2.512	2.51
610	2.517	2.522	2.527	2.532	2.537	2.543	2.548	2.553	2.558	2.563	2.56
620	2.568	2.574	2.579	2.584	2.589	2.594	2.599	2.604	2.610	2.615	2.62
630	2.620	2.625	2.630	2.635	2.641	2.646	2.651	2.656	2.661	2.666	2.67
640	2.672	2.677	2.682	2.687	2.692	2.697	2.703	2.708	2.713	2.718	2.72
650	2.723	2.729	2.734	2.739	2.744	2.749	2.755	2.760	2.765	2.770	2.77
660	2.775	2.781	2.786	2.791	2.796	2.801	2.807	2.812	2.817	2.822	2.82
670	2.827	2.833	2.838	2.843	2.848	2.854	2.859	2.864	2.869	2.874	2.88
680	2.880	2.885	2.890	2.895	2.901	2.906	2.911	2.916	2.922	2.927	2.93
690	2.932	2.937	2.943	2.948	2.953	2.958	2.964	2.969	2.974	2.979	2.98
700	2.985	2.990	2.995	3.000	3.006	3.011	3.016	3.021	3.027	3.032	3.03
710	3.037	3.042	3.048	3.053	3.058	3.063	3.069	3.074	3.079	3.085	3.09
720	3.090	3.095	3.100	3.106	3.111	3.116	3.122	3.127	3.132	3.137	3.14
730	3.143	3.148	3.153	3.159	3.164	3.169	3.174	3.180	3.185	3.190	3.19
740	3.196	3.201	3.206	3.212	3.217	3.222	3.227	3.233	3.238	3.243	3.24
750	3.249	3.254	3.259	3.265	3.270	3.275	3.281	3.286	3.291	3.297	3.30
760	3.302	3.307	3.313	3.318	3.323	3.329	3.334	3.339	3.345	3.350	3.35
770	3.355	3.361	3.366	3.371	3.377	3.382	3.387	3.393	3.398	3.403	3.40
780	3.409	3.414	3.419	3.425	3.430	3.435	3.441	3.446	3.451	3.457	3.46
790	3.462	3.468	3.473	3.478	3.484	3.489	3.494	3.500	3.505	3.510	3.51
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type S thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
800	3.516	3.521	3.527	3.532	3.537	3.543	3.548	3.553	3.559	3.564	3.570
810	3.570	3.575	3.580	3.586	3.591	3.596	3.602	3.607	3.613	3.618	3.623
820	3.623	3.629	3.634	3.640	3.645	3.650	3.656	3.661	3.667	3.672	3.677
830	3.677	3.683	3.688	3.694	3.699	3.704	3.710	3.715	3.721	3.726	3.731
840	3.731	3.737	3.742	3.748	3.753	3.758	3.764	3.769	3.775	3.780	3.786
850	3.786	3.791	3.796	3.802	3.807	3.813	3.818	3.823	3.829	3.834	3.840
860	3.840	3.845	3.851	3.856	3.862	3.867	3.872	3.878	3.883	3.889	3.894
870	3.894	3.900	3.905	3.910	3.916	3.921	3.927	3.932	3.938	3.943	3.949
880	3.949	3.954	3.959	3.965	3.970	3.976	3.981	3.987	3.992	3.998	4.003
890	4.003	4.009	4.014	4.020	4.025	4.030	4.036	4.041	4.047	4.052	4.058
900	4.058	4.063	4.069	4.074	4.080	4.085	4.091	4.096	4.102	4.107	4.113
910	4.113	4.118	4.123	4.129	4.134	4.140	4.145	4.151	4.156	4.162	4.167
920	4.167	4.173	4.178	4.184	4.189	4.195	4.200	4.206	4.211	4.217	4.222
930	4.222	4.228	4.233	4.239	4.244	4.250	4.255	4.261	4.266	4.272	4.277
940	4.277	4.283	4.288	4.294	4.299	4.305	4.310	4.316	4.321	4.327	4.332
950	4.332	4.338	4.343	4.349	4.355	4.360	4.366	4.371	4.377	4.382	4.388
960	4.388	4.393	4.399	4.404	4.410	4.415	4.421	4.426	4.432	4.437	4.443
970	4.443	4.449	4.454	4.460	4.465	4.471	4.476	4.482	4.487	4.493	4.498
980	4.498	4.504	4.510	4.515	4.521	4.526	4.532	4.537	4.543	4.548	4.554
990	4.554	4.559	4.565	4.571	4.576	4.582	4.587	4.593	4.598	4.604	4.610
1000	4.610	4.615	4.621	4.626	4.632	4.637	4.643	4.648	4.654	4.660	4.665
1010	4.665	4.671	4.676	4.682	4.688	4.693	4.699	4.704	4.710	4.715	4.721
1020	4.721	4.727	4.732	4.738	4.743	4.749	4.755	4.760	4.766	4.771	4.777
1030	4.777	4.782	4.788	4.794	4.799	4.805	4.810	4.816	4.822	4.827	4.833
1040	4.833	4.838	4.844	4.850	4.855	4.861	4.866	4.872	4.878	4.883	4.889
1050	4.889	4.895	4.900	4.906	4.911	4.917	4.923	4.928	4.934	4.939	4.945
1060	4.945	4.951	4.956	4.962	4.968	4.973	4.979	4.984	4.990	4.996	5.001
1070	5.001	5.007	5.013	5.018	5.024	5.030	5.035	5.041	5.046	5.052	5.058
1080	5.058	5.063	5.069	5.075	5.080	5.086	5.092	5.097	5.103	5.109	5.114
1090	5.114	5.120	5.125	5.131	5.137	5.142	5.148	5.154	5.159	5.165	5.171
1100	5.171	5.176	5.182	5.188	5.193	5.199	5.205	5.210	5.216	5.222	5.227
1110	5.227	5.233	5.239	5.244	5.250	5.256	5.261	5.267	5.273	5.278	5.284
1120	5.284	5.290	5.295	5.301	5.307	5.312	5.318	5.324	5.330	5.335	5.341
1130	5.341	5.347	5.352	5.358	5.364	5.369	5.375	5.381	5.386	5.392	5.398
1140	5.398	5.404	5.409	5.415	5.421	5.426	5.432	5.438	5.443	5.449	5.455
1150	5.455	5.461	5.466	5.472	5.478	5.483	5.489	5.495	5.501	5.506	5.512
1160	5.512	5.518	5.523	5.529	5.535	5.541	5.546	5.552	5.558	5.563	5.569
1170	5.569	5.575	5.581	5.586	5.592	5.598	5.604	5.609	5.615	5.621	5.627
1180	5.627	5.632	5.638	5.644	5.649	5.655	5.661	5.667	5.672	5.678	5.684
1190	5.684	5.690	5.695	5.701	5.707	5.713	5.718	5.724	5.730	5.736	5.741
1200	5.741	5.747	5.753	5.759	5.764	5.770	5.776	5.782	5.788	5.793	5.799
1210	5.799	5.805	5.811	5.816	5.822	5.828	5.834	5.839	5.845	5.851	5.857
1220	5.857	5.863	5.868	5.874	5.880	5.886	5.891	5.897	5.903	5.909	5.915
1230	5.915	5.920	5.926	5.932	5.938	5.944	5.949	5.955	5.961	5.967	5.972
1240	5.972	5.978	5.984	5.990	5.996	6.001	6.007	6.013	6.019	6.025	6.030
1250	6.030	6.036	6.042	6.048	6.054	6.060	6.065	6.071	6.077	6.083	6.089
1260	6.089	6.094	6.100	6.106	6.112	6.118	6.124	6.129	6.135	6.141	6.147
1270	6.147	6.153	6.158	6.164	6.170	6.176	6.182	6.188	6.193	6.199	6.205
1280	6.205	6.211	6.217	6.223	6.228	6.234	6.240	6.246	6.252	6.258	6.264
1290	6.264	6.269	6.275	6.281	6.287	6.293	6.299	6.305	6.310	6.316	6.322
1300	6.322	6.328	6.334	6.340	6.346	6.351	6.357	6.363	6.369	6.375	6.381
1310	6.381	6.387	6.392	6.398	6.404	6.410	6.416	6.422	6.428	6.434	6.439
1320	6.439	6.445	6.451	6.457	6.463	6.469	6.475	6.481	6.486	6.492	6.498
1330	6.498	6.504	6.510	6.516	6.522	6.528	6.534	6.539	6.545	6.551	6.557
1340	6.557	6.563	6.569	6.575	6.581	6.587	6.593	6.598	6.604	6.610	6.616
1350	6.616	6.622	6.628	6.634	6.640	6.646	6.652	6.658	6.664	6.669	6.675
1360	6.675	6.681	6.687	6.693	6.699	6.705	6.711	6.717	6.723	6.729	6.735
1370	6.735	6.741	6.746	6.752	6.758	6.764	6.770	6.776	6.782	6.788	6.794
1380	6.794	6.800	6.806	6.812	6.818	6.824	6.830	6.836	6.842	6.847	6.853
1390	6.853	6.859	6.865	6.871	6.877	6.883	6.889	6.895	6.901	6.907	6.913
1400	6.913	6.919	6.925	6.931	6.937	6.943	6.949	6.955	6.961	6.967	6.973
1410	6.973	6.979	6.985	6.991	6.997	7.003	7.008	7.014	7.020	7.026	7.032
1420	7.032	7.038	7.044	7.050	7.056	7.062	7.068	7.074	7.080	7.086	7.092
1430	7.092	7.098	7.104	7.110	7.116	7.122	7.128	7.134	7.140	7.146	7.152
1440	7.152	7.158	7.164	7.170	7.176	7.182	7.188	7.194	7.200	7.206	7.212
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type S thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
1450	7.212	7.218	7.224	7.230	7.236	7.242	7.249	7.255	7.261	7.267	7.27
1460	7.273	7.279	7.285	7.291	7.297	7.303	7.309	7.315	7.321	7.327	7.33
1470	7.333	7.339	7.345	7.351	7.357	7.363	7.369	7.375	7.381	7.387	7.39
1480	7.393	7.399	7.405	7.411	7.418	7.424	7.430	7.436	7.442	7.448	7.45
1490	7.454	7.460	7.466	7.472	7.478	7.484	7.490	7.496	7.502	7.508	7.51
1500	7.514	7.521	7.527	7.533	7.539	7.545	7.551	7.557	7.563	7.569	7.57
1510	7.575	7.581	7.587	7.593	7.600	7.606	7.612	7.618	7.624	7.630	7.63
1520	7.636	7.642	7.648	7.654	7.660	7.667	7.673	7.679	7.685	7.691	7.69
1530	7.697	7.703	7.709	7.715	7.721	7.728	7.734	7.740	7.746	7.752	7.75
1540	7.758	7.764	7.770	7.776	7.783	7.789	7.795	7.801	7.807	7.813	7.81
1550	7.819	7.825	7.832	7.838	7.844	7.850	7.856	7.862	7.868	7.874	7.88
1560	7.881	7.887	7.893	7.899	7.905	7.911	7.917	7.923	7.930	7.936	7.94
1570	7.942	7.948	7.954	7.960	7.966	7.973	7.979	7.985	7.991	7.997	8.00
1580	8.003	8.010	8.016	8.022	8.028	8.034	8.040	8.047	8.053	8.059	8.06
1590	8.065	8.071	8.077	8.083	8.090	8.096	8.102	8.108	8.114	8.121	8.12
1600	8.127	8.133	8.139	8.145	8.151	8.158	8.164	8.170	8.176	8.182	8.18
1610	8.189	8.195	8.201	8.207	8.213	8.219	8.226	8.232	8.238	8.244	8.25
1620	8.250	8.257	8.263	8.269	8.275	8.281	8.288	8.294	8.300	8.306	8.31
1630	8.312	8.319	8.325	8.331	8.337	8.343	8.350	8.356	8.362	8.368	8.37
1640	8.375	8.381	8.387	8.393	8.399	8.406	8.412	8.418	8.424	8.431	8.43
1650	8.437	8.443	8.449	8.455	8.462	8.468	8.474	8.480	8.487	8.493	8.49
1660	8.499	8.505	8.512	8.518	8.524	8.530	8.537	8.543	8.549	8.555	8.56
1670	8.562	8.568	8.574	8.580	8.587	8.593	8.599	8.605	8.612	8.618	8.62
1680	8.624	8.630	8.637	8.643	8.649	8.655	8.662	8.668	8.674	8.680	8.68
1690	8.687	8.693	8.699	8.706	8.712	8.718	8.724	8.731	8.737	8.743	8.74
1700	8.749	8.756	8.762	8.768	8.775	8.781	8.787	8.793	8.800	8.806	8.81
1710	8.812	8.819	8.825	8.831	8.837	8.844	8.850	8.856	8.863	8.869	8.87
1720	8.875	8.882	8.888	8.894	8.900	8.907	8.913	8.919	8.926	8.932	8.93
1730	8.938	8.945	8.951	8.957	8.964	8.970	8.976	8.983	8.989	8.995	9.00
1740	9.001	9.008	9.014	9.020	9.027	9.033	9.039	9.046	9.052	9.058	9.06
1750	9.065	9.071	9.077	9.084	9.090	9.096	9.103	9.109	9.115	9.122	9.12
1760	9.128	9.134	9.141	9.147	9.153	9.160	9.166	9.172	9.179	9.185	9.19
1770	9.192	9.198	9.204	9.211	9.217	9.223	9.230	9.236	9.242	9.249	9.25
1780	9.255	9.261	9.268	9.274	9.281	9.287	9.293	9.300	9.306	9.312	9.31
1790	9.319	9.325	9.331	9.338	9.344	9.351	9.357	9.363	9.370	9.376	9.38
1800	9.382	9.389	9.395	9.402	9.408	9.414	9.421	9.427	9.434	9.440	9.44
1810	9.446	9.453	9.459	9.465	9.472	9.478	9.485	9.491	9.497	9.504	9.51
1820	9.510	9.517	9.523	9.529	9.536	9.542	9.549	9.555	9.561	9.568	9.57
1830	9.574	9.581	9.587	9.594	9.600	9.606	9.613	9.619	9.626	9.632	9.63
1840	9.638	9.645	9.651	9.658	9.664	9.671	9.677	9.683	9.690	9.696	9.70
1850	9.703	9.709	9.716	9.722	9.728	9.735	9.741	9.748	9.754	9.761	9.76
1860	9.767	9.773	9.780	9.786	9.793	9.799	9.806	9.812	9.819	9.825	9.83
1870	9.831	9.838	9.844	9.851	9.857	9.864	9.870	9.877	9.883	9.889	9.89
1880	9.896	9.902	9.909	9.915	9.922	9.928	9.935	9.941	9.948	9.954	9.96
1890	9.961	9.967	9.973	9.980	9.986	9.993	9.999	10.006	10.012	10.019	10.02
1900	10.025	10.032	10.038	10.045	10.051	10.058	10.064	10.071	10.077	10.084	10.09
1910	10.090	10.097	10.103	10.110	10.116	10.123	10.129	10.136	10.142	10.149	10.15
1920	10.155	10.162	10.168	10.175	10.181	10.188	10.194	10.201	10.207	10.214	10.22
1930	10.220	10.227	10.233	10.240	10.246	10.253	10.259	10.266	10.272	10.279	10.28
1940	10.285	10.292	10.298	10.305	10.311	10.318	10.324	10.331	10.337	10.344	10.35
1950	10.350	10.357	10.363	10.370	10.376	10.383	10.390	10.396	10.403	10.409	10.41
1960	10.416	10.422	10.429	10.435	10.442	10.448	10.455	10.461	10.468	10.475	10.48
1970	10.481	10.488	10.494	10.501	10.507	10.514	10.520	10.527	10.533	10.540	10.54
1980	10.547	10.553	10.560	10.566	10.573	10.579	10.586	10.592	10.599	10.606	10.61
1990	10.612	10.619	10.625	10.632	10.638	10.645	10.651	10.658	10.665	10.671	10.67
2000	10.678	10.684	10.691	10.697	10.704	10.711	10.717	10.724	10.730	10.737	10.74
2010	10.743	10.750	10.757	10.763	10.770	10.776	10.783	10.789	10.796	10.803	10.80
2020	10.809	10.816	10.822	10.829	10.836	10.842	10.849	10.855	10.862	10.868	10.87
2030	10.875	10.882	10.888	10.895	10.901	10.908	10.915	10.921	10.928	10.934	10.94
2040	10.941	10.948	10.954	10.961	10.967	10.974	10.981	10.987	10.994	11.000	11.00
2050	11.007	11.014	11.020	11.027	11.033	11.040	11.047	11.053	11.060	11.066	11.07
2060	11.073	11.080	11.086	11.093	11.099	11.106	11.113	11.119	11.126	11.132	11.13
2070	11.139	11.146	11.152	11.159	11.166	11.172	11.179	11.185	11.192	11.199	11.20
2080	11.205	11.212	11.219	11.225	11.232	11.238	11.245	11.252	11.258	11.265	11.27
2090	11.272	11.278	11.285	11.291	11.298	11.305	11.311	11.318	11.325	11.331	11.33
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type S thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
2100	11.338	11.345	11.351	11.358	11.364	11.371	11.378	11.384	11.391	11.398	11.40
2110	11.404	11.411	11.418	11.424	11.431	11.437	11.444	11.451	11.457	11.464	11.47
2120	11.471	11.477	11.484	11.491	11.497	11.504	11.511	11.517	11.524	11.531	11.53
2130	11.537	11.544	11.550	11.557	11.564	11.570	11.577	11.584	11.590	11.597	11.60
2140	11.604	11.610	11.617	11.624	11.630	11.637	11.644	11.650	11.657	11.664	11.67
2150	11.670	11.677	11.684	11.690	11.697	11.704	11.710	11.717	11.724	11.730	11.73
2160	11.737	11.744	11.750	11.757	11.764	11.770	11.777	11.784	11.790	11.797	11.80
2170	11.804	11.810	11.817	11.824	11.830	11.837	11.844	11.850	11.857	11.864	11.87
2180	11.870	11.877	11.884	11.890	11.897	11.904	11.910	11.917	11.924	11.931	11.93
2190	11.937	11.944	11.951	11.957	11.964	11.971	11.977	11.984	11.991	11.997	12.00
2200	12.004	12.011	12.017	12.024	12.031	12.037	12.044	12.051	12.058	12.064	12.07
2210	12.071	12.078	12.084	12.091	12.098	12.104	12.111	12.118	12.124	12.131	12.13
2220	12.138	12.145	12.151	12.158	12.165	12.171	12.178	12.185	12.191	12.198	12.20
2230	12.205	12.211	12.218	12.225	12.232	12.238	12.245	12.252	12.258	12.265	12.27
2240	12.272	12.278	12.285	12.292	12.299	12.305	12.312	12.319	12.325	12.332	12.33
2250	12.339	12.346	12.352	12.359	12.366	12.372	12.379	12.386	12.392	12.399	12.40
2260	12.406	12.413	12.419	12.426	12.433	12.439	12.446	12.453	12.460	12.466	12.47
2270	12.473	12.480	12.486	12.493	12.500	12.507	12.513	12.520	12.527	12.533	12.54
2280	12.540	12.547	12.554	12.560	12.567	12.574	12.580	12.587	12.594	12.601	12.60
2290	12.607	12.614	12.621	12.627	12.634	12.641	12.648	12.654	12.661	12.668	12.67
2300	12.675	12.681	12.688	12.695	12.701	12.708	12.715	12.722	12.728	12.735	12.74
2310	12.742	12.748	12.755	12.762	12.769	12.775	12.782	12.789	12.796	12.802	12.80
2320	12.809	12.816	12.822	12.829	12.836	12.843	12.849	12.856	12.863	12.870	12.87
2330	12.876	12.883	12.890	12.896	12.903	12.910	12.917	12.923	12.930	12.937	12.94
2340	12.944	12.950	12.957	12.964	12.971	12.977	12.984	12.991	12.997	13.004	13.01
2350	13.011	13.018	13.024	13.031	13.038	13.045	13.051	13.058	13.065	13.072	13.07
2360	13.078	13.085	13.092	13.098	13.105	13.112	13.119	13.125	13.132	13.139	13.14
2370	13.146	13.152	13.159	13.166	13.173	13.179	13.186	13.193	13.199	13.206	13.21
2380	13.213	13.220	13.226	13.233	13.240	13.247	13.253	13.260	13.267	13.274	13.28
2390	13.280	13.287	13.294	13.301	13.307	13.314	13.321	13.328	13.334	13.341	13.34
2400	13.348	13.354	13.361	13.368	13.375	13.381	13.388	13.395	13.402	13.408	13.41
2410	13.415	13.422	13.429	13.435	13.442	13.449	13.456	13.462	13.469	13.476	13.48
2420	13.483	13.489	13.496	13.503	13.510	13.516	13.523	13.530	13.537	13.543	13.55
2430	13.550	13.557	13.563	13.570	13.577	13.584	13.590	13.597	13.604	13.611	13.61
2440	13.617	13.624	13.631	13.638	13.644	13.651	13.658	13.665	13.671	13.678	13.68
2450	13.685	13.692	13.698	13.705	13.712	13.719	13.725	13.732	13.739	13.746	13.75
2460	13.752	13.759	13.766	13.773	13.779	13.786	13.793	13.800	13.806	13.813	13.82
2470	13.820	13.826	13.833	13.840	13.847	13.853	13.860	13.867	13.874	13.880	13.88
2480	13.887	13.894	13.901	13.907	13.914	13.921	13.928	13.934	13.941	13.948	13.95
2490	13.955	13.961	13.968	13.975	13.982	13.988	13.995	14.002	14.009	14.015	14.02
2500	14.022	14.029	14.036	14.042	14.049	14.056	14.063	14.069	14.076	14.083	14.08
2510	14.089	14.096	14.103	14.110	14.116	14.123	14.130	14.137	14.143	14.150	14.15
2520	14.157	14.164	14.170	14.177	14.184	14.191	14.197	14.204	14.211	14.218	14.22
2530	14.224	14.231	14.238	14.245	14.251	14.258	14.265	14.272	14.278	14.285	14.29
2540	14.292	14.298	14.305	14.312	14.319	14.325	14.332	14.339	14.346	14.352	14.35
2550	14.359	14.366	14.373	14.379	14.386	14.393	14.400	14.406	14.413	14.420	14.42
2560	14.426	14.433	14.440	14.447	14.453	14.460	14.467	14.474	14.480	14.487	14.49
2570	14.494	14.501	14.507	14.514	14.521	14.528	14.534	14.541	14.548	14.554	14.56
2580	14.561	14.568	14.575	14.581	14.588	14.595	14.602	14.608	14.615	14.622	14.62
2590	14.629	14.635	14.642	14.649	14.655	14.662	14.669	14.676	14.682	14.689	14.69
2600	14.696	14.703	14.709	14.716	14.723	14.729	14.736	14.743	14.750	14.756	14.76
2610	14.763	14.770	14.777	14.783	14.790	14.797	14.803	14.810	14.817	14.824	14.83
2620	14.830	14.837	14.844	14.851	14.857	14.864	14.871	14.877	14.884	14.891	14.89
2630	14.898	14.904	14.911	14.918	14.925	14.931	14.938	14.945	14.951	14.958	14.96
2640	14.965	14.972	14.978	14.985	14.992	14.998	15.005	15.012	15.019	15.025	15.03
2650	15.032	15.039	15.045	15.052	15.059	15.066	15.072	15.079	15.086	15.092	15.09
2660	15.099	15.106	15.113	15.119	15.126	15.133	15.139	15.146	15.153	15.160	15.16
2670	15.166	15.173	15.180	15.186	15.193	15.200	15.207	15.213	15.220	15.227	15.23
2680	15.233	15.240	15.247	15.254	15.260	15.267	15.274	15.280	15.287	15.294	15.30
2690	15.300	15.307	15.314	15.321	15.327	15.334	15.341	15.347	15.354	15.361	15.36
2700	15.367	15.374	15.381	15.388	15.394	15.401	15.408	15.414	15.421	15.428	15.43
2710	15.434	15.441	15.448	15.455	15.461	15.468	15.475	15.481	15.488	15.495	15.50
2720	15.501	15.508	15.515	15.521	15.528	15.535	15.542	15.548	15.555	15.562	15.56
2730	15.568	15.575	15.582	15.588	15.595	15.602	15.608	15.615	15.622	15.628	15.63
2740	15.635	15.642	15.649	15.655	15.662	15.669	15.675	15.682	15.689	15.695	15.70

ITS-90 Table for type S thermocouple											
°F	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
2750	15.702	15.709	15.715	15.722	15.729	15.735	15.742	15.749	15.755	15.762	15.76
2760	15.769	15.775	15.782	15.789	15.795	15.802	15.809	15.815	15.822	15.829	15.83
2770	15.835	15.842	15.849	15.855	15.862	15.869	15.875	15.882	15.889	15.895	15.90
2780	15.902	15.909	15.915	15.922	15.929	15.935	15.942	15.949	15.955	15.962	15.96
2790	15.969	15.975	15.982	15.989	15.995	16.002	16.009	16.015	16.022	16.029	16.03
2800	16.035	16.042	16.049	16.055	16.062	16.069	16.075	16.082	16.089	16.095	16.10
2810	16.102	16.108	16.115	16.122	16.128	16.135	16.142	16.148	16.155	16.162	16.16
2820	16.168	16.175	16.182	16.188	16.195	16.202	16.208	16.215	16.221	16.228	16.23
2830	16.235	16.241	16.248	16.255	16.261	16.268	16.275	16.281	16.288	16.294	16.30
2840	16.301	16.308	16.314	16.321	16.328	16.334	16.341	16.347	16.354	16.361	16.36
2850	16.367	16.374	16.381	16.387	16.394	16.400	16.407	16.414	16.420	16.427	16.43
2860	16.434	16.440	16.447	16.453	16.460	16.467	16.473	16.480	16.486	16.493	16.50
2870	16.500	16.506	16.513	16.520	16.526	16.533	16.539	16.546	16.553	16.559	16.56
2880	16.566	16.572	16.579	16.586	16.592	16.599	16.605	16.612	16.619	16.625	16.63
2890	16.632	16.638	16.645	16.652	16.658	16.665	16.671	16.678	16.685	16.691	16.69
2900	16.698	16.704	16.711	16.718	16.724	16.731	16.737	16.744	16.751	16.757	16.76
2910	16.764	16.770	16.777	16.783	16.790	16.797	16.803	16.810	16.816	16.823	16.82
2920	16.829	16.836	16.843	16.849	16.856	16.862	16.869	16.876	16.882	16.889	16.89
2930	16.895	16.902	16.908	16.915	16.922	16.928	16.935	16.941	16.948	16.954	16.96
2940	16.961	16.967	16.974	16.981	16.987	16.994	17.000	17.007	17.013	17.020	17.02
2950	17.026	17.033	17.040	17.046	17.053	17.059	17.066	17.072	17.079	17.085	17.09
2960	17.092	17.099	17.105	17.112	17.118	17.125	17.131	17.138	17.144	17.151	17.15
2970	17.157	17.164	17.171	17.177	17.184	17.190	17.197	17.203	17.210	17.216	17.22
2980	17.223	17.229	17.236	17.242	17.249	17.255	17.262	17.268	17.275	17.282	17.28
2990	17.288	17.295	17.301	17.308	17.314	17.321	17.327	17.334	17.340	17.347	17.35
3000	17.353	17.360	17.366	17.373	17.379	17.386	17.392	17.399	17.405	17.412	17.41
3010	17.418	17.425	17.431	17.438	17.444	17.451	17.457	17.464	17.470	17.477	17.48
3020	17.483	17.490	17.496	17.503	17.509	17.516	17.522	17.529	17.535	17.542	17.54
3030	17.548	17.555	17.561	17.568	17.574	17.581	17.587	17.594	17.600	17.607	17.61
3040	17.613	17.620	17.626	17.633	17.639	17.645	17.652	17.658	17.665	17.671	17.67
3050	17.678	17.684	17.691	17.697	17.704	17.710	17.717	17.723	17.729	17.736	17.74
3060	17.742	17.749	17.755	17.762	17.768	17.775	17.781	17.787	17.794	17.800	17.80
3070	17.807	17.813	17.819	17.826	17.832	17.839	17.845	17.852	17.858	17.864	17.87
3080	17.871	17.877	17.884	17.890	17.896	17.903	17.909	17.915	17.922	17.928	17.93
3090	17.935	17.941	17.947	17.954	17.960	17.966	17.973	17.979	17.985	17.992	17.99
3100	17.998	18.004	18.011	18.017	18.023	18.030	18.036	18.042	18.049	18.055	18.06
3110	18.061	18.068	18.074	18.080	18.086	18.093	18.099	18.105	18.112	18.118	18.12
3120	18.124	18.130	18.137	18.143	18.149	18.155	18.162	18.168	18.174	18.180	18.18
3130	18.187	18.193	18.199	18.205	18.211	18.218	18.224	18.230	18.236	18.242	18.24
3140	18.248	18.255	18.261	18.267	18.273	18.279	18.285	18.292	18.298	18.304	18.31
3150	18.310	18.316	18.322	18.328	18.334	18.341	18.347	18.353	18.359	18.365	18.37
3160	18.371	18.377	18.383	18.389	18.395	18.401	18.407	18.413	18.419	18.425	18.43
3170	18.431	18.437	18.443	18.449	18.455	18.461	18.467	18.473	18.479	18.485	18.49
3180	18.491	18.497	18.503	18.509	18.515	18.521	18.527	18.533	18.539	18.545	18.55
3190	18.551	18.557	18.562	18.568	18.574	18.580	18.586	18.592	18.598	18.603	18.60
3200	18.609	18.615	18.621	18.627	18.633	18.638	18.644	18.650	18.656	18.661	18.66
3210	18.667	18.673	18.679	18.684	18.690						

ITS-90 Table for type S thermocouple										
°C	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
600	5.239	5.249	5.259	5.269	5.280	5.290	5.300	5.310	5.320	5.331
610	5.341	5.351	5.361	5.372	5.382	5.392	5.402	5.413	5.423	5.433
620	5.443	5.454	5.464	5.474	5.485	5.495	5.505	5.515	5.526	5.536
630	5.546	5.557	5.567	5.577	5.588	5.598	5.608	5.618	5.629	5.639
640	5.649	5.660	5.670	5.680	5.691	5.701	5.712	5.722	5.732	5.743
650	5.753	5.763	5.774	5.784	5.794	5.805	5.815	5.826	5.836	5.846
660	5.857	5.867	5.878	5.888	5.898	5.909	5.919	5.930	5.940	5.950
670	5.961	5.971	5.982	5.992	6.003	6.013	6.024	6.034	6.044	6.055
680	6.065	6.076	6.086	6.097	6.107	6.118	6.128	6.139	6.149	6.160
690	6.170	6.181	6.191	6.202	6.212	6.223	6.233	6.244	6.254	6.265
700	6.275	6.286	6.296	6.307	6.317	6.328	6.338	6.349	6.360	6.370
710	6.381	6.391	6.402	6.412	6.423	6.434	6.444	6.455	6.466	6.476
720	6.486	6.497	6.508	6.518	6.529	6.539	6.550	6.561	6.571	6.582
730	6.593	6.603	6.614	6.624	6.635	6.646	6.656	6.667	6.678	6.688
740	6.699	6.710	6.720	6.731	6.742	6.752	6.763	6.774	6.784	6.795
750	6.806	6.817	6.827	6.838	6.849	6.859	6.870	6.881	6.892	6.902
760	6.913	6.924	6.934	6.945	6.956	6.967	6.977	6.988	6.999	7.010
770	7.020	7.031	7.042	7.053	7.064	7.074	7.085	7.096	7.107	7.117
780	7.128	7.139	7.150	7.161	7.172	7.182	7.193	7.204	7.215	7.226
790	7.236	7.247	7.258	7.269	7.280	7.291	7.302	7.312	7.323	7.334
800	7.345	7.356	7.367	7.378	7.388	7.399	7.410	7.421	7.432	7.443
810	7.454	7.465	7.476	7.487	7.497	7.508	7.519	7.530	7.541	7.552
820	7.563	7.574	7.585	7.596	7.607	7.618	7.629	7.640	7.651	7.662
830	7.673	7.684	7.695	7.706	7.717	7.728	7.739	7.750	7.761	7.772
840	7.783	7.794	7.805	7.816	7.827	7.838	7.849	7.860	7.871	7.882
850	7.893	7.904	7.915	7.926	7.937	7.948	7.959	7.970	7.981	7.992
860	8.003	8.014	8.026	8.037	8.048	8.059	8.070	8.081	8.092	8.103
870	8.114	8.125	8.137	8.148	8.159	8.170	8.181	8.192	8.203	8.214
880	8.226	8.237	8.248	8.259	8.270	8.281	8.293	8.304	8.315	8.326
890	8.337	8.348	8.360	8.371	8.382	8.393	8.404	8.416	8.427	8.438
900	8.449	8.460	8.472	8.483	8.494	8.505	8.517	8.528	8.539	8.550
910	8.562	8.573	8.584	8.595	8.607	8.618	8.629	8.640	8.652	8.663
920	8.674	8.685	8.697	8.708	8.719	8.731	8.742	8.753	8.765	8.776
930	8.787	8.798	8.810	8.821	8.832	8.844	8.855	8.866	8.878	8.889
940	8.900	8.912	8.923	8.935	8.946	8.957	8.969	8.980	8.991	9.003
950	9.014	9.025	9.037	9.048	9.060	9.071	9.082	9.094	9.105	9.117
960	9.128	9.139	9.151	9.162	9.174	9.185	9.197	9.208	9.219	9.231
970	9.242	9.254	9.265	9.277	9.288	9.300	9.311	9.323	9.334	9.345
980	9.357	9.368	9.380	9.391	9.403	9.414	9.426	9.437	9.449	9.460
990	9.472	9.483	9.495	9.506	9.518	9.529	9.541	9.552	9.564	9.576
1000	9.587	9.599	9.610	9.622	9.633	9.645	9.656	9.668	9.680	9.691
1010	9.703	9.714	9.726	9.737	9.749	9.761	9.772	9.784	9.795	9.807
1020	9.819	9.830	9.842	9.853	9.865	9.877	9.888	9.900	9.911	9.923
1030	9.935	9.946	9.958	9.970	9.981	9.993	10.005	10.016	10.028	10.040
1040	10.051	10.063	10.075	10.086	10.098	10.110	10.121	10.133	10.145	10.156
1050	10.168	10.180	10.191	10.203	10.215	10.227	10.238	10.250	10.262	10.273
1060	10.285	10.297	10.309	10.320	10.332	10.344	10.356	10.367	10.379	10.391
1070	10.403	10.414	10.426	10.438	10.450	10.461	10.473	10.485	10.497	10.509
1080	10.520	10.532	10.544	10.556	10.567	10.579	10.591	10.603	10.615	10.626
1090	10.638	10.650	10.662	10.674	10.686	10.697	10.709	10.721	10.733	10.745
1100	10.757	10.768	10.780	10.792	10.804	10.816	10.828	10.839	10.851	10.863
1110	10.875	10.887	10.899	10.911	10.922	10.934	10.946	10.958	10.970	10.982
1120	10.994	11.006	11.017	11.029	11.041	11.053	11.065	11.077	11.089	11.101
1130	11.113	11.125	11.136	11.148	11.160	11.172	11.184	11.196	11.208	11.220
1140	11.232	11.244	11.256	11.268	11.280	11.291	11.303	11.315	11.327	11.339
1150	11.351	11.363	11.375	11.387	11.399	11.411	11.423	11.435	11.447	11.459
1160	11.471	11.483	11.495	11.507	11.519	11.531	11.542	11.554	11.566	11.578
1170	11.590	11.602	11.614	11.626	11.638	11.650	11.662	11.674	11.686	11.698
1180	11.710	11.722	11.734	11.746	11.758	11.770	11.782	11.794	11.806	11.818
1190	11.830	11.842	11.854	11.866	11.878	11.890	11.902	11.914	11.926	11.939
1200	11.951	11.963	11.975	11.987	11.999	12.011	12.023	12.035	12.047	12.059
1210	12.071	12.083	12.095	12.107	12.119	12.131	12.143	12.155	12.167	12.179
1220	12.191	12.203	12.216	12.228	12.240	12.252	12.264	12.276	12.288	12.300
1230	12.312	12.324	12.336	12.348	12.360	12.372	12.384	12.397	12.409	12.421
1240	12.433	12.445	12.457	12.469	12.481	12.493	12.505	12.517	12.529	12.542
°C	0	1	2	3	4	5	6	7	8	9

ITS-90 Table for type S thermocouple											
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Thermoelectric Voltage in mV											
-40	-0.236	-0.232	-0.228	-0.224	-0.219	-0.215	-0.211	-0.207	-0.203	-0.199	-0.19
-30	-0.194	-0.190	-0.186	-0.181	-0.177	-0.173	-0.168	-0.164	-0.159	-0.155	-0.15
-20	-0.150	-0.146	-0.141	-0.136	-0.132	-0.127	-0.122	-0.117	-0.113	-0.108	-0.10
-10	-0.103	-0.098	-0.093	-0.088	-0.083	-0.078	-0.073	-0.068	-0.063	-0.058	-0.05
0	-0.053	-0.048	-0.042	-0.037	-0.032	-0.027	-0.021	-0.016	-0.011	-0.005	0.00
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type S thermocouple											
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	0.000	0.005	0.011	0.016	0.022	0.027	0.033	0.038	0.044	0.050	0.05
10	0.055	0.061	0.067	0.072	0.078	0.084	0.090	0.095	0.101	0.107	0.11
20	0.113	0.119	0.125	0.131	0.137	0.143	0.149	0.155	0.161	0.167	0.17
30	0.173	0.179	0.185	0.191	0.197	0.204	0.210	0.216	0.222	0.229	0.23
40	0.235	0.241	0.248	0.254	0.260	0.267	0.273	0.280	0.286	0.292	0.29
50	0.299	0.305	0.312	0.319	0.325	0.332	0.338	0.345	0.352	0.358	0.36
60	0.365	0.372	0.378	0.385	0.392	0.399	0.405	0.412	0.419	0.426	0.43
70	0.433	0.440	0.446	0.453	0.460	0.467	0.474	0.481	0.488	0.495	0.50
80	0.502	0.509	0.516	0.523	0.530	0.538	0.545	0.552	0.559	0.566	0.57
90	0.573	0.580	0.588	0.595	0.602	0.609	0.617	0.624	0.631	0.639	0.64
100	0.646	0.653	0.661	0.668	0.675	0.683	0.690	0.698	0.705	0.713	0.72
110	0.720	0.727	0.735	0.743	0.750	0.758	0.765	0.773	0.780	0.788	0.79
120	0.795	0.803	0.811	0.818	0.826	0.834	0.841	0.849	0.857	0.865	0.87
130	0.872	0.880	0.888	0.896	0.903	0.911	0.919	0.927	0.935	0.942	0.95
140	0.950	0.958	0.966	0.974	0.982	0.990	0.998	1.006	1.013	1.021	1.02
150	1.029	1.037	1.045	1.053	1.061	1.069	1.077	1.085	1.094	1.102	1.11
160	1.110	1.118	1.126	1.134	1.142	1.150	1.158	1.167	1.175	1.183	1.19
170	1.191	1.199	1.207	1.216	1.224	1.232	1.240	1.249	1.257	1.265	1.27
180	1.273	1.282	1.290	1.298	1.307	1.315	1.323	1.332	1.340	1.348	1.35
190	1.357	1.365	1.373	1.382	1.390	1.399	1.407	1.415	1.424	1.432	1.44
200	1.441	1.449	1.458	1.466	1.475	1.483	1.492	1.500	1.509	1.517	1.52
210	1.526	1.534	1.543	1.551	1.560	1.569	1.577	1.586	1.594	1.603	1.61
220	1.612	1.620	1.629	1.638	1.646	1.655	1.663	1.672	1.681	1.690	1.69
230	1.698	1.707	1.716	1.724	1.733	1.742	1.751	1.759	1.768	1.777	1.78
240	1.786	1.794	1.803	1.812	1.821	1.829	1.838	1.847	1.856	1.865	1.87
250	1.874	1.882	1.891	1.900	1.909	1.918	1.927	1.936	1.944	1.953	1.96
260	1.962	1.971	1.980	1.989	1.998	2.007	2.016	2.025	2.034	2.043	2.05
270	2.052	2.061	2.070	2.078	2.087	2.096	2.105	2.114	2.123	2.132	2.14
280	2.141	2.151	2.160	2.169	2.178	2.187	2.196	2.205	2.214	2.223	2.23
290	2.232	2.241	2.250	2.259	2.268	2.277	2.287	2.296	2.305	2.314	2.32
300	2.323	2.332	2.341	2.350	2.360	2.369	2.378	2.387	2.396	2.405	2.41
310	2.415	2.424	2.433	2.442	2.451	2.461	2.470	2.479	2.488	2.497	2.50
320	2.507	2.516	2.525	2.534	2.544	2.553	2.562	2.571	2.581	2.590	2.59
330	2.599	2.609	2.618	2.627	2.636	2.646	2.655	2.664	2.674	2.683	2.69
340	2.692	2.702	2.711	2.720	2.730	2.739	2.748	2.758	2.767	2.776	2.78
350	2.786	2.795	2.805	2.814	2.823	2.833	2.842	2.851	2.861	2.870	2.88
360	2.880	2.889	2.899	2.908	2.917	2.927	2.936	2.946	2.955	2.965	2.97
370	2.974	2.983	2.993	3.002	3.012	3.021	3.031	3.040	3.050	3.059	3.06
380	3.069	3.078	3.088	3.097	3.107	3.116	3.126	3.135	3.145	3.154	3.16
390	3.164	3.173	3.183	3.192	3.202	3.212	3.221	3.231	3.240	3.250	3.25
400	3.259	3.269	3.279	3.288	3.298	3.307	3.317	3.326	3.336	3.346	3.35
410	3.355	3.365	3.374	3.384	3.394	3.403	3.413	3.423	3.432	3.442	3.45
420	3.451	3.461	3.471	3.480	3.490	3.500	3.509	3.519	3.529	3.538	3.54
430	3.548	3.558	3.567	3.577	3.587	3.596	3.606	3.616	3.626	3.635	3.64
440	3.645	3.655	3.664	3.674	3.684	3.694	3.703	3.713	3.723	3.732	3.74
450	3.742	3.752	3.762	3.771	3.781	3.791	3.801	3.810	3.820	3.830	3.84
460	3.840	3.850	3.859	3.869	3.879	3.889	3.898	3.908	3.918	3.928	3.93
470	3.938	3.947	3.957	3.967	3.977	3.987	3.997	4.006	4.016	4.026	4.03
480	4.036	4.046	4.056	4.065	4.075	4.085	4.095	4.105	4.115	4.125	4.13
490	4.134	4.144	4.154	4.164	4.174	4.184	4.194	4.204	4.213	4.223	4.23
500	4.233	4.243	4.253	4.263	4.273	4.283	4.293	4.303	4.313	4.323	4.33
510	4.332	4.342	4.352	4.362	4.372	4.382	4.392	4.402	4.412	4.422	4.43
520	4.432	4.442	4.452	4.462	4.472	4.482	4.492	4.502	4.512	4.522	4.53
530	4.532	4.542	4.552	4.562	4.572	4.582	4.592	4.602	4.612	4.622	4.63
540	4.632	4.642	4.652	4.662	4.672	4.682	4.692	4.702	4.712	4.722	4.73
550	4.732	4.742	4.752	4.762	4.772	4.782	4.793	4.803	4.813	4.823	4.83
560	4.833	4.843	4.853	4.863	4.873	4.883	4.893	4.904	4.914	4.924	4.93
570	4.934	4.944	4.954	4.964	4.974	4.984	4.995	5.005	5.015	5.025	5.03
580	5.035	5.045	5.055	5.066	5.076	5.086	5.096	5.106	5.116	5.127	5.13
590	5.137	5.147	5.157	5.167	5.178	5.188	5.198	5.208	5.218	5.228	5.23
°C	0	1	2	3	4	5	6	7	8	9	10

ITS-90 Table for type S thermocouple										
°C	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
1250	12.554	12.566	12.578	12.590	12.602	12.614	12.626	12.638	12.650	12.662
1260	12.675	12.687	12.699	12.711	12.723	12.735	12.747	12.759	12.771	12.783
1270	12.796	12.808	12.820	12.832	12.844	12.856	12.868	12.880	12.892	12.905
1280	12.917	12.929	12.941	12.953	12.965	12.977	12.989	13.001	13.014	13.026
1290	13.038	13.050	13.062	13.074	13.086	13.098	13.111	13.123	13.135	13.147
1300	13.159	13.171	13.183	13.195	13.208	13.220	13.232	13.244	13.256	13.268
1310	13.280	13.292	13.305	13.317	13.329	13.341	13.353	13.365	13.377	13.390
1320	13.402	13.414	13.426	13.438	13.450	13.462	13.474	13.487	13.499	13.511
1330	13.523	13.535	13.547	13.559	13.572	13.584	13.596	13.608	13.620	13.632
1340	13.644	13.657	13.669	13.681	13.693	13.705	13.717	13.729	13.742	13.754
1350	13.766	13.778	13.790	13.802	13.814	13.826	13.839	13.851	13.863	13.875
1360	13.887	13.899	13.911	13.924	13.936	13.948	13.960	13.972	13.984	13.996
1370	14.009	14.021	14.033	14.045	14.057	14.069	14.081	14.094	14.106	14.118
1380	14.130	14.142	14.154	14.166	14.178	14.191	14.203	14.215	14.227	14.239
1390	14.251	14.263	14.276	14.288	14.300	14.312	14.324	14.336	14.348	14.360
1400	14.373	14.385	14.397	14.409	14.421	14.433	14.445	14.457	14.470	14.482
1410	14.494	14.506	14.518	14.530	14.542	14.554	14.567	14.579	14.591	14.603
1420	14.615	14.627	14.639	14.651	14.664	14.676	14.688	14.700	14.712	14.724
1430	14.736	14.748	14.760	14.773	14.785	14.797	14.809	14.821	14.833	14.845
1440	14.857	14.869	14.881	14.894	14.906	14.918	14.930	14.942	14.954	14.966
1450	14.978	14.990	15.002	15.015	15.027	15.039	15.051	15.063	15.075	15.087
1460	15.099	15.111	15.123	15.135	15.148	15.160	15.172	15.184	15.196	15.208
1470	15.220	15.232	15.244	15.256	15.268	15.280	15.292	15.304	15.317	15.329
1480	15.341	15.353	15.365	15.377	15.389	15.401	15.413	15.425	15.437	15.449
1490	15.461	15.473	15.485	15.497	15.509	15.521	15.534	15.546	15.558	15.570
1500	15.582	15.594	15.606	15.618	15.630	15.642	15.654	15.666	15.678	15.690
1510	15.702	15.714	15.726	15.738	15.750	15.762	15.774	15.786	15.798	15.810
1520	15.822	15.834	15.846	15.858	15.870	15.882	15.894	15.906	15.918	15.930
1530	15.942	15.954	15.966	15.978	15.990	16.002	16.014	16.026	16.038	16.050
1540	16.062	16.074	16.086	16.098	16.110	16.122	16.134	16.146	16.158	16.170
1550	16.182	16.194	16.205	16.217	16.229	16.241	16.253	16.265	16.277	16.289
1560	16.301	16.313	16.325	16.337	16.349	16.361	16.373	16.385	16.396	16.408
1570	16.420	16.432	16.444	16.456	16.468	16.480	16.492	16.504	16.516	16.527
1580	16.539	16.551	16.563	16.575	16.587	16.599	16.611	16.623	16.634	16.646
1590	16.658	16.670	16.682	16.694	16.706	16.718	16.729	16.741	16.753	16.765
1600	16.777	16.789	16.801	16.812	16.824	16.836	16.848	16.860	16.872	16.883
1610	16.895	16.907	16.919	16.931	16.943	16.954	16.966	16.978	16.990	17.002
1620	17.013	17.025	17.037	17.049	17.061	17.072	17.084	17.096	17.108	17.120
1630	17.131	17.143	17.155	17.167	17.178	17.190	17.202	17.214	17.225	17.237
1640	17.249	17.261	17.272	17.284	17.296	17.308	17.319	17.331	17.343	17.355
1650	17.366	17.378	17.390	17.401	17.413	17.425	17.437	17.448	17.460	17.472
1660	17.483	17.495	17.507	17.518	17.530	17.542	17.553	17.565	17.577	17.588
1670	17.600	17.612	17.623	17.635	17.647	17.658	17.670	17.682	17.693	17.705
1680	17.717	17.728	17.740	17.751	17.763	17.775	17.786	17.798	17.809	17.821
1690	17.832	17.844	17.855	17.867	17.878	17.890	17.901	17.913	17.924	17.936
1700	17.947	17.959	17.970	17.982	17.993	18.004	18.016	18.027	18.039	18.050
1710	18.061	18.073	18.084	18.095	18.107	18.118	18.129	18.140	18.152	18.163
1720	18.174	18.185	18.196	18.208	18.219	18.230	18.241	18.252	18.263	18.274
1730	18.285	18.297	18.308	18.319	18.330	18.341	18.352	18.362	18.373	18.384
1740	18.395	18.406	18.417	18.428	18.439	18.449	18.460	18.471	18.482	18.493
1750	18.503	18.514	18.525	18.535	18.546	18.557	18.567	18.578	18.588	18.599
1760	18.609	18.620	18.630	18.641	18.651	18.661	18.672	18.682	18.693	
°C	0	1	2	3	4	5	6	7	8	9

ITS-90 Table for type T thermocouple										
°F	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1
Thermoelectric Voltage in mV										
-450							-6.258	-6.257	-6.256	-6.255
-440	-6.254	-6.253	-6.252	-6.251	-6.250	-6.248	-6.247	-6.245	-6.243	-6.242
-430	-6.240	-6.238	-6.236	-6.234	-6.232	-6.230	-6.227	-6.225	-6.222	-6.220
-420	-6.217	-6.215	-6.212	-6.209	-6.206	-6.203	-6.200	-6.197	-6.194	-6.191
-410	-6.187	-6.184	-6.180	-6.177	-6.173	-6.170	-6.166	-6.162	-6.158	-6.154
-400	-6.150	-6.146	-6.141	-6.137	-6.133	-6.128	-6.124	-6.119	-6.115	-6.110
-390	-6.105	-6.100	-6.095	-6.090	-6.085	-6.080	-6.075	-6.069	-6.064	-6.059
-380	-6.053	-6.047	-6.042	-6.036	-6.030	-6.025	-6.019	-6.013	-6.007	-6.001
-370	-5.994	-5.988	-5.982	-5.976	-5.969	-5.963	-5.956	-5.950	-5.943	-5.937
-360	-5.930	-5.923	-5.916	-5.909	-5.902	-5.896	-5.888	-5.881	-5.874	-5.867
-350	-5.860	-5.853	-5.845	-5.838	-5.830	-5.823	-5.815	-5.808	-5.800	-5.792
-340	-5.785	-5.777	-5.769	-5.761	-5.753	-5.745	-5.737	-5.729	-5.721	-5.713
-330	-5.705	-5.697	-5.688	-5.680	-5.672	-5.663	-5.655	-5.646	-5.638	-5.629
-320	-5.620	-5.612	-5.603	-5.594	-5.585	-5.577	-5.568	-5.559	-5.550	-5.541
-310	-5.532	-5.523	-5.513	-5.504	-5.495	-5.486	-5.476	-5.467	-5.458	-5.448
-300	-5.439	-5.429	-5.420	-5.410	-5.400	-5.391	-5.381	-5.371	-5.361	-5.351
-290	-5.341	-5.332	-5.322	-5.312	-5.301	-5.291	-5.281	-5.271	-5.261	-5.250
-280	-5.240	-5.230	-5.219	-5.209	-5.198	-5.188	-5.177	-5.167	-5.156	-5.145
-270	-5.135	-5.124	-5.113	-5.102	-5.091	-5.081	-5.070	-5.059	-5.048	-5.036
-260	-5.025	-5.014	-5.003	-4.992	-4.980	-4.969	-4.958	-4.946	-4.935	-4.923
-250	-4.912	-4.900	-4.889	-4.877	-4.865	-4.854	-4.842	-4.830	-4.818	-4.806
-240	-4.794	-4.783	-4.771	-4.759	-4.746	-4.734	-4.722	-4.710	-4.698	-4.685
-230	-4.673	-4.661	-4.648	-4.636	-4.624	-4.611	-4.599	-4.586	-4.573	-4.561
-220	-4.548	-4.535	-4.523	-4.510	-4.497	-4.484	-4.471	-4.458	-4.445	-4.432
-210	-4.419	-4.406	-4.393	-4.380	-4.366	-4.353	-4.340	-4.326	-4.313	-4.300
-200	-4.286	-4.273	-4.259	-4.246	-4.232	-4.218	-4.205	-4.191	-4.177	-4.163
-190	-4.149	-4.136	-4.122	-4.108	-4.094	-4.080	-4.066	-4.052	-4.037	-4.023
-180	-4.009	-3.995	-3.980	-3.966	-3.952	-3.937	-3.923	-3.908	-3.894	-3.879
-170	-3.865	-3.850	-3.836	-3.821	-3.806	-3.791	-3.777	-3.762	-3.747	-3.732
-160	-3.717	-3.702	-3.687	-3.672	-3.657	-3.642	-3.626	-3.611	-3.596	-3.581
-150	-3.565	-3.550	-3.535	-3.519	-3.504	-3.488	-3.473	-3.457	-3.441	-3.426
-140	-3.410	-3.394	-3.379	-3.363	-3.347	-3.331	-3.315	-3.299	-3.283	-3.267
-130	-3.251	-3.235	-3.219	-3.203	-3.187	-3.171	-3.154	-3.138	-3.122	-3.105
-120	-3.089	-3.072	-3.056	-3.040	-3.023	-3.006	-2.990	-2.973	-2.956	-2.940
-110	-2.923	-2.906	-2.889	-2.873	-2.856	-2.839	-2.822	-2.805	-2.788	-2.771
-100	-2.754	-2.737	-2.719	-2.702	-2.685	-2.668	-2.651	-2.633	-2.616	-2.598
-90	-2.581	-2.564	-2.546	-2.529	-2.511	-2.493	-2.476	-2.458	-2.440	-2.423
-80	-2.405	-2.387	-2.369	-2.351	-2.334	-2.316	-2.298	-2.280	-2.262	-2.244
-70	-2.225	-2.207	-2.189	-2.171	-2.153	-2.134	-2.116	-2.098	-2.079	-2.061
-60	-2.043	-2.024	-2.006	-1.987	-1.969	-1.950	-1.931	-1.913	-1.894	-1.875
-50	-1.857	-1.838	-1.819	-1.800	-1.781	-1.762	-1.743	-1.724	-1.705	-1.686
-40	-1.667	-1.648	-1.629	-1.610	-1.591	-1.572	-1.552	-1.533	-1.514	-1.494
-30	-1.475	-1.456	-1.436	-1.417	-1.397	-1.378	-1.358	-1.338	-1.319	-1.299
-20	-1.279	-1.260	-1.240	-1.220	-1.200	-1.181	-1.161	-1.141	-1.121	-1.101
-10	-1.081	-1.061	-1.041	-1.021	-1.001	-0.980	-0.960	-0.940	-0.920	-0.900
0	-0.879	-0.859	-0.839	-0.818	-0.798	-0.777	-0.757	-0.736	-0.716	-0.695

ITS-90 Table for type T thermocouple										
°F	0	1	2	3	4	5	6	7	8	9
Thermoelectric Voltage in mV										
150	2.712	2.737	2.761	2.786	2.810	2.835	2.860	2.884	2.909	2.934
160	2.958	2.983	3.008	3.033	3.058	3.082	3.107	3.132	3.157	3.182
170	3.207	3.232	3.257	3.282	3.307	3.333	3.358	3.383	3.408	3.433
180	3.459	3.484	3.509	3.534	3.560	3.585	3.610	3.636	3.661	3.687
190	3.712	3.738	3.763	3.789	3.814	3.840	3.866	3.891	3.917	3.943
200	3.968	3.994	4.020	4.046	4.071	4.097	4.123	4.149	4.175	4.201
210	4.227	4.253	4.279	4.305	4.331	4.357	4.383	4.409	4.435	4.461
220	4.487	4.513	4.540	4.566	4.592	4.618	4.645	4.671	4.697	4.724
230	4.750	4.776	4.803	4.829	4.856	4.882	4.909	4.935	4.962	4.988
240	5.015	5.042	5.068	5.095	5.122	5.148	5.175	5.202	5.228	5.255
250	5.282	5.309	5.336	5.363	5.389	5.416	5.443	5.470	5.497	5.524
260	5.551	5.578	5.605	5.632	5.660	5.687	5.714	5.741	5.768	5.795
270	5.823	5.850	5.877	5.904	5.932	5.959	5.986	6.014	6.041	6.068
280	6.096	6.123	6.151	6.178	6.206	6.233	6.261	6.288	6.316	6.343
290	6.371	6.399	6.426	6.454	6.482	6.510	6.537	6.565	6.593	6.621
300	6.648	6.676	6.704	6.732	6.760	6.788	6.816	6.844	6.872	6.900
310	6.928	6.956	6.984	7.012	7.040	7.068	7.096	7.124	7.152	7.181
320	7.209	7.237	7.265	7.294	7.322	7.350	7.378	7.407	7.435	7.463
330	7.492	7.520	7.549	7.577	7.606	7.634	7.663	7.691	7.720	7.748
340	7.777	7.805	7.834	7.863	7.891	7.920	7.949	7.977	8.006	8.035
350	8.064	8.092	8.121	8.150	8.179	8.208	8.237	8.266	8.294	8.323
360	8.352	8.381	8.410	8.439	8.468	8.497	8.526	8.555	8.585	8.614
370	8.643	8.672	8.701	8.730	8.759	8.789	8.818	8.847	8.876	8.906
380	8.935	8.964	8.994	9.023	9.052	9.082	9.111	9.141	9.170	9.200
390	9.229	9.259	9.288	9.318	9.347	9.377	9.406	9.436	9.466	9.495
400	9.525	9.555	9.584	9.614	9.644	9.673	9.703	9.733	9.763	9.793
410	9.822	9.852	9.882	9.912	9.942	9.972	10.002	10.032	10.062	10.092
420	10.122	10.152	10.182	10.212	10.242	10.272	10.302	10.332	10.362	10.392
430	10.423	10.453	10.483	10.513	10.543	10.574	10.604	10.634	10.664	10.695
440	10.725	10.755	10.786	10.816	10.847	10.877	10.907	10.938	10.968	10.999
450	11.029	11.060	11.090	11.121	11.151	11.182	11.213	11.243	11.274	11.304
460	11.335	11.366	11.396	11.427	11.458	11.489	11.519	11.550	11.581	11.612
470	11.643	11.673	11.704	11.735	11.766	11.797	11.828	11.859	11.890	11.921
480	11.951	11.982	12.013	12.044	12.075	12.106	12.138	12.169	12.200	12.231
490	12.262	12.293	12.324	12.355	12.386	12.418	12.449	12.480	12.511	12.543
500	12.574	12.605	12.636	12.668	12.699	12.730	12.762	12.793	12.824	12.856
510	12.887	12.919	12.950	12.982	13.013	13.045	13.076	13.108	13.139	13.171
520	13.202	13.234	13.265	13.297	13.328	13.360	13.392	13.423	13.455	13.487
530	13.518	13.550	13.582	13.614	13.645	13.677	13.709	13.741	13.772	13.804
540	13.836	13.868	13.900	13.932	13.964	13.995	14.027	14.059	14.091	14.123
550	14.155	14.187	14.219	14.251	14.283	14.315	14.347	14.379	14.411	14.444
560	14.476	14.508	14.540	14.572	14.604	14.636	14.669	14.701	14.733	14.765
570	14.797	14.830	14.862	14.894	14.926	14.959	14.991	15.023	15.056	15.088
580	15.121	15.153	15.185	15.218	15.250	15.283	15.315	15.347	15.380	15.412
590	15.445	15.477	15.510	15.543	15.575	15.608	15.640	15.673	15.705	15.738
600	15.771	15.803	15.836	15.869	15.901	15.934	15.967	15.999	16.032	16.065
610	16.098	16.130	16.163	16.196	16.229	16.262	16.295	16.327	16.360	16.393
620	16.426	16.459	16.492	16.525	16.558	16.591	16.624	16.657	16.690	16.723
630	16.756	16.789	16.822	16.855	16.888	16.921	16.954	16.987	17.020	17.053
640	17.086	17.120	17.153	17.186	17.219	17.252	17.286	17.319	17.352	17.385
650	17.418	17.452	17.485	17.518	17.552	17.585	17.618	17.652	17.685	17.718
660	17.752	17.785	17.819	17.852	17.886	17.919	17.952	17.986	18.019	18.053
670	18.086	18.120	18.153	18.187	18.221	18.254	18.288	18.321	18.355	18.389
680	18.422	18.456	18.490	18.523	18.557	18.591	18.624	18.658	18.692	18.725
690	18.759	18.793	18.827	18.861	18.894	18.928	18.962	18.996	19.030	19.064
700	19.097	19.131	19.165	19.199	19.233	19.267	19.301	19.335	19.369	19.403
710	19.437	19.471	19.505	19.539	19.573	19.607	19.641	19.675	19.709	19.743
720	19.777	19.811	19.845	19.879	19.913	19.947	19.982	20.016	20.050	20.084
730	20.118	20.152	20.187	20.221	20.255	20.289	20.323	20.358	20.392	20.426
740	20.460	20.495	20.529	20.563	20.597	20.632	20.666	20.700	20.735	20.769
750	20.803	20.838	20.872							
°F	0	1	2	3	4	5	6	7	8	9

ITS-90 Table for type T thermocouple											
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Thermoelectric Voltage in mV											
-260	-6.258	-6.256	-6.255	-6.253	-6.251	-6.248	-6.245	-6.242	-6.239	-6.236	-6.23
-250	-6.232	-6.228	-6.223	-6.219	-6.214	-6.209	-6.204	-6.198	-6.193	-6.187	-6.18
-240	-6.180	-6.174	-6.167	-6.160	-6.153	-6.146	-6.138	-6.130	-6.122	-6.114	-6.10
-230	-6.105	-6.096	-6.087	-6.078	-6.068	-6.059	-6.049	-6.038	-6.028	-6.017	-6.00
-220	-6.007	-5.996	-5.985	-5.973	-5.962	-5.950	-5.938	-5.926	-5.914	-5.901	-5.88
-210	-5.888	-5.876	-5.863	-5.850	-5.836	-5.823	-5.809	-5.795	-5.782	-5.767	-5.75
-200	-5.753	-5.739	-5.724	-5.710	-5.695	-5.680	-5.665	-5.650	-5.634	-5.619	-5.60
-190	-5.603	-5.587	-5.571	-5.555	-5.539	-5.523	-5.506	-5.489	-5.473	-5.456	-5.43
-180	-5.439	-5.421	-5.404	-5.387	-5.369	-5.351	-5.334	-5.316	-5.297	-5.279	-5.26
-170	-5.261	-5.242	-5.224	-5.205	-5.186	-5.167	-5.148	-5.128	-5.109	-5.089	-5.07
-160	-5.070	-5.050	-5.030	-5.010	-4.989	-4.969	-4.949	-4.928	-4.907	-4.886	-4.86
-150	-4.865	-4.844	-4.823	-4.802	-4.780	-4.759	-4.737	-4.715	-4.693	-4.671	-4.64
-140	-4.648	-4.626	-4.604	-4.581	-4.558	-4.535	-4.512	-4.489	-4.466	-4.443	-4.41
-130	-4.419	-4.395	-4.372	-4.348	-4.324	-4.300	-4.275	-4.251	-4.226	-4.202	-4.17
-120	-4.177	-4.152	-4.127	-4.102	-4.077	-4.052	-4.026	-4.000	-3.975	-3.949	-3.92
-110	-3.923	-3.897	-3.871	-3.844	-3.818	-3.791	-3.765	-3.738	-3.711	-3.684	-3.65
-100	-3.657	-3.629	-3.602	-3.574	-3.547	-3.519	-3.491	-3.463	-3.435	-3.407	-3.37
-90	-3.379	-3.350	-3.322	-3.293	-3.264	-3.235	-3.206	-3.177	-3.148	-3.118	-3.08
-80	-3.089	-3.059	-3.030	-3.000	-2.970	-2.940	-2.910	-2.879	-2.849	-2.818	-2.78
-70	-2.788	-2.757	-2.726	-2.695	-2.664	-2.633	-2.602	-2.571	-2.539	-2.507	-2.47
-60	-2.476	-2.444	-2.412	-2.380	-2.348	-2.316	-2.283	-2.251	-2.218	-2.186	-2.15
-50	-2.153	-2.120	-2.087	-2.054	-2.021	-1.987	-1.954	-1.920	-1.887	-1.853	-1.81
-40	-1.819	-1.785	-1.751	-1.717	-1.683	-1.648	-1.614	-1.579	-1.545	-1.510	-1.47
-30	-1.475	-1.440	-1.405	-1.370	-1.335	-1.299	-1.264	-1.228	-1.192	-1.157	-1.12
-20	-1.121	-1.085	-1.049	-1.013	-0.976	-0.940	-0.904	-0.867	-0.830	-0.794	-0.75
-10	-0.757	-0.720	-0.683	-0.646	-0.608	-0.571	-0.534	-0.496	-0.459	-0.421	-0.38
0	-0.383	-0.345	-0.307	-0.269	-0.231	-0.193	-0.154	-0.116	-0.077	-0.039	0.00
°C	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
ITS-90 Table for type T thermocouple											
°C	0	1	2	3	4	5	6	7	8	9	10
Thermoelectric Voltage in mV											
0	0.000	0.039	0.078	0.117	0.156	0.195	0.234	0.273	0.312	0.352	0.39
10	0.391	0.431	0.470	0.510	0.549	0.589	0.629	0.669	0.709	0.749	0.79
20	0.790	0.830	0.870	0.911	0.951	0.992	1.033	1.074	1.114	1.155	1.19
30	1.196	1.238	1.279	1.320	1.362	1.403	1.445	1.486	1.528	1.570	1.61
40	1.612	1.654	1.696	1.738	1.780	1.823	1.865	1.908	1.950	1.993	2.03
50	2.036	2.079	2.122	2.165	2.208	2.251	2.294	2.338	2.381	2.425	2.46
60	2.468	2.512	2.556	2.600	2.643	2.687	2.732	2.776	2.820	2.864	2.90
70	2.909	2.953	2.998	3.043	3.087	3.132	3.177	3.222	3.267	3.312	3.35
80	3.358	3.403	3.448	3.494	3.539	3.585	3.631	3.677	3.722	3.768	3.81
90	3.814	3.860	3.907	3.953	3.999	4.046	4.092	4.138	4.185	4.232	4.27
100	4.279	4.325	4.372	4.419	4.466	4.513	4.561	4.608	4.655	4.702	4.75
110	4.750	4.798	4.845	4.893	4.941	4.988	5.036	5.084	5.132	5.180	5.22
120	5.228	5.277	5.325	5.373	5.422	5.470	5.519	5.567	5.616	5.665	5.71
130	5.714	5.763	5.812	5.861	5.910	5.959	6.008	6.057	6.107	6.156	6.20
140	6.206	6.255	6.305	6.355	6.404	6.454	6.504	6.554	6.604	6.654	6.70
150	6.704	6.754	6.805	6.855	6.905	6.956	7.006	7.057	7.107	7.158	7.20
160	7.209	7.260	7.310	7.361	7.412	7.463	7.515	7.566	7.617	7.668	7.72
170	7.720	7.771	7.823	7.874	7.926	7.977	8.029	8.081	8.133	8.185	8.23
180	8.237	8.289	8.341	8.393	8.445	8.497	8.550	8.602	8.654	8.707	8.75
190	8.759	8.812	8.865	8.917	8.970	9.023	9.076	9.129	9.182	9.235	9.28
200	9.288	9.341	9.395	9.448	9.501	9.555	9.608	9.662	9.715	9.769	9.82
210	9.822	9.876	9.930	9.984	10.038	10.092	10.146	10.200	10.254	10.308	10.36
220	10.362	10.417	10.471	10.525	10.580	10.634	10.689	10.743	10.798	10.853	10.90
230	10.907	10.962	11.017	11.072	11.127	11.182	11.237	11.292	11.347	11.403	11.45
240	11.458	11.513	11.569	11.624	11.680	11.735	11.791	11.846	11.902	11.958	12.01
250	12.013	12.069	12.125	12.181	12.237	12.293	12.349	12.405	12.461	12.518	12.57
260	12.574	12.630	12.687	12.743	12.799	12.856	12.912	12.969	13.026	13.082	13.13
270	13.139	13.196	13.253	13.310	13.366	13.423	13.480	13.537	13.595	13.652	13.70
280	13.709	13.766	13.823	13.881	13.938	13.995	14.053	14.110	14.168	14.226	14.28
290	14.283	14.341	14.399	14.456	14.514	14.572	14.630	14.688	14.746	14.804	14.86
300	14.862	14.920	14.978	15.036	15.095	15.153	15.211	15.270	15.328	15.386	15.44
310	15.445	15.503	15.562	15.621	15.679	15.738	15.797	15.856	15.914	15.973	16.03
320	16.032	16.091	16.150	16.209	16.268	16.327	16.387	16.446	16.505	16.564	16.62
330	16.624	16.683	16.742	16.802	16.861	16.921	16.980	17.040	17.100	17.159	17.21
°C	0	1	2	3	4	5	6	7	8	9	10

Cold versus Platinum Resistance—Thermocouple voltage as a function of temperature (°C), reference junctions at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10	°C	°C	0	1	2	3	4	5	6	7	8	9	20	°C
Thermocouple Voltage in Microvolts													Thermocouple Voltage in Microvolts												
0	0.0	0.1	12.1	18.9	24.8	30.7	36.6	42.2	48.0	53.9	59.5	65.3	80	800	800.0	801.8	803.6	805.4	807.2	809.0	810.8	812.6	814.4	816.2	820
10	61.3	61.7	70.2	76.7	82.3	87.9	93.4	98.9	104.4	110.0	115.5	121.0	130	1300	1300.0	1301.8	1303.6	1305.4	1307.2	1309.0	1310.8	1312.6	1314.4	1316.2	1320
20	120.5	120.1	141.8	148.8	155.7	162.7	169.7	176.7	183.7	190.7	197.7	204.7	210	2100	2100.0	2101.8	2103.6	2105.4	2107.2	2109.0	2110.8	2112.6	2114.4	2116.2	2120
30	180.9	180.1	213.8	218.5	224.0	229.1	234.1	239.5	244.9	250.2	255.6	261.1	270	2700	2700.0	2701.8	2703.6	2705.4	2707.2	2709.0	2710.8	2712.6	2714.4	2716.2	2720
40	241.1	240.8	280.1	283.7	289.3	294.5	299.6	304.8	310.1	315.3	320.5	325.8	330	3300	3300.0	3301.8	3303.6	3305.4	3307.2	3309.0	3310.8	3312.6	3314.4	3316.2	3320
50	301.5	301.3	340.8	343.5	349.1	354.3	359.5	364.7	370.0	375.2	380.5	385.8	390	3900	3900.0	3901.8	3903.6	3905.4	3907.2	3909.0	3910.8	3912.6	3914.4	3916.2	3920
60	361.9	361.8	401.3	403.0	408.6	413.8	419.0	424.2	429.5	434.7	440.0	445.3	450	4500	4500.0	4501.8	4503.6	4505.4	4507.2	4509.0	4510.8	4512.6	4514.4	4516.2	4520
70	422.3	422.3	461.8	462.5	468.1	473.3	478.5	483.8	489.1	494.4	499.7	505.0	510	5100	5100.0	5101.8	5103.6	5105.4	5107.2	5109.0	5110.8	5112.6	5114.4	5116.2	5120
80	482.7	482.8	522.3	523.0	528.6	533.8	539.1	544.4	549.7	555.0	560.3	565.6	570	5700	5700.0	5701.8	5703.6	5705.4	5707.2	5709.0	5710.8	5712.6	5714.4	5716.2	5720
90	543.1	543.2	582.7	583.4	589.0	594.2	599.5	604.8	610.1	615.4	620.7	626.0	630	6300	6300.0	6301.8	6303.6	6305.4	6307.2	6309.0	6310.8	6312.6	6314.4	6316.2	6320
100	603.5	603.6	643.1	643.8	649.4	654.6	660.0	665.3	670.6	675.9	681.2	686.5	690	6900	6900.0	6901.8	6903.6	6905.4	6907.2	6909.0	6910.8	6912.6	6914.4	6916.2	6920
110	663.9	664.0	703.5	704.2	710.0	715.2	720.5	725.8	731.1	736.4	741.7	747.0	750	7500	7500.0	7501.8	7503.6	7505.4	7507.2	7509.0	7510.8	7512.6	7514.4	7516.2	7520
120	724.3	724.4	763.9	764.6	770.4	775.6	780.9	786.2	791.5	796.8	802.1	807.4	810	8100	8100.0	8101.8	8103.6	8105.4	8107.2	8109.0	8110.8	8112.6	8114.4	8116.2	8120
130	784.7	784.8	824.3	825.0	830.8	836.0	841.3	846.6	851.9	857.2	862.5	867.8	870	8700	8700.0	8701.8	8703.6	8705.4	8707.2	8709.0	8710.8	8712.6	8714.4	8716.2	8720
140	845.1	845.2	884.7	885.4	891.2	896.4	901.7	907.0	912.3	917.6	922.9	928.2	930	9300	9300.0	9301.8	9303.6	9305.4	9307.2	9309.0	9310.8	9312.6	9314.4	9316.2	9320
150	905.5	905.6	945.1	945.8	951.6	956.8	962.1	967.4	972.7	978.0	983.3	988.6	990	9900	9900.0	9901.8	9903.6	9905.4	9907.2	9909.0	9910.8	9912.6	9914.4	9916.2	9920
160	965.9	966.0	1005.5	1006.2	1012.0	1017.2	1022.5	1027.8	1033.1	1038.4	1043.7	1049.0	1050	10500	10500.0	10501.8	10503.6	10505.4	10507.2	10509.0	10510.8	10512.6	10514.4	10516.2	10520
170	1026.3	1026.4	1065.9	1066.6	1072.4	1077.6	1082.9	1088.2	1093.5	1098.8	1104.1	1109.4	1110	11100	11100.0	11101.8	11103.6	11105.4	11107.2	11109.0	11110.8	11112.6	11114.4	11116.2	11120
180	1086.7	1086.8	1126.3	1127.0	1132.8	1138.0	1143.3	1148.6	1153.9	1159.2	1164.5	1169.8	1170	11700	11700.0	11701.8	11703.6	11705.4	11707.2	11709.0	11710.8	11712.6	11714.4	11716.2	11720
190	1147.1	1147.2	1186.7	1187.4	1193.2	1198.4	1203.7	1209.0	1214.3	1219.6	1224.9	1230.2	1230	12300	12300.0	12301.8	12303.6	12305.4	12307.2	12309.0	12310.8	12312.6	12314.4	12316.2	12320
200	1207.5	1207.6	1247.1	1247.8	1253.6	1258.8	1264.1	1269.4	1274.7	1280.0	1285.3	1290.6	1290	12900	12900.0	12901.8	12903.6	12905.4	12907.2	12909.0	12910.8	12912.6	12914.4	12916.2	12920
210	1267.9	1268.0	1307.5	1308.2	1314.0	1319.2	1324.5	1329.8	1335.1	1340.4	1345.7	1351.0	1350	13500	13500.0	13501.8	13503.6	13505.4	13507.2	13509.0	13510.8	13512.6	13514.4	13516.2	13520
220	1328.3	1328.4	1367.9	1368.6	1374.4	1379.6	1384.9	1390.2	1395.5	1400.8	1406.1	1411.4	1410	14100	14100.0	14101.8	14103.6	14105.4	14107.2	14109.0	14110.8	14112.6	14114.4	14116.2	14120
230	1388.7	1388.8	1428.3	1429.0	1434.8	1440.0	1445.3	1450.6	1455.9	1461.2	1466.5	1471.8	1470	14700	14700.0	14701.8	14703.6	14705.4	14707.2	14709.0	14710.8	14712.6	14714.4	14716.2	14720
240	1449.1	1449.2	1488.7	1489.4	1495.2	1500.4	1505.7	1511.0	1516.3	1521.6	1526.9	1532.2	1530	15300	15300.0	15301.8	15303.6	15305.4	15307.2	15309.0	15310.8	15312.6	15314.4	15316.2	15320
250	1509.5	1509.6	1549.1	1549.8	1555.6	1560.8	1566.1	1571.4	1576.7	1582.0	1587.3	1592.6	1590	15900	15900.0	15901.8	15903.6	15905.4	15907.2	15909.0	15910.8	15912.6	15914.4	15916.2	15920
260	1569.9	1570.0	1609.5	1610.2	1616.0	1621.2	1626.5	1631.8	1637.1	1642.4	1647.7	1653.0	1650	16500	16500.0	16501.8	16503.6	16505.4	16507.2	16509.0	16510.8	16512.6	16514.4	16516.2	16520
270	1630.3	1630.4	1669.9	1670.6	1676.4	1681.6	1686.9	1692.2	1697.5	1702.8	1708.1	1713.4	1710	17100	17100.0	17101.8	17103.6	17105.4	17107.2	17109.0	17110.8	17112.6	17114.4	17116.2	17120
280	1690.7	1690.8	1730.3	1731.0	1736.8	1742.0	1747.3	1752.6	1757.9	1763.2	1768.5	1773.8	1770	17700	17700.0	17701.8	17703.6	17705.4	17707.2	17709.0	17710.8	17712.6	17714.4	17716.2	17720
290	1751.1	1751.2	1790.7	1791.4	1797.2	1802.4	1807.7	1813.0	1818.3	1823.6	1828.9	1834.2	1830	18300	18300.0	18301.8	18303.6	18305.4	18307.2	18309.0	18310.8	18312.6	18314.4	18316.2	18320
300	1811.5	1811.6	1851.1	1851.8	1857.6	1862.8	1868.1	1873.4	1878.7	1884.0	1889.3	1894.6	1890	18900	18900.0	18901.8	18903.6	18905.4	18907.2	18909.0	18910.8	18912.6	18914.4	18916.2	18920
310	1871.9	1872.0	1911.5	1912.2	1918.0	1923.2	1928.5	1933.8	1939.1	1944.4	1949.7	1955.0	1950	19500	19500.0	19501.8	19503.6	19505.4	19507.2	19509.0	19510.8	19512.6	19514.4	19516.2	19520
320	1932.3	1932.4	1971.9	1972.6	1978.4	1983.6	1988.9	1994.2	1999.5	2004.8	2010.1	2015.4	2010	20100	20100.0	20101.8	20103.6	20105.4	20107.2	20109.0	20110.8	20112.6	20114.4	20116.2	20120
330	1992.7	1992.8	2032.3	2033.0	2038.8	2044.0	2049.3	2054.6	2059.9	2065.2	2070.5	2075.8	2070	20700	20700.0	20701.8	20703.6	20705.4	20707.2	20709.0	20710.8	20712.6	20714.4	20716.2	20720
340	2053.1	2053.2	2092.7	2093.4	2099.2	2104.4	2109.7	2115.0	2120.3	2125.6	2130.9	2136.2	2130	21300	21300.0	21301.8	21303.6	21305.4	21307.2	21309.0	21310.8	21312.6	21314.4	21316.2	21320
350	2113.5	2113.6	2153.1	2153.8	2159.6	2164.8	2170.1																		

TYPE - C THERMOCOUPLE, ITS-90 TABLE

Thermoelectric Voltage in Millivolts

°C	0	1	2	3	4	5	6	7	8	9	10	°C	°C	0	1	2	3	4	5	6	7	8	9	10	°C
0	0.000	0.013	0.026	0.040	0.053	0.067	0.080	0.094	0.107	0.121	0.135	0	650	11.583	11.603	11.622	11.642	11.661	11.681	11.700	11.720	11.739	11.759	11.778	650
10	0.135	0.148	0.162	0.176	0.189	0.203	0.217	0.231	0.244	0.258	0.272	10	660	11.778	11.798	11.817	11.837	11.857	11.876	11.896	11.915	11.935	11.954	11.974	660
20	0.272	0.286	0.300	0.314	0.328	0.342	0.356	0.370	0.384	0.398	0.412	20	670	11.974	11.993	12.013	12.032	12.052	12.071	12.091	12.110	12.130	12.149	12.169	670
30	0.412	0.426	0.440	0.454	0.469	0.483	0.497	0.511	0.525	0.540	0.554	30	680	12.169	12.188	12.208	12.227	12.247	12.266	12.286	12.305	12.325	12.344	12.364	680
40	0.554	0.568	0.583	0.597	0.612	0.626	0.640	0.655	0.669	0.684	0.698	40	690	12.364	12.383	12.403	12.422	12.442	12.461	12.481	12.500	12.519	12.539	12.558	690
50	0.698	0.713	0.727	0.742	0.757	0.771	0.786	0.801	0.815	0.830	0.845	50	700	12.558	12.578	12.597	12.617	12.636	12.656	12.675	12.695	12.714	12.734	12.753	700
60	0.845	0.860	0.874	0.889	0.904	0.919	0.934	0.948	0.963	0.978	0.993	60	710	12.753	12.772	12.792	12.811	12.831	12.850	12.870	12.889	12.909	12.928	12.947	710
70	0.993	1.008	1.023	1.038	1.053	1.068	1.083	1.098	1.114	1.129	1.144	70	720	12.947	12.967	12.986	13.006	13.025	13.045	13.064	13.083	13.103	13.122	13.142	720
80	1.144	1.159	1.174	1.189	1.205	1.220	1.235	1.250	1.266	1.281	1.296	80	730	13.142	13.161	13.180	13.200	13.219	13.239	13.258	13.277	13.297	13.316	13.336	730
90	1.296	1.312	1.327	1.342	1.358	1.373	1.389	1.404	1.420	1.435	1.451	90	740	13.336	13.355	13.374	13.394	13.413	13.432	13.452	13.471	13.491	13.510	13.529	740
100	1.451	1.466	1.482	1.497	1.513	1.529	1.544	1.560	1.576	1.591	1.607	100	750	13.529	13.549	13.568	13.587	13.607	13.626	13.645	13.665	13.684	13.703	13.723	750
110	1.607	1.623	1.639	1.654	1.670	1.686	1.702	1.718	1.733	1.749	1.765	110	760	13.723	13.742	13.761	13.781	13.800	13.819	13.839	13.858	13.877	13.897	13.916	760
120	1.765	1.781	1.797	1.813	1.829	1.845	1.861	1.877	1.893	1.909	1.925	120	770	13.916	13.935	13.955	13.974	13.993	14.012	14.032	14.051	14.070	14.090	14.109	770
130	1.925	1.941	1.957	1.973	1.989	2.006	2.022	2.038	2.054	2.070	2.087	130	780	14.109	14.128	14.147	14.167	14.186	14.205	14.224	14.244	14.263	14.282	14.302	780
140	2.087	2.103	2.119	2.135	2.152	2.168	2.184	2.201	2.217	2.233	2.250	140	790	14.302	14.321	14.340	14.359	14.378	14.398	14.417	14.436	14.455	14.475	14.494	790
150	2.250	2.266	2.283	2.299	2.316	2.332	2.349	2.365	2.382	2.398	2.415	150	800	14.494	14.513	14.532	14.551	14.571	14.590	14.609	14.628	14.647	14.667	14.686	800
160	2.415	2.431	2.448	2.464	2.481	2.498	2.514	2.531	2.548	2.564	2.581	160	810	14.686	14.705	14.724	14.743	14.762	14.782	14.801	14.820	14.839	14.858	14.877	810
170	2.581	2.598	2.614	2.631	2.648	2.665	2.682	2.698	2.715	2.732	2.749	170	820	14.877	14.897	14.916	14.935	14.954	14.973	14.992	15.011	15.030	15.050	15.069	820
180	2.749	2.766	2.783	2.800	2.816	2.833	2.850	2.867	2.884	2.901	2.918	180	830	15.069	15.088	15.107	15.126	15.145	15.164	15.183	15.202	15.221	15.241	15.260	830
190	2.918	2.935	2.952	2.969	2.986	3.003	3.020	3.038	3.055	3.072	3.089	190	840	15.260	15.279	15.298	15.317	15.336	15.355	15.374	15.393	15.412	15.431	15.450	840
200	3.089	3.106	3.123	3.140	3.158	3.175	3.192	3.209	3.227	3.244	3.26	200	850	15.450	15.469	15.488	15.507	15.526	15.545	15.564	15.583	15.602	15.621	15.640	850
210	3.261	3.278	3.296	3.313	3.330	3.348	3.365	3.382	3.400	3.417	3.434	210	860	15.640	15.659	15.678	15.697	15.716	15.735	15.754	15.773	15.792	15.811	15.830	860
220	3.434	3.452	3.469	3.487	3.504	3.522	3.539	3.557	3.574	3.592	3.609	220	870	15.830	15.849	15.868	15.887	15.906	15.925	15.944	15.963	15.982	16.001	16.020	870
230	3.609	3.627	3.644	3.662	3.679	3.697	3.714	3.732	3.750	3.767	3.785	230	880	16.020	16.038	16.057	16.076	16.095	16.114	16.133	16.152	16.171	16.190	16.208	880
240	3.785	3.803	3.820	3.838	3.856	3.873	3.891	3.909	3.927	3.944	3.962	240	890	16.208	16.227	16.246	16.265	16.284	16.303	16.322	16.340	16.359	16.378	16.397	890
250	3.962	3.980	3.998	4.015	4.033	4.051	4.069	4.087	4.104	4.122	4.140	250	900	16.397	16.416	16.435	16.453	16.472	16.491	16.510	16.529	16.547	16.566	16.585	900
260	4.140	4.158	4.176	4.194	4.212	4.230	4.248	4.266	4.284	4.301	4.319	260	910	16.585	16.604	16.623	16.641	16.660	16.679	16.698	16.716	16.735	16.754	16.773	910
270	4.319	4.337	4.355	4.373	4.391	4.410	4.428	4.446	4.464	4.482	4.500	270	920	16.773	16.791	16.810	16.829	16.848	16.866	16.885	16.904	16.923	16.941	16.960	920
280	4.500	4.518	4.536	4.554	4.572	4.590	4.608	4.627	4.645	4.663	4.681	280	930	16.960	16.979	16.997	17.016	17.035	17.053	17.072	17.091	17.109	17.128	17.147	930
290	4.681	4.699	4.717	4.736	4.754	4.772	4.790	4.809	4.827	4.845	4.863	290	940	17.147	17.165	17.184	17.203	17.221	17.240	17.258	17.277	17.296	17.314	17.333	940
300	4.863	4.882	4.900	4.918	4.937	4.955	4.973	4.992	5.010	5.028	5.047	300	950	17.333	17.352	17.370	17.389	17.407	17.426	17.444	17.463	17.482	17.500	17.519	950
310	5.047	5.065	5.083	5.102	5.120	5.139	5.157	5.175	5.194	5.212	5.231	310	960	17.519	17.537	17.556	17.574	17.593	17.611	17.630	17.648	17.667	17.686	17.704	960
320	5.231	5.249	5.268	5.286	5.305	5.323	5.342	5.360	5.379	5.397	5.416	320	970	17.704	17.723	17.741	17.760	17.778	17.796	17.815	17.833	17.852	17.870	17.889	970
330	5.416	5.434	5.453	5.471	5.490	5.508	5.527	5.546	5.564	5.583	5.601	330	980	17.889	17.907	17.926	17.944	17.963	17.981	17.999	18.018	18.036	18.055	18.073	980
340	5.601	5.620	5.639	5.657	5.676	5.695	5.713	5.732	5.751	5.769	5.788	340	990	18.073	18.092	18.110	18.128	18.147	18.165	18.184	18.202	18.220	18.239	18.257	990
350	5.788	5.807	5.825	5.844	5.863	5.882	5.900	5.919	5.938	5.956	5.975	350	1000	18.257	18.275	18.294	18.312	18.330	18.349	18.367	18.385	18.404	18.422	18.440	1000
360	5.975	5.994	6.013	6.032	6.050	6.069	6.088	6.107	6.126	6.144	6.163	360	1010	18.440	18.459	18.477	18.495	18.513	18.532	18.550	18.568	18.587	18.605	18.623	1010
370	6.163	6.182	6.201	6.220	6.239	6.257	6.276	6.295	6.314	6.333	6.352	370	1020	18.623	18.641	18.660	18.678	18.696	18.714	18.732	18.751	18.769	18.787	18.805	1020
380	6.352	6.371	6.390	6.409	6.427	6.446	6.465	6.484	6.503	6.522	6.541	380	1030	18.805	18.824	18.842	18.860	18.878	18.896	18.914	18.933	18.951	18.969	18.987	1030
390	6.541	6.560	6.579	6.598	6.617	6.636	6.655	6.674	6.693	6.712	6.731	390	1040	18.987	19.005	19.023	19.041	19.060	19.078	19.096	19.114	19.132	19.150	19.168	1040
400	6.731	6.750	6.769	6.788	6.807	6.826	6.845	6.864	6.883	6.902	6.921	400	1050	19.168	19.186	19.204	19.223	19.241	19.259	19.277	19.295	19.313	19.331	19.349	1050
410	6.921	6.940	6.959	6.979	6.998	7.017	7.036	7.055	7.074	7.093	7.112	410	1060	19.349	19.367	19.385	19.403	19.421	19.439	19.457	19.475	19.493	19.511	19.529	1060
420	7.112	7.131	7.151	7.170	7.189	7.208	7.227	7.246	7.265	7.284	7.304	420	1070	19.529	19.547	19.565	19.583	19.601	19.619	19.637	19.655	19.673	19.691	19.709	1070
430	7.304	7.323	7.342	7.361	7.380	7.400	7.419	7.438	7.457	7.476	7.496	430	1080	19.709	19.727	19.744	19.762	19.780	19.798	19.816	19.834	19.852	19.870	19.888	1080
440	7.496	7.515	7.534	7.553	7.572	7.592	7.611	7.630	7.649	7.669	7.688	440	1090	19.888	19.905	19.923	19.941	19.959	19.977	19.995	20.013	20.030	20.048	20.066	1090
450	7.68																								

TYPE - C THERMOCOUPLE, ITS-90 TABLE

Thermoelectric Voltage in Millivolts

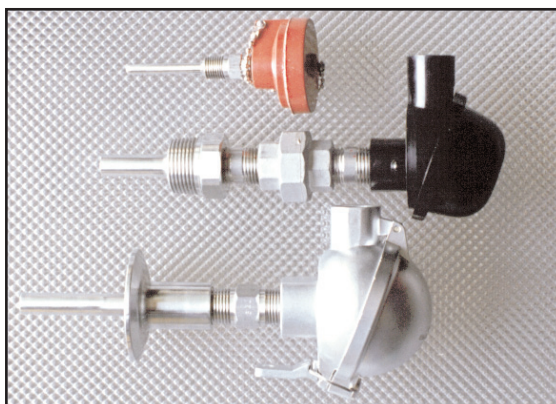
°C	0	1	2	3	4	5	6	7	8	9	10	°C	°C	0	1	2	3	4	5	6	7	8	9	10	°C
1300	23.514	23.530	23.547	23.564	23.580	23.597	23.614	23.630	23.647	23.663	23.680	1300	1950	33.041	33.054	33.066	33.079	33.091	33.104	33.116	33.129	33.141	33.154	33.166	1950
1310	23.680	23.697	23.713	23.730	23.746	23.763	23.779	23.796	23.812	23.829	23.846	1310	1960	33.166	33.179	33.191	33.204	33.216	33.229	33.241	33.254	33.266	33.278	33.291	1960
1320	23.846	23.862	23.879	23.895	23.912	23.928	23.945	23.961	23.978	23.994	24.010	1320	1970	33.291	33.303	33.316	33.328	33.341	33.353	33.365	33.378	33.390	33.402	33.415	1970
1330	24.010	24.027	24.043	24.060	24.076	24.093	24.109	24.126	24.142	24.158	24.175	1330	1980	33.415	33.427	33.439	33.452	33.464	33.476	33.489	33.501	33.513	33.525	33.538	1980
1340	24.175	24.191	24.208	24.224	24.240	24.257	24.273	24.290	24.306	24.322	24.339	1340	1990	33.538	33.550	33.562	33.575	33.587	33.599	33.611	33.623	33.636	33.648	33.660	1990
1350	24.339	24.355	24.371	24.388	24.404	24.420	24.437	24.453	24.46	24.485	24.502	1350	2000	33.660	33.672	33.684	33.697	33.709	33.721	33.733	33.745	33.757	33.769	33.782	2000
1360	24.502	24.518	24.534	24.551	24.567	24.583	24.599	24.616	24.632	24.648	24.664	1360	2010	33.782	33.794	33.806	33.818	33.830	33.842	33.854	33.866	33.878	33.890	33.902	2010
1370	24.664	24.680	24.697	24.713	24.729	24.745	24.762	24.778	24.794	24.810	24.826	1370	2020	33.902	33.914	33.926	33.938	33.950	33.962	33.974	33.986	33.998	34.010	34.022	2020
1380	24.826	24.842	24.859	24.875	24.891	24.907	24.923	24.939	24.955	24.971	24.988	1380	2030	34.022	34.034	34.046	34.058	34.070	34.082	34.094	34.106	34.118	34.130	34.142	2030
1390	24.988	25.004	25.020	25.036	25.052	25.068	25.084	25.100	25.116	24.132	25.148	1390	2040	34.142	34.153	34.165	34.177	34.189	34.201	34.213	34.225	34.236	34.248	34.260	2040
1400	25.148	25.164	25.180	25.196	25.212	25.228	25.244	25.260	25.276	25.292	25.308	1400	2050	34.260	34.272	34.284	34.295	34.307	34.319	34.331	34.342	34.354	34.366	34.378	2050
1410	25.308	25.324	25.340	25.356	25.372	25.388	25.404	25.420	25.436	25.452	25.468	1410	2060	34.378	34.389	34.401	34.413	34.424	34.436	34.448	34.459	34.471	34.483	34.494	2060
1420	25.468	25.484	25.500	25.516	25.532	25.547	25.563	25.579	25.595	25.611	25.627	1420	2070	34.494	34.506	34.518	34.529	34.541	34.552	34.564	34.576	34.587	34.599	34.610	2070
1430	25.627	25.643	25.658	25.674	25.690	25.706	25.722	25.738	25.753	25.769	25.785	1430	2080	34.610	34.622	34.633	34.645	34.656	34.668	34.679	34.691	34.702	34.714	34.725	2080
1440	25.785	25.801	25.817	25.832	25.848	25.864	25.880	25.896	25.911	25.927	25.943	1440	2090	34.725	34.737	34.748	34.760	34.771	34.782	34.794	34.805	34.817	34.828	34.839	2090
1450	25.943	25.959	25.974	25.990	26.006	26.021	26.037	26.053	26.069	26.084	26.100	1450	2100	34.839	34.851	34.862	34.874	34.885	34.896	34.908	34.919	34.930	34.942	34.953	2100
1460	26.100	26.116	26.131	26.147	26.163	26.178	26.194	26.209	26.225	26.241	26.256	1460	2110	34.953	34.964	34.975	34.987	34.998	35.009	35.020	35.032	35.043	35.054	35.065	2110
1470	26.256	26.272	26.288	26.303	26.319	26.334	26.350	26.366	26.381	26.397	26.412	1470	2120	35.065	35.077	35.088	35.099	35.110	35.121	35.132	35.144	35.155	35.166	35.177	2120
1480	26.412	26.428	26.443	26.459	26.474	26.490	26.505	26.521	26.537	26.552	26.568	1480	2130	35.177	35.188	35.199	35.210	35.221	35.232	35.243	35.254	35.265	35.277	35.288	2130
1490	26.568	26.583	26.599	26.614	26.629	26.645	26.660	26.676	26.691	26.707	26.722	1490	2140	35.288	35.299	35.310	35.321	35.332	35.343	35.353	35.364	35.375	35.386	35.397	2140
1500	26.722	26.738	26.753	26.768	26.784	26.799	26.815	26.830	26.845	26.861	26.876	1500	2150	35.397	35.408	35.419	35.430	35.441	35.452	35.463	35.474	35.484	35.495	35.506	2150
1510	26.876	26.892	26.907	26.922	26.938	26.953	26.968	26.984	26.999	27.014	27.030	1510	2160	35.506	35.517	35.528	35.539	35.549	35.560	35.571	35.582	35.592	35.603	35.614	2160
1520	27.030	27.045	27.060	27.076	27.091	27.106	27.121	27.137	27.152	27.167	27.183	1520	2170	35.614	35.625	35.635	35.646	35.657	35.668	35.678	35.689	35.700	35.710	35.721	2170
1530	27.183	27.198	27.213	27.228	27.244	27.259	27.274	27.289	27.304	27.320	27.335	1530	2180	35.721	35.731	35.742	35.753	35.763	35.774	35.784	35.795	35.806	35.816	35.827	2180
1540	27.335	27.350	27.365	27.380	27.396	27.411	27.426	27.441	27.456	27.471	27.486	1540	2190	35.827	35.837	35.848	35.858	35.869	35.879	35.890	35.900	35.911	35.921	35.932	2190
1550	27.486	27.502	27.517	27.532	27.547	27.562	27.577	27.592	27.607	27.622	27.637	1550	2200	35.932	35.942	35.953	35.963	35.973	35.984	35.994	36.004	36.015	36.025	36.036	2200
1560	27.637	27.653	27.668	27.683	27.698	27.713	27.728	27.743	27.758	27.773	27.788	1560	2210	36.036	36.046	36.056	36.067	36.077	36.087	36.097	36.108	36.118	36.128	36.138	2210
1570	27.788	27.803	27.818	27.833	27.848	27.863	27.878	27.893	27.908	27.923	27.938	1570	2220	36.138	36.149	36.159	36.169	36.179	36.189	36.200	36.210	36.220	36.230	36.240	2220
1580	27.938	27.953	27.968	27.983	27.997	28.012	28.027	28.042	28.057	28.072	28.087	1580	2230	36.240	36.250	36.260	36.271	36.281	36.291	36.301	36.311	36.321	36.331	36.341	2230
1590	28.087	28.102	28.117	28.132	28.146	28.161	28.176	28.191	28.206	28.221	28.236	1590	2240	36.341	36.351	36.361	36.371	36.381	36.391	36.401	36.411	36.421	36.431	36.441	2240
1600	28.236	28.250	28.265	28.280	28.295	28.310	28.324	28.339	28.354	28.369	28.383	1600	2250	36.441	36.451	36.460	36.470	36.480	36.490	36.500	36.510	36.520	36.529	36.539	2250
1610	28.531	28.546	28.560	28.575	28.590	28.604	28.619	28.634	28.648	28.663	28.678	1610	2260	36.539	36.549	36.559	36.569	36.578	36.588	36.598	36.608	36.617	36.627	36.637	2260
1620	28.531	28.546	28.560	28.575	28.590	28.604	28.619	28.634	28.648	28.663	28.678	1620	2270	36.637	36.646	36.656	36.666	36.675	36.685	36.695	36.704	36.714	36.723	36.733	2270
1630	28.678	28.692	28.707	28.722	28.736	28.751	28.765	28.780	28.795	28.809	28.824	1630	2280	36.733	36.743	36.752	36.762	36.771	36.781	36.790	36.800	36.809	36.819	36.828	2280
1640	28.824	28.838	28.853	28.868	28.882	28.897	28.911	28.926	28.940	28.955	28.969	1640	2290	36.828	36.838	36.847	36.857	36.866	36.875	36.885	36.894	36.903	36.913	36.922	2290
1650	28.969	28.984	28.998	29.013	29.027	29.042	29.056	29.071	29.085	29.100	29.114	1650	2300	36.922	36.932	36.941	36.950	36.959	36.969	36.978	36.987	36.997	37.006	37.015	2300
1660	29.114	29.129	29.143	29.158	29.172	29.187	29.201	29.215	29.230	29.244	29.259	1660	2310	37.015	37.024	37.033	37.043	37.052	37.061	37.070	37.079	37.088	37.097	37.107	2310
1670	29.259	29.273	29.287	29.302	29.316	29.331	29.345	29.359	29.374	29.388	29.402	1670													
1680	29.402	29.417	29.431	29.445	29.460	29.474	29.488	29.503	29.517	29.531	29.546	1680													
1690	29.546	29.560	29.574	29.588	29.603	29.617	29.631	29.645	29.660	29.674	29.688	1690													
1700	29.688	29.702	29.716	29.731	29.745	29.759	29.773	29.787	29.802	29.816	29.830	1700													
1710	29.830	29.844	29.858	29.872	29.886	29.901	29.915	29.929	29.943	29.957	29.971	1710													
1720	29.971	29.985	29.999	30.013	30.027	30.041	30.056	30.070	30.084	30.098	30.112	1720													
1730	30.112	30.126	30.140	30.154	30.168	30.182	30.196	30.210	30.224	30.238	30.252	1730													
1740	30.252	30.266	30.280	30.294	30.308	30.321	30.335	30.349	30.363	30.377	30.391	1740													
1750	30.391	30.405	30																						

DECIMAL EQUIVALENT CHART

INCH FRACTION	DECIMAL EQUIV.		INCH FRACTION	DECIMAL EQUIV.		INCH FRACTION	DECIMAL EQUIV.
1/64	.0156		23/64	.3594		45/64	.7031
1/32	.0312		3/8	.375		23/32	.7187
3/64	.0469		24/64	.3906		47/64	.7344
1/16	.0625		13/32	.4062		3/4	.75
5/64	.0781		27/64	.4219		49/64	.7656
3/32	.0937		7/16	.4375		25/32	.7812
7/64	.1094		39/64	.4531		51/64	.7969
1/8	.125		15/32	.4687		13/16	.8125
9/64	.1406		31/64	.4844		53/64	.8281
5/32	.1562		1/2	.5		27/32	.8437
11/64	.1719		33/64	.5156		55/64	.8594
3/16	.1875		17/32	.5312		7/8	.875
13/64	.2031		35/64	.5469		57/64	.8906
7/32	.2187		9/16	.5625		29/32	.9062
15/64	.2344		37/64	.5781		59/64	.9219
1/4	.25		19/32	.5937		15/16	.9375
17/64	.2656		39/64	.6094		61/64	.9531
9/32	.2812		5/8	.625		31/32	.9687
19/64	.2969		41/64	.6406		63/64	.9844
5/16	.3125		21/32	.6562		1	1.00
21/64	.3281		43/64	.6719			
11/32	.3437		11/16	.6875			

THERMOCOUPLE TEMPERATURE LIMITS

	Material	Couple Condition	AWG					
			8	14	16	20	24	30
S R	Platinum and Platinum-Rhodium	Bare Protected	- -	- -	- -	- 2800 F	- 2700 F	- 2400 F
T	Copper and Constantan	Bare Protected	- -	600°F 700°F	500°F 600°F	400°F 500°F	400°F 400°F	400°F 400°F
J	Iron and Constantan	Bare Protected	1200°F 1400°F	900°F 1100°F	900°F 1100°F	800°F 900°F	650°F 700°F	600°F 700°F
K	Chromel and Alumel	Bare Protected	2000°F 2300°F	1700°F 2000°F	1700°F 2000°F	1600°F 1800°F	1400°F 1600°F	1300°F 1500°F
E	Chromel and Constantan	Bare Protected	1400°F 1600°F	1100°F 1200°F	1100°F 1200°F	900°F 1000°F	700°F 800°F	700°F 800°F



MATERIAL SELECTION INFORMATION

The following information is a guide line for selecting thermocouple, RTD and thermowell materials based on the process fluid. Factors such as catalytic reaction, contamination and electrolysis are taken into consideration. However, in many cases there are even more variables which must be examined.

These suggestions are to be used only as guide lines and are based on the most economical material selection. JMS Southeast will not take any responsibility if these recommendations are not satisfactory for specific applications. Consult JMS Southeast for special applications and our engineering department will assist you in your selection.

SUBSTANCE	CONDITIONS	RECOMMENDED METAL	SUBSTANCE	CONDITIONS	RECOMMENDED METAL	SUBSTANCE	CONDITIONS	RECOMMENDED METAL
Acetate Solvents	Crude or Pure	Monel or Nickel	Ethyl Acetate		Monel	" "	85% - 70°F	Hastelloy B
Acetic Acid	10% - 70°F	304 Stainless Steel	Ethyl Chloride	70°F	304 Stainless Steel	" "	85% - 212°F	Hastelloy B
" "	50% - 70°F	304 Stainless Steel	Ethylene Glycol		Steel (C1018)	Picric Acid	70°F	304 Stainless Steel
" "	50% - 212°F	316 Stainless Steel	Ethyl Sulphate	70°F	Monel	Potassium Bromide	70°F	316 Stainless Steel
" "	99% - 70°F	430 Stainless Steel	Ferric Chloride	1% - 70°F	316 Stainless Steel	Potassium Carbonate	1% - 70°F	304 Stainless Steel
" "	99% - 212°F	430 Stainless Steel	" "	5% - 70°F	Tantalum	Potassium Chlorate	70°F	304 Stainless Steel
Acetic Anhydride		Monel	" "	5% - Boiling	Tantalum	Potassium Chloride	5% - 70°F	304 Stainless Steel
Acetone	212°F	304 Stainless Steel	Ferric Sulphate	5% - 70°F	304 Stainless Steel	" "	5% - 212°F	304 Stainless Steel
Acetylene		304, Monel, Nickel	Ferrous Sulphate	Dilute 70°F	304 Stainless Steel	Potassium Hydroxide	5% - 70°F	304 Stainless Steel
Alcohol Ethyl	70°F	304 Stainless Steel	Formaldehyde		304 Stainless Steel	" "	25% - 212°F	304 Stainless Steel
" "	212°F	304 Stainless Steel	Freon		Steel (C1018)	" "	50% - 212°F	316 Stainless Steel
Alcohol Methyl	70°F	304 Stainless Steel	Formic Acid	5% - 70°F	316 Stainless Steel	Potassium Nitrate	5% - 70°F	304 Stainless Steel
" "	212°F	304 Stainless Steel	" "	5% - 150°F	316 Stainless Steel	" "	5% - 212°F	304 Stainless Steel
Aluminum	Molten	Cast Iron	Gallic Acid	5% - 70°F	Monel	Potassium		
Aluminum Acetate	Saturated	304 Stainless Steel	" "	5% - 150°F	Monel	Permanganate	5% - 70°F	304 Stainless Steel
Aluminum Sulphate	10% - 70°F	304 Stainless Steel	Gasoline	70°F	304 Stainless Steel	Potassium Sulphate	5% - 70°F	304 Stainless Steel
" "	Saturated 70°F	304 Stainless Steel	Glucose	70°F	304 Stainless Steel	" "	5% - 212°F	304 Stainless Steel
" "	10% - 212°F	316 Stainless Steel	Glycerine	70°F	304 Stainless Steel	Potassium Sulphide	70°F	304 Stainless Steel
" "	Saturated 212°F	316 Stainless Steel	Glycerol		304 Stainless Steel	Propane		304 Stainless Steel
Ammonia	All concentrations 70°F	304 Stainless Steel	Heat Treating		446 Stainless Steel	Pyrogalllic Acid		304 Stainless Steel
Ammonium Chloride	All concentrations 212°F	316 Stainless Steel	Hydrobromic Acid	48% - 212°F	Hastelloy B	Quinine Bisulphate	Dry	316 Stainless Steel
Ammonium Nitrate	All concentrations 70°F	304 Stainless Steel	Hydrochloric Acid	1% - 70°F	Hastelloy C	Quinine Sulphate	Dry	304 Stainless Steel
" "	All concentrations 212°F	304 Stainless Steel	" "	1% - 212°F	Hastelloy B	Resin		304 Stainless Steel
Ammonium Sulphate	5% - 70°F	304 Stainless Steel	" "	5% - 70°F	Hastelloy C	Rosin	Molten	304 Stainless Steel
" "	10% - 212°F	316 Stainless Steel	" "	5% - 212°F	Hastelloy B	Sea Water		Monel
" "	Saturated 212°F	316 Stainless Steel	" "	25% - 70°F	Hastelloy B	Salommoniac		Monel
Aniline	All concentrations 70°F	304 Stainless Steel	" "	25% - 212°F	Hastelloy B	Salicylic Acid		Nickel
Amylacetate		Monel	Hydrocyanic Acid		316 Stainless Steel	Shellac		304 Stainless Steel
Asphalt		Steel (C1018)	Hydrofluoric Acid		Hastelloy C	Soap	70°F	304 Stainless Steel
" "		Phosphor Bronze, Monel, Nickel	Hydrogen Peroxide	70°F	316 Stainless Steel	Sodium Bicarbonate	All concentrations 70°F	304 Stainless Steel
Barium Carbonate	70°F	304 Stainless Steel	" "	212°F	316 Stainless Steel	" "	5% - 150°F	304 Stainless Steel
Barium Chloride	5% - 70°F	Monel	Hydrogen Sulphide	Wet and dry	316 Stainless Steel	Sodium Bisulphate		Monel
" "	Saturated 70°F	Monel	Iodine	70°F	Tantalum	Sodium Carbonate	5% - 70°F	304 Stainless Steel
" "	Aqueous - Hot	316 Stainless Steel	Kerosene	70°F	304 Stainless Steel	" "	5% - 150°F	304 Stainless Steel
Barium Hydroxide		Steel (C1018)	Lactic Acid	5% - 70°F	304 Stainless Steel	Sodium Chloride	5% - 70°F	316 Stainless Steel
Barium Sulphite		Nichrome	" "	5% - 150°F	316 Stainless Steel	Sodium Chloride	5% - 150°F	316 Stainless Steel
Benzaldehyde		Steel (C1018)	" "	10% - 212°F	Tantalum	" "	Saturated - 70°F	316 Stainless Steel
Benzene	70°F	304 Stainless Steel	Lacquer	70°F	316 Stainless Steel	" "	Saturated - 212°F	316 Stainless Steel
Benzine		Steel (C1018)	Latex		Steel (C1018)	Sodium Fluoride	5% - 70°F	Monel
" "		Monel, Inconel	Lime Sulphur		Steel (C1018), 304, Monel	Sodium Hydroxide		304 Stainless Steel
Benzol	Hot	304 Stainless Steel	Linseed Oil	70°F	304 Stainless Steel	Sodium Hypochlorite	5% still	316 Stainless Steel
Boric Acid	5% Hot or Cold	Monel	Magnesium Chloride	5% - 70°F	Monel	Sodium Nitrate	Fused	317 Stainless Steel
Bromine	70°F	Tantalum	" "	5% - 212°F	Nickel	Sodium Peroxide		316 Stainless Steel
Buladiene		Brass, 304	Magnesium Sulphate	Cold and Hot	Monel	Sodium Phosphate		Steel (C1018)
Butane	70°F	304 Stainless Steel	Malic Acid	Cold and Hot	316 Stainless Steel	Sodium Silicate		Steel (C1018)
Butylacetate		Monel	Mercury		Steel (C1018), 304, Monel	Sodium Sulphate	70°F	304 Stainless Steel
Butyl Alcohol		Copper	Methane	70°F	Monel	Sodium Sulphide	70°F	316 Stainless Steel
Butylenes		Steel (C1018)	Milk		Steel (1020)	Sodium Sulphite	150°F	304 Stainless Steel
" "		Phosphor Bronze	Mixed Acids		304, Nickel	Steam		304 Stainless Steel
Butyric Acid	5% - 70°F	304 Stainless Steel	[Sulphuric and Nitric — all temp. and %]		Carpenter #20	Stearic Acid		304 Stainless Steel
" "	5% - 150°F	304 Stainless Steel	Molasses		Steel (C1018), 304, Monel, Nickel	Sulphur Dioxide	Moist Gas - 70°F	316 Stainless Steel
Calcium Bisulfite	70°F	316 Stainless Steel	Muriatic Acid	70°F	Tantalum	" "	Gas - 575°F	304 Stainless Steel
Calcium Chlorate	Dilute 70°F	304 Stainless Steel	Naphtha	70°F	304 Stainless Steel	Sulphur	Dry - Molten	304 Stainless Steel
" "	Dilute 150°F	304 Stainless Steel	Natural Gas	70°F	304 Stainless Steel	" "	Wet	316 Stainless Steel
Calcium Hydroxide	10% - 212°F	304 Stainless Steel	Neon	70°F	304 Stainless Steel	Sulphuric Acid	5% - 70°F	Carp. 20, Hastelloy B
" "	20% - 212°F	304 Stainless Steel	Nickel Chloride	70°F	304 Stainless Steel	" "	5% - 212°F	Carp. 20, Hastelloy B
" "	50% - 212°F	317 Stainless Steel	Nickel Sulphate	Hot and Cold	304 Stainless Steel	" "	10% - 70°F	Carp. 20, Hastelloy B
Carbolic Acid	All 212°F	316 Stainless Steel	Nitric Acid	5% - 70°F	304 Stainless Steel	" "	10% - 212°F	Carp. 20, Hastelloy B
Carbon Dioxide	Dry	Steel (C1018), Monel	" "	20% - 70°F	304 Stainless Steel	" "	50% - 70°F	Carp. 20, Hastelloy B
Carbon Dioxide	Wet	Aluminum, Monel, Nickel	" "	50% - 70°F	304 Stainless Steel	" "	50% - 212°F	Carp. 20, Hastelloy B
Carbon Tetrachloride	10% - 70°F	Monel	" "	50% - 212°F	304 Stainless Steel	" "	90% - 70°F	Carp. 20, Hastelloy B
Chlorex Caustic		316SS, 317SS	" "	65% - 212°F	316 Stainless Steel	" "	90% - 212°F	Hastelloy B
Chlorine Gas	Dry 70°F	317 Stainless Steel	" "	Concentrated - 70°F	304 Stainless Steel	Tannic Acid	70°F	304 Stainless Steel
" "	Moist 70°F	Hastelloy C	" "	Concentrated - 212°F	304 Stainless Steel	Tar		Steel (C1018), 304, Monel, Nickel
" "	Moist 212°F	Hastelloy C	Nitrobenzene	70°F	304 Stainless Steel	Tartaric Acid	70°F	304 Stainless Steel
Chromic Acid	5% - 70°F	304 Stainless Steel	Nitrous Acid		304 Stainless Steel	" "	150°F	316 Stainless Steel
" "	10% - 212°F	316 Stainless Steel	Oleic Acid	70°F	316 Stainless Steel	Tin	Molten	Cast Iron
" "	50% - 212°F	316 Stainless Steel	Oleum	70°F	316 Stainless Steel	Tolvene		Aluminum, Phosphor Bronze, Monel
Citric Acid	15% - 70°F	304 Stainless Steel	Oxalic Acid	5% - Hot and Cold	316 Stainless Steel	Trichloroethylene		Steel (C1018)
" "	15% - 212°F	317 Stainless Steel	" "	10% - 212°F	Monel	Turpentine		304 Stainless Steel
" "	Concentrated 212°F	304 Stainless Steel	Oxygen	70°F	Steel (C1018)	Varnish		304 Stainless Steel
Coal Tar	Hot	Aluminum	Oxygen	Liquid	304 Stainless Steel	Vegetable Oils		Steel (C1018), 304, Monel
Coke Oven Gas		304, 316	Palmitic Acid		316 Stainless Steel	" "		304 Stainless Steel
Copper Nitrate		304, 316	Petroleum Ether		304 Stainless Steel	Vinegar		Copper, Steel
Copper Sulphate		304, 316	Phenol		304 Stainless Steel	Water	Fresh	(C1018), Monel
Core Oils		316 Stainless Steel	Pentane		304 Stainless Steel	Water	Salt	Aluminum Brass, Monel
Cottonseed Oil		Steel (C1018)	Phosphoric Acid	1% - 70°F	304 Stainless Steel	Whiskey, Wine		304, Nickel
" "		Monel, Nickel	" "	5% - 70°F	304 Stainless Steel	Xylene		Copper
Creosols		304 Stainless Steel	" "	10% - 70°F	316 Stainless Steel	Zinc	Molten	Cast Iron
Creosote Crude		Steel (C1018), Monel	" "	10% - 212°F	Hastelloy C	Zinc Chloride	5% - 70°F	Monel
" "		Nickel	" "	30% - 70°F	Hastelloy B	Zinc Sulphate	Saturated - 70°F	304 Stainless Steel
Cyanogen Gas		304 Stainless Steel	" "	30% - 212°F	Hastelloy B	" "	25% - 212°F	304 Stainless Steel
Dowtherm		Steel (C1018)						
Epsom Salt	Hot and Cold	304 Stainless Steel						
Ether	70°F	304 Stainless Steel						

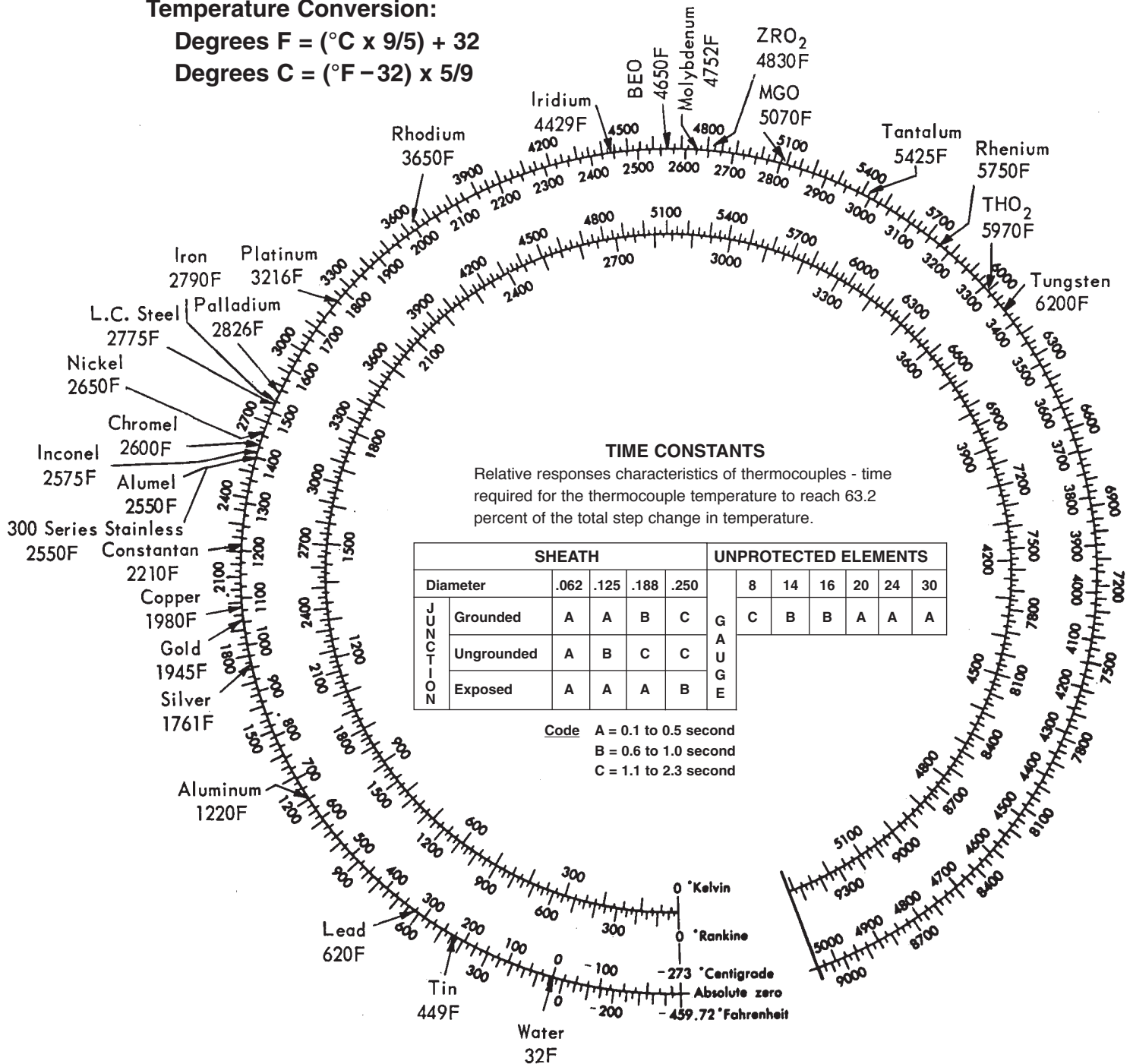
TEMPERATURE CONVERSION CHART (°F and °C)

SHOWING MELTING POINTS OF COMMONLY USED ELEMENTS

Temperature Conversion:

$$\text{Degrees F} = (^\circ\text{C} \times 9/5) + 32$$

$$\text{Degrees C} = (^\circ\text{F} - 32) \times 5/9$$



Useful Range of Thermocouples— 458°F to + 4800°F

NOMINAL PHYSICAL PROPERTIES OF ELEMENT

Thermoelement Material										
Property	Positive (+) Conductors						Negative (-) Conductors			
	J	T	K,E	N+	R	S	J,T,E	K	R,S	N-
Melting Point (°C)	1535	1083	1430	1410	1870	1850	1210	1400	1773	1400
Electrical Resistivity Ohms/CMF @ 20°C	60.14	10.37	425	.560			294	177	63.80	.220
Thermal Conductivity Watts/cm/°C @ 100°C	.662	3.88	.192	.031			.212	.297	.695	.055
Specific Heat Cal./GM/°C @ 20°C	.1065	.0921	.107	0.11			.094	.125	.0324	0.12
Density-lb/in ³	.2840	.3233	.3154				.322	.3107	.7750	
Tensile Strength Annealed-PSI	50,000	35,000	95,000	110,00			60,000	85,000		95,000
Magnetic Strength @ 20°C	Strong	None	None	None	None	None	None	Weak	None	None
Specific Gravity	7.86	8.92	8.73	.852			8.9	8.60	21.45	.870

TABLE 1. Characteristics Compositions of Thermoelement Alloys.

CHEMICAL composition (weight %)										
Alloy	Cr	Si	Mg	Mn	Al	Fe	Co	C	Cu	Ni
nicrosil	14.2	1.4	-	-	-	0.1	-	.03	-	bal.
nisil	-	4.4	0.1	-	-	0.1	-	-	-	bal.
type (or EP)	9.3	0.5	-	0.5	-	0.5	0.5	-	-	bal.
type KN	-	1.1	-	2.8	1.9	0.5	0.5	-	0.5	bal.
type JP	-	-	-	.25	-	bal.	-	-	.12	-
type JN	-	-	-	.75	-	0.3	0.3	-	bal.	44.5
type TP	-	-	-	-	-	-	-	-	99.95	-
type TN (or EN)	-	-	-	0.1	-	0.1	-	-	bal.	45

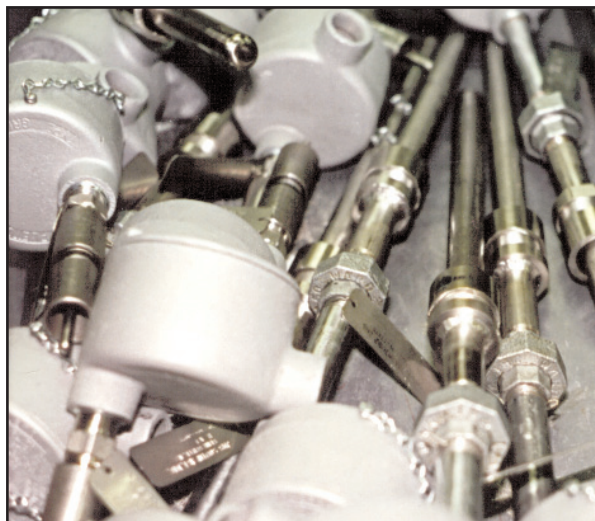
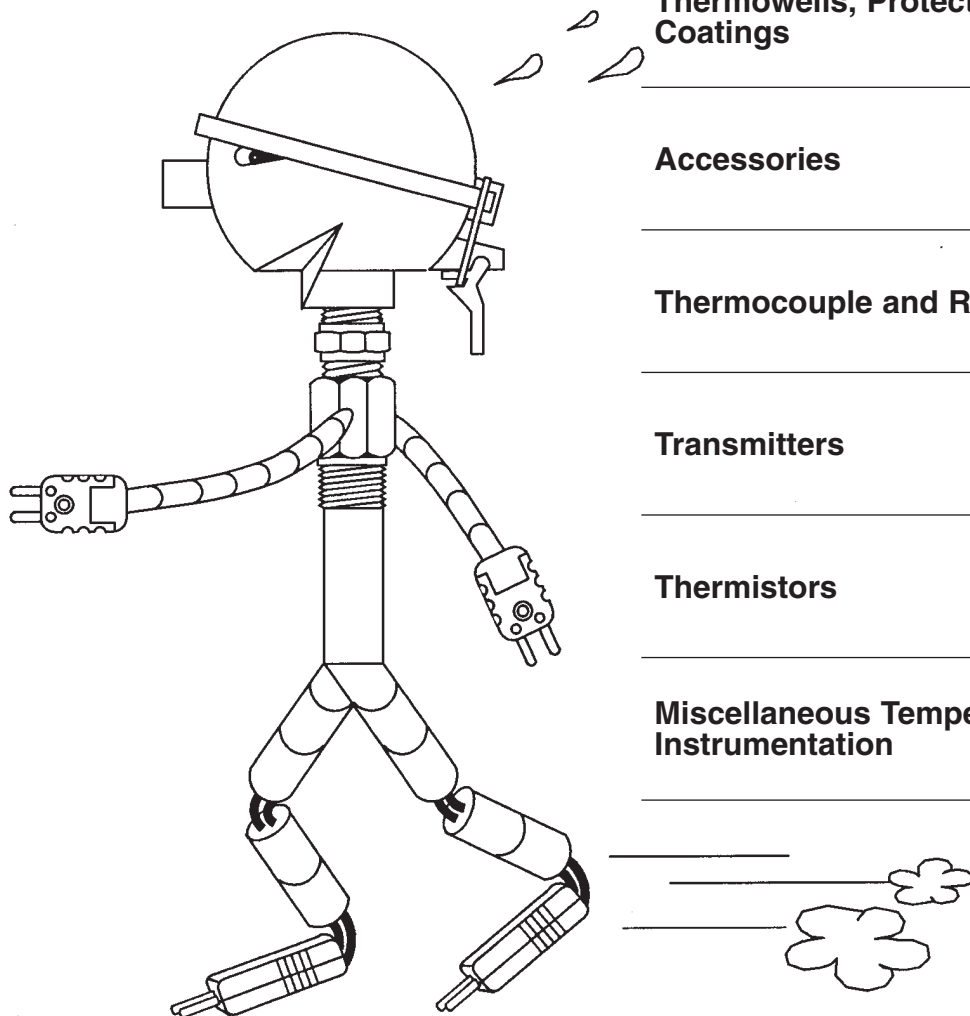


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Notes

1-800-873-1835



JMS Southeast, Inc.
Temperature Measurement

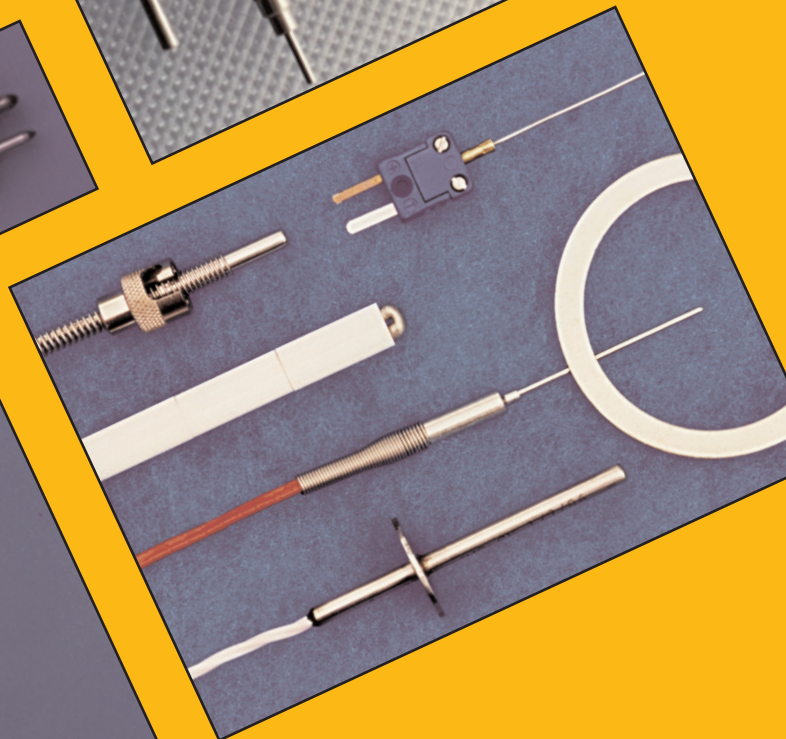
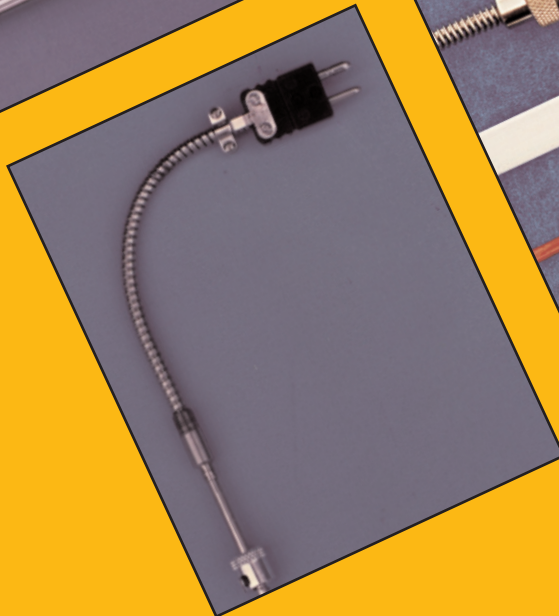
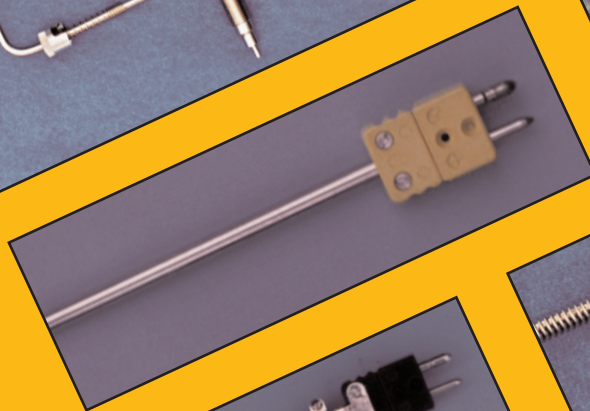
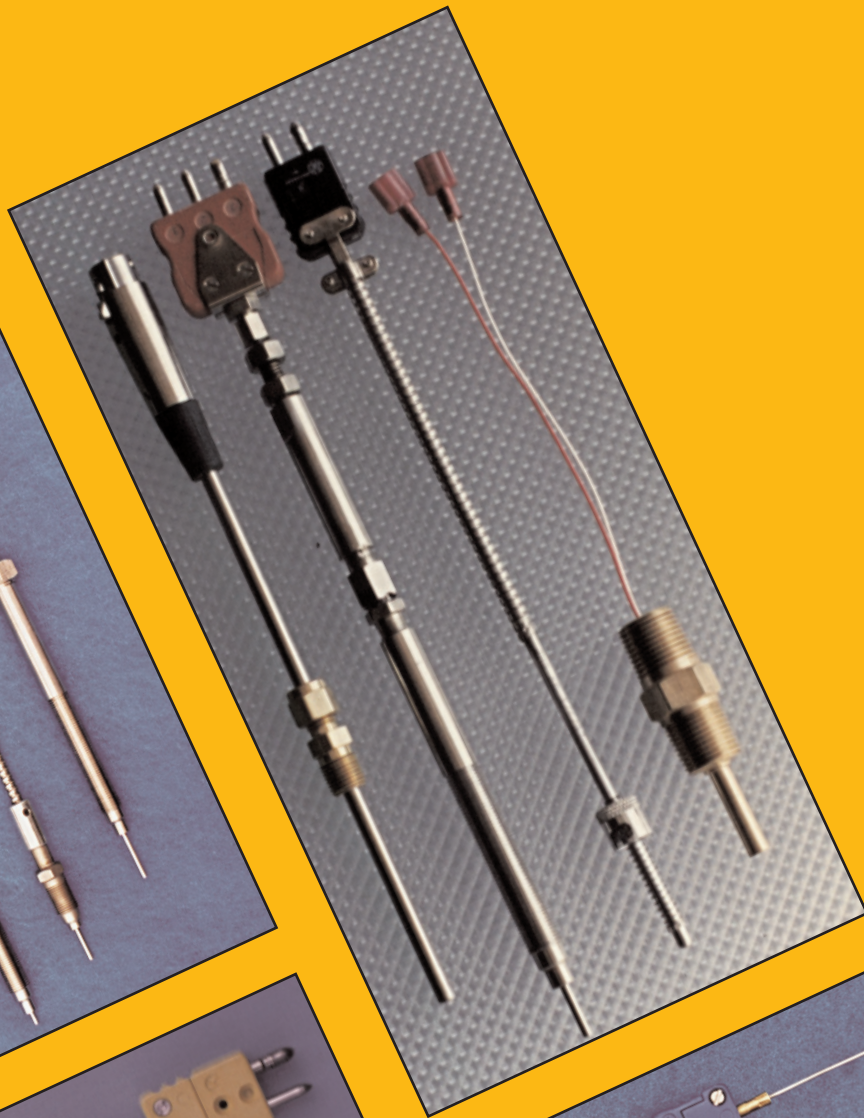
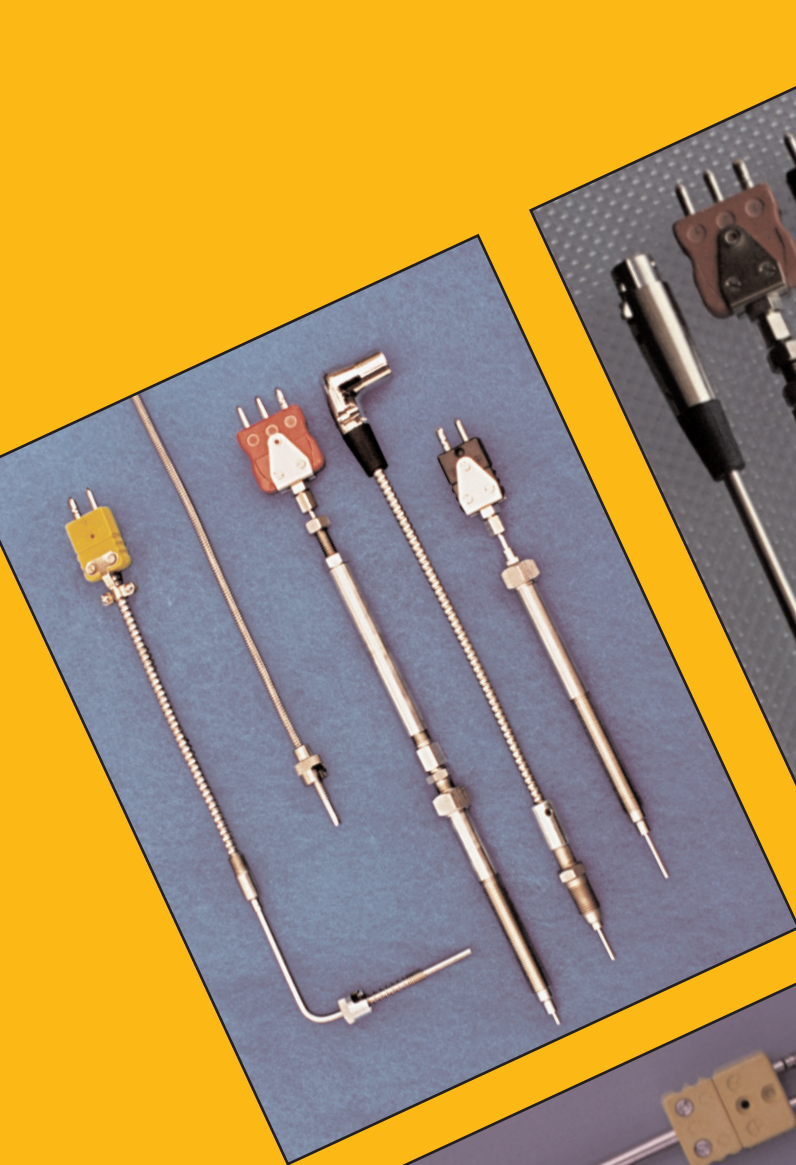


SECTION 2



**Plastics
Sensors**





PLASTICS SENSORS

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NOTE: JMS Southeast, Inc. is a stocking distributor for electric heaters and controllers. Please call for any requirements.

PLASTICS SENSORS

BAYONET TEMPERATURE SENSORS

Bayonet style attachments are the most common in Plastics Processing. JMS has adapted this useful and safe design to other industrial sensors to utilize the best features of both.

Our standard design and most commonly used is the Adjustable Bayonet attachment device which incorporates a chrome plated brass cap with a 303 stainless steel spring. The spring fits like chinese handcuffs around the appropriately sized sensor and remains in position until such a time as the user adjusts it. This enables the same sensor to be used for many different applications in the same facility. It also makes for lower inventory levels which your accountant will love.

The other attachment devices we make for your sensors are standard in the industry. For those "Old Dogs" who refuse to try something innovative we still offer the fixed bayonet design. The length of this sensor cannot be changed and will only go in the hole it was specifically built to fit.

#1	SERIES	
2	Plastics Sensors	
#2	DESIGN [8]	
M	MgO insulated (SWAGED)	
H	Hollow tube	
#3	TYPE	TEMP. RANGE (°F)
J	Iron/Constantan	32 to 1400
K	Chromel/Alumel	32 to 2300
T	Copper/Constantan	-300 to 700
E	Chromel/Constantan	-300 to 1600
3	100Ω Platinum RTD (.00385 alpha, 3 wire)	-200 to 1000
X	Other, specify	
#4	OUTSIDE DIAMETER	
C	3/16" (.188")	
D	1/8" (.125")	
B	1/4" (.250") (SWAGED only)	
X	Other, specify	
#5	LIMITS OF ERROR	ELEMENT CONSTRUCTION
1	Standard	Single
2	Standard	Dual
3	Special	Single
4	Special	Dual
X	Other, specify	
#6	CONSTRUCTION	
S	Straight	
4	45° bend	
9	90° bend	
X	Specify bend	
#7	MAXIMUM TEMPERATURE AT WHICH TIP WILL BE EXPOSED	
A	<100°C (212°F)	=2 PVC*
B	<200°C (392°F)	=3 Teflon*
C	<285°C (550°F)	=5 Kapton*
D	<482°C (900°F)	=1 Fiberglass*
E	<705°C (1300°F)	=4 HT Fiberglass*
F	>705°C (1300°F)	=7 Bare ends (heat shrink)*
#8	MEASURING JUNCTION [9]	
G	Grounded	
U	Ungrounded (RTD's are always ungrounded)	
I	Isolated	
E	Exposed	
X	Other, specify	
#9	IMMERSION LENGTH (L)	
3"	Length in inches	

Note: Hollow tube sensors should never be used to measure temperatures above 900°F.

Note: 304 SS standard sheath material.

[] BRACKETS INDICATE PAGE NUMBERS ON WEB OR FULL CATALOG FOR ADDITIONAL TECHNICAL INFORMATION
WWW.JMS-SE.COM

SWAGED ONLY

Note: See appropriate drawing on page 2-1 & 2-2 before you specify the immersion length.

*If no transition (Z) is in symbol 13, we recommend these corresponding selections for primary wire insulation on hollow tube sensors.

PLASTICS SENSORS

#10 ATTACHING DEVICES					
J	Adjustable bayonet (Standard)	X	Other, specify		
F	Fixed bayonet				
P	Brass compression fitting 1/8" NPT				
N	Non-Immersion nozzle				
M	Nozzle melt				
Z	N/A				

Use "0" in symbol #9 for standard length. (See drawings on this page.)

Note: Non-fixed fittings do not affect the immersion length.

#11 ADAPTER TYPE					
1/8" NPT	3/8" x 24	NICKEL PLATED STEEL SLOT HEAD MOUNTING ADAPTER (FOR BAYONET ONLY)			
Z	Z	No adapter required	K	1/4" NPT X 1 1/4" long for 1/4" bayonet	
A	E	7/8" overall length			
B	F	1 1/2" overall length			
C	G	2 1/2" overall length			
D	J	3 1/2" overall length			
X	X	Other, specify			

#12 LEAD WIRE TYPE & LENGTH IN INCHES	T/C	RTD	
Z	No lead wires	20 awg	24 awg
1	Glass braid	20 awg	24 awg
3	FEP teflon	20 awg	24 awg
6	Glass braid / flex armor overall	20 awg	24 awg
7	Teflon / flex armor overall	20 awg	24 awg
8	Glass braid / stainless steel overbraid	20 awg	24 awg
X	Other, specify		

Note: 24 awg wire or smaller may be used if necessary.

#13 TYPE OF TRANSITION [1-16]	
H	Heat shrink
S	Size on size
T	3/8" OD (Standard)
R	1/4" OD
X	Other, specify
Z	No transition
C	Cuttable design (No crimp at end of tube / nylon insert)

Note: For high humidity / moisture environments $\leq 500^{\circ}$ F put a "2" after your selection.

Note: For high temperature at the transition area use an X + type of transition and maximum temperature.

Note: When "Z" no transition is specified for a hollow tube sensor, the extension lead is crimped to the tube.

#14 COLD END TERMINATION [SECT 6, CHOOSE AS MANY AS APPLICABLE]	
A	Bare ends
B	Miniature plug (6A1B2)
C	Standard plug (6A1C2)
D	Miniature jack
E	Standard jack
F	High temperature plug ($< 800^{\circ}$ F)
G	High temperature jack ($< 800^{\circ}$ F)
H	Explosion proof Nema 7 head (6I / 6PT)
K	Spade lugs (6JL)
L	Aluminum head w/ hinged cover (6L / 6B4)
M	Aluminum head w/ screw cover & chain (6M / 6B4)
N	Cast iron head w/ screw cover & chain (6N / 6B4)
O	Open ceramic terminal block (6N)
Q	Black nylon Nema 4 head (6Q / 6B4)

Note: For any other cold end terminations, use symbol X and describe using appropriate part numbers from section 6 in place of symbol #14.

#15 TAGGING AND CALIBRATION OPTIONS (USE ONLY IF APPLICABLE)	
----	See page 1-2 #14 for ordering selections.

FIXED BAYONET

NON-IMMERSION NOZZLE

NOZZLE MELT

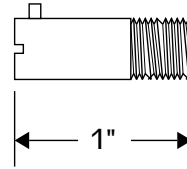
J A 6 (36") T C

2-2

BAYONET ACCESSORIES

NICKEL PLATED STEEL SLOT HEAD ADAPTERS

SYMBOL			LENGTH
1/8" NPT	3/8"-24	1/4" NPT	
2A	2E	6BA	7/8" overall length
2A1	----		1 1/4" overall length
2B	2F		1 1/2" overall length
2C	2G		2 1/2" overall length
2D	2J		3 1/2" overall length

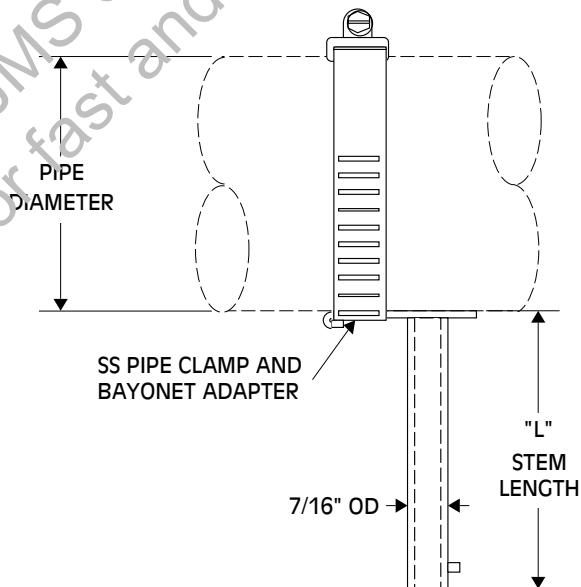


NOTE: To order adapters of different lengths, use 2A + X for 1/8" NPT and 2E + X for 3/8"-24 threads. You must specify length.

STAINLESS STEEL PIPE CLAMP ADAPTERS

#1	SERIES		
2C	Pipe clamp bayonet adapter		
#2	"L" LENGTH OF STEM IN INCHES		
R	1 3/4"		
S	3 3/4"		
T	8 3/4"		
X	Other, specify		
#3	BAND CLAMP DIAMETER (INCHES)		STANDARD PIPE SIZE (INCHES)
	MIN.	MAX.	
1	7/16	25/32	1/4 to 3/8
2	1 1/16	1 1/4	1/2 to 3/4
3	1 1/6	2	1 to 1 1/2
4	2 1/16	3	2 to 2 1/2
5	3 15/16	4 1/4	3 to 3 1/2
6	3 9/16	4 1/2	4
7	5 1/8	6	5
8	6 1/8	7	6

Note: "L" = Length of stem. Should be equal to the maximum insulation thickness + 3/4". The bayonet sensor length should be "L" + 3/4".



2C	S	3	
----	---	---	--

PLASTIC MELT SENSORS

Plastic melt thermocouples and RTD's can fit directly into the melt stream of extruder heads. They can be used to control melt temperature gradients within the melt stream, to monitor incoming melt temperatures, or to achieve control of nozzle and nozzle manifold temperatures. All plastic melt bolts are Stainless Steel. The bolt tips are back filled with a ceramic insulator. The probe is .125" O.D.

#1	SERIES	
2P	Plastic Melt Sensor	
#2	STYLE [2-6]	
4	*Bolt with 1 1/2" bendable metal extension and plug	
5	Bolt with direct mount plug	
6	**Bolt with 24" of kapton insulated wire with flexible armor and plug	
X	Other, specify	
*Tubular extension between bolt and plug can be formed by hand at application site to any desired angle. If a longer metal extension from hex to plug connection is required, use X and specify length desired. Example: 2PXJ13BGP X=4-6"		
**If a length other than 24" of flex armor is required, use X and specify length desired. Example: 2PXJ13BCP X=6-36"		
#3	SENSOR TYPE [1-1, 3-3]	
J	Iron/Constantan, standard limits of error	
A	100Ω Platinum RTD .00385 alpha (3 wire) ±.12 % accuracy Thin film is Standard .	
X	Other, specify	
#4	LIMITS OF ERROR	ELEMENT CONSTRUCTION
1	Standard	Single
2	Standard	Dual
3	Special	Single
4	Special	Dual
X	Other, specify	
#5	BOLT LENGTH (B) [5]	
3	3"	
6	6"	
X	Other, specify	
#6	IMMERSION (I) [6]	
A	Flush	
B	1/2" Immersion	
C	1" Immersion	
X	Other, specify	
#7	MEASURING JUNCTION [9]	
G	Grounded	
U	Ungrounded (RTD's are always ungrounded)	
E	Exposed	
I	Isolated	
X	Other, specify	
For special wetted parts facing, use X + description. i.e. X=Grounded + Hastalloy facing		
#8	MAXIMUM SERVICE TEMPERATURE	
P	Below 500°F	
Q	500°F - 900°F	
#9	TAGGING AND CALIBRATION OPTIONS (USE ONLY IF APPLICABLE)	
See page 1-2 #14 for ordering selections.		

1/4" DIRECT
1 1/2" BENDABLE

1" MUST BE < 500° F

2P	5	J	1	6	B	G	P	
----	---	---	---	---	---	---	---	--

ADJUSTABLE PLASTIC MELT SENSORS

Adjustable plastic melt sensors can be used to measure temperature gradients in melt streams. This design gives you the ability to have an adjustable immersion depth during full operation at maximum flow rates and pressure.

The length of the measuring junction is controlled by adjusting the setting of the knurled adjusting screw.

The probe should be adjusted to flush prior to melt cool down to eliminate probe breakage on start up.

This design also eliminates melt stream barriers and turbulence that could affect product quality.

It is used to profile dimensional stream temperature variations.

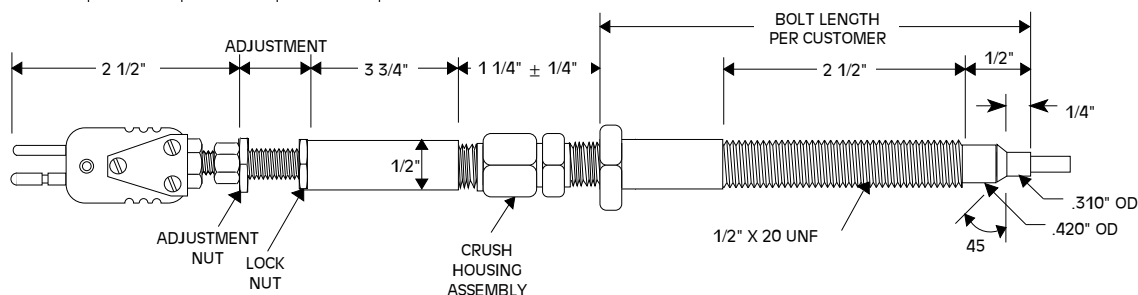
SPECIFICATIONS:

304 SS sheath, .125" O.D. Maximum temperature rating is 900°F. Pressure rating is 15,000 PSI.

TO INSTALL PROBE:

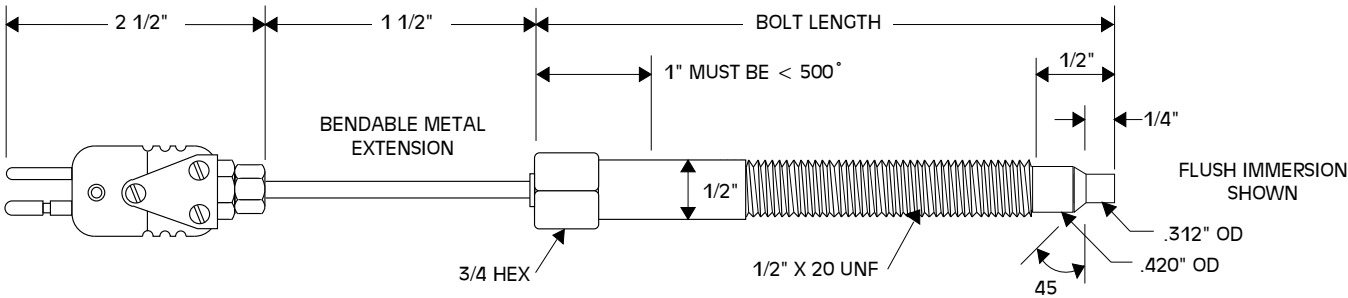
- 1) Use wrench only on hex closest to hot end.
- 2) Use fingers to adjust depth and lock nut.
- 3) **Do not use wrench on any part of assembly when machine is hot or under pressure.**

#1	SERIES
27	Adjustable plastic melt sensor
#2	SENSOR TYPE [3-3]
J	Iron/Constantan
3	100Ω Platinum, .00385 alpha, RTD (3 wire)
X	Other, specify
#3	BOLT LENGTH
3	3" Bolt
5	5" Bolt
7	7" Bolt
X	Other, specify
#4	IMMERSION JUNCTION [9]
A	1/8" - 1"
B	1/8" - 2 1/2"
X	Other, specify
#5	MEASURING JUNCTION
G	Grounded (Standard)
U	Ungrounded (RTD'S are always ungrounded)
E	Exposed (Recommended for profiling)
I	Isolated
X	Other, specify
#6	MAXIMUM SERVICE TEMPERATURE
P	Below 500°F
Q	500°F - 900°F
#7	TAGGING AND CALIBRATION OPTIONS (USE ONLY IF APPLICABLE)
—	See page 1-2 #14 for ordering selections.

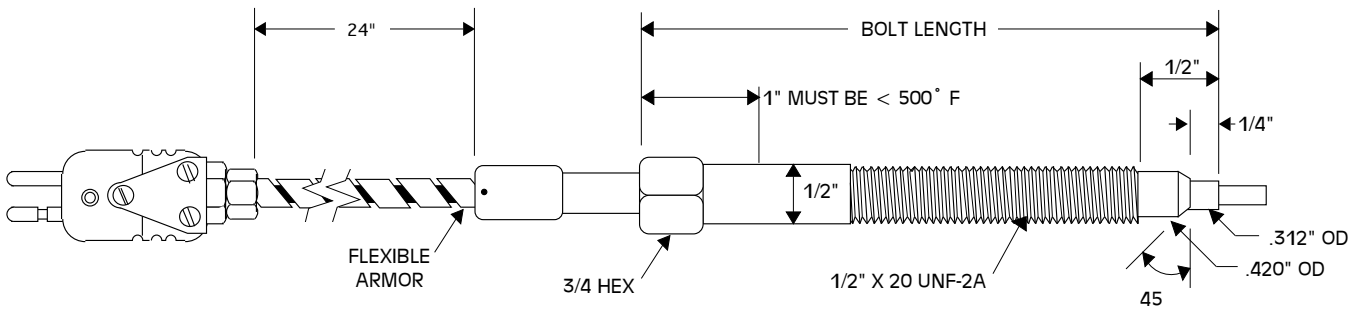


27	J	5	B	G	P	
----	---	---	---	---	---	--

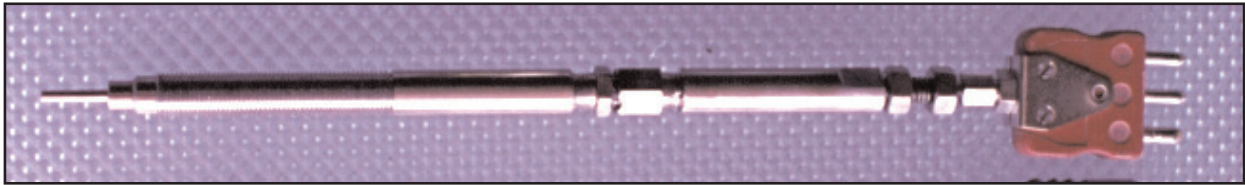
PLASTIC MELT SENSORS



BOLT WITH 1 1/2" BENDABLE METAL EXTENSION AND FLUSH IMMERSION



BOLT WITH 24" FLEXIBLE ARMOR AND 1/2" IMMERSION

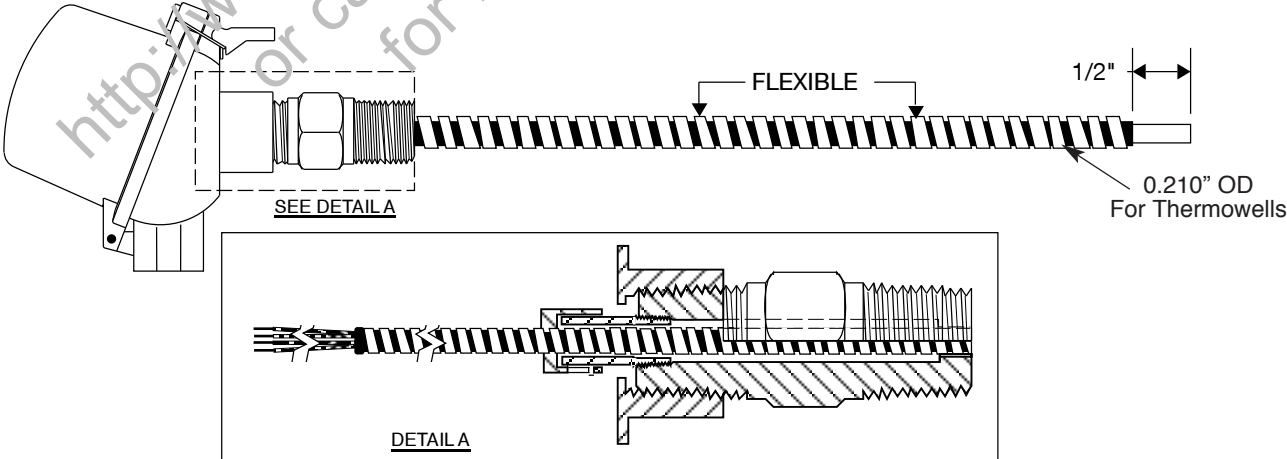


ADJUSTABLE PLASTIC MELT SENSOR

FLEX-ARMOR ADJUSTABLE DEPTH SENSOR

The flexible armor adjustable depth sensor allows adjustable immersion and spring loading in the field by simply moving the bayonet cap up and down the flexible armor. The construction is a hollow-tube design using 20 gauge or smaller fiberglass insulated wire inserted into the 1/8" or 3/16" tubing or flex armor. The flex armor is also rigid for the first 1" past the tip or hot end. Thermocouples have a flush immersion. The picture below shows a variation of this thermocouple. Good for dry temperatures between 55°F up to 900°F.

#1	SERIES
2K	Flexible armor adjustable depth sensor
#2	SENSOR TYPE
J	Iron/Constantan (Standard)
K	Chromel/Alumel
T	Copper/Constantan
E	Chromel/Constantan
3	100Ω Platinum RTD (.00385 alpha, ±.12 %Ω @ 0°C, 3 wire)
X	Other, specify
#3	DIAMETER OF FLEX
1	.125 ID .210" OD.
2	.188 ID (Standard) .270" OD.
#4	TUBE LENGTH
"	Length in inches
Z	Flush - no tube (Standard)
#5	JUNCTION
G	Grounded (Standard)
U	Ungrounded - (RTDs are always ungrounded)
#6	LEAD WIRE LENGTH
48"	Length in inches
60"	(Stainless Steel armor)
X	Other, specify
#7	COLD END TERMINATION
A	Bare ends (Standard)
C	Standard plug
E	Standard jack
I	Explosion proof head, 3/4" x 3/4" connection with fitting
R	High dome, general purpose head with hinged cover, 1/2" x 1/2" connection with fitting
K	Spade lugs (compensated)
I	Junction box connector
X	Other, specify
Note: If bayonet adapter is needed for mounting, see pg. 2-3.	
Use symbol #1 in item #3	
#8	TAGGING AND CALIBRATION OPTIONS (USE ONLY IF APPLICABLE)
----	See page 1-2 #14 for ordering selections.

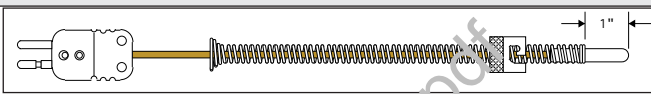


2K	J	2	Z	G	60"	T	
----	---	---	---	---	-----	---	--

SPRING ADJUSTABLE DEPTH SENSOR

The JMS Southeast spring adjustable sensor allows adjustable immersion in the field by moving the bayonet cap up and down the 12" spring. The construction is a hollow-tube design. Single element wire is 20 awg solid and dual element may be smaller to accommodate the tubing diameter. The wires are fiberglass insulated with stainless steel overbraid inserted into a .188" Ø tubing. (Available in .188" Ø only) The tube length immersion is 1". This design is good for dry temperatures between 55° F up to 900° F.

#1	SERIES				
2Q	Spring adjustable depth bayonet sensor				
#2	SENSOR TYPE				
J	Iron/Constantan (Standard)				
K	Chromel/Alumel				
T	Copper/Constantan				
E	Chromel/Constantan				
3	100Ω Platinum RTD (.00385 alpha, ±.12 %Ω @ 0°C, 3 wire)				
X	Other, specify				
#3	LEAD WIRE LENGTH				
48"	Length in inches				
60"	(Measured from front of spring to back of cable clamp.)				
X	Other, specify				
#4	JUNCTION				
G	Grounded (Standard)				
U	Ungrounded - (RTDs are always ungrounded)				
#5	COLD END TERMINATION [6-7]				
A	Bare ends (Standard)				
C	Standard plug				
E	Standard jack				
K	Spade lugs (compensated)				
T	Junction box connector				
X	Other, specify				
#6	TAGGING AND CALIBRATION OPTIONS (USE ONLY IF APPLICABLE)				
--	See page 1-2 #14 for ordering selections.				



Part Number: 1-600-873-1835
Current Part No. obsolete - available at JMS - Catalog - final.pdf
www.jms-se.com/pdf/JMS directly at 1-600-873-1835 and friendly assistance.

2Q	J	60"	G	C	
----	---	-----	---	---	--

MgO VS HOLLOW TUBE

Bayonet thermocouples can be constructed with magnesium oxide sheath material of .125" or .188" O.D. Hollow tube units are made with lead wires inserted in tubing of .125" or .188" outer diameter. The magnesium oxide insulation is a dry, uncontaminated compacted ceramic powder. The MgO gives the thermocouple high insulation resistance and dielectric strength. Also, it allows excellent insulation of the positive and negative wire conductors in relation to each other and to the outer sheath. Among the outstanding features of sheath material are: (A) flexibility to bend or form to twice the radius of the sheath diameter, (B) its rigidity to maintain size and shape after bending or straightening, (C) vibration or shock has no effect on the material, (D) sheath material withstands pressures upward to 50,000 psi, and (E) sheath material may be used in applications where temperatures may range from -400° to 3000°F depending on requirements and selection of materials.

INSULATOR	PURITY %	MELTING POINT °C	°F	USABLE TEMP. °C	°F
MAGNESIA (MGO)	96.4% (std)	2790	5050	1650	3000
	99.4% (must specify)				
	99.8% (must specify)				

New insulation materials are being developed. Use an X and describe to specify.

The hollow-tube design is used for disposable thermocouples that can be replaced easily. Their life is about half of that of a magnesium oxide insulated thermocouple. The advantage of a hollow-tube design is the cost. It is the least expensive design, for the short run.

MEASURING JUNCTION



GROUNDING JUNCTION

The **grounded** thermocouple junction is an integral part of the thermocouple sheath tip.

Advantages:

- fast response time in relation to ungrounded and isolated junctions.
- protects the wires from environmental chemicals and corrosives.
- prolongs the operational life of the thermocouple. Longer lifespan than the exposed junction thermocouple.
- it is recommended for high pressure applications.
- it is the least expensive construction.

Disadvantages:

- thermal expansion of sheath material may differ from element to cause mechanical stress and work hardening of metals.
- ground loops may cause interference with instruments.
- faults in insulation are more difficult to detect.



UNGROUNDING JUNCTION

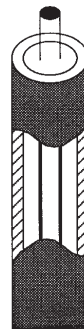
The **ungrounded** thermocouple junction is electrically insulated and electrically isolated from the outer sheath material. In a dual ungrounded thermocouple, one common junction is electrically insulated from the outside sheath.

Advantages:

- the thermocouple junction is isolated from the ground.
- defects in the MgO insulation can be detected by measuring resistance from loop to sheath.
- long term drift under cycling conditions is minimized.

Disadvantages:

- response time is usually slower than grounded thermocouples.
- more expensive than grounded thermocouples.



EXPOSED JUNCTION

The **exposed** thermocouple junction extends beyond the protective metallic sheath.

Advantages:

- recommended for measurement of noncorrosive static gas, or air.
- very fast response time, faster than grounded junction.

Disadvantages:

- cannot be used in an environment with a high percentage of solids, high pressure, or flowing material since the junction is exposed to this environment.

Isolated thermocouple junctions are used in a dual or triple thermocouple when the junctions are isolated from the outer sheath material as well as from each other.

Advantages:

- the two elements are insulated from ground.
- performs better than ungrounded or grounded junctions in a thermal cycling environment.

Disadvantages:

- slower response time than a grounded dual thermocouple.



ISOLATED JUNCTION

* For tip sensitivity information, see pg. 3-8.

Please Note:

JMS Southeast has helped develop several new & innovative designs for measuring temperature in numerous sorts of plastic melt situations, from automatic profiling of nozzle melts to surface temperatures. Ask us & we'll refer you to the real experts in plastics extrusion & molding!

Notes

1-800-873-1835

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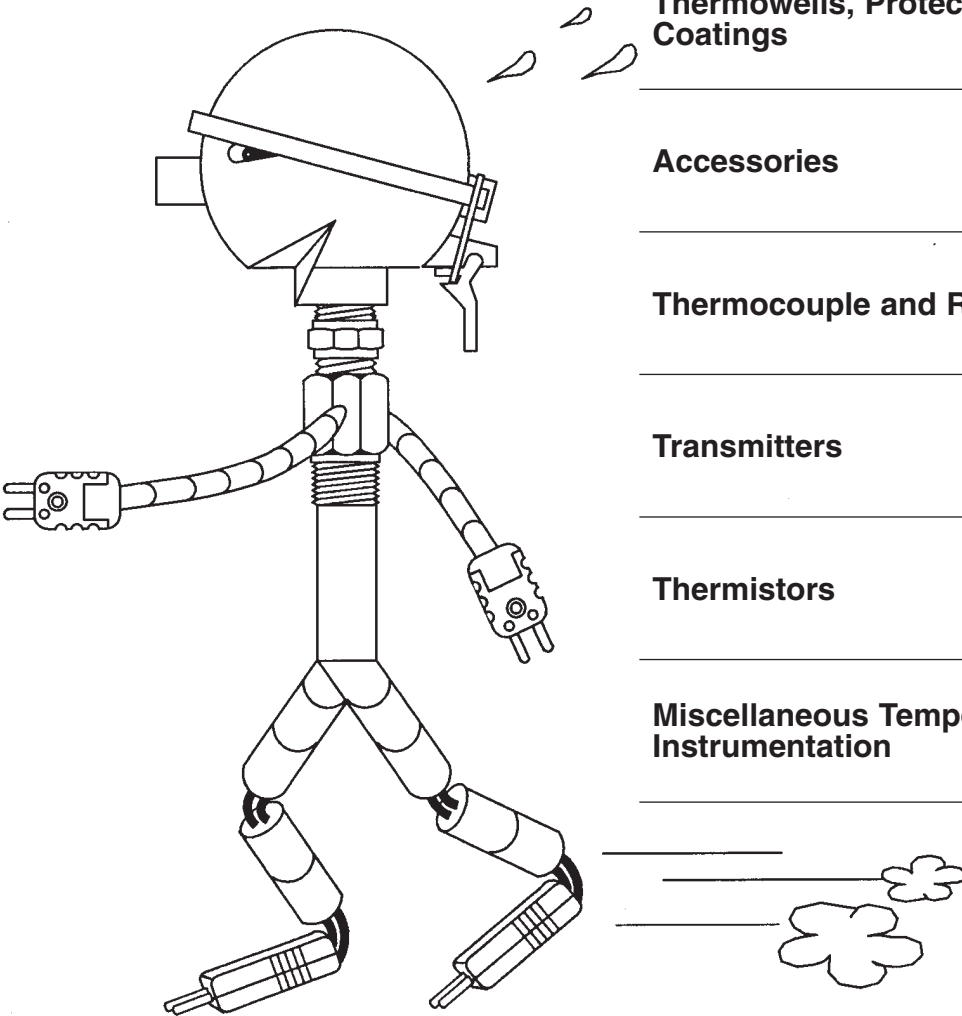
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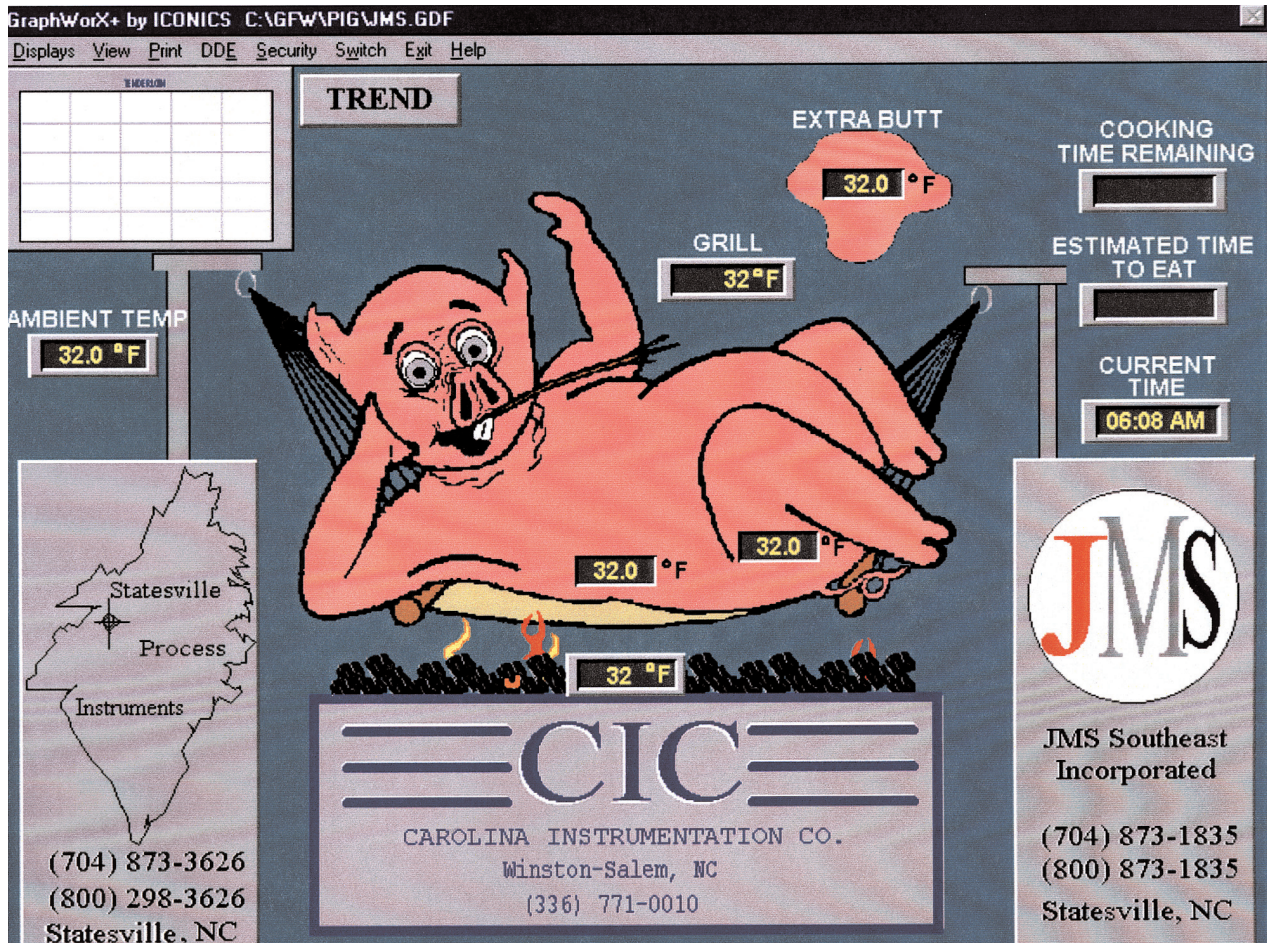
9

Miscellaneous Temperature Instrumentation

10

Swiftly Sensor





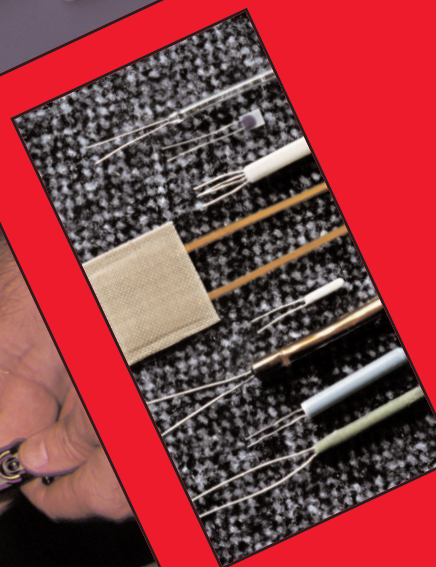
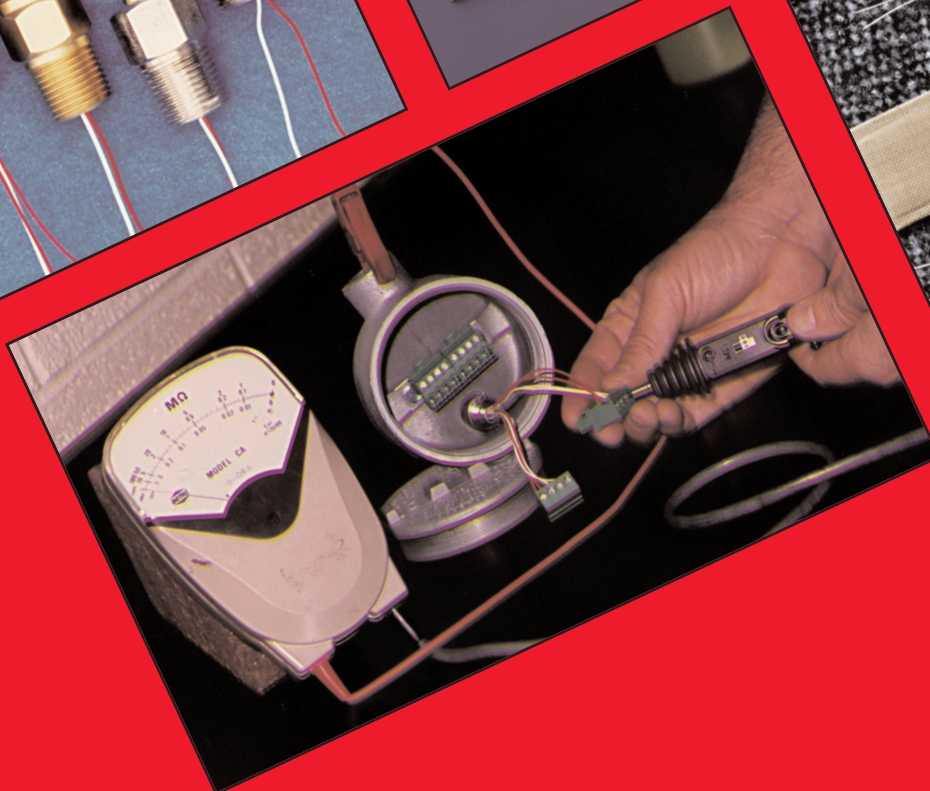
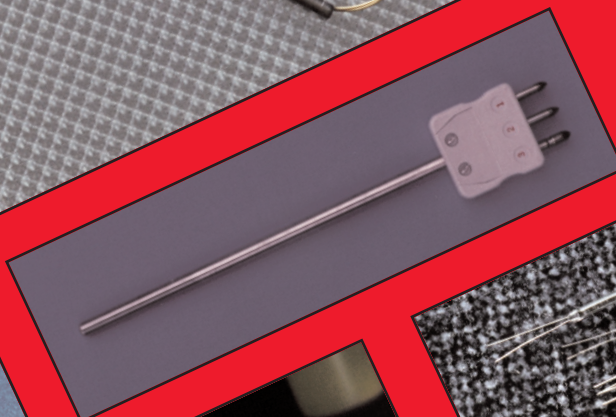
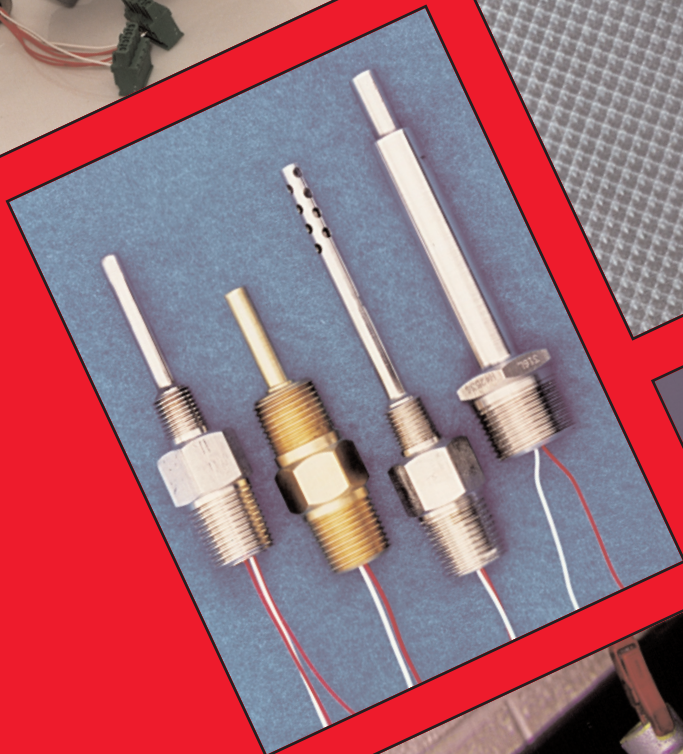


JMS Southeast, Inc.
Temperature Measurement



Resistance Temperature Devices





RESISTANCE TEMPERATURE DETECTORS

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Note: JMS Southeast, Inc. uses the new volt, ohm international standard approved by the National Institute of Standards and Technology (NIST) - formerly the National Bureau of Standards - to be effective 1/90.

RESISTANCE TEMPERATURE DEVICES (RTD'S)

#1	SERIES
3	RTD

#2	ELEMENT TYPE [4, 9, 10, 11, 15, 18, 22]	Platinum 0.00385 alpha ($\Omega/\Omega^{\circ}\text{C}$)
B	$\pm 0.25^{\circ}\text{C}$ (Competitor's Std)	B
E	$\pm 0.1^{\circ}\text{C}$ (JMS Standard)	A
P	$\pm 0.06^{\circ}\text{C}$ *	AA
S	$\pm 0.01^{\circ}\text{C}$ (Best Accuracy *)	1/4 AA
X	Other, specify [3-22]	

* For best results, use a 4 wire RTD for high accuracy (types P & S).

#3	ELEMENT CONSTRUCTION [4]	[3-11]
S	Single	Standard construction
D	Dual	Standard construction
J	Single	Swaged construction
K	Dual	Swaged construction
X	Other, specify	

Note: Use swaged for high temperature, bendability, high vibration and/or longer than 6 ft.

#4	TUBE DIAMETER - *MUST CHOOSE 1 FROM EACH COLUMN* [5-10, 1-13]
A	3/8" (.375")
B	1/4" (.250")
C	3/16" (.188")
D	1/8" (.125")
X	Other, specify
Z	N/A

#5	TUBE MATERIAL [11, 12]
K	316 Stainless Steel
I	316 L SS
M	I-600 (Use if symbol #7 > 500°F)
C	Teflon Coated SS
X	Other, specify

For fixed fittings and types S, C, B, D & N (symbol #8) this length normally equals the "A" dimension if a thermowell is used. (See Section 5)

#6	LENGTH (L) (See sketches on Pg. 3-1, 2, & 3 for "L")
"	Immersion length in inches

#7	MAX. TEMPERATURE AT WHICH TIP WILL BE EXPOSED [4, 8, 9, 11, 12]
A	0°C (32°F) =5 Kapton*
B	<200°C (392°F) =3 Teflon*
C	<285°C (550°F) =5 Kapton*
D	<350°C (662°F) =1 Fiberglass*
E	<661°C (1222°F) =4 HT Fiberglass*

*If no transition (Z) is in symbol 13, we recommend these corresponding selections for primary wire insulation in symbol 10.

#8	STANDARD INDUSTRIAL ATTACHING DEVICE [SECTION 6]
W	Fixed NPT ss fitting - double threaded
S	Spring-loaded NPT SS fitting - double threaded
C	Spring-loaded NPT SS fitting w/ oil ring - double threaded
D	Spring-loaded ss fitting - single threaded
B	Bayonet spring loaded assembly for thermowells & heads
*E	Adjustable spring over .250", .188", .125" sheath
F	Reverse mounted steel plug fixed for attaching head
G	Fixed stainless steel to sheath
*H	Compression fitting ss w/ ss ferrule
*I	Compression fitting ss w/ teflon ferrule
*J	Compression fitting ss w/ lava ferrule
*K	Compression fitting ss w/ nylon ferrule
*L	Compression fitting brass w/ brass ferrule
N4	4" Nipple-Union-Nipple (NUN4G1)
N6	6" Nipple-Union-Nipple (NUN6G1)
S4	4" Spring-Loaded-Union-Nipple (NU4G1)
S6	6" Spring-Loaded-Union-Nipple (NU6G1)
X	Other, specify or if more than 1 is needed
Z	N/A (No fitting needed)

For materials other than SS, (ex: brass, carbon steel, etc.) Use X + material + letter designation

(See page 1-3) FOR MORE NIPPLE OPTIONS.

*** Length is calculated without consideration of these attaching device. (See dwg on pg. 3-2)**

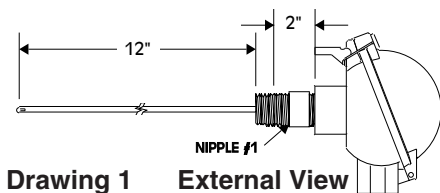
****[] BRACKETS INDICATE PAGE NUMBERS ON WEB OR FULL CATALOG FOR ADDITIONAL TECHNICAL INFORMATION**
WWW.JMS-SE.COM

3	E	S	B	K	12"	B	W
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SECTION 3

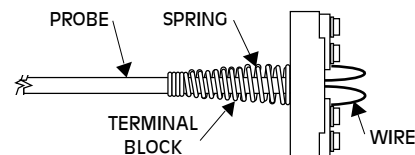
3-2

NIPPLE-UNION-NIPPLE EXTENSION ASSEMBLIES

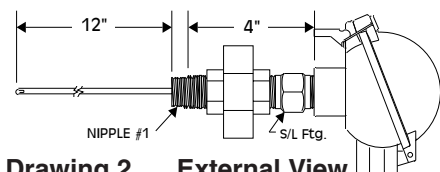


Drawing 1 External View

Drawing 1 - Nipple Only
Minimum Nipple L=1"
Ex. Part#: 3ESBK12"CEZZYZL
X = N2"G1

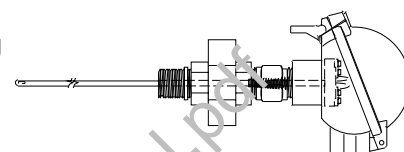


Direct Mounted Spring on Terminal Block

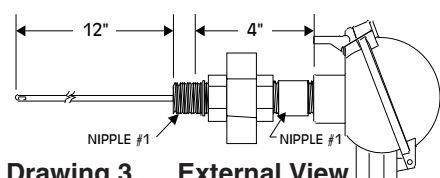


Drawing 2 External View

Drawing 2 - Nipple-Union with Machined 1/2" x 1/2" Spring Loaded Fitting
Minimum NU L=4" (includes S/L fitting)
Ex. Part#: 3ESBK12"CSXZZYZL
X = NU6"G1

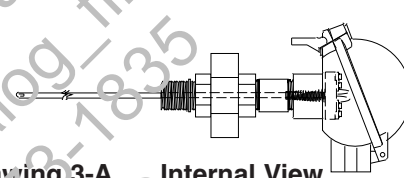


Drawing 2-A Internal View



Drawing 3 External View

Drawing 3 - Nipple-Union-Nipple with Spring Against Terminal Block
Minimum NUN L=4"
EX. Part#: 3ESBK12"CEZZYZL
X = NUN6"G1



Drawing 3-A Internal View

An extension assembly may be needed to provide extra length for your RTD in order to extend your RTD head through insulation, or away from the heat of the process. This extension can include a pipe nipple only or a nipple-union-nipple or a nipple-union with a spring-loaded fitting from symbol #8 page 3-1.

Standard nipples and unions are 1/2" NPT and are available in galvanized or stainless steel. The union joins two nipples in an extension assembly and has a standard pressure rating of 150 pounds.

When a nipple-union-nipple or nipple only assembly is used and spring loading of the thermocouple element is required, there are two different methods of spring loading the sensor. The preferred method is to use the machined 1/2" by 1/2" NPT spring-loaded stainless steel fitting as one of the nipples (see symbol #8, S page 3-1). With this design, the probe is secured within the fitting and is mounted to the head in a rigid manner (see drawing #2 above). The appropriate part number for this assembly would be selected from symbols #8 (S) and #9 (X) from page 3-1 and 3-2, in addition to the symbols on this page. A cheaper method is a spring mounted over the probe and loaded against the bottom of the terminal block in the head. With this method the probe is not supported within the nipple-union-nipple. It is secured only by the wires into the terminal block. (See drawings 1 & 3 above). We do not recommend that you use this method of spring loading if your probe is mounted horizontally.

When a nipple-union-nipple is specified, the nipple and union closest to the head or cold end termination (drawing 2 & 3 above) is kept at an approximate length of 3 1/2". The length of the NUN is varied by the nipple length beyond the union on the probe end of the assembly.

For example, if a NUN 6" G is required, nipple #2 length would equal approximately 2 1/2".

When specifying this sensor extension, the nipple-union-nipple length tolerance is $\pm 1/2"$.

#1	EXTENSION ASSEMBLY			
N	Nipple Only (Dwg #1)			
NU	Nipple-Union (Dwg #2)			
NUN	Nipple-Union-Nipple (Dwg #3)			
	#2	LENGTH		
	--"	Specify length in inches		
	#3	MATERIAL		
	G	Galvanized Steel		
	H	304 Stainless Steel		
	C	Black Steel		
		#4	PRESSURE RATING	
		1	#150	- A351 spec (Standard)
		2	#3000	- A182 spec
		3	#6000	- A182 spec
		X	Other, specify	
			} ASTM	
NUN	6"	G	1	

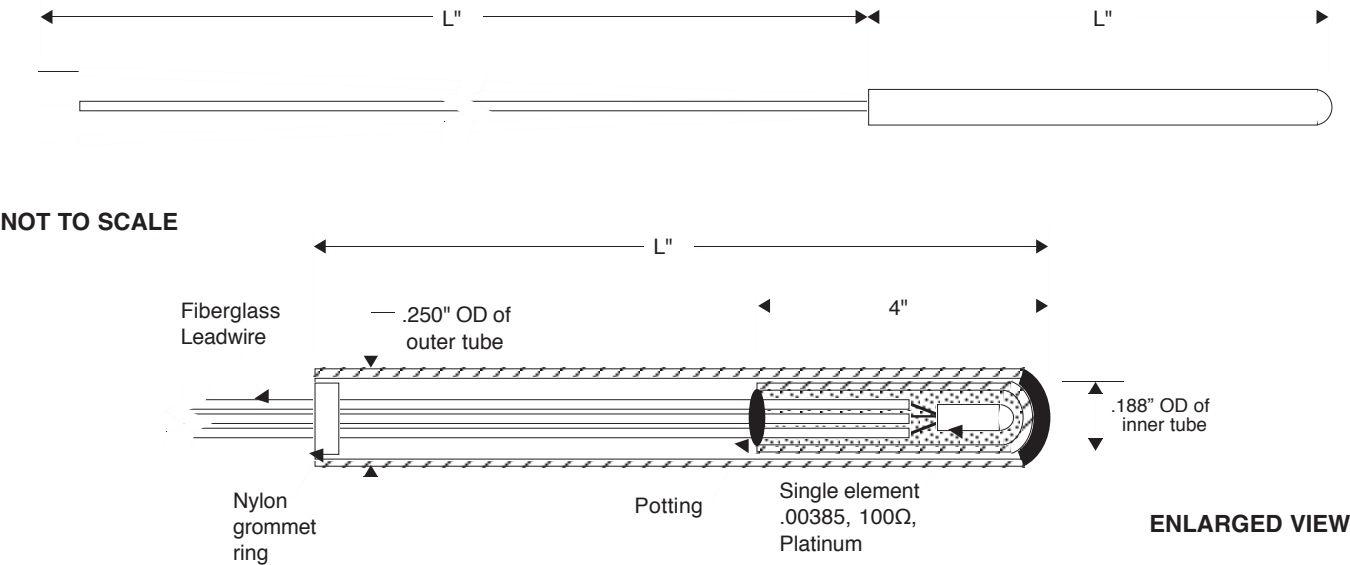
CUT TO LENGTH / UNIVERSAL RTD

JMS Southeast manufactures a cuttable resistance temperature detector that can be cut to 4” in length from a standard length of 24”. The design provides flexibility to the end user that enables him/her to order one RTD length for all applications. The standard universal RTD is the 100 ohm, .00385 ohm/ohm/C DIN, single element. The tubing is 316 stainless with an outside diameter of 1/4”. This unit is potted with high temperature cement and assembled with 48” of fiberglass lead-wire with no cold end termination. If a different fitting or longer leadwire is required, change these characters in the part number accordingly on pages 3-1 and 3-2. If the probe will be used at temperatures above 550°F change symbol “7” accordingly.

Feel free to call JMS for additional information. A typical JMS part number for this standard unit is as follows:

3ESQK24”DZZ1-48”ZYZA
[For Cuttable Thermocouples go to page 2-1 and 2-2]

Special note: Cuttable sensors may not provide the best accuracy over periods of time. They are not recommended for critical applications.



HIGH TEMPERATURE RTD'S

JMS now offers an industrial RTD, capable of withstanding temperatures and vibration previously requiring a thermocouple. Manufactured using a special high temperature cable, the probe can be bent to a radius of twice its diameter.

Inconel 600 is primarily used for high temperature applications; while 316 stainless steel is available for situations where high vibration is the main concern. Solid leads of 24 awg. for the .188" diameter probes and 22 awg. for the .250" diameter probes match the temperature and vibration resistant qualities of this special design.

Following is a table outlining the available initial calibration specifications for this probe design. Ordering of these elements may be made on page 3-1.

Tube Material	Tube Diameters	Element Construction	Resistor Class ≥1/2 W 0.1
316 SS, Inconel 600	.188"	Single 3-wire, Single 4-wire Dual 3-wire	
316 SS, Inconel 600	.250"	Single 3-wire, Dual 3-wire Single 4-wire	

AVERAGING RTD'S

Continuous averaging resistance temperature detectors are most frequently used in air washing and air handling systems where turbulent and stratified air flow may effect the temperature measurement in a tip sensitive probe. The average temperature of the air in the duct can be measured with this type of sensor.

Any application which requires an averaging of temperature across an area would be suited for this sensor type.

The operating temperature range for a continuous averaging RTD is from -100 to 400°F. The lower temperature and temperatures up to 500°F are handled with a multipoint design (4, 8, or 16 points).

Please contact JMS Southeast with any questions or application problems you may have.

#1	SERIES									
3A	Averaging RTD									
#2	Element Type 0.00385, IEC 751; 1983, 100Ω @ 0°C									
E	(-50° TO 275° F)		P16	Platinum 16 point, <900°F		Note: Call the JMS Engineering Department for information about averaging thermocouples, swamp boxes and special proprietary multipoint designs.				
P4	Platinum 4 point, <900°F		X	Other, specify						
P8	Platinum 8 point, <900°F									
#3	TUBE DIAMETER									
B	1/4" (.250")		C	3/16" (.188")						
#4	SENSING LENGTH									
	Inches									
#5	TUBE MATERIAL									
K	316 Stainless Steel		F	Copper						
#6	TOTAL PROBE LENGTH									
	Length in inches									
#7	STANDARD INDUSTRIAL FITTINGS									
W	Fixed NPT ss fitting - double threaded. Sheath diameters less than 3/16", fittings are brazed to sheath.									
B	Bayonet spring loaded assembly for thermowells & heads									
R	Reverse mounted steel plug fixed to sheath for attaching head									
G	Fixed stainless steel to sheath									
H	Compression fitting ss w/ ss ferrule									
I	Compression fitting ss w/ teflon ferrule									
J	Compression fitting ss w/ lava ferrule									
K	Compression fitting ss w/ nylon ferrule									
X	Other, specify									
Z	N/A (No fitting needed)									
Note: To specify extensions such as nipples, unions, couplings, use X and see pg 3-3 for complete part #.										
#8	PROCESS NPT									
L	1/8"		X	Other, specify						
M	1/4"		Z	N/A						
P	1/2"									
#9	LEAD WIRE TYPE & LENGTH IN INCHES [SEE SECTION 7]									
1"	Glass braid									
3"	Teflon									
6"	Glass braid / flex armor overall									
7"	Teflon / flexible armor overall									
8"	Glass braid / SS overbraid (3 wire only)									
9"	Three conductor teflon with overall jacket of teflon tape									
10"	Three conductor teflon / SS overbraid with overall jacket of teflon tape									
X	Other, specify									
Z	No leadwire									
#10	WIRE CONFIGURATION									
T	2 Wire		W	4 Wire						
Y	3 Wire		V	4 Wire (Compensating loop)						
#11	MAX TEMP. OF TRANSITION									
P	< 500° F		Note: Q potting may not comply with ASTM megohm check.							
Q	> 500° F									

Diagram labels: Diameter, Lead Length, Cold End Case (2"), Temperature Sensitive Length.

3A	E	B	12"	K	18"	I	M	3-36"	Y	P
----	---	---	-----	---	-----	---	---	-------	---	---

AVERAGING RTD'S

#12	COLD END TERMINATION [SEE SECTION 6] Pick as many as applicable			
A	Bare ends	R	High dome head (6R)	
**B	Miniature plug	V*	Hermetic connector (6DC) - Male	
**C	Standard plug	W*	Microphone style connector (6DA) - Male	
D	Miniature jack	X	Other, specify	
E	Standard jack			
F	High temperature plug (< 800° F)			* Use double symbol here for matching female connector. i.e. B/BB (male with matching female).
G	High temperature jack (< 800° F)			**We do not advise using these connectors for RTD's
I	Explosion proof Nema 7 head (6I / 6PT)			Note: For any other cold end termination, use appropriate part numbers from Section 6 in place of symbol #12.
K	Spade lugs (6SL)			
L	Aluminum head w/ hinged cover (6L / 6B4)			
M	Aluminum head w/ screw cover & chain (6M / 6B4)			
N	Cast iron head w/ screw cover (6N / 6B4)			
O	Open terminal block (6M)			
Q	Black nylon Nema 4 head (6Q / 6B4)			
#13	TAGGING AND CALIBRATION OPTIONS (USE ONLY IF APPLICABLE)			
1	TAGGING	5	CALIBRATION	Calibrate at specified point(s). Corrections data will be provided for each point.
2		6		Calibrate specified temperature range. Corrections data will be provided for all temperatures within the range.
3				Note: You must specify increments & range. Ex. 0 to 300°F, 0.1° increments
4		7		CE Marking [PAGE XV]

C	1
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LOW COST AVERAGING RTD'S

Sense temperature of air streams in ducts and plenums. Sensors include a junction box with gasket to prevent leakage and vibration noise.

These thermometers have a continuous element to sense true average temperature along their entire length. They provide accurate composite reading in locations where air may be stratified into hot and cold layers.

Rigid averaging sensors have a brass case. Bendable models have aluminum sheaths (copper on special order) formable to a radius of 4". Bendable sensors can criss-cross ducts to average temperatures in two dimensions.

Specifications:

Temperature range: -45.5 to 135° C (-50 to 275° F)

Gasket: 100° C (212° F)

Leadwire: 22awg, teflon insulated, 8" long

Sheath diameter: .188" OD.

#1	SERIES				
3L	Platinum, 100 @ 0° C, α=.00385				
#2	SENSOR TYPE				
56	Rigid Sensor				
57	Bendable Sensor				
#3	WIRE CONFIGURATION				
T	2 Wire				
Y	3 Wire				
#4	INSERTION LENGTH				
	Length in inches (Standard Lengths for Rigid type (inches): 12", 18", 24", 48", 60", 72") (Standard Lengths for Bendable type (feet): 6 Ft, 12 Ft, 24 Ft)				
#5	OPTIONS				
A	Weatherproof connection box (2.12" W X 4.0" H X 1.75" D)				
B	Sensor only, no box				
C	Stainless steel tag				
X	Other				
3L	56	T	60"	A	

RTD'S - RESISTANCE TEMPERATURE DETECTORS

RTD's work on the principle that there is a positive correlation between the electrical resistance of a metal conductor and changes in temperature. The standard temperature range is from -200°F to 900°F. High temperature assemblies are available which can operate at up to 1475°F.

The advantages of using RTD's include accuracy, repeatability, and stability. Another advantage is that cold junction compensation is unnecessary. Copper wire is used for all connections. The signal level of an RTD is over ten times higher than that of a thermocouple which eliminates the need for high gain amplifiers. The signal is also less susceptible to noise than thermocouples. The accuracy of a 4 wire RTD is independent of the distance between the sensor and the readout instrument.

COMPONENTS OF RTD's

The Platinum Resistance Element

This is the actual temperature sensing portion of the RTD. Elements range in length from 1/8" to 3" (See Pg 3-8). There are many options. The standard resistance is 100 ohms at 0°C and the standard temperature coefficient is an alpha of 0.00385. A complete list of options is listed on page 3-22.

Outside diameter / Inside diameter

The most standard outside diameter is 1/4". However, outside diameters range from .063" to .500". A selection of tube diameters can be found on page 1.

Tubing Material

316 Stainless steel is commonly used for all assemblies up to 500°F. Above 500°F it is advisable to use Inconel 600. A list of some materials available is on page 1.

Process Connection

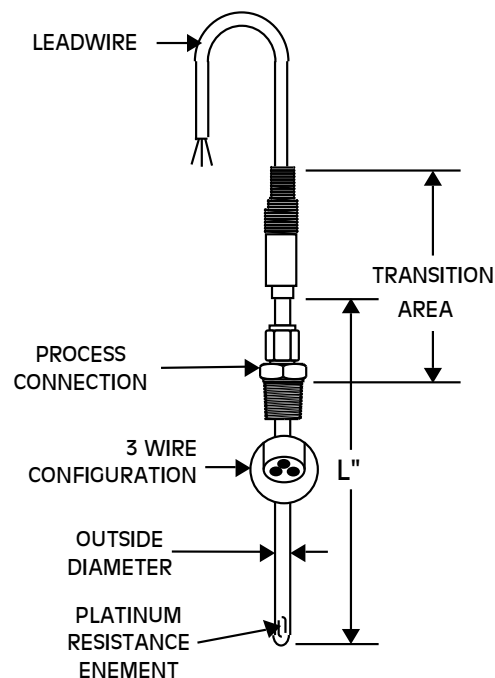
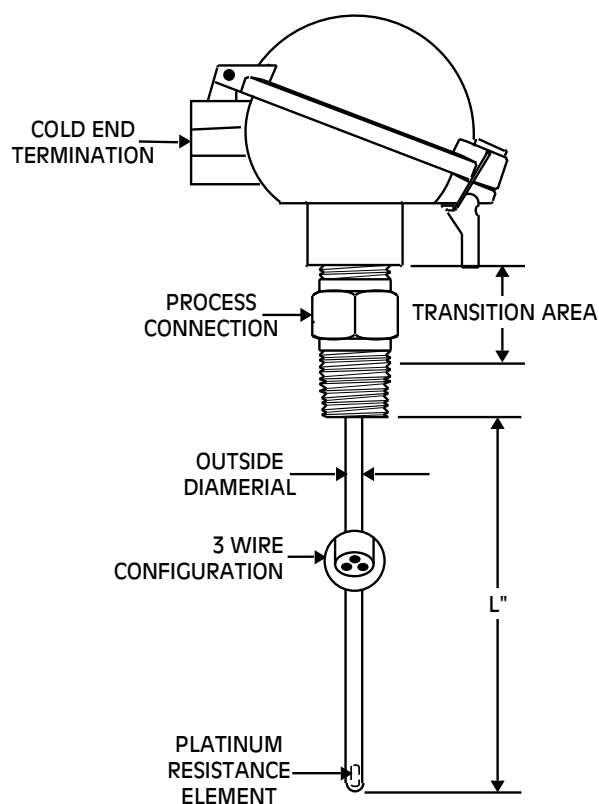
Process connection fittings include compression fittings and 1/2" N.P.T. x 1/2" N.P.T. welded or spring-loaded fittings. Various connection options are listed on page 1.

Wire Configuration and Insulation

RTD's are available in two, three, and four wire configurations. Three wire configuration is the most common. See page 3-17 for further information on selecting wire configuration for your application. Teflon and fiberglass are the standard wire insulation materials. Teflon is moisture resistant and has a maximum temperature rating of 400°F. Fiberglass is used for high temperature applications because it has a maximum temperature rating of 1000°F. AlO_2 powder is used to fill voids. Hard ceramic insulators may be used for high temperatures.

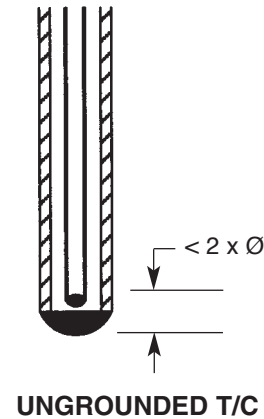
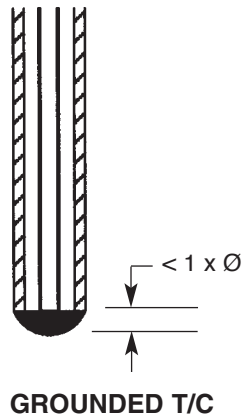
Cold End Termination

This may be in the form of bare wires, plugs, or terminal heads. The accessory section contains a wide variety of these options. Standard cold end terminations are listed on page 3-2.



TIP SENSITIVITY

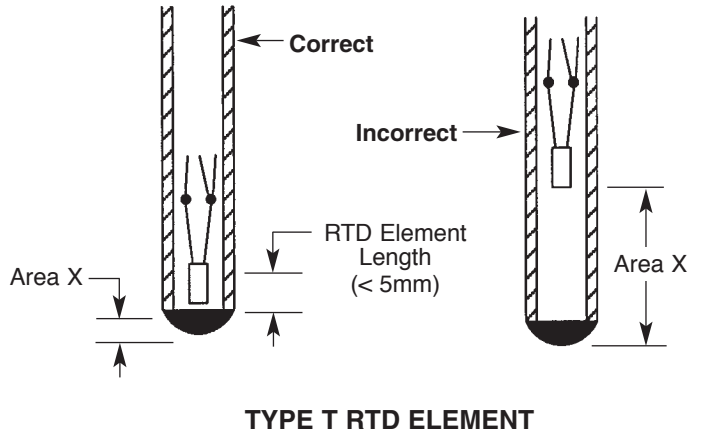
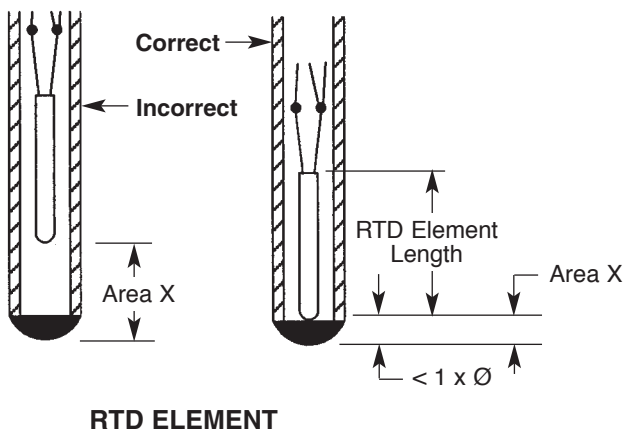
Tip sensitivity in the finished probe is usually not considered a serious factor in sensor specifications. However, JMS SE believes tip sensitivity is extremely critical if the customer is to receive the same results time after time. For instance, if the sensor was originally designed to minimize penetration into the process, a thin film sensor might have been used. If that sensor is later replaced with a standard 15mm long element, response time will change drastically, affecting the PID of a control situation and certainly the total temperature reading of the process would be upset.



AREA X (How far is the tip of the sensing element from the tip of the tube?)

In any sensor or probe the location of the element inside the tube is critical. Even if the sensor element was 2" away from the tip, that condition would go undetected using the ASTM tests. (18 x Ø for wire thermocouples) JMS tests for the element placement on our sensors in order to assure consistency of your measurements.

Area X = $< 1 \times \text{Ø}$.



RTD element length: E, P, S standard = 8mm - 15mm
 "T" thin film = 2mm - 5mm
 Others = 8mm - 50mm

Special designs can be used to obtain certain tip sensitivity. Ask your sales representative at JMS.

RTD STANDARDS

Maximum Operating Range = -200°C to 850°C (-392°F to 1562°F)

Note: RTD's are not commonly used above 900°F. However, JMS offers a special high temperature RTD which will withstand temperatures up to 1560°F.

Interchangeability = $\pm .01^{\circ}\text{C}$ to $.25^{\circ}\text{C}$ at 0°C

Stability = Less than $.05^{\circ}\text{C}$ shift per year.

Electric Supply = AC or DC ≤ 500 Hz.

Nominal Operating Current ≤ 1 milliamperes.

Maximum Safe Current = 20 Milliamperes.

Insulation Resistance = 100 mega ohms minimum at 50 VDC.

Probe Encapsulation = High purity alumina oxide.

Time constant for RTD element without tubing = 1 second maximum for the sensor to reach 63.2% of a step change in temperature in water at 3 feet per second.

RTD probes will usually not have a transition if the lead wires are less than 12" in length.

Accuracy

The standard accuracy of JMS Southeast's RTD is .1% of resistance at 0°C . Accuracies of .03% and .01% of resistance at 0°C are also available.

Stability

JMS Southeast bulbs are aged as part of the manufacturing process, thus ensuring high levels of stability. Generally the resistance at 0°C will hold less than a $.05^{\circ}\text{C}$ shift per year.

Vibration

JMS detectors can withstand a vibration level of 30g over the frequency range 10 Hz to 1 KHz.

Pressure

JMS RTD's are insensitive to large changes of pressure.

Response Time

Response time of JMS Southeast metal encapsulated probes is dependent on the outside diameter of the probe and the immersion media, usually matches that of the same size ungrounded thermocouple. (See page 1-13)

Self Heating

When tested in accordance with requirements of BS 1904: 1964 Section 3.16 the indicated temperature rise in the temperature detector with a power of 10.0mW dissipated in it, will not exceed $+.3^{\circ}\text{C}$.



RESISTANCE TEMPERATURE DETECTORS

General Information

A resistance temperature detector or platinum resistance thermometer works on the principle that the electrical resistance of a metal changes in a significant and repeatable way when temperature changes. This resistance is inversely proportional to cross sectional area and proportional to length.

Platinum is the most widely used metal for resistance temperature detection due to the following characteristics:

- 1) chemical inertness
- 2) a temperature coefficient of resistance that is large enough to give readily measurable resistance changes with temperature
- 3) an almost strain free fabrication metal (in that resistance doesn't drastically change with strain)
- 4) an almost linear relation between resistance and temperature

Each resistance versus temperature relation for an RTD is qualified by a term known as "alpha". "Alpha" is the slope of the resistance between 0°C and 100°C. This is also referred to as the temperature coefficient of resistance, with the most common being 0.00385Ω/Ω/°C.

Other types of RTD's manufactured include copper, nickel and nickel alloys.

The amount of resistance of an individual RTD bulb (100Ω, 200Ω, etc.) is determined by the amount of metal between the terminal points and by the configuration of the element.

When ordering an RTD, the alpha and resistance value at 0°C (i.e.: Ro) must be specified to match the measuring instrumentation used with the RTD.

The RTD standard must also be specified. There are several RTD standards set by various organizations. These specifications are not identical and read out instrumentation must be adjusted for the specific standard of the RTD used with that equipment. Differences in the alpha values of these standards can cause errors in measurement of an RTD if one standard is connected to the instrumentation of another standard.

The following chart indicates some common RTD standards.

ORGANIZATION	STANDARD	ALPHA	NOMINAL RESISTANCE(ohms) AT 0°C
American Scientific Apparatus Makers Association (SAMA)	RC21-4-1966	0.003923	98.129
British Standards Association	B.S. 1904-1964	0.003850	100
Fachnormenausschuß Elektrotechnik im Deutschen Normenausschuß	DIN 43760	0.003850	100
International Electrotechnical Commission (Supersedes BS & DIN)	IEC 751: 1983	0.003850	100
US Department of Defense	MIL-T-24388	0.00392	100

RESISTANCE TEMPERATURE DETECTORS

JMS TYPE "S" ("S" Stands for SUPER!)

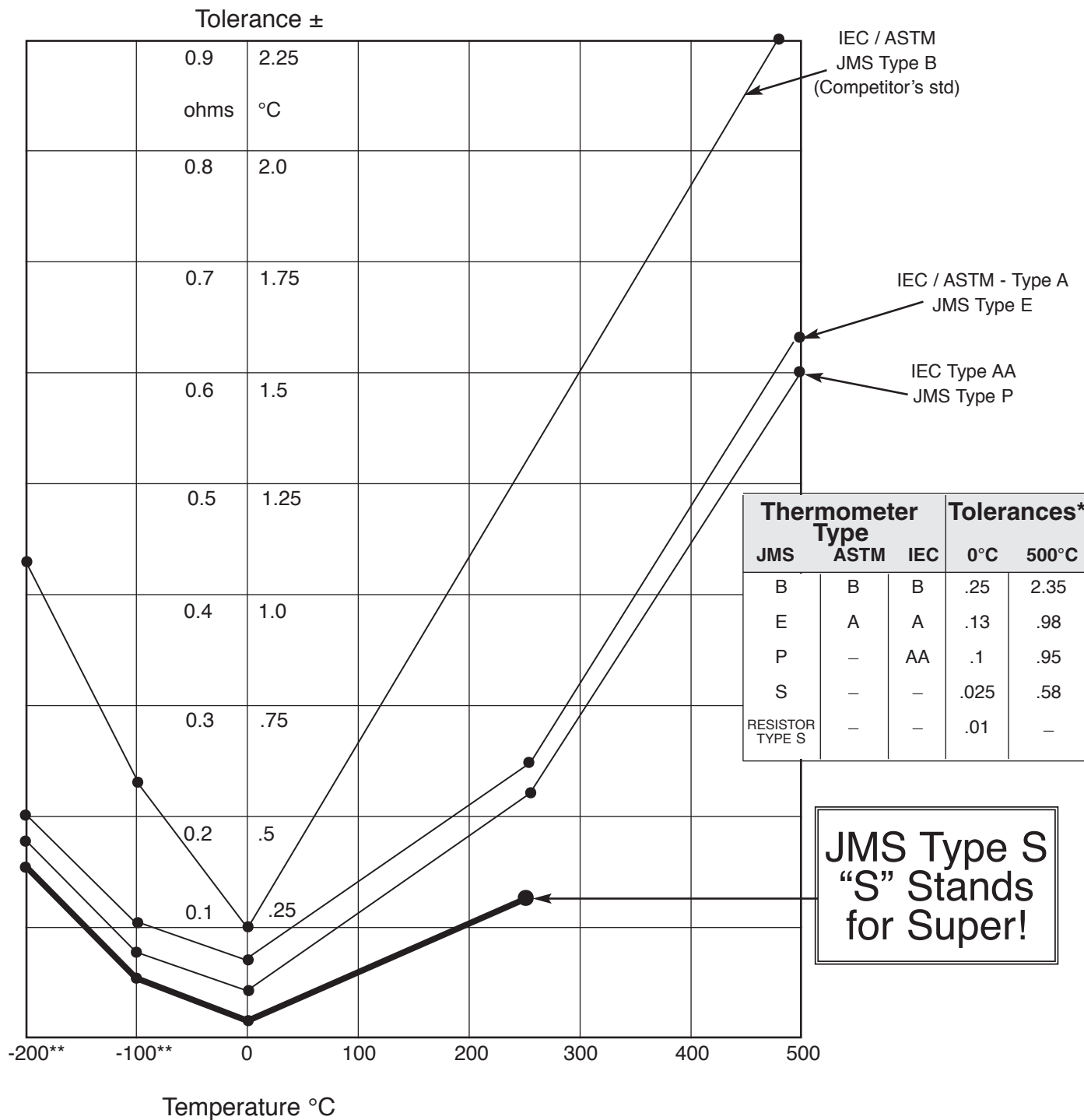
-Meets DIN 43760, I.E.C. 751 .00385 ohms/ohms/°C, to

1/10 design tolerance at initial resistor calibration

Not available in dual element swaged

-Tip sensitivity = 1 Ø + 1/2" (See page 3-8)

-Probe can be manufactured as a 3/32", 1/8", 1/4" or larger tube



* Initial Calibration Accuracy

** Negative tolerances extrapolated from ASTM E1137

TUBE MATERIAL

JMS Southeast, Inc., recommends stainless steel tubing as the encapsulation for RTD's in most industrial applications.

If a corrosive environment exists, 316 low carbon stainless steel is recommended due to its resistance to corrosiveness. A more detailed explanation of this phenomenon follows.

For high temperature RTD's above 500°F, we recommend I600 encapsulation due to the absence of iron in I600. Platinum RTD bulbs sometimes experience "poisoning" at high temperatures due to iron migration. The iron attacks the grain boundaries of the platinum and the alpha of the bulb is erroneously lowered, thus yielding lower temperature readings than actual.

Please contact JMS for questions concerning environmental condition questions or exotic material needs for probe encapsulation.

CORROSION IN 316 STAINLESS STEEL VERSUS 316 LOW CARBON STAINLESS STEEL

Barbara Feldhacker Hudson

JMS Southeast, Inc.
Statesville, NC

BACKGROUND:

When 316 stainless steel is welded it is exposed to temperatures in the range of 1000°F to 1600°F and carbon readily diffuses toward the grain boundaries in this temperature range. This excess carbon in these areas adjacent to the grain boundaries combines with the chromium in the steel to form chromium carbides. This action depletes the effective chromium content near and at the grain boundaries, leaving this area of the metal susceptible to corrosive attack. When welding occurs and this phenomenon occurs, the chromium from within these grains cannot replenish this shortage rapidly enough to overcome this susceptibility. This is called "sensitization."

Stainless steel loses its resistance to corrosion when the chromium content drops below 10.5-11%. Intergranular corrosion occurs when the chromium content along the grain boundaries drops below this amount. The less chromium present the more rapid the attack that could ensue.

Corrosion also occurs more readily in austenitic stainless steels that contain more than .03% carbon due to the fact that complex chromium carbides precipitate along grain boundaries when the chromium ties up with this carbon. After the metal is cooled from the 1000°F-1600°F temperature range, any areas that experienced that temperature and are depleted of chromium are very susceptible to corrosion. In the manufacture of resistance temperature detectors, approximately the last 3 inches of the probe and the weld area experience these temperatures. Therefore, they are prime candidates for corrosion.

CORROSION PREVENTION:

There are a number of ways to combat the susceptibility of corrosion in 316 stainless steel. We have investigated a number of options. Water quenching of the entire susceptible area would avoid this corrosive property due to the fact that this cooling would dissolve the chromium carbides and the chromium content would be again uniform throughout the metal. Water quenching cools the metals rapidly enough to prevent the combination of chromium with carbon. We, at JMS, felt this option was not as feasible due to the problem of quenching every probe in manufacturing. This could not be done to an RTD assembly due to the fact that it would cause thermal shock to the probe and a sudden strain to the RTD bulb. RTD's are susceptible to strain and thermal shock and this could be detrimental to the sensor.

A second method of avoiding the corrosion phenomenon in 316 stainless steel is to add carbide forming elements to the stainless steels. If the carbon in the metal is tied up with other elements, it can not tie up with chromium and the free chromium present could not form chromium carbides and migrate to the grain boundaries. Some elements added to stainless steels for this purpose are titanium, columbium and tantalum. These elements have greater affinity for carbon than chromium so they stabilize the steel against chromium depletion. An example of this is Monel. This is a

TUBE MATERIAL

more expensive option than what JMS Southeast decided upon.

A third method to avoid this possibility of corrosion of 316 stainless steel is to keep the steel in the “sensitizing” temperature range (1000°F-1600°F) for a long enough time for thermal stabilization to take place. The chromium carbides do form at the grain boundaries; however, after additional time, the chromium can diffuse into the area of impoverished grain boundaries.

The option was not feasible however, due to the fact that this thermal stabilization usually takes four hours. This is difficult to impossible to accomplish during welding. The method that JMS Southeast decided upon to combat corrosion in 316 stainless steel is to keep the carbon content so low in the metal that there is not adequate carbon present to form detrimental amounts of chromium carbide. If there is not enough carbon to tie up with the chromium then the chromium does not become depleted and corrosion is much less likely to occur. This type of protection is accomplished by using 316 low carbon stainless steel (316L) which has a maximum carbon content of .03%.

In an environment containing chlorides, the 316 stainless steel probe is at an even greater risk due to the fact that chlorides promote the formation of active/passive electrolytic cells. This can be explained by the fact that all stainless steels are passive under most conditions; however, if the probe is exposed to the “sensitization” temperature range and this molecular transformation occurs it forms anodic area (opposite the passive area). The oxygen around these two areas serves as a depolarizer and corrosion proceeds at an accelerated rate at the point the two areas meet.

Chlorides also have a higher valence state. Any chloride in an appreciable concentration is a source of trouble in promoting corrosion. Therefore, the use of 316 low carbon stainless steel becomes even more necessary in a chloride atmosphere if the metal is to endure a satisfactory lifetime. This occurs in an area that has been welded and is adjacent to the non-affected area.

Another problem of chlorides is that deposits may occur in crevices on the probe. In a crevice, oxygen supply is limited and cannot repair the passive oxide film. A crevice stays damp longer than a fully exposed surface. Salts are likely to accumulate in crevices particularly if the area around the crevice is alternately wet and dry. If the oxygen concentration decreases below a level necessary to maintain passivity in the anodic area, there is a double electrolytic effect. The difference in oxygen concentration alone will tend to promote attack on the anodic area and the potential between the passive and active area is already quite high, so corrosion becomes even more aggressive. Chlorides, being electrolytes will not contribute to passivity and will become very acidic thus accelerating the corrosive attack even more.

It is difficult to predict the corrosion rate of 316 stainless steel or 316 low carbon stainless steel due to the environmental variables; however, our experience has shown an increase of up to twice the life in a low carbon stainless steel probe versus a standard stainless steel probe. The problem with pitting corrosion and crevice corrosion in an RTD probe is that through these openings in the metal sheath, the RTD bulb can become contaminated and fail. If quantified specimen tests are needed, the ASTM lists some approved corrosion testing procedures.

In the ASTM A262-64 Standard two widely used intergranular corrosion susceptibility tests are described. They include the Huey test, which test subject samples to five 48 hours boils in 65% nitric acid solutions. A weight loss after each boil is noted and translated to a corrosion rate in inches per month. This test, however, indicates overall corrosion not grain boundary corrosion.

A second test is the oxalic acid etch test which involves etching a polished specimen then examining the appearance under a microscope. Comparisons are then made to some ASTM photographs.

Two other tests listed in A262 are the boiling sulfuric acid-ferric sulfate solution test and the nitric acid-hydrofluoric acid test at room temperature. These are not as widely used, however.

In conclusion, corrosion of 316 stainless steel in a chloride environment is a definite problem. To minimize this problem, low carbon stainless steel metal should be used in this environment as the encapsulation for RTD probes. If this is not done, the RTD longevity will be substantially reduced. JMS Southeast recommends the use of 316 low carbon stainless steel to all our customers who are using RTD's for temperature measurement in a process that contains chlorides.

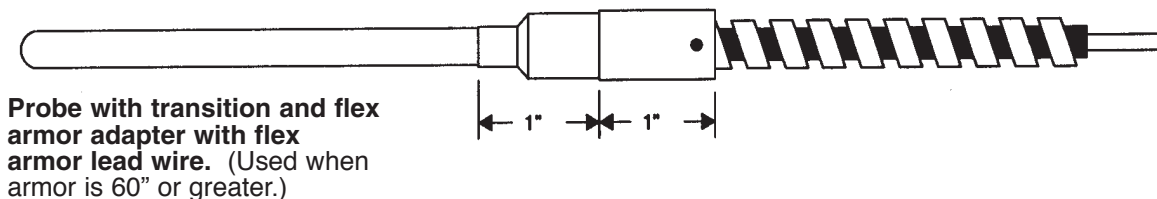
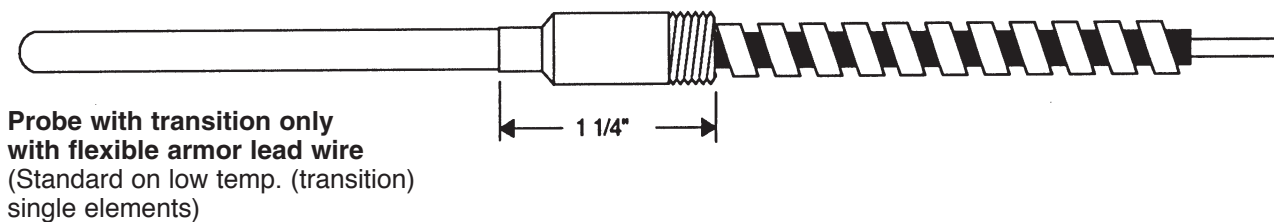
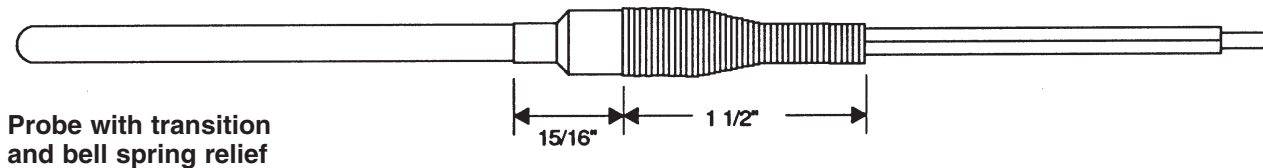
REFERENCES:

1. Zak, C.A., “Intergranular Corrosion of Austenitic Stainless Steels” Metallurgy of Tubing/Volume 8
2. American Society for Metals, “Metals Handbook” Volume 8, No. 1, 1961

RTD TRANSITIONS

The transition on an RTD assembly supports the lead wires attached to the RTD probe and contains the protective potting compound used to encapsulate the probe. The transition is stainless steel and has a .375" outside diameter for 3/4", and tapers down over the probe for an additional 1/4". This 1/4" outer diameter is approximately .055" larger than the probe outer diameter.

The bell spring adds approximately 1" to the rigid length of the probe.



JMS provides special hermetic sealing from moisture for those sensors used in high humidity / moisture or total immersion environments. Use a "2" after your selection in symbol #13 page 3-2. Any moisture penetrating the transition will kill the integrity of the electrical property of the sensor. Our special hermetic sealing will prevent this as well as possible in any environment. See page1-16 for more information.

TOLERANCES

Tolerances of RTD's are specified as a function of temperature.

They can be expressed in ohms, temperature, or percentages.

JMS now features RTD Thermometers using platinum resistors with a tolerance as low as 0.01% of resistance @ 0°C.

Better accuracies are possible by performing calibrations on a sensor at several different temperatures and listing exact resistance readings of that RTD at those temperatures. This is a more expensive method, but can be cost effective when accuracy is critical in a process. (See pages VIII, IX, X)

Readout instrumentation of RTD's converts resistance to temperature. Typical accuracies of this equipment are 0.1%. Lead wire and connection error for 2 and 3 wire RTD's can be significant.

After an RTD is manufactured there are some conditions that can alter the accuracy and reliability of an RTD. Moisture within the RTD can decrease the resistance value of the RTD and cause errors. Bad seals on the RTD are usually the cause. High temperatures can cause the insulation material's electrical resistance to decrease significantly. Also, at high temperatures, if any iron exists within the probe, iron migration can cause a poisoning of the platinum, thus measurement errors.

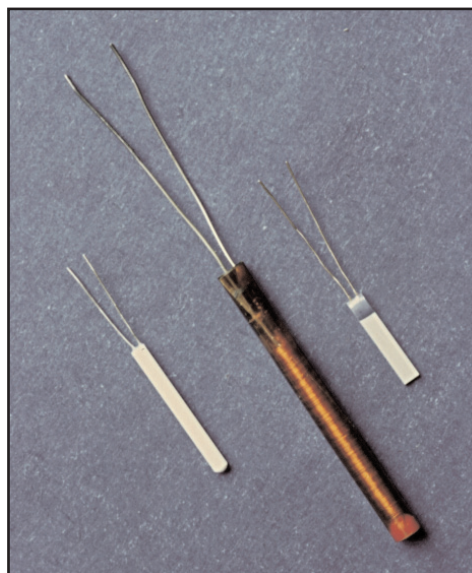
Physical or mechanical changes can cause shifts in the calibration of RTD's.

Rapid cooling can cause defects in the platinum structure and thus measurement errors. The defects can usually be eliminated by reannealing at 450°C.

Vibration in the process can also cause a drift in RTD's by causing a shift in the windings.

Stretching or strain on a metal can change it's resistance independent of temperature.

Due to the fact that RTD's are wound on a mandrel and supported in some way, the expansion coefficient of the supporting medium should match that of platinum, or else the actual contact of the winding with the medium used should be minimized. Thin film, thick film, totally supported, partially supported and bird cage constructions all have specific applications. JMS Southeast, Inc. manufactures high quality RTD's using thin film and semi-supported bulbs.



4, one hour sessions training video.
\$1200.00 - Call for information.

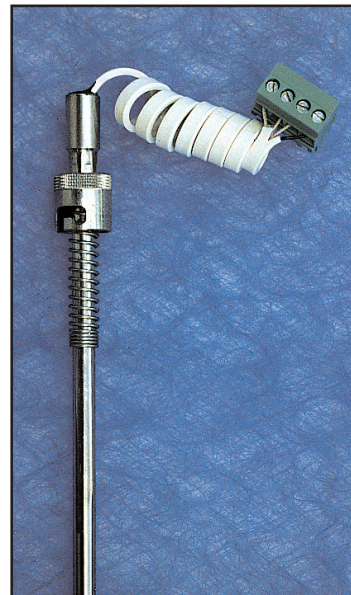
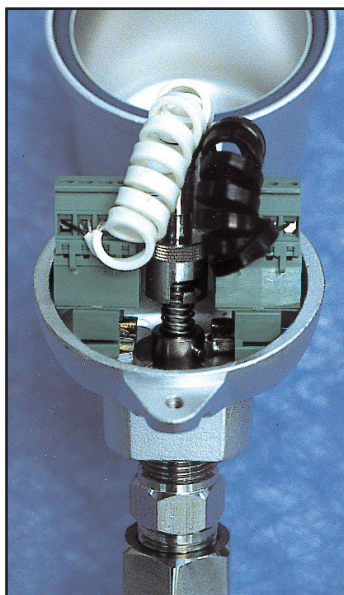
THERMOCOUPLES VS RTD'S

The following chart indicates some inherent advantages and disadvantages of RTD's or thermocouples.

	THERMOCOUPLE	RTD'S
Accuracy	Limits of error wider than RTD	Limits of error smaller than thermocouples
Ruggedness	Excellent	Sensitive to strain, shock, and pressure
Temperature	-400° to 4200°F	-200° to 1500° F
Size	Can be as small as .01" sheath material, tip sensitive	Size limited to 1/16", temperature sensitive for length of bulb
Drift	Should be checked periodically, higher than RTD's	0.01 to 0.1°C per year, less drift than thermocouple
Resolution	Must resolve millivolts per degree, lower signal to noise ratio	Ohms per degree, much higher signal to noise ratio than thermocouple
Cold Junction Reference	Required	Not required
Lead wire	Must match lead wire calibration to thermocouple calibration	Can use copper lead wire for extension wire
Response	Can be made small enough for millisecond response time	Thermal mass restricts time to seconds or more
Cost	Low	Higher than thermocouples

Why a 3 minute egg in Denver, Colorado is softer than a 3 minute egg in Denver, North Carolina.

BOILING POINT OF WATER					
ALTITUDE FT	B>P> °F	ATM. PRESS. PSIA	ALTITUDE FT	B>P> °F	ATM. PRESS. PSIA
0	212	14.7	8000	198	10.98
1000	210	14.21	9000	196	10.58
2000	209	13.72	10000	194	10.19
3000	207	13.23	11000	192	9.81
4000	205	12.75	12000	191	9.45
5000	203	12.29	13000	189	9.09
6000	201	11.83	14000	187	8.75
7000	199	11.39	15000	185	8.41



LEADWIRE CONFIGURATION EXPLANATION

A resistance temperature detector determines the temperature by measuring resistance. The sensing element is usually a small diameter wire manufactured so that its resistance will change in a known and consistent manner. To measure the resistance accurately and consistently, other extraneous resistances must be compensated for or minimized. A major cause of extraneous resistance is leadwire in series with the RTD. The readout is the sum of the bulb resistance and the leadwire resistances. The leadwire resistance can be compensated in most applications by a three wire RTD leadwire configuration.

In the three wire configuration, the power supply is taken to one side of the resistance temperature detector. This puts the other two leadwires in opposite arms of the wheatstone bridge so that they cancel each other out and have little effect on the bridge output voltage. In the 3 wire configuration, the resistance of the lead wire length is compensated for in the Wheatstone bridge. This design is recommended for most industrial applications.

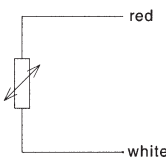
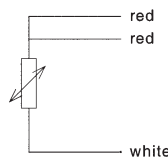
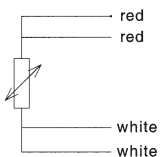
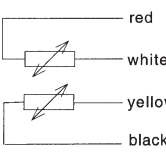
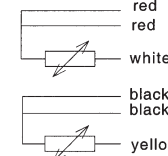
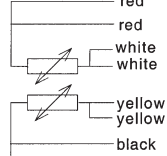
An even more accurate wire configuration is the 4 wire design. In this design, leadwires #1 and #2 are on one side of the power supply while leadwires #3 and #4 are on the other side of the power supply. All four leadwire resistances in this case are negated and the bulb resistance stands as the resistance input alone. We strongly recommend this design. You must have a good 4 wire input device. Call us for recommendations.

Note:

For numbering sequence of connectors and terminal blocks see Section 6.

*Note:

The different colors for the 2nd set are used when the wire are not otherwise distinguishable

SEE NOTE	2 - Wire Configuration	3 - Wire Configuration	4 - Wire Configuration
SINGLE			
* 2 DUAL			

RTD Operation and Installation Instructions:

RTD's are installed by means of compression fittings, welded or spring-loaded NPT fittings, or bayonet fittings.

Follow these instructions for installation of an RTD with a 1/2" x 1/2" NPT fitting:

- (1) Insert RTD into process hole or opening.
- (2) Tighten probe into place by turning probe into threaded connection.

If cold-end termination of the RTD is wired into head and you have a spring loaded fitting, then the wires should be disconnected from the terminal block to prevent twisting and shorting.

ELECTRICAL:

Make sure the extension wire is clean so that a good electrical connection will result at the terminal block. We recommend the use of a lacquer, cement, or other moisture proof sealing to prevent oxidation and the loosening of terminals. Connect the positive extension wire to the positive RTD wire and the negative extension wire to the negative RTD wire. Wires are color coded for identification as follows:

When using THERMOCOUPLE STYLE PLUGS (6A type, see pg 6-3)

Two Wire Configuration:

Connect the white wire to the positive connection terminal and connect the red wire to the negative connection terminal.

Three Wire Configuration:

The two red wires are common. Connect the white wire to the largest pin connection terminal and the two red wires to the two small pin connection terminals. The second red wire is the compensating lead wire.

RESISTANCE CHARACTERISTICS

Characteristics

The temperature/resistance relationships and tolerances on this page are valid for the sensing resistor at its measuring points. For thermometers they are valid for the complete thermometer at its terminals.

In the case of two-wire connections the resistance values of the leads between the measuring point of the resistor and the terminals must be considered. They may be indicated on the thermometer and must be subtracted from measured values in ohms. In some cases it also may be advisable to consider the temperature coefficient of the leadwires and the temperature distribution along their length.

Temperature/resistance relationships

The temperature/resistance relationships used in this standard are as follows:

for the range of -200°C to 0°C:

$$R_t = R_0[1 + At + Bt^2 + c(t - 100^\circ\text{C}) t^3]$$

for the range of 0°C to 850°C:

$$R_t = R_0(1 + At + Bt^2)$$

For the quality of platinum commonly used for industrial resistance thermometers, the values of the constants in these equations are:

$$A = 3.9083 \times 10^{-3} \text{ }^\circ\text{C}^{-1}$$

$$B = 5.775 \times 10^{-7} \text{ }^\circ\text{C}^{-2}$$

$$C = 4.183 \times 10^{-12} \text{ }^\circ\text{C}^{-4}$$

t = Modulus of temperature without sign

For resistance thermometers satisfying the above relationships, the temperature coefficient is defined as:

$$a = \frac{(R_{100} - R_0)}{100 \times R_0} \quad \text{has the value } 0.00385055^\circ\text{C}^{-1}$$

where

R_{100} is the resistance at 100°C;
 R_0 is the resistance at 0°C.

These equations and coefficients are listed as the basis for the temperature / resistance tables in this book. The calibration of individual thermometers will yield different coefficients.

Values of temperatures in this book are based on the International Temperature Scale of 1990 (ITS 90).

Resistance values

Most resistors are constructed to have a nominal resistance of 100Ω. The resistance vs. temperature table is calculated for a resistance of 100.00 Ω at 0°C. For other nominal resistances R_{nom} such as 500 Ω or 1000Ω the table can be used by multiplying the table values with the factor $R_{\text{nom}}/100$.

General Requirements (Tolerances)

Sensing resistors

The tolerance values of wirewound resistors are classified in table 1 and the values of film resistors are classified in table 2.

Table 1: Tolerance classes for wound resistors

Tolerance class	Tolerance value (°C)	Temperature range of validity of tolerances
W 0.1	$\pm(0.1^\circ\text{C} + 0.0017 [t])$	-50°C + 250°C
W 0.15	$\pm(0.15^\circ\text{C} + 0.002 [t])$	-100°C to 450°C
W 0.3	$\pm(0.3^\circ\text{C} + 0.005 [t])$	-196°C to 661°C
W 0.6	$\pm(0.6^\circ\text{C} + 0.01 [t])$	-196°C to 661°C

Table 2: Tolerance classes for film resistors

Tolerance class	Tolerance value (°C)	Temperature range of validity of tolerances
F 0.1	$\pm(0.1^\circ\text{C} + 0.0017 [t])$	-50°C + 250°C
F 0.15	$\pm(0.15^\circ\text{C} + 0.002 [t])$	-50°C to 450°C
F 0.3	$\pm(0.3^\circ\text{C} + 0.005 [t])$	-50°C to 661°C
F 0.6	$\pm(0.6^\circ\text{C} + 0.01 [t])$	-50°C to 661°C

Table 3: Tolerance classes for thermometers (finished probes)

Tolerance * class	Tolerance values (°C)	
AA	$\pm(0.1^\circ\text{C} + 0.0017 [t])$	-50 to 250°C
A	$\pm(0.13^\circ\text{C} + 0.0017 [t])$	-100 to 450°C
B	$\pm(0.25^\circ\text{C} + 0.0042 [t])$	-196 to 600°C
C	$\pm(0.6^\circ\text{C} + 0.01 [t])$	-196 to 600°C

* These tolerances meet or exceed ASTM / IEC thermometer class. They do not necessarily determine the working range of the thermometer.

RESISTANCE vs. RTD TEMPERATURE SPECIFICATIONS

Temperature (°C) vs. Resistance (Ω)

°C	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	/C°
-200	18.52										
-100	60.26	56.19	52.11	48.00	43.88	39.72	35.54	31.34	27.10	22.83	.415
0	100.00	99.09	92.16	88.22	84.27	80.31	76.33	72.33	68.33	64.30	.357
°C	0	10	20	30	40	50	60	70	80	90	/C°
0	100.00	103.90	107.79	111.67	115.54	119.40	123.24	127.08	130.90	134.71	.385
100	138.51	142.29	146.07	149.83	153.58	157.33	161.05	164.77	168.48	172.17	.374
200	175.86	179.53	183.19	186.84	190.47	194.10	197.71	201.31	204.90	208.48	.361
300	212.05	215.61	219.15	222.68	226.21	229.72	233.21	236.70	240.18	243.64	.350
400	247.09	250.53	253.96	257.38	260.78	264.18	267.56	270.93	274.29	277.64	.339
500	280.98	284.30	287.62	290.92	294.21	297.49	300.75	304.01	307.25	310.49	.327
600	313.71	316.92	320.12	323.30	326.48	329.64	332.79	335.93	339.06	342.18	.316
700	345.28	348.38	351.46	354.53	357.59	360.64	363.67	366.70	369.71	372.71	.304
800	375.70	378.68	381.65	384.60	387.55	390.48					

JMS Type B (Industry standard)

Temperature (°C)	-250	-220	-200	-100	0	100	200	300	400	500	600	700	800	850
Tolerance (±°C)	1.6	1.4	1.3	0.8	0.3	0.8	1.3	1.8	2.3	2.8	3.3	3.8	4.3	4.6
(± Ω)	1.0	0.7	0.6	0.3	0.1	0.3	0.5	0.6	0.8	0.9	1.1	1.3	1.4	1.5

Temperature (°F) vs. Resistance (Ω)

°F	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	/F°
-200	48.49										
-100	71.01	68.78	66.55	64.31	62.07	59.82	57.57	55.31	53.04	50.77	.225
0	93.03	90.85	88.66	86.47	84.27	82.07	79.87	77.66	75.45	73.23	.220
°F	0	10	20	30	40	50	60	70	80	90	/F°
0	93.03	95.21	97.39	99.56	101.73	103.90	106.06	108.22	110.37	112.53	.216
100	114.67	116.82	118.96	121.10	123.23	125.36	127.49	129.61	131.73	133.85	.213
200	135.96	138.07	140.18	142.28	144.38	146.48	148.57	150.66	152.74	154.82	.209
300	156.90	158.97	161.04	163.11	165.17	167.23	169.29	171.34	173.39	175.44	.206
400	177.48	179.52	181.56	183.59	185.61	187.64	189.66	191.68	193.69	195.70	.202
500	197.71	199.71	201.71	203.71	205.70	207.69	209.68	211.66	213.64	215.61	.199
600	217.58	219.55	221.51	223.47	225.43	227.39	229.34	231.68	233.23	235.17	.195
700	237.10	239.03	240.96	242.89	244.81	246.73	248.64	250.55	252.46	254.37	.192
800	256.27	258.16	260.06	261.95	263.83	265.72	267.60	269.47	271.34	273.21	.188
900	275.08	276.94	278.80	280.65	282.50	284.35	286.19	288.03	289.87	291.70	.185
1000	293.53	295.36	297.18	299.00	300.82	302.63	304.44	306.24	308.04	309.84	.181
1100	311.64	313.43	315.22	317.00	318.78	320.56	322.33	324.10	325.86	327.63	.177
1200	329.30	331.03	332.79	334.76	336.74	338.71	340.69	342.66	344.64	346.62	.169
1300	347.50	348.38	350.07	351.77	353.46	355.16	356.85	358.55	360.25	361.94	.162
1400	363.67	365.17	366.67	368.17	369.67	371.17	372.67	374.18	375.68	377.12	.150
1500	378.68	380.58	382.48	384.38	386.30	388.21	390.12				

JMS Type B (Industry standard)

Temperature (°F)	-200	-100	0	32	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1560
Tolerance (±°F)	1.8	1.1	0.7	0.6	0.7	0.9	1.5	2.0	2.7	3.3	3.9	4.5	5.4	6.0	6.5	7.0	7.6	8.4	9.0	9.4
(± Ω)		0.3	0.2	0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.8	.09	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.5

Nominal Resistance

The platinum element of the standard industrial type RTD has a base reference resistance of 100 Ω at 0°C.

Platinum 100 Ω, temperature coefficient = 0.00385/Ω/°C.

This meets the ASTM standard 1137 and also meets the IEC 751. All readings based on ITS 90 - International Temperature Scale 1990.

TEMPERATURE vs RESISTANCE TABLE

Din 43760, 100Ω Platinum RTD
Alpha=.00385

Temp. (degrees C)	0	(-10)	(-20)	(-30)	(-40)	(-50)	(-60)	(-70)	(-80)	(-90)
-200	18.53	14.36	10.41							
-100	60.20	56.13	52.04	47.93	43.80	39.65	35.48	31.28	27.05	22.78
0	100.00	96.07	92.13	88.17	84.21	80.25	76.28	72.29	68.28	64.25
	0	(10)	(20)	(30)	(40)	(50)	(60)	(70)	(80)	(90)
0	100.00	103.90	107.79	111.67	115.54	119.40	123.24	127.07	130.89	134.70
100	138.50	142.28	146.06	149.82	153.57	157.32	161.04	164.76	168.47	172.16
200	175.84	179.51	183.17	186.82	190.46	194.08	197.70	201.30	204.88	208.46
300	212.03	215.58	219.13	222.66	226.18	229.69	233.19	236.67	240.15	243.61
400	247.06	250.50	253.93	257.34	260.75	264.14	267.52	270.89	274.25	277.60
500	280.93	284.26	287.57	290.87	294.16	297.43	300.70	303.95	307.20	310.43
600	313.65	316.86	320.05	323.24	326.41	329.57	332.72	335.86	338.99	342.10

NOTE: Due to the interchangeability tolerance of the RTD's, the JMS type E matches both DIN 43760 / IEC 751, and British Standard BS 1904 curves.

BS 1904, 100Ω Platinum RTD
Alpha=.00385

Temp. (degrees C)	0	(-10)	(-20)	(-30)	(-40)	(-50)	(-60)	(-70)	(-80)	(-90)
-200	18.56	14.40	10.45							
-100	60.28	56.21	52.12	48.01	43.88	39.72	35.54	31.34	27.11	22.83
0	100.00	96.09	92.16	88.23	84.29	80.32	76.34	72.35	68.34	64.32
	0	(10)	(20)	(30)	(40)	(50)	(60)	(70)	(80)	(90)
0	100.00	103.90	107.79	111.67	115.54	119.40	123.24	127.07	130.89	134.70
100	138.50	142.29	146.06	149.82	153.57	157.31	161.04	164.76	168.46	172.16
200	175.83	179.50	183.16	186.82	190.45	194.07	197.69	201.29	204.88	208.46
300	212.02	215.58	219.12	222.66	226.18	229.69	233.19	236.68	240.16	243.61
400	247.08	250.52	253.95	257.37	260.77	264.17	267.56	270.94	274.29	277.64
500	280.98	284.31	287.67	290.93	294.22	297.50	300.76	304.02	307.27	310.51
600	313.72	316.93	320.12	323.31	326.50	329.60	332.80	335.90	339.10	342.20

NOTE: Due to the interchangeability tolerance of the RTD's, the JMS type E matches both DIN 43760 / IEC 751, and British Standard BS 1904 curves.

SAMA RC21-4 1966, 98.1Ω Platinum RTD
Alpha=.003923
JMS TYPE F [3-22]

Temp. (degrees C)	0	(-10)	(-20)	(-30)	(-40)	(-50)	(-60)	(-70)	(-80)	(-90)
-200	16.67									
-100	58.40	54.34	50.26	46.15	42.02	37.87	33.69	29.48	25.24	20.97
0	98.13	94.22	90.29	86.36	84.41	78.44	74.47	70.47	66.47	62.44
	0	(10)	(20)	(30)	(40)	(50)	(60)	(70)	(80)	(90)
0	98.13	102.03	105.92	109.80	113.67	117.52	121.37	125.20	129.02	132.83
100	136.63	140.41	144.19	147.95	151.70	155.44	159.17	162.89	166.06	170.29
200	173.97	177.64	181.30	184.95	188.58	192.22	195.83	199.43	203.02	206.60
300	210.17	213.73	217.27	220.80	224.33	227.84	231.34	234.83	238.30	241.77
400	245.22	248.66	252.09	255.51	258.92	262.32	265.70	269.07	272.43	275.78
500	279.12	282.45	285.76	289.07	292.36	295.64	298.91	302.17	305.42	308.65
600	311.88									

TEMPERATURE vs RESISTANCE TABLE

JISC 1604-1981, 100Ω Platinum RTD
Alpha=.003916
JMS TYPE G

Temp. (degrees C)	0	(-10)	(-20)	(-30)	(-40)	(-50)	(-60)	(-70)	(-80)	(-90)
-200	17.05									
-100	59.57	55.43	51.28	47.10	42.90	38.67	34.41	03.12	25.80	21.44
0	100.00	92.03	92.03	88.02	84.00	79.97	75.92	71.86	67.78	63.68
	0	(10)	(20)	(30)	(40)	(50)	(60)	(70)	(80)	(90)
0	100.00	103.97	107.93	111.87	115.81	119.73	123.64	127.54	131.42	135.30
100	139.16	143.01	146.85	150.68	154.49	158.30	162.09	165.87	169.64	173.40
200	177.14	180.87	184.60	188.30	192.00	195.69	199.36	203.03	206.68	210.31
300	213.94	217.56	221.16	224.75	228.33	231.90	235.46	239.00	242.53	246.05
400	249.56	253.06	256.55	260.02	263.48	266.93	270.37	273.80	277.21	280.61
500	284.00	287.38	290.75	294.11	297.45	300.78	304.10	307.41	310.71	313.99
600	317.27	320.53	323.78							

Laboratory Grade, 100Ω Platinum RTD
Alpha=.003925
JMS TYPE L

Temp. (degrees C)	0	(-10)	(-20)	(-30)	(-40)	(-50)	(-60)	(-70)	(-80)	(-90)
0	100.00	96.02	92.02	88.01	83.99	79.96	75.91			
	0	(10)	(20)	(30)	(40)	(50)	(60)	(70)	(80)	(90)
0	100.00	103.97	107.93	111.88	115.82	119.75	123.66	127.56	131.45	135.33
100	139.20	143.06	146.90	150.73	154.55	158.36	162.16	165.94	169.72	173.48
200	177.23	180.97	184.69	188.41	192.11	195.80	199.48	203.15	206.80	210.45
300	214.08	217.70	221.31	224.91	228.50	232.07	235.63	239.19	242.72	246.25
400	249.76	253.27	256.76	260.24	263.71	267.16	270.61	274.04	277.46	280.88
500	284.27	287.66	291.03	294.40	297.75	301.09	304.42	307.73	3011.04	314.33
600	317.61	320.88	324.14	327.38	330.62	333.84	337.05	340.25	343.44	346.61

NOTE: Based on NIST Supplementary ITS-90. These values were available at time of publication but subject to approval by ASTM as laboratory grade.

Uncommon American 100Ω Platinum RTD
Alpha=.003902
JMS TYPE H

Temp. (degrees C)	0	(-10)	(-20)	(-30)	(-40)	(-50)	(-60)	(-70)	(-80)	(-90)
-100	59.69									
0	100.00	96.03	92.06	88.06	84.06	80.04	76.01	71.96	67.89	63.80
	0	(10)	(20)	(30)	(40)	(50)	(60)	(70)	(80)	(90)
0	100.00	103.96	107.90	111.83	115.75	119.66	123.55	127.44	131.31	135.17
100	139.02	142.86	146.68	150.50	154.30	158.09	161.87	165.64	169.39	173.14
200	176.87	180.59	184.30	188.00	191.68	195.35	199.02	202.67	206.31	209.93
300	213.55	217.15	220.74	224.32	227.89	231.45	234.99	238.52	242.05	245.56
400	249.05	252.54	256.01	259.48	262.93	266.37	269.79	273.21	276.62	280.01
500	283.39	286.76	290.11	293.46	296.79	300.12	303.43	306.73	310.01	313.29
600	316.55	319.80	323.04	326.27	329.49	332.70				

NON STANDARD RESISTORS

NON STANDARD, BUT COMMONLY USED RTD'S

*Letter Designation	Standard	Alpha	Resistor Tolerance at 0°C	Reference page
F	SAMA	.003923	0.1	3-22
G	JISC	.003916	0.1	3-21
L	NIST	.003925	0.007	3-21
H	NONE	.003902	0.15	3-21

* May be used for symbol #2 (page 3-1)

ADDITIONAL RTD ELEMENT TYPES

The following are available in addition to the RTD element types listed on page 3-1. Elements may be specified with an "X" in the part number.

ALPHA	RESISTANCE VALUE	TOLERANCE
Platinum - 0.003750	1000 ohms @ 0 deg. C	±0.2%
Platinum - 0.003850	10 ohms @ 0 deg.C	±0.2%
Platinum - 0.003850	10 ohms @ 20 deg. C	±0.2%
Platinum - 0.003850	10 ohms @ 25 deg. C	±0.2%
Platinum - 0.003850	20 ohms @ 0 deg. C	±0.2%
Platinum - 0.003850	50 ohms @ 0 deg. C	±0.2%
Platinum - 0.003850	200 ohms @ 0 deg. C	±0.1%
Platinum - 0.003850	500 ohms @ 0 deg. C	±0.1%
Platinum - 0.003850	1000 ohms @ 0 deg. C	±0.1%
Platinum - 0.003900	100 ohms @ 0 deg. C	±0.2%
Platinum - 0.003900	130 ohms @ 0 deg. C	±0.1%
Platinum - 0.003910	8 ohms @ 0 deg. C	±0.5%
Platinum - 0.003910	10 ohms @ 0 deg. C	±0.5%
Platinum - 0.003910	32 ohms @ 0 deg. C	±0.5%
Platinum - 0.003910	98.129 ohms @ 0 deg. C	±0.1%
Platinum - 0.003910	100 ohms @ 0 deg. C	±0.5%
Platinum - 0.003910	500 ohms @ deg. C	±0.5%
Platinum - 0.003920	100 ohms @ 0 deg. C	±0.1 deg. C
Platinum - 0.003920	200 ohms @ 0 deg. C	±0.1 deg. C
Platinum - 0.003920	500 ohms @ 0 deg. C	±0.1 deg. C
Platinum - 0.003926	25.5 ohms @ 0 deg. C	±0.1%
Platinum - 0.003926	100 ohms @ 0 deg. C	±0.5%
Platinum - 0.003926	200 ohms @ 0 deg. C	±0.5%
Platinum - 0.003926	470 ohms @ 0 deg. C	±0.5%
Platinum - 0.003926	500 ohms @ 0 deg. C	±0.5%
Nickel - N/A	110 ohms @ 0 deg. C	±0.5%
Ni Fe - N/A	1000 ohms deg. @ 21.1 deg. C	±0.5%
Ni Fe - N/A	2000 ohms @ 21.1 deg. C	±0.5%
Copper - N/A	100 ohms @ 25 deg.C	±0.2%

RESISTANCE / TEMPERATURE TABLE

COPPER 10Ω AT 25°C

°C	0	1	2	3	4	5	6	7	8	9
-190	1.471	1.430	1.389	1.348	1.306	1.265	1.223	1.182	1.140	1.009
-180	1.884	1.843	1.802	1.761	1.719	1.678	1.637	1.596	1.554	1.513
-170	2.295	2.254	2.213	2.172	2.131	2.090	2.049	2.008	1.967	1.925
-160	2.705	2.664	2.623	2.582	2.541	2.500	2.459	2.418	2.377	2.336
-150	3.112	3.072	3.031	2.990	2.949	2.909	2.868	2.827	2.786	2.745
-140	3.519	3.478	3.437	3.397	3.356	3.316	3.275	3.234	3.194	3.153
-130	3.923	3.883	3.842	3.802	3.762	3.721	3.681	3.640	3.600	3.559
-120	4.326	4.286	4.246	4.206	4.165	4.125	4.085	4.044	4.004	3.964
-110	4.728	4.688	4.648	4.608	4.567	4.527	4.487	4.447	4.407	4.366
-100	5.128	5.088	5.048	5.008	4.968	4.928	4.888	4.848	4.808	4.768
-90	5.526	5.486	5.446	5.407	5.367	5.327	5.287	5.247	5.208	5.168
-80	5.923	5.883	5.844	5.804	5.764	5.725	5.685	5.645	5.606	5.566
-70	6.318	6.279	6.239	6.200	6.160	6.121	6.081	6.042	6.002	5.962
-60	6.712	6.672	6.633	6.594	6.554	6.515	6.476	6.436	6.397	6.358
-50	7.104	7.064	7.025	6.986	6.947	6.908	6.869	6.830	6.790	6.751
-40	7.490	7.451	7.413	7.374	7.335	7.296	7.258	7.220	7.181	7.142
-30	7.876	7.838	7.799	7.761	7.722	7.683	7.645	7.606	7.568	7.529
-20	8.263	8.224	8.185	8.147	8.108	8.070	8.031	7.992	7.954	7.915
-10	8.649	8.610	8.572	8.533	8.494	8.456	8.417	8.378	8.340	8.301
0	9.035	9.996	9.958	8.919	8.881	8.842	8.805	8.765	8.726	8.687
0	9.035	9.074	9.112	9.151	9.189	9.228	9.267	9.305	9.344	9.383
10	9.421	9.460	9.498	9.537	9.576	9.614	9.653	9.692	9.730	9.769
20	9.807	9.846	9.885	9.923	9.962	10.000	10.039	10.078	10.116	10.155
30	10.194	10.232	10.271	10.309	10.348	10.387	10.425	10.464	10.502	10.541
40	10.580	10.618	10.657	10.696	10.734	10.773	10.811	10.850	10.889	10.927
50	10.966	11.005	11.043	11.082	11.120	11.159	11.198	11.236	11.275	11.313
60	11.352	11.391	11.429	11.468	11.507	11.545	11.584	11.622	11.661	11.700
70	11.738	11.777	11.816	11.854	11.893	11.931	11.970	12.009	12.047	12.086
80	12.124	12.163	12.202	12.240	12.279	12.318	12.356	12.395	12.433	12.472
90	12.511	12.549	12.588	12.627	12.665	12.704	12.742	12.781	12.820	12.858
100	12.897	12.935	12.974	13.013	13.051	13.090	13.129	13.167	13.206	13.244
110	13.283	13.322	13.360	13.399	13.437	13.476	13.515	13.553	13.592	13.631
120	13.669	13.708	13.746	13.785	13.824	13.862	13.901	13.940	13.978	14.017
130	14.055	14.094	14.133	14.171	14.210	14.248	14.287	14.326	14.364	14.403
140	14.442	14.480	14.519	14.557	14.596	14.635	14.673	14.712	14.751	14.789
150	14.828	14.867	14.906	14.945	14.984	15.022	15.061	15.100	15.139	15.178
160	15.217	15.256	15.295	15.334	15.373	15.412	15.451	15.490	15.529	15.568
170	15.607	15.646	15.685	15.724	15.763	15.802	15.840	15.879	15.918	15.957
180	15.996	16.035	16.074	16.113	16.152	16.191	16.230	16.269	16.308	16.347
190	16.386	16.425	16.464	16.503	16.542	16.581	16.620	16.659	16.698	16.737
200	16.776	16.815	16.854	16.893	16.932	16.971	17.010	17.049	17.088	17.127
210	17.166	17.205	17.244	17.283	17.321	17.360	17.399	17.438	17.477	17.516
220	17.555	17.594	17.633	17.672	17.711	17.750	17.789	17.828	17.867	17.906
230	17.945	17.984	18.023	18.062	18.101	18.140	18.179	18.218	18.257	18.296
240	18.335	18.374	18.413	18.452	18.491	18.530	18.569	18.608	18.648	18.687
250	18.726	18.765	18.804	18.843	18.882	18.921	18.960	18.999	18.038	18.077
260	19.116									

RESISTANCE / TEMPERATURE TABLE

NICKEL 120Ω AT 0°C

°C	0	1	2	3	4	5	6	7	8	9
-70	73.10	72.45	71.80	71.15	70.50	69.85	69.20	68.55	67.90	67.25
-60	79.62	78.97	78.31	77.66	77.01	76.36	75.71	75.06	74.40	73.75
-50	86.17	85.51	84.86	84.20	83.55	82.89	82.84	81.58	80.93	80.27
-40	92.76	92.10	91.44	90.78	90.12	89.46	88.80	88.14	87.48	86.83
-30	99.41	98.74	98.07	97.41	96.74	96.07	95.41	94.75	94.08	93.42
-20	106.15	105.47	104.79	104.11	103.44	102.77	102.09	101.42	100.75	100.08
-10	113.00	112.31	111.62	110.93	110.25	109.56	108.87	108.19	107.51	106.83
0	120.00	119.29	118.58	117.88	117.17	116.47	115.77	115.08	114.38	113.69
0	120.00	120.71	121.42	122.13	112.85	123.57	124.28	125.00	125.72	126.45
10	127.17	127.90	128.63	129.36	130.09	130.82	131.56	132.29	133.03	133.77
20	134.52	135.26	136.01	136.76	137.51	138.26	139.02	139.77	140.53	141.29
30	142.06	142.82	143.59	144.36	145.13	145.90	146.68	147.46	148.23	149.01
40	149.79	150.58	151.36	152.15	152.94	153.74	154.53	155.33	156.13	156.93
50	157.74	158.55	159.36	160.17	160.98	161.80	162.62	163.44	164.26	165.08
60	165.90	166.73	167.56	168.38	169.21	170.05	170.88	171.72	172.56	173.40
70	174.25	175.10	175.95	176.80	177.66	178.51	179.37	180.24	181.10	181.97
80	182.84	183.71	184.59	185.46	186.34	187.22	188.10	188.98	189.87	190.75
90	191.64	192.53	193.42	194.32	195.21	196.11	197.01	197.91	198.82	199.73
100	200.64	201.55	202.46	203.38	204.30	205.22	206.14	207.06	207.99	208.92
110	209.85	210.78	211.72	212.66	213.60	214.54	215.49	216.44	217.39	218.34
120	219.29	220.25	221.21	222.17	223.14	224.10	225.07	226.04	227.01	227.99
130	228.96	229.94	230.92	231.90	232.89	233.88	234.87	235.86	236.85	237.85
140	238.85	239.85	240.85	241.86	242.86	243.87	244.88	245.89	246.91	247.93
150	248.95	249.97	251.00	242.02	253.05	254.09	255.12	256.16	257.21	258.25
160	259.30	260.35	261.40	262.45	263.51	264.57	265.63	266.60	267.76	268.83
170	269.91	270.98	272.06	273.14	274.22	275.30	276.39	277.48	278.57	279.67
180	280.77	281.87	282.98	284.09	285.21	286.33	287.45	288.57	289.70	290.83
190	291.96	293.10	294.24	295.38	296.52	297.67	298.82	299.97	301.13	302.29
200	303.46	304.62	305.80	306.97	308.15	309.34	310.52	311.72	312.91	314.11
210	315.31	316.52	317.72	318.94	320.15	321.37	322.59	323.82	325.05	326.29
220	327.53	328.77	330.02	331.27	332.52	333.78	335.05	336.32	337.59	338.86
230	340.14	341.42	342.71	344.00	345.30	346.59	347.90	349.20	350.51	351.82
240	353.14	354.46	355.79	357.12	358.45	359.79	361.13	362.47	363.82	365.18
250	366.53	376.89	369.26	370.62	372.00	373.37	374.75	376.13	377.52	378.91
260	380.31	381.70	385.11	384.52	385.93	387.34	388.77	390.19	391.62	393.05
270	394.49	395.93	379.38	398.82	400.28	401.73	403.19	404.66	406.12	407.60
280	409.07	410.55	412.03	413.52	415.01	416.51	418.01	419.51	421.02	422.53
290	424.05	425.57	427.09	428.62	430.16	431.70	433.24	434.78	436.33	437.89
300	439.44	441.00	442.57	444.13	445.70	447.28	448.86	450.44	452.02	453.61
310	455.20	456.80	458.40	460.00	461.60	463.20	464.80	466.40	468.00	46.60
320	471.20									

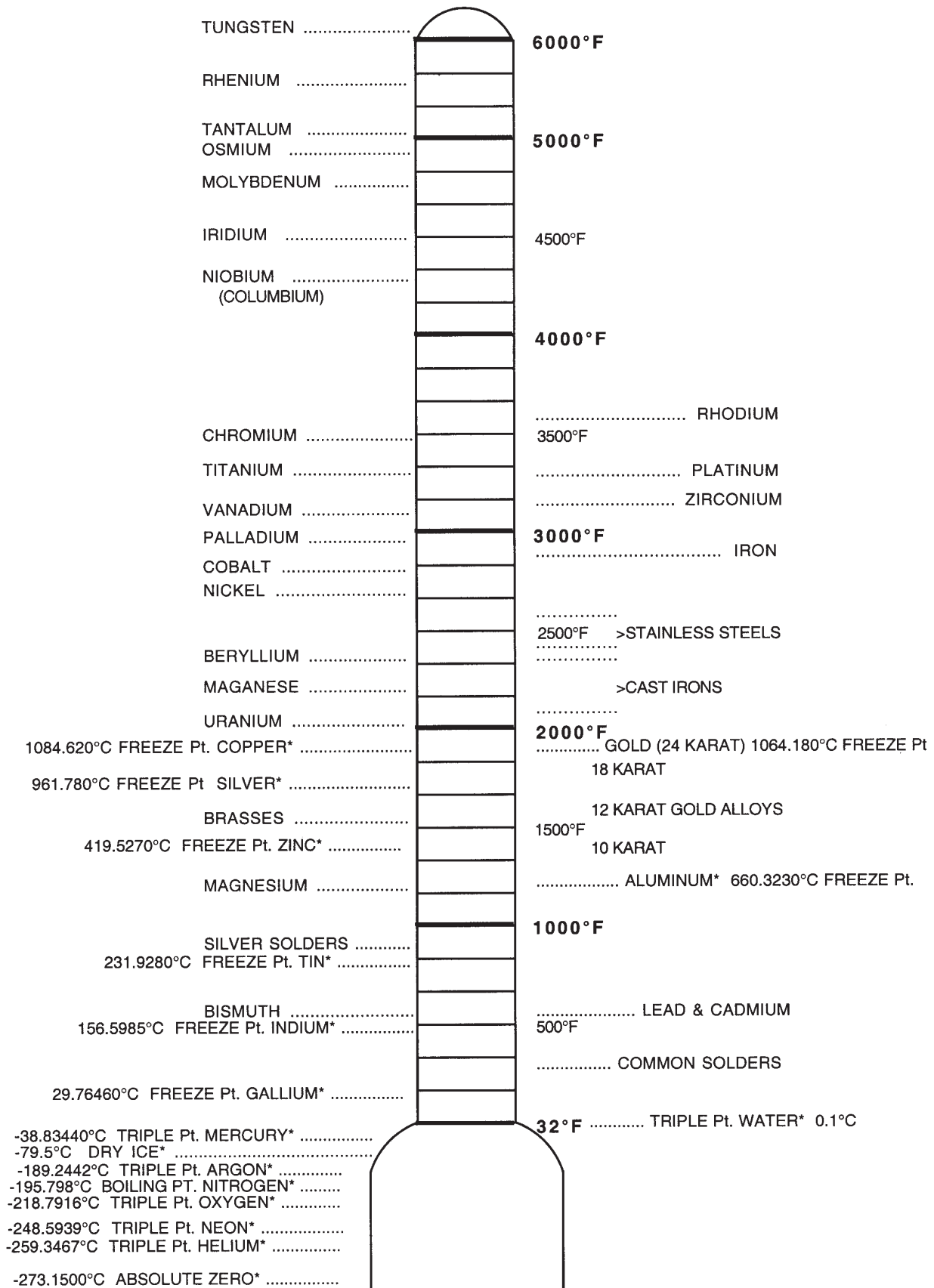
TEMPERATURE CONVERSION TABLE

Read known temperature in bold face type.
Corresponding temperature in degrees
Fahrenheit will be found in column to the right
Corresponding temperature in degrees
Centigrade will be found in column to the left.

C.	F.	C.	F.
0.56	1	1.8	3.33
1.11	2	3.6	3.89
1.67	3	5.4	4.44
2.22	4	7.2	5.00
2.78	5	9.0	5.56
			6
			7
			8
			9
			10
			10.8
			12.6
			14.4
			16.2
			18.0

0 to 100				100 to 1000				1000 to 2000				2000 to 3000			
C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.
-17.8	0	32	10.0	50	122.0	38	100	212	260	500	932	538	1000	1832	816
-17.2	1	33.8	10.6	51	123.8	43	110	230	266	510	950	543	1010	1850	821
-16.7	2	35.6	11.1	52	125.6	49	120	248	271	520	968	549	1020	1868	827
-16.1	3	37.4	11.7	53	127.4	54	130	266	277	530	986	554	1030	1886	832
-15.6	4	39.2	12.2	54	129.2	60	140	284	282	540	1004	560	1040	1904	838
-15.0	5	41.0	12.8	55	131.0	66	150	302	288	550	1022	566	1050	1922	843
-14.4	6	42.8	13.3	56	132.8	71	160	320	293	560	1040	571	1060	1940	849
-13.9	7	44.6	13.9	57	134.6	77	170	338	299	570	1058	577	1070	1958	854
-13.3	8	46.4	14.4	58	136.4	82	180	356	304	580	1076	582	1080	1976	860
-12.8	9	48.2	15.0	59	138.2	88	190	374	310	590	1094	588	1090	1994	866
-12.2	10	50.0	15.6	60	140.0	93	200	392	316	600	1112	593	1100	2012	871
-11.7	11	51.8	16.1	61	141.8	99	210	410	321	610	1130	599	1110	2030	877
-11.1	12	53.6	16.7	62	143.6	100	212	413	327	620	1148	604	1120	2048	882
-10.6	13	55.4	17.2	63	145.4	104	220	428	332	630	1166	610	1130	2066	888
-10.0	14	57.2	17.8	64	147.2	110	230	446	338	640	1184	616	1140	2084	893
-9.44	15	59.0	18.3	65	149.0	116	240	464	343	650	1202	621	1150	2102	899
-8.89	16	60.8	18.9	66	150.8	121	250	482	349	660	1220	627	1160	2120	904
-8.33	17	62.6	19.4	67	152.6	127	260	500	354	670	1238	632	1170	2138	910
-7.78	18	64.4	20.0	68	154.4	132	270	518	360	680	1256	638	1180	2156	916
-7.22	19	66.2	20.6	69	156.2	138	280	536	366	690	1274	643	1190	2174	921
-6.67	20	68.0	21.1	70	158.0	143	290	554	371	700	1292	649	1200	2192	927
-6.11	21	69.8	21.7	71	159.8	149	300	572	377	710	1310	654	1210	2210	932
-5.56	22	71.6	22.2	72	161.6	154	310	590	382	720	1328	660	1220	2228	938
-5.00	23	73.4	22.8	73	163.4	160	320	608	388	730	1346	666	1230	2246	943
-4.44	24	75.2	23.3	74	165.2	166	330	626	393	740	1364	671	1240	2264	949
-3.89	25	77.0	23.9	75	167.0	171	340	644	399	750	1382	677	1250	2282	954
-3.33	26	78.8	24.4	76	168.8	177	350	662	404	760	1400	682	1260	2300	960
-2.78	27	80.6	25.0	77	170.6	182	360	680	410	770	1418	688	1270	2318	966
-2.22	28	82.4	25.6	78	172.4	188	370	698	416	780	1436	693	1280	2336	971
-1.67	29	84.2	26.1	79	174.2	193	380	716	421	790	1454	699	1290	2354	977
-1.11	30	86.0	26.7	80	176.0	199	390	734	427	800	1472	704	1300	2372	982
-0.56	31	87.8	27.2	81	177.8	204	400	752	432	810	1490	710	1310	2390	988
0	32	89.6	27.8	82	179.6	210	410	770	438	820	1508	716	1320	2408	993
0.56	33	91.4	28.3	83	181.4	216	420	788	443	830	1526	721	1330	2426	999
1.11	34	93.2	28.9	84	183.2	221	430	806	449	840	1544	727	1340	2444	1004
1.67	35	95.0	29.4	85	185.0	227	440	824	454	850	1562	732	1350	2462	1010
2.22	36	96.8	30.0	86	186.8	232	450	842	460	860	1580	738	1360	2480	1016
2.78	37	98.6	30.6	87	188.6	238	460	860	466	870	1598	743	1370	2498	1021
3.33	38	100.4	31.1	88	190.4	243	470	878	471	880	1616	749	1380	2516	1027
3.89	39	102.2	31.7	89	192.2	249	480	896	477	890	1634	754	1390	2534	1032
4.44	40	104.0	32.2	90	194.0	254	490	914	482	900	1652	760	1400	2552	1038
5.00	41	105.8	32.8	91	195.8				488	910	1670	766	1410	2570	1043
5.56	42	107.6	33.3	92	197.6				493	920	1688	771	1420	2588	1049
6.11	43	109.4	33.9	93	199.4				499	930	1706	777	1430	2606	1054
6.67	44	111.2	34.4	94	201.2				504	940	1724	782	1440	2624	1060
7.22	45	113.0	35.0	95	203.0				510	950	1742	788	1450	2642	1066
7.78	46	114.8	35.6	96	204.8				516	960	1760	793	1460	2660	1071
8.33	47	116.6	36.1	97	206.6				521	970	1778	799	1470	2678	1077
8.89	48	118.4	36.7	98	208.4				527	980	1796	804	1480	2696	1082
9.44	49	120.2	37.2	99	210.2				532	990	1814	810	1490	2714	1088
			37.8	100	212.0				538	1000	1832				1093
															2000
															3632
															1649
															3000
															5432

FREEZING TEMPERATURE OF METALS



* Represents information from ITS-90 Temperature Scale.

THE INTERNATIONAL SYSTEM OF UNITS (SI)

The information provided below is for convenient reference in providing product specification is SI.

SI Base Units

SI is founded on seven base units:

Quantity	Name of Unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	centigrade or fahrenheit	C or F
amount of substance	mole	mole
luminous intensity	candela	cd

There are also two supplementary units:

Quantity	Name of Unit	Symbol
plane angle	radian	rad
solid angle	steradian	sr

SI Derived Units

Derived units are formed with base and/or supplementary units.

Quantity	Name	Symbol	Equivalent to ____
force	newton	N	$\text{kg}\cdot\text{m}/\text{s}^2$
pressure	pascal	Pa	N/m^2
work, energy, quantity of heat	joule	J	$\text{N}\cdot\text{m}$
power, heat flow rate	watt	W	J/s
quantity of electricity	coulomb	C	$\text{A}\cdot\text{s}$
electrical potential	volt	V	V/A
electric resistance	ohm	Ω	V/A
electric capacitance	farad	F	C/V
electric conductance	siemens	S	A/V
magnetic flux	weber	Wb	$\text{V}\cdot\text{s}$
inductance	henry	H	Wb/A
magnetic flux density	tesla	T	Wb/m^2
frequency	hertz	Hz	$1/\text{s}$
luminous flux	lumen	lm	$\text{cd}\cdot\text{sr}$
illuminance	lux	lx	lm/m^2
activity	becquerel	Bq	$1/\text{s}$
absorbed dose	gray	Gy	J/kg

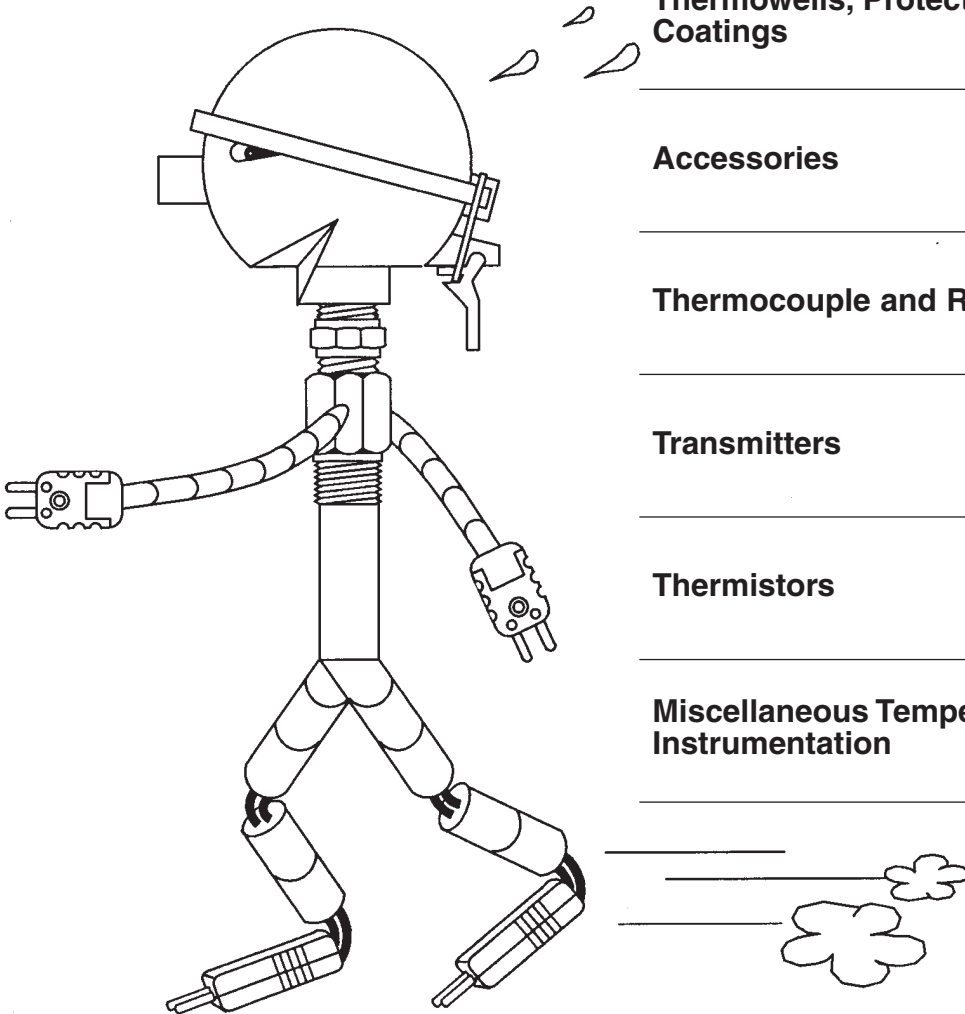
Common Prefixes

Prefix	Symbol	Means Multiple by	Or by
mega	M	1,000,000	10^6
kilo	k	1,000	10^3
hecto*	h	100	10^2
deka*	da	10	10
deci*	d	0.1	10^{-1}
centi*	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	u	0.000,000,1	10^{-6}

*should be avoided when possible

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JMS Southeast, Inc.
Temperature Measurement



Specialty Sensors



SPECIALTY SENSORS

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JMS Southeast endeavors to manufacture very unique sensors to satisfy our customers' application needs. If you don't find the sensor you desire, please contact JMS for assistance.

CUSTOM DESIGN **OFF THE SHELF TIME!**

For other types of sensors/transducers (infrared, mercury and glass, bimetals, etc.) not manufactured by but available through JMS, See Section 10.

LABORATORY THERMOMETERS

JMS offers 7 different reference probes for laboratory use...

STANDARD PLATINUM RESISTANCE THERMOMETERS

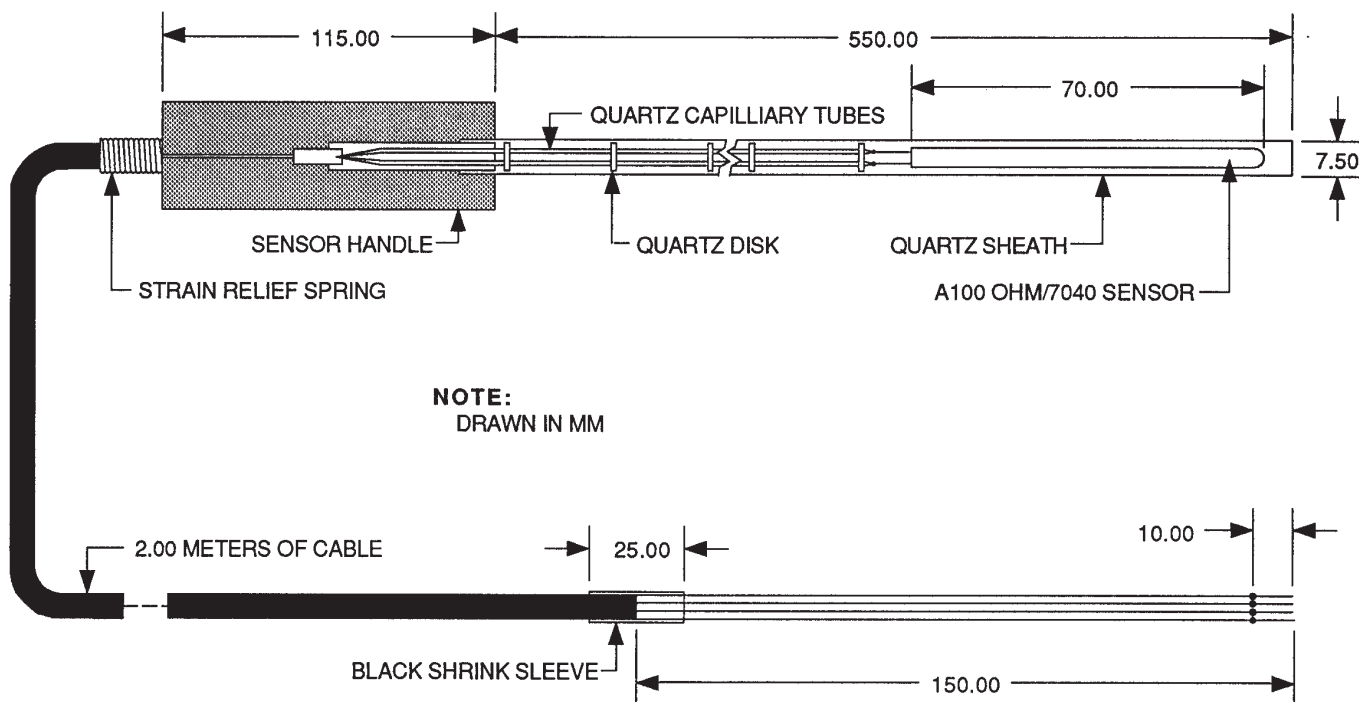
The first and most accurate of the laboratory probes is the SPRT. It has the tightest specifications and is also the most fragile and expensive. Typical drift rates are about 0.001°K annually or about 0.002°C after 100 hours at 660°C.

The SPRT allows the user to realize ITS 90. Our most common unit is the 4ZP model which allows the realization from the boiling point of nitrogen (-195.798°C) to the zinc freezing point (419.527°C). The JMS 4AP unit allows the user to realize ITS 90 from 0°C to the freezing point of aluminum (660.323°C).

Model # [3-21]	R@0°C*	Alpha Coefficient*
4ZP25.5C**	25.5Ω	.003925
4ZP100C**	100Ω	.003925
4AP25.5**	25.5Ω	.003925

* Calibration report will document the exact numbers along with the TPW/MPG ratios.

** The "C" in the part number indicates we will provide calibration. If you intend to send the probe to NIST or some other lab for calibration / certificate, omit the "C"



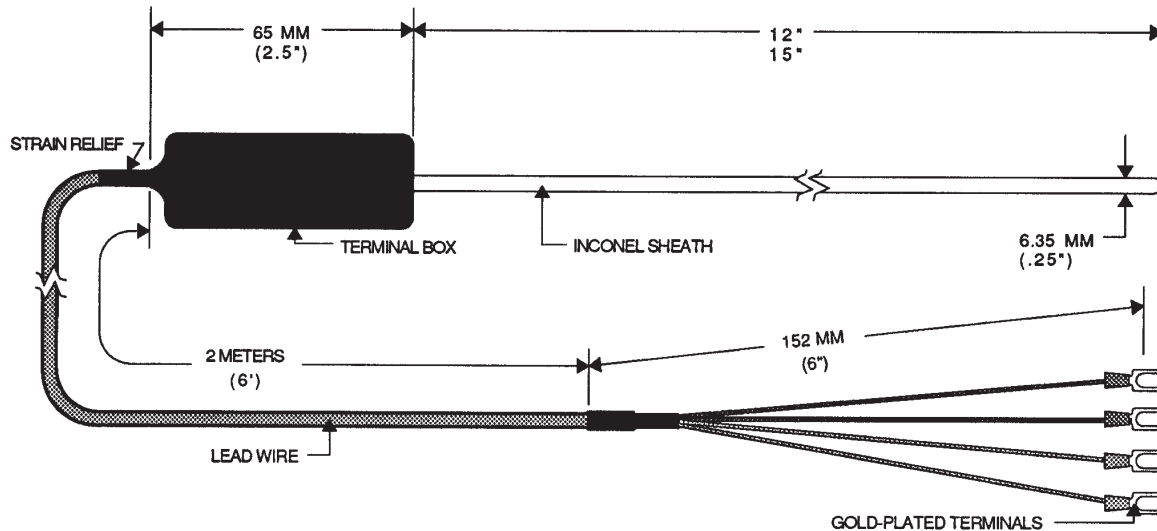
Note: ITS 90 says that an SPRT should have a resistance at melting point of gallium greater than 1.11807 times it's water triple point resistance. That means that you should not use an RTD with a 0.00385 alpha coefficient as an SPRT. However the experience of JMS Southeast indicates that they are great as secondary standards and are described on the following pages.

LABORATORY THERMOMETERS

SECONDARY STANDARD RTD'S

These sensors are intended to be used as the standard for a working laboratory. For instance, JMS uses these types of probes as the reference for our day to day comparison calibrations done on the sensors you use in your processes. We use the SPRT mentioned on the previous page to calibrate and validate this secondary standard.

The secondary standard covers the full range from -200°C to 660°C. It is only slightly more drift prone than the SPRT. (<0.003°C per year or <0.005°C after 500 hours @ 600°C (estimated)) It is much more rugged than the SPRT it has an Inconel 600 sheath, which might not break if dropped on a laboratory floor.



It can be manufactured to any length using the following part numbers:

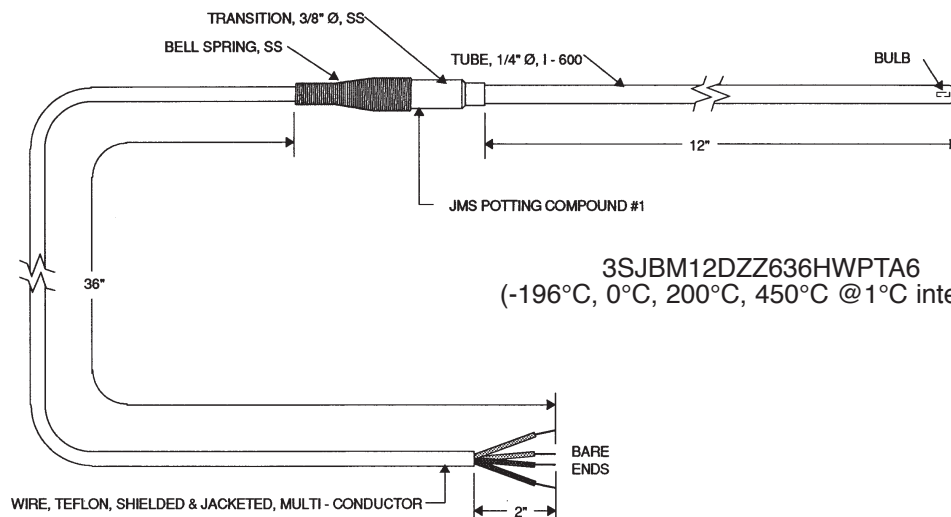
4SS (length in inches) 25.5 C* (25.5Ω@0°C)

4SS (length in inches) 100 C* (100Ω@0°C)

*indicates a standard calibration will be done using 5 points between -200°C and 600°C. If you intend to send to another lab for calibration, omit the "C".

PRECISION INDUSTRIAL RTD

Our Precision Industrial RTD can be specified by using the pages from the regular RTD section. They can be made in almost any size or shape.



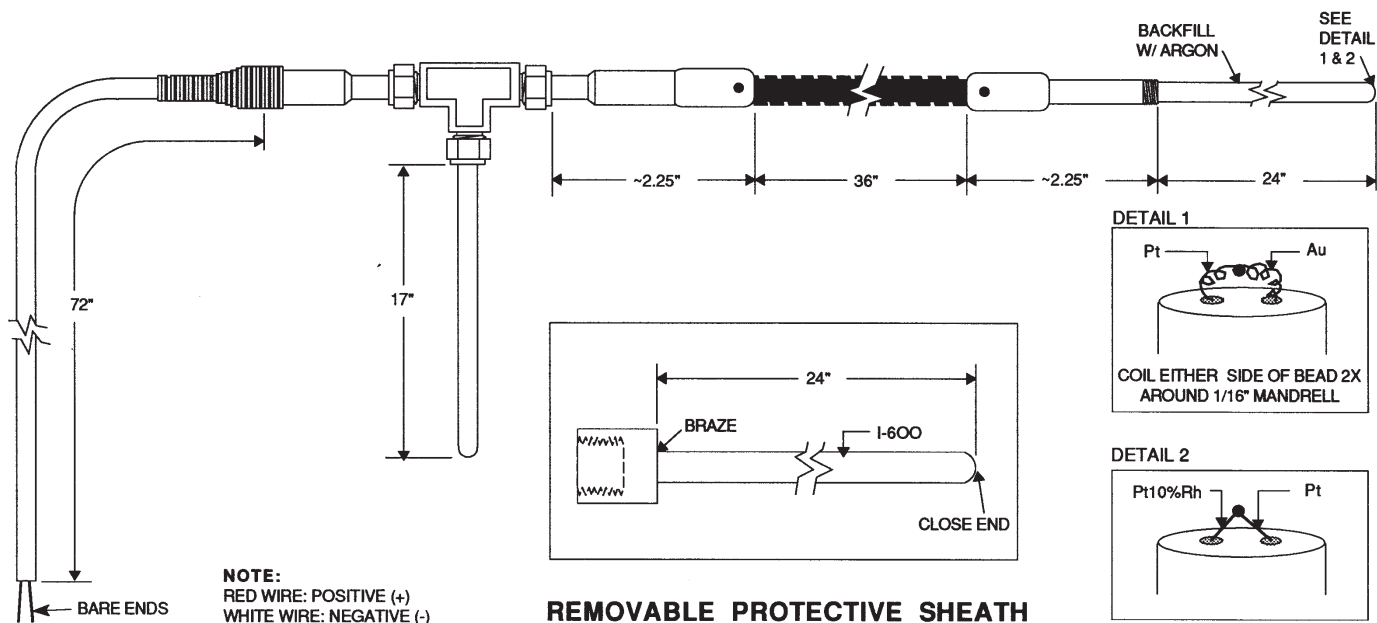
3SJBM12DZZ636HWPTA6
(-196°C, 0°C, 200°C, 450°C @ 1°C intervals)

GOLD-PLATINUM-RHODIUM LABORATORY THERMOMETERS

JMS STANDARDS THERMOCOUPLE

IPTS 68 allowed the use of type S thermocouples as a method to realize the temperatures above the range of an RTD. ITS 90 does not speak to the use of thermocouples, but they are recognized by many labs as a secondary standard and are great for comparison calibrations. ASTM and NIST still and will continue to recognize the use of Pt/Au and Pt/PtRh in laboratories, and NIST has defined the millivolt tables (Seebeck Coefficients) which are included in section 1 of this catalog. These tables are taken from ASTM E-1751 and ASTM E-230.

Use the appropriate drawing number to order.



These two referenced sensors are an excellent choice for comparing calibration equations in an industrial facility. An accurate and traceable millivolt meter plus one of these probes is all you need to do a totally accurate and effective standards traceable calibration.

Comparison of compositions of probes

JMS Part #4PTAUC*	JMS Part #4PTRHC*
Pt/Au	Pt/PtRh
0 - 1000°C	0 - 1450°C
Non alloyed metals	Higher range
Calibration extremely close to standard	
±0.2°C or better	±1.0°C or better

*A calibration is supplied with any probe and for no calibration, omit the C in the part #.

See Section 1 for temperature / EMF Tables.

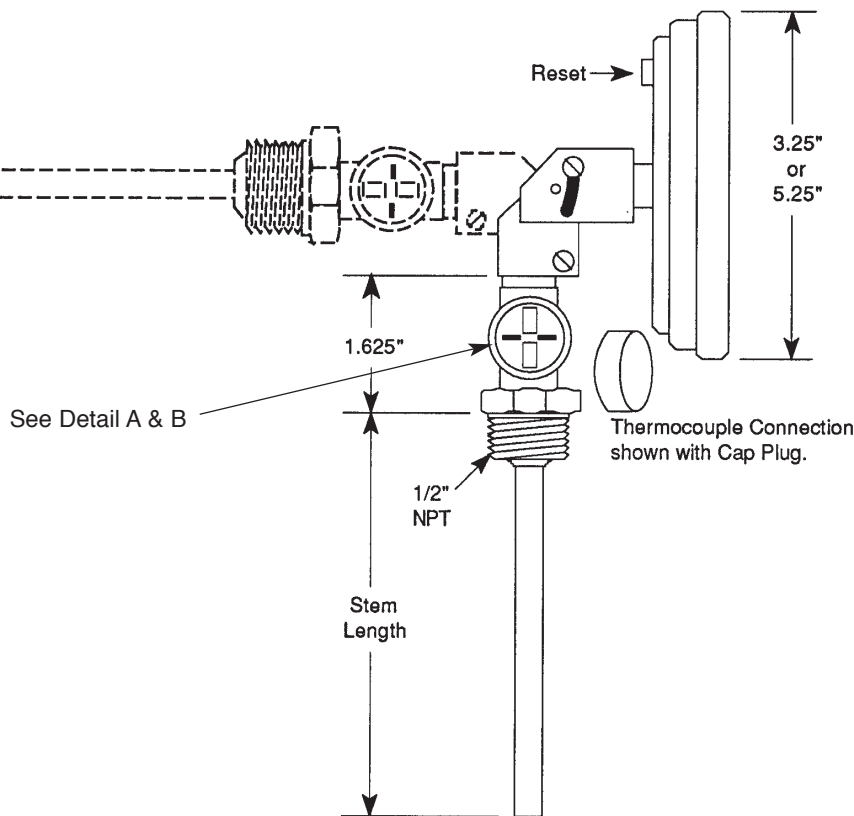
SINTERING, FURNACE & GLASS THERMOCOUPLES

#1	SERIES
4G	Sintering, furnace & glass thermocouple (Purged and packed with high temperature inert gas.)
#2	TYPE
S R B C X	Platinum/Platinum 10% Rhodium Platinum/Platinum 13% Rhodium Platinum 6% Rhodium/Platinum 30% Rhodium Tungsten 5% Rhenium/Tungsten 26% Rhenium Other, specify
#3	OUTSIDE DIAMETER
B C D E F X Z	1/4" (Standard) 3/16" 1/8" 1/16" 1/25" Other, specify N/A
#4	SHEATH MATERIAL
A B R S T M X	Platinum - 10% Rhodium Platinum - 20% Rhodium Molybdenum (purged) Tantalum Titanium Inconel 600 Other, specify
#5	THERMOCOUPLE JUNCTION
G U	Grounded Ungrounded (Standard)
#6	IMERSION LENGTH
"	Length in inches
#7	INSULATION
M A B H X	MgO Al ₂ O ₃ (Standard) BeO HfO ₂ Other, specify
#8	FITTINGS
Z F G H X	No Fitting (Standard) Reverse mounted steel plug fixed for attaching head Fixed stainless steel to sheath Compression fitting ss w/ ss ferrule Other, specify
#9	PROCESS NPT
A B C X Z	1/2 1/4 1/8 Other, specify N/A (Standard)
#10	COLD END TERMINATION
C F I L M N X	Standard plug Hi temp std plug (Standard) Explosion proof Nema 7 head Aluminum head w/ hinged cover Aluminum head w/ screw cover & chain Cast iron head w/ screw cover Other, specify

Technical drawing of a thermocouple assembly. It shows a cross-section of the head with a thermocouple junction, a .312 inch diameter tube, a purge port, and a braze. Dimensions include .25 inch for the head height, 3 inches for the tube length, and .75 inch for the tube diameter. Labels include 'BRAZE', 'PURGE PORT', 'TUBE Ø (.312\"

4G	S	B	R	U	14"	A	Z	A	F
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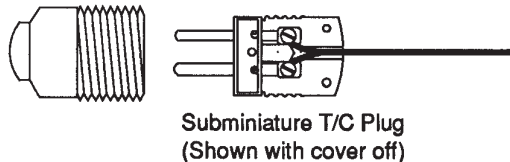
ANALOG BEMOMETER



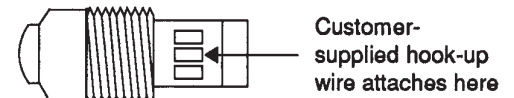
***Unites Bimetal
with Either
Thermocouple or
RTD Technology!***

- **Bimetal Dependability**
- **Thermocouple / RTD Accuracy**
- **Direct AND Electronic Reading**
 - **Easy To Use**
 - **Easy To Calibrate**
- **Two Sensors in One Instrument**

Thermocouple Connection

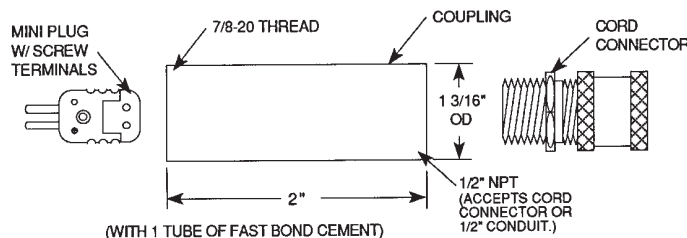


RTD Terminal Block Connection (3 pos.)



Permanent Wiring Kit

Detail A



Detail B

This thermometer combines the convenience, simplicity, and self-powered actuation of a bimetal thermometer with the digital accuracy and data acquisition capabilities of a thermocouple or RTD. With standards traceable to the NIST, this new instrument offers simplified calibration for ISO 9000 compliance and other statistical process control requirements. It is also ideal in applications requiring easy and quick readability while still affording a means of electronic data acquisition. There is no need to add access points or thermowells to your existing process in order to gain different types or readings. Plus two temperature sensors to work at each location.

This is available with a 3" or 5" dial, in a Back Connected or Adjustable angle case, 1/4" stem diameter in lengths to 12", 1/2" NPT connection, in ranges from -100°F (-70°C) to 500°F (260°C), with Fahrenheit, Celsius and Dual Scale Dials available. Thermocouple output may be accessed via a plug-in connector; RTD output is accessed by a terminal block. Both have 1/2" conduit threaded mounting and a plastic cap standard. Optional weatherproof housing is available. Construction is of type 304 series stainless steel with a glass crystal. It is hermetically sealed per ASME B40.3 standard. It also comes with a one-year warranty.

ANALOG BEMOMETER

How To Order Your Adjustable Angle Bemometer:

KEY MODEL NUMBER: 30 060 0 01 K - **PWK** (Optional)
 Table 1: Basic Model _____
 Table 2: Stem Length _____
 Table 3: Scale Type (F, C or F&C) _____
 Table 4: Range _____
 Table 5: Sensor Type _____
 Permanent Wiring Kit

Table 1 - Model

KEY	DESCRIPTION
30	3" Back connection (with reset)
32	3" Adjustable angle (with reset)
50	5" Back connection (with reset)
52	5" Adjustable angle (with reset)

Table 2 - Stem Length

KEY	DESCRIPTION - Max. 12"
4	Length in inches
6	
9	
12	
X	Other, specify

Table 3 - Scale Type

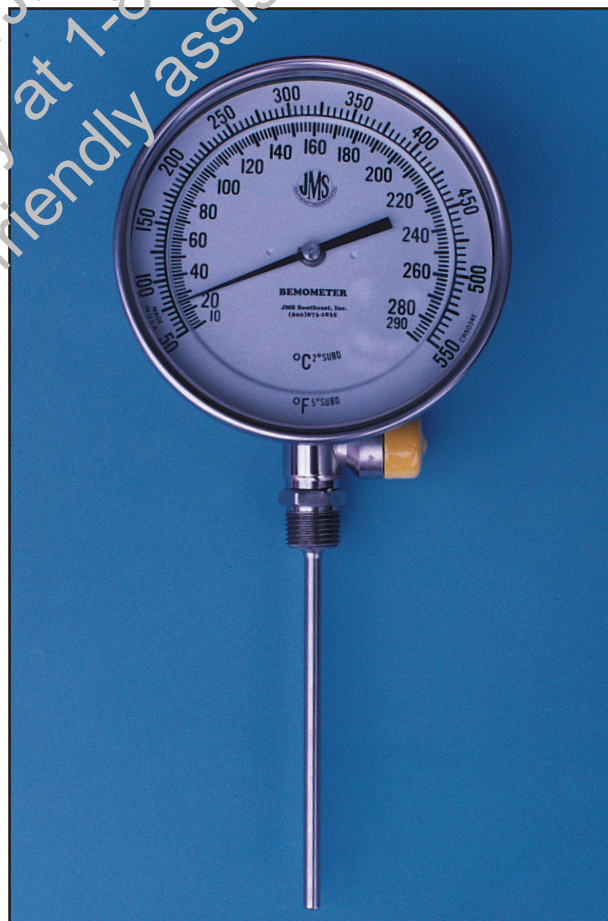
KEY	DESCRIPTION
0	Dual scale Fahrenheit and Celsius
1	Single scale Celsius only
2	Single scale Fahrenheit only

Table 4 - Standard Ranges

KEY	DESCRIPTION		
	Dual scale F/C	Celsius only	Fahrenheit only
01	-100/150F & -70/70C	-70/70C	-100/150
02	-40/120F & -40/50C	-50/50C	-40/120F
03	25/125F & -5/50C	0/50C	25/125F
04	0/140F & -20/60C		0/140F
05	0/200F & -15/90C	0/100C	0/200F
06	0/250F & -20/120C	-20/120C	0/250F
07	20/240F & -5/115C		20/240F
08	50/300F & 10/150C	0/150C	50/300F
09	50/400F & 10/200C	0/200C	50/400F
10	50/500F & 10/260C	0/250C	50/500F

Table 5 - Sensor Type

KEY	DESCRIPTION
J	Thermocouple output, Type J
K	Thermocouple output, Type K
E	Thermocouple output, Type E
T	Thermocouple output, Type T
3	100Ω RTD output, 3 wire



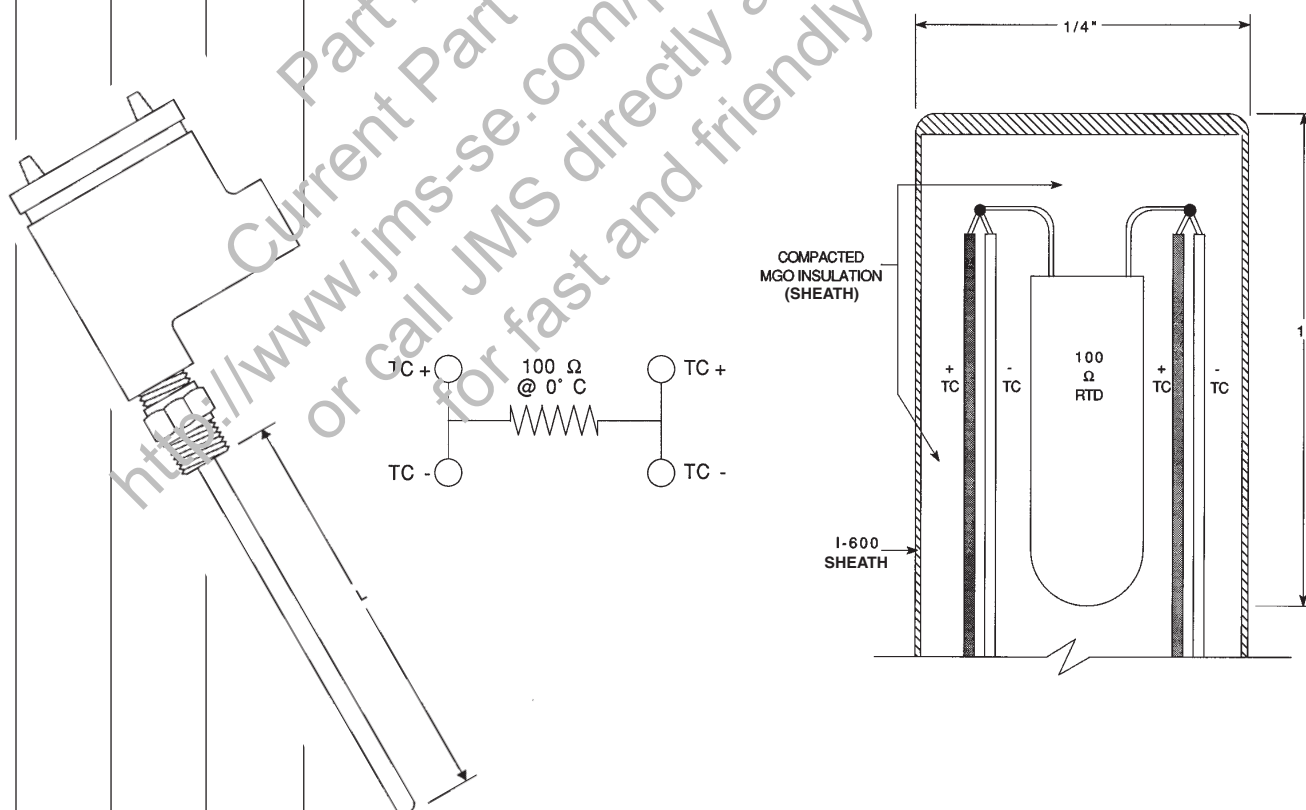
COMBINATION THERMOCOUPLES AND RTD'S

JMS Southeast, Inc., manufactures a sensor that contains both a thermocouple and an RTD. The standard design allows the user to check and validate readings with one sensor while using another type for control or monitoring. Although two thermocouples can be used simultaneously, it is not advisable to use the thermocouple and RTD at the same time.

This type of sensor can be used in applications that require two different inputs. One advantage of this system is that the conditions which adversely affect a thermocouple may not affect the RTD and vice versa. Therefore, combination sensors provide a back-up sensor in the same probe. In extremely high temperature applications, this procedure is not recommended. JMS Southeast can also manufacture triple elements of just about any combination. Contact JMS for details.

There are three types of popular transmitters which accept this sensor directly. We recommend our 8B (AI-2000) and the 8A (AI-1000).

#1	SERIES
4C	Combination, 4 wire, dual element, 1/4" diameter, ungrounded/ non isolated thermocouple and RTD
#2	THERMOCOUPLE TYPE
J	Dual element J thermocouple
K	Dual element K thermocouple
T	Dual element T thermocouple
N	Dual element N thermocouple
X	Other, specify
#3	RTD TYPE
3	Single element 100Ω Platinum RTD (.00385)
X	Other, specify
#4	TEMPERATURE LIMITS
1	Hollow tube < 550° F (T/C's and RTD's are not electrically connected)
2	Sheath < 1200° F (Type K & N thermocouples only)



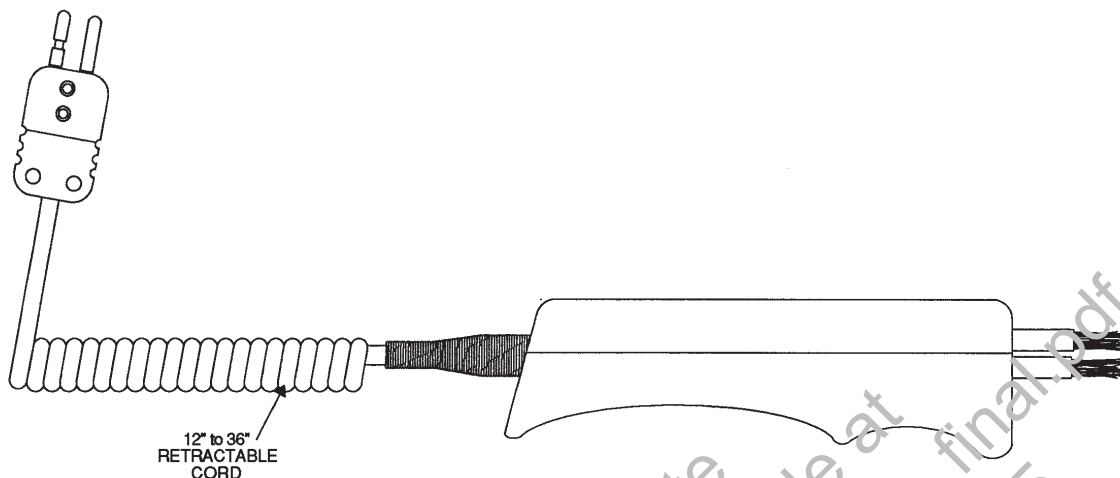
4C	J	3	1
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COMBINATION THERMOCOUPLES AND RTD'S

#5	IMMERSION LENGTH (L)				
--"	Immersion in inches				
	#6	STANDARD INDUSTRIAL FITTING			
	S	Spring loaded 1/2"x 1/2" NPT SS fitting			
	W	Welded 1/2" x 1/2" NPT SS fitting			
	B	Bayonet style (standard) 1/2" process connection			
		COMPRESSION FITTINGS			
	H	Stainless steel with SS ferrule - 1/8" NPT			
	M	Stainless steel with SS ferrule - 1/4" NPT			
	P	Stainless steel with SS ferrule - 1/2" NPT			
	X	Other, specify			
	#7	LEAD WIRE INSULATION AND LENGTH IN INCHES [3-2]			
	Z	No lead wire			
	1"	Kapton - Standard for hollow tube			
	3"	Teflon			
	6"	Kapton/flex armor overall			
	X	Other, specify			
	#8	TYPE OF TRANSITION [1-16, 3-14]			
	T	3/8" OD			
	X	Other, specify			
	Z	No transition			
	#9	COLD END TERMINATION [SEE SECTION 6] Pick as many as applicable			
	A	Bare ends			
	I	Explosion proof Nema 7 head (CI / 6B2)			
	K	Spade lugs (6SL)			
	L	Aluminum head w/ hinged cover (6LW / 6NFB)			
	M	Aluminum head w/ screw cover & chain (6M / 6G)			
	N	Cast iron head w/ screw cover (6N / 6G)			
	O	Open ceramic terminal block (6O)			
	Q	Black nylon Nema 4 head (6Q / 6C)			
	R	High dome head (6R)			
	V	Hermetic connector (6VC) Male*			
	W	Microphone style connector (6DA) Male*			
	X	Other, specify			
	#10	TAGGING AND CALIBRATION OPTIONS (USE ONLY IF APPLICABLE)			
		See page 12 #14 for ordering selections.			

12"	W	Z	Z	N	
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BRUSH THERMOCOUPLES



The JMS Brush Thermocouple can be used in applications in which a surface temperature of a stationary or moving electrically conducting surface is needed.

True temperature measurement of a surface is very hard to obtain. Previous designs called for the probe to fully contact with as small a junction as possible, spring load with as even pressure as possible, insulate around the surface to be measured, or combinations of all these methods.

All of the above methods have proven to have their own particular faults. When compared to an infrared sensor, which does accurately measure surface temperature (unit must have correct emissivity adjustment), most of these above mentioned sensors either read much hotter or colder than the infrared. However, even the infrared style exhibits problems when emissivity levels fall beneath .4 or less (most metallic surfaces).

JMS has applied for a patent on this brush sensor because of its unique design and widespread application, i.e., molds, rolls, bearings, nozzles, plates, pipes, engines, etc., it is usually preferred in a hand held design, but can be adapted for permanent mounting.

Standard calibration for this sensor is usually K because of its resistance to corrosion and stiffness. But any type thermocouple may utilize this design. Call or write for further information.

#1	SERIES			
4B	Specialty brush sensor			
	#2	TYPE		
	J	Iron/Constantan		
	K	Chromel/Alumel (Standard)		
	X	Other, specify		
	#3	DESIGN		
	S	Standard handle / 12" polyvinyl coil cord. Length will stretch from 12" to 36"		
	X	Other, specify		
	#4	COLD END TERMINATION		
	A	Bare ends		
	B	Miniature plug (Standard)		
	C	Standard plug		
	#5	REPLACEMENT BRUSHES		
	0	None		
	1 +	Number of sets of replacement brushes		

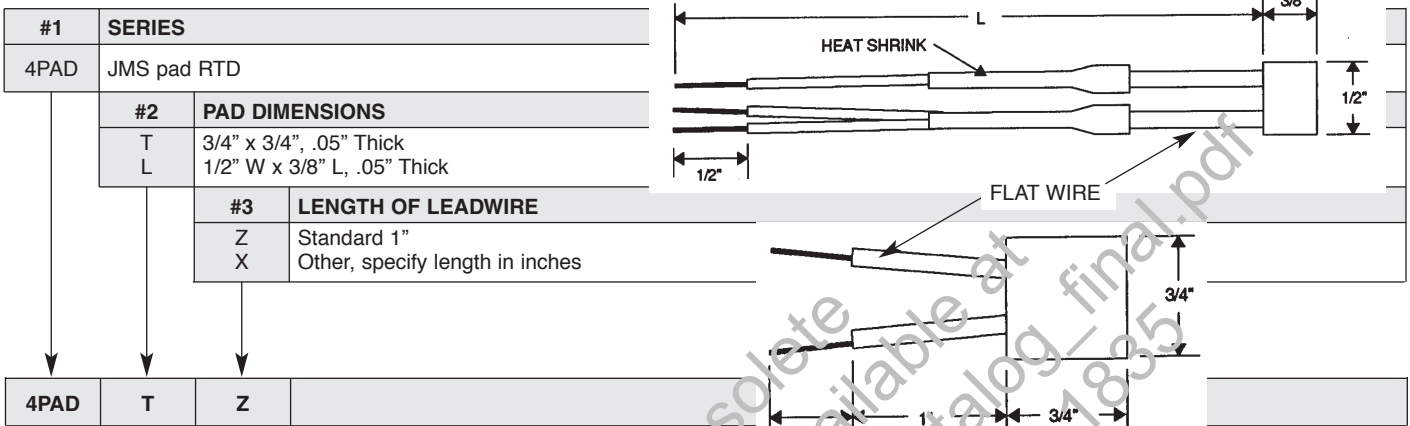
For replacement brushes only, use part #4B __ ZZ.

4B	K	S	B	2	
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PAD RTD'S

The JMS pad RTD is a speciality sensor which provides a fast response surface measurement. It is a 100 ohm platinum RTD with an alpha of $.00385 \Omega/\Omega/^{\circ}\text{C}$. Pad material is fiberglass coated with a silicon rubber.

The pad RTD has an effective operating range from -200°C to 250°C and its tolerance is $.1\%$. Additional teflon lead-wire is configured as a 3 wire RTD.



MULTIPOINT SENSOR ASSEMBLIES

A multipoint sensor allows the measurement of a temperature profile across a large area. Thermocouples or RTD's are arranged with measuring junctions at various points along a probe, allowing the measurement of various points from a complete assembly.

Many elements can be spaced along a probe. This opens up possibilities for improved profiling in catalytic reactors, for example, where flow interference prevents inserting large numbers of individual probes.

Multipoint probes can also be used to give a temperature profile where stratification of a tanks contents may be of concern.

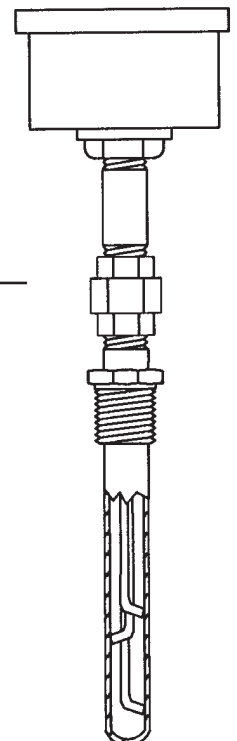
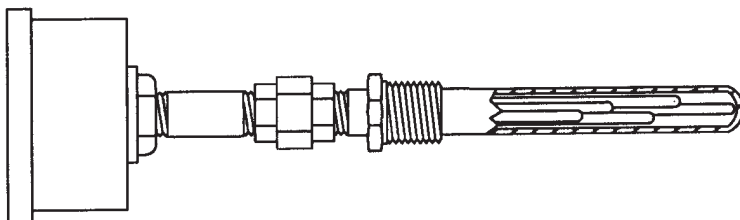
JMS will custom design your assembly to give you the most accurate temperature measurement for your process.

The following information and/or drawing is needed to properly design your assembly.

- Thermocouple calibration or RTD element type
- Outside diameter of pipe and pipe material.
- Number of elements required and lengths.
- Junction style of thermocouple.
- Sensor material (bare wire, 316 SS tubing, or sheath material).
- Overall length of the entire assembly.
- Process connection.
- Accuracy required.
- Cold-end termination.
- Maximum operating temperature.

Removable / Replaceable Sensor Design - Now Available

NEW!



Note: JMS has a proprietary design which assures consistent response time for each probe, plus removability for recalibration. Call and ask about it!

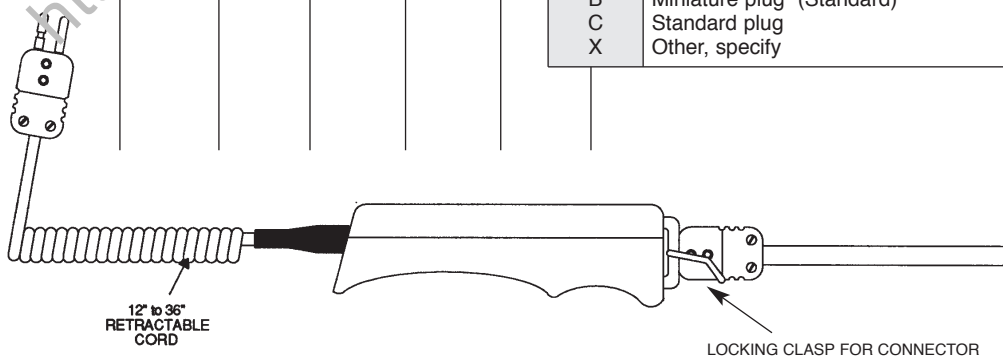
HAND HELD SENSORS

DESCRIPTION

The standard JMS hand held sensor is 316 stainless steel.

#1	SERIES
4H	Hand held sensor
#2	TYPE
J	Iron/Constantan, standard limits of error
K	Chromel/Alumel, standard limits of error
T	Copper/Constantan, standard limits of error
E	Chromel/Constantan, standard limits of error
3	RTD 100Ω Platinum .00385 alpha, 3 wire, .12% accuracy
X	Other, specify
#3	OUTSIDE DIAMETER
A	3/8" (.375")
B	1/4" (.250")
C	3/16" (.188")
D	1/8" (.125")
E	1/16" (.063")
X	Other, specify
#4	LENGTH OF SHEATH [L]
--"	Length in inches
#5	MEASURING JUNCTION
G	Grounded
U	Ungrounded (RTD's are always ungrounded)
E	Exposed
X	See order symbols on Page 1-13 for special junctions such as pointed tip and gas/air.
#6	PRESENCE OF HANDLE
H	Handle
X	Other, specify
Z	N/A
#7	LEAD WIRE INSULATION AND LENGTH IN INCHES
S	Coil-cord. Length will stretch from 12" to 36" (Standard)
2	20 awg PVC
3	20 awg Teflon
5	20 awg Kapton
6	20 awg Glass braid/Flexible armor overall
7	20 awg Teflon/Flexible armor overall
8	20 awg Glass braid/Stainless steel overbraid
9	3 conductor Teflon with overall jacket of Teflon (RTD only)
10	3 conductor Teflon/Stainless steel overbraid with overall jacket of Teflon. (RTD only)
X	Other, specify
#8	COLD END TERMINATION
A	Bare ends
B	Miniature plug (Standard)
C	Standard plug
X	Other, specify

Other styles of hand-held sensors are available. Contact JMS Southeast, Inc. for your custom design.



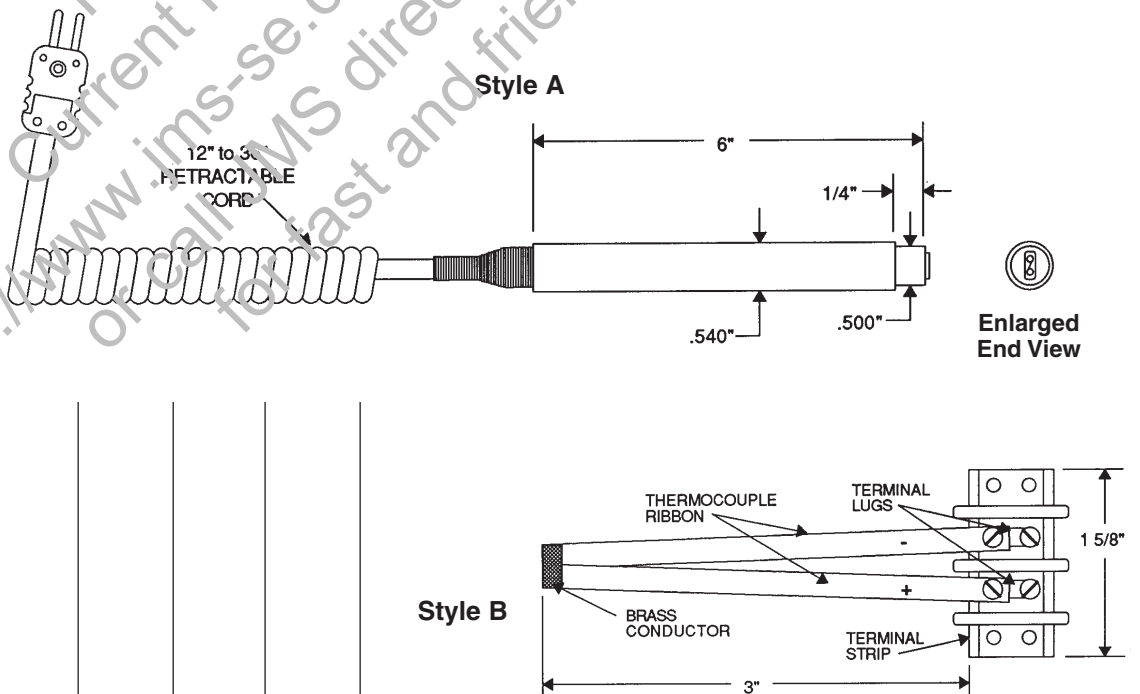
4H	J	B	6"	G	H	9-36"	B
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SURFACE PROBES

JMS offers this standard surface probe as an option to the brush sensor (also included in this section) for surface temperature measurements.

Most all of these types of probes have a common weakness. Since the tips must remain in contact with the surface being measured, the tips are prone to damage and failure. Unlike our competitors, our design allows you to easily replace the tip and get back to business.

#1	SERIES
4	Surface Measurement Thermocouple
#2	STYLE
A	Hand Held
B	Permanent Mount
#3	TYPE
J	Iron/Constantan, standard limits of error
K	Chromel/Alumel, standard limits of error
X	Other, specify
#4	LENGTH
2	Standard
X	Other, specify
#5	LEAD WIRE INSULATION AND LENGTH IN INCHES
S	Standard retractable cord. 12" to 36" long (PVC)
X	Other, specify
Z	N/A (For Style B)
#6	COLD END TERMINATION
B	Miniature plug (Standard for Style A)
X	Other, specify
Z	N/A (For Style B)
#7	# OF REPLACEMENT TIPS
0	None
1	Number of tips



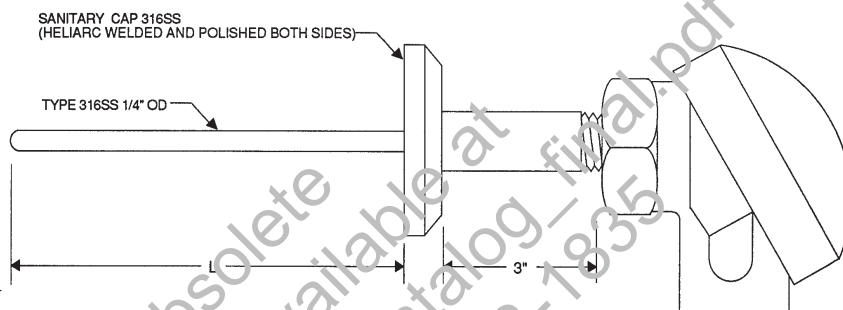
4	A	J	2	S	B	1
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3A APPROVED SANITARY SENSORS

CIP (clean-in-place) line of 3-A certified sanitary thermocouples and RTD's from JMS are specially designed to meet the needs of the food, dairy, beverage, pharmaceutical, chemical and cosmetic industries. They are ideally suited for a number of applications where corrosion and contamination are factors. They are fabricated from stainless steel using a method assuring imperfection-free surfaces.

Units may be supplied utilizing sanitary caps from Alloy Products, Cherry-Burrell or Lapish Tri-Clover, or spring loaded fittings in sanitary thermowells. Each design is polished to a No. 4 finish to assure that there are no pits, folds or crevices. The exterior nipple, also stainless steel, can be joined to a coated or plastic connection head, designed to withstand caustic washdown. A typical RTD or Thermocouple may be used with a sanitary thermowell, see pages 1-1 and 3-1.

#1	SERIES
4A	Sanitary Sensors
#2	TYPE
J	Iron/Constantan
K	Chromel/Alumel
T	Copper/Constantan
E	Chromel/Constantan
3	RTD 100Ω Platinum .00385 alpha, 3 wire [Pg 3-17, 3-18]
X	Other, specify



#3	LIMITS OF ERROR	ELEMENT CONSTRUCTION
1	Standard	Single
2	Standard	Dual
3	Special	Single
4	Special	Dual
X	Other, specify	

#4	MEASURING JUNCTION
G	Grounded
U	Ungrounded
I	Isolated
Note: RTD is always ungrounded from tubing.	

#5	IMMERSION LENGTH (L)
--"	Length in inches

#6	SANITARY CAP OPTIONS - CLAMP FITTINGS
A	Alloy Products (K16A)
B	Cherry-Burrell (16AI-14I) (Must specify standard or screwed)
T	Tri-Clover (16 AMP)

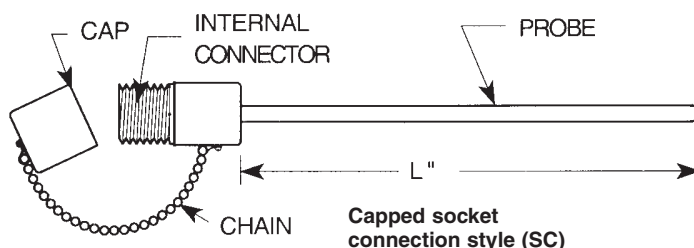
#7	SANITARY CAP OPTIONS - BEVEL SEAT FITTINGS
U	Alloy Products (16APV with No. 13H Nut)
Y	Cherry-Burrell (16A-14 with No. 13H Nut)
Y	Tri-Clover (16A with No. 13H Nut)

SEE NOTE 1

#8	STANDARD INDUSTRIAL FITTINGS
R	Spring loaded with 1/2" x 1/2" NPT 4" nipple (To be used with a sanitary thermowell. See page 5-5.)
X	Other, specify
Z	N/A



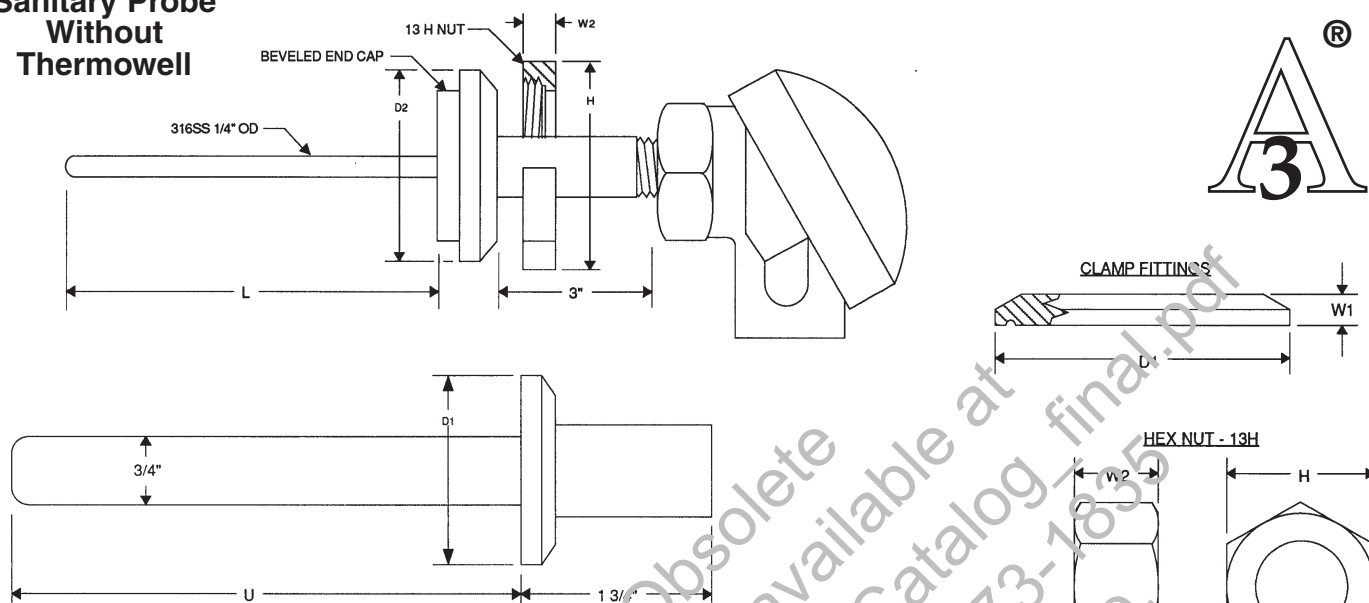
Note 1: All caps are mounted facing the hot end - unless specified here. ie. Use X + brand of cap + reverse mount



4A	J	1	G	12"	A
----	---	---	---	-----	---

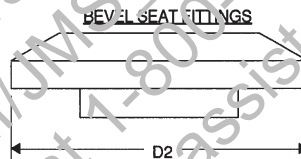
3A APPROVED SANITARY SENSORS

Sanitary Probe Without Thermowell



Standard Industrial Sanitary Thermowells

[See 5-5 and 5-6 for ordering info on TWells]



#7	CAP TUBE SIZE	CLAMP FITTING A (inches) B		BEVEL SEAT FITTING A (inches) B		HEX NUT - 13H A (inches) B	
15	1 1/2"	.250	1.984	1.844	N/A	31/32	2.4062
20	2"	.250	2.516	2.375	N/A	.250	3
25	2 1/2"	.250	3.047	2.906	N/A	.250	3.5938
30	3"	.250	3.579	3.438	N/A	.250	4.1875
40	4"	.312	4.682	4.500	N/A	.312	5.4375
Z	Not Applicable						
X	Other, specify						

#8	FINISH	
H	#4 Finish (Standard)	
E	Electropolish	
P	Passivate (includes #4 Finish)	

#9	LEAD WIRE TYPE AND LENGTH IN INCHES	MAX. TEMP. °F
Z	No lead wire	
1"	Glass braid	900°F
3"	Teflon	400°F
X	Other, specify	

#10	COLD END TERMINATION
A	Bare ends
6P	Epoxy coated cast head with gasket
WP	White plastic head (3A Standard)
SC	Capped socket connection (with mating connection) - See Pg. 4-13
X	Other, specify*

*When specifying another style connection head or no head, be sure to observe requirements and restrictions as imposed by the 3-A Standard #09-09.

15	H	3-36"	A
----	---	-------	---

CONTINUOUS THERMOCOUPLE TRANSDUCER CABLE

FTLD® - The Heat-Seeking Thermocouple

Introduction

The FTLD Continuous Thermocouple® is a temperature measuring sensor, which takes the form of a thin flexible cable. Like its predecessor CT°C®, it is a heat-seeking thermocouple, using similar thermo-electric techniques, but designed especially to reveal changes in the narrow band of temperatures only a few degrees above normal ambient.

FTLD is able to measure the maximum temperature detected between its two ends, then track any increase, even if the position of the "hot-spot" changes. Such ability offers an immense opportunity to prevent loss due to overheat, in commercial as well as industrial applications.

This advanced form of detector permits the design of overheat warning systems, which are highly sensitive to early departures from normal, yet exhibit an extraordinary freedom from false alarms.

Operating Principle

A Circuit formed from two dissimilar wires joined at both ends, develops an emf (voltage) proportional to the difference in the two junction temperatures. This is the long established Thermo-electric effect, and today the junctions are known as the "Measuring Junction". See diagrams below.

Although an FTLD sensor performs like a normal thermocouple, the measuring junction is not formed by directly joining the two wires. More remarkably, the Measuring Junction is not fixed, but becomes concentrated at the hottest point within the insulation resistance when subjected to an increase in temperature.

The nature of the insulation causing this phenomenon is such that the voltage developed between the two wires always relates to the highest temperature along the cable sheath.

Features

- Stable
- Moisture resistant
- Sensor needs no power
- Virtually free from false alarms
- Ambient temperature compensation
- Early warning of abnormal temperature
- Alarm point unaffected by cold weather
- Simple apparatus (Hazardous Area)
- User adjustable alarm settings
- No site calibration

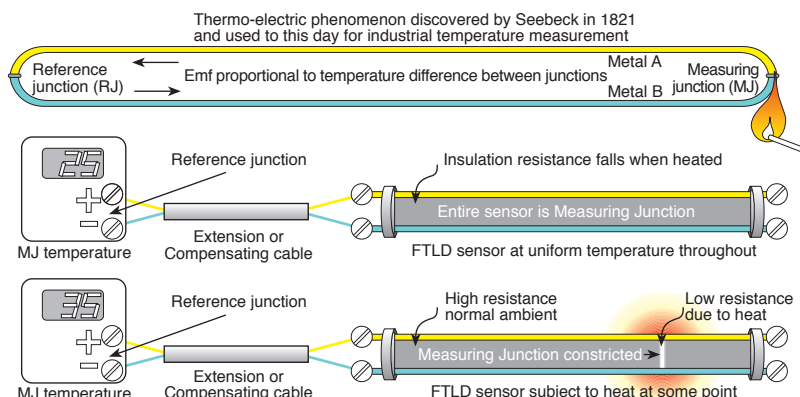
Advantages

- Self-generating temperature sensor
- Measures maximum temperature
- Initial site temperature check not needed
- Visible operating status
- Optional rate of change alarm (same unit)
- Alarm settings directly in degrees
- Alarms can be set before installation
- Interchangeable sensors
- Sensor not microphonic
- System check facility in sub zero band
- Alarm units for mains power or low voltage
- Sensor need not be near alarm unit

Specification

- Protective sheath - Dual layer PTFE
- Measuring element - Type "K" thermocouple - insulated
- Sensor output - Millivolts DC related to maximum cable temperature
- Normal operating range - -29 to 80°C (-20 to 176°F)
- Survival range - -40 to 200°C (-40 to 392°F)
- EMI protection - Twisted cores & metallised tape tube
- Insulation - Glass fibre impregnated with special insulating material
- Minimum bend radius - 40 mm
- Construction - Twisted pair, NTC insulation, EMI screen, outer sheath
- Sizes - 3.5mm OD approx. Cut to length as required
- Minimum length - 15 meters
- Hazardous area use - Measuring element is "Simple Apparatus"

FTLD® - System Operating Principle



By measuring both the sensor output and the temperature at its own terminals the instrument is able to compute the hot spot temperature and make automatic compensation for ambient temperature changes

CONTINUOUS THERMOCOUPLE TRANSDUCER CABLE

FTLD® - Prevention of Loss due to Overheat

Think of your sphere of work, look around you - is there more you can do?

The Application

Temperature rise due to unrestrained release of physical or chemical energy, is a regular cause of serious loss in industry, commerce and everyday life. It is responsible for countless incidents, the financial consequences of which range from minor to catastrophic.

One common example of temperature rise ending in loss, is combustion. Some others are wear, distortion, fracture, melting, drying, and seizure.

Breakdown at temperatures well below the boiling point of water, is an area of particular concern - one where losses from shut-down can be enormous. For example, temperatures at which ordinary heat detectors remain dormant, can destroy the electronics crucial to computers, communications and data handling equipment.

For many years point type temperature detectors of various types, including conventional thermocouples, have been used to monitor processes and plant risk from heat induced damage. In almost every case the inevitable compromise between numbers (cost), and detector coverage (efficiency), has defeated the exercise.

FTLD offers a very powerful and cost effective alternative to any currently available system, by eliminating the question of where to place the sensor; by constantly monitoring maximum temperature in the area covered; and by possessing such stability, that false alarms are virtually non-existent.

Very often, a loss-inducing condition begins with temperature rising very slowly above normal for the installation at risk. This is the time when corrective action has the greatest chance of success. An FTLD system capitalizes on this opportunity by alerting operating personnel to the onset of a dangerous condition, some time before the main danger temperature alarm is initiated.

Areas of Risk

Storage & Maintenance

Foodstuffs, Beverages & Medicines
Wines & Spirits
Coal, Gas & Oil
Fabric, Timber & Building Materials
Clothing
Paper & Board
Aircraft, Ship & Vehicle
Maintenance

Communications

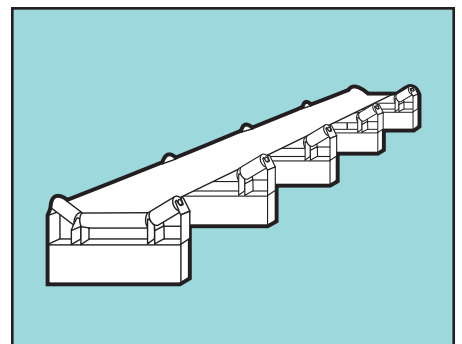
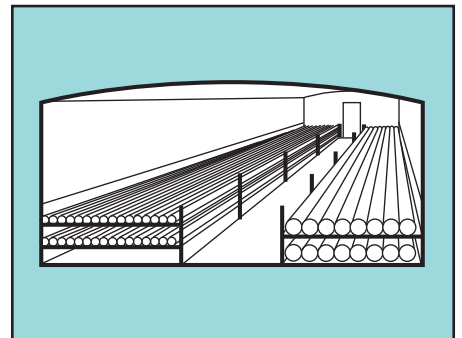
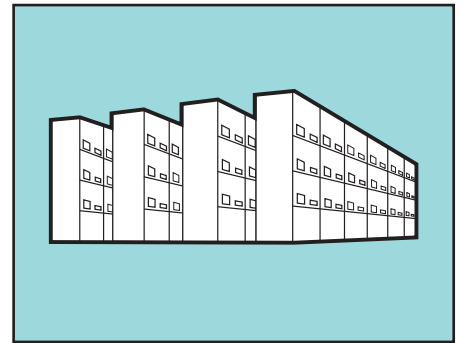
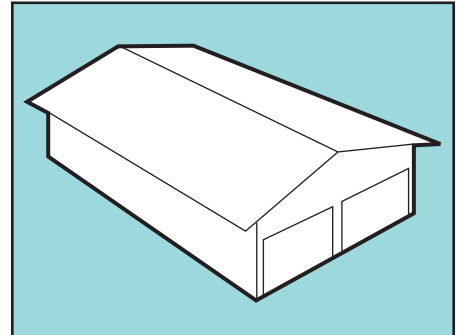
Telephone Exchanges
Computer Installations
Radio, Radar & Television Stations
Television & Film Studios
Data & Signal Cable Ducts
Instrumentation & Control Rooms
Civil & Defense Facilities

Services

Food Production & Supply
Manufacturing Facilities
Rail, Road & Cable Tunnels
Fuel, Water & Sewage Treatment
Airports, Seaports, Rail & Bus
Stations
Hospitals, Schools & Universities
Shopping, Sports & Leisure
Centers

Materials Handling

Oil & Gas Pumps & Valves
Coal Conveyors & Silos
Electricity Sub-stations
Air, Sea & Land Vehicles
Agriculture
Ship, Aircraft & vehicle Loading
Goods & Mail Distribution



**ASK ABOUT OUR
HIGH TEMPERATURE
VERSION < 1800°F.**

EXOTIC THERMOCOUPLE SELECTIONS

JMS Southeast can provide a variety of exotic thermocouple designs and materials. The following information explains some of our capabilities. Please contact JMS Southeast for ordering information on these assemblies.

SENSOR TYPES

TYPE	THERMOELEMENTS	MAX. TEMP.°C
S	Platinum/Platinum 10% Rhodium	1600
B	Platinum 6% Rhodium/Platinum 30% Rhodium	1600
R	Platinum/Platinum 13% Rhodium	1600
W5 (C)	Tungsten 5% Rhenium/Tungsten 26% Rhenium	2200
W3 (D)	Tungsten 3% Rhenium/Tungsten 26% Rhenium	2200
W (G)	Tungsten/Tungsten 26% Rhenium	2200

Not
ANSI

(See Pg. 1-1 for standard materials.)

SHEATH MATERIAL

SHEATH MATERIALS	RECOMMENDED* TEMPERATURE		MELTING** POINT		WORKING ENVIRONMENT
	°C	°F	°C	°F	
Aluminum	427	800	660	1220	I
Boron Nitride	2000	3632	3000	5432	I, V, O***
Brass	371	700	1000	1832	I, V
Columbium (Niobium)	1981	3600	2468	4474	V
Copper	316	600	1083	1981	I, V
Graphite	3000	5425	3652	6606	I, V
Hastelloy X	1204	2200	1260-1354	2300-2470	O, I, V
Hastelloy C	1093	2000	1149	2100	O, R, I, V
Inconel 702	1204	2200			O, I
Molybdenum	2204	4000	2610	4730	I, V, R
Platinum	1677	3050	1760	3200	O, I, V
Silicon Nitride	1750	3182	1900	3452	I, V
Silicon Carbide	2200	3992	2700	4892	I, V
S/S 310	1149	2100	1399	2550	O, I, V
Tantalum	2483	4500	3000	5425	I, V
Titanium	850	1562	1675	3047	I, V
Tungsten	3000	5425	3315+	6000+	I, V, R

V=Vacuum

I=Inert

O=Oxidizing

R=Reducing-Hydrogen

*Recommended temperatures indicated are for supported vertical installations and may be reduced if used in an unsupported horizontal direction.

**The melting points listed may not be always considered accurate as some materials sublime before melting.

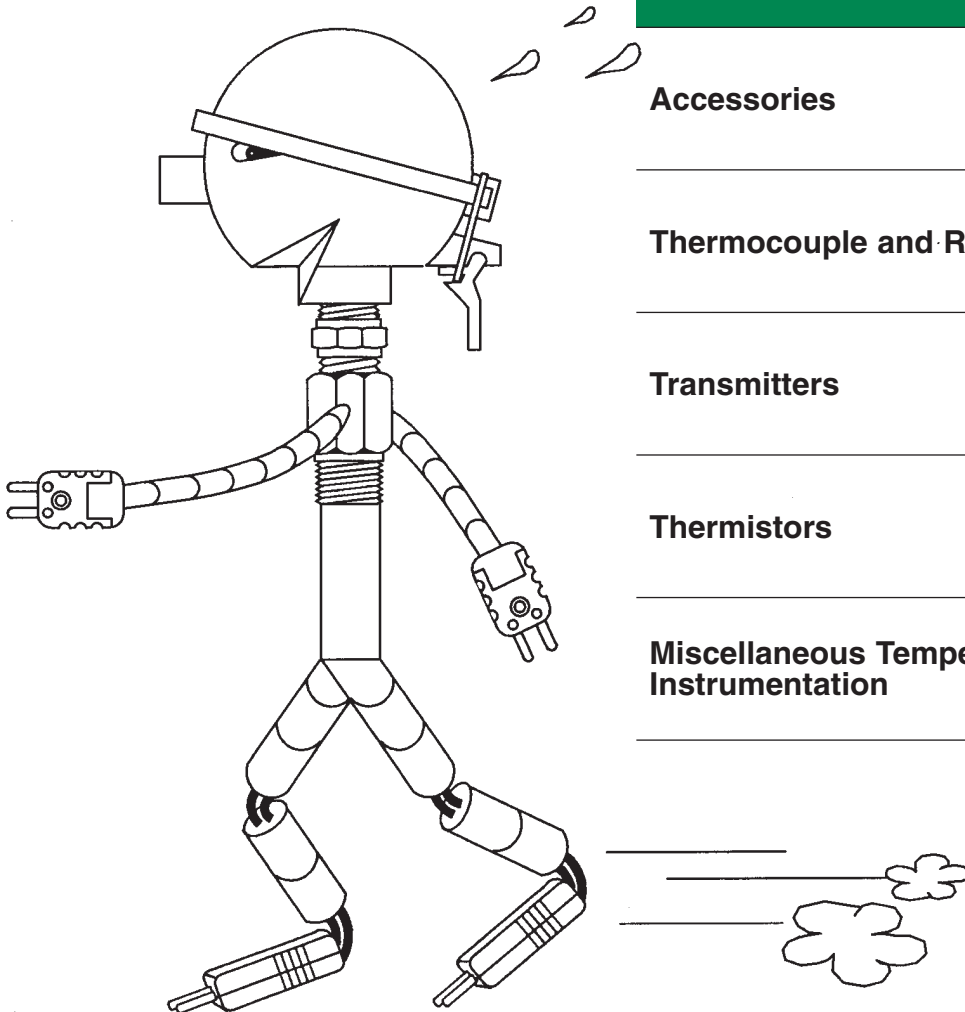
**Boron Nitride may be used to 850°C in an oxidizing environment.

INSULATION MATERIAL

INSULATION MATERIALS		RECOMMENDED* TEMPERATURE		MELTING** POINT		WORKING ENVIRONMENT
		°C	°F	°C	°F	
Magnesium Oxide	MgO	2300	4172	2800	5072	I, O
Alumina Oxide	Al ₂ O ₂	1900	3452	2050	3722	V, I, O
Hafnia Oxide	HfO ₂	2400	4352	2812	5094	O, V, I
Boron Nitride	Bn	2000	3632	3000	5432	V, I, O

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Swiftly Sensor



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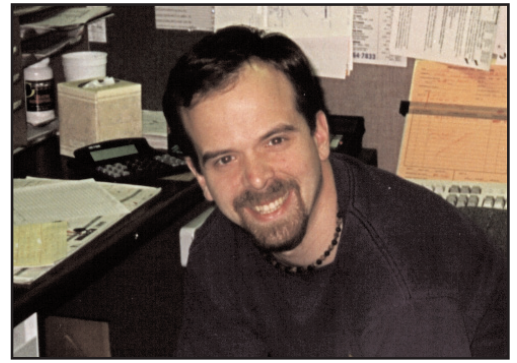
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Notes

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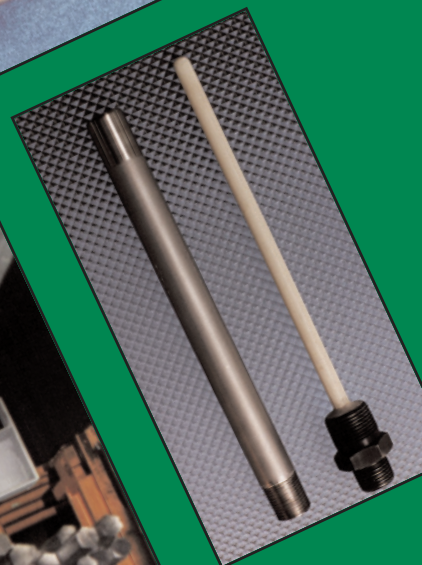
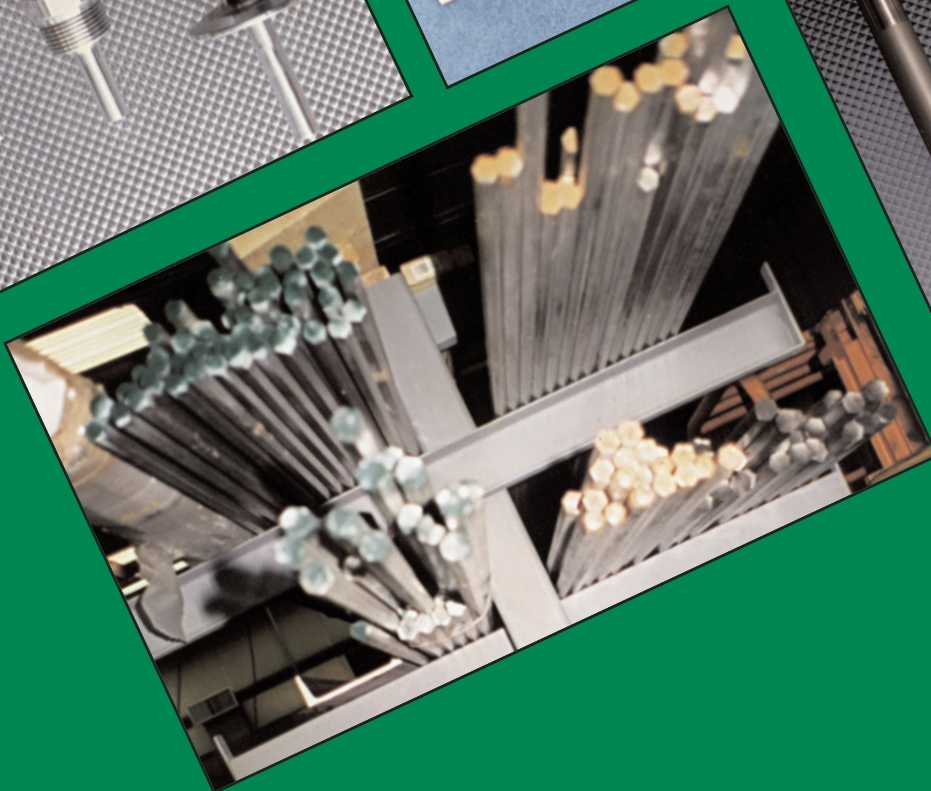
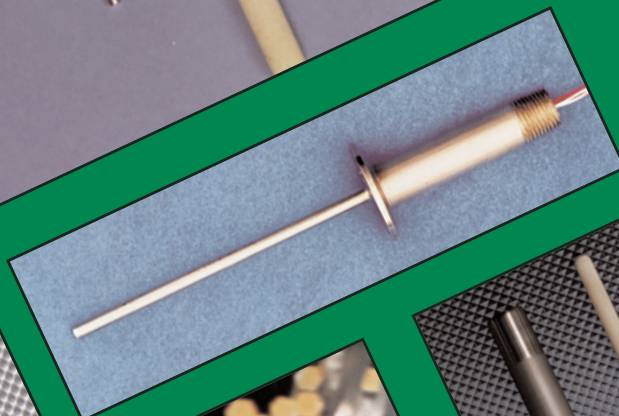
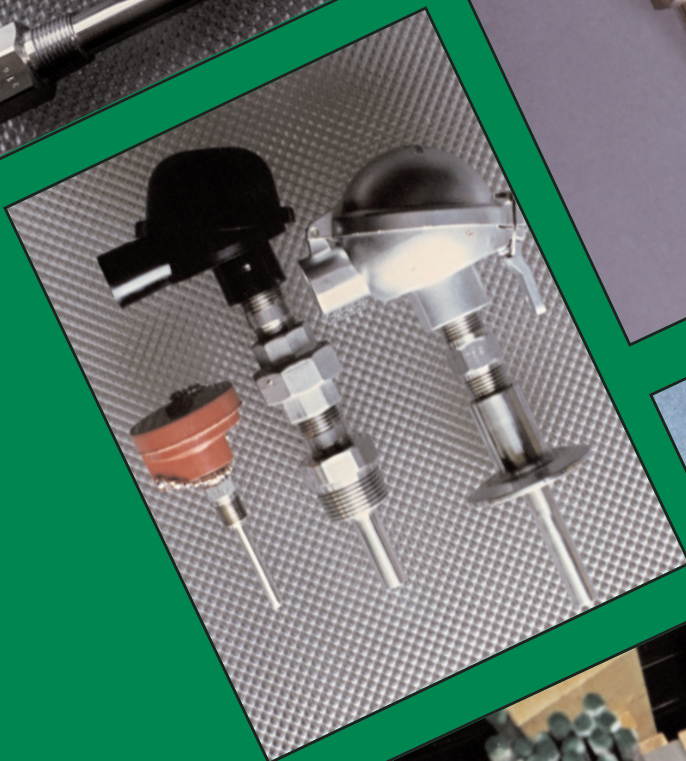


JMS Southeast, Inc.
Temperature Measurement



Thermowells, Protection Tubes, and Coatings





THERMOWELLS

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THREADED AND SOCKET WELD THERMOWELLS

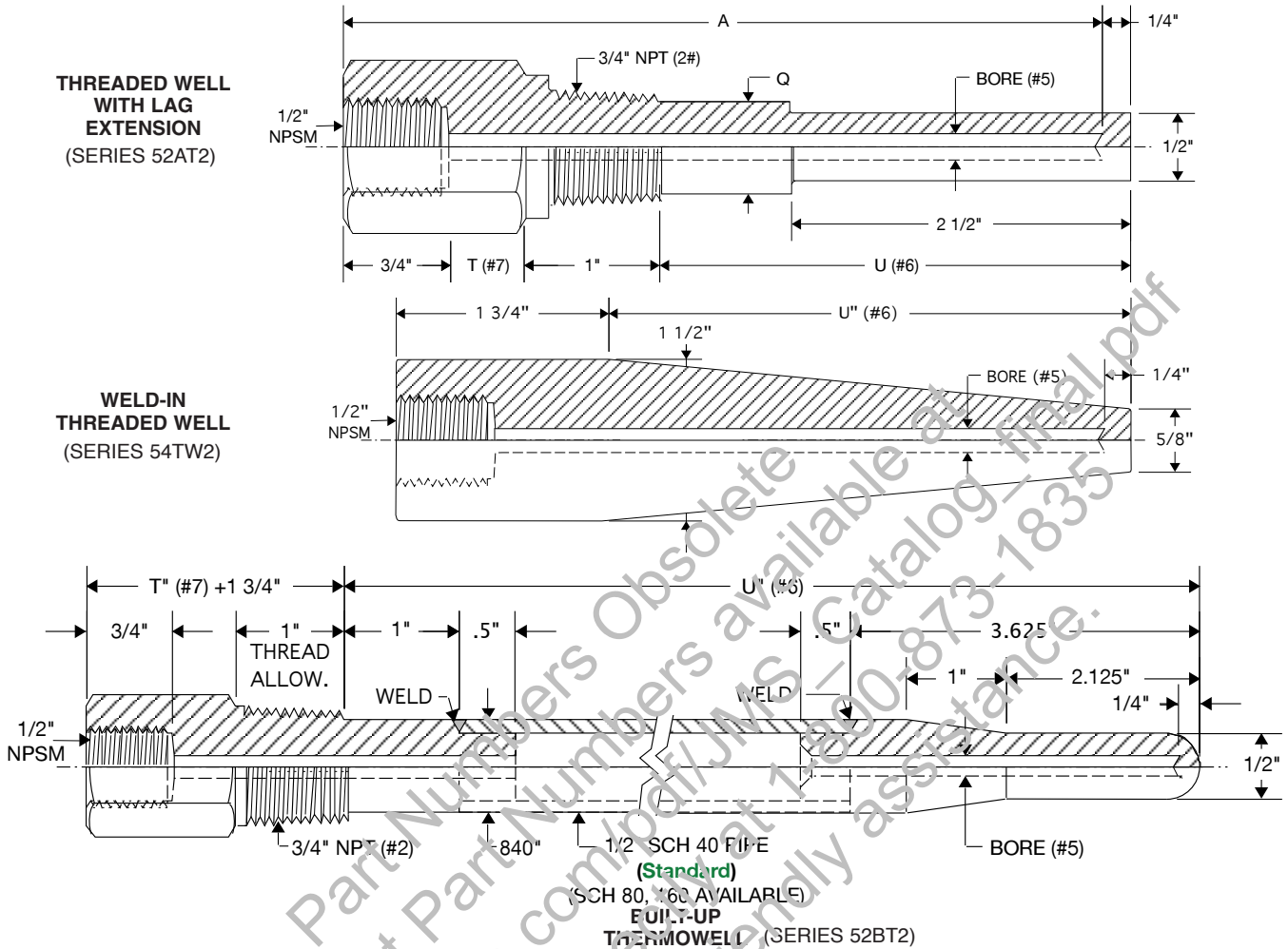
#1	SERIES [See pages 20-24 for complete information on dimensions, velocity ratings, and pressure ratings]			
5	Thermowells - Add "W" here for a plug with a chain attached to well. (i.e. 5W)			
#2	THREADED WELLS / EXTERNAL THREAD		SOCKET WELL WELDELET SIZE	
1	1/2" NPT		N/A	
2	3/4" NPT (Standard)		3/4" (Standard)	
3	1" NPT		1"	
4	1 1/2" NPT		1 1/2"	
X	Other, specify			
#3	SHANK STYLE [15]			
A	Step shank (Standard)			
S	Straight shank			
T	Tapered shank			
B	Built up step shank (Recommended for over 22 1/2", see drawing on 5-2) (Other shank styles are available)			
X	Other, specify			
#4	THREADED OR SOCKET WELD WELLS			
T	Threaded well design			
S	Socket well design			
W	Weld-in (Tapered shank standard)			
X	Other, specify			
#5	BORE SIZE			
2	.260" ID used for .250" OD sensors (Standard)			
3	.385" ID used for .375" OD sensors (straight or tapered only)			
X	Other, specify			
#6	U (INSERTION) DEPTH [13]	STANDARD "T" DIMENSION	SENSOR LENGTH	
			NO LAG	WITH LAG
B	2 1/2"	2	4	6
C	4 1/2"	3	6	9
D	6"	3	7 1/2	10 1/2
E	7 1/2"	3	9	12
F	10 1/2"	3	12	15
G	13 1/2"	3	15	18
H	16 1/2"	3	18	21
I	22 1/2"	3	24	27
X	Other, specify			
#7	T (LAG) EXTENSION [15]			
T	Standard lag (For length see Table in Symbol #6)			
U	N/A (No lag)			
X	Other, specify			
#8	WELL MATERIAL [31-34]			
E	F22			
F	F11			
G	Carbon steel			
H	304 Stainless steel			
I	Low Carbon 304 Stainless steel			
J	310 Stainless steel			
K	316 Stainless steel (Standard)			
L	Low Carbon 316 Stainless steel			
M	Inconel 600			
N	Monel			
Q	Hastelloy C			
S	Titanium			
X	Other, specify (i.e.: Teflon, PVC, Nickel, etc.)			
#9	TAGGING OPTIONS			
1	STAMPING	Stamped on well (Standard)		
X		Other		
Z		N/A Note: You must always specify information required on tag.		

***Note:** JMS recommends the use of the "Built Up" design if longer than 22 1/2" See page 5-2 for drawing.

[] BRACKETS INDICATE PAGE NUMBERS ON WEB OR FULL CATALOG FOR ADDITIONAL TECHNICAL INFORMATION WWW.JMS-SE.COM

5	2	A	T	2	E	T	H	1
---	---	---	---	---	---	---	---	---

THREADED AND SOCKET WELD THERMOWELLS



LIMITED SPACE THERMOWELLS

#1	SERIES
5L	Limited Space Thermowells - Add "W" here for a plug with a chain attached to well. (i.e. 5LW)
#2	WELL MATERIAL
H	304 Stainless steel
K	316 Stainless steel
M	Inconel 600
X	Other, specify
#3	TAGGING OPTIONS
1	Stamped on well (Standard)
X	Other
Z	N/A
	Note: You must always specify information required on tag

Note:
Immersion length of a spring-loaded sensor to fit this well is 2 1/2".

LIMITED SPACE THERMOWELL

5L	M	1	
----	---	---	--

FLANGED THERMOWELLS

#1	SERIES [See pages 25-27 for complete information on dimensions, velocity ratings, and pressure ratings]				
5T	Thermowells - Add "W" here for a plug with a chain attached to well. (i.e. 5TW)				
#2	CONFIGURATION				
A	Step shank (Standard)				
S	Straight shank				
T	Tapered shank				
#3	BORE SIZE				
2	.260" ID used for .250" OD sensors (Standard)				
3	.385" ID used for .375" OD sensors (straight or tapered only)				
X	Other, specify				
#4	U (INSERTION) DEPTH [15]	"U" DIMENSION	SENSOR LENGTH		
A	2"	2"	4"		
B	4"	4"	5"		
C	7"	7"	9"		
D	10"	10"	12"		
E	13"	13"	15"		
F	16"	16"	18"		
G	22"	22"	24"		
X	Other, specify				
#5	T (LAG) EXTENSION [15]				
T = $\frac{Z}{N/A}$	Length in inches N/A (Standard)				
#6	WELL MATERIAL [31-34]				
G	Carbon steel	P	Molybdenum		
H	304 Stainless steel	Q	Hastelloy C		
I	Low Carbon 304 Stainless steel	R	Tantalum		
J	316 Stainless steel	S	Titanium		
K	316 Stainless steel	X	Other, specify		
L	Low Carbon 316 Stainless steel				
M	Inconel 600				
N	Monel				
O	Hastelloy B				
Note: Special jackets and coating are available for thermowells. Call our engineering department for more information. See pages 5-35 - 5-39.					

Series 5TS

SPECIFY FLANGE SIZE
RATING & MATERIAL #8 - #10

Series 5TA

SPECIFY FLANGE SIZE
RATING & MATERIAL #8 - #10

↓

↓

↓

↓

↓

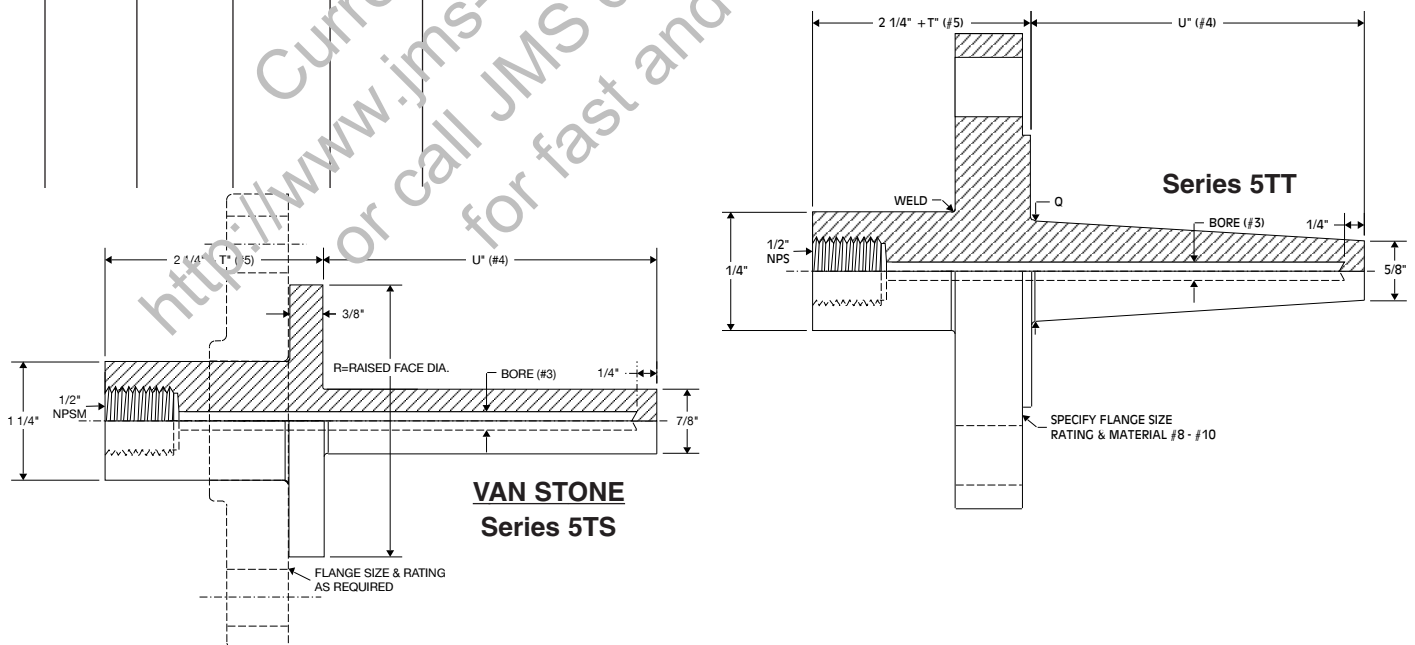
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5T	A	2	C	Z	H
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FLANGED THERMOWELLS

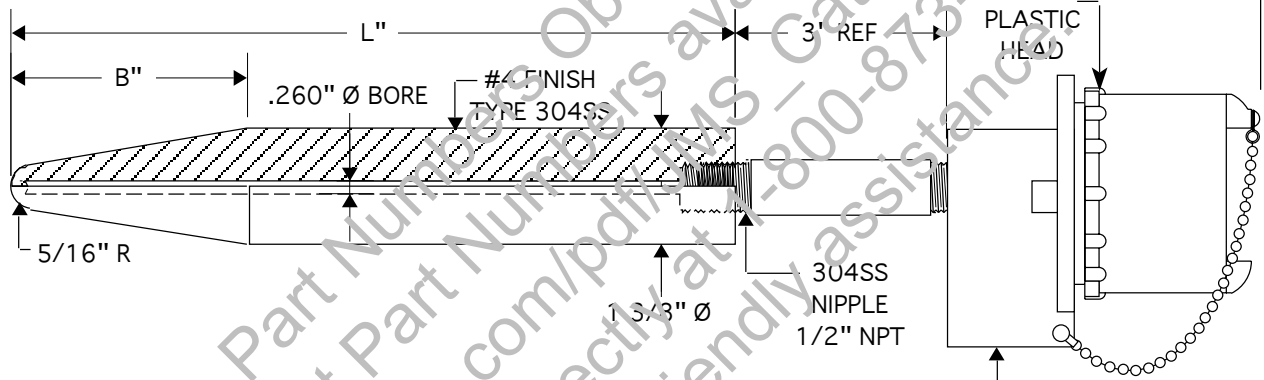
#7	SIZE OF FLANGE		
3	1"	7	Van Stone 1 1/2" (1.900")
4	1 1/2"	X	Other, specify
5	2"		
6	Van Stone 1" (1.315")		
#8	*FLANGE RATING		
A	150*		
B	300*		
C	400*		
D	600*		*Pounds rating per ANSI B-16.5
E	900*		
F	1500*		
X	Other, specify		
#9	FACING		
1	Raised face (Standard)		
2	Flat face		
#10	FLANGE MATERIAL [31-34]		
G	Carbon steel		
H	304 Stainless steel		
I	Low Carbon 304 Stainless steel		
J	310 Stainless steel		
K	316 Stainless steel		
L	Low Carbon 316 Stainless steel		
M	Inconel 600		
N	Monel*		
O	Hastelloy B*		
P	Molybdenum*		
Q	Hastelloy C*		
R	Tantalum*		
S	Titanium*		
X	Other, specify		
#11	TAGGING OPTIONS		
1	STAMPING	Stamped on well (Standard)	
X		Other	
Z		N/A	
		Note: You must always specify information required on tag	

Note: For complete information on flange dimensions see page 5-27.



4	A	1	H	1
---	---	---	---	---

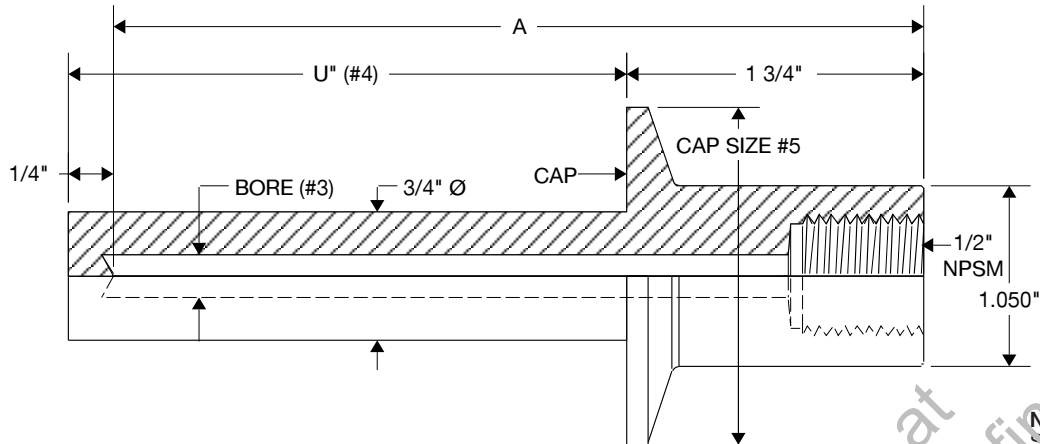
SPRING LOAD SENSOR FOR POSITIVE CONTACT



Thermocouple: 1(insert type or I/C)1BKU(insert length)EZ76GZA
RTD: 3ESBK(insert length)BEZ34ZWZA

#1	SERIES			
5C	3-A Certified Sanitary Thermowells - Add "V" here for a plug with a chain attached to well. (i.e. 5CW)			
	#2	L THERMOWELL LENGTH	B, TAPER LENGTH	REPLACEMENT SENSOR LENGTH (SPRING LOADED)
	10 1/8	10 1/8"	3 1/4"	14 1/8"
	11 7/8	11 7/8"	5"	15 1/2"
	13 1/8	13 1/8"	3 3/4"	17 1/8"
	14 1/8	14 1/8"	6 1/16"	18 1/8"
	16 5/8	16 5/8"	9 9/16"	20 5/8"
	#3	TAGGING OPTIONS		
	1	STAMPING	Stamped on well (Standard)	
	X		Other	
	Z		N/A Note: You must always specify information required on tag	
Note: Does not include head and nipple. Thermowell Only				
5C	10 1/8	1		

SANITARY THERMOWELLS

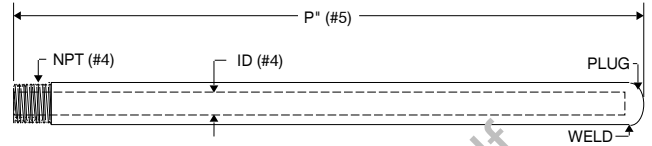


Note: Straight Shank shown.
See page 5-20 for details.

#1	SERIES		
5F	Sanitary Thermowells - Add "W" here for a plug with a chain attached to well. (i.e. 5FW)		
#2	STYLE [25-27]		
A S T	Step shank (Standard) Straight shank Tapered shank		
#3	BORE SIZE		
2 3 X	.260" ID .385" ID Other, specify		
#4	U (INSERTION) DEPTH [15]	"U" DIMENSION	SENSOR LENGTH
B C D E Y	2 1/2" 3 1/2" 4" 7 1/2" Other, specify	2 1/2" 4 1/2" 6" 7 1/2" 9"	4" 6" 7 1/2" 9"
#5	CAP SIZE [SECTION 4]		
A B C X	1" 1 1/2" 2" Other, specify		
#6	BRAND OF CAP	All caps are mounted facing the hot end - unless specified here. i.e. Use X + brand of cap + reverse mount	
T A B X	Tri-Clover (16 AMP) Alloy Products (K16A) Cherry Burrell (16Al - 14l) Other, specify		
#7	MATERIAL		
H K L M X	304 Stainless steel 316 Stainless steel Low Carbon 316 Stainless steel Inconel 600 Other, specify		
#8	POLISH		
H E P	High polish (#4 Finish) Standard Electropolish or (8G finish) Passivate (After #4 Finish)		
#9	TAGGING OPTIONS		
1 X Z	STAMPING Stamped on well (Standard) Other N/A		
Note: You must always specify information required on tag			

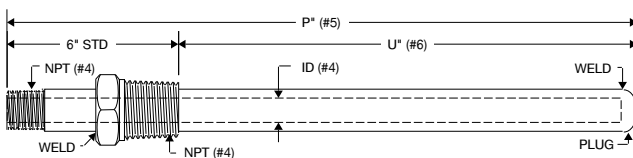
METAL PROTECTION TUBES

#1	SERIES						
5P	Metal protection tube - Add "W" here for a cap and chain to fit over open end. (i.e. 5PW)						
#2	RESPONSE TYPE						
1	Fast response tip						
2	Standard response tip						
#3	ATTACHING DEVICES						
B	Carbon steel bushing						
K	Stainless steel bushing						
J	Cast iron floor flange						
Z	N/A						
X	Other, specify (i.e.: 3" 150 lb raised face.)						
#4	**NOMINAL SIZE	I.D.	O.D.	N.P.T. [30]	STANDARD BUSHING PROCESS CONNECTION	STANDARD FLOOR FLANGE SIZE	
18	1/8"	.269	.405	1/8"	1/4" NPT	3"	
14	1/4"	.364	.540	1/4"	1/2" NPT	3"	
12	1/2"	.622	.840	1/2"	3/4" NPT	3"	
34	3/4"	.824	1.050	3/4"	1" NPT	4"	
10	1"	1.049	1.315	1"	1 1/4" NPT	4"	
X	Other, specify						
**Refers to schedule 40 pipe. For other pipe schedules, use "X" in the above symbol and specify the pipe schedule in description. Ex.: 5P1BX1210C X=12 Schedule 80 pipe.							
#5	OVERALL LENGTH (P)						
A	12"						
B	18"						
C	24"						
D	30"						
E	36"						
F	42"						
G	48"						
H	54"						
I	60"						
X	Other, specify						
#6	FIXED OR ADJUSTABLE MOUNTING METHOD						
U	Insert "U" dimension. (Only if using a permanently fixed attaching device. See drawing below)						
Z	N/A (Bushing if specified will be adjustable)						
#7	PROTECTION TUBE MATERIAL [31-34]						
C	Carbon steel						
H	304 Stainless steel						
J	310 Stainless steel						
K	316 Stainless steel - (Standard)						
M	Inconel 600						
X	446 Stainless steel						
X	Other, specify						
#8	TAGGING OPTIONS						
1	Stamped on well (Standard)						
X	Other						
Z	N/A						
Note: You must always specify information required on tag							

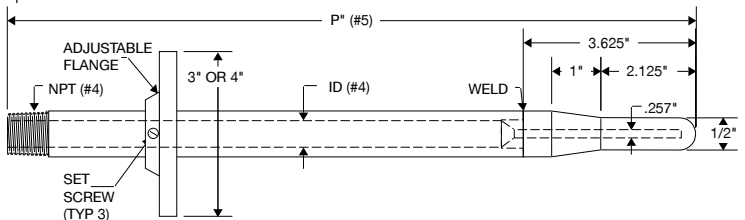


Style 5P2Z

Style 5P2B12A9K



Style 5P1J12BZH



5P	2	B	12	A	9"	K	1
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CERAMIC PROTECTION TUBES

Alumina and mullite protection tubes are used at high temperatures that have a small slope of temperature change. Any thermocouple type can be used in these ceramic tubes; however, platinum-rhodium and chromel-alumel are used most often due to their high operating temperature range. "Alumina" is an alumina oxide ceramic (99.7% Al₂O₃) and "mullite" is a compound of alumina and silica. Alumina tubes can be used at 3400°F (1870°C) and mullite tubes can be used at 3100°F (1700°C). They are somewhat gas tight, sensitive to thermal shock, and can crack if one end of the tube is heated at a different rate than the other. If the tube is exposed to a significant sharp decline or rise in temperature, the tube may crack.

Platinum-Rhodium thermocouples should always be protected in a ceramic protection tube. Alumina should be used rather than mullite for all atmospheres except oxidizing, where mullite can be used. The silicon from the mullite can contaminate the platinum-rhodium thermocouple.

We recommend that the user preheat the entire tube to ≈ 900°F before installing it into a hot process environment.

#1	SERIES
5D	Ceramic Protection Tubes - Add "W" here for a cap and chain to fit over open end. (i.e. 5DW)
#2	MATERIAL
A	Alumina
M	Mullite
#3	ATTACHING DEVICE
O	No mounting fitting
P	Open both ends, no mounting fitting
C	Collar* (See chart below for collar dimensions)
B	Mounting bushing (Standard)
S	Carbon steel mounting sleeve - (4" long sleeve is standard)
X	Other, specify
#4	TUBE SIZE I.D. x O.D.
14	1/4" x 3/8"
38	3/8" x 1/2"
76	7/16" x 11/16"
12	1/2" x 3/4" Standard
34	3/4" x 1"
10	1" x 1 1/4"
X	Other, specify
#5	LENGTH (L)
A	6"
B	12" Standard
C	18"
D	24" Standard
E	30"
F	36"
X	Other, specify
#6	TAGGING OPTIONS
Y	Stamped on well Standard
X	Other
Z	N/A
STAMPING	Note: You must always specify information required on tag

NOTE:
Bushings are always 1/2" NPT head connection, and 3/4" NPT process connection. Bushings are not standard for 3/4" x 1" or 1" x 1 1/4" ceramic tubes.
For tubes smaller than 11/16" OD, the "L" length will equal the total length including the bushing.

CS sleeve for tube NPT will equal tube OD (ie: 1" OD will use 1" NPT threads). It can be used to attach adjustable flanges and bushings as shown on page 5-7. Use "X" in symbol number 3 and describe.

5D A B 12 B 1

Style 5DAO and 5DMO

Style 5DAC and 5DMC

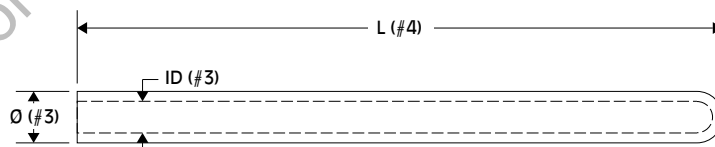
Style 5DAB12 and 5DMB12 (SEE NOTE)

MULLITE/ALUMINA PROTECTION TUBES

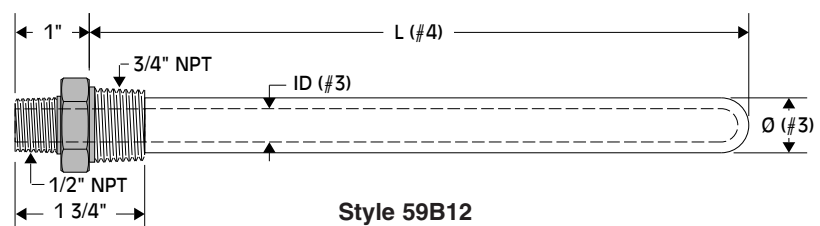
The composition of this tube is 80% alumina and 20% silica. This protection tube has excellent thermal shock characteristics (3.0×10^{-6} in/in/ degrees F). It can be characterized as a mullite tube with a higher percentage of alumina than a typical mullite tube would have. It has an outer diameter of 3/4" and an inner diameter of 1/2". It is a light green color. When fully supported, the tube can be exposed to 2900 degrees F. This protection tube is a compromise between mullite and alumina yielding a high quality ceramic tube with excellent thermal shock resistance. Due to the silica content, a platinum/rhodium thermocouple should not be used in it without a primary alumina tube to insulate the thermocouple.

#1	SERIES
59	Mullite / Alumina Ceramic Protection Tube - Add "W" here for a cap and chain to fit over open end. (i.e. 59W)
#2	TUBE STYLE
B	Mounting Bushing - (1/2" NPT head connection and 3/4" NPT process connection)
Z	No Bushing
X	Other, specify
#3	NOMINAL TUBE SIZE
14	I.D. 1/4" O.D. 3/8"
56	5/16" 1/2"
38	3/8" 1/2"
76	7/16" 11/16"
12	1/2" 3/4" (Standard)
#4	TUBE LENGTH (OVERALL)
A	12" (Standard)
B	18"
C	24" (Standard)
D	36"
X	Other, specify
#5	TAGGING OPTIONS
1	Stamped on veil (Standard)
X	Other
Z	N/A
STA: P: NG	Note: You must always specify information required on tag

NOTE:
Bushings are always 1/2" NPT head connection, and 3/4" NPT process connection.
Bushings are not standard for 3/4" x 1" or 1" x 1 1/4" ceramic tubes.
For tubes smaller than 11/16" OD, the "L" length will equal the total length including the bushing.



Style 59Z12



Style 59B12

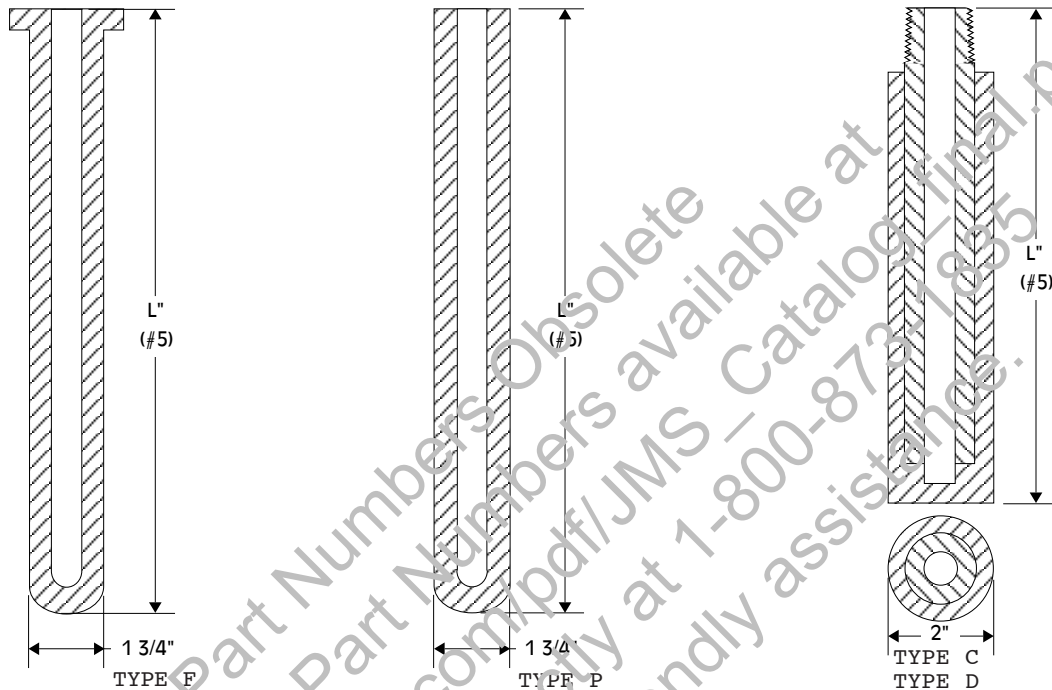
59	B	12	12"	1
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BONDED SILICON CARBIDE PROTECTION TUBES

Silicon carbide protection tubes provide excellent thermal conductivity for quick response to temperature changes. They can be used to replace cast iron tubes, eliminating the possibility of iron pick-up. Spread surface treatment assures adequate protection of the thermocouple.

JMS Southeast offers two types of silicon carbide protection tubes. Type A and B are dense silica bonded silicon carbide and are manufactured with a flange or a plain end as the following drawings indicate.

Type C and D are carbon bonded silicon carbide and graphite. They are manufactured with a black steel pipe located down the center. They have a 1/2" or 3/4" NPT connection to thread into place instead of a flange for mounting as Type A.



#1	SERIES			
5B	Protection Tube - Add "W" here for a cap and chain to fit over open end. (i.e. 5BW)			
	#2	MATERIAL		
	SC	Silicon carbide		
		#3	MOUNTING	
		F	Flange silicon carbide tube (1" I.D. x 1 3/4" O.D.)	
		P	Plain end silicon carbide tube (1" I.D. x 1 3/4" O.D.)	
		C	1/2" NPT threaded silicon carbide tube with reinforced pipe	
		D	3/4" NPT threaded silicon carbide tube with reinforced pipe	
		#4	SIZE	
		2	1/2" I.D. x 2" O.D.	
		3	3/4" I.D. x 2" O.D.	
		4	1" I.D. x 1 3/4" O.D. (for symbols F & P above)	
			#5	LENGTH (L)
			A	18"
			B	24"
			X	Other, specify
5B	SC	F	4	18"

BONDED SILICON CARBIDE PROTECTION TUBES

TYPE 5BSCF CLASSIFICATION

Physical Data: (Typical)	English Units	S.I. Units
Porosity:	14-17%	14-17%
Bulk Density:	161-168 lb/ft ³	2,570-2,690 kg/m ³
True Specific Gravity:	.112-.113 lb/in ³	3.10-3.12 gm/cm ³
Crushing Strength (RT):	14000-18000 psi	96.5-124.0 MPa
Modulus of Rupture (RT):	3000-4000 psi	20.7-27.6 MPa
Modulus of Elasticity (RT):	9-13 x 10 ⁶ psi	62-90 kPa
Load Test, Fail Temperature with 25 psi (172 kPa) Load:	Above 3000°F	Above 1650°C
Coef. of Thermal Expansion: (100 to 1000°C)	2.6 x 10 ⁻⁶ /°F	4.7 x 10 ⁻⁶ /K
Thermal Conductivity:	<u>BTU/hr/ft²/°F/in</u> 105	<u>W/mK</u> 15.1
Chemical Analysis: (Typical)		
Silicon Carbide	(SiC)	86.10%
Silica	(SiO ₂)	11.75%
Alumina	(Al ₂ O ₃)	0.78%
Iron Oxide	(Fe ₂ O ₃)	1.05%
Lime	(CaO)	0.21%
Magnesia	(MgO)	0.10%
Alkalies	(Na ₂ O, K ₂ O)	Trace

CARBON BONDED SILICON CARBIDE & GRAPHITE

TYPE 5BSCP, 5BSCC CLASSIFICATION

Physical Data: (Typical)	English Units	S.I. Units
Porosity:	27-33%	27-33%
Bulk Density:	112-125 lb/ft ³	1800-2000 kg/m ³
Crushing Strength (RT):	1500 psi	10.3 MPa
Modulus of Rupture (2250°F):	200-500 psi	1.4-3.4 MPa
Coef. of Thermal Expansion:	1.5 x 10 ⁻⁶ /°F	2.7 x 10 ⁻⁶ /K
Specific Heat	0.20 BTU/lb/°F	.84 kJ/kgK
Thermal Conductivity:	105 BTU/ft ² /hr/°F/in	15.1 W/mK
Electrical Resistivity (@ RT) 0.012 ohm-cm (@ 2200°F)	0.0076 ohm-cm	
Thermal Shock Resistance	Excellent	
Chemical Analysis: (Typical)		
Silicon Carbide	(SiC)	44.52%
Carbon	(C)	28-36%
Silica	(SiO ₂)	11%
Alumina	(Al ₂ O ₃)	5%
Iron Oxide	(Fe ₂ O ₃)	0.7%
Glaze	—	3%

The information contained in this data sheet has been determined through the application of accepted engineering practice and is believed to be reliable. Since the conditions of application and use of our products are beyond our control, no warranty is expressed or implied regarding accuracy of the information, the results to be obtained from the use of the product, or that such use will not infringe on any patent. This information is furnished with the express condition that you will make your own tests to determine the suitability of the product for your particular use.

SILICON NITRIDE PROTECTION TUBE

SIALON

JMS Southeast, Inc. offers a protection tube for use in molten non-ferrous materials such as molten aluminum, brass, and copper. This special JMS protection tube material is a solid solution of alumina oxide in silicon nitride. Maximum temperature is 1250°C (2280°F) in molten metals. The physical properties are shown below.

TYPICAL PHYSICAL PROPERTIES (SIALON)

Bulk Density	(g/cm ³)	3.25
App. Specific Gravity	(g/cm ³)	3.26
Porosity	(%)	<1
Cold Bend Strength	(25°C) (MPa) (kpsi)	945 137
Hot Bend Strength	(1200°C) (MPa) (kpsi)	560 81
Elastic Modulus	(GPa) (x 10 ³ psi)	288 42
Ther. Exp. Coeff. (20-1000°C)	(x 10 ⁻⁶ C ⁻¹)	3.04
Thermal Conduct	(400°C) (W/mK)	21.3
Critical ΔT	(°C)	950
Hardness (VRN, 1 kg Load)		1650

#1	SERIES		
5E	Silicon Nitride Protection Tube (Sialon)		
	#2	TUBE SIZES	BUSHING
	1	28mm OD x 16mm ID (1.1" OD x .630" ID)	1 1/4"
	2	22mm OD x 12mm ID (.866" OD x .472" ID)	1"
	3	16mm OD x 9mm ID (.630" OD x .354" ID)	3/4"
	4	12.5mm OD x 6.5mm ID (.492" OD x .256" ID)	1/2"
	X	Other, specify	
	#3	TOTAL TUBE LENGTH	
	A	5.91" (150mm)	
	B	11.81" (300mm)	
	C	15.75" (400mm)	
	D	17.72" (450mm)	
	E	23.62" (600mm)	
	X	Other, specify	
	#4	TUBE STYLE	
	B	Mounting bushing	
	S	Carbon steel mounting sleeve - (4" long sleeve is standard)	
	X	Other, specify	
	Z	No fitting	
5E	1	A	S

MCPT - METAL CERAMIC PROTECTION TUBES

#1	SERIES	
5G	Metal Ceramic Protection Tube 5/8" ID x 7/8" OD, 3/4" NPT Conduit Connector	
	#2	LENGTH (L)
	1	9"
	2	12"
	3	18" (Standard)
	4	30" (Standard)
	5	36"
	6	48" (Standard)
	X	Other, specify

Note: Length measured from bottom of threads to closed end.

5G	3	
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The MCPT consists of a hard abrasion-resistant chromium and alumina oxide material. It has good strength at temperatures where many high-temperature metals melt. It is more susceptible to thermal shock than a metal protection tube, however, more resistant to shock than a ceramic protection tube.

The MCPT exhibits good wear resistance and abrasion resistance. It has a hardness of Rockwell C37, which indicates the crushing strength of the material rather than the true hardness of the entire body.

This protection tube serves as an excellent option in the following applications:

RECOMMENDED APPLICATIONS

1. Molten copper and brass to 2100°F intermittent and continuous immersions.
2. Corrosive SO₂ and SO₃ gas (to 2200°F) and SO₂ and HF gas (to 2000°F).
3. Open hearth furnace checker chambers to 2200°F.
4. Steel mill soaking pits to 2200°F.
5. Pelletizing chamber of Taconite refining operation to 2100°F.
6. Molten zinc to 1600°F.
7. Molten lead to 650°F.
8. Basic steels and slags to 300°F (intermittent and 2200°F (continuous in open hearth and general foundry practices).
9. Calcining kilns to 2200°F.
10. Barium titanate (barium oxide service to 2200°F).
11. Magnesium oxide calcining kilns.
12. Fluid bed cement process with severe corrosion and temperature to 2200°F (fluid method of producing builder's cement).
13. Gas and ethylene cracking atmosphere.
14. Atmosphere directly upon burning sodium (1800-2200°F).
15. Oil fired furnace chambers.
16. Atmosphere directly above molten glass in an open hearth glass furnace.
17. Molten silver solder.
18. Molten tin.
19. Borax flux.
20. Copper matte.
21. Boiling sulphuric acid-97%.
22. Blast furnace stove dome and bustle pipes.

NON-RECOMMENDED APPLICATIONS

1. Molten aluminum.
2. Cryolite.
3. Tin (stannous) chloride (750°F).
4. Acid slag.
5. Carbide slag.
6. Molten glass.
7. Boiling sulphuric acid-10%.
8. Carburizing atmospheres.
9. Nitriding atmospheres.
10. Barium chloride salt bath.
11. Sodium Nitrate-nitrate salt bath.

This protection tube is most commonly used in molten metal applications. It is less common than ceramic and metal protection tubes in industrial application.

—5/8" I.D. x 7.8" O.D., 3/4" conduit connector.

—Any length.

—Accepts 8 gauge wire or smaller

—Superior oxidation resistance up to 2200°F.

—Above 2800°F, softening begins.

—Suggested pre-heating of tube to 900°F if application involves immersion in molten metal 2000°F or higher.

—Impermeable except under high vacuum.

—Maximum recommended continuous operating temperature is 2500°F.

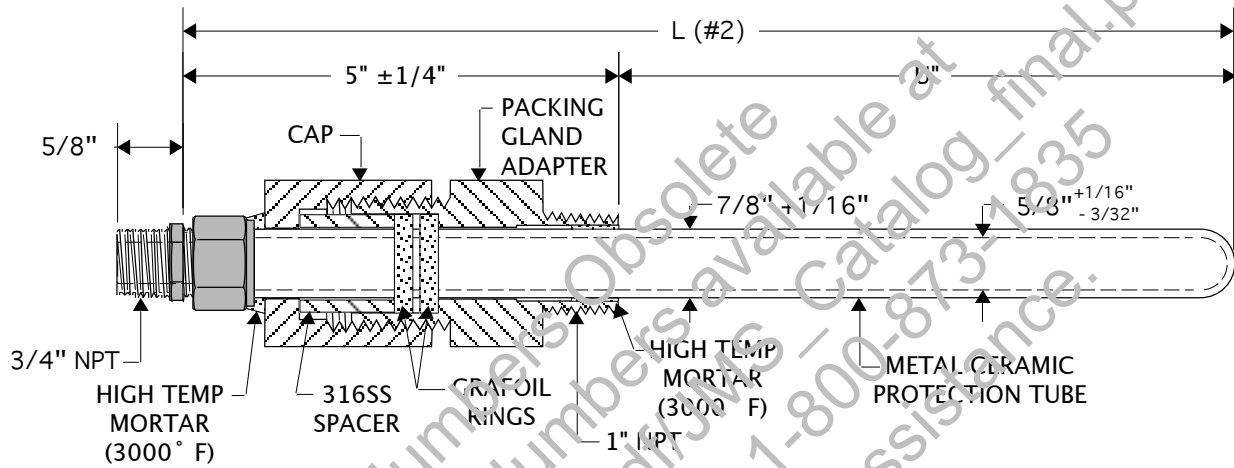
Note: A special fitting is available that is recommended for extreme conditions. See page 5-14 for additional information.

*UCAR® LT-1 Metal Ceramic is a product of Union Carbide Corp.

MCPT WITH OPTIONAL FITTING

JMS Southeast, Inc. offers the special optional fitting pictured below for mounting the metal ceramic protection tube in high temperature sealed environments.

The minimum "U" length available is 2.35".



#1	SERIES
5J	Metal Ceramic Protection Tube With Optional Fitting
#2	LENGTH (L)
1	9"
2	12"
3	18" (Standard)
4	30" (Standard)
5	36"
6	48" (Standard)
X	Other, specify

5J	3	
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GENERAL THERMOWELL INFORMATION

THERMOWELLS

Process Connection

Provides a means of mounting, supporting, and/or sealing the thermowell into the process system.

Types:

Threaded: Standard N.P.T.'s are 1/2", 3/4", and 1".

Socket Weld: Standard pipe sizes are 3/4" and 1" nominal. JMS socket wells are 3000lb rated. Other rating must be separately specified.

Flanged Welded: Large variety of flange sizes and pound ratings available.

Shank Construction

Straight: The outside diameter is the same size along the immersion length.

Step: The outside diameter at the end of the well is 1/2" to provide quicker response time.

Tapered: Used for high velocity applications. The outside diameter decreases gradually along the immersion length.

Q Dimension

The thickest part of the shank of the well on the hot side of the process connection or flange. Its dependent on the bore size and the process connection size.

Bore Size

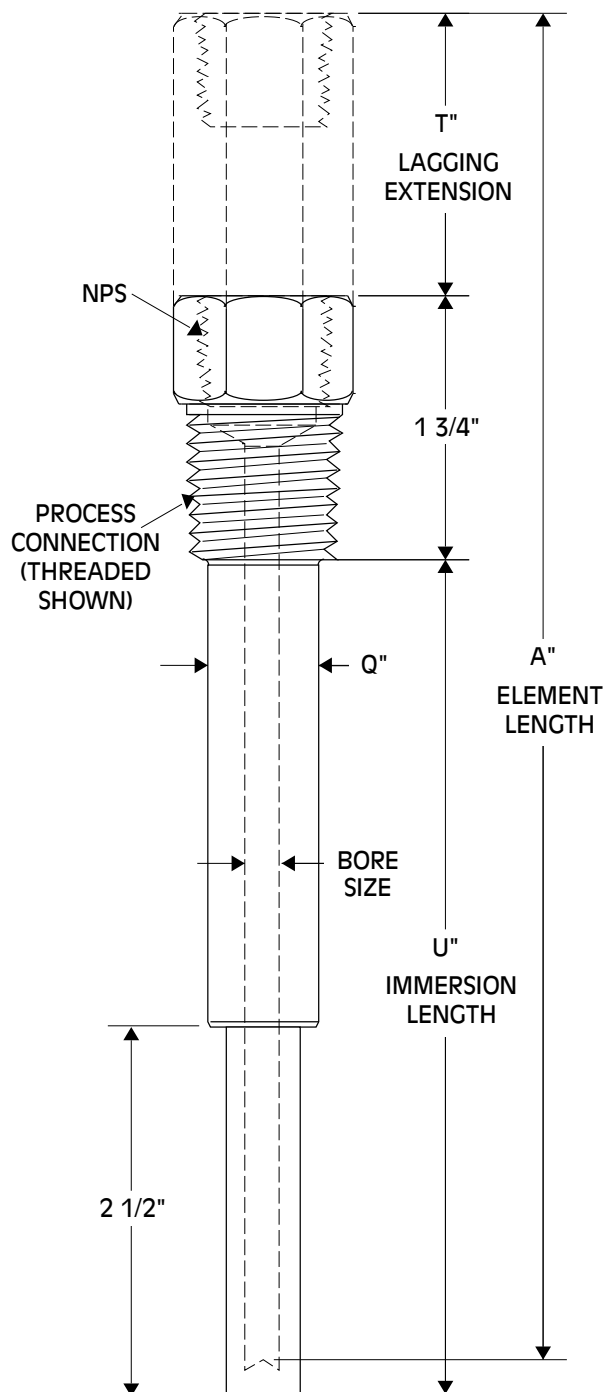
The inside diameter of a thermowell. Standard bore sizes are .260 and .385.

Immersion ("U") Length

Immersion length of the thermowell. The "U" length is measured from the bottom of the process connection to the tip of the thermowell.

Lagging Extension ("T") Length

The lagging extension exists behind the process connection and is used to extend the hex length and enable the probe to extend through insulation or walls.



Note:

JMS has a complete design guide on disc for your use. Call and ask for the Thermowell Design Guide.

STANDARD THERMOWELL MANUFACTURING TOLERANCES

JMS Thermowells meet or exceed the following standards:

(Copies are available from JMS Southeast, Inc., ANSI, or the issuing body.)

ASME B40.9 - Thermowells for Thermometer and Electrical Temperature Sensors

SAMA RC17-10-1963 - Bushings and Wells for Temperature Sensing Elements

ISA 1.02.01 - Thermowells

IEC 61520 - Functional Dimensions of Metal Thermowells for Thermometer Sensors

The following specifications are for .260 and .385 bore thermowells:

Lengths: $\pm 1/16$ " on lengths 12" or less

$\pm 1/8$ " on lengths 12" or over

Wells up to 38" bore depths are drilled from solid bar stock to specified tip thickness (1/4" standard). A built-up design is necessary after 38 1/4" overall length.

Bore I.D. Tolerance:

$\pm .001$

O.D. Tolerances:

Fractional: $\pm .015$

Decimal: $\pm .005$ on .000 place

$\pm .010$ on .00 place

Concentricity of Bore to O.D.:

$\pm 10\%$ of minimum wall thickness

End Thickness:

Gun drill bottom, $1/4" \pm 1/16"$.

Male Threads (NPT):

± 1 turn of thread gauge

Female Threads:

1/2" NPS standard, 1/2" NPT available upon request

Radius Under Threads and Flanges:

1/8" is standard, $\pm 1/16"$

1/16" on Van Stone

Lagging Extension:

Lagging on wells is left as hex and is not turned. For material not available in hex, round bars with wrench flats will be furnished.

End of Wells:

Break corners. No burrs.

Wetted Surfaces Finish for "U" Dimension

63 ST is our standard surface finish. A mirror polish is available upon request. 8 RMS is our standard for a mirror polish, and must be specified on the order. Electropolish or electroplating is also available. There is an additional charge for mirror, electropolish or electroplating.

Stamping:

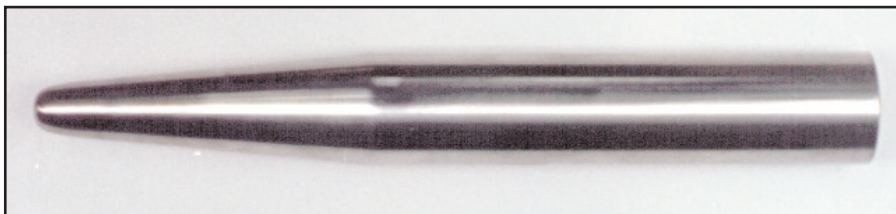
Material code and type of material is stamped on hex or round.

Flanged Wells:

Made in accordance with ANSI B16.5 with serrated raised face. We also furnish 125 RMS smooth face which must be specified when needed. Other surface finishes are available upon request.

Weld Configuration:

Front groove welds are 1/4" wide by 5/16" deep. Rear groove welds are 1/8" wide by 1/8" deep "V". Welds are machined, leaving 1/4" radius. Full penetration welds are available upon request.



THERMOWELL DESIGN GUIDELINES

Design Procedure***

The purpose of this design procedure is to enable the user to determine if a well selected for thermometry considerations is strong enough to withstand specific application conditions of temperature, pressure, velocity, and vibration. Well failures are caused by forces imposed by static pressure, steady state flow, and vibration. Separate evaluations of each of the above effects should be made in order to determine the limiting condition. This design procedure does not allow for effects due to corrosion or erosion.

The natural frequency of a well designed in accordance with Fig. 1.1 and of the dimensions given in Table 1.1 is given by the following equation:

$$f_n = \frac{K_f}{L^2} \sqrt{\frac{E}{\gamma}} \dots [1]$$

where

f_n = natural frequency of the well at use temperature, cycles per sec

L = length of well as given in Fig. 1.1, in.

E = modulus of elasticity of well material at use temperature, psi

γ = specific weight of well material at use temperature, lb per cu in.

K_f = a constant obtained from Table 1.2

The wake or Strouhal frequency is given by:

$$f_w = 2.64 \frac{V}{B} \dots [2]$$

where

f_w = wake frequency, cycles per sec

V = fluid velocity, fps

B = diameter at tip (Fig. 1.1), in.

The ratio of wake to natural frequency (f_w/f_n) shall not exceed 0.8, and when this condition is met, the Magnification Factor, relationship of dynamic to static amplitude is given by:

$$F_M = \frac{(f_w/f_n)^2}{1 - (f_w/f_n)^2} = \frac{r^2}{1 - r^2} \dots [3]$$

For $r \leq 0.8$

where

F_M = magnification factor, dimensionless

r = frequency ratio, (f_w/f_n), dimensionless

STRESS ANALYSIS

The maximum pressure that a thermometer, well can withstand for a given material at a given temperature shall be computed from the following:

$$P = K_1 S \dots [4]$$

where

P = maximum allowable static gage pressure, psi

S = allowable stress for material at operating temperature as given in the ASME Boiler and Pressure Vessel or Piping Codes, psi

K_1 = a stress constant obtained from Table 1-3.

The maximum length that a thermometer well can be made for a given service is dependent upon both vibratory and steady state stress. The necessity for keeping the frequency ratio at 0.8 or less imposes one limitation on maximum length. The other limitation is one of steady state stress considerations, as given by the following equation:

$$L_{max} = \frac{K_2}{V} \sqrt{\frac{v(S - K_3 P_0)}{1 + F_M}} \dots [5]$$

where

L_{max} = maximum value of L (as shown in Fig. 1.1) for a given service, in.

V = fluid velocity, fps

v = specific volume of the fluid, cu ft per lb.

S = allowable stress for material at operating temperature as given in the ASME Boiler and Pressure vessel or Piping Codes, psi

P_0 = static operating gage pressure, psi

K_2 = magnification factor as computed from Eq [3]

K_3 = stress constants obtained from Table 1-3.

TABLE 1.1 WELL DIMENSIONS, IN. IN.
Nominal Size of Sensing Element

Dimension	Nominal Size of Sensing Element
	1/4
A (minimum)	13/16
B (minimum)	5/8
d (minimum)	0.254
D (maximum)	0.262

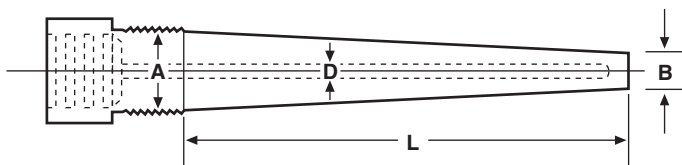
TABLE 1.2 VALUES OF K_f
Well Length

L, in.	K_f
2 1/2	2.06
4 1/2	2.07
7 1/2	2.08
10 1/2	2.09
16	2.09
24	2.09

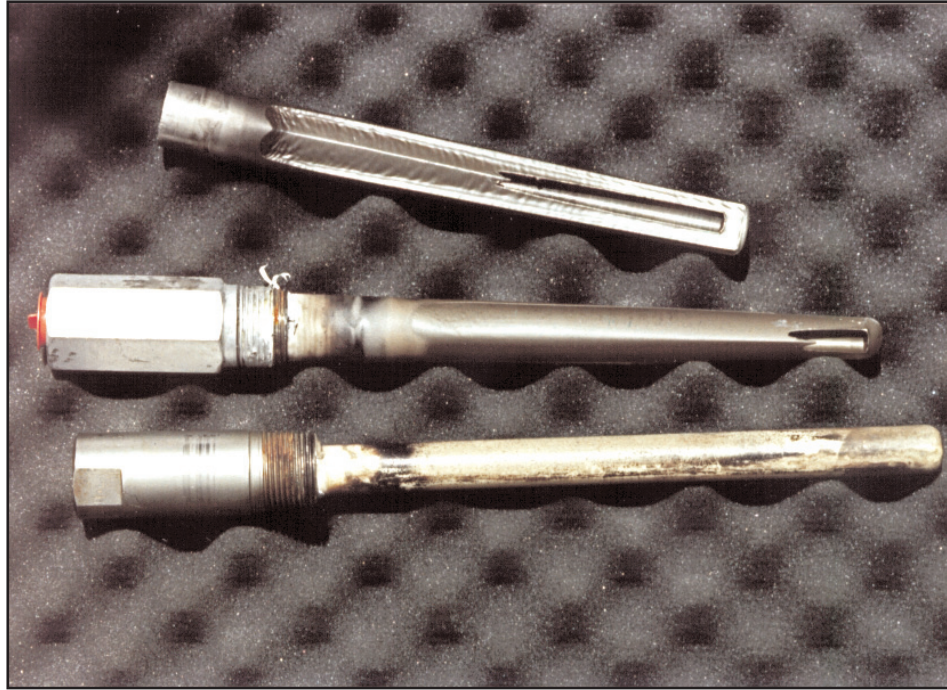
TABLE 1.3 VALUES OF STRESS CONSTANTS

Stress Constant
K_1 0.412
K_2 37.5
K_3 0.116

*** Power Test Code Thermometer Wells, J.W. Murdock, Journal of Engineering for Power, Trans. ASME, vol. 81, 1959.



THERMOWELL DESIGN GUIDELINES



Note: For high erosion and low pressure applications, ask for JMS drawing #8135. For high erosion and high pressure applications, ask for JMS drawing #11468. These are JMS-SE proprietary designs.

Table 4: Allowable Stress Values (PSI)¹

MATERIAL	TEMPERATURE °F						
	0	300	500	700	900	1100	1300
Aluminum (1100)	2,350	1,850	--	--	--	--	--
Aluminum (6061-T6)	6,000	5,000	--	--	--	--	--
Nickel	10,000	10,000	9,500	--	--	--	--
Steel ²	11,250	11,000	10,250	9,000	7,750	6,500	--
304SS	18,750	13,750	11,400	10,500	10,000	8,250	--
316SS	18,750	16,400	15,500	15,100	11,650	8,500	3,400
310SS	18,750	14,600	12,600	11,300	10,300	9,450	3,500
321 - 347SS	18,750	15,300	13,500	12,200	11,300	9,100	4,000
410SS	15,000	13,800	12,850	12,050	9,650	2,900	2,200
446SS	17,500	16,100	15,000	--	--	--	--
A182-F11	16,150	16,150	16,150	16,150	13,100	4,000	--
A182-F22	17,500	17,500	17,500	17,500	14,000	4,200	--
Copper	6,000	5,000	--	--	--	--	--
Admiralty Brass	10,000	10,000	--	--	--	--	--
Monel 400	16,600	13,600	13,100	13,100	8,000	--	--
Inconel 600	20,000	18,800	18,500	18,500	16,000	3,000	4,150
Incoloy 800 ³	15,600	12,100	10,400	9,600	9,100	8,800	--
Hastelloy B ⁴	25,000	24,750	21,450	--	--	--	--
Hastelloy X ⁵	23,350	18,850	16,000	15,500	15,500	15,500	9,500

1. Values from ASME Boiler and Pressure Vessel Code Section VIII - Unfired Pressure Vessels, 1965.

2. ASME Spec. Min, Tensile = 45,000 PSI

3. ASME Code (See Note 1), Case 1325 (special ruling)

4. ASME Code (See Note 1), Case 1323 (special ruling)

5. ASME Code (See Note 1), Case 1321 (special ruling)

Note:
JMS has a complete design guide on disc for your use. Call and ask for the Thermowell Design Guide.

3 IMPORTANT THINGS TO REMEMBER WHEN ATTEMPTING TO DETERMINE THE INSERTION LENGTH OF A THERMOWELL

THERMOWELL SELECTION CRITERIA

1. Selecting the proper insertion length is critical to the accuracy of your sensor. In considering length, it is important to allow the entire sensitive portion of the sensor to extend into the medium being measured. The proper length for a sensor installed into a liquid is the sensitive portion plus at least $5 \times \text{Ø}$. For gas or air, a probe should be installed a minimum of $10 \times \text{Ø}$ plus the sensitive length.

Generally, wire wound RTD's have a sensitive portion around 5/8". Shorter sensitive lengths are available with thin film and ceramic RTD's upon request. Both thermocouples and thermistors have small sensitive lengths so they are the best choice when working with short insertion lengths.

Note: It is important to consider the amount of the well passing through insulation, walls, fittings, etc., when determining the proper insertion length.

2. In selecting a thermowell, vibration is an important variable to be considered. When thermowells fail, they most often fail due to the vibrational effects they encounter. The pressure and temperature of a process does not usually have as much effect on the life of the thermowell as the fluid velocity of the media.

The media, flowing by the well forms a turbulent wake which has a definite frequency based on the diameter of the well and the flow of the fluid. The well must have sufficient stiffness so the wake frequency will never equal the natural frequency of the well itself. The flowing liquid generates a wake frequency around the well called the Von Karman Trail. Ask us about our Thermowell Program.

The tapered thermowell provides greater stiffness for the same sensitivity than straight thermowells.

The thermowell material chosen is mainly based on the corrosion conditions of the process and temperature range of the operation.

Pressure and velocity flow tables follow to aid our customers as a guide in the selection of thermowells.

Wells are safe if the resonant frequency is below the natural frequency of the well and if the fluid velocity is changing or fluctuating through the critical velocity point.

The values are very conservative and intended as a guide only.

JMS Southeast will be happy to assist you in the event of questions concerning your application and the selection of thermowells.

3. Ask for our design disk which calculates the stem loss temperature errors and velocity ratings for all common materials and mounting methods for thermowells.

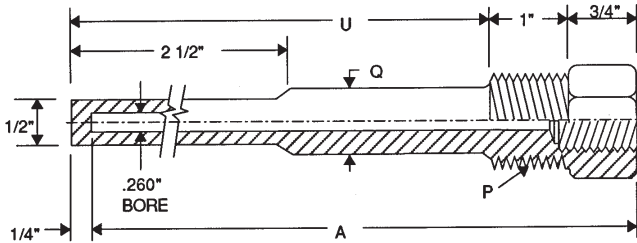


Note:

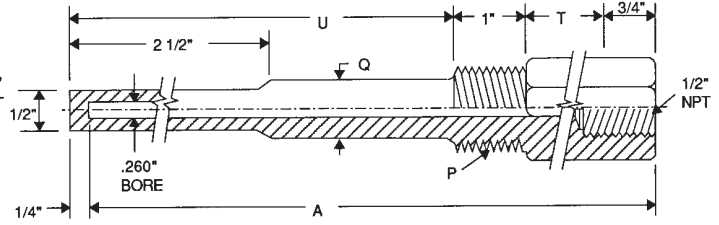
JMS has a complete design guide on disc for your use. Call and ask for the Thermowell Design Guide.

THERMOWELL DIMENSIONS, VELOCITY, AND PRESSURE RATING

STANDARD THREADED STEP SHANK .260" BORE THERMOWELLS FOR 1/4" DIAMETER ELEMENTS



SERIES 51AT, 52AT, 53AT



SERIES 51AT, 52AT, 53AT with Lag

STEP SHANK .260 BORE

EXTERNAL THREAD P	SYMBOL	STEM LGTH. A	INSERT. LGTH. U	SHANK DIA Q
1/2" NPT	51AT-U 2 1/2	4	2 1/2	1/2
	-U 4 1/2	6	4 1/2	5/8
	-U 7 1/2	9	7 1/2	5/8
	-U 10 1/2	12	10 1/2	5/8
	-U 13 1/2	15	13 1/2	5/8
	-U 16 1/2	18	16 1/2	5/8
3/4" NPT	-U 22 1/2	24	22 1/2	5/8
	52AT-U 2 1/2	4	2 1/2	1/2
	-U 4 1/2	6	4 1/2	3/4
	-U 7 1/2	9	7 1/2	3/4
	-U 10 1/2	12	10 1/2	3/4
	-U 13 1/2	15	13 1/2	3/4
1" NPT	-U 16 1/2	18	16 1/2	3/4
	-U 22 1/2	24	22 1/2	3/4
	53AT-U 2 1/2	4	2 1/2	1/2
	-U 4 1/2	6	4 1/2	7/8
	-U 7 1/2	9	7 1/2	7/8
	-U 10 1/2	12	10 1/2	7/8
	-U 13 1/2	15	13 1/2	7/8
	-U 16 1/2	18	16 1/2	7/8
	-U 22 1/2	24	22 1/2	7/8

STEP SHANK WITH LAG EXTENSION .260 BORE

EXTERNAL THREAD P	SYMBOL	STEM LGTH. A	INSERT. LGTH. U	LAG EXT. T	SHANK DIA Q
1/2" NPT	51AT-U 2 1/2 T2	6	2 1/2	2	1/2
	-U 4 1/2 T3	9	4 1/2	3	5/8
	-U 7 1/2 T3	12	7 1/2	3	5/8
	-U 10 1/2 T3	15	10 1/2	3	5/8
	-U 13 1/2 T3	18	13 1/2	3	5/8
	-U 19 1/2 T3	24	19 1/2	3	5/8
3/4" NPT	52AT-U 2 1/2 T2	6	2 1/2	2	1/2
	-U 4 1/2 T3	9	4 1/2	3	3/4
	-U 7 1/2 T3	12	7 1/2	3	3/4
	-U 10 1/2 T3	15	10 1/2	3	3/4
	-U 13 1/2 T3	18	13 1/2	3	3/4
	-U 19 1/2 T3	24	19 1/2	3	3/4
1" NPT	53AT-U 2 1/2 T2	6	2 1/2	2	1/2
	-U 4 1/2 T3	9	4 1/2	3	7/8
	-U 7 1/2 T3	12	7 1/2	3	7/8
	-U 10 1/2 T3	15	10 1/2	3	7/8
	-U 13 1/2 T3	18	13 1/2	3	7/8
	-U 19 1/2 T3	24	19 1/2	3	7/8

MAXIMUM FLUID VELOCITY FEET PER SECOND

Well Type	Material	INSERTION LENGTH—"U"							
		2 1/2	4 1/2	7 1/2	10 1/2	13 1/2	16 1/2	19 1/2	22 1/2
1/2"-260 Bore and 1/2"-260 Bore with Lag Extension	Brass	207 (59.3)	75.5 (32.2)	27.3 (19.7)	13.9	8.4	5.6	4.1	3.0
	Carbon Steel	290 (106)	105 (59)	38.2 (36.3)	19.4	11.8	7.8	5.7	4.2
	A.I.S.I. 304 & 316	300 (148)	109 (82.2)	39.5 (34.4)	20.1	12.2	8.1	5.9	4.4
	Monel	261 (118)	95 (65.5)	34.4	17.5	10.5	7.1	5.2	3.8
	Brass	207 (59.3)	89.1 (39.8)	32.2 (23.9)	16.4	9.9	6.6	4.8	3.6
	Carbon Steel	290 (106)	123 (71.2)	44.9 (42.7)	22.8	13.8	9.3	6.7	4.9
3/4"-260 Bore and 3/4"-260 Bore with Lag Extension	A.I.S.I. 304 & 316	300 (148)	128 (99.3)	46.4 (41.7)	23.6	14.3	9.6	6.9	5.1
	Monel	261 (118)	112 (79.8)	40.6	20.7	12.4	8.3	6.1	4.5
	Brass	207 (59.3)	102 (47.6)	37.0 (28)	18.8	11.4	7.6	5.5	4.1
	Carbon Steel	290 (106)	143 (84.3)	51.6 (50.6)	26.2	15.9	10.6	7.6	5.7
	A.I.S.I. 304 & 316	300 (148)	148 (117)	53.5	27.2	16.5	11.0	7.9	5.9
	Monel	261 (118)	128 (93.3)	46.7	23.7	14.4	9.5	6.9	5.1

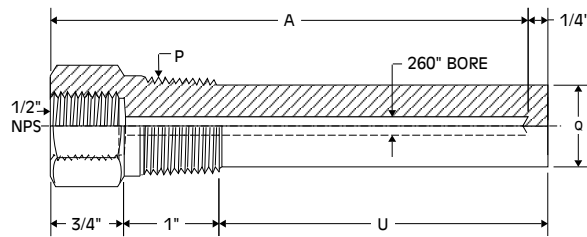
PRESSURE (LB. PER SQ. INCH)-TEMPERATURE

Material	Temperature—°F						
	70°	200°	400°	600°	800°	1000°	1200°
Brass	5000	4200	1000	—	—	—	—
Carbon Steel	5200	5000	4800	4600	3500	1500	—
A.I.S.I. 304	7000	6200	5600	5400	5200	4500	1650
A.I.S.I. 316	7000	7000	6400	6200	6100	5100	2500
Monel	6500	6000	5400	5300	5200	1500	—

NOTE:
THE VALUES IN PARENTHESIS REPRESENT SAFE VALUES FOR WATER FLOW WHILE THE VALUES NOT IN PARENTHESIS MAY BE USED FOR STREAM, AIR, GAS AND FLUIDS WITH SIMILAR DENSITY

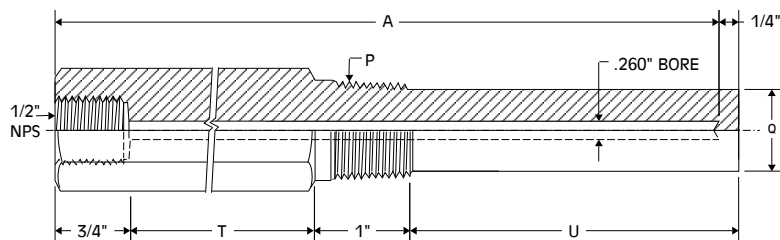
THERMOWELL DESIGN

STANDARD THREADED STRAIGHT SHANK .260" BORE THERMOWELLS FOR 1/4" DIAMETER ELEMENTS



SERIES 51ST, 52ST, 53ST

Note:
JMS has a complete design guide on disc for your
use. Call and ask for the Thermowell Design Guide.



SERIES 51ST, 52ST, 53ST with Lag

THERMOWELL DIMENSIONS, VELOCITY, AND PRESSURE RATING

STRAIGHT SHANK .260 BORE

EXTERNAL THREAD P	SYMBOL	STEM LGTH. A	INSERT. LGTH. U	SHANK DIA Q
1/2" NPT	51ST-U 2 1/2	4	2 1/2	5/8
	-U 4 1/2	6	4 1/2	5/8
	-U 7 1/2	9	7 1/2	5/8
	-U 10 1/2	12	10 1/2	5/8
	-U 13 1/2	15	13 1/2	5/8
	-U 16 1/2	18	16 1/2	5/8
	-U 22 1/2	24	22 1/2	5/8
3/4" NPT	52ST-U 2 1/2	4	2 1/2	3/4
	-U 4 1/2	6	4 1/2	3/4
	U 7 1/2	9	7 1/2	3/4
	U 10 1/2	12	10 1/2	3/4
	-U 13 1/2	15	13 1/2	3/4
	-U 16 1/2	18	16 1/2	3/4
	-U 22 1/2	24	22 1/2	3/4
1" NPT	53ST-U 2 1/2	4	2 1/2	7/8
	-U 4 1/2	6	4 1/2	7/8
	-U 7 1/2	9	7 1/2	7/8
	-U 10 1/2	12	10 1/2	7/8
	-U 13 1/2	15	13 1/2	7/8
	-U 16 1/2	18	16 1/2	7/8
	-U 22 1/2	24	22 1/2	7/8

STRAIGHT SHANK WITH LAG EXTENSION .260 BORE

EXTERNAL THREAD P	SYMBOL	STEM LGTH. A	INSERT. LGTH. U	LAG EXT. T	SHANK DIA Q
1/2" NPT	51ST-U 2 1/2 T2	6	2 1/2	2	5/8
	-U 4 1/2 T3	9	4 1/2	3	5/8
	-U 7 1/2 T3	12	7 1/2	3	5/8
	-U 10 1/2 T3	15	10 1/2	3	5/8
	-U 13 1/2 T3	18	13 1/2	3	5/8
	-U 19 1/2 T3	24	19 1/2	3	5/8
3/4" NPT	52ST-U 2 1/2 T2	6	2 1/2	2	3/4
	-U 4 1/2 T3	9	4 1/2	3	3/4
	-U 7 1/2 T3	12	7 1/2	3	3/4
	-U 10 1/2 T3	15	10 1/2	3	3/4
	-U 13 1/2 T3	18	13 1/2	3	3/4
	-U 19 1/2 T3	24	19 1/2	3	3/4
1" NPT	53ST-U 2 1/2 T2	6	2 1/2	2	7/8
	-U 4 1/2 T3	9	4 1/2	3	7/8
	-U 7 1/2 T3	12	7 1/2	3	7/8
	-U 10 1/2 T3	15	10 1/2	3	7/8
	-U 13 1/2 T3	18	13 1/2	3	7/8
	-U 19 1/2 T3	24	19 1/2	3	7/8

MAXIMUM FLUID VELOCITY FEET PER SECOND

Well Type	Material	INSERTION LENGTH-"U"							
		2 1/2	4 1/2	7 1/2	10 1/2	13 1/2	16 1/2	19 1/2	22 1/2
1/2"-260 Bore and 1/2"-260 Bore with Lag Extension	Brass	207 (59.3)	75.5 (32.2)	27.3 (19.7)	13.9	8.4	5.6	4.1	3.0
	Carbon Steel	290 (106)	105 (59)	38.2 (36.3)	19.4	11.8	7.8	5.7	4.2
	A.I.S.I. 304 & 316	300 (148)	109 (82.2)	39.5	20.1	12.2	8.1	5.9	4.4
	Monel	261 (118)	95 (65.5)	34.4	17.5	10.5	7.1	5.2	3.8
	Brass	207 (59.3)	89.1 (39.8)	32.2 (23.9)	16.4	9.9	6.6	4.8	3.6
	Carbon Steel	290 (106)	123 (71.2)	44.9 (42.7)	22.8	13.8	9.3	6.7	4.9
3/4"-260 Bore and 1"-260 Bore with Lag Extension	A.I.S.I. 304 & 316	300 (148)	128 (99.3)	46.4	23.6	14.3	9.6	6.9	5.1
	Monel	261 (118)	112 (79.8)	40.6	20.7	12.4	8.3	6.1	4.5
	Brass	207 (59.3)	102 (47.6)	37.0 (28)	18.8	11.4	7.6	5.5	4.1
	Carbon Steel	290 (106)	143 (84.3)	51.6 (50.6)	26.2	15.9	10.6	7.6	5.7
	A.I.S.I. 304 & 316	300 (148)	148 (117)	53.5	27.2	16.5	11.0	7.9	5.9
	Monel	261 (118)	128 (93.3)	46.7	23.7	14.4	9.5	6.9	5.1

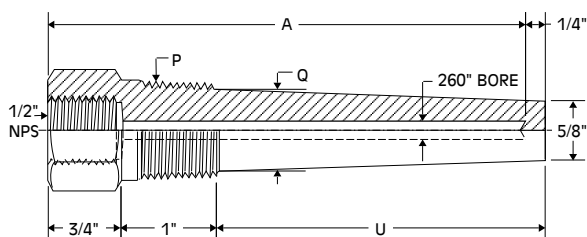
Note: The values in parenthesis represent safe values for water flow while the values not in parenthesis may be used for steam, air, gas and fluids with similar density.

PRESSURE (LB. PER SQ. INCH)-TEMPERATURE

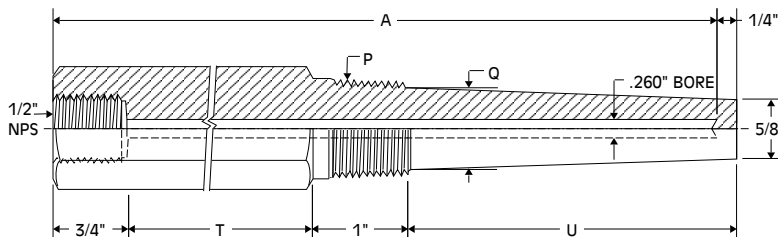
Material	Temperature—°F						
	70°	200°	400°	600°	800°	1000°	1200°
Brass	5000	4200	1000	—	—	—	—
Carbon Steel	5200	5000	4800	4600	3500	1500	—
A.I.S.I. 304	7000	6200	5600	5400	5200	4500	1650
A.I.S.I. 316	7000	7000	6400	6200	6100	5100	2500
Monel	6500	6000	5400	5300	5200	1500	—

THERMOWELL DIMENSIONS, VELOCITY, AND PRESSURE RATING

STANDARD THREADED TAPERED SHANK .260" BORE THERMOWELLS FOR 1/4" DIAMETER ELEMENTS



SERIES 52TT, 53TT



SERIES 52TT, 53TT with Lag

TAPERED SHANK .260 BORE

EXTERNAL THREAD P	SYMBOL	STEM LGTH. A	INSERT. LGTH. U	SHANK DIA Q
3/4" NPT	52TT-U 2 1/2	4	2 1/2	7/8
	-U 4 1/2	6	4 1/2	7/8
	-U 7 1/2	9	7 1/2	7/8
	-U 10 1/2	12	10 1/2	7/8
	-U 13 1/2	15	13 1/2	7/8
	-U 16 1/2	18	16 1/2	7/8
	-U 22 1/2	24	22 1/2	7/8
1" NPT	53TT-U 2 1/2	4	2 1/2	1 1/16
	-U 4 1/2	6	4 1/2	1 1/16
	-U 7 1/2	9	7 1/2	1 1/16
	-U 10 1/2	12	10 1/2	1 1/16
	-U 13 1/2	15	13 1/2	1 1/16
	-U 16 1/2	18	16 1/2	1 1/16
	-U 22 1/2	24	22 1/2	1 1/16

TAPERED SHANK WITH LAG EXTENSION .260 BORE

EXTERNAL THREAD P	SYMBOL	STEM LGTH. A	INSERT. LGTH. U	LAG EXT. T	SHANK DIA Q
3/4" NPT	52TT-U 2 1/2 T2	6	2 1/2	2	7/8
	-U 4 1/2 T3	9	4 1/2	3	7/8
	-U 7 1/2 T3	12	7 1/2	3	7/8
	-U 10 1/2 T3	15	10 1/2	3	7/8
	-U 13 1/2 T3	18	13 1/2	3	7/8
	-U 19 1/2 T3	24	19 1/2	3	7/8
1" NPT	53TT-U 2 1/2 T2	6	2 1/2	2	1 1/16
	-U 4 1/2 T3	9	4 1/2	3	1 1/16
	-U 7 1/2 T3	12	7 1/2	3	1 1/16
	-U 10 1/2 T3	15	10 1/2	3	1 1/16
	-U 13 1/2 T3	18	13 1/2	3	1 1/16
	-U 19 1/2 T3	24	19 1/2	3	1 1/16

MAXIMUM FLUID VELOCITY FEET PER SECOND

Note: The values in parenthesis represent safe values for water flow while the values not in parenthesis may be used for steam, air, gas and fluids with similar density.

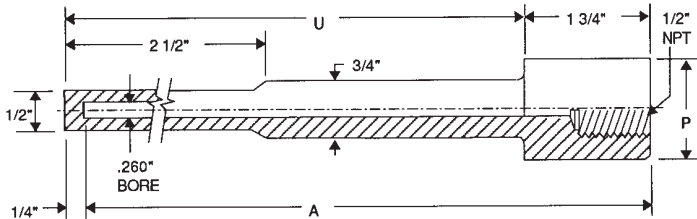
Well Type	Material	INSERTION LENGTH—"U"							
		2 1/2	4 1/2	7 1/2	10 1/2	13 1/2	16 1/2	19 1/2	22 1/2
3/4"-260Bore and 3/4"-260 Bore with Lag Extension	Brass	305 (97.5)	93.8 (54.1)	33.9	17.1	10.5	7.0	5.0	3.7
	Carbon Steel	386 (175)	180 (97.2)	65.3 (58.3)	33.0	20.1	13.4	9.6	7.1
	A.I.S.I. 304 & 316	440 (243)	197 (135)	71.2	36.0	22.0	14.7	0.5	7.8
	Monel	354 (195)	155 (108)	56.1	28.4	17.3	11.6	7.5	5.6
	Brass	354 (161)	108 (89.5)	39.4	19.8	12.2	8.1	5.8	4.3
	Carbon Steel	448 (289)	209 (161)	75.7	38.4	23.3	15.5	11.1	8.2
1"-260 Bore and 1"-260Bore with Lag Extension	A.I.S.I. 304 & 316	490 (403)	228 (225)	82.5	41.8	25.5	17.1	12.2	9.1
	Monel	410 (322)	179 (178)	65.1	33.0	20.1	13.5	8.7	6.5

PRESSURE (LB. PER SQ. INCH)-TEMPERATURE

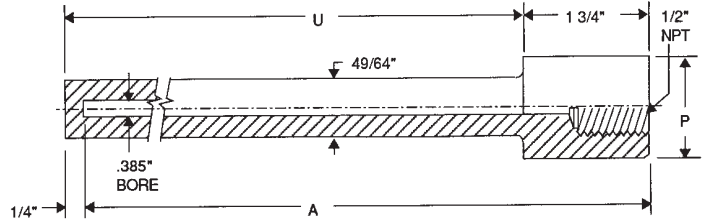
Material	Temperature—°F						
	70°	200°	400°	600°	800°	1000°	1200°
Brass	5300	4750	1100	—	—	—	—
Carbon Steel	5950	5750	5450	5250	4000	1750	—
A.I.S.I. 304	7800	7050	6400	6150	6000	5190	1875
A.I.S.I. 316	7800	7800	7250	7100	6950	5800	2720
Monel	7450	6850	6150	6100	5940	175	—

THERMOWELL DIMENSIONS, VELOCITY, AND PRESSURE RATING

SOCKET-WELD .260" BORE, .385" BORE THERMOWELLS FOR 1/4" AND 3/8" DIAMETER ELEMENTS



SERIES 52AS, 53AS



SERIES 52SS, 53SS

SOCKET-WELD THERMOWELLS .260 BORE

PIPE SIZE P	SYMBOL	STEM LGTH. A	LENGTH INSERT U
3/4" Nominal (1.050 Dia.)	52AS-U 2 1/2	4	2 1/2
	-U 4 1/2	6	4 1/2
	-U 7 1/2	9	7 1/2
	-U 10 1/2	12	10 1/2
	-U 13 1/2	15	13 1/2
	-U 16 1/2	18	16 1/2
	-U 22 1/2	24	22 1/2
1" Nominal (1.315 Dia.)	53AS-U 2 1/2	4	2 1/2
	-U 4 1/2	6	4 1/2
	U 7 1/2	9	7 1/2
	U 10 1/2	12	10 1/2
	-U 13 1/2	15	13 1/2
	-U 16 1/2	18	16 1/2
	-U 22 1/2	24	22 1/2

SOCKET-WELD THERMOWELLS .385 BORE

PIPE SIZE P	SYMBOL	STEM LGTH. A	LENGTH INSERT U
3/4" Nominal (1.050 Dia.)	52SS-U 2 1/2	4	2 1/2
	-U 4 1/2	6	4 1/2
	-U 7 1/2	9	7 1/2
	-U 10 1/2	12	10 1/2
	-U 13 1/2	15	13 1/2
	-U 16 1/2	18	16 1/2
	-U 22 1/2	24	22 1/2
1" Nominal (1.315 Dia.)	53SS-U 2 1/2	4	2 1/2
	-U 4 1/2	6	4 1/2
	U 7 1/2	9	7 1/2
	U 10 1/2	12	10 1/2
	-U 13 1/2	15	13 1/2
	-U 16 1/2	18	16 1/2
	-U 22 1/2	24	22 1/2

SECTION 5

MAXIMUM FLUID VELOCITY FEET PER SECOND

Well Type	Material	INSERTION LENGTH—"U"						
		2 1/2	4 1/2	7 1/2	10 1/2	13 1/2	16 1/2	22 1/2
3/4"-260 Bore	Carbon Steel A.I.S.I.—304 & 316	290 (106)	123 (71.2)	44.9 (42.7)	22.8	13.8	9.3	4.9
		300 (148)	128 (99.3)	46.4	23.6	14.3	9.6	5.1
		290 (106)	143 (84.3)	51.6 (50.6)	26.2	15.9	10.6	5.7
1"-260 Bore	Carbon Steel A.I.S.I.—304 & 316	300 (148)	148 (117)	53.5	27.2	16.5	11.0	5.9
		426 (260)	192 (144)	69.5	35.4	20.5	14.3	7.7
		449 (360)	199	71.9	36.6	21.2	14.8	8.0
3/4"-385 Bore and 1"-385 Bore	Carbon Steel A.I.S.I.—304 & 316							

Note: The values in parenthesis represent safe values for water flow while the values not in parenthesis may be used for steam, air, gas and fluids with similar density.

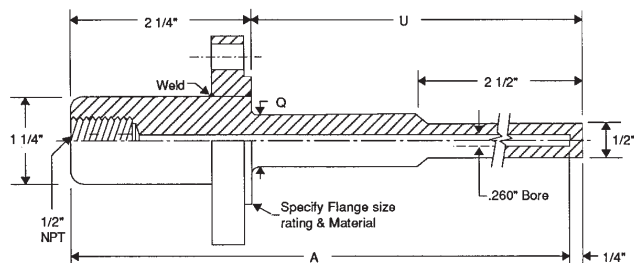
PRESSURE (LB. PER SQ. INCH)-TEMPERATURE

Material	Temperature—°F						
	70°	200°	400°	600°	800°	1000°	1200°
Brass	5000	4200	1000	—	—	—	—
Carbon Steel	5200	5000	4800	4600	3500	1500	—
A.I.S.I. 304	7000	6200	5600	5400	5200	4500	1650
A.I.S.I. 316	7000	7000	6400	6200	6100	5100	2500
Monel	6500	6000	5400	5300	5200	1500	—

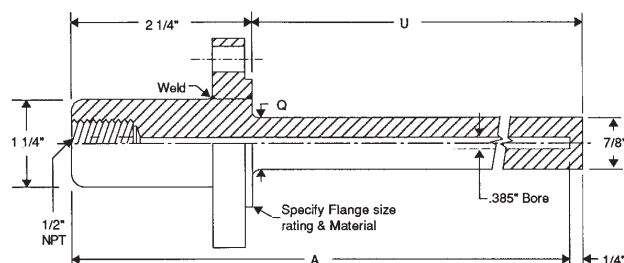
THERMOWELL DIMENSIONS, VELOCITY, AND PRESSURE RATING

FLANGED

STRAIGHT AND STEP SHANK .260" BORE, .385" BORE THERMOWELLS FOR 1/4" AND 3/8" DIAMETER ELEMENTS



SERIES 5T2A



SERIES 5TS3

FLANGED THERMOWELLS .260 BORE

SYMBOL	ELEM. LGTH. A	INSERT LGTH. U	SHANK DIA. Q
5TA2-U 2	4	2	3/4
-U 4	6	4	3/4
-U 7	9	7	3/4
-U 10	12	10	3/4
-U 13	15	13	3/4
-U 16	18	16	3/4
-U 22	24	22	3/4

FLANGED THERMOWELLS .385 BORE

SYMBOL	ELEM. LGTH. A	INSERT LGTH. U	SHANK DIA. Q
5TS3-U 2	4	2	7/8
-U 4	6	4	7/8
-U 7	9	7	7/8
-U 10	12	10	7/8
-U 13	15	13	7/8
-U 16	18	16	7/8
-U 22	24	22	7/8

MAXIMUM FLUID VELOCITY FEET PER SECOND

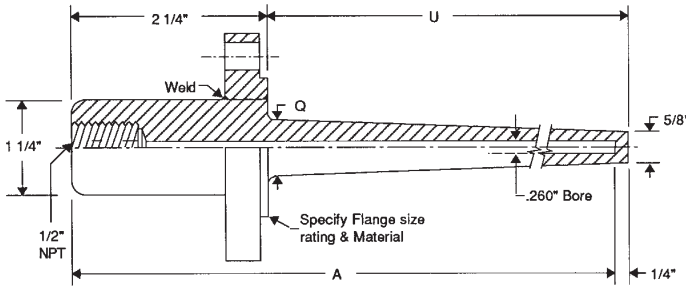
Note: The values in parenthesis represent safe values for water flow while the values not in parenthesis may be used for steam, air, gas and fluids with similar density.

Well Type	Material	INSERTION LENGTH-"U"						
		2	4	7	10	13	16	22
5TA2 and 5TS2	Carbon Steel	404	184	67.0	34.0	20.6	13.7	7.4
	A.I.S.I.	(129)	(71.2)	(42.7)				
	304 & 316	430	192	69.7	35.4	21.5	14.3	7.7
	Monel	(179)	(99.3)	(59.6)				
5TA3 and 5TS3	Carbon Steel	350	168	61	31.0	18.8	12.5	6.7
	A.I.S.I.	(143)	(79.8)	(47.7)				
	304 & 316	410	248	91.3	45.7	27.6	18.5	10.0
	Monel	(152)	(84.3)	(50.6)				
	Carbon Steel	444	258	95.2	47.6	28.8	19.3	10.4
	A.I.S.I.	(211)	(117)	(70.3)				
	304 & 316	338	226	83.3	41.6	25.2	16.9	9.1
	Monel	(168)	(93.3)	(56.0)				

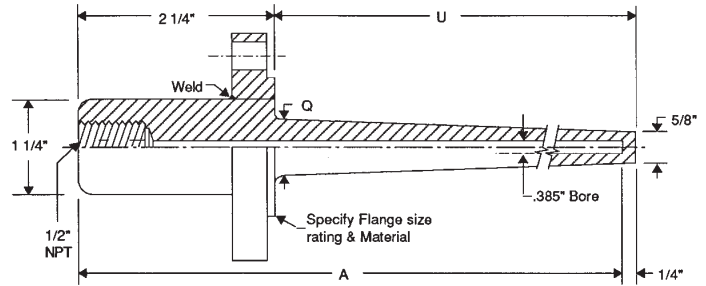
THERMOWELL DIMENSIONS, VELOCITY, AND PRESSURE RATING

FLANGED

TAPERED SHANK .260" BORE, .385" BORE THERMOWELLS FOR 1/4" AND 3/8" DIAMETER ELEMENTS



SERIES 5TT2



SERIES 5TT3

FLANGED THERMOWELLS .260 BORE

SYMBOL	ELEM. LGTH. A	INSERT LGTH. U	SHANK DIA. Q
5TT2-U 2	4	2	Specify Q Dimensions when making order
-U 4	6	4	
-U 7	9	7	
-U 10	12	10	
-U 13	15	13	
-U 16	18	16	
-U 22	24	22	

FLANGED THERMOWELLS .385 BORE

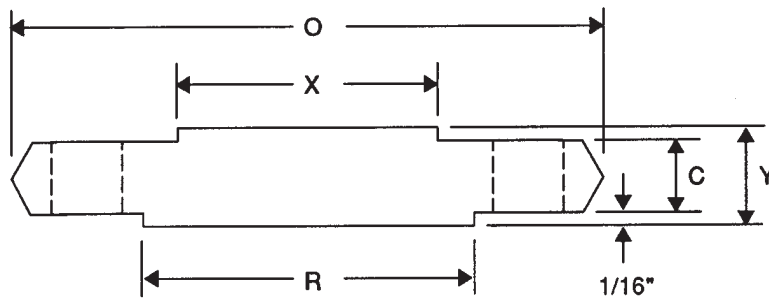
SYMBOL	ELEM. LGTH. A	INSERT LGTH. U	SHANK DIA. Q
5TT3-U 2	4	2	Specify Q Dimensions when making order
-U 4	6	4	
-U 7	9	7	
-U 10	12	10	
-U 13	15	13	
-U 16	18	16	
-U 22	24	22	

MAXIMUM FLUID VELOCITY FEET PER SECOND

Well Type	Material	INSERTION LENGTH-"U"						
		2	4	7	10	13	16	22
5TT2	Carbon Steel	603	227	74	36	21	14	7.5
		(273)	(125)	(67)				
	304 & 316	687	249	81	39.8	23.6	15.5	8.2
		(379)	(170)					
	Monel	553	196	64	31	18	12	6
		(304)	(136)					
5TT3	Carbon Steel	550	241	78.9	38	22.8	15	7.9
		(356)	(144)					
	304 & 316	648	257	83.8	41	24	16	8.4
		(467)	(194)					
	Monel	531	217	71	34.8	20.6	13	7
		(398)	(169)					

Note: The values in parenthesis represent safe values for water flow while the values not in parenthesis may be used for steam, air, gas and fluids with similar density.

DIMENSIONS FOR THERMOWELL FLANGES

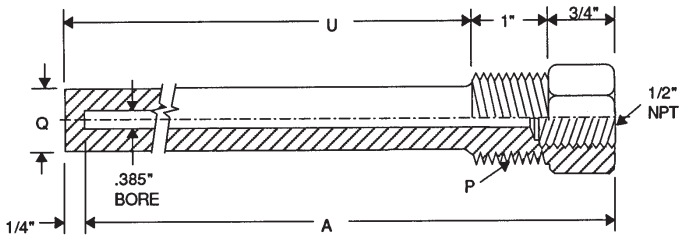


150 POUND 1/16” RAISED FACE			O	C	X	Y	R
MATERIALS AVAILABLE INCLUDE	Flange Size	Weight in lbs.	Outside Diameter	Thickness	Diameter of Hub	Length	Diameter of Raised Face
Carbon Steel							
304 Stainless Steel	1/2	1.05	3.50	.44	1.19	.62	1.38
Low Carbon 304 Stainless Steel	3/4	1.50	3.88	.50	1.50	.62	1.69
310 Stainless Steel	1	2.25	4.25	.56	1.94	.69	2.00
316 Stainless Steel	1 1/4	3.13	4.62	.62	2.31	.81	2.50
Low Carbon 316 Stainless Steel	1 1/2	3.97	5.00	.69	2.56	.88	2.88
Inconel 600	2	6.50	6.00	.75	3.06	1.00	3.62
Monel	2 1/2	9.30	7.00	.88	3.56	1.12	4.12
Hastelloy B	3	10.4	7.50	.94	4.25	1.19	5.00
Molybdenum	4	17.6	9.00	.94	5.31	1.31	6.19
Hastelloy C	5	19.0	10.00	.94	6.44	1.44	7.31
Tantalum	6	31.6	11.00	1.00	7.56	1.56	8.50
Titanium	8	53.6	13.50	1.12	9.69	1.75	10.62
300 POUND 1/16” RAISED FACE			O	C	X	Y	R
MATERIALS AVAILABLE INCLUDE	Flange Size	Weight in lbs.	Outside Diameter	Thickness	Diameter of Hub	Length	Diameter of Raised Face
Carbon Steel							
304 Stainless Steel	1/2	1.60	3.75	.56	1.50	.88	1.38
Low Carbon 304 Stainless Steel	3/4	3.03	4.62	.62	1.88	1.00	1.69
310 Stainless Steel	1	3.94	4.88	.69	2.12	1.06	2.00
316 Stainless Steel	1 1/4	4.50	5.25	.75	2.50	1.06	2.50
Low Carbon 316 Stainless Steel	1 1/2	7.38	6.12	.81	2.75	1.19	2.88
Inconel 600	2	8.28	6.50	.88	3.31	1.31	3.62
Monel	2 1/2	13.1	7.50	1.00	3.94	1.50	4.12
Hastelloy B	3	17.5	8.25	1.12	4.62	1.69	5.00
Molybdenum	4	31.2	10.00	1.25	5.75	1.88	6.19
Hastelloy C	5	41.6	11.00	1.38	7.00	2.00	7.31
Tantalum	6	55.2	12.50	1.44	8.12	2.06	8.50
Titanium	8	96.0	15.00	1.62	10.25	2.44	10.62

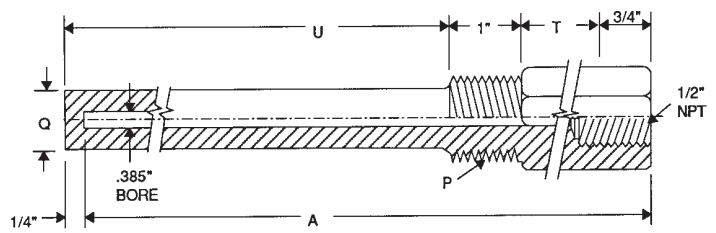
Dimensions are in inches.

THERMOWELL DIMENSIONS, VELOCITY, AND PRESSURE RATING

STANDARD THREADED STRAIGHT SHANK .385" BORE THERMOWELLS FOR 3/8" DIAMETER ELEMENTS



SERIES 52ST, 53ST



SERIES 52ST, 53ST with Lag

STRAIGHT SHANK .385 BORE

EXTERNAL THREAD P	SYMBOL	STEM LGTH. A	INSERT. LGTH. U	SHANK DIA Q
3/4" NPT	52ST-U 2 1/2	4	2 1/2	49/64
	-U 4 1/2	6	4 1/2	49/64
	-U 7 1/2	9	7 1/2	49/64
	-U 10 1/2	12	10 1/2	49/64
	-U 13 1/2	15	13 1/2	49/64
	-U 16 1/2	18	16 1/2	49/64
1" NPT	-U 22 1/2	24	22 1/2	49/64
	53ST-U 2 1/2	4	2 1/2	7/8
	-U 4 1/2	6	4 1/2	7/8
	-U 7 1/2	9	7 1/2	7/8
	-U 10 1/2	12	10 1/2	7/8
	-U 13 1/2	15	13 1/2	7/8
	-U 16 1/2	18	16 1/2	7/8
	-U 22 1/2	24	22 1/2	7/8

STRAIGHT SHANK WITH LAG EXTENSION .385 BORE

EXTERNAL THREAD P	SYMBOL	STEM LGTH. A	INSERT. LGTH. U	LAG EXT. T	SHANK DIA Q
3/4" NPT	52ST-U 2 1/2 T2	6	2 1/2	2	49/64
	-U 4 1/2 T3	9	4 1/2	3	49/64
	-U 7 1/2 T3	12	7 1/2	3	49/64
	-U 10 1/2 T3	15	10 1/2	3	49/64
	-U 13 1/2 T3	18	13 1/2	3	49/64
	-U 19 1/2 T3	24	19 1/2	3	49/64
1" NPT	53ST-U 2 1/2 T2	6	2 1/2	2	7/8
	-U 4 1/2 T3	9	4 1/2	3	7/8
	-U 7 1/2 T3	12	7 1/2	3	7/8
	-U 10 1/2 T3	15	10 1/2	3	7/8
	-U 13 1/2 T3	18	13 1/2	3	7/8
	-U 19 1/2 T3	24	19 1/2	3	7/8

MAXIMUM FLUID VELOCITY FEET PER SECOND

Material	INSERTION LENGTH-"U"							
	2 1/2	4 1/2	7 1/2	10 1/2	13 1/2	16 1/2	19 1/2	22 1/2
Brass	290 (145)	150 (80)	54.1 (48)	27.6	16.7	11.1	8.0	6.0
Carbon Steel	326 (260)	192 (144)	69.5	35.4	20.5	14.3	10.3	7.7
A.I.S.I.-304 & 316	349 (360)	199	71.9	36.6	21.2	14.8	10.7	8.0
Monel	316 (320)	189 (178)	68.1	34.8	20.8	14.0	10.0	7.5

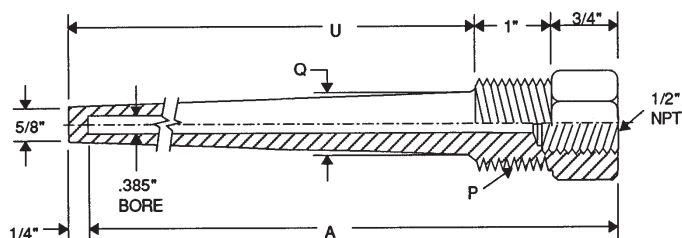
PRESSURE (LB. PER SQ. INCH)-TEMPERATURE

Material	Temperature—°F						
	70°	200°	400°	600°	800°	1000°	1200°
Brass	5000	4200	1000	—	—	—	—
Carbon Steel	5200	5000	4800	4600	3500	1500	—
A.I.S.I. 304	7000	6200	5600	5400	5200	4500	1650
A.I.S.I. 316	7000	7000	6400	6200	6100	5100	2500
Monel	6500	6000	5400	5300	5200	1500	—

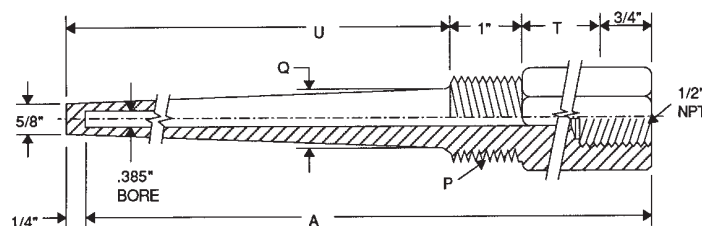
Note: The values in parenthesis represent safe values for water flow while the values not in parenthesis may be used for steam, air, gas and fluids with similar density.

THERMOWELL DIMENSIONS, VELOCITY, AND PRESSURE RATING

HEAVY DUTY THREADED TAPERED SHANK .385" BORE THERMOWELLS FOR 3/8" DIAMETER ELEMENTS



SERIES 52TT, 53TT



SERIES 52TT, 53TT with Lag

TAPERED SHANK .385 BORE

EXTERNAL THREAD P	SYMBOL	STEM LGTH. A	INSERT. LGTH. U	SHANK DIA Q
3/4" NPT	52TT-U 2 1/2	4	2 1/2	7/8
	-U 4 1/2	6	4 1/2	7/8
	-U 7 1/2	9	7 1/2	7/8
	-U 10 1/2	12	10 1/2	7/8
	-U 13 1/2	15	13 1/2	7/8
	-U 16 1/2	18	16 1/2	7/8
1" NPT	-U 22 1/2	24	22 1/2	7/8
	53TT-U 2 1/2	4	2 1/2	1 1/16
	-U 4 1/2	6	4 1/2	1 1/16
	U 7 1/2	9	7 1/2	1 1/16
	U 10 1/2	12	10 1/2	1 1/16
	-U 13 1/2	15	13 1/2	1 1/16
	-U 16 1/2	18	16 1/2	1 1/16
	-U 22 1/2	24	22 1/2	1 1/16

TAPERED SHANK WITH LAG EXTENSION .385 BORE

EXTERNAL THREAD P	SYMBOL	STEM LGTH. A	INSERT. LGTH. U	LAG EXT. T	SHANK DIA Q
3/4" NPT	52TT-U 2 1/2 T2	6	2 1/2	2	7/8
	-U 4 1/2 T3	9	4 1/2	3	7/8
	-U 7 1/2 T3	12	7 1/2	3	7/8
	-U 10 1/2 T3	15	10 1/2	3	7/8
	-U 13 1/2 T3	18	13 1/2	3	7/8
	-U 19 1/2 T3	24	19 1/2	3	7/8
1" NPT	53TT-U 2 1/2 T2	6	2 1/2	2	1 1/16
	-U 4 1/2 T3	9	4 1/2	3	1 1/16
	-U 7 1/2 T3	12	7 1/2	3	1 1/16
	-U 10 1/2 T3	15	10 1/2	3	1 1/16
	-U 13 1/2 T3	18	13 1/2	3	1 1/16
	-U 19 1/2 T3	24	19 1/2	3	1 1/16

MAXIMUM FLUID VELOCITY FEET PER SECOND

Note: The values in parenthesis represent safe values for water flow while the values not in parenthesis may be used for steam, air, gas and fluids with similar density.

Well Type	Material	INSERTION LENGTH-"U"							
		2 1/2	4 1/2	7 1/2	10 1/2	13 1/2	16 1/2	19 1/2	22 1/2
3/4"-.385 Bore and 3/4"-.385 Bore with Lag Extension	Brass	276 (127)	124 (79)	44	22	13	8	6	4
	Carbon Steel	352 (228)	191 (114)	689	35	21	14	10	7.5
	304 & 316	415 (299)	203 (154)	73.2	37.3	22.5	15	11	8
	Monel	340 (255)	172 (134)	62	31	19	12.8	8	6
1"-.385 Bore and 1"-.385 Bore with Lag Extension	Brass	321 (150)	129 (83.5)	46.8	23.6	14.5	9.6	6.9	5.1
	Carbon Steel	410 (270)	249 (150)	90.3	45.6	27.8	18.5	13.2	9.8
	304 & 316	483 (350)	272 (208)	97.3	49.7	30.4	20.3	14.5	10.7
	Monel	396 (306)	214 (167)	77.5	39.2	23.8	16	10.3	7.7

PRESSURE (LB. PER SQ. INCH)-TEMPERATURE

Material	Temperature—°F						
	70°	200°	400°	600°	800°	1000°	1200°
Brass	5000	4200	1000	—	—	—	—
Carbon Steel	5200	5000	4800	4600	3500	1500	—
A.I.S.I. 304	7000	6200	5600	5400	5200	4500	1650
A.I.S.I. 316	7000	7000	6400	6200	6100	5100	2500
Monel	6500	6000	5400	5300	5200	1500	—

DECIMAL EQUIVALENTS OF PIPE SIZES

Dimensions in Inches - Wall Thickness of:

PIPE SIZE	OUTSIDE DIAMETER	SCH 40 / INSIDE DIAMETER	SCH 80 / INSIDE DIAMETER	SCH 160 / INSIDE DIAMETER
1/8	.405	.068 / .269	.095 / .215	N/A
1/4	.540	.088 / .384	.119 / .302	N/A
3/8	.678	.091 / .493	.126 / .423	N/A
1/2	.840	.109 / .622	.147 / .548	.187 / .466
3/4	1.050	.113 / .824	.154 / .742	.218 / .614
1	1.315	.133 / 1.049	.179 / .957	.250 / .815
1 1/4	1.660	.140 / 1.380	.191 / 1.278	.250 / 1.160
1 1/2	1.900	.145 / 1.610	.200 / 1.500	.281 / 1.338
2	2.375	.154 / 2.067	.218 / 1.939	.343 / 1.689
6	6.625	.280 / 6.065	.432 / 5.761	.718 / 5.189
9	9.625	.342 / 8.941	.500 / 8.625	N/A
12	12.750	.406 / 11.938	.687 / 11.376	1.312 / 10.126
24	24.000	.375 / 23.25	500 / 23.00	2.344 / 19.312

THEORETICAL BURSTING AND COLLAPSING PRESSURES FOR PIPE Stainless Steel (ASTM-A-312)

NOMINAL SIZE (INCHES)	SCHEDULE NUMBER	OUTSIDE DIAMETER (INCHES)	WALL THICKNESS (INCHES)	INSIDE DIAMETER (INCHES)	INTERNAL PRESSURE, PSI BURSTING	EXTERNAL PRESSURE, PSI COLLAPSING
1/8	40	0.405	0.068	0.269	25,185	10,761
	80	0.405	0.095	0.215	35,185	15,441
1/4	40	0.540	0.088	0.384	24,444	10,415
	80	0.540	0.119	0.302	33,055	14,445
3/8	40	0.678	0.091	0.493	20,192	8,397
	80	0.678	0.126	0.423	27,876	12,021
1/2	40	0.840	0.109	0.622	19,464	8,084
	80	0.840	0.147	0.548	26,250	11,260
3/4	40	1.050	0.113	0.824	16,142	6,529
	80	1.050	0.154	0.742	22,000	9,271
1	40	1.315	0.133	1.049	15,171	6,075
	80	1.315	0.179	0.957	20,418	8,530
1 1/4	40	1.660	0.140	1.380	12,650	3,895
	80	1.660	0.191	1.278	17,259	7,052
1 1/2	40	1.900	0.145	1.610	11,447	4,332
	80	1.900	0.200	1.500	15,789	6,364

NOTE: Burst Pressures for Stainless Steel in above chart were calculated using the specified minimum tensile strength, 75,000 p.s.i.

The information and data presented herein are typical or average values and are not a guarantee of maximum or minimum values. Applications specifically suggested for material described herein are made solely for the purpose of illustration to enable the reader to make his own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes.

THEORETICAL BURSTING PRESSURES FOR TUBING (ASTM-A-632) Corresponding to a fiber stress in wall of 10,000 pounds per square inch

OUTSIDE DIAMETER (INCHES)	WALL THICKNESS - DECIMAL INCH						
	BWG EQUIVALENT						
	.020 25	.028 22	.035 20	.049 18	.065 16	.095 13	.120 11
1/8	3200	5200	5600	7840			
3/16	2133	2987	3933	5227			
1/4	1600	2240	2800	3920	5200	7600	
5/16	1280	1792	2240	3136	4160	6100	
3/8	1057	1493	1867	2613	3467	5067	6400
1/2	800	1120	1400	1960	2600	3800	4800

The table (S=10,000) affords easy calculations with appropriate multipliers shown below. For theoretical bursting pressures, use tensile values. For theoretical bulging pressures, use yield values. Working pressures will vary depending upon safety factors required for environmental conditions involved as determined by your design engineer and appropriate codes.

Material	Tensile (Multiplier)	Yield (Multiplier)
6061-T6 Aluminum	42,000 psi (x 4.2)	35,000 psi (x3.5)
Annealed Low Carbon Steel	55,000 psi (x 5.5)	25,000 psi (x 2.5)
Annealed 18-8 Stainless	75,000 psi (x 7.5)	30,000 psi (x3.0)
1/8 Hard 18-8 Stainless	105,000 psi (x 10.5)	75,000 psi (x7.5)
Cold Dr. 21-6-9 Stainless	142,000 psi (x 14.2)	120,000 psi (x 12.0)

The above table is based on the best known and most widely used formula for calculating the bursting pressure of tubes, namely Barlow's: $P = \frac{2St}{D}$

P = Internal pressure in p.s.i. S = Fiber stress of tube in p.s.i. t = Wall thickness in inches D = Outside diameter in inches
The information and data presented herein are typical of averaging values and are not a guarantee of maximum or minimum values. Applications specifically suggested for material described herein are made solely for the purpose of illustration to enable the reader to make his own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes.

MATERIAL SELECTION INFORMATION

The following information is a guide line for selecting thermocouple, RTD and thermowell materials based on the process fluid. Factors such as catalytic reaction, contaminations and electrolysis are taken into consideration. However, in many cases there are even more variables which must be examined.

These suggestions are to be used only as guide lines and are based on the most economical material selection. JMS Southeast will not take any responsibility if these recommendations are not satisfactory for specific applications. Consult JMS Southeast for special applications and our engineering department will assist you in your selection.

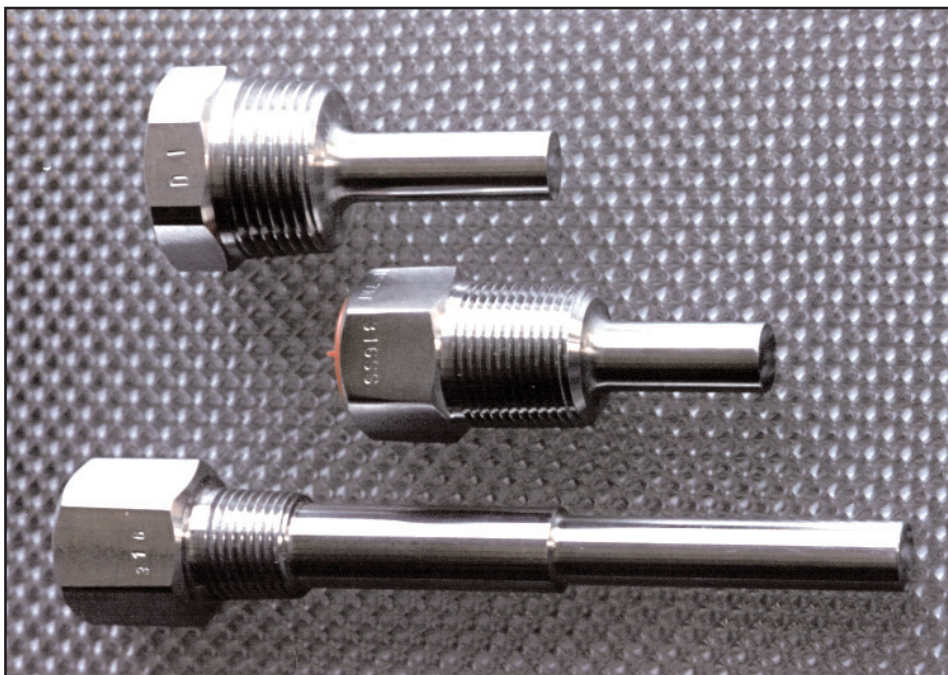
SUBSTANCE	CONDITIONS	RECOMMENDED METAL	SUBSTANCE	CONDITIONS	RECOMMENDED METAL	SUBSTANCE	CONDITIONS	RECOMMENDED METAL
Acetate Solvents	Crude or Pure	Monel or Nickel	Ethyl Acetate		Monel	" "	85% - 70°F	Hastelloy B
Acetic Acid	10% - 70°F	304 Stainless Steel	Ethyl Chloride	70°F	304 Stainless Steel	" "	85% - 212°F	Hastelloy B
" "	50% - 70°F	304 Stainless Steel	Ethylene Glycol		Steel (C1018)	Picric Acid	70°F	304 Stainless Steel
" "	50% - 212°F	316 Stainless Steel	" "	70°F	Monel	Potassium Bromide	70°F	316 Stainless Steel
" "	99% - 70°F	430 Stainless Steel	Ethyl Sulphate		316 Stainless Steel	Potassium Carbonate	1% - 70°F	304 Stainless Steel
" "	99% - 212°F	430 Stainless Steel	Ferric Chloride	1% - 70°F	Tantalum	Potassium Chlorate	70°F	304 Stainless Steel
Acetic Anhydride		Monel	" "	5% - 70°F	Tantalum	Potassium Chloride	5% - 70°F	304 Stainless Steel
Acetone	212°F	304 Stainless Steel	" "	5% - Boiling	Tantalum	" "	5% - 212°F	304 Stainless Steel
Acetylene		304, Monel, Nickel	Ferric Sulphate	5% - 70°F	304 Stainless Steel	Potassium Hydroxide	5% - 70°F	304 Stainless Steel
Alcohol Ethyl	70°F	304 Stainless Steel	Ferrous Sulphate	Dilute 70°F	304 Stainless Steel	" "	25% - 212°F	304 Stainless Steel
" "	212°F	304 Stainless Steel	Formaldehyde		304 Stainless Steel	" "	50% - 212°F	316 Stainless Steel
Alcohol Methyl	70°F	304 Stainless Steel	Freon		Steel (C1018)	Potassium Nitrate	5% - 70°F	304 Stainless Steel
" "	212°F	304 Stainless Steel	Formic Acid	5% - 70°F	316 Stainless Steel	" "	5% - 212°F	304 Stainless Steel
Aluminum	Molten	Cast Iron	" "	5% - 150°F	316 Stainless Steel	Potassium		
Aluminum Acetate	Saturated	304 Stainless Steel	Gallic Acid	5% - 70°F	Monel	Permanganate	5% - 70°F	304 Stainless Steel
Aluminum Sulphate	10% - 70°F	304 Stainless Steel	" "	5% - 150°F	Monel	Potassium Sulphate	5% - 70°F	304 Stainless Steel
" "	Saturated 70°F	304 Stainless Steel	Gasoline	70°F	304 Stainless Steel	" "	5% - 212°F	304 Stainless Steel
" "	10% - 212°F	316 Stainless Steel	Glucose	70°F	304 Stainless Steel	Potassium Sulphide	70°F	304 Stainless Steel
" "	Saturated 212°F	316 Stainless Steel	Glycerine	70°F	304 Stainless Steel	Propane		304 Stainless Steel
Ammonia	All concentrations 70°F	304 Stainless Steel	Glycerol		446 Stainless Steel	Pyregallic Acid		304 Stainless Steel
Ammonium Chloride	All concentrations 212°F	316 Stainless Steel	Heat Treating		Hastelloy B	Quinine Bisulphate	Dry	316 Stainless Steel
Ammonium Nitrate	All concentrations 70°F	304 Stainless Steel	Hydrobromic Acid	48% - 212°F	Hastelloy C	Quinine Sulphate	Dry	304 Stainless Steel
" "	All concentrations 212°F	304 Stainless Steel	Hydrochloric Acid	1% - 70°F	Hastelloy C	Resin		304 Stainless Steel
Ammonium Sulphate	5% - 70°F	304 Stainless Steel	" "	1% - 212°F	Hastelloy B	Rosin	Molten	304 Stainless Steel
" "	10% - 212°F	316 Stainless Steel	" "	5% - 70°F	Hastelloy C	Sea Water		Monel
" "	Saturated 212°F	316 Stainless Steel	" "	5% - 212°F	Hastelloy B	Salomoniac		Monel
Aniline	All concentrations 70°F	304 Stainless Steel	" "	25% - 70°F	Hastelloy B	Salicylic Acid		Nickel
Amylacetate		Monel	Hydrocyanic Acid		316 Stainless Steel	Shellac		304 Stainless Steel
Asphalt		Steel (C1018)	Hydrofluoric Acid		Hastelloy C	Soap	70°F	304 Stainless Steel
		Phosphor Bronze, Monel, Nickel	Hydrogen Peroxide	70°F	316 Stainless Steel	Sodium Bicarbonate	All concentrations 70°F	304 Stainless Steel
Barium Carbonate	70°F	304 Stainless Steel	" "	212°F	316 Stainless Steel	" "	5% - 150°F	304 Stainless Steel
Barium Chloride	5% - 70°F	Monel	Hydrogen Sulphide	Well and dry	316 Stainless Steel	Sodium Bisulphate		Monel
" "	Saturated 70°F	Monel	Iodine	70°F	Tantalum	Sodium Carbonate	5% - 70°F	304 Stainless Steel
" "	Aqueous - Hot	316 Stainless Steel	Kerosene	70°F	304 Stainless Steel	" "	5% - 150°F	304 Stainless Steel
Barium Hydroxide		Steel (C1018)	Lactic Acid	5% - 70°F	304 Stainless Steel	Sodium Chloride	5% - 70°F	316 Stainless Steel
Barium Sulphite		Nichrome	" "	5% - 150°F	316 Stainless Steel	Sodium Chloride	5% - 150°F	316 Stainless Steel
Benzaldehyde		Steel (C1018)	" "	10% - 212°F	Tantalum	" "	Saturated - 70°F	316 Stainless Steel
Benzene	70°F	304 Stainless Steel	Lacquer	70°F	316 Stainless Steel	" "	Saturated - 212°F	316 Stainless Steel
Benzine		Steel (C1018)	Latex		Steel (C1018)	Sodium Fluoride	5% - 70°F	Monel
		Monel, Inconel	Lime Sulphur		Steel (C1018), 304, Monel	Sodium Hydroxide		304 Stainless Steel
Benzol	Hot	304 Stainless Steel	Linseed Oil	70°F	304 Stainless Steel	Sodium Hypochlorite	5% still	316 Stainless Steel
Boric Acid	5% Hot or Cold	304 Stainless Steel	Magnesium Chloride	5% - 70°F	Monel	Sodium Nitrate	Fused	317 Stainless Steel
Bromine	70°F	Tantalum	" "	5% - 212°F	Nickel	Sodium Peroxide		304 Stainless Steel
Buladiene		Brass, 304	Magnesium Sulphate	Cold and Hot	Monel	Sodium Phosphate		Steel (C1018)
Bulane	70°F	304 Stainless Steel	Malic Acid	Cold and Hot	316 Stainless Steel	Sodium Silicate		Steel (C1018)
Butylacetate		Monel	Mercury		Steel (C1018), 304, Monel	Sodium Sulphate	70°F	304 Stainless Steel
Butyl Alcohol		Copper	Methane	70°F	Monel	Sodium Sulphide	70°F	316 Stainless Steel
Butylenes		Steel (C1018), Phosphor Bronze	Milk		Steel (I020)	Sodium Sulphite	150°F	304 Stainless Steel
Butyric Acid	5% - 70°F	304 Stainless Steel	Mixed Acids		304, Nickel	Steam		304 Stainless Steel
" "	5% - 150°F	304 Stainless Steel	(Sulphuric and Nitric — all temp. and %)		Carpenter # 20	Stearic Acid		304 Stainless Steel
Calcium Bisulfite	70°F	316 Stainless Steel	Molasses		Steel (C1018), 304, Monel, Nickel	Sulphur Dioxide	Moist Gas - 70°F	316 Stainless Steel
Calcium Chlorate	Dilute 70°F	304 Stainless Steel	Muriatic Acid	70°F	Tantalum	" "	Gas - 575°F	304 Stainless Steel
" "	Dilute 150°F	304 Stainless Steel	Naphtha	70°F	304 Stainless Steel	" "	Dry - Molten	304 Stainless Steel
Calcium Hydroxide	10% - 212°F	304 Stainless Steel	" "	70°F	304 Stainless Steel	" "	Well	316 Stainless Steel
" "	20% - 212°F	304 Stainless Steel	Natural Gas	70°F	304 Stainless Steel	Sulphuric Acid	5% - 70°F	Carp. 20, Hastelloy B
" "	50% - 212°F	317 Stainless Steel	Neon	70°F	304 Stainless Steel	" "	5% - 212°F	Carp. 20, Hastelloy B
Carbolic Acid	All 212°F	316 Stainless Steel	Nickel Chloride	70°F	304 Stainless Steel	" "	10% - 70°F	Carp. 20, Hastelloy B
Carbon Dioxide	Dry	Steel (C1018), Monel	" "	70°F	304 Stainless Steel	" "	10% - 212°F	Carp. 20, Hastelloy B
Carbon Dioxide	Well	Aluminum, Monel, Nickel	Nickel Sulphate	Hot and Cold	304 Stainless Steel	" "	50% - 70°F	Carp. 20, Hastelloy B
Carbon Tetrachloride	10% - 70°F	Monel	Nitric Acid	5% - 70°F	304 Stainless Steel	" "	50% - 212°F	Carp. 20, Hastelloy B
Chlorox Caustic		316SS, 317SS	" "	20% - 70°F	304 Stainless Steel	" "	90% - 70°F	Carp. 20, Hastelloy B
Chlorine Gas	Dry 70°F	317 Stainless Steel	" "	50% - 70°F	304 Stainless Steel	" "	90% - 212°F	Hastelloy D
" "	Moist 70°F	Hastelloy C	" "	50% - 212°F	304 Stainless Steel	Tannic Acid	70°F	304 Stainless Steel
" "	Moist 212°F	Hastelloy C	" "	65% - 212°F	316 Stainless Steel	Tar		Steel (C1018), 304, Monel, Nickel
Chromic Acid	5% - 70°F	304 Stainless Steel	" "	Concentrated - 70°F	304 Stainless Steel	Tartaric Acid	70°F	304 Stainless Steel
" "	10% - 212°F	316 Stainless Steel	" "	Concentrated - 212°F	Tantalum	" "	150°F	316 Stainless Steel
" "	50% - 212°F	316 Stainless Steel	Nitrobenzene	70°F	304 Stainless Steel	Tin	Molten	Cast Iron
Citric Acid	15% - 70°F	304 Stainless Steel	Nitrous Acid		304 Stainless Steel	Tolvene		Aluminum, Phosphor Bronze, Monel
" "	15% - 212°F	316 Stainless Steel	Oleum	70°F	316 Stainless Steel	Trichloroethylene		Steel (C1018)
" "	Concentrated 212°F	317 Stainless Steel	Oxalic Acid	5% - Hot and Cold	304 Stainless Steel	Turpentine		304 Stainless Steel
Coal Tar	Hot	304 Stainless Steel	" "	10% - 212°F	304 Stainless Steel	Varnish		304 Stainless Steel
Coke Oven Gas		Aluminum	Oxygen	70°F	Monel	Vegetable Oils		Steel (C1018), 304, Monel
Copper Nitrate		304, 316	Oxygen	Liquid	Steel (C1018)	Vinegar		Monel
Copper Sulphate		304, 316	Palmitic Acid		304 Stainless Steel	Water	Fresh	304 Stainless Steel
Core Oils		316 Stainless Steel	Petroleum Ether		316 Stainless Steel	" "		Copper, Steel
Cottonseed Oil		Steel (C1018), Monel, Nickel	Phenol		304 Stainless Steel	" "	Salt	(C1018), Monel
Creosols		304 Stainless Steel	Pentane		304 Stainless Steel	Water		Aluminum, Brass, Monel
Creosote Crude		Steel (C1018), Monel, Nickel	Phosphoric Acid	1% - 70°F	304 Stainless Steel	Whiskey, Wine		304, Nickel
Cyanogen Gas		304 Stainless Steel	" "	5% - 70°F	304 Stainless Steel	Xylene		Copper
Dowtherm		Steel (C1018)	" "	10% - 70°F	316 Stainless Steel	Zinc	Molten	Cast Iron
Epsom Salt	Hot and Cold	304 Stainless Steel	" "	10% - 212°F	Hastelloy C	Zinc Chloride		Monel
Ether	70°F	304 Stainless Steel	" "	30% - 70°F	Hastelloy B	Zinc Sulphate	5% - 70°F	304 Stainless Steel
			" "	30% - 212°F	Hastelloy B	" "	Saturated - 70°F	304 Stainless Steel
						" "	25% - 212°F	304 Stainless Steel

MATERIAL SELECTION INFORMATION

METALLIC THERMOWELL MATERIALS

SUMMARY TABLE

DESIGNATION	NOMINAL COMPOSITION	MAXIMUM TEMP. (cont. serv. air)	MELTING POINT
304SS	18% Chromium 9% Nickel	1652°F	2600 - 2750°F
310SS	25% Chromium 20% Nickel	2100°F	2500 - 2550°F
316SS	18% Chromium 12% Nickel 2-3% Molybdenum	1700°F	2500 - 2550°F
304LSS	Similar to 304SS with reduced carbon	800°F	2600 - 2750°F
Inconel 600	76% Nickel 15.5% Chromium 8.0% Iron	2100°F	2470 - 2575°F
Hastelloy B3	65% Nickel 28% Molybdenum 1.5% Cr 1.5% Iron	800°F	2500 - 2585°F
Hastelloy C276	57% Nickel 16% Molybdenum 15.5% Chromium 4% Tungsten 5% Iron	800°F	2415 - 2500°F
Monel	65% Nickel 32% Copper	1000°F	2450°F



MATERIAL SELECTION INFORMATION

COMPARATIVE CORROSION RATINGS

For Carbon Steel, Inconel, Monel, Nickel, 303 Stainless Steel, 304 Stainless Steel, 316 Stainless Steel, and Teflon.

The data in this chart is reprinted here with the permission of Hoke, Inc., One Tenakill Park, Cresskill, New Jersey 07626.

This chart is a guide to the selection of a corrosion resistant protection tube. Changes in temperature, concentration, pressure, agitation, aeration, and impurities can nullify these ratings. The only way to determine the suitability of a protection material in a media is by performance tests. Mechanical strength of the protection tube must also be considered. Unless otherwise marked, all pressures and temperatures are atmospheric. This listing does not imply that other materials are not suitable for use in the media listed.

IDENTIFICATION OF TRADENAMED MATERIALS

Inconel, Monel International Nickel Co.
Teflon E.I. DuPont

RATINGS

- A Substantial Resistance-Preferred material of construction.
- B Moderate Resistance-Satisfactory for use under most conditions; very slight swelling for elastomers.
- C Questionable Resistance-Use with caution.
- D Inadequate Resistance-Not recommended.
- X No information available

LIMITATIONS

1. To 220° F.
2. Subject to stress corrosion at high temperatures and in concentrated solutions.
3. Subject to pitting at air solution line when solution is allowed to dry on metal surface.

Corrosive Media	Carbon Steel	Inconel	Monel	Nickel	303 & 304 Stainless Steel	316 Stainless Steel	Teflon
Acetate Solvents, Crude	D	A	B	B	A	A	A
Acetate Solvents, Pure	C	A	A	A	A	A	A
Acetaldehyde, 100%	X	B	A	B	A	A	A
Acetic Acid, 95%	D	A	A	A	B	A	A
Acetic Acid Vapors, 100%, Hot	B	B	B	B	D	E	A
Acetic Anhydride, Boiling	D	A	A	B	B	A	A
Acetone	B	A	A	A	A	A	A
Alcohols	B	A	A	A	A	A	A
Alum. Potassium, 10%	D	B	B	B	B-3	A	A
Aluminum Chloride, 10%	D	B	B	B	D	C-3	A
Aluminum Chloride, 10%, Boiling	D	C	C	B	D	D	A
Aluminum Sulfate, 10%	D	A	A	A	C	B	A
Aluminum Sulfate, <10%, Boiling	D	B	B	B	D	B	A
Aluminum Sulfate, >10%, Boiling	D	B	B	B	D	B	A
Amines	B	A	A	A	A	A	A
Ammonia, Anhydrous	B	A	A	A	A	A	A
Ammonium Chloride, 10%	C	A	A	A	B-3	A	A
Ammonium Chloride, <10%, Boiling	D	B	B	B	D	C-3	A
Ammonium Chloride, >10%, Boiling	D	C	B	B	D	C-3	A
Ammonium Hydroxide, Hot	B	A	D	D	A	A	A
Ammonium Nitrate	B	A	C	C	A	A	A
Ammonium Persulfate, 5%	D	A	D	D	A	A	A
Ammonium Phosphate, Dibasic, 5%	D	A	B	C	A	A	A
Ammonium Sulfate, <10%	C	B	A	B	B	B	A
Ammonium Sulfate, >10%, Boiling	D	B	B	B	C-3	B-3	A
Ammonium Sulfite, Boiling	D	D	C	D	C	B	A
Aniline Hydrochloride	D	B	B	B	D	C	A
Antimony Trichloride	D	B	B	B	D	C	A
Asphalt	B	A	A	B	A	A	A

Corrosive Media	Carbon Steel	Inconel	Monel	Nickel	316 Stainless Steel	303 & 304 Stainless Steel	Teflon
Barium Chloride, 5%	C	A	A	A	A	A	A
Barium Chloride, >5%, Hot	D	B	A	A	C-3	B-3	A
Barium Hydroxide	C	A	A	A	A	A	A
Barium Nitrate	C	B	C	C	A	A	A
Beer, 160°F	C	A	A	A	A	A	A
Beet Sugar, Liquor, Hot	B	A	A	A	A	A	A
Benzene, Hot	B	A	A	A	A	A	A
Benzoic Acid	B	A	A	A	A	A	A
Blood	D	A	A	A	A	A	A
Borax, Hot	B	A	A	B	A	A	A
Boric Acid, 5%, Hot	D	A	B	B	B	B	A
Bromine, Dry Gas	D	B	A	A	D	D	A
Bromine, Moist Gas	D	D	C	C	D	D	A
Buttermilk	D	A	A	A	A	A	A
Butyric Acid, Dilute	X	A	A	A	A	A	A
Butyric Acid, Hot, Conc.	D	B	B	C	C	B	A
Calcium Bisulfite, Hot	D	D	D	D	C	B	A
Calcium Chloride, Dilute	C	A	A	A	B-3	A-3	A
Calcium Hydroxide, 10%, Boiling	D	A	A	A	A	A	A
Calcium Hydroxide, 20%, Boiling	D	A	A	A	A	A	A
Calcium Hydroxide, 30%, Boiling	D	A	A	A	C	B	A
Calcium Hypochloride, <2%	C	B	C	C	C-3	B-3	A
Carbolic Acid, 90%	C	A	B	A	A	A	A
Carbon Dioxide, Dry	B	A	A	A	A	A	A
Carbon Disulphide	B	A	B	B	A	A	A
Carbon Tetrachloride, Dry, Hot	C	A	A	A	B	A	A
Carbonic Acid, Saturated	D	A	A	A	A	A	A
Chloroacetic Acid	D	B	B	B	D	C	A
Chloric Acid	D	C	C	C	D	C	A
Chlorinated Water, Sat.	D	C	C	C	D	C-3	A
Chlorine, Dry Gas	B	A	A	A	B	B	A
Chlorine, Moist Gas	D	D	C	C	D	C	A
Chlorosulfonic Acid, Dilute	D	B	B	A	D	B	A
Chromic Acid, Dilute	B	B	B	B	B	A	A
Chromic Acid, >10%, Boiling	D	C	C	D	C	B	A
Chromic Acid, >10%, Boiling	D	C	D	D	D	C	A
Citric Acid, Dilute	D	A	A	B	A	A	A
Citric Acid, Hot, Concentrated	D	B	B	B	C	B	A
Copper Nitrate, Hot, Concentrated	D	C	D	D	A	A	A
Copper Sulfate, Hot, Concentrated	D	B	C	C	B	A	A
Creosote, Hot	B	A	A	A	A	A	A
Cupric Chloride, <2%	D	C	B	B	B-3	B-3	A
Cupric Chloride, 5%	D	D	D	C	D	C-3	A
Dichloroethane, Boiling	D	B	A	A	B	B	A
Ethyl Chloride	A	A	A	A	A	A	A
Ethylene Glycol	A	A	A	A	A	A	A
Fatty Acids, 145°F	C	A	A	A	B	A	A
Ferric Chloride, <1%	D	B	C	B	C-3	B-3	A
Ferric Chloride, >1%	D	D	D	D	D	D	A
Ferric Chloride, <1%, Boiling	D	D	D	D	D	D	A
Ferric Chloride, >1%, Boiling	D	D	D	D	D	D	A
Ferric Nitrate, 5%	D	C	D	D	B	A	A
Ferric Sulfate, 5%	D	B	C	C	B-3	A	A
Ferrous Sulfate, 10%	C	B	A	A	A	A	A
Fluorine, Dry Gas	C	A	A	A	C	B	A
Fluorine, Dry, 300°F	D	B	A	A	D	C	D
Fluorine, Moist Gas	D	B	A	B	D	D	A
Formaldehyde, 40%	C	A	A	A	B	A	A
Formic Acid, <50%	D	A	B	B	B	A	A
Formic Acid, >50%	D	B	B	B	B	A	A
Formic Acid, <50%, Hot	D	B	B	B	B	A	A
Formic Acid, >50%, Hot	D	B	B	B	C	B	A
Freon, Wet	C	B	A	A	C	C	A
Fuel Oil, 140°F	A	A	B	B	A	A	A
Furfural	B	B	B	B	B	B	A
Gasoline, refined	A	A	A	A	A	A	A
Glycerine	A	A	A	A	A	A	A
Hydrochloric Acid, <1%	D	B	B	B	D	B	A
Hydrochloric Acid, 1-20%	D	C	B	B	D	D	A
Hydrochloric Acid, >20%	D	D	D	C	D	D	A
Hydrochloric Acid, <1/2%, 175°F	D	C	B	B	D	D	A
Hydrochloric Acid, 1/2-2%, 175°F	D	D	C	C	D	D	A
Hydrochloric Acid, >2%, 175°F	D	D	D	D	D	D	A

MATERIAL SELECTION INFORMATION

Corrosive Media	Carbon Steel	Inconel	Monel	Nickel	303 & 304 Stainless Steel	316 Stainless Steel	Teflon
Hydrochloric Acid, <1/4%, Boiling	D	C	B	B	D	D	A
Hydrochloric Acid, 1/4-1%, Boiling	D	C	C	C	D	D	A
Hydrochloric Acid, >1%, Boiling	D	D	D	D	D	D	A
Hydrofluoric Acid, <40%	C	C	B	B	D	D	A
Hydrofluoric Acid, >40%	C	C	B	C	D	D	A
Hydrofluoric Acid, Boiling	D	D	B	C	D	D	A
Hydrofluosilic Acid	D	B	A	B	D	C	A
Hydrogen Chloride, Dry	B	A	A	A	D	C	A
Hydrogen Chloride, Moist	D	D	C	C	D	D	A
Hydrogen Fluoride, Dry	C	A	A	A	D	C	A-1
Hydrogen Peroxide, Boiling	D	B	B	B	C	B	A
Hydrogen Sulfide, Dry	B	A	A	A	A	A	A
Hydrogen Sulfide, Moist	C	A	B	B	B	A	A
Iodine, Dry	D	A	A	A	D	B	A
Kerosene	A	A	A	A	A	A	A
Lactic Acid, 5%	D	A	B	B	B	A	A
Lactic Acid, 10%	D	A	B	B	B	A	A
Lactic Acid, Boiling, 5%	D	B	C	C	C	B	A
Lactic Acid, Boiling, 10%	D	B	C	C	D	B	A
Lead Acetate, Hot	D	B	B	C	A	A	A
Magnesium Chloride, Hot, 5%	D	A	A	A	C-3	B-3	A
Magnesium Hydroxide	B	A	A	A	A	A	A
Magnesium Sulfate	B	B	A	B	A	A	A
Magnesium Sulfate, Boiling	C	C	A	B	A	A	A
Mercury	B	A	B-2	A	A	A	A
Mercuric Chloride, <2%	D	D	D	D	D	D	A
Mercuric Chloride, <1/2%, Boiling	D	D	D	D	D	D	A
Mercuric Cyanide	D	B	D	B	B	B	A
Methyl Chloride, Dry	D	A	A	A	B	B	A
Milk	D	A	B	B	A	A	A
Molasses	B	A	A	A	A	A	A
Naptha	B	A	A	A	A	A	A
Nickel Chloride	D	B	B	B	C-3	B-3	A
Nickel Sulfate, Boiling	D	B	A	A	C	C	A
Nitric Acid, 20%	D	B	D	D	A	A	A
Nitric Acid, Fuming	D	B	D	D	B	B	A
Nitric Acid, Boiling, 20%	D	C	D	D	A	A	A
Nitric Acid, Boiling, 65%	D	D	D	D	D	B	A
Nitric Acid, Boiling, Conc.	D	D	D	D	D	D	A
Nitrous Acid	D	B	C	C	B	B	A
Oxalic Acid, <10%	C	A	A	A	A	A	A
Oxalic Acid, 10%	C	A	A	A	A	A	A
Oxalic Acid, Boiling, 10%	D	A	A	B	D	C	A
Oxalic Acid, Boiling, 50%	D	B	B	C	D	C	A
Phosphoric Acid (Ortho), <10%	D	A	B	B	B	A	A
Phosphoric Acid (Ortho), 10-50%	D	A	B	C	C	A	A
Phosphoric Acid (Ortho), >50%	D	A	B	C	C	A	A
Phosphoric Acid (Ortho), <20%, 175°F	D	C	B	D	D	A	A
Phosphoric Acid (Ortho), >20%, 175°F	D	D	B	D	D	B	A
Phosphoric Acid (Ortho), <10%, Boiling	D	D	C	D	D	B	A
Phosphoric Acid (Ortho), 85%, Boiling	D	D	D	D	D	C	A
Picric Acid	C	D	D	D	A	A	A
Potassium Bromide	D	A	A	A	C-3	B-3	A
Potassium Carbonate	B	A	A	A	A	A	A
Potassium Chlorate	B	A	B	B	A	A	A
Potassium Chloride	D	A	A	B	A-3	A-3	A
Potassium Chloride, Hot	D	B	A	B	C-3	B-3	A
Potassium Cyanide	B	B	B	B	B	B	A
Potassium Dichromate, Conc.	C	B	B	C	A	A	A
Potassium Ferricyanide, 5%	C	B	B	B	A	A	A
Potassium Ferrocyanide, 5%	C	X	B	B	A	A	A
Potassium Hydroxide, 50%	B	A	A	A	A	A	A
Potassium Hydroxide, 30%, 175°F	D	A	A	A	A	A	A
Potassium Hydroxide, 50%, 175°F	D	A	A	A	B	A	A
Potassium Hydroxide, 30%, Boiling	D	A	A	A	B	A	A
Potassium Hydroxide, 50%, Boiling	D	A	A	A	B	A	A
Potassium Hypochlorite, Dilute	D	X	D	C	C-3	B-3	A
Potassium Permanganate, Dilute	B	B	A	A	A	A	A
Potassium Sulfate, Dilute	B	A	A	A	A	A	A
Potassium Sulfate, Dilute, Boiling	D	B	B	B	B	B	A
Potassium Sulfide, Saturated	C	A	C	A	A	A	A

Corrosive Media	Carbon Steel	Inconel	Monel	Nickel	303 & 304 Stainless Steel	316 Stainless Steel	Teflon
Propane, Liquid and Gas	B	A	A	A	A	A	A
Pyrogalllic Acid	B	B	A	A	A	A	A
Rosin, Molten	D	A	A	A	A	A	A
Salicylic Acid	D	B	B	B	B	B	A
Silver Bromide	D	C	B	C	B-3	A-3	A
Silver Chloride	D	C	B	C	D	D	A
Silver Nitrate	X	A	C	D	A	A	A
Sodium Acetate	C	A	A	A	A	A	A
Sodium Bisulfate	D	B	A	B	B	B	A
Sodium Bisulfate, 140°F	D	C	B	C	B	B	A
Sodium Bromide, Dilute	X	B	A	B	B-3	A-3	A
Sodium Carbonate, 5%, Hot	B	A	A	A	A	A	A
Sodium Chloride, Dilute	C	A	A	A	A	A	A
Sodium Chloride, Saturated, Boiling	D	A	A	A	C-3	B-3	A
Sodium Cyanide	B	B	A	B	B	B	A
Sodium Fluoride, 5%	D	B	A	A	B-3	A-3	A
Sodium Hydroxide, 50%	B	A	A	A	A	A	A
Sodium Hydroxide, <40%, 175°F	D	A	A	A	A	A	A
Sodium Hydroxide, 40-80%, 175°F	D	A	A	A	A	A	A
Sodium Hydroxide, <30%, Boiling	D	A	B	A	A	A	A
Sodium Hydroxide, >30%, Boiling	D	A	B	A	C	B	A
Sodium Hydroxide, Molten	D	B	B	A	D	D	D
Sodium Hypochlorite (Still), 5%	D	C	C	C	C-3	B-3	A
Sodium Hyposulfite	D	B	A	A	B	A	A
Sodium Nitrate	B	A	B	A	B	A	A
Sodium Perborate	C	A	B	B	A	A	A
Sodium Peroxide	C	A	B	B	A	A	A
Sodium Phosphate, Tribasic	C	A	A	A	A	A	A
Sodium Silicate	B	A	B	B	A	A	A
Sodium Sulfate (All concentrations)	B	B	A	A	B	A	A
Sodium Sulfate, Hot	D	B	A	B	C	B	A
Sodium Sulfide, Saturated	B	A	B	A	B-3	A	A
Sodium Sulfite, Hot	D	C	B	C	B	A	A
Sodium Thiosulfate	D	B	B	B	B	A	A
Stannic Chloride, <5%	D	D	B	B	D	D	A
Stannic Chloride, >5%	D	D	C	D	D	D	A
Stannic Chloride, SG 1.21, Boiling	D	D	D	D	D	D	A
Stannous Chloride, Saturated	D	B	B	B	D	B	A
Steam, 212°F	A	A	A	A	A	A	A
Steam, 600°F	C	A	A	A	A	A	D
Sulfite, Liquors	D	D	D	D	C	B	A
Sulfur, Molten, 266°F	B	A	A	A	B	C	A
Sulfur, Chloride	D	B	B	B	D	C	A
Sulfur Dioxide, 250°F, Dry	B	B	B	B	A	A	A
Sulfur Dioxide, Moist	D	D	D	D	B	A	A
Sulfuric Acid, <2%	D	B	B	B	C	B	A
Sulfuric Acid, 2-40%	D	B	B	B	D	D	A
Sulfuric Acid, 40%	D	B	B	B	D	D	A
Sulfuric Acid, Concentrated	B	B	D	D	B	B	A
Sulfuric Acid, <10%, Boiling	D	C	B	D	D	D	A
Sulfuric Acid, 10-80%, Boiling	D	D	C	D	D	D	A
Sulfuric Acid, Concentrated, Boiling	D	D	D	D	D	D	A
Sulfurous Acid, Saturated	D	D	D	D	B	B	A
Tannic Acid, 10%	D	B	A	A	A	A	A
Tar, Hot	B	A	B	B	A	A	A
Tartaric Acid, 120°F	D	A	A	A	B	A	A
Toluene	A	A	A	A	A	A	A
Trichlorethylene	B	A	A	A	A	A	A
Turpentine	B	A	A	A	A	A	A
Varnish, Hot	C	A	A	A	A	A	A
Vegetable Oils	B	A	B	B	A	A	A
Vinegar	D	A	A	A	A	A	A
Water, Acid Mine	D	A	C	C	A-3	A-3	A
Water, Boiler Feed	B	A	A	A	A	A	A
Water, Distilled	D	A	A	A	A	A	A
Water, Salt Sea	D	B	A	C	C-3	B-3	A
Whiskey, Boiling	D	A	C	B	A	A	A
Wine	D	A	C	B	A	A	A
Xylene, Boiling	X	A	A	B	A	A	A
Zinc Chloride, 5%	D	B	B	B	C-3	B-3	A
Zinc Chloride, 5%, Boiling	D	D	B	C	D	D	A
Zinc Sulfate, Boiling	D	B	A	B	A	A	A

CERAMIC AND METAL COATINGS

FOR THERMOWELLS, PROTECTION TUBES, AND BARE SENSORS

Increasing numbers of industrial firms are specifying reliable, high quality thermal coating for repair, restoration and enhancement of mechanical or process equipment. Knowledgeable operations personnel regularly take advantage of the many cost savings and performance improvements now available from these processes and materials; some of which were previously used only for aerospace applications.

BACKGROUND AND USES

Thermal spraying is a process which uses combustion, electric arc or gas plasma, combined with an inert feeder gas, to apply a wide variety of molten metals, ceramics, oxides, and carbides to a target substrate. Combining various substrates with particular coatings allows engineers to choose from using a coated component instead of a solid one.

Some of the major use categories for thermal spray coatings are to increase wear resistance, prevent corrosion, provide thermal barriers or electrical insulation, and restore parts to their original dimensions. In concert with each of these categories, advanced finishing techniques provide a broad spectrum of surface finishes ranging from 1 RMS to over 300 RMS to meet virtually any requirement.

Plasma Arc Spray

Plasma arc spraying is the workhorse of the thermal spray processes. The material to be sprayed is introduced in powder form in the plasma gas stream either in the torch nozzle or just outside the nozzle. The velocity of the plasma stream that exits the nozzle is about the velocity of sound in air. The velocity of spray is usually increased by constricting the torch nozzle. Argon and helium are popular plasma gases, and if these are properly used, the spray deposit will contain very little oxide. This is a process advantage over thermal spray processes that use air as gas to produce the consumable spray. The intense heat of the plasma does not produce substantial substrate heating. Most of the heat to the substrate comes from the heat from the impinging consumable droplets and substrate temperatures usually do not get over 250 degrees F. When substrate heating becomes a consideration, on for example thin wall tubes, auxiliary jets of inert gas are used for substrate cooling. Hundreds of powder consumables are available. They fall into four different categories: metals, ceramics (primarily oxides and carbides), cermets and composites. The most popular ceramic coatings are aluminum oxide and chromium oxide. They are used mostly for wear applications. Ceramics such as yttria-stabilized zirconia and magnesium zirconate are used for thermal barrier applications. The most popular cermet consumable used in plasma spraying is tungsten carbide/cobalt. The mechanical, physical, and chemical properties of a thermal spray deposit may be different from the properties of the same material in bulk. Plasma spraying has been so extensively used in critical components that there is significant data on the properties of many deposits. In general, the differences between spray and bulk properties are inconsequential.

CERAMIC AND METAL COATINGS

Thermal Combustion Spray

Thermal combustion jet spraying was first offered on a commercial basis in 1981. The consumable to be sprayed is introduced into the center of the jet stream from a powder feeder using a carrier that is compatible with the fuel gas mixture. Bond strength is the product of the particle velocity and temperature. The deposit densities are about 95% or better and porosity of the coating can be as little as 0.5%.

Thermal Combustion Wire Process

The materials that can be sprayed with the wire flame spray process include any material that can be made into flexible wire that will melt in the oxyacetylene flame. Many consumables are available, but the commonly sprayed materials are zinc and aluminum, and are used primarily for corrosion protection. The bronzes and hard steels are used for wear protection, and the soft steels and molybdenum are used as rebuilding material for repair jobs. There is no thickness limit to this process, and deposits as thick as 0.25" have been made. A common thickness for wire spray deposits is 0.030" to 0.050" for wear applications and rebuilding. For corrosion applications, deposits can be as thin as 0.001".

QUALITY ASSURANCE PROGRAM

JMS Southeast, Inc. employs one of the most rigorous Quality Assurance programs in the industry. Our specially formulated powders can be traced from the location where they are mined, through each refining process, to the finished product ready for use at our plant. Each coating application undergoes analysis by either the metallographic or petrographic laboratory prior to release. This assures our customers of receiving consistently reproducible coatings of the highest quality.

CUSTOMER SERVICE

Because we use state-of-the-art coating systems, waste is virtually eliminated and high coating speeds are attained. These factors allow us to offer the highest quality coatings at the most competitive prices available today.

INDUSTRIAL PRODUCTS

Almost any industry can benefit from JMS Southeast's coating experience and service. We have wells and other coated parts for the Textile Industry, Power Industry, Petrochemical Industry, Pulp and Paper, Steel Industry, Aluminum Plants, Glass Plants and Wire Drawing Industry just to name a few.

JMS also has the capabilities to teflon coat any thermowells, protection tubes or sensors as needed. Teflon coating will prolong the life of the sensor by protecting it from many forms of chemical attack.

Please contact JMS for prices on our many coatings services.

FREQUENTLY USED COATINGS

COATING DESIGNATION	NOMINAL CONSTITUENTS	COMMENTS
PLASMA SPRAYS		
USSE-115-P	Molybdenum	Hardness, 350 DPH Bond Strength, 8300 psi
USSE-280-P	Cobalt-Chromium-Aluminum-Yttrium (Co-Cr-Al-Y)	Bond strength 5000 psi
USSE-462-P	Tungsten-Carbide Chrome-Carbide Nickel	Hardness, 800 DPH Bond strength, 8700 psi Porosity, less than 3%
USSE-601-P	Aluminum Oxide	Hardness, 1100 DPH Bond strength, 7000 psi Porosity, less than 4%
USSE-660-P	Zirconium Dioxide-Yttria	Hardness, 260 DPH Bond varies between 2200 psi and 6300 psi
THERMAL HVOF COMBUSTION SPRAYS		
USSE-205-M	Stellite 6-type Alloy	Hardness, 390 DPH Bond strength, 11,000 psi
USSE-230-M	Hastelloy-B-2 Type Alloy	Hardness, 315 DPH Bond strength, 10,000 psi
USSE-231-M	Hastelloy-C-276 Type Alloy	Hardness, 170 DPH Bond strength, 10,000 psi
USSE 282-M	Cobalt-Chrome-Aluminum-Yttrium (Co-Cr-Al-Y)	Hardness, 170 DPH Bond strength, 8000 psi
USSE-422-M	Cr3 C2-Ni Cr	Hardness, 870 DPH Porosity, less than 1% Bond strength, 10,000 psi
USSE-445-M	WC-9 Co	Hardness, 1220 DPH Porosity, less than 1% Bond strength 11,000 psi
USSE-475-M	Tungsten Carbide 10 Cobalt-4Chrome	Hardness, 390 DPH Bond strength, 11,000 psi
WIRE TORCH		
USSE-118-W	Stellite 6-Type Alloy	Hardness, 390 DPH Bond strength, 4000 psi
USSE-206-W	Molybdenum	Hardness, 245 DPH Bond strength, 6000 psi
USSE-240-W	Monel-type composition	Hardness, 150 DPH Bond strength, 4300 psi
USSE-257-W	Nickel-Chrome	Hardness, 195 DPH Bond strength, 4000 psi

ADDITIONAL COATINGS

The following list includes an abbreviated list of additional coatings that are available. Although this list is not all inclusive, it does cover the majority of available coatings.

These lists of coating are for reference only. Please contact JMS's Engineering Department for application assistance. Our qualified staff will help you select the best coating for your application.

COATING DESIGNATION

NOMINAL CONSTITUENTS

PLASMA SPRAY

USSE-120-P	Nickel
USSE-245-P	Nickel-Aluminum
USSE-247-P	Nickel-Graphite
USSE-255-P	Nickel-Chrome
USSE-420-P	Chrome Carbide-Ni Chrome
USSE-446-P	Tungsten Carbide-9 Cobalt
USSE-456-P	Tungsten Carbide-12 Cobalt
USSE-461-P	Tungsten Carbide-17 Cobalt
USSE-476-P	Tungsten Carbide-Cobalt-Chrome
USSE-610-P	Titanium Dioxide
USSE-615-P	Chrome Oxide
USSE-616-P	Chrome Oxide
USSE-680-P	Zirconium Dioxide-Calcium Oxide
USSE-701-P	Aluminum Oxide-40 Titanium Dioxide Ceramlon

THERMAL HVOF COMBUSTION SPRAY

USSE-234-M	403 Stainless Steel
USSE-236-M	316 Stainless Steel
USSE-242-M	420 Stainless Steel
USSE-259-M	Nickel-Chrome
USSE-450-M	WC-1Z Co
USSE-460-M	WC-17 Co
USSE-463-M	Tungsten Carbide-Chrome Carbide-10 Nickel
USSE-481-M	TiC-60-Ni

WIRE TORCH

USSE-101-W	Aluminum
USSE-122-W	Nickel
USSE-125-W	Zinc
USSE-208-W	Bronze
USSE-209-W	Aluminum-Bronze

TEMPERATURE COLOR SCALE*

Color	°F	°C
Black Heat	800 - 900	430 - 480
Faint Red	900 - 1050	480 - 570
Blood Red	1050 - 1170	570 - 630
Dark Cherry Red	1170 - 1240	630 - 670
Medium Cherry Red	1240 - 1370	670 - 740
Cherry or Dull Red	1370 - 1540	740 - 840
Bright Red	1540 - 1650	840 - 900
Red-Orange	1650 - 1730	900 - 940
Orange	1730 - 1810	940 - 990
Lemon Yellow	1810 - 1880	990 - 1080
Light Yellow	1880 - 2190	1080 - 1200
White	2190 & above	1200 & above

*Observations made in a relatively dark place with no eye-shades. Observations in lighter areas will tend to shift temperatures higher.

JMS COATINGS APPLICATION CHECKLIST

The information requested below is a minimum requirement to enable JMS to provide a suitable application solution, particularly in the case of exotic metal and/or elements.

1. Maximum temperature sensor will be exposed to: _____
Continuous _____ Intermittent _____
2. Normal operating temperature _____
3. Process conditions:
 - a) Gas, liquid, etc. _____
(Please provide chemical concentration where possible)
 - b) Approximate flow rate _____
 - c) Special pressure or vibration considerations _____
 - d) Any abrasive conditions _____
4. Temperature element details - RTD or Thermocouple type, etc. (This information is also requested in cases where JMS has been asked to supply only the thermowell.)

Platinum RTD _____	E Thermocouple _____
J Thermocouple _____	R,B,S,Thermocouple _____
K Thermocouple _____	Other _____
5. If a metal other than listed in the JMS catalog is specified (ex. - nickel or black steel), we need to know the content or appropriate ASTM, UNS, AISI-SAE number. _____
6. Is thermal shock a possibility? _____ Is the temperature cycled frequently? _____
Does the probe remain immersed? _____
7. If in gas environment, is it oxidizing, reducing, or inert? _____
8. If this is to be a replacement application, information regarding the successes/failures of other units could be beneficial. When possible, please provide any manufacturer and part number information.
9. Other Comments _____

Jacket	_____
Coating	_____

THERMAL PROCESSING / HEAT TREATING (ANNEALING)

If you wish to have your sensor annealed, you need to provide JMS with the correct time, temperature profiles.

All temperature treating processes start at room temperature.

Select Atmosphere: inert, vacuum, or ambient air

Select Portion of sensor to be temperature treated: hot end only, entire sensor, or component of sensor prior to assembly

Stage #1 Increase / decrease temperature to _____ ° F / C at a rate of _____ ° F / C per minute. (Or instant, or doesn't matter)

Stage # 2 Allow to set at that temperature for _____ hours / minutes.

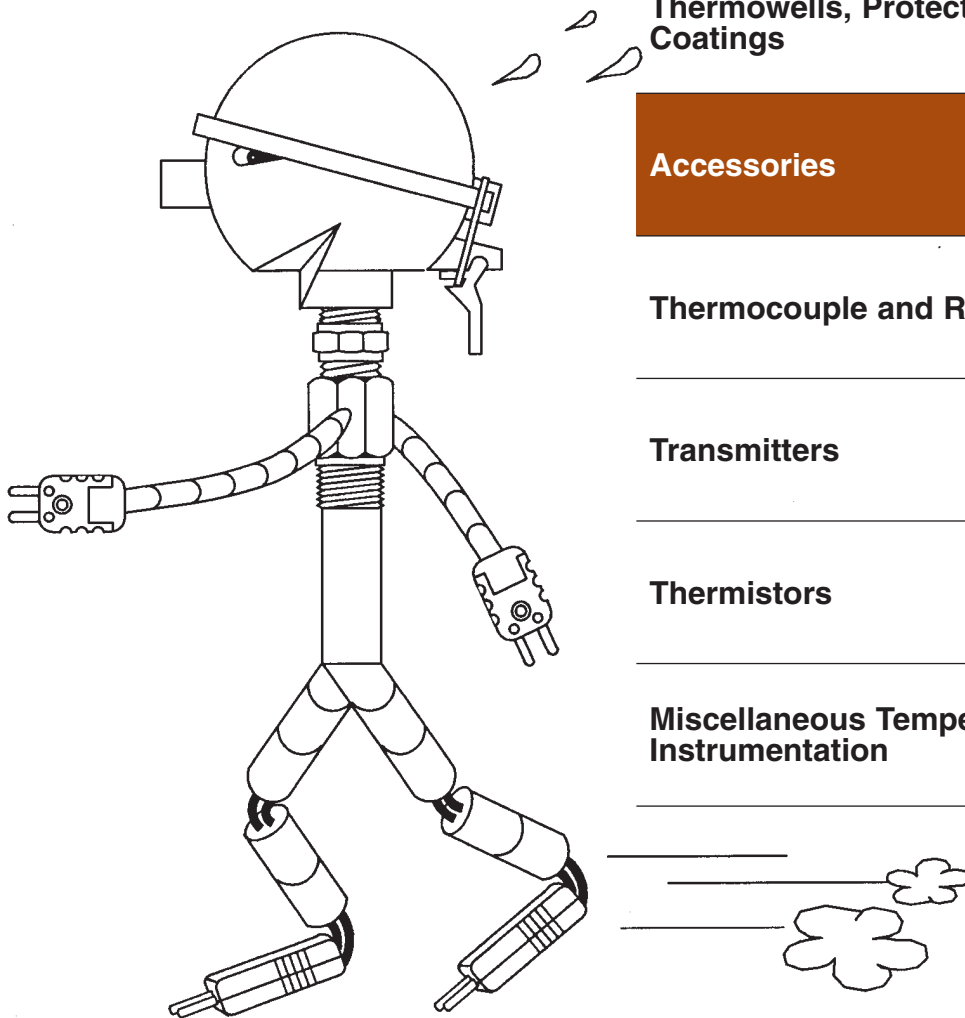
Stage # 3 Increase / decrease temperature to _____ ° F / C at a rate of _____ ° F / C per minute. (Or instant, or doesn't matter)

Note: If water or other liquid quenching is required, please describe.

Specify if parts should be cleaned (buffed) free of any accumulated tarnishing caused by this process.

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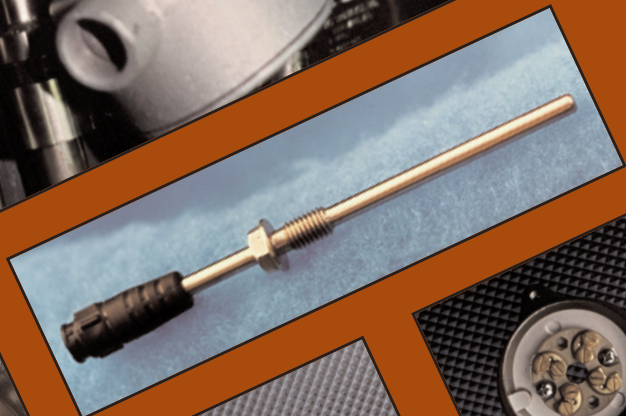
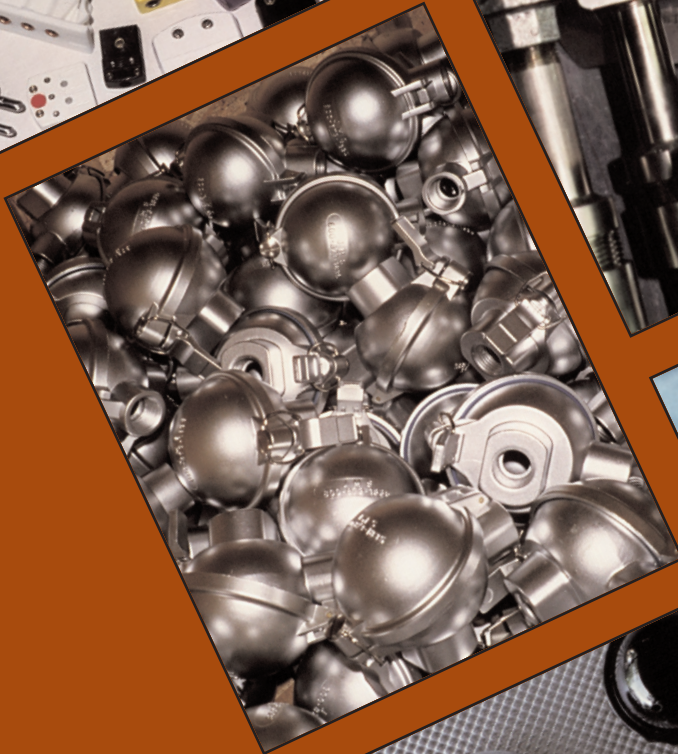


JMS Southeast, Inc.
Temperature Measurement



Accessories



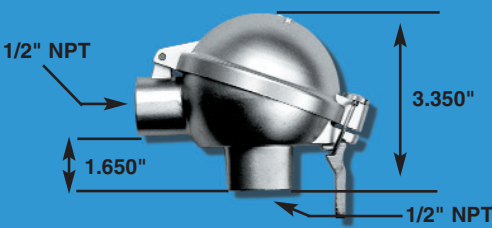
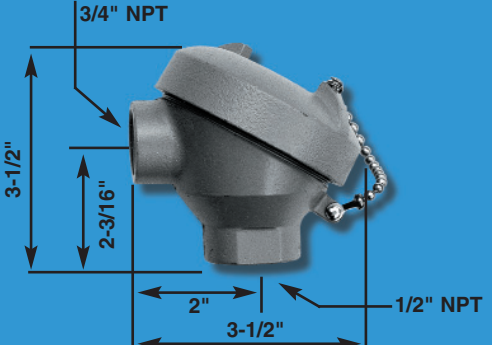
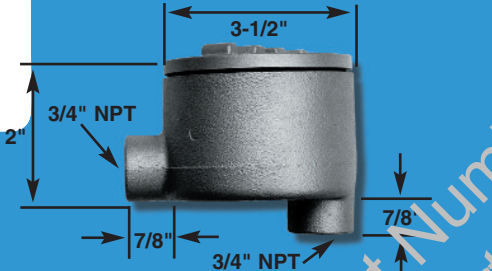
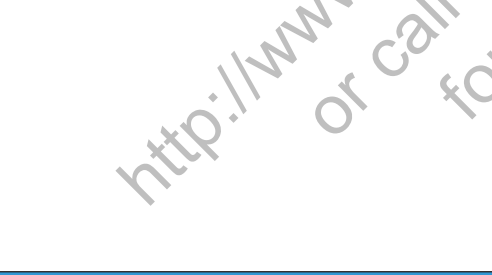
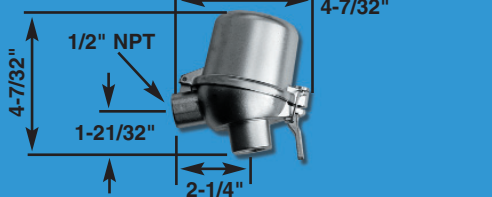
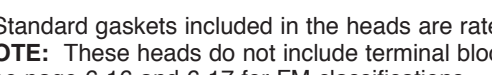
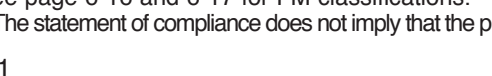


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CONNECTION HEADS

 Diagram of 6L connection head showing dimensions: 1/2" NPT, 1.650", 3.350", 1/2" NPT.	SYMBOL	DESCRIPTION	FEATURES
 Diagram showing 6M, 6N, and 6SS connection heads with dimensions: 3/4" NPT, 3-1/2", 2-3/16", 2", 3-1/2", 1/2" NPT.	6L	General purpose aluminum head with hinged cover 1/2" x 1/2" connection (Standard)	*Corrosion resistant *Moisture resistant *Dust resistant *Durable **NEMA 4 compliance
 Diagram of 6I connection head showing dimensions: 3-1/2", 2", 3/4" NPT, 7/8", 3/4" NPT, 7/8".	6M	General purpose aluminum head with cap and chain 1/2" x 3/4" connection	*Corrosion resistant *Moisture and Dust resistant *Durable **Nema 4
 Diagram of 6N connection head showing dimensions: 3-1/2", 2", 3/4" NPT, 7/8", 3/4" NPT, 7/8".	6N	General purpose cast iron head with cap and chain 1/2" x 3/4" connection	*Rugged construction *Moisture and Dust resistant *Outdoor application *Nema 4
 Diagram of 6SS connection head showing dimensions: 3-1/2", 2", 3/4" NPT, 7/8", 3/4" NPT, 7/8".	6SS	General purpose 316L stainless steel head with cap and chain 1/2" x 3/4" connection	*Chemical and Corrosion resistant *Moisture and Dust resistant *Outdoor application **Nema 4X
 Diagram showing 6R and 6RV connection heads with dimensions: 1/2" NPT, 4-7/32", 1-21/32", 2-1/4", 4-7/32".	6I	Explosion proof head 3/4" x 3/4" connection	*Explosion proof rated for Class I, Groups B, C, D Class I, II, Groups E, F, G, Class III *Moisture resistant *Dust resistant *Cast iron with aluminum cover *UL + CSA Approved
 Diagram of 6I SS connection head showing dimensions: 3-1/2", 2", 3/4" NPT, 7/8", 3/4" NPT, 7/8".	6I SS	Explosion proof stainless steel head 1/2" x 3/4" connection	*Nema 4x *FM *CSA
 Diagram of 6IA connection head showing dimensions: 3-1/2", 2", 3/4" NPT, 7/8", 3/4" NPT, 7/8".	6IA	Explosion proof aluminum head 1/2" x 3/4" connection	*Nema 4 *FM *CSA
 Diagram showing 6R and 6RV connection heads with dimensions: 1/2" NPT, 4-7/32", 1-21/32", 2-1/4", 4-7/32".	6R	High dome, general purpose head with hinged cover, 1/2" x 1/2" connection	*Corrosion resistant *Moisture resistant *Dust resistant *Durable **NEMA 4 compliance
	6RV	High dome, general purpose head with hinged window cover, 1/2" x 1/2" connection	

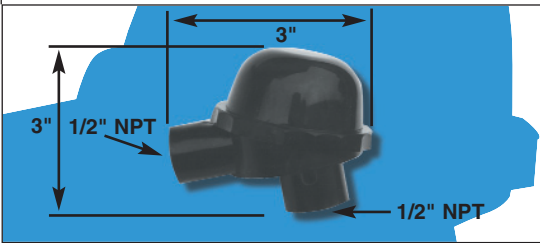
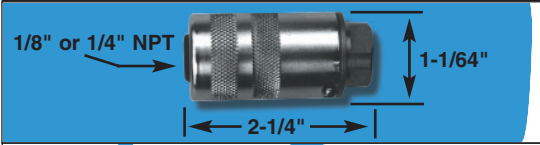
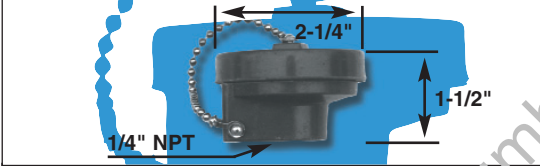
* Standard gaskets included in the heads are rated to 100° C

NOTE: These heads do not include terminal blocks. Terminal blocks can be ordered on page 6-3.

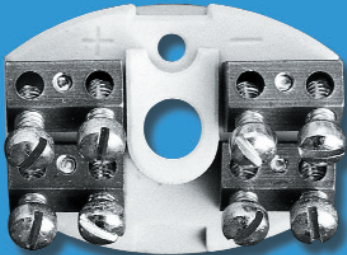
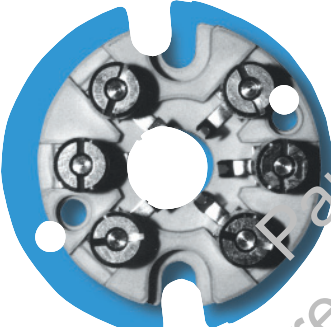
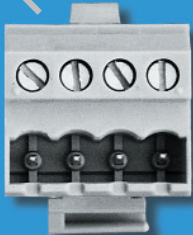
See page 6-16 and 6-17 for FM classifications.

**The statement of compliance does not imply that the products have been approved by UL, CSA or FM, but designed to meet applicable requirements.

CONNECTION HEADS

	SYMBOL	DESCRIPTION	FEATURES
	6WP	White plastic screw-top head (polypropylene) 1/2" x 3/4" connection	*Moisture resistant *Dust resistant *Excellent corrosion resistant *Very light weight *NEMA 4X rated
	6Q	Black plastic (polyamid 6) head 1/2" x 1/2" connection	*Moisture resistant *Dust resistant *Excellent corrosion resistant *Very light weight *NEMA 4 rated
	6S	Cylinder style head	*Small and light weight
	6T 6U	Miniature molded head Hi temp miniature head	*Weatherproof
	60B	90° Pulling Elbow Malleable Iron / Zinc plated 1/2" x 1/2" connection Wire nuts not included	*Raintight *Small and light weight *UL Listed: E-11853 *CSA Certified: 9795

TERMINAL BLOCKS

	SYMBOL /	DESCRIPTION
	# OF TERMINALS	
	6G2 6G4	Ceramic block with brass terminals for type 6M and 6N connection heads. For use with 8 gauge to 14 gauge wires. (See pg. 1-4) Temperature rating of 200°C. Dimensions: 6G2 Height = .790" Width = 2.00" Depth = 1.544" 6G4 Height = 1.146" Width = 2.00" Depth = 1.544"
	6B4 6B6	Ceramic block with brass terminal plate for type 6L, 6M, 6N, 6Q, and 6R connection heads. For use with maximum 20 gauge wire. (See pg. 1-4) Temperature rating of 200°C. Dimensions: 6B4 Diameter = 1.62" Depth = .6" 6B6 Diameter = 1.62" Depth = .6"
	6C8	Ceramic block with nickel plated brass terminal post for type 6L and 6Q connection heads. The terminal posts provide easy access to the wires. For use with maximum 18 gauge wire. Temperature rating of 200°C. Dimensions: 6C8 Diameter = 1.662" Depth = .995"
	6BB4 6BB6	Bakelite terminal block with nicked plated brass terminal post for type 6IA and 6ISS connection heads. For use with maximum 20 gauge wire. Temperature rating of 130°C. Dimensions: 6BB4 Diameter = 1.96" Depth = .9056"
	6PT2 6PT3 6PT4 (shown) 6PT6 6PT8 Note: If not specified, you will receive both male and female components.	Unpluggable terminal blocks for easy calibration and removal of sensors. Terminal body is made of 6.6 Polyimide material, with corrosion proof screw clamp parts. For use with 18 gauge to 24 gauge wires. It is standard with 6R, 6I and 6P connection heads. Temperature rating of 100°C.

* Insert number of terminals behind symbol to complete part number (i.e. 6PT4 or 6M4J).

See page 6-18 for pin connections.

See page 6-5 for thermocouple compensated DIN Rail terminal block.

PLUGS AND JACKS

Connector bodies are molded of glass filled thermoset compounds (will not melt) for high strength and dependability. The standard connectors will withstand ambient temperatures to 400°F continuous and 500°F intermittent. High temperature connectors will withstand ambient temperatures to 800°F continuous and 1000°F intermittent. Standard plugs are color coded per ANSI standards. High temperature plugs are color coded rust. High temperature connectors have nickel plated prongs; and therefore, are good for use in corrosive environments. Other high temperature plugs and jacks are made of ceramic material and can be color coded.

Alloys of prongs match ANSI calibrations to maintain sensing accuracy. Alloys and polarity are identified by symbols molded into the body.

#1	SERIES			
6A	Accessories Plugs and Jacks			
Note: Add a "W" to symbol #2 for a write-on window connector.	#2	CONNECTOR STYLE		
	1	Standard	<425°F	
	2	High temp	<800°F	
	3	Heavy Duty (Solid Pin)	<425°F	
	4	Heavy Duty (Jab In & Solid Pin)	<425°F (Std Size Only)	
	5	Ultra High temp	<1200°F	
	6	Low Noise	<425°F	
	#3	COLD END TERMINATION		
	B	Mini Plug		
	D	Mini Jack		
	C	Standard Plug		
	E	Standard Jack		
Note: Call our Engineering dept. for high temp. vacuum applications and multi-pin connectors. Thermocouple plugs are normally two pin and RTD plugs are three pin. See page 6-7 for preferred RTD connector. Note: See page 6-18 and 6-19 on the web for plug wiring standards.	#4	# OF CIRCUITS		
	2	2 Pole		
	3	3 Pole		
	#3	TYPE	COLOR CODE	
	J	Iron/Constantan	Black	
	T	Copper/Constantan	Blue	
	K	Chromel/Alumel	Yellow	
	E	Chromel/Constantan	Purple	
	S	Copper/#11 Alloy	Green	
	H	Copper/#11 Alloy	Green	
	N	Nicrosil/Nisil	Orange	
	W	Copper/#11 Alloy	Brown	
A	Copper/Copper (For Type-B and RTD's)	White		
6A1C3A & 6A1E3A				
6A6C2J & 6A6E3J				
6A	1W	C	2	J

SUPPORT ACCESSORIES FOR PLUGS AND JACKS

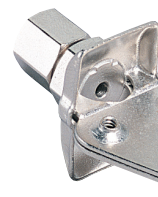
TUBE ADAPTER FOR USE WITH PLUG OR JACK ON SHEATH

Nickel plate steel construction compression fitting. Always used with high temp. connectors and dual connectors mounted to sheath, may be specified on standard plugs and jacks.

SYMBOL	
SINGLE	DUAL
6V063S	6V063D
6V125S	6V125D
6V188S	6V188D
6V250S	6V250D

OUTSIDE TUBE DIAMETER

1/16"
1/8"
3/16"
1/4"



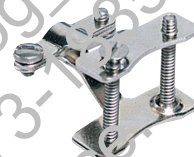
CABLE CLAMP FOR USE WITH PLUG AND JACK WITH LEAD WIRE

Nickel plated steel. For cable up to 3/8" diameter. Always used to support plug mounted on wire lead.

SYMBOL
6H

DESCRIPTION

Cable Clamp



WATER RESISTANT NEOPRENE BOOT FOR USE WITH PLUG AND JACK

SYMBOL
6WPB

DESCRIPTION
Flexible moisture proof boot for connector and wire connection

MAX. TEMP.
212°F



PANEL ADAPTOR

SYMBOL
6ACL

DESCRIPTION
Panel Adaptor

JACK NOT INCLUDED



ROUND SINGLE CIRCUIT PANEL JACK

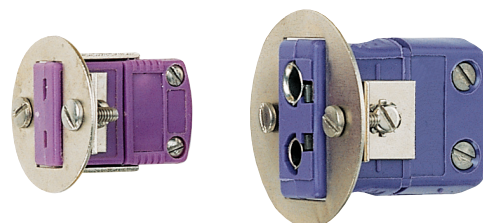
Designed for mounting into an instrument case or control panel from the front. Fits in a standard 3/4" knockout (1 1/8" diameter). Polarity and color coded for identification.

JACK NOT INCLUDED

SYMBOL
6RSC
6RMC

DESCRIPTION
Round Single
Circuit Panel Jack
(Standard)
(Mini)

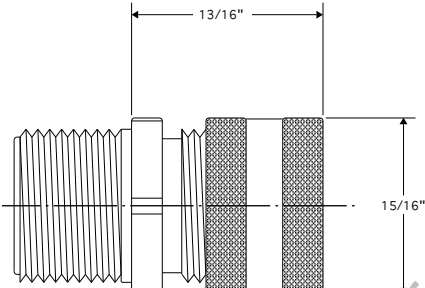
MAX. TEMP.
400°F



SUPPORT ACCESSORIES

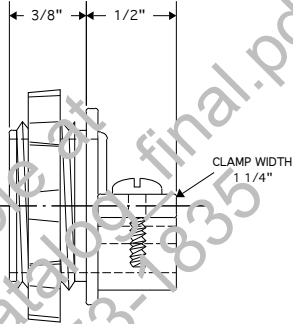
CORD CONNECTOR FOR USE WITH ATTACHING HEAD ASSEMBLIES AND FLEX ARMOR

SYMBOL	DESCRIPTION	MAX. TEMP.
6CC	Cord Connector	250°F



JUNCTION BOX CONNECTOR

SYMBOL	DESCRIPTION	MAX. TEMP.
6JBC	Junction Box Connector	250°F



PLUG LOCK

SYMBOL	DESCRIPTION
6FCL	Plug Lock



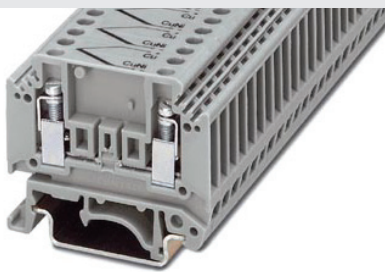
COMPENSATED DIN RAIL THERMOCOUPLE CONNECTIONS

In thermocouple circuits the wires of the thermocouple are connected to extension wires. This is exactly the application for thermocouple terminal blocks.

Extension wires are made of materials which have the same EMF characteristics as the thermocouple. These thermocouple terminal blocks are made up of materials matching the composition of the extension wires.

The thermocouple terminal block pair is clearly marked on the top with an indication of the material on the metal bars. The insulating housing is made of unbreakable polyamid 6.6 and has the universal footing for mounting on all EM/DIN rails. Temperature rated to 200°C. These blocks allow the terminals to be integrated in a panel mounting or other rail layout.

#1	SERIES		
6DR	Din Rail Mountable Thermocouple Connections		
	#2	TYPE OF EXTENSION WIRE	
	J	Iron/Constantan	
	T	Copper/Constantan	
	K	Chromel/Alumel	
	E	Chromel/Constantan	
	R	Copper/Copper Nickel	
	#3	NO. OF PAIRS	
	#	Number of pairs of terminals	
	#4	ACCESSORIES (MAY SELECT MORE THAN ONE)	
	COVER --	Number of end covers	
	PLATE --	Number of partition plates for separation of terminal groups	
	CLAMP --	Number of end clamps for end support of terminal grouping	
6DR	J	4	COVER 2

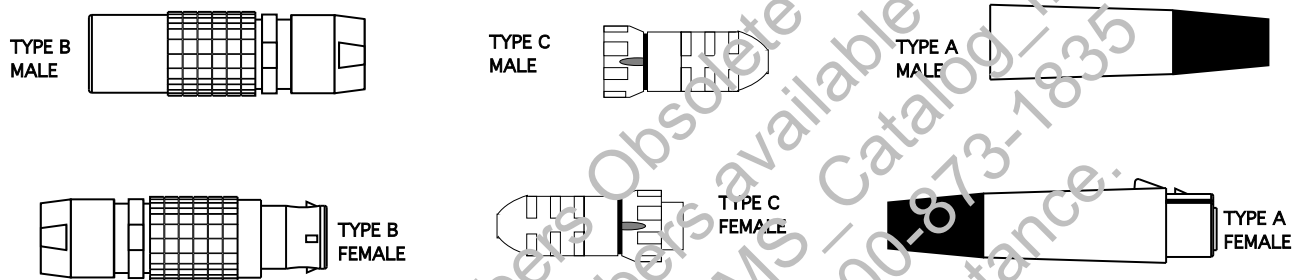


QUICK CONNECTORS

These self-latching quick connectors are designed to assure continuous and accurate temperature monitoring. Available for either thermocouples or RTD's, these connectors overcome the potential connector measurement errors unique to either method of temperature measurement.

In thermocouple circuits the wires of the thermocouple are connected to extension wires. The extension wires are made of materials which, up to 200 degrees C, have the same EMF characteristics as the corresponding thermocouple wire. By using connector pins of the same material as the extension wire the creation of a second thermocouple junction is avoided and the integrity of the signal is maintained.

Screwed connections in an RTD circuit offer a site for oxidation. This will cause an imbalanced bridge and will severely degrade the accuracy of the reading. The soldered connection used in these connectors eliminates this possibility.



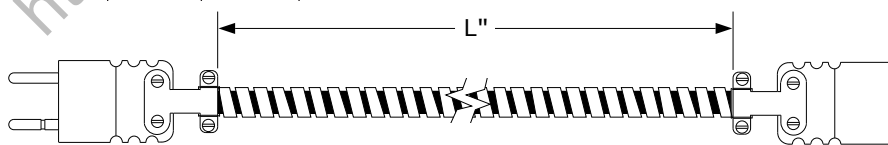
#1	SERIES					
6D	Quick Connectors					
#2	TYPE OF CONNECTOR					
A	US microphone style connector (Standard)					
B	DIN-IEC microphone style connector					
C	Molded / Hermetic connector					
#3	DESCRIPTION					
2	2 wire RTD or T/C compensated					
3	3 wire RTD					
4	4 wire RTD					
X	Other, specify					
#4	TERMINATION					
C	Plug (male)					
E	Jack (female)					
P	Panel mounted jack					
X	Other, specify					
#5	# OF CIRCUITS					
S	Single					
D	Dual					
X	Other, specify					
#6	INSERT ALLOY					
J	Iron/Constantan*					
T	Copper/Constantan*					
K	Chromel/Alumel*					
E	Chromel/Constantan*					
S	Gold Plated - Standard for Type C (above)					
C	Chrome Plated - Standard for Type A (above)					
X	Other, specify					
* Signifies not available for Type A or C connectors.						

See page 6-19 for plug wiring standards.
See pages 6-17 & 6-18 for other sensor connections.

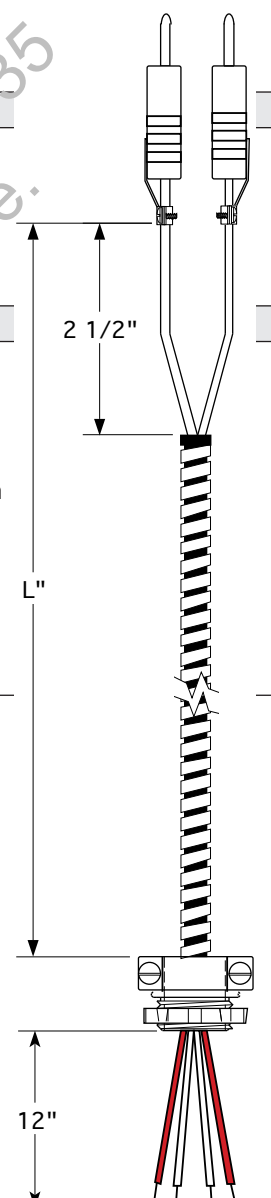
6D	B	2	C	S	J
----	---	---	---	---	---

EXTENSION ASSEMBLIES

#1	SERIES				
6E	Extension Assembly				
	#2	TYPE			
	J	Iron/Constantan			
	T	Copper/Constantan			
	K	Chromel/Alumel			
	E	Chromel/Constantan			
	N	Nicrosil/Nisil			
	*R	Platinum/Platinum 13% Rhodium			
	*S	Platinum/Platinum 10% Rhodium			
	3	100Ω Platinum RTD (.00385 alpha, 3 wire)			
	X	Other, specify			
	*Available in glass braid only.				
	#3	ELEMENT CONSTRUCTION			
	1	Single			
	2	Dual - single connector			
	3	Dual - dual two connectors			
	X	Other, specify			
	#4	LEAD WIRE TYPE & LENGTH IN INCHES			
	1	20 awg Glass braid			
	2	20 awg PVC			
	3	20 awg FEP Teflon			
	4	20 awg Hi-temp glass braid			
	5	20 awg Kapton			
	6	20 awg Glass braid / flexible armor overall. (Standard)			
	X	Other, specify			
	#5	COLD END TERMINATION (CHOOSE A MINIMUM OF TWO OPTIONS)			
	A	Bare ends			
	B	Miniature plug			
	C	Miniature jack			
	D	Standard plug			
	E	Standard jack			
	F	Hi-temp std plug			
	G	Hi-temp std jack			
	W	Type A plug (6DA) [See pg 6-7]			
	V	Type A jack			
	T	Junction box connector			
	K	Spade lugs			
	X	Other, specify			
	Note: All plugs and jacks will be mounted with a cable clamp for mechanical strength.				



Single Extension with Plug & Jack



Dual Extension with Plugs & Junction Box Connector

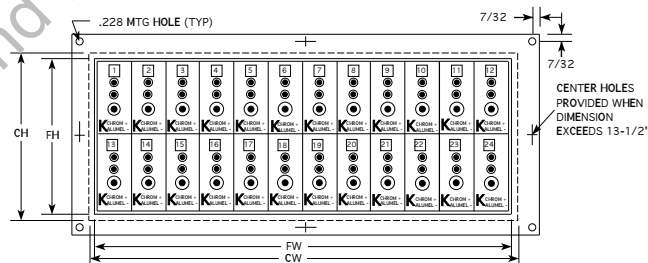
6E
J
1
6-36"
CH

MULTICIRCUIT PANEL WITH MOUNTING FRAME

Multicircuit panels are molded of glass-filled thermoset compounds for high strength and dependability. Panels will withstand ambient temperature of 425°F continuous and 500°F intermittent. One-piece mounting frame is made of 3/32" thick rigid steel with flat black finish. Horizontal mounting style is standard.

#1	SERIES		
6PM	Multicircuit Panel		
	#2	FRAME STYLE	
	1	Standard Frame (Maximum number of jacks per row is 24)	
	2	19" Rack (Maximum number of jacks per row is 22)	
	#3	TYPE	
	S	Standard	
	M	Mini	
	U	Universal	
	#4	DESCRIPTION	19" RACK NUMBER OF ROWS STANDARD HEIGHT
	1	} Number of horizontal rows	1 3 1/2"
	2		2 3 1/2"
	3		3 5 1/4"
	4		4 7"
	X	Other, specify	
	#5	DESCRIPTION	
	#	Total number of circuits	
	X	Other, specify	
		Note: We assume an even number of circuits per row.	
	#6	TYPE	COLOR CODE
	J	Iron/Constantan	Black
	T	Copper/Constantan	Blue
	K	Chromel/Alumel	Yellow
	E	Chromel/Constantan	Purple
	R	Platinum/Platinum 10% Rhodium	Green
	S	Platinum/Platinum 10% Rhodium	Green
	A	Copper/Copper	White
	#7	# OF POLES	
	2	2 poles	
	3	3 poles	

Typical arrangement layout.
Contact our engineering
department for specific drawings.



		CIRCUITS PER ROW																							
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
NUMBER OF ROWS	1	FH = 2 3/16" CH = 2 7/16"	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	2	FH = 4 3/8" CH = 4 5/8"	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
	3	FH = 6 9/16" CH = 6 13/16"	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72
	4	FH = 8 3/4" CH = 7"	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96
	5	FH = 10 15/16" CH = 11 3/16"	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
	6	FH = 13 1/8" CH = 13 3/8"	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144
	7	FH = 15 5/16" CH = 15 9/16"	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147	154	161	168
	8	FH = 17 1/2" CH = 17 3/4"	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160	168	176	184	192
	9	FH = 19 11/16" CH = 19 15/16"	18	27	36	45	54	63	72	81	90	99	107	116	125	134	143	152	161	170	180	189	198	207	216
	10	FH = 21 7/8" CH = 22 1/8"	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240

ROTARY SELECTOR SWITCHES

The JMS Deluxe Switch has an integral face plate and screw/solder terminals.

Terminals are silver plated brass numbered circuits with polarity identification.

Blades and contacts are silver plated with self-cleaning wiper action.

The "OFF" position has terminals available for shorting input circuit when using the switch with a digital meter.

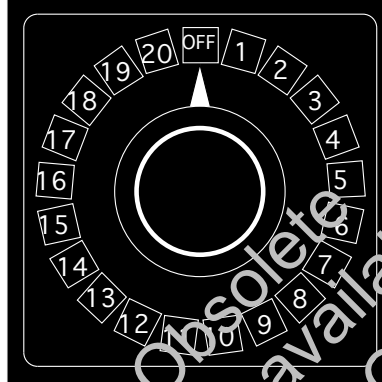
Order numbers 63-2 through 63-10 are break before make.

Order numbers 63-12 through 65-40 and 6R-6 through 6R-36 are make before break.

"Break before make" indicates the previous circuit is broken before the next contact is made.

"Make before break" indicates the second contact is made before the first contact is broken.

SYMBOL	NO. POS.
	2 POLE
63-2	2
63-3	3
63-4	4
63-5	5
63-6	6
63-8	8
63-10	10
63-12	12
63-14	14
63-16	16
63-18	18
63-20	20



SYMBOL	NO. POS.
	2 POLE
65-24	24
65-28	28
65-32	32
65-36	36
65-40	40
	3 POLE
6R-6	6
6R-12	12
6R-24	24
6R-28	28
6R-32	32
6R-36	36

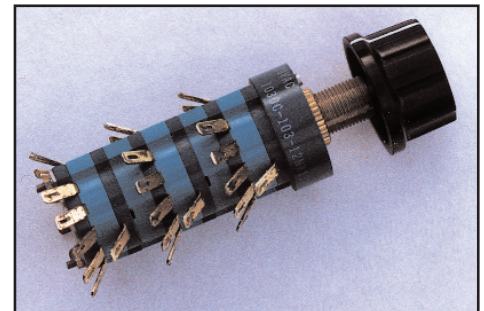
The JMS economy switch has an adhesive backed face plate for the panel. Terminals are gold plated brass numbered circuits. Contacts are the self-cleaning wiper action type. Standard switch is "break before make", however, "make before break" can be supplied upon request.

JMS Southeast stocks both two pole and three pole twelve point economy switches.

#1	DESCRIPTION
6ET12	2 pole 12 point JMS economy switch
6ER12	3 pole 12 point JMS economy switch

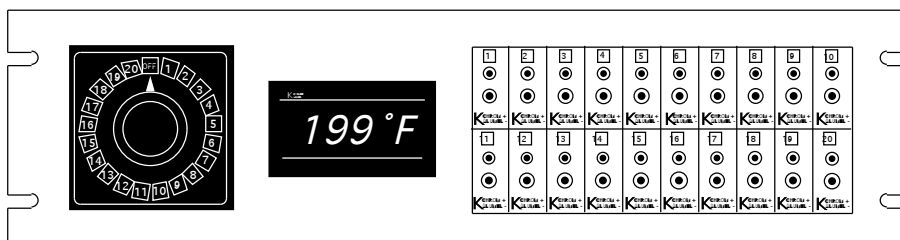


SWITCH MOUNTING



19" JACK PANELS WITH CONNECTORS

Call our engineering department for specific drawings.



JACK PANEL OR PLUG PANEL CONDUIT BOXES

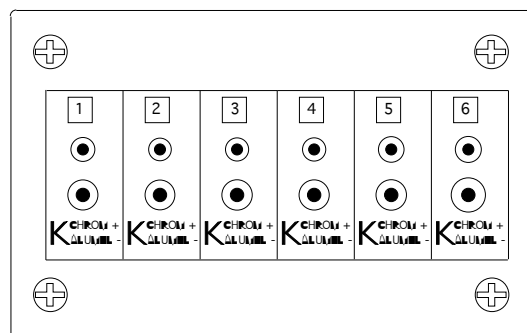
STYLE C



STYLE J



#1	SERIES		
6PB	Jack Panel or Plug Panel Conduit Boxes		
J T K E R S 3	#2	TYPE	COLOR CODE
	#3	DESCRIPTION	
	1 2 3 4 5 6	 Number of circuits. Note: Wire hubs are opposing when mates are connected. Male is left handed and the (Female is ALWAYS right!)	
	#4	BOX STYLE	
	C D E J X Z	C Conduit box cast aluminum locking handle is standard on male box. (1-5 circuits) D Junction box molded fiber-glass (1 - 6 circuits) E Junction box cast aluminum (1-6 circuits) J Junction box - standard mini flat pin connectors (1-6 circuits) X Other, specify Z No Box	
	#5	CONNECTION TYPE	
	M F	Male (Plug) Female (Jack)	



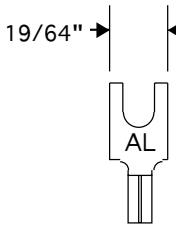
STYLE D, E Iron/Constantan
Black
Copper/Constantan
Blue
Chromel/Alumel
Yellow
Chromel/Constantan

6PB	K	6	J	M
-----	---	---	---	---

SPADE LUGS

Spade lugs are offered in compensating alloys. Spade lugs accept 18 gauge wire or smaller for crimp connections. Each lug has stamped-in designation of thermocouple alloy type.

#1	SERIES	
6SL	Spade Lug	
	#2	THERMOCOUPLE ALLOY
	AL	Alumel
	CH	Chromel
	CO	Constantan
	CP	Copper
	IR	Iron

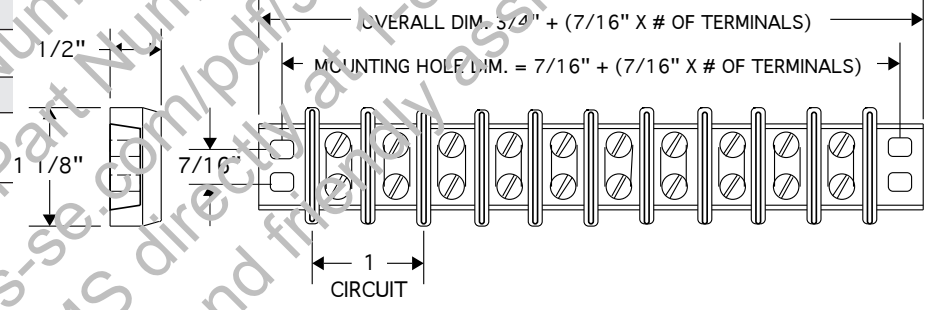


6SL	CH	
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TERMINAL STRIPS

JMS terminal strips are manufactured of general purpose bakelite and will withstand temperatures from 40°F to 250°F. Terminals are nickel-plated brass. Order thermocouple compensated lugs separately.

#1	SERIES	
6TS	Terminal Strip	
	#2	# OF CIRCUITS
	#	Number of circuits (4 screws = 1 circuit)



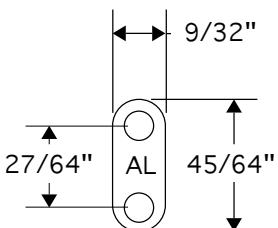
6TS	6	Note: There is a maximum of 10 circuits per strip.
-----	---	--

SECTION 6

TERMINAL LUGS

Terminal lugs are available in thermocouple compensating alloys. They are intended for use with JMS Southeast terminal strips. Each lug is marked with thermocouple alloy.

SERIES	
Terminal Lug	
#2	THERMOCOUPLE ALLOY
AL	Alumel
CH	Chromel
CO	Constantan
CP	Copper
IR	Iron

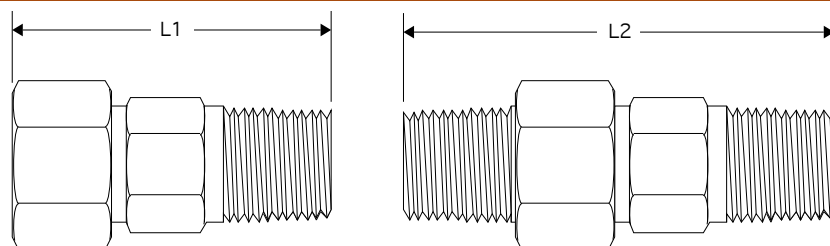


6TL	IR	
-----	----	--

ATTACHING DEVICES

#1	SERIES	
6F	Attaching Device (Fittings)	
	#2	TYPE
	D	Bayonet oil sealed assembly
	B	Bayonet assembly
	W	1/2" x 1/2" stainless steel for welding
	S	1/2" x 1/2" spring-loaded stainless steel
	C	1/2" x 1/2" spring-loaded stainless steel w/ oil ring
	E	Adjustable spring
	A	Spring-loaded w/ threaded retainer
	H	Stainless steel ferrule
	I	Teflon ferrule
	J	Lava ferrule
	K	Nylon ferrule
	L	Brass ferrule
		Compression Style Fitting
	#3	OUTSIDE DIAMETER OF TUBE
	A	3/8" (.375")
	B	1/4" (.250")
	C	3/16" (.188")
	D	1/8" (.125")
	E	1/16" (.063")
	X	Other, specify
	#4	PROCESS NPT ON FITTING
	L	1/8" NPT
	M	1/4" NPT
	P	1/2" NPT
	X	Other, specify
	Z	N/A
	#5	FITTING MATERIAL
	K	Stainless steel (Standard)
	B	Brass
	T	Teflon
	X	Other, specify

MULTICONDUCTOR FEEDTHROUGHS



*** MODEL TO INCLUDE**
 L1 (CAP) OR L2 (CAP)
 +
 TEFLON FERRULE (T)
 OR
 STAINLESS STEEL FERRULE (S)

TO ORDER (Specify model number) Example: 6FT143L1T

SHEATH DIAMETER	MODEL NUMBER *	DIAMETER OF PROBE INCHES	NUMBER OF PROBES	THREAD NPT	LENGTH L1	LENGTH L2*	ACROSS FLATS HOUSING CAP	
1/25"	6FT0403 (L1 OR L2) (T OR S)	.040	3	1/4"	2"	2 1/2"	3/4"	7/8"
	6FT0405 (L1 OR L2) (T OR S)	.040	5	1/4"	2"	2 1/2"	3/4"	7/8"
	6FT0406 (L1 OR L2) (T OR S)	.040	6	1/2"	2 5/8"	3 3/8"	1 1/8"	1 3/8"
	6FT0408 (L1 OR L2) (T OR S)	.040	8	1/2"	2 5/8"	3 3/8"	1 1/8"	1 3/8"
	6FT04010 (L1 OR L2) (T OR S)	.040	10	3/4"	2 13/16"	3 1/2"	1 1/4"	1 1/2"
	6FT04012 (L1 OR L2) (T OR S)	.040	12	3/4"	2 13/16"	3 1/2"	1 1/4"	1 1/2"
	6FT04016 (L1 OR L2) (T OR S)	.040	16	3/4"	2 13/16"	3 1/2"	1 1/4"	1 1/2"
1/16"	6FT1163 (L1 OR L2) (T OR S)	.062	3	1/4"	2"	2 1/2"	3/4"	7/8"
	6FT1165 (L1 OR L2) (T OR S)	.062	5	1/4"	2"	2 1/2"	3/4"	7/8"
	6FT1166 (L1 OR L2) (T OR S)	.062	6	1/2"	2 5/8"	3 3/8"	1 1/8"	1 3/8"
	6FT1168 (L1 OR L2) (T OR S)	.062	8	1/2"	2 5/8"	3 3/8"	1 1/8"	1 3/8"
	6FT11610 (L1 OR L2) (T OR S)	.062	10	3/4"	2 13/16"	3 1/2"	1 1/4"	1 1/2"
	6FT11612 (L1 OR L2) (T OR S)	.062	12	3/4"	2 13/16"	3 1/2"	1 1/4"	1 1/2"
	6FT11616 (L1 OR L2) (T OR S)	.062	16	3/4"	2 13/16"	3 1/2"	1 1/4"	1 1/2"
1/8"	6FT183 (L1 OR L2) (T OR S)	.125	3	1/2"	2 5/8"	3 3/8"	1 1/8"	1 3/8"
	6FT184 (L1 OR L2) (T OR S)	.125	4	1/2"	2 5/8"	3 3/8"	1 1/8"	1 3/8"
	6FT186 (L1 OR L2) (T OR S)	.125	6	3/4"	2 13/16"	3 1/2"	1 1/4"	1 1/2"
	6FT188 (L1 OR L2) (T OR S)	.125	8	3/4"	2 13/16"	3 1/2"	1 1/4"	1 1/2"
3/16"	6FT3163 (L1 OR L2) (T OR S)	.188	3	1/2"	2 5/8"	3 3/8"	1 1/8"	1 3/8"
	6FT3165 (L1 OR L2) (T OR S)	.188	5	3/4"	2 13/16"	3 1/2"	1 1/4"	1 1/2"
1/4"	6FT143 (L1 OR L2) (T OR S)	.250	3	3/4"	2 13/16"	3 1/2"	1 1/4"	1 1/2"

NEMA TYPE ENCLOSURES

The following table is based on ANSI/UL 50-1989 and is reprinted with permission of Underwriters Laboratories, Inc.

NUMBER	INTENDED USE AND DESCRIPTION
1	Indoor use primarily to provide a degree of protection against contact with the enclosed equipment and against a limited amount of falling dirt.
2	Indoor use to provide a degree of protection against limited amounts of falling water and dirt.
3	Outdoor use to provide a degree of protection against wind-blown dust, rain, and sleet; undamaged by the formation of ice on the enclosure.
3R	Outdoor use to provide a degree of protection against falling rain and sleet; undamaged by the formation of ice on the enclosure.
3S	Outdoor use to provide a degree of protection against windblown dust, rain, and sleet; external mechanisms remain operable while ice laden.
4	Indoor or outdoor use to provide a degree of protection against splashing water, wind blown dust and rain, and hose-directed water; undamaged by the formation of ice on the enclosure.
4X	Indoor or outdoor use to provide a degree of protection against splashing water, wind blown dust and rain, and hose-directed water; undamaged by the formation of ice on the enclosure; resists corrosion.
6	Indoor or outdoor use to provide a degree of protection against the entry of water during temporary submersion at a limited depth; undamaged by the formation of ice on the enclosure.
6P	Indoor or outdoor use to provide a degree of protection against the entry of water during prolonged submersion at a limited depth.
11	Indoor use to provide by oil immersion a degree of protection of the enclosed equipment against the corrosive effects of corrosive liquids and gases.
12,12K	Indoor use to provide by oil immersion a degree of protection against dust, falling dirt, and dripping noncorrosive liquids.
13	Indoor use to provide by oil immersion a degree of protection against dust and spraying of water, oil, and noncorrosive coolants.

HAZARDOUS (CLASSIFIED) LOCATIONS

There are definitions essential to understanding the use of Thermocouples and RTDs in hazardous (classified) locations.

Encapsulation: An international term describing a type of protection in which the parts could ignite an explosive atmosphere by either sparking or heating are enclosed in an encapsulant in such a way that this explosive atmosphere cannot be ignited. This type of protection is referred to by CENELEC as "Ex m" in draft Standard EN50028.

Explosion Proof Enclosure: An enclosure that is capable of withstanding an explosion of a gas or vapor within it and of preventing the ignition of an explosive gas or vapor that may surround it and that operates at such an external temperature that a surrounding explosive gas or vapor will not be ignited thereby. This type of enclosure is similar to a flame-proof enclosure.

Explosion Proof Equipment (Apparatus): Equipment or apparatus enclosed in an explosion proof enclosure.

Explosion Proof Seal / Cable: A cable terminator filled with compound and designed to contain an explosion in the enclosure to which it is attached or to minimize passage of flammable gases or vapors from one location or another. A conduit seal may also be used as a cable seal. This method differs from the international method which requires cable glands.

Hermetically Sealed Device: A device that is sealed against the entrance of an external atmosphere and in which the seal is made by fusion. Continuous soldering, brazing, welding and the fusion of glass to metal are examples of recognized methods.

Nonincendive Circuit: AA circuit in which any arc or thermal effect produced in normal operating conditions of the equipment is not capable, under prescribed conditions, of igniting the specified inflammable gas, vapor-in-air mixture, combustible dusts, or ignitable fibers or flyings.

Nonincendive Equipment: Equipment having electrical/electronic circuitry and components that are incapable under normal conditions, of causing ignition of a specified flammable gas or vapor-in-air mixture due to arcing or thermal effect. This type of protection is referred to by IEC as "Ex n." Ex n protection is limited to gas and vapor hazards.

Simple Apparatus (as applied to intrinsic safety): A device that will not generate nor store more than 1.2V., 100mA, 25mW, or 20μJ. Examples are switches, thermocouples, light-emitting diodes, and resistance temperature devices.

At the publication of this catalog, JMS has submitted complete sensor assemblies to FM for testing and approval as meeting all the requirements for Class I, Division II suitability. The approval designs are readily available by drawing and can be ordered thru your salesperson by drawing number 11400.

It should be noted that a hermetically sealed, incapsulated, simple apparatus with explosion proof seals containing non-incendive circuits rates as a nonincendive piece of equipment. Therefore, thermocouples and RTDs so built require no external marking at all. However, the CYA principle might dictate such markings and they are offered by JMS.

(1) Group D equipment shall be permitted for this atmosphere if such equipment is isolated in accordance with Section 501-5(a) of National Electric Code by sealing all conduits 1/2 inch size or larger.

(2) Group C equipment shall be permitted for this atmosphere if such equipment is isolated in accordance with Section 501 -5(a) of National Electric Code by sealing all conduits 1/2 inch size or larger.

(3) For classification of areas involving ammonia atmosphere, see Safety Code for Mechanical Refrigeration (ANSI/ASHRAE 15-1978) and safety requirements for the Storage and Handling of Anhydrous Ammonia (ANSI/CGA G2.1-1972).

(4) A saturated hydrocarbon mixture boiling in the range 20-135 degree C. (68 - 275 degrees F.) Also known by the synonyms benzine, ligroin, petroleum ether, or naphtha.

Compliances:

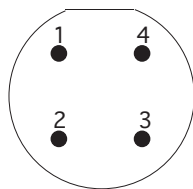
JMS explosion proof products are designed to fulfill the applicable Underwriter's Laboratories and Canadian standards requirements and National Electrical Code Article 500 Hazardous (Classified) Location installations. Where statement of compliances is used in this catalog in reference to UL, CSA, or FM listed standards numbers, it is for identification of products shown in catalog having met design criteria and company tested.

(The statement of compliances does not imply that the products have been approved by Underwriters' Laboratories, Canadian Standards Association or Factory Mutual). Such approvals are covered by listing published by Underwriters' Laboratories, Canadian Standards Association and Factory Mutual and are available upon request.

*Taken from NFPA 497M-1983

*See page 8-24 and 8-25 for more details

LATCHING PLUG WIRING STANDARDS



TYPE A

2 WIRE RTD

3 WIRE RTD

4 WIRE RTD

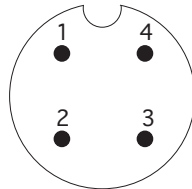
DUAL 2 WIRE RTD

THERMOCOUPLE

* APPROPRIATE POSTIVE COLOR CODE
FOR THERMOCOUPLE TYPE

SINGLE

DUAL



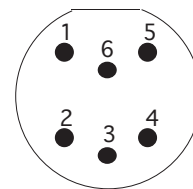
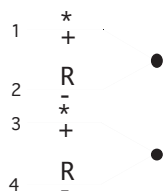
TYPE C

1 — R
2 — W

1 — R
2 — R
4 — W

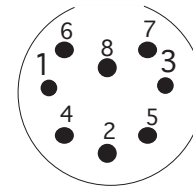
1 — R
2 — R
3 — W
4 — W

1 — R
2 — W
3 — Y
4 — B



DUAL 3 WIRE RTD

1 — R
2 — R
3 — W
4 — B
5 — B
6 — Y



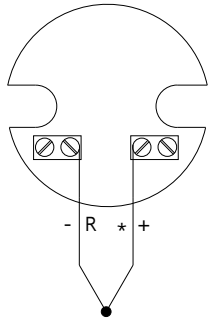
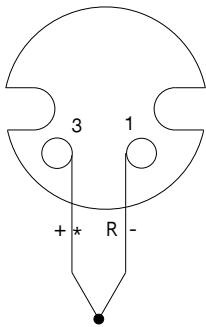
DUAL 4 WIRE RTD
(TYP A ONLY)

1 — R
2 — R
3 — W
4 — W
5 — B
6 — B
7 — Y
8 — Y

TERMINAL WIRING STANDARDS

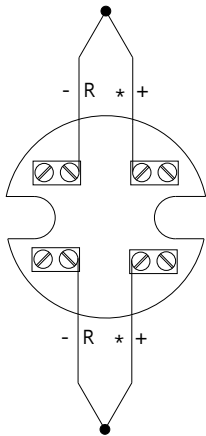
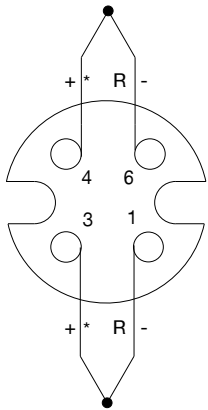
FOR TERMINAL BLOCK 6G, 6B + 6C

6C Terminal Blocks	2 - Wire Configuration	3 - Wire Configuration	4 - Wire Configuration
1 x pt 100	(or Single T/C) 		(or Dual T/C)
2 x pt 100			

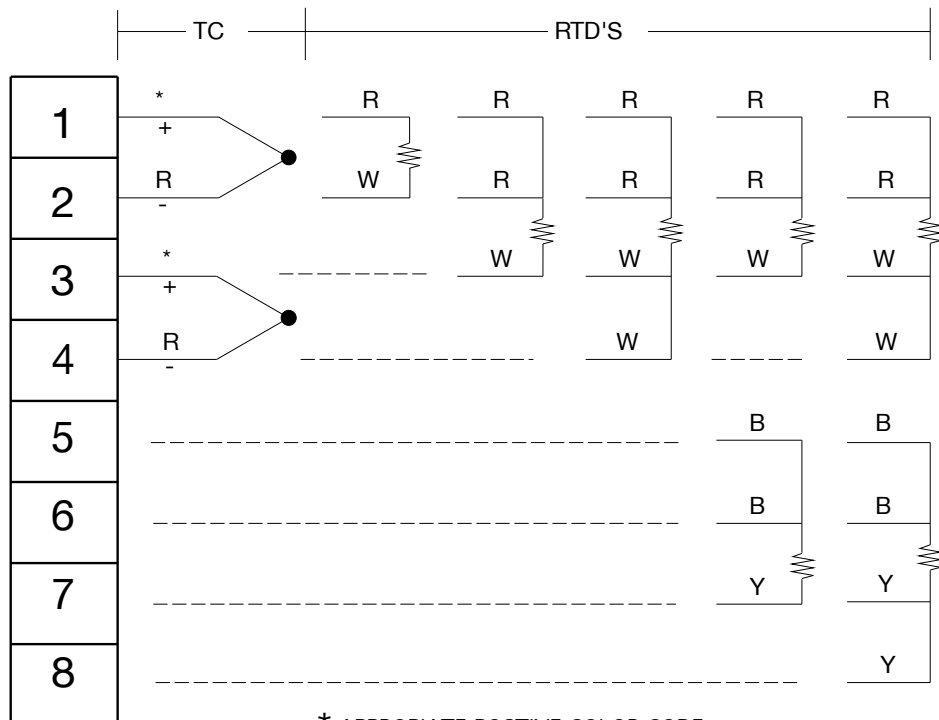
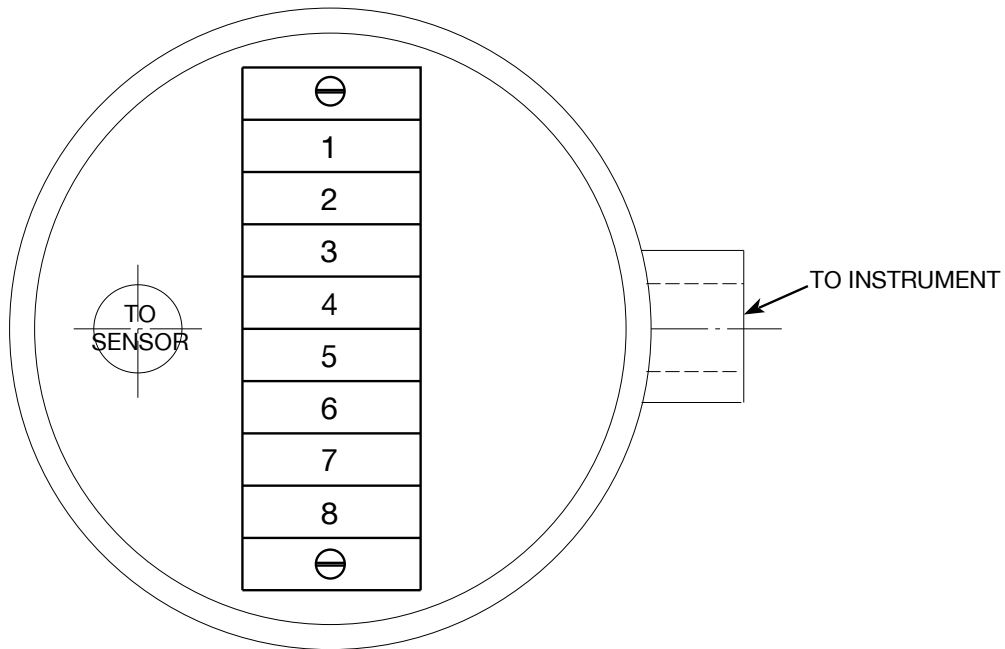


THERMOCOUPLE

* APPROPRIATE POSTIVE COLOR CODE FOR THERMOCOUPLE TYPE



OUT WIRING STANDARDS

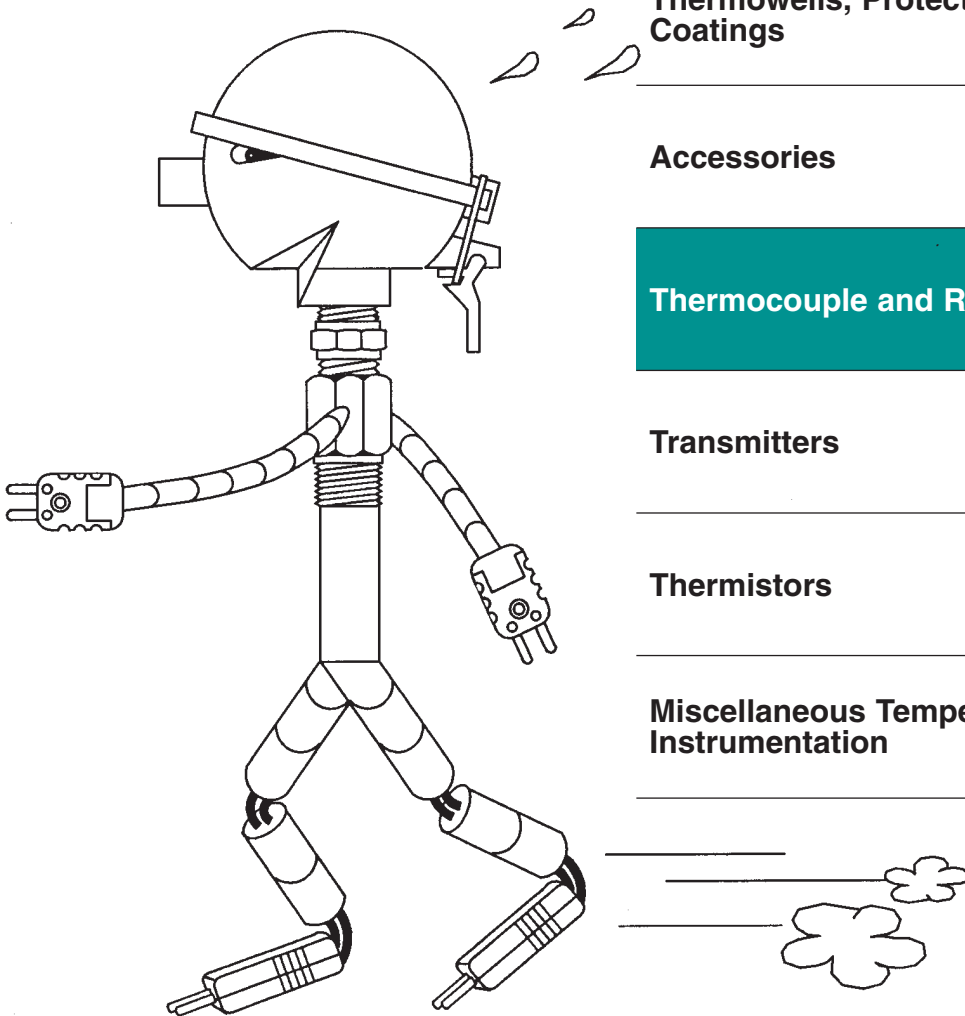


* APPROPRIATE POSTIVE COLOR CODE
FOR THERMOCOUPLE TYPE

Nominal sequence for plugs, terminal blocks and connectors.

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Speciality Sensors

4

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5

Accessories

6

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7

Transmitters

8

Thermistors

9

Miscellaneous Temperature Instrumentation

10

Notes

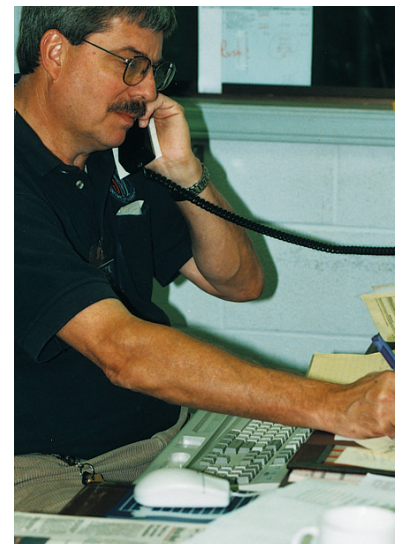
1-800-873-1835

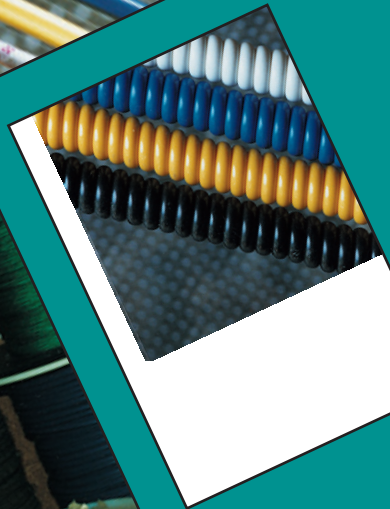


JMS Southeast, Inc.
Temperature Measurement



Thermocouple and RTD Wire





THERMOCOUPLE AND RTD WIRE

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THERMOCOUPLE WIRE

#1	SERIES [6, 7]			
7	Thermocouple Wire			
#2	TYPE			
EXTENSION GRADE [10]	THERMOCOUPLE GRADE [9]			
JX KX TX EX NX RX SX BX CX	J K T E N -- -- -- --	Iron/Constantan Chromel/Alumel Copper/Constantan Chromel/Constantan Nicrosil/Nisil Copper/#11 Alloy Copper/#11 Alloy PCLW 630 / Copper (special order only) Copper / Copper*		
		It is common practice to use plain copper wire for type "B" extension. Use type CX from this selection.		
#3	INSULATION			
*PP PC *PA *KK NN *TF *TT *GG *GS *HG *HS RR *NE X	Polyvinyl chloride Polyvinyl chloride rip cord Polyvinyl chloride with twisted conductors aluminum mylar shield and drain wire Kapton Nylon Fused teflon Extruded teflon Fiberglass braid Fiberglass braid with SS overbraid High temp. fiberglass braid High temp. fiberglass braid with SS overbraid Refrasil Nextel - Heavy weave (for light weave, use X and specify lower weave #) Specify insulation *Standard stock items in 20 gauge. Other insulation and gauge sizes available.			Extension Grade Only
#4	WIRE GAUGE			
16 20 24 28 30 X	16 gauge 20 gauge 24 gauge 28 gauge 30 gauge Specify gauge			
#5	WIRE CONSTRUCTION			
1 2	Solid (standard) Stranded			
[] BRACKETS INDICATE PAGE NUMBERS ON WEB OR FULL CATALOG FOR ADDITIONAL TECHNICAL INFORMATION WWW.JMS-SE.COM				
Unit of Measure = Feet				
7	J	TT	20	1

Note: For special limits of error thermocouple wire use a double calibration symbol. Polyvinyl chloride wire and type R and S fiberglass wire are ordinarily manufactured in extension grade. Kapton, nylon, teflon, fiberglass braid, refrasil, and nextel are ordinarily manufactured in thermocouple grade.

NON-INSULATED SINGLE CONDUCTOR THERMOCOUPLE WIRE

#1	SERIES [7-11]	
7N	Non-Insulated Thermocouple Wire	
	#2	TYPE
	JP Iron JN Constantan KP Chromel KN Alumel EP Chromel EN Constantan NP Nicrosil NN Nisil TP Copper TN Constantan SP* Platinum 10% Rhodium SN* Platinum RP* Platinum 13% Rhodium RN* Platinum BP* Platinum 30% Rhodium BN* Platinum 6% Rhodium W0* Tungsten W3* Tungsten 3% Rhenium W5* Tungsten 5% Rhenium W25* Tungsten 25% Rhenium W26* Tungsten 26% Rhenium	New Type N (Nicrosil/Nisil) bare wire now available, specify as NP (Nicrosil) or NN (Nisil).
	#3	WIRE GAUGE
	8 8 gauge 14 14 gauge 16 16 gauge 20 20 gauge 24 24 gauge (JMS standard for SP, SN, RP, RN, BP, & BN) 28 28 gauge 30 30 gauge X Other, specify	
Unit of Measure = Feet * Unit of Measure = inches Note: See pages 7-16 and 7-17 for weight per unit of measure		
7N	RN	20

MULTI-CONDUCTOR EXTENSION CABLE

Each conductor is insulated with polyvinyl chloride or teflon. An aluminum backed *Mylar tape serves as an electrostatic shield. A solid 20 gauge tinned-copper drain wire is over the bundle in direct contact with the aluminum/mylar shield, thus minimizing any stray EMF's.

Conductors are color coded and numbered for identification. All conductors are insulated with an outer jacket of polyvinyl chloride or teflon insulation approximately .0245" thick.

Multipair extension cable can be manufactured with various quantities of pairs and insulation types. Contact JMS Southeast sales office for any requirements you may have.

*Mylar is a trademark of DuPont Company.

#1	SERIES [6, 7]			
7M	Multi-Conductor Thermocouple Extension Cable			
	#2	TYPE		
	J	Iron/Constantan		
	K	Chromel/Alumel		
	T	Copper/Constantan		
	E	Chromel/Constantan		
	R	Copper/#11 Alloy		
	S	Copper/#11 Alloy		
	B	PCLW 630 / Copper		
	2	2 wire RTD (also used for type B thermocouples)		
	3	3 wire RTD		
4	4 wire RTD			
X	Other, insert calibration needed			
	#3	# OF PAIRS	ESTIMATED O.D.	EST. SHIPPING WT. LBS. PER 1000 FEET
	2	2 (non standard)	.370	53
	4	4	.390	80
	8	8	.480	131
	12	12	.592	198
	16	16	.653	245
	20	20	.680	285
	24	24	.770	338
	X	Other, specify		
	#4	INSULATION		
	P	Polyvinyl chloride		
	T	Teflon - extruded		
	X	Other, specify		
	#5	ALUMINUM MYLAR SHIELD		
	I	Individual pair and overall		
	O	Overall only		
	Z	Not applicable		

Note: Conductors are 20 gauge solid.

Note: Add "S" for stranded conductors

Unit of Measure = Feet

7M	J	4	P	I
----	---	---	---	---

RTD WIRE

#1	SERIES	
7R	RTD Wire	
	#2	INSULATION
	PP	Polyvinyl chloride
	GG	Fiberglass insulated (Standard)
	GS	Fiberglass braid with stainless steel overbraid (available in 3 conductor, 24 awg, Nickel plated copper)
	KK	Kapton insulated
	*TT	Extruded Teflon singles, Teflon wrap overall (Standard) (Conductors properly color coded as per ASTM E1137 & IEC 751)
	X	Other, specify
	#3	NUMBER OF CONDUCTORS
	2	Two conductors (also used for type B thermocouples)
	3	Three conductors
	4	Four conductors
	X	Other, specify
	#4	WIRE GAUGE
	16	16 gauge
	20	20 gauge
	24	24 gauge (Standard)
	28	28 gauge
	30	30 gauge
	X	Specify gauge
	#5	WIRE CONSTRUCTION
	1	Solid
	2	Stranded (Standard)
	#6	SHIELD
	N	No shield
	A	Aluminum Mylar shield

Unit of Measure = Feet

* RTD extension wire is any normal electrical wire. However, color codes for RTD's are specified and maintained by ASTM E1137 & IEC 751. Insulation types maintained in our inventory are teflon for single or dual, 3 or 4 wire RTD's, 24 awg. Also, fiberglass, 4 wire, 24 awg.



RED

WHITE

RED RED

WHITE

RED RED

WHITE WHITE

R R

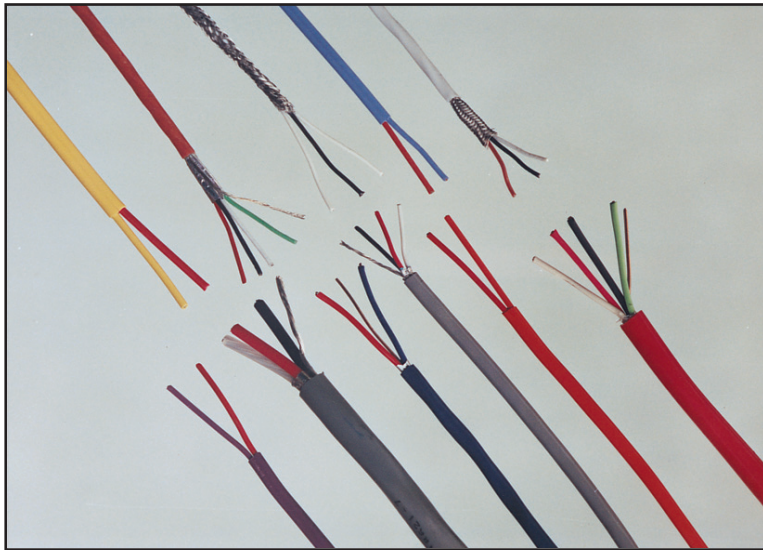
W W RS RS WS WS

COLOR CODES

DUAL ELEMENT

7R	TT	3	24	2	N
----	----	---	----	---	---

WIRE INSULATION MATERIAL



WIRE INSULATION MATERIAL

TEFLON INSULATED WIRE

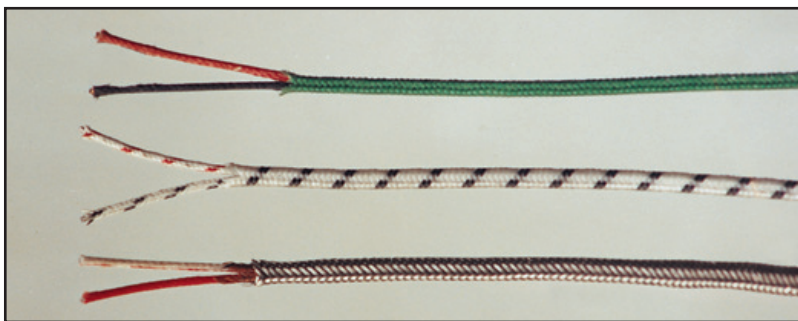
Teflon (extruded) Teflon (extruded) - TT

Color-coded teflon (FEP)* is extruded on the positive and negative conductors and outer jacket. This insulation is unaffected by most corrosive substances, outdoor weather, or lubricants. It is flame resistant and heat aging will not cause embrittlement or cracking. Excellent for cryogenic applications. Offered in thermocouple grade. Temperature rating: Continuous: Up to 400°F and 200°C.

Teflon (Fused TFE Tape) Teflon (Fused TFE Tape) TF

TFE tape is spirally applied to the conductor and heated. This process fuses the tape into a homogeneous layer of TFE. Fused teflon wire offers good abrasion resistance and excellent resistance to both moisture and chemicals. Offered in thermocouple grade. Temperature rating: Continuous: Up to 500°F and 260°C.

*DuPont Trademark



FIBROUS INSULATED WIRE

Fiberglass Braid-GG

Glass braid on individual conductors with glass braid outer jacket. Designed for continuous use in high temperature applications. Poor abrasion and moisture resistance. Offered in thermocouple grade. Temperature rating: Continuous: Up to 900°F and 482°C. Intermittent: Up to 1000°F and 529°C.

Hightemp Fiberglass Braid-HG

A high temperature fiberglass braid is applied over each conductor and then impregnated with a binder. Although the binder improves resistance to abrasion and moisture, it is destroyed above 400°F (204°C). Offered in thermocouple grade. Temperature rating: Continuous: Up to 1300°F and 705°C. Intermittent: Up to 1600°F and 871°C. We recommend SS overbraid with this wire.

Fiberglass Braid with Stainless Steel Overbraid-GS and HS

A stainless steel overbraid is applied to fiberglass wire to increase the wires resistance to abrasion, mechanical and physical damage. It may be applied to 14 through 30 gauge conductors.

Refrasil-RR

Vitreous silica is applied on both positive and negative conductors with a vitreous silica outer jacket. Refrasil is not color coded. Used in high temperature applications. Moisture and abrasion resistance only fair. Offered in thermocouple grade. Temperature rating: Continuous: Up to 1600°F and 871°C. Intermittent: Up to 1800°F and 982°C. We recommend SS overbraid with this wire.

Nextel-NE

A high temperature ceramic fiber is applied over each conductor and then overall. Nextel is not colored coded. Although nextel is not recommended for use with platinum thermocouples, it can be used as an excellent option for other high temperature applications. Its use is limited by the temperature rating of the thermocouple wire it insulates. It is frequently used in furnace and traveling thermocouple applications. Temperature rating: Continuous: Up to 2200°F. Trademark of Sumitomo Corporation. We recommend SS overbraid with this wire.

NOISE IN THERMOCOUPLE CIRCUITS

The reduction of electrical noise pickup by instrument circuits is an important consideration in temperature measurement. Noise obscures small changes in signal level. Electrical noise comes in the form of static, magnetic, common mode and crosstalk.

Static noise is capacitively coupled to the wires in an instrument circuit from power lines or other voltage sources. This type of noise can be reduced or eliminated by the use of a shield placed around the wires.

Magnetic noise occurs when a current goes through a conductor. This can occur around power lines, relays, motors, generators, etc. Twisting the extension wire can minimize this noise, by canceling out these magnetic currents.

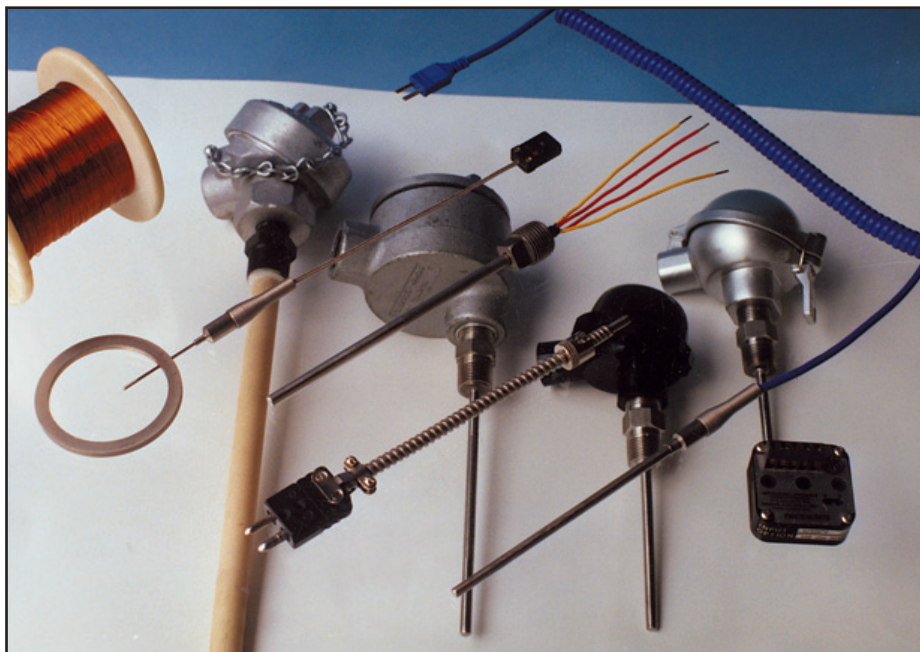
Common Mode noise is dependent upon the electrical connections in the instrument circuit and occurs when different locations in a plant are at different ground potentials. This type of noise is especially detrimental to grounded thermocouples. If the thermocouple is electrically grounded at the measuring point and if the instrument is also grounded, a current will flow between the thermocouple and instrument, which are at different electrical potentials. To combat this problem many instrument manufacturers have neither of their input terminals grounded, incurring a high common mode rejection rating of the system. Another type of common mode noise is created through capacitance which exists between the thermocouple conductors and any metal object near it. The metal objects, being at a different potential than the thermocouple tip, allows currents to flow into the conductors causing a voltage drop along the conductors. This drop adds to the EMF signal and produces noise. The best way to combat this noise problem is to shield the extension wire from the thermocouple to the control instrumentation. The shield is at the same potential for this entire length. The only ground connection in the shield should be at the thermocouple.

Finally, cross talk noise occurs when signals in adjacent pairs of wires transfer to each other. The most common method to eliminate this noise problem in multipair cable is to individually shield each pair of wires and ground each shield individually.

JMS Southeast, Inc., can provide you with shielded and nonshielded thermocouple extension wire ranging from a single pair to 36 pair cable.

Please contact us for any thermocouple wire needs you may have.

Note: When using shielded wire with your sensor, we attach the shield to the tube or sheath with which the sensor is built. The drain wire is bare and left accessible to the end user. If you do not want the shield electrically connected to the sheath or tube, please specify a "Floating Shield" and we will accommodate you. (Normally the drain wire on grounded/shielded thermocouples is left unconnected at the instrument to avoid ground loops.)



THERMOCOUPLE TYPE INFORMATION

JMS offers thermocouples and wire in the following types. Listed below are suggested criteria to consider in selecting the desired type for your application. Contact JMS Southeast if additional information is required.

(J)—Iron vs Constantan

May be used in vacuum, oxidizing, reducing, and inert atmospheres. Heavier gauge wire is recommended for long term life above 1000°F since the iron element oxidizes rapidly at these temperatures.

(T)—Copper vs Constantan

May be used in vacuum, oxidizing, reducing, and inert atmospheres. It is resistant to corrosion in most atmospheres. High stability at sub-zero temperatures and its limits of error are guaranteed at cryogenic temperatures.

(K)—Chromel vs Alumel

Recommended for continuous use in oxidizing or inert atmospheres up to 2300°F (1260°C), especially above 1000°F. Cycling above and below 1800°F (1000°C), is not recommended due to EMF alteration from hysteresis effects. Should not be used in sulfurous or alternating reducing and oxidizing atmospheres unless protected with protection tubes. Fairly reliable and accurate at high temperatures.

(E)—Chromel vs Constantan

May be used in oxidizing or inert atmospheres, but not recommended for alternating oxidizing or inert atmospheres. Not subject to corrosion under most atmospheric conditions. Has the highest EMF produced per degree than any other standard thermocouple and must be protected from sulfurous atmospheres.

(S,R)—Platinum vs Platinum Rhodium

Recommended for use in oxidizing or inert atmospheres. Should not be used in reducing atmospheres, or in contact with any metallic protection tube. Continuous use at very high temperatures may cause excessive grain growth and drifts in calibration.

(N)—Nicrosil vs Nisil

May be used in oxidizing, dry reducing, or inert atmospheres. Must be protected in sulfurous atmospheres. Very reliable and accurate at high temperatures. Can replace Type K thermocouples in many applications.

(W)—Tungsten vs Rhenium

Recommended for use in vacuum, high purity hydrogen, or pure inert atmospheres. May be used at very high temperatures (2316°C). This wire is inherently brittle.

THERMOCOUPLE GRADE VS EXTENSION GRADE WIRE

Thermocouple wire or extension grade wire is recommended to connect thermocouples to the control instrumentation. The thermocouple wire insulation depends upon the environment in which it exists. The calibration of the wire must correlate to the thermocouple calibration. Other considerations in choosing thermocouple extension grade or thermocouple grade wire are temperature range, service, life, and location (conduit, moist atmosphere, etc.).

Thermocouple extension wire should not be used to manufacture a thermocouple, but to transmit the signal from the thermocouple to the instrumentation. An extension grade thermocouple may not be within ANSI standard limits or error.

Thermocouple grade wire can be used to connect the thermocouple to the instrumentation. It is slightly more expensive than the extension grade wire and it is not usually the most economical option for long runs.

ACCURACY OF JMS THERMOCOUPLE WIRE

JMS insulated and bare thermocouple wire is matched to meet standard or special limits of error for temperatures above 32°F (0°C), as given in ANSI MC 96.1 and shown in tables below.

LIMITS OF ERROR FOR THERMOCOUPLE WIRE

THERMOCOUPLE TYPE		°F.				
WIRE ALLOY	ANSI TYPE SYMBOL	TEMPERATURE RANGE °F	STANDARD LIMITS	ORDER CODE	SPECIAL LIMITS	ORDER CODE
Iron (+) vs. Constantan (-)	J	+32° to +545° +545° to +1400°	±4° ±.75%	J	±2° ±.4%	JJ
Chromel™ (+) vs. Alumel™ (-)	K	-330° to -165° -165° to +32° +32° to +545° +545° to +2300°	±2° ±4° ±4° ±.75%	K	±2° ±.4%	KK
Copper (+) vs. Constantan™ (-)	T	-330° to -85° -85° to +270° +270° to +660°	±1.5% ±1.8° ±.75%	T	±.8% ±.9° ±.4%	TT
Chromel™ (+) vs. Constantan™ (-)	E	-330° to -270° -270° to +480° +480° to +640° +640° to +1600°	±1% ±3° ±3° ±5%	E	±1.8° ±1.8° ±.4% ±.4%	EE
Nicrosil™ (+) vs. Nisil™ (-)	N	+32° to +545° +545° to +2300°	±4° ±.75%	N	±2° ±.4%	NN

THERMOCOUPLE TYPE		°C.				
WIRE ALLOY	ANSI TYPE SYMBOL	TEMPERATURE RANGE °C	STANDARD LIMITS	ORDER CODE	SPECIAL LIMITS	ORDER CODE
Iron (+) vs. Constantan (-)	J	0° to +285° +285° to +750	±2.2° ±.75%	J	±1.1° ±.4%	JJ
Chromel™ (+) vs. Alumel™ (-)	K	-200° to -110° -110° to 0° 0° to +285° +285° to +1250	±2° ±2.2° ±2.2° ±.75%	K	±1.1° ±.4%	KK
Copper (+) vs. Constantan™ (-)	T	-200° to -65° -65° to +130° +130° to +350°	±1.5% ±1° ±.75%	T	±.8% ±.5° ±.4%	TT
Chromel™ (+) vs. Constantan™ (-)	E	-200° to -170° -170° to +250° +250° to +340° +340° to +900°	±1% ±1.7° ±1.7° ±5%	E	±1° ±1° ±.4% ±.4%	EE
Nicrosil™ (+) vs. Nisil™ (-)	N	0° to +285° +285° to +1250°	±2.2° ±.75%	N	±1.1° ±.4%	NN

ACCURACY OF JMS EXTENSION WIRE

Thermocouple extension wire has approximately the same thermoelectric characteristics as thermocouple wire, but its accuracy is guaranteed over a more limited range of temperatures. Thermocouple extension wire can offer advantages in cost when used for connections between thermocouples and instruments. For base metal types of thermocouples, extension wire is of substantially the same composition as the corresponding thermocouple type. For noble metal types, however, an entirely different alloy is formulated to match the noble metal characteristics over a specified temperature range. This is necessary due to the high cost of the noble metals which would otherwise be necessary for the interconnection. The "X" in the ordering codes denotes extension grade wire.

LIMITS OF ERROR FOR THERMOCOUPLE EXTENSION WIRE

THERMOCOUPLE TYPE		°F.				
EXTENSION WIRE ALLOY	ANSI TYPE SYMBOL	TEMPERATURE RANGE °F	STANDARD LIMITS	ORDER CODE	SPECIAL LIMITS	ORDER CODE
Copper vs. Constantan™	TX	-75° to +210°	±2°	TX	±1°	TTX
Iron vs. Constantan™	JX	+32 to +400°	±4°	JX	±2°	JJX
Chromel™ (+) vs. Constantan™	EX	+32 to +400°	±3°	EX	±2°	EEX
Chromel™ vs. Alumel™	KX	+32 to +400°	±4°	KX	±2°	KKX
Nicrosil™ vs. Nisil™	NX	+32 to +400°	±4°	NX	±2°	NNX
Copper vs. Copper Alloy	SX	+75 to +400°	±12°	SX		
Copper vs. Copper Alloy	RX			RX		
PCLW630 vs. Copper	BX	+32 to +400°	±4°	BX		
Copper vs. Copper	2CU	+32 to +150°	±2°	BX		
Alloy 203 vs. Alloy 225	W3X	+32 to +500°	±12°	W3X		
Alloy 405 vs. Alloy 426	W5X	+32 to +1600°	±12°	W5X		

THERMOCOUPLE TYPE		°C.				
EXTENSION WIRE ALLOY	ANSI TYPE SYMBOL	TEMPERATURE RANGE °C	STANDARD LIMITS	ORDER CODE	SPECIAL LIMITS	ORDER CODE
Copper vs. Constantan™	TX	-60° to +100°	±1°	TX	±.5°	TTX
Iron vs. Constantan™	JX	+0 to +200°	±2.2°	JX	±1.1°	JJX
Chrome™ (+) vs. Constantan™	EX	0 to +200°	±1.7°	EX	±1.1°	EEX
Chromel™ vs. Alumel™	KX	0 to +200°	±2.2°	KX	±1.1°	KKX
Nicrosil™ vs. Nisil™	NX	0 to +200°	±2.2°	NX	±1.1°	NNX
Copper vs. Copper Alloy	SX	+25 to +200°	±7°	SX		
	RX			RX		
PCLW630 vs. Copper	BX	0 to +200°	±2.2°	BX		
Copper vs. Copper	2CU	0 to 65°	±1°	BX		
Alloy 203 vs. Alloy 225	W3X	0 to 260°	±7°	W3X		
Alloy 405 vs. Alloy 426	W5X	0 to 870°	±7°	W5X		

Special Note: Using Cu/ Cu wire for type B thermocouples can introduce an error from 7°F to 85°F(3.7°C to 48°C) if the connection point is from 212 - 572°F (100 - 300°C). Up to 99% of these errors are avoided by using the appropriate extension wire.

ANSI COLOR CODE FOR THERMOCOUPLE AND THERMOCOUPLE EXTENSION WIRE

ANSI TYPE	EXTENSION WIRE ALLOYS	POLARITY	THERMOCOUPLE WIRE COLOR		T/C EXTENSION WIRE COLOR	
			INDIVIDUAL	OVERALL	INDIVIDUAL	OVERALL
J	Iron Constantan	+JP -JN	White Red	Brown	White Red	Black
K	Chromel Alumel	+KP -KN	Yellow Red	Brown	Yellow Red	Yellow
T	Copper Constantan	+TP -TN	Blue Red	Brown	Blue Red	Blue
E	Chromel Constantan	+EP -EN	Purple Red	Brown	Purple Red	Purple
N	Nicrosil Nisil	+NP -NN	Orange Red	Brown	Orange Red	Orange
RSX	Copper Copper Alloy	+RSP -RSN			Black Red	Green
BX	PCLW630 / Copper Copper	+BP -BN			Grey Red	Grey
*W3X	Alloy 203; Alloy 405	+WP			White / Red	
*W5X	Alloy 225; Alloy 426	-WN			Red	White / Red

*= Not ANSI

UPPER TEMPERATURE LIMITS FOR BARE THERMOCOUPLE WIRE

ANSI TYPE	THERMOCOUPLE TYPE	THERMOCOUPLE WIRE COLOR					
		8 AWG	14 AWG	16 AWG	20 AWG	24 AWG	28 AWG
J	Iron - Constantan	1400°F (760°C)	1100°F (600°C)	900°F (500°C)	900°F (500°C)	700°F (370°C)	700°F (370°C)
K	Chromel - Alumel	2300°F (1260°C)	2000°F (1100°C)	2000°F (1100°C)	1800°F (1000°C)	1600°F (870°C)	1600°F (870°C)
T	Copper - Constantan	--	700°F (370°C)	500°F (260°C)	500°F (260°C)	400°F (200°C)	400°F (200°C)
E	Chromel - Constantan	1600°F (870°C)	1200°F (650°C)	1000°F (550°C)	1000°F (550°C)	800°F (430°C)	800°F (430°C)
N	Nicrosil - Nisil	2300°F (1260°C)	2000°F (1100°C)	2000°F (1100°C)	1800°F (1000°C)	1600°F (870°C)	1600°F (870°C)

ANSI: TYPE, J - Iron / Constantan

Catalog Number	Gauge Size	Conductors	*Ohms	Primary Insulation	Outer Jacket	Min.-Max. O.D.	Est. Shpg. Wt. per M
GG210J	20	Solid	.357	Glass Braid	Glass Braid	.059 x .105"	8 lbs.
GG202J	20	Stranded	.317	Double Glass Braid	Glass Braid	.075 x .137"	9lbs.
KK201J	20	Solid	.357	Fused Kapton Tape	None, Twisted	.087"	10 lbs.
NN201J	20	Solid	.357	Nylon	Nylon	.068 x .120"	11 lbs.
TF201J	20	Solid	.357	(TFE) tape, Teflon	(TFE) tape, Teflon	.065 x .110"	10 lbs.
TX201J	20	Solid	.357	Extruded (FEP) Teflon	Extruded (FEP) Teflon	.072 x .124"	11 lbs.
GG241J	24	Solid	.877	Glass Braid	Glass Braid	.047 x .081"	4 lbs.
KK241J	24	Solid	.877	Fused Kapton Tape	None, Twisted	.063"	5 lbs.
PP241J	24	Solid	.877	Polyvinyl Chloride	None, Rip-Cord	.048 x .096"	4 lbs.
TF241J	24	Solid	.877	(TFE) tape, Teflon	(TFE) tape, Teflon	.047 x .078"	5 lbs.
GG261J	26	Solid	1.394	Glass Wrap	Glass Braid	.040 x .065"	3 lbs.
GG281J	28	Solid	2.216	Glass Wrap	Glass Braid	.037 x .059"	3 lbs.
GG301J	30	Solid	3.520	Glass Wrap (Braid avail.)	Glass Braid	.033 x .053"	3 lbs.

ANSI: TYPE, K - Chromel / AlumeI

GG201K	20	Solid	.590	Glass Braid	Glass Braid	.059 x .105"	8 lbs.
GG202K	20	Stranded	.538	Double Glass Braid	Glass Braid	.075 x .137"	9 lbs.
KK201K	20	Solid	.590	Fused Kapton Tape	None, Twisted	.087"	10 lbs.
RR201K	20	Solid	.590	Vitreous Silica Braid	Vitreous Silica Braid	.102 x .174"	16 lbs.
TF201K	20	Solid	.590	(TFE) tape, Teflon	(TFE) tape, Teflon	.065 x .110"	10 lbs.
TX201K	20	Solid	.590	Teflon Extruded (FEP)	Teflon Extruded	.072 x .124"	11 lbs.
GG241K	24	Solid	1.490	Glass Braid (Wrap avail.)	Glass Braid	.047 x .081"	4 lbs.
PP241K	24	Solid	1.490	Polyvinyl-Rip Cord Const.	None	.048 x .096"	4 lbs.
GG261K	26	Solid	2.370	Glass Wrap	Glass Braid	.040 x .065"	3 lbs.
GG281K	28	Solid	3.770	Glass Braid (Wrap avail.)	Glass Braid	.039 x .064"	3 lbs.
GG301K	30	Solid	5.980	Glass Wrap	Glass Braid	.033 x .053"	2 lbs.

ANSI: TYPE, T - Copper / Constantan

GG201T	20	Solid	.298	Glass Braid (Wrap avail.)	Glass Braid	.059 x .105"	5 lbs
TF201T	20	Solid	.298	(TFE) tape, Teflon	(TFE) tape, Teflon	.065 x .110"	10 lbs.
TX201T	20	Solid	.298	Extruded Teflon (FEP)	Extruded Teflon	.072 x .124"	11 lbs.
GG241T	24	Solid	.753	Glass Braid (Wrap avail.)	Glass Braid	.047 x .081"	4 lbs.
NN241T	24	Solid	.753	Nylon	Nylon	.060 x .095"	6 lbs.
PP241T	24	Solid	.753	Polyvinyl Rip Cord Const.	None	.048 x .096"	3 lbs.
TF241T	24	Solid	.753	(TFE) tape, Teflon	(TFE) tape, Teflon	.047 x .078"	5 lbs.
GG281T	28	Solid	1.905	Glass Braid (Wrap avail.)	Glass Braid	.039 x .064"	3 lbs.
GG301T	30	Solid	3.025	Glass Wrap	Glass Braid	.033 x .053"	2 lbs.

ANSI: TYPE, E - Chromel / Constantan

GG201E	20	Solid	.704	Glass Braid	Glass Braid	.059 x .105"	8 lbs.
GG241E	24	Solid	1.780	Glass Braid	Glass Braid	.047 x .081"	4 lbs.

*ohms per double foot at 20°C (68°F).

SECTION 7

ANSI: TYPE, J - Iron / Constantan

Catalog Number	Gauge Size	Conductors	*Ohms	Primary Insulation	Outer Jacket	Min.-Max. O.D.	Est. Shpg. Wt. per M
PP161JX	16	Solid	.137	Polyvinyl Chloride	Polyvinyl Chloride	.111 x .188"	27 lbs.
PA161JX	16	Solid	.137	PVC/Alum. Mylar Shield (Twisted)	PVC	.222"	28 lbs.
PA201JX	20	Solid	.357	PVC/Alum. Mylar Shield (Twisted)	PVC	.184"	20 lbs.
PP201JX	20	Solid	.357	Polyvinyl Chloride	Polyvinyl Chloride	.095 x .158"	14 lbs.
PP202JX	20	Stranded	.317	Polyvinyl Chloride	Polyvinyl Chloride	.115 x .190"	14 lbs.
PX201JX	20	Solid	.357	(FEP) Extruded Teflon	Extruded Teflon	.072 x .124"	11 lbs.

ANSI: TYPE, K - Chromel / Alumel

PA161KX	16	Solid	.233	PVC/Alum. Mylar Shield (Twisted)	PVC	.222"	28 lbs.
PP161KX	16	Solid	.233	Polyvinyl Chloride	Polyvinyl Chloride	.116 x .188"	27 lbs.
PA201KX	20	Solid	.590	PVC/Alum. Mylar Shield (Twisted)	PVC	.184"	20 lbs.
PP201KX	20	Solid	.590	Polyvinyl Chloride	Polyvinyl Chloride	.195 x .158"	14 lbs.
PP202KX	20	Stranded	.538	Polyvinyl Chloride	Polyvinyl Chloride	.115 x .190"	14 lbs.

ANSI: TYPE, T - Copper / Constantan

PP141TX	14	Solid	.074	Polyvinyl Chloride	Polyvinyl Chloride	.130 x .226"	37 lbs.
PA161TX	16	Solid	.118	PVC/Alum. Mylar Shield (Twisted)	PVC	.222"	20 lbs.
PP161TX	16	Solid	.118	Polyvinyl Chloride	Polyvinyl Chloride	.111 x .188"	28 lbs.
PA201TX	20	Solid	.298	PVC/Alum. Mylar Shield	PVC	.184"	20 lbs.
PP201TX	20	Solid	.298	Polyvinyl Chloride	Polyvinyl Chloride	.095 x .158"	15 lbs.

ANSI: TYPE, E - Chromel / Constantan

PA161EX	16	Solid	.278	PVC/Alum. Mylar Shield (Twisted)	PVC	.222"	20 lbs.
PP201EX	20	Solid	.704	Polyvinyl Chloride	Polyvinyl Chloride	.095 x .158"	15 lbs.

ANSI: TYPE, S and R - Platinum / Rhodium

PP161SX	16	Solid	.016	Polyvinyl Chloride	Polyvinyl Chloride	.116 x .250"	27 lbs.
GG201SX	20	Solid	.040	Glass Braid	Glass Braid	.059 x .105"	8 lbs.
PP201SX	20	Solid	.040	Polyvinyl Chloride	Polyvinyl Chloride	.095 x .158	14 lbs.

*ohms per double foot at 20°C (68°F).

COMPARISON OF WIRE GAUGES

Standard Wire Gauges in Approximate Decimals of an Inch and mm.

American or Brown and Sharp Wire Gauge	Diameter Inches	Diameter Millimeters	British Standard or Imperial	US Standard
1	0.2893	7.348	.300	.281
2	0.2576	6.544	.276	.266
3	0.2294	5.827	.252	.250
4	0.2043	5.189	.232	.234
5	0.1819	4.621	.212	.219
6	0.1620	4.115	.192	.203
7	0.1443	3.665	.176	.188
8	0.1285	3.264	.160	.172
9	0.1144	2.906	.144	.156
10	0.1019	2.588	.128	.141
11	0.0907	2.304	.116	.125
12	0.0808	2.053	.104	.109
13	0.0720	1.829	.092	.0938
14	0.0641	1.628	.080	.0781
15	0.0571	1.450	.072	.0703
16	0.0508	1.291	.064	.0625
17	0.0453	1.150	.056	.0563
18	0.0403	1.024	.048	.0500
19	0.0359	0.9116	.040	.0438
20	0.0320	0.8118	.036	.0375
21	0.0285	0.7230	.032	.0344
22	0.0253	0.6438	.028	.031
23	0.0226	0.5733	.024	.0281
24	0.0201	0.5106	.022	.0250
25	0.0179	0.4547	.020	.0219
26	0.0159	0.4049	.018	.0188
27	0.0142	0.3606	.0164	.0172
28	0.0126	0.3211	.0148	.0156
29	0.0113	0.2859	.0136	.0141
30	0.0100	0.2546	.0124	.0125
31	0.0089	0.2268	.0116	.0109
32	0.0080	0.2019	.0108	.0102
33	0.00708	0.178	.010	.0094
34	0.00630	0.152	.0092	.0086
35	0.00561	0.138	.0084	.0078
36	0.00500	0.127	.0076	.0066
37	0.00445	0.1131	.0068	.0070
38	0.00397	0.1007	.006	.0063
39	0.00353	0.08969	.0052	--
40	0.00314	0.07987	.0048	--

THERMOCOUPLE WIRE SIZES, RESISTANCES, AND WEIGHTS

NOMINAL RESISTANCE AND WEIGHTS

BARE THERMOCOUPLE WIRE AND EXTENSION WIRE
CONDUCTORS BASED ON OHMS PER FOOT AT 70°F

GAUGE	8		14		16		20		24		28		30		38	
B & S DIAMETER	.128		.064		.051		.032		.020		.012		.010		.004	
CONDUCTOR	RES.	FT.	RES.	FT.	RES.	FT.	RES.	FT.	RES.	FT.	RES.	FT.	RES.	FT.	RES.	FT.
Copper	.0006	20	.003	80	.004	127	.010	322	.026	816	.065	2076	.103	3296	.659	20970
Iron	.004	22	.015	91	.024	145	.059	365	.149	926	.376	2356	.598	3741	3.83	23740
Constantan	.018	20	.072	81	.114	128	.291	324	.725	821	1.85	2090	2.94	3318	18.7	21110
Chromel	.026	20	.104	82	.165	130	.415	329	1.05	834	2.70	2121	4.03	3368	27.04	21430
Alumel	.011	20	.043	83	.069	132	.113	334	.438	846	1.11	2153	1.76	3419	11.26	21750
#11 Alloy	.002	20	.007	80	.010	125	.027	322	.070	815	.175	2075	.275	3295	--	20955
Platinum	.004	.56	.016	2.22	.025	3.71	.066	9.17	.166	23.5	--	65.2	.633	93.9	4.15	587
Plat. - 6%	--	.58	--	2.31	--	3.85	--	9.54	--	24.4	--	67.8	--	97.6	--	610
Plat. - 10%	.007	.60	.028	2.37	.044	3.97	.119	9.82	.298	25.2	--	69.8	1.19	100.5	7.45	628
Plat. - 13%	.008	.61	.031	2.43	.049	4.06	.124	10.0	.312	25.7	--	71.4	1.25	102.8	7.80	642
Plat. - 30%	--	.68	--	2.70	--	4.51	--	11.2	--	28.6	--	79.1	--	114.3	--	715

NOTE: All footages stated are in pound units except platinum calibrations which are in troy ounce units

GAUGE CONSTRUCTION CIRCULAR MILS	14 16/26*	16 7/24	17 19/30	20 7/28
	4006	2828	1911	1119
CALIBRATION	RES.	RES.	RES.	RES.
Copper	.003	.004	.005	.009
Iron	.015	.021	.031	.054
Constantan	.073	.104	.165	.263
Chromel	.105	.150	.222	.380
Alumel	.004	.063	.094	.158

THERMOCOUPLE WIRE SIZE AND RESISTANCE TABLE RESISTANCE IN OHMS PER DOUBLE FOOT AT 68°F.

AWG NO.	DIAMETER (inches)	TYPE K Chromel / Alumel	TYPE J Iron / Constantan	TYPE T Copper / Constantan	TYPE E Chromel / Constantan	TYPE S Pt / Pt 10% Rh	TYPE R Pt / Pt 13% Rh	TYPE C* W5% Re / W26% Re	TYPE G* W / W26% Re	TYPE D* W3% Re / W25% Re
6	0.162	0.023	0.014	0.012	0.027	0.007	0.007	0.009	0.008	0.009
8	0.128	0.037	0.022	0.019	0.044	0.011	0.011	0.015	0.012	0.015
10	0.102	0.058	0.034	0.029	0.069	0.018	0.018	0.023	0.020	0.022
12	0.081	0.091	0.054	0.046	0.109	0.028	0.029	0.037	0.031	0.035
14	0.064	0.146	0.087	0.074	0.175	0.045	0.047	0.058	0.049	0.055
16	0.051	0.230	0.137	0.117	0.276	0.071	0.073	0.092	0.078	0.083
18	0.040	0.374	0.222	0.190	0.448	0.116	0.119	0.148	0.126	0.138
20	0.032	0.586	0.357	0.298	0.707	0.185	0.190	0.235	0.200	0.220
24	0.0201	1.490	0.878	0.7526	1.78	0.464	0.478	0.594	0.560	0.560
26	0.0159	2.381	1.405	1.204	2.836	0.740	0.760	0.945	0.803	0.890
30	0.0100	5.984	3.551	3.043	7.169	1.85	1.91	2.38	2.03	2.26
32	0.0080	9.524	5.599	4.758	11.31	1.96	3.04	3.8	3.22	3.60
34	0.0063	15.17	8.946	7.66	18.09	4.66	4.82	6.04	5.10	5.70
36	0.0050	24.08	14.20	12.17	28.76	7.40	7.64	9.6	8.16	9.10
38	0.0039	38.20	23.35	19.99	45.41	11.6	11.95	15.3	12.9	15.3
40	0.00315	60.88	37.01	31.64	73.57	18.6	19.3	24.4	20.6	23.0
44	0.0020	149.6	88.78	76.09	179.2	74.0	76.5	60.2	51.1	56.9
50	0.0010	598.4	355.1	304.3	716.9	185	191	240	204	227
56	0.00049	2408	1420	1217	2876	740	740	1000	850	945

BASE METAL THERMOCOUPLE WIRE FT. / LB.

ANSI CODE	WIRE TYPE	ELEMENT POLARITY	AWG	WIRE FT. / LB
JP	Iron	Positive (+)	8	22.8
			14	91.2
			20	365.0
			24	925.0
			28	2353.0
			30	3767.0
JN	Constantan	Negative (-)	8	20.2
			14	80.9
			20	324.0
			24	821.0
			28	2089.0
			30	3316.0
KP	Chromel	Positive (+)	8	21
			14	83
			20	331
			24	838
			28	2089
			30	3316
KN	Alumel	Negative (-)	8	21
			14	83
			20	331
			24	838
			28	2130
			30	3370
EP	Chromel	Positive (+)	20	328
			24	833
			30	3364
EN	Constantan	Negative (-)	20	324
			24	821
			30	3316
TP	Copper	Positive (+)	20	324
			24	820
			30	3294
TN	Constantan	Negative (-)	20	324
			24	821
			30	3316

HIGH TEMPERATURE THERMOCOUPLE WIRE

ANSI CODE	CODE TYPE	ELEMENT POLARITY	AWG	WIRE IN / T. OZ
SP	Pt-10% Rh	Positive (+)	16	46.4
			20	118.0
			24	302.2
			26	480.0
			28	715.2
SN	Pt	Negative (-)	16	43.3
			20	110.0
			24	281.6
			26	432.0
			28	666.6
RP	Pt-13% Rh	Positive (+)	16	47.4
			20	120.4
			24	308.3
			26	468.0
			28	729.8
RN	Pt	Negative (-)	16	43.3
			20	110.0
			24	281.6
			26	432.0
			28	666.6
BP	Pt-30% Rh	Positive (+)	16	52.7
			20	134.0
			24	343.1
			28	812.3
BN	Pt-6% Rh	Negative (-)	16	45.2
			20	114.8
			24	394.0
			28	695.8
CP	Tungsten 5% Rhenium	Positive (+)	24	308.7
CN	Tungsten 26% Rhenium	Negative (-)	24	304.3

Pt = Platinum
Rh = Rhodium

Notes

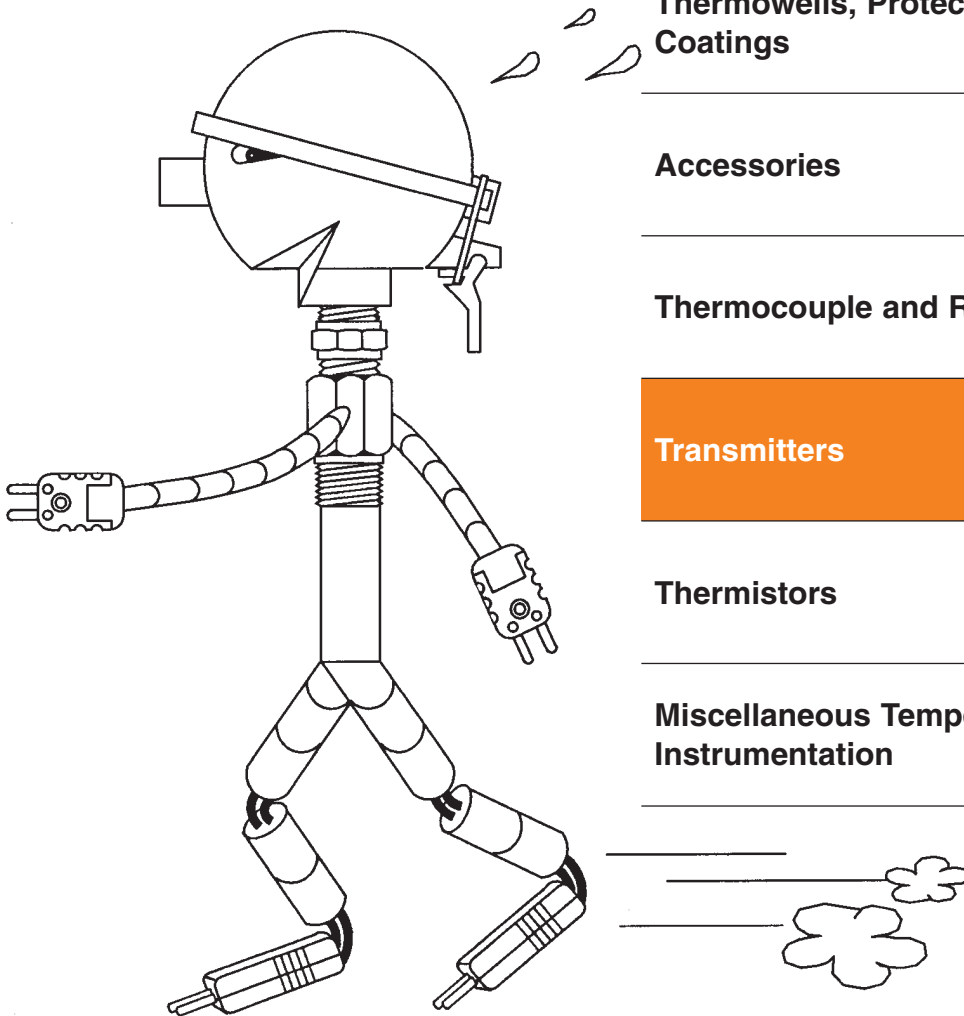
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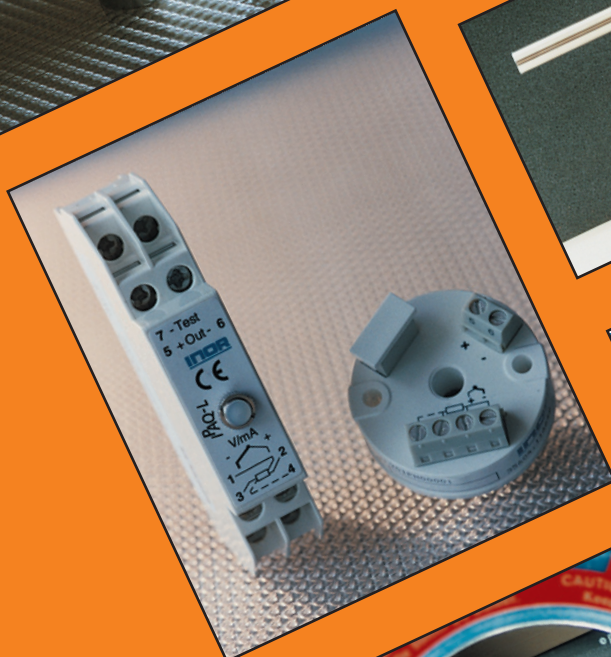


JMS Southeast, Inc.
Temperature Measurement



Transmitters





TRANSMITTERS

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NON-ISOLATED TRANSMITTERS

JMS non-isolated transmitters can be mounted in the following JMS heads; 6L-General purpose aluminum head with hinged cover and 6I-Explosion proof head. See appropriate sensor section for complete assembly information.

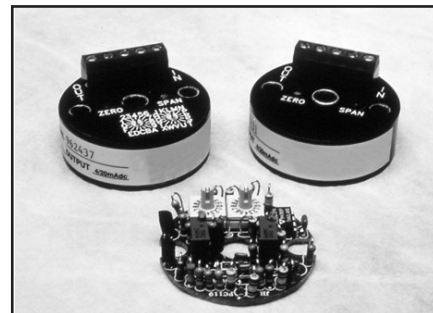
JMS Southeast carries non-standard transmitters. Contact JMS for options other than those listed for the standard transmitters or for any additional information.

#1	SERIES [12, 13]	
8N	Transmitter, Non-Isolated	
#2	INPUT	
*J	Iron/Constantan thermocouple	
*T	Copper/Constantan thermocouple	
*K	Chromel/Alumel thermocouple	
*E	Chromel/Constantan thermocouple	
*S	Platinum 10% Rhodium/Pure Platinum thermocouple	
*R	Platinum 13% Rhodium/Pure Platinum thermocouple	
*B	Platinum 6% Rhodium/Platinum 30% Rhodium thermocouple	
*N	Nicrosil/Nisil thermocouple	
*W	Tungsten/Tungsten 26% Rhenium thermocouple	
3	3 wire, 100Ω, Platinum, α=.00385, RTD (3 - Wire Standard, 2 or 4 Wire use X)	
X	Other, specify	
#3	TEMPERATURE RANGE	
-- to --°C	List desired temperature span	
-- to -- °F	List desired temperature span	
X	Other, specify	
#4	OUTPUT	
4	4 to 20 mA	
X	Other, specify	
#5	MOUNTING	
A	Dual mounting bracket	
S	Dual mounting bracket with 12" cuttable mounting track	
X	Other, specify	
Z	N/A	

Although non-isolated transmitters are available for thermocouples, JMS always recommends the customer use isolated transmitters for their application. See page 8-2 for isolation values to 3750 volts

} For panel mounting

[] BRACKETS
INDICATE PAGE
NUMBERS ON WEB OR
FULL CATALOG FOR
ADDITIONAL
TECHNICAL
INFORMATION
WWW.JMS-SE.COM



8N

*All non-isolated thermocouple transmitters should be used with ungrounded junctions to prevent ground loops and noise interference.

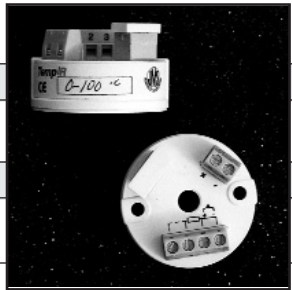
8N	3	50-150F	4	Z
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ISOLATED TRANSMITTERS

These transmitters can be mounted in the JMS explosion proof head. See appropriate sensor section for complete assembly information. Input to output isolation eliminates ground loop errors and permits direct transmission of a signal to a receiver where common mode voltages up to 3700 volts RMS may exist.

JMS Southeast also carries non-standard transmitters. Options other than those listed are available. Contact JMS for information.

#1	SERIES [14, 15, 16, 17]				
8	Transmitter				
#2	TYPE OF TRANSMITTER	I / O ISOLATION	HART		
H	Standard TempIR	1500 VAC	No	Note: H, I, & E are available in slim back Din-Rail mounting package. See WEB for details. Use "R" in front of type to specify in symbol #2.	
C	CAL 9400 (See pg. 8-5, 8-6)	1000 VAC	No		
A	AI-1000 (See pg. 8-8, 8-9)	500 VAC	No		
S	AI-1500 (See pg. 8-10, 8-11)	500 VAC	Yes		
B	AI-2000 (See pg. 8-12)	850 VAC	No		
I	TempIR with Hart Protocol	1500 VAC	Yes		
E	Intrinsically safe TempIR	3750 VAC	No		
D	TempIR / Hart / Intrinsically safe	3750 VAC	Yes		
X	Other				
#3	INPUT				
J	Iron/Constantan thermocouple				
T	Copper/Constantan thermocouple				
K	Chromel/Alumel thermocouple				
E	Chromel/Constantan thermocouple				
S	Platinum 10% Rhodium/Pure Platinum thermocouple				
R	Platinum 13% Rhodium/Pure Platinum thermocouple				
B	Platinum 6% Rhodium/Platinum 30% Rhodium thermocouple				
N	Nicrosil/Nisil thermocouple				
W	Tungsten/Tungsten 26% Rhenium thermocouple				
3	3 wire, 100Ω, Platinum, α=0.00385, RTD (3 - Wire Standard, If 2 or 4 Wire use X)				
X	Other, specify				
Z	N/A				
#4	TEMPERATURE RANGE				
-- to --°C	List desired temperature span				
-- to -- °F	List desired temperature span				
X	Other, specify				
Z	N/A				
#5	OUTPUT				
4	4 to 20 mA	P	Profibus		
X	Other, specify	F	Fieldbus		
#6	SOFTWARE				
Y	Yes - range at factory				
Z	No - range at factory				



8H

Wireless Transmitters

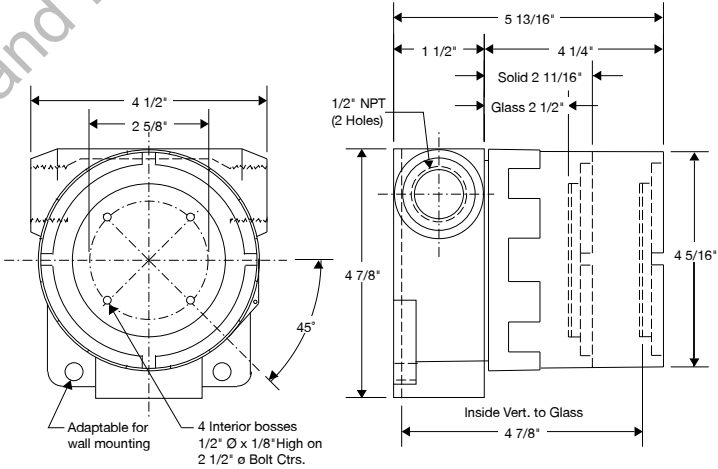
AVAILABLE NOW !!!
 Call our Engineering Dept.
 Wireless Transmitters

8	H	J	50-150°F	4	Z
---	---	---	----------	---	---

INTEGRAL TRANSMITTERS WITH HOUSING AND INDICATOR

#1	SERIES [18]				
888	Transmitter (Includes housing). Use 88Z to exclude housing.				
#2	TYPE OF TRANSMITTER [8-18]	STANDARD HOUSING WITH INDICATOR			
H	Isolated	RV	* See picture below		
N	Non-isolated	RV	** See drawing below		
A	AI-1000 (See pg. 8-8, 8-9)	G	Choose Housing Type in Symbol #7		
S	AI-1500 (Hart) (See pg. 8-10, 8-11)	G			
B	AI-2000 (See pg. 8-12)	H	Note: You may also use selections from page 8-2, symbol #2.		
X	Other, specify (i.e. Different housing from section 6 or customer supplied transmitters, etc.)				
#3	INPUT				
J	Iron/Constantan thermocouple				
T	Copper/Constantan thermocouple				
K	Chromel/Alumel thermocouple				
E	Chromel/Constantan thermocouple				
S	Platinum 10% Rhodium/Pure Platinum thermocouple				
R	Platinum 13% Rhodium/Pure Platinum thermocouple				
B	Platinum 6% Rhodium/Platinum 30% Rhodium thermocouple				
N	Nicrosil/Nisil thermocouple				
C	Tungsten 5% Rhenium/Tungsten 26% Rhenium thermocouple				
3	3 wire, 100Ω, Platinum, α=.00385, RTD (3 wire Standard if 2 wire use X)				
4	4 wire, 100Ω, Platinum, α=.00385, RTD				
X	Other, specify				
#4	TEMPERATURE RANGE				
-- to --°C	List desired temperature span				
-- to --°F	List desired temperature span				
X	Other, specify				
#5	OUTPUT				
4	4 to 20 mA				
X	Other, specify				
#6	INDICATION				
D	Digital (Standard)				
A	Analog (0 to 100% of scale is standard for analog indication. If actual temperature indication is required add an "X" and specify in description.)				
Z	No indication				

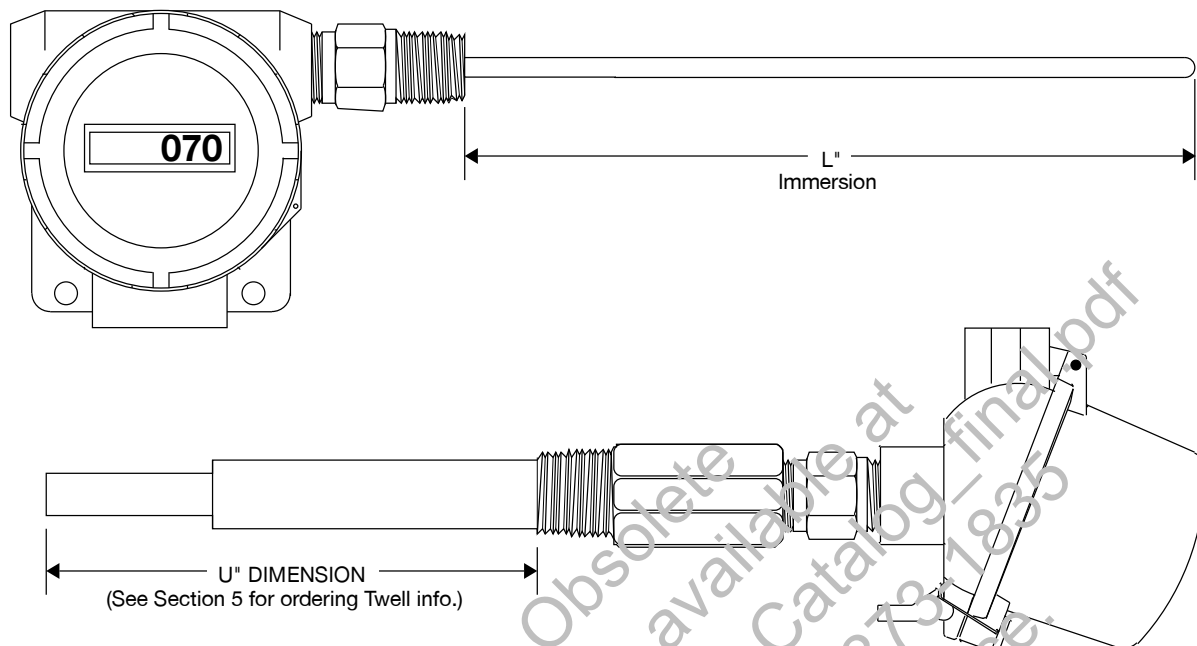




888	A	J	0-300°F	4	D
-----	---	---	---------	---	---

Note: For standard thermocouple or RTD assemblies for the above transmitter see next page. Please see thermocouple, RTD or thermowell section for any assemblies other than those offered on the next page.

INTEGRAL TRANSMITTERS WITH HOUSING AND INDICATOR

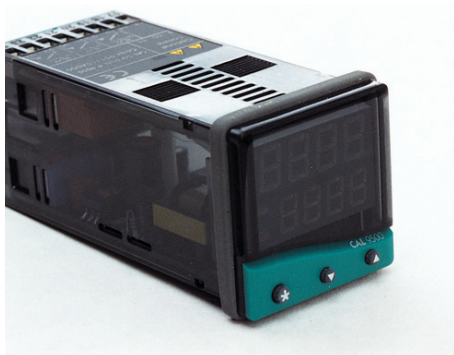


The 888 series specified with these ordering symbols include a temperature sensor assembly with an integral transmitter and indicator.

The assemblies are 316 stainless steel and 1/4" outside diameter. Thermocouples have ungrounded junctions. RTD's have a 3 wire configuration and a 0.00385 alpha. The most popular assembly features a spring-loaded fitting with a thermowell. Although other thermowells are available, the standard well is 316 stainless steel, .260 Bore.

For assemblies other than those listed please consult the appropriate sensor section or contact JMS Southeast.

#7	HOUSING	WORKS WITH (SELECTION #2)	
G	888 2 1/2" Height, Window, short dome	H, N, A & S	
H	888 4 1/4" Height, Window, high dome	H, N, A, S & B	
RV	High dome head w/ hinged cover & Window (6"V) Nema 4	H & N	
X	Other, specify		
#8	FITTING TYPE { 6-13 }		
S	Spring loaded 1/2" x 1/2" NPT		
W	Welded 1/2" x 1/2" NPT		
N	Nipple-Union Nipple - 6" (UN6G1)		
X	Other, specify		
Z	N/A		
#9	IMMERSION LENGTH IN INCHES (L)	THERMOWELL (U) DIMENSION	
4	4"	2 1/2"	
6	6"	4 1/2"	
7	7 1/2"	6"	
9	9"	7 1/2"	
12	12"	10 1/2"	
X	Other, specify	--	
Z	N/A - No well necessary, or if well is already installed		
#10	THERMOWELL		
A	3/4" Process thread, stepped shank (Standard)		
B	3/4" Process thread, tapered shank		
X	Other, specify		
Z	N/A		
R	S	6"	Z



The NEW Dual Display CAL 9500 Temperature Controller With 4-20 mA Retransmission

Dual-display 1/16 DIN Autotune Temperature Controller with Windows™ based Charting and logging

Introducing the most versatile CAL controller of them all, featuring permanent displays of both process and setpoint temperature, together with triple outputs inviting a choice from different combinations of 4-20 mA, relay and SSR driver devices.

In addition, the CALCOMMS™ software package is designed for PC supervision of up to 32 Model 9500 controllers. It is affordable, easy to use and is an ideal way of providing temperature records for management requirements.

CAL 9500

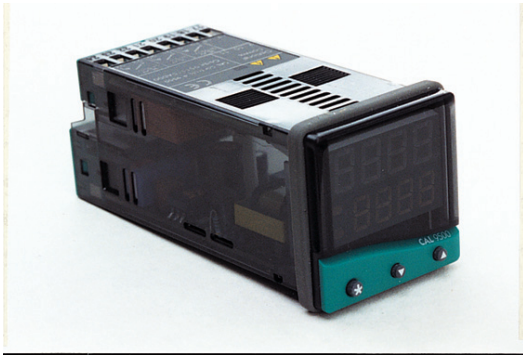
- Dual four digit display
- Full PID Autotune
- Ramp / Soak
- 5 Alarm configurations
- PID Heat-Cool
- Sleeve mounting
- 3 year warranty

CALCOMMS™

- Windows™ based logging and charting software
- Instrument configuration and remote setpoint adjustments
- Recipe / profile save and recall
- Instrument cloning
- Selectable scan rate
- Alarms

CAL 9500

FRONT



SIDE VIEW



BACK



SPECIFICATIONS

Thermocouples

9 types	B,E,J,K,L,N,R,S,T
Standards:	IPTS68/DIN 43710
External resistance	100 Ω Maximum
CJC rejection	20:1 (0.05° / °C) typical

Resistance temperature detectors (RTD)

RTD-2/Pt 100 2 wire	
Standards:	DIN 43760 (100 Ω 0°C/138.5 Ω 100°C Pt)
Bulb current:	0.2mA maximum

Linear process inputs

mV range:	0 to 50mV (0to 20mV, 4 to 20mV)
-----------	---------------------------------

Applicable to all inputs SM = sensor maximum

Calibration accuracy	$\pm 0.25\%$ SM $\pm 1^\circ\text{C}$
Sampling frequency:	input 10Hz, CJC 2 sec.
Common mode rejection:	Negligible effect up to 140dB, 240V, 50-60Hz
Series mode rejection:	60dB, 50-60Hz
Temperature coefficient:	150ppm/°C SM
Reference conditions:	22°C $\pm 2^\circ\text{C}$, rated voltage after 15 minutes setting time

Output devices

SSd/SSd1/SSd2:	solid state relay driver: To switch a remote SSR 5Vdc +0/-15% 15mA non-isolated form A/SPST contacts (AgCdO)
Miniature power relay:	2A/250ac resistive load
r-LY and rLY1:	2A/250ac resistive load
r-LY2:	1A/250ac resistive load

General

Displays:

Upper, 4 Digits high brightness green LED.
10mm (0.4") high.
Lower, 4 Digits high brightness orange LED.
9mm (0.35") high
Digital range - 199 to 9999
Hi-res mode - 199.9 to 999.9

LED output indicators -
flashing SP1 square-green; SP2 round-red

Keypad:

3 full travel elastomeric push buttons

Environmental

Humidity:	Max 80%
Altitude:	up tp 2000m
Installation:	Categories II and III
Pollution:	Degree II
Protection:	NEMA 4X, IP66
EMC emission:	EN50081-1 FCC Rules 15 subpart J Class A
EMC immunity:	EN50082-2
Ambient:	0-50°C (32-130°F)
Mouldings:	Flame retardant polycarbonate

Mechanical:

Front facia 51.0 x 51.0mm (includes gasket)
Sleeve length 106.7mm (with gasket fitted)
Instrument 44.8 x 44.8mm (1/16th DIN)
Overall length 116.2mm

Weight:

130g (4.2oz)

JMS SMART TRANSMITTERS

Model AI-1000 Revision 2 Programmable Temperature Transmitter



The **AI-1000 R2** Programmable Temperature Transmitter combines the best features from smart and analog designs. It's fast, easy-to-use and competitively priced – like an analog transmitter. The AI-1000 R2 is microprocessor-based, highly accurate and accepts a wide variety of inputs – like a smart transmitter. Configure this transmitter with its optional plug-in display or with a PC using the windows-based Accutech Transmitter Manager software. The AI-1000 R2 accepts a wide variety of thermocouples and 2-, 3- and true 4-wire RTD measurements. Span the transmitter anywhere within the sensor's usable range – with no minimum span. Mount the AI-1000 R2 wherever you need it – head mount, yoke mount, panel or wall mount. Its versatility and compact design allow for one transmitter to fit all your needs.

Model AI-1500 HART®, Smart Temperature Transmitter



The **AI-1500 HART®** Smart Temperature Transmitter offers superior performance and unmatched versatility in smart transmitter designs. Automatic self-calibration, digital ambient temperature compensation and fast update speeds put the AI-1500 ahead of the competition. Configure this smart transmitter with its optional plug-in display, an HC275 HART® Communicator or a PC using the windows-based Accutech Transmitter Manager software. Head, yoke, panel or wall mount the AI-1500 to suit any application. The AI-1500 is simply the best transmitter available in its class.

AI-1000 TEMPERATURE TRANSMITTER

Model AI-1000 Revision 2 Programmable Temperature Transmitter

Highlights

- Exceptional Speed and Accuracy
- Guaranteed Measurement Stability
- Automatic Self-Calibration
- Automatic Cold-Junction Compensation
- Digital Ambient Temperature Compensation
- Accepts virtually any Thermocouple or RTD
- Set-up is fast and easy, no hand-held required
- Display Mode or PC Configuration
- Competitive Pricing
- Total Installation Flexibility

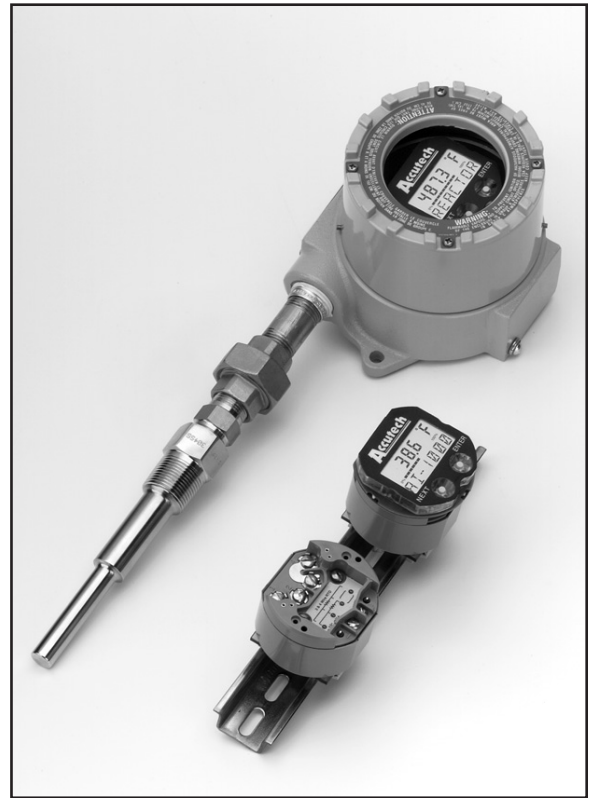
The Accutech AI-1000 Revision 2 Programmable Temperature Transmitter combines the best features of analog and smart designs. It's fast, accurate, versatile and easy-to-use. It will give substantial benefits in a wide range of process industry applications.

Exceptional Capabilities

Capabilities that were once available only in high-priced "Smart" transmitters are now available in the compact, competitively priced AI-1000 R2.

Exceptional Long-term Stability

Accutech pioneered technology for automatic self-calibration. This capability is now available in a compact field transmitter. Automatic self-calibration to on-board reference standards increases measurement reliability and significantly reduces maintenance costs. The digital ambient temperature compensation virtually eliminates ambient temperature drift.



The AI-1000 R2 measurement stability exceeds all transmitters in its price class.

Tremendous Versatility

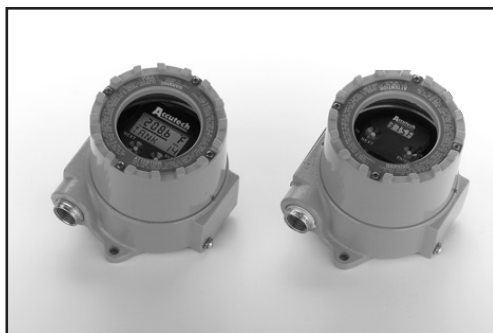
A single AI-1000 R2 transmitter will take virtually any thermocouple, RTD, millivolt or ohm input. It will give you linearized output over any part of the sensor range. The AI-1000 R2 allows you to dramatically reduce inventory and spare parts. You can configure it exactly the way you want. You can even re-configure the transmitter as your needs change! You do not need to stock two transmitter types, one for field mounting and one for panel mounting. One AI-1000 R2 will do it all.

Optional Plug-In Display and Set-Up Tool

The unique, time and cost-saving display options allow you to program and read any AI-1000 R2. No hand-held terminal is required. If you do not need the local read-out, you can unplug the display once you have completed the set-up. You can take it with you!



AI-1000 SPECIFICATIONS



AI-1000 Revision 2 Specifications

Thermocouple Sensors:

NIST Types B, C, E, J, K, N, R, S, & T; DIN Types L & U

RTD Resistance Sensors:

100Ω	Pt DIN curve ($\alpha=0.00385$)	2, 3 or 4 wire
100Ω	Pt SAMA	
	RC21-4 curve ($\alpha=0.003923$)	2, 3 or 4 wire
100Ω	Ni DIN curve*	2, 3 or 4 wire
120Ω	Ni MINCO curve*	2, 3 or 4 wire
10Ω	Cu Curve CR228/229*	2, 3 or 4 wire

* PC Configuration

Millivolt Input Range: -15 to +115 mV DC

Thermocouple and RTD Linearization: Linear output with temperature conforms to NIST and DIN curves within ± 0.05 °C.

Custom Linearization: Programmable, up to 22 points.*
* PC Configuration

Output: Two wire, 4-20mA

Output Ranging Adjustments:

Analog Zero: 100% of sensor range – Non-interacting
Analog Full-scale: Normal or Reverse acting

Minimum Output Span: None.

Output Resolution: 3.6μA

Transmitter Accuracy: Includes transmitter repeatability and hysteresis effects, rated under reference conditions of 24 °C with a supply voltage of 30 VDC.

Digital Accuracy: $\pm 0.025\%$ of the millivolt or ohm equivalent input reading, or the accuracy from the EGU Equivalent Table, whichever is greater. For thermocouples, add ± 0.5 °C for cold junction measurement effect.

D/A Conversion: $\pm 0.06\%$ of the output span.

Analog Accuracy: Sum of the Digital and the D/A conversion errors.

Repeatability: Half of the digital accuracy value.

EGU Equivalent Table

T/C Types	Accuracy	RTD Sensors	Accuracy
B	± 0.6 °C	100Ω Pt	± 0.08 °C
C, R, S	± 0.5 °C	100Ω Ni	± 0.08 °C
E, J, K, N	± 0.2 °C	120Ω Ni	± 0.08 °C
L	± 0.4 °C	10Ω Cu	± 0.6 °C
T (> -150 °C)	± 0.3 °C		
U (> -100 °C)	± 0.4 °C		
Millivolt input	± 0.006 mV	Ohm input	± 0.002 Ω

Dynamic Response:

Start-up Time: 7 seconds.

Ambient Temperature Gradient: Automatic Compensation to 20 °C per hour change.

Update Time: 0.15 second.

Response to Step Input: 0.25 second, minimum; 1 second, typical.

Cold Junction Compensation: Self-correcting to ± 0.5 °C

Ambient Operating Temperature: -40 to 85 °C (-40 to 185 °F)

Ambient Storage Temperature: -40 to 85 °C (-40 to 185 °F)

Ambient Temperature Stability: Self-correcting over the operating temperature.

Long Term Stability: Less than 0.05% of reading plus $\pm 3.6\mu A$ per year.

Automatic Diagnostics: Every 3 seconds, self-checks for zero, span, cold junction temperature, sensor and transmitter malfunction.

Failsafe: User selectable; 3.6mA, 23mA, or OFF.

Interchangeability: All units interchangeable without field calibration.

EMI / RFI Immunity:

Operating Conditions:	Industrial Environment
Immunity According to:	EN 50082-1'
	IEC 100-4-3 30 V/m 80-1000MHz
Emission According to:	EN 55011, Group 1, Class A
	EN 50081-2

Isolation: 500 VAC

Common Mode Rejection: 120 dB

Reverse Polarity Protection: 42 VDC applied with either polarity.

Power and Load:

Supply Voltage (no load):	12 to 42 VDC (30 VDC for I.S.)
Supply Voltage (with load):	$V_{Supply} = (12) + (R_{Load} \text{ in } K\Omega) \times (23mA)$
Supply Voltage Effect:	Less than $\pm 0.005\%$ of Span/Volt.

Approvals: FM/CSA Non-Incendive rating. Intrinsic Safety optional.

Dimensions: Diameter: 2.35"
Height: 1.55" (with DK-1 or DK-2: 1.95")

Weight: 6 oz. (Electronics module only)

Standard Configuration: Type J T/C input. Analog output, 40 to 200 °F. HI failsafes. Configuration parameters may be field programmed via Display Mode with optional DK-1 or DK-2 Display / Keyboards or with a PC using an LSK Modem and Accutech Transmitter Manager Software. See Price List.

Options: Displays, Enclosures, Sensors, and Thermowells available from Accutech. See Price List.

Specifications subject to change without notice.

AI-1500 TEMPERATURE TRANSMITTER

Model AI-1500 HART®, Smart Temperature Transmitter



The Accutech AI-1500 Smart Temperature Transmitter is unique. It's easy to use and moderately priced - like an analog transmitter. It's also versatile, linear, and based on microprocessor logic.

The exceptional versatility of the AI-1500 not only lets you configure your transmitters exactly the way you want them; it also dramatically reduces back-up stock and spare parts. The AI-1500 is fully HART®, compliant and can be used with any HART®, compliant device (such as the HC275 HART®, Communicator).

Superior Performance

- Exceptional Speed and Accuracy
- Guaranteed Measurement Stability
- Automatic Self-Calibration
- Automatic Cold-Junction Compensation
- Digital Ambient Temperature Compensation

Unmatched Versatility

- Accepts virtually any Thermocouple or RTD
- Fully HART® Compliant
- Suitable for Field or Panel Mounting

Simple Operation

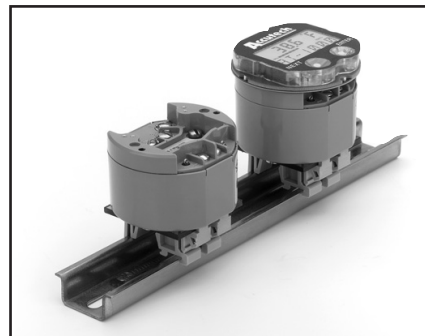
- Fast and Easy Set-up
 - Use Hand-held, Display, or PC
- Optional Plug-In LCD Displays

The AI-1500 can be mounted in explosion proof and weatherproof enclosures, as well as on a DIN rail for panel mounting applications. Local indication can be added at any time by simply plugging in one of the two optional displays. One transmitter on the shelf can back up the needs of an entire facility.

Automatic self-calibration every three seconds to on-board reference standards increases process measurement reliability and significantly reduces ongoing maintenance costs. Digital ambient temperature compensation completely characterizes each transmitter for performance in ambient environments from -40 to +185 °F, resulting in greatly reduced measurement drift.

In direct comparisons, the AI-1500 offers dramatically improved performance and outstanding value over competitive analog, programmable, and smart transmitters. Its stability, accuracy, versatility, reliability, and ease-of-use yield real benefits in process industry applications.

For over ten years, we have had a single focus - building the finest microprocessor-based industrial process instrumentation. This dedication to and knowledge of the industrial environment is built into every Accutech product. As a result, the AI-1500 is not only the best temperature transmitter available, the price and delivery are unmatched.



AI-1500 SPECIFICATIONS

AI-1500 SPECIFICATIONS

SENSOR INPUT	RANGE, °F	ACCURACY	RANGE, °C	ACCURACY
Thermocouple Type B	+ 109 to + 3,308 °F	± 0.99 °F	+ 43 to + 1,820 °C	± 0.55 °C
Thermocouple Type C	+ 32 to + 4,208 °F	± 0.72 °F	0 to + 2,320 °C	± 0.40 °C
Thermocouple Type E	- 454 to + 1,832 °F	± 0.18 °F	- 270 to + 1,000 °C	± 0.10 °C
Thermocouple Type J	- 346 to + 2,129 °F	± 0.27 °F	- 210 to + 1,200 °C	± 0.15 °C
Thermocouple Type K	- 454 to + 2,502 °F	± 0.27 °F	- 270 to + 1,372 °C	± 0.15 °C
Thermocouple Type L	- 328 to + 1,652 °F	± 0.27 °F	- 200 to + 900 °C	± 0.15 °C
Thermocouple Type N	- 454 to + 2,372 °F	± 0.36 °F	- 270 to + 1,300 °C	± 0.20 °C
Thermocouple Type R	- 58 to + 3,214 °F	± 0.81 °F	- 50 to + 1,768 °C	± 0.45 °C
Thermocouple Type S	- 58 to + 3,214 °F	± 0.90 °F	- 50 to + 1,768 °C	± 0.50 °C
Thermocouple Type T	- 454 to + 752 °F	± 0.18 °F	- 270 to + 400 °C	± 0.10 °C
Thermocouple Type U	- 328 to + 1,112 °F	± 0.18 °F	- 200 to + 600 °C	± 0.10 °C
100Ω Platinum RTD DIN Curve ($\alpha = 0.00385$)	- 328 to + 1,562 °F	± 0.09 °F	- 200 to + 850 °C	± 0.05 °C
100Ω Platinum RTD SAMA Curve ($\alpha = 0.003923$)	- 328 to + 1,202 °F	± 0.09 °F	- 200 to + 650 °C	± 0.05 °C
Call Factory for 100Ω Ni, 120Ω Ni, and 10Ω Cu				
Millivolt	- 15 to 115mV	± 0.006 mV		
Ohm	0 to 500 Ω	± 0.002 Ω		

TRANSMITTER ACCURACY: ± 0.01% of the millivolt or ohm equivalent input reading, or the value from the Accuracy Table, whichever is greater; plus ±0.04% of the span. For thermocouples, add ±0.5°C (0.9°F) for cold junction effect.

Accuracy includes transmitter repeatability, hysteresis and linearity as well as A/D conversion error, analog output error, line voltage effects, humidity effect under non-condensing conditions, vibration effect to 2g's & 500Hz.

TRANSMITTER AMBIENT TEMPERATURE EFFECT:

One-half the transmitter accuracy per 28°C (50°F)

TRANSMITTER REPEATABILITY: One-half the transmitter accuracy.

COLD-JUNCTION COMPENSATION: Digital self-correcting over the ambient temperature range to ±0.5°C.

LINEARIZATION: Thermocouple and RTD linearization to ±0.05°C. Custom linearization with 22 point curve via HART® Communications.

OUTPUT: Analog, Two wire 4 to 20mA.

Digital, HART, simultaneous communication

OUTPUT RANGING ADJUSTMENTS:

Analog Zero: 100% of Sensor range – Noninteracting

Analog Full-scale: Normal or Reverse Acting

LONG TERM STABILITY: Stability deviation per year is less than: (0.04% of output the span + 0.05% of the millivolt or ohm equivalent reading)

OPERATING TEMPERATURE RANGE:

-40°C to +85°C -40°F to + 185°F Electronics

-20°C to +70°C - 4°F to + 158°F Display (Full Visibility)

-40°C to +85°C -40°F to + 185°F Display (With reduced visibility)

STORAGE TEMPERATURE RANGE: -50°C to +85°C; -58°F to +185°F

DAMPING: User selectable time constant (63%) from 0 to 32 sec.

FAILSAFE: User settable from 3.6mA or 23mA.

MOUNTING POSITION: No effect on measurement value.

WEIGHT: AI-1500: 6 oz. XP-FN & FG: 2_ lbs. WP-HEAD: 12 oz

ISOLATION: Input to Output 500VAC

INPUT IMPEDANCE: Greater than 1 MΩ

POWER SUPPLY: The transmitter operates on 12 to 42 VDC (30VDC for I/S installations) with no load. Transmitter is protected against reverse polarity connection.

LOAD LIMITATIONS: Loop resistance including optional indicator: $R(K\Omega) = (\text{Supply Voltage} - 12 \text{ VDC}) / (23\text{mA})$

INTERCHANGEABILITY: Fully interchangeable without field calibration

ELECTROMAGNETIC COMPATIBILITY (CE COMPLIANCE):

Transmitter operates within specification in fields from 20 to 1,000MHz with field strengths to 30V/m. Meets EN 50082-1 Generic Immunity Standard and EN 55011 Compatibility Emissions Standard.

DYNAMIC RESPONSE:

UPDATE RATE: 150 milliseconds (7 times per second), typical.

RESPONSE TO STEP CHANGE: 250 milliseconds, minimum;

1 second, typical.

START-UP TIME: 7 sec. Operation to specification less than 30 sec.

AMBIENT TEMPERATURE CHANGE: Self-correcting for ambient temperature changes up to 20°C/hr.

HAZARDOUS LOCATION CERTIFICATIONS:

Explosion Proof: Explosion Proof Housings available with and without windows; CSA and FM approved for Class I, Div I & Div II, Groups B, C, & D; Class II, Div I & II, Groups E, F & G, Class III and are rated for NEMA 4X and NEMA 7 environments.

Nonincendive: Transmitter is CSA and FM rated nonincendive in Class I, Div II, Groups A, B, C & D; Class II, Div II, Groups F & G, Class III, Div II, CENELEC Ex N IIC T4-T6 certification pending.

Intrinsic Safety: The Intrinsically Safe Rated Model AI-1500 I/S is CSA and FM rated Intrinsically Safe for Class I, Div I, Groups A, B, C & D & Class II, Div I, Groups E, F, & G, & Class III, Div I, when installed per AIC Drawing 6022588, Rev A. See manual for details.

CENELEC EEx ia IIC T4-T6 Intrinsically safe certification pending.

OPTIONS:

INTRINSIC SAFETY: Order the AI-1500 I/S

HOUSINGS:

XP-FN: NEMA 7 Explosion-Proof, NEMA 4X Housing

XP-FG: NEMA 7 Explosion-Proof, NEMA 4X with Window

XP-HEAD: NEMA 7 Explosion-Proof, Rain-tight Head

WP-HEAD: IP66 Weatherproof Head

DISPLAYS:

DK-1: One-Line Local Display and Keyboard

DK-2: Two-Line Smart Local Display and Keyboard

THERMOWELLS: Order as required. See Accutech Bulletin PROB

SENSORS: Order as required. See Accutech Bulletin PROB

EXPLOSION-PROOF CERTIFICATION: Consult factory for details

MOUNTING: PY-2 2" Pipe Yoke for XP-FN & XP-FG housings

DIN-KIT R2 DIN Rail Mounting Adapter

STANDARD CONFIGURATION:

Sensor Input J Type Thermocouple

LRV (4mA) 40°F Lower Range Value

URV (20mA) 200°F Upper Range Value

Damping 0 seconds

Output Linear with Temperature

Failsafe Upscale (23mA)

ORDERING INFORMATION: Please order Model AI-1500.

Specify custom configuration, options and companion products as desired.

NOTE: Please note that specifications are determined with the factory default software settings or with the various software parameters set to optimize the performance for a given specification.

HART® is a registered trademark of HART Communications Foundation. Specifications subject to change without notice.

AI-2000 TEMPERATURE TRANSMITTER

Model AI-2000 Revision 4 Smart Temperature Transmitter

Highlights

- Guaranteed Measurement Stability
- Digital Ambient Temperature Compensation
- Automatic Self-Calibration
- Two Year Calibration Warranty
- Accepts virtually any Thermocouple or RTD
- Local and Remote Communication
- No need for Software Upgrades
- Explosion Proof Head or Pipe Mounting
- DIN Rail mounting capabilities
- Meets highest performance accuracy requirements
- Truly Smart – Use Smart Communications® or Display Mode Configuration
- 21 point custom linearization capabilities
- RTD-CAL available for industry leading system accuracy

The AI-2000 Rev. 4 was introduced in 1991 and set the standard for accuracy and stability for temperature measurement in industrial process applications. Its automatic self-calibration and digital ambient temperature compensation has been unrivaled in the process instrumentation marketplace. The AI-2000 Rev. 4 was the first transmitter to offer a 2 year calibration guarantee traceable to NIST standards. Now, the AI-1500 extends this same unique guarantee to three years.



Hundreds of process facilities worldwide depend on the AI-2000 Rev. 4 for their critical temperature measurements. The Stability, Accuracy, Versatility and Ease-of-use of the AI-2000 Rev. 4 allows process facilities to make better products. Off-the-shelf delivery and competitive pricing give customers the flexibility and confidence to standardize on the AI-2000 Rev. 4 Smart Temperature Transmitter.

AI-2000 Rev. 4 Specifications:

DIGITAL OUTPUT ACCURACY: $\pm 0.04\%$ of the millivolt or ohm equivalent reading, or the accuracy from the table below, whichever is greater, plus the effect of a cold junction measurement error of $\pm 0.25^\circ\text{C}$ ($\pm 0.45^\circ\text{F}$) if using a thermocouple sensor.

INPUT	DIGITAL ACCURACY	INPUT	DIGITAL ACCURACY
B T/C	$\pm 0.8^\circ\text{C}$ $\pm 1.44^\circ\text{F}$	S T/C	$\pm 0.6^\circ\text{C}$ $\pm 1.08^\circ\text{F}$
E T/C	$\pm 0.2^\circ\text{C}$ $\pm 0.36^\circ\text{F}$	T T/C	$\pm 0.2^\circ\text{C}$ $\pm 0.36^\circ\text{F}$
J T/C	$\pm 0.2^\circ\text{C}$ $\pm 0.36^\circ\text{F}$	Millivolt	± 0.008 mV
K T/C	$\pm 0.2^\circ\text{C}$ $\pm 0.36^\circ\text{F}$	Pt RTD DIN	$\pm 0.1^\circ\text{C}$ $\pm 0.18^\circ\text{F}$
N T/C	$\pm 0.2^\circ\text{C}$ $\pm 0.36^\circ\text{F}$	Pt RTD (US)	$\pm 0.1^\circ\text{C}$ $\pm 0.18^\circ\text{F}$
R T/C	$\pm 0.6^\circ\text{C}$ $\pm 1.08^\circ\text{F}$	Ni RTD	$\pm 0.1^\circ\text{C}$ $\pm 0.18^\circ\text{F}$

LINEARIZATION: Thermocouple and RTD linearization to $\pm 0.05^\circ\text{C}$. Custom linearization user programmable at 21 points.

OUTPUT: Analog, Two-wire 4 to 20mA
Digital, Two-wire (RS-232, 300 baud with CA-100 adapter)

OUTPUT RANGING ADJUSTMENTS:

Analog Zero: 100% of Sensor range – Noninteracting
Analog Full-scale: Normal or Reverse Acting
Digital Mode: $^\circ\text{C}$, $^\circ\text{F}$, $^\circ\text{K}$, $^\circ\text{R}$, mV (no ranging req'd)

ANALOG ACCURACY: Digital accuracy plus $\pm 4 \mu\text{A}$

REPEATABILITY: One-half the respective accuracy

DYNAMIC RESPONSE:

Turn-on Time: Less than 5 seconds after power-up

Ambient Temperature Gradient: Automatic compensation to $20^\circ\text{C}/\text{hour}$ change

Update Time: 0.15 second; Digital, 1 second

Response To Step Input: Analog; 0.25 second, typical Digital; 1 second, typical, to 95% of final value, 5 seconds, to stated accuracy

COLD JUNCTION COMPENSATION: Automatic correction to $\pm 0.25^\circ\text{C}$

AMBIENT OPERATING TEMPERATURE: -40 to $+167^\circ\text{F}$ (-40 to $+75^\circ\text{C}$)

AMBIENT STORAGE TEMPERATURE: -58 to $+185^\circ\text{F}$ (-50 to $+85^\circ\text{C}$)

AMBIENT TEMPERATURE STABILITY: Self-correcting over the ambient Temperature

LONG TERM STABILITY: Less than 0.5% of reading plus ± 2.1 mA per year

AUTOMATIC DIAGNOSTICS: Every 3 seconds, self-checks for zero, span, cold junction, calibration references, malfunction, and sensor failure

EMI/RFI IMMUNITY: Less than 0.5% of reading (SAMA PMC 33.1c test method) 20 kHz to 1000 MHz, 10 V/meter

ISOLATION: 850 VDC or peak AC

WARRANTY: 2 Year NIST Traceable Guarantee with Certificate of Conformance

NON-ISOLATED TRANSMITTERS

The series N transmitter is a non-isolated 2 wire temperature transmitter. The transmitters are completely potted in a special epoxy with only the screw terminals exposed. **Specification of two wire non-isolated transmitters are as follows:**

OUTPUT:

4/20mA, two-wire (loop-powered) output

ACCURACY:

$\pm 0.1\%$ of span or better (factory calibration)

OPEN INPUT:

Offscale high output (T/C, RTD only)

TEMPERATURE:

$\pm(0.02\% + 1\mu\text{V}/^\circ\text{C})$ or better

STABILITY:

-40 to $+80^\circ\text{C}$ (-40 to 176°F)

POWER:

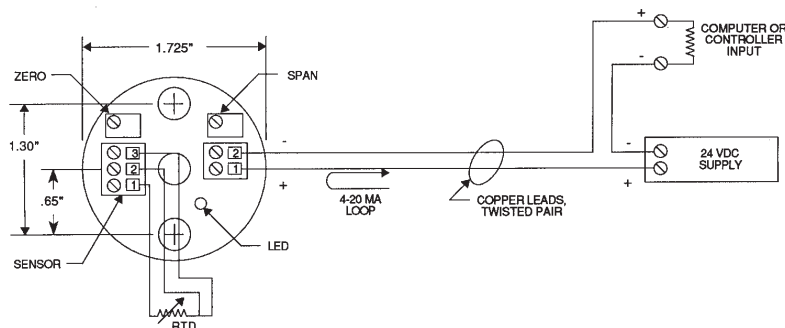
Loop Powered. 12V min, 36V max at output

INPUTS:

DC spans 2mV to 250V, or 1 to 100mA current

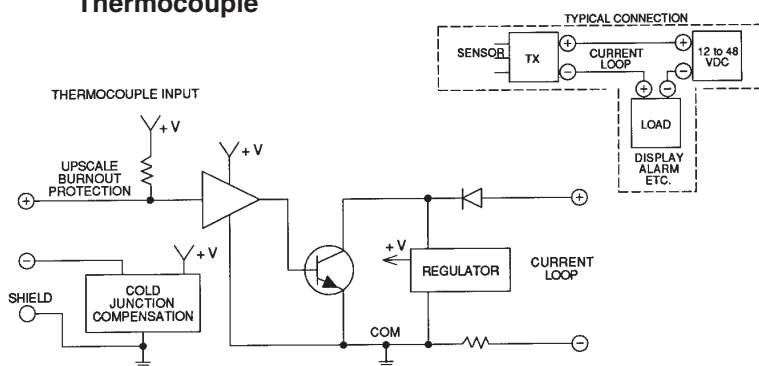
thermocouple minimum span

Installation Instructions:



Block Diagrams and Terminal Connections

Thermocouple



Series: 8N

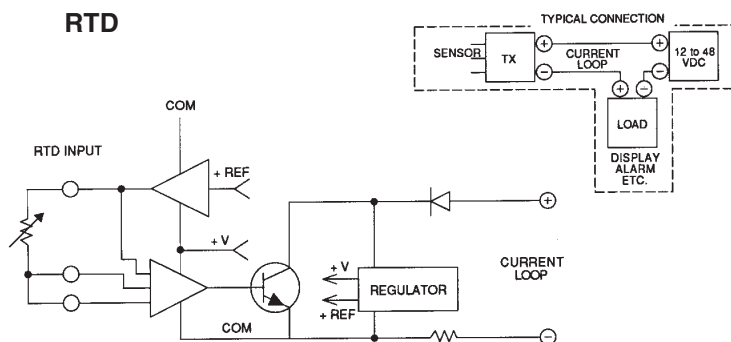
Wiring: For a thermocouple input, the first two terminals looking at the transmitter from the front, are for the (+) and (-) output signal. The thermocouple shield, if used, should be connected to the third terminal from the left. The (-) negative thermocouple lead (usually red), should be connected into the fourth terminal. The (+) positive thermocouple lead should be connected to the fifth terminal.

This transmitter is not recommended for grounded thermocouples.

Series: 8N

For an RTD input, the power supply and output are connected on terminals one and two as described above. The negative/common leads (red) should be connected to terminals 2 and 3. The positive (white) lead should be connected to terminal 1.

RTD



ISOLATED TRANSMITTERS

The JMS 8H, I, and E series isolated transmitter (TempIR) is a 2-wire loop-powered intelligent transmitter. Small size and extreme versatility makes the TempIR an ideal choice for all industrial instrumentation. The transmitter is manufactured for inputs from a wide range of RTD's, thermocouples, plain mV, and resistance. A customized linearization can easily be generated.

A wide power supply range allows for high load in the output loop, e.g. long output leads and multiple instruments. TempIR is configured with TempPRO, the general software to configure the entire temp-family. The program is Windows driven and easy to use. The configuration can be performed on-line, with in and outputs connected. While receiving new parameters, the transmitter will freeze the output signal and return to normal operation after completed transmission of the new parameters.

The 8H series transmitters are microcontroller based and do multiple measurements beyond the standard measurements. One of these controls is to monitor the isolation resistance of the sensor and the sensor leads. This function named, TempIRsense, is available for thermocouples and 3-wire RTD's (see page 8-25 and 8-26 for a technical note).



Performance and design:

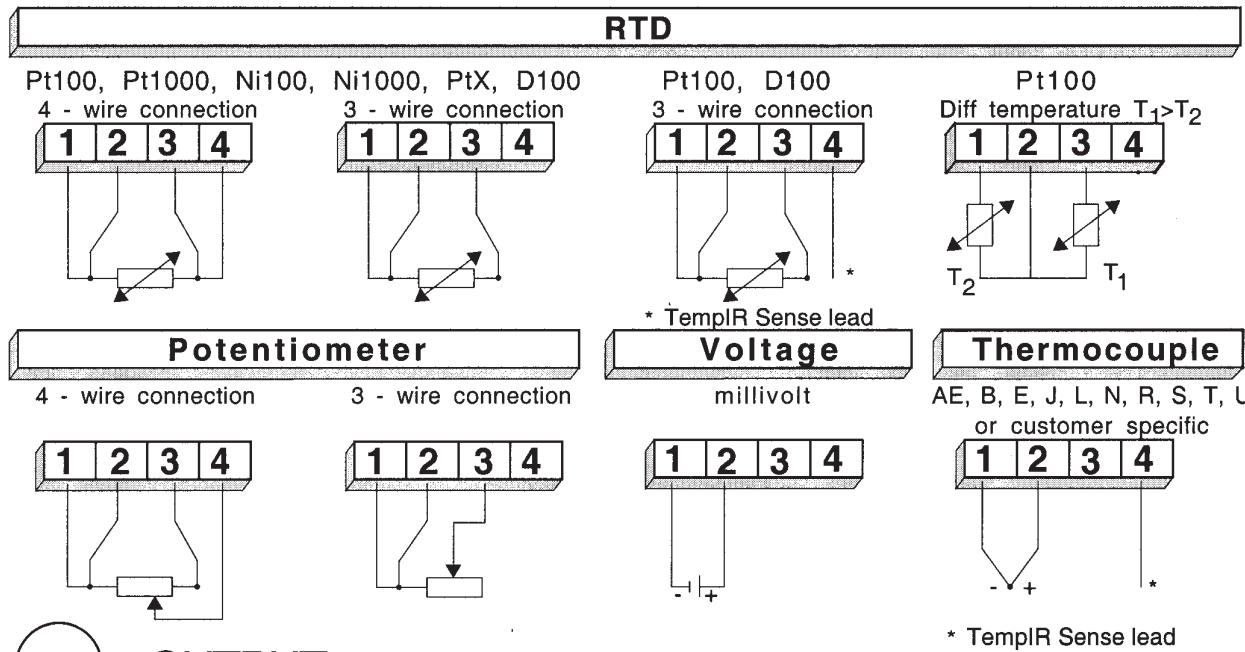
- **Excellent stability**
Long-term stability 0.1% / year.
- **Enhanced total system accuracy**
- **Input-output isolation 1500 VAC**
Eliminates measuring errors due to ground loops.
- **High load capacity**
Only 6.5 V voltage drop over the transmitter allows for high loads.
- **Designed for harsh conditions**
Operation temperature: -40 to +85°C, -40 to +185°F.
Excellent EMC performance.
Durable, shockproof design.
- **Simplified mounting and connection**
For DIN B head or larger.
Large center hole (dia. 7mm / 0.28 inch).

Standard Inputs for:

- **RTD's, Thermocouples, mV and resistance**
Reduced inventory costs.
Simplified plant engineering.
- **True on-line configuration**
Full access to all features while in operation.
- **Customized 40 point linearization**
- **TempIRsense, unique monitoring of insulation resistance**
Detects low sensor isolation (see below).
Selectable sensor break action.
- **Simplified loop check-up**
The transmitter works as an accurate current generator.
- **Easy to configure**
- **On-screen indications and line recording**
Valuable tools for temporary measurements.

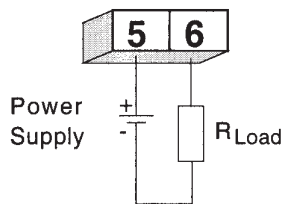
ISOLATED TRANSMITTERS

INPUTS

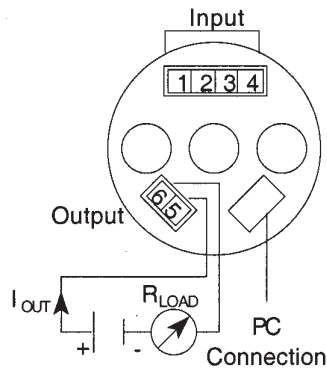


OUTPUT

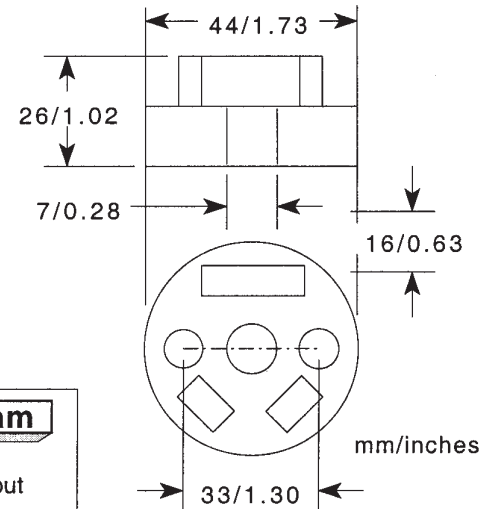
4-20mA Output



Connections

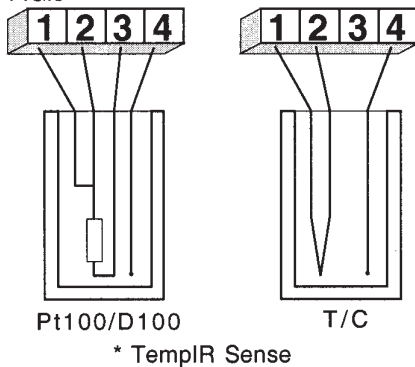


Dimensions



Dimensions

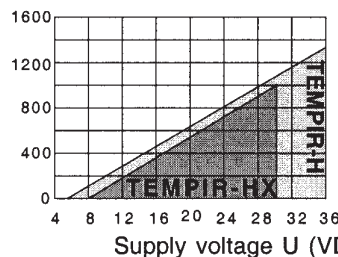
FIG.5



Output load diagram

FIG.6

Permissible R_{LOAD} at 22 mA output
 $R_{LOAD} (\Omega)$



$$R_{LOAD} = (U - 6.5) / 0.022 \quad (\text{TEMPIR - H})$$

$$R_{LOAD} = (U - 8) / 0.022 \quad (\text{TEMPIR - HX})$$

ISOLATED TRANSMITTERS

Specifications

Pt100	3, 4 wire	-200 to +1000°C -328 to +1832°F
Pt1000	3, 4 wire	-200 to +200°C -328 to +392°F
Ni100	3, 4 wire	-60 to +250°C -76 to +482°F
Ni1000	3, 4 wire	-60 to +150°C -76 to +302°F
Potentiometer	3, 4 wire	0 - 2000Ω
Sensor Current		approx. 0.4mA
mAx. Permissible Lead Resistance		25 Ω/lead

T/ C	B, E, J, K, L, N, R, S, T, U
Voltage Input	-10 -500 mV
Input Resistance	>10 Mohm
Total permissible lead resistance for both input leads	500 ohms

	User definable settings
Sensor break detection	3.5 - 22.8 mA
TempIRsense, sensor isolation monitoring	3.5 - 22.8 mA

Zero adjustments		no limitation
Minimum ranges	Pt100, Pt1000	
	Ni100, Ni1000	10°C, 18°F
	Potentiometer	10Ω
	T/C, mV	2 mV

Straight, reversed or any intermediate value	4 - 20 mA
Resolution	5μA
Min output signal	appr. 3.5mA
Max output signal	appr. 23 mA

Selectable filter time for low pass filter	0-60 s
Scan time	appr. 0.5 s
Rise time	10 -90 % appr. 0.3 s
Transformer Isolation In- Out	1500 VAC 1 min

Power supply polarity protected	6.5-36 VDC 10-36 VDC
---------------------------------	-------------------------

Linearity	RTD, mV T/C	0.05% ¹ 0.1% ¹
Calibration	Pt100, Pt1000 Ni100, Ni1000 Potentiometer mV, T/C	The larger of 0.1°C 0.2°F or 0.05% ¹ The larger of 0.1Ω or 0.5% ¹ The larger of 20μV or 0.05% ¹
Cold Junction Compensation	T/C	0.5°C, 0.9°F
Temperature Drift		The larger of 0.005 °C/°C, 0.005 °F/°F or 0.005 %/°C, 0.003%/°F
Cold Junction Compensation	T/C	0.02°C/°C, 0.02°F/°F

Lead Wire Resistance Influence:

RTD 3-wire		See Table 1
RTD 4-wire		negligible
Thermocouple		negligible
Load influence		negligible
Power supply influence		negligible
Long term drift, 25°C, 77°F		typ 0.1%/year

Ambient Temperature	-40 to +85°C -40 to +185°C
---------------------	-------------------------------

Emission, EN 50081-2 Industrial Environment	30-230 MHz, 30dB (μV/m) 230-1000MHz, 37dB (μV/m)
Immunity, EN50082-2 Industrial Environment	RF, air, 80-1000MHz, AM RF, air, 900 MHz, pulse modulated (GSM cellular telephone) RF, cables, 0.15-80 MHz, ESD 4kV contact, 8kV contact, 8kV air discharge Fast transients, cables, 2kV
HF immunity tested for 10v/m	up to 1000MHz

Material	PC +ABS, UL V0
Mounting	DIN B-head or larger
Weight	appr. 50g

¹ selected maximum signal

ISOLATED TRANSMITTERS

The JMS 8H, I, and E are available in a Universal Intelligent 2-wire DIN Rail Transmitter. The combination of competitive pricing, functionality and simple configuration has made these DIN rail transmitters the leading transmitter for industrial temperature measurements.

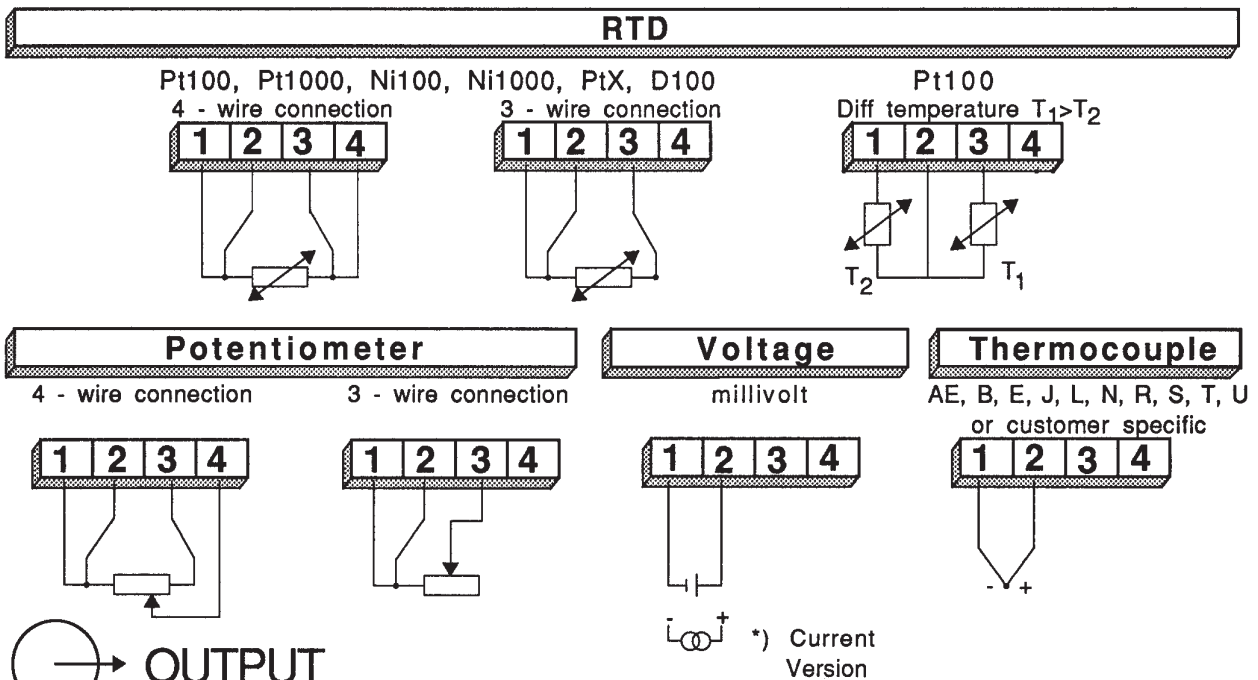
Performance and design:

- Excellent Stability
- Long-term stability 0.1% / year
- Input-Output isolation 1500 VAC
- High load capacity
- Designed for harsh conditions
- Space Saving and simple mounting

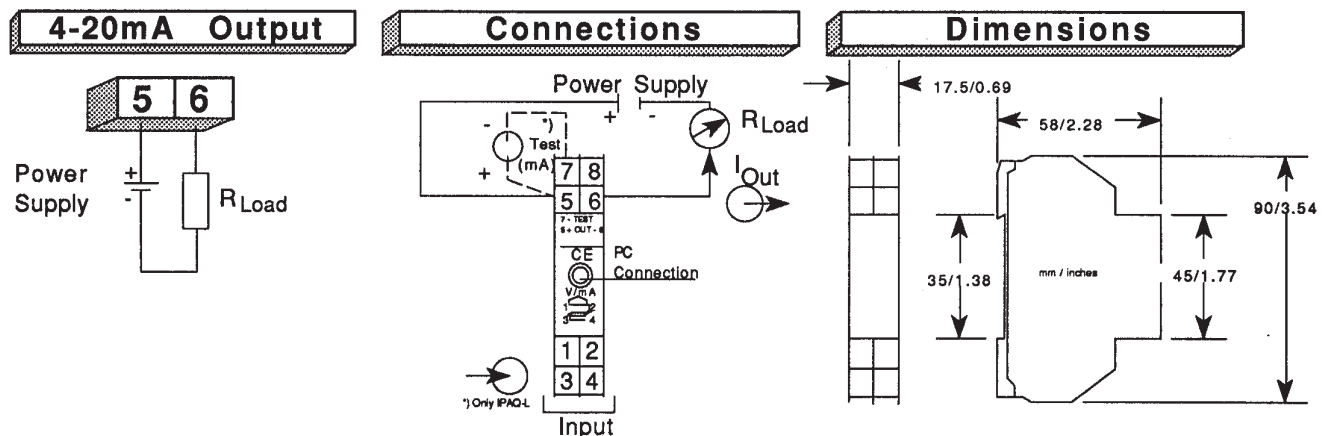
Functions:

- Input for RTD's, T/C's and mV and resistance
- Input for mA
- True on-line communication
- Sensor Diagnostics
- Simplified loop check-up
- On-screen indications and line recording

INPUTS

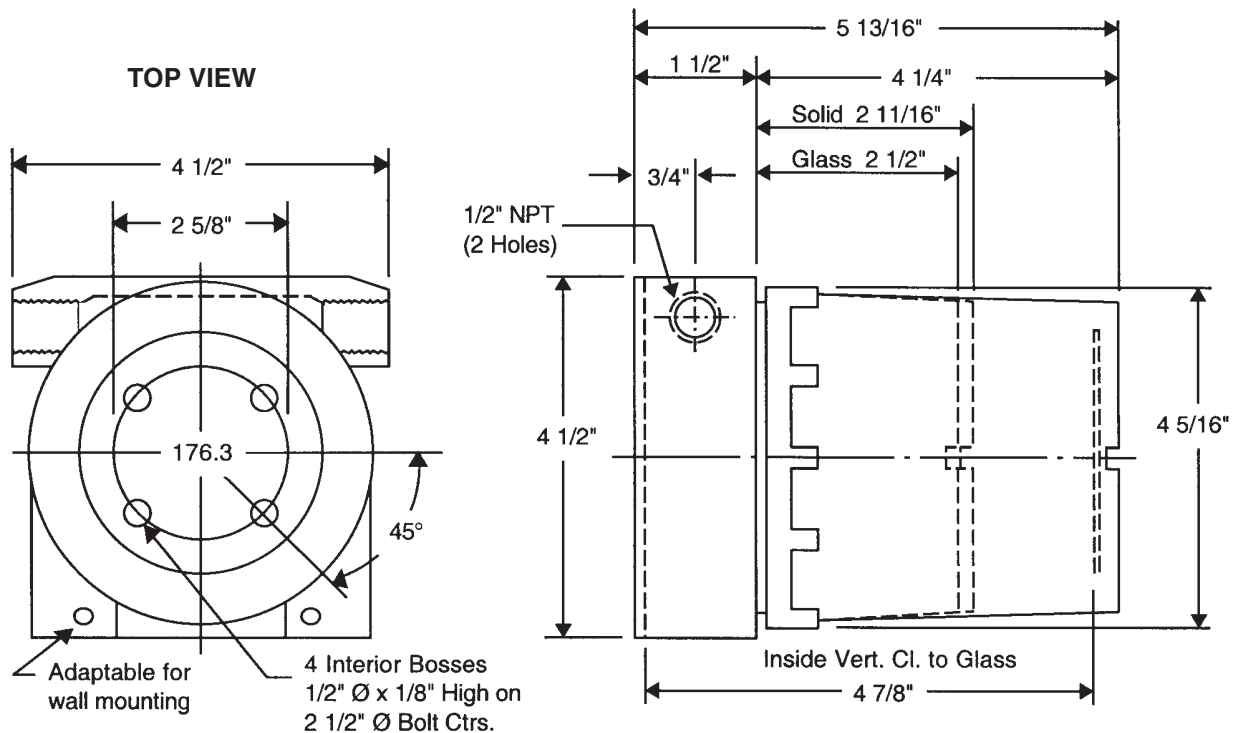


OUTPUT



MODEL 888

- Thermocouple and RTD input.
- RFI sensitive.
- Continuous span and zero field adjustability to 10% of designated span.
- Acceptable for hazardous locations. May be used in Class 1, Groups B, C, D, Class II, Groups E, F, F, and Class III, NEMA 4. See section 8 page 23 and 24 for FM classifications.
- On thermocouple model, cold junction compensation is included.
- Analog or digital temperature indication.
- Isolated or non-isolated transmitter.
- 5 year warranty.



SPECIFICATION

- *Isolation:
1kV optical isolation peak to peak.
- *Calibration Accuracy:
+/- 0.1% of calibrated span of output.
- *Linearity/Repeatability for RTD transmitters:
+/- 0.1%
- *Inputs:
RTD, thermocouple, millivolt signal, DC voltage and milliamp signal.
- Stability:
+/- 0.2% of calibrated span for 6 months.
- Outputs:
4-20 mA DC.
- Span:
Specify span needed.
- Power Supply:
24 VDC +/- 10% regulation.

- Noise Rejection:
Extremely high common mode and normal mode rejection.
- Span and Zero:
Adjustable continuously to 10% or range designated.
- Approximate Output Limits:
3.8 mA DC minimum and 26 mA DC maximum. Upscale burn-out.
- Turn-on time:
2 seconds, no warm up required.

*Indicates "twice as good".

TRANSMITTER SOFTWARE

TempPRO - The user friendly software for TempIR

TempPRO 4.03 is the software with which all user-configurable parameters in TempIR can be reached. TempPRO 4.03 is compatible with windows 3.1 and Windows 95. The software lets you prepare configurations, save them as files and transfer them to any TempIR transmitter. The program is menu-driven and easy to learn. In addition, TempPRO 4.03 configures all products of the Temp family.

Software Features

Engineered Units

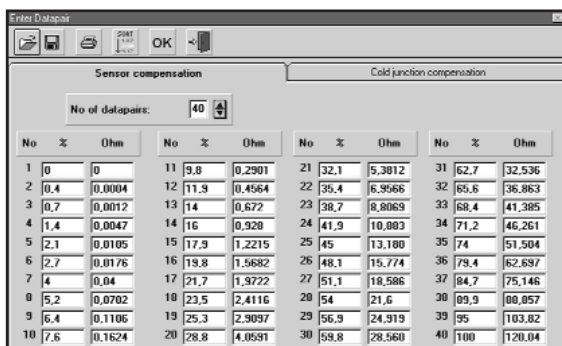
- Ability to use engineering units for directly specifying custom ranges.
- Can be changed instantly by re-arranging the engineering unit.

Customized Linearization

- Utilized in two ways: either by entering datapairs or entering coefficients of a polynomial.

Datapairs

- Up to 40 datapairs can be entered to describe the input signal.
- Up to 7 datapairs can be entered to describe the cold junction compensation of a thermocouple.
- See Fig. 1



No.	°C	Ohm	No.	°C	Ohm	No.	°C	Ohm	No.	°C	Ohm
1	0	0	11	9.8	0.2901	21	32.1	5.3812	31	62.7	32.536
2	0.4	0.0004	12	11.9	0.4564	22	35.4	6.9566	32	65.5	36.863
3	0.7	0.0012	13	14	0.672	23	38.7	8.8069	33	68.4	41.385
4	1.4	0.0047	14	16	0.928	24	41.9	10.893	34	71.2	46.261
5	2.1	0.0105	15	17.9	1.2215	25	45	13.180	35	74	51.504
6	2.7	0.0176	16	19.8	1.5682	26	48.1	15.774	36	78.4	62.897
7	4	0.04	17	21.7	1.9722	27	51.1	18.586	37	84.7	75.146
8	5.2	0.0702	18	23.5	2.4116	28	54	21.6	38	89.9	88.057
9	6.4	0.1106	19	25.3	2.9037	29	56.9	24.919	39	95	103.82
10	7.6	0.1624	20	28.8	4.0591	30	59.8	28.560	40	100	120.04

Documentation

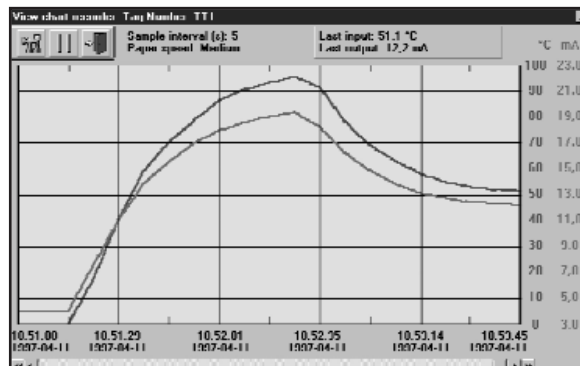
- Configuration protocols can be printed for future use.
- Protocols are time stamped for traceability and furnished with user space for calibration notes.
- Up to 128 characters, for documentation purposes, can be stored in the configuration file.

On Screen Indication

- TempPRO 4.03 will show the measuring values on screen in real time.
- Updating time is user selected.
- Values are displayed in numerals, meters, or bargraphs.
- A lineprinter simulation is a useful feature for startup procedure, etc.
- See Fig. 4

Utilities

- Field calibration permits adjustment of the transmitter in one or two points.
- For this function the sensor / transmitter is subjected to a calibration source (i.e. oven).
- °C, °F are selectable at any time.



Software Requirements

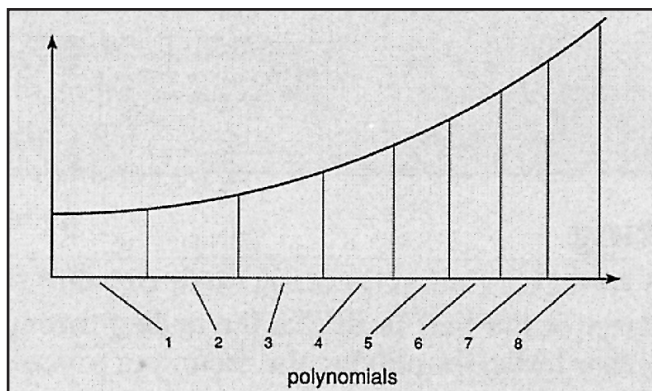
- TempPRO 4.03 is a Windows program.
- Runs on a PC with Win 3.1 or higher or Windows 95.
- Minimum processor requirements are 486, at least 3 MB free hard disk space and a VGA display (640 x 480).

Polynomial

- For polynomial coefficients a sensor can be described by third order polynomials.
- The signal to be linearized can be divided into a maximum of 8 parts where each part is individually described by a separate polynomial of the highest possible accuracy.
- Interesting parts of the signal can be linearized with a higher degree of accuracy.
- The cold junction compensation of a thermocouple can be divided into a maximum of 4 polynomial parts.
- See Fig. 2

File Handling

- Configuration files can be stored for future use.
- TempPRO 4.03 has the ability to save configuration data in ASCII text format.



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The influence of insulation resistance on temperature measurements

Technical Note

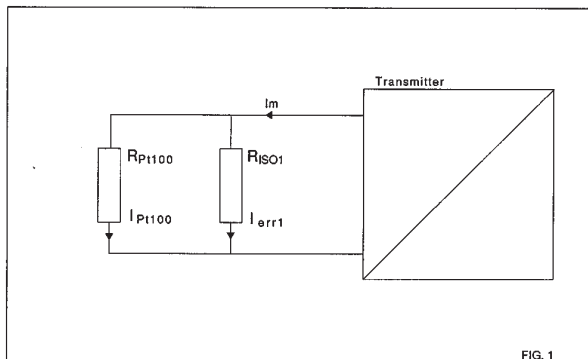
How to get an early warning of low insulation resistance

This Technical Note describes how the insulation resistance influences the measurements on RTD's and thermocouples and how to get an early warning regarding errors due to low insulation.

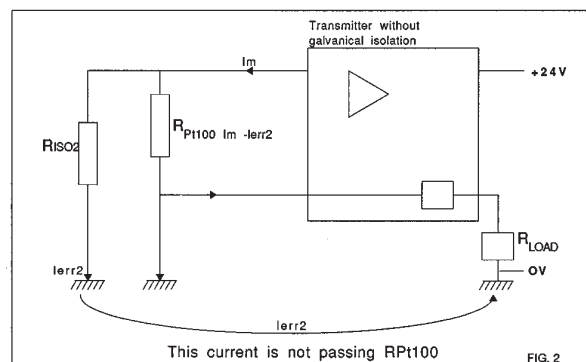
The structure of an RTD and a thermocouple have properties which can lead to erroneous measurements. This is independent of brand and type. One of the most common sources of error is the insulation in the thermometer, which, if too low, can give a serious degradation of the measurement. Insulation can be lowered by moisture, heat, vibration. Physical or chemical influence or radioactive influence. This Technical Note will give an explanation to the necessity of keeping an eye on the insulation resistance.

RTD's

The RTD element is a low-resistance sensor and a too low insulation resistance will influence the measurement. Figure 1 shows the electrical schematic for an RTD and the insulation resistance connected to a temperature transmitter.

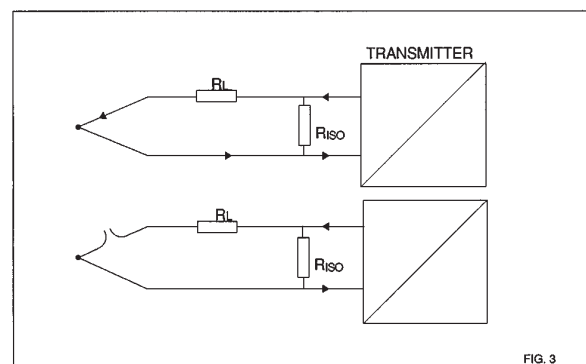


The measuring current goes through the RTD element, but a negligible fraction is normally passing through the high insulation resistance R_{iso1} . When the insulation is lowered, a greater fraction of the current will pass through the insulation. As a result of this, the measured voltage over the combined resistance of RTD and insulation resistance will be lower than if the insulation resistance was sufficiently high. This will give a too low measured temperature value and this is not dependent on whether the transmitter is isolated or not. If the transmitter is without galvanic isolation between input and output, a low insulation resistance between sensor and earth can carry a part of the measuring current. This will also give a too low indicated temperature. With an isolated transmitter this will not happen. Please see Figure 2.



Thermocouples

Low insulation in thermocouple sensors will give other errors. EMF from the thermocouple is not particularly sensitive for low insulation. The problem is rather that a low insulation will give a new measuring point on the location of the low insulation. If this location is near the intended measuring point, the error will be negligible. If the low insulation is in a location where the temperature differs from the measuring point, there is a possibility of a significant error. Low insulation in thermocouples can also give problems with the indication of sensor breakage. Please see Figure 3.



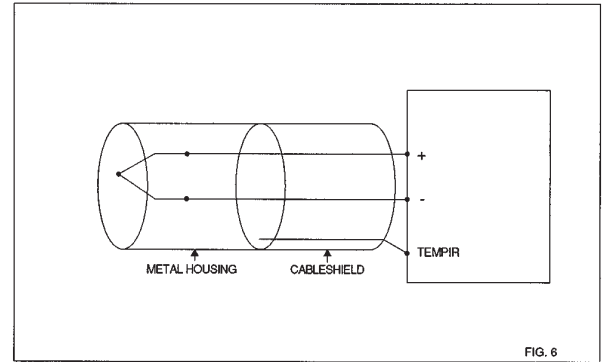
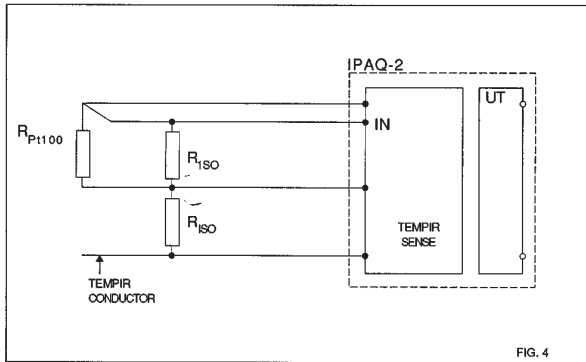
Monitoring the insulation resistance

The TempIRsense transmitter is microcontroller based and does a couple of measurements and controls beyond the standard measurements. One of these controls is to monitor the insulation resistance of the sensor. To accomplish this the sensor must be furnished with an extra conductor. Under certain circumstances there is a possibility of using the cable shield. See below. When the insulation resistance is too low, the TempIRsense will signal this with a twinkling LED (on some models) and the output signal will go to a preprogrammed value.

TECHNICAL INFORMATION - TempIRsense

RTD's

For RTD's the limit in insulation is 500 Kohm. By 400°C the added error is 0.4°C. If the insulation is lowered to 100Kohm there will be an added error of 1.6°C. See Figure 4



One task of the housing is to keep interference outside the measurements. Connecting the housing to the TempIRsense terminal can lead to erroneous measurements. This is also applicable to cable sensors. See Figure 6.

Conclusion

Full control over sensor and connection

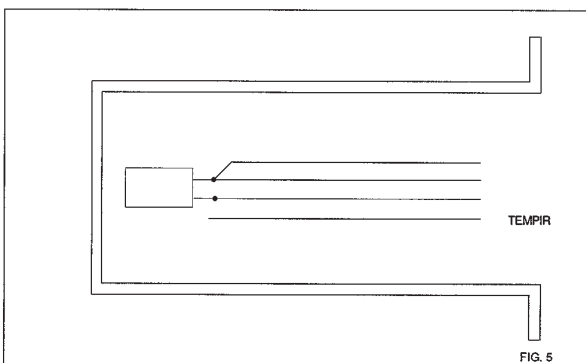
Too low insulation resistance in temperature sensors can give erroneous measurement independent of brand and type. TempIRsense gives the possibility of substituting sensors with low insulation resistance in 3-wire RTD's and thermocouples in time. TempIRsense does not only monitor the sensor but also the conductors from the sensors terminal to the transmitter terminals. This gives full control on the condition of the measuring chain from measuring point to transmitter.

Thermocouples

For thermocouples the limit of low insulation is 50 Kohm. The added error depends on the relation between the lead resistance R and the insulation resistance R_{iso} . The error is also dependent on the temperature difference between the measuring point and the location of the low insulation. Under the following circumstances, measuring temperature 1000°C, ambient temperature 25°C and R equals 50 Ohm there will be an error of 1% if the insulation resistance is 5Kohm. This equals 10°C. It is assumed that the low insulation is in the area with 25°C.

Sensor Solution

TempIRsense is applicable for 3-wire RTD's and thermocouples. For correct usage the sensor must have an extra conductor. This conductor will have a separate terminal and go through the sensor all the way to the sensor element. See Figure 5.



Mineral insulated RTD's and thermocouples use an unconnected conductor. Due to the low insulation resistance in mineral insulated thermocouples at high temperatures, it is not useful to monitor the high temperature end, above 5-600°C depending on application. Instead, it is important to monitor connections and cables from the sensor to the transmitter. It is not recommended to use the housing of the sensor as the monitoring conductor.

Causes of low insulation

- Moisture
- Contamination
- Physical influence (wear, jamming)
- Chemical influence (corrosion)
- Vibration
- Radioactive radiation

Examples of errors

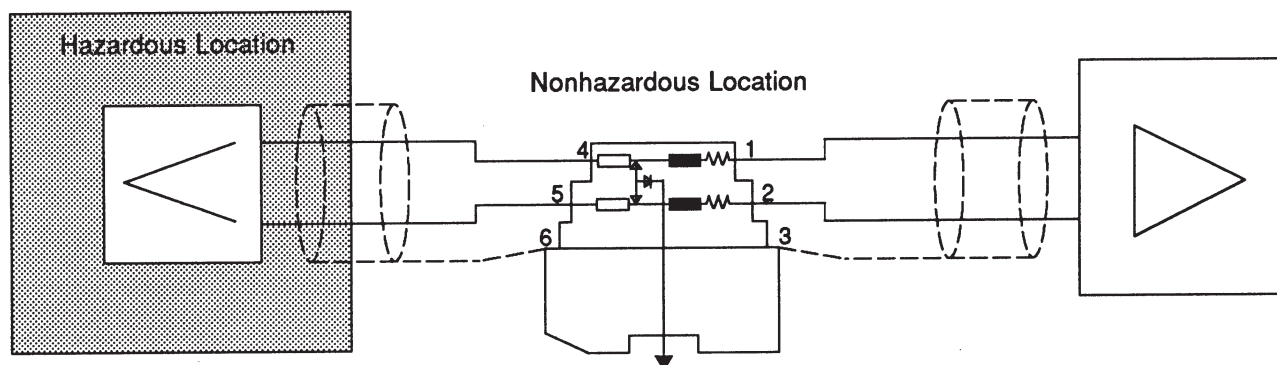
RTD @ 400°C	
Insulation Riso Error	
500K	0.4°C
100K	1.6°C
50K	3.1°C
10K	15°C

Thermocouple type K @1000°C	
Insulation Riso Error	
50K	1°C
20K	2°C
5K	10°C

Ref: See Sensors Magazine, April 1995 Issue.
See Measurements & Control, September 1997 Issue. p. 276.

INTRINSICALLY SAFE TEMPERATURE MEASUREMENT CIRCUITS

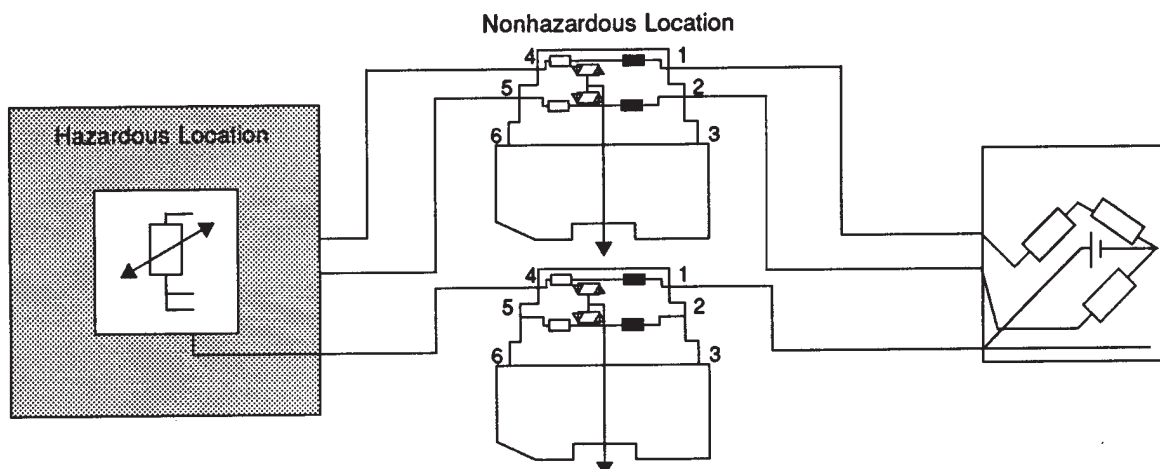
Thermocouple Input for Hazardous Location Groups A - G [using Intrinsic Safety Barriers]



Intrinsic Safety Barrier Selection

Intrinsic Safety Barrier Part Number	Rated Voltage [V]	Maximum Voltage [V max]	Fuse Current [I]	Safety Barrier Resistance [R]	Maximum Leakage Current	Safety Barrier Temperature Coefficient	
MTL 7060ac MTL 7160ac	7.2V 7.2V	8.4V 8.7V	50mA 50mA	101Ω 1101.1Ω	At 7.2V: 10μA 10μA	Max. 1.050	Min. 354 (PPM/°C)

RTD Input for Hazardous Location Groups A - G [using Intrinsic Safety Barriers]



Intrinsic Safety Barrier Selection

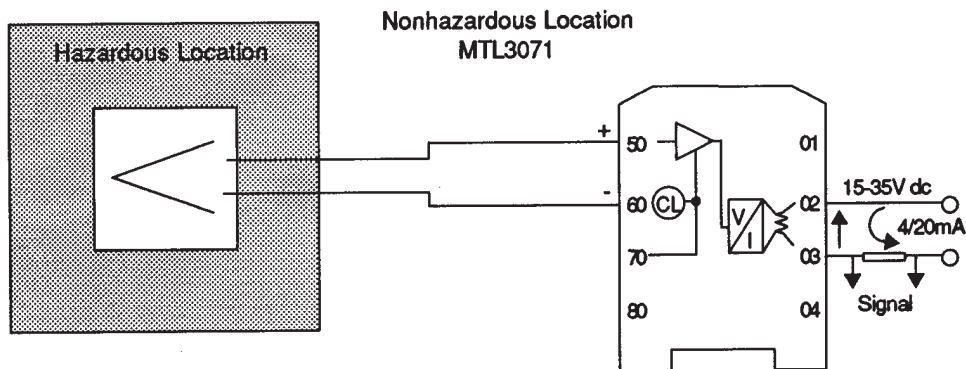
Intrinsic Safety Barrier Part Number	Rated Voltage [V]	Maximum Voltage [V max]	Fuse Current [I]	Safety Barrier Resistance [R]	Maximum Leakage Current	Safety Barrier Temperature Coefficient	
MTL 7055ac	0.6V	3.0V	100mA	24Ω*	At 0.6V: 1μA	Max. 973	Min. 202 (PPM/°C)

*24Ω ±0.15Ω @ 20°C, Channels track within 0.15Ω from -20 to +60°C

JMS recommends and uses MTL Intrinsic Safety and Galvanic Isolation Barriers

ISOLATED INTRINSICALLY SAFE TEMPERATURE

Thermocouple Input for Hazardous Location Groups A - G [using Galvanic Isolation Devices]



Technical Data

Rated Supply Voltage	24V (15 to 35Vdc)
Protection Fuse	50 mA
Power Consumption	0.46 watts max.

Input Data

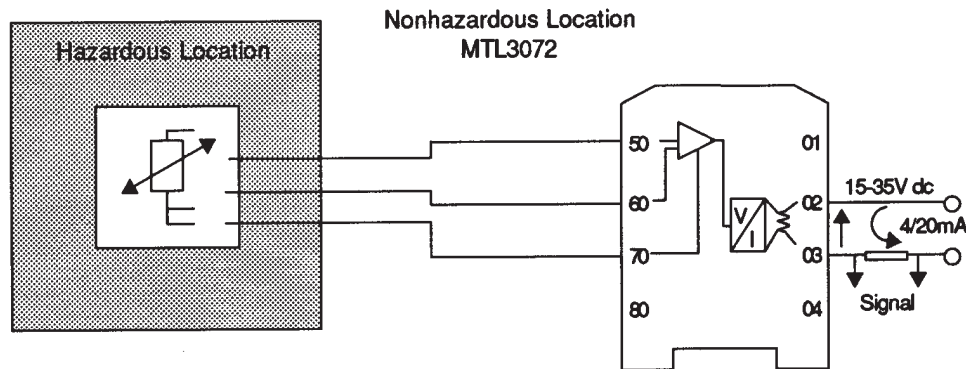
T/C type: J, K, E, T, R, N (or mV)
Span: 4-60mV
Zero: -12 to +60mV

A simple apparatus is a device which will not generate nor store more than 1.2 V, 0.1A, 25mW, or 20 uJ. Some examples include switches, RTDs, thermocouples, and LEDs. Since these devices cannot contribute energy of sufficient magnitude to ignite a hazardous mixture under a fault condition, they may be connected to a certified intrinsically safe circuit, via an associated apparatus, without the evaluation of a third party testing agency.

Load Specification

4-20mA

RTD Input for Hazardous Location Groups A - G [using Galvanic Isolation Devices]



Technical Data

Rated Supply Voltage	24V (15 to 35Vdc)
Protection Fuse	50 mA
Power Consumption	0.46 watts max.
Current Supplied to Field	400µA
Line Resistance:	100Ω max. each line

Input Data

RTD: 2-3 wire 100Ω Platinum
Span: 25 to 800°C
Zero: -200 to +400°C
Potentiometer: 0-300Ω

For all practical reasons no electrical circuit is inherently intrinsically safe. An intrinsically safe system consists of an Associated Apparatus, either a simple or Intrinsically Safe Apparatus, and inter-connecting wiring. When properly installed, the incidence of abnormal spark-causing conditions such as electrical equipment failure, miswiring, overvoltage application to the circuit, or grounding, shorting, or open-circuiting of any lead(s) in the presence of a hazardous mixture, shall not be of sufficient energy to cause ignition.

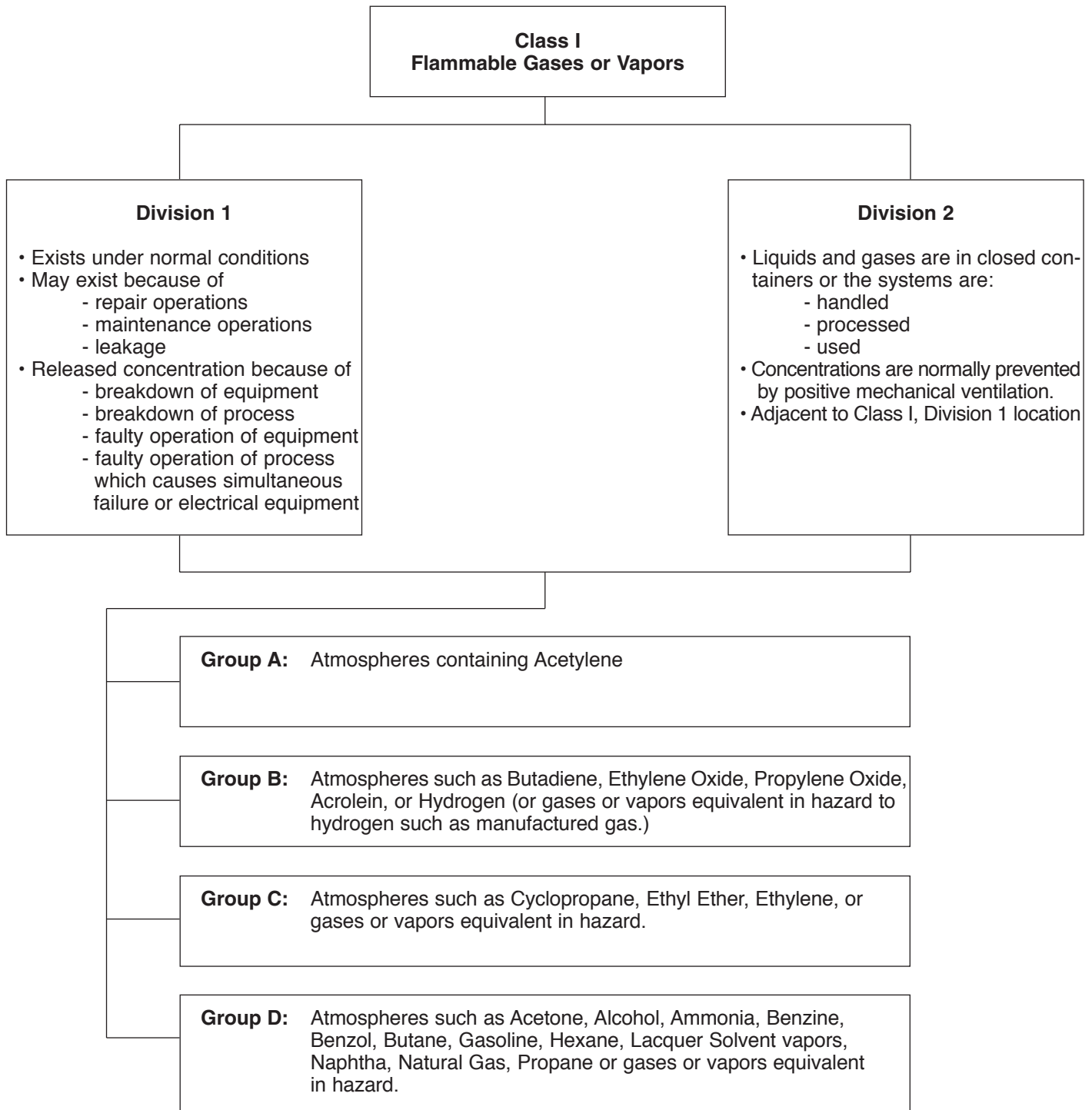
Load Specification

4-20mA

JMS recommends and uses MTL Intrinsic Safety and Galvanic Isolation Barriers

HAZARDOUS LOCATIONS AS CLASSIFIED IN NORTH AMERICA

Hazardous (Classified) Locations In Accordance with Article 500, National Electrical Code - 1990



*See page 6 - 16 for more details

HAZARDOUS LOCATIONS AS CLASSIFIED IN NORTH AMERICA

Class 2 Combustible Dusts

Division 1

- Exists under normal conditions
- Combustible mixture produced by:
 - mechanical failure of equipment or machinery
 - abnormal operation of equipment and provide source of ignition from:
 - simultaneous failure of electrical equipment
 - simultaneous failure of operation of protection devices
 - other caused
- Electrically conductive dusts may be present

Division 2

- Not normally in the air
- Accumulations normally sufficient to interfere with normal operation of electrical equipment or other apparatus
- In the air as a result of infrequent malfunctioning of:
 - handling equipment
 - process equipment
- Accumulations are sufficient to interfere with the safe dissipation of heat from electrical equipment
- Accumulations may be ignited by abnormal conditions or failure of electrical equipment

Group E: Atmospheres containing combustible metal dusts (regardless of resistivity), dusts of similarly hazardous characteristics ($<100 \text{ K}\Omega/\text{cm}$) or electrically conductive dusts

Group F: Atmospheres containing combustible Carbon Black, Charcoal or Coke Dusts which have $> 8\%$ total volatile material or if these dusts are sensitized so that they present an explosion hazard and having a resistivity $> 100 \text{ K}\Omega/\text{cm}$ but $\leq 100 \text{ M}\Omega/\text{cm}$

Group G: Atmospheres containing combustible dusts having a resistivity $> 100 \text{ K}\Omega/\text{cm}$ or electrically nonconductive dusts

Class 3 Ignitable Fibers or Flyings

Division 1

- Fibers or materials producing combustible flyings are manufactured, stored or handled

Division 2

- Fibers are handled except during the process of manufacture or are stored except during the process of manufacture

Not Grouped

- Manufacturers such as textile mills, cotton related mills or clothing plants
- Fibers and flyings include Rayon, Cotton, Sisal, Hemp, Jute and Spanish Moss

*See page 6 - 16
for more details

PLUG-IN SIGNAL CONDITIONERS



FEATURES:

- Isolate, Amplify and Convert Measurement Signals
- Quick-Check LED Output Indication (Most Models)
- 5 Amp, 230VAC Relay Contacts
- Plug-In: Replace without Rewiring
- Industry-Standard Printouts
- DIN/Surface/Track Mount Sockets Available
- AC and DC Powered Models Available
- Seven Year, Full Replacement Warranty



These Transmitters and Alarms amplify, translate, isolate, and alarm on most standard transducer signals as well as DC, AC and frequency inputs. Used in a variety of industrial and process applications, they provide low-cost answers to many measurement, monitoring and control needs.

The broad product range covers most standard transducers as well as some not-so-standard, such as thermistors and IC temperature sensors. All transmitters are available with optional input/output isolation, providing 1,000 Vrms isolation and better than 0.05% linearity. Red/green LEDs indicate alarm status and, on most transmitter models, provide a quick check of the output level.

Proven designs using low-drift ICs and circuitry provide accurate, stable operation. Quality and reliability are enhanced by 100% burn-in and are backed by a seven-year, full replacement.

Available options include AC or DC power, reverse-acting outputs, and urethane coating.

SINGLE ALARM

SPECIFICATIONS:

Transmitter Voltage:
Outputs: 0/1v min, -10/+15v max
Current:
0/1mA min, 0/25mA max
Accuracy: $\pm 0.1\%$ of span or better
(AC inputs $\pm 0.5\%$ of span)
Temp. Stability: $\pm 0.02\%/^{\circ}\text{C}$ or better,
-10 to $+60^{\circ}\text{C}$
Isolation: Input/Output (optional)
-1,000Vac rms
Power -1,500Vac rms

Relay Contacts: Single Alarm, DPDT (2 form C)
Dual Alarm, one SPDT (1 form C)
per trip point
5A max resistive @ 115/230Vac or
30Vdc, 1/8HP max AC inductive
Set Point Adjustment: 0% to 100% of range, with 0.1%
resolution
Deadband Adjustment: 0.25% to 100% of range
Power: AC: 115 or 230Vac, 2.5VA
DC: 12 or 24Vdc, 2.5W

STANDARD TRANSMITTERS AND ALARMS:

INPUTS	TRANSMITTERS		ALARMS	
	Nonisolated	I/O Isolated	Single Trip	Dual Trip
DC (mV, V, mA, A)	JH4010	JH4300	JH1000	JH1020
DC (mV, low drift)	JH4050	JH4310	(Option S)	(Option S)
AC (mV, V, mA, A)	(special)	JH6010I, 6020I	JH1600	JH1620
Thermocouple	JH4100	JH4130	JH1200	JH1220
RTD	JH4001	JH4001I	JH1400	JH1420
Thermistor	JH4005, 4006	JH4005I, 4006I	JH1300, 1300L	JH1320, 1320L
IC Sensor	JH4007	JH4007I	JH1350	JH1370
Potentiometer	JH4003	JH4003I	JH1800	JH1820
Strain Gauge	JH4051	JH4051I	JH1500	JH1520
Frequency	JH7010	JH7010I	JH1700	JH1720



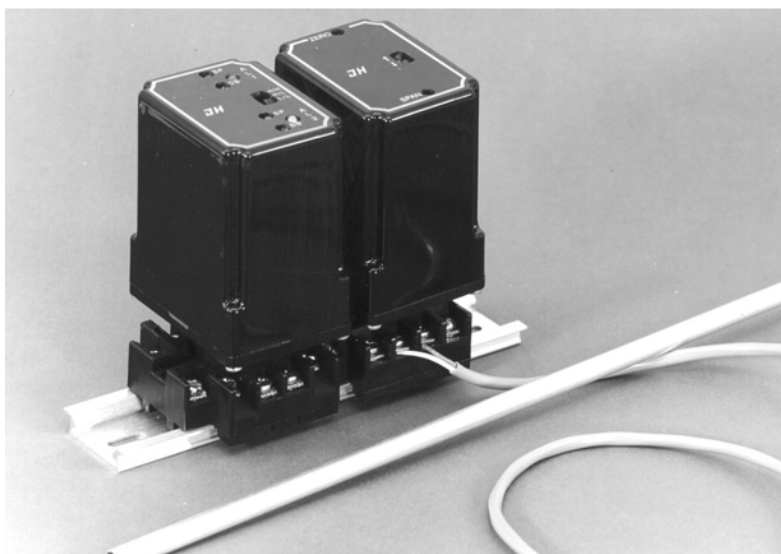
TRANSMITTER

PLUG-IN SIGNAL CONDITIONERS

ADDITIONAL PRODUCTS:

- Switch-Selectable Inputs
- Loop Power for 2 Wire Transmitter
- Add, Subtract
- Multiply, Divide
- Square, Square Root
- Power Supply

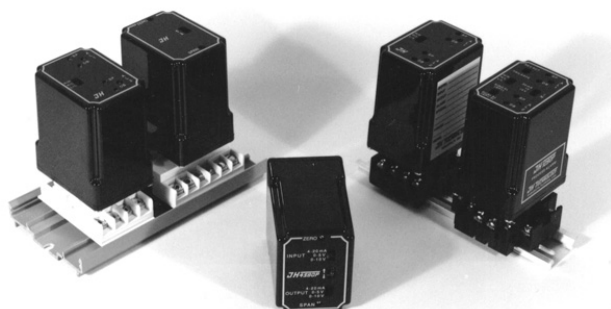
Special-function modules complement the product line, providing the “glue” often needed to complete your system requirements. Process Input Transmitters and Alarms provide top-access switches, allowing the user to select 0-5V, 0-10V or 4-20mA inputs and outputs. Alarms may be set for HI/LO or LO/LO trip, or switch to act as single-trip alarms. Loop-Input modules include 24V regulated excitation to power 4-20mA two-wire input sources.



GROUP with PROBE

Flow computations, averaging, ration measurement and other functions are made possible using the Math Function modules.

FUNCTIONS	TRANSMITTERS		ALARMS	
	Nonisolated	I/O Isolated	Single Trip	Dual Trip
DC Process Inputs (Switchable Selectable)		JH4380P		JH1090P
Loop Input (4-20mA with 24V excitation)	JH4015	JH4305	JH1005	JH1025
4-20mA Isolator (Low Cost)		JH4300C		
Add, Subtract	JH4400 Series	JH4400I Series	JH1100 (A,S)	JH1120 (A,S)
Multiply, Divide	JH4410, 4420	JH44410I, 4420I	JH1100 (M,D)	JH1120 (M,D)
Square, Sq. Root	JH4430, 4440	JH4430I, 4440I	(special)	(special)



GROUP

“ASK ABOUT SPECIALS”

Your needs often can be met by simple internal changes, with little impact on either price or delivery. If you don’t see what you need, please give us a call. We’ll work with you to find a solution.