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A GUIDE TO

Temperature Measurement

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Temperature affects almost every process imaginable, yet it's difficult to measure accurately and reliably. Until now.

Given the variables surrounding temperature measurement, it is little surprise that accuracy and reliability have been a persistant problem.

As world leader, Cropico understand what it takes to reliably gain the most accurate and precise measurements possible.

Calibration laboratories and industries worldwide rely on our expertise and equipment. Great praise indeed.

This handbook offers an overview on the subject of 'Best temperature measurement practice,' explaining common causes of errors and how best to avoid them.

Also included are useful tables of wire and cable characteristics, temperature coefficients and various formula to ensure you make the best choice when selecting measurement equipment and measurement techniques.

We hope you find the booklet a valuable addition to your toolkit.

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TEMPERATURE

Temperature can be defined as the amount of hotness or coldness of a body or environment. It can however, be more accurately described as molecular motion and energy flow, and can be measured in a number of ways i.e. the expansion of a liquid as seen in liquid in glass thermometers, or the change in resistance of a material such as copper or platinum.

Heat

Heat is internal energy that flows from a system at a higher temperature to a system at a lower temperature. Two bodies at the same temperature are said to be in thermal equilibrium. If a body at a higher temperature comes into contact with a body at lower temperature, heat will flow from the higher temperature to the lower one. If an ice cube is placed in a warm drink the heat from the drink will flow into the ice cube and melt it. The ice cube does not transfer its coldness to the drink, but of course the overall effect is for the drink to become slightly cooler.

TEMPERATURE SCALES

There are three temperature scales in common use today. They are Fahrenheit, Celsius, and Kelvin.

Fahrenheit

Daniel Gabriel Fahrenheit (1686-1736) was the German physicist who invented the alcohol thermometer in 1709 and the mercury thermometer in 1714. In 1724, he introduced the temperature scale that bears his name - Fahrenheit Scale. Fahrenheit temperature scale is a scale based on 32 for the freezing point of water and 212 for the boiling point of water. The interval between the two being divided into 180 parts.

Celsius

The Celsius temperature scale is also referred to as the "centigrade" scale. Centigrade means "consisting of or divided into 100 degrees". The Celsius scale, invented by Swedish Astronomer Anders Celsius (1701-1744), has 100 degrees between the freezing point (0 °C) and boiling point (100 °C) of pure water at sea level air pressure. The term "Celsius" was adopted in 1948 by an international conference on weights and measures.

Celsius devised the centigrade scale or "Celsius scale" of temperature in 1742.

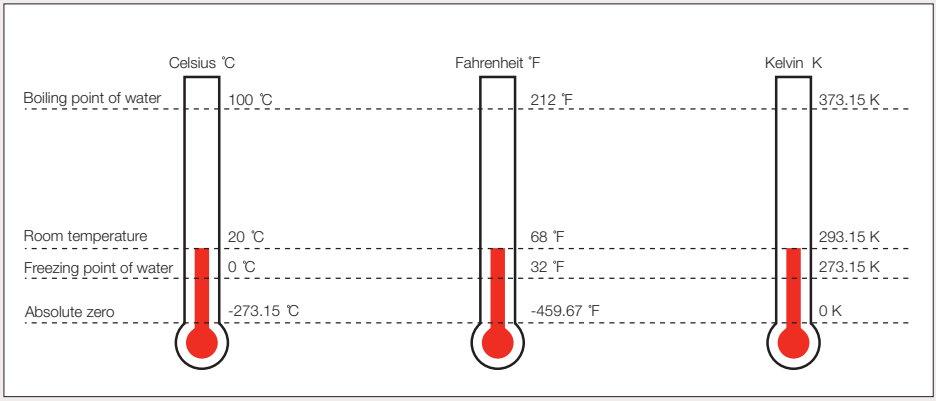
Until the 1970s the Fahrenheit temperature scale was in general common use in English-speaking countries; the Celsius, or centigrade, scale was employed in most other countries and for scientific purposes worldwide. Since that time, however, most English-speaking countries have officially adopted the Celsius scale

Kelvin

Kelvin temperature scale is the base unit of thermodynamic temperature measurement in the International System (SI) of measurement. It is defined as 1/ 273.16 of the triple point (equilibrium among the solid, liquid, and gaseous

phases) of pure water. The kelvin (symbol K without the degree sign) is also the fundamental unit of the Kelvin scale, an absolute temperature scale named after the British physicist William Thomson, Baron Kelvin. Such a scale has as its zero point, absolute zero, the theoretical temperature at which the molecules of a substance have the lowest energy. Many physical laws and formulas can be expressed more simply when an absolute temperature scale is used; accordingly, the Kelvin scale has been adopted as the international standard for scientific temperature measurement. The Kelvin scale is related to the Celsius scale. The difference between the freezing and boiling points of water is 100 degrees in each, so that the Kelvin has the same magnitude as the degree Celsius.

Known Temperature				Required Temperature	Formulae
Celsius	°C	to	°F	Fahrenheit	°F = (1.8 X °C) + 32
Celsius	°C	to	K	Felvin	K = °C + 273.15
Fahrenheit	°F	to	°C	Celsius	°C = (°F - 32)/1.8
Fahrenheit	°F	to	K	Kelvin	K = °F + 459.67)/1.8
Kelvin	°K	to	°C	Celsius	°C = K-273.15
Kelvin	°K	to	°F	Fahrenheit	°F = (1.8 X K) - 459.67



THE INTERNATIONAL PRACTICAL TEMPERATURE SCALE

In 1990 the international practical temperature scale was revised with a very small shift in the definition of the scale reference point from the freezing point of water, as used in the previous 1968 scale, to the triple point of water. The triple point of water is the single combination of pressure and temperature at which pure water, pure ice, and pure water vapour can coexist in a stable equilibrium. This occurs at exactly 273.1598 K (0.0098 °C) and a pressure of 611.73 Pascals (ca. 6.1173 millibars, 0.0060373057 atm) a difference of 0.01°C in the 1990 scale ITS90.

With the introduction of the ITS90 scales the previously called “Degrees Kelvin” became Kelvin. The ITS90 scale has been adopted internationally and supersedes the previous International Practical Temperature Scale of 1968.

TEMPERATURE MEASUREMENT

Whilst temperature is one of the most common parameters measured it is also one of the most difficult to measure with any degree of accuracy. As explained above heat will always flow from the hot source to the less hot and try to find equilibrium. By inserting a probe to measure the temperature of a body you are immediately changing the body’s temperature. The amount of change in temperature caused by the temperature sensor will depend upon several factors;

- The relative masses of the probe and the source
- The difference in temperature between the probe and the source
- The amount of time allowed for the probe to assume the same temperature as the source.

Not only is it difficult to measure temperature without the sensor intruding and changing the temperature, temperature is not a stable, static quantity. It is continually changing and trying to establish its thermal equilibrium. Consider, for example, trying to measure the air temperature in a room. There will be temperature differences and gradients across the room. The temperature near the door will be different to the temperature by the window, and it is important to understand this in the context of your measurements. It can become more important when measuring critical processes, for example a heat treatment oven in which metal components are tempered and hardened by the oven temperatures. The oven needs to be controlled to an even temperature over its whole interior. If there were cooler areas in the corners of the ovens, then some of the components treated may not have received the correct temperatures and be weakened as a result. For components that may be used in, for example, the manufacture of aircraft, this could be disastrous.

To achieve the best measurement results, the type and construction of the measurement sensor needs to be carefully selected. The mass

should be kept to a minimum, the insertion depth of the probe should be sufficient so that any stem conduction does not interfere with the accurate measurement and the sensor should be left attached to the source for sufficient time to allow a state of thermal equilibrium between the source and the probe. Where large areas or components are to be measured it is often necessary to use several probes distributed around the area to be measured.

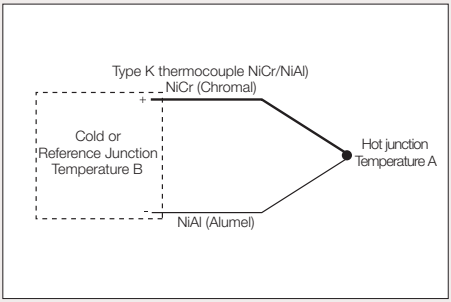
There are several sensor types available and the following sections (Thermocouples, Platinum Resistance temperature detectors (PRTD) and Thermistors (RTD)) will describe the main ones used for accurate temperature measurements.

Typical characteristics of the most common probe types

	Thermocouples	PRTD (Pt100)	Thermistor
Operating range	-200°C to +2000°C	-250°C to +850°C	-200 C to +2000°C
Accuracy (Typical)	Low 1°C	Very High 0.03°C	High 0.1°C
Linearity	Medium	High	Low
Thermal Response	Fast	Slow	Medium
Cost	Low	High	Medium
Long Term Stability	Low	High	Medium
Noise Problems	High	Medium	Low

THERMOCOUPLES

In 1822 an Estonian physician named Thomas Seebeck discovered that the junction between two metals generates a voltage that is a function of temperature. All thermocouples rely on this so-called Seebeck effect. Although in theory any two dissimilar metals when joined together will generate an emf, in practice when making thermocouples a small number of standard material types are used. Probably the most popular thermocouple is the type K (NiCr/NiAl). When the hot junction is heated a small voltage is generated in proportion to the difference in temperature between the heated junction and the cold or reference junction. This cold junction is usually the point at which the wires are connected to the voltmeter or measuring device.



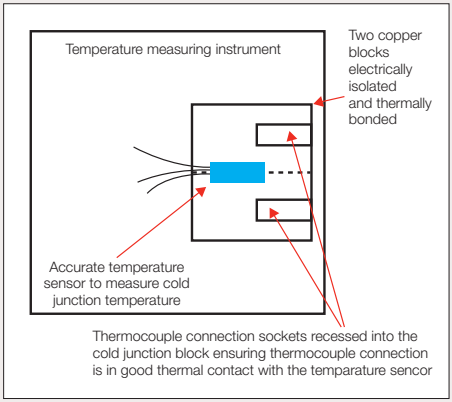
Because the voltage generated is proportional to the difference between the Hot and the Cold junctions, this does not represent the absolute temperature. To measure the absolute temperature we must also know the temperature of the Cold or Reference junction and add this to the difference temperature.

Absolute temperature = Temperature A + Temperature B

For an accurate absolute temperature measurement it is very important that the measuring indicator not only accurately measures the emf generated by the thermocouple but also accurately measures the cold junction temperature which is where the thermocouple is connected to the indicator. Most temperature indicators measure the thermocouple emf reasonably well, but are less able to measure the cold junction temperature with any degree of certainty.

Thermocouple Cold Junction (Reference Junction)

The importance of the cold junction or reference junction compensation when accurately measuring temperature cannot be stressed too highly, and will significantly affect the overall accuracy of absolute temperature measurement. Cropico thermometers are designed with the highest possible Cold junction measurement accuracy, ensuring that the absolute temperature is displayed with the highest degree of accuracy. For the best accuracy, the Cold junction reference point should be inside the instrument away from draughts and external temperature variations. The Reference point should also have a relatively high thermal mass, so any temperature changes are slowly and evenly spread across the Reference junction.



Incorporating a well constructed and accurate cold junction is of course costly and a lot of instrument manufacturers cut corners, and in doing so, increase the errors in the absolute temperature measurement displayed. Costs are cut in the following ways:

- Low cost terminals are used (sometimes not copper) instead of the recessed sockets in the copper block. If non-copper or nickel plated copper terminals are used, then additional thermocouple junctions are formed, which will generate emf. Connecting the thermocouple to terminals which are external to the instrument introduces errors due to non uniform temperatures being maintained. Draughts

blowing across the terminals will produce temperature gradients. This effect can be minimised if the terminals are mounted on heat sinks with a large thermal mass.

- The sensor monitoring the cold junction temperature is of low cost and poor accuracy. Cropico use 4 wire platinum resistance sensors (Pt100) to ensure the best uncertainty of measurement.
- The cold junction sensor being poorly positioned. If external terminals are used then the sensor can only be placed nearby the terminals with no thermal bonding.

WARNING

When selecting your thermocouple measuring instrument, be sure to take into account the cold junction accuracy as well as the measuring accuracy. These are almost always stated separately and some manufacturers don't give a cold junction accuracy statement at all.

Thermocouple Measuring Instruments

When choosing an instrument the accuracy statements should be read carefully and their implications understood. Thermocouples can have wide temperature ranges which make them very attractive for many applications, however, they are very non linear over the temperature range. For example: type K thermocouples can be used over the range -260°C to + 1370°C but the output varies from approximately 14µV/°C at -200°C to approximately 40µ/°C over the range 0...13700°C for the exact outputs, thermocouples tables need to be used see page 15 to 22. Measuring instruments have to be able to cope with this variation in voltage measurement, as well as being able to measure over the range -3.554mV (-100°C) to +41.865mV (+1000°C) with a degree of accuracy. The emf at 0°C is 0.0mV, so the measuring instrument has to be able to measure in the microvolt region accurately. The instrument stated temperature measuring uncertainty has to either be a catch-all statement (example: ±1°C) giving the poorest uncertainty of measurement achieved over the entire range, or the uncertainty measurement split into bands.
(Example: -200...-100°C ±1.0°C: -100...0°C ±0.8°C: 0...200°C ±0.2°C etc.) which gives a much better understanding of the achievable measurement uncertainty. Some manufacturers will state the measurement uncertainty in µV rather than temperature, and whilst this is the truest method of stating the uncertainty it makes it almost impossible to assess the thermometer's measurement performance without consulting the temperature tables and lengthy calculations.

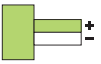
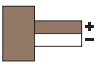
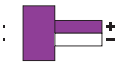
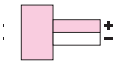
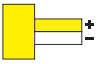
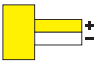
Note: no mention has been made yet of the cold junction accuracy, and some thermometer specifications will not include it at all. Many specifications will include it in very small print, i.e. not obviously part of the main performance specification. The cold junction accuracy statement should give the uncertainty of its measurement at 20°C plus the additional errors for each degree away from 20°C and will look something like this: ±0.5°C at 20°C ±0.1°C per °C deviation. This means that at an ambient temperature of 20°C, the error

which must be added to the measurement uncertainty is ±0.5°C. If the ambient rises to 25°C then the error that must be added is ±[0.5°C + (5 x 0.1°C)] = 0.5 + 0.5 = ±1.0°C. So you can see for a measurement of 200°C the measurement uncertainty can increase five times if made at an ambient temperature of 25°C instead of 20 °C.

One final uncertainty that has to be added is the uncertainty of the thermocouples themselves, and the chart below gives the different types with their characteristics.

Thermocouples are good general purpose sensors, cheap to buy, capable of measuring over a very wide temperature range and can be small in size. There are a number of different thermocouple types available and the following table will assist in choosing the most appropriate type for your application.

Commonly Used Thermocouple Wire

ANSI Code	Alloy Combination		International IEC 584-3 Colour Coding	Temperature Range	Emf over temperature range	Linits of error* standard grade
	+ Lead	- Lead	Thermocouple			
J	Iron (magnetic) Fe	Constantan Copper Nickel Cu-Ni		0 to 750°C	-8.095mV to +69.553mV	2.2°C or 0.75%
K	Nickel-Chromium Ni-Cr	Nickel-Aluminium Ni-Al (magnetic)		-200 to +1250°C	-6.458mV to +54.886mV	2.2°C or 0.75% above 0°C 2.2°C or 2.0% below 0°C
T	Copper cu	Constantan Copper-Nickel Cu-Ni		-200 to +350°C	-6.528mV to +20.872mV	2.2°C or 0.75% above 0°C 1.0°C or 1.5% below 0°C
E	Chromel Nickel-Chromium Ni-Cr	Constantan Copper-Nickel Cu-Ni		-200 to +900°C	-9.835mV to 76.373mV	1.7°C or 0.5% above 0°C 1.7°C or 1.0% below 0°C
N	Nicrosil Ni-Cr-Si	Nisil Ni-Si-Mg		-270 to +1300°C	-4.345mV to 47.513mV	2.2°C or 0.75% above 0°C 2.2°C or 1.0% below 0°C
R	Platinum 13% Rhodium	Platinum Pt		0 to 1450°C	-0.226 to 21.101	1.5°C or 0.25%
S	Platinum 10% Rhodium Pt10%Rh	Platinum Pt		0 to 1450°C	-0.236 to 18.693	1.5°C or 0.25%
B	Platinum 30% Rhodium Pt30%Rh/Pt 6%Rh	Platinum 6% Rhodium Pt%5Rh	N/A	0 to 1700°C	0 to 13.820	0.5°C over 800°C

Type K - Chromel-Alumel.
The best known and dominant thermocouple belonging to the chromium-nickel aluminium group is type K. It is low cost and available in a wide variety of probe shapes and sizes. Its temperature range is extended (-200°C up to 1200°C range) depending on probe construction. Its emf /temperature curve is reasonably linear and its sensitivity is approximately 41 microvolt/ °C.

Type E - Chromel-Constantan
Due to its high sensitivity (68 microvolt/°C), Chromel-Constantan is mainly used in the cryogenic (low temperature) range (-200°C up to +900°C). The fact that it is non magnetic could be a further advantage in some special applications.

Type N - Nicros-Nisil
This thermocouple has very good thermoelectric stability, superior to other base metal thermocouples, and has excellent resistance to high temperature oxidation. The Nicrosil-Nisil thermocouple is ideally suited for accurate measurements in air up to 1200°C. In vacuum or controlled atmosphere, it can withstand temperatures in excess of 1200°C. Its sensitivity of 39 microvolts/°C at 900°C is slightly lower than type K (41 microvolts/°C). Interchangeability tolerances are the same as for type K. The type N thermocouple was designed to be an improved type K and is gaining in popularity.

Type J (Iron / Constantan)
Limited range (-40 to +750 °C) makes type J less popular than type K. The main application is with old equipment that cannot accept 'modern' thermocouples. J types should not be used above 760°C as an abrupt magnetic transformation will cause permanent decalibration. The sensitivity rises to 55microvlts/°C.

Type T - Copper-Constantan
This thermocouple is used less frequently. Its temperature range is limited to -200°C up to +350°C. It is, however, very useful in food, environmental and refrigeration applications. Tolerance class is superior to other base metal types and close tolerance versions are readily obtainable. The emf/temperature curve is quite nonlinear, especially around 0°C, and sensitivity is 42 microvolts/°C.
Thermocouple types B, R and S are all 'noble' metal thermocouples and exhibit similar characteristics. They are the most stable of all thermocouples, but due to their low sensitivity (approx 10 µV/°C), they are usually only used for high temperature measurement (>300 °C).

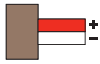
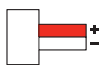
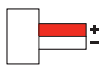
B - Platinum 30% Rhodium - Platinum 6% Rhodium
Type B allows measurements up to 1800°C. It is a very stable thermocouple but less sensitive in the lower range. Output is negligible at room temperature giving the same output at 0°C and 40°C thus making them unusable at low temperature. The revised temperature table for type B only states the accuracy for temperatures above 800°C. Historically these thermocouples

have been the basis of high temperature sensing in spite of their high cost and their low thermoelectric power. Until the launch of the Nicrosil-Nisil thermocouples, type N, they remained the sole option for good thermoelectric stability.

Type S - Platinum 10% Rhodium – Platinum
Suitable for high temperature measurements up to 1600°C, the low sensitivity (approx 10microvolts/°C) and high cost makes them unsuitable for general purpose use. They are normally used in oxidising atmosphere up to 1600°C. Their sensitivity is between 6 and 12 microvolts/°C.

Type R – Platinum 13% Rhodium – Platinum
Similar version to type S, suited for high temperature measurements up to 1600°C, but again with low sensitivity approx 10microvolts/°C making them unsuitable for general purpose use.

International Thermocouple Colour Codes

ANSI Code	Int. IEC 584-3 Colour Coding	British to BS 1843	German to DIN 43710	US Canadian ASTM E-230	Japanese to JIS C1610-1981	French to NFC 42-324
J						
K						
T						
E						
N			No Standard		No Standard	No Standard
R				No Standard		
S				No Standard		

Thermocouple Extension Cable

Thermocouples may be used to monitor the temperature of processes where it is necessary to have the temperature controllers or monitors a relatively long distance from the process. Thermocouples will operate over this long distance without additional errors, even if the temperature along the thermocouple cable run is not constant over its length, or is varying. Thermocouple extension wire has the same characteristics as thermocouple wire, but will usually have a lower temperature range than the thermocouple; this is due to its insulation material. The extension cable is designated with the letter X i.e. extension cable for type J thermocouple would be designated JX.

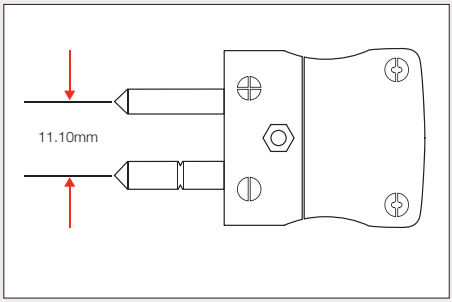
Thermocouple Compensating Cable

Thermocouple compensating cable has very similar characteristics to thermocouple cable over a relatively small temperature range based around the ambient temperatures. It is constructed of a different alloy to the thermocouple and designated with a C i.e. Compensating cable for type K thermocouple is designated KC.

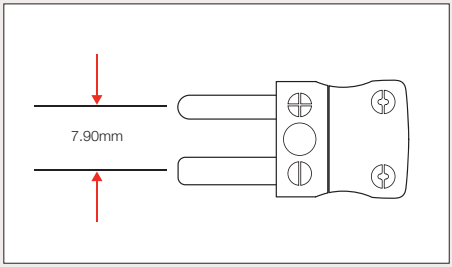
Choosing a Thermocouple

Thermocouples are available either as bare wire 'bead' thermocouples which offer low cost and fast response times, or built into probes. A wide variety of probes are available, suitable for different measuring applications (industrial, scientific, food temperature, medical research etc). One word of warning: when selecting probes take care to ensure they have the correct type of connector. The two common types of connector are 'standard' with round pins and 'miniature' with flat pins; this causes some confusion as 'miniature' connectors are more popular than 'standard' types. When choosing a thermocouple, consideration should be given to the thermocouple type, insulation and probe construction. All of these will have an effect on the measurable temperature range, accuracy and reliability of the readings, listed.

Commonly Used Thermocouple Plugs



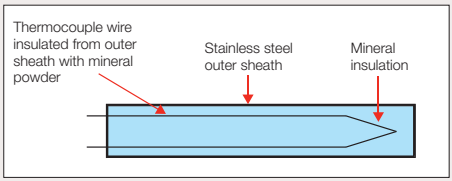
Standard thermocouple plug

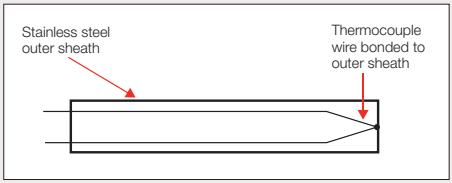


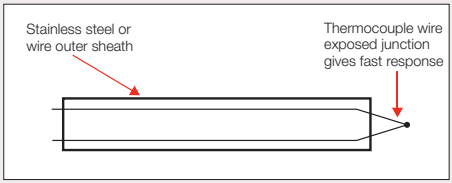
Miniature thermocouple plug

Common Thermocouple Construction

Thermocouples are usually constructed from thin wire which gives them a small thermal mass and correspondingly a quick reaction to temperature changes. They are constructed in many different configurations and shapes to suit the application but generally three basic construction types are used. The outer sheath can be stainless steel or Inconel which will withstand high temperatures and corrosive environments. Mineral insulation is often used to ensure high insulation resistance to the outer sheath. The exposed junction construction gives a fast response, but is more susceptible to physical damage or contamination by the process being measured.







Calibration of Thermocouples

Thermocouples and thermocouple wires are manufactured to give standards that specify the emf generated at specific temperatures. Thermocouple made from the same batch of wire will match each other much closer than the specified standard, but they may be on the edge of the standard's specification. To achieve greater degrees of measurement accuracy, it is beneficial to calibrate the thermocouples by measuring their emf at different temperature points. These temperatures would normally be selected as the critical temperatures of the process they were to monitor. Some measuring instruments have the ability to accept these calibration points and use them to achieve greater measurement accuracy.

Thermocouple calibration can also be compromised due to molecular contamination of the junction formed by the two wires; this can be due to temperature extremes annealing the wire or by cold working the wire, which can be caused by excessive handling, pulling through conduits or excessive vibration etc. This condition is potentially quite serious as the thermocouple appears to be operating correctly but is, in effect, giving measurement errors which can be quite high. Regular checking of the thermocouples and the measuring instrumentation is recommended.

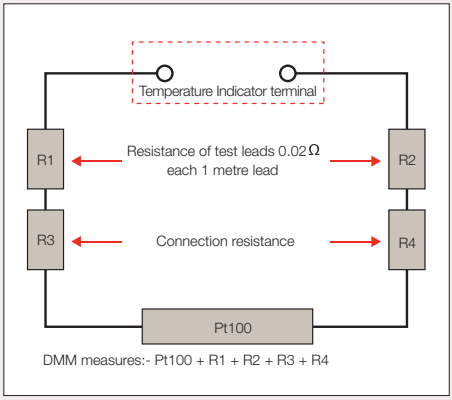
PLATINUM RESISTANCE THERMOMETERS

This type of measuring sensor is much more accurate than thermocouples but they have a more limited temperature range, a higher thermal mass and are more expensive. These resistance thermometers have a linear and repeatable resistance against temperature. The two common types in use are Pt100 which has a resistance of 100Ω at 0°C and Pt25 which has a resistance of 25Ω at 0°C.
Platinum is used because it has a very stable temperature coefficient and, being a noble metal, is not very susceptible to contamination.

Pt100 (IPRT) is the most commonly used and has a temperature coefficient of ? = 0.00385 (European standard) which corresponds to an average resistance change, over the temperature range 0 to 100°C of 0.385Ω per °C. Both the absolute resistance value and the change in resistance per °C are both relatively small and give rise to measurement problems, especially when the resistance of the connection leads are taken into consideration.
There are other standards also in use The US standard for pt100 has an alpha of 0.00392.

Two-Wire Measurements

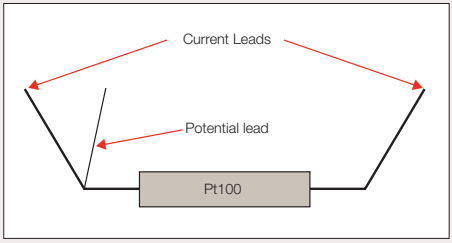
When measuring the resistance of a Pt100 a test current is forced through the component and the test meter measures the voltage at its terminals. The meter then calculates and displays the resulting resistance and is known as a two-wire measurement. It should be noted that the meter measures the voltage at its terminals and not across the component. As a result of this, the voltage drop across the connection leads is also included in the resistance calculation. Good quality test leads will have a resistance of approximately 0.02 ohm per meter. In addition to the resistance of the leads, the resistance of the lead connection will also be included in the measurement and this can be as high as or even higher in value than the leads themselves. The two-wire measurement is not recommended.



Three-Wire Measurement

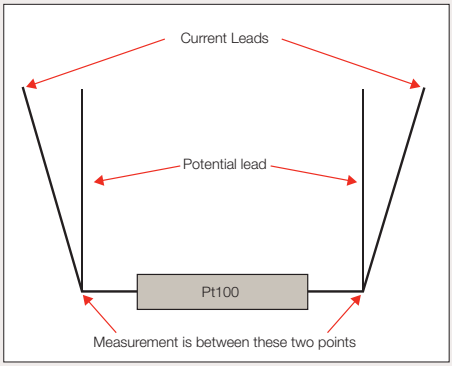
A three-wire connection is quite common in industrial applications and will eliminate most of the effect of the lead resistance on the measured value. Care must be taken to ensure that all three wires are of equal resistance but this is almost impossible to

achieve in practice. The three-wire method will not deliver the same degree of accuracy as a true four-wire system but is better than two wires.



Four-Wire Measurements

This is the most accurate measurement configuration. Two-wires are used to pass a constant current through the Pt100 and the volt drop across the unit is then measured. The impedance of the voltage measurement circuit is high and as a consequence only a very small current flows in the potential circuit, which for practical purposes can be ignored. The result is that the measurement lead resistance can also be ignored.



Two-wire sensors will also have large errors due to lead and connection resistance adding to the measured resistance value.

Three-wire sensors are better than two wires but will still give additional errors due to imbalance of lead resistances.

Four-wire sensors are recommended for accurate and repeatable measurements and the lead resistance can be ignored.

Measurement Errors

When measuring PRTs the measurement current used by most temperature indicators is either DC or low frequency AC. If AC is used, then care in selecting a non inductive sensor is essential as the measurement will be the impedance of the sensor rather than its true DC resistance. There may also be some differences in the temperature measurement between sensors from different manufacturers, as their construction technique may differ, resulting in slightly different impedance values. This AC measurement does, however, eliminate any thermal emf errors that may arise.

When DC current measurement is employed, the true resistance value is measured and used to calculate the corresponding temperature. In this instance impedance errors are not a problem, but errors due to thermal emf must be considered. The best method of countering any thermal emf is to measure the sensor resistances with current flowing in one direction, then reverse

the current and taking a second measurement. The average of these two measurements is the true resistance without any thermal emf. This is often called the switched DC method and is selectable on the Cropico thermometers.

To obtain the best measurement results, the resistance of the Pt100 sensor must be measured with a high degree of accuracy. A temperature change of 1°C will correspond to a resistance change of 0.385Ω so to obtain a measuring accuracy of 0.01°C(10mK) the resistance must be measured to ±0.0385Ω. Example: for a temperature of 100°C the resistance value will be 138.5Ω. To measure this with an accuracy of ±0.01°C, this resistance value must be measured to ±0.0385Ω, which is equal to ±0.028%. If a current of 1mA is used as the measuring current to measure 138.5Ω (100°C), then a voltage of 138.5mV will need to be measured to ±138.5μV, and to measure the temperature change of 0.01°C, a change of 3.85μV must be measured. So you can see a small error in the voltage sensing measurement will give large temperature measurement errors. Cropico's long history of high accuracy low resistance measurement ensures that its range of thermometers offer the highest possible accuracy typically ±10mK.

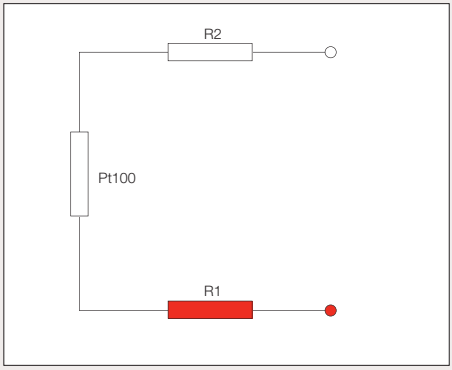
Self Heating

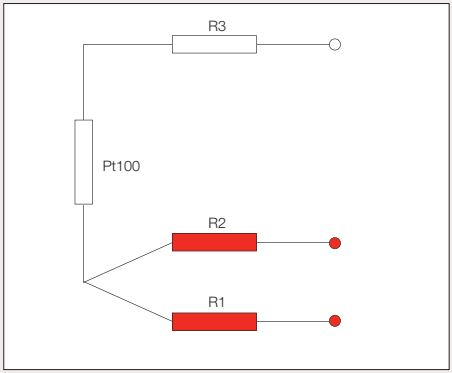
To measure the resistance of the temperature detector, a current must be passed through the device, typically a current 1mA to 5mA is used. A source current of 1mA flowing through the 100Ω resistance will generate 100μW of heat. If the sensor element is unable to dissipate this heat it will indicate an artificially high temperature. This effect can be minimised by using a large sensor element, by ensuring it is in good thermal contact with its measurement environment, and allowing sufficient time for the temperature to stabilise. An alternative is to use a short measurement pulse of current thus minimising the heating effect. The Cropico thermometers may be configured to measure with either a continuous or a short current pulse ensuring that the best possible measurement is made.

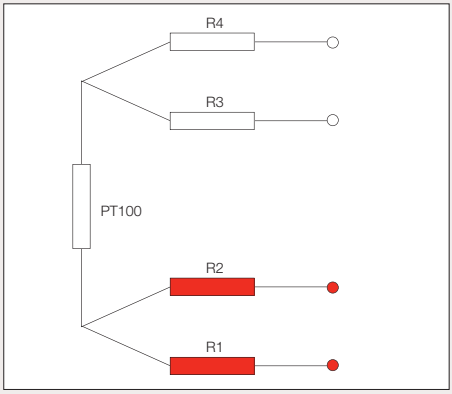
Colour Codes for Pt100

Two, three and four-wire extension leads as per IEC 60751

Note: In practice the industrial grade sensor will have current and potential leads R1,R2 and R3,R4 connected at the same point on the sensor and therefore interchangeable when connecting to the measuring device.







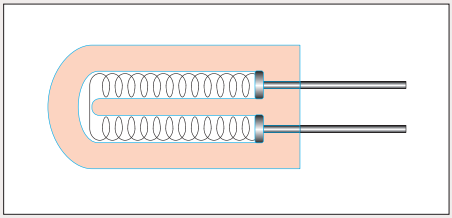
Stability

Whilst Platinum detectors are very stable over time, the design and manufacturing process can adversely affect these properties. During manufacture the detectors need to be heat treated to homogenize the crystal structure and remove any oxides that may have formed. The sensor needs to be supported in a stress-free manner and the finished assembly handled without causing any impact shocks or vibration.

Cycling the sensor between a high and low temperature will also increase errors. A typical drift rate for a Pt100 detector is 0.05°C per year. A high quality detector will exhibit lower drift of approx. 0.005°C to 0.01°C providing the detector is not mechanically stressed and the temperature range is limited. Consult the detector manufacturer for full specification.

Response Time

The Pt100 detectors are normally constructed by bifilar winding the platinum wire onto a small bobbin



Although the detector assemblies can be quite small in size they still have a thermal mass which takes time to warm up and reach thermal equilibrium, and consequently they have a longer response time than thermocouples. The detectors are usually housed in a stainless steel sheath which again increases the response time. When measuring temperatures, the immersion depth is also important as heat will be conducted up the stem of the sensor giving rise to errors. The manufacturer should be consulted regarding the minimum immersion depth.

Pt100 detector can also be constructed on a flat substrate this reduces the size and can be more suitable for some applications.

Table of Accuracies for Pt100 (a=0.00385)

Temperature (°C)	Tolerances					
	Class A IEC 60751 (1995)		Class B IEC 60751 (1995)		1/10 DIN DIN 43760	
	(±°C)	(± ohms)	(±°C)	(± ohms)	(±°C)	(± ohms)
-200	0,55	0,24	1,3	0,56	0.13	0.06
-100	0,35	0,14	0,8	0,32	0.08	0.03
0	0,15	0,06	0,3	0,12	0.03	0.01
100	0,35	0,13	0,8	0,30	0.08	0.03
200	0,55	0,20	1,3	0,48	0.13	0.05
300	0,75	0,27	1,8	0,64	-	-
400	0,95	0,33	2,3	0,79	-	-
500	1,15	0,38	2,8	0,93	-	-
600	1,35	0,43	3,3	1,06	-	-
650	1,45	0,46	3,6	1,13	-	-
700	-	-	3,8	1,17	-	-
800	-	-	4,3	1,28	-	-
850	-	-	4,6	1,34	-	-

Measurement Errors

The main sources of measurement errors are:-

- The use of two-wire sensors
- The use of three-wire sensors
- Thermal emf in non switch DC measurement systems
- Inductive sensors in AC measurement systems
- Self heating of the sensor due to the measurement current flowing through the detector winding
- Insufficient stabilisation time

The measurement errors can be minimised and eliminated by choosing one of the Cropico range of precision thermometers. The accuracy can be further improved by sensor calibration and the Callendar van Dusen coefficients produced from this calibration entered into the Cropico thermometer thus modifying the standard calibration curve to fit the detector characteristics. Whilst the platinum thermometer is one of the most linear temperature detectors it is still necessary to linearise the measured signal. According to the IEC standard IEC751 the non linearity can be expressed as

$$Rt = R^0[1 + At + Bt^2 + C(t - 100)t^3]$$

Where C is only applicable when t = ≤ 0°C. The standard coefficients for A, B, and C are stated in

the IEC standard but may also be calculated for each individual sensor by measuring its resistance values against set temperature standards.

The Callendar van Dusen Method

Calendar van Dusen method for determining these coefficients is commonly used and based on measuring four known temperatures.

R_0 at T_0 = 0°C the triple point of water

R_{100} at t_{100} = 100°C The boiling point of water

R_h at t_h =high temperature (e.g. the freezing point of zinc 419.53°C)

R_1 at t_1 = a low temperature (e.g. the boiling point of oxygen -182.96°C)

The Callendar van Dusen coefficients will be calculated for you by the laboratory calibrating your sensor and so it is not necessary to describe the calculations here.

Pt25 SPRT

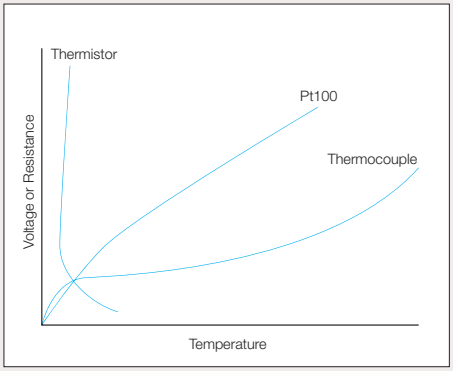
For the highest accuracy, special glass-sheathed standard PRTs, usually of 25 ohms at 0 °C, are calibrated at the fixed points of the International Temperature Scale 1990 (pg 24). ITS-90 specifies equations to relate the resistance to temperature and, using these, uncertainties can be achieved of 0.001 °C or better. Standard PRTs can be used from temperatures as low as -259 °C up to 660 ºC, or even, 962 ºC, with some increase in uncertainty and of loss of reproducibility.

The Cropico range of precision temperature indicators are able to measure with both Pt100 and Pt25 PRT sensors.

THERMISTORS

Thermistors are also a temperature sensitive resistance device and are more sensitive to temperature change than the thermocouple or Pt100. They are generally composed of semiconductor materials and are available with either positive temperature coefficient PTC (resistance increases with temperature) or negative temperature coefficient NTC (resistance decreases with temperature). The NTC types are the more commonly used and the resistance change per °C can be as large as several percent making them very good at detecting small changes in temperature, particularly when it is the change in temperature that we are interested in and not the absolute temperature value. NTC thermistors vary in their resistance values from a few ohms to 100kohms. This value is for a temperature at 25°C. The thermistor is a two-wire device but unlike PRTs the lead resistance is small in comparison with the detector resistance which is typically 1kΩ to 100kΩ and we, therefore, do not need to worry about the lead resistance introducing errors. As with PRTs we must ensure that the measuring current is kept low to avoid the effect of self heating.

Comparison of the different temperature detector types



Thermistor Terminology

Standard reference temperature is the thermistor body temperature at which nominal zero-power resistance is specified, usually 25°C.

Zero-power resistance is the DC resistance value of a thermistor measured at a specified temperature with a power dissipation by the thermistor low enough that any further decrease in power will result in not more than 0.1 percent (or 1/10 of the specified measurement tolerance, whichever is smaller) change in resistance.

Resistance ratio characteristic identifies the ratio of the zero-power resistance of a thermistor measured at 25°C to that resistance measured at 125°C.

Zero-power temperature coefficient of resistance is the ratio at a specified temperature (T), of the rate of change of zero-power resistance with temperature to the zero-power resistance of the thermistor.

NTC thermistor is one in which the zero-power resistance decreases with an increase in temperature.

PTC thermistor is one in which the zero-power resistance increases with an increase in temperature.

Maximum operating temperature is the maximum body temperature at which the thermistor will operate for an extended period of time with acceptable stability of its characteristics. This temperature is the result of internal or external heating, or both, and should not exceed the maximum value specified.

Maximum power rating of a thermistor is the maximum power which a thermistor will dissipate for an extended period of time with acceptable stability of its characteristics.

Dissipation constant is the ratio, (in milliwatts per °C) at a specified ambient temperature, of a change in power dissipation in a thermistor to the resultant body temperature change.

Thermal time constant of a thermistor is the time required for a thermistor to change 63.2 percent of the total difference between its initial and final body temperature when subjected to a step function

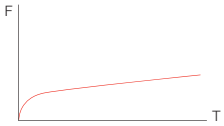
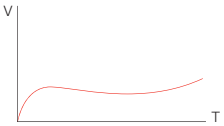
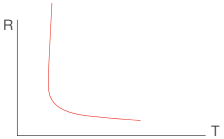
Resistance-temperature characteristic of a thermistor is the relationship between the zero-power resistance of a thermistor and its body temperature.

Temperature-wattage characteristic of a thermistor is the relationship at a specified ambient temperature between the thermistor temperature and the applied steady state wattage.

Current-time characteristic of a thermistor is the relationship at a specified ambient temperature between the current through a thermistor and time, upon application or interruption of voltage to it.

Stability of a thermistor is the ability of a thermistor to retain specified characteristics after being subjected to designated environmental or electrical test conditions.

Sensor Comparison chart

	RTD	Thermocouple	Thermistor
			
Temperature range	-260 to 850°C	-270 to 1800°C	-80 to 150°C (typical)
Sensor Cost	Moderate	Low	Low
System Cost	Moderate	High	Moderate
Stability	Best	Low	Moderate
Sensitivity	Moderate	Low	Best
Linearity	Best	Moderate	Poor
Specify for:	General purpose sensing Highest accuracy Temperature averaging	Highest temperatures	Best sensitivity Narrow ranges (e.g. medical) Point sensing
Advantages	Most Stable Most accurate More Linear than thermocouples	Self Powered Rugged Inexpensive Wide temperature range	High output Fast response
Disadvantages	Expensive Current source required Small ΔR Low absolute resistance	Non linear Low voltage Reference junction required Least stable & Least sensitive	Non linear Limited temperature range Current source required Self heating & Fragile

SI Unit Prefixes

Factor	Name	Symbol
10^{15}	peta	P
10^{12}	tera	T
10^{9}	Giga	G
10^{6}	Mega	M
10^{3}	Kilo	k
10^{2}	Hector	h
10^{1}	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	millo	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

N.B. The following tables are for information purposes and general guidance only. It is not necessarily deemed definitive and is subject to change without notice. Cropico and its associated companies accept no responsibility for any errors or consequential loss or damage which may arise from misinterpretation of the information or procedures. However, every effort has been made to ensure the accuracy of information presented but the reader should refer to manufacturer / supplier data and relevant published standards when producing or using sensors, materials or equipment.

Pt100 Resistance Table

°C	0	1	2	3	4	5	6	7	8	9
-200.00	18.52	-200.00								
-190.00	22.83	22.40	21.97	21.54	21.11	20.68	20.25	19.82	19.38	18.95
-180.00	27.10	26.67	26.24	25.82	25.39	24.97	24.54	24.11	23.68	23.25
-170.00	31.34	30.91	30.49	30.07	29.64	29.22	28.80	28.37	27.95	27.52
-160.00	35.54	35.12	34.70	34.28	33.86	33.44	33.02	32.60	32.18	31.76
-150.00	39.72	39.31	38.89	38.47	38.05	37.64	37.22	36.80	36.38	35.96
-140.00	43.88	43.46	43.05	42.63	42.22	41.80	41.39	40.97	40.56	40.14
-130.00	48.00	47.59	47.18	46.77	46.36	45.94	45.53	45.12	44.70	44.29
-120.00	52.11	51.70	51.29	50.88	50.47	50.06	49.65	49.24	48.83	48.42
-110.00	56.19	55.79	55.38	54.97	54.56	54.15	53.75	53.34	52.93	52.52
-100.00	60.26	59.85	59.44	59.04	58.63	58.23	57.82	57.41	57.01	56.60
-90.00	64.30	63.90	63.49	63.09	62.68	62.28	61.88	61.47	61.07	60.66
-80.00	68.33	67.92	67.52	67.12	66.72	66.31	65.91	65.51	65.11	64.70
-70.00	72.33	71.93	71.53	71.13	70.73	70.33	69.93	69.53	69.13	68.73
-60.00	76.33	75.93	75.53	75.13	74.73	74.33	73.93	73.53	73.13	72.73
-50.00	80.31	79.91	79.51	79.11	78.72	78.32	77.92	77.52	77.12	76.73
-40.00	84.27	83.87	83.48	83.08	82.69	82.29	81.89	81.50	81.10	80.70
-30.00	88.22	87.83	87.43	87.04	86.64	86.25	85.85	85.46	85.06	84.67
-20.00	92.16	91.77	91.37	90.98	90.59	90.19	89.80	89.40	89.01	88.62
-10.00	96.09	95.69	95.30	94.91	94.52	94.12	93.73	93.34	92.95	92.55
0.00	100.00	99.61	99.22	98.83	98.44	98.04	97.65	97.26	96.87	96.48
0.00	100.00	100.39	100.78	101.17	101.56	101.95	102.34	102.73	103.12	103.51
10.00	103.90	104.29	104.68	105.07	105.46	105.85	106.24	106.63	107.02	107.40
20.00	107.79	108.18	108.57	108.96	109.35	109.73	110.12	110.51	110.90	111.29
30.00	111.67	112.06	112.45	112.83	113.22	113.61	114.00	114.38	114.77	115.15
40.00	115.54	115.93	116.31	116.70	117.08	117.47	117.86	118.24	118.63	119.01
50.00	119.40	119.78	120.17	120.55	120.94	121.32	121.71	122.09	122.47	122.86
60.00	123.24	123.63	124.01	124.39	124.78	125.16	125.54	125.93	126.31	126.69
70.00	127.08	127.46	127.84	128.22	128.61	128.99	129.37	129.75	130.13	130.52
80.00	130.90	131.28	131.66	132.04	132.42	132.80	133.18	133.57	133.95	134.33
90.00	134.71	135.09	135.47	135.85	136.23	136.61	136.99	137.37	137.75	138.13
100.00	138.51	138.88	139.26	139.64	140.02	140.40	140.78	141.16	141.54	141.91
110.00	142.29	142.67	143.05	143.43	143.80	144.18	144.56	144.94	145.31	145.69
120.00	146.07	146.44	146.82	147.20	147.57	147.95	148.33	148.70	149.08	149.46
130.00	149.83	150.21	150.58	150.96	151.33	151.71	152.08	152.46	152.83	153.21
140.00	153.58	153.96	154.33	154.71	155.08	155.46	155.83	156.20	156.58	156.95
150.00	157.33	157.70	158.07	158.45	158.82	159.19	159.56	159.94	160.31	160.68
160.00	161.05	161.43	161.80	162.17	162.54	162.91	163.29	163.66	164.03	164.40
170.00	164.77	165.14	165.51	165.89	166.26	166.63	167.00	167.37	167.74	168.11
180.00	168.48	168.85	169.22	169.59	169.96	170.33	170.70	171.07	171.43	171.80
190.00	172.17	172.54	172.91	173.28	173.65	174.02	174.38	174.75	175.12	175.49
200.00	175.86	176.22	176.59	176.96	177.33	177.69	178.06	178.43	178.79	179.16
210.00	179.53	179.89	180.26	180.63	180.99	181.36	181.72	182.09	182.46	182.82
220.00	183.19	183.55	183.92	184.28	184.65	185.01	185.38	185.74	186.11	186.47
230.00	186.84	187.20	187.56	187.93	188.29	188.66	189.02	189.38	189.75	190.11
240.00	190.47	190.84	191.20	191.56	191.92	192.29	192.65	193.01	193.37	193.74
250.00	194.10	194.46	194.82	195.18	195.55	195.91	196.27	196.63	196.99	197.35
260.00	197.71	198.07	198.43	198.79	199.15	199.51	199.87	200.23	200.59	200.95
270.00	201.31	201.67	202.03	202.39	202.75	203.11	203.47	203.83	204.19	204.55

Pt100 Resistance Table (cont)

°C	0	1	2	3	4	5	6	7	8	9
280.00	204.90	205.26	205.62	205.98	206.34	206.70	207.05	207.41	207.77	208.13
290.00	208.48	208.84	209.20	209.56	209.91	210.27	210.63	210.98	211.34	211.70
300.00	212.05	212.41	212.76	213.12	213.48	213.83	214.19	214.54	214.90	215.25
310.00	215.61	215.96	216.32	216.67	217.03	217.38	217.74	218.09	218.44	218.80
320.00	219.15	219.51	219.86	220.21	220.57	220.92	221.27	221.63	221.98	222.33
330.00	222.68	223.04	223.39	223.74	224.09	224.45	224.80	225.15	225.50	225.85
340.00	226.21	226.56	226.91	227.26	227.61	227.96	228.31	228.66	229.02	229.37
350.00	229.72	230.07	230.42	230.77	231.12	231.47	231.82	232.17	232.52	232.87
360.00	233.21	233.56	233.91	234.26	234.61	234.96	235.31	235.66	236.00	236.35
370.00	236.70	237.05	237.40	237.74	238.09	238.44	238.79	239.13	239.48	239.83
380.00	240.18	240.52	240.87	241.22	241.56	241.91	242.26	242.60	242.95	243.29
390.00	243.64	243.99	244.33	244.68	245.02	245.37	245.71	246.06	246.40	246.75
400.00	247.09	247.44	247.78	248.13	248.47	248.81	249.16	249.50	249.85	250.19
410.00	250.53	250.88	251.22	251.56	251.91	252.25	252.59	252.93	253.28	253.62
420.00	253.96	254.30	254.65	254.99	255.33	255.67	256.01	256.35	256.70	257.04
430.00	257.38	257.72	258.06	258.40	258.74	259.08	259.42	259.76	260.10	260.44
440.00	260.78	261.12	261.46	261.80	262.14	262.48	262.82	263.16	263.50	263.84
450.00	264.18	264.52	264.86	265.20	265.53	265.87	266.21	266.55	266.89	267.22
460.00	267.56	267.90	268.24	268.57	268.91	269.25	269.59	269.92	270.26	270.60
470.00	270.93	271.27	271.61	271.94	272.28	272.61	272.95	273.29	273.62	273.96
480.00	274.29	274.63	274.96	275.30	275.63	275.97	276.30	276.64	276.97	277.31
490.00	277.64	277.98	278.31	278.64	278.98	279.31	279.64	279.98	280.31	280.64
500.00	280.98	281.31	281.64	281.98	282.31	282.64	282.97	283.31	283.64	283.97
510.00	284.30	284.63	284.97	285.30	285.63	285.96	286.29	286.62	286.95	287.29
520.00	287.62	287.95	288.28	288.61	288.94	289.27	289.60	289.93	290.26	290.59
530.00	290.92	291.25	291.58	291.91	292.24	292.56	292.89	293.22	293.55	293.88
540.00	294.21	294.54	294.86	295.19	295.52	295.85	296.18	296.50	296.83	297.16
550.00	297.49	297.81	298.14	298.47	298.80	299.12	299.45	299.78	300.10	300.43
560.00	300.75	301.08	301.41	301.73	302.06	302.38	302.71	303.03	303.36	303.69
570.00	304.01	304.34	304.66	304.98	305.31	305.63	305.96	306.28	306.61	306.93
580.00	307.25	307.58	307.90	308.23	308.55	308.87	309.20	309.52	309.84	310.16
590.00	310.49	310.81	311.13	311.45	311.78	312.10	312.42	312.74	313.06	313.39
600.00	313.71	314.03	314.35	314.67	314.99	315.31	315.64	315.96	316.28	316.60
610.00	316.92	317.24	317.56	317.88	318.20	318.52	318.84	319.16	319.48	319.80
620.00	320.12	320.43	320.75	321.07	321.39	321.71	322.03	322.35	322.67	322.98
630.00	323.30	323.62	323.94	324.26	324.57	324.89	325.21	325.53	325.84	326.16
640.00	326.48	326.79	327.11	327.43	327.74	328.06	328.38	328.69	329.01	329.32
650.00	329.64	329.96	330.27	330.59	330.90	331.22	331.53	331.85	332.16	332.48
660.00	332.79	333.11	333.42	333.74	334.05	334.36	334.68	334.99	335.31	335.62
670.00	335.93	336.25	336.56	336.87	337.18	337.50	337.81	338.12	338.44	338.75
680.00	339.06	339.37	339.69	340.00	340.31	340.62	340.93	341.24	341.56	341.87
690.00	342.18	342.49	342.80	343.11	343.42	343.73	344.04	344.35	344.66	344.97
700.00	345.28	345.59	345.90	346.21	346.52	346.83	347.14	347.45	347.76	348.07
710.00	348.38	348.69	348.99	349.30	349.61	349.92	350.23	350.54	350.84	351.15
720.00	351.46	351.77	352.08	352.38	352.69	353.00	353.30	353.61	353.92	354.22
730.00	354.53	354.84	355.14	355.45	355.76	356.06	356.37	356.67	356.98	357.28
740.00	357.59	357.90	358.20	358.51	358.81	359.12	359.42	359.72	360.03	360.33
750.00	360.64	360.94	361.25	361.55	361.85	362.16	362.46	362.76	363.07	363.37
760.00	363.67	363.98	364.28	364.58	364.89	365.19	365.49	365.79	366.10	366.40
770.00	366.70	367.00	367.30	367.60	367.91	368.21	368.51	368.81	369.11	369.41
780.00	369.71	370.01	370.31	370.61	370.91	371.21	371.51	371.81	372.11	372.41
790.00	372.71	373.01	373.31	373.61	373.91	374.21	374.51	374.81	375.11	375.41
800.00	375.70	376.00	376.30	376.60	376.90	377.19	377.49	377.79	378.09	378.39
810.00	378.68	378.98	379.28	379.57	379.87	380.17	380.46	380.76	381.06	381.35
820.00	381.65	381.95	382.24	382.54	382.83	383.13	383.42	383.72	384.01	384.31
830.00	384.60	384.90	385.19	385.49	385.78	386.08	386.37	386.67	386.96	387.25
840.00	387.55	387.84	388.14	388.43	388.72	389.02	389.31	389.60	389.90	390.19
850.00	390.48	850.00								

ITS-90 Table for Type S thermocouple

Thermoelectric Voltage in mV

°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
-50	-0.236										
-40	-0.194	-0.199	-0.203	-0.207	-0.211	-0.215	-0.219	-0.224	-0.228	-0.232	-0.236
-30	-0.150	-0.155	-0.159	-0.164	-0.168	-0.173	-0.177	-0.181	-0.186	-0.190	-0.194
-20	-0.103	-0.108	-0.113	-0.117	-0.122	-0.127	-0.132	-0.136	-0.141	-0.146	-0.150
-10	-0.053	-0.058	-0.063	-0.068	-0.073	-0.078	-0.083	-0.088	-0.093	-0.098	-0.103
0	0.000	-0.005	-0.011	-0.016	-0.021	-0.027	-0.032	-0.037	-0.042	-0.048	-0.053

°C	0	1	2	3	4	5	6	7	8	9	10
0	0.000	0.005	0.011	0.016	0.022	0.027	0.033	0.038	0.044	0.050	0.055
10	0.055	0.061	0.067	0.072	0.078	0.084	0.090	0.095	0.101	0.107	0.113
20	0.113	0.119	0.125	0.131	0.137	0.143	0.149	0.155	0.161	0.167	0.173
30	0.173	0.179	0.185	0.191	0.197	0.204	0.210	0.216	0.222	0.229	0.235
40	0.235	0.241	0.248	0.254	0.260	0.267	0.273	0.280	0.286	0.292	0.299
50	0.299	0.305	0.312	0.319	0.325	0.332	0.338	0.345	0.352	0.358	0.365
60	0.365	0.372	0.378	0.385	0.392	0.399	0.405	0.412	0.419	0.426	0.433
70	0.433	0.440	0.446	0.453	0.460	0.467	0.474	0.481	0.488	0.495	0.502
80	0.502	0.509	0.516	0.523	0.530	0.538	0.545	0.552	0.559	0.566	0.573
90	0.573	0.580	0.588	0.595	0.602	0.609	0.617	0.624	0.631	0.639	0.646
100	0.646	0.653	0.661	0.668	0.675	0.683	0.690	0.698	0.705	0.713	0.720
110	0.720	0.727	0.735	0.743	0.750	0.758	0.765	0.773	0.780	0.788	0.795
120	0.795	0.803	0.811	0.818	0.826	0.834	0.841	0.849	0.857	0.865	0.872
130	0.872	0.880	0.888	0.896	0.903	0.911	0.919	0.927	0.935	0.942	0.950
140	0.950	0.958	0.966	0.974	0.982	0.990	0.998	1.006	1.013	1.021	1.029
150	1.029	1.037	1.045	1.053	1.061	1.069	1.077	1.085	1.094	1.102	1.110
160	1.110	1.118	1.126	1.134	1.142	1.150	1.158	1.167	1.175	1.183	1.191
170	1.191	1.199	1.207	1.216	1.224	1.232	1.240	1.249	1.257	1.265	1.273
180	1.273	1.282	1.290	1.298	1.307	1.315	1.323	1.332	1.340	1.348	1.357
190	1.357	1.365	1.373	1.382	1.390	1.399	1.407	1.415	1.424	1.432	1.441
200	1.441	1.449	1.458	1.466	1.475	1.483	1.492	1.500	1.509	1.517	1.526
210	1.526	1.534	1.543	1.551	1.560	1.569	1.577	1.586	1.594	1.603	1.612
220	1.612	1.620	1.629	1.638	1.646	1.655	1.663	1.672	1.681	1.690	1.698
230	1.698	1.707	1.716	1.724	1.733	1.742	1.751	1.759	1.768	1.777	1.786
240	1.786	1.794	1.803	1.812	1.821	1.829	1.838	1.847	1.856	1.865	1.874
250	1.874	1.882	1.891	1.900	1.909	1.918	1.927	1.936	1.944	1.953	1.962
260	1.962	1.971	1.980	1.989	1.998	2.007	2.016	2.025	2.034	2.043	2.052
270	2.052	2.061	2.070	2.078	2.087	2.096	2.105	2.114	2.123	2.132	2.141
280	2.141	2.151	2.160	2.169	2.178	2.187	2.196	2.205	2.214	2.223	2.232
290	2.232	2.241	2.250	2.259	2.268	2.277	2.287	2.296	2.305	2.314	2.323
300	2.323	2.332	2.341	2.350	2.360	2.369	2.378	2.387	2.396	2.405	2.415
310	2.415	2.424	2.433	2.442	2.451	2.461	2.470	2.479	2.488	2.497	2.507
320	2.507	2.516	2.525	2.534	2.544	2.553	2.562	2.571	2.581	2.590	2.599
330	2.599	2.609	2.618	2.627	2.636	2.646	2.655	2.664	2.674	2.683	2.692
340	2.692	2.702	2.711	2.720	2.730	2.739	2.748	2.758	2.767	2.776	2.786
350	2.786	2.795	2.805	2.814	2.823	2.833	2.842	2.851	2.861	2.870	2.880
360	2.880	2.889	2.899	2.908	2.917	2.927	2.936	2.946	2.955	2.965	2.974
370	2.974	2.983	2.993	3.002	3.012	3.021	3.031	3.040	3.050	3.059	3.069
380	3.069	3.078	3.088	3.097	3.107	3.116	3.126	3.135	3.145	3.154	3.164
390	3.164	3.173	3.183	3.192	3.202	3.212	3.221	3.231	3.240	3.250	3.259
400	3.259	3.269	3.279	3.288	3.298	3.307	3.317	3.326	3.336	3.346	3.355
410	3.355	3.365	3.374	3.384	3.394	3.403	3.413	3.423	3.432	3.442	3.451
420	3.451	3.461	3.471	3.480	3.490	3.500	3.509	3.519	3.529	3.538	3.548
430	3.548	3.558	3.567	3.577	3.587	3.596	3.606	3.616	3.626	3.635	3.645
440	3.645	3.655	3.664	3.674	3.684	3.694	3.703	3.713	3.723	3.732	3.742
450	3.742	3.752	3.762	3.771	3.781	3.791	3.801	3.810	3.820	3.830	3.840
460	3.840	3.850	3.859	3.869	3.879	3.889	3.898	3.908	3.918	3.928	3.938
470	3.938	3.947	3.957	3.967	3.977	3.987	3.997	4.006	4.016	4.026	4.036
480	4.036	4.046	4.056	4.065	4.075	4.085	4.095	4.105	4.115	4.125	4.134

ITS-90 Table for Type S thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
490	4.134	4.144	4.154	4.164	4.174	4.184	4.194	4.204	4.213	4.223	4.233
500	4.233	4.243	4.253	4.263	4.273	4.283	4.293	4.303	4.313	4.323	4.332
510	4.332	4.342	4.352	4.362	4.372	4.382	4.392	4.402	4.412	4.422	4.432
520	4.432	4.442	4.452	4.462	4.472	4.482	4.492	4.502	4.512	4.522	4.532
530	4.532	4.542	4.552	4.562	4.572	4.582	4.592	4.602	4.612	4.622	4.632
540	4.632	4.642	4.652	4.662	4.672	4.682	4.692	4.702	4.712	4.722	4.732
550	4.732	4.742	4.752	4.762	4.772	4.782	4.793	4.803	4.813	4.823	4.833
560	4.833	4.843	4.853	4.863	4.873	4.883	4.893	4.904	4.914	4.924	4.934
570	4.934	4.944	4.954	4.964	4.974	4.984	4.995	5.005	5.015	5.025	5.035
580	5.035	5.045	5.055	5.066	5.076	5.086	5.096	5.106	5.116	5.127	5.137
590	5.137	5.147	5.157	5.167	5.178	5.188	5.198	5.208	5.218	5.228	5.239
600	5.239	5.249	5.259	5.269	5.280	5.290	5.300	5.310	5.320	5.331	5.341
610	5.341	5.351	5.361	5.372	5.382	5.392	5.402	5.413	5.423	5.433	5.443
620	5.443	5.454	5.464	5.474	5.485	5.495	5.505	5.515	5.526	5.536	5.546
630	5.546	5.557	5.567	5.577	5.588	5.598	5.608	5.618	5.629	5.639	5.649
640	5.649	5.660	5.670	5.680	5.691	5.701	5.712	5.722	5.732	5.743	5.753
650	5.753	5.763	5.774	5.784	5.794	5.805	5.815	5.826	5.836	5.846	5.857
660	5.857	5.867	5.878	5.888	5.898	5.909	5.919	5.930	5.940	5.950	5.961
670	5.961	5.971	5.982	5.992	6.003	6.013	6.024	6.034	6.044	6.055	6.065
680	6.065	6.076	6.086	6.097	6.107	6.118	6.128	6.139	6.149	6.160	6.170
690	6.170	6.181	6.191	6.202	6.212	6.223	6.233	6.244	6.254	6.265	6.275
700	6.275	6.286	6.296	6.307	6.317	6.328	6.338	6.349	6.360	6.370	6.381
710	6.381	6.391	6.402	6.412	6.423	6.434	6.444	6.455	6.465	6.476	6.486
720	6.486	6.497	6.508	6.518	6.529	6.539	6.550	6.561	6.571	6.582	6.593
730	6.593	6.603	6.614	6.624	6.635	6.646	6.656	6.667	6.678	6.688	6.699
740	6.699	6.710	6.720	6.731	6.742	6.752	6.763	6.774	6.784	6.795	6.806
750	6.806	6.817	6.827	6.838	6.849	6.859	6.870	6.881	6.892	6.902	6.913
760	6.913	6.924	6.934	6.945	6.956	6.967	6.977	6.988	6.999	7.010	7.020
770	7.020	7.031	7.042	7.053	7.064	7.074	7.085	7.096	7.107	7.117	7.128
780	7.128	7.139	7.150	7.161	7.172	7.182	7.193	7.204	7.215	7.226	7.236
790	7.236	7.247	7.258	7.269	7.280	7.291	7.302	7.312	7.323	7.334	7.345
800	7.345	7.356	7.367	7.378	7.388	7.399	7.410	7.421	7.432	7.443	7.454
810	7.454	7.465	7.476	7.487	7.497	7.508	7.519	7.530	7.541	7.552	7.563
820	7.563	7.574	7.585	7.596	7.607	7.618	7.629	7.640	7.651	7.662	7.673
830	7.673	7.684	7.695	7.706	7.717	7.728	7.739	7.750	7.761	7.772	7.783
840	7.783	7.794	7.805	7.816	7.827	7.838	7.849	7.860	7.871	7.882	7.893
850	7.893	7.904	7.915	7.926	7.937	7.948	7.959	7.970	7.981	7.992	8.003
860	8.003	8.014	8.026	8.037	8.048	8.059	8.070	8.081	8.092	8.103	8.114
870	8.114	8.125	8.137	8.148	8.159	8.170	8.181	8.192	8.203	8.214	8.226
880	8.226	8.237	8.248	8.259	8.270	8.281	8.293	8.304	8.315	8.326	8.337
890	8.337	8.348	8.360	8.371	8.382	8.393	8.404	8.416	8.427	8.438	8.449
900	8.449	8.460	8.472	8.483	8.494	8.505	8.517	8.528	8.539	8.550	8.562
910	8.562	8.573	8.584	8.595	8.607	8.618	8.629	8.640	8.652	8.663	8.674
920	8.674	8.685	8.697	8.708	8.719	8.731	8.742	8.753	8.765	8.776	8.787
930	8.787	8.798	8.810	8.821	8.832	8.844	8.855	8.866	8.878	8.889	8.900
940	8.900	8.912	8.923	8.935	8.946	8.957	8.969	8.980	8.991	9.003	9.014
950	9.014	9.025	9.037	9.048	9.060	9.071	9.082	9.094	9.105	9.117	9.128
960	9.128	9.139	9.151	9.162	9.174	9.185	9.197	9.208	9.219	9.231	9.242
970	9.242	9.254	9.265	9.277	9.288	9.300	9.311	9.323	9.334	9.345	9.357
980	9.357	9.368	9.380	9.391	9.403	9.414	9.426	9.437	9.449	9.460	9.472
990	9.472	9.483	9.495	9.506	9.518	9.529	9.541	9.552	9.564	9.576	9.587
1000	9.587	9.599	9.610	9.622	9.633	9.645	9.656	9.668	9.680	9.691	9.703
1010	9.703	9.714	9.726	9.737	9.749	9.761	9.772	9.784	9.795	9.807	9.819
1020	9.819	9.830	9.842	9.853	9.865	9.877	9.888	9.900	9.911	9.923	9.935
1030	9.935	9.946	9.958	9.970	9.981	9.993	10.005	10.016	10.028	10.040	10.051
1040	10.051	10.063	10.075	10.086	10.098	10.110	10.121	10.133	10.145	10.156	10.168
1050	10.168	10.180	10.191	10.203	10.215	10.227	10.238	10.250	10.262	10.273	10.285
1060	10.285	10.297	10.309	10.320	10.332	10.344	10.356	10.367	10.379	10.391	10.403

ITS-90 Table for Type S thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
1070	10.403	10.414	10.426	10.438	10.450	10.461	10.473	10.485	10.497	10.509	10.520
1080	10.520	10.532	10.544	10.556	10.567	10.579	10.591	10.603	10.615	10.626	10.638
1090	10.638	10.650	10.662	10.674	10.686	10.697	10.709	10.721	10.733	10.745	10.757
1100	10.757	10.768	10.780	10.792	10.804	10.816	10.828	10.839	10.851	10.863	10.875
1110	10.875	10.887	10.899	10.911	10.922	10.934	10.946	10.958	10.970	10.982	10.994
1120	10.994	11.006	11.017	11.029	11.041	11.053	11.065	11.077	11.089	11.101	11.113
1130	11.113	11.125	11.136	11.148	11.160	11.172	11.184	11.196	11.208	11.220	11.232
1140	11.232	11.244	11.256	11.268	11.280	11.291	11.303	11.315	11.327	11.339	11.351
1150	11.351	11.363	11.375	11.387	11.399	11.411	11.423	11.435	11.447	11.459	11.471
1160	11.471	11.483	11.495	11.507	11.519	11.531	11.542	11.554	11.566	11.578	11.590
1170	11.590	11.602	11.614	11.626	11.638	11.650	11.662	11.674	11.686	11.698	11.710
1180	11.710	11.722	11.734	11.746	11.758	11.770	11.782	11.794	11.806	11.818	11.830
1190	11.830	11.842	11.854	11.866	11.878	11.890	11.902	11.914	11.926	11.939	11.951
1200	11.951	11.963	11.975	11.987	11.999	12.011	12.023	12.035	12.047	12.059	12.071
1210	12.071	12.083	12.095	12.107	12.119	12.131	12.143	12.155	12.167	12.179	12.191
1220	12.191	12.203	12.216	12.228	12.240	12.252	12.264	12.276	12.288	12.300	12.312
1230	12.312	12.324	12.336	12.348	12.360	12.372	12.384	12.397	12.409	12.421	12.433
1240	12.433	12.445	12.457	12.469	12.481	12.493	12.505	12.517	12.529	12.542	12.554
1250	12.554	12.566	12.578	12.590	12.602	12.614	12.626	12.638	12.650	12.662	12.675
1260	12.675	12.687	12.699	12.711	12.723	12.735	12.747	12.759	12.771	12.783	12.796
1270	12.796	12.808	12.820	12.832	12.844	12.856	12.868	12.880	12.892	12.905	12.917
1280	12.917	12.929	12.941	12.953	12.965	12.977	12.989	13.001	13.014	13.026	13.038
1290	13.038	13.050	13.062	13.074	13.086	13.098	13.111	13.123	13.135	13.147	13.159
1300	13.159	13.171	13.183	13.195	13.208	13.220	13.232	13.244	13.256	13.268	13.280
1310	13.280	13.292	13.305	13.317	13.329	13.341	13.353	13.365	13.377	13.390	13.402
1320	13.402	13.414	13.426	13.438	13.450	13.462	13.474	13.487	13.499	13.511	13.523
1330	13.523	13.535	13.547	13.559	13.572	13.584	13.596	13.608	13.620	13.632	13.644
1340	13.644	13.657	13.669	13.681	13.693	13.705	13.717	13.729	13.742	13.754	13.766
1350	13.766	13.778	13.790	13.802	13.814	13.826	13.839	13.851	13.863	13.875	13.887
1360	13.887	13.899	13.911	13.924	13.936	13.948	13.960	13.972	13.984	13.996	14.009
1370	14.009	14.021	14.033	14.045	14.057	14.069	14.081	14.094	14.106	14.118	14.130
1380	14.130	14.142	14.154	14.166	14.178	14.191	14.203	14.215	14.227	14.239	14.251
1390	14.251	14.263	14.276	14.288	14.300	14.312	14.324	14.336	14.348	14.360	14.373
1400	14.373	14.385	14.397	14.409	14.421	14.433	14.445	14.457	14.470	14.482	14.494
1410	14.494	14.506	14.518	14.530	14.542	14.554	14.567	14.579	14.591	14.603	14.615
1420	14.615	14.627	14.639	14.651	14.664	14.676	14.688	14.700	14.712	14.724	14.736
1430	14.736	14.748	14.760	14.773	14.785	14.797	14.809	14.821	14.833	14.845	14.857
1440	14.857	14.869	14.881	14.894	14.906	14.918	14.930	14.942	14.954	14.966	14.978
1450	14.978	14.990	15.002	15.015	15.027	15.039	15.051	15.063	15.075	15.087	15.099
1460	15.099	15.111	15.123	15.135	15.148	15.160	15.172	15.184	15.196	15.208	15.220
1470	15.220	15.232	15.244	15.256	15.268	15.280	15.292	15.304	15.317	15.329	15.341
1480	15.341	15.353	15.365	15.377	15.389	15.401	15.413	15.425	15.437	15.449	15.461
1490	15.461	15.473	15.485	15.497	15.509	15.521	15.534	15.546	15.558	15.570	15.582
1500	15.582	15.594	15.606	15.618	15.630	15.642	15.654	15.666	15.678	15.690	15.702
1510	15.702	15.714	15.726	15.738	15.750	15.762	15.774	15.786	15.798	15.810	15.822
1520	15.822	15.834	15.846	15.858	15.870	15.882	15.894	15.906	15.918	15.930	15.942
1530	15.942	15.954	15.966	15.978	15.990	16.002	16.014	16.026	16.038	16.050	16.062
1540	16.062	16.074	16.086	16.098	16.110	16.122	16.134	16.146	16.158	16.170	16.182
1550	16.182	16.194	16.205	16.217	16.229	16.241	16.253	16.265	16.277	16.289	16.301
1560	16.301	16.313	16.325	16.337	16.349	16.361	16.373	16.385	16.396	16.408	16.420
1570	16.420	16.432	16.444	16.456	16.468	16.480	16.492	16.504	16.516	16.527	16.539
1580	16.539	16.551	16.563	16.575	16.587	16.599	16.611	16.623	16.634	16.646	16.658
1590	16.658	16.670	16.682	16.694	16.706	16.718	16.729	16.741	16.753	16.765	16.777
1600	16.777	16.789	16.801	16.812	16.824	16.836	16.848	16.860	16.872	16.883	16.895
1610	16.895	16.907	16.919	16.931	16.943	16.954	16.966	16.978	16.990	17.002	17.013
1620	17.013	17.025	17.037	17.049	17.061	17.072	17.084	17.096	17.108	17.120	17.131
1630	17.131	17.143	17.155	17.167	17.178	17.190	17.202	17.214	17.225	17.237	17.249
1640	17.249	17.261	17.272	17.284	17.296	17.308	17.319	17.331	17.343	17.355	17.366

ITS-90 Table for Type S thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
1650	17.366	17.378	17.390	17.401	17.413	17.425	17.437	17.448	17.460	17.472	17.483
1660	17.483	17.495	17.507	17.518	17.530	17.542	17.553	17.565	17.577	17.588	17.600
1670	17.600	17.612	17.623	17.635	17.647	17.658	17.670	17.682	17.693	17.705	17.717
1680	17.717	17.728	17.740	17.751	17.763	17.775	17.786	17.798	17.809	17.821	17.832
1690	17.832	17.844	17.855	17.867	17.878	17.890	17.901	17.913	17.924	17.936	17.947
1700	17.947	17.959	17.970	17.982	17.993	18.004	18.016	18.027	18.039	18.050	18.061
1710	18.061	18.073	18.084	18.095	18.107	18.118	18.129	18.140	18.152	18.163	18.174
1720	18.174	18.185	18.196	18.208	18.219	18.230	18.241	18.252	18.263	18.274	18.285
1730	18.285	18.297	18.308	18.319	18.330	18.341	18.352	18.362	18.373	18.384	18.395
1740	18.395	18.406	18.417	18.428	18.439	18.449	18.460	18.471	18.482	18.493	18.503
1750	18.503	18.514	18.525	18.535	18.546	18.557	18.567	18.578	18.588	18.599	18.609
1760	18.609	18.620	18.630	18.641	18.651	18.661	18.672	18.682	18.693		

This section contains coefficients for type S thermocouples for the two subranges of temperature listed below. The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order. The equation is of the form E = sum(i=0 to n) c_i t^i.

Temperature Range (°C)
-50.000 to 1064.180
1064.180 to 1664.500
1664.500 to 1768.100

name: reference function on ITS-90
type: S
temperature units: °C
emf units: mV
range: -50.000, 1064.180, 8
0.000000000000E+00
0.540313308631E-02
0.125934289740E-04
-0.232477968689E-07
0.322028823036E-10
-0.331465196389E-13
0.255744251786E-16
-0.125068871393E-19
0.271443176145E-23

range: 064.180, 1664.500, 4
0.132900444085E+01
0.334509311344E-02
0.654805192818E-05
-0.164856259209E-08
0.129989605174E-13

range: 1664.500, 1768.100, 4
0.146628232636E+03
-0.258430516752E+00
0.163693574641E-03
-0.330439046987E-07
-0.943223690612E-14

This section contains coefficients of approximate inverse functions for type S thermocouples for the subranges of temperature and voltage listed below. The range of errors of the approximate inverse function for each subrange is also given. The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order. The equation is of the form
t_90 = d_0 + d_1*E + d_2*E^2 + ... + d_n*E^n,
where E is in mV and t_90 is in °C.

Temperature range (°C)	Voltage range (mV)	Error range (° C)
-50. to 250.	-0.235 to 1.874	-0.02 to 0.02
250. to 1200.	1.874 to 11.950	-0.01 to 0.01
1064. to 1664.5	0.332 to 17.536	-0.0002 to 0.0002
1664.5 to 1768.1	17.536 to 18.693	-0.002 to 0.002

Inverse coefficients for type S:

Temperature Range:	-50. 250.	250. 1200.	1064. 1664.5	1664.5 1768.1
Voltage Range:	-0.235 1.874	1.874 11.950	10.332 17.536	17.536 18.693
0.00000000E+00	1.291507177E+01	-8.087801117E+01	5.333875126E+04	
1.84949460E+02	1.466298863E+02	1.621573104E+02	-1.235892298E+04	
-8.00504062E+01	-1.534713402E+01	-8.536869453E+00	1.092657613E+03	
1.02237430E+02	3.145945973E+00	4.719686976E-01	-4.265693686E+01	
-1.52248592E+02	-4.163257839E-01	-1.441693666E-02	6.247205420E-01	
1.88821343E+02	3.187963771E-02	2.081618890E-04	0.000000000E+00	
-1.59085941E+02	-1.291637500E-03	0.000000000E+00	0.000000000E+00	
8.23027880E+01	2.183475087E-05	0.000000000E+00	0.000000000E+00	
-2.34181944E+01	-1.447379511E-07	0.000000000E+00	0.000000000E+00	
2.79786260E+00	8.211272125E-09	0.000000000E+00	0.000000000E+00	
Error Range:	-0.02 0.02	-0.01 0.01	-0.0002 0.0002	-0.002 0.002

ITS-90 Table for Type R thermocouple

Thermoelectric Voltage in mV

°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
-50	-0.226										
-40	-0.188	-0.192	-0.196	-0.200	-0.204	-0.208	-0.211	-0.215	-0.219	-0.223	-0.226
-30	-0.145	-0.150	-0.154	-0.158	-0.163	-0.167	-0.171	-0.175	-0.180	-0.184	-0.188
-20	-0.100	-0.105	-0.109	-0.114	-0.119	-0.123	-0.128	-0.132	-0.137	-0.141	-0.145
-10	-0.051	-0.056	-0.061	-0.066	-0.071	-0.076	-0.081	-0.086	-0.091	-0.095	-0.100
0	0.000	-0.005	-0.011	-0.016	-0.021	-0.026	-0.031	-0.036	-0.041	-0.046	-0.051

°C	0	1	2	3	4	5	6	7	8	9	10
0	0.000	0.005	0.011	0.016	0.021	0.027	0.032	0.038	0.043	0.049	0.054
10	0.054	0.060	0.065	0.071	0.077	0.082	0.088	0.094	0.100	0.105	0.111
20	0.111	0.117	0.123	0.129	0.135	0.141	0.147	0.153	0.159	0.165	0.171
30	0.171	0.177	0.183	0.189	0.195	0.201	0.207	0.214	0.220	0.226	0.232
40	0.232	0.239	0.245	0.251	0.258	0.264	0.271	0.277	0.284	0.290	0.296
50	0.296	0.303	0.310	0.316	0.323	0.329	0.336	0.343	0.349	0.356	0.363
60	0.363	0.369	0.376	0.383	0.390	0.397	0.403	0.410	0.417	0.424	0.431
70	0.431	0.438	0.445	0.452	0.459	0.466	0.473	0.480	0.487	0.494	0.501
80	0.501	0.508	0.516	0.523	0.530	0.537	0.544	0.552	0.559	0.566	0.573
90	0.573	0.581	0.588	0.595	0.603	0.610	0.618	0.625	0.632	0.640	0.647
100	0.647	0.655	0.662	0.670	0.677	0.685	0.693	0.700	0.708	0.715	0.723
110	0.723	0.731	0.738	0.746	0.754	0.761	0.769	0.777	0.785	0.792	0.800
120	0.800	0.808	0.816	0.824	0.832	0.839	0.847	0.855	0.863	0.871	0.879
130	0.879	0.887	0.895	0.903	0.911	0.919	0.927	0.935	0.943	0.951	0.959
140	0.959	0.967	0.976	0.984	0.992	1.000	1.008	1.016	1.025	1.033	1.041
150	1.041	1.049	1.058	1.066	1.074	1.082	1.091	1.099	1.107	1.116	1.124
160	1.124	1.132	1.141	1.149	1.158	1.166	1.175	1.183	1.191	1.200	1.208
170	1.208	1.217	1.225	1.234	1.242	1.251	1.260	1.268	1.277	1.285	1.294
180	1.294	1.303	1.311	1.320	1.329	1.337	1.346	1.355	1.363	1.372	1.381
190	1.381	1.389	1.398	1.407	1.416	1.425	1.433	1.442	1.451	1.460	1.469
200	1.469	1.477	1.486	1.495	1.504	1.513	1.522	1.531	1.540	1.549	1.558
210	1.558	1.567	1.575	1.584	1.593	1.602	1.611	1.620	1.629	1.639	1.648
220	1.648	1.657	1.666	1.675	1.684	1.693	1.702	1.711	1.720	1.729	1.739
230	1.739	1.748	1.757	1.766	1.775	1.784	1.794	1.803	1.812	1.821	1.831
240	1.831	1.840	1.849	1.858	1.868	1.877	1.886	1.895	1.905	1.914	1.923
250	1.923	1.933	1.942	1.951	1.961	1.970	1.980	1.989	1.998	2.008	2.017
260	2.017	2.027	2.036	2.046	2.055	2.064	2.074	2.083	2.093	2.102	2.112
270	2.112	2.121	2.131	2.140	2.150	2.159	2.169	2.179	2.188	2.198	2.207
280	2.207	2.217	2.226	2.236	2.246	2.255	2.265	2.275	2.284	2.294	2.304
290	2.304	2.313	2.323	2.333	2.342	2.352	2.362	2.371	2.381	2.391	2.401
300	2.401	2.410	2.420	2.430	2.440	2.449	2.459	2.469	2.479	2.488	2.498
310	2.498	2.508	2.518	2.528	2.538	2.547	2.557	2.567	2.577	2.587	2.597
320	2.597	2.607	2.617	2.626	2.636	2.646	2.656	2.666	2.676	2.686	2.696
330	2.696	2.706	2.716	2.726	2.736	2.746	2.756	2.766	2.776	2.786	2.796
340	2.796	2.806	2.816	2.826	2.836	2.846	2.856	2.866	2.876	2.886	2.896
350	2.896	2.906	2.916	2.926	2.937	2.947	2.957	2.967	2.977	2.987	2.997
360	2.997	3.007	3.018	3.028	3.038	3.048	3.058	3.068	3.079	3.089	3.099
370	3.099	3.109	3.119	3.130	3.140	3.150	3.160	3.171	3.181	3.191	3.201
380	3.201	3.212	3.222	3.232	3.242	3.253	3.263	3.273	3.284	3.294	3.304
390	3.304	3.315	3.325	3.335	3.346	3.356	3.366	3.377	3.387	3.397	3.408
400	3.408	3.418	3.428	3.439	3.449	3.460	3.470	3.480	3.491	3.501	3.512
410	3.512	3.522	3.533	3.543	3.553	3.564	3.574	3.585	3.595	3.606	3.616
420	3.616	3.627	3.637	3.648	3.658	3.669	3.679	3.690	3.700	3.711	3.721
430	3.721	3.732	3.742	3.753	3.764	3.774	3.785	3.795	3.806	3.816	3.827
440	3.827	3.838	3.848	3.859	3.869	3.880	3.891	3.901	3.912	3.922	3.933
450	3.933	3.944	3.954	3.965	3.976	3.986	3.997	4.008	4.018	4.029	4.040
460	4.040	4.050	4.061	4.072	4.083	4.093	4.104	4.115	4.125	4.136	4.147
470	4.147	4.158	4.168	4.179	4.190	4.201	4.211	4.222	4.233	4.244	4.255
480	4.255	4.265	4.276	4.287	4.298	4.309	4.319	4.330	4.341	4.352	4.363

ITS-90 Table for Type R thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
490	4.363	4.373	4.384	4.395	4.406	4.417	4.428	4.439	4.449	4.460	4.471
500	4.471	4.482	4.493	4.504	4.515	4.526	4.537	4.548	4.558	4.569	4.580
510	4.580	4.591	4.602	4.613	4.624	4.635	4.646	4.657	4.668	4.679	4.690
520	4.690	4.701	4.712	4.723	4.734	4.745	4.756	4.767	4.778	4.789	4.800
530	4.800	4.811	4.822	4.833	4.844	4.855	4.866	4.877	4.888	4.899	4.910
540	4.910	4.922	4.933	4.944	4.955	4.966	4.977	4.988	4.999	5.010	5.021
550	5.021	5.033	5.044	5.055	5.066	5.077	5.088	5.099	5.111	5.122	5.133
560	5.133	5.144	5.155	5.166	5.178	5.189	5.200	5.211	5.222	5.234	5.245
570	5.245	5.256	5.267	5.279	5.290	5.301	5.312	5.323	5.335	5.346	5.357
580	5.357	5.369	5.380	5.391	5.402	5.414	5.425	5.436	5.448	5.459	5.470
590	5.470	5.481	5.493	5.504	5.515	5.527	5.538	5.549	5.561	5.572	5.583
600	5.583	5.595	5.606	5.618	5.629	5.640	5.652	5.663	5.674	5.686	5.697
610	5.697	5.709	5.720	5.731	5.743	5.754	5.766	5.777	5.789	5.800	5.812
620	5.812	5.823	5.834	5.846	5.857	5.869	5.880	5.892	5.903	5.915	5.926
630	5.926	5.938	5.949	5.961	5.972	5.984	5.995	6.007	6.018	6.030	6.041
640	6.041	6.053	6.065	6.076	6.088	6.099	6.111	6.122	6.134	6.146	6.157
650	6.157	6.169	6.180	6.192	6.204	6.215	6.227	6.238	6.250	6.262	6.273
660	6.273	6.285	6.297	6.308	6.320	6.332	6.343	6.355	6.367	6.378	6.390
670	6.390	6.402	6.413	6.425	6.437	6.448	6.460	6.472	6.484	6.495	6.507
680	6.507	6.519	6.531	6.542	6.554	6.566	6.578	6.589	6.601	6.613	6.625
690	6.625	6.636	6.648	6.660	6.672	6.684	6.695	6.707	6.719	6.731	6.743
700	6.743	6.755	6.766	6.778	6.790	6.802	6.814	6.826	6.838	6.849	6.861
710	6.861	6.873	6.885	6.897	6.909	6.921	6.933	6.945	6.956	6.968	6.980
720	6.980	6.992	7.004	7.016	7.028	7.040	7.052	7.064	7.076	7.088	7.100
730	7.100	7.112	7.124	7.136	7.148	7.160	7.172	7.184	7.196	7.208	7.220
740	7.220	7.232	7.244	7.256	7.268	7.280	7.292	7.304	7.316	7.328	7.340
750	7.340	7.352	7.364	7.376	7.389	7.401	7.413	7.425	7.437	7.449	7.461
760	7.461	7.473	7.485	7.498	7.510	7.522	7.534	7.546	7.558	7.570	7.583
770	7.583	7.595	7.607	7.619	7.631	7.644	7.656	7.668	7.680	7.692	7.705
780	7.705	7.717	7.729	7.741	7.753	7.766	7.778	7.790	7.802	7.815	7.827
790	7.827	7.839	7.851	7.864	7.876	7.888	7.901	7.913	7.925	7.938	7.950
800	7.950	7.962	7.974	7.987	7.999	8.011	8.024	8.036	8.048	8.061	8.073
810	8.073	8.086	8.098	8.110	8.123	8.135	8.147	8.160	8.172	8.185	8.197
820	8.197	8.209	8.222	8.234	8.247	8.259	8.272	8.284	8.296	8.309	8.321
830	8.321	8.334	8.346	8.359	8.371	8.384	8.396	8.409	8.421	8.434	8.446
840	8.446	8.459	8.471	8.484	8.496	8.509	8.521	8.534	8.546	8.559	8.571
850	8.571	8.584	8.597	8.609	8.622	8.634	8.647	8.659	8.672	8.685	8.697
860	8.697	8.710	8.722	8.735	8.748	8.760	8.773	8.785	8.798	8.811	8.823
870	8.823	8.836	8.849	8.861	8.874	8.887	8.899	8.912	8.925	8.937	8.950
880	8.950	8.963	8.975	8.988	9.001	9.014	9.026	9.039	9.052	9.065	9.077
890	9.077	9.090	9.103	9.115	9.128	9.141	9.154	9.167	9.179	9.192	9.205
900	9.205	9.218	9.230	9.243	9.256	9.269	9.282	9.294	9.307	9.320	9.333
910	9.333	9.346	9.359	9.371	9.384	9.397	9.410	9.423	9.436	9.449	9.461
920	9.461	9.474	9.487	9.500	9.513	9.526	9.539	9.552	9.565	9.578	9.590
930	9.590	9.603	9.616	9.629	9.642	9.655	9.668	9.681	9.694	9.707	9.720
940	9.720	9.733	9.746	9.759	9.772	9.785	9.798	9.811	9.824	9.837	9.850
950	9.850	9.863	9.876	9.889	9.902	9.915	9.928	9.941	9.954	9.967	9.980
960	9.980	9.993	10.006	10.019	10.032	10.046	10.059	10.072	10.085	10.098	10.111
970	10.111	10.124	10.137	10.150	10.163	10.177	10.190	10.203	10.216	10.229	10.242
980	10.242	10.255	10.268	10.282	10.295	10.308	10.321	10.334	10.347	10.361	10.374
990	10.374	10.387	10.400	10.413	10.427	10.440	10.453	10.466	10.480	10.493	10.506
1000	10.506	10.519	10.532	10.546	10.559	10.572	10.585	10.599	10.612	10.625	10.638
1010	10.638	10.652	10.665	10.678	10.692	10.705	10.718	10.731	10.745	10.758	10.771
1020	10.771	10.785	10.798	10.811	10.825	10.838	10.851	10.865	10.878	10.891	10.905
1030	10.905	10.918	10.932	10.945	10.958	10.972	10.985	10.998	11.012	11.025	11.039
1040	11.039	11.052	11.065	11.079	11.092	11.106	11.119	11.132	11.146	11.159	11.173
1050	11.173	11.186	11.200	11.213	11.227	11.240	11.253	11.267	11.280	11.294	11.307
1060	11.307	11.321	11.334	11.348	11.361	11.375	11.388	11.402	11.415	11.429	11.442

ITS-90 Table for Type R thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
1070	11.442	11.456	11.469	11.483	11.496	11.510	11.524	11.537	11.551	11.564	11.578
1080	11.578	11.591	11.605	11.618	11.632	11.646	11.659	11.673	11.686	11.700	11.714
1090	11.714	11.727	11.741	11.754	11.768	11.782	11.795	11.809	11.822	11.836	11.850
1100	11.850	11.863	11.877	11.891	11.904	11.918	11.931	11.945	11.959	11.972	11.986
1110	11.986	12.000	12.013	12.027	12.041	12.054	12.068	12.082	12.096	12.109	12.123
1120	12.123	12.137	12.150	12.164	12.178	12.191	12.205	12.219	12.233	12.246	12.260
1130	12.260	12.274	12.288	12.301	12.315	12.329	12.342	12.356	12.370	12.384	12.397
1140	12.397	12.411	12.425	12.439	12.453	12.466	12.480	12.494	12.508	12.521	12.535
1150	12.535	12.549	12.563	12.577	12.590	12.604	12.618	12.632	12.646	12.659	12.673
1160	12.673	12.687	12.701	12.715	12.729	12.742	12.756	12.770	12.784	12.798	12.812
1170	12.812	12.825	12.839	12.853	12.867	12.881	12.895	12.909	12.922	12.936	12.950
1180	12.950	12.964	12.978	12.992	13.006	13.019	13.033	13.047	13.061	13.075	13.089
1190	13.089	13.103	13.117	13.131	13.145	13.158	13.172	13.186	13.200	13.214	13.228
1200	13.228	13.242	13.256	13.270	13.284	13.298	13.311	13.325	13.339	13.353	13.367
1210	13.367	13.381	13.395	13.409	13.423	13.437	13.451	13.465	13.479	13.493	13.507
1220	13.507	13.521	13.535	13.549	13.563	13.577	13.590	13.604	13.618	13.632	13.646
1230	13.646	13.660	13.674	13.688	13.702	13.716	13.730	13.744	13.758	13.772	13.786
1240	13.786	13.800	13.814	13.828	13.842	13.856	13.870	13.884	13.898	13.912	13.926
1250	13.926	13.940	13.954	13.968	13.982	13.996	14.010	14.024	14.038	14.052	14.066
1260	14.066	14.081	14.095	14.109	14.123	14.137	14.151	14.165	14.179	14.193	14.207
1270	14.207	14.221	14.235	14.249	14.263	14.277	14.291	14.305	14.319	14.333	14.347
1280	14.347	14.361	14.375	14.390	14.404	14.418	14.432	14.446	14.460	14.474	14.488
1290	14.488	14.502	14.516	14.530	14.544	14.558	14.572	14.586	14.601	14.615	14.629
1300	14.629	14.643	14.657	14.671	14.685	14.699	14.713	14.727	14.741	14.755	14.770
1310	14.770	14.784	14.798	14.812	14.826	14.840	14.854	14.868	14.882	14.896	14.911
1320	14.911	14.925	14.939	14.953	14.967	14.981	14.995	15.009	15.023	15.037	15.052
1330	15.052	15.066	15.080	15.094	15.108	15.122	15.136	15.150	15.164	15.179	15.193
1340	15.193	15.207	15.221	15.235	15.249	15.263	15.277	15.291	15.306	15.320	15.334
1350	15.334	15.348	15.362	15.376	15.390	15.404	15.419	15.433	15.447	15.461	15.475
1360	15.475	15.489	15.503	15.517	15.531	15.546	15.560	15.574	15.588	15.602	15.616
1370	15.616	15.630	15.645	15.659	15.673	15.687	15.701	15.715	15.729	15.743	15.758
1380	15.758	15.772	15.786	15.800	15.814	15.828	15.842	15.856	15.871	15.885	15.899
1390	15.899	15.913	15.927	15.941	15.955	15.969	15.984	15.998	16.012	16.026	16.040
1400	16.040	16.054	16.068	16.082	16.097	16.111	16.125	16.139	16.153	16.167	16.181
1410	16.181	16.196	16.210	16.224	16.238	16.252	16.266	16.280	16.294	16.309	16.323
1420	16.323	16.337	16.351	16.365	16.379	16.393	16.407	16.422	16.436	16.450	16.464
1430	16.464	16.478	16.492	16.506	16.520	16.534	16.549	16.563	16.577	16.591	16.605
1440	16.605	16.619	16.633	16.647	16.662	16.676	16.690	16.704	16.718	16.732	16.746
1450	16.746	16.760	16.774	16.789	16.803	16.817	16.831	16.845	16.859	16.873	16.887
1460	16.887	16.901	16.915	16.930	16.944	16.958	16.972	16.986	17.000	17.014	17.028
1470	17.028	17.042	17.056	17.071	17.085	17.099	17.113	17.127	17.141	17.155	17.169
1480	17.169	17.183	17.197	17.211	17.225	17.240	17.254	17.268	17.282	17.296	17.310
1490	17.310	17.324	17.338	17.352	17.366	17.380	17.394	17.408	17.423	17.437	17.451
1500	17.451	17.465	17.479	17.493	17.507	17.521	17.535	17.549	17.563	17.577	17.591
1510	17.591	17.605	17.619	17.633	17.647	17.661	17.676	17.690	17.704	17.718	17.732
1520	17.732	17.746	17.760	17.774	17.788	17.802	17.816	17.830	17.844	17.858	17.872
1530	17.872	17.886	17.900	17.914	17.928	17.942	17.956	17.970	17.984	17.998	18.012
1540	18.012	18.026	18.040	18.054	18.068	18.082	18.096	18.110	18.124	18.138	18.152
1550	18.152	18.166	18.180	18.194	18.208	18.222	18.236	18.250	18.264	18.278	18.292
1560	18.292	18.306	18.320	18.334	18.348	18.362	18.376	18.390	18.404	18.417	18.431
1570	18.431	18.445	18.459	18.473	18.487	18.501	18.515	18.529	18.543	18.557	18.571
1580	18.571	18.585	18.599	18.613	18.627	18.640	18.654	18.668	18.682	18.696	18.710
1590	18.710	18.724	18.738	18.752	18.766	18.779	18.793	18.807	18.821	18.835	18.849
1600	18.849	18.863	18.877	18.891	18.904	18.918	18.932	18.946	18.960	18.974	18.988
1610	18.988	19.002	19.015	19.029	19.043	19.057	19.071	19.085	19.098	19.112	19.126
1620	19.126	19.140	19.154	19.168	19.181	19.195	19.209	19.223	19.237	19.250	19.264
1630	19.264	19.278	19.292	19.306	19.319	19.333	19.347	19.361	19.375	19.388	19.402
1640	19.402	19.416	19.430	19.444	19.457	19.471	19.485	19.499	19.512	19.526	19.540

ITS-90 Table for Type R thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
1650	19.540	19.554	19.567	19.581	19.595	19.609	19.622	19.636	19.650	19.663	19.677
1660	19.677	19.691	19.705	19.718	19.732	19.746	19.759	19.773	19.787	19.800	19.814
1670	19.814	19.828	19.841	19.855	19.869	19.882	19.896	19.910	19.923	19.937	19.951
1680	19.951	19.964	19.978	19.992	20.005	20.019	20.032	20.046	20.060	20.073	20.087
1690	20.087	20.100	20.114	20.127	20.141	20.154	20.168	20.181	20.195	20.208	20.222
1700	20.222	20.235	20.249	20.262	20.275	20.289	20.302	20.316	20.329	20.342	20.356
1710	20.356	20.369	20.382	20.396	20.409	20.422	20.436	20.449	20.462	20.475	20.488
1720	20.488	20.502	20.515	20.528	20.541	20.554	20.567	20.581	20.594	20.607	20.620
1730	20.620	20.633	20.646	20.659	20.672	20.685	20.698	20.711	20.724	20.736	20.749
1740	20.749	20.762	20.775	20.788	20.801	20.813	20.826	20.839	20.852	20.864	20.877
1750	20.877	20.890	20.902	20.915	20.928	20.940	20.953	20.965	20.978	20.990	21.003
1760	21.003	21.015	21.027	21.040	21.052	21.065	21.077	21.089	21.101		

This section contains coefficients for type R thermocouples for the two subranges of temperature listed below. The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order. The equation is of the form * E = sum(i=0 to n) c_i t^i.

Temperature Range (°C)
-50.000 to 1064.180
1064.180 to 1664.500
1664.500 to 1768.100

name: reference function on ITS-90
type: R
temperature units: °C
emf units: mV

range: -50.000, 1064.180, 9
0.000000000000E+00
0.528961729765E-02
0.139166589782E-04
-0.238855693017E-07
0.356916001063E-10
-0.462347666298E-13
0.500777441034E-16
-0.373105886191E-19
0.157716482367E-22
-0.281038625251E-26

range: 1064.180, 1664.500, 5
0.295157925316E+01
-0.252061251332E-02
0.159564501865E-04
-0.764085947576E-08
0.205305291024E-11
-0.293359668173E-15

range: 1664.500, 1768.100, 4
0.152321181209E+03
-0.268819888545E+00
0.171280280471E-03
-0.345895706453E-07
-0.934633971046E-14

This section contains coefficients of approximate inverse functions for type R thermocouples for the subranges of temperature and voltage listed below. The range of errors of the approximate inverse function for each subrange is also given. The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order.
The equation is of the form t_90 = d_0 + d_1*E + d_2*E^2 + ... + d_n*E^n, where E is in mV and t_90 is in °C.
*

Temperature range (°C)	Voltage range (mV)	Error range (° C)
-50. to 250.	-0.226 to 1.923	-0.02 to 0.02
250. to 1200.	1.923 to 13.228	-0.005 to 0.005
1064. to 1664.5	11.361 to 19.739	-0.0005 to 0.001
1664.5 to 1768.1	19.739 to 21.103	-0.001 to 0.002

Inverse coefficients for type R:

Temperature Range:	-50. 250.	250. 1200.	1064. 1664.5	1664.5 1768.1
Voltage Range:	-0.226 1.923	1.923 13.228	11.361 19.739	19.739 21.103

0.0000000E+00 1.334584505E+01 -8.199599416E+01 3.406177836E+04
1.8891380E+02 1.472644573E+02 1.553962042E+02 -7.023729171E+03
-9.3835290E+01 -1.844024844E+01 -8.342197663E+00
5.582903813E+02

1.3068619E+02	4.031129726E+00	4.279433549E-01	-1.952394635E+01
-2.2703580E+02	-6.249428360E-01	-1.191577910E-02	2.560740231E-01
3.5145659E+02	6.468412046E-02	1.492290091E-04	0.000000000E+00
-3.8953900E+02	-4.458750426E-03	0.000000000E+00	0.000000000E+00
2.8239471E+02	1.994710149E-04	0.000000000E+00	0.000000000E+00
-1.2607281E+02	-5.313401790E-06	0.000000000E+00	0.000000000E+00
3.1353611E+01	6.481976217E-08	0.000000000E+00	0.000000000E+00
-3.3187769E+00	0.000000000E+00	0.000000000E+00	0.000000000E+00

Error Range:	-0.02 0.02	-0.005 0.005	-0.0005 0.001	-0.001 0.002

ITS-90 Table for Type B thermocouple

Thermoelectric Voltage in mV

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

ITS-90 Table for Type B thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
580	1.675	1.680	1.686	1.692	1.698	1.704	1.709	1.715	1.721	1.727	1.733
590	1.733	1.739	1.745	1.750	1.756	1.762	1.768	1.774	1.780	1.786	1.792
600	1.792	1.798	1.804	1.810	1.816	1.822	1.828	1.834	1.840	1.846	1.852
610	1.852	1.858	1.864	1.870	1.876	1.882	1.888	1.894	1.901	1.907	1.913
620	1.913	1.919	1.925	1.931	1.937	1.944	1.950	1.956	1.962	1.968	1.975
630	1.975	1.981	1.987	1.993	1.999	2.006	2.012	2.018	2.025	2.031	2.037
640	2.037	2.043	2.050	2.056	2.062	2.069	2.075	2.082	2.088	2.094	2.101
650	2.101	2.107	2.113	2.120	2.126	2.133	2.139	2.146	2.152	2.158	2.165
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	2.296
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	3.078
790	3.078	3.085	3.093	3.100	3.108	3.116	3.123	3.131	3.138	3.146	3.154
800	3.154	3.161	3.169	3.177	3.184	3.192	3.200	3.207	3.215	3.223	3.230
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	3.386
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	3.708
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	4.213
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	4.475
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	5.018
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	5.394
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	5.682
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	5.878
1110	5.878	5.887	5.897	5.907	5.917	5.927	5.937	5.947	5.956	5.966	5.976
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	6.276
1150	6.276	6.286	6.296	6.306	6.316	6.326	6.336	6.346	6.356	6.367	6.377

ITS-90 Table for Type B thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
1160	6.377	6.387	6.397	6.407	6.417	6.427	6.438	6.448	6.458	6.468	6.478
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	6.786
1200	6.786	6.797	6.807	6.818	6.828	6.838	6.849	6.859	6.869	6.880	6.890
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	7.524
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
1300	7.848	7.859	7.870	7.881	7.892	7.903	7.914	7.924	7.935	7.946	7.957
1310	7.957	7.968	7.979	7.990	8.001	8.012	8.023	8.034	8.045	8.056	8.066
1320	8.066	8.077	8.088	8.099	8.110	8.121	8.132	8.143	8.154	8.165	8.176
1330	8.176	8.187	8.198	8.209	8.220	8.231	8.242	8.253	8.264	8.275	8.286
1340	8.286	8.298	8.309	8.320	8.331	8.342	8.353	8.364	8.375	8.386	8.397
1350	8.397	8.408	8.419	8.430	8.441	8.453	8.464	8.475	8.486	8.497	8.508
1360	8.508	8.519	8.530	8.542	8.553	8.564	8.575	8.586	8.597	8.608	8.620
1370	8.620	8.631	8.642	8.653	8.664	8.675	8.687	8.698	8.709	8.720	8.731
1380	8.731	8.743	8.754	8.765	8.776	8.787	8.799	8.810	8.821	8.832	8.844
1390	8.844	8.855	8.866	8.877	8.889	8.900	8.911	8.922	8.934	8.945	8.956
1400	8.956	8.967	8.979	8.990	9.001	9.013	9.024	9.035	9.047	9.058	9.069
1410	9.069	9.080	9.092	9.103	9.114	9.126	9.137	9.148	9.160	9.171	9.182
1420	9.182	9.194	9.205	9.216	9.228	9.239	9.251	9.262	9.273	9.285	9.296
1430	9.296	9.307	9.319	9.330	9.342	9.353	9.364	9.376	9.387	9.398	9.410
1440	9.410	9.421	9.433	9.444	9.456	9.467	9.478	9.490	9.501	9.513	9.524
1450	9.524	9.536	9.547	9.558	9.570	9.581	9.593	9.604	9.616	9.627	9.639
1460	9.639	9.650	9.662	9.673	9.684	9.696	9.707	9.719	9.730	9.742	9.753
1470	9.753	9.765	9.776	9.788	9.799	9.811	9.822	9.834	9.845	9.857	9.868
1480	9.868	9.880	9.891	9.903	9.914	9.926	9.937	9.949	9.961	9.972	9.984
1490	9.984	9.995	10.007	10.018	10.030	10.041	10.053	10.064	10.076	10.088	10.099
1500	10.099	10.111	10.122	10.134	10.145	10.157	10.168	10.180	10.192	10.203	10.215
1510	10.215	10.226	10.238	10.249	10.261	10.273	10.284	10.296	10.307	10.319	10.331
1520	10.331	10.342	10.354	10.365	10.377	10.389	10.400	10.412	10.423	10.435	10.447
1530	10.447	10.458	10.470	10.482	10.493	10.505	10.516	10.528	10.540	10.551	10.563
1540	10.563	10.575	10.586	10.598	10.609	10.621	10.633	10.644	10.656	10.668	10.679
1550	10.679	10.691	10.703	10.714	10.726	10.738	10.749	10.761	10.773	10.784	10.796
1560	10.796	10.808	10.819	10.831	10.843	10.854	10.866	10.877	10.889	10.901	10.913
1570	10.913	10.924	10.936	10.948	10.959	10.971	10.983	10.994	11.006	11.018	11.029
1580	11.029	11.041	11.053	11.064	11.076	11.088	11.099	11.111	11.123	11.134	11.146
1590	11.146	11.158	11.169	11.181	11.193	11.205	11.216	11.228	11.240	11.251	11.263
1600	11.263	11.275	11.286	11.298	11.310	11.321	11.333	11.345	11.357	11.368	11.380
1610	11.380	11.392	11.403	11.415	11.427	11.438	11.450	11.462	11.474	11.485	11.497
1620	11.497	11.509	11.520	11.532	11.544	11.555	11.567	11.579	11.591	11.602	11.614
1630	11.614	11.626	11.637	11.649	11.661	11.673	11.684	11.696	11.708	11.719	11.731
1640	11.731	11.743	11.754	11.766	11.778	11.790	11.801	11.813	11.825	11.836	11.848
1650	11.848	11.860	11.871	11.883	11.895	11.907	11.918	11.930	11.942	11.953	11.965
1660	11.965	11.977	11.988	12.000	12.012	12.024	12.035	12.047	12.059	12.070	12.082
1670	12.082	12.094	12.105	12.117	12.129	12.141	12.152	12.164	12.176	12.187	12.199
1680	12.199	12.211	12.222	12.234	12.246	12.257	12.269	12.281	12.292	12.304	12.316
1690	12.316	12.327	12.339	12.351	12.363	12.374	12.386	12.398	12.409	12.421	12.433
1700	12.433	12.444	12.456	12.468	12.479	12.491	12.503	12.514	12.526	12.538	12.549
1710	12.549	12.561	12.572	12.584	12.596	12.607	12.619	12.631	12.642	12.654	12.666
1720	12.666	12.677	12.689	12.701	12.712	12.724	12.736	12.747	12.759	12.770	12.782
1730	12.782	12.794	12.805	12.817	12.829	12.840	12.852	12.863	12.875	12.887	12.898

ITS-90 Table for Type B thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
1740	12.898	12.910	12.921	12.933	12.945	12.956	12.968	12.980	12.991	13.003	13.014
1750	13.014	13.026	13.037	13.049	13.061	13.072	13.084	13.095	13.107	13.119	13.130
1760	13.130	13.142	13.153	13.165	13.176	13.188	13.200	13.211	13.223	13.234	13.246
1770	13.246	13.257	13.269	13.280	13.292	13.304	13.315	13.327	13.338	13.350	13.361
1780	13.361	13.373	13.384	13.396	13.407	13.419	13.430	13.442	13.453	13.465	13.476
1790	13.476	13.488	13.499	13.511	13.522	13.534	13.545	13.557	13.568	13.580	13.591
1800	13.591	13.603	13.614	13.626	13.637	13.649	13.660	13.672	13.683	13.694	13.706
1810	13.706	13.717	13.729	13.740	13.752	13.763	13.775	13.786	13.797	13.809	13.820
1820	13.820										

This section contains coefficients for type B thermocouples for the two subranges of temperature listed below. The coefficients are in units of °C and mV and are listed in the order of constant* term up to the highest order.
The equation is of the form E = sum(i=0 to n) c_i t^i.

Temperature Range (°C)
0.000 to 630.615
630.615 to 1820.000

name: reference function on ITS-90
type: B
temperature units: °C
emf units: mV

range: 0.000, 630.615, 6
0.000000000000E+00
-0.246508183460E-03
0.590404211710E-05
-0.132579316360E-08
0.156682919010E-11
-0.169445292400E-14
0.629903470940E-18

range: 630.615, 1820.000, 8
-0.389381686210E+01
0.285717474700E-01
-0.848851047850E-04
0.157852801640E-06
-0.168353448640E-09
0.111097940130E-12
-0.445154310330E-16
0.989756408210E-20
-0.937913302890E-24

This section contains coefficients of approximate inverse functions for type B thermocouples for the subranges of temperature and voltage listed below. The range of errors of the approximate inverse function for each subrange is also given.
The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order.
The equation is of the form t_90 = d_0 + d_1*E + d_2*E^2 + ... + d_n*E^n, where E is in mV and t_90 is in °C.

Temperature range (°C)	Voltage range (mV)	Error range (° C)
250. to 700.	0.291 to 2.431	-0.02 to 0.03
700. to 1800.	2.431 to 13.820	-0.01 to 0.02

Inverse coefficients for type B:

Temperature Range:	250. 700.	700. 1820.
Voltage Range:	0.291 2.431	2.431 13.820
	9.8423321E+01	2.1315071E+02
	6.9971500E+02	2.8510504E+02
	-8.4765304E+02	-5.2742887E+01
	1.0052644E+03	9.9160804E+00
	-8.3345952E+02	-1.2965303E+00
	4.5508542E+02	1.1195870E-01
	-1.5523037E+02	-6.0625199E-03
	2.9886750E+01	1.8661696E-04
	-2.4742860E+00	-2.4878585E-06
Error Range:	-0.02 0.03	-0.01 0.02

ITS-90 Table for Type N thermocouple

Thermoelectric Voltage in mV

°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
-270	-4.345										
-260	-4.336	-4.337	-4.339	-4.340	-4.341	-4.342	-4.343	-4.344	-4.344	-4.345	-4.345
-250	-4.313	-4.316	-4.319	-4.321	-4.324	-4.326	-4.328	-4.330	-4.332	-4.334	-4.336
-240	-4.277	-4.281	-4.285	-4.289	-4.293	-4.297	-4.300	-4.304	-4.307	-4.310	-4.313
-230	-4.226	-4.232	-4.238	-4.243	-4.248	-4.254	-4.258	-4.263	-4.268	-4.273	-4.277
-220	-4.162	-4.169	-4.176	-4.183	-4.189	-4.196	-4.202	-4.209	-4.215	-4.221	-4.226
-210	-4.083	-4.091	-4.100	-4.108	-4.116	-4.124	-4.132	-4.140	-4.147	-4.154	-4.162
-200	-3.990	-4.000	-4.010	-4.020	-4.029	-4.038	-4.048	-4.057	-4.066	-4.074	-4.083
-190	-3.884	-3.896	-3.907	-3.918	-3.928	-3.939	-3.950	-3.960	-3.970	-3.980	-3.990
-180	-3.766	-3.778	-3.790	-3.803	-3.815	-3.827	-3.838	-3.850	-3.862	-3.873	-3.884
-170	-3.634	-3.648	-3.662	-3.675	-3.688	-3.702	-3.715	-3.728	-3.740	-3.753	-3.766
-160	-3.491	-3.506	-3.521	-3.535	-3.550	-3.564	-3.578	-3.593	-3.607	-3.621	-3.634
-150	-3.336	-3.352	-3.368	-3.384	-3.400	-3.415	-3.431	-3.446	-3.461	-3.476	-3.491
-140	-3.171	-3.188	-3.205	-3.221	-3.238	-3.255	-3.271	-3.288	-3.304	-3.320	-3.336
-130	-2.994	-3.012	-3.030	-3.048	-3.066	-3.084	-3.101	-3.119	-3.136	-3.153	-3.171
-120	-2.808	-2.827	-2.846	-2.865	-2.883	-2.902	-2.921	-2.939	-2.958	-2.976	-2.994
-110	-2.612	-2.632	-2.652	-2.672	-2.691	-2.711	-2.730	-2.750	-2.769	-2.789	-2.808
-100	-2.407	-2.428	-2.448	-2.469	-2.490	-2.510	-2.531	-2.551	-2.571	-2.592	-2.612
-90	-2.193	-2.215	-2.237	-2.258	-2.280	-2.301	-2.322	-2.344	-2.365	-2.386	-2.407
-80	-1.972	-1.995	-2.017	-2.039	-2.062	-2.084	-2.106	-2.128	-2.150	-2.172	-2.193
-70	-1.744	-1.767	-1.790	-1.813	-1.836	-1.859	-1.882	-1.905	-1.927	-1.950	-1.972
-60	-1.509	-1.533	-1.557	-1.580	-1.604	-1.627	-1.651	-1.674	-1.698	-1.721	-1.744
-50	-1.269	-1.293	-1.317	-1.341	-1.366	-1.390	-1.414	-1.438	-1.462	-1.485	-1.509
-40	-1.023	-1.048	-1.072	-1.097	-1.122	-1.146	-1.171	-1.195	-1.220	-1.244	-1.269
-30	-0.772	-0.798	-0.823	-0.848	-0.873	-0.898	-0.923	-0.948	-0.973	-0.998	-1.023
-20	-0.518	-0.544	-0.569	-0.595	-0.620	-0.646	-0.671	-0.696	-0.722	-0.747	-0.772
-10	-0.260	-0.286	-0.312	-0.338	-0.364	-0.390	-0.415	-0.441	-0.467	-0.492	-0.518
0	0.000	-0.026	-0.052	-0.078	-0.104	-0.131	-0.157	-0.183	-0.209	-0.234	-0.260

°C	0	1	2	3	4	5	6	7	8	9	10
0	0.000	0.026	0.052	0.078	0.104	0.130	0.156	0.182	0.208	0.235	0.261
10	0.261	0.287	0.313	0.340	0.366	0.393	0.419	0.446	0.472	0.499	0.525
20	0.525	0.552	0.578	0.605	0.632	0.659	0.685	0.712	0.739	0.766	0.793
30	0.793	0.820	0.847	0.874	0.901	0.928	0.955	0.983	1.010	1.037	1.065
40	1.065	1.092	1.119	1.147	1.174	1.202	1.229	1.257	1.284	1.312	1.340
50	1.340	1.368	1.395	1.423	1.451	1.479	1.507	1.535	1.563	1.591	1.619
60	1.619	1.647	1.675	1.703	1.732	1.760	1.788	1.817	1.845	1.873	1.902
70	1.902	1.930	1.959	1.988	2.016	2.045	2.074	2.102	2.131	2.160	2.189
80	2.189	2.218	2.247	2.276	2.305	2.334	2.363	2.392	2.421	2.450	2.480
90	2.480	2.509	2.538	2.568	2.597	2.626	2.656	2.685	2.715	2.744	2.774
100	2.774	2.804	2.833	2.863	2.893	2.923	2.953	2.983	3.012	3.042	3.072
110	3.072	3.102	3.133	3.163	3.193	3.223	3.253	3.283	3.314	3.344	3.374
120	3.374	3.405	3.435	3.466	3.496	3.527	3.557	3.588	3.619	3.649	3.680
130	3.680	3.711	3.742	3.772	3.803	3.834	3.865	3.896	3.927	3.958	3.989
140	3.989	4.020	4.051	4.083	4.114	4.145	4.176	4.208	4.239	4.270	4.302
150	4.302	4.333	4.365	4.396	4.428	4.459	4.491	4.523	4.554	4.586	4.618
160	4.618	4.650	4.681	4.713	4.745	4.777	4.809	4.841	4.873	4.905	4.937
170	4.937	4.969	5.001	5.033	5.066	5.098	5.130	5.162	5.195	5.227	5.259
180	5.259	5.292	5.324	5.357	5.389	5.422	5.454	5.487	5.520	5.552	5.585
190	5.585	5.618	5.650	5.683	5.716	5.749	5.782	5.815	5.847	5.880	5.913
200	5.913	5.946	5.979	6.013	6.046	6.079	6.112	6.145	6.178	6.211	6.245
210	6.245	6.278	6.311	6.345	6.378	6.411	6.445	6.478	6.512	6.545	6.579
220	6.579	6.612	6.646	6.680	6.713	6.747	6.781	6.814	6.848	6.882	6.916
230	6.916	6.949	6.983	7.017	7.051	7.085	7.119	7.153	7.187	7.221	7.255
240	7.255	7.289	7.323	7.357	7.392	7.426	7.460	7.494	7.528	7.563	7.597
250	7.597	7.631	7.666	7.700	7.734	7.769	7.803	7.838	7.872	7.907	7.941
260	7.941	7.976	8.010	8.045	8.080	8.114	8.149	8.184	8.218	8.253	8.288

ITS-90 Table for Type N thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
270	8.288	8.323	8.358	8.392	8.427	8.462	8.497	8.532	8.567	8.602	8.637
280	8.637	8.672	8.707	8.742	8.777	8.812	8.847	8.882	8.918	8.953	8.988
290	8.988	9.023	9.058	9.094	9.129	9.164	9.200	9.235	9.270	9.306	9.341
300	9.341	9.377	9.412	9.448	9.483	9.519	9.554	9.590	9.625	9.661	9.696
310	9.696	9.732	9.768	9.803	9.839	9.875	9.910	9.946	9.982	10.018	10.054
320	10.054	10.089	10.125	10.161	10.197	10.233	10.269	10.305	10.341	10.377	10.413
330	10.413	10.449	10.485	10.521	10.557	10.593	10.629	10.665	10.701	10.737	10.774
340	10.774	10.810	10.846	10.882	10.918	10.955	10.991	11.027	11.064	11.100	11.136
350	11.136	11.173	11.209	11.245	11.282	11.318	11.355	11.391	11.428	11.464	11.501
360	11.501	11.537	11.574	11.610	11.647	11.683	11.720	11.757	11.793	11.830	11.867
370	11.867	11.903	11.940	11.977	12.013	12.050	12.087	12.124	12.160	12.197	12.234
380	12.234	12.271	12.308	12.345	12.382	12.418	12.455	12.492	12.529	12.566	12.603
390	12.603	12.640	12.677	12.714	12.751	12.788	12.825	12.862	12.899	12.937	12.974
400	12.974	13.011	13.048	13.085	13.122	13.159	13.197	13.234	13.271	13.308	13.346
410	13.346	13.383	13.420	13.457	13.495	13.532	13.569	13.607	13.644	13.682	13.719
420	13.719	13.756	13.794	13.831	13.869	13.906	13.944	13.981	14.019	14.056	14.094
430	14.094	14.131	14.169	14.206	14.244	14.281	14.319	14.356	14.394	14.432	14.469
440	14.469	14.507	14.545	14.582	14.620	14.658	14.695	14.733	14.771	14.809	14.846
450	14.846	14.884	14.922	14.960	14.998	15.035	15.073	15.111	15.149	15.187	15.225
460	15.225	15.262	15.300	15.338	15.376	15.414	15.452	15.490	15.528	15.566	15.604
470	15.604	15.642	15.680	15.718	15.756	15.794	15.832	15.870	15.908	15.946	15.984
480	15.984	16.022	16.060	16.099	16.137	16.175	16.213	16.251	16.289	16.327	16.366
490	16.366	16.404	16.442	16.480	16.518	16.557	16.595	16.633	16.671	16.710	16.748
500	16.748	16.786	16.824	16.863	16.901	16.939	16.978	17.016	17.054	17.093	17.131
510	17.131	17.169	17.208	17.246	17.285	17.323	17.361	17.400	17.438	17.477	17.515
520	17.515	17.554	17.592	17.630	17.669	17.707	17.746	17.784	17.823	17.861	17.900
530	17.900	17.938	17.977	18.016	18.054	18.093	18.131	18.170	18.208	18.247	18.286
540	18.286	18.324	18.363	18.401	18.440	18.479	18.517	18.556	18.595	18.633	18.672
550	18.672	18.711	18.749	18.788	18.827	18.865	18.904	18.943	18.982	19.020	19.059
560	19.059	19.098	19.136	19.175	19.214	19.253	19.292	19.330	19.369	19.408	19.447
570	19.447	19.485	19.524	19.563	19.602	19.641	19.680	19.718	19.757	19.796	19.835
580	19.835	19.874	19.913	19.952	19.990	20.029	20.068	20.107	20.146	20.185	20.224
590	20.224	20.263	20.302	20.341	20.379	20.418	20.457	20.496	20.535	20.574	20.613
600	20.613	20.652	20.691	20.730	20.769	20.808	20.847	20.886	20.925	20.964	21.003
610	21.003	21.042	21.081	21.120	21.159	21.198	21.237	21.276	21.315	21.354	21.393
620	21.393	21.432	21.471	21.510	21.549	21.588	21.628	21.667	21.706	21.745	21.784
630	21.784	21.823	21.862	21.901	21.940	21.979	22.018	22.058	22.097	22.136	22.175
640	22.175	22.214	22.253	22.292	22.331	22.370	22.410	22.449	22.488	22.527	22.566
650	22.566	22.605	22.644	22.684	22.723	22.762	22.801	22.840	22.879	22.919	22.958
660	22.958	22.997	23.036	23.075	23.115	23.154	23.193	23.232	23.271	23.311	23.350
670	23.350	23.389	23.428	23.467	23.507	23.546	23.585	23.624	23.663	23.703	23.742
680	23.742	23.781	23.820	23.860	23.899	23.938	23.977	24.016	24.056	24.095	24.134
690	24.134	24.173	24.213	24.252	24.291	24.330	24.370	24.409	24.448	24.487	24.527
700	24.527	24.566	24.605	24.644	24.684	24.723	24.762	24.801	24.841	24.880	24.919
710	24.919	24.959	24.998	25.037	25.076	25.116	25.155	25.194	25.233	25.273	25.312
720	25.312	25.351	25.391	25.430	25.469	25.508	25.548	25.587	25.626	25.666	25.705
730	25.705	25.744	25.783	25.823	25.862	25.901	25.941	25.980	26.019	26.058	26.098
740	26.098	26.137	26.176	26.216	26.255	26.294	26.333	26.373	26.412	26.451	26.491
750	26.491	26.530	26.569	26.608	26.648	26.687	26.726	26.766	26.805	26.844	26.883
760	26.883	26.923	26.962	27.001	27.041	27.080	27.119	27.158	27.198	27.237	27.276
770	27.276	27.316	27.355	27.394	27.433	27.473	27.512	27.551	27.591	27.630	27.669
780	27.669	27.708	27.748	27.787	27.826	27.866	27.905	27.944	27.983	28.023	28.062
790	28.062	28.101	28.140	28.180	28.219	28.258	28.297	28.337	28.376	28.415	28.455
800	28.455	28.494	28.533	28.572	28.612	28.651	28.690	28.729	28.769	28.808	28.847
810	28.847	28.886	28.926	28.965	29.004	29.043	29.083	29.122	29.161	29.200	29.239
820	29.239	29.279	29.318	29.357	29.396	29.436	29.475	29.514	29.553	29.592	29.632
830	29.632	29.671	29.710	29.749	29.789	29.828	29.867	29.906	29.945	29.985	30.024
840	30.024	30.063	30.102	30.141	30.181	30.220	30.259	30.298	30.337	30.376	30.416

ITS-90 Table for Type N thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
850	30.416	30.455	30.494	30.533	30.572	30.611	30.651	30.690	30.729	30.768	30.807
860	30.807	30.846	30.886	30.925	30.964	31.003	31.042	31.081	31.120	31.160	31.199
870	31.199	31.238	31.277	31.316	31.355	31.394	31.433	31.473	31.512	31.551	31.590
880	31.590	31.629	31.668	31.707	31.746	31.785	31.824	31.863	31.903	31.942	31.981
890	31.981	32.020	32.059	32.098	32.137	32.176	32.215	32.254	32.293	32.332	32.371
900	32.371	32.410	32.449	32.488	32.527	32.566	32.605	32.644	32.683	32.722	32.761
910	32.761	32.800	32.839	32.878	32.917	32.956	32.995	33.034	33.073	33.112	33.151
920	33.151	33.190	33.229	33.268	33.307	33.346	33.385	33.424	33.463	33.502	33.541
930	33.541	33.580	33.619	33.658	33.697	33.736	33.774	33.813	33.852	33.891	33.930
940	33.930	33.969	34.008	34.047	34.086	34.124	34.163	34.202	34.241	34.280	34.319
950	34.319	34.358	34.396	34.435	34.474	34.513	34.552	34.591	34.629	34.668	34.707
960	34.707	34.746	34.785	34.823	34.862	34.901	34.940	34.979	35.017	35.056	35.095
970	35.095	35.134	35.172	35.211	35.250	35.289	35.327	35.366	35.405	35.444	35.482
980	35.482	35.521	35.560	35.598	35.637	35.676	35.714	35.753	35.792	35.831	35.869
990	35.869	35.908	35.946	35.985	36.024	36.062	36.101	36.140	36.178	36.217	36.256
1000	36.256	36.294	36.333	36.371	36.410	36.449	36.487	36.526	36.564	36.603	36.641
1010	36.641	36.680	36.718	36.757	36.796	36.834	36.873	36.911	36.950	36.988	37.027
1020	37.027	37.065	37.104	37.142	37.181	37.219	37.258	37.296	37.334	37.373	37.411
1030	37.411	37.450	37.488	37.527	37.565	37.603	37.642	37.680	37.719	37.757	37.795
1040	37.795	37.834	37.872	37.911	37.949	37.987	38.026	38.064	38.102	38.141	38.179
1050	38.179	38.217	38.256	38.294	38.332	38.370	38.409	38.447	38.485	38.524	38.562
1060	38.562	38.600	38.638	38.677	38.715	38.753	38.791	38.829	38.868	38.906	38.944
1070	38.944	38.982	39.020	39.059	39.097	39.135	39.173	39.211	39.249	39.287	39.326
1080	39.326	39.364	39.402	39.440	39.478	39.516	39.554	39.592	39.630	39.668	39.706
1090	39.706	39.744	39.783	39.821	39.859	39.897	39.935	39.973	40.011	40.049	40.087
1100	40.087	40.125	40.163	40.201	40.238	40.276	40.314	40.352	40.390	40.428	40.466
1110	40.466	40.504	40.542	40.580	40.618	40.655	40.693	40.731	40.769	40.807	40.845
1120	40.845	40.883	40.920	40.958	40.996	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	41.600
1140	41.600	41.638	41.675	41.713	41.751	41.788	41.826	41.864	41.901	41.939	41.976
1150	41.976	42.014	42.052	42.089	42.127	42.164	42.202	42.239	42.277	42.314	42.352
1160	42.352	42.390	42.427	42.465	42.502	42.540	42.577	42.614	42.652	42.689	42.727
1170	42.727	42.764	42.802	42.839	42.877	42.914	42.951	42.989	43.026	43.064	43.101
1180	43.101	43.138	43.176	43.213	43.250	43.288	43.325	43.362	43.399	43.437	43.474
1190	43.474	43.511	43.549	43.586	43.623	43.660	43.698	43.735	43.772	43.809	43.846
1200	43.846	43.884	43.921	43.958	43.995	44.032	44.069	44.106	44.144	44.181	44.218
1210	44.218	44.255	44.292	44.329	44.366	44.403	44.440	44.477	44.514	44.551	44.588
1220	44.588	44.625	44.662	44.699	44.736	44.773	44.810	44.847	44.884	44.921	44.958
1230	44.958	44.995	45.032	45.069	45.105	45.142	45.179	45.216	45.253	45.290	45.326
1240	45.326	45.363	45.400	45.437	45.474	45.510	45.547	45.584	45.621	45.657	45.694
1250	45.694	45.731	45.767	45.804	45.841	45.877	45.914	45.951	45.987	46.024	46.060
1260	46.060	46.097	46.133	46.170	46.207	46.243	46.280	46.316	46.353	46.389	46.425
1270	46.425	46.462	46.498	46.535	46.571	46.608	46.644	46.680	46.717	46.753	46.789
1280	46.789	46.826	46.862	46.898	46.935	46.971	47.007	47.043	47.079	47.116	47.152
1290	47.152	47.188	47.224	47.260	47.296	47.333	47.369	47.405	47.441	47.477	47.513
1300	47.513										

This section contains coefficients for type N thermocouples for the two subranges of temperature listed below. The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order. The equation is of the form E = sum(i=0 to n) c_i t^i.

Temperature Range (ºC)
-270.000 to 0.000
0.000 to 1300.000

name: reference function on ITS-90
type: N
temperature units: °C
emf units: mV

range: -270.000, 0.000, 8
0.000000000000E+00
0.261591059620E-01
0.109574842280E-04
-0.938411115540E-07
-0.464120397590E-10
-0.263033577160E-11
-0.226534380030E-13
-0.760893007910E-16
-0.934196678350E-19

range: 0.000, 1300.000, 10
0.000000000000E+00
0.259293946010E-01
0.157101418800E-04
0.438256272370E-07
-0.252611697940E-09
0.643118193390E-12
-0.100634715190E-14
0.997453389920E-18
-0.608632456070E-21
0.208492293390E-24
-0.306821961510E-28

This section contains coefficients of approximate inverse functions for type N thermocouples for the subranges of temperature and voltage listed below. The range of errors of the approximate inverse function for each subrange is also given.
The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order.
The equation is of the form t_90 = d_0 + d_1*E + d_2*E^2 + ... + d_n*E^n, where E is in mV and t_90 is in °C.

Temperature range (°C)	Voltage range (mV)	Error range (° C)
-200. to 0.	-3.990 to 0.000	-0.02 to 0.03
0. to 600.	0.000 to 20.613	-0.02 to 0.03
600. to 1300.	20.613 to 47.513	-0.04 to 0.02

Inverse coefficients for type N:

Temperature	-200.	0.	600.
Range:	0.	600.	1300.
Voltage	-3.990	0.000	20.613
Range:	0.000	20.613	47.513
	0.0000000E+00	0.00000E+00	1.972485E+01
	3.8436847E+01	3.86896E+01	3.300943E+01
	1.1010485E+00	-1.08267E+00	-3.915159E-01
	5.2229312E+00	4.70205E-02	9.855391E-03
	7.2060525E+00	-2.12169E-06	-1.274371E-04
	5.8488586E+00	-1.17272E-04	7.767022E-07
	2.7754916E+00	5.39280E-06	0.000000E+00
	7.7075166E-01	-7.98156E-08	0.000000E+00
	1.1582665E-01	0.00000E+00	0.000000E+00
	7.3138868E-03	0.00000E+00	0.000000E+00
Error	-0.02	-0.02	-0.04
Range:	0.03	0.03	0.02

ITS-90 Table for Type K thermocouple

Thermoelectric Voltage in mV

°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
-270	-6.458										
-260	-6.441	-6.444	-6.446	-6.448	-6.450	-6.452	-6.453	-6.455	-6.456	-6.457	-6.458
-250	-6.404	-6.408	-6.413	-6.417	-6.421	-6.425	-6.429	-6.432	-6.435	-6.438	-6.441
-240	-6.344	-6.351	-6.358	-6.364	-6.370	-6.377	-6.382	-6.388	-6.393	-6.399	-6.404
-230	-6.262	-6.271	-6.280	-6.289	-6.297	-6.306	-6.314	-6.322	-6.329	-6.337	-6.344
-220	-6.158	-6.170	-6.181	-6.192	-6.202	-6.213	-6.223	-6.233	-6.243	-6.252	-6.262
-210	-6.035	-6.048	-6.061	-6.074	-6.087	-6.099	-6.111	-6.123	-6.135	-6.147	-6.158
-200	-5.891	-5.907	-5.922	-5.936	-5.951	-5.965	-5.980	-5.994	-6.007	-6.021	-6.035
-190	-5.730	-5.747	-5.763	-5.780	-5.797	-5.813	-5.829	-5.845	-5.861	-5.876	-5.891
-180	-5.550	-5.569	-5.588	-5.606	-5.624	-5.642	-5.660	-5.678	-5.695	-5.713	-5.730
-170	-5.354	-5.374	-5.395	-5.415	-5.435	-5.454	-5.474	-5.493	-5.512	-5.531	-5.550
-160	-5.141	-5.163	-5.185	-5.207	-5.228	-5.250	-5.271	-5.292	-5.313	-5.333	-5.354
-150	-4.913	-4.936	-4.960	-4.983	-5.006	-5.029	-5.052	-5.074	-5.097	-5.119	-5.141
-140	-4.669	-4.694	-4.719	-4.744	-4.768	-4.793	-4.817	-4.841	-4.865	-4.889	-4.913
-130	-4.411	-4.437	-4.463	-4.490	-4.516	-4.542	-4.567	-4.593	-4.618	-4.644	-4.669
-120	-4.138	-4.166	-4.194	-4.221	-4.249	-4.276	-4.303	-4.330	-4.357	-4.384	-4.411
-110	-3.852	-3.882	-3.911	-3.939	-3.968	-3.997	-4.025	-4.054	-4.082	-4.110	-4.138
-100	-3.554	-3.584	-3.614	-3.645	-3.675	-3.705	-3.734	-3.764	-3.794	-3.823	-3.852
-90	-3.243	-3.274	-3.306	-3.337	-3.368	-3.400	-3.431	-3.462	-3.492	-3.523	-3.554
-80	-2.920	-2.953	-2.986	-3.018	-3.050	-3.083	-3.115	-3.147	-3.179	-3.211	-3.243
-70	-2.587	-2.620	-2.654	-2.688	-2.721	-2.755	-2.788	-2.821	-2.854	-2.887	-2.920
-60	-2.243	-2.278	-2.312	-2.347	-2.382	-2.416	-2.450	-2.485	-2.519	-2.553	-2.587
-50	-1.889	-1.925	-1.961	-1.996	-2.032	-2.067	-2.103	-2.138	-2.173	-2.208	-2.243
-40	-1.527	-1.564	-1.600	-1.637	-1.673	-1.709	-1.745	-1.782	-1.818	-1.854	-1.889
-30	-1.156	-1.194	-1.231	-1.268	-1.305	-1.343	-1.380	-1.417	-1.453	-1.490	-1.527
-20	-0.778	-0.816	-0.854	-0.892	-0.930	-0.968	-1.006	-1.043	-1.081	-1.119	-1.156
-10	-0.392	-0.431	-0.470	-0.508	-0.547	-0.586	-0.624	-0.663	-0.701	-0.739	-0.778
0	0.000	-0.039	-0.079	-0.118	-0.157	-0.197	-0.236	-0.275	-0.314	-0.353	-0.392

°C	0	1	2	3	4	5	6	7	8	9	10
0	0.000	0.039	0.079	0.119	0.158	0.198	0.238	0.277	0.317	0.357	0.397
10	0.397	0.437	0.477	0.517	0.557	0.597	0.637	0.677	0.718	0.758	0.798
20	0.798	0.838	0.879	0.919	0.960	1.000	1.041	1.081	1.122	1.163	1.203
30	1.203	1.244	1.285	1.326	1.366	1.407	1.448	1.489	1.530	1.571	1.612
40	1.612	1.653	1.694	1.735	1.776	1.817	1.858	1.899	1.941	1.982	2.023
50	2.023	2.064	2.106	2.147	2.188	2.230	2.271	2.312	2.354	2.395	2.436
60	2.436	2.478	2.519	2.561	2.602	2.644	2.685	2.727	2.768	2.810	2.851
70	2.851	2.893	2.934	2.976	3.017	3.059	3.100	3.142	3.184	3.225	3.267
80	3.267	3.308	3.350	3.391	3.433	3.474	3.516	3.557	3.599	3.640	3.682
90	3.682	3.723	3.765	3.806	3.848	3.889	3.931	3.972	4.013	4.055	4.096
100	4.096	4.138	4.179	4.220	4.262	4.303	4.344	4.385	4.427	4.468	4.509
110	4.509	4.550	4.591	4.633	4.674	4.715	4.756	4.797	4.838	4.879	4.920
120	4.920	4.961	5.002	5.043	5.084	5.124	5.165	5.206	5.247	5.288	5.328
130	5.328	5.369	5.410	5.450	5.491	5.532	5.572	5.613	5.653	5.694	5.735
140	5.735	5.775	5.815	5.856	5.896	5.937	5.977	6.017	6.058	6.098	6.138
150	6.138	6.179	6.219	6.259	6.299	6.339	6.380	6.420	6.460	6.500	6.540
160	6.540	6.580	6.620	6.660	6.701	6.741	6.781	6.821	6.861	6.901	6.941
170	6.941	6.981	7.021	7.060	7.100	7.140	7.180	7.220	7.260	7.300	7.340
180	7.340	7.380	7.420	7.460	7.500	7.540	7.579	7.619	7.659	7.699	7.739
190	7.739	7.779	7.819	7.859	7.899	7.939	7.979	8.019	8.059	8.099	8.138
200	8.138	8.178	8.218	8.258	8.298	8.338	8.378	8.418	8.458	8.499	8.539
210	8.539	8.579	8.619	8.659	8.699	8.739	8.779	8.819	8.860	8.900	8.940
220	8.940	8.980	9.020	9.061	9.101	9.141	9.181	9.222	9.262	9.302	9.343
230	9.343	9.383	9.423	9.464	9.504	9.545	9.585	9.626	9.666	9.707	9.747
240	9.747	9.788	9.828	9.869	9.909	9.950	9.991	10.031	10.072	10.113	10.153
250	10.153	10.194	10.235	10.276	10.316	10.357	10.398	10.439	10.480	10.520	10.561
260	10.561	10.602	10.643	10.684	10.725	10.766	10.807	10.848	10.889	10.930	10.971

ITS-90 Table for Type K thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
270	10.971	11.012	11.053	11.094	11.135	11.176	11.217	11.259	11.300	11.341	11.382
280	11.382	11.423	11.465	11.506	11.547	11.588	11.630	11.671	11.712	11.753	11.795
290	11.795	11.836	11.877	11.919	11.960	12.001	12.043	12.084	12.126	12.167	12.209
300	12.209	12.250	12.291	12.333	12.374	12.416	12.457	12.499	12.540	12.582	12.624
310	12.624	12.665	12.707	12.748	12.790	12.831	12.873	12.915	12.956	12.998	13.040
320	13.040	13.081	13.123	13.165	13.206	13.248	13.290	13.331	13.373	13.415	13.457
330	13.457	13.498	13.540	13.582	13.624	13.665	13.707	13.749	13.791	13.833	13.874
340	13.874	13.916	13.958	14.000	14.042	14.084	14.126	14.167	14.209	14.251	14.293
350	14.293	14.335	14.377	14.419	14.461	14.503	14.545	14.587	14.629	14.671	14.713
360	14.713	14.755	14.797	14.839	14.881	14.923	14.965	15.007	15.049	15.091	15.133
370	15.133	15.175	15.217	15.259	15.301	15.343	15.385	15.427	15.469	15.511	15.554
380	15.554	15.596	15.638	15.680	15.722	15.764	15.806	15.849	15.891	15.933	15.975
390	15.975	16.017	16.059	16.102	16.144	16.186	16.228	16.270	16.313	16.355	16.397
400	16.397	16.439	16.482	16.524	16.566	16.608	16.651	16.693	16.735	16.778	16.820
410	16.820	16.862	16.904	16.947	16.989	17.031	17.074	17.116	17.158	17.201	17.243
420	17.243	17.285	17.328	17.370	17.413	17.455	17.497	17.540	17.582	17.624	17.667
430	17.667	17.709	17.752	17.794	17.837	17.879	17.921	17.964	18.006	18.049	18.091
440	18.091	18.134	18.176	18.218	18.261	18.303	18.346	18.388	18.431	18.473	18.516
450	18.516	18.558	18.601	18.643	18.686	18.728	18.771	18.813	18.856	18.898	18.941
460	18.941	18.983	19.026	19.068	19.111	19.154	19.196	19.239	19.281	19.324	19.366
470	19.366	19.409	19.451	19.494	19.537	19.579	19.622	19.664	19.707	19.750	19.792
480	19.792	19.835	19.877	19.920	19.962	20.005	20.048	20.090	20.133	20.175	20.218
490	20.218	20.261	20.303	20.346	20.389	20.431	20.474	20.516	20.559	20.602	20.644
500	20.644	20.687	20.730	20.772	20.815	20.857	20.900	20.943	20.985	21.028	21.071
510	21.071	21.113	21.156	21.199	21.241	21.284	21.326	21.369	21.412	21.454	21.497
520	21.497	21.540	21.582	21.625	21.668	21.710	21.753	21.796	21.838	21.881	21.924
530	21.924	21.966	22.009	22.052	22.094	22.137	22.179	22.222	22.265	22.307	22.350
540	22.350	22.393	22.435	22.478	22.521	22.563	22.606	22.649	22.691	22.734	22.776
550	22.776	22.819	22.862	22.904	22.947	22.990	23.032	23.075	23.117	23.160	23.203
560	23.203	23.245	23.288	23.331	23.373	23.416	23.458	23.501	23.544	23.586	23.629
570	23.629	23.671	23.714	23.757	23.799	23.842	23.884	23.927	23.970	24.012	24.055
580	24.055	24.097	24.140	24.182	24.225	24.267	24.310	24.353	24.395	24.438	24.480
590	24.480	24.523	24.565	24.608	24.650	24.693	24.735	24.778	24.820	24.863	24.905
600	24.905	24.948	24.990	25.033	25.075	25.118	25.160	25.203	25.245	25.288	25.330
610	25.330	25.373	25.415	25.458	25.500	25.543	25.585	25.627	25.670	25.712	25.755
620	25.755	25.797	25.840	25.882	25.924	25.967	26.009	26.052	26.094	26.136	26.179
630	26.179	26.221	26.263	26.306	26.348	26.390	26.433	26.475	26.517	26.560	26.602
640	26.602	26.644	26.687	26.729	26.771	26.814	26.856	26.898	26.940	26.983	27.025
650	27.025	27.067	27.109	27.152	27.194	27.236	27.278	27.320	27.363	27.405	27.447
660	27.447	27.489	27.531	27.574	27.616	27.658	27.700	27.742	27.784	27.826	27.869
670	27.869	27.911	27.953	27.995	28.037	28.079	28.121	28.163	28.205	28.247	28.289
680	28.289	28.332	28.374	28.416	28.458	28.500	28.542	28.584	28.626	28.668	28.710
690	28.710	28.752	28.794	28.835	28.877	28.919	28.961	29.003	29.045	29.087	29.129
700	29.129	29.171	29.213	29.255	29.297	29.338	29.380	29.422	29.464	29.506	29.548
710	29.548	29.589	29.631	29.673	29.715	29.757	29.798	29.840	29.882	29.924	29.965
720	29.965	30.007	30.049	30.090	30.132	30.174	30.216	30.257	30.299	30.341	30.382
730	30.382	30.424	30.466	30.507	30.549	30.590	30.632	30.674	30.715	30.757	30.798
740	30.798	30.840	30.881	30.923	30.964	31.006	31.047	31.089	31.130	31.172	31.213
750	31.213	31.255	31.296	31.338	31.379	31.421	31.462	31.504	31.545	31.586	31.628
760	31.628	31.669	31.710	31.752	31.793	31.834	31.876	31.917	31.958	32.000	32.041
770	32.041	32.082	32.124	32.165	32.206	32.247	32.289	32.330	32.371	32.412	32.453
780	32.453	32.495	32.536	32.577	32.618	32.659	32.700	32.742	32.783	32.824	32.865
790	32.865	32.906	32.947	32.988	33.029	33.070	33.111	33.152	33.193	33.234	33.275
800	33.275	33.316	33.357	33.398	33.439	33.480	33.521	33.562	33.603	33.644	33.685
810	33.685	33.726	33.767	33.808	33.848	33.889	33.930	33.971	34.012	34.053	34.093
820	34.093	34.134	34.175	34.216	34.257	34.297	34.338	34.379	34.420	34.460	34.501
830	34.501	34.542	34.582	34.623	34.664	34.704	34.745	34.786	34.826	34.867	34.908
840	34.908	34.948	34.989	35.029	35.070	35.110	35.151	35.192	35.232	35.273	35.313

ITS-90 Table for Type K thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
850	35.313	35.354	35.394	35.435	35.475	35.516	35.556	35.596	35.637	35.677	35.718
860	35.718	35.758	35.798	35.839	35.879	35.920	35.960	36.000	36.041	36.081	36.121
870	36.121	36.162	36.202	36.242	36.282	36.323	36.363	36.403	36.443	36.484	36.524
880	36.524	36.564	36.604	36.644	36.685	36.725	36.765	36.805	36.845	36.885	36.925
890	36.925	36.965	37.006	37.046	37.086	37.126	37.166	37.206	37.246	37.286	37.326
900	37.326	37.366	37.406	37.446	37.486	37.526	37.566	37.606	37.646	37.686	37.725
910	37.725	37.765	37.805	37.845	37.885	37.925	37.965	38.005	38.044	38.084	38.124
920	38.124	38.164	38.204	38.243	38.283	38.323	38.363	38.402	38.442	38.482	38.522
930	38.522	38.561	38.601	38.641	38.680	38.720	38.760	38.799	38.839	38.878	38.918
940	38.918	38.958	38.997	39.037	39.076	39.116	39.155	39.195	39.235	39.274	39.314
950	39.314	39.353	39.393	39.432	39.471	39.511	39.550	39.590	39.629	39.669	39.708
960	39.708	39.747	39.787	39.826	39.866	39.905	39.944	39.984	40.023	40.062	40.101
970	40.101	40.141	40.180	40.219	40.259	40.298	40.337	40.376	40.415	40.455	40.494
980	40.494	40.533	40.572	40.611	40.651	40.690	40.729	40.768	40.807	40.846	40.885
990	40.885	40.924	40.963	41.002	41.042	41.081	41.120	41.159	41.198	41.237	41.276
1000	41.276	41.315	41.354	41.393	41.431	41.470	41.509	41.548	41.587	41.626	41.665
1010	41.665	41.704	41.743	41.781	41.820	41.859	41.898	41.937	41.976	42.014	42.053
1020	42.053	42.092	42.131	42.169	42.208	42.247	42.286	42.324	42.363	42.402	42.440
1030	42.440	42.479	42.518	42.556	42.595	42.633	42.672	42.711	42.749	42.788	42.826
1040	42.826	42.865	42.903	42.942	42.980	43.019	43.057	43.096	43.134	43.173	43.211
1050	43.211	43.250	43.288	43.327	43.365	43.403	43.442	43.480	43.518	43.557	43.595
1060	43.595	43.633	43.672	43.710	43.748	43.787	43.825	43.863	43.901	43.940	43.978
1070	43.978	44.016	44.054	44.092	44.130	44.169	44.207	44.245	44.283	44.321	44.359
1080	44.359	44.397	44.435	44.473	44.512	44.550	44.588	44.626	44.664	44.702	44.740
1090	44.740	44.778	44.816	44.853	44.891	44.929	44.967	45.005	45.043	45.081	45.119
1100	45.119	45.157	45.194	45.232	45.270	45.308	45.346	45.383	45.421	45.459	45.497
1110	45.497	45.534	45.572	45.610	45.647	45.685	45.723	45.760	45.798	45.836	45.873
1120	45.873	45.911	45.948	45.986	46.024	46.061	46.099	46.136	46.174	46.211	46.249
1130	46.249	46.286	46.324	46.361	46.398	46.436	46.473	46.511	46.548	46.585	46.623
1140	46.623	46.660	46.697	46.735	46.772	46.809	46.847	46.884	46.921	46.958	46.995
1150	46.995	47.033	47.070	47.107	47.144	47.181	47.218	47.256	47.293	47.330	47.367
1160	47.367	47.404	47.441	47.478	47.515	47.552	47.589	47.626	47.663	47.700	47.737
1170	47.737	47.774	47.811	47.848	47.884	47.921	47.958	47.995	48.032	48.069	48.105
1180	48.105	48.142	48.179	48.216	48.252	48.289	48.326	48.363	48.399	48.436	48.473
1190	48.473	48.509	48.546	48.582	48.619	48.656	48.692	48.729	48.765	48.802	48.838
1200	48.838	48.875	48.911	48.948	48.984	49.021	49.057	49.093	49.130	49.166	49.202
1210	49.202	49.239	49.275	49.311	49.348	49.384	49.420	49.456	49.493	49.529	49.565
1220	49.565	49.601	49.637	49.674	49.710	49.746	49.782	49.818	49.854	49.890	49.926
1230	49.926	49.962	49.998	50.034	50.070	50.106	50.142	50.178	50.214	50.250	50.286
1240	50.286	50.322	50.358	50.393	50.429	50.465	50.501	50.537	50.572	50.608	50.644
1250	50.644	50.680	50.715	50.751	50.787	50.822	50.858	50.894	50.929	50.965	51.000
1260	51.000	51.036	51.071	51.107	51.142	51.178	51.213	51.249	51.284	51.320	51.355
1270	51.355	51.391	51.426	51.461	51.497	51.532	51.567	51.603	51.638	51.673	51.708
1280	51.708	51.744	51.779	51.814	51.849	51.885	51.920	51.955	51.990	52.025	52.060
1290	52.060	52.095	52.130	52.165	52.200	52.235	52.270	52.305	52.340	52.375	52.410
1300	52.410	52.445	52.480	52.515	52.550	52.585	52.620	52.654	52.689	52.724	52.759
1310	52.759	52.794	52.828	52.863	52.898	52.932	52.967	53.002	53.037	53.071	53.106
1320	53.106	53.140	53.175	53.210	53.244	53.279	53.313	53.348	53.382	53.417	53.451
1330	53.451	53.486	53.520	53.555	53.589	53.623	53.658	53.692	53.727	53.761	53.795
1340	53.795	53.830	53.864	53.898	53.932	53.967	54.001	54.035	54.069	54.104	54.138
1350	54.138	54.172	54.206	54.240	54.274	54.308	54.343	54.377	54.411	54.445	54.479
1360	54.479	54.513	54.547	54.581	54.615	54.649	54.683	54.717	54.751	54.785	54.819
1370	54.819	54.852	54.886								

This section contains coefficients for type K thermocouples for the two subranges of temperature listed below. The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order. The equation below 0 °C is of the form E = sum(i=0 to n) c_i t^i.

The equation above 0 °C is of the form
E = sum(i=0 to n) c_i t^i + a0 exp(a1 (t - a2)^2).

Temperature Range (°C)
-270.000 to 0.000
0.000 to 1372.000

name: reference function on ITS-90
type: K
temperature units: °C
emf units: mV

range: -270.000, 0.000, 10
0.000000000000E+00
0.394501280250E-01
0.236223735980E-04
-0.328589067840E-06
-0.499048287770E-08
-0.675090591730E-10
-0.574103274280E-12
-0.310888728940E-14
-0.104516093650E-16
-0.198892668780E-19
-0.163226974860E-22

range: 0.000, 1372.000, 9
-0.176004136860E-01
0.389212049750E-01
0.185587700320E-04
-0.994575928740E-07
0.318409457190E-09
-0.560728448890E-12
0.560750590590E-15
-0.320207200030E-18
0.971511471520E-22
-0.121047212750E-25

exponential:
a0 = 0.118597600000E+00
a1 = -0.118343200000E-03
a2 = 0.126968600000E+03

This section contains coefficients of approximate inverse functions for type K thermocouples for the subranges of temperature and voltage listed below. The range of errors of the approximate inverse function for each subrange is also given. The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order.
The equation is of the form t_90 = d_0 + d_1*E + d_2*E^2 + ... + d_n*E^n, where E is in mV and t_90 is in °C.

Temperature range (°C)	Voltage range (mV)	Error range (° C)
-200. to 0.	-5.891 to 0.000	-0.02 to 0.04
0. to 500.	0.000 to 20.644	-0.05 to 0.04
500. to 1372.	20.644 to 54.886	-0.05 to 0.06

Inverse coefficients for type K:

Temperature Range:	-200. 0.	0. 500.	500. 1372.
Voltage Range:	-5.891 0.000	0.000 20.644	20.644 54.886
	0.0000000E+00	0.000000E+00	-1.318058E+02
	2.5173462E+01	2.508355E+01	4.830222E+01
	-1.1662878E+00	7.860106E-02	-1.646031E+00
	-1.0833638E+00	-2.503131E-01	5.464731E-02
	-8.9773540E-01	8.315270E-02	-9.650715E-04
	-3.7342377E-01	-1.228034E-02	8.802193E-06
	-8.6632643E-02	9.804036E-04	-3.110810E-08
	-1.0450598E-02	-4.413030E-05	0.000000E+00
	-5.1920577E-04	1.057734E-06	0.000000E+00
	0.0000000E+00	-1.052755E-08	0.000000E+00
Error Range:	-0.02 0.04	-0.05 0.04	-0.05 0.06

ITS-90 Table for Type E thermocouple

Thermoelectric Voltage in mV

°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
-270	-9.835										
-260	-9.797	-9.802	-9.808	-9.813	-9.817	-9.821	-9.825	-9.828	-9.831	-9.833	-9.835
-250	-9.718	-9.728	-9.737	-9.746	-9.754	-9.762	-9.770	-9.777	-9.784	-9.790	-9.797
-240	-9.604	-9.617	-9.630	-9.642	-9.654	-9.666	-9.677	-9.688	-9.698	-9.709	-9.718
-230	-9.455	-9.471	-9.487	-9.503	-9.519	-9.534	-9.548	-9.563	-9.577	-9.591	-9.604
-220	-9.274	-9.293	-9.313	-9.331	-9.350	-9.368	-9.386	-9.404	-9.421	-9.438	-9.455
-210	-9.063	-9.085	-9.107	-9.129	-9.151	-9.172	-9.193	-9.214	-9.234	-9.254	-9.274
-200	-8.825	-8.850	-8.874	-8.899	-8.923	-8.947	-8.971	-8.994	-9.017	-9.040	-9.063
-190	-8.561	-8.588	-8.616	-8.643	-8.669	-8.696	-8.722	-8.748	-8.774	-8.799	-8.825
-180	-8.273	-8.303	-8.333	-8.362	-8.391	-8.420	-8.449	-8.477	-8.505	-8.533	-8.561
-170	-7.963	-7.995	-8.027	-8.059	-8.090	-8.121	-8.152	-8.183	-8.213	-8.243	-8.273
-160	-7.632	-7.666	-7.700	-7.733	-7.767	-7.800	-7.833	-7.866	-7.899	-7.931	-7.963
-150	-7.279	-7.315	-7.351	-7.387	-7.423	-7.458	-7.493	-7.528	-7.563	-7.597	-7.632
-140	-6.907	-6.945	-6.983	-7.021	-7.058	-7.096	-7.133	-7.170	-7.206	-7.243	-7.279
-130	-6.516	-6.556	-6.596	-6.636	-6.675	-6.714	-6.753	-6.792	-6.831	-6.869	-6.907
-120	-6.107	-6.149	-6.191	-6.232	-6.273	-6.314	-6.355	-6.396	-6.436	-6.476	-6.516
-110	-5.681	-5.724	-5.767	-5.810	-5.853	-5.896	-5.939	-5.981	-6.023	-6.065	-6.107
-100	-5.237	-5.282	-5.327	-5.372	-5.417	-5.461	-5.505	-5.549	-5.593	-5.637	-5.681
-90	-4.777	-4.824	-4.871	-4.917	-4.963	-5.009	-5.055	-5.101	-5.147	-5.192	-5.237
-80	-4.302	-4.350	-4.398	-4.446	-4.494	-4.542	-4.589	-4.636	-4.684	-4.731	-4.777
-70	-3.811	-3.861	-3.911	-3.960	-4.009	-4.058	-4.107	-4.156	-4.205	-4.254	-4.302
-60	-3.306	-3.357	-3.408	-3.459	-3.510	-3.561	-3.611	-3.661	-3.711	-3.761	-3.811
-50	-2.787	-2.840	-2.892	-2.944	-2.996	-3.048	-3.100	-3.152	-3.204	-3.255	-3.306
-40	-2.255	-2.309	-2.362	-2.416	-2.469	-2.523	-2.576	-2.629	-2.682	-2.735	-2.787
-30	-1.709	-1.765	-1.820	-1.874	-1.929	-1.984	-2.038	-2.093	-2.147	-2.201	-2.255
-20	-1.152	-1.208	-1.264	-1.320	-1.376	-1.432	-1.488	-1.543	-1.599	-1.654	-1.709
-10	-0.582	-0.639	-0.697	-0.754	-0.811	-0.868	-0.925	-0.982	-1.039	-1.095	-1.152
0	0.000	-0.059	-0.117	-0.176	-0.234	-0.292	-0.350	-0.408	-0.466	-0.524	-0.582

°C	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	0.591
10	0.591	0.651	0.711	0.770	0.830	0.890	0.950	1.010	1.071	1.131	1.192
20	1.192	1.252	1.313	1.373	1.434	1.495	1.556	1.617	1.678	1.740	1.801
30	1.801	1.862	1.924	1.986	2.047	2.109	2.171	2.233	2.295	2.357	2.420
40	2.420	2.482	2.545	2.607	2.670	2.733	2.795	2.858	2.921	2.984	3.048
50	3.048	3.111	3.174	3.238	3.301	3.365	3.429	3.492	3.556	3.620	3.685
60	3.685	3.749	3.813	3.877	3.942	4.006	4.071	4.136	4.200	4.265	4.330
70	4.330	4.395	4.460	4.526	4.591	4.656	4.722	4.788	4.853	4.919	4.985
80	4.985	5.051	5.117	5.183	5.249	5.315	5.382	5.448	5.514	5.581	5.648
90	5.648	5.714	5.781	5.848	5.915	5.982	6.049	6.117	6.184	6.251	6.319
100	6.319	6.386	6.454	6.522	6.590	6.658	6.725	6.794	6.862	6.930	6.998
110	6.998	7.066	7.135	7.203	7.272	7.341	7.409	7.478	7.547	7.616	7.685
120	7.685	7.754	7.823	7.892	7.962	8.031	8.101	8.170	8.240	8.309	8.379
130	8.379	8.449	8.519	8.589	8.659	8.729	8.799	8.869	8.940	9.010	9.081
140	9.081	9.151	9.222	9.292	9.363	9.434	9.505	9.576	9.647	9.718	9.789
150	9.789	9.860	9.931	10.003	10.074	10.145	10.217	10.288	10.360	10.432	10.503
160	10.503	10.575	10.647	10.719	10.791	10.863	10.935	11.007	11.080	11.152	11.224
170	11.224	11.297	11.369	11.442	11.514	11.587	11.660	11.733	11.805	11.878	11.951
180	11.951	12.024	12.097	12.170	12.243	12.317	12.390	12.463	12.537	12.610	12.684
190	12.684	12.757	12.831	12.904	12.978	13.052	13.126	13.199	13.273	13.347	13.421
200	13.421	13.495	13.569	13.644	13.718	13.792	13.866	13.941	14.015	14.090	14.164
210	14.164	14.239	14.313	14.388	14.463	14.537	14.612	14.687	14.762	14.837	14.912
220	14.912	14.987	15.062	15.137	15.212	15.287	15.362	15.438	15.513	15.588	15.664
230	15.664	15.739	15.815	15.890	15.966	16.041	16.117	16.193	16.269	16.344	16.420
240	16.420	16.496	16.572	16.648	16.724	16.800	16.876	16.952	17.028	17.104	17.181
250	17.181	17.257	17.333	17.409	17.486	17.562	17.639	17.715	17.792	17.868	17.945
260	17.945	18.021	18.098	18.175	18.252	18.328	18.405	18.482	18.559	18.636	18.713

ITS-90 Table for Type E thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
270	18.713	18.790	18.867	18.944	19.021	19.098	19.175	19.252	19.330	19.407	19.484
280	19.484	19.561	19.639	19.716	19.794	19.871	19.948	20.026	20.103	20.181	20.259
290	20.259	20.336	20.414	20.492	20.569	20.647	20.725	20.803	20.880	20.958	21.036
300	21.036	21.114	21.192	21.270	21.348	21.426	21.504	21.582	21.660	21.739	21.817
310	21.817	21.895	21.973	22.051	22.130	22.208	22.286	22.365	22.443	22.522	22.600
320	22.600	22.678	22.757	22.835	22.914	22.993	23.071	23.150	23.228	23.307	23.386
330	23.386	23.464	23.543	23.622	23.701	23.780	23.858	23.937	24.016	24.095	24.174
340	24.174	24.253	24.332	24.411	24.490	24.569	24.648	24.727	24.806	24.885	24.964
350	24.964	25.044	25.123	25.202	25.281	25.360	25.440	25.519	25.598	25.678	25.757
360	25.757	25.836	25.916	25.995	26.075	26.154	26.233	26.313	26.392	26.472	26.552
370	26.552	26.631	26.711	26.790	26.870	26.950	27.029	27.109	27.189	27.268	27.348
380	27.348	27.428	27.507	27.587	27.667	27.747	27.827	27.907	27.986	28.066	28.146
390	28.146	28.226	28.306	28.386	28.466	28.546	28.626	28.706	28.786	28.866	28.946
400	28.946	29.026	29.106	29.186	29.266	29.346	29.427	29.507	29.587	29.667	29.747
410	29.747	29.827	29.908	29.988	30.068	30.148	30.229	30.309	30.389	30.470	30.550
420	30.550	30.630	30.711	30.791	30.871	30.952	31.032	31.112	31.193	31.273	31.354
430	31.354	31.434	31.515	31.595	31.676	31.756	31.837	31.917	31.998	32.078	32.159
440	32.159	32.239	32.320	32.400	32.481	32.562	32.642	32.723	32.803	32.884	32.965
450	32.965	33.045	33.126	33.207	33.287	33.368	33.449	33.529	33.610	33.691	33.772
460	33.772	33.852	33.933	34.014	34.095	34.175	34.256	34.337	34.418	34.498	34.579
470	34.579	34.660	34.741	34.822	34.902	34.983	35.064	35.145	35.226	35.307	35.387
480	35.387	35.468	35.549	35.630	35.711	35.792	35.873	35.954	36.034	36.115	36.196
490	36.196	36.277	36.358	36.439	36.520	36.601	36.682	36.763	36.843	36.924	37.005
500	37.005	37.086	37.167	37.248	37.329	37.410	37.491	37.572	37.653	37.734	37.815
510	37.815	37.896	37.977	38.058	38.139	38.220	38.300	38.381	38.462	38.543	38.624
520	38.624	38.705	38.786	38.867	38.948	39.029	39.110	39.191	39.272	39.353	39.434
530	39.434	39.515	39.596	39.677	39.758	39.839	39.920	40.001	40.082	40.163	40.243
540	40.243	40.324	40.405	40.486	40.567	40.648	40.729	40.810	40.891	40.972	41.053
550	41.053	41.134	41.215	41.296	41.377	41.457	41.538	41.619	41.700	41.781	41.862
560	41.862	41.943	42.024	42.105	42.185	42.266	42.347	42.428	42.509	42.590	42.671
570	42.671	42.751	42.832	42.913	42.994	43.075	43.156	43.236	43.317	43.398	43.479
580	43.479	43.560	43.640	43.721	43.802	43.883	43.963	44.044	44.125	44.206	44.286
590	44.286	44.367	44.448	44.529	44.609	44.690	44.771	44.851	44.932	45.013	45.093
600	45.093	45.174	45.255	45.335	45.416	45.497	45.577	45.658	45.738	45.819	45.900
610	45.900	45.980	46.061	46.141	46.222	46.302	46.383	46.463	46.544	46.624	46.705
620	46.705	46.785	46.866	46.946	47.027	47.107	47.188	47.268	47.349	47.429	47.509
630	47.509	47.590	47.670	47.751	47.831	47.911	47.992	48.072	48.152	48.233	48.313
640	48.313	48.393	48.474	48.554	48.634	48.715	48.795	48.875	48.955	49.035	49.116
650	49.116	49.196	49.276	49.356	49.436	49.517	49.597	49.677	49.757	49.837	49.917
660	49.917	49.997	50.077	50.157	50.238	50.318	50.398	50.478	50.558	50.638	50.718
670	50.718	50.798	50.878	50.958	51.038	51.118	51.197	51.277	51.357	51.437	51.517
680	51.517	51.597	51.677	51.757	51.837	51.916	51.996	52.076	52.156	52.236	52.315
690	52.315	52.395	52.475	52.555	52.634	52.714	52.794	52.873	52.953	53.033	53.112
700	53.112	53.192	53.272	53.351	53.431	53.510	53.590	53.670	53.749	53.829	53.908
710	53.908	53.988	54.067	54.147	54.226	54.306	54.385	54.465	54.544	54.624	54.703
720	54.703	54.782	54.862	54.941	55.021	55.100	55.179	55.259	55.338	55.417	55.497
730	55.497	55.576	55.655	55.734	55.814	55.893	55.972	56.051	56.131	56.210	56.289
740	56.289	56.368	56.447	56.526	56.606	56.685	56.764	56.843	56.922	57.001	57.080
750	57.080	57.159	57.238	57.317	57.396	57.475	57.554	57.633	57.712	57.791	57.870
760	57.870	57.949	58.028	58.107	58.186	58.265	58.343	58.422	58.501	58.580	58.659
770	58.659	58.738	58.816	58.895	58.974	59.053	59.131	59.210	59.289	59.367	59.446
780	59.446	59.525	59.604	59.682	59.761	59.839	59.918	59.997	60.075	60.154	60.232
790	60.232	60.311	60.390	60.468	60.547	60.625	60.704	60.782	60.860	60.939	61.017
800	61.017	61.096	61.174	61.253	61.331	61.409	61.488	61.566	61.644	61.723	61.801
810	61.801	61.879	61.958	62.036	62.114	62.192	62.271	62.349	62.427	62.505	62.583
820	62.583	62.662	62.740	62.818	62.896	62.974	63.052	63.130	63.208	63.286	63.364
830	63.364	63.442	63.520	63.598	63.676	63.754	63.832	63.910	63.988	64.066	64.144
840	64.144	64.222	64.300	64.377	64.455	64.533	64.611	64.689	64.766	64.844	64.922

ITS-90 Table for Type E thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
850	64.922	65.000	65.077	65.155	65.233	65.310	65.388	65.465	65.543	65.621	65.698
860	65.698	65.776	65.853	65.931	66.008	66.086	66.163	66.241	66.318	66.396	66.473
870	66.473	66.550	66.628	66.705	66.782	66.860	66.937	67.014	67.092	67.169	67.246
880	67.246	67.323	67.400	67.478	67.555	67.632	67.709	67.786	67.863	67.940	68.017
890	68.017	68.094	68.171	68.248	68.325	68.402	68.479	68.556	68.633	68.710	68.787
900	68.787	68.863	68.940	69.017	69.094	69.171	69.247	69.324	69.401	69.477	69.554
910	69.554	69.631	69.707	69.784	69.860	69.937	70.013	70.090	70.166	70.243	70.319
920	70.319	70.396	70.472	70.548	70.625	70.701	70.777	70.854	70.930	71.006	71.082
930	71.082	71.159	71.235	71.311	71.387	71.463	71.539	71.615	71.692	71.768	71.844
940	71.844	71.920	71.996	72.072	72.147	72.223	72.299	72.375	72.451	72.527	72.603
950	72.603	72.678	72.754	72.830	72.906	72.981	73.057	73.133	73.208	73.284	73.360
960	73.360	73.435	73.511	73.586	73.662	73.738	73.813	73.889	73.964	74.040	74.115
970	74.115	74.190	74.266	74.341	74.417	74.492	74.567	74.643	74.718	74.793	74.869
980	74.869	74.944	75.019	75.095	75.170	75.245	75.320	75.395	75.471	75.546	75.621
990	75.621	75.696	75.771	75.847	75.922	75.997	76.072	76.147	76.223	76.298	76.373
1000	76.373										

This section contains coefficients for type E thermocouples for the two subranges of temperature listed below. The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order. The equation is of the form E = sum(i=0 to n) c_i t^i.

Temperature Range (°C)
-270.000 to 0.000
0.000 to 1000.000

name: reference function on ITS-90
type: E
temperature units: °C
emf units: mV

range: -270.000, 0.000, 13
0.000000000000E+00
0.586655087080E-01
0.454109771240E-04
-0.779980486860E-06
-0.258001608430E-07
-0.594525830570E-09
-0.932140586670E-11
-0.102876055340E-12
-0.803701236210E-15
-0.439794973910E-17
-0.164147763550E-19
-0.396736195160E-22
-0.558273287210E-25
-0.346578420130E-28

range: 0.000, 1000.000, 10
0.000000000000E+00
0.586655087100E-01
0.450322755820E-04
0.289084072120E-07
-0.330568966520E-09
0.650244032700E-12
-0.191974955040E-15
-0.125366004970E-17
0.214892175690E-20
-0.143880417820E-23
0.359608994810E-27

This section contains coefficients of approximate inverse functions for type E thermocouples for the subranges of temperature and voltage listed below. The range of errors of the approximate inverse function for each subrange is also given.
The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order.
The equation is of the form t_90 = d_0 + d_1*E + d_2*E^2 + ... + d_n*E^n, where E is in mV and t_90 is in °C.

Temperature range (°C)	Voltage range (mV)	Error range (° C)
-200. to 0.	-8.825 to 0.000	-0.01 to 0.03
0. to 1000.	0.000 to 76.373	-0.02 to 0.02

Inverse coefficients for type E:

Temperature Range:	-200. 0.	0. 1000.
Voltage Range:	-8.825 0.000	0.000 76.373
	0.0000000E+00	0.0000000E+00
	1.6977288E+01	1.7057035E+01
	-4.3514970E-01	-2.3301759E-01
	-1.5859697E-01	6.5435585E-03
	-9.2502871E-02	-7.3562749E-05
	-2.6084314E-02	-1.7896001E-06
	-4.1360199E-03	8.4036165E-08
	-3.4034030E-04	-1.3735879E-09
	-1.1564890E-05	1.0629823E-11
	0.0000000E+00	-3.2447087E-14
Error Range:	-0.01 0.03	-0.02 0.02

ITS-90 Table for Type T thermocouple

Thermoelectric Voltage in mV

°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
-270	-6.258										
-260	-6.232	-6.236	-6.239	-6.242	-6.245	-6.248	-6.251	-6.253	-6.255	-6.256	-6.258
-250	-6.180	-6.187	-6.193	-6.198	-6.204	-6.209	-6.214	-6.219	-6.223	-6.228	-6.232
-240	-6.105	-6.114	-6.122	-6.130	-6.138	-6.146	-6.153	-6.160	-6.167	-6.174	-6.180
-230	-6.007	-6.017	-6.028	-6.038	-6.049	-6.059	-6.068	-6.078	-6.087	-6.096	-6.105
-220	-5.888	-5.901	-5.914	-5.926	-5.938	-5.950	-5.962	-5.973	-5.985	-5.996	-6.007
-210	-5.753	-5.767	-5.782	-5.795	-5.809	-5.823	-5.836	-5.850	-5.863	-5.876	-5.888
-200	-5.603	-5.619	-5.634	-5.650	-5.665	-5.680	-5.695	-5.710	-5.724	-5.739	-5.753
-190	-5.439	-5.456	-5.473	-5.489	-5.506	-5.523	-5.539	-5.555	-5.571	-5.587	-5.603
-180	-5.261	-5.279	-5.297	-5.316	-5.334	-5.351	-5.369	-5.387	-5.404	-5.421	-5.439
-170	-5.070	-5.089	-5.109	-5.128	-5.148	-5.167	-5.186	-5.205	-5.224	-5.242	-5.261
-160	-4.865	-4.886	-4.907	-4.928	-4.949	-4.969	-4.989	-5.010	-5.030	-5.050	-5.070
-150	-4.648	-4.671	-4.693	-4.715	-4.737	-4.759	-4.780	-4.802	-4.823	-4.844	-4.865
-140	-4.419	-4.443	-4.466	-4.489	-4.512	-4.535	-4.558	-4.581	-4.604	-4.626	-4.648
-130	-4.177	-4.202	-4.226	-4.251	-4.275	-4.300	-4.324	-4.348	-4.372	-4.395	-4.419
-120	-3.923	-3.949	-3.975	-4.000	-4.026	-4.052	-4.077	-4.102	-4.127	-4.152	-4.177
-110	-3.657	-3.684	-3.711	-3.738	-3.765	-3.791	-3.818	-3.844	-3.871	-3.897	-3.923
-100	-3.379	-3.407	-3.435	-3.463	-3.491	-3.519	-3.547	-3.574	-3.602	-3.629	-3.657
-90	-3.089	-3.118	-3.148	-3.177	-3.206	-3.235	-3.264	-3.293	-3.322	-3.350	-3.379
-80	-2.788	-2.818	-2.849	-2.879	-2.910	-2.940	-2.970	-3.000	-3.030	-3.059	-3.089
-70	-2.476	-2.507	-2.539	-2.571	-2.602	-2.633	-2.664	-2.695	-2.726	-2.757	-2.788
-60	-2.153	-2.186	-2.218	-2.251	-2.283	-2.316	-2.348	-2.380	-2.412	-2.444	-2.476
-50	-1.819	-1.853	-1.887	-1.920	-1.954	-1.987	-2.021	-2.054	-2.087	-2.120	-2.153
-40	-1.475	-1.510	-1.545	-1.579	-1.614	-1.648	-1.683	-1.717	-1.751	-1.785	-1.819
-30	-1.121	-1.157	-1.192	-1.228	-1.264	-1.299	-1.335	-1.370	-1.405	-1.440	-1.475
-20	-0.757	-0.794	-0.830	-0.867	-0.904	-0.940	-0.976	-1.013	-1.049	-1.085	-1.121
-10	-0.383	-0.421	-0.459	-0.496	-0.534	-0.571	-0.608	-0.646	-0.683	-0.720	-0.757
0	0.000	-0.039	-0.077	-0.116	-0.154	-0.193	-0.231	-0.269	-0.307	-0.345	-0.383

°C	0	1	2	3	4	5	6	7	8	9	10
0	0.000	0.039	0.078	0.117	0.156	0.195	0.234	0.273	0.312	0.352	0.391
10	0.391	0.431	0.470	0.510	0.549	0.589	0.629	0.669	0.709	0.749	0.790
20	0.790	0.830	0.870	0.911	0.951	0.992	1.033	1.074	1.114	1.155	1.196
30	1.196	1.238	1.279	1.320	1.362	1.403	1.445	1.486	1.528	1.570	1.612
40	1.612	1.654	1.696	1.738	1.780	1.823	1.865	1.908	1.950	1.993	2.036
50	2.036	2.079	2.122	2.165	2.208	2.251	2.294	2.338	2.381	2.425	2.468
60	2.468	2.512	2.556	2.600	2.643	2.687	2.732	2.776	2.820	2.864	2.909
70	2.909	2.953	2.998	3.043	3.087	3.132	3.177	3.222	3.267	3.312	3.358
80	3.358	3.403	3.448	3.494	3.539	3.585	3.631	3.677	3.722	3.768	3.814
90	3.814	3.860	3.907	3.953	3.999	4.046	4.092	4.138	4.185	4.232	4.279
100	4.279	4.325	4.372	4.419	4.466	4.513	4.561	4.608	4.655	4.702	4.750
110	4.750	4.798	4.845	4.893	4.941	4.988	5.036	5.084	5.132	5.180	5.228
120	5.228	5.277	5.325	5.373	5.422	5.470	5.519	5.567	5.616	5.665	5.714
130	5.714	5.763	5.812	5.861	5.910	5.959	6.008	6.057	6.107	6.156	6.206
140	6.206	6.255	6.305	6.355	6.404	6.454	6.504	6.554	6.604	6.654	6.704
150	6.704	6.754	6.805	6.855	6.905	6.956	7.006	7.057	7.107	7.158	7.209
160	7.209	7.260	7.310	7.361	7.412	7.463	7.515	7.566	7.617	7.668	7.720
170	7.720	7.771	7.823	7.874	7.926	7.977	8.029	8.081	8.133	8.185	8.237
180	8.237	8.289	8.341	8.393	8.445	8.497	8.550	8.602	8.654	8.707	8.759
190	8.759	8.812	8.865	8.917	8.970	9.023	9.076	9.129	9.182	9.235	9.288
200	9.288	9.341	9.395	9.448	9.501	9.555	9.608	9.662	9.715	9.769	9.822
210	9.822	9.876	9.930	9.984	10.038	10.092	10.146	10.200	10.254	10.308	10.362
220	10.362	10.417	10.471	10.525	10.580	10.634	10.689	10.743	10.798	10.853	10.907
230	10.907	10.962	11.017	11.072	11.127	11.182	11.237	11.292	11.347	11.403	11.458
240	11.458	11.513	11.569	11.624	11.680	11.735	11.791	11.846	11.902	11.958	12.013
250	12.013	12.069	12.125	12.181	12.237	12.293	12.349	12.405	12.461	12.518	12.574
260	12.574	12.630	12.687	12.743	12.799	12.856	12.912	12.969	13.026	13.082	13.139

ITS-90 Table for Type T thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
270	13.139	13.196	13.253	13.310	13.366	13.423	13.480	13.537	13.595	13.652	13.709
280	13.709	13.766	13.823	13.881	13.938	13.995	14.053	14.110	14.168	14.226	14.283
290	14.283	14.341	14.399	14.456	14.514	14.572	14.630	14.688	14.746	14.804	14.862
300	14.862	14.920	14.978	15.036	15.095	15.153	15.211	15.270	15.328	15.386	15.445
310	15.445	15.503	15.562	15.621	15.679	15.738	15.797	15.856	15.914	15.973	16.032
320	16.032	16.091	16.150	16.209	16.268	16.327	16.387	16.446	16.505	16.564	16.624
330	16.624	16.683	16.742	16.802	16.861	16.921	16.980	17.040	17.100	17.159	17.219
340	17.219	17.279	17.339	17.399	17.458	17.518	17.578	17.638	17.698	17.759	17.819
350	17.819	17.879	17.939	17.999	18.060	18.120	18.180	18.241	18.301	18.362	18.422
360	18.422	18.483	18.543	18.604	18.665	18.725	18.786	18.847	18.908	18.969	19.030
370	19.030	19.091	19.152	19.213	19.274	19.335	19.396	19.457	19.518	19.579	19.641
380	19.641	19.702	19.763	19.825	19.886	19.947	20.009	20.070	20.132	20.193	20.255
390	20.255	20.317	20.378	20.440	20.502	20.563	20.625	20.687	20.748	20.810	20.872
400	20.872										

This section contains coefficients for type T thermocouples for the two subranges of temperature listed below. The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order. The equation is of the form E = sum(i=0 to n) c_i t^i.

Temperature Range (°C)
-270.000 to 0.000
0.000 °C to 400.000

name: reference function on ITS-90
type: T
temperature units: °C
emf units: mV

range: -270.000, 0.000, 14
0.000000000000E+00
0.387481063640E-01
0.441944343470E-04
0.118443231050E-06
0.200329735540E-07
0.901380195590E-09
0.226511565930E-10
0.360711542050E-12
0.384939398830E-14
0.282135219250E-16
0.142515947790E-18
0.487686622860E-21
0.107955392700E-23
0.139450270620E-26
0.797951539270E-30

range: 0.000, 400.000, 8
0.000000000000E+00
0.387481063640E-01
0.332922278800E-04
0.206182434040E-06
-0.218822568460E-08
0.109968809280E-10
-0.308157587720E-13
0.454791352900E-16
-0.275129016730E-19

This section contains coefficients of approximate inverse functions for type T thermocouples for the subranges of temperature and voltage listed below. The range of errors of the approximate inverse function for each subrange is also given.
The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order.
The equation is of the form t_90 = d_0 + d_1*E + d_2*E^2 + ... + d_n*E^n, where E is in mV and t_90 is in °C.

Temperature range (°C)	Voltage range (mV)	Error range (° C)
-200. to 0.	-5.603 to 0.000	-0.02 to 0.04
.0 to 400.	0.000 to 20.872	-0.03 to 0.03

Inverse coefficients for type T:

Temperature Range:	-200.	0.
	0.	400.
Voltage Range:	-5.603	0.000
	0.000	20.872

0.0000000E+00	0.000000E+00
2.5949192E+01	2.592800E+01
-2.1316967E-01	-7.602961E-01
7.9018692E-01	4.637791E-02
4.2527777E-01	-2.165394E-03
1.3304473E-01	6.048144E-05
2.0241446E-02	-7.293422E-07
1.2668171E-03	0.000000E+00

Error Range:	-0.02	-0.03
	0.04	0.03

ITS-90 Table for Type J thermocouple

Thermoelectric Voltage in mV

°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
-210	-8.095										
-200	-7.890	-7.912	-7.934	-7.955	-7.976	-7.996	-8.017	-8.037	-8.057	-8.076	-8.095
-190	-7.659	-7.683	-7.707	-7.731	-7.755	-7.778	-7.801	-7.824	-7.846	-7.868	-7.890
-180	-7.403	-7.429	-7.456	-7.482	-7.508	-7.534	-7.559	-7.585	-7.610	-7.634	-7.659
-170	-7.123	-7.152	-7.181	-7.209	-7.237	-7.265	-7.293	-7.321	-7.348	-7.376	-7.403
-160	-6.821	-6.853	-6.883	-6.914	-6.944	-6.975	-7.005	-7.035	-7.064	-7.094	-7.123
-150	-6.500	-6.533	-6.566	-6.598	-6.631	-6.663	-6.695	-6.727	-6.759	-6.790	-6.821
-140	-6.159	-6.194	-6.229	-6.263	-6.298	-6.332	-6.366	-6.400	-6.433	-6.467	-6.500
-130	-5.801	-5.838	-5.874	-5.910	-5.946	-5.982	-6.018	-6.054	-6.089	-6.124	-6.159
-120	-5.426	-5.465	-5.503	-5.541	-5.578	-5.616	-5.653	-5.690	-5.727	-5.764	-5.801
-110	-5.037	-5.076	-5.116	-5.155	-5.194	-5.233	-5.272	-5.311	-5.350	-5.388	-5.426
-100	-4.633	-4.674	-4.714	-4.755	-4.796	-4.836	-4.877	-4.917	-4.957	-4.997	-5.037
-90	-4.215	-4.257	-4.300	-4.342	-4.384	-4.425	-4.467	-4.509	-4.550	-4.591	-4.633
-80	-3.786	-3.829	-3.872	-3.916	-3.959	-4.002	-4.045	-4.088	-4.130	-4.173	-4.215
-70	-3.344	-3.389	-3.434	-3.478	-3.522	-3.566	-3.610	-3.654	-3.698	-3.742	-3.786
-60	-2.893	-2.938	-2.984	-3.029	-3.075	-3.120	-3.165	-3.210	-3.255	-3.300	-3.344
-50	-2.431	-2.478	-2.524	-2.571	-2.617	-2.663	-2.709	-2.755	-2.801	-2.847	-2.893
-40	-1.961	-2.008	-2.055	-2.103	-2.150	-2.197	-2.244	-2.291	-2.338	-2.385	-2.431
-30	-1.482	-1.530	-1.578	-1.626	-1.674	-1.722	-1.770	-1.818	-1.865	-1.913	-1.961
-20	-0.995	-1.044	-1.093	-1.142	-1.190	-1.239	-1.288	-1.336	-1.385	-1.433	-1.482
-10	-0.501	-0.550	-0.600	-0.650	-0.699	-0.749	-0.798	-0.847	-0.896	-0.946	-0.995
0	0.000	-0.050	-0.101	-0.151	-0.201	-0.251	-0.301	-0.351	-0.401	-0.451	-0.501

°C	0	1	2	3	4	5	6	7	8	9	10
0	0.000	0.050	0.101	0.151	0.202	0.253	0.303	0.354	0.405	0.456	0.507
10	0.507	0.558	0.609	0.660	0.711	0.762	0.814	0.865	0.916	0.968	1.019
20	1.019	1.071	1.122	1.174	1.226	1.277	1.329	1.381	1.433	1.485	1.537
30	1.537	1.589	1.641	1.693	1.745	1.797	1.849	1.902	1.954	2.006	2.059
40	2.059	2.111	2.164	2.216	2.269	2.322	2.374	2.427	2.480	2.532	2.585
50	2.585	2.638	2.691	2.744	2.797	2.850	2.903	2.956	3.009	3.062	3.116
60	3.116	3.169	3.222	3.275	3.329	3.382	3.436	3.489	3.543	3.596	3.650
70	3.650	3.703	3.757	3.810	3.864	3.918	3.971	4.025	4.079	4.133	4.187
80	4.187	4.240	4.294	4.348	4.402	4.456	4.510	4.564	4.618	4.672	4.726
90	4.726	4.781	4.835	4.889	4.943	4.997	5.052	5.106	5.160	5.215	5.269
100	5.269	5.323	5.378	5.432	5.487	5.541	5.595	5.650	5.705	5.759	5.814
110	5.814	5.868	5.923	5.977	6.032	6.087	6.141	6.196	6.251	6.306	6.360
120	6.360	6.415	6.470	6.525	6.579	6.634	6.689	6.744	6.799	6.854	6.909
130	6.909	6.964	7.019	7.074	7.129	7.184	7.239	7.294	7.349	7.404	7.459
140	7.459	7.514	7.569	7.624	7.679	7.734	7.789	7.844	7.900	7.955	8.010
150	8.010	8.065	8.120	8.175	8.231	8.286	8.341	8.396	8.452	8.507	8.562
160	8.562	8.618	8.673	8.728	8.783	8.839	8.894	8.949	9.005	9.060	9.115
170	9.115	9.171	9.226	9.282	9.337	9.392	9.448	9.503	9.559	9.614	9.669
180	9.669	9.725	9.780	9.836	9.891	9.947	10.002	10.057	10.113	10.168	10.224
190	10.224	10.279	10.335	10.390	10.446	10.501	10.557	10.612	10.668	10.723	10.779
200	10.779	10.834	10.890	10.945	11.001	11.056	11.112	11.167	11.223	11.278	11.334
210	11.334	11.389	11.445	11.501	11.556	11.612	11.667	11.723	11.778	11.834	11.889
220	11.889	11.945	12.000	12.056	12.111	12.167	12.222	12.278	12.334	12.389	12.445
230	12.445	12.500	12.556	12.611	12.667	12.722	12.778	12.833	12.889	12.944	13.000
240	13.000	13.056	13.111	13.167	13.222	13.278	13.333	13.389	13.444	13.500	13.555
250	13.555	13.611	13.666	13.722	13.777	13.833	13.888	13.944	13.999	14.055	14.110
260	14.110	14.166	14.221	14.277	14.332	14.388	14.443	14.499	14.554	14.609	14.665
270	14.665	14.720	14.776	14.831	14.887	14.942	14.998	15.053	15.109	15.164	15.219
280	15.219	15.275	15.330	15.386	15.441	15.496	15.552	15.607	15.663	15.718	15.773
290	15.773	15.829	15.884	15.940	15.995	16.050	16.106	16.161	16.216	16.272	16.327
300	16.327	16.383	16.438	16.493	16.549	16.604	16.659	16.715	16.770	16.825	16.881
310	16.881	16.936	16.991	17.046	17.102	17.157	17.212	17.268	17.323	17.378	17.434
320	17.434	17.489	17.544	17.599	17.655	17.710	17.765	17.820	17.876	17.931	17.986

ITS-90 Table for Type J thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
330	17.986	18.041	18.097	18.152	18.207	18.262	18.318	18.373	18.428	18.483	18.538
340	18.538	18.594	18.649	18.704	18.759	18.814	18.870	18.925	18.980	19.035	19.090
350	19.090	19.146	19.201	19.256	19.311	19.366	19.422	19.477	19.532	19.587	19.642
360	19.642	19.697	19.753	19.808	19.863	19.918	19.973	20.028	20.083	20.139	20.194
370	20.194	20.249	20.304	20.359	20.414	20.469	20.525	20.580	20.635	20.690	20.745
380	20.745	20.800	20.855	20.911	20.966	21.021	21.076	21.131	21.186	21.241	21.297
390	21.297	21.352	21.407	21.462	21.517	21.572	21.627	21.683	21.738	21.793	21.848
400	21.848	21.903	21.958	22.014	22.069	22.124	22.179	22.234	22.289	22.345	22.400
410	22.400	22.455	22.510	22.565	22.620	22.676	22.731	22.786	22.841	22.896	22.952
420	22.952	23.007	23.062	23.117	23.172	23.228	23.283	23.338	23.393	23.449	23.504
430	23.504	23.559	23.614	23.670	23.725	23.780	23.835	23.891	23.946	24.001	24.057
440	24.057	24.112	24.167	24.223	24.278	24.333	24.389	24.444	24.499	24.555	24.610
450	24.610	24.665	24.721	24.776	24.832	24.887	24.943	24.998	25.053	25.109	25.164
460	25.164	25.220	25.275	25.331	25.386	25.442	25.497	25.553	25.608	25.664	25.720
470	25.720	25.775	25.831	25.886	25.942	25.998	26.053	26.109	26.165	26.220	26.276
480	26.276	26.332	26.387	26.443	26.499	26.555	26.610	26.666	26.722	26.778	26.834
490	26.834	26.889	26.945	27.001	27.057	27.113	27.169	27.225	27.281	27.337	27.393
500	27.393	27.449	27.505	27.561	27.617	27.673	27.729	27.785	27.841	27.897	27.953
510	27.953	28.010	28.066	28.122	28.178	28.234	28.291	28.347	28.403	28.460	28.516
520	28.516	28.572	28.629	28.685	28.741	28.798	28.854	28.911	28.967	29.024	29.080
530	29.080	29.137	29.194	29.250	29.307	29.363	29.420	29.477	29.534	29.590	29.647
540	29.647	29.704	29.761	29.818	29.874	29.931	29.988	30.045	30.102	30.159	30.216
550	30.216	30.273	30.330	30.387	30.444	30.502	30.559	30.616	30.673	30.730	30.788
560	30.788	30.845	30.902	30.960	31.017	31.074	31.132	31.189	31.247	31.304	31.362
570	31.362	31.419	31.477	31.535	31.592	31.650	31.708	31.766	31.823	31.881	31.939
580	31.939	31.997	32.055	32.113	32.171	32.229	32.287	32.345	32.403	32.461	32.519
590	32.519	32.577	32.636	32.694	32.752	32.810	32.869	32.927	32.985	33.044	33.102
600	33.102	33.161	33.219	33.278	33.337	33.395	33.454	33.513	33.571	33.630	33.689
610	33.689	33.748	33.807	33.866	33.925	33.984	34.043	34.102	34.161	34.220	34.279
620	34.279	34.338	34.397	34.457	34.516	34.575	34.635	34.694	34.754	34.813	34.873
630	34.873	34.932	34.992	35.051	35.111	35.171	35.230	35.290	35.350	35.410	35.470
640	35.470	35.530	35.590	35.650	35.710	35.770	35.830	35.890	35.950	36.010	36.071
650	36.071	36.131	36.191	36.252	36.312	36.373	36.433	36.494	36.554	36.615	36.675
660	36.675	36.736	36.797	36.858	36.918	36.979	37.040	37.101	37.162	37.223	37.284
670	37.284	37.345	37.406	37.467	37.528	37.590	37.651	37.712	37.773	37.835	37.896
680	37.896	37.958	38.019	38.081	38.142	38.204	38.265	38.327	38.389	38.450	38.512
690	38.512	38.574	38.636	38.698	38.760	38.822	38.884	38.946	39.008	39.070	39.132
700	39.132	39.194	39.256	39.318	39.381	39.443	39.505	39.568	39.630	39.693	39.755
710	39.755	39.818	39.880	39.943	40.005	40.068	40.131	40.193	40.256	40.319	40.382
720	40.382	40.445	40.508	40.570	40.633	40.696	40.759	40.822	40.886	40.949	41.012
730	41.012	41.075	41.138	41.201	41.265	41.328	41.391	41.455	41.518	41.581	41.645
740	41.645	41.708	41.772	41.835	41.899	41.962	42.026	42.090	42.153	42.217	42.281
750	42.281	42.344	42.408	42.472	42.536	42.599	42.663	42.727	42.791	42.855	42.919
760	42.919	42.983	43.047	43.111	43.175	43.239	43.303	43.367	43.431	43.495	43.559
770	43.559	43.624	43.688	43.752	43.817	43.881	43.945	44.010	44.074	44.139	44.203
780	44.203	44.267	44.332	44.396	44.461	44.525	44.590	44.655	44.719	44.784	44.848
790	44.848	44.913	44.977	45.042	45.107	45.171	45.236	45.301	45.365	45.430	45.494
800	45.494	45.559	45.624	45.688	45.753	45.818	45.882	45.947	46.011	46.076	46.141
810	46.141	46.205	46.270	46.334	46.399	46.464	46.528	46.593	46.657	46.722	46.786
820	46.786	46.851	46.915	46.980	47.044	47.109	47.173	47.238	47.302	47.367	47.431
830	47.431	47.495	47.560	47.624	47.688	47.753	47.817	47.881	47.946	48.010	48.074
840	48.074	48.138	48.202	48.267	48.331	48.395	48.459	48.523	48.587	48.651	48.715
850	48.715	48.779	48.843	48.907	48.971	49.034	49.098	49.162	49.226	49.290	49.353
860	49.353	49.417	49.481	49.544	49.608	49.672	49.735	49.799	49.862	49.926	49.989
870	49.989	50.052	50.116	50.179	50.243	50.306	50.369	50.432	50.495	50.559	50.622
880	50.622	50.685	50.748	50.811	50.874	50.937	51.000	51.063	51.126	51.188	51.251
890	51.251	51.314	51.377	51.439	51.502	51.565	51.627	51.690	51.752	51.815	51.877
900	51.877	51.940	52.002	52.064	52.127	52.189	52.251	52.314	52.376	52.438	52.500

ITS-90 Table for Type J thermocouple (cont)

Thermoelectric Voltage in mV

°C	0	1	2	3	4	5	6	7	8	9	10
910	52.500	52.562	52.624	52.686	52.748	52.810	52.872	52.934	52.996	53.057	53.119
920	53.119	53.181	53.243	53.304	53.366	53.427	53.489	53.550	53.612	53.673	53.735
930	53.735	53.796	53.857	53.919	53.980	54.041	54.102	54.164	54.225	54.286	54.347
940	54.347	54.408	54.469	54.530	54.591	54.652	54.713	54.773	54.834	54.895	54.956
950	54.956	55.016	55.077	55.138	55.198	55.259	55.319	55.380	55.440	55.501	55.561
960	55.561	55.622	55.682	55.742	55.803	55.863	55.923	55.983	56.043	56.104	56.164
970	56.164	56.224	56.284	56.344	56.404	56.464	56.524	56.584	56.643	56.703	56.763
980	56.763	56.823	56.883	56.942	57.002	57.062	57.121	57.181	57.240	57.300	57.360
990	57.360	57.419	57.479	57.538	57.597	57.657	57.716	57.776	57.835	57.894	57.953
1000	57.953	58.013	58.072	58.131	58.190	58.249	58.309	58.368	58.427	58.486	58.545
1010	58.545	58.604	58.663	58.722	58.781	58.840	58.899	58.957	59.016	59.075	59.134
1020	59.134	59.193	59.252	59.310	59.369	59.428	59.487	59.545	59.604	59.663	59.721
1030	59.721	59.780	59.838	59.897	59.956	60.014	60.073	60.131	60.190	60.248	60.307
1040	60.307	60.365	60.423	60.482	60.540	60.599	60.657	60.715	60.774	60.832	60.890
1050	60.890	60.949	61.007	61.065	61.123	61.182	61.240	61.298	61.356	61.415	61.473
1060	61.473	61.531	61.589	61.647	61.705	61.763	61.822	61.880	61.938	61.996	62.054
1070	62.054	62.112	62.170	62.228	62.286	62.344	62.402	62.460	62.518	62.576	62.634
1080	62.634	62.692	62.750	62.808	62.866	62.924	62.982	63.040	63.098	63.156	63.214
1090	63.214	63.271	63.329	63.387	63.445	63.503	63.561	63.619	63.677	63.734	63.792
1100	63.792	63.850	63.908	63.966	64.024	64.081	64.139	64.197	64.255	64.313	64.370
1110	64.370	64.428	64.486	64.544	64.602	64.659	64.717	64.775	64.833	64.890	64.948
1120	64.948	65.006	65.064	65.121	65.179	65.237	65.295	65.352	65.410	65.468	65.525
1130	65.525	65.583	65.641	65.699	65.756	65.814	65.872	65.929	65.987	66.045	66.102
1140	66.102	66.160	66.218	66.275	66.333	66.391	66.448	66.506	66.564	66.621	66.679
1150	66.679	66.737	66.794	66.852	66.910	66.967	67.025	67.082	67.140	67.198	67.255
1160	67.255	67.313	67.370	67.428	67.486	67.543	67.601	67.658	67.716	67.773	67.831
1170	67.831	67.888	67.946	68.003	68.061	68.119	68.176	68.234	68.291	68.348	68.406
1180	68.406	68.463	68.521	68.578	68.636	68.693	68.751	68.808	68.865	68.923	68.980
1190	68.980	69.037	69.095	69.152	69.209	69.267	69.324	69.381	69.439	69.496	69.553
1200	69.553										

This section contains coefficients for type J thermocouples for the two subranges of temperature listed below. The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order. The equation is of the form E = sum(i=0 to n) c_i t^i.

Temperature Range (°C)
-210.000 to 760.000
760.000 to 1200.000

name: reference function on ITS-90
type: J
temperature units: °C
emf units: mV

range: -210.000, 760.000, 8
0.000000000000E+00
0.503811878150E-01
0.304758369300E-04
-0.856810657200E-07
0.132281952950E-09
-0.170529583370E-12
0.209480906970E-15
-0.125383953360E-18
0.156317256970E-22

range: 760.000, 1200.000, 5
0.296456256810E+03
-0.149761277860E+01
0.317871039240E-02
-0.318476867010E-05
0.157208190040E-08
-0.306913690560E-12

This section contains coefficients of approximate inverse functions for type J thermocouples for the subranges of temperature and voltage listed below. The range of errors of the approximate inverse function for each subrange is also given.
The coefficients are in units of °C and mV and are listed in the order of constant term up to the highest order.
The equation is of the form t_90 = d_0 + d_1*E + d_2*E^2 + ... + d_n*E^n, where E is in mV and t_90 is in °C.

Temperature range (°C)	Voltage range (mV)	Error range (° C)
-210. to 0.	-8.095 to 0.000	-0.05 to 0.03
0. to 760.	0.000 to 42.919	-0.04 to 0.04
760. to 1200	42.919 to 69.553	-0.04 to 0.03

Inverse coefficients for type J:

Temperature Range:	-210. 0.	0. 760.	760. 1200.
Voltage Range:	-8.095 0.000	0.000 42.919	42.919 69.553
	0.0000000E+00	0.000000E+00	-3.11358187E+03
	1.9528268E+01	1.978425E+01	3.00543684E+02
	-1.2286185E+00	-2.001204E-01	-9.94773230E+00
	-1.0752178E+00	1.036969E-02	1.70276630E-01
	-5.9086933E-01	-2.549687E-04	-1.43033468E-03
	-1.7256713E-01	3.585153E-06	4.73886084E-06
	-2.8131513E-02	-5.344285E-08	0.00000000E+00
	-2.3963370E-03	5.099890E-10	0.00000000E+00
	-8.3823321E-05	0.000000E+00	0.00000000E+00
Error Range:	-0.05 0.03	-0.04 0.04	-0.04 0.03

Glossary of Terms

Accuracy	The uncertainty of a measurement which is the closeness of the agreement with the actual value.
Ambient temperature	The nominal temperature that surrounds a device or system.
Alloy	A combination of two or more metals mixture or metallic and non metallic elements usually fused together. Brass is an Alloy of Zinc and Copper.
ANSI	American National Standards Institute.
Cable	A general term usually used to describe conductors of large diameter.
Conductivity	The reciprocal of electrical resistance.
DMM	Digital Multimeter.
Emf	Electromotive force is the rate at which energy is drawn from a source that produces a flow of electricity in a circuit; expressed in volts.
Electric current	The rate of charge flow past a given point in an electric circuit, measured in coulombs/second. The unit is the ampere.
IEC	The International Electrotechnical Commission is the international standards and conformity assessment body for all fields of electrotechnology.
IEEE488	Is a short range digital communications bus. Originally created for use with automated test equipment. Also know as GPIB (General Purpose Interface Bus).
Impedance	A measure of the response of an electric circuit to an electric current. The actual value is frequency dependent. The current is opposed by the capacitance, inductance and resistance of the circuit.
Inductance	Unit of measure is the Henry (H) and is best described as the behaviour of a coil of wire in resisting any change of electric current through it.
IPRT	Industrial Platinum Resistance Thermometer.
Kelvin	The base unit of temperature in the International System of Units.
Kelvin connection	A 4-wire method of connection which avoids errors due to wire resistance.
Noise	Interfering and unwanted currents or voltages in an electrical device or system. Electrical noise, or simply noise, has a significant effect on the design and operation of almost all electrical measuring systems.
Ohm	Defined as the electrical resistance between two points on a conductor when a constant potential difference of 1 volt applied to these points produces in the conductor a current of 1 ampere.
Ohmmeter	A generic name for all 4 terminal resistance measuring instruments.

Potential Leads	The potential leads of a 4 terminal measuring instrument which measure the voltage across the RX. Designated P and P1 or +U and –U depending upon manufacturer.
PLC	Programmable Logic Controller.
ppm	Parts per million.
Precision	The reproducibility and reliability of a measurement.
PRTD	Platinum Resistance Temperature Device. Used for accurately sensing temperature. The more common ones are Pt100 and Pt25.
Pt100	A platinum resistance detector with a resistance of 100Ω at 0°C.
Pt25	A platinum resistance detector with a resistance of 25Ω at 0°C.
Range	The maximum reading possible at the selected setting.
Resistance	The degree to which a conductor opposes and electrical current.
Resolution	The smallest increment that a meter will display.
RS232	The RS232 interface is a serial port for transmission of data in serial bit format.
RTD	Resistance Temperature Device typically a Thermistor.
Rx	Resistance of unknown value.
Scale length	The largest value a measuring instrument can display for the range selected.
SI units	The International System of units is a scientific method of expressing magnitude and quantity.
Source Leads	The current leads of a 4 terminal measuring instrument. Designated C and C1 or +I and - I depending on manufacturer.
SPRT	Standard Platinum Resistance Thermometer.
Thermal Mass	Thermal mass, in the most general sense, is any mass that absorbs and holds heat.
Thermal Response	The manner in which a body responds to a change in temperature.
Thermistor	A temperature sensitive resistor, usually made from specially processed oxides.
Thermocouple	A temperature sensor created by joining two dissimilar metals. The junction produces a small voltage as a function of the temperature.

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