

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

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

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

PROPERTIES of THERMOCOUPLES

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

*Trademark of now defunct Hoskins Manufacturing Co.

REFRACTORY THERMOCOUPLES (Tungsten-Rhenium)

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

Trademark of now defunct Hoskins Manufacturing Co.
W₃ & W₅ reference tables per ASTM E 988. Type letter symbols not assigned by ASTM.

NON-STANDARD THERMOCOUPLES

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

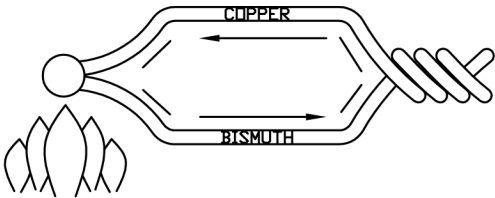
BASIC THERMOCOUPLE CONCEPT

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

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

DISCOVERY OF THE THERMOCOUPLE

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

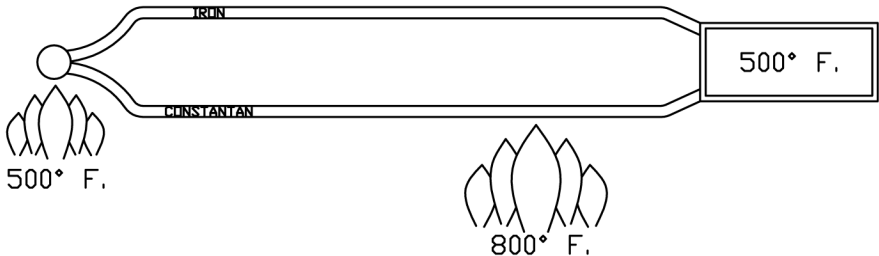


In 1834, French physicist Jean Peltier discovered that when electrical current is sent through a circuit made of dissimilar conducting materials that heat is absorbed at one junction and given up at the other, known as the Peltier Effect.

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

STATEMENT of LAWS

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



LAW OF HOMOGENEOUS METALS

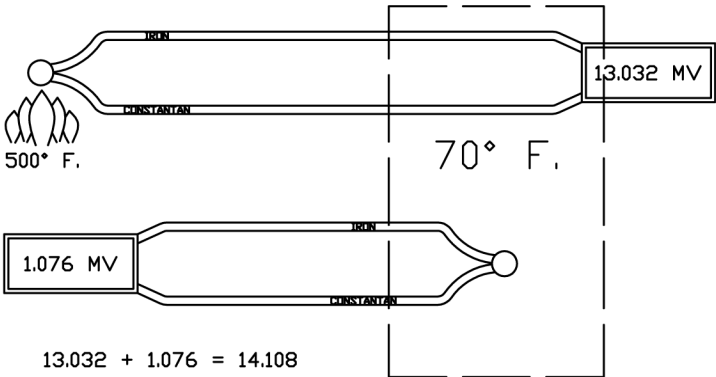
A thermoelectric current cannot be sustained in a circuit of a single homogeneous material, however varying in cross-section, by the application of heat alone.

What it means: use thermocouple extension wire and connectors.

LAW OF INTERMEDIATE TEMPERATURES

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

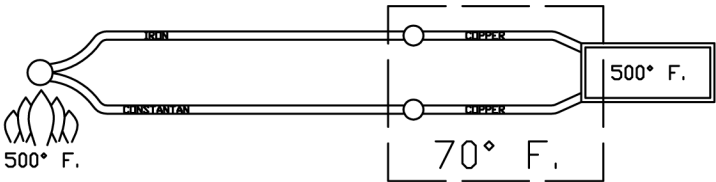
What it means: cold junction compensation is easily controlled by instrumentation



LAW OF INTERMEDIATE METALS

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

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



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

TECHNICAL REFERENCE

BASE METAL THERMOCOUPLES

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

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

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

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

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

19/20 Alloy: Nickel/Nickel Moly. 19/20 Alloy thermocouples provide a very stable reading in reducing atmospheres at elevated temperatures. Can be used in an oxidizing atmosphere with proper protection.

NOBLE METAL THERMOCOUPLES

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

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

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

REFRACTORY THERMOCOUPLES

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

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

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

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



SECTION TECH

STANDARD THERMOCOUPLES

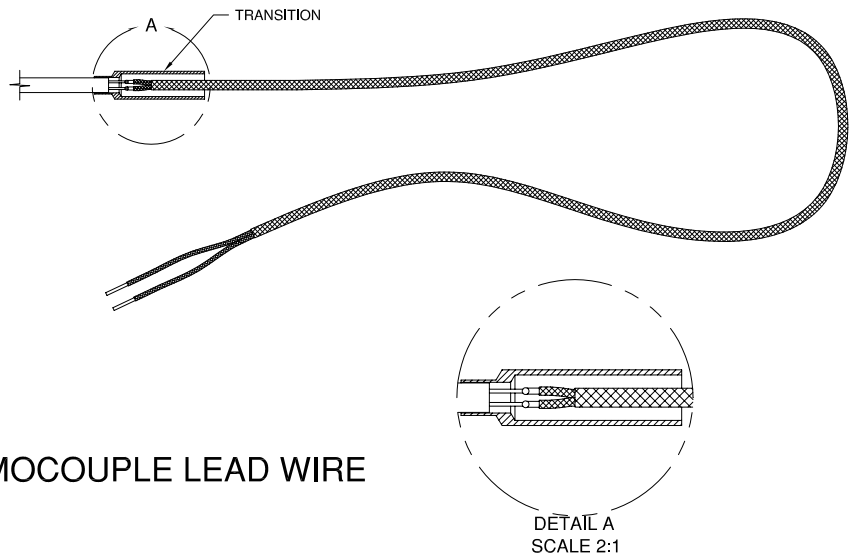
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TECHNICAL REFERENCE

Thermo Electric stocks a variety of insulated thermocouple and RTD lead wire for termination from the sheath solid wire to flexible lead wire. This is accomplished by attaching the lead wires by welding or soldering to the solid wires inside the sheath and encasing the area inside a sealed transition. For flexibility lead wires are mostly supplied with stranded conductors in 20 or 24 gauge. Thermocouple lead wires utilize the same alloys as the the sensor. Thermocouple lead wire is calibrated and traceable to the National Institute for Standards and Technology (NIST) for conformance to ISA and ANSI standards. RTD lead wires are mostly 24 gauge nickel plated copper. Insulation can be selected for such requirements as high abrasion , moisture and chemical resistance. Metal coverings are available for increased resistance to mechanical stress and abrasion. Twisted shielded wires for electrical interference rejection are also available.



THERMOCOUPLE LEAD WIRE

Fiberglass Insulation - Ordering Code 1

Standard 20 gauge stranded wires, fiberglass braided insulation over each wire, parallel with a fiberglass jacket. Fiberglass is saturated with a polyester silicone enamel coating for improved durability and handling. Suitable for continuous temperature rating of 950°F (510°C) and intermitting to 1200°F (649°C). Fiberglass provides high tensile strength, excellent dielectric constant and resistance to most oils and acids.

Fiberglass Insulation with Stainless Steel Armor - Ordering Code 2

Same as code 1 with additional protection of an interlocking or square lock stainless steel flexible armor. Armor provides protection from physical abuse and is ideal for connection to junction boxes or control cabinets by means of BX connectors or cable glands.

Fiberglass Insulation with Stainless Steel Overbraid - Ordering Code 3

Same as code 1 with additional protection of a stainless steel braided outer jacket. Braid provides higher resistance to abrasion and mechanical damage maintaining approximately the same diameter.

PVC Insulation - Ordering Code 4

Standard 20 gauge stranded wires, flame retardent PVC insulation over each wire, parallel with a flame retardent PVC jacket. PVC provides excellent resistance to moisture, chemical and solvents. Suitable for continuous temperature rating of 221°F (105°C). Excellent dielectric strength.

TEFLON® Insulation - Ordering Code 5

Standard 20 gauge stranded wires, extruded Teflon (FEP) insulation over each wire, parallel with extruded Teflon (FEP) jacket. Teflon insulation is chemically inert and thermally stable, low coefficient of friction and has excellent electrical properties. Teflon is highly flexible has excellent mechanical strength and is unaffected by most chemicals. Suitable for continuous temperature rating of 400°F (205°C). Teflon is FDA approved for use in the pharmaceutical, food and beverage industry.

PVC Insulation with Stainless Steel Armor - Ordering Code 8

Same as code 4 with additional protection of an interlocking or square lock stainless steel flexible armor. Armor provides protection from physical abuse and is ideal for connection to junction boxes or control cabinets by means of BX connectors or cable glands. Armor available with a PVC outer jacket for additional moisture protection.

Transitions

Manufactured from 300 series stainless steel and filled with an epoxy potting compound. Potting compound seals the sheath from moisture and other contaminants. The transition is hex crimped or silver soldered to the sheath. Lead wires with shielding can be supplied with the drain wire attached to the inside of the transition.

Potting Compounds

Potting compounds fill the transition providing a durable water seal. Standard potting is suitable for temperature up to 350°F (177°C). Other higher temperature potting compounds are available on request.



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SECTION TECH

LEADWIRE for TEMPERATURE SENSORS

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TECHNICAL REFERENCE

Questions as to the definition and use of thermocouples in series or parallel come up on occasion. In an attempt to generally clarify most of these questions, the following information is offered.

Series - Frequently referred to as a thermopile.

Thermocouples connected in series produce an EMF signal that is additive. That is, the output from a number of thermocouples is added together to produce a total output of all the thermocouples. With reference to Sketch No.1, we will assume that A is iron and B is constantan. We will further assume the reference junctions are at 32°F and the measuring junctions are at 200°F. From our catalog thermocouple temperature millivolt tables, we see that the output of a single thermocouple at 200°F is 4.906 millivolts. With four couples in a series, as in sketch no.1, we add 4.906 millivolts four times to get a final millivolt output of 19.624 millivolts. The formula for working this out is:

$$E = ET1 + ET2 + ET3 + ET4$$

Two common applications are:

1. Measuring temperature where a very minute change is critical to the application. By enlarging the signal, these small changes can be detected more easily on simple instruments.
2. Working a voltage sensitive relay where a small change is not sufficient to trip the contact. Care must be taken in this case so that you do not exceed a workable external resistance factor.

Parallel - Frequently referred to as averaging thermocouples.

Thermocouples connected in parallel produce an EMF the same as for a single thermocouple. If all the thermocouples are of equal resistance and their measuring junctions are at various temperatures, then the EMF generated will correspond to the average of the temperatures of the individual junctions. Looking at sketch no. 2, let us again assume that A is iron and B is constantan. Let us also assume the reference temperature T1 is at 32°F. If T2 is 200°F, T3 is at 205°F, T4 is at 210°F and T5 is 215°F, and all couples are of equal resistance, we will get an output of 207 - 1/2°F which is the average temperature. The formula which applies is

$$EMF = \frac{T2+T3+T4+T5}{4}$$

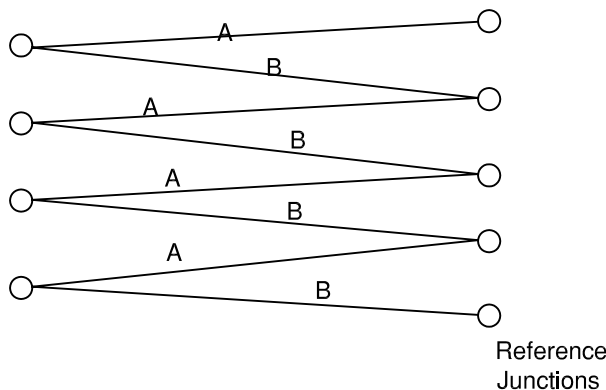
It is not always possible to make all parallel couples of equal resistance. When this presents a problem we can add swamping resistors in series with each couple. If we have four couples varying between 8 and 12 ohms and add a 200 ohm swamping resistor in series with each, we reduce the differences to insignificant fractions of the total resistance.

Two common applications are:

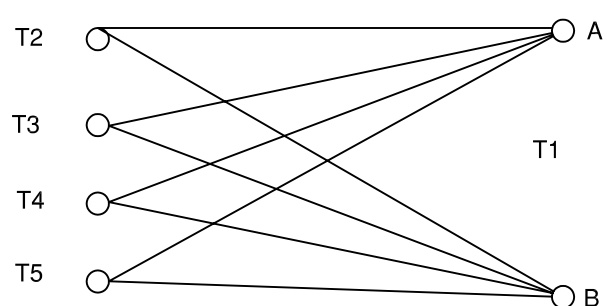
1. Aircraft harness assemblies where a group of couples are placed in a ring around the exhaust system and lead back to a single cockpit indicator.
2. An inexpensive method of high temperature alarm using a single instrument for alarm indication. This would be a good application for digital monitors is sensitive enough to sense small changes in EMF signals.

Grounds which introduce cross connections between either the series or parallel combination of thermocouples are not permissible.

Series Wiring



Parallel Wiring



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SECTION TECH

**THERMOCOUPLE
SERIES & PARALLEL MEASUREMENTS**

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TECHNICAL REFERENCE

Control of "Noise" in Instrumentation Circuits.

The type of signal transmitted by the sensor is related to its sensitivity to noise. The lower the voltage level and the higher the impedance of a circuit, the greater the circuit's sensitivity to noise of all types. The following discussion describes the major types of noise and commonly accepted solutions for each.

There are four types of noise which affect process instruments:

Common Mode: Different ground potentials at each location in a process plant cause common mode noise to be a problem. Two different grounds in an instrument circuit mean a current will flow between them, causing noise to be added to the signal being transmitted. Using a receiver which has a high common mode rejection ratio will control this type of common mode interference. A second type of common mode interference will occur even when a high quality receiver is used and is a particular problem in thermocouple extension wire circuits. Most thermocouples used are the "grounded" type. That is, the couple is connected physically and electrically to the well in which it is installed. When a thermocouple circuit shield (or any nearby metallic object, such as conduit, tray, building frames, etc.) is at a different potential than the couple, charging currents flow in the extension wire, causing interference to be superimposed on the thermocouple signal. Grounding the shield circuit at the couple and only at the couple will eliminate noise problems from common mode. Multipair cables used with thermocouples must be the individually shielded, isolated pair shield type so that the shield circuit may be maintained at the individual couple ground potential all the way back to the control room.

Cross Talk: This occurs with AC instrument signals, especially pulse-type signals, where more than one circuit is carried in the same cable. It is the tendency for a signal to be coupled from one pair to another within the cable, resulting in noise being superimposed on a circuit. Cross talk noise may be eliminated by the use of cables with individually shielded, isolated pair shields. The pair shield protects against noise picked up from adjacent pairs, as well as reducing noise by the pair it surrounds.

Static: Static interference is caused by the electric field radiated by a voltage source being coupled capacitively into the instrument circuit. The best way of fighting static noise is to place the circuit inside a total coverage shield which isolates the pair of wires from outside influence. The grounded shield intercepts static interference and carries it off to ground. The shield must be grounded in order to reduce static noise; an ungrounded shield will not reduce noise.

Magnetic noise: Produced by currents flowing through conductors and pieces of electrical equipment such as motors, generators, etc. As the current flows through equipment, a magnetic field is radiated around the conductor. As this field passes through the space between the conductors in an instrument circuit, a current is set up in the instrument circuit to oppose the magnetic field (transformer action). This current causes a noise to be superimposed on the signal in the instrument circuit. The best way of fighting this type of noise is to twist the wires in the instrument circuit. Twisting causes the noise to be canceled in adjacent sections of the wire. This is the least expensive, most effective way of combating magnetic noise.

Process Instrumentation

Recently there have been many changes in recording, indicating and controlling instruments used in the process industries. For the purpose of this discussion, however, there are three general classifications of receiving instruments in which the majority of process instruments can be replaced. They are:

A to D Converters, Computers: An analog signal is conditioned, amplified and then converted to a digital signal either for input to a computer or for telemetry transmission, or the signal is amplified and fed to a recording system or time sampled.

Potentiometer and Bridge: Input signal is conditioned, sent through a chopper, either mechanical or electronic, to compare with a standard voltage or to null. The output signal is amplified and then drives a chart recorder pen or indicator to a "balance" or "null" position.

Current Elements: Current flowing in instrument loop is converted directly to a torque to move a chart recorder pen or meter pointer. No electronic circuits are involved. (This Classification includes pyrometers.)

In systems with amplifiers, excessive noise levels cause overloading of the amplifier input with a resultant shift in the operating characteristics of the amplifier. The amplifier output is then no longer proportional to the input signal and serious errors result. When A to D converters are involved or when time sampling is taking place, noise will cause significant errors in the readings.

Plant Installation Notes

Besides the electrical problems which are considered in choosing the proper wire and cable, one should also consider what a particular wire or cable installation must withstand from a mechanical standpoint. If a cable is being installed in an open tray, or underground, armor should be provided to protect against damage from crushing or the impact of falling objects. If the cable is to be pulled a great distance, suspended from two points or buried where shifting ground will cause tensile forces on the cable, an armor which acts as a strength member should be considered. Armoring should be used where crush and impact resistance is required. Where tensile strength is important, a served wire armor will provide this protection, as well as crush and impact resistance.

Precautions taken during design, engineering and installations can also reduce the effects of noise considerably. Routing of instrument cables away from noise sources such as power cables, motors, generators, and any arc-producing equipment will greatly reduce the chance of noise pickup. Putting signals of the same relative strength into the same cable and excluding any higher level signals will reduce the chances of cross talk. Shielding of data transmission circuits will reduce pickup by nearby instrument circuits. Twisting of control and power cables will reduce the magnetic noise pickup in nearby instrument circuits. Separation of instrument circuits from noise sources will reduce the noise problem considerably, as both static and magnetic fields fall off fairly rapidly as distance from the source is increased.

Where shields are employed in both the single pair wires and in multipair cables for noise protection, there are some important ground rules to follow:

1 To protect against common mode noise pickup within the wire and cable, a shield circuit should be grounded at the point which the instrument circuit is grounded and isolated from all other grounds; i.e., with a grounded couple, ground the shield on the extension wire at the couple. As the shield circuit is carried back to the control room through a junction box and a multipair cable, connect the pair shield in the cable to the single pair which leads to the couple without grounding the shield in the junction box or connecting it to any other shield (or other pairs). The shield should not be grounded in the control room.

2. Ground all shields. An ungrounded shield will not provide noise protection.

3. Ground a shield at one point only.



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





































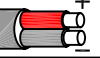
SECTION TECH




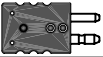
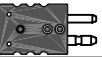
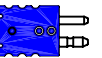



NOISE INTERFERENCE



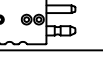
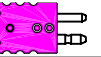
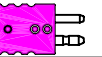
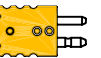
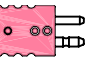


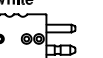
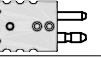
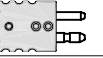
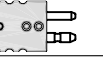
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TECHNICAL REFERENCE

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

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

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

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



SECTION TECH

THERMOCOUPLE COLOR CODES

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