LABFACILITY THERMOCOUPLE & PLATINUM RESISTANCE THERMOMETRY – AT A GLANCE

THERMOCOUPLE

SELECTING SENSOR CABLES: GUIDE TO INSULATION & COVERING

Which insulation Material?	usable temperature range	Application Notes
PVC	-10°C to 105°C	Good general purpose insulation for 'light' environments. Waterproof and very flexible.
PFA (extruded)	-75°C to 250°C	Resistant to oils, acids other adverse agents and fluids. Good mechanical strength and flexibility. PTFE better for steam/elevated pressure environments
PTFE (taped & wrapped)	-75°C to 250/300°C	Resistant to oils, acids other adverse agents and fluids. Good mechanical strength and flexibility.
Glassfibre (varnished)	-60°C to 350/400°C	Good temperature range but will not prevent ingress of fluids. Fairly flexible but does not provide good mechanical protection.
High temperature glassfibre	-60°C to 700°C	Will withstand temperature up to 700°C but will not prevent ingress of fluids. Fairly flexible, not good protection against physical disturbance.
Ceramic Fibre	0 to 1000°C	Will withstand high temperature, up to 1000°C. Will not protect against fluids or physical disturbance.
Glassfibre (varnished) stainless steel overbraid	-60°C to 350/400°C	Good resistance to physical disturbance and high temperature (up to 400°C). Will not prevent ingress of fluids.

Screened or unscreened? With long cable runs, the cable may need to be screened and earthed at one end (at the instrument) to minimise noise pick-up (interference) on the measuring circuit. Alternative types of screened cable construction are available and these include the use of copper or mylar screening. Twisted pair configurations are offered and these can incorporate screening as required.

THERMOCOUPLE ACCURACIES

Tolerance classes for thermocouples to IEC 60584-2(1982) (Amend 1-1989) BS EN60584-2(1993)

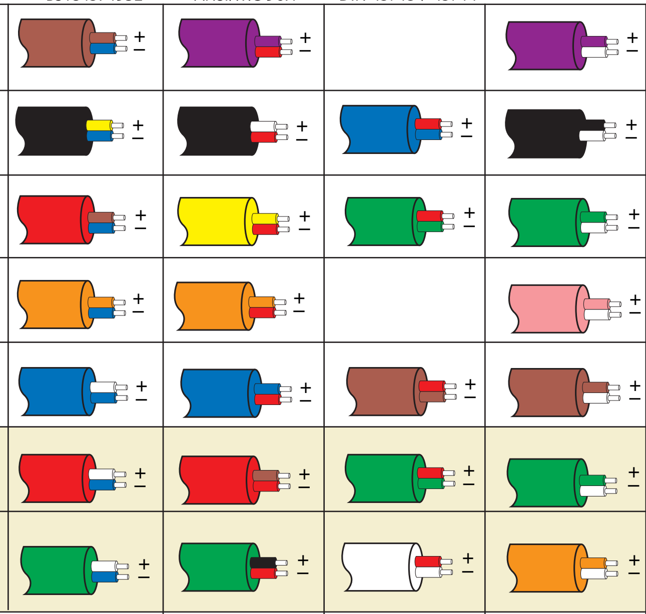
Fe-Con (J)	Class 1	- 40 +750°C:	±0.004	. t	or ±1.5°C
	Class 2	- 40 +750°C:	±0.0075	. t	or ±2.5°C
	Class 3	- -	-		
Cu-Con (T)	Class 1	- 40 +350°C:	±0.004	. t	or ±0.5°C
	Class 2	- 40 +350°C:	±0.0075	. t	or ±1.0°C
	Class 3	-200 + 40°C:	±0.015	. t	or ±1.0°C
NiCr -Ni (K) and NiCrSi-NiSi (N)	Class 1	- 40 +1000°C:	±0.004	. t	or ±1.5°C
	Class 2	- 40 +1200°C:	±0.0075	. t	or ±2.5°C
	Class 3	-200 + 40°C:	±0.015	. t	or ±2.5°C
NiCr-Con (E)	Class 1	- 40 +800°C:	±0.004	. t	or ±1.5°C
	Class 2	- 40 +900°C:	±0.0075	. t	or ±2.5°C
	Class 3	-200 + 40°C:	±0.015	. t	or ±2.5°C
Pt10Rh-Pt (S) and Pt13Rh-Pt (R)	Class 1	0 +1600°C:	±[1+(t-1000).0.003]		or ±1.0°C
	Class 2	- 40 +1600°C:	±0.0025	. t	or ±1.5°C
	Class 3	- -	-		
Pt30Rh-Pt6Rh (B)	Class 1	- -	-		
	Class 2	+600 +1700°C:	±0.0025	. t	or ±1.5°C
	Class 3	+600 +1700°C:	±0.005	. t	or ±4.0°C

Note: t = actual temperature Use the larger of the two deviation values

COLOUR CODES: THERMOCOUPLE CONNECTORS, EXTENSION AND COMPENSATING WIRES AND CABLES

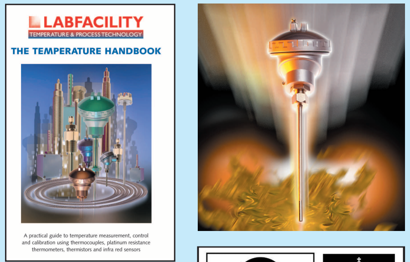
INSULATION COLOUR CODES
Extension & Compensating Leads

TYPE	CONDUCTORS +/-	BRITISH BS1843: 1952 (former standard)	AMERICAN ANSI/MC 96.1 (former standard)	GERMAN DIN 43713 / 43714 (former standard)	IEC 60584-3(2007) BS EN60584-3(2008)	CABLE CODE
EX	NICKEL CHROMIUM/CONSTANTAN (Nickel Chromium/Copper Nickel, Chromel/Constantan, T1/Advance, NiCr/Constantan)					EX
J	IRON*/CONSTANTAN (Iron/Copper Nickel, Fe/Konst Iron/Advance, Fe/Constantan I/C)					JX
K	NICKEL CHROMIUM/NICKEL ALUMINIUM* (NC/NA, Chromel/ Alumel, C/A, T1/T2, NiCr/Ni, NiCr/ NiAL)					KX
N	NICROSIL/NISIL					NX NC
T	COPPER/CONSTANTAN (Copper/Copper Nickel, Cu/Con, Copper/Advance)					TX
Vx	COPPER/CONSTANTAN (LOW NICKEL) (Cu/Constantan) Compensating for K (Cu/Constantan)					KCB
U	COPPER/COPPER NICKEL Compensating for Platinum 10% or 13% Rhodium/Platinum (Codes S & R respectively) (Copper/Cupronic Cu/CuNi, Copper/No. 11 Alloy)					RCA SCA
	* Magnetic, ( ) Alternative & Trade Name	FOR THERMOCOUPLE CONNECTORS body colours are similar to outer sheath colours			FOR THERMOCOUPLE CONNECTORS body colours are similar to outer sheath colours	



CALIBRATION GUIDE

Thermocouple Type	100°C	emf in absolute millivolts (IEC 584) 400°C	800°C	1000°C	1200°C	1500°C
T	4.279	20.872	-	-	-	-
E	6.319	28.946	61.017	76.373	-	-
J	5.269	21.848	45.494	57.953	69.553	-
K	4.096	16.397	33.275	41.276	48.838	-
N	2.774	12.974	28.455	36.256	43.846	-
R	0.647	3.408	7.950	10.506	13.228	17.451
S	0.646	3.259	7.345	9.587	11.951	15.582
B	0.033	0.787	3.154	4.834	6.786	10.099



Refer to the Labfacility Temperature Handbook for more information

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LABFACILITY THERMOCOUPLE & PLATINUM RESISTANCE THERMOMETRY – AT A GLANCE

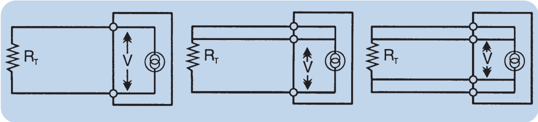
PLATINUM RESISTANCE THERMOMETER

PRACTICAL BRIDGE CIRCUITS FOR 2, 3 AND 4 WIRE THERMOMETERS

The connection between the thermometer assembly and the instrumentation. The cabling introduces electrical resistance which is placed in series with the resistance thermometer. **The two resistances are therefore cumulative and could be interpreted as an increased temperature if the lead resistance is not allowed for.** The longer and/or the smaller the diameter of the cable, the greater the lead resistance will be and the measurement errors could be appreciable. In the case of a **2 wire connection**, little can be done about this problem and some measurement error will result according to the cabling and input circuit arrangement.

For this reason, **a 2 wire arrangement is only suitable for short cable lengths**. If it is essential to use only 2 wires, ensure that the largest possible diameter of conductors is specified and that the length of cable is minimised to keep cable resistance to as low a value as possible.

The use of 3 wires, when dictated either by probe construction or by the input termination of the measuring instrument, will allow for a good level of lead resistance compensation. **However the compensation technique is based on the assumption that the resistance of all three leads is identical** and that they all reside at the same ambient temperature; this is not always the case. **Optimum accuracy is therefore achieved with a 4 wire configuration**.



RESISTANCE V TEMPERATURE AND TOLERANCES FOR PLATINUM RESISTORS TO IEC 751(1995)/BS EN60751(1996)

Temp (°C)	Resistance (Ω)	Tolerance Class A (±°C)	Class A (±Ω)	Class B (±°C)	Class B (±Ω)
-200	18.52	0.55	0.24	1.3	0.56
-100	60.26	0.35	0.14	0.8	0.32
0	100.00	0.15	0.06	0.3	0.12
100	138.51	0.35	0.13	0.8	0.30
200	175.86	0.55	0.20	1.3	0.48
300	212.05	0.75	0.27	1.8	0.64
400	247.09	0.95	0.33	2.3	0.79
500	280.98	1.15	0.38	2.8	0.93
600	313.71	1.35	0.43	3.3	1.06
650	329.64	1.45	0.46	3.6	1.13
700	345.28	–	–	3.8	1.17
800	375.70	–	–	4.3	1.28
850	390.48	–	–	4.6	1.34

STEM CONDUCTION

This is the mechanism by which heat is conducted from or to the process medium by the probe itself; an apparent reduction or increase respectively in measured temperature results. The **immersion depth** (the length of that part of the probe which is directly in contact with the medium) must be such as to ensure that the "sensing" length is exceeded (double the sensing length is recommended). Small immersion depths result in a large temperature gradient between the sensor and the surroundings which results in a large heat flow.

The ideal immersion depth can be achieved in practice by moving the probe into or out of the process medium incrementally; with each adjustment, note any apparent change in indicated temperature. The correct depth will result in no change in indicated temperature.

For calibration purposes 150 to 300mm immersion is required depending on the probe construction.

SELF-HEATING

In order to measure the voltage dropped across the Pt sensing resistor, a current must be passed through it. The measuring current produces heat dissipation in the sensor. This results in an increased temperature indication. It is necessary to minimise the current flow as much as possible; 1mA or less is usually acceptable.

If the sensor is immersed in flowing liquid or gas, the effect is reduced because of more rapid heat removal. Conversely, in still gas for example, the effect may be significant. The self-heating coefficient E is expressed as:

$$E = \Delta t / (R - I^2)$$

Where Δt = (indicated temperature) – (temperature of the medium)

R = Pt resistance

I = measurement current

NEW TOLERANCE CLASSES FOR RESISTORS to IEC 60751(2008)

For wire wound resistors: Tolerance class	For wire wound resistors: Temperature range of validity °C	For film resistors: Tolerance class	For film resistors: Temperature range of validity °C	Tolerance value[a] °C
W 0.1	–100 to +350	F 0.1	0 to +150	± (0.1 + 0.0017 I t I)
W 0.15	–100 to +450	F 0.15	–30 to +300	± (0.15 + 0.002 I t I)
W 0.3	–196 to +660	F 0.3	–50 to +500	± (0.3 + 0.005 I t I)
W 0.6	–196 to +660	F 0.6	–50 to +600	± (0.6 + 0.01 I t I)

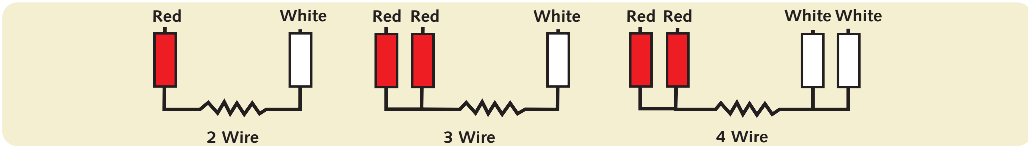
[a] I t I = modulus of temperature in °C without regard to sign. For any value of R_o

NEW TOLERANCE CLASSES FOR THERMOMETERS to IEC 60751(2008)

Tolerance class	Temperature range of validity °C: Wire wound resistors	Temperature range of validity °C: Film resistors	Tolerance values[a] °C
AA	–50 to +250	0 to +150	± (0.1 + 0.0017 I t I)
A	–100 to +450	–30 to +300	± (0.15 + 0.002 I t I)
B	–196 to +600	–50 to +500	± (0.3 + 0.005 I t I)
C	–196 to +600	–50 to +600	± (0.6 + 0.01 I t I)

[a] I t I = modulus of temperature in °C without regard to sign. For any value of R_o

RECOMMENDED TERMINATION COLOUR CODES IEC 751(1995)



For dual sensors, IEC 60751(2008) specifies yellow & black(or grey) (instead of red & white as shown) to be introduced for the additional sensing resistor.

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