Hand made platinum resistance temperature detectors

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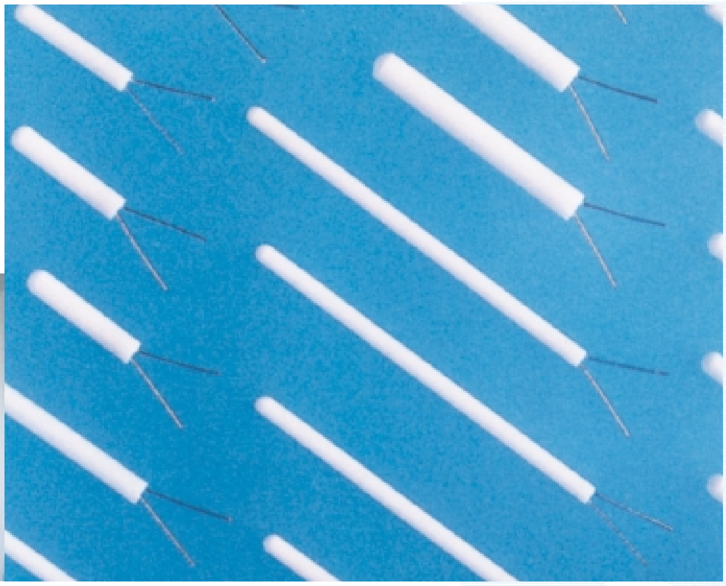
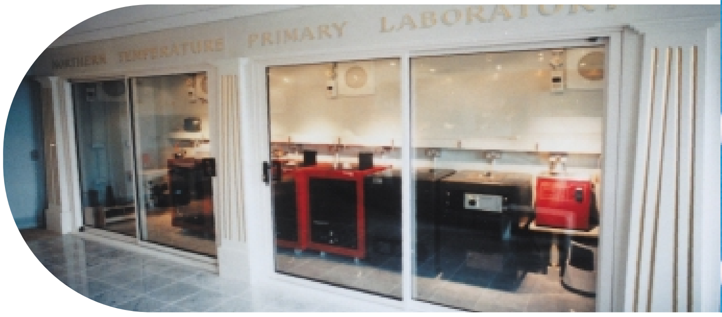
TDIs platinum resistance temperature detectors are hand assembled by our skilled team.





Introduction

Thermal Developments International produce a wide range of partially supported, wire wound Platinum Resistance Temperature Detectors to the highest international standards.

The construction chosen gives the best compromise between ruggedness and stability of any of the available industrial PRTD's.

During 1986, our sister company Isothermal Technology Ltd 'Isotech', obtained approval from NAMAS for the use of their calibration laboratory as part of the United Kingdom Accreditation Service.

Their UKAS laboratory provides comparisons to National Standards held at the National Physical Laboratory. The use of this calibration facility by TDI enables us to guarantee a very high standard of quality control.

Isotech's NTPL Calibration Laboratory is also the first privately owned UKAS laboratory to be recognized as being able to realise ITS90 and hence it has Primary Laboratory status.

Their facilities cover the temperature range from -196°C to +1300°C and offer calibration of resistance thermometers from -196°C to +962°C and thermocouples from -196°C to +1300°C

During the Accreditation of Isotech's laboratory they had to evaluate many of their special calibration baths. These evaluations are available on a limited supply to would-be purchasers of such equipment.

A list of Isotech Publications is available, please contact us for further information, and their brochure describing the Laboratory's services.

Isotech's UKAS Laboratory is also approved for DC voltages and Resistance.

NOTES REGARDING NAMAS - ISO 9000

NAMAS recognises the difficulties laboratories face when customers and purchasing departments specify that they will only use ISO 9000 approved suppliers. The problem largely arises from ignorance of the standards to which NAMAS laboratories work and how they relate to the ISO 9000 series of standards.

Few purchasers or clients realise that EN45001 and ISO Guide 25, to which Isothermal Technology's laboratory works, exist or that they contain requirements for both quality systems and technical competence. It is noted at the beginning of ISO Guide 25 and M10 that laboratories complying with M10 also comply with the relevant requirements of ISO 9002.

In order to assist laboratories propagating this message, NAMAS now awards accreditation certificates stating this.

RTD Reasons for staying wire wound

Introduction

Among the 7 basic quantities; four: mass, length, time and temperature are so intimately linked with human existence that it is incredible that there was no comprehension concerning temperature until the 18th century. It took a further century to crystallise into anything that might be called a proper definition of temperature.

The difficulty is that temperature is not related to an easily perceived quantity.

Temperature in Classical Thermodynamics

The Zeroth law of thermodynamics helps us to define temperature. One way of stating the Zeroth law of thermodynamics is that "if two systems in thermal equilibrium each have the same temperature as a third, then they also have the same temperature as each other".

Two main results follow from the above.

The first is the analysis of the term 'Thermal Equilibrium' and its practical implications; the second is the consideration of how and to what accuracy we can measure temperature.

A perfect system does not exist in practice. The temperature of an object is affected by the temperature measuring device and conversely, the temperature sensor is both temporarily and permanently affected by the system or object being measured.

Ultimately, the ability to measure temperature is limited by these constraints. Scientists and Mathematicians have tried to convert the laws of heat transfer and thermodynamics into a practical form.

International Temperature Scale of 1990

The temperature scale which is accepted world-wide is called the International Temperature Scale of 1990 (ITS-90) and is the best attempt to reconcile the laws of thermodynamics with the practical world of temperature measurement.

Over the temperature range -200°C to +850°C the internationally accepted working standard is the Platinum Resistance Thermometer (PRT).

Since the early days of resistance thermometry and the work of Callender on the platinum resistance thermometer, the subject of resistance thermometry has undergone considerable changes. In addition to the classical platinum resistance thermometer, used for work of the highest accuracy over an increasingly wide range of temperature, there is now extensive industrial use of resistance thermometers employing wire elements of either platinum, copper or nickel, or screen-printed thick film elements of platinum.

Thermistors can now provide an excellent low cost means of precise thermometry in the room temperature range. For scientific applications at low temperatures there are resistance thermometers with elements of rhodium-iron, germanium, carbon or carbon-glass. In many industrial applications, the resistance thermometer is replacing the thermocouple as the main process control instrument.

At temperatures below 650°C the best industrial resistance thermometers are now more accurate and more reliable than any available thermocouple. In addition, the increasing use of microprocessors in instrumentation is allowing a much more rapid and sophisticated use to be made of the information contained in the signal from the thermometer, than was previously possible.

A detailed understanding of the electrical conduction process is clearly not a prerequisite for the proper use of a resistance thermometer to measure temperature. Nevertheless, investigations aimed at improving its reproducibility, extending its range, or using it to the very highest accuracy, are unlikely to be very productive without at least a passing acquaintance with the underlying theory of what is observed.

The Conduction Mechanism in Platinum

A consideration of the electric conduction in pure metals, alloys and semiconductors shows that the conduction mechanism is very complex. The basis of our present knowledge is the idea that the free electrons travel through the metal as plane waves modified by a function having the periodicity of the lattice. This disposition is too brief to explain fully the mechanisms, however, the theory suggests that a wire wound platinum resistance thermometer will follow a quadratic of the type $RT = Ro\,(1+At + Bt^2)$ for a wide range of temperature above ambient.

Usefully, A = Alpha (1 + Delta/100°C)
B = 10-4 Alpha Delta $°C^2$

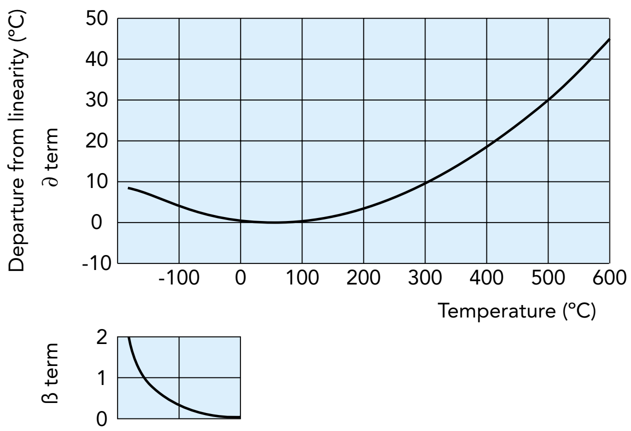
Alpha and Delta are characteristic of each thermometer showing respectively the mean slope of the resistance / temperature curve between 0°C and 100°C, and the departure from linearity in the same range.

Alpha is a good indication of purity, and the state of anneal of the thermometer.

Delta depends upon the thermal expansion and the density of states curve near the fermi energy.

Both these quantities depend upon the purity of the wire, and indicate that Delta and Alpha are related. For temperatures below 0°C, departure from linearity becomes too great for a quadratic equation and so a further term 13 was added in 1925, which was up-dated in 1968 to a 20-term polynomial.

The table below shows that departure from linearity of a platinum thermometer over temperature range -200°C to +600°C.



Working Standard to ITS-90

High-precision platinum resistance thermometers are generally 25 ohm value at 0°C having an alpha value of 0.003926 or above and a wire diameter of typically 0.07mm. To minimise leakage resistance between leads at high temperatures, the leads are insulated from one another by mica, silica or sapphire. Common designs are in the form of either a single wire in a bifilar winding on a mica cross, a coil wound in twisted silica tubes, or wire supported in alumina tubes. All these designs are aimed at producing a strain-free thermometer that can expand and contract on heating and cooling without the wire rubbing or being scratched by their support. These thermometers are usually filled with dry air and sealed after preliminary annealing during manufacture.

The air is to ensure that the platinum operates under oxidising rather than reducing conditions.

It is important to understand the background above if the choice of industrial platinum sensor is to be made correctly.

Industrial Platinum Thermometers

Ideally, the working standards described above would be used for industrial temperature measurements, however, because of their cost, fragile nature and low vibration properties, a class of PRT has been developed called the Industrial PRT.

The fine wire used is drawn through laser drilled sapphire or diamond dies which give repeatable results without contamination of the wire.

The best industrial types of wire wound platinum resistance thermometers conform closely to the requirements described above for working platinum resistance thermometers (PRT's).

They are constructed with an alloy comprising of pure platinum alloyed with other platinum group metals to reduce the alpha value to the IEC Publication of 751, 1995 value of 0.003850 or of pure platinum having an alpha value of 0.003916 and above.

Modern techniques of PRT manufacture use ceramic materials of a very high purity. The processing of the wire into its high purity alumina ceramic is achieved without contamination of the platinum. Special annealing and tailor design of the vibration/stability properties of the PRT now ensures accuracies and stabilities verging on those achieved by standard PRT's.

Wire Wound PRT's still involve a considerable amount of skilled operator time and may be considered 'hand made'.

This hand work enables a flexible approach to be made to the types and sizes of PRT's available, and together with the accuracies and stabilities which can be supplied, gives the user a choice of hundreds of types, sizes and grades of PRT.

Nearly all are 100 ohms at 0°C and the majority outside the USA and Japan have an Alpha value of 0.003850.

They may be split into two broad categories; wire wound and film types. Of the wire wound types, two main assembly techniques are used.

Firstly, a bifilar winding is wound around a glass or ceramic bobbin, attached to leads and sealed by a layer of glass. This type is very rugged and will withstand high vibration. However, this form of construction is subject to strain during temperature cycling and is also not directly in contact with air.

Secondly, a fine coil of platinum wire is led through holes in an alumina tube and attached to more robust leads. The coil is then attached along part (partially supported) or all (totally supported) of its length and the leads are sealed in place with either glass, or ceramics.

The latter construction, if properly engineered, is the closest to the requirements of the working standard thermometer. It can have low vibration and high stability, or high vibration and lower stability characteristics depending upon customers requirements, and is also often not hermetically sealed so that air can circulate round the platinum wire.

The major developments in industrial wire wound platinum resistance thermometers have been-

A In the area of ceramic technology, with purer aluminium oxides available which are less liable to affect the alpha value of platinum.

B In the wire production and drawing techniques. Ingots, tailor-made to an alpha of 0.003850 can be produced and drawn through laser drilled sapphire or diamond dies without contamination of the wire.

C In the construction of the PRT, where attention to cleanliness and quality control yields of over 70% of very close tolerance resistance thermometers.

D Using the above technologies, smaller and smaller resistance thermometers are available.

Film Thermometers may also be categorised into two types

THICK FILM, the spreading of a glass/platinum paste through a silk screen onto a substance.

THIN FILM, the evaporation of metal or alloy via a vacuum onto a substrate, usually alumina.

Many, many articles have been written about platinum film thermometers over the past 30 years since their introduction into the market, but, reverting to the basic description of our ITS-90 working standard thermometer, they fail to meet a number of requirements. These are:

A That the film or paste is not free to expand and contract in the same way that an unsupported or partially supported wire wound thermometer would be. In fact, they have been described as platinum strain gauges!

B The paste or film, contains very little metal, it is - therefore very easily subject to contamination. To overcome this, glass coverings are used, which preludes air from circulating past the platinum, and the glass coating may react with the platinum in the film. The glass also creates a secondary strain gauge effect.

C The metal may not be homogeneous. This is particularly true for thick film where the conduction mechanism is entirely different than that of the wire.

D The characteristics of the film thermometer are affected by the firing temperature and therefore the characteristics vary from batch to batch.

E The thin film units are so small that they are subject to quite high self-heating, especially where 1000 ohm thermometers are concerned.

F Because most are flat, they are not ideally suited for going inside stainless steel tubular sheaths.

G The attachment between lead and film is a weak mechanical link in the construction.

H The joint between film and output lead gives rise to thermocouple effects of unwanted voltages.

I Restricted sizes and alpha values. By the time these practical objections have been overcome, the film thermometer is as costly as its wire wound counterpart, without providing the user with many advantages to compensate for the shortcomings.

The film thermometer has been projected as the replacement for wire wound detectors over the full -200 to +600°C range. This is an incorrect approach. The largest market, and that for which film thermometers are most suited, is between -50 and 200°C, i.e., the domestic market, especially where surface measurements are important. Figures recently quoted of ±0.06% stability over this range, compare with quoted values of ±0.005% for wire wound over a 1 year duty cycle and ±0.002% over the range 25°C to 150°C.

Time Response

In the final analysis, the time response of a temperature sensor assembly is a function only of its total thermal mass, i.e., sheath, filling, PRT and leads together with its possible air gaps internally and with the object whose temperature is being measured. Generally, air gaps give the largest contribution to the time response of a platinum resistance thermometer.

Self Heating

A Platinum Resistance Thermometer is also a heater, since the power (I^2R) has to be dissipated. In evaluating this phenomenon it is normal to increase the current by $\sqrt{2}$ thus doubling the power and noting the increase in temperature. One can generalise and say that the self-heating is a function of the resistance, the square of the current and the surface area of the thermometer. Thus, a very small sensor, such as a thin film type, will tend to have a large self-heating coefficient as will a thermometer having a large resistance. This can mean that small 1000 ohm thin film units will have up to 100 times more sensitivity to self-heating than a medium sized wire wound type.

Things to remember when selecting a thermometer

A user will eventually end up with a channel of temperature measurement comprising of sensor, sheath, pocket, head, cable, amplifier and probably a data logger. The overall channel will cost between £100 and £500 each, but without the sensor being stable and accurate the money is wasted. The platinum resistance thermometer as described at the beginning of this article is the internationally accepted working standard for temperature measurement between -200°C and +650°C because of its superior performance above all alternatives. Its Industrial counterpart, the wire wound platinum resistance thermometer, customised for high vibration or high stability performance is also the most accurate alternative for industrial temperature measurement over the same temperature range. The thin film thermometer, where its small size and surface temperature measuring advantage can be utilized have added another alternative over the range -50°C to +200°C for the mass, and domestic market.

Future Trends

On large and sophisticated plant, accurate temperature measurements can often be best achieved by transmitting a 4 to 20mA signal to a central data acquisition system. Thus, more and more, the sensor, sheath and electronics are being integrated with one package. This means that reliability is becoming more important, since a failure is a system failure rather than a component failure. Because of this, the designer must be more aware, not less, of the sensor being used.

The general trend from thermocouple to resistance thermometry continues as does the trend to more accurate temperature measurement.

Probably the optimum sensor size and specification to minimise errors due to self-heating etc and still give best long term stability would be 15-25mm long by 1.5 to 3mm diameter specified to BS EN Standard Class A or DIN standard Class A or IEC Document 751.

ITS 90

At the beginning of 1990, some fundamental changes in Metrology occurred. Firstly, the value of 'Ohm' changes, secondly the temperature assigned to the fixed points of the IPTS change. These changes are relatively small and may be ignored in normal industrial usage.

The 100 Ω @ Ro Element should be correctly written as an 99.999839Ω @ Ro Element, and all multiplicants should be reduced by the same factor.

From a temperature point of view 0°C remains, but for example; water boiling point reduces by about 0.023°C and the point at which Silver Freezes reduces by approximately 0.15°C.

Full details are printed in the ITS 90 Document.

However, since the Degree Celsius is still defined as 1/273.16 of the interval between absolute Zero and the Triple Point of Water, the R/T Tables do not change on the Temperature Axis.

Stability of Industrial PRTs

The most stable standard PRTs, when used to measure very accurately, for example the freeze plateau of a Zinc point cell are checked at the triple point of water before and after each measurement. They are not considered to be stable.

However, the much cheaper industrial PRTs are considered to be stable over a period of years. Clearly this cannot be.

The IEC & BSEN specifications discuss stability, each requires that after 10 temperature cycles, the value of resistance at 0°C should not change by more than 0.05Ω (0.12°C).

You can imagine the implications of this on a detector purchased as a 1/10 Din standard. Fortunately in most cases the situation is not so bad, detectors cycled over smaller temperature ranges shift less. How much less is impossible to quantify except experimentally.

Partially Supported Construction

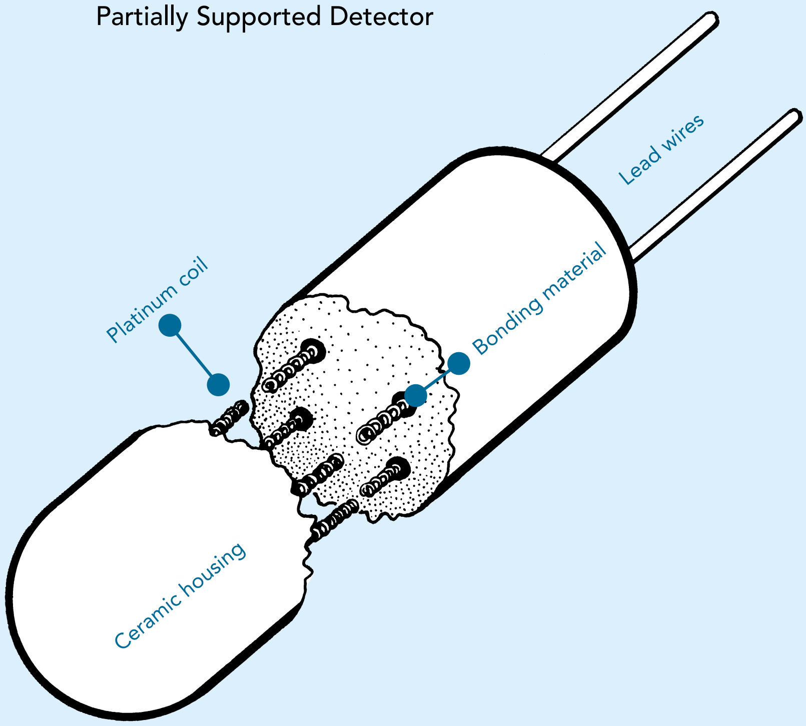
The partially supported detector is most used in industrial environments where a compromise is accepted between laboratory standard stability and usage in vibrational situations.

In this construction the wire is wound into a very small coil and inserted into axial holes in a high purity alumina rod. A small quantity of glass adhesive is introduced into these holes which, after firing, firmly secures part of each turn onto the alumina.

This results in a detector in which the majority of the platinum wire is free to move, giving excellent long term stability, and which will withstand levels of vibration up to 30G without damage.

The operating temperature range covered is from -200°C to +800°C, and the units will continue to operate up to, and be undamaged by, temperatures as high as 1100°C.

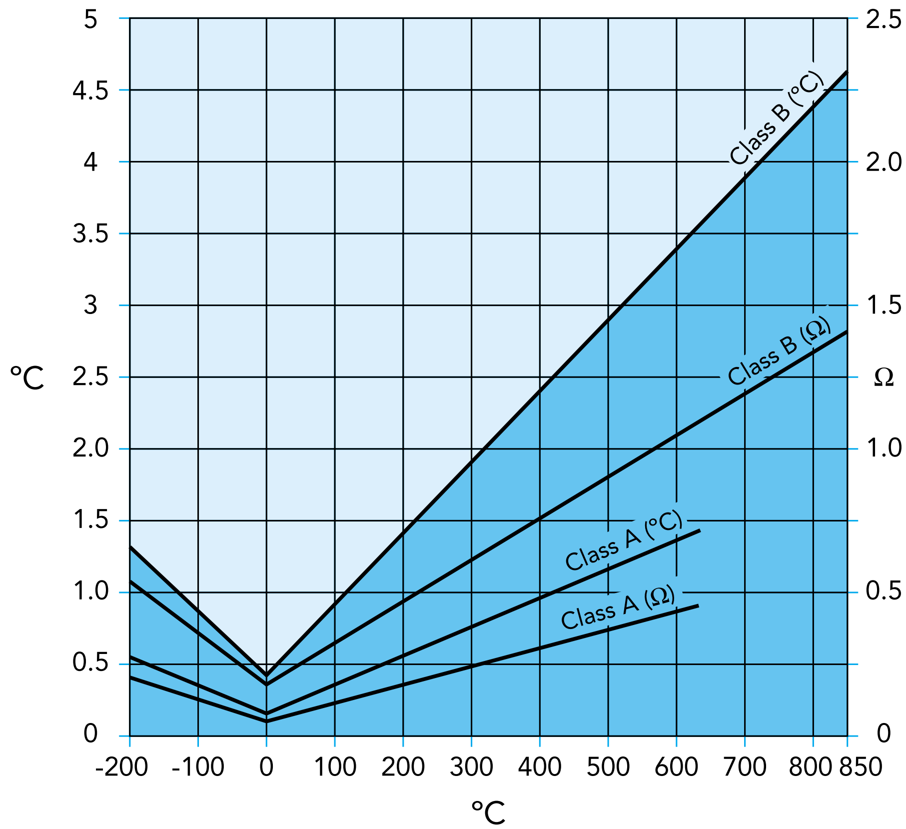
Partially Supported Detector



Tolerances for 100 Ω thermometers

temp °C	class A ±°C	class A ±°Ω	class B ±°C	class B ±°Ω
-200	0.55	0.24	1.3	0.56
-100	0.35	0.14	0.8	0.32
0	0.15	0.06	0.3	0.12
100	0.35	0.13	0.80	0.30
200	0.55	0.20	1.3	0.48
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
700	-	-	3.8	1.17
800	-	-	4.3	1.28
850	-	-	4.6	1.34

Tolerance values as a function of temperature for 100 Ω thermometers



PRTDs sold by TDI are manufactured by hand, to very high standards, under the most rigorous of Quality Control Conditions. A TDI Quality Assurance Manual is available to any prospective customer upon request. All materials used in their manufacture are traceable to Quality Control assurance by the various suppliers. All production is carried out under clean conditions with much of the production assembled with the use of microscopes. The units are visually checked for quality at least 4 times during production. In a final check **all** units are checked against a known standard which has been calibrated in the Calibration Laboratory of Isotech, whose U.K.A.S. accreditation enables us to have a close quality control. During the manufacture, all units are aged at temperatures higher than those specified by the various standard bodies. This treatment gives our units a high degree of stability at normal working temperature. During the final grading, units are selected to higher tolerances than those stipulated. Alpha value of sensing wire is better than 0.003850 +/-0.000006. This is better than the Class B requirement of +/-0.000012.

Vibration

When correctly supported, units will withstand a minimum vibration level of 30g over the frequency range 10hz to 1Khz. Units from normal production have been subjected to many varied ranges of vibration, and we have in-house ability to test to a Customer's needs should they have any special requirement.

Stability

Detectors typically conform to BSEN Stability figures. Drift of less than ±0.05% of its initial value after ten thermal cycles from 0°C to 600°C and from -200°C to 0°C. Stability is a compromise between vibration performance and there are various options available.

Self Heating

Less than 0.3°C with 10mW dissipation when tested in a stirred ice bath.

Detector Specification

Normally 3 types of alpha value platinum are available for use in the construction of our PRTDs.

1 Designated P - (White Cap)

Specification to:
A BS EN 60751 1996 **B** DIN 43760 1980 **C** IEC 751 1995

(The European Standard EN 60751:1995 has the status of the BS EN 60751:1996 British Standard)

Resistance at 0°C 100 ohms
Alpha Value - 0.003850°C^{-1}

Other Tolerances

As well as the standard tolerances, TDI produce closer tolerance versions of their products:

Typically:	±0.05%	(1/2DIN B)
	±0.03%	(1/3 DIN B)
	±0.02%	(1/5 DIN B)
	±0.01%	(1/10 DIN B)

being the interchangeability at 0°C.
As the detector is used further away from 0°C these errors can be expected to increase in accordance with an alpha uncertainty of ±3ppm.

If further requirements pertain, then Calibration in our sister company Isotech's U.K.A.S. Laboratory is essential.
NB Great care in assembly is required to maintain the accuracy provided by the close tolerance detector.

2 Designated A - (Pink cap)

Specification to:
A JIS C1604 - 1981 (Japanese Industrial Standard)
B US Standard Curve

Resistance at 0°C 100 ohms or 50 ohms.
Alpha Value - 0.003916°C^{-1}
Tolerance at 0°C for
A JIS C1604 1981
±0.15°C
±0.2°C
±0.5°C
B US Standard ±0.1 ohms

Variations as required under various SAMA Standard can be made to order with variations of Ro.

3 Designated S - (Blue Cap)

Originally specified for British Aircraft Industry.
Specification to BS 2G 148
Resistance at 0°C = 130 ohms
Alpha Tolerance - 0.003900°C^{-1}
Tolerance at 0°C - ±0.1% or Ro.
Variations of Ro are available on request.

Thermal response time

BS EN 60751:1996 & IEC 751: 1995
Require that the response time for a 50% change (~0.5) in resistance to a step temperature change be recorded. The normal 63.2% value is not recommended. However it is the accepted figure. Hence the table below gives the 63.2% figure. The 50% figure may be obtained by reducing the times given by approximately 10%. 90% response times can be obtained by multiplying the the times given by a factor of 3. To obtain the time constants at other flow rates and for other liquids and gases, the times may be multiplied by the inverse of the ratio masses of fluids per second passing the element.

Ceramic diameter (mm)	4.5	3.2	2.8	2.4	2.0	1.6	1.5	1.2	0.9
Typical time (secs) to 63% of final value, 50% step, water flowing at 1m/s.	0.7	0.4	0.4	0.3	0.25	0.15	0.1	0.08	0.03

Hermetically sealed units

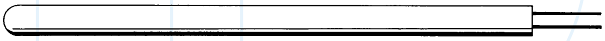
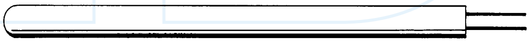
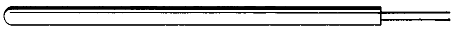
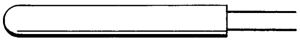
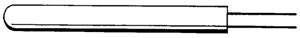
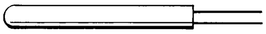
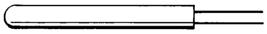
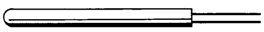
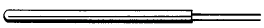
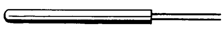
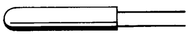
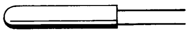
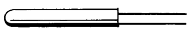
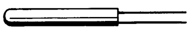
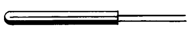
For optimum stability, air should be allowed to circulate around the platinum coil. For this reason our detectors are not Hermetically sealed. Care must therefore be taken to prevent the ingress of moisture or gases from contaminating the detector by enclosing it in a suitable sheath. However applications have arisen where detectors have to be totally immersed; or to operate in conditions of high humidity. For special cases units can be hermetically sealed. These units are made to order only.

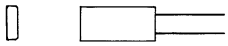
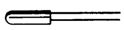
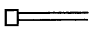
PRTD Standards

For producing working standards to the International Temperature Scale of 1990 (ITS-90) an alpha Value of at least 0.003925 is required. TDI produce a 25.5 ohm detector which when correctly assembled will meet the ITS-90 requirements.

A full working standard sensor assembly is produced by our sister company Isothermal Technology Ltd. For full details ask for model 909.

Thermal Developments International produce a wide range of Detectors using wire conforming to IEC 751 - 1995

All dimensions in mm Detectors shown same size		Resistance tolerance at 0°C	Ceramic length (mm)	Ceramic diameter (mm)	Sensing length (mm)
P100/7040		0.1%	70 + 0 - 0.5	4 + 0 - 0.03	65 ± 1
P100/6548		0.1%	65 + 0 - 0.5	4.75+0 - 0.03	62 ± 1
P100/5024 P2100/5024		0.1%	50 + 0 - 0	2.4 + 0 - 0.03	47 ± 1
P100/5015 P2100/5015		0.1%	50 + 0 - 0.5	1.5 + 0 - 0.03	47 ± 1
P100/3045 P2100/3045		0.1%	30 + 0 - 0.5	4.5 + 0 - 0.03	27 ± 1
P100/3038 P2100/3038		0.1%	30 + 0 - 0.5	3.8 + 0 - 0.03	27 ± 1
P100/2532 P2100/2532		0.1%	25 + 0 - 0.5	3.2 + 0 - 0.03	22 ± 1
P100/2528 P2100/2528		0.1%	25 + 0 - 0.5	2.8 + 0 - 0.03	22 ± 1
P100/2524 P2100/2524		0.1%	25 + 0 - 0.5	2.4 + 0 - 0.03	22 ± 1
P100/2516 P2100/2516		0.1%	25 + 0 - 0.5	1.6 + 0 - 0.03	22 ± 1
P100/2515 P2100/2515		0.1%	25 + 0 - 0.5	1.5 + 0 - 0.03	22 ± 1
P100/2020 P2100/2020		0.1%	20 + 0 - 0.5	2.0 + 0 - 0.03	17 ± 1
P100/1545 P2100/1545		0.1%	15 + 0 - 0.5	4.5 + 0 - 0.03	12 ± 1
P100/1532 P2100/1532		0.1%	15 + 0 - 0.5	3.2 + 0 - 0.03	12 ± 1
P100/1530 P2100/1530		0.1%	15 + 0 - 0.5	3.0 + 0 - 0.03	12 ± 1
P100/1528 P2100/1528		0.1%	15 + 0 - 0.5	2.8 + 0 - 0.03	12 ± 1
P100/1524 P2100/1524		0.1%	15 + 0 - 0.5	2.4 + 0 - 0.03	12 ± 1
P100/1520 P2100/1520		0.1%	15 + 0 - 0.5	2.0 + 0 - 0.03	12 ± 1
P100/1516 P2100/1516		0.1%	15 + 0 - 0.5	1.6 + 0 - 0.03	12 ± 1
P100/1516/16 Square		0.1%	15 + 0 - 0.5	1.6 + 0/-5% X 1.6 ± 0/-5%	12 ± 1
P100/1515 P2100/1515		0.1%	15 + 0 - 0.5	1.5 + 0 - 0.03	12 ± 1
P100/1512		0.1%	15 + 0 - 0.5	1.2 ± 0 - 0.03	12 ± 1
P100/1509		0.1%	15 + 0 - 0.5	0.9 ± 5%	12 ± 1
P100/1508		0.1%	15 + 0 - 0.5	0.8 + 0 - 0.1	12 ± 1
P100/1016		0.1%	10 + 0 - 0.5	1,6 + 0 - 0.03	8 ± 1

All dimensions in mm Detectors shown same size		Resistance tolerance at 0°C	Ceramic length (mm)	Ceramic diameter (mm)	Sensing length (mm)
P100/1016/5 Flat		0.1%	10 + 0 - 0.5	5.0 + 0/-0.5% X 1.6 ± 0.5%	10 ± 1
P100/1012		0.1%	10 + 0 - 0.5	1.2 ± 0 - 0.03	8 + 0 - 1
P100/1008		0.1%	10 + 0 - 0.5	0.8 + 0 - 0.1	8 ± 1
P100/0815		0.1%	8 + 0 - 0,5	1,5 + 0 - 0,03	8 ± 1
P100/0620		0.1%	6 + 0 - 0.5	2.0 ± 3%	6 + 0 - 1
P100/0445		0.1%	4 + 0 - 0.5	4.4 ± 0.1	3 ± 1

Dimensions shown above should be used as a guideline to TDI's numerous detectors.

Whilst every effort is taken through our Quality Control System to ensure that each detector conforms to these specifications, unfortunately, there may from time to time be a singular detector that does not. In the very rare event that this may happen, TDI would like to explain that it will only arise due to the fact that each and every detector is completely hand assembled and therefore they may slightly vary in size.

SPECIALS

High Temperature Detectors

TDI have developed two types of temperature detector which are able to remain stable with continuous temperature cycling up to 700°C. However, they are also capable of measuring temperatures up to 1000°C with little or no drift.

For more details, please request a full calibration report on High Temperature Bore Glassed (H.T.B.G.) Detectors and/or High Temperature Powder Filled (H.T.P.F.) Detectors.

High Vibration Detectors

These units have been developed to withstand very high vibration well above the IEC 751 requirements. High vibration detectors are suitable for use up to 300°C with high vibration without movement of the platinum coil. Above 300°C there will be a high level of drift if temperature cycled.

Characteristics

Temperature/Resistance Relationships

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

- for the range -200°C to 0°C:

$R_t=R_0\ [1+sAt+Bt^2+C(t-100°C)t^3]$

- for the range of 0 to 850°C

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

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

A = $3.908\ 02 \times 10^{-3}\ °C^{-1}$

B = $-5.802 \times 10^{-7}\ °C^{-2}$

C = $-4.273\ 50 \times 10^{-12}\ °C^{-4}$

For resistance thermometers satisfying the above relationships the temperature coefficient:

$\propto = 0.003850\ \Omega \bullet \Omega^{-1} \bullet °C^{-1}$

alpha is defined as follows:

$$\propto = \frac{R_{100} - R_0}{100 \times R_0}\ \Omega \bullet \Omega^{-1} \bullet °C^{-1}$$

where R_{100} = resistance at 100°C and R_0 resistance at 0°C.

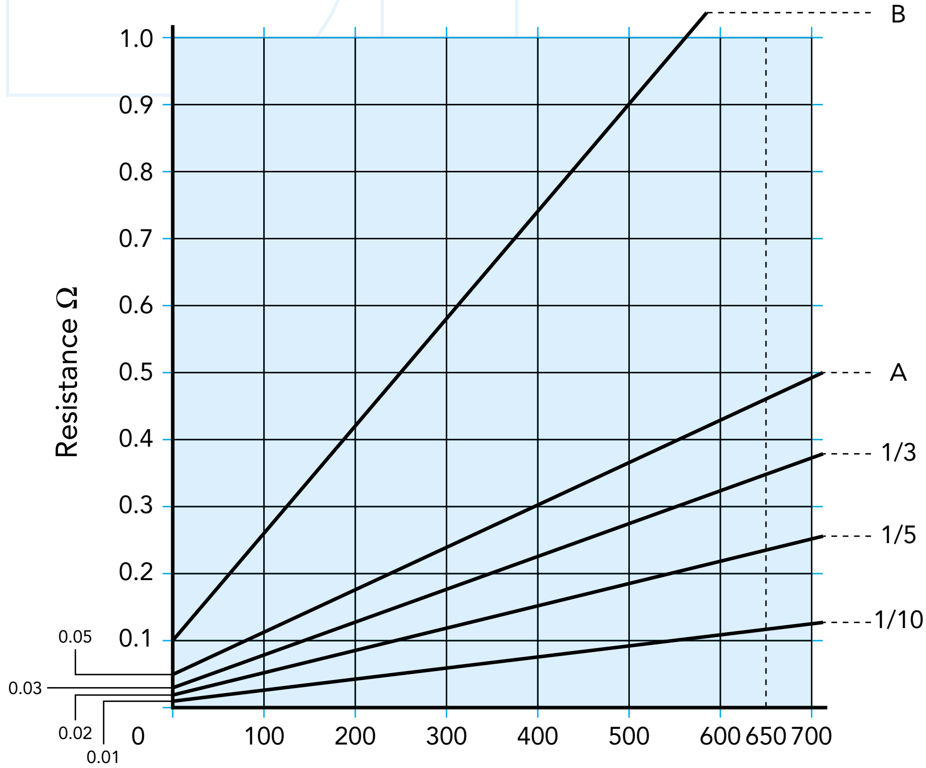
These equations are listed as the basis for the temperature/resistance tables of this standard and are not intended to be used for the calibration of individual thermometers.

Values of temperature in this standard are in the International Temperature Scale of 1990 (ITS-90).

Notes - Unless specified by the manufacturer the resistance values defined by the above equations do not include resistance of the leads between the sensing resistor and the terminations.

TDI Temperature/Resistance

∝ = 0.003850±6ppm



NOTE: all units will be within the tolerances above due to a closer alpha value than the ±6PPM quoted.

Resistance values

Most temperature detectors are constructed to have a nominal resistance at 0°C of 100Ω. However, due to customer requirements, within certain physical limits, any resistance value from 1 ohm at 0°C to 1000 ohms can be made.

Tolerances

The tolerance values of resistance thermometers are classified as follows:

Tolerance class	Tolerance (0°C)	
A	0.15	+0.002 (t)*
B	0.3	+0.005 (t)

*(t) = modulus of temperature in degrees Celsius without regard to sign.

Thermometers of 100Ω nominal resistance value shall be classified according to degree of conformity with the values of Table 1. Class A tolerances shall not be applied to 100Ω resistance thermometers at temperatures above 650°C.

Calibration

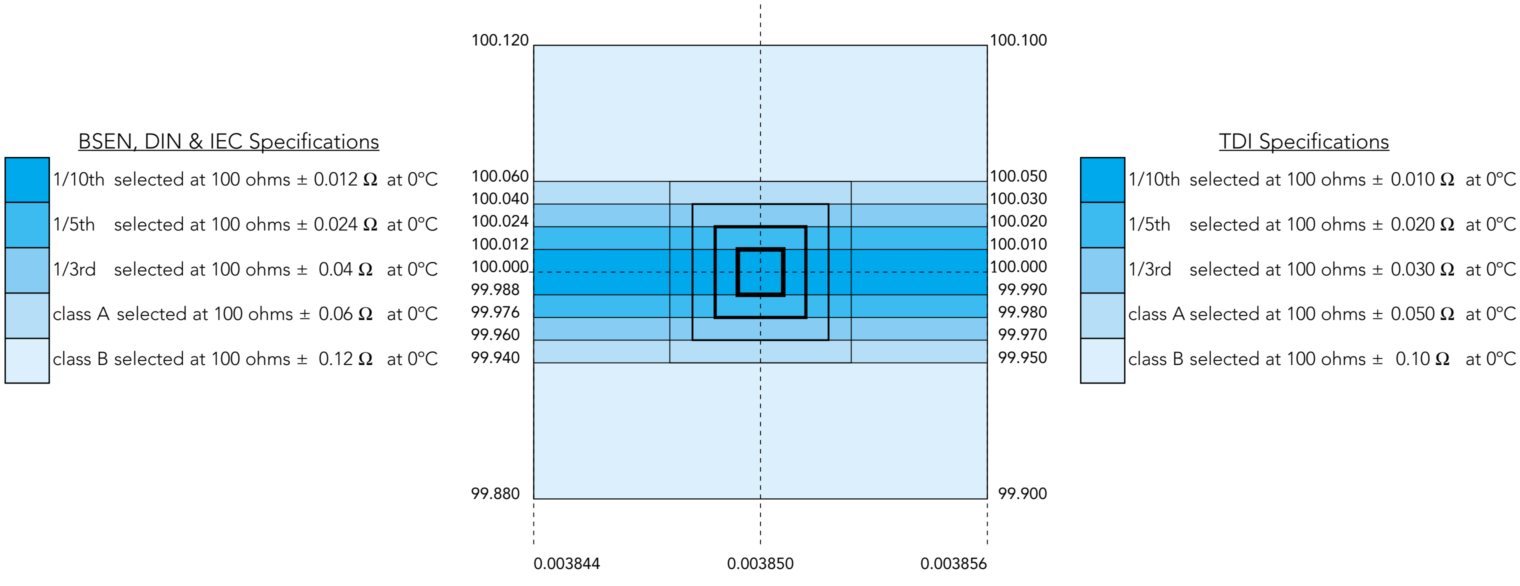
For all detectors the point of Calibration is 5mm from the end of the ceramic. Each single detector has two leads of Pure Platinum with Duplex units having four leads of Pure Platinum.

To avoid contamination and errors caused by using dissimilar metals, only platinum is used in the construction of our PRTD's.

Lead resistance values

ceramic diameter mm	lead diameter mm	lead resistance ohms/mm
4.5	0.4	0.0009
3.8	0.4	
3.2	0.4	
3.0	0.4	
2.8	0.4	
2.4	0.4	
2.0	0.265	0.002
1.6	0.265	
1.5	0.265	
1.2	0.265	
0.9	0.15	0.0063

PRTD Tolerances



As shown above, TDI always select detectors at a tighter tolerance than required by international standards.

Notes concerning tolerances of T.D.I. PRTDs
Confusion exists concerning the conformance of elements, called Sensing Resistors in the IEC 751 1995 standard, to other various international standards.

In order to understand this concern it must be noted that the IEC 751 1995 standard combined the specifications of the BS 1904:1984 and DIN 43760 1980 standards. Therefore, it is written about COMPLETE SENSOR ASSEMBLIES and their performance, NOT just about the Sensing Resistor.

Nonetheless, the sensing resistor will meet the Tolerances and Resistance/Temperature characteristics of IEC 751 1995 standard. However, it cannot meet all the requirements of this standard, as it refers to a complete assembly consisting of sheath, filling, sensing resistor, leads and terminals etc.

Closer Tolerances than Class A and Class B
Customers often ask for Sensing Resistors (PRT's, RTD's, Pt 100's, Platinum Elements ..... and various other descriptive terms) to closer tolerances than the IEC 751 Class A or Class B specifications. Typically, these are quoted as a fraction of the norm' ie. 1/10 of IEC Class B.

To understand this request, we must consider the following two aspects of the sensing resistor:

1) Its length, which defines R_0
The length is under control of the manufacturer. Hence, when describing a 1/10 Din Detector, the manufacturer is selecting 1/10 of the designated Class B tolerance at 0°C

and

2) Its composition of the Platinum Alloy, which dictates its slope or the resistance change with temperature.
The composition of the wire alloy is controlled during the manufacture of the metal used for the sensing resistor. The tightest specification normally accepted by a wire manufacturer is ± 3ppm (parts per million). The composition of the wire is normally defined by the Alpha Value, a measure in which the wire changes resistance with temperature. The perfect value for this parameter is 0.003850 for DIN standards ±3ppm. Therefore, this means 0.003853 to 0.003847. A 1ppm error in alpha causes an error at 100°C of approximately 0.025°C in addition to the 0°C error.

Understandably, the IEC 751 1995 Class B specification represents a spread of ±12ppm on the composition of the Platinum Alloy, and 0.12% on the length of the Sensing Resistor.

IEC 751 1995 Class A specification represents a spread of ±6ppm on the composition of the Platinum Alloy, and 0.06% on the length of the Sensing Resistor.

For example: a sensing resistor specified as 1/5 of IEC 751 Class A represents a spread of ±6ppm on the composition of the Platinum Alloy, and 0.012% on the length of the Sensing Resistor.

(±6ppm is about the best any supplier of Platinum Alloy can produce on a commercial basis).

This is about the limit of currently available commercial production sensing resistors, which when built into protection sheaths will meet the remaining requirements of IEC 751.

For further information the reader is referred to the 'Isotech Journal of Thermometry' Volume 2 Issue 2.

Industrial Platinum Resistance Thermometer Sensors

R(0) = 100.00Ω

°C ITS 90	0	1	2	3	4	5	6	7	8	9	10	°C ITS 90
-200	18.52											-200
-190	22.83	22.40	21.97	21.54	21.11	20.68	20.25	19.82	19.38	18.95	18.52	-190
-180	27.10	26.67	26.24	25.82	25.39	24.97	24.54	24.11	23.68	23.25	22.83	-180
-170	31.34	30.91	30.49	30.07	29.64	29.22	28.80	28.37	27.95	27.52	27.10	-170
-160	35.54	35.12	34.70	34.28	33.86	33.44	33.02	32.60	32.18	31.76	31.34	-160
-150	39.72	39.31	38.89	38.47	38.05	37.64	37.22	36.80	36.38	35.96	35.54	-150
-140	43.88	43.46	43.05	42.63	42.22	41.80	41.39	40.97	40.56	40.14	39.72	-140
-130	48.00	47.59	47.18	46.77	46.36	45.94	45.53	45.12	44.70	44.29	43.88	-130
-120	52.11	51.70	51.29	50.88	50.47	50.06	49.65	49.24	48.83	48.42	48.00	-120
-110	56.19	55.79	55.48	54.97	54.56	54.15	53.75	53.34	52.93	52.52	52.11	-110
-100	60.26	59.85	59.44	59.04	58.63	58.23	57.82	57.41	57.01	56.60	56.19	-100
-90	64.30	63.90	63.49	63.09	62.68	62.28	61.88	61.47	61.07	60.66	60.26	-90
-80	68.33	67.92	67.52	67.12	66.72	66.31	65.91	65.51	65.11	64.70	64.30	-80
-70	72.33	71.93	71.53	71.13	70.73	70.33	69.93	69.53	69.13	68.73	68.33	-70
-60	76.33	75.93	75.53	75.13	74.73	74.33	73.93	73.53	73.13	72.73	72.33	-60
-50	80.31	79.91	79.51	79.11	78.72	78.32	77.92	77.52	77.12	76.73	76.33	-50
-40	84.27	83.87	83.48	83.08	82.69	82.29	81.89	81.50	81.10	80.70	80.31	-40
-30	88.22	87.83	87.43	87.04	86.64	86.25	85.85	85.46	85.06	84.67	84.27	-30
-20	92.16	91.77	91.37	90.98	90.59	90.19	89.80	89.40	89.01	88.62	88.22	-20
-10	96.09	95.69	95.30	94.91	94.52	94.12	93.73	93.34	92.95	92.55	92.16	-10
0	100.00	99.61	99.22	98.83	98.44	98.04	97.65	97.26	96.87	96.48	96.09	0
0	100.00	100.39	100.78	101.17	101.56	101.95	102.34	102.73	103.12	103.51	103.90	0
10	103.90	104.29	104.68	105.07	105.46	105.85	106.24	106.63	107.02	107.40	107.79	10
20	107.79	108.18	108.57	108.96	109.35	109.73	110.12	110.51	110.90	111.29	111.67	20
30	111.67	112.06	112.45	112.83	113.22	113.61	114.00	114.38	114.77	115.15	115.54	30
40	115.54	115.93	116.31	116.70	117.08	117.47	117.86	118.24	118.63	119.01	119.40	40
50	119.40	119.78	120.17	120.55	120.94	121.32	121.71	122.09	122.47	122.86	123.24	50
60	123.24	123.63	124.01	124.39	124.78	125.16	125.54	125.93	126.31	126.69	127.08	60
70	127.08	127.46	127.84	128.22	128.61	128.99	129.37	129.75	130.13	130.52	130.90	70
80	130.90	131.28	131.66	132.04	132.42	132.80	133.18	133.57	133.95	134.33	134.71	80
90	134.71	135.09	135.47	135.85	136.23	136.61	136.99	137.37	137.75	138.13	138.51	90
100	138.51	138.88	139.26	139.64	140.02	140.40	140.78	141.16	141.54	141.91	142.29	100
110	142.29	142.67	143.05	143.43	143.80	144.18	144.56	144.94	145.31	145.69	146.07	110
120	146.07	146.44	146.82	147.20	147.57	147.95	148.33	148.70	149.08	149.46	149.83	120
130	149.83	150.21	150.58	150.96	151.33	151.71	152.08	152.46	152.83	153.21	153.58	130
140	153.58	153.96	154.33	154.71	155.08	155.46	155.83	156.20	156.58	156.95	157.33	140
150	157.33	157.70	158.07	158.45	158.82	159.19	159.56	159.94	160.31	160.68	161.05	150
160	161.05	161.43	161.80	162.17	162.54	162.91	163.29	163.66	164.03	164.40	164.77	160
170	164.77	165.14	165.51	165.89	166.26	166.63	167.00	167.37	167.74	168.11	168.48	170
180	168.48	168.85	169.22	169.59	169.96	170.33	170.70	171.07	171.43	171.80	172.17	180
190	172.17	172.54	172.91	173.28	173.65	174.02	174.38	174.75	175.12	175.49	175.86	190
200	175.86	176.22	176.59	176.96	177.33	177.69	178.06	178.43	178.79	179.16	179.53	200
210	179.53	179.89	180.26	180.63	180.99	181.36	181.72	182.09	182.46	182.82	183.19	210
220	183.19	183.55	183.92	184.28	184.65	185.01	185.38	18574	186.11	186.47	186.84	220
230	186.84	187.20	187.56	187.93	188.29	188.66	189.02	189.38	189.75	190.11	190.47	230
240	190.47	190.84	191.20	191.56	191.92	192.29	192.65	193.01	193.37	193.74	194.10	240
250	194.10	194.46	194.82	195.18	195.55	195.91	196.27	196.63	196.99	197.35	197.71	250
260	197.71	198.07	198.43	198.79	199.15	199.51	199.87	200.23	200.59	200.95	201.31	260
270	201.31	201.67	202.03	202.39	202.75	203.11	203.47	203.83	204.19	204.55	204.9	270
280	204.90	205.26	205.62	205.98	206.34	206.7	207.05	207.41	207.77	208.13	208.48	280
290	208.48	208.84	209.20	209.56	209.91	210.27	210.63	210.98	211.34	211.70	212.05	290
300	212.05	212.41	212.76	213.12	213.48	213.83	214.19	214.54	214.90	215.25	215.61	300
310	215.61	215.96	216.32	216.67	217.03	217.38	217.74	218.09	218.44	218.8	219.15	310
320	219.15	219.51	219.86	220.21	220.57	220.92	221.27	221.63	221.98	222.23	222.68	320
330	222.68	223.04	223.39	223.74	224.09	224.45	224.80	225.15	225.50	225.85	226.21	330
340	226.21	226.56	226.91	227.26	227.61	227.96	228.31	228.66	229.02	229.37	229.72	340
350	229.72	230.07	230.42	230.77	231.12	231.47	231.82	232.17	232.52	232.87	232.21	350
360	233.21	233.56	233.91	234.26	234.61	234.96	235.31	235.66	236.00	236.35	236.70	360
370	236.70	237.05	237.40	237.74	238.09	238.44	238.79	239.13	239.48	239.93	240.18	370
380	240.18	240.52	240.87	241.22	241.56	241.91	242.26	242.60	242.95	243.29	243.64	380

Industrial Platinum Resistance Thermometer Sensors

R(0) = 100.00Ω

°C ITS 90	0	1	2	3	4	5	6	7	8	9	10	°C ITS 90
390	243.64	243.99	244.33	244.68	245.02	245.37	245.71	246.06	246.40	246.75	247.09	390
400	247.09	247.44	247.78	248.13	248.47	247.81	249.16	249.50	249.85	250.19	250.53	400
410	250.53	250.88	251.22	251.56	251.91	252.25	252.59	252.93	253.28	253.62	253.96	410
420	253.96	254.30	254.65	254.99	255.33	255.67	256.01	256.35	256.70	257.04	257.38	420
430	257.38	257.72	258.06	258.40	258.74	259.08	259.42	259.76	260.10	260.44	260.78	430
440	260.78	261.12	261.46	261.80	262.14	262.48	262.82	263.16	263.50	253.84	264.18	440
450	264.18	264.52	264.86	265.20	265.53	265.87	266.21	266.55	266.89	267.22	267.56	450
460	267.56	267.90	268.24	268.57	268.91	269.25	269.59	269.92	270.26	270.60	270.93	460
470	270.93	271.27	271.61	271.94	272.28	272.61	272.95	273.29	273.62	273.96	274.29	470
480	274.29	274.63	274.96	275.30	275.63	275.97	276.30	276.64	276.97	277.31	277.64	480
490	277.64	277.98	278.31	278.64	278.98	279.31	279.64	279.98	280.31	280.64	280.98	490
500	280.98	281.31	281.64	281.98	282.31	282.64	282.97	283.31	283.64	283.97	284.30	500
510	284.30	284.63	284.97	285.30	285.63	285.96	286.29	286.62	286.95	287.29	287.62	510
520	287.62	287.95	288.28	288.61	288.94	289.27	289.60	289.93	290.26	290.59	290.92	520
530	290.92	291.25	291.58	291.91	292.24	292.56	292.89	293.22	293.55	293.88	294.21	530
540	294.21	294.54	294.86	295.19	295.52	295.85	296.18	286.50	296.83	297.16	297.49	540
550	297.49	297.81	298.14	298.47	298.80	299.12	299.45	299.78	300.10	300.43	300.75	550
560	300.75	301.08	301.41	301.73	302.06	302.38	302.71	303.03	303.36	303.69	304.01	560
570	304.01	304.34	304.66	304.98	305.31	305.63	305.96	306.29	306.61	306.93	307.25	570
580	307.25	307.58	307.90	308.23	308.55	308.87	309.20	309.52	308.98	310.16	310.49	580
590	310.49	310.81	311.13	311.45	311.78	312.10	312.42	312.74	313.06	313.39	313.71	590
600	313.71	314.03	314.35	314.67	314.99	315.31	315.64	315.96	316.28	316.60	316.92	600
610	316.92	317.24	317.56	317.88	318.20	318.52	318.84	319.16	319.48	319.80	320.12	610
620	320.12	320.43	320.75	321.07	321.39	321.71	322.03	322.35	322.67	322.98	323.30	620
630	323.30	323.62	323.94	324.26	324.57	324.89	325.21	325.53	325.84	326.16	326.48	630
640	326.48	326.79	321.11	327.43	327.74	328.06	328.38	328.69	329.01	329.32	329.64	640
650	329.64	329.96	330.27	330.59	330.90	331.22	331.53	331.85	332.16	332.48	332.79	650
660	332.79	333.11	333.42	333.74	334.05	334.36	334.68	334.99	335.31	335.62	335.93	660
670	335.93	336.25	336.56	336.87	337.18	337.50	337.81	338.12	338.44	338.75	339.06	670
680	339.06	339.37	339.69	340.00	340.31	340.62	340.93	341.24	341.56	341.87	342.18	680
690	342.18	342.49	342.80	343.11	343.42	343.73	344.04	344.35	344.66	344.97	345.28	690
700	345.28	345.59	345.90	346.21	346.52	346.83	347.14	347.45	347.76	348.07	348.38	700
710	348.38	348.69	348.99	349.30	349.61	349.92	350.23	350.54	350.84	351.15	351.46	710
720	351.46	351.77	352.08	352.38	352.69	353.00	353.30	353.61	353.92	354.22	354.53	720
730	354.53	354.84	355.14	355.45	355.76	356.06	356.37	356.67	356.98	357.28	357.59	730
740	357.59	357.90	358.20	358.51	358.81	359.12	359.42	359.72	360.03	360.33	360.64	740
750	360.64	360.94	361.25	361.55	361.85	362.16	362.46	362.76	363.07	363.37	363.67	750
760	363.67	363.98	364.28	364.58	364.89	365.19	365.49	365.79	366.10	366.40	366.70	760
770	366.70	367.00	367.30	367.60	367.91	368.21	368.51	368.81	369.11	369.41	369.71	770
780	369.71	370.01	370.31	370.61	370.91	371.21	371.51	371.81	372.11	372.41	372.71	780
790	372.71	373.01	373.31	373.61	373.91	374.21	374.51	374.81	375.11	375.41	375.70	790
800	375.70	376.00	376.30	376.60	376.90	377.19	377.49	377.79	378.09	378.39	378.68	800
810	378.68	378.98	379.28	379.57	379.87	380.17	380.46	380.76	381.06	381.35	381.65	810
820	381.65	381.95	382.24	382.54	382.83	383.13	383.42	373.72	384.01	384.31	384.60	820
830	384.60	384.90	385.19	385.49	385.78	386.08	386.37	386.67	386.96	387.25	387.55	830
840	387.55	387.84	388.14	388.43	388.72	389.02	389.31	389.60	389.90	390.19	390.48	840
850	390.48											850

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

for the range -200°C to 0°C:

$R_1 = R_0[1 + At + Bt^2 + C(t - 100°C)t^3]$

for the range 0°C to 850°C:

$R_1 = R_0(1 + At + Bt^2)$

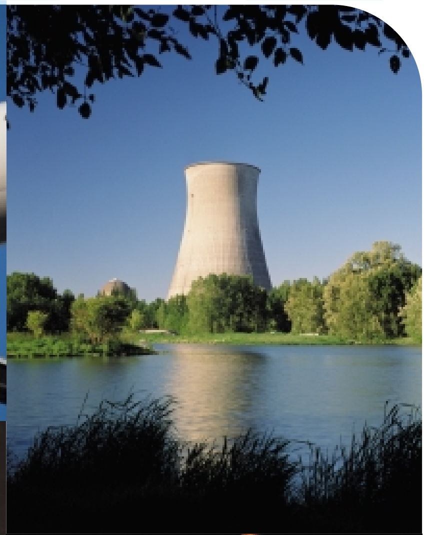
For the quality of platinum commonly used for industrial resistance thermometers the values of the constants in these equations are:

A = 3.9083 • 10^{-3} $°C^{-1}$
B = -5.775 • 10^{-7} $°C^{-2}$
C = -4.183 • 10^{-12} $°C^{-4}$

Tolerances for 100 ohm - 50 ohm Thermometer with Alpha 0.003916

Nominal resistance	Measured temperature °C	Class index 0.15 Temperature °C	Class index 0.2 Temperature °C	Class index 0.5 Temperature °C
100Ω	-200	±0.45	±0.55	±1.3
	-100	±0.30	±0.35	±0.8
	0	±0.15	±0.15	±0.3
	100	±0.30	±0.35	±0.8
	200	±0.45	±0.55	±1.3
	300	±0.60	±0.75	±1.8
	350	±0.68	±0.85	±2.05
	400	-	±0.95	±2.3
	500	-	±1.15	±2.8
50Ω	-200	±0.45	±0.55	±1.3
	-100	±0.30	±0.35	±0.8
	0	±0.15	±0.15	±0.3
	100	±0.30	±0.35	±0.8
	200	±0.45	±0.55	±1.3
	300	±0.60	±0.75	±1.8
	350	±0.68	±0.85	±2.05
	400	-	±0.95	±2.3
	500	-	±1.15	±2.8






It is impossible to list the applications of TDI's platinum resistance detectors - they are in use world wide in situations such as oil rigs and power stations to medicine and calibration

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