Frequently Asked Questions about Platinum RTD Elements

Platinum RTD Specifications

What is the difference between the IEC 60751 specification and the DIN EN 60751 specification?

The IEC 60751 and DIN EN 60751 specifications are identical. The DIN specification is basically the IEC spec with a cover page added.

What is the difference between the IEC 60751 specification and the ASTM E1137 specification?

Both specifications apply to the standard 3850ppm temperature coefficient platinum curve, and are based upon the ITS-90 temperature scale. One primary difference between the two specifications is the definition of tolerance classes, as follows

IEC 60751 (2008)		ASTM E1137	
Tolerance Class	Tolerance Definition	Tolerance Grade	Tolerance Definition
Class F0.3 (Class B)	±(0.3 + 0.005 |t|)	Grade B	±(0.25 + 0.0042 |t|)
Class F0.15 (Class A)	±(0.15 + 0.002 |t|)	Grade A	±(0.13 + 0.0017 |t|)
Where |t| is the absolute value of temperature in °C			

'F' indicates thin film element. If the tolerance of a wirewound element is being defined, substitute 'W'.

A customer asked for a temperature sensor assembly with a platinum RTD element that meets the requirements of DIN 43760. Is this a valid specification for a platinum RTD sensor?

No. DIN 43760 Sept 68 applied to both 100 ohm nickel and platinum RTD elements. The next version of the specification, DIN 43760 Sept 87, applied only to nickel elements, and no longer applied to platinum elements. DIN EN 60751 is the applicable DIN specification for platinum RTD elements.

A customer has asked me to build a temperature probe with a “JIS curve Pt100” RTD element. What is this curve, and can Heraeus supply an element that meets this curve?

The customer may be referring to a Pt100 element with a temperature coefficient of 3916 ppm, which was defined by the JIS C1604-1987 (and earlier) specification. Heraeus Nexensos supplies TC 3916ppm ceramic wirewound elements, in resistance values up to Pt500.

The more recent JIS C1604-1997 version specifies a temperature coefficient of 3850ppm, matching the DIN/IEC standard. Please confirm your customer's temperature coefficient requirement before ordering.

I've seen references to a F0.3 tolerance. What does this mean?

"F0.3" tolerance is equivalent to a class B tolerance (F=thin film, W=wirewound, 0.3 indicates ±0.3 Deg C @ 0 Deg C). The tolerance nomenclature for platinum temperature sensing elements was revised in the IEC 60751 2008-07 specification (also in the DIN EN 60751 2009-05 specification). The following table relates the old tolerance designation to the new.

Old Tolerance Designation	New Tolerance Designation
Class ⅓B	*0.1
Class A	*0.15
Class B	*0.3
Class 2B	*0.6
Substitute * with 'F' for Thin Film, 'W' for wirewound	

Thin Film vs. Wirewound RTD element

Thin Film or Wirewound Platinum RTD Element – which one should I choose?4

The requirement of the specific application dictates the type of element used, but typically, the default choice is a Thin Film Element. Intrinsically vibration-resistant and lower in cost than a Wirewound Element, the Thin Film Element meets the needs of most temperature sensing applications. The following table summarizes the advantages of each type:

Thin-Film Element Advantages	Wirewound Element Advantages
Low-cost	Higher source currents possible
Fast response time	Lower self-heating constant
Low thermal mass	Wider operating temperature range
High vibration resistance	Wider tight tolerance temperature range
High thermal shock resistance	Customizable R0 values
Small size footprint	Larger diameter lead wires

Choosing a Thin Film Element

What are the key characteristics of each Thin Film type? Why would I choose one type over another?

The Thin Film Element types supplied by Heraeus Nexensos differ primarily by operating temperature range. The table below summarizes the various types. The min/max operating temperature of your application must fall within the operating range specified for the part. Using a part outside the rated operating range may produce unpredictable results, and is not recommended. Please see individual data sheets for the specific properties of each type.

Element Type	Operating Temperature	Lead Wire Material	Recommended Connection Method
C	-196 to +150°C	AgPd	soft soldering
L/LN	-50 to +400°C	AgPd -- silver coated Nickel	soft soldering
M	-70 to +500°C	Ni/Pt	hard soldering, welding, crimping
HM	-70 to +600°C	PtPd	hard soldering, welding
HL	-70 to +750°C	Pt/NiCr	hard soldering, welding
HD	-70 to +850°C	Pt	hard soldering, welding

I notice that some of the Thin Film Element types are available in a variety of sizes. Why would I choose one size over another?

For a new application, we typically recommend the M222 type (2.3mm L x 2.1mm W). The M222 has a relatively low unit price, and will fit in a variety of probe sizes. For existing applications, a larger size element, such as the M1020 (9.5mm L x 1.9mm W) may be required to match an existing size footprint. The following table summarizes some size-dependent properties.

Smaller element	Larger element
Faster response time	Higher source currents possible
Higher self-heating constant	Lower self-heating constant
Self-heats at lower power	Requires higher power to self-heat
Fits in small ID sensor housings	Larger contact area for surface mounting

Temperature Coefficient

How is the temperature coefficient of a Platinum RTD Element defined?

The temperature coefficient, also referred to as the “alpha value”, is the average change in resistance between 0 and 100 °C, and calculated using the formula

$$\alpha = \frac{R_{100} - R_0}{R_0 * 100\ °C}$$

Where R100 is the resistance at 100 °C and R0 is the resistance at 0 °C

What temperature coefficients are available for Platinum RTD Elements?

Heraeus Nexensos supplies Platinum RTD Elements with the following temperature coefficients:

Thin Film	Wirewound (sales HST-USA only)
3850ppm	3850ppm
3750ppm (Pt1000 only)	3916ppm
3770ppm (Pt200 for automotive application only)	

Resistance vs. Temperature Characteristic

How is the resistance vs. temperature characteristic of a Platinum RTD Element defined?

The Callendar–Van Dusen equation describes the relationship of resistance to temperature in Platinum RTD Elements.

For temperatures t equal to and above 0 Deg C, the equation is $R(t) = R0*(1+A*t+B*t^2)$
For temperatures t below 0 Deg C, the equation is $R(t) = R0*(1+A*t+B*t^2+C*(t-100°C)*t^3)$
Where A, B, & C are constants for specific RTD curves.

The constants for the IEC 60751 TC 3850ppm curve are:

A = 3.9083*10-3 °C-1
B = -5.775*10-7 °C-2
C = -4.183*10-12 °C-4

RTD Element Physical Properties

What is the self-heating constant?

The self-heating constant defines the temperature rise in degrees Kelvin per mW of applied power. The constant of each RTD Element is measured in a standard condition of ice water at 0 Deg C. Since the constant is measured under conditions that don't necessarily reflect a typical application environment, the self-heating constant is primarily used to compare the self-heating properties of one element to another. In addition, the actual use conditions greatly influence the self-heating constant. For example, potting the element in a thermally conductive material increases the surface area and thermal mass, effectively lowering the self-heating constant. If an element is used in a full or partial vacuum, however, the opposite can occur—the self-heating constant can increase due to the reduced thermal conductivity of the surrounding medium. In temperature-sensing applications, self-heating, if excessive, can introduce significant measurement error. The dependency of self-heating on the thermal conductivity of the surrounding medium can also be exploited to measure fluid level, flow, thermal conductivity, fluid density, etc.

Heraeus Nexensos Platinum RTD data sheets date response time data for each part. A response time is stated for "T0.5" and "T0.9". What does this mean?

"T0.5" means the time elapsed to respond to 50% of a step change in temperature. Similarly, "T0.9" means the time elapsed to respond to 90% of a step change in temperature. Let's use actual response time data from the M222 thin film data sheet (below) as an example:

Response Time	water current (v=0.4m/s):	t0.5 = 0.05s
		t0.9= 0.15s
	air stream (v=2m/s):	t0.5= 3.0s
		t0.9= 10.0s

The data sheet states a t0.5 response time of 0.05 seconds in water. This means if an element is exposed to a step change in temperature from 50 to 100°C, after 0.05 seconds, the element body temperature will be 75°C (50% of step change between 50 & 100°C), and after a total of 0.1 seconds, the element body temperature will be 87.5°C (50% of the step change from 75 to 100°C.

The following table provides illustration of the concept:

Time response for RTD element with T0.5=0.05s Step change in temperature from 50 to 100°C		
Actual Time Elapsed Seconds	Time Constants	Element Body Temperature Deg C
0.00	0	50.00
0.05	1	75.00
0.10	2	87.50
0.15	3	93.75
0.20	4	96.88
0.25	5	98.44
0.30	6	99.22
0.35	7	99.61
0.40	8	99.80
0.45	9	99.90
0.50	10	99.95
0.55	11	99.98
0.60	12	99.99

Assembly Considerations

Are there any special precautions need be taken when handling Platinum RTD Elements, or incorporating them into assemblies?

Handling & Installation of Platinum RTD Sensors from Heraeus Nexensos GmbH

Handling

Sensors must be handled carefully to avoid damage. Plastic or plastic coated metal tweezers are recommended. Pliers or clamps should not be used. The element should not be subjected to any clamping forces.
To avoid lead strain, the lead wires should not be bent in the vicinity of the sensor body. Avoid frequent bending or repositioning of lead wires.

Connection techniques

The preferred connection technologies are welding, brazing, or soft soldering, depending upon the lead wire and temperature rating of the element. Recommended connection techniques are specified on each thin film element data sheet. Generally, welding is recommended for Ni or Pt coated Ni lead wires, and soft soldering is recommended for silver alloy, silver coated Nickel or gold-plated lead wires.

For elements with gold-alloy lead wires, such as the C416 type, only solder alloys specifically designed for use with gold should be used. Other alloys not specifically recommended for use with gold wire may cause irreversible lead wire damage.

Connection method details:

Laser welding: A laser lap or butt weld is the preferred connection technique. Ultrasonic welding: Prior to welding, bend the leads away from the plane of the element body to eliminate internal damage.

Spot welding/resistance welding: A widely used, reliable connection technique.

Crimping: High-quality gas-tight crimping is recommended to avoid high contact resistance.

Soft soldering: Insure that solder alloy is compatible with lead wire material, and melting point is higher than maximum application temperature. All flux must be removed from the element and lead wires unless you use non clean flux.

Brazing: During the brazing operation, the element body temperature must not exceed the maximum rated temperature. Heat sink the element leads, if necessary, during brazing, to avoid overheating. The brazing time should be less than 3 seconds.

Lead wire length

The nominal resistance of the sensor element is measured on the wire 8mm (at the standard length of 10mm) from the element body. Cutting the lead wire will decrease the resistance and can shift the calibration (e.g. leave class F0,15 or F0,1). This impact is more serious for a Pt 100 compare to a Pt1000. Similarly, adding extension leads will increase the resistance. A 3 or 4 wire connection at the 8mm point may be used to compensate the resistance from the additional lead length.

Encapsulation and Potting

The thermal expansion coefficient of the potting material should match the expansion coefficient of alumina ceramic, the sensor substrate material, to avoid measurement errors or part failure due to thermal expansion mismatch.

Rigid epoxies should be avoided, especially when the maximum operating temperature exceeds the glass transition temperature of the potting material.
End-users have reported successful use of thermally conductive non-rigid silicone potting materials.
Encapsulation materials must be chemically neutral. In particular, ceramic potting materials containing fluorine compounds should be avoided.
If the element is potted in a housing, the housing should be free from contaminants, such as flux, organics, etc., to avoid element damage at elevated temperature.

Please refer to individual data sheets for any requirements specific to a particular element type.

Storage

Platinum sensing elements should be stored in a corrosive-free environment. The elements should be stored with adequate protection against shock, bending or crushing forces, etc. In high humidity environments, it may be necessary to dry the sensor before installation. To avoid corrosion elements with Silver/Palladium wires or silver coated Nickel wires should be stored in a nitrogen atmosphere.

Please refer to individual data sheets for any special handling or storage requirements.

Element appearance

I noticed that the appearance of the "blue glazing (fixation drop)" is slightly varying and it not always covering the complete surface of element. Is there any influence on the performance of the sensor element?

We call the blue glazing "fixation drop". Its function is to provide an additional protection and stress relive for the bonding area (where the wire is bonded to the pad).

The fixation drop itself and its height is controlled in our production process. Due to the consistency and the application process of the drop it can slightly vary from batch to batch. Heraeus Nexensos is specifying and checking the overall size of the element.

The functional layer of the chip is covered with a special protection glass. This ensures the safety and function of the element. Therefore, it doesn't impact the electric properties (resistance, tolerance, signal stability, etc.) if the fixation drop covers slightly more or less of the sensor area.