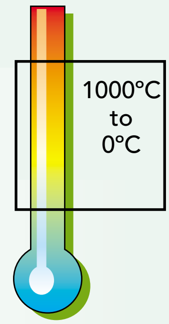
Platinum/Gold

Thermocouple



Since 1995 Isotech have been producing various designs of special Pt/Au, Pt/Pd, Pd/Au thermocouples for researchers. From our experience we can now offer the most popular of these, the Pt/Au thermocouple in a standard form.

All wires are 99.999+% pure and are fully annealed according to the recommendations of McLaren Assembly also follows his prescriptions which have never been bettered.

After final assembly and annealing the Pt/Au thermocouples will conform to the reference function derived by Burns within ±0.05°C.

For smaller uncertainties we calibrate the thermocouple at the Tin, Zinc, Aluminium and Silver Fixed Points. The associated uncertainties being Zinc±2.5mK, Aluminium±4mK and Silver ±6mK (1 sigma). The reproducibility of the thermocouples is less than ±0.05°C.

We achieve these results because:

1. All materials are selected for their purity and high quality.

2. All parts are pre-aged and annealed prior to construction.

3. The construction allows for differential expansion of the Gold and the Platinum by having a coil of platinum bridge the two thermo elements at their measuring junction.

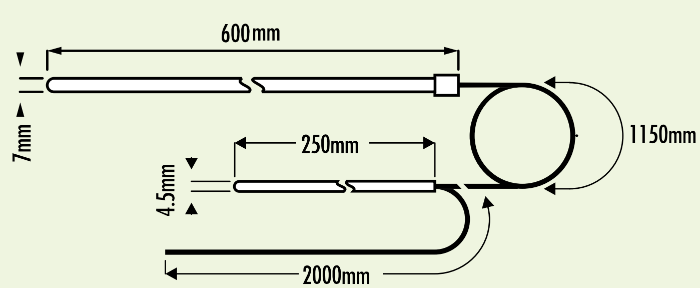
4. There are no joins between the measuring and reference junctions.

5. The reference junction is also researched and we use thermally pure copper wire of selected diameter which has been pre-annealed in inert gas to maintain the accuracy of the measuring junction.

6. The reference junction needs to be placed in an accurate reference system such as a Water Triple Point Cell or an Isotech Zeref.

7. An article describing in detail the construction, handling and operation of the thermocouple is provided free with each unit.

Economic alternative to HTSPRT's
Construction allows for differential expansion
Accuracy of ±0.05°C over the whole temperature range



Temperature Range	0°C to 1000°C
Sheath materials Measuring Junction Reference Junction	 Quartz Stainless Steel
Thermo-element Purities Platinum Gold	 99.999% Pure 99.999% Pure
Calibration Uncertainties	less than 0.015°C with fixed points (refer to text)
Stability	±0.05°C
Dimensions	Refer to drawing
Carrying Case	Included as standard

How to order

Model type Pt/Au Thermocouple

Including emf vs. temperature traceable calibration certificate and carrying case

ISOTECH'S Au/Pt thermocouple conforms to the reference function and uncertainties listed below

For more information see "Gold Versus Platinum Thermocouples: performance data and an ITS-90 based reference function". G.W. Burns et al. American Institute of Physics.

The new reference function for Au/Pt thermocouples is of the form:

$$E=p(t_{90}) = \sum_{i=1}^{9} a_i (t_{90})^i$$

Equation ②

where t_{90} is in degrees Celsius and E is the *emf* in microvolts. The coefficients of Eq. (2) for the range 0°C to 1000°C are given in Table II. The random component of uncertainty for $p(t_{90})$, where $p(t_{90})$ is data from two typical thermocouples fitted with a 9th degree polynominal by the method of least squares, is calculated using Working-Hotelling confidence bands. The upper and lower 95% confidence bands at temperature t_h are $p(t_h) \pm v(t_h)$, where

$$V(t_h) = \sqrt{9F_{0.95}(9{,}995)}\, s_h$$

Equation ①

the critical value $F_{0.95}(9{,}995) = 1.89$ is the upper 95 percent point of the F distribution with 9 and 995 degrees of freedom, and s_h is the standard deviation of $p(t_h)$ at temperature t_h. The Working-Hotelling bands are appropriate for unlimited use of the reference function. Representative values are shown in table 1. Values of E and the first and second derivatives of E with respect to t_{90} computed from Eq. (2) at selected values of t_{90} are given in Table III.

Table I

Random uncertainties (μV) for $p(t_{90})$ from 95% Working - Hotelling Confidence bands.

t_{90} / °C	$P(t_{90})$	$V(t_{90})$
0	0.00	0.00
100	777.90	0.02
200	1845.08	0.02
300	3141.77	0.02
400	4633.43	0.02
500	6300.95	0.02
600	8135.10	0.01
700	10132.25	0.02
800	12290.89	0.02
900	14609.31	0.02
1000	17085.31	0.04

Table II

Coefficients for Au/Pt thermocouple reference function for the range 0°C to 1000°C

a_1	6.03619861	a_5	$-4.24206193 \times 10^{-11}$
a_2	$1.93672974 \times 10^{-2}$	a_6	$4.56927038 \times 10^{-14}$
a_3	$-2.22998614 \times 10^{-5}$	a_7	$-3.39430259 \times 10^{-17}$
a_4	$3.28711859 \times 10^{-8}$	a_8	$1.42981590 \times 10^{-20}$
		a_9	$-2.51672787 \times 10^{-24}$

Table III

Values of *E* and the first and second derivatives of *E* with respect to t_{90} computed from equation (2) at selected values of t_{90}

t_{90} / °C	*E* μV	dE/dt_{90} μV/°C	d^2E/dt^2_{90}, nV/°C²
0.00	0.00	6.036	38.73
0.01	0.06	6.037	38.73
29.7646	196.26	7.133	35.08
156.5985	1350.94	10.861	24.90
231.928	2236.18	12.599	21.46
419.527	4945.63	16.157	17.27
630.615	8729.30	19.658	16.24
660.323	9320.44	20.139	16.20
961.78	16120.49	24.945	15.65
1000.00	17085.31	25.543	15.64

Since the reference given by Eq. (2) is not well suited for calculating values of temperature from values of *emf*, two inverse functions are included here for that purpose. These inverse functions give values of temperature that agree with values obtained from the reference function to at least ±5m°C, where the *emf* (*E*) is given in microvolts. Equation (3) gives the form of an inverse function for the Au/Pt thermocouple for the temperature and *emf* ranges, 0°C to 209°C and 0μV to 1953μV. The coefficients for Eq. (3) are given in Table IV.

$$t_{90} = \sum_{i=1}^{8} b_i (E)^i$$

Equation ③

Table IV

Table IV. Coefficients of the inverse function, Eq. (3), for the Au/Pt thermocouple for the range 0°C to 209°C.

b_1	1.6543903×10^{-1}	b_5	$4.8495536 \times 10^{-14}$
b_2	$-8.4098835 \times 10^{-5}$	b_6	$-2.0138760 \times 10^{-17}$
b_3	8.4166132×10^{-8}	b_7	$4.7475626 \times 10^{-21}$
b_4	$-7.5174691 \times 10^{-11}$	b_8	$-4.7973082 \times 10^{-25}$

Equation (4) gives the form of an inverse function for the Au/Pt thermocouple for the temperature and *emf* ranges, 209°C to 1000°C and 1953μV to 17085μV. The coefficients for Eq. (4) are given in Table V.

$$t_{90} = \sum_{i=0}^{11} b_i ((E - 9645)/7620)^i$$

Equation ④

Table V

Table V. Coefficients of the inverse function, Eq. (4), for the Au/Pt thermocouple for the range 209°C to 1000°C.

b_0	6.763360×10^{2}	b_6	-3.385575
b_1	3.735504×10^{2}	b_7	3.853735
b_2	-5.537363×10^{1}	b_8	1.178891
b_3	1.701900×10^{1}	b_9	-2.702558
b_4	-6.098761	b_{10}	-1.686158
b_5	2.457162	b_{11}	1.876968

To get the most accurate results from thermocouples a 0°C reference and a very high quality digital voltmeter are required.

For the very smallest uncertainties from our Platinum/Gold thermocouple we recommend that the cold junction be a Water Triple Point Cell. See page 5.

Alternatively the Automatic Zeref apparatus is nearly as good (see Databook 4).

Free accessories for your Primary Laboratory

When you purchase your Primary Laboratory from Isotech we will provide you with a complete set of 20 Journals of Thermometry in a 2 volume gold and maroon presentation set free of charge, together with other accessories that will make your Primary Laboratory run easily and smoothly.

Training

Isotech offers the widest choice of educational packages available.

For a full list of our services consult Databook 5.