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We create chemistry

High temperature thermocouple wire

Overview

BASF has supplied science and industry with thermocouple wire for well over 100 years. During this time, BASF has shared in satisfying the needs of the user by constant dedication to the technology through improvement and innovation. We stand ready to continue this tradition and welcome your inquiry. Our team of experts consist of metallurgists, metrologists, and experienced process application engineers. We would be pleased to provide whatever assistance you may need in making a selection, determining solutions to your application problems or placing an order.

Nobel metals and their alloys have long been recognized as the most reliable sensing elements for high temperature measurement. Among their outstanding properties are:

- High Melting Point
- Reproducible EMF
- Resistance to Corrosion
- Stability of Calibration
- Oxidation Resistant

When coupled with the Iridium Rhodium and Tungsten-Rhenium systems temperature measurement and control can be achieved upwards of 2300ºC with reliability.

To assist users in selecting materials best suited for their purpose as much physical, chemical and application information as is reliably available has been included in this bulletin.

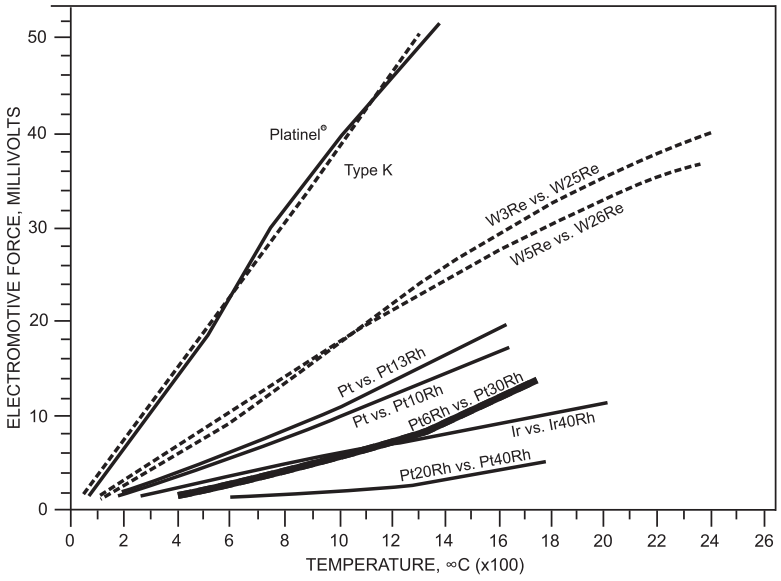
Precious metals expertise

Metals – particularly those in the platinum group – are critical components of many products made by BASF such as contact thermocouples. Ensuring that those raw materials are where they need to be, when they need to be there, in the form they need to be and at the lowest possible cost is what BASF's Materials Services group is all about. Given our unique understanding of market fundamentals, such as current and future supply, technology changes and market risks, we help ensure that BASF and our customers have a cost-effective, reliable supply of the raw materials they need.

A fundamental understanding of precious metal and precious metal technologies is also critical. The experience of our research and development group in precious metal and precious metal technologies is unmatched. From Fibro® platinum to Platinel® thermocouple wire we have led the industry with breakthrough innovations. No one knows more about precious metals. We are the precious metal experts.

Standards and tolerances

All BASF produced thermocouple wire confirms to the latest version of available and existing international standards. For all combinations, the emf-Temperature relationships are in accord with the applicable International Electrotechnical Commission (IEC) Standards which incorporate all major national institutions. Conformance and interchangeability tolerances of all combinations are detailed in their respective bulletin section.



Comparative emf vs. temperature relationship of common thermocouple materials.

High temperature thermocouple wire summary

Platinel®

A development by BASF that brings together the high electrical output of the nickel base alloys with the oxidation resistance and stability of the precious metals. Often used as a direct replacement for “K” - Type base metals in process control applications where long life, stability, and continuous trouble-free performance is required.

Recommended temperature range

0 to 1300ºC continuously

0 to 1350ºC intermittently

Environment

Oxidizing..... Preferred

Neutral..... Acceptable

Reducing ..... Possible

Vacuum ..... Dependent on application

Tolerance

Premium +/- 3/8% of temperature from 400ºC to 1300ºC.

Standard +/- _% of temperature from 400ºC to 1300ºC

Type S: Pt vs. Pt 10 Rh

One of the most popular and widely used noble metal thermocouple combinations. Known for its high accuracy over a broad temperature range, this combination has excellent mechanical and chemical properties, low electrical resistivity, and is readily obtainable in uniform quality and in very fine diameters.

Recommended temperature range

400ºC to 1400ºC continuously

400ºC to 1700ºC intermittently

Environment

Oxidizing.....Preferred

Neutral.....Acceptable

Reducing .....Not recommended

Vacuum .....Dependent on application

Availability

All sizes readily available to .002” diameter (0.05 mm) and smaller on special order.

Tolerance

Available to two conformance levels: premium grade and standard grade.

Special tolerances available on request.

Type R: Pt vs. Pt 13 Rh

Widely used around the world. This combination is almost identical to Type S except for slightly higher thermoelectric output which accommodates instruments that have been calibrated for this output.

Recommended temperature range

800ºC to 1600ºC continuously

800ºC to 1770ºC intermittently

Environment

Oxidizing..... Preferred

Neutral..... Acceptable

Reducing ..... Not recommended

Vacuum ..... Dependent on application

Availability

All sizes readily available to .002” diameter (0.05 mm) and smaller on special order.

Tolerance

Available to two conformance levels: premium grade and standard grade.

Special tolerances available on request.

High temperature thermocouple wire summary

Type B: Pt 6 Rh vs. Pt 30 Rh

This widely used thermocouple is very similar to other Pt and Rh combinations. It has been demonstrated to perform well at the higher application temperatures where other combinations may be subject to accelerated drift or physical degradation. It is unique in that, at reference junction temperatures below 100ºC, compensating lead wire is generally not necessary, plain copper conductors are adequate.

Recommended temperature range

400ºC to 1400ºC continuously

400ºC to 1700ºC intermittently

Environment

Oxidizing..... Preferred

neutral ..... Acceptable

Reducing ..... Not recommended

Vacuum ..... Dependent on application

Availability

All sizes readily available to .002" diameter (0.05 mm) and smaller on special order.

Tolerance

Available to two conformance levels: premium grade and standard grade.

Special tolerances available on request.

Pt 20 Rh vs. Pt 40 Rh

A unique combination with strong, but limited, applications. An extremely stable combination for very high temperature use in problematic environments. Its low sensitivity (4 microvolts per ºC) requires the use of direct emf reading instruments. An excellent researcher's tool for high temperature measurement.

Recommended temperature range

1000ºC to 1800ºC continuously

1000ºC to 1850ºC intermittently

Environment

Oxidizing..... Preferred

Neutral..... Acceptable

Reducing ..... Not recommended

Vacuum ..... Dependent on application

Tolerance

Lot calibration provided for use with the detailed emf-Temperature tables provided within this bulletin.

Iridium vs. Iridium 40 Rhodium

The only thermocouple combination that can be used up to 2000ºC in oxidizing environments. It is also usable continuously in vacuum and neutral atmospheres.

Recommended temperature range

1000ºC to 2000ºC continuously

Environment

Oxidizing..... Limited

Neutral..... Preferred

Reducing ..... Possible

Vacuum ..... Possible

Tolerance

Lot calibration provided for use with the detailed emf-Temperature tables provided within this bulletin.

High temperature themocouple wire summary

W 3 Re vs. W 25 Re and W 5 Re vs. W 26 Re

These refractory metal combinations provide the ability to measure and control temperatures up to 2800°C, limited only by the availability of suitable insulation. The W 3 Re / W 25 Re combination introduced the concept of doping the low rhenium alloy leg in order to improve ductility and handling. Today's improved version of the W 5 Re / W 26 Re combination, is also doped for similar benefits.

Recommended temperature range

400°C to 2400°C continuously

400°C to 2800°C intermittently

Environment

Oxidizing ..... Not possible

Neutral ..... Acceptable

Reducing ..... Acceptable

Vacuum ..... Not recommended above 1800°C

Tolerance

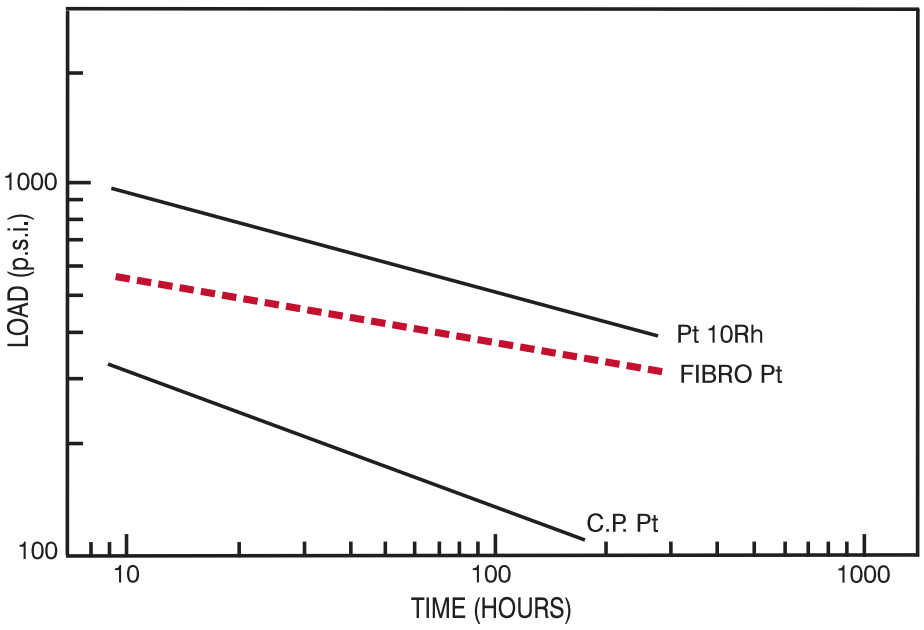
± 1% temperature from 400°C to 2400°C.

Fibro® platinum

Fibro platinum is a product of BASF's extensive research and development efforts. By a proprietary process, thermocouple grade platinum is produced with an elongated grain structure without additives or dispersements, that imparts high temperature strength and increased thermocouple stability.

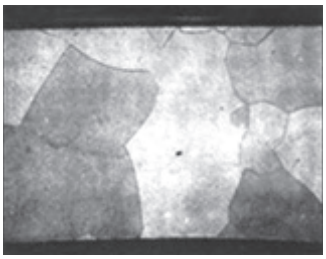
Used as a direct replacement for the platinum leg in either Type S or R thermocouples. Fibro platinum increases the strength of the thermo element of the negative leg to almost that of the alloy leg. Use of Fibro Pt permits a reduction in conductor size from .020 to .018 while achieving the same strength.

The grain structure of Fibro platinum also encourages its use as the winding in resistance thermometer elements. RTD sensors made with Fibro demonstrate superior mechanical stability and greater reliability at higher temperatures.

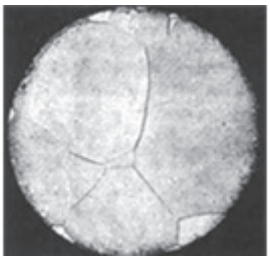


Stress to rupture at 1450° C

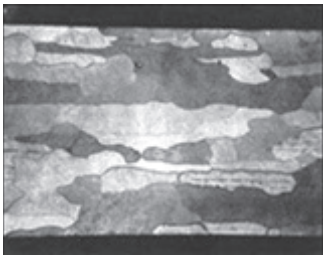
Note that Fibro platinum wire approaches the load bearing capabilities of Pt 10 Rh T/C wire (Pt 13 Rh is similar)



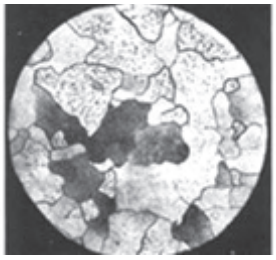
Pt-Longitudinal



Pt-Cross Section



Fibro Pt-Longitudinal



Fibro Pt-Cross Section

Photo micrograph of .032 dia. Fibro Pt wire and regular Pt wire after being heated to 1400° C for 10 hours. Longitudinal and cross section. Note the reduced grain growth of Fibro Pt. (100x reduced 50%).

Introduction

Platinel thermocouple wire is a proprietary precious metal combination developed to closely approximate the type K calibration curve. It demonstrates superior corrosion resistance, stability, and is usable to 1300°C. Platinel is the only high output thermocouple combination capable of serving at this temperature in an oxidizing environment.

One of the most popular and common applications for Platinel is use as a direct substitute for K type materials. Platinel has demonstrated superior life and stability at process temperatures in excess of 950°C.

Annealing

To develop the full emf of Platinel and to realize the stability benefits, the conductors must be fully annealed. Bare wire can be annealed electrically in air at 1200°C for 15 minutes. Mineral oxide compacted insulated-metal sheath assemblies should be annealed at no lower than 1050°C for 10 minutes.

Compensating lead wire

The use of type K wire as an extension wire for Platinel is strongly discouraged. There is sufficient difference between the two calibrations to cause reading errors of more than 20°C to develop under certain conditions.

A compensating lead wire is available that matches Platinel to within 150 micro-volts up to 175°C. This material is available in 20 gage solid and stranded conductors with Teflon and Fiberglass insulation.

Part No. P2X-20-TEF: Teflon Jacket over Teflon on conductors.

Part No. P2X-20X-GG: Impregnated glass jacket over glass on conductors.

Compensating lead wire color code

Positive conductor ..... yellow

Negative conductor ..... red

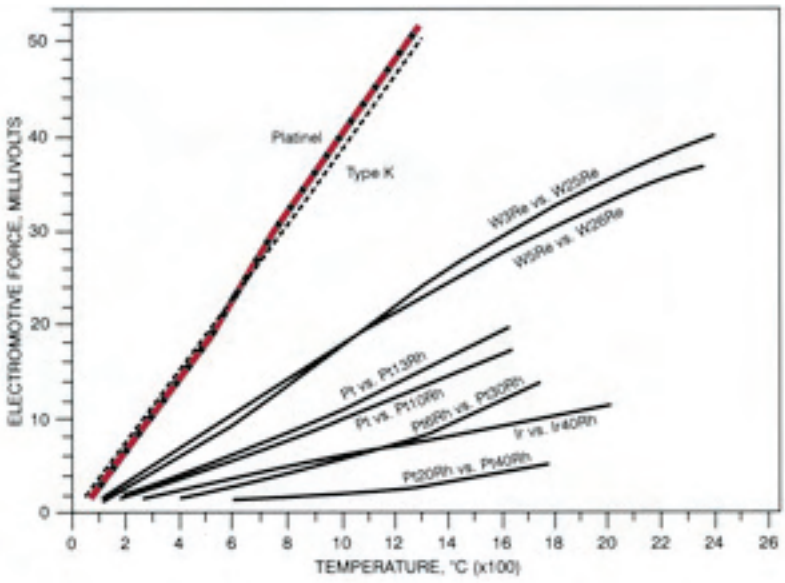
Jacket ..... black

Compensating lead wire resistivity (room temperature)

Positive conductor 415 ohm (cir-mil) ft

Negative conductor 30 ohm (cir-mil) ft

Comparative emf vs. temperature relationship of common thermocouple materials



Stability data

A number of tests have been conducted on the emf stability of Platinel. As in all thermocouple applications, the environment, duty cycle, handling, temperature, etc. have a strong influence. Because each application is unique, the following data is provided only as a guide for consideration.

Steady state drift

Furnace test, change in calibration (°C) after indicated number of hours soaking at the indicated temperature.

Calibration temp °C	2658 hr. soak at 1200°C	1008 hr. soak at 1300°C
400	-1.8	+2.0
600	-0.3	+2.0
800	-0.3	+3.0
1000	-0.3	+3.0
1200	+1.8	+1.0

Cycling drift

Change in calibration after 20,500 cycles between 100°C and 1250°C over a three month period.

Calibration temp. °C	Calibration shift °C
600	2.0
800	2.0
1000	3.0
1200	3.0

Calibration comparison

The following tabulation provides a cursory view of the emf output of Platinel and type K thermocouples. As can be seen there is sufficiently close matching between these materials to permit direct substitution in most industrial application's. All modern equipment manufactures produce process control instruments calibrated for Platinel.

Platinel vs. type K thermocouple wire		
Temp. °C	Platinel (mV)	Type K (mV)
200	7.113	8.133
400	15.665	16.396
600	24.658	24.902
800	33.414	33.277
1000	41.521	41.269
1200	48.877	48.828

Tolerance

Platinel thermocouple wire is supplied as a calibrated matched pair. Individual elements should not be intermixed without consultation with the factory and the establishment of the necessary specifications. Detailed lot calibration charts at 10°C and 1°C intervals are available on special order.

Temp. °C	Standard grade	Standard grade
200	±.150 mV	±.100mV
400	±.150	±.100
600	±.202	±.101
800	±.252	±.126
1000	±.292	±.146
1200	±.315	±.158

Weight for select wire diameters

(troy oz/ft)

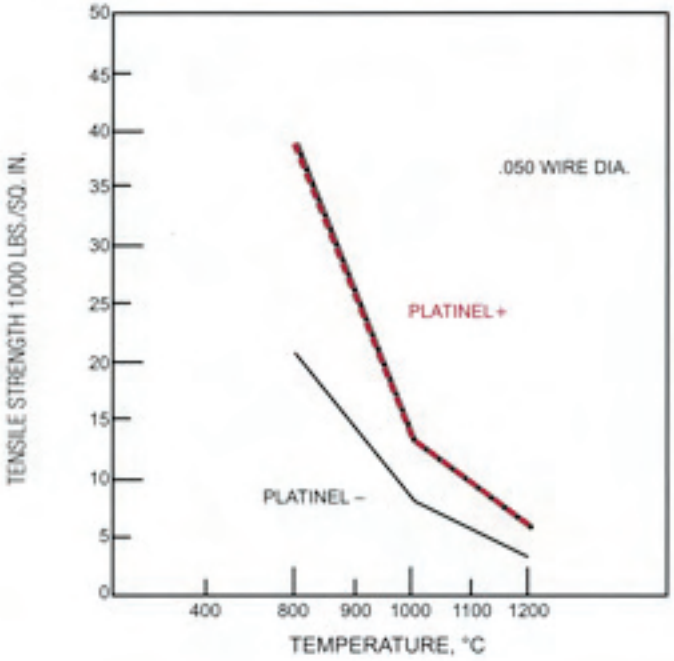
Diameter (inch)	Platinel +	Platinel –
0.005	0.00183	0.00197
0.007	0.00359	0.00387
0.008	0.00470	0.00505
0.009	0.00594	0.00639
0.010	0.00734	0.00790
0.012	0.01057	0.01137
0.015	0.01652	0.01777
0.018	0.02379	0.02559
0.020	0.02938	0.03159
0.022	0.03555	0.03823
0.025	0.04591	0.04937
0.028	0.05759	0.06193
0.030	0.06611	0.07109
0.032	0.07521	0.08088
0.034	0.08494	0.09134
0.036	0.09522	0.10240
0.038	0.10605	0.11405
0.040	0.11751	0.12636
0.042	0.12958	0.13935
0.045	0.14876	0.15998
0.048	0.16926	0.18201
0.050	0.18361	0.19745

Melting range	Liquidus	Solidus
Platinel +	1608°C	1570°C
Platinel –	1447°C	1426°C

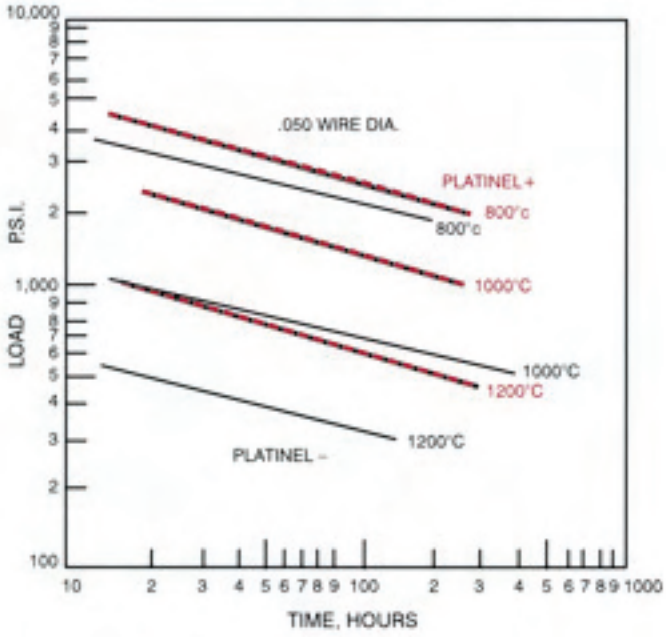
Density	gm/cm
Platinel +	14.93
Platinel –	15.91

Composition	
Platinel +	55 Pd 31 Pt 14 Au
Platinel –	65 Au 35 Pd

Tensile strength data at elevated temperatures for Platinel



Stress to rupture curves for Platinel



Modulus of elasticicity (psi x 10^6)

Temp. °C	Platinel +	Platinel –
0	20.9	19.2
100	20.9	19.2
200	20.6	18.8
300	19.8	18.1
400	19.5	17.6
500	19.1	17.0
600	18.6	16.4

Electrical resistivity for Platinel thermocouple wire

Ohm (cir-mil) ft

Temp. °C	Platinel +	Platinel –
0	184	144
200	216	156
400	247	164
600	273	172
800	297	184
1000	321	199
1200	342	215

Thermal conductivity

Watts/cm °C

Temp. °C	Platinel +	Platinel –
20	9.332	0.281
100	0.390	0.317
200	0.463	0.369
300	0.529	0.420
400	0.590	0.470
500	0.644	0.518
600	0.691	0.564
700	0.733	0.610
800	0.768	0.655
900	0.797	0.697

Coefficients of linear thermal expansion

(unit/unit/°C) from °C

Temp. °C	Platinel +	Platinel –
200	5.89×10^{-6}	7.92×10^{-6}
400	8.80×10^{-6}	1.10×10^{-5}
600	1.03×10^{-5}	1.05×10^{-5}
800	1.12×10^{-5}	1.21×10^{-5}
1000	1.19×10^{-5}	1.29×10^{-5}

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Reference table – Platinel thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
0	0.000	0.030	0.060	0.090	0.120	0.150	0.180	0.210	0.241	0.271
10	0.302	0.332	0.363	0.394	0.424	0.455	0.486	0.517	0.548	0.579
20	0.610	0.641	0.673	0.704	0.735	0.767	0.798	0.830	0.862	0.894
30	0.925	0.957	0.989	1.021	1.053	1.085	1.117	1.150	1.182	1.214
40	1.247	1.279	1.312	1.345	1.377	1.410	1.443	1.476	1.509	1.542
50	1.575	1.608	1.641	1.674	1.707	1.741	1.774	1.808	1.841	1.875
60	1.908	1.942	1.976	2.010	2.044	2.078	2.112	2.146	2.180	2.214
70	2.248	2.282	2.317	2.351	2.386	2.420	2.455	2.489	2.524	2.559
80	2.593	2.628	2.663	2.698	2.733	2.768	2.803	2.838	2.874	2.909
90	2.944	2.980	3.015	3.050	3.086	3.122	3.157	3.193	3.229	3.264
100	3.300	3.336	3.372	3.408	3.444	3.480	3.516	3.553	3.589	3.625
110	3.661	3.698	3.734	3.771	3.807	3.844	3.881	3.917	3.954	3.991
120	4.028	4.064	4.101	4.138	4.175	4.212	4.250	4.287	4.324	4.361
130	4.399	4.436	4.473	4.511	4.548	4.586	4.623	4.661	4.699	4.736
140	4.774	4.812	4.850	4.888	4.925	4.963	5.001	5.039	5.078	5.116
150	5.154	5.192	5.230	5.269	5.307	5.346	5.384	5.422	5.461	5.500
160	5.538	5.577	5.615	5.654	5.693	5.732	5.771	5.810	5.848	5.887
170	5.926	5.965	6.005	6.044	6.083	6.122	6.161	6.201	6.240	6.279
180	6.319	6.358	6.398	6.437	6.477	6.516	6.556	6.596	6.635	6.675
190	6.715	6.755	6.794	6.834	6.874	6.914	6.954	6.994	7.034	7.074
200	7.115	7.156	7.195	7.235	7.275	7.316	7.356	7.396	7.437	7.477
210	7.518	7.558	7.599	7.639	7.680	7.721	7.761	7.802	7.843	7.884
220	7.924	7.965	8.006	8.047	8.088	8.129	8.170	8.211	8.252	8.293
230	8.334	8.375	8.416	8.458	8.499	8.540	8.582	8.623	8.664	8.706
240	8.747	8.788	8.830	8.871	8.913	8.955	8.996	9.038	9.079	9.121
250	9.163	9.205	9.246	9.288	9.330	9.372	9.414	9.456	9.498	9.540
260	9.581	9.623	9.666	9.708	9.750	9.792	9.834	9.876	9.918	9.961
270	10.003	10.045	10.087	10.130	10.172	10.214	10.257	10.299	10.342	10.384
280	10.427	10.469	10.512	10.554	10.597	10.639	10.682	10.725	10.767	10.810
290	10.853	10.896	10.938	10.981	11.024	11.067	11.110	11.153	11.196	11.238
300	11.281	11.324	11.367	11.410	11.453	11.497	11.540	11.583	11.626	11.669
310	11.712	11.755	11.799	11.842	11.885	11.928	11.972	12.015	12.058	12.102
320	12.145	12.188	12.232	12.275	12.319	12.362	12.405	12.449	12.492	12.536
330	12.580	12.623	12.667	12.710	12.754	12.798	12.841	12.885	12.929	12.972
340	13.016	13.060	13.104	13.147	13.191	13.235	13.279	13.323	13.366	13.410
350	13.454	13.498	13.542	13.586	13.630	13.674	13.718	13.762	13.806	13.850
360	13.894	13.938	13.982	14.026	14.070	14.114	14.159	14.203	14.247	14.291
370	14.335	14.379	14.424	14.468	14.512	14.556	14.601	14.645	14.689	14.733
380	14.778	14.822	14.866	14.911	14.955	15.000	15.044	15.088	15.133	15.177
390	15.222	15.266	15.311	15.355	15.400	15.444	15.489	15.533	15.578	15.622
400	15.667	15.711	15.756	15.800	15.845	15.890	15.934	15.979	16.023	16.068
410	16.113	16.157	16.202	16.247	16.291	16.336	16.381	16.425	16.470	16.515
420	16.560	16.604	16.649	16.694	16.739	16.784	16.828	16.873	16.918	16.963
430	17.008	17.052	17.097	17.142	17.187	17.232	17.277	17.321	17.366	17.411
440	17.456	17.501	17.546	17.591	17.636	17.681	17.726	17.771	17.816	17.860
450	17.905	17.950	17.995	18.040	18.085	18.130	18.175	18.220	18.265	18.310
460	18.355	18.400	18.445	18.490	18.535	18.580	18.625	18.670	18.715	18.760
470	18.806	18.851	18.896	18.941	18.986	19.031	19.076	19.121	19.166	19.211
480	19.256	19.301	19.346	19.391	19.437	19.482	19.527	19.572	19.617	19.662
490	19.707	19.752	19.797	19.843	19.888	19.933	19.978	20.023	20.068	20.113
500	20.158	20.204	20.249	20.294	20.339	20.384	20.429	20.474	20.519	20.565
510	20.610	20.655	20.700	20.745	20.790	20.835	20.880	20.926	20.971	21.016
520	21.061	21.106	21.151	21.196	21.242	21.287	21.332	21.377	21.422	21.467
530	21.512	21.557	21.603	21.648	21.693	21.738	21.783	21.828	21.873	21.918
540	21.963	22.009	22.054	22.099	22.144	22.189	22.234	22.279	22.324	22.369
550	22.414	22.459	22.504	22.550	22.595	22.640	22.685	22.730	22.775	22.820
560	22.866	22.910	22.955	23.000	23.045	23.090	23.135	23.180	23.225	23.270
570	23.315	23.360	23.405	23.450	23.496	23.540	23.585	23.630	23.675	23.720
580	23.765	23.810	23.855	23.900	23.945	23.990	24.035	24.080	24.125	24.169
590	24.214	24.259	24.304	24.349	24.394	24.439	24.484	24.528	24.573	24.618
600	24.663	24.708	24.753	24.797	24.842	24.887	24.932	24.977	25.021	25.066
610	25.111	25.156	25.201	25.245	25.290	25.335	25.379	25.424	25.469	25.514
620	25.558	25.603	25.648	25.692	25.737	25.782	25.826	25.871	25.915	25.960
630	26.005	26.049	26.094	26.138	26.183	26.228	26.272	26.317	26.361	26.406
640	26.450	26.495	26.539	26.584	26.628	26.673	26.717	26.762	26.806	26.850

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Reference table – Platinel thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
650	26.895	26.939	26.984	27.028	27.072	27.117	27.161	27.205	27.250	27.294
660	27.338	27.383	27.427	27.471	27.515	27.560	27.604	27.648	27.692	27.737
670	27.781	27.825	27.869	27.913	27.957	28.002	28.046	28.090	28.134	28.178
680	28.222	28.266	28.310	28.354	28.398	28.442	28.486	28.530	28.574	28.618
690	28.662	28.706	28.750	28.794	28.838	28.882	28.925	28.969	29.013	29.057
700	29.101	29.145	29.188	29.232	29.276	29.320	29.363	29.407	29.451	29.494
710	29.538	29.582	29.625	29.669	29.713	29.756	29.800	29.843	29.887	29.930
720	29.974	30.017	30.061	30.104	30.148	30.191	30.235	30.278	30.322	30.365
730	30.408	30.452	30.495	30.538	30.582	30.625	30.668	30.711	30.755	30.798
740	30.841	30.884	30.928	30.971	31.014	31.057	31.100	31.143	31.186	31.229
750	31.272	31.315	31.358	31.401	31.444	31.487	31.530	31.573	31.616	31.659
760	31.702	31.745	31.788	31.831	31.874	31.916	31.959	32.002	32.045	32.088
770	32.130	32.173	32.216	32.259	32.301	32.344	32.387	32.429	32.472	32.514
780	32.557	32.600	32.642	32.685	32.727	32.770	32.812	32.855	32.897	32.940
790	32.982	33.025	33.067	33.110	33.152	33.195	33.237	33.279	33.322	33.364
800	33.406	33.449	33.491	33.533	33.575	33.618	33.660	33.702	33.744	33.786
810	33.828	33.871	33.913	33.955	33.997	34.039	34.081	34.123	34.165	34.207
820	34.249	34.291	34.333	34.375	34.417	34.459	34.501	34.543	34.585	34.626
830	34.668	34.710	34.752	34.794	34.836	34.877	34.919	34.961	35.002	35.044
840	35.086	35.127	35.169	35.211	35.252	35.294	35.336	35.377	35.419	35.460
850	35.502	35.543	35.585	35.626	35.668	35.709	35.750	35.792	35.833	35.875
860	35.916	35.957	35.999	36.040	36.081	36.122	36.164	36.205	36.246	36.287
870	36.328	36.370	36.411	36.452	36.493	36.534	36.575	36.616	36.657	36.698
880	36.739	36.780	36.821	36.862	36.903	36.944	36.985	37.026	37.067	37.108
890	37.148	37.189	37.230	37.271	37.312	37.352	37.393	37.434	37.474	37.515
900	37.556	37.596	37.637	37.678	37.718	37.759	37.799	37.840	37.880	37.921
910	37.961	38.002	38.042	38.083	38.123	38.163	38.204	38.244	38.284	38.325
920	38.365	38.405	38.446	38.486	38.526	38.566	38.606	38.647	38.687	38.727
930	38.767	38.807	38.847	38.887	38.927	38.967	39.007	39.047	39.087	39.127
940	39.167	39.207	39.247	39.287	39.327	39.367	39.406	39.446	39.486	39.526
950	39.565	39.605	39.645	39.685	39.724	39.764	39.804	39.843	39.883	39.922
960	39.962	40.001	40.041	40.080	40.120	40.159	40.199	40.238	40.278	40.317
970	40.356	40.396	40.435	40.474	40.514	40.553	40.592	40.631	40.671	40.710
980	40.749	40.788	40.827	40.866	40.906	40.945	40.984	41.023	41.062	41.101
990	41.140	41.179	41.218	41.257	41.296	41.334	41.373	41.412	41.451	41.490
1000	41.529	41.567	41.606	41.645	41.684	41.722	41.761	41.800	41.838	41.877
1010	41.915	41.954	41.993	42.031	42.070	42.108	42.147	42.185	42.223	42.262
1020	42.300	42.339	42.377	42.415	42.454	42.492	42.530	42.569	42.607	42.645
1030	42.683	42.721	42.760	42.798	42.836	42.874	42.912	42.950	42.988	43.026
1040	43.064	43.102	43.140	43.178	43.216	43.254	43.292	43.330	43.368	43.405
1050	43.443	43.481	43.519	43.557	43.594	43.632	43.670	43.707	43.745	43.783
1060	43.820	43.858	43.895	43.933	43.971	44.008	44.046	44.083	44.120	44.158
1070	44.195	44.233	44.270	44.307	44.345	44.382	44.419	44.457	44.494	44.531
1080	44.568	44.605	44.643	44.680	44.717	44.754	44.791	44.828	44.865	44.902
1090	44.939	44.976	45.013	45.050	45.087	45.124	45.161	45.198	45.235	45.272
1100	45.308	45.345	45.382	45.419	45.455	45.492	45.529	45.565	45.602	45.639
1110	45.675	45.712	45.748	45.785	45.822	45.858	45.895	45.931	45.967	46.004
1120	46.040	46.077	46.113	46.149	46.186	46.222	46.258	46.295	46.331	46.367
1130	46.403	46.439	46.476	46.512	46.548	46.584	46.620	46.656	46.692	46.728
1140	46.764	46.800	46.836	46.872	46.908	46.944	46.980	47.016	47.051	47.087
1150	47.123	47.159	47.195	47.230	47.266	47.302	47.337	47.373	47.409	47.444
1160	47.480	47.515	47.551	47.586	47.622	47.657	47.693	47.728	47.764	47.799
1170	47.835	47.870	47.905	47.941	47.976	48.011	48.046	48.082	48.117	48.152
1180	48.187	48.223	48.258	48.293	48.328	48.363	48.398	48.433	48.468	48.503
1190	48.538	48.573	48.608	48.643	48.678	48.713	48.817	48.782	48.817	48.852
1200	48.887	48.921	48.956	48.991	49.026	49.060	49.095	49.129	49.164	49.199
1210	49.233	49.268	49.302	49.337	49.371	49.406	49.440	49.475	49.509	49.543
1220	49.578	49.612	49.646	49.681	49.715	49.749	49.783	49.818	49.852	49.886
1230	49.920	49.954	49.988	50.023	50.057	50.091	50.125	50.159	50.193	50.227
1240	50.261	50.294	50.328	50.362	50.396	50.430	50.464	50.498	50.531	50.565
1250	50.599	50.632	50.666	50.700	50.734	50.767	50.801	50.834	50.868	50.901
1260	50.935	50.968	51.002	51.035	51.069	51.102	51.136	51.169	51.202	51.236
1270	51.269	51.302	51.336	51.369	51.402	51.435	51.468	51.502	51.535	51.568
1280	51.601	51.634	51.667	51.700	51.733	51.766	51.799	51.832	51.865	51.898
1290	51.931	51.963	51.996	52.029	52.062	52.095	52.127	52.160	52.193	52.226

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Reference table – Platinel thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1300	52.258	52.291	52.323	52.356	52.389	52.421	52.454	52.486	52.519	52.551
1310	52.584	52.616	52.648	52.681	52.713	52.745	52.778	52.810	52.842	52.875
1320	52.907	52.939	52.971	53.003	53.035	53.067	53.100	53.132	53.164	53.196
1330	53.228	53.260	53.292	53.324	53.355	53.387	53.419	53.451	53.483	53.515
1340	53.546	53.578	53.10	53.641	53.673	53.705	53.736	53.768	53.800	53.831
1350	53.863	53.894	53.926	53.957	53.989	54.020	54.051	54.083	54.114	54.145
1360	54.177	54.208	54.239	54.270	54.302	54.333	54.364	54.395	54.426	54.457
1370	54.488	54.519	54.550	54.581	54.612	54.643	54.674	54.705	54.736	54.767
1380	54.798	43.818	43.859	54.890	54.921	54.951	54.982	55.013	55.043	55.074
1390	55.104	55.135	55.165	55.196	55.226	55.257				

Coefficients used to compute the reference table

$E = C_0 + C_n T^n$

For 0°C to 746°C		
C_0	=	0.000 000 0
C_1	=	$2.981\,971\,6 \times 10^{02}$
C_2	=	$3.517\,515\,2 \times 10^{05}$
C_3	=	$-3.487\,842\,8 \times 10^{08}$
C_4	=	$1.4.85\,132\,7 \times 10^{11}$
C_5	=	$-3.637\,46\,7 \times 10^{15}$

For 746.6°C to 1395°C		
C_0	=	-8.962 183 8
C_1	=	$8.537\,720\,0 \times 10^{02}$
C_2	=	$-1.057\,023\,3 \times 10^{04}$
C_3	=	$1.542\,493\,7 \times 10^{07}$
C_4	=	$-1.285\,511\,5 \times 10^{10}$
C_5	=	$5.443\,876\,0 \times 10^{14}$
C_6	=	$-9.321\,126\,9 \times 10^{18}$

Introduction

The Pt vs. Pt 10 Rh thermocouple combination is letter designated as "S" by international agreement. This combination had its start in 1886 when Henri Le Chatelier demonstrated its superior stability and utility over the existing art then in place. It has been used extensively since and was the defining instrument for realizing portions of the International Practical Temperature Scale from 1927 to as recent as 1990.

The thermocouple is suitable for use continuously to 1450°C in oxidizing conditions with excursions to 1750°C with appropriate precautions.

Application suggestions

The Application notes section of this catalog provides a number of suggestions and recommendations for the use of precious metal thermocouples. A brief review of some of these topics will provide guidance for achieving a long and serviceable life from your thermocouple.

Stocking policy

Popular sizes of .020" and .032" diameter are routinely carried in stock for rapid 5-day turnaround. Expedite orders of 24 hrs. or less are generally accommodated but subject to prior scheduling. Other sizes may be in inventory depending on demand or requested positioning.

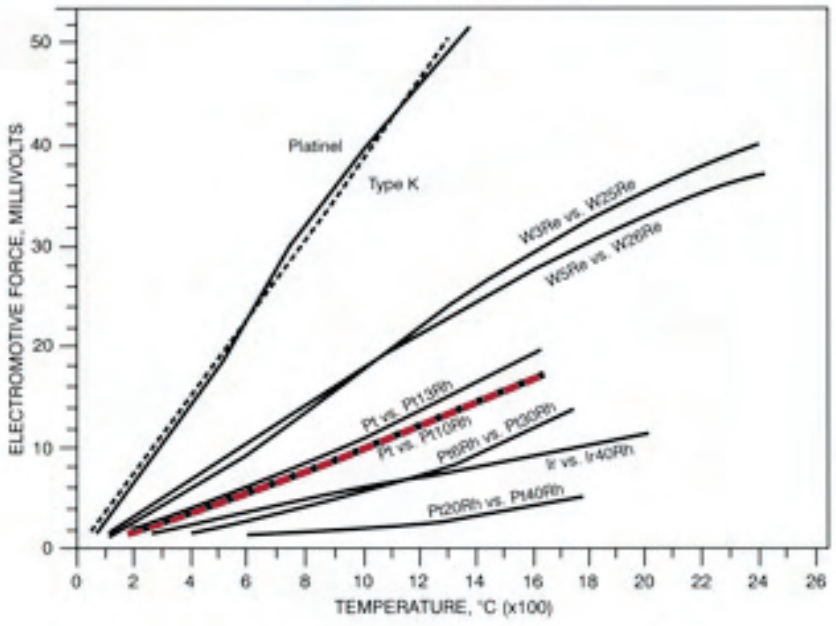
Compensating extension wire

Extension wires are inserted between the measuring and the reference junction. These wires have an approximate equivalent emf-temperature relationship and are commercially available from a number of sources. Commercial compliance tolerance is ± 5°C between a connector temperature of 0°C and 200°C. See the Application notes section for additional information on the use and limits of compensating extension wire.

Annealing

To achieve maximum compliance of the wires thermal electric properties, it is important that they be fully annealed. All wire is supplied, unless otherwise specified, in the fully annealed condition and represents the optimum compromise for handleability.

Comparative emf vs. temperature relationship of common thermocouple materials



Temperature scale

Type S thermocouple wire is available certified to comply with the emf temperature relationships of the International Scale of 1990 (ITS 90) or the International Practical Temperature Scale of 1968 (IPTS 68) as is desired. The difference between these two scales is insignificant in the majority of most practical applications. Please see the Application notes section for additional information.

Tolerances and limits of error

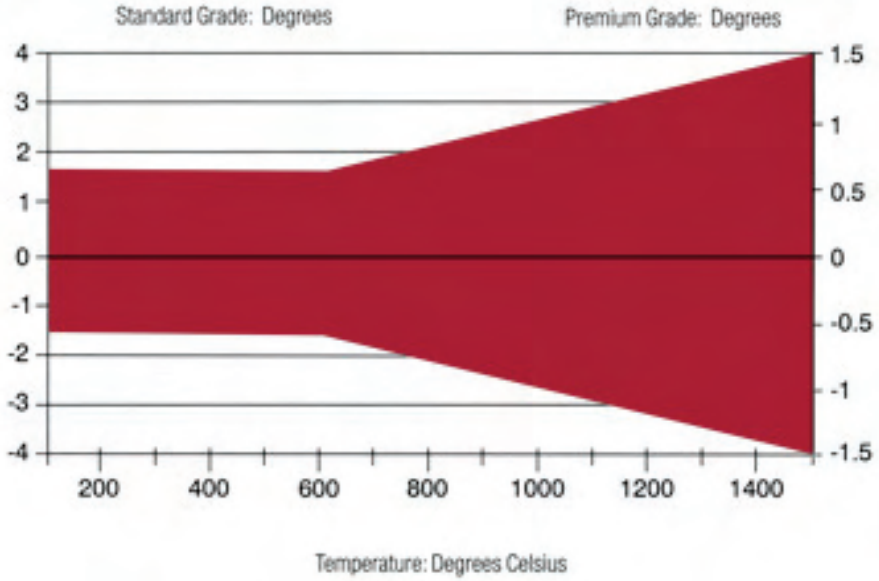
Two grades of Type S thermocouple wire are provided differing mainly in the compliance with published emf Temperature Tables. Both grades are made from highly purified metals whose selection is based on Glow Dischard Mass Spectroscopy. Melting and working are conducted under tightly controlled conditions which are subject to rigid quality control. Thermal electric calibration is conducted to insure compliance with published specifications during various stages of the manufacturing process to prevent loss of quality and mechanical integrity.

The thermocouple wire as supplied is guaranteed to conform to all internationally recognized standards such as ASTM230, ANSI MC 96.1, BS. 4937, IEC 584-2, DIN 4371 and JIS 1602 to the following limits of error and can be used interchangeably to within these limits:

Standard Grade	± 1.5°C or ± 0.25% whichever is greater from 0°C to 1600°C
Premium Grade	± 0.6°C or ± 0.10% whichever is greater from 0°C to 1600°C

These interchangeability tolerances are shown graphically below:

Limits of Error
Type S thermocouples
Premium & Standard Grade



Melting point	
Pt	1768°C
Pt 10 Rh	1850°C

Density	(gm/cm³)	troy oz/in³
Pt	21.45	11.31
Pt 10 Rh	20.01	10.54

Polarity	
Pt	–
Pt 10 Rh	+

Coefficient of linear thermal expansion

(unit/unit/°C) x 10^{-6}

Temp range °C	Pt	Pt 10 Rh
0-100	9.0	10.0
0-200	9.2	10.0
0-300	9.3	10.1
0-400	9.4	10.1
0-500	9.5	10.2
0-600	9.7	10.2
0-700	9.8	10.3
0-800	9.9	10.3
0-900	10.1	10.4
0-1000	10.2	10.5
0-1100		10.7
0-1200		11.8
0-1300		11.0
0-1400		11.2
0-1500		11.7

Thermal conductivity

Joules cm/cm² sec. °C

Temp. °C	Pt	Pt 10Rh
20	0.74	0.38
100	0.72	
1000	0.67	
1500	0.63	

Youngs Modulus

PSI @ 20°C	
Pt	24.5×10^6
Pt 10 Rh	28.2×10^6

Electrical resistivity for Pt & Pt 10 Rh thermocouple wire

Temp	microhm-cm		ohm (cir-mil) ft	
Celsius	Pt	Pt 10 Rh	Pt	Pt 10 Rh
0	9.85	18.40	59.30	110.77
20	10.59	19.43	63.75	116.97
100	13.66	21.45	82.23	129.13
200	17.39	24.47	104.69	147.31
300	21.01	27.42	126.48	165.07
400	24.52	30.29	147.61	182.35
500	27.90	33.08	167.96	199.14
600	31.18	35.82	187.70	215.64
700	34.35	38.51	206.79	231.83
800	37.38	41.11	225.03	247.48
900	40.31	43.61	242.67	262.53
1000	43.12	46.05	259.58	277.22
1100	45.82	48.45	275.84	291.67
1200	48.41	50.80	291.43	305.82
1300	50.88	53.12	306.30	319.78
1400	53.24	55.40	320.50	333.51
1500	55.47	57.65	333.93	347.05

Weight for select wire diameters

(troy oz/ft)

Diameter (inch)	Pt	Pt 10 Rh
0.005	4.816	3.972
0.006	3.344	2.758
0.007	2.457	2.027
0.008	1.881	1.552
0.009	1.486	1.226
0.010	1.204	0.993
0.011	0.995	0.821
0.012	0.836	0.690
0.013	0.712	0.588
0.014	0.614	0.507
0.015	0.535	0.441
0.016	0.470	0.388
0.017	0.417	0.344
0.018	0.372	0.306
0.019	0.334	0.275
0.020	0.301	0.248
0.021	0.273	0.225
0.022	0.249	0.205
0.023	0.228	0.188
0.024	0.209	0.172
0.025	0.193	0.159
0.026	0.178	0.147
0.027	0.165	0.136
0.028	0.154	0.127
0.029	0.143	0.118
0.030	0.134	0.110
0.031	0.125	0.103
0.032	0.118	0.097

Wire footage per Troy ounce for select diameters

Diameter (inch)	Pt	Pt 10 Rh
.005	375.0	402.0
.010	93.9	100.7
.015	41.7	44.8
.020	23.5	25.2
.032	9.2	9.8

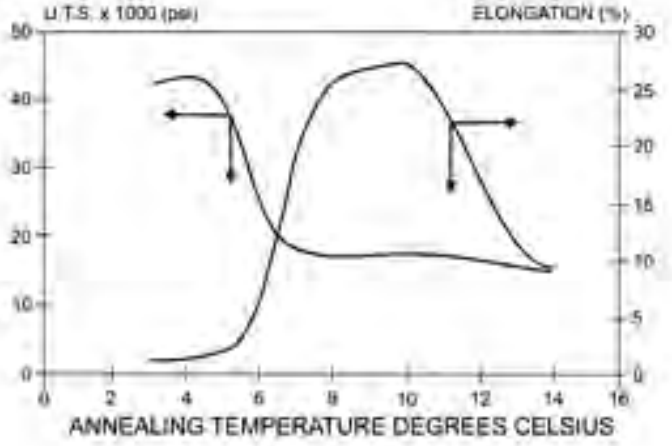
Room temperature resistance for select wire diameters

(ohms/ft)

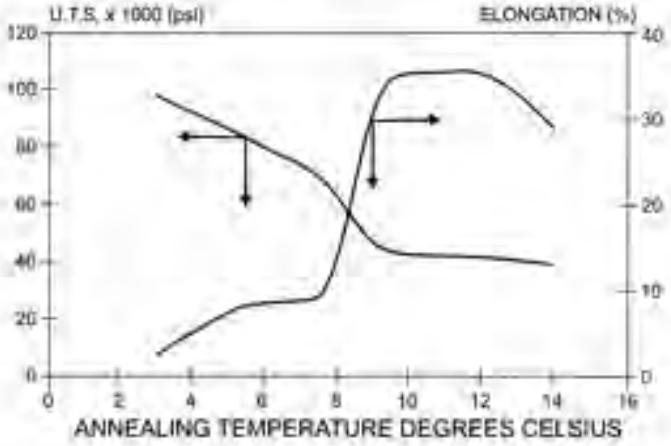
Diameter (inch)	Pt	Pt 10 Rh
0.005	2.368	4.432
0.006	1.664	3.078
0.007	1.208	2.261
0.008	0.925	1.731
0.009	0.731	1.368
0.010	0.592	1.108
0.011	0.489	0.916
0.012	0.411	0.769
0.013	0.350	0.656
0.014	0.302	0.565
0.015	0.263	0.492
0.016	0.231	0.433
0.017	0.205	0.383
0.018	0.183	0.342
0.019	0.164	0.307
0.020	0.148	0.277
0.021	0.134	0.251
0.022	0.122	0.229
0.023	0.112	0.209
0.024	0.103	0.192
0.025	0.095	0.177
0.026	0.088	0.164
0.027	0.081	0.152
0.028	0.076	0.141
0.029	0.070	0.132
0.030	0.066	0.123
0.031	0.062	0.115
0.032	0.058	0.108
0.033	0.054	0.102
0.034	0.051	0.096
0.035	0.048	0.090
0.036	0.046	0.085
0.037	0.043	0.081
0.038	0.041	0.077
0.039	0.039	0.073
0.040	0.037	0.069
0.041	0.035	0.066
0.042	0.034	0.063
0.043	0.032	0.060
0.044	0.031	0.057
0.045	0.029	0.055
0.046	0.028	0.052
0.047	0.027	0.050
0.048	0.026	0.048
0.049	0.025	0.046
0.050	0.024	0.044

Room temperature tensile data

Pt T/C wire

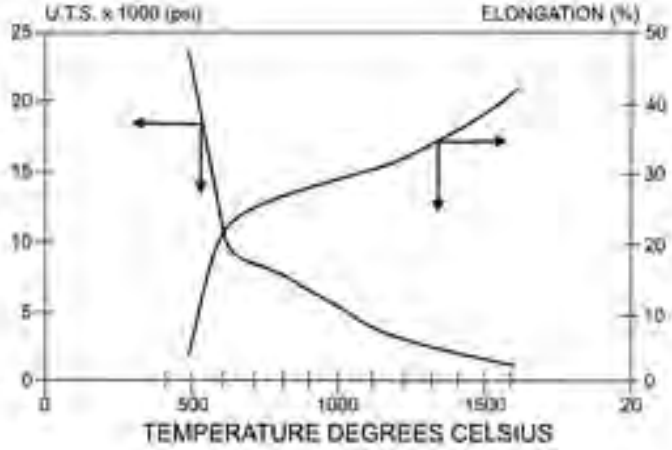


Pt 10 Rh T/C wire

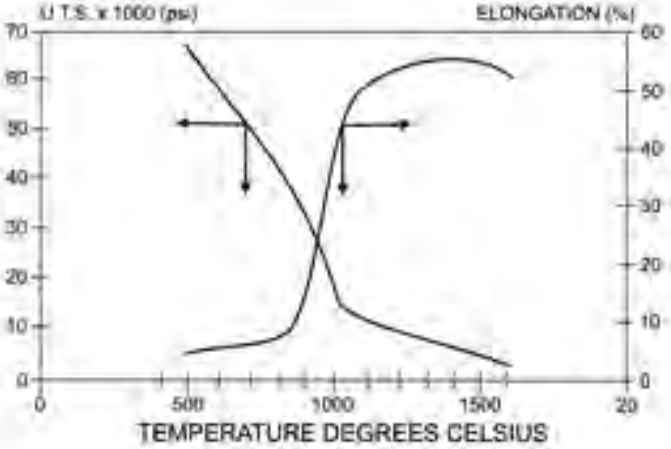


Hot tensile data

Pt T/C wire



Pt 10 Rh T/C wire



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Reference table – Pt vs. Pt 10 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
0	0.000	0.005	0.011	0.016	0.022	0.027	0.033	0.038	0.044	0.050
10	0.055	0.061	0.067	0.072	0.078	0.084	0.090	0.095	0.101	0.107
20	0.113	0.119	0.125	0.131	0.137	0.143	0.149	0.155	0.161	0.167
30	0.173	0.179	0.185	0.191	0.197	0.204	0.210	0.216	0.222	0.229
40	0.235	0.241	0.248	0.254	0.260	0.267	0.273	0.280	0.286	0.292
50	0.299	0.305	0.312	0.319	0.325	0.332	0.338	0.345	0.352	0.358
60	0.365	0.372	0.378	0.385	0.392	0.399	0.405	0.412	0.419	0.426
70	0.433	0.440	0.446	0.453	0.460	0.467	0.474	0.481	0.488	0.495
80	0.502	0.509	0.516	0.523	0.530	0.538	0.545	0.552	0.559	0.566
90	0.573	0.580	0.588	0595	0.602	0.609	0.617	0.624	0.631	0.639
100	0.646	0.653	0.661	0.668	0.675	0.683	0.690	0.698	0.705	0.713
110	0.720	0.727	0.735	0.743	0.750	0.758	0.765	0.773	0.780	0.788
120	0.795	0.803	0.811	0.818	0.826	0.834	0.841	0.849	0.857	0.865
130	0.872	0.880	0.888	0.896	0.903	0.911	0.919	0.927	0.935	0.942
140	0.950	0.958	0.966	0.974	0.982	0.990	0.998	1.006	1.013	1.021
150	1.029	1.037	1.045	1.053	1.061	1.069	1.077	1.086	1.094	1.102
160	1.110	1.118	1.126	1.134	1.142	1.150	1.158	1.167	1.175	1.183
170	1.191	1.199	1.207	1.216	1.224	1.232	1.240	1.249	1.257	1.265
180	1.273	1.282	1.290	1.298	1.307	1.315	1.323	1.332	1.340	1.348
190	1.357	1.365	1.373	1.382	1.390	1.399	1.407	1.415	1.424	1.432
200	1.441	1.449	1.458	1.466	1.475	1.483	1.492	1.500	1.509	1.517
210	1.526	1.534	1.543	1.551	1.560	1.569	1.577	1.586	1.594	1.603
220	1.612	1.620	1.629	1.638	1.646	1.655	1.663	1.672	1.681	1.690
230	1.698	1.707	1.716	1.724	1.733	1.742	1.751	1.759	1.768	1.777
240	1.786	1.794	1.803	1.812	1.821	1.829	1.838	1.847	1.856	1.865
250	1.874	1.882	1.891	1.900	1.909	1.918	1.927	1.936	1.944	1.953
260	1.962	1.971	1.980	1.989	1.998	2.007	2.016	2.025	2.034	2.043
270	2.052	2.061	2.070	2.078	2.087	2.096	2.105	2.114	2.123	2.132
280	2.142	2.151	2.160	2.169	2.178	2.187	2.196	2.205	2.214	2.223
290	2.232	2.241	2.250	2.259	2.268	2.277	2.287	2.296	2.305	2.314
300	2.323	2.332	2.341	2.350	2.360	2.369	2.378	2.387	2.396	2.405
310	2.415	2.424	2.433	2.442	2.451	2.461	2.470	2.479	2.488	2.497
320	2.507	2.516	2.525	2.534	2.544	2.553	2.562	2.571	2.580	2.590
330	2.599	2.609	2.618	2.627	2.636	2.646	2.655	2.664	2.674	2.683
340	2.692	2.702	2.711	2.720	2.730	2.739	2.748	2.758	2.767	2.776
350	2.786	2.795	2.805	2.814	2.823	2.833	2.842	2.851	2.861	2.870
360	2.880	2.889	2.899	2.908	2.917	2.927	2.936	2.946	2.955	2.965
370	2.974	2.983	2.993	3.002	3.012	3.021	3.031	3.040	3.050	3.059
380	3.069	3.078	3.088	3.097	3.107	3.116	3.126	3.135	3.145	3.154
390	3.164	3.173	3.183	3.192	3.202	3.212	3.221	3.231	3.240	3.250
400	3.259	3.269	3.279	3.288	3.298	3.307	3.317	3.326	3.336	3.346
410	3.355	3.365	3.374	3.384	3.394	3.403	3.413	3.423	3.432	3.442
420	3.451	3.461	3.471	3.480	3.490	3.500	3.509	3.519	3.529	3.538
430	3.548	3.558	3.567	3.577	3.587	3.596	3.606	3.616	3.626	3.635
440	3.645	3.655	3.664	3.674	3.684	3.694	3.703	3.713	3.723	3.732
450	3.742	3.752	3.762	3.771	3.781	3.791	3.801	3.810	3.820	3.830
460	3.840	3.850	3.859	3.869	3.879	3.889	3.898	3.908	3.918	3.928
470	3.938	3.947	3.957	3.967	3.977	3.987	3.997	4.006	4.016	4.026
480	4.036	4.046	4.056	4.065	4.075	4.085	4.095	4.105	4.115	4.125
490	4.134	4.144	4.154	4.164	4.174	4.184	4.194	4.204	4.214	4.223
500	4.233	4.243	4.253	4.263	4.273	4.283	4.293	4.303	4.313	4.323
510	4.332	4.342	4.352	4.362	4.372	4.382	4.392	4.402	4.412	4.422
520	4.432	4.442	4.452	4.462	4.472	4.482	4.492	4.502	4.512	4.522
530	4.532	4.542	4.552	4.562	4.572	4.582	4.592	4.602	4.612	4.622
540	4.632	4.642	4.652	4.662	4.672	4.682	4.692	4.702	4.712	4.722
550	4.732	4.742	4.752	4.762	4.772	4.782	4.793	4.803	4.813	4.823
560	4.833	4.843	4.853	4.863	4.873	4.883	4.893	4.904	4.914	4.924
570	4.934	4.944	4.954	4.964	4.974	4.984	4.995	5.005	5.015	5.025
580	5.035	5.045	5.055	5.066	5.076	5.086	5.096	5.106	5.116	5.127
590	5.137	5.147	5.157	5.167	5.178	5.188	5.198	5.208	5.218	5.228
600	5.239	5.249	5.259	5.269	5.280	5.290	5.300	5.310	5.320	5.331
610	5.341	5.351	5.361	5.372	5.382	5.392	5.402	5.413	5.423	5.433
620	5.443	5.454	5.464	5.474	5.485	5.495	5.505	5.515	5.526	5.536
630	5.546	5.557	5.567	5.577	5.588	5.598	5.608	5.618	5.629	5.639
640	5.649	5.660	5.670	5.680	5.691	5.701	5.712	5.723	5.732	5.743

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Reference table – Pt vs. Pt 10 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
650	5.753	5.763	5.774	5.784	5.794	5.805	5.815	5.826	5.836	5.846
660	5.857	5.867	5.878	5.888	5.898	5.909	5.919	5.930	5.940	5.950
670	5.961	5.971	5.982	5.992	6.003	6.013	6.024	6.034	6.044	6.055
680	6.065	6.076	6.086	6.097	6.107	6.118	6.128	6.139	6.149	6.160
690	6.170	6.181	6.191	6.202	6.212	6.223	6.233	6.244	6.254	6.265
700	6.275	6.286	6.296	6.307	6.317	6.328	6.338	6.349	6.360	6.370
710	6.381	6.391	6.402	6.412	6.423	6.434	6.444	6.455	6.465	6.476
720	6.486	6.497	6.508	6.518	6.529	6.539	6.550	6.561	6.571	6.582
730	6.593	6.603	6.614	6.624	6.635	6.646	6.656	6.667	6.678	6.688
740	6.699	6.710	6.720	6.731	6.742	6.752	6.763	6.774	6.784	6.795
750	6.806	6.817	6.827	6.838	6.849	6.859	6.870	6.881	6.892	6.902
760	6.913	6.924	6.934	6.945	6.956	6.967	6.977	6.988	6.999	7.010
770	7.020	7.031	7.042	7.053	7.064	7.074	7.085	7.096	7.107	7.117
780	7.128	7.139	7.150	7.161	7.172	7.182	7.193	7.204	7.215	7.226
790	7.236	7.247	7.258	7.269	7.280	7.291	7.302	7.312	7.323	7.334
800	7.345	7.356	7.367	7.378	7.388	7.399	7.410	7.421	7.432	7.443
810	7.454	7.465	7.476	7.487	7.498	7.508	7.519	7.530	7.541	7.552
820	7.563	7.574	7.585	7.596	7.607	7.618	7.629	7.640	7.651	7.662
830	7.673	7.684	7.695	7.706	7.717	7.728	7.739	7.750	7.761	7.772
840	7.783	7.794	7.805	7.816	7.827	7.838	7.849	7.860	7.871	7.882
850	7.893	7.904	7.915	7.926	7.937	7.948	7.959	7.970	7.981	7.992
860	8.003	8.014	8.026	8.037	8.048	8.059	8.070	8.081	8.092	8.103
870	8.114	8.125	8.137	8.148	8.159	8.170	8.181	8.192	8.203	8.215
880	8.226	8.237	8.248	8.259	8.270	8.281	8.293	8.293	8.304	8.326
890	8.337	8.348	8.360	8.371	8.382	8.393	8.404	8.416	8.427	8.438
900	8.449	8.460	8.472	8.483	8.494	8.505	8.517	8.528	8.539	8.550
910	8.562	8.573	8.584	8.595	8.607	8.618	8.629	8.640	8.652	8.663
920	8.674	8.685	8.697	8.708	8.719	8.731	8.742	8.753	8.765	8.776
930	8.787	8.798	8.810	8.821	8.832	8.844	8.855	8.866	8.878	8.889
940	8.900	8.912	8.923	8.935	8.946	8.957	8.969	8.980	8.991	9.003
950	9.014	9.025	9.037	9.048	9.060	9.071	9.082	9.094	9.105	9.117
960	9.128	9.139	9.151	9.162	9.174	9.185	9.197	9.208	9.219	9.231
970	9.242	9.254	9.265	9.277	9.288	2.300	9.311	9.323	9.334	9.345
980	9.357	9.368	9.380	9.391	9.403	9.414	9.426	9.437	9.449	9.460
990	9.472	9.483	9.495	9.506	9.518	9.529	9.541	9.552	9.564	9.576
1000	9.587	9.599	9.610	9.622	9.633	9.645	9.656	9.668	9.680	9.691
1010	9.703	9.714	9.726	9.737	9.749	9.761	9.772	9.784	9.795	9.807
1020	9.819	9.830	9.842	9.853	9.865	9.877	9.888	9.900	9.911	9.923
1030	9.935	9.946	9.958	9.970	9.981	9.993	10.005	10.016	10.028	10.040
1040	10.051	10.063	10.075	10.086	10.098	10.110	10.121	10.133	10.145	10.156
1050	10.168	10.180	10.191	10.203	10.215	10.227	10.238	10.250	10.262	10.273
1060	10.285	10.297	10.309	10.320	10.332	10.344	10.356	10.367	10.380	10.391
1070	10.403	10.414	10.426	10.438	10.450	10.461	10.473	10.485	10.497	10.509
1080	10.520	10.532	10.544	10.556	10.567	10.579	10.591	10.603	10.615	10.627
1090	10.638	10.650	10.662	10.674	10.686	10.697	10.709	10.721	10.733	10.745
1100	10.757	10.768	10.780	10.792	10.804	10.816	10.828	10.839	10.851	10.863
1110	10.875	10.887	10.899	10.911	10.922	10.934	10.946	10.958	10.970	10.982
1120	10.994	11.006	11.018	11.029	11.041	11.053	11.065	11.077	11.089	11.101
1130	11.113	11.125	11.136	11.148	11.160	11.172	11.184	11.196	11.208	11.220
1140	11.232	11.244	11.256	11.268	11.280	11.291	11.303	11.315	11.327	11.339
1150	11.351	11.363	11.375	11.387	11.399	11.411	11.423	11.435	11.447	11.459
1160	11.471	11.483	11.495	11.507	11.519	11.531	11.542	11.554	11.566	11.578
1170	11.590	11.602	11.614	11.626	11.638	11.650	11.662	11.674	11.686	11.698
1180	11.710	11.722	11.734	11.746	11.758	11.770	11.782	11.794	11.806	11.818
1190	11.830	11.842	11.854	11.866	11.878	11.890	11.902	11.914	11.927	11.939
1200	11.951	11.963	11.975	11.987	11.999	12.011	12.023	12.035	12.047	12.059
1210	12.071	12.083	12.095	12.107	12.119	12.131	12.143	12.155	12.167	12.179
1220	12.191	12.203	12.216	12.228	12.240	12.252	12.264	12.276	12.288	12.300
1230	12.312	12.324	12.336	12.348	12.360	12.372	12.384	12.397	12.409	12.421
1240	12.433	12.445	12.457	12.469	12.481	12.493	12.505	12.517	12.529	12.542
1250	12.554	12.566	12.578	12.590	12.602	12.614	12.626	12.638	12.650	12.662
1260	12.675	12.687	12.699	12.711	12.723	12.735	12.747	12.759	12.771	12.783
1270	12.796	12.808	12.820	12.832	12.844	12.856	12.868	12.880	12.892	12.905
1280	12.917	12.929	12.941	12.953	12.965	12.977	12.989	13.001	13.014	13.026
1290	13.038	13.050	13.062	13.074	13.086	13.098	13.111	13.123	13.135	13.147

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Reference table – Pt vs. Pt 10 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1300	13.159	13.171	13.183	13.195	13.208	13.220	13.232	13.244	13.257	13.268
1310	13.280	13.292	13.305	13.317	13.329	13.341	13.353	13.365	13.377	13.390
1320	13.402	13.414	13.426	13.438	13.450	13.462	13.474	13.487	13.499	13.511
1330	13.523	13.535	13.547	13.559	13.572	13.584	13.596	13.608	13.620	13.632
1340	13.644	13.657	13.669	13.681	13.693	13.705	13.717	13.729	13.742	13.754
1350	13.766	13.778	13.790	13.802	13.814	13.827	13.839	13.851	13.863	13.875
1360	13.887	13.899	13.911	13.924	13.936	13.948	13.960	13.972	13.984	13.996
1370	14.009	14.021	14.033	14.045	14.057	14.069	14.081	14.094	14.106	14.118
1380	14.130	14.142	14.154	14.166	14.178	14.191	14.203	14.215	14.227	14.239
1390	14.251	14.263	14.276	14.288	14.300	14.312	14.324	14.336	14.348	14.360
1400	14.373	14.385	14.397	14.409	14.421	14.433	14.445	14.457	14.470	14.482
1410	14.494	14.506	14.518	14.530	14.542	14.554	14.567	14.579	14.591	14.603
1420	14.615	14.627	14.639	14.651	14.664	14.676	14.688	14.700	14.712	14.724
1430	14.736	14.748	14.760	14.773	14.785	14.797	14.809	14.821	14.833	14.845
1440	14.857	14.869	14.882	14.894	14.906	14.918	14.930	14.942	14.954	14.966
1450	14.978	14.990	15.002	15.015	15.027	15.039	15.051	15.063	15.075	15.087
1460	15.099	15.111	15.123	15.135	15.148	15.160	15.172	15.184	15.196	15.208
1470	15.220	15.232	15.244	15.256	15.268	15.280	15.292	15.304	15.317	15.329
1480	15.341	15.353	15.365	15.377	15.389	15.401	15.413	15.425	15.437	15.449
1490	15.461	15.473	15.485	15.497	15.509	15.521	15.534	15.546	15.558	15.570
1500	15.582	15.594	15.606	15.618	15.630	15.642	15.654	15.666	15.678	15.690
1510	15.702	15.714	15.726	15.738	15.750	15.726	15.774	15.786	15.798	15.810
1520	15.822	15.834	15.846	15.858	15.870	15.882	15.894	15.906	15.918	15.930
1530	15.942	15.954	15.966	15.978	15.990	16.002	16.014	16.026	16.038	16.050
1540	16.062	16.074	16.086	16.098	16.110	16.122	16.134	16.146	16.158	16.170
1550	16.182	16.194	16.205	16.217	16.229	16.241	16.253	16.265	16.277	16.289
1560	16.301	16.313	16.325	16.337	16.349	16.361	16.373	16.385	16.396	16.408
1570	16.420	16.432	16.444	16.456	16.468	16.480	16.492	16.504	16.516	16.527
1580	16.539	16.551	16.563	16.575	16.587	16.599	16.611	16.623	16.634	16.646
1590	16.658	16.670	16.682	16.694	16.706	16.718	16.729	16.741	16.753	16.765
1600	16.777	16.789	16.801	16.812	16.824	16.836	16.848	16.860	16.872	16.883
1610	16.895	16.907	16.919	16.931	16.943	16.954	16.966	16.978	16.990	17.002
1620	17.013	17.025	17.037	17.049	17.061	17.072	17.084	17.096	17.108	17.120
1630	17.131	17.143	17.155	17.167	17.178	17.190	17.202	17.214	17.225	17.237
1640	17.249	17.261	17.272	17.284	17.296	17.308	17.319	17.331	17.343	17.355
1650	17.366	17.378	17.390	17.401	17.413	17.425	17.437	17.448	17.460	17.472
1660	17.483	17.495	17.507	17.518	17.530	17.542	17.553	17.565	17.577	17.588
1670	17.600	17.612	17.623	17.635	17.647	17.658	17.670	17.682	17.693	17.705
1680	17.717	17.728	17.740	17.751	17.763	17.775	17.786	17.798	17.809	17.821
1690	17.832	17.844	17.855	17.867	17.878	17.890	17.901	17.913	17.924	17.936
1700	17.947	17.959	17.970	19.982	17.993	18.004	18.016	18.027	18.039	18.050
1710	18.061	18.073	18.084	18.095	18.107	18.118	18.129	18.140	18.152	18.163
1720	18.174	18.185	18.196	18.208	18.219	18.230	18.241	18.252	18.263	18.274
1730	18.285	18.297	18.308	18.319	18.330	18.341	18.352	18.363	18.373	18.384
1740	18.395	18.406	18.417	18.428	18.439	18.450	18.460	18.471	18.482	18.493
1750	18.503	18.514	18.525	18.535	18.546	18.557	18.567	18.578	18.588	18.599
1760	18.609	18.620	18.630	18.641	18.651	18.661	18.672	18.682	18.693	

Introduction

The Pt vs. Pt 13 Rh thermocouple combination is letter designated "R" by international agreement. This combination was created at the turn of the century to compensate for national differences in realizing the emf-temperature relationship of the Le Chatelier thermocouple. The increase of rhodium content compensated for the differences and permitted continued use of the existing instrumentation on a nationally regional basis. Tradition has produced the popularity of the "R" calibration making it as popular as the type "S".

The only significant difference between the "R" & "S" is a slightly higher electrical output with a subsequently higher sensitivity. The thermocouple is suitable for use to 1450°C in oxidizing conditions with excursions to 1650°C with appropriate precautions.

Stocking policy

Popular sizes of .020" and .032" diameter are routinely carried in stock for rapid 5-day turn-around. Expedite orders of 24 hours or less are generally accommodated but subject to prior scheduling. Other sizes may be in inventory depending on demand or requested positioning.

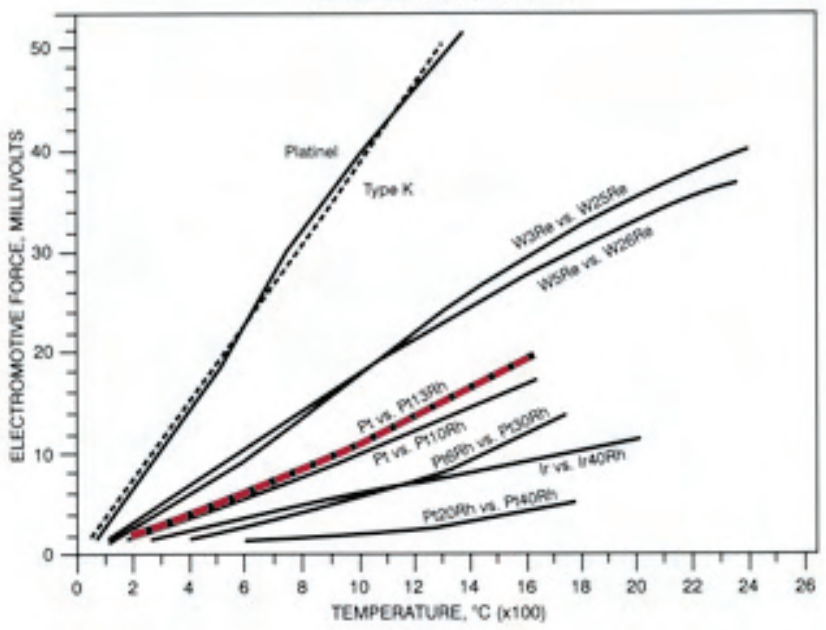
Compensating extension wire

Extension wires are inserted between the measuring and the reference junction. These wires have an approximate equivalent emf-temperature relationship and are commercially available from a number of sources. Commercial compliance tolerance is ± 5°C between a connection temperature of 0°C and 200°C. See the Application notes section for additional information on the use and limits of compensating extension wire.

Annealing

To achieve maximum compliance of the wires thermal electric properties, it is important that they be fully annealed. All wire is supplied, unless otherwise specified, in the fully annealed condition and represents the optimum compromise for handleability.

Comparative emf vs. temperature relationship of common thermocouple materials



Temperature scale

Type R thermocouple wire is available certified to comply with the emf temperature relationships of the International Scale of 1990 (ITS 90) or the International Practical Temperature Scale of 1968 (IPTS 68) as is desired. The difference between these two scales is insignificant in the majority of most practical applications. Please see the Application notes section for additional information.

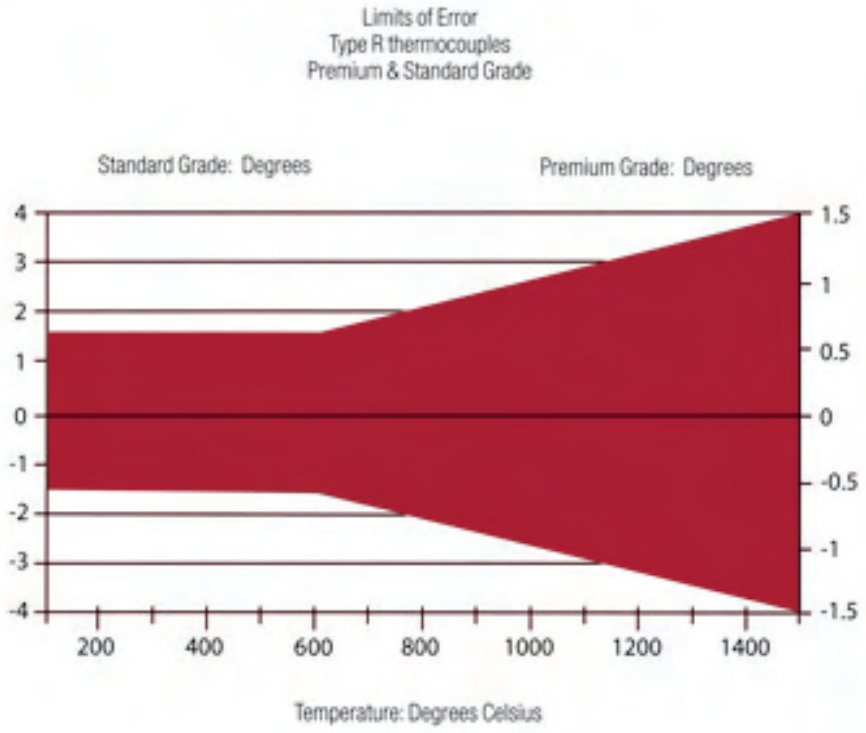
Tolerances and limits of error

Two grades of Type R thermocouple wire are provided differing mainly in the compliance with published emf-temperature tables. Both grades are made from highly purified metals whose selection is based on Glow Dischard Mass Spectroscopy. Melting and working are conducted under tightly controlled conditions which are subject to rigid quality control standards. Thermal electric calibration is conducted to insure compliance with published specification during various stages of the manufacturing process to prevent loss of quality and mechanical integrity.

The thermocouple wire as supplied is guaranteed to conform to all internationally recognized standards such as ASTM230, ANSI MC 96.1, BS. 4937, IEC 584-2, DIN 4371 and JIS 1602 to the following limits of error and can be used interchangeably to within these limits:

Standard Grade	± 1.5°C or ± 0.25% whichever is greater from 0°C to 1450°C
Premium Grade	± 0.6°C or ± 0.10% whichever is greater from 0°C to 1450°C

These interchangeability tolerances are shown graphically below:



Melting point	
Pt	1768°C
Pt 13 Rh	1860°C

Density	(gm/cm³)	troy oz/in³
Pt	21.45	11.31
Pt 13 Rh	19.61	10.33

Polarity	
Pt	–
Pt 13 Rh	+

Coefficient of linear thermal expansion

20°C to 100°C	
Pt	9.0 x 10^6 units/unit/°C
Pt 13 Rh	9.0 x 10^6 units/unit/°C

Electrical resistivity for Pt & Pt 13 Rh thermocouple wire

Temp	microhm-cm		ohm (cir-mil) ft	
Celsius	Pt	Pt 13 Rh	Pt	Pt 13 Rh
0	9.85	19.01	59.30	114.44
20	10.59	19.60	63.75	117.99
100	13.66	21.97	82.23	132.26
200	17.39	24.86	104.69	149.66
300	21.01	27.68	126.48	166.63
400	24.52	30.43	147.61	183.19
500	27.90	33.15	167.96	199.56
600	31.18	35.83	187.70	215.70
700	34.35	38.46	206.79	231.53
800	37.38	41.00	225.03	246.82
900	40.31	43.48	242.67	261.75
1000	43.12	45.89	259.58	276.26
1100	45.82	48.25	275.84	290.47
1200	48.41	50.27	291.43	302.63
1300	50.88	52.85	306.30	318.16
1400	53.24	55.09	320.50	331.64
1500	55.47	57.30	333.93	344.95

Thermal conductivity at 100°C

cal-cm/s•cm^2•°C	
Pt	.0171
Pt 10 Rh	.088

Youngs Modulus

PSI @ 20° C	
Pt	24.5 x 10^6
Pt 10 Rh	29.4 x 10^6

Weight for select wire diameters

(troy oz/ft)

Diameter (inch)	Pt	Pt 13 Rh
0.005	0.002661	0.002431
0.006	0.003832	0.003501
0.007	0.005216	0.004765
0.008	0.006813	0.006224
0.009	0.008622	0.007876
0.010	0.010650	0.009729
0.011	0.012880	0.011766
0.012	0.015330	0.014004
0.013	0.017990	0.016434
0.014	0.020860	0.019056
0.015	0.023950	0.021878
0.016	0.027250	0.024893
0.017	0.030760	0.028099
0.018	0.034490	0.031507
0.019	0.038430	0.035106
0.020	0.042580	0.038897
0.021	0.046940	0.042880
0.022	0.051520	0.047064
0.023	0.056310	0.051439
0.024	0.061320	0.056016
0.025	0.066530	0.060775
0.026	0.071960	0.065735
0.027	0.077600	0.070888
0.028	0.083460	0.076241
0.029	0.089520	0.081777
0.030	0.095810	0.087522
0.031	0.102300	0.093451
0.032	0.109000	0.099572

Wire footage per Troy ounce for select diameters

Diameter (inch)	Pt	Pt 13 Rh
.005	375.0	411.0
.010	93.9	102.3
.015	41.7	45.7
.020	23.5	25.7
.032	9.2	10.0

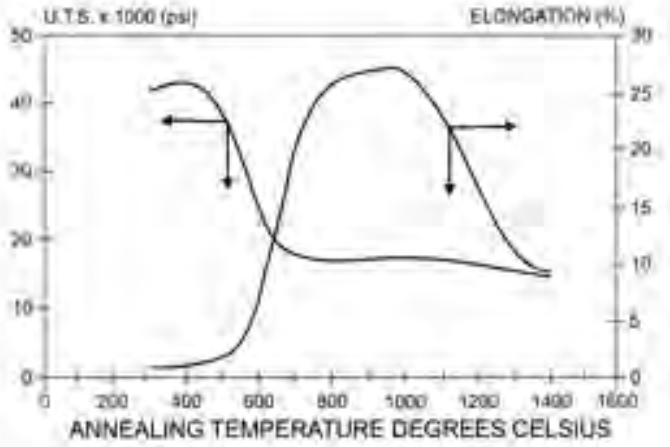
Room temperature resistance for select wire diameters

(ohms/ft)

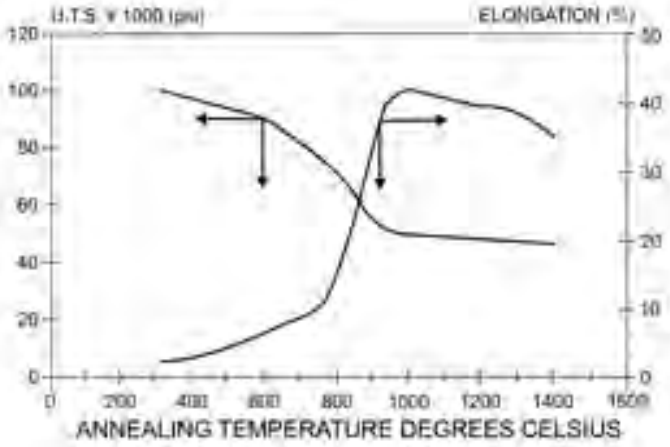
Diameter (inch)	Pt	Pt 13 Rh
0.005	2.368	4.576
0.006	1.664	3.178
0.007	1.208	2.335
0.008	0.925	1.788
0.009	0.731	1.412
0.010	0.592	1.144
0.011	0.489	0.945
0.012	0.411	0.794
0.013	0.350	0.677
0.014	0.302	0.584
0.015	0.263	0.508
0.016	0.231	0.447
0.017	0.205	0.396
0.018	0.183	0.353
0.019	0.164	0.317
0.020	0.148	0.286
0.021	0.134	0.259
0.022	0.122	0.236
0.023	0.112	0.216
0.024	0.103	0.199
0.025	0.095	0.183
0.026	0.088	0.169
0.027	0.081	0.157
0.028	0.076	0.146
0.029	0.070	0.136
0.030	0.066	0.127
0.031	0.062	0.119
0.032	0.058	0.112
0.033	0.054	0.105
0.034	0.051	0.099
0.035	0.048	0.093
0.036	0.046	0.088
0.037	0.043	0.084
0.038	0.041	0.079
0.039	0.039	0.075
0.040	0.037	0.072
0.041	0.035	0.068
0.042	0.034	0.065
0.043	0.032	0.062
0.044	0.031	0.059
0.045	0.029	0.056
0.046	0.028	0.054
0.047	0.027	0.052
0.048	0.026	0.050
0.049	0.025	0.048
0.050	0.024	0.046

Room temperature tensile data

Pt T/C wire

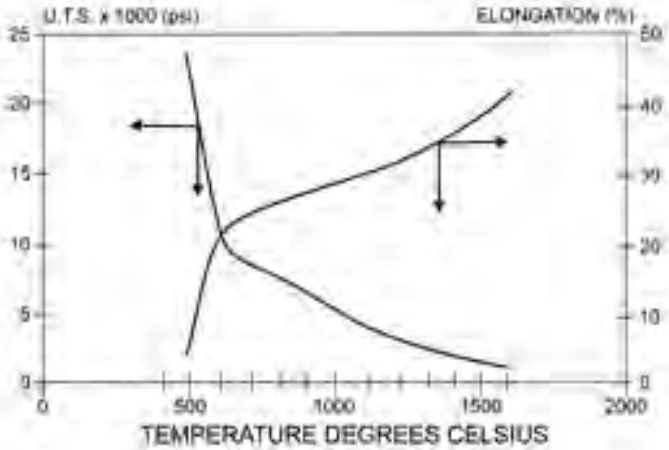


Pt 13 Rh T/C wire

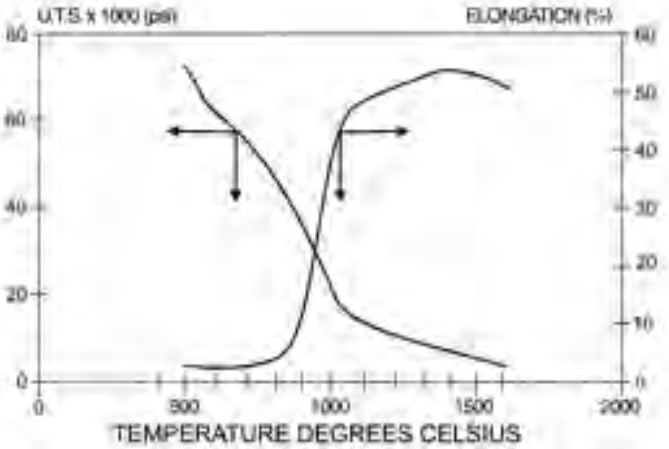


Hot tensile data

Pt T/C wire



Pt 13 Rh T/C wire



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Reference table – Pt vs. Pt 13 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
0	0.000	0.005	0.011	0.016	0.021	0.027	0.032	0.038	0.043	0.049
10	0.054	0.060	0.065	0.071	0.077	0.082	0.088	0.094	0.100	0.105
20	0.111	0.117	0.123	0.129	0.135	0.141	0.147	0.153	0.159	0.165
30	0.171	0.177	0.183	0.189	0.195	0.201	0.207	0.214	0.220	0.226
40	0.232	0.239	0.245	0.251	0.258	0.264	0.271	0.277	0.284	0.290
50	0.297	0.303	0.310	0.316	0.323	0.329	0.336	0.343	0.349	0.356
60	0.363	0.369	0.376	0.383	0.390	0.397	0.403	0.410	0.417	0.424
70	0.431	0.438	0.445	0.452	0.459	0.466	0.473	0.480	0.487	0.494
80	0.501	0.508	0.516	0.523	0.530	0.537	0.544	0.552	0.559	0.566
90	0.573	0.581	0.588	0.595	0.603	0.610	0.618	0.625	0.632	0.640
100	0.647	0.655	0.662	0.670	0.677	0.685	0.693	0.700	0.708	0.715
110	0.723	0.731	0.738	0.746	0.754	0.761	0.769	0.777	0.785	0.792
120	0.800	0.808	0.816	0.824	0.832	0.839	0.847	0.855	0.863	0.871
130	0.879	0.887	0.895	0.903	0.911	0.919	0.927	0.935	0.943	0.951
140	0.959	0.967	0.976	0.984	0.992	1.000	1.008	1.016	1.025	1.033
150	1.041	1.049	1.058	1.066	1.074	1.082	1.091	1.099	1.107	1.116
160	1.124	1.132	1.141	1.149	1.158	1.166	1.175	1.183	1.191	1.200
170	1.208	1.217	1.225	1.234	1.242	1.251	1.260	1.268	1.277	1.285
180	1.294	1.303	1.311	1.320	1.329	1.337	1.346	1.355	1.363	1.372
190	1.381	1.389	1.398	1.407	1.416	1.425	1.433	1.442	1.451	1.460
200	1.469	1.477	1.486	1.495	1.504	1.513	1.522	1.531	1.540	1.549
210	1.558	1.567	1.575	1.584	1.593	1.602	1.611	1.620	1.629	1.639
220	1.648	1.657	1.666	1.675	1.684	1.693	1.702	1.711	1.720	1.729
230	1.739	1.748	1.757	1.766	1.775	1.784	1.794	1.803	1.812	1.821
240	1.831	1.840	1.849	1.858	1.868	1.877	1.886	1.895	1.905	1.914
250	1.923	1.933	1.942	1.951	1.961	1.970	1.980	1.989	1.998	2.008
260	2.017	2.027	2.036	2.046	2.055	2.064	2.074	2.083	2.093	2.102
270	2.112	2.121	2.131	2.140	2.150	2.159	2.169	2.179	2.188	2.198
280	2.207	2.217	2.226	2.236	2.246	2.255	2.265	2.275	2.284	2.294
290	2.304	2.313	2.323	2.333	2.342	2.352	2.362	2.371	2.381	2.391
300	2.401	2.410	2.420	2.430	2.440	2.449	2.459	2.469	2.479	2.488
310	2.498	2.508	2.518	2.528	2.538	2.547	2.557	2.567	2.577	2.587
320	2.597	2.607	2.617	2.626	2.636	2.646	2.656	2.666	2.676	2.686
330	2.696	2.706	2.716	2.726	2.736	2.746	2.756	2.766	2.776	2.786
340	2.796	2.806	2.816	2.826	2.836	2.846	2.856	2.866	2.876	2.886
350	2.896	2.906	2.916	2.926	2.937	2.947	2.957	2.967	2.977	2.987
360	2.997	3.007	3.018	3.028	3.038	3.048	3.058	3.068	3.079	3.089
370	3.099	3.109	3.119	3.130	3.140	3.150	3.160	3.171	3.181	3.191
380	3.201	3.212	3.222	3.232	3.242	3.253	3.263	3.273	3.284	3.294
390	3.304	3.315	3.325	3.335	3.346	3.356	3.366	3.377	3.387	3.397
400	3.408	3.418	3.428	3.439	3.449	3.460	3.470	3.480	3.491	3.501
410	3.512	3.522	3.533	3.543	3.553	3.564	3.574	3.585	3.959	3.606
420	3.616	3.627	3.637	3.648	3.658	3.669	3.679	3.690	3.700	3.711
430	3.721	3.732	3.742	3.753	3.764	3.774	3.785	3.795	3.806	3.816
440	3.827	3.838	3.848	3.859	3.869	3.880	3.891	3.901	3.912	3.922
450	3.933	3.944	3.954	3.965	3.976	3.986	3.997	4.008	4.018	4.029
460	4.040	4.050	4.061	4.072	4.083	4.093	4.104	4.115	4.125	4.136
470	4.147	4.158	4.168	4.179	4.190	4.201	4.211	4.222	4.233	4.244
480	4.255	4.265	4.276	4.287	4.298	4.309	4.319	4.330	4.341	4.352
490	4.363	4.373	4.384	4.395	4.406	4.417	4.428	4.439	4.450	4.460
500	4.471	4.482	4.493	4.504	4.515	4.526	4.537	4.548	4.559	4.569
510	4.580	4.591	4.602	4.613	4.624	4.635	4.646	4.657	6.668	4.679
520	4.690	4.701	4.712	4.723	4.734	4.745	4.756	4.767	4.778	4.789
530	4.800	4.811	4.822	4.833	4.844	4.855	4.866	4.877	4.888	4.899
540	4.910	4.922	4.933	4.944	4.955	4.966	4.977	4.988	4.999	5.010
550	5.021	5.033	5.044	5.055	5.066	5.077	5.088	5.099	5.111	5.122
560	5.133	5.144	5.155	5.166	5.178	5.189	5.200	5.211	5.222	5.234
570	5.245	5.256	5.267	5.279	5.290	5.301	5.312	5.323	5.335	5.346
580	5.357	5.368	5.380	5.391	5.402	5.414	5.425	5.436	5.448	5.459
590	5.470	5.481	5.493	5.504	5.515	5.527	5.538	5.549	5.561	5.572
600	5.583	5.595	5.606	5.618	5.629	5.640	5.652	5.663	5.674	5.686
610	5.697	5.709	5.720	5.731	5.743	5.754	5.766	5.777	5.789	5.800
620	5.812	5.823	5.834	5.846	5.857	5.869	5.880	5.892	5.903	5.915
630	5.926	5.938	5.949	5.961	5.972	5.984	5.995	6.007	6.018	6.030
640	6.041	6.053	6.065	6.076	6.088	6.099	6.111	6.122	6.134	6.146

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Reference table – Pt vs. Pt 13 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
650	6.157	6.169	6.180	6.192	6.204	6.215	6.227	6.238	6.250	6.262
660	6.273	6.285	6.297	6.308	6.320	6.332	6.343	6.355	6.367	6.378
670	6.390	6.402	6.413	6.425	6.437	6.448	6.460	6.472	6.484	6.495
680	6.507	6.519	6.531	6.542	6.554	6.566	6.578	6.589	6.601	6.613
690	6.625	6.636	6.648	6.660	6.672	6.684	6.695	6.707	6.719	6.731
700	6.743	6.755	6.766	6.778	6.790	6.802	6.814	6.826	6.838	6.849
710	6.861	6.873	6.885	6.897	6.909	6.921	6.933	6.945	6.956	6.968
720	6.980	6.992	7.004	7.016	7.028	7.040	7.052	7.064	7.076	7.088
730	7.100	7.112	7.124	7.136	7.148	7.160	7.172	7.184	7.196	7.208
740	7.220	7.232	7.244	7.256	7.268	7.280	2.292	7.304	7.316	7.328
750	7.340	7.352	7.364	7.376	7.389	7.401	7.413	7.425	7.437	7.449
760	7.461	7.473	7.485	7.498	7.510	7.522	7.534	7.546	7.558	7.570
770	7.583	7.595	7.607	7.619	7.631	7.644	7.656	7.668	7.680	7.692
780	7.705	7.717	7.729	7.741	7.753	7.766	7.778	7.790	7.802	7.815
790	7.827	7.839	7.851	7.864	7.876	7.888	7.901	7.913	7.925	7.938
800	7.950	7.962	7.974	7.987	7.999	8.011	8.024	8.036	8.048	8.061
810	8.073	8.086	8.098	8.110	8.123	8.135	8.147	8.160	8.172	8.185
820	8.197	8.209	8.222	8.234	8.247	8.259	8.272	8.284	8.296	8.309
830	8.321	8.334	8.346	8.359	8.371	8.384	8.396	8.409	8.421	8.434
840	8.446	8.459	8.471	8.484	8.496	8.509	8.521	8.534	8.546	8.559
850	8.571	8.584	8.597	8.609	8.622	8.634	8.647	8.659	8.672	8.685
860	8.697	8.710	8.722	8.735	8.748	8.760	8.773	8.785	8.798	8.811
870	8.823	8.836	8.849	8.861	8.874	8.887	8.899	8.912	8.925	8.937
880	8.950	8.963	8.975	8.988	9.001	9.014	9.026	9.039	9.052	9.065
890	9.077	9.090	9.103	9.115	9.128	9.141	9.154	9.167	9.179	9.192
900	9.205	9.218	9.230	9.243	9.256	9.269	9.282	9.294	9.307	9.320
910	9.333	9.346	9.359	9.371	9.384	9.397	9.410	9.423	9.436	9.449
920	9.461	9.474	9.487	9.500	9.513	9.526	9.539	9.552	9.565	9.578
930	9.590	5.603	9.616	9.629	9.642	9.655	9.668	9.681	9.694	9.707
940	9.720	9.733	9.746	9.759	9.772	9.785	9.798	9.811	9.824	9.837
950	9.850	9.863	9.876	9.889	9.902	9.915	9.928	9.941	9.954	9.967
960	9.980	9.993	10.006	10.019	10.032	10.046	10.059	10.072	10.085	10.098
970	10.111	10.124	10.137	10.150	10.163	10.177	10.190	10.203	10.216	10.229
980	10.242	10.255	10.269	10.282	10.295	10.308	10.321	10.334	10.348	10.361
990	10.374	10.387	10.400	10.413	10.427	10.440	10.453	10.466	10.480	10.493
1000	10.506	10.519	10.532	10.546	10.559	10.572	10.585	10.599	10.612	10.625
1010	10.638	10.652	10.665	10.678	10.692	10.705	10.718	10.732	10.745	10.758
1020	10.771	10.785	10.798	10.811	10.825	10.838	10.851	10.865	10.878	10.891
1030	10.905	10.918	10.932	10.945	10.958	10.972	10.985	10.998	11.012	11.025
1040	11.039	11.052	11.065	11.079	11.092	11.106	11.119	11.132	11.146	11.159
1050	11.173	11.186	11.200	11.213	11.227	11.240	11.253	11.267	11.280	11.294
1060	11.307	11.321	11.334	11.348	11.361	11.375	11.388	11.402	11.415	11.429
1070	11.442	11.456	11.469	11.483	11.496	11.510	11.524	11.537	11.551	11.564
1080	11.578	11.591	11.605	11.618	11.632	11.646	11.659	11.673	11.686	11.700
1090	11.714	11.727	11.741	11.754	11.768	11.782	11.795	11.809	11.822	11.836
1100	11.850	11.863	11.877	11.891	11.904	11.918	11.931	11.945	11.959	11.972
1110	11.986	12.000	12.013	12.027	12.041	12.054	12.068	12.082	12.096	12.109
1120	12.123	12.137	12.150	12.164	12.178	12.191	12.205	12.219	12.233	12.246
1130	12.260	12.274	12.288	12.301	12.315	12.329	12.342	12.356	12.370	12.384
1140	12.398	12.411	12.425	12.439	12.453	12.466	12.480	12.494	12.508	12.521
1150	12.535	12.549	12.563	12.577	12.590	12.604	12.618	12.632	12.646	12.659
1160	12.673	12.687	12.701	12.715	12.729	12.742	12.756	12.770	12.784	12.798
1170	12.812	12.825	12.839	12.853	12.867	12.881	12.895	12.909	12.922	12.936
1180	12.950	12.964	12.978	12.992	13.006	13.019	13.033	13.047	13.061	13.075
1190	13.089	13.103	13.117	13.131	13.145	13.158	13.172	13.186	13.200	13.214
1200	13.228	13.242	13.256	13.270	13.284	13.298	13.312	13.325	13.339	13.353
1210	13.367	13.381	13.395	13.409	13.423	13.437	13.451	13.465	13.479	13.493
1220	13.507	13.521	13.535	13.549	13.563	13.577	13.590	13.604	13.618	13.632
1230	13.646	13.660	13.674	13.688	13.702	13.716	13.730	13.744	13.758	13.772
1240	13.786	13.800	13.814	13.828	13.842	13.856	13.870	13.884	13.898	13.912
1250	13.926	13.940	13.954	13.968	13.982	13.996	14.010	14.024	14.038	14.052
1260	14.066	14.081	14.095	14.109	14.123	14.137	14.151	14.165	14.179	14.193
1270	14.207	14.221	14.235	14.249	14.263	14.277	14.291	14.305	14.319	14.333
1280	14.347	14.361	14.375	14.390	14.404	14.418	14.432	14.446	14.460	14.474
1290	14.488	14.502	14.516	14.530	14.544	14.558	14.572	14.586	14.601	14.615

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Reference table – Pt vs. Pt 13 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1300	14.629	14.643	14.657	14.671	14.685	14.699	14.713	14.727	14.741	14.755
1310	14.770	14.784	14.798	14.812	14.826	14.840	14.854	14.868	14.882	14.896
1320	14.911	14.925	14.939	14.953	14.967	14.981	14.995	15.009	15.023	15.037
1330	15.052	15.066	15.080	15.094	15.108	15.122	15.136	15.150	15.164	15.179
1340	15.193	15.207	15.221	15.235	15.249	15.263	15.277	15.291	15.306	15.320
1350	15.334	15.348	15.362	15.376	15.390	15.404	15.419	15.433	15.447	15.461
1360	15.475	15.489	15.503	15.517	15.532	15.546	15.560	15.574	15.588	15.602
1370	15.616	15.630	15.645	15.659	15.673	15.687	15.701	15.715	15.729	15.743
1380	15.758	15.772	15.786	15.800	15.814	15.828	15.842	15.856	15.871	15.885
1390	15.899	15.913	15.927	15.941	15.955	15.969	15.984	15.998	16.012	16.026
1400	16.040	16.054	16.068	16.082	16.097	16.111	16.125	16.139	16.153	16.167
1410	16.181	16.196	16.210	16.224	16.238	16.252	16.266	16.280	16.294	16.309
1420	16.323	16.337	16.351	16.365	16.379	16.393	16.407	16.422	16.436	16.450
1430	16.464	16.478	16.492	16.506	16.520	16.534	16.549	16.563	16.577	16.591
1440	16.605	16.619	16.633	16.647	16.662	16.676	16.690	16.704	16.718	16.732
1450	16.746	16.760	16.774	16.789	16.803	16.817	16.831	16.845	16.859	16.873
1460	16.887	16.901	16.915	16.930	16.944	16.958	16.972	16.986	17.000	17.014
1470	17.028	17.042	17.056	17.071	17.085	17.099	17.113	17.127	17.141	17.155
1480	17.169	17.183	17.197	17.211	17.225	17.240	17.254	17.268	17.282	17.296
1490	17.310	17.324	17.338	17.352	17.366	17.380	17.394	17.408	17.423	17.437
1500	17.451	17.465	17.479	17.493	17.407	17.521	17.535	17.549	17.563	17.577
1510	17.591	17.605	17.619	17.633	17.647	17.661	17.676	17.690	17.704	17.718
1520	17.732	17.746	17.760	17.774	17.788	17.802	17.816	17.830	17.844	17.858
1530	17.872	17.886	17.900	17.914	17.928	17.942	17.956	17.970	17.984	17.998
1540	18.012	18.026	18.040	18.054	18.068	18.082	18.096	18.110	18.124	18.138
1550	18.152	18.166	18.180	18.194	18.208	18.222	18.236	18.250	18.264	18.278
1560	18.292	18.306	18.320	18.334	18.348	18.362	18.376	18.390	18.404	18.417
1570	18.431	18.445	18.459	18.473	18.487	18.501	18.515	18.529	18.543	18.557
1580	18.571	18.585	18.599	18.613	18.627	18.640	18.654	18.668	18.682	18.696
1590	18.710	18.724	18.738	18.752	18.766	18.780	18.793	18.807	18.821	18.835
1600	18.849	18.863	18.877	18.891	18.904	18.918	18.932	18.946	18.960	18.974
1610	18.988	19.002	19.015	19.029	19.043	19.057	19.071	19.085	19.098	19.112
1620	19.126	19.140	19.154	19.168	19.181	19.195	19.209	19.223	19.237	19.250
1630	19.264	19.278	19.292	19.306	19.319	19.333	19.347	19.361	19.375	19.388
1640	19.402	19.416	19.430	19.444	19.457	19.471	19.485	19.499	19.512	19.526
1650	19.540	19.554	19.567	19.581	19.595	19.609	19.622	19.636	19.650	19.663
1660	19.677	19.691	19.705	19.718	19.732	19.746	19.759	19.773	19.787	19.800
1670	19.814	19.828	19.841	19.855	19.869	19.882	19.896	19.910	19.923	19.937
1680	19.951	19.964	19.978	19.992	20.005	20.019	20.032	20.046	20.060	20.073
1690	20.087	20.100	20.114	20.127	20.141	20.154	20.168	20.181	20.195	20.208
1700	20.222	20.235	20.249	20.262	20.275	20.289	20.302	20.316	20.329	20.342
1710	20.356	20.369	20.382	20.396	20.409	20.422	20.436	20.449	20.462	20.475
1720	20.488	20.502	20.515	20.528	20.541	20.554	20.567	20.581	20.594	20.607
1730	20.620	20.633	20.646	20.659	20.671	20.685	20.698	20.711	20.724	20.736
1740	20.749	20.762	20.775	20.788	20.801	20.813	20.826	20.839	20.852	20.864
1750	20.877	20.890	20.902	20.915	20.928	20.940	20.953	20.965	20.978	20.990
1760	21.003	21.015	21.027	21.040	21.052	21.065	21.07	21.089	21.101	

Introduction

The Pt 6 Rh vs. Pt 30 Rh thermocouple combination has received letter designation B and is the third most prominent and popular member of the precious metal system. It was developed to extend the application temperature range of the Pt-Rh system when the limits of the "S" and "R" were determined to be governed by the contamination of the high purity platinum element. Lower temperature use is influenced by the low emf sensitivity and the formation of a tenacious rhodium oxide below approximately 950°C which negatively impacts the thermocouples stability.

Type "B" thermocouples have proven to be highly successful in the glass and ceramics industry for process control and monitoring. In properly constructed assemblies, stable life time service in excess of five years at temperatures in the 1650°C region are taken as typical.

Application suggestions

The Application notes section of this catalog provides a number of suggestions and recommendations for the use of precious metal thermocouples. A brief review of some of these topics will provide guidance for achieving a long and serviceable life from your thermocouple.

Compensating extension wire

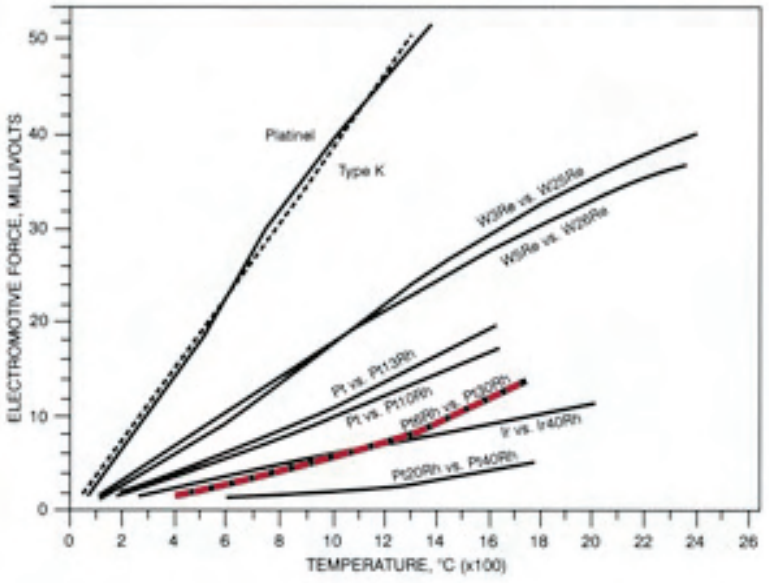
Extension wires are inserted between the measuring and read out instruments reference junction. These extension wires provide thermal electric compensation for the thermocouple signal for the temperature at which they are connected to the thermocouple wire. Due to the low output of the B thermocouple at temperatures less than 60°C, simple copper conductors for each leg are suitable. For junction temperatures up to 200°C compensating wire must be used to keep compliance to the emf-temperature tables within 3°C.

See the Application notes section for additional information on the use and limits of compensating extension wire.

Stocking policy

Popular sizes of .020" and .032" diameter are routinely carried in stock for rapid 5-day turnaround. Expedite orders of 24 hours or less are generally accommodated but subject to prior scheduling. Other sizes may be in inventory depending on demand or requested positioning.

Comparative emf vs. temperature relationship of common thermocouple materials



Annealing

To achieve maximum compliance of the wires thermal electric properties it is important that they be fully annealed. All wire is supplied, unless otherwise specified, in the fully annealed condition and represents the optimum compromise for handleability.

Temperature scale

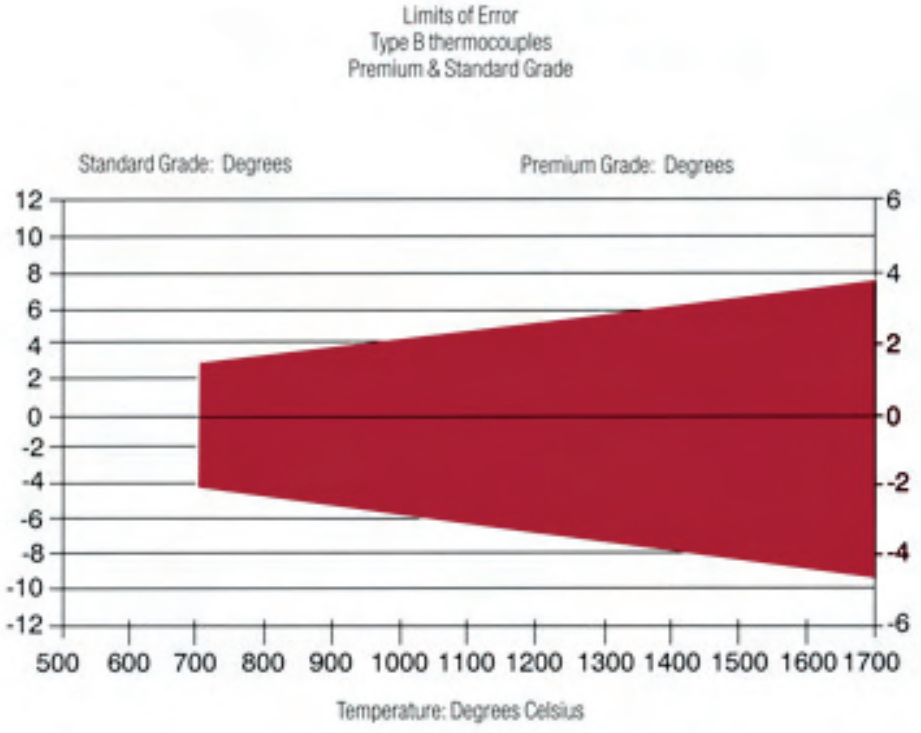
Type B thermocouple wire is available certified to comply with the emf-temperature relationship of the International Temperature Scale of 1990 (ITS 90) or the International Practical Temperature Scale of 1968 (IPTS 68) as is desired. The differences between these two scales is insignificant in the majority of most practical applications. Please see the Application notes section for additional information.

Tolerances and limits of error

The thermocouple wire as supplied is guaranteed to conform to all internationally recognized standards such as ASTM230, ANSI MC 96.1, BS 4937, IEC 584-2, DIN 4371 and JIS 1602 to the following limits of error and can be used interchangeably to within these limits:

Standard Grade	± 2.5°C or ± 0.5% whichever is greater from 700°C to 1700°C
Premium Grade	± 1.5°C or ± 0.25% whichever is greater from 700°C to 1700°C

These interchangeability tolerances are shown graphically below:



Melting point	
Pt 6 Rh	1823°C
Pt 30 Rh	1927°C

Density	(gm/cm³)	troy oz/in³
Pt 6 Rh	20.55	10.83
Pt 30 Rh	17.52	9.23

Polarity	
Pt 6 Rh	–
Pt 30 Rh	+

Coefficient of linear thermal expansion

20°C to 100°C	
Pt 6 Rh	9.0 x 10^{6} units/unit/°C
Pt 30 Rh	9.0 x 10^{6} units/unit/°C

Electrical resistivity for Pt 6 Rh & Pt 30 Rh thermocouple wire

Temp	microhm-cm		ohm (cir-mil) ft	
Celsius	Pt 6 Rh	Pt 30 Rh	Pt 6 Rh	Pt 30 Rh
0	16.50	20.00	99.33	120.40
100	20.50	23.50	123.41	141.47
200	23.50	26.00	141.47	156.52
300	26.80	29.50	161.34	177.59
400	29.90	32.50	180.00	195.65
500	33.50	35.80	201.67	215.52
600	36.50	39.20	219.73	235.98
700	39.80	42.30	239.60	254.65
800	43.00	45.10	258.86	271.50
900	46.00	48.00	276.92	288.96
1000	49.50	50.80	297.99	305.82
1100	51.50	52.90	310.03	318.46
1200	54.10	55.00	325.68	331.10
1300	54.80	55.60	329.90	334.71

Youngs Modulus

PSI @ 20° C	
Pt 6 Rh	25.4 x 10^{6}
Pt 30 Rh	36.5 x 10^{6}

Weight for select wire diameters

(troy oz/ft)

Diameter (inch)	Pt 6 Rh	Pt 30 Rh
0.005	0.002550	0.002184
0.006	0.003671	0.003145
0.007	0.004997	0.004281
0.008	0.006528	0.005591
0.009	0.008261	0.007076
0.010	0.010204	0.008740
0.011	0.012340	0.010571
0.012	0.014688	0.012581
0.013	0.017236	0.014764
0.014	0.019986	0.017120
0.015	0.022946	0.019656
0.016	0.026108	0.022364
0.017	0.029471	0.025245
0.018	0.033045	0.028306
0.019	0.036820	0.031540
0.020	0.040796	0.034945
0.021	0.044973	0.038524
0.022	0.049361	0.042282
0.023	0.053951	0.046214
0.024	0.058751	0.050325
0.025	0.063742	0.054601
0.026	0.068945	0.059058
0.027	0.074349	0.063686
0.028	0.079963	0.068496
0.029	0.085769	0.073469
0.030	0.091796	0.078631
0.031	0.102300	0.093451
0.032	0.104433	0.089456

Wire footage per Troy ounce for select diameters

Diameter (inch)	Pt 6 Rh	Pt 30 Rh
.005	392.0	457.0
.010	98.0	114.4
.015	43.5	50.8
.020	24.5	28.6
.032	9.6	11.2

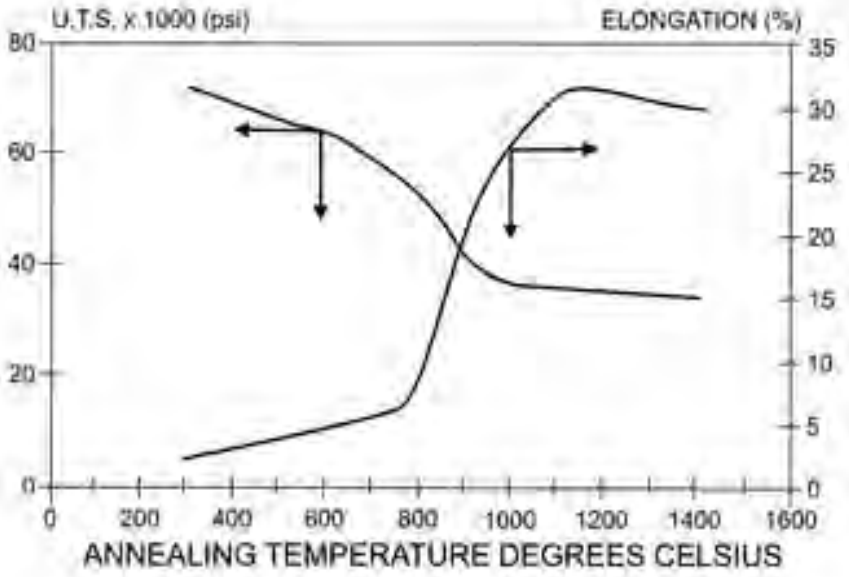
Room temperature resistance for select wire diameters

(ohms/ft)

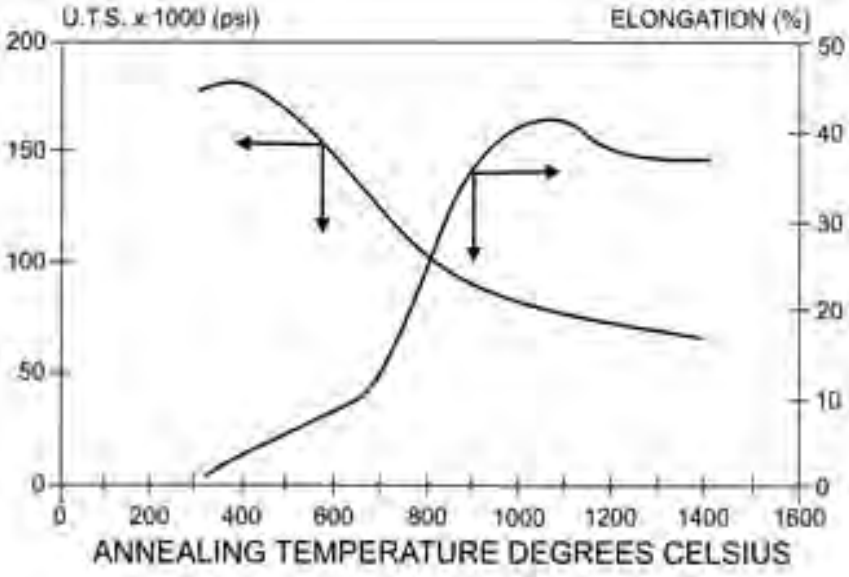
Diameter (inch)	Pt 6 Rh	Pt 30 Rh
0.005	4.044	4.576
0.006	2.808	3.178
0.007	2.063	2.335
0.008	1.580	1.788
0.009	1.248	1.412
0.010	1.011	1.144
0.011	0.836	0.945
0.012	0.702	0.794
0.013	0.598	0.677
0.014	0.516	0.584
0.015	0.449	0.508
0.016	0.395	0.447
0.017	0.350	0.396
0.018	0.312	0.353
0.019	0.280	0.317
0.020	0.253	0.286
0.021	0.229	0.259
0.022	0.209	0.236
0.023	0.191	0.216
0.024	0.176	0.199
0.025	0.162	0.183
0.026	0.150	0.169
0.027	0.139	0.157
0.028	0.129	0.146
0.029	0.120	0.136
0.030	0.112	0.127
0.031	0.105	0.119
0.032	0.099	0.112
0.033	0.093	0.105
0.034	0.087	0.099
0.035	0.083	0.093
0.036	0.078	0.088
0.037	0.074	0.084
0.038	0.070	0.079
0.039	0.066	0.075
0.040	0.063	0.072
0.041	0.060	0.068
0.042	0.057	0.065
0.043	0.055	0.062
0.044	0.052	0.059
0.045	0.050	0.056
0.046	0.048	0.054
0.047	0.046	0.052
0.048	0.044	0.050
0.049	0.042	0.048
0.050	0.040	0.046

Room temperature tensile data

Pt 6 Rh T/C wire



Pt 30 Rh T/C wire



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Reference table Pt 6 Rh vs. Pt 30 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
0	0.000	-0.000	-0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002
10	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003	-0.003
20	-0.003	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002	-0.002	-0.002
30	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001
40	-0.000	-0.000	-0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.002
50	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.006
60	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.011
70	0.011	0.012	0.012	0.013	0.014	0.014	0.015	0.015	0.016	0.017
80	0.017	0.018	0.019	0.020	0.020	0.021	0.022	0.022	0.023	0.024
90	0.025	0.026	0.026	0.027	0.028	0.029	0.030	0.031	0.031	0.032
100	0.033	0.034	0.035	0.036	0.037	0.038	0.039	0.040	0.041	0.042
110	0.043	0.044	0.045	0.046	0.047	0.048	0.049	0.050	0.051	0.052
120	0.053	0.055	0.056	0.057	0.058	0.059	0.060	0.062	0.063	0.064
130	0.065	0.066	0.068	0.069	0.070	0.072	0.073	0.074	0.075	0.077
140	0.078	0.079	0.081	0.082	0.084	0.085	0.086	0.088	0.089	0.091
150	0.092	0.094	0.095	0.096	0.098	0.099	0.101	0.103	0.104	0.106
160	0.107	0.109	0.110	0.112	0.113	0.115	0.117	0.118	0.120	0.122
170	0.123	0.125	0.127	0.128	0.130	0.132	0.134	0.135	0.137	0.139
180	0.141	0.142	0.144	0.146	0.148	0.150	0.151	0.153	0.155	0.157
190	0.159	0.161	0.163	0.165	0.166	0.168	0.170	0.172	0.174	0.176
200	0.178	0.180	0.182	0.184	0.186	0.188	0.190	0.192	0.195	0.197
210	0.199	0.201	0.203	0.205	0.207	0.209	0.212	0.214	0.216	0.218
220	0.220	0.222	0.225	0.227	0.229	0.231	0.234	0.236	0.238	0.241
230	0.243	0.245	0.248	0.250	0.252	0.255	0.257	0.259	0.262	0.264
240	0.267	0.269	0.271	0.274	0.276	0.279	0.281	0.284	0.286	0.289
250	0.291	0.294	0.296	0.299	0.301	0.304	0.307	0.309	0.312	0.314
260	0.317	0.320	0.322	0.325	0.328	0.330	0.333	0.336	0.338	0.341
270	0.344	0.347	0.349	0.352	0.355	0.358	0.360	0.363	0.366	0.369
280	0.372	0.375	0.377	0.380	0.383	0.386	0.389	0.391	0.395	0.398
290	0.401	0.404	0.407	0.410	0.413	0.416	0.419	0.422	0.425	0.428
300	0.431	0.434	0.437	0.440	0.443	0.446	0.449	0.452	0.455	0.459
310	0.462	0.465	0.468	0.471	0.474	0.478	0.481	0.484	0.487	0.490
320	0.494	0.497	0.500	0.503	0.507	0.510	0.513	0.517	0.520	0.523
330	0.527	0.530	0.533	0.537	0.540	0.544	0.547	0.550	0.554	0.557
340	0.561	0.564	0.568	0.571	0.575	0.578	0.582	0.585	0.589	0.592
350	0.596	0.599	0.603	0.607	0.610	0.614	0.617	0.621	0.625	0.628
360	0.632	0.636	0.639	0.643	0.647	0.650	0.654	0.658	0.662	0.665
370	0.669	0.673	0.677	0.680	0.684	0.688	0.692	0.696	0.700	0.703
380	0.707	0.711	0.715	0.719	0.723	0.727	0.731	0.735	0.738	0.742
390	0.746	0.750	0.754	0.758	0.762	0.766	0.770	0.774	0.778	0.782
400	0.787	0.791	0.795	0.799	0.803	0.807	0.811	0.815	0.819	0.824
410	0.828	0.832	0.836	0.840	0.844	0.849	0.853	0.857	0.861	0.866
420	0.870	0.874	0.878	0.883	0.887	0.891	0.896	0.900	0.904	0.909
430	0.913	0.917	0.922	0.926	0.930	0.935	0.939	0.944	0.948	0.953
440	0.957	0.961	0.966	0.970	0.975	0.979	0.984	0.988	0.993	0.997
450	1.002	1.007	1.011	1.016	1.020	1.025	1.030	1.034	1.039	1.043
460	1.048	1.053	1.057	1.062	1.067	1.071	1.076	1.081	1.086	1.090
470	1.095	1.100	1.105	1.109	1.114	1.119	1.124	1.129	1.133	1.138
480	1.143	1.148	1.153	1.158	1.163	1.167	1.172	1.177	1.182	1.187
490	1.192	1.197	1.202	1.207	1.212	1.217	1.222	1.227	1.232	1.237
500	1.242	1.247	1.252	1.257	1.262	1.267	1.272	1.277	1.282	1.288
510	1.318	1.324	1.329	1.334	1.339	1.344	1.350	1.355	1.360	1.365
520	1.344	1.350	1.355	1.360	1.365	1.371	1.376	1.381	1.387	1.392
530	1.397	1.402	1.408	1.413	1.418	1.424	1.429	1.435	1.440	1.445
540	1.451	1.456	1.462	1.467	1.473	1.478	1.483	1.489	1.494	1.500
550	1.505	1.511	1.516	1.522	1.527	1.533	1.539	1.544	1.550	1.555
560	1.561	1.566	1.572	1.578	1.583	1.589	1.595	1.600	1.606	1.612
570	1.617	1.623	1.629	1.634	1.640	1.646	1.652	1.657	1.663	1.669
580	1.675	1.680	1.686	1.692	1.698	1.704	1.709	1.715	1.721	1.727
590	1.733	1.739	1.745	1.750	1.756	1.762	1.768	1.774	1.780	1.786
600	1.792	1.798	1.804	1.810	1.816	1.822	1.828	1.834	1.840	1.846
610	1.852	1.858	1.864	1.870	1.876	1.882	1.888	1.894	1.901	1.907
620	1.913	1.919	1.925	1.931	1.937	1.944	1.950	1.956	1.962	1.968
630	1.975	1.981	1.987	1.993	2.000	2.006	2.012	2.018	2.025	2.031
640	2.037	2.043	2.050	2.056	2.062	2.069	2.075	2.082	2.088	2.094

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Reference table Pt 6 Rh vs. Pt 30 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
650	2.101	2.107	2.113	2.120	2.126	2.133	2.139	2.146	2.152	2.158
660	2.165	2.171	2.178	2.184	2.191	2.197	2.204	2.210	2.217	2.224
670	2.230	2.237	2.243	2.250	2.256	2.263	2.270	2.276	2.283	2.289
680	2.296	2.303	2.309	2.316	2.323	2.329	2.336	2.343	2.350	2.356
690	2.363	2.370	2.376	2.383	2.390	2.397	2.403	2.410	2.417	2.424
700	2.431	2.437	2.444	2.451	2.458	2.465	2.472	2.479	2.485	2.492
710	2.499	2.506	2.513	2.520	2.527	2.534	2.541	2.548	2.555	2.562
720	2.569	2.576	2.582	2.590	2.597	2.604	2.611	2.618	2.625	2.632
730	2.639	2.646	2.653	2.660	2.667	2.674	2.681	2.688	2.696	2.703
740	2.710	2.717	2.724	2.731	2.738	2.746	2.753	2.760	2.767	2.775
750	2.782	2.789	2.796	2.803	2.811	2.818	2.825	2.833	2.840	2.847
760	2.854	2.862	2.869	2.876	2.884	2.891	2.899	2.906	2.913	2.921
770	2.928	2.935	2.943	2.950	2.958	2.965	2.973	2.980	2.987	2.995
780	3.002	3.010	3.017	3.025	3.032	3.040	3.047	3.055	3.063	3.070
790	3.078	3.085	3.093	3.100	3.108	3.116	3.123	3.131	3.138	3.146
800	3.154	3.161	3.169	3.177	3.184	3.192	3.200	3.207	3.215	3.223
810	3.230	3.238	3.246	3.254	3.261	3.269	3.277	3.285	3.292	3.300
820	3.308	3.316	3.324	3.331	3.339	3.347	3.355	3.363	3.371	3.379
830	3.386	3.394	3.402	3.410	3.418	3.426	3.434	3.442	3.450	3.458
840	3.466	3.474	3.482	3.490	3.498	3.506	3.514	3.522	3.530	3.538
850	3.546	3.554	3.562	3.570	3.578	3.586	3.594	3.602	3.610	3.618
860	3.626	3.634	3.643	3.651	3.659	3.667	3.675	3.683	3.692	3.700
870	3.708	3.716	3.724	3.732	3.741	3.749	3.757	3.766	3.774	3.782
880	3.790	3.798	3.807	3.815	3.823	3.832	3.840	3.848	3.857	3.865
890	3.873	3.882	3.890	3.898	3.907	3.915	3.923	3.932	3.940	3.949
900	3.957	3.965	3.974	3.982	3.991	3.999	4.008	4.016	4.025	4.33
910	4.041	4.050	4.058	4.067	4.075	4.084	4.093	4.101	4.110	4.118
920	4.127	4.135	4.144	4.152	4.161	4.170	4.178	4.187	4.195	4.204
930	4.213	4.221	4.230	4.239	4.247	4.256	4.265	4.273	4.282	4.291
940	4.299	4.308	4.317	4.326	4.334	4.343	4.352	4.360	4.369	4.378
950	4.387	4.396	4.404	4.413	4.422	4.431	4.440	4.448	4.457	4.466
960	4.475	4.484	4.493	4.501	4.510	4.519	4.528	4.537	4.546	4.555
970	4.564	4.573	4.582	4.591	4.599	4.608	4.617	4.626	4.635	4.644
980	4.653	4.662	4.671	4.680	4.689	4.698	4.707	4.716	4.725	4.734
990	4.743	4.753	4.762	4.771	4.780	4.789	4.798	4.807	4.816	4.825
1000	4.834	4.843	4.853	4.862	4.871	4.880	4.889	4.898	4.908	4.917
1010	4.926	4.935	4.944	4.954	4.963	4.972	4.981	4.990	5.000	5.009
1020	5.018	5.027	5.037	5.046	5.055	5.065	5.074	5.083	5.092	5.102
1030	5.111	5.120	5.130	5.139	5.148	5.158	5.167	5.176	5.186	5.195
1040	5.205	5.214	5.223	5.233	5.242	5.252	5.261	5.271	5.280	5.289
1050	5.299	5.308	5.318	5.327	5.337	5.346	5.356	5.365	5.375	5.384
1060	5.394	5.403	5.413	5.422	5.432	5.441	5.451	5.460	5.470	5.480
1070	5.489	5.499	5.508	5.518	5.528	5.537	5.547	5.556	5.566	5.576
1080	5.585	5.595	5.605	5.614	5.624	5.634	5.643	5.653	5.663	5.672
1090	5.682	5.692	5.702	5.711	5.721	5.731	5.740	5.750	5.760	5.770
1100	5.780	5.789	5.799	5.809	5.819	5.828	5.838	5.848	5.858	5.868
1110	5.878	5.887	5.897	5.907	5.917	5.927	5.937	5.947	5.956	5.966
1120	5.976	5.986	5.996	6.006	6.016	6.026	6.036	6.046	6.056	6.066
1130	6.075	6.085	6.095	6.105	6.115	6.125	6.135	6.145	6.155	6.165
1140	6.175	6.185	6.195	6.205	6.215	6.225	6.235	6.245	6.256	2.266
1150	6.276	6.286	6.296	6.306	6.316	6.326	6.336	6.346	6.356	6.367
1160	6.377	6.387	6.397	6.407	6.417	6.427	6.438	6.448	6.458	6.468
1170	6.478	6.488	6.499	6.509	6.519	6.529	6.539	6.550	6.560	6.570
1180	6.580	6.591	6.601	6.611	6.621	6.632	6.642	6.652	6.663	6.673
1190	6.683	6.693	6.704	6.714	6.724	6.735	6.645	6.755	6.766	6.776
1200	6.786	6.797	6.807	6.818	6.828	6.838	6.849	6.859	6.869	6.880
1210	6.890	6.901	6.911	6.922	6.932	6.942	6.953	6.963	6.974	6.984
1220	6.995	7.005	7.016	7.026	7.037	7.047	7.058	7.068	7.079	7.089
1230	7.100	7.110	7.121	7.131	7.142	7.152	7.163	7.173	7.184	7.194
1240	7.205	7.216	7.226	7.237	7.247	7.258	7.269	7.279	7.290	7.300
1250	7.311	7.322	7.332	7.343	7.353	7.364	7.375	7.385	7.396	7.407
1260	7.417	7.428	7.439	7.449	7.460	7.471	7.482	7.492	7.503	7.514
1270	7.524	7.535	7.546	7.557	7.567	7.578	7.589	7.600	7.610	7.621
1280	7.632	7.643	7.653	7.664	7.675	7.686	7.697	7.707	7.718	7.729
1290	7.740	7.751	7.761	7.772	7.783	7.794	7.805	7.816	7.827	7.837

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Reference table Pt 6 Rh vs. Pt 30 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1300	7.848	7.859	7.870	8.881	7.892	7.903	7.914	7.924	7.935	7.946
1310	7.957	7.968	7.979	7.990	8.001	8.012	8.023	8.034	8.045	8.056
1320	8.066	8.077	8.088	8.099	8.110	8.121	8.132	8.143	8.154	8.165
1330	8.176	8.187	8.198	8.209	8.220	8.231	8.242	8.253	8.264	8.275
1340	8.286	8.298	8.309	8.320	8.331	8.342	8.353	8.364	8.375	8.386
1350	8.397	8.408	8.419	8.430	8.441	8.453	8.464	8.475	8.486	8.497
1360	8.508	8.519	8.530	8.542	8.553	8.564	8.575	8.586	8.597	8.608
1370	8.620	8.631	8.642	8.653	8.664	8.675	8.687	8.698	8.709	8.720
1380	8.731	8.743	8.754	8.765	8.776	8.787	8.799	8.810	8.821	8.832
1390	8.844	8.855	8.866	8.877	8.889	8.900	8.911	8.922	8.934	8.945
1400	8.956	8.967	8.979	8.990	9.001	9.013	9.024	9.035	9.047	9.058
1410	9.069	9.080	9.092	9.103	9.114	9.126	9.137	9.148	9.160	9.171
1420	9.182	9.194	9.205	9.216	9.228	9.239	9.251	9.262	9.273	9.285
1430	9.296	9.307	9.319	9.330	9.342	9.353	9.364	9.376	9.387	9.398
1440	9.410	9.421	9.433	9.444	9.456	9.467	9.478	9.490	4.501	9.513
1450	9.524	9.536	9.547	9.558	9.570	9.581	9.593	9.604	9.616	9.627
1460	9.639	9.650	9.662	9.673	9.684	9.696	9.707	9.719	9.730	9.742
1470	9.753	9.765	9.776	9.788	9.799	9.811	9.822	9.834	9.845	9.857
1480	9.868	9.880	9.891	9.903	9.914	9.926	9.937	9.949	9.961	9.972
1490	9.984	9.995	10.007	10.018	10.030	10.041	10.053	10.064	10.076	10.088
1500	10.099	10.111	10.122	10.134	10.145	10.157	10.168	10.180	10.192	10.203
1510	10.215	10.226	10.238	10.250	10.261	10.273	10.284	10.296	10.307	10.319
1520	10.331	10.342	10.354	10.365	10.377	10.389	10.400	10.412	10.423	10.435
1530	10.447	10.458	10.470	10.482	10.493	10.505	10.516	10.528	10.540	10.551
1540	10.563	10.575	10.586	10.598	10.609	10.621	10.633	10.644	10.656	10.668
1550	10.679	10.691	10.703	10.714	10.726	10.738	10.749	10.761	10.773	10.784
1560	10.796	10.808	10.819	10.831	10.843	10.854	10.866	10.878	10.889	10.901
1570	10.913	10.924	10.936	10.948	10.959	10.971	10.983	10.994	11.006	11.018
1580	11.029	11.041	11.053	11.064	11.076	11.088	11.099	11.111	11.123	11.134
1590	11.146	11.158	11.169	11.181	11.193	11.205	11.216	11.228	11.240	11.251
1600	11.263	11.275	11.286	11.298	11.310	11.321	11.333	11.345	11.357	11.368
1610	11.380	11.392	11.403	11.415	11.427	11.438	11.450	11.462	11.474	11.485
1620	11.497	11.509	11.520	11.532	11.544	11.555	11.567	11.579	11.591	11.602
1630	11.614	11.626	11.637	11.649	11.661	11.673	11.684	11.696	11.708	11.719
1640	11.731	11.743	11.754	11.766	11.778	11.790	11.801	11.813	11.825	11.836
1650	11.848	11.860	11.871	11.883	11.895	11.907	11.918	11.930	11.942	11.953
1660	11.965	11.977	11.988	12.000	12.012	12.024	12.035	12.047	12.059	12.070
1670	12.082	12.094	12.105	12.117	12.129	12.141	12.152	12.164	12.176	12.187
1680	12.199	12.211	12.222	12.234	12.246	12.257	12.269	12.281	12.292	12.304
1690	12.316	12.327	12.339	12.351	12.363	12.374	12.386	12.398	12.409	12.421
1700	12.433	12.444	12.456	12.468	12.479	12.491	12.503	12.514	12.526	12.538
1710	12.549	12.561	12.572	12.584	12.596	12.607	12.619	12.631	12.642	12.654
1720	12.666	12.677	12.689	12.701	12.712	12.724	12.736	12.747	12.759	12.770
1730	12.782	12.794	12.805	12.817	12.829	12.840	12.852	12.863	12.875	12.887
1740	12.898	12.910	12.922	12.933	12.945	12.956	12.968	12.980	12.991	13.003
1750	13.014	13.026	13.038	13.049	13.061	13.072	13.084	13.095	13.107	13.119
1760	13.130	13.142	13.153	13.165	13.176	13.188	13.200	13.211	13.223	13.234
1770	13.246	13.257	13.269	13.280	13.292	13.304	13.315	13.327	13.338	13.350
1780	13.361	13.373	13.384	13.396	13.407	13.419	13.430	13.442	13.453	13.465
1790	13.476	13.488	13.499	13.511	13.522	13.534	13.545	13.557	13.568	13.580
1800	13.591	13.603	13.614	13.626	13.637	16.649	13.660	13.672	13.683	13.694
1810	13.706	13.706	13.717	13.729	13.740	13.752	13.763	13.775	13.786	13.797
1820	13.820									

Introduction

Tungsten-Rhenium thermocouple combinations developed by BASF permit thermometric temperature measurement far in excess of conventional ISA standard letter-designated thermocouples. The traditional base metal thermocouple materials can be used to measure temperature to about 1200ºC while the noble metal combinations are usable with reliability to about 1700ºC. The refractory metal combinations, consisting of tungsten and rhenium, are usable to 2800ºC and are limited only by the environment in which they are used and their insulating materials.

Technical overview of Tungsten-Rhenium thermoelements

In early attempts, pure tungsten was used as the positive leg versus tungsten-26 rhenium as the negative leg. The feasibility of measuring high temperatures was demonstrated with this combination. However, the pure tungsten leg proved to be brittle after high temperature use. Once annealed at about 1200ºC, the tungsten leg has a brittle to ductile transition temperature of around 275ºC. Alloying the tungsten with modest amounts of rhenium only partially aided the ductility. At the same time the addition of large amounts of rhenium, while helpful to a certain extent, adversely affected the emf of the new combination and, hence, its sensitivity.

Doping – a significant improvement

Subsequently, it was found that the addition of grain stabilizing dopants to the positive or high tungsten leg provided the ultimate cure without adversely affecting the thermoelectric properties. The BASF-supplied W 5 Re and W 3 Re positive leg is doped to enhance the formation of elongated grains, which, in turn, provide the necessary mechanical integrity even after exposure to high temperatures.

Calibration of thermocouple wire

Tungsten-rhenium thermocouple wire is calibrated, by comparison to NIST master standards, in a specially designed inert environment (high purity helium) electrically heated furnace. The furnace is capable of achieving 2400ºC and is equipped for thermoelectric comparison techniques or calibration by direct optical pyrometer temperature determination using an isothermal black body.

A lot-calibration report is provided for each matched pair of thermocouple wires which provides the emf versus temperature relationship at 100ºC to 2300ºC. At additional cost, a computerized calibration report can be provided at 10ºC and 1ºC intervals.

Availability

BASF maintains a substantial stock of matched pair thermocouple wire for immediate shipment. Wire sizes include .005”, .010”, and .015” and .020” diameters.

Interchangeability

Matched pairs of tungsten-rhenium thermocouple wire comply with the published calibration tables to +/- 1% from 400ºC to 2300ºC. Compliance with these tables can only be assured by using matched pairs as supplied Indiscriminate use of mixed lot remnants can lead to large temperature measurement errors.

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Physical properties

The following properties for the tungsten-thermocouple alloys are provided as a guide for consideration of their use in the intended application.

Property		Thermo element			
		W 3 Re	W 5 Re	W 25 Re	W 26 Re
Polarity		+	+	–	–
Melting point		3360°C	3350°C	3120°C	3120°C
Density, 20°C	lb/in³	0.70	0.70	0.71	0.71
	grm/cc	19.4	19.4	19.7	19.7
Resistivity (microhm-cm)					
	20°C	9.7	11.9	28.9	28.9
	1000°C	38.8	39.9	56.3	56.3
	2000°C	71.5	73.9	89.2	89.2
UTS (1000 psi)	20°C	180	200	210	200
	1000°C		65		95
	2000°C		26		24
Elongation (% in 10")					
	20°C	20	24	20	20
	1000°C		24		20
	2000°C		24		27

Electrical resistance

(Ohms/ft at 20°C)

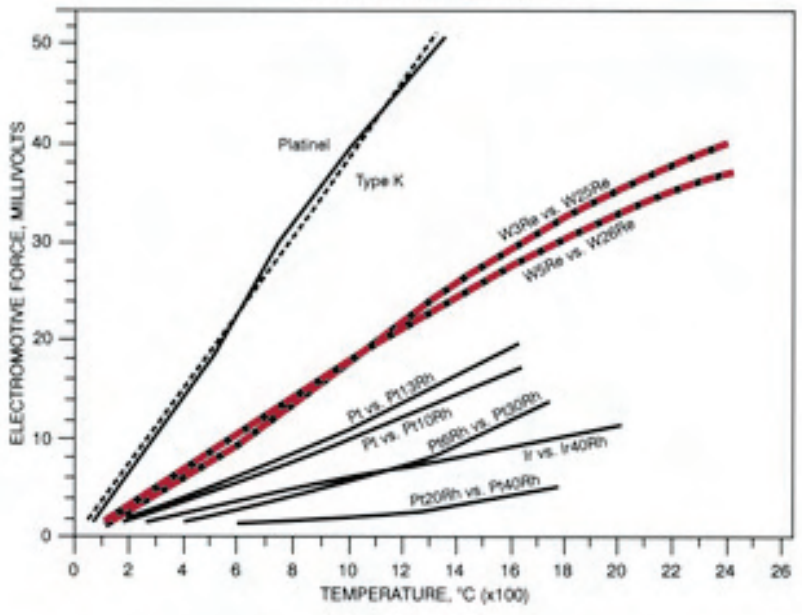
Diameter (inch)	W 3 Re	W 5 Re	W 25 Re	W 26 Re
.005	2.236	2.864	6.956	6.960
.010	0.584	0.716	1.739	1.740
.015	0.260	0.318	0.773	0.773
.020	0.146	0.179	0.435	0.435

Weight table

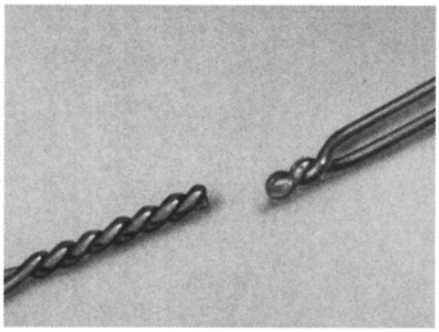
(troy oz/ft)

Diameter	W 3 Re/W 5 Re	W 25 Re/W 26 Re
.005"	.00241	.00244
.010"	.00963	.00976
.015"	.0217	.0390
.020"	.0385	.0390

Comparative emf vs. temperature relationship of common thermocouple materials



Application notes for the use of Tungsten-Rhenium thermocouple wire



W/Re junctions are best made by making a tight twist between the wires and welding back to 1½ or 2 turns.

Tungsten-rhenium thermocouples possess unique properties not shared by the more familiar base and noble metal combinations.

Use in any oxygen-bearing environment is generally detrimental. Oxygen partial pressures greater than 10^{-4} torr are known to cause physical degradation in only a few hours at temperatures of 1000°C.

Carbonaceous environments, either through vapor, gas or solid phase, can be expected to cause formation of carbides which embrittle the material causing physical failure along with decalibration.

Vacuum of 10^{-5} torr at about 1800°C and higher is known to cause preferential vaporization of rhenium causing a drastic shift in calibration.

Inert environments of argon and helium, if dry, are safe as is hydrogen. Dry nitrogen has also been found to be suitable.

Insulation

Tungsten-rhenium thermocouples are generally limited in temperature use due to the lack of suitable insulation materials. High purity Al_20_3 is generally usable to 1750°C/1850°C (fusion temperature 2030°C) if it is supported from sagging. Trace impurities present within the ceramic may also have a deleterious effect.

Beryllia

Beryllia (BeO) has been used to 2150°C and in select cases to 2300°C. It has great thermal stability and high resistance to reduction along with unusually high thermal conductivity at elevated temperatures but a very low electrical conductivity. When hard-fired beryllia insulators are used, dimensional changes should be considered in the design of the temperature measuring system if it is to be used at or above around 2150°C (3900°F). At this temperature beryllia undergoes a phase change which results in an approximate 1% swelling, or increase in original size over and above normal thermal expansion. The problem is usually not serious in swaged thermocouples where crushable beryllia is used.

Beryllia will volatilize in the presence of water vapor above 1000°C forming beryllium hydroxide. Because of its toxicity, safety precautions must be observed with the use of BeO to prevent absorption of the material into the body, particularly by inhalation of dust or fumes.

Magnesia

Magnesia (MgO) insulation is used predominantly in the swaged type assemblies and performs moderately well at temperatures to 1750°C. This material requires some care in the fabrication of these assemblies and the use of dry, uncontaminated crushable ceramic. Because of the hygroscopic nature of magnesia, moisture can be absorbed through the exposed ends of the sheathed assembly. For this reason, the couples should be produced with ends closed in a suitable manner.

Other materials

More exotic ceramics such as thoria (ThO_2), ceria (CeO_2), hafnia (HfO_2) and boron-nitride (BN) have been used with varying degrees of success. With the exception of BN, these materials suffer from relatively low insulation resistance at elevated temperatures.

Inherent trace impurities in the ceramics may spur decalibration reactions or, at worst, cause catastrophic failure. In all cases, the ceramics must be clean, dry, and chemically compatible with the sheath material if so employed.

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Reference table – W 3 Re vs. W 25 Re thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
0	0.000	0.010	0.019	0.029	0.039	0.048	0.058	0.068	0.078	0.088
10	0.098	0.108	0.118	0.128	0.138	0.148	0.159	0.169	0.179	0.189
20	0.200	0.210	0.221	0.231	0.242	0.252	0.263	0.273	0.284	0.295
30	0.305	0.316	0.327	0.338	0.349	0.360	0.371	0.382	0.393	0.404
40	0.415	0.426	0.437	0.448	0.460	0.471	0.482	0.494	0.505	0.517
50	0.528	0.540	0.551	0.563	0.574	0.586	0.598	0.609	0.621	0.633
60	0.645	0.657	0.668	0.680	0.692	0.704	0.716	0.728	0.741	0.753
70	0.765	0.777	0.789	0.802	0.814	0.826	0.839	0.851	0.863	0.876
80	0.888	0.901	0.914	0.926	0.939	0.951	0.964	0.977	0.990	1.002
90	1.015	1.028	1.041	1.054	1.067	1.080	1.093	1.106	1.119	1.132
100	1.145	1.158	1.172	1.185	1.198	1.212	1.225	1.238	1.252	1.265
110	1.278	1.292	1.305	1.319	1.333	1.346	1.360	1.374	1.387	1.401
120	1.415	1.428	1.442	1.456	1.470	1.484	1.498	1.512	1.526	1.540
130	1.554	1.568	1.582	1.596	1.610	1.624	1.639	1.653	1.667	1.681
140	1.696	1.710	1.725	1.739	1.753	1.768	1.782	1.797	1.811	1.826
150	1.841	1.855	1.870	1.884	1.899	1.914	1.929	1.943	1.958	1.973
160	1.988	2003	2.018	2.033	2.048	2.063	2.078	2.093	2.108	2.123
170	2.138	2.153	2.168	2.183	2.199	2.214	2.229	2.244	2.260	2.275
180	2.290	2.306	2.321	2.337	2.352	2.368	2.383	2.399	2.414	2.430
190	2.445	2.461	2.477	2.492	2.508	2.524	2.539	2.555	2.571	2.587
200	2.603	2.618	2.634	2.650	2.666	2.682	2.698	2.714	2.730	2.746
210	2.762	2.778	2.794	2.810	2.826	2.843	2.859	2.875	2.891	2.907
220	2.924	2.940	2.956	2.973	2.989	3.005	3.022	3.038	3.055	3.071
230	3.088	3.104	3.121	3.137	3.154	3.170	3.187	3.203	3.220	3.237
240	3.253	3.270	3.287	3.303	3.320	3.337	3.354	3.371	3.387	3.404
250	3.421	3.438	3.455	3.472	3.489	3.506	3.523	3.540	3.557	3.574
260	3.591	3.608	3.625	3.642	3.659	3.676	3.693	3.711	3.728	3.745
270	3.762	3.780	3.797	3.814	3.831	3.849	3.866	3.883	3.901	3.918
280	3.936	3.953	3.970	3.988	4.005	4.023	4.040	4.058	4.075	4.093
290	4.111	4.128	4.146	4.163	4.181	4.199	4.216	4.234	4.252	4.269
300	4.287	4.305	4.323	4.340	4.358	4.376	4.394	4.412	4.430	4.447
310	4.465	4.483	4.501	4.519	4.537	4.555	4.573	4.591	4.609	4.627
320	4.645	4.663	4.681	4.699	4.717	4.735	4.753	4.772	4.790	4.808
330	4.826	4.844	4.862	4.881	4.899	4.917	4.935	4.954	4.972	4.990
340	5.009	5.027	5.045	5.064	5.082	5.100	5.119	5.137	5.156	5.174
350	5.192	5.211	5.229	5.248	5.266	5.285	5.303	5.322	5.340	5.359
360	5.378	5.396	5.415	5.433	5.452	5.471	5.489	5.508	5.527	5.545
370	5.564	5.583	5.601	5.620	5.639	5.658	5.676	5.695	5.174	5.733
380	5.752	5.770	5.789	5.808	5.827	5.846	5.865	5.884	5.902	5.921
390	5.940	5.959	5.978	5.997	6.016	6.035	6.054	6.073	6.092	6.111
400	6.130	6.149	6.168	6.187	6.206	6.225	6.245	6.264	6.283	6.302
410	6.321	6.340	6.359	6.378	6.398	6.417	6.436	6.455	6.474	6.494
420	6.513	6.532	6.551	6.571	6.590	6.609	6.628	6.648	6.667	6.686
430	6.706	6.725	6.744	6.764	6.783	6.802	6.822	6.841	6.861	6.880
440	6.899	6.919	6.938	6.958	6.977	6.997	7.016	7.035	7.055	7.074
450	7.094	7.113	7.133	7.152	7.172	7.191	7.211	7.231	7.250	7.270
460	7.289	7.309	7.328	7.348	7.368	7.387	7.407	7.427	7.446	7.466
470	7.485	7.505	7.525	7.544	7.564	7.584	7.604	7.623	7.643	7.663
480	7.682	7.702	7.722	7.742	7.761	7.781	7.801	7.821	7.840	7.860
490	7.880	7.900	7.920	7.939	7.959	7.979	7.999	8.019	8.038	8.058
500	8.078	8.098	8.118	8.138	8.158	8.178	8.197	8.217	8.237	8.257
510	8.277	8.297	8.317	8.337	8.357	8.377	8.397	8.417	8.437	8.457
520	8.476	8.496	8.516	8.536	8.556	8.576	8.596	8.616	8.636	8.656
530	8.676	8.696	8.717	8.737	8.757	8.777	8.797	8.817	8.837	8.857
540	8.877	8.897	8.917	8.937	8.957	8.977	8.997	9.018	9.038	9.058
550	9.078	9.098	9.118	9.138	9.158	9.178	9.199	9.219	9.239	9.259
560	9.279	9.299	9.320	9.340	9.360	9.380	9.400	9.420	9.441	9.461
570	9.481	9.501	9.521	9.542	9.562	9.582	9.602	9.622	9.643	9.663
580	9.683	9.703	9.723	9.744	9.764	9.784	9.804	9.825	9.845	9.865
590	9.885	9.906	9.926	9.946	9.966	9.987	10.007	10.027	10.048	10.068
600	10.088	10.108	10.129	10.149	10.169	10.190	10.210	10.230	10.250	10.271
610	10.291	10.311	10.332	10.352	10.372	10.393	10.413	10.433	10.454	10.474
620	10.494	10.515	10.535	10.555	10.576	10.596	10.616	10.637	10.657	10.677
630	10.698	10.718	10.738	10.759	10.779	10.799	10.820	10.840	10.860	10.881
640	10.901	10.921	10.942	10.962	10.983	11.003	11.023	11.044	11.064	11.084

BASF
The Chemical Company

Reference table – W 3 Re vs. W 25 Re thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
650	11.105	11.125	11.146	11.166	11.186	11.207	11.227	11.247	11.268	11.288
660	11.309	11.329	11.349	11.370	11.390	11.410	11.431	11.451	11.472	11.492
670	11.512	11.533	11.553	11.574	11.594	11.614	11.635	11.655	11.676	11.696
680	11.716	11.737	11.757	11.778	11.798	11.818	11.839	11.859	11.880	11.900
690	11.921	11.941	11.961	11.982	12.002	12.023	12.043	12.063	12.084	12.104
700	12.125	12.145	12.165	12.186	12.206	12.227	12.247	12.268	12.288	12.308
710	12.329	12.349	12.370	12.390	12.410	12.431	12.451	12.472	12.492	12.513
720	12.533	12.533	12.574	12.594	12.615	12.635	12.656	12.676	12.696	12.717
730	12.737	12.758	12.778	12.799	12.819	12.840	12.860	12.880	12.901	12.921
740	12.942	12.962	12.983	13.003	13.023	13.044	13.064	13.085	13.105	13.126
750	13.146	13.167	13.187	13.207	13.228	13.248	13.269	13.289	13.310	13.330
760	13.351	13.371	13.392	13.412	13.433	13.453	13.473	13.494	13.514	13.535
770	13.555	13.576	13.596	13.617	13.637	13.658	13.678	13.699	13.719	13.740
780	13.760	13.781	13.801	13.822	13.842	13.863	13.883	13.904	13.924	13.945
790	13.965	13.986	14.006	14.027	14.047	14.068	14.008	14.109	14.129	14.150
800	14.170	14.191	14.211	14.232	14.252	14.273	14.293	14.314	14.334	14.355
810	14.375	14.396	14.416	14.436	14.457	14.477	14.498	14.518	14.539	14.559
820	14.580	14.600	14.621	14.641	14.662	14.682	14.703	14.723	14.744	14.764
830	14.784	14.805	14.825	14. 846	14.866	14.887	14.907	14.928	14.948	14.969
840	14.989	15.009	15.030	15.050	15.071	15.091	15.112	15.132	15.152	15.173
850	15.193	15.214	15.234	15.255	15.275	15.295	15.316	15.336	15.357	15.377
860	15.398	15.418	15.438	15.459	15.479	15.500	15.520	15.540	15.561	15.581
870	15.602	15.622	15.642	15.663	15.683	15703	15.724	15.744	15.765	15.785
880	15.805	15.826	15.846	15.866	15.887	15.907	15.928	15.948	15.968	15.989
890	16.009	16.029	16.050	16.070	16.090	16.111	16.131	16.151	16.172	16.192
900	16.212	16.233	16 .253	16.273	16.294	16.314	16.334	16.354	16.375	16.395
910	16.415	16.436	16.456	16.476	16.497	16.517	16.537	16.557	16.578	16.598
920	16.618	16.638	16.659	16.679	16.699	16.720	16.740	16.760	16.780	16.801
930	16.821	16.841	16.861	16.881	16.902	16.922	16.942	16.962	16.983	17.003
940	17.023	17.043	17.063	17.084	17.104	17.124	17.144	17.164	17.185	17.205
950	17.225	17.245	17.265	17.285	17.306	17.326	17.346	17.366	17.386	17.406
960	17.427	17.447	17.467	17.487	17.507	17.527	17.547	17.568	17.588	17.608
970	17.628	17.648	17.668	17.688	17.708	17.728	17.748	17.769	17.789	17.809
980	17.829	17.849	17.869	17.889	17.909	17.929	18.949	18.969	18.989	18.009
990	18.029	18.049	18.069	18.090	18.110	18.130	18.150	18.170	18.190	18.210
1000	18.230	18.250	18.270	18.290	18.310	18.330	18.350	18.370	18.390	18.410
1010	18.430	18.450	18.469	18.489	18.509	18.529	18.549	18.569	18.589	18.609
1020	18.629	18.649	18.669	18.689	18.709	18.729	18.749	18.768	18.788	18.808
1030	18.828	18.848	18.868	18.888	18.908	18.928	18.947	18.967	18.987	19.007
1040	19.027	19.047	19.067	19.086	19.106	19.126	19.146	19.166	19.186	19.205
1050	19.225	19.245	19.265	19.285	19.304	19.324	19.344	19.364	19.384	19.403
1060	19.423	19.443	19.463	19.482	19.502	19.522	19.542	19.561	19.581	19.601
1070	19.621	19.640	19.660	19.680	19.700	19.719	19.739	19.759	19.778	19.798
1080	19.818	19.837	19.857	19.877	19.896	19.916	19.936	19.955	19.975	19.995
1090	20.014	20.034	20.054	20.073	20.093	20.113	20.132	20.152	20.171	20.191
1100	20.211	20.230	20.250	20.269	20.289	20.309	20.328	20.348	20.367	20.387
1110	20.406	20.426	20.446	20.465	20.485	20.504	20.524	20.543	20.563	20.582
1120	20.602	20.621	20.641	20.660	20.680	20.699	20.719	20.738	20.758	20.777
1130	20.797	20.816	20.836	20.855	20.875	20.894	20.914	20.933	20.952	20.972
1140	20.991	21.011	21.030	21.050	21.069	21.088	21.108	21.127	21.147	21.166
1150	21.185	21.205	21.224	21.243	21.263	21.282	21.301	21.321	21.340	21.360
1160	21.379	21.398	21.418	21.437	21.456	21.475	21.495	21.514	21.533	21.553
1170	21.572	21.591	21.611	21.630	21.649	21.668	21.688	21.707	21.726	21.745
1180	21.765	21.784	21.803	21.822	21.842	21.861	21.880	21.899	21.918	21.938
1190	21.957	21.976	21.995	22.014	22.034	22.053	22.072	22.091	22.110	22.129
1200	22.149	22.168	22.187	22.206	22.225	22.244	22.263	22.283	22.302	22.321
1210	22.340	22.359	22.378	22.397	22.416	22.435	22.454	22.473	22.493	22.512
1220	22.531	22.550	22.569	22.588	22.607	22.626	22.645	22.664	22.683	22.702
1230	22.721	22.740	22.759	22.778	22.797	22.816	22.835	22.854	22.873	22.892
1240	22.911	22.930	22.949	22.968	22.987	23.006	23.024	23.043	23.062	23.081
1250	23.100	23.119	23.138	23.157	23.176	23.195	23.214	23.232	23.251	23.270
1260	23.289	23.308	23.327	23.346	23.364	23.383	23.402	23.421	23.440	23.459
1270	23.477	23.496	23.515	23.534	23.553	23.571	23.590	23.609	23.628	23.647
1280	23.665	23.684	23.703	23.722	23.740	23.759	23.778	23.797	23.815	23.834
1290	23.853	23.871	23.890	23.909	23.928	23.946	23.965	23.984	24.002	24.021

BASF
The Chemical Company

Reference table – W 3 Re vs. W 25 Re thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1300	24.040	24.058	24.077	24.096	24.114	24.133	24.152	24.170	24.189	24.208
1310	24.226	24.245	24.263	24.282	24.301	24.319	24.338	24.356	24.375	24.394
1320	24.412	24.431	24.449	24.468	24.486	24.505	24.523	24.542	24.561	24.579
1330	24.598	24.616	24.635	24.653	24.672	24.690	24.709	24.727	24.746	24.764
1340	24.783	24.801	24.820	24.838	24.856	24.875	24.893	24.912	24.930	24.949
1350	24.967	24.985	25.004	25.022	25.041	25.059	25.078	25.096	25.114	25.133
1360	25.151	25.169	25.188	25.206	25.224	25.243	25.261	25.280	25.298	25.316
1370	25.335	25.353	25.371	25.389	25.408	25.426	25.444	25.463	25.481	25.499
1380	25.517	25.536	25.554	25.572	25.591	25.609	25.627	25.645	25.664	25.682
1390	25.700	25.718	25.736	25.755	25.773	25.791	25.809	25.827	25.846	25.864
1400	25.882	25.900	25.918	25.936	25.955	25.973	25.991	26.009	26.027	26.045
1410	26.063	26.082	26.100	26.118	26.136	26.154	26.172	26.190	26.208	26.226
1420	26.244	26.262	26.281	26.299	26.317	26.335	26.353	26.371	26.389	26.407
1430	26.425	26.443	26.461	26.479	26.497	26.515	26.533	26.551	26.569	26.587
1440	26.605	26.623	26.641	26.659	26.677	26.695	26.712	26.730	26.748	26.766
1450	26.784	26.802	26.820	26.838	26.856	26.874	26.892	26.909	26.927	26.945
1460	26.963	26.981	26.999	27.017	27.035	27.052	27.070	27.088	27.106	27.124
1470	27.141	27.159	27.177	27.195	27.213	27.230	27.248	27.266	27.284	27.302
1480	27.319	27.337	27.355	27.373	27.390	27.408	27.426	27.444	27.461	27.479
1490	27.497	27.514	27.532	27.550	27.567	27.585	27.603	27.621	27.638	27.656
1500	27.673	27.691	27.709	27.726	27.744	27.762	27.779	27.797	27.815	27.832
1510	27.850	27.867	27.885	27.903	27.920	27.938	27.955	27.973	27.990	28.008
1520	28.026	28.043	28.061	28.078	28.096	28.113	28.131	28.148	28.166	28.183
1530	28.201	28.218	28.236	28.253	28.271	28.288	28.306	28.323	28.341	28.358
1540	28.375	28.393	28.410	28.428	28.445	28.463	28.480	28.497	28.515	28.532
1550	28.550	28.567	28.584	28.602	28.619	28.636	28.654	28.671	28.688	28.706
1560	28.723	28.740	28.758	28.775	28.792	28.810	28.827	28.844	28.862	28.879
1570	28.896	28.913	28.931	28.948	28.965	28.982	29.000	29.017	29.034	29.051
1580	29.069	29.086	29.103	29.120	29.137	29.155	29.172	29.189	29.206	29.223
1590	29.241	29.258	29.275	29.292	29.309	29.326	29.343	29.361	29.378	29.395
1600	29.412	29.429	29.446	29.463	29.480	29.497	29.514	29.532	29.549	29.566
1610	29.583	29.600	29.617	29.634	29.651	29.668	29.685	29.702	29.719	29.736
1620	29.753	29.770	29.787	29.804	29.821	29.838	29.855	29.872	29.889	29.906
1630	29.923	29.939	29.956	29.973	29.990	30.007	30.024	30.041	30.058	30.075
1640	30.092	30.108	30.125	30.142	30.159	30.176	30.193	30.210	30.226	30.243
1650	30.260	30.277	30.294	30.311	30.327	30.344	30.361	30.378	30.394	30.411
1660	30.428	30.445	30.461	30.478	30.495	30.512	30.528	30.545	30.562	30.579
1670	30.595	30.612	30.629	30.645	30.662	30.679	30.695	30.712	30.729	30.745
1680	30.762	30.779	30.795	30.812	30.828	30.845	30.862	30.878	30.895	30.911
1690	30.928	30.944	30.961	30.978	30.994	31.011	31.027	31.044	31.060	31.077
1700	31.093	31.110	31.126	31.143	31.159	31.176	31.192	31.209	31.225	31.242
1710	31.258	31.275	31.291	31.307	31.324	31.340	31.357	31.373	31.389	31.406
1720	31.422	31.439	31.455	31.471	31.488	31.504	31.520	31.537	31.553	31.569
1730	31.586	31.602	31.618	31.635	31.651	31.667	31.684	31.700	31.716	31.732
1740	31.749	31.765	31.781	31.797	31.814	31.830	31.846	31.862	31.878	31.895
1750	31.911	31.927	31.943	31.959	31.976	31.992	32.008	32.024	32.040	32.056
1760	32.072	32.088	32.105	32.121	32.137	32.153	32.169	32.185	32.201	32.217
1770	32.233	32.249	32.265	32.281	32.297	32.313	32.329	32.345	32.361	32.377
1780	32.393	32.409	32.425	32.441	32.457	32.473	32.489	32.505	32.521	32.537
1790	32.553	32.569	32.585	32.600	32.616	32.632	32.648	32.664	32.680	32.696
1800	32.712	32.727	32.743	32.759	32.775	32.791	32.806	32.822	32.838	32.854
1810	32.870	32.885	32.901	32.917	32.933	32.948	32.964	32.980	32.995	33.011
1820	33.027	33.042	33.058	33.074	33.090	33.105	33.121	33.136	33.152	33.168
1830	33.183	33.199	33.215	33.230	33.246	33.261	33.277	33.292	33.308	33.324
1840	33.339	33.355	33.370	33.386	33.401	33.417	33.432	33.448	33.463	33.479
1850	33.494	33.510	33.525	33.540	33.556	33.571	33.587	33.602	33.618	33.633
1860	33.648	33.664	33.679	33.694	33.710	33.725	33.741	33.756	33.771	33.786
1870	33.802	33.817	33.832	33.848	33.863	33.878	33.893	33.909	33.924	33.939
1880	33.954	33.970	33.985	34.000	34.015	34.030	34.046	34.061	34.076	34.091
1890	34.106	34.121	34.136	34.152	34.167	34.182	34.197	34.212	34.227	34.242
1900	34.257	34.272	34.287	34.302	34.317	34.332	34.347	34.362	34.377	34.392
1910	34.407	34.422	34.437	34.452	34.467	34.482	34.497	34.512	34.527	34.542
1920	34.556	34.571	34.586	34.601	34.616	34.631	34.646	34.660	34.675	34.690
1930	34.705	34.720	34.734	34.749	34.764	34.779	34.793	34.808	34.823	34.838
1940	34.852	34.867	34.882	34.896	34.911	34.926	34.940	34.955	34.970	34.984

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Reference table – W 3 Re vs. W 25 Re thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1950	34.999	35.013	35.028	35.043	35.057	35.072	35.086	35.101	35.115	35.130
1960	35.144	35.159	35.173	35.188	35.202	35.217	35.231	35.246	35.260	35.275
1970	35.289	35.303	35.318	35.332	35.347	35.361	35.375	35.390	35.404	35.418
1980	35.433	35.447	35.461	35.476	35.490	35.504	35.518	35.533	35.547	35.561
1990	35.575	35.590	35.604	35.618	35.632	35.646	35.660	35.675	35.689	35.703
2000	35.717	35.731	35.745	35.759	35.773	35.787	35.801	35.816	35.830	35.844
2010	35.858	35.872	35.886	35.900	35.914	35.927	35.941	35.955	35.969	35.983
2020	35.997	36.011	36.025	36.039	36.053	36.067	36.080	36.094	36.108	36.122
2030	36.136	36.149	36.163	36.177	36.191	36.204	36.218	36.232	36.246	36.259
2040	36.273	36.287	36.300	36.314	36.328	36.341	36.355	36.368	36.382	36.396
2050	36.409	36.423	36.436	36.450	36.463	36.477	36.490	36.504	36.517	36.531
2060	36.544	36.558	36.571	36.585	36.598	56.611	36.625	36.638	36.652	36.665
2070	36.678	36.692	36.705	36.718	36.731	36.745	36.758	36.771	36.784	36.798
2080	36.811	36.824	36.837	36.850	36.864	36.877	36.890	36.903	36.916	36.299
2090	36.942	36.955	36.969	36.982	36.995	37.008	37.021	37.034	37.047	37.060
2100	37.073	37.086	37.099	37.111	37.124	37.137	37.150	37.163	37.176	37.189
2110	37.202	37.214	37.227	37.240	37.253	37.266	37.278	37.291	37.304	37.317
2120	37.329	37.342	37.355	37.367	37.380	37.393	37.405	37.418	37.430	37.443
2130	37.456	37.468	37.481	37.493	37.506	37.518	37.531	37.543	37.556	37.568
2140	37.580	37.593	37.605	37.618	37.630	37.642	37.655	37.667	37.679	37.692
2150	37.704	37.716	37.729	37.741	37.753	37.765	37.777	37.790	37.802	37.814
2160	37.826	37.838	37.850	37.862	37.875	37.887	37.899	37.911	37.923	37.935
2170	37.947	37.959	37.971	37.983	37.995	38.006	38.018	38.030	38.042	38.054
2180	38.066	38.078	38.089	38.101	38.113	38.125	38.137	38.148	38.160	38.172
2190	38.183	38.195	38.207	38.218	38.230	38.242	38.253	38.265	38.276	38.288
2200	38.299	38.311	38.323	38.334	38.345	38.357	38.368	38.380	38.391	38.403
2210	38.414	38.425	38.437	38.448	38.459	38.471	38.482	38.493	38.504	38.515
2220	38.527	38.538	38.549	38.560	38.571	38.582	38.594	38.605	38.616	38.627
2230	38.638	38.649	38.660	38.671	38.682	38.693	38.704	38.715	38.725	38.736
2240	38.747	38.758	38.769	38.780	38.790	38.801	38.812	38.823	38.833	38.844
2250	38.855	38.865	38.876	38.887	38.897	38.907	38.918	38.929	38.940	38.950
2260	38.961	38.971	38.982	38.992	39.002	39.013	39.023	39.034	39.044	39.054
2270	39.065	39.075	39.085	39.095	39.106	39.116	39.126	39.136	39.146	39.157
2280	39.167	39.177	39.187	39.197	39.207	39.217	39.227	39.237	39.247	39.257
2290	39.267	39.277	39.287	39.296	39.306	39.316	39.326	39.336	39.345	39.355
2300	39.365	39.375	39.384	39.394	39.404	39.413	39.423	39.432	39.442	39.452
2310	39.461	39.471	39.480	39.490	39.499	39.508				

Coefficients used to compute the above reference table

$E = C_0 + C_n T^n$

For 0°C to 783°C		
C_0	=	0.000 000 0
C_1	=	$9.952\,192\,9 \times 10^{-3}$
C_2	=	$2.006\,837\,1 \times 10^{-5}$
C_3	=	$-1.376\,612\,1 \times 10^{-8}$
C_4	=	$-1.162\,054\,2 \times 10^{-11}$
C_5	=	$3.987\,530\,0 \times 10^{-14}$
C_6	=	$-4.242\,975\,7 \times 10^{-17}$
C_7	=	$1.682\,122\,5 \times 10^{-2}$

For 783°C to 2315°C		
C_0	=	2.209 735 4
C_1	=	$-1.450\,061\,2 \times 10^{-3}$
C_2	=	$4.289\,823\,4 \times 10^{-5}$
C_3	=	$-4.281\,640\,9 \times 10^{-8}$
C_4	=	$2.413\,260\,9 \times 10^{-11}$
C_5	=	$-8.188\,554\,1 \times 10^{-15}$
C_6	=	$1.587\,320\,9 \times 10^{-18}$
C_7	=	$-1.432\,097\,5 \times 10^{-22}$

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Reference table – W 5 Re vs. W 26 Re thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
0	0.000	0.013	0.027	0.040	0.054	0.067	0.081	0.094	0.108	0.122
10	0.135	0.149	0.163	0.176	0.190	0.204	0.218	0.231	0.245	0.259
20	0.273	0.287	0.301	0.315	0.329	0.342	0.356	0.370	0.385	0.399
30	0.413	0.427	0.441	0.455	0.469	0.483	0.498	0.512	0.526	0.540
40	0.555	0.569	0.583	0.598	0.612	0.627	0.641	0.656	0.670	0.685
50	0.699	0.714	0.728	0.743	0.757	0.772	0.787	0.801	0.816	0.831
60	0.846	0.860	0.875	0.890	0.905	0.920	0.934	0.949	0.964	0.979
70	0.994	1.009	1.024	1.039	1.054	1.069	1.084	1.099	1.114	1.129
80	1.145	1.160	1.175	1.190	1.205	1.221	1.236	1.251	1.266	1.282
90	1.297	1.312	1.328	1.343	1.359	1.374	1.389	1.405	1.420	1.436
100	1.451	1.467	1.483	1.498	1.514	1.529	1.545	1.561	1.576	1.592
110	1.608	1.624	1.639	1.655	1.671	1.687	1.702	1.718	1.734	1.750
120	1.766	1.782	1.798	1.814	1.830	1.846	1.862	1.878	1.894	1.910
130	1.926	1.942	1.958	1.974	1.990	2.006	2.023	2.039	2.055	2.071
140	2.087	2.104	2.120	2.136	2.152	2.169	2.185	2.201	2.218	2.234
150	2.251	2.267	2.283	2.300	2.316	2.333	2.349	2.366	2.382	2.399
160	2.415	2.432	2.449	2.465	2.482	2.498	2.515	2.532	2.548	2.565
170	2.582	2.599	2.615	2.632	2.649	2.666	2.682	2.699	2.716	2.733
180	2.750	2.767	2.784	2.800	2.817	2.834	2.851	2.868	2.885	2.902
190	2.919	2.936	2.953	2.970	2.987	3.004	3.021	3.039	3.056	3.073
200	3.090	3.107	3.124	3.141	3.159	3.176	3.193	3.210	3.228	3.245
210	3.262	3.279	3.297	3.314	3.331	3.349	3.366	3.383	3.401	3.418
220	3.436	3.453	3.470	3.488	3.505	3.523	3.540	3.558	3.575	3.593
230	3.610	3.628	3.645	3.663	3.680	3.698	3.716	3.733	3.751	3.768
240	3.786	3.804	3.821	3.839	3.857	3.875	3.892	3.910	3.928	3.945
250	3.963	3.981	3.999	4.017	4.034	4.052	4.070	4.088	4.106	4.124
260	4.141	4.159	4.177	4.195	4.213	4.231	4.249	4.267	4.285	4.303
270	4.321	4.339	4.357	4.375	4.393	4.411	4.429	4.447	4.467	4.483
280	4.501	4.519	4.537	4.555	4.573	4.592	4.610	4.628	4.646	4.664
290	4.682	4.701	4.719	4.737	4.755	4.773	4.792	4.810	4.828	4.846
300	4.865	4.883	4.901	4.920	4.938	4.956	4.974	4.993	5.011	5.030
310	5.048	5.066	5.085	5.103	5.121	5.140	5.158	5.177	5.195	5.214
320	5.232	5.250	5.269	5.287	5.306	5.324	5.343	5.361	5.380	5.398
330	5.417	5.435	5.454	5.473	5.491	5.510	5.528	5.547	5.565	5.584
340	5.603	5.621	5.640	5.658	5.677	5.696	5.714	5.733	5.752	5.770
350	5.789	5.808	5.827	5.845	5.864	5.883	5.901	5.920	5.939	5.958
360	5.976	5.995	6.014	6.033	6.051	6.070	6.089	6.108	6.127	6.145
370	6.164	6.183	6.202	6.221	6.240	6.259	6.277	6.296	6.315	6.334
380	6.353	6.372	6.391	6.410	6.429	6.447	6.466	6.485	6.504	6.523
390	6.542	6.561	6.580	6.599	6.618	6.637	6.656	6.675	6.694	6.713
400	6.732	6.751	6.770	6.789	6.808	6.827	6.846	6.865	6.884	6.903
410	6.922	6.941	6.961	6.980	6.999	7.018	7.037	7.056	7.075	7.094
420	7.113	7.132	7.152	7.171	7.190	7.209	7.228	7.247	7.267	7.286
430	7.305	7.324	7.343	7.362	7.382	7.401	7.420	7.439	7.458	7.478
440	7.497	7.516	7.535	7.554	7.594	7.593	7.612	7.631	7.651	7.670
450	7.689	7.708	7.728	7.747	7.766	7.786	7.805	7.824	7.843	7.863
460	7.882	7.901	7.921	7.940	7.959	7.979	7.998	8.017	8.037	8.056
470	8.075	8.095	8.114	8.133	8.153	8.172	8.191	8.211	8.230	8.249
480	8.269	8.288	8.308	8.327	8.346	8.366	8.385	8.404	8.424	8.443
490	8.463	8.482	8.502	8.521	8.540	8.560	8.579	8.599	8.618	8.637
500	8.657	8.676	8.696	8.715	8.735	8.754	8.774	8.793	8.812	8.832
510	8.851	8.871	8.890	8.910	8.929	8.949	8.968	8.988	9.007	9.027
520	9.046	9.066	9.085	9.105	9.124	9.144	9.163	9.183	9.202	9.222
530	9.241	9.261	9.280	9.300	9.319	9.339	9.358	9.378	9.397	9.417
540	9.436	9.456	9.475	9.495	9.514	9.534	9.553	9.573	9.592	9.612
550	9.631	9.651	9.670	9.690	9.710	9.729	9.749	9.768	9.788	9.807
560	9.827	9.846	9.866	9.885	9.905	9.925	9.944	9.964	9.983	10.003
570	10.022	10.042	10.061	10.081	10.100	10.120	10.140	10.159	10.179	10.198
580	10.218	10.237	10.257	10.276	10.296	10.316	10.335	10.355	10.374	10.394
590	10.413	10.433	10.452	10.472	10.491	10.511	10.531	10.550	10.570	10.589
600	10.609	10.628	10.648	10.667	10.687	10.706	10.726	10.746	10.765	10.785
610	10.804	10.824	10.843	10.863	10.882	10.902	10.921	10.941	10.960	10.980
620	10.999	11.019	11.038	11.058	11.077	11.097	11.117	11.136	11.156	11.175
630	11.195	11.214	11.234	11.253	11.273	11.292	11.312	11.331	11.351	11.370
640	11.390	11.409	11.429	11.448	11.468	11.487	11.507	11.526	11.546	11.565

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Reference table – W 5 Re vs. W 26 Re thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
650	11.585	11.604	11.624	11.643	11.663	11.682	11.702	11.721	11.741	11.760
660	11.780	11.799	11.818	11.838	11.857	11.877	11.896	11.916	11.935	11.974
670	11.974	11.994	12.013	12.033	12.052	12.072	12.091	12.111	12.130	12.150
680	12.169	12.189	12.208	12.228	12.247	12.267	12.286	12.306	12.325	12.344
690	12.364	12.383	12.403	12.422	12.442	12.461	12.481	12.500	12.520	12.539
700	12.559	12.578	12.597	12.617	12.636	12.656	12.675	12.695	12.714	12.734
710	12.753	12.772	12.792	12.811	12.831	12.850	12.870	12.889	12.908	12.928
720	12.947	12.967	12.986	13.006	13.025	13.044	13.064	13.083	13.103	13.122
730	13.141	13.161	13.180	13.200	13.219	13.238	13.258	13.277	13.297	13.316
740	13.335	13.355	13.374	13.393	13.413	13.432	13.452	13.471	13.490	13.510
750	13.529	13.548	13.568	13.587	13.606	13.626	13.645	13.665	13.684	13.703
760	13.723	13.742	13.761	13.781	13.800	13.819	13.839	13.858	13.877	13.896
770	13.916	13.935	13.954	13.974	13.993	14.012	14.032	14.051	14.070	14.089
780	14.109	14.128	14.147	14.167	14.186	14.205	14.224	14.244	14.263	14.282
790	14.301	14.321	14.340	14.359	14.378	14.398	14.417	14.436	14.455	14.475
800	14.494	14.513	14.532	14.551	14.571	14.590	14.609	14.628	14.647	14.667
810	14.686	14.706	14.724	14.743	14.763	14.782	14.801	14.820	14.839	14.858
820	14.878	14.897	14.916	14.935	14.954	14.973	14.993	15.012	15.031	15.050
830	15.069	15.088	15.107	15.126	15.146	15.165	15.184	15.203	15.222	15.241
840	15.260	15.279	15.298	15.317	15.336	15.356	15.375	15.394	15.413	15.432
850	15.451	15.470	15.489	15.508	15.527	15.546	15.565	15.584	15.603	15.622
860	15.641	15.660	15.679	15.698	15.717	15.736	15.755	15.774	15.793	15.812
870	15.831	15.850	15.869	15.888	15.907	15.926	15.945	15.964	15.983	16.002
880	16.021	16.040	16.058	16.077	16.096	16.115	16.134	16.153	16.172	16.191
890	16.210	16.229	16.248	16.266	16.285	16.304	16.323	16.342	16.361	16.380
900	16.398	16.417	16.436	16.455	16.474	16.493	16.511	16.530	16.549	16.568
910	16.587	16.606	16.624	16.643	16.662	16.681	16.699	16.718	16.737	16.756
920	16.775	16.793	16.812	16.831	16.850	16.868	16.887	16.906	16.924	16.943
930	16.962	16.981	16.999	17.018	17.037	17.055	17.074	17.093	17.111	17.130
940	17.149	17.167	17.186	17.205	17.223	17.242	17.261	17.279	17.298	17.317
950	17.335	17.354	17.373	17.391	17.410	17.428	17.447	17.465	17.484	17.503
960	17.521	17.540	17.558	17.577	17.595	17.614	17.633	17.651	17.670	17.688
970	17.707	17.725	17.744	17.762	17.781	17.799	17.818	17.836	17.855	17.873
980	17.892	17.910	17.929	17.947	17.966	17.984	18.002	18.021	18.039	18.058
990	18.076	18.095	18.113	18.131	18.150	18.168	18.187	18.205	18.223	18.242
1000	18.260	18.279	18.297	18.315	18.334	18.352	18.370	18.389	18.407	18.425
1010	18.444	18.462	18.480	18.499	18.517	18.535	18.553	18.572	18.590	18.608
1020	18.627	18.645	18.663	18.681	18.700	18.718	18.736	18.754	18.773	18.791
1030	18.809	18.827	18.845	18.864	18.882	18.900	18.918	18.936	18.955	18.973
1040	18.991	19.009	19.027	19.045	19.064	19.082	19.100	19.118	19.136	19.154
1050	19.172	19.190	19.208	19.227	19.245	19.263	19.281	19.299	19.317	19.335
1060	19.353	19.371	19.389	19.407	19.425	19.443	19.461	19.479	19.497	19.515
1070	19.533	19.551	19.569	19.587	19.605	19.623	19.641	19.659	19.677	19.695
1080	19.713	19.731	19.749	19.767	19.785	19.803	19.821	19.839	19.856	19.874
1090	19.892	19.910	19.928	19.946	19.964	19.982	19.999	20.017	20.035	20.053
1100	20.071	20.089	20.106	20.124	20.142	20.160	20.178	20.195	20.213	20.231
1110	20.249	20.267	20.284	20.302	20.320	20.338	20.355	20.373	20.391	20.409
1120	20.426	20.444	20.462	20.479	20.497	20.515	20.532	20.550	20.568	20.585
1130	20.603	20.621	20.638	20.656	20.674	20.691	20.709	20.727	20.744	20.762
1140	20.779	20.797	20.815	20.832	20.850	20.867	20.885	20.902	20.920	20.938
1150	20.955	20.973	20.990	21.008	21.025	21.043	21.060	21.078	21.095	21.113
1160	21.130	21.148	21.165	21.183	21.200	21.218	21.235	21.253	21.270	21.287
1170	21.305	21.322	21.340	21.357	21.375	21.392	21.409	21.427	21.444	21.461
1180	21.479	21.496	21.514	21.531	21.548	21.566	21.583	21.600	21.618	21.635
1190	21.652	21.670	21.687	21.704	21.721	21.739	21.756	21.773	21.790	21.808
1200	21.825	21.842	21.859	21.877	21.894	21.911	21.928	21.946	21.963	21.980
1210	21.997	22.014	22.032	22.049	22.066	22.083	22.100	22.117	22.135	22.152
1220	22.169	22.186	22.203	22.220	22.237	22.254	22.271	22.289	22.306	22.323
1230	22.340	22.357	22.374	22.391	22.408	22.425	22.442	22.459	22.476	22.493
1240	22.510	22.527	22.544	22.561	22.578	22.595	22.612	22.629	22.646	22.633
1250	22.680	22.697	22.714	22.731	22.748	22.765	22.782	22.799	22.815	22.832
1260	22.849	22.866	22.883	22.900	22.917	22.934	22.950	22.967	22.984	23.001
1270	23.018	23.035	23.052	23.068	23.085	23.102	23.119	23.136	23.152	23.169
1280	23.186	23.203	23.219	23.236	23.253	23.270	23.286	23.303	23.320	23.337
1290	23.353	23.370	23.387	23.403	23.420	23.437	23.453	23.470	23.487	23.503

BASF
The Chemical Company

Reference table – W 5 Re vs. W 26 Re thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1300	23.520	23.537	23.553	23.570	23.587	23.603	23.620	23.636	23.653	23.670
1310	23.686	23.703	23.719	23.736	23.753	23.769	23.786	23.802	23.819	23.835
1320	23.852	23.868	23.885	23.901	23.918	23.934	23.951	23.967	23.984	24.000
1330	24.017	24.033	24.050	24.066	24.083	24.099	24.116	24.132	24.148	24.165
1340	24.181	24.198	24.214	24.230	24.247	24.263	24.280	24.296	24.312	24.329
1350	24.345	24.361	24.378	24.394	24.410	24.427	24.443	24.459	24.476	24.492
1360	24.508	24.524	24.541	24.557	24.573	24.590	24.606	24.622	24.638	24.655
1370	24.671	24.687	24.703	24.719	24.736	24.752	24.768	24.784	24.800	24.817
1380	24.833	24.849	24.865	24.881	24.897	24.913	24.930	24.946	24.962	24.978
1390	24.994	25.010	25.026	25.042	25.058	25.075	25.091	25.107	25.123	25.139
1400	25.155	25.171	25.187	25.203	25.219	25.235	25.251	25.267	25.283	25.299
1410	25.315	25.331	25.347	25.363	25.379	25.395	25.411	25.427	25.443	25.459
1420	25.475	25.490	25.506	25.522	25.538	25.554	25.570	25.586	25.602	25.618
1430	25.633	25.649	25.665	25.681	25.697	25.713	25.729	25.744	25.760	25.776
1440	25.792	25.808	25.823	25.839	25.855	25.871	25.886	25.902	25.918	25.934
1450	25.949	25.965	25.981	25.997	26.012	26.028	26.044	26.060	26.075	26.091
1460	26.107	26.122	26.138	26.154	26.169	16.185	26.201	26.216	26.232	26.248
1470	26.263	26.279	26.294	26.310	26.326	26.341	26.357	26.372	26.388	26.403
1480	26.419	26.435	26.450	26.466	26.481	26.497	26.512	26.528	26.543	26.559
1490	26.574	26.590	26.605	26.621	26.636	26.652	26.667	26.683	26.698	26.714
1500	26.729	26.744	26.760	26.775	26.791	26.806	26.822	26.837	26.852	26.868
1510	26.883	26.899	26.914	26.929	26.945	26.960	26.975	26.991	27.006	27.021
1520	27.037	27.052	27.067	27.083	27.098	27.113	27.128	27.144	27.159	27.174
1530	27.190	27.205	27.220	27.235	27.250	27.266	27.281	27.296	27.311	27.327
1540	27.342	27.357	27.372	27.387	27.403	27.418	27.433	27.448	27.463	27.478
1550	27.493	27.509	27.524	27.539	27.554	27.569	27.584	27.599	27.614	27.629
1560	27.645	27.660	27.675	27.690	27.705	27.720	27.735	27.750	27.765	27.780
1570	27.795	27.810	27.825	27.840	27.855	27.870	27.885	27.900	27.915	27.930
1580	27.945	27.960	27.975	27.990	28.005	28.020	28.034	28.049	28.064	28.079
1590	28.094	28.109	28.124	28.139	28.154	28.169	28.183	28.198	28.213	28.228
1600	28.243	28.258	28.272	28.287	28.302	28.317	28.332	28.346	28.361	28.376
1610	28.391	28.406	28.420	28.435	28.450	28.465	28.479	28.494	28.509	28.524
1620	28.538	28.553	28.568	28.582	28.597	28.612	28.626	28.641	28.656	28.670
1630	28.685	28.700	28.714	28.729	28.744	28.758	28.773	28.787	28.802	28.817
1640	28.831	28.846	28.860	28.875	28.890	28.904	28.919	28.933	28.948	28.962
1650	28.977	28.991	29.006	29.020	29.035	29.049	29.064	29.078	29.093	29.107
1660	29.122	29.136	29.151	29.165	29.180	29.194	29.209	29.223	29.237	29.252
1670	29.266	29.281	29.295	29.309	29.324	29.338	29.353	29.367	29.381	29.396
1680	29.410	29.424	29.439	29.453	29.467	29.482	29.496	29.510	29.525	29.539
1690	29.553	29.567	29.582	29.596	29.610	29.625	29.639	29.653	29.667	29.681
1700	29.696	29.710	29.724	29.738	29.753	29.767	29.781	29.795	29.809	29.823
1710	29.838	29.852	29.866	29.880	29.894	29.908	29.922	29.937	29.951	29.965
1720	29.979	29.993	30.007	30.021	30.035	30.049	30.063	30.077	30.091	30.106
1730	30.120	30.134	30.148	30.162	30.176	30.190	30.204	30.218	30.232	30.246
1740	30.260	30.274	30.288	30.302	30.315	30.329	30.343	30.357	30.371	30.385
1750	30.399	30.413	30.427	30.441	30.455	30.469	30.482	30.496	30.510	30.524
1760	30.538	30.552	30.565	30.579	30.593	30.607	30.621	30.635	30.648	30.662
1770	30.676	30.690	30.704	30.717	30.731	30.745	30.759	30.772	30.786	30.800
1780	30.813	30.827	30.841	30.855	30.868	30.882	30.896	30.909	30.923	30.937
1790	30.950	30.964	30.978	30.991	31.005	31.019	31.032	31.046	31.059	31.073
1800	31.087	31.100	31.114	31.127	31.141	31.154	31.168	31.182	31.195	31.209
1810	31.222	31.236	31.249	31.263	31.276	31.290	31.303	31.317	31.330	31.344
1820	31.357	31.371	31.384	31.397	31.411	31.424	31.438	31.451	31.465	31.478
1830	31.491	31.505	31.518	31.532	31.545	31.558	31.572	31.585	31.598	31.612
1840	31.625	31.638	31.652	31.665	31.678	31.692	31.705	31.718	31.731	31.745
1850	31.758	31.771	31.784	31.798	31.811	31.824	31.837	31.851	31.864	31.877
1860	31.890	31.903	31.917	31.930	31.943	31.956	31.969	31.982	31.996	32.009
1870	32.022	32.035	32.048	32.061	32.074	32.087	32.101	32.114	32.127	32.140
1880	32.153	32.166	32.179	32.192	32.205	32.218	32.231	32.244	32.257	32.270
1890	32.283	32.296	32.309	32.322	32.335	32.348	32.361	32.374	32.387	32.400
1900	32.413	32.426	32.439	32.451	32.464	32.477	32.490	32.503	32.516	32.529
1910	32.542	32.554	32.567	32.580	32.593	32.606	32.619	32.631	32.644	32.657
1920	32.670	32.683	32.695	32.708	32.721	32.734	32.746	32.759	32.772	32.784
1930	32.797	32.810	32.823	32.835	32.848	32.861	32.873	32.886	32.899	32.911
1940	32.924	32.937	32.949	32.962	32.974	32.987	33.000	33.012	33.025	33.037

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Reference table – W 5 Re vs. W 26 Re thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1950	33.050	33.063	33.075	33.088	33.100	33.113	33.125	33.138	33.150	33.163
1960	33.175	33.188	33.200	33.213	33.225	33.238	33.250	33.263	33.275	33.287
1970	33.300	33.312	33.325	33.337	33.350	33.362	33.374	33.387	33.399	33.411
1980	33.424	33.436	33.448	33.461	33.473	33.485	33.498	33.510	33.522	33.535
1990	33.547	33.559	33.571	33.584	33.596	33.608	33.620	33.632	33.645	33.657
2000	33.669	33.681	33.693	33.706	33.718	33.730	33.742	33.754	33.766	33.779
2010	33.791	33.803	33.815	33.827	33.839	33.851	33.863	33.875	33.887	33.899
2020	33.911	33.923	33.936	33.948	33.960	33.972	33.984	33.996	34.008	34.019
2030	34.031	34.043	34.055	34.067	34.079	34.091	34.103	34.115	34.127	34.139
2040	34.151	34.163	34.174	34.186	34.198	34.210	34.222	34.234	34.245	34.257
2050	34.269	34.281	34.293	34.304	34.316	34.328	34.340	34.351	34.363	34.375
2060	34.387	34.398	34.410	34.422	34.433	34.445	34.457	34.468	34.480	34.492
2070	34.503	34.515	34.527	34.538	34.550	34.561	34.573	34.585	34.596	34.608
2080	34.619	34.631	34.642	34.654	34.665	34.677	34.688	34.700	34.711	34.723
2090	34.734	34.746	34.757	34.769	34.780	34.792	34.803	34.814	34.826	34.837
2100	34.849	34.860	34.871	34.883	34.894	34.905	34.917	34.928	34.939	34.951
2110	34.962	34.973	34.984	34.996	35.007	35.018	35.029	35.041	35.052	35.063
2120	35.074	35.085	35.097	35.108	35.119	35.130	35.141	35.152	35.164	35.175
2130	35.186	35.197	35.208	35.219	35.230	35.241	35.252	35.263	35.274	35.285
2140	35.296	35.307	35.318	35.329	35.340	35.351	35.362	35.373	35.384	35.395
2150	35.406	35.417	35.428	35.439	35.450	35.461	35.472	35.482	35.493	35.504
2160	35.515	35.526	35.537	35.547	35.558	35.569	35.580	35.591	35.601	35.612
2170	35.623	35.634	35.644	35.655	35.666	35.676	35.687	35.698	35.708	35.719
2180	35.730	35.740	35.751	35.762	35.772	35.783	35.793	35.804	35.814	35.825
2190	35.836	35.846	35.857	35.867	35.878	35.888	35.899	35.909	35.920	35.930
2200	35.940	35.951	35.961	35.972	35.982	35.993	36.003	36.013	36.024	36.034
2210	36.044	36.055	36.065	36.075	36.086	36.096	36.106	36.116	36.127	36.137
2220	36.147	36.157	36.168	36.178	36.188	36.198	36.208	36.219	36.229	36.239
2230	36.249	36.259	36.269	36.279	36.289	36.300	36.310	36.320	36.330	36.340
2240	36.350	36.360	36.370	36.380	36.390	36.400	36.410	36.420	36.430	36.440
2250	36.449	36.459	36.469	36.479	36.489	36.499	36.509	36.519	36.528	36.538
2260	36.548	36.558	36.568	36.577	36.587	36.597	36.607	36.616	36.626	36.636
2270	36.645	36.655	36.665	36.675	36.684	36.694	36.703	36.713	36.723	36.732
2280	36.742	36.751	36.761	36.771	36.780	36.790	36.799	36.809	36.818	36.828
2290	36.837	36.846	36.856	36.865	36.875	36.884	36.894	36.903	36.912	36.922
2300	36.931	36.940	36.950	36.959	36.968	36.978	36.987	36.996	37.005	37.015
2310	37.024	37.033	37.042	37.051	37.061	37.070				

Coefficients used to compute the above reference table

$E = C_0 + C_n T^n$

For 0°C to 783°C		
C_0	=	0.000 000 0
C_1	=	$1.340\,603\,2 \times 10^{-02}$
C_2	=	$1.192\,499\,2 \times 10^{-05}$
C_3	=	$-7.980\,635\,4 \times 10^{-09}$
C_4	=	$-5.078\,751\,5 \times 10^{-12}$
C_5	=	$1.316\,419\,7 \times 10^{-14}$
C_6	=	$-7.919\,733\,2 \times 10^{-18}$

For 783°C to 2315°C		
C_0	=	$4.052\,882\,3 \times 10^{01}$
C_1	=	$1.150\,935\,5 \times 10^{-02}$
C_2	=	$1.569\,645\,3 \times 10^{-05}$
C_3	=	$-1.370\,441\,2 \times 100^{-8}$
C_4	=	$5.229\,087\,3 \times 10^{-12}$
C_5	=	$-9.208\,275\,8 \times 10^{-16}$
C_6	=	$4.524\,511\,2 \times 10^{-20}$

Introduction

Iridium and Iridium Rhodium alloys play an important part in high temperature measurement and control. While of comparatively modest use, sufficient continuous demand exists for this material in highly stressed operating conditions. This system is the only thermo-couple combination that can be used in oxidizing environments up to 2000°C for short periods of time. Successful service has been in such diverse applications as crystal growth, jet engine combustor exhaust experimentation and rocket nozzle design and development.

Traditional usage has standardized upon the Ir vs. Ir 40 Rh combination delegating all previous combinations to obsolescence.

Compensating lead wire

No standard lead wire exists for the Ir - Ir 40 Rh combination. Various laboratory users have reported use of Cu vs. Type 347SS, or Type 304SS; and Cu vs. Aluminum. In all cases, individual lot calibration curves were required to further compensate for the deviations that existed. The recommended practice is to use Cu vs. Cu and insure that the junction point be maintained at a steady temperature and a first order correction be applied for the amount that this temperature deviates from 0°C.

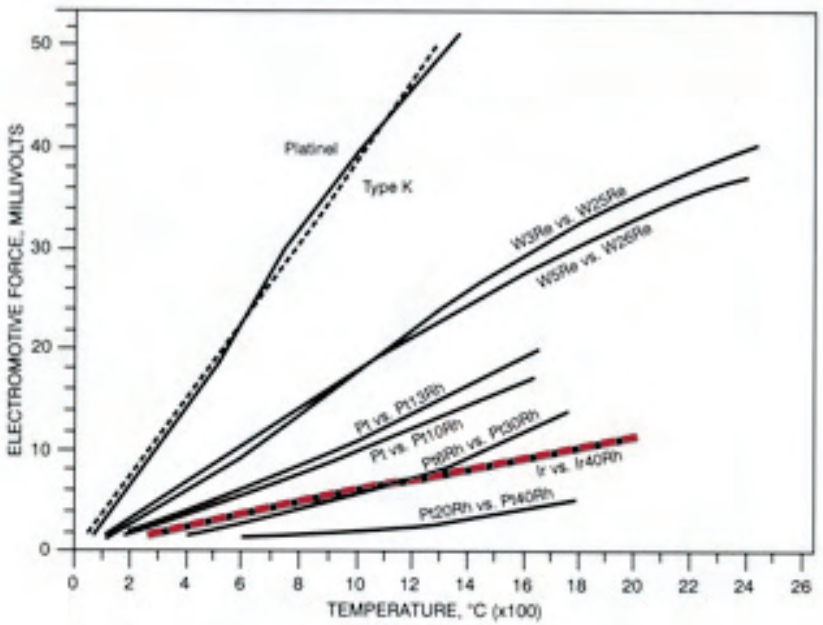
Tolerance

Due to the limited demand for the Ir vs. Ir 40 Rh combination, manufacture to a specific tolerance is not feasible. A batch calibration is provided with each lot at no additional charge for use with the appended reference tables.

Stocking policy

Small quantities of matched pairs of Ir vs. Ir 40 Rh wire at .020 inch diameter are generally in stock but are subject to prior demand and long replacement lead times.

Comparative emf vs. temperature relationship of common thermocouple materials indicates the relative positive of the Ir vs. Ir 40 Rh combination



Melting point	
Ir	2447°C
Ir 40 Rh	2290°C

Density	(gm/cm³)	troy oz/in³
Ir	22.54	11.87
Ir 40 Rh	15.15	7.98

Polarity	
Ir	–
Ir 40 Rh	+

Electrical resistivity for Ir & Ir 40 Rh thermocouple wire

Temp	microhm-cm		ohm (cir-mil) ft	
Celsius	Ir	Ir 40 Rh	Ir	Ir 40 Rh
0	4.62	10.24	27.81	61.64
100	6.46	12.28	38.89	73.93
200	8.30	14.39	49.97	86.63
300	10.15	16.56	61.10	99.69
400	12.01	18.82	72.30	113.30
500	14.02	21.16	84.40	127.38
600	16.10	23.56	96.92	141.83
700	18.22	26.00	109.68	156.52
800	20.38	28.54	122.69	171.81
900	22.60	31.18	136.05	187.70
1000	25.03	33.97	150.68	204.50
1100	27.49	36.85	165.49	221.84
1200	30.00	39.73	180.60	239.17
1300	32.53	42.62	195.83	256.57
1400	35.05	45.50	211.00	273.91
1500	37.57	48.38	226.17	291.25
1600	40.09	51.26	241.34	308.59
1700	42.09	54.15	253.38	325.98
1800	45.12	57.03	271.62	343.32
1900	47.64	59.16	286.79	356.14
2000	50.16	62.80	301.96	378.06
2100	52.68	65.68	317.13	395.39
2200	55.20	68.57	332.30	412.79
2300	57.72	71.45	347.47	430.13

Resistance for select wire diameters

Ohms/ft

Diameter (inch)	Ir	Ir 40 Rh
0.005	1.280	1.344
0.006	0.889	0.933
0.007	0.653	0.686
0.008	0.500	0.525
0.009	0.395	0.415
0.010	0.320	0.336
0.012	0.222	0.233
0.014	0.163	0.171
0.016	0.125	0.131
0.018	0.099	0.104
0.020	0.080	0.084
0.024	0.056	0.058
0.028	0.041	0.043
0.030	0.036	0.037

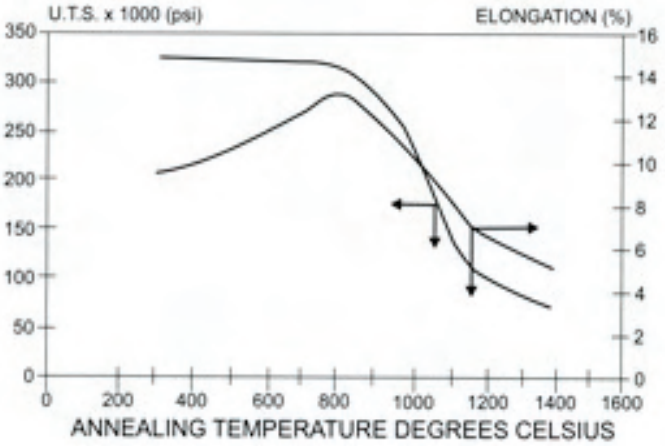
Weight table

(troy oz/ft)

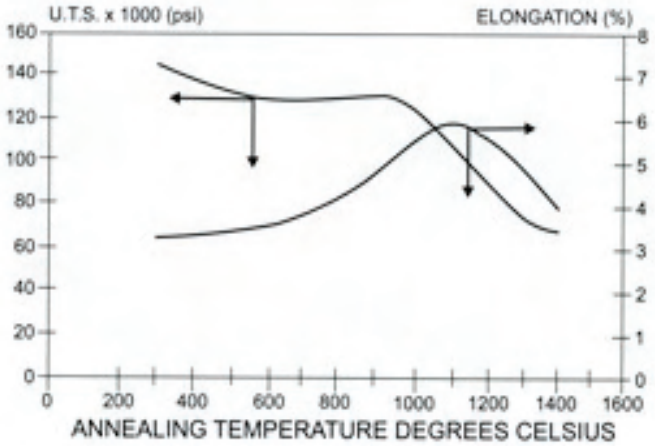
Diameter (inch)	Ir	Ir 40 Rh
0.005	0.002810	0.002102
0.006	0.004046	0.003027
0.007	0.005508	0.004121
0.008	0.007194	0.005382
0.009	0.009104	0.006811
0.010	0.011245	0.008414
0.011	0.013600	0.010175
0.012	0.016187	0.012111
0.013	0.018996	0.014212
0.014	0.022026	0.016479
0.015	0.025289	0.018921
0.016	0.028773	0.021528
0.017	0.032479	0.024300
0.018	0.036418	0.027247
0.019	0.040578	0.030360
0.020	0.044960	0.033638
0.021	0.049564	0.037083
0.022	0.054400	0.040701
0.023	0.059458	0.044485
0.024	0.064748	0.048443
0.025	0.070249	0.052559
0.026	0.075983	0.056858
0.027	0.081938	0.061304
0.028	0.088125	0.065933
0.029	0.094524	0.070721
0.030	0.101166	0.075690
0.031	0.108019	0.080817
0.032	0.115093	0.086110

Room temperature tensile data

Ir T/C wire



Ir 40 Rh T/C wire



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Reference table – Ir vs. Ir 40 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
0	0.000	0.003	0.006	0.009	0.012	0.016	0.019	0.022	0.025	0.028
10	0.032	0.035	0.038	0.041	0.045	0.048	0.051	0.054	0.058	0.061
20	0.064	0.068	0.071	0.075	0.078	0.081	0.085	0.088	0.092	0.095
30	0.099	0.102	0.106	0.109	0.113	0.116	0.120	0.123	0.127	0.131
40	0.134	0.138	0.141	0.145	0.149	0.152	0.156	0.160	0.163	0.167
50	0.171	0.175	0.178	0.182	0.186	0.190	0.193	0.197	0.201	0.205
60	0.209	0.212	0.216	0.220	0.224	0.228	0.232	0.236	0.240	0.244
70	0.248	0.252	0.256	0.260	0.264	0.268	0.272	0.276	0.280	0.284
80	0.288	0.292	0.296	0.300	0.304	0.308	0.312	0.316	0.320	0.325
90	0.329	0.333	0.337	0.341	0.346	0.350	0.354	0.358	0.362	0.367
100	0.371	0.375	0.379	0.384	0.388	0.392	0.397	0.401	0.405	0.410
110	0.414	0.418	0.423	0.427	0.432	0.436	0.440	0.445	0.449	0.454
120	0.458	0.463	0.467	0.471	0.476	0.480	0.485	0.489	0494	0.499
130	0.503	0.508	0.512	0.517	0.521	0.526	0.530	0.535	0.540	0.544
140	0.549	0.554	0.558	0.563	0.567	0.572	0.577	0.582	0.586	0.591
150	0.596	0.600	0.605	0.610	0.615	0.619	0.624	0.629	0.634	0.638
160	0.643	0.648	0.653	0.658	0.662	0.667	0.672	0.677	0.682	0.687
170	0.691	0.696	0.701	0.706	0.711	0.716	0.721	0.726	0.731	0.736
180	0.741	0.746	0.750	0.755	0.760	0.765	0.770	0.775	0.780	0.785
190	0.790	0.795	0.800	0.805	0.811	0.816	0.821	0.826	0.831	0.836
200	0.841	0.846	0.851	0.856	0.861	0.866	0.872	0.877	0.882	0.887
210	0.892	0.897	0.903	0.908	0.913	0.918	0.923	0.928	0.934	0.939
220	0.944	0.949	0.955	0.960	0.965	0.970	0.976	0.981	0.986	0.991
230	0.977	1.002	1.007	1.012	1.018	1.023	1.028	1.034	1.039	1.044
240	1.050	1.055	1.060	1.066	1.071	1.077	1.082	1.087	1.093	1.098
250	1.103	1.109	1.114	1.120	1.125	1.130	1.136	1.141	1.147	1.152
260	1.158	1.163	1.169	1.174	1.180	1.185	1.190	1.196	1.201	1.207
270	1.212	1.218	1.223	1.229	1.234	1.240	1.246	1.251	1.257	1.262
280	1.268	1.273	1.279	1.284	1.290	1.296	1.301	1.307	1.312	1.318
290	1.323	1.329	1.335	1.340	1.346	1.351	1.357	1.363	1.368	1.374
300	1.380	1.385	1.391	1.397	1.402	1.408	1.414	1.419	1.425	1.431
310	1.436	1.442	1.448	1.453	1.459	1.465	1.470	1.476	1.482	1.488
320	1.493	1.499	1.505	1.510	1.516	1.522	1.528	1.533	1.539	1.545
330	1.551	1.556	1.562	1.568	1.574	1.579	1.585	1.591	1.597	1.603
340	1.608	1.614	1.620	1.626	1.631	1.637	1.643	1.649	1.655	1.661
350	1.666	1.672	1.678	1.684	1.690	1.695	1.701	1.707	1.713	1.719
360	1.725	1.731	1.736	1.742	1.748	1.754	1.760	1.766	1.772	1.777
370	1.783	1.789	1.795	1.801	1.807	1.813	1.819	1.824	1.830	1.836
380	1.842	1.848	1.854	1.860	1.866	1.872	1.878	1.883	1.889	1.895
390	1.901	1.907	1.913	1.919	1.925	1.931	1.937	1.943	1.949	1.955
400	1.961	1.966	1.972	1.978	1.984	1.990	1.996	2.002	2.008	2.014
410	2.020	2.026	2.032	2.038	2.044	2.050	2.056	2.062	2.068	2.074
420	2.080	2.086	2.092	2.098	2.104	2.110	2.116	2.122	2.128	2.134
430	2.140	2.146	2.152	2.158	2.164	2.170	2.176	2.182	2.188	2.194
440	2.200	2.206	2.212	2.218	2.224	2.230	2.236	2.242	2.248	2.254
450	2.260	2.266	2.272	2.278	2.284	2.290	2.296	2.302	2.308	2.314
460	2.320	2.326	2.332	2.338	2.344	2.350	2.356	2.362	2.368	2.374
470	2.380	2.386	2.392	2.399	2.405	2.411	2.417	2.423	2.429	2.435
480	2.441	2.447	2.453	2.459	2.465	2.471	2.477	2.483	2.489	2.495
490	2.502	2.508	2.514	2.520	2.526	2.532	2.538	2.544	2.550	2.556
500	2.562	2.568	2.574	2.580	2.587	2.593	2.599	2.605	2.611	2.617
510	2.623	2.629	2.635	2.641	2.647	2.653	2.660	2.666	2.672	2.678
520	2.684	2.690	2.696	2.702	2.708	2.714	2.720	2.727	2.733	2.739
530	2.745	2.751	2.757	2.763	2.769	2.775	2.781	2.788	2.794	2.800
540	2.806	2.812	2.818	2.824	2.830	2.836	2.842	2.849	2.855	2.861
550	2.867	2.873	2.879	2.885	2.891	2.897	2.904	2.910	2.916	2.922
560	2.928	2.934	2.940	2.946	2.952	2.959	2.965	2.971	2.977	2.983
570	2.989	2.995	3.001	3.007	3.014	3.020	3.026	3.032	3.038	3.044
580	3.050	3.056	3.062	3.069	3.075	3.081	3.087	3.093	3.099	3.105
590	3.111	3.117	3.123	3.130	3.136	3.142	3.148	3.154	3.160	3.166
600	3.172	3.178	3.184	3.191	3.197	3.203	3.209	3.215	3.221	3.227
610	3.233	3.239	3.245	3.251	3.257	3.264	3.270	3.276	3.282	3.288
620	3.294	3.300	3.306	3.312	3.318	3.324	3.330	3.336	3.342	3.348
630	3.354	3.360	3.366	3.372	3.378	3.384	3.390	3.396	3.402	3.408
640	3.414	3.420	3.426	3.432	3.438	3.444	3.450	3.456	3.462	3.468

BASF
The Chemical Company

Reference table – Ir vs. Ir 40 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
650	3.474	3.481	3.487	3.493	3.499	3.505	3.511	3.517	3.523	3.528
660	3.534	3.540	3.546	3.552	3.558	3.564	3.570	3.576	3.582	3.588
670	3.594	3.600	3.606	3.612	3.618	3.624	3.630	3.636	3.642	3.648
680	3.654	3.660	3.666	3.672	3.678	3.684	3.90	3.696	3.702	3.708
690	3.714	3.720	3.726	3.732	3.738	3.744	3.750	3.756	3.761	3.767
700	3.773	3.779	3.785	3.791	3.797	3.803	3.809	3.815	3.821	3.827
710	3.833	3.839	3.845	3.851	3.857	3.862	3.868	3.874	3.880	3.886
720	3.892	3.898	3.904	3.910	3.916	3.922	3.928	3.933	3.939	3.945
730	3.951	3.957	3.963	3.969	3.975	3.981	3.987	3.993	3.998	4.004
740	4.010	4.016	4.022	4.028	4.034	4.040	4.046	4.051	4.057	4.063
750	4.069	4.075	4.081	4.087	4.093	4.098	4.104	4.110	4.116	4.122
760	4.128	4.134	4.140	4.145	4.151	4.157	4.163	4.169	4.175	4.181
770	4.186	4.192	4.198	4.204	4.210	4.216	4.221	4.227	4.233	4.239
780	4.245	4.251	4.257	4.262	4.268	4.274	4.280	4.286	4.291	4.297
790	4.303	4.309	4.315	4.321	4.326	4.332	4.338	4.344	4.350	4.355
800	4.361	4.367	4.373	4.379	4.384	4.390	4.396	4.402	4.408	4.413
810	4.419	4.425	4.431	4.437	4.442	4.448	4.454	4.460	4.465	4.471
820	4.477	4.483	4.489	4.494	4.500	4.506	4.512	4.517	4.523	4.529
830	4.535	4.540	4.546	4.552	4.558	4.563	4.569	4.575	4.581	4.586
840	4.592	4.598	4.604	4.609	4.615	4.621	4.627	4.632	4.638	4.644
850	4.649	4.655	4.661	4.667	4.672	4.678	4.684	4.689	4.695	4.701
860	4.707	4.712	4.718	4.724	4.729	4.735	4.741	4.746	4.752	4.758
870	4.764	4.769	4.775	4.781	4.786	4.792	4.798	4.803	4.809	4.815
880	4.820	4.826	4.832	4.837	4.843	4.849	4.854	4.860	4.866	4.871
890	4.877	4.883	4.888	4.894	4.900	4.905	4.911	4.917	4.922	4.928
900	4.933	4.939	4.945	4.950	4.956	4.962	4.967	4.973	4.979	4.984
910	4.990	4.995	5.001	5.007	5.012	5.018	5.024	5.029	5.035	5.040
920	5.046	5.052	5.057	5.063	5.068	5.074	5.080	5.085	5.091	5.096
930	5.102	5.108	5.113	5.119	5.124	5.130	5.135	5.141	5.147	5.152
940	5.158	5.163	5.169	5.174	5.180	5.186	5.191	5.197	5.202	5.208
950	5.213	5.219	5.224	5.230	5.236	5.241	5.247	5.252	5.258	5.263
960	5.269	5.274	5.280	5.285	5.291	5.297	5.302	5.308	5.313	5.319
970	5.324	5.330	5.335	5.341	5.346	5.352	5.357	5.363	5.368	5.374
980	5.379	5.385	5.390	5.396	5.401	5.407	5.412	5.418	5.423	5.429
990	5.434	5.440	5.445	5.451	5.456	5.462	5.467	5.473	5.478	5.484
1000	5.489	5.495	5.500	5.506	5.511	5.516	5.522	5.527	5.533	5.538
1010	5.544	5.549	5.555	5.560	5.566	5.571	5.577	5.582	5.587	5.593
1020	5.598	5.604	5.609	5.615	5.620	5.626	5.631	5.636	5.642	5.647
1030	5.653	5.658	5.664	5.669	5.674	5.680	5.685	5.691	5.696	5.701
1040	5.707	5.712	5.718	5.723	5.729	5.734	5.739	5.745	5.750	5.756
1050	5.761	5.766	5.772	5.777	5.783	5.788	5.793	5.799	5.804	5.809
1060	5.815	5.820	5.826	5.831	5.836	5.842	5.847	5.852	5.858	5.863
1070	5.869	5.874	5.879	5.885	5.890	5.895	5.901	5.906	5.911	5.917
1080	5.922	5.928	5.933	5.938	5.944	5.949	5.954	5.960	5.965	5.970
1090	5.976	5.981	5.986	5.992	5.997	6.002	6.008	6.013	6.018	6.024
1100	6.029	6.034	6.040	6.045	6.050	6.056	6.061	6.066	6.072	6.077
1110	6.082	6.088	6.093	6.098	6.103	6.109	6.114	6.119	6.125	6.130
1120	6.135	6.141	6.146	6.151	6.156	6.162	6.167	6.172	6.178	6.183
1130	6.188	6.193	6.199	6.204	6.209	6.215	6.220	6.225	6.230	6.236
1140	6.241	6.246	6.252	6.257	6.262	6.267	6.273	6.278	6.283	6.288
1150	6.294	6.299	6.304	6.309	6.315	6.320	6.325	6.330	6.336	6.341
1160	6.346	6.351	6.357	6.362	6.367	6.372	6.378	6.383	6.388	6.393
1170	6.399	6.404	6.409	6.414	6.420	6.425	6.430	6.435	6.441	6.446
1180	6.451	6.456	6.461	6.467	6.472	6.477	6.482	6.488	6.493	6.498
1190	6.503	6.508	6.515	6.519	6.524	6.529	6.535	6.540	6.545	6.550
1200	6.555	6.561	6.566	6.571	6.576	6.581	6.587	6.592	6.597	6.602
1210	6.607	6.613	6.618	6.623	6.628	6.633	6.639	6.644	6.649	6.654
1220	6.659	6.664	6.670	6.675	6.680	6.685	6.690	6.696	6.701	6.706
1230	6.711	6.716	6.721	6.727	6.732	6.737	6.742	6.747	6.752	6.758
1240	6.763	6.768	6.773	6.778	6.783	6.789	6.794	6.799	6.804	6.809
1250	6.814	6.820	6.825	6.830	6.835	6.840	6.845	6.851	6.856	6.861
1260	6.866	6.871	6.876	6.881	6.887	6.892	6.897	6.902	6.907	6.912
1270	6.918	6.923	6.928	6.933	6.938	6.943	6.948	6.953	6.959	6.964
1280	6.969	6.974	6.070	6.984	6.989	6.995	7.000	7.005	7.010	7.015
1290	7.020	7.025	7.030	7.036	7.041	7.046	7.051	7.056	7.061	7.066

BASF
The Chemical Company

Reference table – Ir vs. Ir 40 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1300	7.072	7.077	7.082	7.087	7.092	7.097	7.102	7.107	7.112	7.118
1310	7.123	7.128	7.133	7.138	7.143	7.148	7.153	7.159	7.164	7.169
1320	7.174	7.179	7.184	7.189	7.194	7.199	7.205	7.210	7.215	7.220
1330	7.225	7.230	7.235	7.240	7.245	7.250	7.256	7.261	7.266	7.271
1340	7.276	7.281	7.286	7.291	7.296	7.302	7.307	7.312	7.317	7.322
1350	7.327	7.332	7.337	7.342	7.347	7.352	7.358	7.363	7.368	7.373
1360	7.378	7.383	7.388	7.393	7.398	7.403	7.409	7.414	7.419	7.424
1370	7.429	7.434	7.439	7.444	7.449	7.454	7.459	7.465	7.470	7.475
1380	7.480	7.485	7.490	7.495	7.500	7.505	7.510	7.515	7.520	7.526
1390	7.531	7.536	7.541	7.546	7.551	7.556	7.561	7.566	7.571	7.576
1400	7.581	7.587	7.592	7.597	7.602	7.607	7.612	7.617	7.622	7.627
1410	7.632	7.637	7.642	7.648	7.653	7.658	7.663	7.668	7.673	7.678
1420	7.683	7.688	7.693	7.698	7.703	7.709	7.714	7.719	7.724	7.729
1430	7.734	7.739	7.744	7.749	7.754	7.759	7.764	7.769	7.775	7.780
1440	7.785	7.790	7.795	7.800	7.805	7.810	7.815	7.820	7.825	7.830
1450	7.835	7.841	7.846	7.851	7.856	7.861	7.866	7.871	7.876	7.881
1460	7.886	7.891	7.896	7.902	7.907	7.912	7.917	7.922	7.927	7.932
1470	7.937	7.942	7.947	7.952	7.957	7.963	7.968	7.973	7.978	7.983
1480	7.988	7.993	7.998	8.003	8.008	8.013	8.018	8.023	8.029	8.034
1490	8.039	8.044	8.049	8.054	8.059	8.064	8.069	8.074	8.079	8.085
1500	8.090	8.095	8.100	8.105	8.110	8.115	8.120	8.125	8.130	8.135
1510	8.140	8.146	8.151	8.156	8.161	8.166	8.171	8.176	8.181	8.186
1520	8.191	8.196	8.202	8.207	8.212	8.217	8.222	8.227	8.232	8.237
1530	8.242	8.247	8.253	8.258	8.263	8.268	8.273	8.278	8.283	8.288
1540	8.293	8.298	8.304	8.309	8.314	8.319	8.324	8.329	8.334	8.339
1550	8.344	8.349	8.355	8.360	8.365	8.370	8.375	8.380	8.385	8.390
1560	8.395	8.401	8.406	8.411	8.416	8.421	8.426	8.431	8.436	8.441
1570	8.447	8.452	8.457	8.462	8.467	8.472	8.477	8.482	8.487	8.493
1580	8.498	8.503	8.508	8.513	8.518	8.523	8.528	8.534	8.539	8.544
1590	8.549	8.554	8.559	8.564	8.569	8.575	8.580	8.585	8.590	8.595
1600	8.600	8.605	8.610	8.616	8.621	8.626	8.631	8.636	8.641	8.646
1610	8.652	8.657	8.662	8.667	8.672	8.677	8.682	8.688	8.693	8.698
1620	8.703	8.708	8.713	8.718	8.724	8.729	8.734	8.739	8.744	8.749
1630	8.754	8.760	8.765	8.770	8.775	8.780	8.785	8.791	8.796	8.801
1640	8.806	8.811	8.816	8.822	8.827	8.832	8.837	8.842	8.847	8.853
1650	8.858	8.863	8.868	8.873	8.878	8.884	8.889	8.894	8.899	8.904
1660	8.909	8.915	8.920	8.925	8.930	8.935	8.941	8.946	8.951	8.956
1670	8.961	8.967	8.972	8.977	8.982	8.987	8.992	8.998	9.003	9.008
1680	9.013	9.018	9.024	9.029	9.034	9.039	9.044	9.050	9.055	9.060
1690	9.065	9.070	9.076	9.081	9.086	9.091	9.097	9.102	9.107	9.112
1700	9.117	9.123	9.128	9.133	9.138	9.143	9.149	9.154	9.159	9.164
1710	9.170	9.175	9.180	9.185	9.191	9.196	9.201	9.206	9.211	9.217
1720	9.222	9.227	9.232	9.238	9.243	9.248	9.253	9.259	9.264	9.269
1730	9.274	9.280	9.285	9.290	9.295	9.301	9.306	9.311	9.316	9.322
1740	9.327	9.332	9.337	9.343	9.348	9.353	9.358	9.364	9.369	9.374
1750	9.380	9.385	9.390	3.395	9.401	9.406	9.411	9.416	9.422	9.427
1760	9.432	9.438	9.443	9.448	9.453	9.459	9.464	9.469	9.475	9.480
1770	9.485	9.490	9.496	9.501	9.506	9.512	9.517	9.522	9.528	9.533
1780	9.538	9.543	9.549	9.554	9.559	9.565	9.570	9.575	9.581	9.586
1790	9.591	9.597	9.602	9.607	9.613	9.618	9.623	9.629	9.634	9.639
1800	9.645	9.650	9.655	9.661	9.666	9.671	9.677	9.682	9.687	9.693
1810	9.698	9.703	9.709	9.714	9.179	9.725	9.730	9.735	9.741	9.746
1820	9.751	9.757	9.762	9.768	9.773	9.778	9.784	9.789	9.794	9.800
1830	9.805	9.810	9.816	9.821	9.827	9.832	9.837	9.843	9.848	9.854
1840	9.859	9.864	9.870	9.875	9.880	9.886	9.891	9.897	9.902	9.907
1850	9.913	9.918	9.924	9.929	9.934	9.940	9.945	9.951	9.956	9.961
1860	9.967	9.972	9.978	9.983	9.989	9.994	9.999	10.005	10.010	10.016
1870	10.021	10.027	10.032	10.037	10.043	10.048	10.054	10.059	10.065	10.070
1880	10.075	10.081	10.086	10.092	10.097	10.103	10.108	10.114	10.119	10.124
1890	10.130	10.135	10.141	10.146	10.152	10.157	10.163	10.168	10.174	10.179
1900	10.185	10.190	10.195	10.201	10.206	10.212	10.217	10.223	10.228	10.234
1910	10.239	10.245	10.250	10.256	10.261	10.267	10.272	10.278	10.283	10.289
1920	10.294	10.300	10.305	10.311	10.316	10.322	10.327	10.333	10.338	10.344
1930	10.349	10.355	10.360	10.366	10.371	10.377	10.382	10.388	10.393	10.399
1940	10.404	10.410	10.416	10.421	10.427	10.432	10.438	10.443	10.449	10.454

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Reference table – Ir vs. Ir 40 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1950	10.460	10.465	10.471	10.476	10.482	10.488	10.493	10.499	10.504	10.510
1960	10.515	10.521	10.526	10.532	10.538	10.543	10.549	10.554	10.560	10.565
1970	10.571	10.577	10.582	10.588	10.593	10.599	10.604	10.610	10.615	10.621
1980	10.627	10.632	10.638	10.644	10.649	10.655	10.660	10.666	10.671	10.677
1990	10.683	10.688	10.694	10.700	10.705	10.711	10.716	10.722	10.728	10.733
2000	10.739	10.744	10.750	10.756	10.761	10.767	10.773	10.778	10.784	10.789
2010	10.795	10.801	10.806	10.812	10.818	10.823	10.829	10.834	10.840	10.846
2020	10.851	10.857	10.863	10.868	10.874	10.880	10.885	10.891	10.897	10.902
2030	10.908	10.914	10.919	10.925	10.931	10.936	10.942	10.948	10.953	10.959
2040	10.965	10.970	10.976	10.982	10.987	10.993	10.999	11.004	11.010	11.016
2050	11.021	11.027	11.033	11.039	11.044	11.050	11.056	11.061	11.067	11.073
2060	11.078	11.084	11.090	11.096	11.101	11.107	11.113	11.118	11.124	11.130
2070	11.136	11.141	11.147	11.153	11.158	11.164	11.170	11.176	11.181	11.187
2080	11.193	11.199	11.204	11.210	11.216	11.222	11.227	11.233	11.239	11.244
2090	11.250	11.256	11.262	11.267	11.273	11.279	11.285	11.290	11.296	11.302
2100	11.308	11.314	11.319	11.325	11.331	11.337	11.342	11.348	11.354	11.360
2110	11.365									

Coefficients used to compute the above reference table

$E = C_0 + C_n T^n$

For 0°C to 630.615°C		
C_0	=	0.000 000 0
C_1	=	$3.087\,001\,6 \times 10^{-03}$
C_2	=	$6.964\,977\,3 \times 10^{-06}$
C_3	=	$-7.889\,050\,4 \times 10^{-09}$
C_4	=	$2.770\,059\,1 \times 10^{-12}$
C_5	=	$2.676\,241\,3 \times 10^{-14}$
C_6	=	$-1.041\,804\,0 \times 10^{-16}$
C_7	=	$1.527\,086\,7 \times 10^{-19}$
C_8	=	$-7.963\,408\,2 \times 10^{-23}$

For 630.615°C to 2110°C		
C_0	=	$-9.683\,908\,2 \times 10^{-02}$
C_1	=	$3.658\,861\,5 \times 10^{-03}$
C_2	=	$5.745\,518\,9 \times 10^{-06}$
C_3	=	$-6,054\,794\,3 \times 10^{-09}$
C_4	=	$2.723\,539\,3 \times 10^{-12}$
C_5	=	$-5.179\,703\,7 \times 10^{-16}$
C_6	=	$3.082\,188\,6 \times 10^{-20}$

Introduction

A characteristic of all platinum-rhodium alloy combinations used in thermocouple metrology is the increased service temperature obtainable with increased rhodium content. The Pt 20 Rh vs. Pt 40 Rh thermocouple can be used in oxidizing conditions up to 1800°C with short time possible exposure to 1850°C. This combination is characterized by a very low emf sensitivity, limited application and usage but with strong application in ultra high, variable atmosphere research and process furnaces.

Compensating lead wire

Compensating lead wire is not available for the Pt 20 Rh vs. Pt 40 Rh combination. Due to the low sensitivity of the combination (approximately 4 microvolts per °C in the upper use temperatures), and the low output below 40°C plain copper lead wire can be used without introducing errors of more than 4 or 5°C.

Stocking policy

An effort is made to maintain a small inventory of material in stock at .020" inch diameter. This inventory is subject to prior demand and long lead time refurbishment.

Tolerance

Due to the very limited demand for this thermocouple combination, no attempt is made to hold the emf-temperature relationship to any specific tolerance. A lot calibration report is provided with each shipment which can be used with the detailed tables as here in provided to apply the necessary interpolation corrections.

Stability

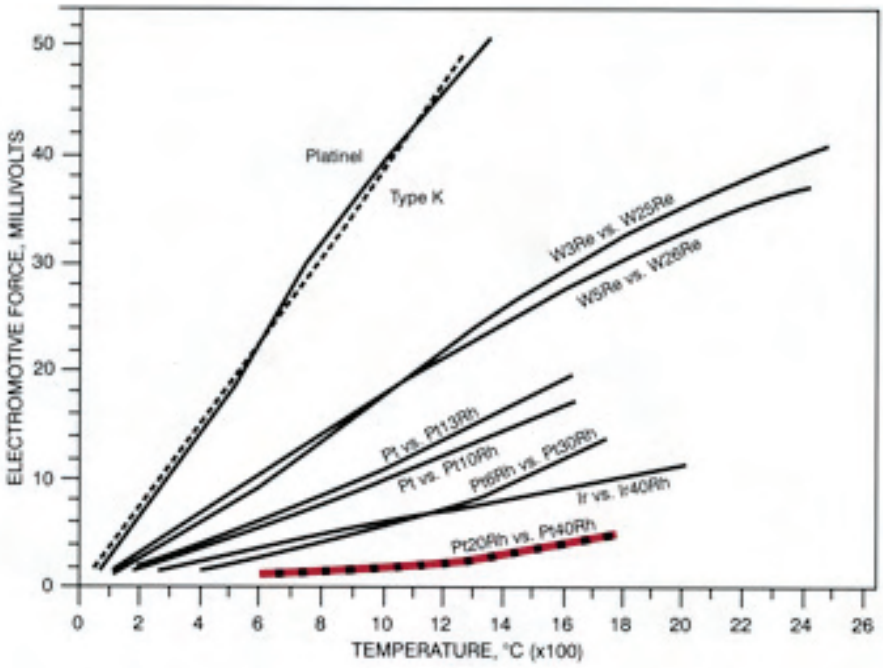
The performance, including stability of all thermocouples, is dependent on their handling and preparation prior to use and on the conditions of the application. The following test results were recorded on four samples used in clean air laboratory furnace control applications and are provided only as a guide for consideration.

Calibration	Time at temperature			
Temp. °C	170 hrs.	668 hrs.	772 hrs.	372 hrs.
1000	-21	-29	-45	-30
1100	-21	-27	-27	-45
1200	-20	-24	-35	-25
1300	-18	-17	-39	-35
1400	-17	-14	-26	-24
1500	-15	-10	-16	-17
1600	-14	-10	-12	-26

Physical properties

The following properties for Pt 20 Rh and Pt 40 Rh are provided as a guide for consideration of their use in the intended application.

Comparative emf vs. temperature relationship of common thermocouple materials indicates the relative position of the Pt 20 Rh vs. Pt 40 Rh Thermocouple



Melting point	
Pt 20 Rh	1885°C
Pt 40 Rh	1925°C

Density	(gm/cm³)	troy oz/in³
Pt 20 Rh	18.74	9.87
Pt 40 Rh	16.63	8.76

Polarity	
Pt 20 Rh	–
Pt 40 Rh	+

Temperature coefficient of resistance

0 to 100°C		
Pt 20 Rh	18.74	9.87
Pt 40 Rh	16.63	8.76

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Weight for select wire diameters

(troy oz/ft)

Diameter (inch)	Pt 20 Rh	Pt 40 Rh
0.005	0.002323	0.002061
0.006	0.003345	0.002968
0.007	0.004553	0.004039
0.008	0.005946	0.005276
0.009	0.007525	0.006677
0.010	0.009295	0.008247
0.011	0.011242	0.009974
0.012	0.013380	0.011872
0.013	0.015702	0.013931
0.014	0.018207	0.016154
0.015	0.020904	0.018547
0.016	0.023784	0.021102
0.017	0.026847	0.023821
0.018	0.030103	0.026709
0.019	0.033542	0.029760
0.020	0.037164	0.032974
0.021	0.040969	0.036350
0.022	0.044967	0.039897
0.023	0.049147	0.043606
0.024	0.053520	0.047486
0.025	0.058067	0.051521
0.026	0.062807	0.055726
0.027	0.067729	0.060093
0.028	0.072844	0.064631
0.029	0.078133	0.069324
0.030	0.083623	0.074195
0.031	0.089287	0.079221
0.032	0.095135	0.084410

Room temperature resistance for select wire diameters

(ohms/ft)

Diameter (inch)	Pt 20 Rh	Pt 40 Rh
0.005	4.816	3.972
0.006	3.344	2.758
0.007	2.457	2.027
0.008	1.881	1.552
0.009	1.486	1.226
0.010	1.204	0.993
0.011	0.995	0.821
0.012	0.836	0.690
0.013	0.712	0.588
0.014	0.614	0.507
0.015	0.535	0.441
0.016	0.470	0.388
0.017	0.417	0.344
0.018	0.372	0.306
0.019	0.334	0.275
0.020	0.301	0.248
0.021	0.273	0.225
0.022	0.249	0.205
0.023	0.228	0.188
0.024	0.209	0.172
0.025	0.193	0.159
0.026	0.178	0.147
0.027	0.165	0.136
0.028	0.154	0.127
0.029	0.143	0.118
0.030	0.134	0.110
0.031	0.125	0.103
0.032	0.118	0.097

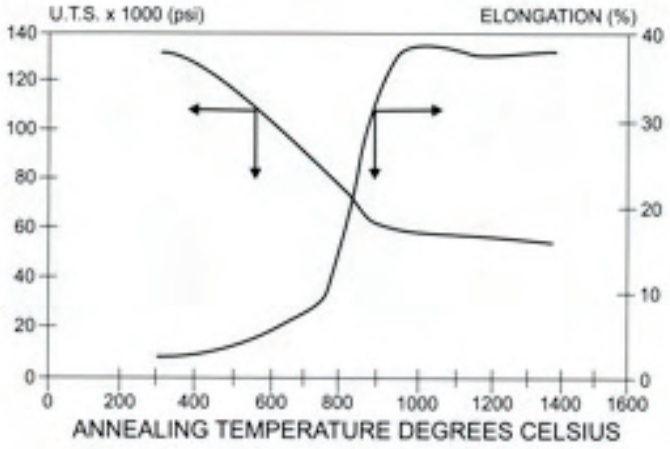
Resistivity at temperature

Ohms (cir-mil) ft.

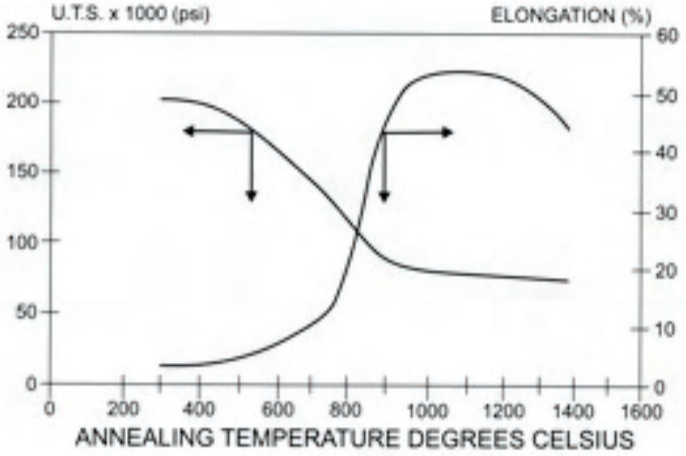
Temp. °C	Pt 20 Rh	Pt 40 Rh
20	125	105
1000	263	245
1200	290	275
1300	302	290
1400	314	305
1500	326	320
1600	340	335
1700	355	350
1800	371	365

Room temperature tensile data

Pt 20 Rh T/C wire

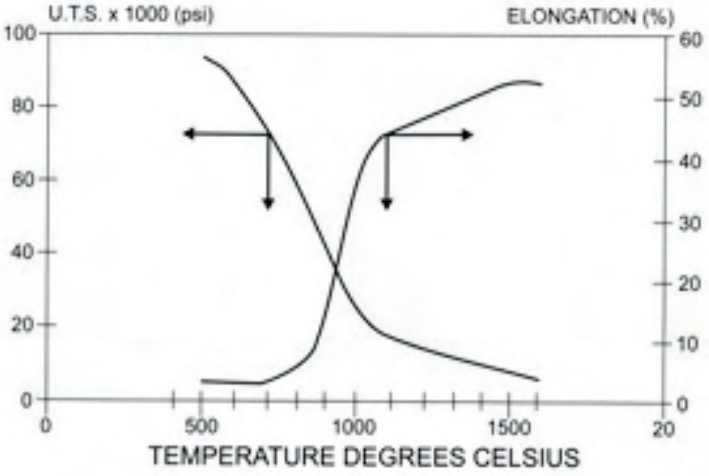


Pt 40 Rh T/C wire

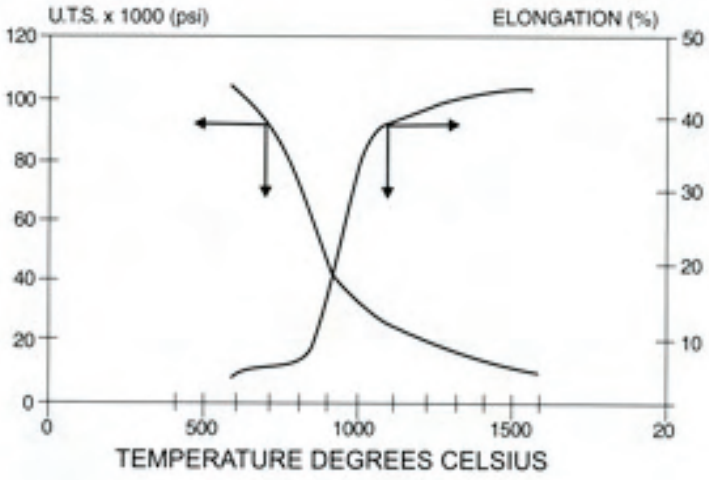


Hot tensile data

Pt 20 Rh T/C wire



Pt 40 Rh T/C wire



Coefficients used to compute the above reference table

$E = C_0 + C_n T^n$

For 0°C to 951.7°C		
C_0	=	0.000 000 0
C_1	=	$3.624\,628\,9 \times 10^{-04}$
C_2	=	$3.936\,032\,0 \times 10^{-7}$
C_3	=	$4.259\,413\,7 \times 10^{-10}$
C_4	=	$1.038\,298\,5 \times 10^{-12}$
C_5	=	$-1.540\,693\,9 \times 10^{-15}$
C_6	=	$1.003\,397\,4 \times 10^{-22}$
C_7	=	$-2.849\,716\,0 \times 10^{-22}$

For 951.7°C to 1888°C		
C_0	=	$-9.120\,187\,7 \times 10^{01}$
C_1	=	$3.524\,693\,1 \times 10^{-03}$
C_2	=	$-3.907\,744\,2 \times 10^{-06}$
C_3	=	$3.672\,869\,7 \times 10^{-09}$
C_4	=	$-1.082\,471\,0 \times 10^{-12}$
C_5	=	$1.151\,628\,0 \times 10^{-16}$
C_6	=	$-1.261\,964\,0 \times 10^{-20}$

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Reference table – Pt 20 Rh vs. Pt 40 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
0	0.000	0.000	0.001	0.001	0.001	0.002	0.002	0.003	0.003	0.003
10	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.007	0.007
20	0.007	0.008	0.008	0.009	0.009	0.009	0.010	0.010	0.010	0.011
30	0.011	0.012	0.012	0.012	0.013	0.013	0.014	0.014	0.014	0.015
40	0.015	0.016	0.016	0.016	0.017	0.017	0.018	0.018	0.018	0.019
50	0.019	0.020	0.020	0.020	0.021	0.021	0.022	0.022	0.022	0.023
60	0.023	0.024	0.024	0.025	0.025	0.025	0.026	0.026	0.027	0.027
70	0.027	0.028	0.028	0.029	0.029	0.030	0.030	0.030	0.031	0.031
80	0.032	0.032	0.033	0.033	0.034	0.034	0.034	0.035	0.035	0.036
90	0.036	0.037	0.037	0.038	0.038	0.038	0.039	0.039	0.040	0.040
100	0.041	0.041	0.042	0.042	0.043	0.043	0.043	0.044	0.044	0.045
110	0.045	0.046	0.046	0.047	0.047	0.048	0.048	0.049	0.049	0.050
120	0.050	0.051	0.051	0.052	0.052	0.052	0.053	0.053	0.054	0.054
130	0.055	0.055	0.056	0.056	0.057	0.057	0.058	0.058	0.059	0.059
140	0.060	0.060	0.061	0.061	0.062	0.063	0.063	0.064	0.064	0.065
150	0.065	0.066	0.066	0.067	0.067	0.068	0.068	0.069	0.069	0.070
160	0.070	0.071	0.071	0.072	0.072	0.073	0.074	0.074	0.075	0.075
170	0.076	0.076	0.077	0.077	0.078	0.079	0.079	0.080	0.080	0.081
180	0.081	0.082	0.082	0.083	0.084	0.084	0.085	0.085	0.086	0.086
190	0.087	0.088	0.088	0.089	0.089	0.090	0.091	0.091	0.092	0.092
200	0.093	0.093	0.094	0.095	0.095	0.096	0.096	0.097	0.098	0.098
210	0.099	0.100	0.100	0.101	0.101	0.102	0.103	0.103	0.104	0.104
220	0.105	0.106	0.106	0.107	0.108	0.108	0109	0.110	0.110	0.111
230	0.111	0.112	0.113	0.113	0.114	0.115	0.115	0.116	0.117	0.117
240	0.118	0.119	0.119	0.120	0.121	0.121	0.122	0.123	0.123	0.124
250	0.125	0.125	0.126	0.127	0.127	0.128	0.129	0.129	0.130	0.131
260	0.132	0.132	0.133	0.134	0.134	0.135	0.136	0.136	0.137	0.138
270	0.139	0.139	0.140	0.141	0.141	0.142	0.143	0.144	0.144	0.145
280	0.146	0.147	0.147	0.148	0.149	0.150	0.150	0.151	0.152	0.153
290	0.153	0.154	0.155	0.156	0.156	0.157	0.158	0.159	0.159	0.160
300	0.161	0.162	0.163	0.163	0.164	0.165	0.166	0.166	0.167	0.168
310	0.169	0.170	0.170	0.171	0.172	0.173	0.174	0.175	0.175	0.176
320	0.177	0.178	0.179	0.179	0.180	0.181	0.182	0.183	0.184	0.184
330	0.185	0.186	0.187	0.188	0.189	0.189	0.190	0.191	0.192	0.193
340	0.194	0.195	0.195	0.196	0.197	0.198	0.199	0.200	0.201	0.202
350	0.202	0.203	0.204	0.205	0.206	0.207	0.208	0.209	0.210	0.211
360	0.211	0.212	0.213	0.214	0.215	0.216	0.217	0.218	0.219	0.220
370	0.221	0.222	0.223	0.223	0.224	0.225	0.226	0.227	0.228	0.229
380	0.230	0.231	0.232	0.233	0.234	0.235	0.236	0.237	0.238	0.239
390	0.240	0.241	0.242	0.243	0.244	0.245	0.246	0.247	0.248	0.249
400	0.250	0.251	0.252	0.253	0.254	0.255	0.256	0.257	0.258	0.259
410	0.260	0.261	0.262	0.263	0.264	0.265	0.266	0.267	0.268	0.269
420	0.270	0.271	0.272	0.273	0.274	0.276	0.377	0.278	0.279	0.280
430	0.281	0.282	0.283	0.284	0.285	0.286	0.287	0.289	0.290	0.291
440	0.292	0.293	0.294	0.295	0.296	0.297	0.299	0.300	0.301	0.302
450	0.303	0.304	0.305	0.306	0.308	0.309	0.310	0.311	0.312	0.313
460	0.315	0.316	0.317	0.318	0.319	0.320	0.322	0.323	0.324	0.325
470	0.326	0.327	0.329	0.330	0.331	0.332	0.333	0.335	0.336	0.337
480	0.338	0.339	0.341	0.342	0.343	0.344	0.346	0.347	0.348	0.349
490	0.351	0.352	0.353	0.354	0.356	0.357	0.358	0.359	0.361	0.362
500	0.363	0.364	0.366	0.367	0.368	0.369	0.371	0.372	0.373	0.375
510	0.376	0.377	0.379	0.380	0.381	0.382	0.384	0.385	0.386	0.388
520	0.389	0.390	0.392	0.393	0.394	0.396	0.397	0.398	0.400	0.401
530	0.402	0.404	0.405	0.407	0.408	0.409	0.411	0.412	0.413	0.415
540	0.416	0.418	0.419	0.420	0.422	0.423	0.425	0.426	0.427	0.429
550	0.430	0.432	0.433	0.434	0.436	0.437	0.439	0.440	0.442	0.443
560	0.444	0.446	0.447	0.449	0.450	0.452	0.453	0.455	0.456	0.458
570	0.459	0.461	0.462	0.464	0.465	0.467	0.468	0.470	0.471	0.473
580	0.474	0.476	0.477	0.479	0.480	0.482	0.483	0.485	0.486	0.488
590	0.489	0.491	0.492	0.494	0.495	0.497	0.499	0.500	0.502	0.503
600	0.505	0.506	0.508	0.509	0.511	0.513	0.514	0.516	0.517	0.519
610	0.521	0.522	0.524	0.525	0.527	0.529	0.530	0.532	0.534	0.535
620	0.537	0.538	0.540	0.542	0.543	0.545	0.547	0.548	0.550	0.552
630	0.553	0.555	0.557	0.558	0.560	0.562	0.563	0.565	0.567	0.568
640	0.570	0.572	0.573	0.575	0.577	0.579	0.580	0.582	0.584	0.585

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Reference table – Pt 20 Rh vs. Pt 40 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
650	0.587	0.589	0.591	0.592	0.594	0.596	0.598	0.599	0.601	0.603
660	0.605	0.606	0.608	0.610	0.612	0.613	0.615	0.617	0.619	0.621
670	0.622	0.624	0.626	0.628	0.630	0.631	0.633	0.635	0.637	0.639
680	0.640	0.642	0.644	0.646	0.648	0.650	0.651	0.653	0.655	0.657
690	0.659	0.661	0.663	0.664	0.666	0.668	0.670	0.672	0.674	0.676
700	0.678	0.680	0.681	0.683	0.685	0.687	0.689	0.691	0.693	0.695
710	0.697	0.699	0.701	0.702	0.704	0.706	0.708	0.710	0.712	0.714
720	0.716	0.718	0.720	0.722	0.724	0.726	0.728	0.730	0.732	0.734
730	0.736	0.738	0.740	0.742	0.744	0.746	0.748	0.750	0.752	0.754
740	0.756	0.758	0.760	0.762	0.764	0.766	0.768	0.770	0.772	0.774
750	0.776	0.778	0.781	0.783	0.785	0.788	0.789	0.791	0.793	0.795
760	0.797	0.799	0.801	0.803	0.806	0.808	0.810	0.812	0.814	0.816
770	0.818	0.820	0.823	0.825	0.827	0.829	0.831	0.833	0.835	0.838
780	0.840	0.842	0.844	0.846	0.848	0.851	0.853	0.855	0.857	0.859
790	0.862	0.864	0.866	0.868	0.870	0.873	0.875	0.877	0.879	0.881
800	0.884	0.886	0.888	0.890	0.893	0.895	0.897	0.899	0.902	0.904
810	0.906	0.908	0.911	0.913	0.915	0.918	0.920	0.922	0.924	0.927
820	0.929	0.931	0.934	0.936	0.938	0.941	0.943	0.945	0.947	0.950
830	0.952	0.954	0.957	0.959	0.962	0.964	0.966	0.969	0.971	0.973
840	0.976	0.978	0.980	0.983	0.985	0.988	0.990	0.992	0.995	0.997
850	1.000	1.002	1.004	1.007	1.009	1.012	1.014	1.016	1.019	1.021
860	1.024	1.026	1.029	1.031	1.033	1.036	1.038	1.041	1.043	1.046
870	1.048	1.051	1.053	1.056	1.058	1.061	1.063	1.066	1.068	1.071
880	1.073	1.076	1.078	1.081	1.083	1.086	1.088	1.091	1.093	1.096
890	1.098	1.101	1.103	1.106	1.109	1.111	1.114	1.116	1.119	1.121
900	1.124	1.127	1.129	1.132	1.134	1.137	1.139	1.142	1.145	1.147
910	1.150	1.152	1.155	1.158	1.160	1.163	1.166	1.168	1.171	1.173
920	1.176	1.179	1.181	1.184	1.187	1.189	1.192	1.195	1.197	1.200
930	1.203	1.205	1.208	1.211	1.213	1.216	1.219	1.222	1.224	1.227
940	1.230	1.232	1.235	1.238	1.240	1.243	1.246	1.249	1.251	1.254
950	1.257	1.260	1.262	1.265	1.268	1.271	1.273	1.276	1.279	1.282
960	1.284	1.287	1.290	1.293	1.296	1.298	1.301	1.304	1.307	1.310
970	1.312	1.315	1.318	1.321	1.324	1.326	1.329	1.332	1.335	1.338
980	1.341	1.343	1.346	1.349	1.352	1.355	1.358	1.360	1.363	1.366
990	1.369	1.372	1.375	1.378	1.381	1.383	1.386	1.389	1.392	1.395
1000	1.398	1.401	1.404	1.407	1.409	1.412	1.415	1.418	1.421	1.424
1010	1.427	1.430	1.433	1.436	1.439	1.442	1.445	1.448	1.451	1.454
1020	1.456	1.459	1.462	1.465	1.468	1.471	1.474	1.477	1.480	1.483
1030	1.486	1.489	1.492	1.495	1.498	1.501	1.504	1.507	1.510	1.513
1040	1.516	1.519	1.522	1.525	1.528	1.531	1.535	1.538	1.541	1.544
1050	1.547	1.550	1.553	1.556	1.559	1.562	1.565	1.568	1.571	1.574
1060	1.577	1.581	1.584	1.587	1.590	1.593	1.596	1.599	1.602	1.605
1070	1.609	1.612	1.615	1.618	1.621	1.624	1.627	1.630	1.634	1.637
1080	1.640	1.643	1.646	1.649	1.653	1.656	1.659	1.662	1.665	1.668
1090	1.672	1.675	1.678	1.681	1.684	1.688	1.691	1.694	1.697	1.700
1100	1.704	1.707	1.710	1.713	1.717	1.720	1.723	1.726	1.729	1.733
1110	1.736	1.739	1.742	1.746	1.749	1.752	1.756	1.759	1.762	1.765
1120	1.769	1.772	1.775	1.779	1.782	1.785	1.788	1.792	1.795	1.798
1130	1.802	1.805	1.808	1.812	1.815	1.818	1.822	1.825	1.828	1.832
1140	1.835	1.838	1.842	1.845	1.848	1.852	1.855	1.858	1.862	1.865
1150	1.869	1.872	1.875	1.879	1.882	1.885	1.889	1.892	1.896	1.899
1160	1.903	1.906	1.909	1.913	1.916	1.920	1.923	1.926	1.930	1.933
1170	1.937	1.940	1.944	1.947	1.951	1.954	1.957	1.961	1.964	1.968
1180	1.971	1.975	1.978	1.982	1.985	1.989	1.992	1.996	1.999	2.003
1190	2.006	2.010	2.013	2.017	2.020	2.024	2.027	2.031	2.034	2.038
1200	2.041	2.045	2.049	2.052	2.056	2.059	2.063	2.066	2.070	2.073
1210	2.077	2.081	2.084	2.088	2.091	2.095	2.098	2.102	2.106	2.109
1220	2.113	2.116	2.120	2.124	2.127	2.131	2.134	2.138	2.142	2.145
1230	2.149	2.153	2.156	2.160	2.163	2.167	2.171	2.174	2.178	2.182
1240	2.185	2.189	2.193	2.196	2.200	2.204	2.207	2.211	2.215	2.218
1250	2.222	2.226	2.230	2.233	2.237	2.241	2.244	2.248	2.252	2.255
1260	2.259	2.263	2.267	2.270	2.274	2.278	2.282	2.285	2.289	2.293
1270	2.297	2.300	2.304	2.308	2.312	2.315	2.319	2.323	2.327	2.330
1280	2.334	2.338	2.342	2.346	2.349	2.353	2.357	2.361	2.364	2.368
1290	2.372	2.376	2.380	2.384	2.387	2.391	2.395	2.399	2.403	2.406

BASF
The Chemical Company

Reference table – Pt 20 Rh vs. Pt 40 Rh thermocouple

Temperature °C ITS 90, EMF in millivolts, Ref. junction 0°C

°C	0	1	2	3	4	5	6	7	8	9
1300	2.410	2.414	2.418	2.422	2.426	2.430	2.433	2.437	2.441	2.445
1310	2.449	2.453	2.457	2.460	2.464	2.468	2.472	2.476	2.480	2.484
1320	2.488	2.492	2.495	2.499	2.503	2.507	2.511	2.515	2.519	2.523
1330	2.527	2.531	2.535	2.538	2.542	2.546	2.550	2.554	2.558	2.562
1340	2.566	2.570	2.574	2.578	2.582	2.586	2.590	2.594	2.598	2.602
1350	2.606	2.610	2.614	2.618	2.622	2.626	2.630	2.634	2.638	2.642
1360	2.646	2.650	2.654	2.658	2.662	2.666	2.670	2.674	2.678	2.682
1370	2.686	2.690	2.694	2.698	2.702	2.706	2.710	2.714	2.718	2.722
1380	2.726	2.730	2.734	2.738	2.742	2.746	2.750	2.755	2.759	2.763
1390	2.767	2.771	2.775	2.779	2.783	2.787	2.791	2.795	2.799	2.804
1400	2.808	2.812	2.816	2.820	2.824	2.828	2.832	2.836	2.841	2.845
1410	2.849	2.853	2.857	2.861	2.865	2.869	2.874	2.878	2.882	2.886
1420	2.890	2.894	2.899	2.903	2.907	2.911	2.915	2.919	2.923	2.928
1430	2.932	2.936	2.940	2.944	2.949	2.953	2.957	2.961	2.965	2.969
1440	2.974	2.978	2.982	2.986	2.990	2.995	2.999	3.003	3.007	3.012
1450	3.016	3.020	3.024	3.028	3.033	3.037	3.041	3.045	3.050	3.054
1460	3.058	3.062	3.067	3.071	3.075	3.079	3.084	3.088	3.092	3.096
1470	3.101	3.105	3.109	3.113	3.118	3.122	3.126	3.130	3.135	3.139
1480	3.143	3.148	3.152	3.156	3.160	3.165	3.169	3.173	3.178	3.182
1490	3.186	3.190	3.195	3.199	3.203	3.208	3.212	3.216	3.221	3.225
1500	3.229	3.234	3.238	3.242	3.247	3.251	3.255	3.260	3.264	3.268
1510	3.273	3.277	3.281	3.286	3.290	3.294	3.299	3.303	3.307	3.312
1520	3.316	3.320	3.325	3.329	3.333	3.338	3.342	3.347	3.351	3.555
1530	3.360	3.364	3.368	3.373	3.377	3.382	3.386	3.390	3.395	3.399
1540	3.404	3.408	3.412	3.417	3.421	3.425	3.430	3.434	3.439	3.443
1550	3.447	3.452	3.456	3.461	3.465	3.470	3.474	3.478	3.483	3.487
1560	3.492	3.496	3.500	3.505	3.509	3.514	3.518	3.523	3.527	3.531
1570	3.536	3.540	3.545	3.549	3.554	3.558	3.563	3.567	3.571	3.576
1580	3.580	3.585	3.589	3.594	3.598	3.603	3.607	3.611	3.616	3.620
1590	3.625	3.629	3.634	3.638	3.643	3.647	3.652	3.656	3.661	3.665
1600	3.670	3.674	3.678	3.683	3.687	3.692	3.696	3.701	3.705	3.710
1610	3.714	3.719	3.723	3.728	3.732	3.737	3.741	3.746	3.750	3.755
1620	3.759	3.764	3.768	3.773	3.777	3.782	3.786	3.791	3.795	3.800
1630	3.804	3.809	3.813	3.818	3.822	3.827	3.831	3.836	3.840	3.845
1640	3.849	3.854	3.858	3.863	3.867	3.872	3.876	3.881	3.885	3.890
1650	3.894	3.899	3.903	3.908	3.912	3.917	3.921	3.926	3.931	3.935
1660	3.940	3.944	3.949	3.953	3.958	3.962	3.967	3.971	3.976	3.980
1670	3.985	3.989	3.994	3.998	4.003	4.008	4.012	4.017	4.021	4.026
1680	4.030	4.035	4.039	4.044	4.048	4.053	4.057	4.062	4.067	4.071
1690	4.076	4.080	4.085	4.089	4.094	4.098	4.103	4.107	4.112	4.116
1700	4.121	4.126	4.130	4.135	4.139	4.144	4.148	4.153	4.157	4.162
1710	4.168	4.171	4.176	4.180	4.185	4.189	4.194	4.198	4.203	4.207
1720	4.212	4.216	4.221	4.226	4.230	4.235	4.239	4.244	4.248	4.253
1730	4.257	4.262	4.266	4.271	4.276	4.280	4.285	4.289	4.294	4.298
1740	4.303	4.307	4.312	4.317	4.321	4.326	4.330	4.335	4.339	4.344
1750	4.348	4.353	4.357	4.362	4.366	4.371	4.376	4.380	4.385	4.389
1760	4.394	4.398	4.403	4.407	4.412	4.416	4.421	4.426	4.430	4.435
1770	4.439	4.444	4.448	4.453	4.457	4.462	4.466	4.471	4.475	4.480
1780	4.484	4.489	4.494	4.498	4.503	4.507	4.512	4.516	4.521	4.525
1790	4.530	4.534	4.539	4.543	4.548	4.552	4.557	4.561	4.566	4.571
1800	4.575	4.580	4.584	4.589	4.593	4.598	4.602	4.607	4.611	4.616
1810	4.620	4.625	4.629	4.634	4.638	4.643	4.647	4.652	4.656	4.661
1820	4.665	4.670	4.674	4.679	4.683	4.688	4.692	4.697	4.701	4.706
1830	4.710	4.715	4.719	4.724	4.728	4.733	4.737	4.742	4.746	4.751
1840	4.755	4.760	4.764	4.768	4.773	4.777	4.782	4.786	4.791	4.795
1850	4.800	4.804	4.809	4.813	4.818	4.822	4.827	4.831	4.835	4.840
1860	4.844	4.849	4.853	4.858	4.862	4.867	4.871	4.875	4.880	4.884
1870	4.889	4.893	4.898	4.902	4.907	4.911	4.915	4.920	4.924	4.929
1880	4.933	4.938	4.942	4.946	4.951	4.955	4.960	4.964	4.968	

Notes on the use of precious metal thermocouples

Platinum-Rhodium thermocouples are robust devices as demonstrated by their years of highly reliable service in extreme conditions. Great care is given in their preparation in order to insure reliability in use. However, the accuracy and life of these couples can be affected adversely if a few simple precautions are not taken.

Contamination

The failure of these thermocouples in use can occur in several ways - mechanical breakage and a change in thermoelectric properties. In both cases, contamination may be the cause of failure.

Thermo-mechanical grain growth

Grain growth can contribute to the mechanical failure of thermocouple wires. Pure Platinum, in particular, is subject to this after prolonged service at high temperature. Small strains in the wire caused by handling, vibration or thermal cycling can increase the tendency for grain growth to occur. A common observation of heat affected grain growth is the periodic necking down or flattening of the wire. This necking down weakens the wire and is generally characterized by one single grain boundary traversing across the full wire diameter.

Whenever it is necessary to use a thermocouple in a vertical position, it is important that the couple is set up so that the wire does not support the weight of the insulators. The combination of high temperature and stress on the wires can result in early failure.

Type S Thermocouple exhibiting grain growth & slippage producing early failure. Surface contamination is evident in one leg near the junction

Chemical contamination

Chemical contamination of precious metal thermoelements can cause decalibration, structural weakening and in severe case catastrophic failure.

Reducing gases such as carbon monoxide and hydrogen do not have an adverse effect on the types R, S and B thermocouples directly, but it is known that these gases reduce impurity oxides such as silica and iron which are usually present in the refractories and ceramic insulators or protection tubes of even the highest purity. The silicon reduced from the silica is known to react with the platinum to form a melting eutectic (MP830°C) while the reduced iron seriously affects the ductility and the emf. Close contact of these couples by easily reduced oxides of any metal should not be permitted. Fingerprints, "fly ash" from the assembly area or process vapors can provide sufficient reducing agents for reactions to take place. The platinum-rhodium system is a good catalyst and can accelerate or prompt reactions to occur at its own detriment at temperatures below those normally anticipated for the reactions to otherwise happen.

Atmosphere

Types S, R and B thermocouples have been used for short periods of time in vacuum. Long time exposure to vacuum is not recommended unless special care is taken to prevent metallic vapors or detrimental "vacuum" outgassing contingents from coming into contact with the wires.

It has been reported that unstable hydrocarbons "crack" in contact with platinum group metals, causing damage to these metals by grain boundary migration of carbon.

Unprotected platinum/rhodium thermocouples are attacked by phosphorous, arsenic, sulfur and vapors of metals such as zinc and lead. This attack generally results in brittleness and hot shortness.

All contact between bare couples and caustic alkalis, nitrates, cyanides, alkaline earths and the hydroxides of barium and lithium, should be avoided because these substances attack platinum at red heat.

Thermal diffusion

Thermal diffusion of rhodium into the platinum leg is often credited with the cause of emf drift in precious metal thermocouples. Diffusion at the hot junction is an extremely slow process and, for the majority of applications, can be considered as being of no importance. It is only when there is a variation in concentration in a region of a temperature gradient that the thermocouple will give spurious results due to diffusion and this may, of course, occur in the measurements of surface temperature.

Select properties of refractories used with thermocouple wire

Ohms (cir-mil) ft.

Refractory	Composition	Melt point	Recommended use temp	Thermal stress resistance
Sapphire	99.9% Al_2O_3	2030°C	1950°C	Very good
Sintered Alumina	99.8% Al_2O_3	2030°C	1850°C	Good
Sintered Beryllia	99.8% BeO	2570°C	2025°C	Excellent
Sintered Magnesia	99.08% MgO	2800°C	1900°C	Fair-Poor
Sintered Mullite	60 Al_2O_3 - 36 SiO_2	1810°C	1500°C	Good
Sintered Spinel	99.8% Mg•Al_2O_4	2135°C	1000°C	Fair
Sintered Thoria	99.8% ThO_2	3050°C	2500°C	Fair-Poor
Stabilized Zirconia	92% ZrO_2 4HfO_2 + 4CaO	2550°C	2200°C	Fair-Good

Calibration

The temperature-emf relationship for a specific thermocouple is a definite physical property and therefore does not depend on details of the apparatus or method used to determine this relationship. For this reason, thermocouples can be calibrated by any of several methods, the choice of which depends on type of thermocouple, temperature range, accuracy required, size of wires, apparatus available and personal preference.

At BASF, platinum-rhodium thermocouples are generally calibrated by comparison to NIST calibrated master standards in a specially designed Pt-Rh alloy electrically heated furnace. Calibration of the Pt/Rh wires is facilitated by computerized data acquisition which drives the furnace and records the emf and temperature automatically. So called primary, or melt point determination facilities are available and can be used for most exacting demands with a slight improvement of the overall uncertainty value.

Reference tables

Practical use of thermocouples requires that the selected thermocouple meet an established or standardized temperature-emf relationship within acceptable tolerance limits. This is necessary in order to permit interchangeability on a national and global basis when commercially available readout equipment is used. The tables in this bulletin are based on the most recently agreed upon version known as the International Temperature Scale of 1990 (ITS 90). This scale, or definition of the emf-temperature relationship of commonly used thermocouple supersedes that known as the International Practical Temperature Scale of 1968 (IPTS 68) which, in turn, replaced the IPTS 48 scale.

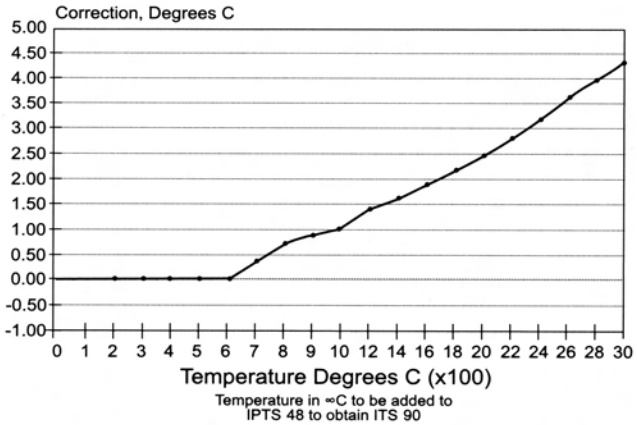
The IPTS 48 scale is seldom experienced in today's technology but small pockets of use persist, especially in the steel and heavy metals industry. The difference between the IPTS 48 and ITS 90 is shown graphically and highlights that a significant correction must be made to the IPTS 48 to realize the more accurate temperature definition of ITS 90.

The IPTS 68 scale is extensively in use and is anticipated will remain so for many years due to the insignificant difference between it and ITS 90. The graph shows that corrections of less than 0.5°C are required to correct for scale differences for temperatures upto 1500°C. The magnitude of this correction is generally well within the applications reliability and accuracy estimates and is generally within the calibration uncertainty for the thermocouple system.

Temperature scale correction

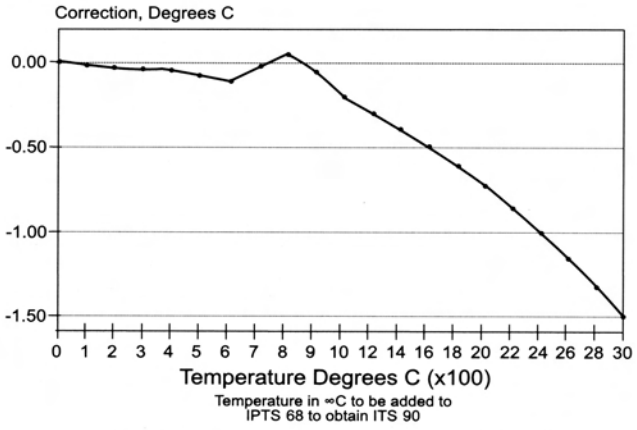
Temperature difference been scales relative to the ITS 90

IPTS 48 to ITS 90



Temperature in °C to be added to IPTS-48 to obtain ITS-90

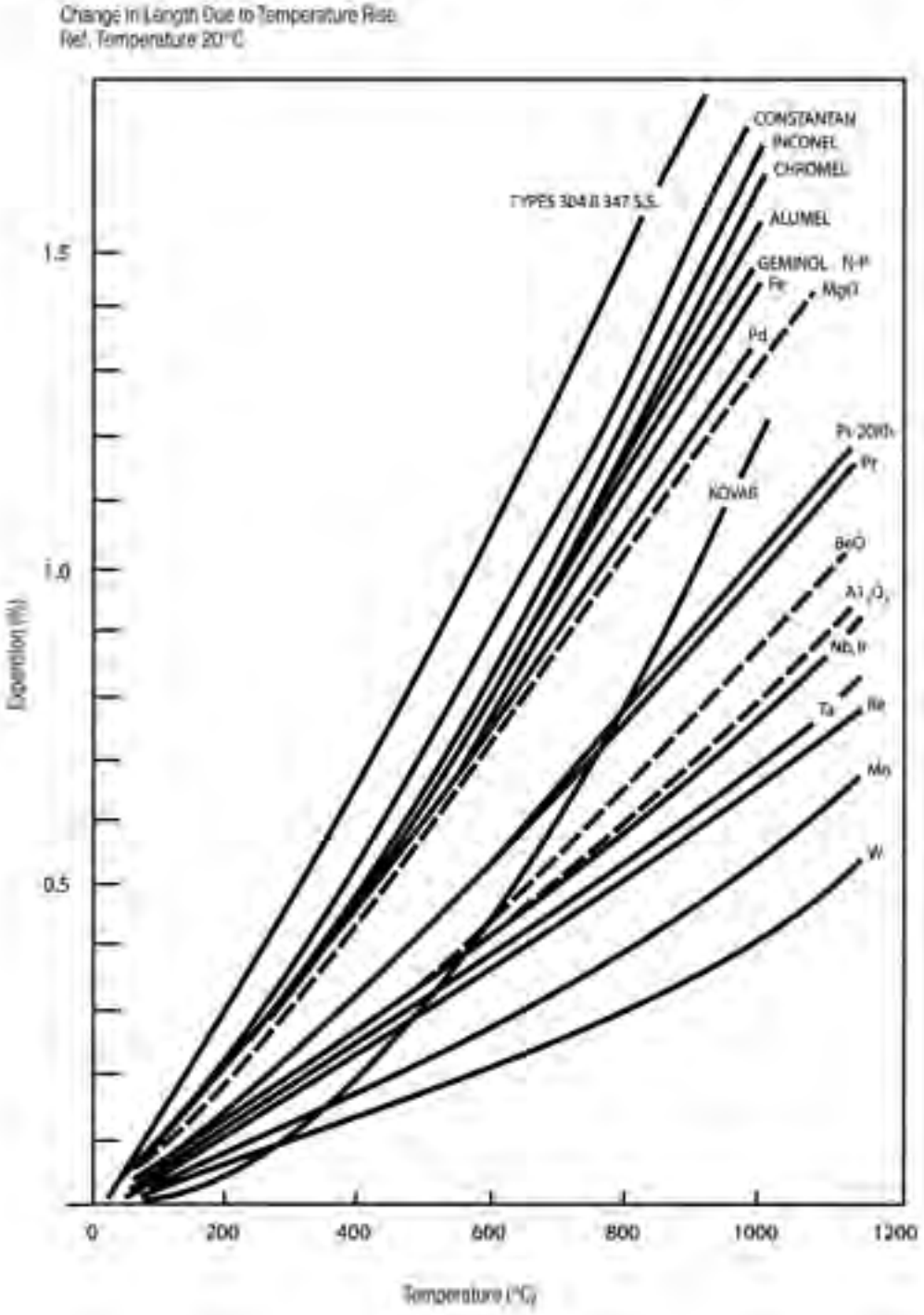
IPTS 68 to ITS 90



Temperature in °C to be added to IPTS-68 to obtain ITS-90

Thermal mechanical expansion

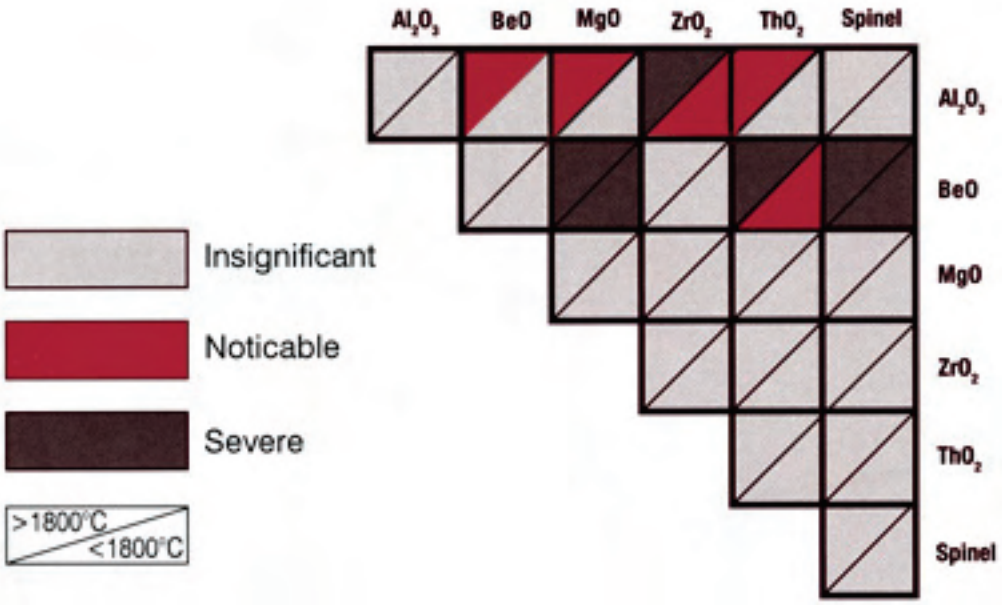
The following graph is provided as an aide for the metrologist in thermocouple design. In many applications, increased attention paid to thermal expansion of components would significantly improve thermocouple performance.



Ceramic insulation

Judicious use of insulators and protection tubes will eliminate problems with many of the contaminants listed here. A variety of ceramics, some of which are gas tight, are available but it should be kept in mind that no single ceramic will suit all applications. In general, mullite and siliminite ceramic insulators and protection tubes are to be avoided except at very low temperatures and used always in air. At higher temperatures high purity alumina (99.5% Al_2O_3) should be used. More specifically, the impurity within the minimum "high purity" alumina is more important and should be reviewed for minimal amounts of easily reduced elements.

At very high temperatures the different ceramics can enter into reactions between themselves causing catastrophic reactions to occur which generally can be expected to destroy the thermocouple. The following tabulation provides guidance for those materials recorded to have reacted. Caution must be exercised in using this data as unrecorded conditions could have had a contributary effect.



Errors in degrees Celsius to published tables for select compensating extension wires at various connection temperatures for Type B, R & S thermocouples
(Hot Junction Temperature 1000°C)

Connection temp. °C	Cu-Cu (B)	Cu-CuMn (B)	Cu-CuMN (S & R)
50	0.2 °C	0.4 °C	1.9 °C
100	3.6	-0.4	1.7
150	10.1	-1.0	.7
200	19.5	-2.5	-2.08
250	31.9	-6.3	-5.20
300	47.2	-7.6	-8.

Compensating extension wire

The emf-temperature relationship of the compensating extension wire only approximates the thermocouple calibration over a defined temperature range. Outside of this range significant errors can be realized. The following data was recorded in actual practice and is provided as a guide for further thought. Cu-Cu is copper/copper while Cu-CuMn is understood to reference the Copper-Copper/Manganese alloy system.

Helpful conversion tables

The following conversion tables have proven helpful to the thermal electric metrologist and are provided as a guide and an aide in obtaining full benefit from BASF brand thermocouple wire.

Introduction

The Weight Tables provide a convenient means to accurately estimate the amount of material involved in any dimensioned quantity of wire. All precious metals are sold and supplied on a weight basis, subsequently these tables should be used as a guide in assessing the cost of any specific object.

The weight tables are provided as a reference. They must be multiplied by a WEIGHT CONVERSION FACTOR in order to obtain the actual weight for a particular material or alloy.

Weight conversion factors

To convert wire table weights to the correct weight for a specific metal or alloy, use the following multiplication factors.

Metal or alloy	Multiplier	Metal or alloy	Multiplier
Platinum (Pt)	1.000	Ruthenium (Ru)	.5804
Palladium (Pd)	.5604	Pt 5 Ru	.9651
Pd 50 Pt	.7179	Pt 8 Ru	.9453
Pd 5 Ru	.5614	Pt 10 Ru	.9326
Pd 8 Ru	.5619	Pt 11 Ru	.9263
Pd 11 Ru	.5625	Gold (Au)	.9007
Pd 20 Ag	.5400	Pt 5 Au	.9944
Pd 25 Ag	.5406	Au 10 Cu	.8069
Pd 40 Ag	.5295	Au 30 Pt	.9282
Pd 40 Cu	.4930	Silver (Ag)	.4890
Iridium (Ir)	1.0559	Ag 3 Pd	.4908
Pt 5 Ir	1.0027	Ag 10 Pd	.4952
Pt 10 Ir	1.0053	Ag 20 Pd	.5016
Pt 15 Ir	1.0080	Ag 30 Pd	.5074
Pt 20 Ir	1.0107	Ag 50 Pd	.5220
Pt 25 Ir	1.0134	Ag 3 Pt	.4968
Pt 30 Ir	1.0161	Nickel (Ni)	.4150
Ir 40 Rh	.7900	Pt 3 Ni	.9957
Ir 50 Rh	.7450	Pt 5 Ni	.9343
Ir 60 Rh	.7050	Pt 10 Ni	.8766
Rhodium (Rh)	.5786	Tungsten (W)	.8990
Pt 1 Rh	.9930	Pt 4 W	.9955
Pt 3½ Rh	.9752	Pt 8 W	.9100
Pt 5 Rh	.9648	W 3 Re or W 5 Re	.9044
Pt 6 Rh	.9581	W 25 Re or W 26 Re	.9161
Pt 10 Rh	.9321	Special Alloys	
Pt 13 Rh	.9135	89 Pt 15 Rh 6 Ru	.9796
Pt 20 Rh	.8728	90 Pt 5 Pd 5 Rh	.9299
Pt 25 Rh	.8459	69 Au 25 Ag 6 Pt	.7500
Pt 30 Rh	.8207	Platinel +	.6960
Pt 40 Rh	.7744	Platinel -	.7417
Pt 50 Rh	.7330	Mo	.4764

Weight tables

Weight per foot of wire in troy ounces and grams

(Multiply ounces or grams by the Weight Conversion Factor to obtain the correct weight for a particular metal.)

B. & S. gauge	Diameter (inches)	Troy ounces	Grams
50	.001	.0001065	.00331
49	.0011	.0001288	.00400
	.0012	.0001533	.00476
	.0013	.0001799	.00559
47	.0014	.0002086	.00648
	.0015	.0002395	.00744
	.0016	.0002725	.00847
	.0017	.0003076	.00956
	.0018	.0003449	.01072
	.0019	.0003843	.01195
44	.002	.0004258	.01324
	.0021	.0004694	.01459
	.0022	.0005152	.01602
	.0023	.0005631	.01751
	.0024	.0006132	.01907
42	.0025	.0006653	.02069
	.0026	.0007196	.02238
	.0027	.0007760	.02413
41	.0028	.0008346	.02595
	.0029	.0008952	.02784
	.003	.0009581	.02980
40	.0031	.001023	.03181
	.0032	.001090	.03390
	.0033	.001159	.03604
	.0034	.001231	.03828
39	.0035	.001304	.04055
	.0036	.001380	.04292
	.0037	.001457	.04531
	.0038	.001537	.04780
	.0039	.001619	.05035
38	.004	.001703	.05296
37	.0045	.002156	.06705
36	.005	.002661	.08276
35	.0055	.003220	.1002
	.006	.003832	.1192
	.0065	.004498	.1399
33	.007	.005216	.1622
	.0075	.005988	.1862
32	.008	.006813	.2119
	.0085	.007691	.2392
31	.009	.008622	.2682
	.0095	.009607	.2988
30	.010	.01065	.3313
29	.011	.01288	.4006
	.012	.01533	.4768
28	.013	.01799	.5596
27	.014	.02086	.6488
	.015	.02395	.7449
26	.016	.02725	.8476
	.017	.03076	.9567

B. & S. gauge	Diameter (inches)	Troy ounces	Grams
25	.018	.03449	1.073
	.019	.03843	1.195
24	.020	.04258	1.324
	.021	.04694	1.460
	.022	.05152	1.602
23	.023	.05631	1.751
	.024	.06132	1.907
22	.025	.06653	2.069
	.026	.07196	2.238
	.027	.07760	2.414
21	.028	.08346	2.596
	.029	.08952	2.784
	.030	.09581	2.980
	.031	.1023	3.182
20	.032	.1090	3.182
	.033	.1159	3.605
	.034	.1231	3.829
	.035	.1304	4.056
19	.036	.1380	4.292
	.037	.1457	4.532
	.038	.1537	4.781
	.039	.1619	5.036
18	.040	.1730	5.297
	.041	.1789	5.564
	.042	.1878	5.841
	.043	.1968	6.118
	.044	.2061	6.410
17	.045	.2156	6.706
	.046	.2253	7.008
	.047	.2352	7.316
	.048	.2453	7.630
	.049	.2556	7.950
	.050	.2661	8.277
16	.051	.2769	8.613
	.052	.2878	8.952
	.053	.2990	9.300
	.054	.3104	9.655
	.055	.3220	10.02
	.056	.3338	10.38
15	.057	.3459	10.76
	.058	.3581	11.14
	.059	.3705	11.52
	.060	.3832	11.92
	.061	.3961	12.32
	.062	.4092	12.73
	.063	.4225	13.14
14	.064	.4360	13.56
	.065	.4498	13.99
	.066	.4637	14.42
	.067	.4779	14.86
	.068	.4922	15.31
	.069	.5068	15.76
	.070	.5216	16.22
	.071	.5366	16.69
13	.072	.5518	17.16
	.073	.5672	17.64
	.074	.5829	18.13

B. & S. gauge	Diameter (inches)	Troy ounces	Grams
13	.075	.5988	18.62
	.076	.6149	19.13
	.077	.6311	19.63
	.078	.6476	20.14
	.079	.6643	20.66
	.080	.6812	21.19
12	.081	.6984	21.72
	.082	.7161	22.27
	.083	.7333	22.81
	.084	.7511	23.36
	.085	.7691	23.92
	.086	.7873	24.49
	.087	.8057	25.06
	.088	.8244	25.64
	.089	.8432	26.23
	.090	.8622	26.82
11	.091	.8815	27.42
	.092	.9010	28.02
	.093	.9207	28.64
	.094	.9406	29.26
	.095	.9607	29.88
	.096	.9810	30.51
	.097	1.002	31.17
	.098	1.022	31.79
	.099	1.043	32.44
	.100	1.065	33.13
	.101	1.086	33.78
10	.102	1.108	34.46
	.103	1.129	35.12
	.104	1.151	35.80
	.105	1.174	36.52
	.106	1.196	37.20
	.107	1.219	37.92
	.108	1.242	38.63
	.109	1.265	39.35
	.110	1.288	40.06
	.111	1.312	40.81
	.112	1.335	41.52
	.113	1.359	42.27
9	.114	1.383	43.02
	.115	1.408	43.79
	.116	1.432	44.54
	.117	1.457	45.32
	.118	1.482	46.10
	.119	1.507	46.87
	.120	1.533	47.68
	.121	1.558	48.46
	.122	1.584	49.27
	.123	1.611	50.11
	.124	1.637	50.92
	.125	1.664	51.76
	.126	1.690	52.56
	.127	1.717	53.40
8	.128	1.744	54.24
	.129	1.771	55.08
	.130	1.799	55.96
	.131	1.827	56.83
	.132	1.855	57.70
	.133	1.883	58.57
	.134	1.912	59.47
	.135	1.941	60.37
	.136	1.969	61.24
	.137	1.998	62.14
	.138	2.027	63.05

Weight tables (continued)

Weight per foot of wire in troy ounces and grams

(Multiply ounces or grams by the Weight Conversion Factor to obtain the correct weight for a particular metal.)

B. & S. gauge	Diameter (inches)	Troy ounces	Grams
8	.139	2.057	63.98
	.140	2.086	64.88
	.141	2.146	66.75
	.143	2.177	67.71
7	.144	2.208	68.63
	.145	2.239	69.63
	.146	2.270	70.60
	.147	2.301	71.57
	.148	2.332	72.53
	.149	2.363	73.50
	.150	2.395	74.49
	.151	2.427	75.49
	.152	2.459	76.48
	.153	2.492	77.51
	.154	2.525	78.54
	.155	2.558	79.56
	.156	2.591	80.59
	.157	2.624	81.62
	.158	2.657	82.64
	.159	2.691	83.70
	.160	2.725	84.76
	.161	2.759	85.81
6	.162	2.794	86.90
	.163	2.828	87.96
	.164	2.864	89.08
	.165	2.899	90.17
	.166	2.934	91.26
	.167	2.969	92.35
	.168	3.004	93.43
	.169	3.040	94.55
	.170	3.076	95.67
	.171	3.113	96.83
	.172	3.149	97.94
	.173	3.186	99.10
	.174	3.224	100.3
	.175	3.261	101.4
	.176	3.298	102.6
	.177	3.335	103.7
	.178	3.373	104.9
	.179	3.411	106.1
	.180	3.449	107.3
	.181	3.487	108.5
5	.182	3.526	109.7
	.183	3.565	110.9
	.184	3.604	112.1
	.185	3.644	113.3
	.186	3.684	114.6
	.187	3.723	115.8
	.188	3.762	117.0
	.189	3.803	118.3
	.190	3.843	119.5
	.191	3.883	120.8
	.192	3.924	122.1
	.193	3.965	123.3
	.194	4.007	124.6

B. & S. gauge	Diameter (inches)	Troy ounces	Grams
5	.195	4.048	125.9
	.196	4.090	127.2
	.197	4.131	128.5
	.198	4.173	129.8
	.199	4.215	131.2
	.200	4.258	132.4
	.201	4.301	133.8
	.202	4.344	135.1
	.203	4.387	136.5
4	.204	4.431	137.8
	.205	4.474	139.2
	.206	4.518	140.5
	.207	4.562	141.9
	.208	4.606	143.3
	.209	4.650	144.6
	.210	4.694	146.0
	.211	4.739	147.4
	.212	4.784	148.8
	.213	4.830	150.2
	.214	4.876	151.7
	.215	4.921	153.1
	.216	4.967	154.5
	.217	5.013	155.9
	.218	5.059	157.4
	.219	5.106	158.8
	.220	5.152	160.2
	.221	5.199	161.7
	.222	5.246	163.2
	.223	5.294	164.7
	.224	5.342	166.2
	.225	5.390	167.6
	.226	5.438	169.1
	.227	5.486	170.6
	.228	5.534	172.1
3	.229	5.582	173.6
	.230	5.631	175.1
	.231	5.680	176.9
	.232	5.730	178.2
	.233	5.779	179.7
	.234	5.830	181.3
	.235	5.880	182.9
	.236	5.930	184.4
	.237	5.980	186.0
	.238	6.030	187.5
	.239	6.080	189.1
	.240	6.132	190.7
	.241	6.183	192.3
	.242	6.234	193.9
	.243	6.286	195.5
	.244	6.339	197.2
	.245	6.390	198.8
	.246	6.443	200.4
	.247	6.496	202.0
	.248	6.547	203.6
	.249	6.601	205.3
	.250	6.653	206.9

Length conversion table

Unit	Inches	Feet	Millimeters	Centimeters	Meters
linear inch	1.0	0.0833	25.400	2.54	0.0254
linear foot	12.0	1.0	304.800	30.480	0.3048
linear millimeter	0.03937	0.00328	1.0	0.1	0.001
linear centimeter	0.3937	0.0328	10.0	1.0	0.01
linear meter	39.37	3.2808	1000.0	100.0	1.0

Volume conversion table

Unit	Cu. inches	Cu. feet	Cu. millimeters	Cu. c entimeters	Cu. meters
cubic inch	1.0	0.0000578	16387.0	16.387	0.00001639
cubic foot	1728.0	1.0	28316736.0	28316.7	0.028317
cubic millimeter	0.000061	0.000000035	1.0	0.001	0.000000001
cubic centimeter	0.061	0.000035	1000.0	1.0	0.000001
cubic meter	61023.0	35.314	1000000000.0	1000000.0	1.0

Area conversion table

Unit	Sq. inches	Sq. feet	Sq. millimeters	Sq. centimeters	Sq. meters	
square inch	1.0	0.00694	645.16	6.4516	0.064516	0.000645
square foot	144.0	1.0	92903.0	9.2903	0.0929	
square millimeter	0.00155	0.00001076	1.0	0.01	0.0001	0.000001
square centimeter	0.155	0.001076	100.0	1.0	0.010	0.0001
square decimeter	15.500	0.1076	10000.0	100.0	1.0	0.010
square meter	1550.0	10.76	1000000.0	10000.0	100.0	1.0

Pressure conversion table

Unit	Kilograms per sq. cm	Pounds per sq. feet	Atmospheres	Inches mercury @ 0°C	Inches water @0°C	Millimeters mercury @ 0°C	Millimeters water @0°C
kilograms per square centimeter	1.0	14.22	0.9678	28.96	394.05	735.5	1006.9
pounds per square inch	0.07031	1.0	0.06804	2.036	27.70	51.7	703.5
atmospheres	1.0332	14.696	1.0	29.92	407.14	760.0	10340.0
inches mercury at 0°C	0.03453	0.4912	0.03342	1.0	13.61	25.4	345.6
inches water at 15°C	0.002538	0.0361	0.002456	0.07349	1.0	1.87	25.4
millimeters mercury at 0°C	0.001360	0.019338	0.001447	0.03937	0.535745	1.0	14.96
millimeters water at 15°C	0.000099	0.001421	0.000097	0.002894	0.03937	0.066837	1.0

Temperature conversion table

°F		°C
-36.4	-38	-38.89
-32.8	-36	-37.78
-29.2	-34	-36.67
-25.6	-32	-35.56
-22.0	-30	-34.44
+17.6	-8	-22.22
+21.2	-6	-21.11
+24.8	-4	-20.00
+28.4	-2	-18.89
+32.0	0	-17.78
+35.6	+2	-16.67
+39.2	+4	-15.56
+42.8	+6	-14.44
+46.4	+8	-13.33
+50.0	+10	-12.22
+53.6	+12	-11.11
+57.2	+14	-10.00
+60.8	+16	-8.89
+64.4	+18	-7.78
+68.0	+20	-6.67
+71.6	+22	-5.56
+75.2	+24	-4.44
+78.8	+26	-3.33
+82.4	+28	-2.22
+86.0	+30	-1.11
+89.6	+32	0.00
+93.2	+34	+1.11
+96.8	+36	+2.22
+100.4	+38	+3.33
+104.0	+40	+4.44
107.6	42	5.56
111.2	44	6.67
114.8	46	7.78
118.4	48	8.89
122.0	50	10.00
125.6	52	11.11
129.2	54	12.12
132.8	56	13.33
136.4	58	14.44
140.0	60	15.56
143.6	62	16.67
147.2	64	17.78
150.8	66	18.89
154.4	68	20.00
158.0	70	21.11
161.6	72	22.22
165.2	74	23.33
168.9	76	24.44
172.4	78	25.56
176.0	80	26.67
179.6	82	27.78
183.2	84	28.89
186.8	86	30.00
190.0	88	31.11
194.0	90	32.22
197.6	92	33.33
201.2	94	34.44
204.8	96	35.56
208.4	98	36.67
212.0	100	37.78
215.6	102	38.89
219.2	104	40.00
222.8	106	41.11
226.4	108	42.22
230.0	110	43.33

°F		°C
233.6	112	44.44
237.2	114	45.56
240.8	116	46.67
244.4	118	47.78
248.0	120	48.89
251.6	122	50.00
255.2	124	51.11
258.8	126	52.22
262.4	128	53.33
266.0	130	54.44
269.6	132	55.56
273.2	134	56.67
276.8	136	57.78
280.4	138	58.89
284.0	140	60.00
287.6	142	61.11
291.2	144	62.22
294.8	146	63.33
298.4	148	64.44
302.0	150	65.56
305.6	152	66.67
309.2	154	67.78
312.8	156	68.89
316.4	158	70.00
320.0	160	71.11
323.6	162	72.22
327.2	164	73.33
330.8	166	74.44
334.4	168	75.56
338.0	170	76.67
341.6	172	77.78
345.2	174	78.89
348.8	176	80.00
352.4	178	81.11
356.0	180	82.22
359.6	182	83.33
363.2	184	84.44
366.8	186	85.56
370.4	188	86.67
374.0	190	87.78
377.6	192	88.89
381.2	194	90.00
384.8	196	91.11
388.4	198	92.22
392.0	200	93.33
395.6	202	94.44
399.2	204	95.56
402.8	206	96.67
406.4	208	97.78
410.0	210	98.89
413.6	212	100.00
417.2	214	101.11
420.8	216	102.22
424.4	218	103.33
428.0	220	104.44
431.6	222	105.56
435.2	224	106.67
438.8	226	107.78
442.4	228	108.89
446.0	230	110.00
449.6	232	111.11
453.2	234	112.22
456.8	236	113.33
460.4	238	114.44
464.0	240	115.56

°F		°C
467.6	242	116.67
471.2	244	117.78
474.8	246	118.89
478.4	248	120.00
482.0	250	121.11
485.6	252	122.22
489.2	254	123.33
492.8	256	124.44
496.4	258	125.56
500.0	260	126.67
503.6	262	127.78
507.2	264	128.89
510.8	266	130.00
514.4	268	131.00
518.0	270	132.22
521.6	272	133.33
525.2	274	134.44
528.8	276	135.56
532.4	278	136.67
536.0	280	137.78
539.6	282	138.89
543.2	284	140.00
546.8	286	141.11
550.4	288	142.22
554.0	290	143.33
557.6	292	144.44
561.2	294	145.56
564.8	296	146.67
568.4	298	147.78
572.0	300	148.89
575.6	302	150.00
579.2	304	151.11
582.8	306	152.22
586.4	308	153.33
590.0	310	154.44
593.6	312	155.56
597.2	314	156.67
600.8	316	157.78
604.4	318	158.89
608.0	320	160.00
611.6	322	161.11
615.2	324	162.22
618.8	326	163.33
622.4	328	164.44
626.0	330	165.56
629.6	332	166.67
633.2	334	167.78
636.8	336	168.89
640.4	338	170.00
644.0	340	171.11
647.6	342	172.22
651.2	344	173.33
654.8	346	174.44
658.4	348	175.56
662.0	350	176.67
665.6	352	177.78
669.2	354	178.89
672.8	356	180.00
676.4	358	181.11
680.0	360	182.22
683.6	362	183.33
687.2	364	184.44
690.8	366	185.56
694.4	368	186.67
698.0	370	187.78

°F		°C
701.6	372	188.89
705.2	374	190.00
708.8	376	191.11
712.4	378	192.22
716.0	380	193.33
719.6	382	194.44
723.2	384	195.56
726.8	386	196.67
730.4	388	197.78
734.0	390	198.89
737.6	392	200.00
741.2	394	201.11
744.8	396	202.22
748.4	398	203.33
752.0	400	204.44
755.6	402	205.56
759.2	404	206.67
762.8	406	207.78
766.4	408	208.89
770.0	410	210.00
773.6	412	211.11
777.2	414	212.22
780.8	416	213.33
784.4	418	214.44
788.0	420	215.56
791.6	422	216.67
795.2	424	217.78
798.8	426	218.89
802.4	428	220.00
806.0	430	221.11
809.6	432	222.22
813.2	434	223.33
816.8	436	224.44
820.4	438	225.56
824.0	440	226.67
827.6	442	227.78
831.2	444	228.89
834.8	446	230.00
838.4	448	231.11
842.0	450	232.22
845.6	452	233.33
849.2	454	234.44
852.8	456	235.56
856.4	458	236.67
860.0	460	237.78
863.6	462	238.89
867.2	464	240.00
870.8	466	241.11
874.4	468	242.22
878.0	470	243.33
881.6	472	244.44
885.2	474	245.56
888.8	476	246.67
892.4	478	247.78
896.0	480	248.89
899.6	482	250.00
903.2	484	251.11
906.8	486	252.22
910.4	488	253.33
914.0	490	254.44
917.6	492	255.56
921.2	494	256.67
924.8	496	257.78
928.4	498	258.89
932.0	500	260.00

Temperature conversion table

°F		°C
935.6	502	261.11
939.2	504	262.22
942.8	506	263.33
946.4	508	264.44
950.0	510	265.56
953.6	512	266.67
957.2	514	267.78
960.8	516	268.89
964.4	518	270.00
968.0	520	271.11
971.6	522	272.22
975.2	524	273.33
978.8	526	274.44
982.4	528	275.56
986.0	530	276.67
989.6	532	277.78
993.2	534	278.89
996.8	536	280.00
1000.4	538	281.11
1004.0	540	282.22
1007.6	542	283.33
1011.2	544	284.44
1014.8	546	285.56
1018.4	548	286.67
1022.0	550	287.78
1040.0	560	293.33
1058.0	570	298.89
1076.0	580	304.44
1094.0	590	310.00
1112.0	600	315.56
1130.0	610	321.11
1148.0	620	326.67
1166.0	630	332.22
1184.0	640	337.78
1202.0	650	343.33
1220.0	660	348.89
1238.0	670	354.44
1256.0	680	360.00
1274.0	690	365.56
1292.0	700	371.11
1310.0	710	376.67
1328.0	720	382.22
1346.0	730	387.78
1364.0	740	393.33
1382.0	750	398.89
1400.0	760	404.44
1418.0	770	410.00
1436.0	780	415.56
1454.0	790	421.11
1472.0	800	426.67
1490.0	810	432.22
1508.0	820	437.76
1526.0	830	443.33
1544.0	840	448.89
1562.0	850	454.44
1580.0	860	460.00
1598.0	870	465.56
1616.0	880	471.11
1634.0	890	476.67
1652.0	900	482.22
1670.0	910	487.78
1688.0	920	493.33
1706.0	930	498.89
1724.0	940	504.44
1742.0	950	510.00

°F		°C
1760.0	960	515.56
1778.0	970	521.11
1796.0	980	526.67
1814.0	990	532.22
1832.0	1000	537.78
1850.0	1010	543.33
1868.0	1020	548.89
1886.0	1030	554.44
1904.0	1040	560.00
1922.0	1050	565.56
1940.0	1060	571.11
1958.0	1070	576.67
1976.0	1080	582.22
1994.0	1090	587.78
2012.0	1100	593.33
2030.0	1110	598.89
2048.0	1120	604.44
2066.0	1130	610.00
2084.0	1140	615.56
2102.0	1150	621.11
2120.0	1160	626.67
2138.0	1170	632.22
2156.0	1180	637.78
2174.0	1190	643.33
2192.0	1200	648.89
2210.0	1210	654.44
2228.0	1220	660.00
2246.0	1230	665.56
2264.0	1240	671.11
2282.0	1250	676.67
2300.0	1250	676.67
2318.0	1260	682.22
2336.0	1280	693.33
2354.0	1290	698.89
2372.0	1300	704.44
2390.0	1310	710.00
2408.0	1320	715.56
2426.0	1330	721.11
2444.0	1340	726.67
2462.0	1350	732.22
2480.0	1360	737.78
2498.0	1370	743.33
2516.0	1380	748.89
2534.0	1390	754.44
2552.0	1400	760.00
2570.0	1410	765.56
2588.0	1420	771.11
2606.0	1430	776.67
2624.0	1440	782.22
2642.0	1450	787.78
2660.0	1460	793.33
2678.0	1470	798.89
2696.0	1480	804.44
2714.0	1490	810.00
2732.0	1500	815.56
2750.0	1510	821.11
2768.0	1520	826.67
2786.0	1530	832.22
2804.0	1540	837.78
2822.0	1550	843.33
2840.0	1560	848.89
2858.0	1570	854.44
2876.0	1580	860.00
2894.0	1590	865.56
2912.0	1600	871.11

°F		°C
2930.0	1610	876.67
2948.0	1620	882.22
2966.0	1630	887.78
2984.0	1640	893.33
3002.0	1650	898.89
3020.0	1660	904.44
3038.0	1670	910.00
3056.0	1680	915.56
3074.0	1690	921.11
3092.0	1700	926.67
3110.0	1710	932.22
3128.0	1720	937.78
3146.0	1730	943.33
3164.0	1740	948.89
3182.0	1750	954.44
3200.0	1760	960.00
3218.0	1770	965.56
3236.0	1780	971.11
3254.0	1790	976.67
3272.0	1800	982.22
3290.0	1810	987.78
3308.0	1820	993.33
3326.0	1830	998.89
3344.0	1840	1004.4
3362.0	1850	1010.0
3380.0	1860	1015.6
3398.0	1870	1021.1
3416.0	1880	1026.7
3434.0	1890	1032.2
3452.0	1900	1037.8
3470.0	1910	1043.3
3488.0	1920	1048.9
3506.0	1930	1054.4
3524.0	1940	1060.0
3542.0	1950	1065.5
3560.0	1960	1071.1
3578.0	1970	1076.7
3596.0	1980	1082.2
3614.0	1990	1087.8
3632.0	2000	1093.3
3650.0	2010	1098.9
3668.0	2020	1104.4
3686.0	2030	1110.0
3704.0	2040	1115.6
3722.0	2050	1121.1
3740.0	2060	1126.7
3758.0	2070	1132.2
3776.0	2080	1137.8
3794.0	2090	1143.3
3712.0	2100	1148.9
3830.0	2110	1154.4
3848.0	2120	1160.0
3866.0	2130	1165.5
3884.0	2140	1171.1
3902.0	2150	1176.7
3920.0	2160	1182.2
3938.0	2170	1187.8
3956.0	2180	1193.3
3974.0	2190	1198.9
3992.0	2200	1204.4
4010.0	2210	1210.0
4028.0	2220	1215.6
4046.0	2230	1221.1
4064.0	2240	1226.7
4082.0	2250	1232.2

°F		°C
4100.0	2260	1237.8
4118.0	2270	1243.3
4136.0	2280	1248.9
4154.0	2290	1254.4
4172.0	2300	1260.0
4190.0	2310	1265.6
4208.0	2320	1271.1
4226.0	2330	1276.7
4244.0	2340	1282.2
4262.0	2350	1287.8
4280.0	2360	1293.3
4298.0	2370	1298.9
4316.0	2380	1304.4
4334.0	2390	1310.0
4352.0	2400	1315.6
4370.0	2410	1321.1
4388.0	2420	1326.7
4406.0	2430	1332.2
4424.0	2440	1337.8
4442.0	2450	1343.3
4460.0	2460	1348.9
4478.0	2470	1354.4
4496.0	2480	1360.0
4514.0	2490	1365.6
4532.0	2500	1371.1
4550.0	2510	1376.7
4568.0	2520	1382.2
4586.0	2530	1387.8
4604.0	2540	1393.3
4622.0	2550	1398.9
4640.0	2560	1404.0
4658.0	2570	1410.0
4676.0	2580	1415.6
4694.0	2590	1421.1
4712.0	2600	1426.7
4730.0	2610	1432.2
4748.0	2620	1437.8
4766.0	2630	1443.3
4784.0	2640	1448.9
4802.0	2650	1454.4
4820.0	2660	1460.0
4838.0	2670	1465.6
4856.0	2680	1471.1
4874.0	2690	1476.7
4892.0	2700	1482.2
49.10.0	2710	1487.8
4928.0	2720	1493.3
4946.0	2730	1498.9
4964.0	2740	1504.4
4982.0	2750	1510.0
5000.0	2760	1515.6
5018.0	2770	1521.1
5036.0	2780	1526.7
5054.0	2790	1532.2
5072.0	2800	1537.8
5090.0	2810	1543.3
5108.0	2820	1548.9
5126.0	2830	1554.4
5144.0	2840	1560.0
5162.0	2850	1565.6
5180.0	2860	1571.1
5198.0	2870	1576.7
5216.0	2880	1582.2
5234.0	2890	1587.8
5252.0	2900	1593.3

Temperature conversion table

°F		°C
5270.0	2910	1598.9
5288.0	2920	1604.4
5306.0	2930	1610.0
5324.0	2940	1615.6
5342.0	2950	1621.1
5360.0	2960	1626.7
5378.0	2970	1632.2
5396.0	2980	1637.8
5414.0	2990	1643.3
5432.0	3000	1648.9
5450.0	3010	1654.4
5468.0	3020	1660.0
5486.0	3030	1665.6
5504.0	3040	1671.1
5522.0	3050	1676.7
5540.0	3060	1682.2
5558.0	3070	1687.3
5576.0	3080	1693.3
5594.0	3090	1698.9
5612.0	3100	1704.4

°F		°C
5702.0	3150	1732.2
5792.0	3200	1760.0
5882.0	3250	1787.8
5972.0	3300	1815.6
6062.0	3350	1843.3
6152.0	3400	1871.1
6242.0	3450	1898.9
6332.0	3500	1926.7
6422.0	3550	1954.4
6512.0	3600	1982.2
6602.0	3650	2010.0
6692.0	3700	2037.8
6782.0	3750	2065.6
6872.0	3800	2093.3
6962.0	3850	2121.1
7052.0	3900	2148.9
7142.0	3950	2176.7
7232.0	4000	2204.4
7322.0	4050	2232.2
7412.0	4100	2260.0

°F		°C
7502.0	4150	2287.8
7592.0	4200	2315.6
7682.0	4250	2343.3
7772.0	4300	2371.1
7862.0	4350	2398.9
7952.0	4400	2426.7
8042.0	4450	2454.4
8132.0	4500	2482.2
8222.0	4550	2510.0
8312.0	4600	2537.8
8402.0	4650	2565.6
8492.0	4700	2593.3
8582.0	4750	2621.1
8672.0	4800	2648.9
8762.0	4850	2676.7
8852.0	4900	2704.4
8942.0	4950	2732.2
9032.0	5000	2760.0
9122.0	5050	2787.8
9212.0	5100	2815.6

°F		°C
9302.0	5150	2843.3
9392.0	5200	2871.1
9482.0	5250	2898.9
9572.0	5300	2926.7
9662.0	5350	2954.4
9752.0	5400	2982.2
9842.0	5450	3010.0
9932.0	5500	3037.8
10,022.0	5550	3065.6
10,112.0	5600	3093.3

Conversion table of troy, avoirdupois and metric weights

Unit	Troy grain	Troy dwt	Troy ounce	Troy pound	Avoir ounce	Avoir pound	Milligram	Gram	Kilogram
1 troy grain	1.0	0.04166	0.0020833	0.000173611	0.00228571	0.00014285	64.79897	0.06479897	0.000064798
1 troy dwt	24.0	1.0	0.05	0.0041666	0.0548571	0.0034285	1555.1754	1.5551754	0.001555175
1 troy ounce	480.0	20.0	1.0	0.08333333	1.0971428	0.0685714	31103.495	31.103495	0.03110349
1 troy pound	5760.0	240.0	12.0	1.0	13.165714	0.822857	373241.9478	373.24194478	0.37324194
1 avoir ounce	7000.0	291.66666	14.583333	1.215277	16.0	1.0	453592.6449	453.5926449	0.45359264
1 milligram	0.015432349	0.00064301	0.00003251	0.00000026792	0.00003527	1.0	0.001	0.000001	
1 gram	15.432349	0.6430145	0.03215072	0.0026792272	0.03527394	0.00220462	1000.0	1.0	0.001
1 kilogram	15432.349	643.0145	32.150727	2.67922725	3.527394	2.20462	1000000.0	1000.0	1.0

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