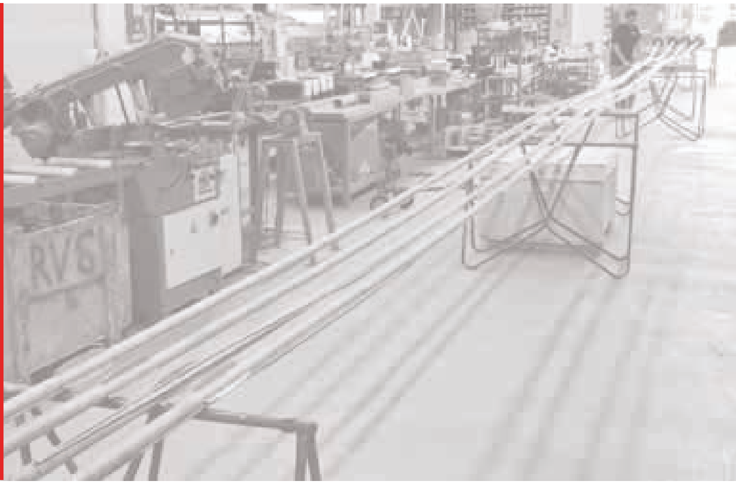
THERMO ELECTRIC
INSTRUMENTATION

Temperature Guide Book



Innovative Temperature Measurement Solutions

THERMO ELECTRIC INSTRUMENTATION B.V.

"We are an innovative organisation and highly experienced specialists in temperature measuring solutions. Spanning over 50 years of temperature sensing manufacturing, the original activities of Thermo Electric addressed a specific market need: measuring exhaust gas temperatures from aeroplane engines.

Today our company is proud to manufacture and supply a complete range of temperature sensors, wires, cables and connectors for almost every application and market. We are at the forefront of technology for temperature sensing and ancillary equipment. Our products continue to outperform in the field, providing reliable solutions worldwide.

We manufacture products capable of withstanding corrosive chemicals, vibrations, extreme temperatures and high pressures, ranging from the absolute zero point (-273 °C) to over 2.700 °C. It is here where we are at our best.

Our business touches global markets, however we act locally. Our network of factories, distribution, sales and service centers span Europe, Middle East and Asia.

We have also had the fortunate pleasure of working on the most prestige engineering contracts, alongside some of the largest organizations for many years. The successes we have experienced on these major projects can be attributed to our highly knowledgeable and experienced workforce.

Thermo Electric Instrumentation has over 60 personnel strategically placed in major industrial areas. This global strategy allows us to service our customers worldwide, providing the individual temperature measuring solutions that are required in today's market".

Jan-Willem Noordermeer
Managing Director Thermo Electric Instrumentation B.V.

MANUFACTURING FACILITIES

We have dedicated manufacturing and testing facilities located in The Netherlands. Thermo Electric temperature sensing products are supplied direct from our headquarters to our customers, through sales and service centres across the globe.

High standards and efficient supply

Our dedicated central production and engineering facilities allow us to maintain our high standards and best practice in engineering and design. This expertise is reflected in the efficient supply of Thermo Electric temperature sensors and in our consistent achievement of quality in the field.

Services

- Wake frequency calculations according ASME PTC19.3 (2010) for thermowells
- X-rays
- Welding robot
- Manufacturing record book
- Quality inspection plan
- Explosion safe certificate Exi, Exe, Exd, Exn
- Material certificate (according EN10204 3.1 and NACE MR0175)
- Cleaning for oxygen service
- Visual inspection
- Dimensional check
- Drawings for approval
- WPS and PQR for welded Thermowells
- Batch certificate
- Certificate of origin
- Certificate of conformance
- CSA/US
- IEC-Ex
- CCOE
- KTL
- ATEX
- GOST R

Test Facilities

- Functional performance test
- Loop resistant test
- Insulation resistance test
- Pressure test
- Calibration test From -200 °C up to 1.500 °C (RvA/ILAC)
- Calibration test for each instrument, mV, mA, Ohms and V (RvA/ILAC)
- Vacuum test
- Helium leak test
- PMI test

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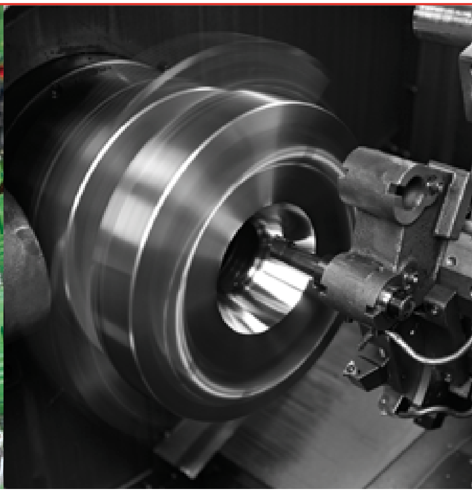


DELIVERY PROGRAMM

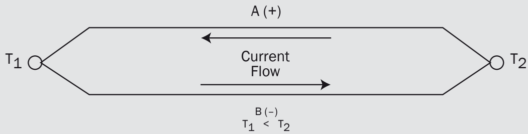
Besta	Level switches and capacitive level sensors
Gemini	One and two-channels data loggers
Gems	Pressure level and flow switches/transmitters
Honeywell	Pressure and temperature transmitters, recorders and controllers
ITT Neo-Dyn	Pressure and temperature switches
Nuova Fima	Bi-metals, pressure gauges and transmitters with chemical seals
Thermo Electric	Temperature sensors and accessories
Weka	Magnetic switches

CONTENT

SEEBECK EFFECT

T.J. Seebeck discovered the phenomenon of thermo electricity in 1821. He found the so called ‘Seebeck Effect’: if a formed circuit consists of two dissimilar metallic conductors A & B and one of the junctions of A & B is at a temperature T1 while the other junction is at a higher temperature T2; then a current will flow in the circuit and will continue to flow as long as the two junctions have different temperatures.
The E.M.F. (electromotive force) that produces this current is called the ‘Seebeck Thermal EMF’: if A is (+) compared to (B), then the current flows from A to B at T1 (fig. 1).

Fig. 1 Seebeck Effect

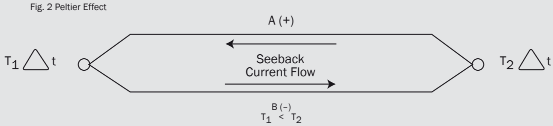


PELTIER EFFECT

In 1834 Jean C.A. Peltier reported that when a current flows across the junction of two metals, it gives rise to absorption or liberation of heat (depending upon the direction of the current). If the current happens to flow in the same direction as the current produced by the ‘Seebeck Effect’ at the hot junction (T2), heat is absorbed whereas at the cold junction (T1) heat is liberated.
For example:

- Heat is absorbed (T+_ t) when:
  a current flows across a copper-constantan hot junction from the constantan (B) to the copper (A), minus to plus.
- Conversely, heat is liberated (T- _ t) when:
  a current flows across the same junction from copper (A) to constantan (B), plus to minus (fig. 2).

Fig. 2 Peltier Effect



MAGNITUDE OF PELTIER EFFECT

It can be shown that the magnitude of the 'Peltier Effect' is given by:
- the product of the absolute temperature (°K) of the junction;
- and the rate of change of the thermal EMF of the junction at that temperature (fig. 3).

If a complete analysis is done, you will find that the 'Peltier Effect' produces no measurable change in temperature of the junction if the only current through it is due to the thermal EMF.

Fig. 3

$$\text{Magnitude of Peltier Effect} = \left(\text{Junction Temp. in } ^\circ\text{K} \right) \times \left(\text{Rate of emf Change at Junction Temp.} \right)$$

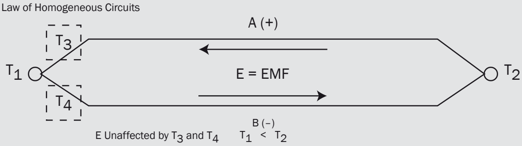
THERMO ELECTRIC LAWS

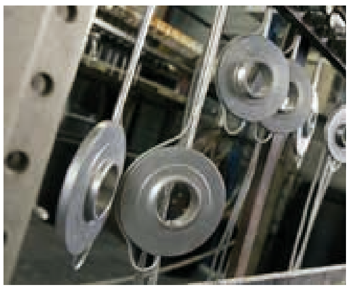
Many investigations of thermo electric circuits have been made and have resulted in the establishment of several basic precepts. These precepts, while stated in many different ways, can be reduced to three fundamental laws:
- Law of Homogeneous Circuits
- Law of Intermediate Metals
- Law of Successive or Intermediate Temperatures

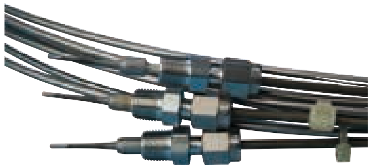
Law of Homogeneous Circuits

This law states that 'an electric current cannot be sustained in a circuit of a single homogeneous metal, however varying in section, by the application of heat alone'. If a junction of two dissimilar metals is maintained at T1, while the other is at T2, the developed thermal EMF is independent and unaffected by any temperature distribution along the wires T3 and T4 (fig. 4).

Fig. 4 Law of Homogeneous Circuits







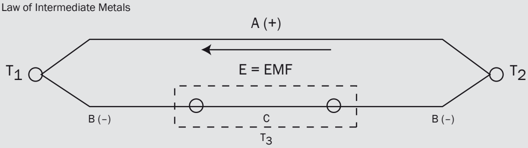
Law of Intermediate Metals

When thermocouples are used, it is usually necessary to introduce additional metals into a circuit. This happens when an instrument is used to measure the EMF and the junction is soldered or welded.

It would seem that the introduction of other metals would modify the EMF developed by the thermocouple and destroy its calibration. However the 'Law of Intermediate Metals' states that: the introduction of a third metal into a circuit will have no effect upon the generated EMF, so long as the junctions of the third metal with the other two metals are at the same temperature.

If two dissimilar metals A & B with their junctions at T1 & T2 and a third metal C are joined on one leg (if C is kept at a uniform temperature along its entire length), the total EMF in the circuit will be unaffected (fig. 5).

Fig. 5 Law of Intermediate Metals

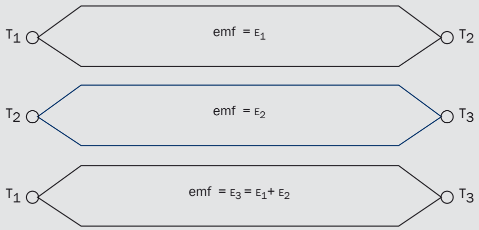


Law of Intermediate Temperatures

In most industrial installations, it is not practical to maintain the reference junction of a thermocouple at a constant temperature. So, some means must be provided to bring the EMF developed at the reference junction to a value equal to that which would be generated with a reference junction maintained at a standard temperature, usually 0 °C (32 °F).

The 'Law of Intermediate Temperatures' provides a mean for relating the EMF generated by a thermocouple under ordinary conditions, to a standardized constant temperature. In effect, the Law states that: the sum of the EMF's generated by two thermocouples (one with its junction at 0 °C (32 °F) and some reference temperature and the other with its junction at the same reference temperature and the measured temperature) is equivalent to the EMF produced by a single thermocouple with its junction at 0 °C (32 °F) and the measured temperature (fig. 6).

Fig. 6 Law of Successive or Intermediate Temperatures



emf's are Additive for Temperatures Intervals

Summary of the three laws

The three fundamental laws may be combined and stated as follows:

- the algebraic sum of the thermo electric EMF's generated in any given circuit containing any number of dissimilar homogeneous metals, is a function only of the temperature of the junction;
- if all but one of the junctions in such a circuit are maintained at some reference temperature, the EMF generated depends only on the temperature of that one junction and can be used as a measure of its temperature.

THERMOCOUPLE BODY CONSTRUCTION

There are many types of thermocouples available on today's market. Each has its own particular advantages and disadvantages. In many cases, thermocouples and their accessories are designed for a specific temperature measurement problem.
In other cases, thermocouples are manufactured with a wide variety of possible applications. It is not the intention to compare one type of thermocouple with another, or to compare the thermocouple of one manufacturer with another. No thermocouple is suitable for all needs. Thermocouples must be selected to meet the needs of a particular installation. The next basic types can be of use to guide you in your selection process.

Three basic types of construction:
1. Wire
2. Mineral insulated
3. Thermowell

1. Wire type construction

The most basic thermocouple construction is the 'wire type'. It consists of two dissimilar metals, homogeneously joined at one end to form the measuring junction.
A common factor inherent in all wire type constructions is the fact that they all have an exposed junction: although it offers good response time, it is subject to environmental restrictions.

In most cases the advantages are: a good response time, ruggedness and high temperature use. The disadvantage is the exposed junction: which means that it is susceptible to the environment (oxidizing and reducing atmospheres) and therefore it must be protected.

2. Mineral insulated construction

In order to overcome the disadvantages of the 'wire type construction', manufacturers developed the mineral insulation thermocouple. The 'mineral insulated construction' consists of two thermocouple material wires embedded in a ceramic insulation and protected by a metallic sheath.

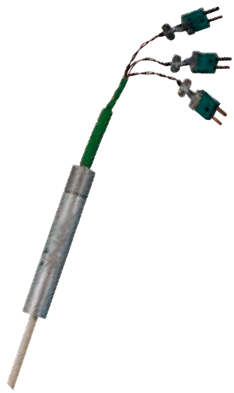
The two primary components of this construction are:
1. The mineral insulation material
2. The metallic sheath

Sheath material characteristics

The table on the next page shows just some of the many different materials which can be used to protect the minerally insulated thermocouple. The two most important parameters in selecting the sheath material are: the operating temperature and the atmospheric environment. The atmospheric environmental parameters are oxidizing, reducing, neutral and vacuum. For example, SS 304 can be used in each type of atmosphere with a maximum operating temperature of 890 °C (1,650 °F).

Mineral insulated thermocouple sheath material				
Sheath material	**Melting point °C**	**Max. temperature in air °C**	**Operating # atmosphere**	**Continuous max. temp °C**
304 SS	1400°C	1048°C	O,R,N,V	895°C
310 SS	1400°C	1071°C	O,R,N,V	1145°C
316 SS	1250°C	960°C	O,R,N,V	930°C
321 SS	1415°C	815°C	O,R,N,V	871°C
347 SS	1425°C	915°C	O,R,N,V	871°C
Inconel	1398°C	1095°C	O,N,V (c.)	1145°C
Copper	1082°C	315°C	O,R,N,V (b)	315°C
Aluminium	660°C	425°C	O,R,N,V	371°C
Platinum	1770°C	1648°C	O,N (c.)	1648°C
Molybdenum	2620°C	535°C	V,N,R	2626°C
Tantalum	3004°C	400°C	V	2760°C
Titanium	1815°C	315°C	V,N	1090°C

# Key
O = Oxidizing
R = Reducing
N = Neutral
V = Vacuum
(b) = Scales readiliy in oxidizing atmospheres
(c) = Sensitive to sulphur corrosion



Mineral insulation

The table below shows only a portion of the materials that can be used; however, the four shown are the most common.
The most important parameters to be considered in selecting the mineral insulations are the upper temperature limit and the performance characteristics at the temperature. Of course there are other parameters which should also be considered such as: resistively, purity and crushability. However, they are secondary to temperature. For example: MgO, the most commonly used (as exhibited by this table) has an upper temperature limit of 2,395 °C with high resistivity, excellent purity and very good crushability.

					STABILITY				
Insulation material	**Formula**	**Melting point °C**	**Max. limit in oxi. Atm °C**	**Thermal shock res.**	**Reducing Atm**	**Carbon**	**Acid slag**	**Basic slag**	**Metal**
Alumina	Al 2 O 3	2037°C	1954°C	Good	Good	Fair	Good	Good	Good
Magnesium	MgO	2760°C	2395°C	Fair	Poor	Good	Poor	Good	Fair
Thoria	ThO 2	3315°C	2700°C	Poor	Good	Fair	Poor	Good	Exc.
Zirconia	ZrO 2	2590°C	2510°C	Fair	Good	Fair	Good	Poor	Good

3. Thermowells and protection tubes

Thermowells and protection tubes are used to shield thermocouple sensing elements against mechanical damage and corrosive or contaminating atmospheres.
The various types and constructions which are available enable the user to select the right combination to meet individual needs.

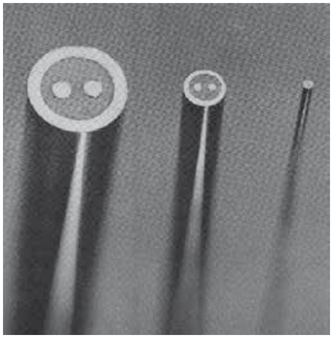
For example: cast iron protection tubes are used primarily in molten aluminium, magnesium and zinc applications. On the other hand, the ceramic tubes are used in industries such as: iron and steel, glass, cement and lime processing. Their principal advantages include: resistance to high temperatures and thermal shock, chemical inertness, good abrasion resistance and high dielectric strength.

THERMOCOUPLES IN MINERAL INS. CONSTRUCTION

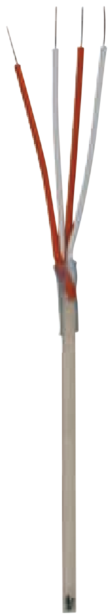
One of the many advantages of a mineral insulated cable is the protection offered to the thermocouple wires, afforded by the metal sheath. For long service life, only contamination free sheathing of known chemical and physical compositions is used.

Our standard diameters for our MI-cable (mineral insulated thermocouple cable)

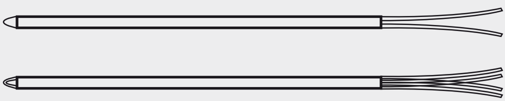
Diameter		Type T/C	Sheath Material
0.15	mm	K	Inconel 600 or SS 316
0.25	mm	K	Inconel 600 or SS 316
0.5	mm	K,N,J and T	Inconel 600 or SS 316
1.0	mm	K,N,J and T	Inconel 600 or SS 316
1.5	mm	K,N,J and T	Inconel 600 or SS 316
1/16	inch	K,N,J and T	Inconel 600 or SS 316
3.0	mm	K,N,J,R,S and T	Inconel 600 or SS 316
1/8	inch	K,N,J,R,S and T	Inconel 600 or SS 316
3/16	inch	K,N,J,R,S and T	Inconel 600 or SS 316
6.0	mm	K,N,J,R,S and T	Inconel 600 or SS 316
1/4	inch	K,N,J,R,S,and T	Inconel 600 or SS 316
5/16	inch	K,N and J	Inconel 600 or SS 316
1/2	inch	K	Inconel 600 or SS 446



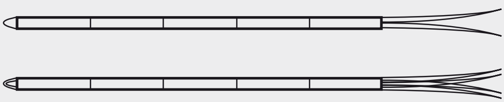
The table above lists the most common constructions. Other diameters and sheath materials are available upon request. For example: type N thermocouples are available with several sheath materials of Nicrobel and/or Pyrosil; for the platinum rhodium thermocouples, which can be higher in temperature, we recommend to use this in a construction with beads (fig. 1).



For the optimal use of type R, S and B thermocouples we use a nominal wire size of 0.5 mm as standard. The insulation material for this type of thermocouple will be aluminium oxide 99.7% purity.

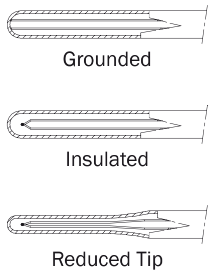


Beaded element ceramic insulator with one bead



Beaded element ceramic insulators with several beads

COMMON MEASURING JUNCTION TYPES



The hot junction is the junction which is subjected to the process or medium that is being measured or controlled.
Three common types of junctions:
1. Grounded
2. Insulated
3. Exposed (fast response)

Of these three the one which has the highest application rate in greatest use, is the grounded junction. As will be seen, its characteristics meet most requirements.

Grounded junction

In this construction the mineral insulation is completely sealed from containments and the measuring junction becomes an integral part of the tip of the thermocouple. The response time, as we will see later, approaches that of an exposed loop thermocouple. In addition, the junction conductors are completely protected from harsh environmental conditions. Small diameter thermocouples may be selected to match or better the response time of exposed loop thermocouples, yet the operational lift and upper temperature limit of the junction will be extended due to protection offered by the sheath.

Insulated measuring junction

In this construction the thermocouple conductors are welded together to form the junction which is insulated from the external sheath with the mineral insulation. The response time for an insulated junction is longer than it is for a grounded junction thermocouple of the same outside diameter. In insulated junction thermocouples, however, conductors are electrically insulated from the sheath. A feature advantageous in applications where thermocouples are used:
- in conductive solutions;
- for differential averaging (paralleled);
- for additive (series) applications;
- wherever isolation of the measuring circuitry is required.

Exposed loop junction

The exposed loop junction offers a faster thermal response time than the other two types of junctions. However this type of junction is limited to mild environmental conditions or one time usage under more severe conditions.

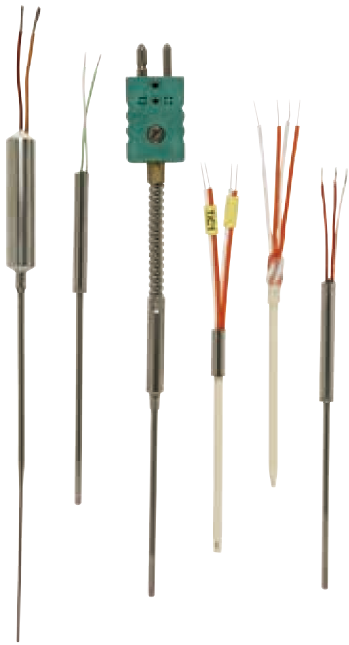
RESPONSE TIME

Some of the typical response times encountered when using these three types of junctions:

- Insulated 4.5 seconds
- Grounded 1.7 seconds
- Exposed 0.1 seconds

All values are for 6.35 mm outside diameter mineral insulated cable.

Values listed are based on the average response time of several minerally insulated cables. The time in seconds indicates time taken to undergo a change in temperature of 63.2 %.
The tests where performed during a step change from room temperature to boiling water.
Test per ASTM STP 470A (full response is approximated five time constants).



Diameter	Junction	Time in sec.
0.5 mm	insulated	0.15
0.5 mm	grounded	0.05
1.0 mm	insulated	0.3
1.0 mm	grounded	0.1
3.0 mm	insulated	1.3
3.0 mm	grounded	0.7
4.8 mm	insulated	2.2
4.8 mm	grounded	1.1
6.0 mm	insulated	4.5
6.0 mm	grounded	2.1
6.0 mm	exposed	0.1

As a general rule, it can be stated that the greater the mass of the junction, the greater the response time and the longer the service life.

THERMOCOUPLE CALIBRATION NO LIMITS OF ERROR

The object of calibrating any thermocouple or wire is to determine temperature-EMF output (voltage produced at a given temperature) as compared to the calibration table or curve.

Comparison method

This method is just what it implies: the comparison of the EMF of an unknown thermocouple with a working standard (usually another thermocouple) at the same temperature. Accuracy is first limited by the accuracy of the standard. A secondary effect limiting accuracy is the ability of the observer to bring the unknown thermocouple junction to the same temperature as the standard's measuring element.

Fixed point method

This method entails measuring unknown thermocouples at a known temperature as defined by the International Temperature Scale.

LIMITS OF ERROR: STANDARD & PREMIUM GRADE

No thermocouple can be more accurate than the wire from which it is made. Certain limits of error have been established by manufacturers and Engineering Societies to define acceptable wires for use in thermocouples.

The accuracy with which wire conforms to the tables, is determined by checking the wire at predetermined points against NBS Certified Platinum. Checking against platinum insures that individual wires can be paired and remain within standard limits. For instance: measurement at 150 °C with a type K thermocouple insures that the result will be 150 °C ±2.5 °C for standard grade material and 150 °C ±1.5°C with premium grade material.
Measurement at 550 °C with the same type K thermocouple insures that the result will be at 550 °C ±0.75% for standard grade material and at 550 °C ±0.4% for premium grade material.

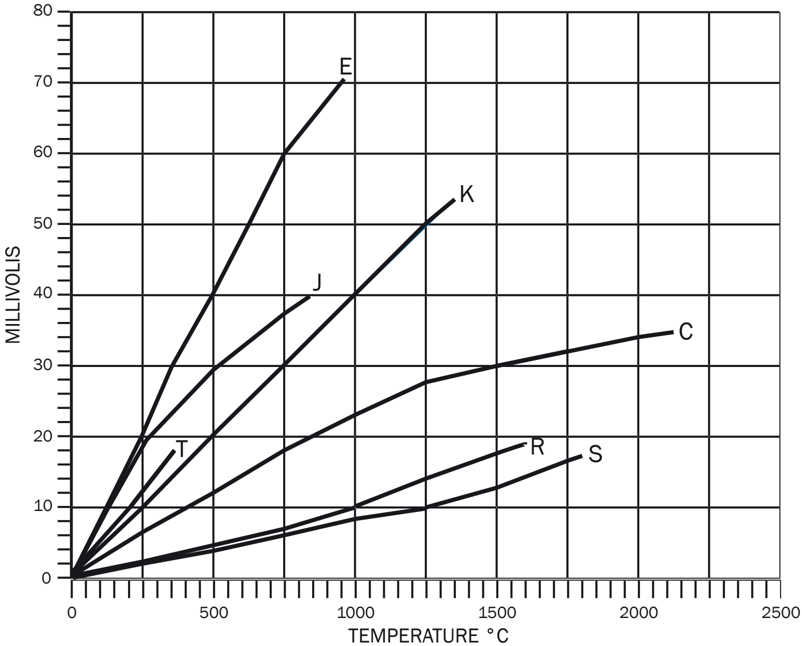
Fixed points available for selecting thermocouples

The fixed points for which values have been assigned or determined accurately and at which it has been found convenient to calibrate thermocouples are given. In selecting the points at which to calibrate a thermocouple, one has a choice between a boiling point and a freezing point.

For example: the boiling point of oxygen or the freezing point of mercury. In determining the EMF of a thermocouple at freezing point, the time during dissertation which observations may be taken is limited to the period of freezing, after which the material must be melted again before taking futher observations. In case of boiling points, there is no such limit in since the material can be boiled continiously.

This brochure attempted to summarize the important aspects of thermocouple temperature sensors. It has primarily been aimed at the industrial user in order to help him understand more fully the basic principles of thermocouples. The field of temperature measurement is so vast, that each topic could have been a brochure itself.

We have briefly described the theoretical foundation of the thermocouple thermometry aspect, the basic construction of the thermocouples, two methods of calibration and the critical parameters to be considered in the selection of practical sensors.



TOLERANCE CLASSES FOR THERMOCOUPLES (REFERENCE JUNCTION AT 0 °C)

TYPE	NAME	Range °C	Range °C	Acc. IEC 584 Class 1	Acc. IEC 584 Class 2	Acc. IEC 584 Class 3
						Basic -200°C to +40°C
J	IRON-CONSTANTAN	-40	750	±1,5°C OR 0,4% t	±2,5°C OR 0,75% t	±2,5°C OR 0,15% t
K	CHROMEL-ALUMEL	-40	1200	±1,5°C OR 0,4% t	±2,5°C OR 0,75% t	±2,5°C OR 0,15% t
N	NICROSIL-NISIL	-40	1200	±1,5°C OR 0,4% t	±2,5°C OR 0,75% t	±2,5°C OR 015% t
E	CHROMEL-CONSTANTAN	-40	900	±1,5°C OR 0,4% t	±2,5°C OR 0,75% t	±2,5°C OR 015% t
T	COPPER-CONSTANTAN	-40	350	±0,5°C OR 0,4% t	±1,0°C OR 0,75% t	±1,0°C OR 0,15 t
R	PLATINUM 13%Rh-PLATINUM	0	1600	±1,0	±1,5°C OR 0,25% t	N.A.
S	PLATINUM 10%Rh-PLATINUM	0	1600	±1,0	±1,5°C OR 0,25% t	N.A.
B	PLATINUM 6%Rh-PLATINUM 30%Rh	600	1800	N.A.	±1,5°C OR 0,25% t	N.A.

FOR OTHER INTERNATIONAL THERMOCOUPLE STANDARDS PLEASE CONTACT OUR SALES OFFICE

ANSI (ASTM)
BS
DIN
JIS

Type J: Iron/copper-nickel (1)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
-210	-8 095										-210
-200	-7 890	-7 912	-7 934	-7 955	-7 976	-7 996	-8 017	-8 037	-8 057	-8 076	-200
-190	-7 659	-7 683	-7 707	-7 731	-7 755	-7 778	-7 801	-7 824	-7 846	-7 868	-190
-180	-7 403	-7 429	-7 456	-7 482	-7 508	-7 534	-7 559	-7 585	-7 610	-7 634	-180
-170	-7 123	-7 152	-7 181	-7 209	-7 237	-7 265	-7 293	-7 321	-7 348	-7 376	-170
-160	-6 821	-6 653	-6 883	-6 914	-6 944	-6 975	-7 005	-7 035	-7 064	-7 094	-160
-150	-6 500	-6 533	-6 566	-6 698	-6 631	-6 663	-6 695	-6 727	-6 759	-6 790	-150
-140	-6 159	-6 194	-6 229	-6 263	-6 296	-6 332	-6 366	-6 400	-6 433	-6 467	-140
-130	- 5 801	-5 838	-5 874	-5 910	-5 946	-5 952	-6 018	-6 054	-6 089	-6 124	-130
-120	-5 426	-5 465	-5 503	-5 541	-5 578	-5 616	-5 653	-5 690	-5 727	-5 764	-120
-110	-5 037	-5 076	-5 116	-5 155	-5 194	-5 233	-5 272	-5 311	-5 350	-5 388	-110
-100	-4 633	-4 674	-4 714	-4 755	-4 796	-4 836	-4 877	-4 917	-4 957	-4 997	-100
-90	-4 215	-4 257	-4 300	-4 342	-4 384	-4 425	-4 467	-4 509	-4 550	-4 591	-90
-80	-3 786	-3 829	-3 872	-3 916	-3 959	-4 002	-4 045	-4 088	-4 130	-4 173	-80
-70	-3 344	-3 389	-3 434	-3 478	-3 522	-3 566	-3 610	-3 654	-3 698	-3 742	-70
-60	-2 893	-2 936	-2 984	-3 029	-3 075	-3 120	-3 165	-3 210	-3 255	-3 300	-60
-50	-2 431	-2 524	-2 524	-2 571	-2 617	-2 663	-2 709	-2 765	-2 801	-2 847	-50
-40	-1 961	-2 008	-2 055	-2 103	-2 150	-2 197	-2 244	-2 291	-2 335	-2 385	-40
-30	-1 482	-1 530	-1 578	-1 626	-1 674	-1 722	-1 770	-1 818	-1 865	-1 913	-30
-20	-995	-1 044	-1 093	-1 142	-1 190	-1 239	-1 283	-1 336	-1 385	-1 433	-20
-10	-501	-550	-600	-50	-699	-749	-798	-847	-896	-946	-10
0	0	-50	-101	-151	-201	-251	-301	-351	-401	-451	0

Electromotive force as a function of temperature

Type J: Iron/copper-nickel (continued) (2)

	E/μV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
0	0	50	101	151	202	253	303	354	405	456	0
10	507	558	609	660	711	762	814	865	916	956	10
20	1 019	1 071	1 122	1 174	1 226	1 277	1 329	1 381	1 433	1 485	20
30	1 537	1 589	1 641	1 693	1 745	1 797	1 849	1 902	1 954	2 006	30
40	2 059	2 111	2 164	2 216	2 269	2 322	2 374	2 427	2 480	2 532	40
50	2 585	2 638	2 691	2 744	2 797	2 850	2 903	2 956	3 008	3 062	50
60	3 116	3 169	3 222	3 275	3 329	3 382	3 438	3 489	3 543	3 596	60
70	3 650	3 703	3 757	3 810	3 864	3 918	3 971	4 025	4 078	4 133	70
80	4 187	4 240	4 294	4 348	4 402	4 456	4 510	4 584	4 618	4 672	80
90	4 726	4 781	4 835	4 889	4 943	4 997	5 052	5 106	5 160	5 215	90
100	5 269	5 323	5 378	5 432	5 487	5 541	5 596	6 650	5 705	5 759	100
110	5 814	5 868	5 923	5 977	6 032	6 087	6 141	6 196	6 251	6 306	110
120	6 360	6 415	6 470	6 525	6 579	6 634	6 689	6 744	6 799	6 854	120
130	6 909	6 964	7 019	7 074	7 129	7 184	7 239	7 294	7 349	7 404	130
140	7 459	7 514	7 569	7 624	7 679	7 734	7 789	7 844	7 900	7 955	140
150	8 010	8 065	8 120	8 175	8 231	8 285	8 341	8 396	8 452	8 507	150
160	8 562	8 618	8 673	8 728	8 783	8 839	8 894	8 949	9 005	9 060	160
170	9 115	9 171	9 226	9 282	9 337	9 392	9 448	9 503	9 559	9 614	170
180	9 669	9 725	9 780	9 836	9 891	9 947	10 002	10 057	10 113	10 168	180
190	10 224	10 279	10 335	10 390	10 446	10 501	10 557	10 612	10 668	10 723	190
200	10 779	10 834	10 890	10 945	11 001	11 056	11 112	11 167	11 223	11 278	200
210	11 334	11 389	11 445	11 501	11 556	11 612	11 667	11 723	11 778	11 834	210
220	11 889	11 945	12 000	12 056	12 111	12 167	12 222	12 278	12 334	12 389	220
230	12 445	12 500	12 556	12 611	12 667	12 722	12 778	12 833	12 889	12 944	230
240	13 000	13 056	13 111	13 167	13 222	13 278	13 333	13 389	13 444	13 500	240
250	13 555	13 611	13 666	13 722	13 777	13 833	13 888	13 944	13 999	14 055	250
260	14 110	14 166	14 221	14 277	14 332	14 388	14 443	14 499	14 554	14 609	260
270	14 665	14 720	14 776	14 831	14 887	14 942	14 998	15 053	15 109	15 164	270
280	15 219	15 275	15 330	15 388	15 441	15 496	15 552	15 607	15 663	15 718	280
290	15 773	15 829	15 884	15 940	15 995	16 050	16 106	16 161	16 216	16 272	290

Electromotive force as a function of temperature

Type J: Iron/copper-nickel (continued) (3)

	E/μV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
600	33 102	33 161	33 219	33 278	33 337	33 395	33 454	33 513	33 571	33 630	600
610	33 689	33 748	33 807	33 866	33 925	33 984	34 043	34 102	34 161	34 220	610
620	34 279	34 338	34 397	34 457	34 516	34 575	34 635	34 694	34 754	34 813	620
630	34 673	34 932	34 992	35 051	35 111	35 171	35 230	35 290	35 350	35 410	630
640	35 470	35 530	35 590	35 650	35 710	35 770	35 830	35 890	35 950	36 010	640
650	36 071	36 131	36 191	36 252	36 312	36 373	36 433	36 494	36 554	36 615	650
660	36 675	36 736	36 797	36 858	36 918	36 979	37 040	37 101	37 162	37 223	660
670	37 284	37 345	37 406	37 467	37 528	37 590	37 651	37 712	37 773	37 835	670
680	37 896	37 958	38 019	38 081	38 142	38 204	38 265	38 327	38 389	38 450	680
690	38 512	38 574	38 636	38 698	38 760	38 822	38 884	38 946	39 008	39 070	690
700	39 132	39 194	39 256	39 318	39 381	39 443	39 505	39 588	39 630	39 693	700
710	39 755	39 818	39 880	39 943	40 005	40 068	40 131	40 193	40 256	40 319	710
720	40 382	40 445	40 508	40 570	40 633	40 696	40 759	40 822	40 886	40 949	720
730	41 012	41 075	41 138	41 201	41 265	41 328	41 391	41 455	41 518	41 581	730
740	41 645	41 708	41 772	41 835	41 899	41 962	42 026	42 090	42 153	42 217	740
750	42 281	42 344	42 406	42 472	42 536	42 599	42 663	42 727	42 791	42 855	750
760	42 919	42 983	43 047	43 111	43 175	43 239	43 303	43 367	43 431	43 495	760
770	43 559	43 624	43 688	43 752	43 817	43 881	43 945	44 010	44 074	44 139	770
780	44 203	44 267	44 332	44 396	44 461	44 525	44 590	44 655	44 719	44 784	780
790	44 848	44 913	44 977	45 042	45 107	45 171	45 236	45 301	45 365	45 430	790
800	45 494	45 559	45 624	45 688	45 753	45 818	45 882	45 947	46 011	46 076	800
810	46 141	46 205	46 270	46 315	46 399	46 464	46 628	46 593	46 657	46 722	810
820	46 786	46 851	46 915	46 980	47 044	47 109	47 173	47 238	47 302	47 367	820
830	47 431	47 495	47 560	47 624	47 688	47 753	47 817	47 881	47 946	48 010	830
840	48 074	48 138	48 202	48 267	48 331	48 395	48 459	48 523	48 587	48 651	840
850	48 715	48 779	48 843	48 907	48 971	49 034	49 098	49 162	49 226	49 290	850
860	49 353	49 417	49 481	49 544	49 608	49 672	49 735	49 799	49 862	49 926	860
870	49 989	50 520	50 116	50 179	50 243	50 306	50 369	50 432	50 495	50 559	870
880	50 622	50 685	50 748	50 811	50 874	50 937	51 000	51 063	51 126	51 188	880
890	51 251	51 314	51 377	51 439	51 502	51 565	51 627	51 690	51 752	51 815	890

Electromotive force as a function of temperature

Type J: Iron/copper-nickel (continued) (4)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
600	33 102	33 161	33 219	33 278	33 337	33 395	33 454	33 513	33 571	33 630	600
610	33 689	33 748	33 807	33 866	33 925	33 984	34 043	34 102	34 161	34 220	610
620	34 279	34 338	34 397	34 457	34 516	34 575	34 635	34 694	34 754	34 813	620
630	34 673	34 932	34 992	35 051	35 111	35 171	35 230	35 290	35 350	35 410	630
640	35 470	35 530	35 590	35 650	35 710	35 770	35 830	35 890	35 950	36 010	640
650	36 071	36 131	36 191	36 252	36 312	36 373	36 433	36 494	36 554	36 615	650
660	36 675	36 736	36 797	36 858	36 918	36 979	37 040	37 101	37 162	37 223	660
670	37 284	37 345	37 406	37 467	37 528	37 590	37 651	37 712	37 773	37 835	670
680	37 896	37 958	38 019	38 081	38 142	38 204	38 265	38 327	38 389	38 450	680
690	38 512	38 574	38 636	38 698	38 760	38 822	38 884	38 946	39 008	39 070	690
700	39 132	39 194	39 256	39 318	39 381	39 443	39 505	39 588	39 630	39 693	700
710	39 755	39 818	39 880	39 943	40 005	40 068	40 131	40 193	40 256	40 319	710
720	40 382	40 445	40 508	40 570	40 633	40 696	40 759	40 822	40 886	40 949	720
730	41 012	41 075	41 138	41 201	41 265	41 328	41 391	41 455	41 518	41 581	730
740	41 645	41 708	41 772	41 835	41 899	41 962	42 026	42 090	42 153	42 217	740
750	42 281	42 344	42 406	42 472	42 536	42 599	42 663	42 727	42 791	42 855	750
760	42 919	42 983	43 047	43 111	43 175	43 239	43 303	43 367	43 431	43 495	760
770	43 559	43 624	43 688	43 752	43 817	43 881	43 945	44 010	44 074	44 139	770
780	44 203	44 267	44 332	44 396	44 461	44 525	44 590	44 655	44 719	44 784	780
790	44 848	44 913	44 977	45 042	45 107	45 171	45 236	45 301	45 365	45 430	790
800	45 494	45 559	45 624	45 688	45 753	45 818	45 882	45 947	46 011	46 076	800
810	46 141	46 205	46 270	46 315	46 399	46 464	46 628	46 593	46 657	46 722	810
820	46 786	46 851	46 915	46 980	47 044	47 109	47 173	47 238	47 302	47 367	820
830	47 431	47 495	47 560	47 624	47 688	47 753	47 817	47 881	47 946	48 010	830
840	48 074	48 138	48 202	48 267	48 331	48 395	48 459	48 523	48 587	48 651	840
850	48 715	48 779	48 843	48 907	48 971	49 034	49 098	49 162	49 226	49 290	850
860	49 353	49 417	49 481	49 544	49 608	49 672	49 735	49 799	49 862	49 926	860
870	49 989	50 520	50 116	50 179	50 243	50 306	50 369	50 432	50 495	50 559	870
880	50 622	50 685	50 748	50 811	50 874	50 937	51 000	51 063	51 126	51 188	880
890	51 251	51 314	51 377	51 439	51 502	51 565	51 627	51 690	51 752	51 815	890

Electromotive force as a function of temperature

Type J: Iron/copper-nickel (continued) (5)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
900	51 877	51 940	52 002	52 064	52 127	52 189	52 251	52 314	52 376	52 438	900
910	52 500	52 582	52 624	52 686	52 748	52 810	52 872	52 934	52 996	53 057	910
920	53 119	53 181	53 243	53 304	53 366	53 427	53 489	53 550	53 612	53 673	920
930	53 735	53 796	53 857	53 919	53 980	54 041	54 102	54 164	54 225	54 286	930
940	54 347	54 408	54 469	54 530	54 591	54 652	54 713	54 773	54 834	54 895	940
950	54 956	55 016	55 077	55 138	55 198	55 259	55 319	55 380	55 440	55 501	950
960	55 561	55 622	55 682	55 742	55 803	55 863	55 923	55 983	56 043	56 104	960
970	56 164	56 224	56 284	56 344	56 404	56 484	56 524	56 584	56 643	56 703	970
980	56 763	56 823	56 883	56 942	57 002	57 062	57 121	57 181	57 240	57 300	980
990	57 360	57 419	57 479	57 538	57 597	57 657	57 716	57 776	57 835	57 894	990
1 000	57 953	58 013	58 072	58 131	58 190	58 249	58 309	58 368	58 427	58 486	1 000
1 010	58 545	58 604	58 663	58 422	58 781	58 840	58 899	58 957	59 016	59 075	1 010
1 020	59 134	59 193	59 252	59 310	59 369	59 428	59 487	59 545	59 604	59 663	1 020
1 030	59 721	59 780	59 838	59 897	59 956	60 014	60 073	60 131	60 190	60 248	1 030
1 040	60 307	60 365	60 423	60 482	60 540	60 599	60 657	60 715	60 774	60 832	1 040
1 050	60 890	60 949	61 007	61 065	61 123	61 182	61 240	61 298	61 356	61 415	1 050
1 060	61 473	61 531	61 589	61 647	61 705	61 763	61 822	61 880	61 938	61 996	1 060
1 070	62 054	62 112	62 170	62 228	62 286	62 344	62 402	62 480	62 518	62 576	1 070
1 080	62 634	62 692	62 750	62 808	62 866	62 924	62 982	63 040	63 098	63 156	1 080
1 090	63 214	63 271	63 329	63 387	63 445	63 503	63 561	63 619	63 677	63 734	1 090
1 100	63 792	63 850	63 908	63 966	64 024	64 081	64 139	64 197	64 255	64 313	1 100
1 110	64 370	64 428	64 486	64 544	64 602	64 659	64 717	64 775	64 833	64 890	1 110
1 120	64 948	65 008	65 064	65 121	65 179	65 237	65 295	65 352	65 410	65 468	1 120
1 130	65 525	65 583	65 641	65 699	65 756	65 814	65 872	65 929	65 987	66 045	1 130
1 140	66 102	66 160	66 218	66 275	66 333	66 391	66 448	66 506	66 564	66 621	1 140
1 150	66 579	66 737	66 794	66 852	68 910	66 967	67 025	67 082	67 140	67 198	1 150
1 160	67 255	67 313	67 370	67 428	67 486	67 543	57 601	67 658	67 716	67 773	1 160
1 170	67 831	67 888	67 946	68 003	68 061	68 119	68 176	68 234	68 291	68 348	1 170
1 180	68 406	68 463	68 521	68 578	68 636	68 693	68 751	68 808	66 865	68 923	1 180
1 190	68 980	69 037	69 095	69 152	69 209	69 267	69 324	69 381	69 439	69 496	1 190
1 200	69 553										1 200

Electromotive force as a function of temperature

Type K: Nickel-chromium/nickel-aluminium (6)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
-270	-6 458										-270
-260	-6 441	-6 444	-6 446	-6 448	-6 450	-6 452	-6 453	-6 455	-6 456	-6457	-260
-250	-6 404	-6 408	-6 413	-6 417	-6 421	-6 425	-6 429	-6 432	-6 435	-6438	-250
-240	-6 344	-6 351	-6 358	-6 364	-6 370	-6 377	-6 382	-6 388	-6 393	-6399	-240
-230	-6 262	-6 271	-6 280	-6 289	-6 297	-6 306	-6 314	-6 322	-6 329	-6337	-230
-220	-6 158	-6 170	-6 181	-6 192	-6 202	-6 213	-6 223	-6 233	-6 243	-6252	-220
-210	-6 035	-6 048	-6 061	-6 074	-6 087	-6 099	-6 111	-6 123	-6 135	-6147	-210
-200	-5 891	-5 907	-5 922	-5 936	-5 951	-5 965	-5 980	-5 994	-6 007	-6021	-200
-190	-5 730	-5 747	-5 763	-5 780	-5 797	-5 813	-5 829	-5 645	-5 861	-5876	-190
-180	-5 550	-5 569	-5 588	-5 606	-5 624	-5 642	-5 660	-5 678	-5 695	-5713	-180
-170	-5 354	-5 374	-5 395	-5 415	-5 435	-5 454	-5 474	-5 493	-5 512	-5531	-170
-160	-5 141	-5 163	-5 185	-5 207	-5 228	-5 250	-5 271	-5 292	-5 313	-5333	-160
-150	-4 913	-4 936	-4 960	-4 983	-5 008	-5 029	-5 062	-5 074	-5 097	-5119	-150
-140	-4 669	-4 694	-4 719	-4 744	-4 768	-4 793	-4 817	-4 841	-4 865	-4889	-140
-130	-4 411	-4 437	-4 463	-4 490	-4 516	-4 542	-4 567	-4 593	-4 618	-4644	-130
-120	-4 138	-4 166	-4 194	-4 221	-4 249	-4 276	-4 303	-4 330	-4 357	-4384	-120
-110	-3 852	-3 882	-3 911	-3 939	-3 968	-3 997	-4 025	-4 054	-4 082	-4110	-110
-100	-3 554	-3 584	-3 614	-3 645	-3 675	-3 705	-3 734	-3 764	-3 794	-3823	-100
-90	-3 243	-3 274	-3 306	-3 337	-3 368	-3 400	-3 431	-3 462	-3 492	-3523	-90
-80	-2 920	-2 953	-2 986	-3 018	-3 050	-3 083	-3 115	-3 147	-3 179	-3211	-80
-70	-2 587	-2 620	-3 654	-2 688	-2 721	-2 755	-2 788	-2 821	-2 854	-2887	-70
-60	-2 243	-2 278	-2 312	-2 347	-2 382	-2 416	-2 450	-2 485	-2 519	-2553	-60
-50	-1 889	-1 925	-1 961	-1 996	-2 032	-2 067	-2 103	-2 138	-2 173	-2208	-50
-40	-1 527	-1 564	-1 600	-1 637	-1 673	-1 709	-1 745	-1782	-1 818	-1 854	-40
-30	-1 156	-1 194	-1 231	-1 266	-1 305	-1 343	-1 380	-1417	-1 453	-1 490	-30
-20	-778	-816	-854	-892	-930	-968	-1 006	-1043	-1 081	-1119	-20
-10	-392	-431	-470	-508	-547	-586	-624	-663	-701	-739	-10
0	0	-39	-79	-118	-157	-197	-236	-275	-314	-353	0

Electromotive force as a function of temperature

Type K: Nickel-chrome/nickel-aluminium (suite)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
300	12 209	12 250	12 291	12 333	12 374	12 416	12 457	12 499	12 540	12 582	300
310	12 624	12 665	12 707	12 748	12 790	12 831	12 873	12 915	12 956	12 998	310
320	13 040	13 081	13 123	13 165	13 206	13 248	13 290	13 331	13 373	13 415	320
330	13 457	13 498	13 540	13 582	13 624	13 665	13 707	13 749	13 791	13 833	330
340	13 874	13 916	13 958	14 000	14 042	14 084	14 126	14 167	14 209	14 251	340
350	14 293	14 335	14 377	14 419	14 461	14 503	14 545	14 587	14 629	14 671	350
360	14 713	14 755	14 797	14 839	14 881	14 923	14 985	15 007	15 049	15 091	360
370	15 133	15 175	15 217	15 259	15 301	15 343	15 385	15 427	15 469	15 511	370
380	15 554	15 596	15 638	15 680	15 722	15 784	15 806	15 849	15 891	15 933	380
390	15 975	16 017	16 059	16 102	16 144	16 186	16 228	16 270	16 313	16 355	390
400	16 397	16 439	16 482	16 524	16 586	16 608	16 651	16 693	16 735	16 778	400
410	16 820	16 882	16 904	16 947	16 989	17 031	17 074	17 116	17 158	17 201	410
420	17 243	17 285	17 328	17 370	17 413	17 455	17 497	17 540	17 582	17 624	420
430	17 667	17 709	17 752	17 794	17 837	17 879	17 921	17 964	18 006	18 049	430
440	18 091	18 134	18 176	18 218	18 261	18 303	18 346	18 388	18 431	18 473	440
450	18 516	18 558	18 601	18 643	18 686	18 728	18 771	18 813	18 856	18 898	450
460	18 941	18 983	19 026	19 068	19 111	19 154	19 196	19 239	19 281	19 324	460
470	19 368	19 409	19 451	19 494	19 537	19 579	19 622	19 664	19 707	19 750	470
480	19 792	19 835	19 877	19 920	19 962	20 005	20 048	20 090	20 133	20 175	480
490	20 128	20 261	20 303	20 346	20 389	20 431	20 474	20 516	20 559	20 602	490
500	20 644	20 687	20 730	20 772	20 815	20 857	20 900	20 943	20 985	21 028	500
510	21 071	21 113	21 156	21 199	21 241	21 284	21 326	21 389	21 412	21 454	510
520	21 497	21 540	21 582	21 625	21 668	21 710	21 753	21 796	21 838	21 881	520
530	21 924	21 966	22 009	22 052	22 094	22 137	22 179	22 222	22 265	22 307	530
540	22 350	22 393	22 435	22 478	22 521	22 583	22 606	22 649	22 691	22 734	540
550	22 776	22 819	22 862	22 904	22 947	22 990	23 032	23 075	23 117	23 160	550
560	23 203	23 245	23 288	23 331	23 373	23 416	23 458	23 501	23 544	23 586	560
570	23 629	23 671	23 714	23 757	23 799	23 842	23 884	23 927	23 970	24 012	570
580	24 055	24 097	24 140	24 182	24 225	24 267	24 310	24 353	24 395	24 438	580
590	24 480	24 523	24 565	24 608	24 650	24 693	24 735	24 778	24 820	24 863	590

Electromotive force as a function of temperature

Type K: Nickel-chrome/nickel-aluminium (suite)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
300	12 209	12 250	12 291	12 333	12 374	12 416	12 457	12 499	12 540	12 582	300
310	12 624	12 665	12 707	12 748	12 790	12 831	12 873	12 915	12 956	12 998	310
320	13 040	13 081	13 123	13 165	13 206	13 248	13 290	13 331	13 373	13 415	320
330	13 457	13 498	13 540	13 582	13 624	13 665	13 707	13 749	13 791	13 833	330
340	13 874	13 916	13 958	14 000	14 042	14 084	14 126	14 167	14 209	14 251	340
350	14 293	14 335	14 377	14 419	14 461	14 503	14 545	14 587	14 629	14 671	350
360	14 713	14 755	14 797	14 839	14 881	14 923	14 985	15 007	15 049	15 091	360
370	15 133	15 175	15 217	15 259	15 301	15 343	15 385	15 427	15 469	15 511	370
380	15 554	15 596	15 638	15 680	15 722	15 784	15 806	15 849	15 891	15 933	380
390	15 975	16 017	16 059	16 102	16 144	16 186	16 228	16 270	16 313	16 355	390
400	16 397	16 439	16 482	16 524	16 586	16 608	16 651	16 693	16 735	16 778	400
410	16 820	16 882	16 904	16 947	16 989	17 031	17 074	17 116	17 158	17 201	410
420	17 243	17 285	17 328	17 370	17 413	17 455	17 497	17 540	17 582	17 624	420
430	17 667	17 709	17 752	17 794	17 837	17 879	17 921	17 964	18 006	18 049	430
440	18 091	18 134	18 176	18 218	18 261	18 303	18 346	18 388	18 431	18 473	440
450	18 516	18 558	18 601	18 643	18 686	18 728	18 771	18 813	18 856	18 898	450
460	18 941	18 983	19 026	19 068	19 111	19 154	19 196	19 239	19 281	19 324	460
470	19 368	19 409	19 451	19 494	19 537	19 579	19 622	19 664	19 707	19 750	470
480	19 792	19 835	19 877	19 920	19 962	20 005	20 048	20 090	20 133	20 175	480
490	20 128	20 261	20 303	20 346	20 389	20 431	20 474	20 516	20 559	20 602	490
500	20 644	20 687	20 730	20 772	20 815	20 857	20 900	20 943	20 985	21 028	500
510	21 071	21 113	21 156	21 199	21 241	21 284	21 326	21 389	21 412	21 454	510
520	21 497	21 540	21 582	21 625	21 668	21 710	21 753	21 796	21 838	21 881	520
530	21 924	21 966	22 009	22 052	22 094	22 137	22 179	22 222	22 265	22 307	530
540	22 350	22 393	22 435	22 478	22 521	22 583	22 606	22 649	22 691	22 734	540
550	22 776	22 819	22 862	22 904	22 947	22 990	23 032	23 075	23 117	23 160	550
560	23 203	23 245	23 288	23 331	23 373	23 416	23 458	23 501	23 544	23 586	560
570	23 629	23 671	23 714	23 757	23 799	23 842	23 884	23 927	23 970	24 012	570
580	24 055	24 097	24 140	24 182	24 225	24 267	24 310	24 353	24 395	24 438	580
590	24 480	24 523	24 565	24 608	24 650	24 693	24 735	24 778	24 820	24 863	590

Electromotive force as a function of temperature

Type K: Nickel-chromium/nickel-aluminium (continued) (10)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
600	24 905	24 948	24 990	25 033	25 075	25 118	25 160	25 203	25 245	25 288	600
610	25 330	25 373	25 415	25 458	25 500	25 543	25 586	25 627	25 670	25 712	610
620	25 755	25 797	25 840	25 882	25 924	25 967	26 009	26 052	26 094	26 136	620
630	26 179	26 221	26 263	26 306	26 348	26 390	26 433	26 475	26 517	26 560	630
640	26 602	26 644	26 687	26 729	26 771	26 814	26 856	26 898	26 940	26 983	640
650	27 025	27 067	27 109	27 152	27 194	27 236	27 278	27 320	27 363	27 405	650
660	27 447	27 489	27 531	27 574	27 616	27 658	27 700	27 742	27 784	27 826	660
670	27 869	27 911	27 953	27 995	28 037	28 079	28 121	28 163	28 205	28 247	670
680	28 289	28 332	28 374	26 416	28 458	28 500	28 542	28 584	28 626	28 668	680
690	28 710	28 752	28 794	28 835	28 877	28 919	28 961	29 003	29 045	29 087	690
700	29 129	29 171	29 213	29 256	29 297	29 338	29 380	29 422	29 464	29 506	700
710	29 548	29 589	29 631	29 673	29 715	29 757	29 798	29 840	29 882	29 924	710
720	29 965	30 007	30 049	30 090	30 132	30 174	30 216	30 257	30 299	30 341	720
730	30 382	30 424	30 466	30 507	30 549	30 590	30 632	30 674	30 715	30 757	730
740	30 798	30 840	30 881	30 923	30 964	31 006	31 047	31 089	31 130	31 172	740
750	31 213	31 255	31 296	31 338	31 379	31 421	31 462	31 504	31 545	31 586	750
760	31 628	31 869	31 710	31 752	31 793	31 834	31 876	31 917	31 958	32 000	760
770	32 041	32 082	32 124	32 165	32 206	32 247	32 289	32 330	32 371	32 412	770
780	32 453	32 495	32 536	32 577	32 618	32 659	32 700	32 742	32 783	32 824	780
790	32 885	32 906	32 947	32 988	33 029	33 070	33 111	33 152	33 193	33 234	790
800	33 275	33 316	33 357	33 398	33 439	33 480	33 521	33 562	33 603	33 644	800
810	33 685	33 726	33 767	33 808	33 848	33 889	33 930	33 971	34 012	34 053	810
820	34 093	34 134	34 175	34 216	34 257	34 297	34 338	34 379	34 420	34 460	820
830	34 501	34 542	34 582	34 623	34 664	34 704	34 745	34 786	34 826	34 867	830
840	34 908	34 948	34 989	35 029	35 070	35 110	35 151	35 192	35 232	35 273	840
850	35 313	35 354	35 394	35 436	35 475	35 516	35 556	35 596	35 637	35 677	850
860	35 718	35 758	35 798	35 839	35 879	35 920	35 960	36 000	36 041	36 081	860
870	36 121	36 162	36 202	36 242	36 282	36 323	36 363	36 403	36 443	36 484	870
880	36 524	36 564	36 604	36 644	36 685	36 725	36 765	36 805	36 845	36 885	880
890	36 925	36 965	37 006	37 046	37 086	37 126	37 166	37 206	37 248	37 288	890

Electromotive force as a function of temperature

Type K: Nickel-chromium/nickel-aluminium (continued) (11)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
900	37 326	37 366	37 406	37 446	37 486	37 526	37 566	37 606	37 646	37 686	900
910	37 725	37 765	37 805	37 845	37 885	37 925	37 965	38 005	38 044	38 084	910
920	38 124	38 164	38 204	38 243	38 283	38 323	38 363	38 402	38 442	38 482	920
930	38 522	38 561	38 601	38 641	38 660	38 720	38 760	38 799	38 839	38 878	930
940	38 918	38 958	38 997	39 037	39 076	39 116	39 155	39 185	39 235	39 274	940
950	39 314	39 353	39 393	39 432	39 471	39 511	39 550	39 590	39 629	39 669	950
960	39 708	39 747	39 787	39 826	39 866	39 905	39 944	39 984	40 023	40 062	960
970	40 101	40 141	40 180	40 219	40 259	40 298	40 337	40 376	40 415	40 455	970
980	40 494	40 533	40 572	40 611	40 651	40 690	40 729	40 768	40 807	40 846	980
990	40 885	40 924	40 963	41 002	41 042	41 081	41 120	41 159	41 198	41 237	990
1 000	41 276	41 315	41 354	41 393	41 431	41 470	41 509	41 548	41 587	41 626	1 000
1 010	41 665	41 704	41 743	41 781	41 820	41 859	41 898	41 937	41 976	42 014	1 010
1 020	42 053	42 092	42 131	42 169	42 208	42 247	42 286	42 324	42 363	42 402	1 020
1 030	42 440	42 479	42 518	42 556	42 595	42 633	42 672	42 711	42 749	42 788	1 030
1 040	42 826	42 865	42 903	42 942	42 980	43 019	43 057	43 096	43 134	43 173	1 040
1 050	43 211	43 250	43 288	43 327	43 365	43 403	43 442	43 480	43 518	43 557	1 050
1 060	43 595	43 633	43 672	43 710	43 748	43 787	43 825	43 863	43 901	43 940	1 060
1 070	43 978	44 016	44 054	44 092	44 130	44 169	44 207	44 245	44 283	44 321	1 070
1 080	44 359	44 397	44 435	44 473	44 512	44 550	44 588	44 626	44 664	44 702	1 080
1 090	44 740	44 778	44 816	44 853	44 891	44 929	44 967	45 005	45 043	45 081	1 090
1 100	45 119	45 157	45 194	45 232	45 270	45 308	45 346	45 383	45 421	45 459	1 100
1 110	45 497	45 534	45 572	45 610	45 647	45 685	45 723	45 760	45 798	45 836	1 110
1 120	45 873	45 911	45 948	45 986	46 024	46 061	46 099	46 136	46 174	46 211	1 120
1 130	46 249	46 296	46 324	46 361	46 398	46 436	46 473	46 511	46 548	46 585	1 130
1 140	46 623	46 660	46 697	46 735	46 772	46 809	46 847	46 884	46 921	46 958	1 140
1 150	46 995	47 033	47 070	47 107	47 144	47 181	47 218	47 256	47 293	47 330	1 150
1 160	47 367	47 404	47 441	47 478	47 515	47 552	47 589	47 626	47 663	47 700	1 160
1 170	47 737	47 774	47 811	47 848	47 884	47 921	47 958	47 995	48 032	48 069	1 170
1 180	48 105	48 142	48 179	48 216	48 252	48 289	48 326	48 383	48 399	48 436	1 180
1 190	48 476	48 509	48 546	48 582	48 619	48 656	48 692	48 729	48 765	48 802	1 190

Electromotive force as a function of temperature

Type K: Nickel-chromium/nickel-aluminium (concluded) (12)

	E/μV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
1 200	48 838	48 875	48 911	48 948	48 984	49 021	49 057	49 093	49 130	49 166	1 200
1 210	49 202	49 239	49 275	49 311	49 348	49 384	49 420	49 456	49 493	49 529	1 210
1 220	49 565	49 601	49 637	49 674	49 710	49 746	49 782	49 818	49 854	49 890	1 220
1 230	49 926	49 962	49 998	50 034	50 070	50 106	50 142	50 178	50 214	50 250	1 230
1 240	50 286	50 322	50 358	50 393	50 429	50 465	50 501	50 537	50 572	50 608	1 240
1 250	50 644	50 880	50 715	50 751	50 787	50 822	50 858	50 894	50 929	50 965	1 250
1 260	51 000	51 036	51 071	51 107	51 142	51 178	51 213	51 249	51 284	51 320	1 260
1 270	51 355	51 391	51 426	51 461	51 497	51 532	51 567	51 603	51 638	51 673	1 270
1 280	51 708	51 744	51 779	51 814	51 849	51 885	51 920	51 955	51 990	52 025	1 280
1 290	52 060	52 095	52 130	52 165	52 200	52 235	52 270	52 305	52 340	52 375	1 290
1 300	52 410	52 445	52 480	52 515	52 550	52 585	52 620	52 654	52 689	52 724	1 300
1 310	52 759	52 794	52 828	52 863	52 898	52 932	52 967	53 002	53 037	53 071	1 310
1 320	53 106	53 140	53 175	53 210	53 244	53 279	53 313	53 348	53 382	53 417	1 320
1 330	53 451	53 486	53 520	53 555	53 589	53 623	53 658	53 692	53 727	53 761	1 330
1 340	53 795	53 830	53 864	53 898	53 932	53 967	54 001	54 035	54 069	54 104	1 340
1 350	54 138	54 172	54 206	54 240	54 274	54 308	54 343	54 377	54 411	54 445	1 350
1 360	54 479	54 513	54 547	54 581	54 615	54 849	54 683	54 717	54 751	54 785	1 360
1 370	54 819	54 852	54 886								1 370

Electromotive force as a function of temperature

Type N: Nickel-chrome-silicium/nickel-silicium

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
-270	-4 345										
-260	-4 336	-4 337	-4 339	-4 340	-4 341	-4 342	-4 343	-4 344	-4 344	-4 345	-260
-250	-4 313	-4 316	-4 319	-4 321	-4 324	-4 326	-4 328	-4 330	-4 332	-4 334	-250
-240	-4 277	-4 281	-4 285	-4 289	-4 293	-4 297	-4 300	-4 304	-4 307	-4 310	-240
-230	-4 226	-4 232	-4 238	-4 243	-4 248	-4 254	-4 258	-4 263	-4 268	-4 273	-230
-220	-4 261	-4 169	-4 176	-4 183	-4 189	-4 196	-4 202	-4 209	-4 215	-4 221	-220
-210	-4 083	-4 091	-4 100	-4 108	-4 116	-4 124	-4 132	-4 140	-4 147	-4 154	-210
-200	-3 990	-4 000	-4 010	-4 020	-4 029	-4 038	-4 048	-4 057	-4 066	-4 074	-200
-190	-3 884	-3 896	-3 907	-3 918	-3 928	-3 939	-3 950	-3 960	-3 970	-3 980	-190
-180	-3 766	-3 776	-3 790	-3 803	-3 815	-3 827	-3 838	-3 850	-3 862	-3 873	-180
-170	-3 634	-3 648	-3 662	-3 675	-3 688	-3 702	-3 715	-3 728	-3 740	-3 753	-170
-160	-3 491	-3 508	-3 521	-3 535	-3 550	-3 564	-3 578	-3 593	-3 607	-3 621	-160
-150	-3 336	-3 352	-3 368	-3 384	-3 400	-3 415	-3 431	-3 446	-3 461	-3 476	-150
-140	-3 171	-3 181	-3 205	- 3 221	- 3 238	-3 255	-3 271	-3 288	-3 304	-3 320	-140
-130	-2 994	-3 012	-3 030	-3 048	-3 066	-3 084	-3 101	-3 119	-3 136	-3 153	-130
-120	-2 808	-2 827	-2 846	-2 865	-2 883	-2 902	-2 921	-2 939	-2 958	-2 976	-120
-110	-2 612	-2 632	-2 652	-2 672	-2 691	-2 711	-2 730	-2 750	-2 769	-2 789	-110
-100	-2 407	-2 428	-2 448	-2 469	-2 490	-2 510	-2 531	-2 551	-2 471	-2 592	-100
-90	-2 193	-2 215	-2 237	-2 258	-2 280	-2 301	- 2 322	-2 344	-2 365	-2 386	-90
-80	-1 972	-1 995	-2 017	-2 039	-2 062	-2 084	-2 106	-2 128	-2 150	-2 172	-80
-70	-1 744	-1 767	-1 790	-1 813	-1 836	-1 859	-1 882	-1 905	-1 927	-1 950	-70
-60	-1 509	-1 533	-1 557	-1 580	-1 604	-1 627	-1 651	-1 674	-1 698	-1 721	-60
-50	-1 269	-1 293	-1 317	-1 341	-1 366	-1 390	-1 414	-1 438	-1 462	-1 485	-50
-40	-1 023	-1 048	-1 072	-1 097	-1 122	-1 146	-1 171	-1 195	-1 220	-1 244	-40
-30	-772	-798	-823	-848	-873	-898	-923	-948	-973	-998	-30
-20	-518	-544	-569	-595	-620	-646	-671	-696	-722	-747	-20
-10	-260	-286	-312	-338	-364	-390	-415	-441	-467	-492	-10
0	0	-26	-52	-78	-104	-131	-157	-183	-209	-234	0

Electromotive force as a function of temperature

Type N: Nickel-chromium-silcon/nickel-silcon (continued) (13)

E/µV											
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
0	0	26	52	78	104	130	156	182	208	235	0
10	261	287	313	340	366	393	419	446	472	499	10
20	525	552	578	605	632	659	685	712	739	766	20
30	793	820	847	874	901	928	955	963	1 010	1 037	30
40	1 065	1 092	1 119	1 147	1 174	1 202	1 229	1 257	1 284	1 312	40
50	1 340	1 368	1 395	1 423	1 451	1 479	1 507	1 535	1 563	1 591	50
60	1 619	1 647	1 675	1 703	1 732	1 760	1 788	1 817	1 845	1 873	60
70	1 902	1 930	1 959	1 988	2 016	2 045	2 074	2 102	2 131	2 160	70
80	2 189	2 218	2 247	2 276	2 305	2 334	2 363	2 392	2 421	2 450	80
90	2 480	2 509	2 538	2 568	2 597	2 626	2 656	2 685	2 715	2 744	90
100	2 774	2 804	2 833	2 863	2 893	2 923	2 953	2 963	3 012	3 042	100
110	3 072	3 102	3 133	3 163	3 193	3 223	3 253	3 283	3 314	3 344	110
120	3 374	3 406	3 435	3 466	3 496	3 527	3 557	3 588	3 619	3 649	120
130	3 680	3 711	3 742	3 772	3 803	3 834	3 865	3 896	3 927	3 958	130
140	3 989	4 020	4 051	4 063	4 114	4 145	4 176	4 208	4 239	4 270	140
150	4 302	4 333	4 365	4 396	4 428	4 459	4 491	4 523	4 554	4 586	150
160	4 618	4 650	4 681	4 713	4 745	4 777	4 809	4 841	4 873	4 905	160
170	4 937	4 969	5 001	5 033	5 066	5 098	5 130	5 162	5 195	5 227	170
180	5 259	5 292	5 324	5 357	5 389	5 422	5 454	5 487	5 520	5 552	180
190	5 585	5 618	5 650	5 683	5 716	5 749	5 782	5 815	5 847	5 880	190
200	5 913	5 946	5 979	6 013	6 046	6 079	6 112	6 145	6 178	6 211	200
210	6 245	6 278	6 311	6 345	6 378	6 411	6 445	6 478	6 512	6 545	210
220	6 579	6 612	6 646	6 680	6 713	6 747	6 781	6 814	6 848	6 882	220
230	6 916	6 949	6 983	7 017	7 051	7 085	7 119	7 153	7 187	7 221	230
240	7 255	7 289	7 323	7 357	7 392	7 426	7 460	7 494	7 528	7 583	240
250	7 697	7 631	7 666	7 700	7 734	7 769	7 803	7 838	7 872	7 907	250
260	7 941	7 976	8 010	8 045	8 080	8 114	8 149	8 184	8 218	8 253	260
270	8 288	8 323	8 356	8 392	8 427	8 462	8 497	8 532	8 567	8 602	270
280	8 637	8 672	8 707	8 742	8 777	8 812	8 847	8 882	8 918	8 953	280
290	8 988	9 023	9 058	9 094	9 129	9 184	9 200	9 235	9 270	9 306	290

Electromotive force as a function of temperature

Type N: Nickel-chromium-silicone/nickel-silicon (continued)

	E/μV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
300	9 341	9 377	9 412	9 448	9 483	9 519	9 554	9 590	9 625	9 661	300
310	9 695	9 732	9 766	9 803	9 839	9 875	9 910	9 946	9 982	10 018	310
320	10 054	10 089	10 125	10 161	10 197	10 233	10 269	10 305	10 341	10 377	320
330	10 413	10 449	10 485	10 521	10 557	10 593	10 629	10 665	10 701	10 737	330
340	10 774	10 810	10 846	10 882	10 918	10 935	10 991	11 027	11 064	11 100	340
350	11 136	11 173	11 209	11 245	11 282	11 318	11 355	11 391	11 428	11 464	350
360	11 501	11 537	11 574	11 610	11 647	11 683	11 720	11 757	11 793	11 830	360
370	11 867	11 903	11 940	11 977	12 013	12 050	12 087	12 124	12 160	12 197	370
380	12 234	12 271	12 308	12 345	12 382	12 418	12 455	12 492	12 529	12 566	380
390	12 603	12 640	12 677	12 714	12 751	12 788	12 825	12 862	12 899	12 937	390
400	12 974	13 011	13 048	13 085	13 122	13 159	13 197	13 234	12 271	13 308	400
410	13 346	13 383	13 420	13 457	13 495	13 532	13 569	13 607	13 644	13 682	410
420	13 719	13 756	13 794	13 831	13 869	13 906	13 944	13 981	14 019	14 056	420
430	14 094	14 131	13 169	14 206	14 244	14 281	14 319	14 356	14 394	14 432	430
440	14 469	14 507	14 545	14 582	14 620	14 658	14 695	14 733	14 771	14 809	440
450	14 846	14 884	14 922	14 960	14 998	15 035	15 073	15 111	15 149	15 187	450
460	15 225	15 262	15 300	15 338	15 376	15 414	15 452	15 490	15 528	15 566	460
470	15 604	15 642	15 680	15 718	15 756	15 794	15 832	15 870	15 908	15 946	470
480	15 984	16 022	16 060	16 099	16 137	16 176	16 213	16 251	16 289	16 327	480
490	16 368	16 404	16 442	16 480	16 518	16 557	16 595	16 633	16 671	16 710	490
500	16 748	16 766	16 824	16 863	16 901	16 939	16 978	17 016	17 054	17 093	500
510	17 131	17 169	17 208	17 246	17 285	17 323	17 361	17 400	17 438	17 477	510
520	17 515	17 554	17 592	17 630	17 669	17 707	17 746	17 784	17 823	17 881	520
530	17 900	17 938	17 977	18 016	18 054	18 093	18 131	18 170	18 208	18 247	530
540	18 286	18 324	18 363	18 401	18 440	18 479	18 517	18 556	18 595	18 633	540
550	18 672	18 711	18 749	18 788	18 827	18 865	18 904	18 943	18 982	19 020	550
560	19 059	19 088	19 136	19 175	19 214	19 253	19 292	19 330	19 369	19 408	560
570	19 447	19 485	19 524	19 583	19 602	19 641	19 680	19 718	19 757	19 796	570
580	19 835	19 874	19 913	19 952	19 990	20 029	20 068	20 107	20 146	20 185	580
590	20 224	20 263	20 302	20 341	20 379	20 418	20 457	20 496	20 535	20 574	590

Electromotive force as a function of temperature

Type N: Nickel-chromium-silicone/nickel-silicon (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
600	20 613	20 652	20 691	20 730	20 769	20 808	20 847	20 885	20 925	20 984	600
610	20 013	21 042	21 081	21 120	21 159	21 198	21 237	21 276	21 315	21 354	610
620	21 393	21 432	21 471	21 510	21 549	21 588	21 628	21 667	21 706	21 745	620
630	21 784	21 823	21 862	21 901	21 940	21 979	22 018	22 058	22 097	22 136	630
640	22 175	22 214	22 253	22 292	22 331	22 370	22 410	22 449	22 488	22 527	640
650	22 566	22 605	22 644	22 684	22 723	22 762	22 801	22 840	22 879	22 919	650
660	22 958	22 997	23 036	23 075	23 115	23 154	23 193	23 232	23 271	23 311	660
670	23 350	23 389	23 428	23 467	23 507	23 546	23 585	23 624	23 663	23 703	670
680	23 742	23 781	23 820	23 860	23 899	23 938	23 977	24 016	24 056	24 095	680
690	24 134	24 173	24 213	24 252	24 291	24 330	24 370	24 409	24 448	24 487	690
700	24 527	24 566	24 605	24 644	24 684	24 723	24 762	24 801	24 841	24 880	700
710	24 919	24 959	24 998	25 037	25 076	25 116	25 155	25 194	25 233	25 273	710
720	25 312	25 351	25 391	25 430	25 469	25 508	25 548	25 587	25 625	25 666	720
730	25 705	25 744	25 783	25 823	25 862	25 901	25 941	25 980	26 019	26 058	730
740	26 098	26 137	26 176	26 216	26 255	26 294	26 333	26 373	26 412	26 541	740
750	26 491	26 530	26 569	26 608	26 648	26 687	26 726	26 766	26 805	26 844	750
760	26 833	26 923	26 962	27 001	27 041	27 080	27 119	27 158	27 198	27 237	760
770	27 278	27 316	27 355	27 394	27 433	27 473	27 512	27 551	27 591	27 630	770
780	27 669	27 708	27 748	27 787	27 826	27 866	27 905	27 944	27 983	28 023	780
790	28 062	28 101	28 140	28 180	28 219	28 258	28 297	28 337	28 376	28 415	790
800	28 456	28 494	28 533	28 572	28 612	28 651	28 690	28 729	28 769	28 808	800
810	28 847	28 886	28 926	28 965	29 004	29 043	29 088	29 122	29 161	29 200	810
820	29 239	29 279	29 318	29 367	29 396	29 436	29 475	29 514	29 553	29 592	820
830	29 632	29 671	29 710	29 749	29 789	29 828	29 867	29 906	29 945	29 985	830
840	30 024	30 063	30 102	30 141	30 181	30 220	30 259	30 298	30 337	30 378	840
850	30 416	30 455	30 494	30 533	30 572	30 611	30 651	30 690	30 729	30 768	850
860	30 807	30 846	30 886	30 925	30 964	31 003	31 042	31 081	31 120	31 160	860
870	31 199	31 238	31 277	31 316	31 355	31 394	31 433	31 473	31 512	31 551	870
880	31 590	31 629	31 668	31 707	31 746	31 785	31 824	31 863	31 903	31 942	880
890	31 981	32 020	32 059	32 098	32 137	32 176	32 215	32 254	32 293	32 332	890

Electromotive force as a function of temperature

Type N: Nickel-chromium-silicon/nickel-silicon (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
900	32 371	32 410	32 449	32 488	32 527	32 566	32 605	32 644	32 683	32 722	900
910	32 761	32 800	32 839	32 878	32 917	32 956	32 995	33 034	33 073	33 112	910
920	33 151	33 190	33 229	33 268	33 307	33 346	33 385	33 424	33 463	33 502	920
930	33 541	33 580	33 619	33 658	33 697	33 736	33 774	33 813	33 852	33 891	930
940	33 930	33 969	34 008	34 047	34 086	34 124	34 163	34 202	34 241	34 280	940
950	34 319	34 358	34 396	34 435	34 474	34 513	34 552	34 591	34 629	34 668	950
960	34 707	34 746	34 785	34 823	34 862	34 901	34 940	34 979	35 017	35 056	960
970	35 095	35 134	35 172	35 211	35 250	35 289	35 327	35 366	35 405	35 444	970
980	35 482	35 521	35 560	35 598	35 637	35 676	35 714	35 753	35 792	35 831	980
990	35 869	35 908	35 946	35 985	36 024	36 062	36 101	36 140	36 178	36 217	990
1 000	36 256	36 294	36 333	36 371	36 410	36 449	36 487	36 526	36 564	36 603	1 000
1 010	36 641	36 680	36 718	36 757	36 796	36 834	36 873	36 911	36 950	36 988	1 010
1 020	37 027	37 065	37 104	37 142	37 181	37 219	37 258	37 296	37 334	37 373	1 020
1 030	37 411	37 450	37 488	37 527	37 565	37 603	37 642	37 680	37 719	37 757	1 030
1 040	37 795	37 834	37 872	37 911	37 949	37 967	38 026	38 064	38 102	38 141	1 040
1 050	38 179	38 217	38 256	38 294	38 332	38 370	38 409	38 447	38 485	38 524	1 050
1 060	38 562	38 600	38 638	38 677	38 715	38 753	38 791	38 829	38 868	38 906	1 060
1 070	38 944	38 982	39 020	39 059	39 097	39 135	39 173	39 211	39 249	39 287	1 070
1 080	39 326	39 364	39 402	39 440	39 478	39 516	39 554	39 592	39 630	39 668	1 080
1 090	39 706	39 744	39 783	39 821	39 859	39 897	39 935	39 973	40 011	40 049	1 090
1 100	40 087	40 125	40 163	40 201	40 238	40 276	40 314	40 352	40 390	40 428	1 100
1 110	40 466	40 504	40 542	40 580	40 618	40 655	40 693	40 731	40 769	40 807	1 110
1 120	40 845	40 683	40 920	40 958	40 996	41 034	41 072	41 109	41 147	41 185	1 120
1 130	41 223	41 260	41 298	41 336	41 374	41 411	41 449	41 487	41 525	41 562	1 130
1 140	41 600	41 638	41 675	41 713	41 751	41 788	41 826	41 864	41 901	41 939	1 140
1 150	41 976	42 014	42 052	42 089	42 127	42 164	42 202	42 239	42 277	42 314	1 150
1 160	42 352	42 390	42 427	42 465	42 502	42 540	42 577	42 614	42 652	42 689	1 160
1 170	42 727	42 764	42 802	42 839	42 877	42 914	42 951	42 989	43 026	43 064	1 170
1 180	43 101	43 138	43 176	43 213	43 250	43 288	43 325	43 362	43 399	43 437	1 180
1 190	43 474	43 511	43 549	43 586	43 623	43 660	43 698	43 735	43 772	43 809	1 190

Electromotive force as a function of temperature

Type N: Nickel-chromium-silicon/nickel-silicon

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
1 200	43 846	43 884	43 921	43 958	43 995	44 032	44 069	44 106	44 144	44 181	1 200
1 210	44 218	44 255	44 292	44 329	44 366	44 403	44 440	44 477	44 514	44 551	1 210
1 220	44 588	44 625	44 662	44 699	44 736	44 773	44 810	44 847	44 884	44 921	1 220
1 230	44 958	44 995	45 032	45 069	45 105	45 142	45 179	45 216	45 253	45 290	1 230
1 240	45 326	45 363	45 400	45 437	45 474	45 510	45 547	45 584	45 621	45 657	1 240
1 250	45 694	45 731	45 767	45 804	45 841	45 877	45 914	45 951	45 987	46 024	1 250
1 260	46 060	46 097	46 133	46 170	46 207	46 243	46 280	46 316	46 353	46 389	1 260
1 270	46 425	46 462	46 498	46 535	46 571	46 608	46 644	46 680	46 717	46 753	1 270
1 280	46 789	46 826	46 862	46 898	46 935	46 971	47 007	47 043	47 079	47 116	1 280
1 290	47 152	47 188	47 224	47 260	47 296	47 333	47 369	47 405	47 441	47 477	1 290
1 300	47 513										1 300

Electromotive force as a function of temperature

Type T: Copper/copper-nickel

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
-270	-6 258										-270
-260	-6 232	-6 236	-6 239	-6 242	-6 245	-6 248	-6 251	-6 253	-6 255	-6 256	-260
-250	-6 180	-6 187	-6 193	-6 198	-6 204	-6 209	-6 214	-6 219	-6 223	-6 228	-250
-240	-6 105	-6 114	-6 122	-6 130	-6 138	-6 146	-6 153	-6 160	-6 167	-6 174	-240
-230	-6 007	-6 017	-6 028	-6 038	-6 049	-6 059	-6 068	-6 078	-6 087	-6 096	-230
-220	-5 888	-5 901	-5 914	-5 926	-5 938	-5 950	-5 962	-5 973	-5 985	-5 996	-220
-210	-5 753	-5 767	-5 782	-5 795	-5 809	-5 823	-5 836	-5 850	-5 863	-5 876	-210
-200	-5 603	-5 619	-5 634	-5 650	-5 665	-5 680	-5 695	-5 710	-5 724	-5 739	-200
-190	-5 439	-5 456	-5 473	-5 489	-5 506	-5 523	-5 539	-5 555	-5 571	-5 587	-190
-180	-5 261	-5 279	-5 297	-5 316	-5 334	-5 351	-5 369	-5 387	-5 404	-5 421	-180
-170	-5 070	-5 089	-5 109	-5 128	-5 148	-5 167	-5 186	-5 205	-5 224	-5 242	-170
-160	-4 865	-4 886	-4 907	-4 928	-4 949	-4 969	-4 989	-5 010	-5 030	-5 050	-160
-150	-4 648	-4 671	-4 693	-4 715	-4 737	-4 759	-4 780	-4 802	-4 823	-4 844	-150
-140	-4 419	-4 443	-4 466	-4 489	-4 512	-4 535	-4 558	-4 581	-4 604	-4 626	-140
-130	-4 177	-4 202	-4 226	-4 251	-4 275	-4 300	-4 324	-4 348	-4 372	-4 395	-130
-120	-3 923	-3 949	-3 975	-4 000	-4 026	-4 052	-4 077	-4 102	-4 127	-4 152	-120
-110	-3 657	-3 684	-3 711	-3 738	-3 765	-3 791	-3 818	-3 844	-3 871	-3 897	-110
-100	-3 379	-3 407	-3 435	-3 463	-3 491	-3 519	-3 547	-3 574	-3 602	-3 629	-100
-90	-3 089	-3 118	-3 148	-3 177	-3 206	-3 235	-3 264	-3 293	-3 322	-3 350	-90
-80	-2 788	-2 818	-2 849	-2 879	-2 910	-2 940	-2 970	-3 000	-3 030	-3 059	-80
-70	-2 476	-2 507	-2 539	-2 571	-2 602	-2 633	-2 664	-2 695	-2 726	-2 757	-70
-60	-2 153	-2 186	-2 218	-2 251	-2 283	-2 316	-2 348	-2 380	-2 412	-2 444	-60
-50	-1 819	-1 853	-1 887	-1 920	-1 954	-1 987	-2 021	-2 054	-2 087	-2 120	-50
-40	-1 475	-1 510	-1 545	-1 579	-1 614	-1 648	-1 663	-1 717	-1 751	-1 785	-40
-30	-1 121	-1 157	-1 192	-1 228	-1 264	-1 299	-1 335	-1 370	-1 405	-1 440	-30
-20	-757	-794	-830	-867	-904	-940	-976	-1 013	-1 049	-1 085	-20
-10	-383	-421	-459	-496	-534	-571	-808	-646	-683	-720	-10
0	0	-39	-77	-116	-154	-193	-231	-269	-307	-345	0

Electromotive force as a function of temperature

Type T: Copper/copper-nickel (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
0	0	39	78	117	156	195	234	273	312	352	0
10	391	431	470	510	549	589	629	669	709	749	10
20	790	830	870	911	951	992	1 033	1 074	1 114	1 165	20
30	1 196	1 238	1 279	1 320	1 362	1 403	1 445	1 486	1 528	1 570	30
40	1 612	1 654	1 696	1 738	1 780	1 823	1 865	1 908	1 950	1 993	40
50	2 036	2 079	2 122	2 165	2 208	2 251	2 294	2 338	2 381	2 425	50
60	2 468	2 512	2 556	2 600	2 643	2 587	2 732	2 776	2 820	2 864	60
70	2 908	2 953	2 998	3 043	3 087	3 132	3 177	3 222	3 267	3 312	70
80	3 358	3 403	3 448	3 494	3 539	3 585	3 631	3 677	3 722	3 768	80
90	3 814	3 860	3 907	3 953	3 999	4 046	4 092	4 138	4 185	4 232	90
100	4 279	4 325	4 372	4 419	4 466	4 513	4 561	4 608	4 655	4 702	100
110	4 750	4 798	4 845	4 893	4 941	4 988	5 036	5 084	5 132	5 180	110
120	5 228	5 277	5 325	5 373	5 422	5 470	5 519	5 567	5 616	5 665	120
130	5 714	5 763	5 812	5 861	5 910	5 959	6 008	6 057	6 107	6 156	130
140	6 206	6 255	6 305	6 355	6 404	5 454	6 504	6 554	6 604	6 654	140
150	6 704	6 754	6 805	6 855	6 905	6 956	7 008	7 057	7 107	7 158	150
160	7 209	7 260	7 310	7 361	7 412	7 463	7 515	7 566	7 617	7 668	160
170	7 720	7 771	7 823	7 874	7 926	7 977	8 029	8 081	8 133	8 185	170
180	8 237	8 289	8 341	8 393	8 445	8 497	8 550	8 802	8 654	8 707	180
190	8 759	8 812	8 865	8 917	8 970	9 023	9 076	9 129	9 182	9 235	190
200	9 288	9 341	9 395	9 448	9 501	9 555	9 606	9 662	9 715	9 769	200
210	9 822	9 874	9 930	9 984	10 038	10 092	10 146	10 200	10 254	10 308	210
220	10 362	10 417	10 471	10 525	10 580	10 634	10 689	10 743	10 798	10 853	220
230	10 907	10 962	11 017	11 072	11 127	11 182	11 237	11 292	11 347	11 403	230
240	11 458	11 513	11 569	11 624	11 680	11 735	11 791	11 846	11 902	11 958	240
250	12 013	12 069	12 125	12 181	12 237	12 293	12 349	12 405	12 461	12 518	250
260	12 574	12 630	12 687	12 743	12 799	12 856	12 912	12 969	13 026	13 082	260
270	13 139	13 196	13 253	13 310	13 366	13 423	13 480	13 537	13 595	13 652	270
280	13 709	13 766	13 823	13 881	13 938	13 995	14 053	14 110	14 168	14 226	280
290	14 283	14 341	14 399	14 456	14 514	14 572	14 630	14 688	14 746	14 804	290

Electromotive force as a function of temperature

Type T: Copper/copper-nickel (concluded)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
300	14 862	14 920	14 978	15 036	15 095	15 153	15 211	15 270	15 328	15 386	300
310	15 445	15 503	15 562	15 621	15 679	15 738	15 797	15 856	15 914	15 973	310
320	16 032	16 091	16 150	16 209	16 268	16 327	16 387	16 446	16 505	16 564	320
330	16 624	16 683	16 742	16 802	16 861	16 921	16 980	17 040	17 100	17 159	330
340	17 219	17 279	17 339	17 399	17 458	17 518	17 578	17 638	17 698	17 759	340
350	17 819	17 879	17 939	17 999	18 060	18 120	18 180	18 241	18 301	18 362	350
360	18 422	18 483	18 543	18 604	18 665	18 725	18 786	18 847	18 908	18 969	360
370	19 030	19 091	19 152	19 213	19 274	19 335	19 396	19 457	19 518	19 579	370
380	19 641	19 702	19 763	19 825	19 886	19 947	20 009	20 070	20 132	20 193	380
390	20 255	20 317	20 378	20 440	20 502	20 563	20 625	20 687	20 748	20 810	390
400	20 872										400

Electromotive force as a function of temperature

Type E: Nickel-chromium/copper-nickel

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
-270	-9 835										-270
-260	-9 797	-9 802	-9 808	-9 813	-9 817	-9 821	-9 825	-9 828	-9 831	-9 833	-260
-250	-9 718	-9 728	-9 737	-9 746	-9 754	-9 762	-9 770	-9 777	-9 784	-9 790	-250
-240	-9 604	-9 617	-9 630	-9 642	-9 654	-9 666	-9 677	-9 688	-9 698	-9 709	-240
-230	-9 455	-9 471	-9 487	-9 503	-9 519	-9 534	-9 548	-9 563	-9 577	-9 591	-230
-220	-9 274	-9 293	-9 313	-9 331	-9 350	-9 368	-9 386	-9 404	-9 421	-9 438	-220
-210	-9 063	-9 085	-9 107	-9 129	-9 151	-9 172	-9 193	-9 214	-9 234	-9 254	-210
-200	-8 825	-8 850	-8 874	-8 899	-8 923	-8 947	-8 971	-8 994	-9 017	-9 040	-200
-190	-8 561	-8 588	-8 616	-8 643	-8 669	-8 696	-8 722	-8 748	-8 774	-8 799	-190
-180	-8 273	-8 303	-8 333	-8 362	-8 391	-8 420	-8 449	-8 477	-8 505	-8 533	-180
-170	-7 963	-7 995	-8 027	-8 059	-8 090	-8 121	-8 152	-8 183	-8 213	-8 243	-170
-160	-7 632	-7 666	-7 700	-7 733	-7 767	-7 800	-7 833	-7 866	-7 899	-7 931	-160
-150	-7 279	-7 315	-7 351	-7 387	-7 423	-7 458	-7 493	-7 528	-7 563	-7 597	-150
-140	-6 907	-6 945	-6 983	-7 021	-7 058	-7 096	-7 133	-7 170	-7 206	-7 243	-140
-130	-6 516	-6 556	-6 596	-6 636	-6 675	-6 714	-6 753	-6 792	-6 831	-6 669	-130
-120	-6 107	-6 149	-6 191	-6 232	-6 273	-6 314	-6 355	-6 396	-6 436	-6 476	-120
-110	-5 681	-5 724	-5 767	-5 810	-5 853	-5 896	-5 939	-5 981	-6 023	-6 065	-110
-100	-5 237	-5 282	-5 327	-5 372	-5 417	-5 461	-5 505	-5 549	-5 593	-5 637	-100
-90	-4 777	-4 824	-4 871	-4 917	-4 963	-5 009	-5 055	-5 101	-5 147	-5 192	-90
-80	-4 302	-4 350	-4 398	-4 446	-4 494	-4 542	-4 589	-4 636	-4 684	-4 731	-80
-70	-3 811	-3 861	-3 911	-3 960	-4 009	-4 058	-4 107	-4 156	-4 205	-4 254	-70
-60	-3 306	-3 357	-3 408	-3 459	-3 510	-3 561	-3 611	-3 661	-3 711	-3 761	-60
-50	-2 787	-2 840	-2 892	-2 944	-2 996	-3 048	-3 100	-3 152	-3 204	-3 255	-50
-40	-2 255	-2 309	-2 362	-2 416	-2 469	-2 523	-2 576	-2 629	-2 682	-2 735	-40
-30	-1 709	-1 765	-1 820	-1 874	-1 929	-1 984	-2 038	-2 083	-2 147	-2 201	-30
-20	-1 152	-1 208	-1 264	-1 320	-1 376	-1 432	-1 488	-1 543	-1 599	-1 654	-20
-10	-582	-639	-697	-764	-811	-868	-925	-982	-1 039	-1 095	-10
0	0	-59	-117	-176	-234	-292	-350	-408	-466	-524	0

Electromotive force as a function of temperature

Type E: Nickel-chromic acid/copper-nickel (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
0	0	59	118	176	235	294	354	413	472	532	0
10	591	651	711	770	830	890	950	1 010	1 071	1 131	10
20	1 192	1 252	1 313	1 373	1 434	1 495	1 556	1 617	1 678	1 740	20
30	1 801	1 862	1 924	1 986	2 047	2 109	2 171	2 233	2 295	2 357	30
40	2 420	2 482	2 545	2 607	2 670	2 733	2 795	2 858	2 921	2 984	40
50	3 048	3 111	3 174	3 238	3 301	3 365	3 429	3 492	3 556	3 620	50
60	3 685	3 749	3 813	3 877	3 942	4 008	4 071	4 136	4 200	4 265	60
70	4 330	4 395	4 480	4 526	4 591	4 656	4 722	4 788	4 853	4 919	70
80	4 985	5 051	5 117	5 183	5 249	5 315	5 382	5 448	5 514	5 581	80
90	5 648	5 714	5 781	5 848	5 915	5 982	6 049	6 117	6 184	6 251	90
100	6 319	6 386	6 454	6 522	6 590	6 658	6 725	6 794	6 862	6 930	100
110	6 998	7 065	7 135	7 203	7 272	7 341	7 409	7 476	7 547	7 616	110
120	7 685	7 754	7 823	7 892	7 962	8 031	8 101	8 170	8 240	8 308	120
130	8 379	8 449	8 519	8 589	8 659	8 729	8 799	8 869	8 940	9 010	130
140	9 061	9 151	9 222	9 292	9 363	9 434	9 505	9 576	9 647	9 718	140
150	9 789	9 860	9 931	10 003	10 074	10 145	10 217	10 288	10 360	10 432	150
160	10 503	10 575	10 647	10 719	10 791	10 863	10 935	11 007	11 080	11 152	160
170	11 224	11 297	11 369	11 442	11 514	11 587	11 660	11 733	11 805	11 878	170
180	11 951	12 024	12 097	12 170	12 243	12 317	12 390	12 463	12 537	12 610	180
190	12 684	12 757	12 831	12 904	12 978	13 052	13 128	13 199	13 273	13 347	190
200	13 421	13 495	13 569	13 644	13 718	13 792	13 866	13 941	14 015	14 090	200
210	14 164	14 239	14 313	14 388	14 463	14 537	14 612	14 687	14 762	14 837	210
220	14 912	14 987	15 062	15 137	15 212	15 287	15 362	15 438	15 513	15 588	220
230	15 684	15 739	15 815	15 890	15 966	16 041	16 117	16 193	16 269	16 344	230
240	16 420	16 496	16 572	16 648	16 724	16 800	16 878	16 952	17 028	17 104	240
250	17 181	17 257	17 333	17 409	17 486	17 562	17 639	17 715	17 792	17 868	250
260	17 945	18 021	18 098	18 175	18 252	18 328	18 405	18 482	18 559	18 636	260
270	18 713	18 790	18 867	18 944	19 021	19 098	19 175	19 252	19 330	19 407	270
280	19 484	19 561	19 639	19 716	19 794	19 871	19 948	20 026	20 103	20 181	280
290	20 259	20 336	20 414	20 492	20 559	20 647	20 725	20 803	20 880	20 958	290

Electromotive force as a function of temperature

Type E: Nickel-chromium/copper-nickel (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
300	21 036	21 114	21 192	21 270	21 348	21 426	21 504	21 582	21 660	21 739	300
310	21 817	21 895	21 973	22 051	22 130	22 208	22 286	22 365	22 443	22 522	310
320	22 600	22 678	22 757	22 835	22 914	22 993	23 071	23 150	23 226	23 307	320
330	23 386	23 464	23 543	23 622	23 701	23 780	23 858	23 937	24 016	24 095	330
340	24 174	24 253	24 332	24 411	24 490	24 569	24 648	24 727	24 806	24 885	340
350	24 964	25 044	25 123	25 202	25 281	25 360	25 440	25 519	25 598	25 678	350
360	25 757	25 836	25 916	25 995	26 075	26 154	26 233	26 313	26 392	26 472	360
370	26 552	26 631	26 711	26 790	26 870	26 950	27 029	27 109	27 189	27 268	370
380	27 348	27 428	27 507	27 587	27 667	27 747	27 827	27 907	27 986	28 066	380
390	28 146	28 226	28 306	28 386	28 466	28 546	28 626	28 706	28 786	28 866	390
400	28 946	29 026	29 106	29 186	29 268	29 346	29 427	29 507	26 587	29 667	400
410	29 747	29 827	29 908	29 988	30 068	30 148	30 229	30 309	30 389	30 470	410
420	30 550	30 630	30 711	30 791	30 871	30 952	31 032	31 112	31 193	31 273	420
430	31 354	31 434	31 515	31 595	31 676	31 756	31 837	31 917	31 998	32 078	430
440	32 159	32 239	32 320	32 400	32 481	32 562	32 842	32 723	32 803	32 884	440
450	32 965	33 045	33 126	33 207	33 287	33 368	33 449	33 529	33 610	33 691	450
460	33 772	33 852	33 933	34 014	34 095	34 175	34 256	34 337	34 418	34 498	460
470	34 579	34 660	34 741	34 822	34 902	34 983	35 064	35 145	35 226	35 307	470
480	35 387	35 466	35 549	35 630	35 711	35 792	35 873	35 954	36 034	36 115	480
490	36 196	36 277	36 358	36 439	36 520	36 601	36 682	36 763	36 843	36 924	490
500	37 005	37 086	37 167	37 248	37 329	37 410	37 491	37 572	37 653	37 734	500
510	37 815	37 896	37 977	38 058	38 139	38 220	38 300	38 381	38 462	38 543	510
520	38 624	38 705	38 786	38 867	38 948	39 029	39 110	39 191	39 272	39 353	520
530	39 434	39 515	39 596	39 677	39 758	39 839	39 920	40 001	40 062	40 163	530
540	40 243	40 324	40 405	40 486	40 567	40 648	40 729	40 810	40 891	40 972	540
550	41 053	41 134	41 215	41 296	41 377	41 457	41 538	41 619	41 700	41 781	550
560	41 862	41 943	42 024	42 105	42 185	42 266	42 347	42 428	42 509	42 590	560
570	42 671	42 751	42 832	42 913	42 994	43 075	43 156	43 236	43 317	43 398	570
580	43 479	43 560	43 640	43 721	43 802	43 883	43 963	44 044	44 125	44 206	580
590	44 286	44 367	44 448	44 529	44 609	44 690	44 771	44 851	44 932	45 013	590

Electromotive force as a function of temperature

Type E: Nickel-chromium/copper-nickel (continued)

	E/μV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
600	45 093	45 174	45 255	45 335	45 416	45 497	45 577	45 658	45 736	45 819	600
610	45 900	45 980	46 061	46 141	46 222	46 302	46 383	46 463	46 544	46 624	610
620	46 705	46 785	46 866	46 946	47 027	47 107	47 188	47 268	47 349	47 429	620
630	47 509	47 590	47 670	47 751	47 831	47 911	47 992	48 072	48 152	48 233	630
640	48 313	48 393	48 474	48 554	48 634	48 715	48 795	48 875	48 955	49 035	640
650	49 116	49 196	49 276	49 356	49 436	49 517	49 597	49 677	49 757	49 837	650
660	49 917	49 997	50 077	50 157	50 238	50 318	50 398	50 478	50 556	50 638	660
670	50 718	50 798	50 878	50 958	51 038	51 118	51 197	51 277	51 357	51 437	670
680	51 517	51 597	51 677	51 757	51 837	51 916	51 996	52 076	52 156	52 236	680
690	52 315	52 395	52 475	52 555	52 634	52 714	52 794	52 873	52 953	53 033	690
700	53 112	53 192	53 272	53 351	53 431	53 510	53 580	53 670	53 749	53 829	700
710	53 908	53 988	54 067	54 147	54 226	54 306	54 385	54 465	54 544	54 624	710
720	54 703	54 782	54 862	54 941	55 021	55 100	55 179	56 259	55 338	55 417	720
730	55 497	55 576	55 655	55 734	55 814	55 893	55 972	56 051	56 131	56 210	730
740	56 289	56 368	56 447	56 526	56 606	56 685	56 764	56 843	56 922	57 001	740
750	57 080	57 159	57 238	57 317	57 396	57 475	57 554	57 633	57 712	57 791	750
760	57 870	57 949	58 028	58 107	58 186	58 265	58 343	58 422	58 501	58 580	760
770	58 659	58 738	68 816	58 895	58 974	59 053	59 131	59 210	59 289	59 367	770
780	59 446	59 525	59 604	59 682	59 761	59 839	59 918	59 997	60 075	60 154	780
790	60 232	60 311	60 390	60 468	60 547	60 625	60 704	60 782	60 860	60 939	790
800	61 017	61 096	61 174	61 253	61 331	61 409	61 488	61 566	61 644	61 723	800
810	61 801	61 879	61 958	62 036	62 114	62 192	62 271	62 349	62 427	62 505	810
820	62 583	62 662	62 740	62 818	62 896	62 974	63 052	63 130	63 208	63 286	820
830	63 364	63 442	63 520	63 598	63 676	63 754	63 832	63 910	63 988	64 066	830
840	64 144	64 222	64 300	64 377	64 556	64 533	64 611	64 689	64 766	64 844	840
850	64 922	65 000	65 077	65 155	65 233	65 310	65 388	65 465	65 543	65 621	850
860	65 698	65 776	65 853	65 931	66 008	66 086	66 163	66 241	66 318	66 396	860
870	66 473	66 550	66 628	66 705	66 782	66 660	66 837	67 014	67 092	67 169	870
880	67 246	67 323	67 400	67 478	67 555	67 632	67 709	67 786	67 863	67 940	880
890	68 017	68 094	68 171	68 248	68 325	68 402	68 479	68 556	68 633	68 710	890

Electromotive force as a function of temperature

Type E: Nickel-chromium/copper-nickel (concluded)

	E/μV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
900	68 787	68 863	68 940	69 017	69 094	69 171	69 247	69 324	69 401	69 477	900
910	69 554	69 631	69 707	69 784	69 860	69 937	70 013	70 090	70 166	70 243	910
920	70 319	70 396	70 472	70 548	70 625	70 701	70 777	70 854	70 930	71 006	920
930	71 062	71 159	71 235	71 311	71 387	71 463	71 539	71 615	71 692	71 768	930
940	71 844	71 920	71 996	72 072	72 147	72 223	72 299	72 375	72 451	72 527	940
950	72 603	72 678	72 754	72 830	72 906	72 981	73 057	73 133	73 208	73 284	950
960	73 360	73 435	73 511	73 586	73 662	73 738	73 813	73 889	73 964	74 040	960
970	74 115	74 190	74 266	74 341	74 417	74 492	74 567	74 643	74 718	74 793	970
980	74 869	74 944	75 019	75 095	75 170	75 245	75 320	75 395	75 471	75 546	980
990	75 621	75 696	75 771	75 847	75 922	75 997	76 072	76 147	76 223	76 298	990
1000	76 373										1 000

Electromotive force as a function of temperature

Type R: Platinum-13% thorium/platinum (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
0	0	5	11	16	21	27	32	38	43	49	0
10	54	60	65	71	77	82	88	94	100	105	10
20	111	117	123	129	135	141	147	153	159	165	20
30	171	177	183	189	195	201	207	214	220	226	30
40	232	239	245	251	258	264	271	277	284	290	40
50	295	303	310	316	323	329	336	343	349	356	50
60	363	369	376	383	390	397	403	410	417	424	60
70	431	438	445	452	459	466	473	480	487	494	70
80	501	508	516	523	530	537	544	552	559	566	80
90	573	581	588	595	603	610	618	625	632	640	90
100	647	665	662	670	677	685	693	700	708	715	100
110	723	731	738	746	754	761	769	777	785	792	110
120	800	808	816	824	832	839	847	855	863	871	120
130	879	887	895	903	911	919	927	935	843	951	130
140	959	967	976	934	992	1 000	1 008	1 016	1 025	1 033	140
150	1 041	1 049	1 058	1 066	1 074	1 082	1 091	1 099	1 107	1 116	150
160	1 124	1 132	1 141	1 149	1 158	1 166	1 175	1 183	1 191	1 200	160
170	1 208	1 217	1 225	1 234	1 242	1 251	1 260	1 268	1 277	1 285	170
180	1 294	1 303	1 311	1 320	1 329	1 337	1 346	1 355	1 363	1 372	180
190	1 381	1 389	1 398	1 407	1 416	1 425	1 433	1 442	1 451	1 460	190
200	1 469	1 477	1 486	1 495	1 504	1 513	1 522	1 531	1 540	1 549	200
210	1 558	1 567	1 575	1 584	1 593	1 602	1 611	1 620	1 629	1 639	210
220	1 648	1 667	1 666	1 675	1 684	1 693	1 702	1 711	1 720	1 729	220
230	1 739	1 748	1 757	1 766	1 775	1 784	1 794	1 803	1 812	1 821	230
240	1 831	1 840	1 849	1 858	1 868	1 877	1 886	1 895	1 905	1 914	240
250	1 923	1 933	1 942	1 951	1 961	1 970	1 980	1 989	1 998	2 008	250
260	2 017	2 027	2 036	2 046	2 055	2 064	2 074	2 083	2 093	2 102	260
270	2 112	2 121	2 131	2 140	2 150	2 159	2 169	2 179	2 188	2 198	270
280	2 207	2 217	2 226	2 236	2 246	2 255	2 265	2 275	2 284	2 294	280
290	2 304	2 313	2 223	2 333	2 342	2 352	2 362	2 371	2 381	2 391	290

Electromotive force as a function of temperature

Type R: Platinum–13 % thorium/platinum (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
300	2 401	2 410	2 420	2 430	2 440	2 449	2 459	2 469	2 479	2 488	300
310	2 498	2 508	2 518	2 528	2 538	2 547	2 557	2 567	2 577	2 587	310
320	2 597	2 607	2 617	2 626	2 636	2 646	2 656	2 666	2 676	2 686	320
330	2 696	2 706	2 716	2 726	2 736	2 746	2 756	2 766	2 776	2 786	330
340	2 796	2 806	2 816	2 826	2 836	2 846	2 856	2 866	2 876	2 886	340
350	2 896	2 906	2 916	2 926	2 937	2 947	2 957	2 967	2 977	2 987	350
360	2 997	3 007	3 018	3 028	3 038	3 048	3 058	3 068	3 079	2 089	360
370	3 099	3 109	3 119	3 130	3 140	3 150	3 160	3 171	3 181	3 191	370
380	3 201	3 212	3 222	3 232	3 242	3 253	3 263	3 273	3 284	3 294	380
390	3 304	3 315	3 325	3 335	3 346	3 356	3 366	3 377	3 387	3 397	390
400	3 408	3 418	3 428	3 439	3 449	3 460	3 470	3 480	3 491	3 501	400
410	3 512	3 522	3 533	3 543	3 553	3 564	3 574	3 585	3 595	3 606	410
420	3 616	3 627	3 637	3 648	3 658	3 669	3 679	3 690	3 700	3 711	420
430	3 721	3 732	3 742	3 753	3 784	3 774	3 785	3 795	3 808	3 816	430
440	3 827	3 838	3 848	3 859	3 869	3 880	3 891	3 901	3 912	3 922	440
450	3 933	3 944	3 954	3 965	3 976	3 988	3 997	4 008	4 018	4 029	450
460	4 040	4 050	4 061	4 072	4 083	4 093	4 104	4 115	4 125	4 136	460
470	4 147	4 158	4 168	4 179	4 190	4 201	4 211	4 222	4 233	4 244	470
480	4 255	4 265	4 276	4 287	4 298	4 309	4 319	4 330	4 341	4 352	480
490	4 363	4 373	4 384	4 395	4 406	4 417	4 428	4 439	4 449	4 460	490
500	4 471	4 482	4 493	4 504	4 515	4 526	4 537	4 548	4 558	4 569	500
510	4 580	4 591	4 602	4 613	4 624	4 635	4 646	4 657	4 668	4 679	510
520	4 690	4 701	4 712	4 723	4 734	4 745	4 756	4 767	4 778	4 789	520
530	4 800	4 811	4 822	4 833	4 844	4 835	4 866	4 877	4 888	4 899	530
540	4 910	4 922	4 953	4 944	4 955	4 966	4 977	4 988	4 999	5 010	540
550	5 021	5 033	5 044	5 055	5 066	5 077	5 088	5 099	5 111	5 122	550
560	5 133	5 144	5 155	5 166	5 178	5 189	5 200	5 211	5 222	5 234	560
570	5 245	5 256	5 267	5 279	5 290	5 301	5 312	5 323	5 335	5 346	570
580	5 357	5 369	5 380	5 391	5 402	5 414	5 425	5 436	5 448	5 459	580
590	5 470	5 481	5 493	5 504	5 515	5 527	5 538	5 549	5 591	5 572	590

Electromotive force as a function of temperature

Type R: Platinum–13% rhodium/platinum (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
600	5 583	5 595	5 606	5 618	5 629	5 640	5 652	5 663	5 674	5 686	600
610	5 697	5 709	5 720	5 731	5 743	5 754	5 766	5 777	5 789	5 800	610
620	5 812	5 823	5 834	5 846	5 857	5 869	5 880	5 892	5 903	5 915	620
630	5 926	5 938	5 949	5 961	5 972	5 984	5 995	6 007	6 018	6 030	630
640	6 041	6 053	6 065	6 076	6 088	6 099	6 111	6 122	6 134	6 146	640
650	6 157	6 169	6 180	6 192	6 204	6 215	6 227	6 238	6 250	6 262	650
660	6 273	6 285	6 297	6 308	6 320	6 332	6 343	6 355	6 367	6 378	660
670	6 390	6 402	6 413	6 425	6 437	6 448	6 460	6 472	6 484	6 495	670
680	6 507	6 519	6 531	6 542	6 554	6 566	6 578	6 589	6 601	6 613	680
690	6 625	6 636	6 648	6 660	6 672	6 684	6 695	6 707	6 719	6 731	690
700	6 743	6 755	6 766	6 778	6 790	6 802	6 814	6 826	6 838	6 849	700
710	6 861	6 873	6 885	6 897	6 909	6 921	6 933	6 945	6 956	6 968	710
720	6 980	6 992	7 004	7 016	7 028	7 040	7 052	7 064	7 076	7 088	720
730	7 100	7 112	7 124	7 138	7 148	7 160	7 172	7 184	7 196	7 208	730
740	7 220	7 232	7 244	7 256	7 268	7 280	7 292	7 304	7 316	7 328	740
750	7 340	7 352	7 364	7 376	7 389	7 401	7 413	7 425	7 437	7 449	750
760	7 461	7 473	7 485	7 498	7 510	7 522	7 534	7 546	7 558	7 570	760
770	7 583	7 595	7 607	7 619	7 631	7 644	7 656	7 668	7 680	7 692	770
780	7 705	7 717	7 729	7 741	7 753	7 766	7 778	7 790	7 802	7 815	780
790	7 827	7 839	7 851	7 864	7 876	7 888	7 901	7 913	7 925	7 938	790
800	7 950	7 962	7 974	7 967	7 999	8 011	8 024	8 036	8 048	8 081	800
810	8 073	8 066	8 088	8 110	8 123	8 135	8 147	8 160	8 172	8 185	810
820	8 197	8 208	8 222	8 234	8 247	8 259	8 272	8 284	8 296	8 309	820
830	8 321	8 334	8 346	8 369	8 371	8 384	8 396	8 409	8 421	8 434	830
840	8 446	8 459	8 471	8 484	8 496	8 509	8 521	8 534	8 546	8 559	840
850	8 571	8 584	8 597	8 609	8 622	8 634	8 847	8 659	8 672	8 685	850
860	8 697	8 710	8 722	8 735	8 748	8 760	8 773	8 785	8 798	8 811	860
870	8 823	8 836	8 849	8 861	8 874	8 887	8 899	8 912	8 925	8 937	870
880	8 950	8 963	8 975	8 988	9 001	9 014	9 026	9 039	9 052	9 065	880
890	9 077	9 090	9 103	9 115	9 128	9 141	9 154	9 167	9 179	9 192	890

Electromotive force as a function of temperature

Type R: Platinum–13% rhodium/platinum (continued)

T90/ºC	E/µV 0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
900	9 205	9 218	9 230	9 243	9 256	9 269	9 282	9 294	9 307	9 320	900
910	9 333	9 346	9 359	9 371	9 384	9 397	9 410	9 423	9 436	9 449	910
920	9 461	9 474	9 487	9 500	9 513	9 526	9 539	9 552	9 565	9 578	920
930	9 590	9 603	9 616	9 629	9 642	9 655	9 668	9 681	9 694	9 707	930
940	9 720	9 733	9 746	9 759	9 772	9 785	9 798	9 811	9 824	9 837	940
950	9 850	9 863	9 876	9 889	9 902	9 915	9 928	9 941	9 954	9 967	950
960	9 980	9 993	10 008	10 019	10 032	10 046	10 059	10 072	10 085	10 098	960
970	10 111	10 124	10 137	10 150	10 163	10 177	10 190	10 203	10 216	10 229	970
980	10 242	10 255	10 268	10 282	10 295	10 308	10 321	10 334	10 347	10 361	980
990	10 374	10 387	10 400	10 413	10 427	10 440	10 453	10 466	10 480	10 493	990
1 000	10 506	10 519	10 532	10 546	10 559	10 572	10 585	10 599	10 612	10 625	1 000
1 010	10 638	10 652	10 665	10 678	10 692	10 705	10 718	10 731	10 745	10 758	1 010
1 020	10 771	10 785	10 798	10 811	10 825	10 838	10 851	10 865	10 878	10 891	1 020
1 030	10 905	10 918	10 932	10 945	10 958	10 972	10 965	10 998	11 012	11 025	1 030
1 040	11 039	11 052	11 065	11 079	11 092	11 106	11 119	11 132	11 146	11 159	1 040
1 050	11 173	11 186	11 200	11 213	11 227	11 240	11 253	11 267	11 280	11 294	1 050
1 060	11 307	11 321	11 334	11 348	11 361	11 375	11 388	11 402	11 415	11 429	1 060
1 070	11 442	11 456	11 469	11 483	11 498	11 510	11 524	11 537	11 551	11 564	1 070
1 080	11 678	11 591	11 605	11 618	11 632	11 646	11 659	11 573	11 686	11 700	1 080
1 090	11 714	11 727	11 741	11 754	11 768	11 782	11 795	11 809	11 822	11 836	1 090
1 100	11 850	11 863	11 877	11 891	11 904	11 918	11 931	11 945	11 959	11 972	1 100
1 110	11 986	12 000	12 013	12 027	12 041	12 054	12 068	12 082	12 096	12 109	1 110
1 120	12 123	12 137	12 150	12 164	12 178	12 191	12 205	12 219	12 233	12 246	1 120
1 130	12 260	12 274	12 288	12 301	12 315	12 329	12 342	12 356	12 370	12 384	1 130
1 140	12 397	12 411	12 425	12 439	12 453	12 466	12 480	12 494	12 508	12 521	1 140
1 150	12 535	12 549	12 563	12 577	12 590	12 604	12 618	12 632	12 646	12 659	1 150
1 160	12 673	12 687	12 701	12 715	12 729	12 742	12 756	12 770	12 784	12 798	1 160
1 170	12 812	12 825	12 839	12 853	12 867	12 881	12 895	12 909	12 922	12 936	1 170
1 180	12 950	12 964	12 978	12 992	13 006	13 019	13 033	13 047	13 061	13 075	1 180
1 190	13 089	13 103	13 117	13 131	13 145	13 158	13 172	13 186	13 200	13 214	1 190

Electromotive force as a function of temperature

Type R: Platinum–13% rhodium/platinum (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
1 200	13 228	13 242	13 256	13 270	13 284	13 298	13 311	13 325	13 339	13 353	1 200
1 210	13 367	13 381	13 395	13 409	13 423	13 437	13 451	13 465	13 479	13 493	1 210
1 220	13 608	13 521	13 535	13 549	13 563	13 577	13 590	13 604	13 618	13 632	1 220
1 230	13 646	13 660	13 674	13 688	13 702	13 716	13 730	13 744	13 758	13 772	1 230
1 240	13 786	13 800	13 814	13 828	13 842	13 856	13 870	13 884	13 898	13 945	1 240
1 250	13 926	13 940	13 954	13 968	13 982	13 996	14 010	14 024	14 038	14 052	1 250
1 260	14 066	14 081	14 095	14 109	14 123	14 137	14 151	14 165	14 179	14 193	1 260
1 270	14 207	14 221	14 235	14 249	14 263	14 277	14 291	14 305	14 319	14 333	1 270
1 280	14 347	14 361	14 375	14 390	14 404	14 418	14 432	14 446	14 460	14 474	1 280
1 290	14 488	14 502	14 516	14 530	14 544	14 558	14 572	14 586	14 601	14 615	1 290
1 300	14 629	14 643	14 657	14 671	14 685	14 699	14 713	14 727	14 741	14 755	1 300
1 310	14 770	14 784	14 798	14 812	14 826	14 840	14 854	14 868	14 882	14 896	1 310
1 320	14 911	14 925	14 939	14 953	14 967	14 981	14 995	15 009	15 023	15 037	1 320
1 330	15 052	15 066	15 080	15 094	15 108	15 122	15 136	15 150	15 164	15 179	1 330
1 340	15 193	15 207	15 221	15 235	15 249	15 263	15 277	15 291	15 306	15 320	1 340
1 350	15 334	15 348	15 362	15 376	15 390	15 404	15 419	15 433	15 447	15 461	1 350
1 360	15 475	15 489	15 503	15 517	15 531	15 546	15 560	15 574	15 588	15 602	1 360
1 370	15 616	15 630	15 645	15 659	15 673	15 687	15 701	15 715	15 729	15 743	1 370
1 380	15 758	15 772	15 786	15 800	15 814	15 828	15 842	15 856	15 871	15 885	1 380
1 390	15 899	15 913	15 927	15 940	15 955	15 969	15 984	15 998	16 012	16 026	1 390
1 400	16 040	16 054	16 068	16 082	16 097	16 111	16 125	16 139	16 153	16 167	1 400
1 410	16 181	16 196	16 210	16 224	16 238	16 252	16 266	16 280	16 294	16 309	1 410
1 420	16 323	16 337	16 351	16 365	16 379	16 393	16 407	16 422	16 436	16 450	1 420
1 430	16 464	16 478	16 492	16 506	16 520	16 534	16 549	16 563	16 577	16 591	1 430
1 440	16 605	16 619	16 633	16 647	16 662	16 676	16 690	16 704	16 718	16 732	1 440
1 450	16 748	16 760	16 774	16 789	16 803	16 817	16 831	16 845	16 859	16 873	1 450
1 460	16 887	16 901	16 915	16 930	16 944	16 958	16 972	16 986	17 000	17 014	1 460
1 470	17 028	17 042	17 056	17 071	17 085	17 099	17 113	17 127	17 141	17 155	1 470
1 480	17 169	17 183	17 197	17 211	17 225	17 240	17 254	17 268	17 252	17 296	1 480
1 490	17 310	17 324	17 336	17 352	17 366	17 380	17 394	17 408	17 423	17 437	1 490

Electromotive force as a function of temperature

Type R: Platinum–13% rhodium/platinum (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
1 500	17 451	17 465	17 479	17 493	17 507	17 521	17 535	17 549	17 563	17 577	1 500
1 510	17 591	17 605	17 619	17 633	17 647	17 661	17 676	17 690	17 704	17 718	1 510
1 520	17 732	17 746	17 760	17 774	17 788	17 802	17 816	17 830	17 844	17 858	1 520
1 530	17 872	17 886	17 900	17 914	17 928	17 942	17 956	17 970	17 984	17 998	1 530
1 540	18 012	18 026	18 040	18 054	18 068	18 082	18 096	18 110	18 124	18 138	1 540
1 550	18 152	18 166	18 180	18 194	18 208	18 222	18 236	18 250	18 264	18 278	1 550
1 560	18 292	18 306	18 320	18 334	18 348	18 362	18 376	18 390	18 404	18 417	1 560
1 570	18 431	18 445	18 459	18 473	18 487	18 501	18 515	18 529	18 543	18 567	1 570
1 580	18 571	18 585	18 699	18 613	18 627	18 640	18 654	18 668	18 682	18 696	1 580
1 590	18 710	18 724	18 738	18 752	18 786	18 779	18 793	18 807	18 821	18 835	1 590
1 600	18 849	18 863	18 877	18 891	18 904	18 918	18 932	18 946	18 960	18 974	1 600
1 610	18 988	19 002	19 015	19 029	19 043	19 057	19 071	19 085	19 098	19 112	1 610
1 620	19 126	19 140	19 154	19 168	19 181	19 195	19 209	19 223	19 237	19 250	1 620
1 630	19 264	19 278	19 292	19 306	19 319	19 333	19 347	19 361	19 375	19 388	1 630
1 640	19 402	19 416	19 430	19 444	19 457	19 471	19 485	19 499	19 512	19 526	1 640
1 650	19 540	19 554	19 567	19 561	19 595	19 609	19 622	19 636	19 650	19 663	1 650
1 660	19 677	19 691	19 705	19 718	19 732	19 746	19 759	19 773	19 787	19 800	1 660
1 670	19 814	19 828	19 841	19 855	19 869	19 882	19 896	19 910	19 923	19 937	1 670
1 680	19 951	19 964	19 978	19 992	20 005	20 019	20 032	20 046	20 060	20 073	1 680
1 690	20 067	20 100	20 114	20 127	20 141	20 154	20 168	20 181	20 195	20 208	1 690
1 700	20 222	20 235	20 249	20 262	20 275	20 289	20 302	20 316	20 329	20 342	1 700
1 710	20 356	20 369	20 382	20 396	20 409	20 422	20 436	20 449	20 462	20 475	1 710
1 720	20 488	20 502	20 515	20 528	20 541	20 554	20 567	20 581	20 594	20 607	1 720
1 730	20 620	20 633	20 646	20 659	20 672	20 685	20 598	20 711	20 724	20 736	1 730
1 740	20 749	20 762	20 775	20 788	20 801	20 813	20 826	20 839	20 652	20 864	1 740
1 750	20 877	20 890	20 902	20 915	20 928	20 940	20 953	20 965	20 978	20 990	1 750
1 760	21 003	21 015	21 027	21 040	21 052	21 065	21 077	21 089	21 101		1 760

Electromotive force as a function of temperature

Type S: Platinum–10% rhodium/platinum (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
0	0	5	11	16	22	27	33	38	44	50	0
10	55	61	67	72	78	84	90	95	101	107	10
20	113	119	125	131	137	143	149	155	161	167	20
30	173	179	185	191	197	204	210	216	222	229	30
40	235	241	248	254	260	267	273	280	286	292	40
50	299	305	312	319	325	332	338	345	352	358	50
60	365	372	378	385	392	399	405	412	419	426	60
70	433	440	446	453	460	467	474	481	488	495	70
80	502	509	516	523	530	538	545	552	559	566	80
90	573	580	588	595	602	609	617	624	631	639	90
100	646	653	661	668	675	683	690	698	705	713	100
110	720	727	735	743	750	758	765	773	780	788	110
120	795	803	811	818	828	834	841	849	857	865	120
130	872	880	888	896	903	911	919	927	935	942	130
140	950	658	966	974	982	990	998	1 006	1 013	1 021	140
150	1 029	1 037	1 045	1 053	1 061	1 069	1 077	1 085	1 094	1 102	150
160	1 110	1 118	1 126	1 134	1 142	1 150	1 158	1 167	1 175	1 183	160
170	1 191	1 199	1 207	1 216	1 224	1 232	1 240	1 249	1 257	1 265	170
180	1 273	1 282	1 290	1 296	1 307	1 315	1 323	1 332	1 340	1 348	180
190	1 357	1 365	1 373	1 382	1 390	1 399	1 407	1 415	1 424	1 432	190
200	1 441	1 449	1 458	1 466	1 475	1 483	1 492	1 500	1 509	1 517	200
210	1 526	1 534	1 543	1 551	1 560	1 569	1 577	1 586	1 594	1 603	210
220	1 612	1 620	1 629	1 638	1 646	1 655	1 663	1 672	1 681	1 690	220
230	1 698	1 707	1 716	1 724	1 733	1 742	1 751	1 759	1 768	1 777	230
240	1 786	1 794	1 803	1 812	1 821	1 829	1 838	1 847	1 856	1 865	240
250	1 874	1 882	1 891	1 900	1 909	1 918	1 927	1 936	1 944	1 953	250
260	1 962	1 971	1 980	1 989	1 998	2 007	2 016	2 025	2 034	2 043	260
270	2 052	2 061	2 070	2 078	2 087	2 096	2 105	2 114	2 123	2 132	270
280	2 141	2 151	2 160	2 169	2 178	2 187	2 196	2 205	2 214	2 223	280
290	2 232	2 241	2 250	2 259	2 268	2 277	2 287	2 296	2 305	2 314	290

Electromotive force as a function of temperature

Type S: Platinum–10% rhodium/platinum (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
300	2 323	2 332	2 341	2 350	2 360	2 369	2 378	2 387	2 396	2 405	300
310	2 415	2 424	2 433	2 442	2 451	2 461	2 470	2 479	2 488	2 497	310
320	2 507	2 516	2 525	2 534	2 544	2 553	2 562	2 571	2 581	2 590	320
330	2 599	2 609	2 616	2 627	2 636	2 646	2 655	2 664	2 674	2 683	330
340	2 692	2 702	2 711	2 720	2 730	2 739	2 748	2 758	2 767	2 776	340
350	2 786	2 795	2 805	2 814	2 823	2 833	2 842	2 851	2 861	2 870	350
360	2 880	2 889	2 899	2 908	2 917	2 927	2 836	2 946	2 955	2 965	360
370	2 974	2 983	2 993	3 002	3 012	3 021	3 031	3 040	3 050	3 059	370
380	3 069	3 078	3 088	3 097	3 107	3 116	3 126	3 135	3 145	3 154	380
390	3 164	3 173	3 183	3 192	3 202	3 212	3 221	3 231	3 240	3 250	390
400	3 259	3 269	3 279	3 288	3 298	3 307	3 317	3 326	3 336	3 346	400
410	3 355	3 365	3 374	3 384	3 394	3 404	3 413	3 423	3 432	3 442	410
420	3 451	3 461	3 471	3 480	3 490	3 500	3 509	3 519	3 529	3 538	420
430	3 548	3 558	3 567	3 577	3 587	3 596	3 606	3 616	3 626	3 635	430
440	3 645	3 655	3 664	3 674	3 684	3 694	3 703	3 713	3 723	3 732	440
450	3 742	3 752	3 762	3 771	3 781	3 791	3 801	3 810	3 820	3 830	450
460	3 840	3 860	3 859	3 869	3 879	3 889	3 898	3 908	3 918	3 928	460
470	3 938	3 947	3 957	3 967	3 977	3 987	3 997	4 006	4 016	4 026	470
480	4 036	4 046	4 058	4 065	4 075	4 085	4 095	4 105	4 115	4 125	480
490	4 134	4 144	4 154	4 164	4 174	4 184	4 194	4 204	4 213	4 223	490
500	4 233	4 243	4 253	4 263	4 273	4 283	4 293	4 303	4 313	4 323	500
510	4 332	4 342	4 352	4 362	4 372	4 382	4 392	4 402	4 412	4 422	510
520	4 432	4 442	4 452	4 462	4 472	4 482	4 492	4 502	4 512	4 522	520
530	4 532	4 542	4 552	4 562	4 572	4 582	4 592	4 602	4 612	4 622	530
540	4 632	4 642	4 652	4 662	4 672	4 682	4 692	4 702	4 712	4 722	540
550	4 732	4 742	4 752	4 762	4 772	4 782	4 793	4 803	4 813	4 823	550
560	4 833	4 843	4 853	4 863	4 873	4 883	4 893	4 904	4 914	4 924	560
570	4 934	4 944	4 954	4 964	4 974	4 984	4 995	5 005	5 015	5 025	570
580	5 035	5 045	5 055	5 066	5 076	5 086	5 096	5 106	5 116	5 127	580
590	5 137	5 147	5 157	5 167	5 178	5 188	5 198	5 208	5 218	5 228	590

Electromotive force as a function of temperature

Type S: Platinum–10% rhodium/platinum (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
600	5 239	5 249	5 259	5 269	5 280	5 290	5 300	5 310	5 320	5 331	600
610	5 341	5 351	5 361	5 372	5 382	5 392	5 402	5 413	5 423	5 433	610
620	5 443	5 454	5 464	5 474	5 485	5 495	5 505	5 515	5 526	5 536	620
630	5 546	5 567	5 687	5 577	5 588	5 698	5 608	5 618	5 629	5 839	630
640	5 649	5 660	5 670	5 680	5 691	5 701	5 712	5 722	5 732	5 743	640
650	5 753	5 763	5 774	5 784	5 794	5 805	5 815	5 826	5 836	5 846	650
660	5 857	5 867	5 878	5 888	5 898	5 909	5 919	5 930	5 940	5 950	660
670	5 961	5 971	5 982	5 992	6 003	6 013	6 024	6 034	6 044	6 055	670
680	6 065	6 076	6 086	6 097	6 107	6 118	6 128	6 139	6 149	6 160	680
690	6 170	6 181	6 191	6 202	6 212	6 223	6 233	6 244	6 254	6 265	690
700	6 275	6 286	6 296	6 307	6 317	6 328	6 338	6 349	6 360	6 370	700
710	6 381	6 391	6 402	6 412	6 423	6 434	6 444	6 455	6 465	6 476	710
720	6 488	6 497	6 508	6 518	6 529	6 539	6 550	6 561	6 571	6 582	720
730	6 593	6 603	6 614	6 624	6 635	6 646	6 656	6 667	6 678	6 688	730
740	6 699	6 710	6 720	6 731	6 742	6 752	6 763	6 774	6 784	6 795	740
750	6 806	6 817	6 827	6 838	5 849	6 859	6 870	6 881	6 892	6 902	750
760	6 913	6 924	6 934	6 945	6 956	6 967	6 977	6 988	6 999	7 010	760
770	7 020	7 031	7 042	7 053	7 084	7 074	7 085	7 096	7 107	7 117	770
780	7 128	7 139	7 150	7 161	7 172	7 182	7 193	7 204	7 215	7 226	780
790	7 236	7 247	7 258	7 269	7 280	7 291	7 302	7 312	7 323	7 334	790
800	7 345	7 356	7 367	7 378	7 388	7 399	7 410	7 421	7 432	7 443	800
810	7 454	7 465	7 476	7 487	7 497	7 508	7 519	7 530	7 541	7 552	810
820	7 563	7 574	7 585	7 596	7 607	7 618	7 629	7 640	7 651	7 662	820
830	7 673	7 684	7 695	7 706	7 717	7 728	7 739	7 750	7 761	7 772	830
840	7 783	7 794	7 805	7 816	7 827	7 838	7 849	7 860	7 871	7 882	840
850	7 893	7 904	7 915	7 926	7 937	7 948	7 959	7 970	7 981	7 992	850
860	8 003	8 014	8 026	8 037	8 048	8 059	8 070	8 081	8 092	8 103	860
870	8 114	8 125	8 137	8 148	8 159	8 170	8 181	8 192	8 203	8 214	870
880	8 226	8 237	8 248	8 259	8 270	8 281	8 293	8 304	8 315	8 326	880
890	8 337	8 348	8 380	8 371	8 382	8 393	8 404	8 416	8 427	8 438	890

Electromotive force as a function of temperature

Type S: Platinum–10% rhodium/platinum (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
900	8 449	8 460	8 472	8 483	8 494	8 505	8 517	8 528	8 539	8 550	900
910	8 562	8 573	8 584	8 595	8 607	8 618	8 629	8 640	8 652	8 663	910
920	8 674	8 685	8 697	8 708	8 719	8 731	8 742	8 753	8 765	8 776	920
930	8 787	8 798	8 810	8 821	8 832	8 844	8 855	8 866	8 878	8 889	930
940	8 900	8 912	8 923	8 935	8 946	8 957	8 969	8 980	8 991	9 003	940
950	9 014	9 025	9 037	9 048	9 060	9 071	9 082	9 094	9 105	9 117	950
960	9 128	9 139	9 151	9 162	9 174	9 185	9 197	9 208	9 219	9 231	960
970	9 242	9 254	9 265	9 277	9 288	9 300	9 311	9 323	9 334	9 345	970
980	9 357	9 368	9 380	9 391	9 403	9 414	9 426	9 437	9 449	9 460	980
990	9 472	9 483	9 495	9 506	9 518	9 529	9 541	9 552	9 564	9 576	990
1 000	9 587	9 599	9 610	9 622	9 633	9 645	9 656	9 666	9 880	9 691	1 000
1 010	9 703	9 714	9 726	9 737	9 749	9 761	9 772	9 784	9 795	9 807	1 010
1 020	9 819	9 830	9 842	9 853	9 865	9 877	9 888	9 900	9 911	9 923	1 020
1 030	9 935	9 946	9 958	9 970	9 981	9 993	10 005	10 018	10 028	10 040	1 030
1 040	10 051	10 063	10 076	10 086	10 098	10 110	10 121	10 133	10 145	10 156	1 040
1 050	10 168	10 180	10 191	10 203	10 215	10 227	10 238	10 250	10 262	10 273	1 050
1 060	10 285	10 297	10 309	10 320	10 332	10 344	10 356	10 367	10 379	10 391	1 060
1 070	10 403	10 414	10 426	10 438	10 450	10 461	10 473	10 485	10 497	10 509	1 070
1 080	10 520	10 532	10 544	10 556	10 567	10 579	10 591	10 603	10 615	10 626	1 080
1 090	10 638	10 650	10 662	10 674	10 688	10 697	10 709	10 721	10 733	10 745	1 090
1 100	10 757	10 768	10 780	10 792	10 804	10 816	10 828	10 839	10 851	10 863	1 100
1 110	10 675	10 887	10 899	10 911	10 922	10 934	10 946	10 958	10 970	10 982	1 110
1 120	10 994	11 006	11 017	11 029	11 041	11 053	11 065	11 077	11 089	11 101	1 120
1 130	11 113	11 125	11 136	11 148	11 160	11 172	11 184	11 196	11 208	11 220	1 130
1 140	11 232	11 244	11 256	11 268	11 280	11 291	11 303	11 315	11 327	11 339	1 140
1 150	11 351	11 363	11 375	11 387	11 399	11 411	11 423	11 435	11 447	11 459	1 150
1 160	11 471	11 483	11 495	11 507	11 519	11 531	11 542	11 554	11 566	11 578	1 160
1 170	11 590	11 602	11 614	11 626	11 638	11 650	11 662	11 674	11 686	11 698	1 170
1 180	11 710	11 722	11 734	11 746	11 758	11 770	11 782	11 794	11 806	11 818	1 180
1 190	11 830	11 842	11 854	11 866	11 878	11 890	11 902	11 914	11 926	11 939	1 190

Electromotive force as a function of temperature

Type S: Platinum–10% rhodium/platinum (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
1 200	11 951	11 963	11 975	11 967	11 999	12 011	12 023	12 035	12 047	12 059	1 200
1 210	12 071	12 083	12 095	12 107	12 119	12 131	12 143	12 155	12 167	12 179	1 210
1 220	12 191	12 203	12 216	12 228	12 240	12 252	12 264	12 276	12 268	12 300	1 220
1 230	12 312	12 324	12 336	12 348	12 360	12 372	12 384	12 397	12 409	12 421	1 230
1 240	12 433	12 445	12 457	12 469	12 481	12 493	12 505	12 517	12 529	12 542	1 240
1 250	12 554	12 566	12 578	12 590	12 602	12 614	12 626	12 638	12 650	12 662	1 250
1 260	12 675	12 687	12 699	12 711	12 723	12 735	12 747	12 759	12 771	12 783	1 260
1 270	12 796	12 808	12 820	12 832	12 844	12 856	12 868	12 880	12 892	12 905	1 270
1 280	12 917	12 929	12 941	12 953	12 965	12 977	12 989	13 001	13 014	13 026	1 280
1 290	13 038	13 050	13 062	13 074	13 086	13 098	13 111	13 123	13 135	13 147	1 290
1 300	13 159	13 171	13 183	13 195	13 208	13 220	13 232	13 244	13 256	13 268	1 300
1 310	13 280	13 292	13 305	13 317	13 329	13 341	13 953	13 365	13 377	13 390	1 310
1 320	13 402	13 414	13 426	13 438	13 450	13 462	13 474	13 487	13 499	13 511	1 320
1 330	13 523	13 535	13 547	13 559	13 572	13 584	13 596	13 606	13 620	13 632	1 330
1 340	13 644	13 657	13 669	13 681	13 693	13 705	13 717	13 729	13 742	13 754	1 340
1 350	13 766	13 778	13 790	13 802	13 814	13 826	13 839	13 851	13 863	13 875	1 350
1 360	13 887	13 899	13 911	13 924	13 936	13 948	13 960	13 972	13 884	13 996	1 360
1 370	14 009	14 021	14 033	14 045	14 057	14 069	14 081	14 094	14 106	14 118	1 370
1 380	14 130	14 142	14 154	14 166	14 178	14 191	14 203	14 215	14 227	14 239	1 380
1 390	14 251	14 263	14 276	14 288	14 300	14 312	14 324	14 336	14 348	14 360	1 390
1 400	14 373	14 385	14 397	14 409	14 421	14 433	14 445	14 457	14 470	14 482	1 400
1 410	14 494	14 506	14 518	14 530	14 542	14 554	14 567	14 579	14 591	14 603	1 410
1 420	14 615	14 627	14 639	14 651	14 664	14 676	14 688	14 700	14 712	14 724	1 420
1 430	14 736	14 748	14 760	14 773	14 785	14 797	14 809	14 821	14 833	14 845	1 430
1 440	14 857	14 869	14 881	14 894	14 906	14 918	14 930	14 942	14 954	14 966	1 440
1 450	14 978	14 990	15 002	15 015	15 027	15 039	15 051	15 063	15 075	15 087	1 450
1 460	15 099	15 111	15 123	15 135	15 148	15 160	15 172	15 184	15 196	15 208	1 460
1 470	15 220	15 232	15 244	15 256	15 268	15 280	15 292	15 304	15 317	15 329	1 470
1 480	15 341	15 353	15 365	15 377	15 389	15 401	15 413	15 425	15 437	15 449	1 480
1 490	15 461	15 473	15 485	15 497	15 509	15 521	15 534	15 546	15 558	15 570	1 490

Electromotive force as a function of temperature

Type S: Platinum–10% rhodium/platinum (concluded)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
1 500	15 582	15 594	15 606	15 618	15 630	15 642	15 654	15 666	15 678	15 690	1 500
1 510	15 702	15 714	15 726	15 738	15 750	15 762	15 774	15 786	15 798	15 810	1 510
1 520	15 822	15 834	15 846	15 858	15 870	15 882	15 894	15 906	15 918	15 930	1 520
1 530	15 942	15 954	15 966	15 978	15 990	16 002	16 014	16 026	16 038	16 050	1 530
1 540	16 062	16 074	16 086	16 098	16 110	16 122	16 134	16 146	16 158	16 170	1 540
1 550	16 182	16 194	16 205	16 217	16 229	16 241	16 253	16 265	16 277	16 289	1 550
1 560	16 301	16 313	16 325	16 337	16 349	16 361	16 373	16 385	16 396	16 408	1 560
1 570	16 420	16 432	16 444	16 456	16 468	16 480	16 492	16 504	16 516	16 527	1 570
1 580	16 539	16 551	16 563	16 575	16 587	16 599	16 611	16 623	16 634	16 646	1 580
1 590	16 658	16 670	16 682	16 694	16 706	16 718	16 729	16 741	16 753	16 785	1 590
1 600	16 777	16 789	16 801	16 812	16 824	16 836	16 848	16 860	16 872	16 883	1 600
1 610	16 895	16 907	16 919	16 931	16 943	16 954	16 966	16 978	16 990	17 002	1 610
1 620	17 013	17 025	17 037	17 049	17 061	17 072	17 084	17 096	17 108	17 120	1 620
1 630	17 131	17 143	17 155	17 167	17 178	17 190	17 202	17 214	17 225	17 237	1 630
1 640	17 249	17 261	17 272	17 284	17 296	17 308	17 319	17 331	17 343	17 355	1 640
1 650	17 366	17 378	17 390	17 401	17 413	17 425	17 437	17 448	17 460	17 472	1 650
1 660	17 483	17 495	17 507	17 518	17 530	17 542	17 553	17 565	17 577	17 588	1 660
1 670	17 600	17 612	17 623	17 635	17 647	17 658	17 670	17 682	17 693	17 705	1 670
1 680	17 717	17 728	17 740	17 751	17 763	17 775	17 786	17 798	17 809	17 821	1 680
1 690	17 832	17 844	17 855	17 867	17 878	17 890	17 901	17 913	17 924	17 936	1 690
1 700	17 947	17 959	17 970	17 982	17 993	18 004	18 016	18 027	18 039	18 050	1 700
1 710	18 061	18 073	18 084	18 095	18 107	18 118	18 129	18 140	18 152	18 163	1 710
1 720	18 174	18 185	18 196	18 208	18 219	18 230	18 241	18 252	18 263	18 274	1 720
1 730	18 285	18 297	18 308	18 319	18 330	18 341	18 352	18 362	18 373	18 384	1 730
1 740	18 395	18 406	18 417	18 428	18 439	18 449	18 460	18 471	18 482	18 493	1 740
1 750	18 503	18 614	18 525	18 535	18 546	18 557	18 567	18 578	18 588	18 599	1 750
1 760	18 609	18 620	18 630	18 641	18 651	18 661	18 672	18 682	18 693		1 760

Electromotive force as a function of temperature

Type B: Platinum–30% rhodium/platinum–6% rhodium

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
0	0	0	0	-1	-1	-1	-1	-1	-2	-2	0
10	-2	-2	-2	-2	-2	-2	-2	-2	-3	-3	10
20	-3	-3	-3	-3	-3	-2	-2	-2	-2	-2	20
30	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	30
40	0	0	0	0	0	1	1	1	2	2	40
50	2	3	3	3	4	4	4	5	5	6	50
60	6	7	7	8	8	9	9	10	10	11	60
70	11	12	12	13	14	14	15	15	16	17	70
80	17	18	19	20	20	21	22	22	23	24	80
90	25	26	26	27	28	29	30	31	31	32	90
100	33	34	35	36	37	38	39	40	41	42	100
110	43	44	45	46	47	48	49	50	51	52	110
120	53	55	56	57	58	59	60	62	63	64	120
130	65	66	68	69	70	72	73	74	75	77	130
140	78	79	81	82	84	85	86	88	89	91	140
150	92	94	95	96	98	99	101	102	104	106	150
160	107	109	110	112	113	115	117	118	120	122	160
170	123	125	127	128	130	132	134	135	137	139	170
180	141	142	144	146	148	150	151	153	155	157	180
190	159	161	163	165	166	168	170	172	174	176	190
200	178	180	182	184	186	188	190	192	196	197	200
210	199	201	203	204	207	209	212	214	216	218	210
220	220	222	225	227	229	231	234	236	238	241	220
230	243	245	248	250	252	255	257	259	262	264	230
240	267	269	271	274	276	279	281	284	286	289	240
250	291	294	296	299	301	304	307	309	312	314	250
260	317	320	322	325	328	330	333	336	338	341	260
270	344	347	349	352	355	358	360	363	366	369	270
280	372	375	377	380	383	386	389	392	395	398	280
290	401	404	407	410	413	416	419	422	425	428	290

Electromotive force as a function of temperature

Type B: Platinum–30% rhodium/platinum–6% rhodium (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
300	431	434	437	440	443	446	449	452	455	458	300
310	462	466	468	471	474	478	481	484	487	490	310
320	494	497	500	503	507	510	513	517	520	523	320
330	527	530	533	537	540	544	547	550	554	557	330
340	561	564	568	571	575	578	582	585	589	592	340
350	596	599	603	607	610	614	617	621	625	928	350
360	632	636	639	643	647	650	654	658	662	665	360
370	669	673	677	680	684	688	692	696	700	703	370
380	707	711	715	719	723	727	731	735	738	742	380
390	746	750	754	758	762	766	770	774	778	782	390
400	787	791	795	799	803	807	811	815	819	824	400
410	828	832	836	840	844	849	853	857	861	866	410
420	870	874	878	883	887	891	896	900	904	909	420
430	913	917	922	926	930	935	939	944	948	953	430
440	957	961	966	970	975	979	984	986	993	994	440
450	1 002	1 007	1 011	1 016	1 020	1 025	1 030	1 034	1 039	1 043	450
460	1 048	1 053	1 057	1 062	1 067	1 071	1 076	1 081	1 086	1 090	460
470	1 095	1 100	1 106	1 109	1 114	1 119	1 124	1 129	1 133	1 138	470
480	1 143	1 148	1 153	1 158	1 163	1 167	1 172	1 177	1 182	1 187	480
490	1 192	1 197	1 202	1 207	1 212	1 217	1 222	1 227	1 232	1 237	490
500	1 242	1 247	1 252	1 257	1 262	1 267	1 272	1 277	1 282	1 288	500
510	1 293	1 298	1 303	1 308	1 313	1 318	1 324	1 329	1 334	1 339	510
520	1 344	1 350	1 355	1 380	1 365	1 371	1 376	1 381	1 387	1 392	520
530	1 397	1 402	1 408	1 413	1 418	1 424	1 429	1 435	1 440	1 445	530
540	1 451	1 456	1 462	1 467	1 472	1 478	1 483	1 489	1 494	1 500	540
550	1 505	1 511	1 516	1 522	1 527	1 533	1 539	1 544	1 550	1 555	550
560	1 561	1 566	1 572	1 578	1 583	1 589	1 595	1 600	1 606	1 612	560
570	1 617	1 623	1 629	1 634	1 640	1 646	1 652	1 657	1 663	1 669	570
580	1 675	1 660	1 686	1 692	1 698	1 704	1 709	1 715	1 721	1 727	580
590	1 733	1 739	1 745	1 750	1 756	1 762	1 768	1 774	1 780	1 786	590

Electromotive force as a function of temperature

Type B: Platinum–30% rhodium/platinum–6% rhodium (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
600	1 792	1 798	1 804	1 810	1 816	1 822	1 828	1 834	1 840	1 846	600
610	1 852	1 858	1 864	1 870	1 876	1 882	1 888	1 894	1 901	1 907	610
620	1 913	1 919	1 925	1 931	1 937	1 944	1 950	1 956	1 962	1 968	620
630	1 975	1 981	1 987	1 993	1 999	2 006	2 012	2 018	2 025	2 031	630
640	2 037	2 043	2 050	2 056	2 062	2 069	2 075	2 082	2 088	2 094	640
650	2 101	2 107	2 113	2 120	2 126	2 133	2 139	2 146	2 152	2 158	650
660	2 165	2 171	2 178	2 184	2 191	2 197	2 204	2 210	2 217	2 224	660
670	2 230	2 237	2 243	2 250	2 256	2 263	2 270	2 276	2 283	2 289	670
680	2 296	2 303	2 309	2 316	2 323	2 329	2 336	2 343	2 350	2 356	680
690	2 363	2 370	2 376	2 383	2 390	2 397	2 403	2 410	2 417	2 424	690
700	2 431	2 437	2 444	2 451	2 458	2 465	2 472	2 479	2 485	2 492	700
710	2 499	2 506	2 513	2 520	2 527	2 534	2 541	2 548	2 556	2 562	710
720	2 569	2 576	2 583	2 590	2 597	2 604	2 611	2 618	2 625	2 632	720
730	2 639	2 646	2 653	2 660	2 667	2 574	2 681	2 688	2 696	2 703	730
740	2 710	2 717	2 724	2 731	2 738	2 746	2 753	2 760	2 767	2 775	740
750	2 782	2 789	2 796	2 803	2 811	2 818	2 825	2 833	2 840	2 847	750
760	2 854	2 862	2 869	2 876	2 884	2 891	2 898	2 906	2 913	2 921	760
770	2 928	2 935	2 943	2 950	2 958	2 965	2 973	2 980	2 987	2 995	770
780	3 002	3 010	3 017	3 025	3 032	3 040	3 047	3 055	3 062	3 070	780
790	3 078	3 085	3 093	3 100	3 108	3 116	3 123	3 131	3 138	3 146	790
800	3 154	3 161	3 169	3 177	3 184	3 192	3 200	3 207	3 215	3 223	800
810	3 230	3 238	3 246	3 254	3 261	3 269	3 277	3 285	3 292	3 300	810
820	3 308	3 316	3 324	3 331	3 339	3 347	3 365	3 363	3 371	3 379	820
830	3 386	3 394	3 402	3 410	3 418	3 426	3 434	3 442	3 450	3 458	830
840	3 466	3 474	3 482	3 490	3 498	3 506	3 514	3 522	3 530	3 538	840
850	3 546	3 554	3 582	3 570	3 578	3 586	3 594	3 602	3 610	3 618	850
860	3 626	3 634	3 643	3 651	3 659	3 667	3 675	3 683	3 692	3 700	860
870	3 708	3 716	3 724	3 732	3 741	3 749	3 757	3 765	3 774	3 782	870
880	3 790	3 798	3 807	3 815	3 823	3 832	3 840	3 848	3 857	3 865	880
890	3 673	3 882	3 890	3 898	3 907	3 915	3 923	3 932	3 940	3 949	890

Electromotive force as a function of temperature

Type B: Platinum–30% rhodium/platinum–6% rhodium (continued)

	E/μV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
900	3 957	3 965	3 974	3 982	3 991	3 999	4 008	4 016	4 024	4 033	900
910	4 041	4 050	4 058	4 067	4 075	4 084	4 093	4 101	4 110	4 118	910
920	4 127	4 135	4 144	4 152	4 161	4 170	4 178	4 187	4 195	4 204	920
930	4 213	4 221	4 230	4 239	4 247	4 256	4 265	4 273	4 282	4 291	930
940	4 299	4 308	4 317	4 326	4 334	4 343	4 352	4 360	4 369	4 378	940
950	4 387	4 396	4 404	4 413	4 422	4 431	4 440	4 448	4 457	4 466	950
960	4 475	4 484	4 493	4 501	4 510	4 519	4 528	4 537	4 546	4 555	960
970	4 564	4 573	4 582	4 591	4 599	4 608	4 617	4 626	4 635	4 644	970
980	4 653	4 662	4 671	4 680	4 689	4 698	4 707	4 716	4 725	4 734	980
990	4 743	4 753	4 762	4 771	4 780	4 789	4 798	4 807	4 816	4 825	990
1 000	4 834	4 843	4 853	4 862	4 871	4 880	4 889	4 898	4 908	4 917	1 000
1 010	4 926	4 935	4 944	4 954	4 963	4 972	4 981	4 990	5 000	5 009	1 010
1 020	5 018	5 027	5 037	5 046	5 055	5 065	5 074	5 083	5 092	5 102	1 020
1 030	5 111	5 120	5 130	5 139	5 148	5 158	5 167	5 176	5 186	5 195	1 030
1 040	5 205	5 214	5 223	5 233	5 242	5 252	5 261	5 270	5 280	5 289	1 040
1 050	5 299	5 308	5 318	5 327	5 337	5 346	5 356	5 365	5 375	5 384	1 050
1 060	5 394	5 403	5 413	5 422	5 432	5 441	5 451	5 480	5 470	5 480	1 060
1 070	5 489	5 499	5 508	5 518	5 528	5 537	5 547	5 556	5 566	5 578	1 070
1 080	5 585	5 595	5 605	5 614	5 624	5 634	5 643	5 653	5 663	5 672	1 080
1 090	5 682	5 692	5 702	5 711	5 721	5 731	5 740	5 750	5 760	5 770	1 090
1 100	5 780	5 789	5 799	5 809	5 819	5 828	5 838	5 848	5 858	5 868	1 100
1 110	5 878	5 887	5 897	5 907	5 917	5 927	5 937	5 947	5 956	5 968	1 110
1 120	5 976	5 986	5 996	6 006	6 016	6 026	6 036	6 046	6 055	6 065	1 120
1 130	6 075	6 085	6 095	6 105	6 115	6 125	6 135	6 145	6 155	6 165	1 130
1 140	6 175	6 185	6 195	6 205	6 215	6 225	6 235	6 245	6 256	6 266	1 140
1 150	6 276	6 286	6 296	6 306	6 316	6 326	6 336	6 346	6 356	6 367	1 150
1 160	6 377	6 387	6 397	6 407	6 417	6 427	6 438	6 448	6 458	6 468	1 160
1 170	6 478	6 488	6 499	6 509	6 519	6 529	6 539	6 550	6 560	6 570	1 170
1 180	6 580	6 591	6 601	6 611	6 621	6 632	6 642	6 652	6 663	6 673	1 180
1 190	6 683	6 693	6 704	6 714	6 724	6 735	6 745	6 755	6 766	6 776	1 190

Electromotive force as a function of temperature

Type B: Platinum–30% rhodium/platinum–6% rhodium (continued)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
1 200	6 786	6 797	6 807	6 818	6 828	6 838	6 849	6 859	6 869	6 880	1 200
1 210	6 890	6 901	6 911	6 922	6 932	6 942	6 953	6 963	6 974	6 984	1 210
1 220	6 995	7 005	7 016	7 026	7 037	7 047	7 058	7 068	7 079	7 089	1 220
1 230	7 100	7 110	7 121	7 131	7 142	7 152	7 163	7 173	7 184	7 194	1 230
1 240	7 205	7 216	7 226	7 237	7 247	7 258	7 269	7 279	7 290	7 300	1 240
1 250	7 311	7 322	7 332	7 343	7 353	7 364	7 375	7 385	7 396	7 407	1 250
1 260	7 417	7 428	7 439	7 449	7 460	7 471	7 482	7 492	7 503	7 514	1 260
1 270	7 524	7 535	7 546	7 557	7 567	7 578	7 589	7 600	7 610	7 621	1 270
1 280	7 632	7 643	7 653	7 664	7 675	7 686	7 697	7 707	7 718	7 729	1 280
1 290	7 740	7 751	7 761	7 772	7 783	7 794	7 805	7 816	7 827	7 837	1 290
1 300	7 848	7 859	7 870	7 881	7 892	7 903	7 914	7 924	7 935	7 946	1 300
1 310	7 957	7 968	7 979	7 990	8 001	8 012	8 023	8 034	8 045	8 056	1 310
1 320	8 066	8 077	8 086	8 099	8 110	8 121	8 132	8 143	8 154	8 165	1 320
1 330	8 176	8 187	8 198	8 209	8 220	8 231	8 242	8 253	8 264	8 275	1 330
1 340	8 286	8 298	8 309	8 320	8 331	8 342	8 353	8 364	8 375	8 386	1 340
1 350	8 397	8 408	8 419	8 430	8 441	8 453	8 464	8 475	8 486	8 497	1 350
1 360	8 508	8 519	8 530	8 542	8 553	8 564	8 575	8 586	8 597	8 608	1 360
1 370	8 620	8 631	8 842	6 653	8 664	8 675	8 687	8 698	8 709	8 720	1 370
1 380	8 731	8 743	8 754	8 765	8 776	8 787	8 799	8 810	8 821	8 832	1 380
1 390	8 844	8 855	8 866	8 877	8 889	8 900	8 911	8 922	8 934	8 945	1 390
1 400	8 956	8 967	8 979	8 990	9 001	9 013	9 024	9 035	9 047	9 058	1 400
1 410	9 069	9 080	9 092	9 103	9 114	9 126	9 137	9 148	9 160	9 171	1 410
1 420	9 182	9 194	9 205	9 216	9 228	9 239	9 251	9 262	9 273	9 285	1 420
1 430	9 296	9 307	9 319	9 330	9 342	9 353	9 364	9 376	9 387	9 398	1 430
1 440	9 410	9 421	9 433	9 444	9 456	9 467	9 478	9 490	9 501	9 513	1 440
1 450	9 524	9 536	9 547	9 558	9 570	9 581	9 593	9 604	9 616	9 627	1 450
1 460	9 639	9 650	9 662	9 673	9 684	9 696	9 707	9 719	9 730	9 742	1 460
1 470	9 753	9 765	9 776	9 788	9 799	9 811	9 822	9 834	9 945	9 857	1 470
1 480	9 868	9 880	9 891	9 903	9 914	9 926	9 937	9 949	9 961	9 972	1480
1 490	9 984	9 995	10 007	10 018	10 030	10 041	10 053	10 064	10 076	10 088	1 490

Electromotive force as a function of temperature

Type B: Platinum–30% rhodium/platinum–6% rhodium (continued)

T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
	E/µV										
1 500	10 099	10 111	10 122	10 134	10 145	10 167	10 168	10 180	10 192	10 203	1 500
1 510	10 215	10 226	10 236	10 249	10 261	10 273	10 284	10 296	10 307	10 319	1 510
1 520	10 331	10 342	10 354	10 365	10 377	10 389	10 400	10 412	10 423	10 435	1 520
1 530	10 447	10 458	10 470	10 482	10 493	10 505	10 516	10 528	10 540	10 551	1 530
1 540	10 563	10 575	10 586	10 598	10 609	10 621	10 633	10 644	10 658	10 668	1 540
1 550	10 679	10 691	10 703	10 714	10 726	10 738	10 749	10 761	10 773	10 784	1 550
1 560	10 796	10 808	10 819	10 831	10 843	10 854	10 866	10 877	10 889	10 901	1 560
1 570	10 913	10 924	10 936	10 948	10 959	10 971	10 983	10 994	11 006	11 018	1 570
1 580	11 029	11 041	11 053	11 064	11 076	11 088	11 099	11 111	11 123	11 134	1 580
1 590	11 146	11 158	11 169	11 181	11 193	11 205	11 216	11 228	11 240	11 251	1 590
1 600	11 263	11 275	11 286	11 298	11 310	11 321	11 333	11 345	11 357	11 368	1 600
1 610	11 380	11 392	11 403	11 415	11 427	11 438	11 450	11 462	11 474	11 485	1 610
1 620	11 497	11 509	11 520	11 532	11 544	11 556	11 567	11 579	11 591	11 602	1 620
1 630	11 614	11 626	11 637	11 649	11 661	11 673	11 684	11 696	11 708	11 719	1 630
1 640	11 731	11 743	11 754	11 766	11 778	11 790	11 801	11 813	11 825	11 836	1 640
1 650	11 848	11 860	11 871	11 883	11 895	11 907	11 918	11 930	11 942	11 953	1 650
1 660	11 965	11 977	11 988	12 000	12 012	12 024	12 035	12 047	12 059	12 070	1 660
1 670	12 082	12 094	12 105	12 117	12 129	12 141	12 152	12 164	12 176	12 187	1 670
1 680	12 199	12 211	12 222	12 234	12 246	12 257	12 269	12 281	12 292	12 304	1 680
1 690	12 316	12 327	12 339	12 351	12 363	12 374	12 386	12 398	12 409	12 421	1 690
1 700	12 433	12 444	12 456	12 468	12 479	12 491	12 503	12 514	12 526	12 538	1 700
1 710	12 549	12 561	12 572	12 584	12 596	12 607	12 619	12 631	12 642	12 654	1 710
1 720	12 666	12 677	12 689	12 701	12 712	12 724	12 736	12 747	12 759	12 770	1 720
1 730	12 782	12 794	12 805	12 817	12 829	12 840	12 852	12 883	12 875	12 887	1 730
1 740	12 898	12 910	12 921	12 933	12 945	12 956	12 968	12 980	12 991	13 003	1 740
1 750	13 014	13 026	13 037	13 049	13 061	13 072	13 084	13 095	13 107	13 119	1 750
1 760	13 130	13 142	13 153	13 165	13 176	13 188	13 200	13 211	13 223	13 234	1 760
1 770	13 246	13 257	13 269	13 280	13 292	13 304	13 315	13 327	13 338	13 350	1 770
1 780	13 361	13 373	13 384	13 396	13 407	13 419	13 430	13 442	13 453	13 485	1 780
1 790	13 476	13 488	13 499	13 511	13 522	13 534	13 545	13 557	13 568	13 580	1 790

Electromotive force as a function of temperature

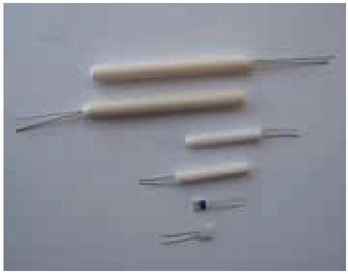
Type B: Platinum–30% rhodium/platinum–6% rhodium (concluded)

	E/µV										
T90/ºC	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	T90/ºC
1 800	13 591	13 603	13 614	13 626	13 637	13 649	13 660	13 672	13 683	13 694	1 800
1 810	13 706	13 717	13 729	13 740	13 752	13 763	13 775	13 786	13 797	13 809	1 810
1 820	13 820										1 820

Electromotive force as a function of temperature

RESISTANCE TEMPERATURE DETECTOR

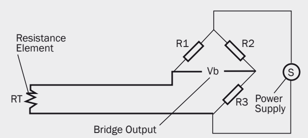
A Resistance Temperature Detector (RTD) operates under the principle that the electrical resistance of certain metals increases or decreases in a repeatable and predictable manner with a temperature change.
RTD's may have a lower temperature range than some thermocouples and a slower response time, however, they are more stable and repeatable over long periods of time. RTD's higher signal outputs make them easier to interface with computers & data loggers. They reduce the effects of radio frequency interference.
RTD's are used in: the plastic processing industry, environmental test chambers, motor windings, pumps and bearings, ovens, kilns, waste treatment and the pulp & paper industry. RTD's are available in the same configurations of thermocouples to suit the most applications.



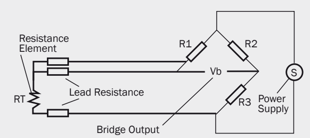
Basic RTD's constructions

- Flat film constructions, ceramic insulation
- Sealed bifilar winding, ceramic insulation
- Sealed bifilar winding, glass insulation

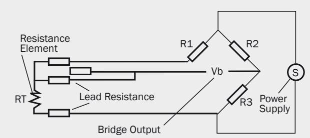
Standard wiring systems



2-wiring system



3-wiring system



4-wiring system

RTD BODY CONSTRUCTION (PT100)

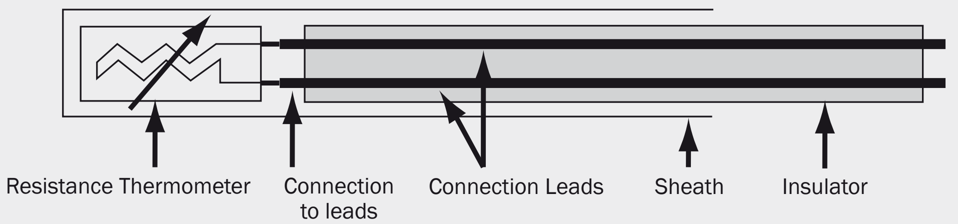
There are many RTD types available on today's market. Each has its own particular advantages and disadvantages. In many cases, RTD's and their accessories are designed for a specific temperature measurement problem. In other cases, RTD's are manufactured with a wide variety of possible applications. It is not the intention to compare one RTD type with another, or to compare the RTD of one manufacturer with another. RTD's must be selected to meet the needs of a particular installation.

Two examples as a guide in the selection process:
- Tube type construction
- Mineral insulated type

Tube type construction

The most basic RTD construction is the tube type construction. The wires can be made of several materials (depending on the temperature range) such as copper, silver or nickel clad copper wire.
The insulation material of the wires can be PVC, Silicon or PTFE insulators for temperature up to 250 °C. Above this temperature the isolation material will be ceramic. The total construction is not bendable and is normally not used in applications with a lot of vibrations.

A basic construction for RTD's



MINERAL INSULATED TYPE

The most common used RTD construction is mineral insulated. The mineral insulated type is bendable and can be used in applications with high vibration conditions.
The construction:
- 4 conductors from several materials
- Isolated with magnesium powder (MgO)
- SS outer sheath
- Available diameters: from 1.5 mm, with a measuring system of 4 wire, up to 6.4 mm

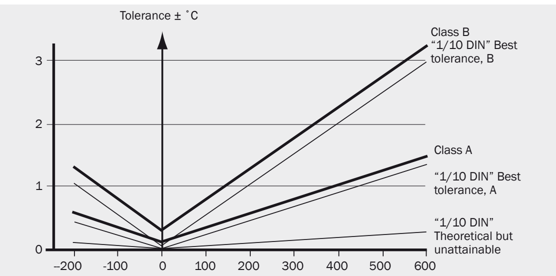
Commercial platinum grades are produced which exhibit a change of resistance of 0.385 ohms/°C (European Fundamental Interval). The sensor is usually made to have a resistance of 100 ohms at 0 °C, this is defined in BS EN 60751:1996. The American Fundamental Interval is 0.392 ohms/°C.

Accuracy according IEC 60751n, can be 1/3,1/5,1/6 and 1/10 at 0 °C

Temperature	Class A, ±°C	Class B, ±°C
-200 °C	0,55 °C	1,3 °C
0 °C	0,15 °C	0,3 °C
+100 °C	0,35 °C	0,8 °C
+200 °C	0,55 °C	1,3 °C
+300 °C	0,75 °C	1,8 °C
+500 °C	1,15 °C	2,8 °C
+700 °C		-3,8 °C

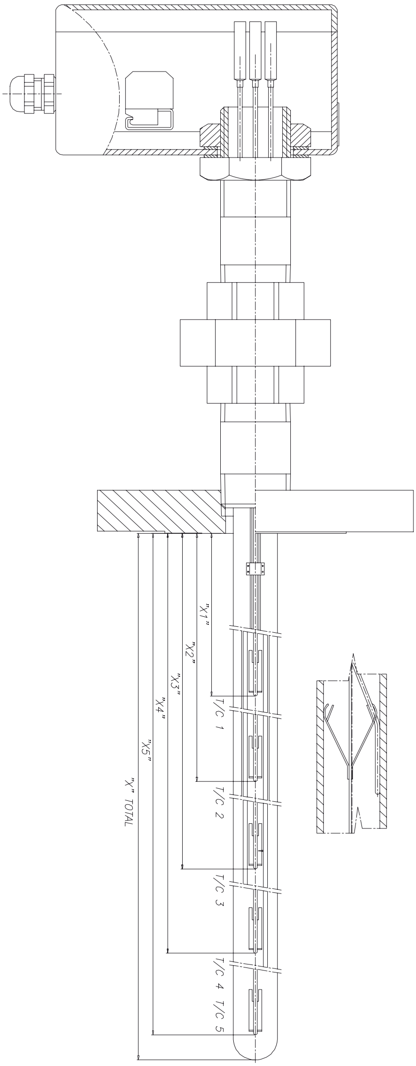
Upon request, RTD's such as: Pt 400, Pt500 and Pt1000.
For other international Pt100 standards, please contact our office.

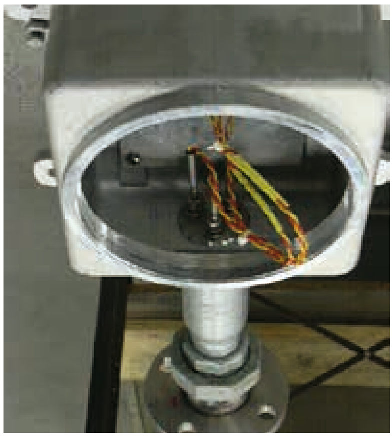
ANSI	: alpha 0.00379	instead of 0.00385 IEC
JIS	: alpha 0.003916	instead of 0.00385 IEC



°C	Ω	°C	Ω	°C	Ω	°C	Ω
-200	18.52	20	107.79	240	190.47	460	267.56
-195	20.68	25	109.73	245	192.29	465	269.56
-190	22.83	30	111.67	250	194.10	470	270.93
-185	24.97	35	113.61	255	195.91	475	272.61
-180	27.10	40	115.54	260	197.71	480	274.29
-175	29.22	45	117.47	265	199.51	485	275.97
-170	31.33	50	119.40	270	201.31	490	277.64
-165	33.44	55	121.32	275	203.11	495	279.31
-160	35.54	60	123.24	280	204.90	500	280.98
-155	37.64	65	125.16	285	206.70	505	282.64
-150	39.72	70	127.08	290	208.48	510	284.30
-145	41.80	75	128.99	295	210.27	515	298.96
-140	43.88	80	130.90	300	212.05	520	287.62
-135	45.94	85	132.80	305	213.83	525	289.27
-130	48.00	90	134.71	310	215.61	530	290.92
-125	50.06	95	136.61	315	217.38	535	292.56
-120	52.11	100	138.51	320	219.15	540	294.21
-115	54.15	105	140.40	325	220.92	545	295.85
-110	56.19	110	142.29	330	222.69	550	297.49
-105	58.23	115	144.18	335	224.45	555	299.12
-100	60.26	120	156.07	340	226.21	560	300.75
-95	62.28	125	147.95	345	227.96	565	302.38
-90	64.30	130	149.83	350	229.72	570	304.01
-85	66.31	135	151.71	355	231.47	575	305.63
-80	68.33	140	153.58	360	233.21	580	307.25
-75	70.33	145	155.46	365	234.96	585	308.87
-70	72.33	150	157.33	370	236.70	590	310.49
-65	74.33	155	159.19	375	238.44	595	312.10
-60	76.33	160	161.05	380	240.18	600	313.71
-55	78.32	165	162.91	385	241.91	605	315.31
-50	80.31	170	164.77	390	243.64	610	316.92
-45	82.29	175	166.63	395	245.37	615	318.52
-40	84.27	180	168.48	400	247.09	620	320.12
-35	86.25	185	170.33	405	248.81	625	321.71
-30	88.22	190	172.17	410	250.53	630	323.30
-25	90.19	195	174.02	415	252.25	635	324.89
-20	92.16	200	175.86	420	253.96	640	326.48
-15	94.12	205	177.69	425	255.97	645	328.06
-10	96.09	210	179.53	430	257.38	650	329.64
-5	98.04	215	181.36	435	259.08	655	331.22
0	100.00	220	183.19	440	260.78	660	332.79
5	101.95	225	185.01	445	262.48		
10	103.90	230	186.84	450	264.18		
15	105.85	235	188.66	455	265.87		

MULTI POINT





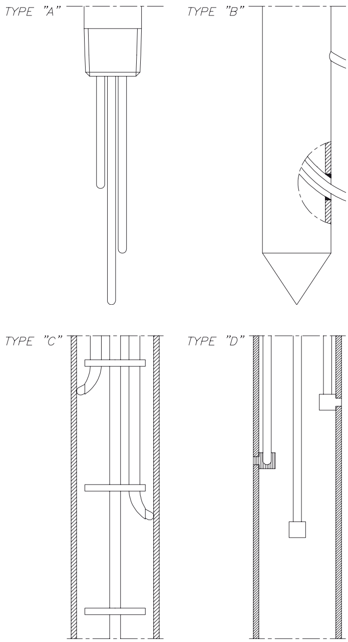
MULTI POINT

Type 'A'
Type 'A' Mi-cable (MgO) thermocouples are free hanging for use in non pressurized applications.

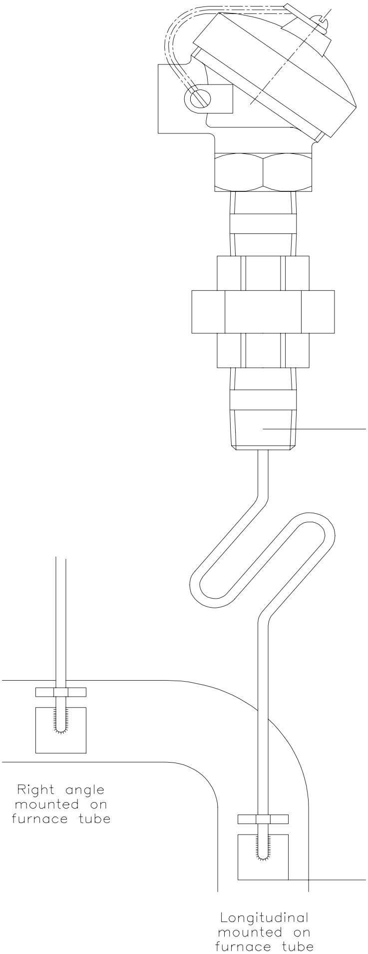
Type 'B'
Type 'B' Mi-cable (MgO) thermocouples can be retracted for transport and mounting purposes. Individually replaceable without disassembling the complete unit.

Type 'C'
Type 'C' Mi-cable (MgO) thermocouples are spring loaded to connect with the inner wall of the thermowell. This construction allows replacement of the thermocouple during operation.

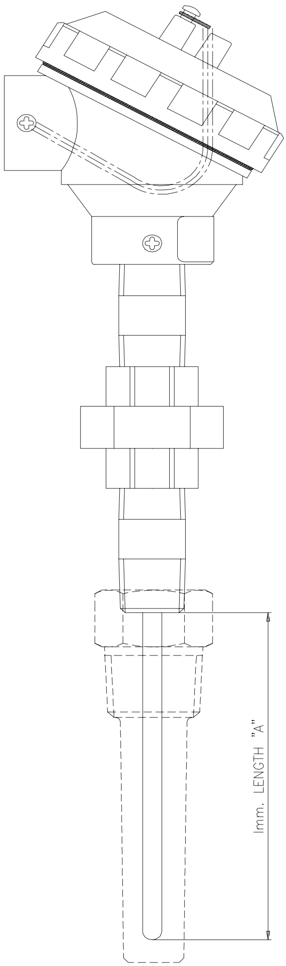
Type 'D'
Each Type 'D' Mi-cable (MgO) or beaded type thermo- couple is enclosed in a guide tube which terminates at a special block, welded to the thermowell at the point to be measured.
Each thermocouple can be replaced during operation.



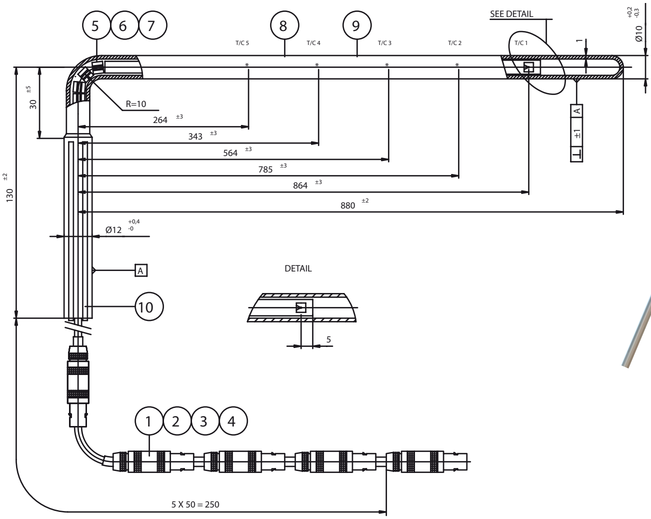
TUBE SKIN

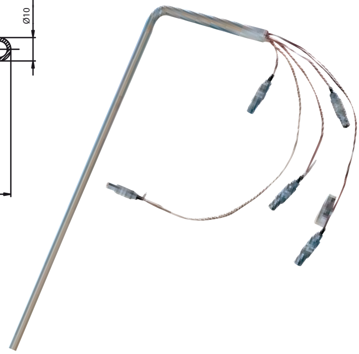

Right angle
mounted on
furnace tube
Longitudinal
mounted on
furnace tube

INDUSTRIAL TEMPERATURE SENSOR

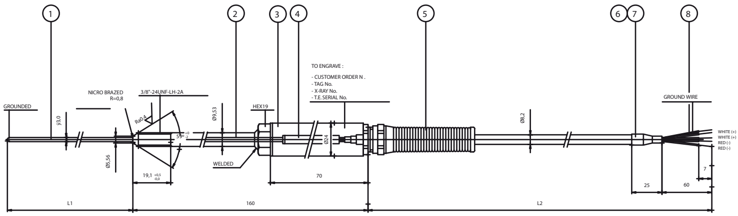


SEMI-CONDUCTOR

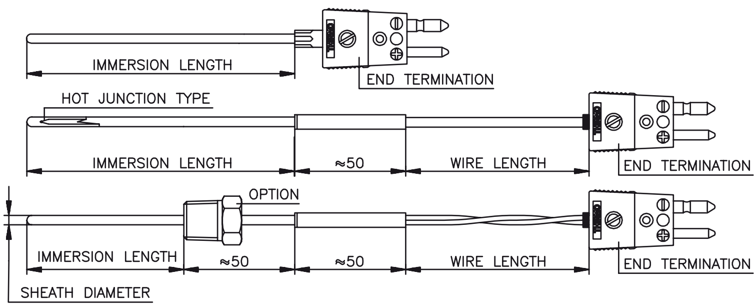




HIGH PRESSURE



MINIATURE MINERAL INSULATED CABLE



F.A.Q.'S

1. Q. How many metres of T/C wire can I run?

A. *For a specific instrument, check its specifications to see if there are any limits to the input impedance. However as a rule of thumb, limit the resistance to 100 Ohms maximum, depending on the conductor diameter of the wire: the larger the diameter, the less resistance/metre, the longer the run can be. If the environment is electrically noisy, then a transmitter may be required which transmit a 4-20 mA signal that can be run a longer distance and is more resistant to noise.*

2. Q. Should I use a grounded or ungrounded probe?

A. *It depends on the instrumentation. If there is any chance that there may be a reference to ground (common in controllers with non-isolated inputs), then an ungrounded probe is required. If the instrument is a handheld indicator, then a grounded probe can almost always be used.*

3. Q. Can I split my one thermocouple signal to two separate instruments?

A. *No. The T/C signal is a very low-level millivolt signal, and should only be connected to one device. Splitting into two devices may result in bad readings or loss of signal. The solution is to use a dual T/C or convert one T/C (output a 4-20mA signal) by using a transmitter or signal conditioner which can send the new signal to more than one instrument.*

4. Q. What are the accuracies and the temperature ranges of the various thermocouples?

A. They are summarized in the tables of the International Standards (page 18). *It is important to know that both accuracy and ranges depend on a.o.: the thermocouple alloys, the temperature being measured, the construction of the sensor, the material of the sheath, the media being measured, the state of the media (liquid, solid or gas) and the diameter of either the thermocouple wire (if it is exposed) or the sheath diameter (if the thermocouple wire is not exposed but sheathed).*

5. Q. How can I choose between thermocouples, resistance temperature detectors (RTD's) and thermistors?

A. *You have to consider the characteristics and costs of the various sensors as well as the available instrumentation. Thermocouples generally can measure temperatures over wide temperature ranges, are inexpensively and very rugged. They are not accurate or stable as RTD's and thermistors. RTD's are stable and have a fairly wide temperature range but are not as rugged and inexpensively as thermocouples. Since they require the use of an electric current to make measurements, RTD's are subject to inaccuracies from self-heating. Thermistors tend to be more accurate than RTD's or thermocouples, but they have a much more limited temperature range.*

F.A.Q.'S

6. Q. What is the drift of a thermocouple type K?

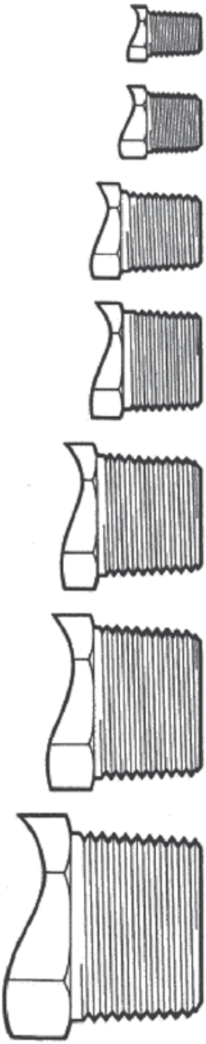
A. T/C type K can be drifted in several temperature ranges: from 450 °C to 550 °C or in a measuring area of 800 °C. When you work in a process like ethylene furnaces and your process temperature is fluctuated between 850 °C and 200 °C and back to 850 °C with an interval of approx. 6 to 8 weeks, your chosen construction is an industrial thermocouple with a metal sheath into a protection tube of SS or ceramic. The drift of a thermocouple in this application can be approx. 30 °C within one year.

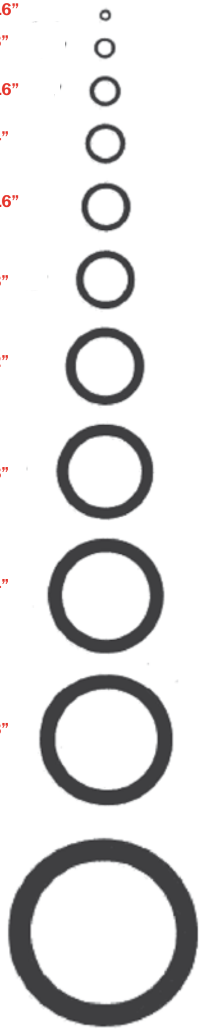
7. Q. What is the response time for thermocouples?

A. Depending on the diameter of the thermocouple itself and the measuring junction (grounded or ungrounded). When you use mineral insulated thermocouples, the ASTM STP 470 A specifies the following: 'Values listed are the average of several mineral insulated elements, checked in each category. They show the time required to indicate 63.2% of a temperature change. The tests were performed during a step change from room temperature to boiling water.'

Diameter	Hot Junction	Time in sec.
1,0 mm	ungrounded	0,3
1,0 mm	grounded	0,1
3,0 mm	ungrounded	1,3
3,0 mm	grounded	0,7
4,8 mm	ungrounded	2,2
4,8 mm	grounded	1,1
6,0 mm	ungrounded	4,5
6,0 mm	grounded	2,0

PIPE THREAD SIZE NPT	TUBING O.D. SIZE
1/16" NPT	1/16"
1/8" NPT	1/8"
1/4" NPT	3/16"
3/8" NPT	1/4"
1/2" NPT	5/16"
3/4" NPT	3/8"
1" NPT	1/2"
	5/8"
	3/4"
	7/8"
	1"





Nominal Pipe size	O.D.	Standard		Extra strong		Double extra strong		Schedule		Schedule		Schedule	
		STD		XS		XXS		10		20		30	
Inches	mm	Wall	Wt	Wall	Wt	Wall	WT	Wall	WT	Wall	WT	Wall	WT
1/8”	10,3	1,7	0,357	2,4	0,470								
1/4”	13,7	2,2	0,625	3,0	0,804								
3/8”	17,1	2,3	0,848	3,2	1,10								
1/2”	21,3	2,8	1,26	3,7	1,62	7,5	2,54						
3/4”	26,7	2,9	1,68	3,9	2,19	7,8	3,63						
1”	33,4	3,4	2,50	4,5	3,23	9,1	5,45						
1.1/4”	42,2	3,6	3,38	4,9	4,46	9,7	7,75						
1.1/2”	48,3	3,7	4,05	5,1	5,40	10,2	9,54						
2”	60,3	3,9	5,43	5,5	7,47	11,1	13,4						
2.1/2”	73	5,2	8,62	7,0	11,4	14	20,4						
3”	88,9	5,5	11,3	7,6	15,3	15,2	27,7						
3.1/2”	101,6	5,7	13,6	8,1	18,6	16,2	34						
4”	114,3	6	16,1	8,6	22,3	17,1	41,1						
5”	141,3	6,6	21,8	9,5	30,9	19	57,4						
6”	168,3	7,1	28,2	11,0	42,5	21,9	79,1						
8”	219,1	8,2	42,5	12,7	64,6	22,2	108			6,4	33,3	7	36,7
10”	273	9,3	60,2	12,7	81,5	25,4	155			6,4	41,7	7,8	50,9
12”	323,9	9,5	73,8	12,7	97,4	25,4	187			6,4	49,7	8,4	65,1
14”	355,6	9,5	81,2	12,7	107			6,4	54,6	7,9	68,1	9,5	81,2
16”	406,4	9,5	93,1	12,7	123			6,4	62,6	7,9	77,9	9,5	93,1
18”	457,2	9,5	105	12,7	139			6,4	70,5	7,9	87,8	11,1	122
20”	508	9,5	117	12,7	155			6,4	78,5	9,5	117	12,7	155
22”	558,8	9,5	129	12,7	171			6,4	86,4	9,5	129	12,7	171
24”	609,6	9,5	141	12,7	187			6,4	94,7	9,5	141	14,3	210
26”	660,4	9,5	153	12,7	203			7,9	128	12,7	203		
28”	711,2	9,5	165	12,7	219			7,9	138	12,7	219	15,9	272
30”	762	9,5	176	12,7	234			7,9	147	12,7	234	15,9	292
32”	812,8	9,5	188	12,7	250			7,9	157	12,7	250	15,9	312
34”	863,6	9,5	200	12,7	266			7,9	167	12,7	266	15,9	332
36”	914,4	9,5	212	12,7	282			7,9	177	12,7	282	15,9	351

Asme b 36,10 pipe schedules
Wall= walthickness in mm
Wt = weights in kg/p/mtr

10. PIPE & TUBE END SIZE CHART
PIPE SCHEDULES

Nominal Pipe size	O.D.	Schedule		Schedule		Schedule		Schedule		Schedule		Schedule			
Inches	mm	Wall	40 Wt	Wall	60 Wt	80 Wall	Wt	100 Wall	Wt	120 Wall	Wt	140 Wall	Wt	160 Wall	Wt
1/8”	10,3	1,7	0,357			2,4	0,470								
1/4”	13,7	2,2	0,625			3,0	0,804								
3/8”	17,1	2,3	0,848			3,2	1,10								
1/2”	21,3	2,8	1,26			3,7	1,62							4,8	1,9
3/4”	26,7	2,9	1,68			3,9	2,19							5,6	2,89
1”	33,4	3,4	2,50			4,5	3,23							6,4	4,23
1.1/4”	42,2	3,6	3,38			4,9	4,46							6,4	5,6
1.1/2”	48,3	3,7	4,05			5,1	5,40							7,1	7,23
2”	60,3	3,9	5,43			5,5	7,47							8,7	11,1
2.1/2”	73	5,2	8,62			7,0	11,4							9,5	14,9
3”	88,9	5,5	11,3			7,6	15,3							11,1	21,3
3.1/2”	101,6	5,7	13,6			8,1	18,6								
4”	114,3	6	16,1			8,6	22,3			11,1	28,3			13,5	33,5
5”	141,3	6,6	21,8			9,5	30,9			12,7	40,2			15,9	49,0
6”	168,3	7,1	28,2			11,0	42,5			14,3	54,2			18,3	67,5
8”	219,1	8,2	42,5	10,3	53,1	12,7	64,6	15,1	75,8	18,3	90,7	20,6	101	23,0	112
10”	273	9,3	60,2	12,7	81,5	15,1	95,8	18,3	115	21,4	133	25,4	156	28,6	172
12”	323,9	10,3	79,7	14,3	109	17,4	132	21,4	160	25,4	187	28,6	208	33,3	239
14”	355,6	11,1	94,3	15,1	126	19,0	158	23,8	195	27,8	224	31,8	253	35,7	281
16”	406,4	12,7	123	16,7	160	21,4	203	26,2	245	30,9	286	36,5	333	40,5	365
18”	457,2	14,3	156	19	206	23,8	254	29,4	310	34,9	363	39,7	408	45,2	459
20”	508	15,1	183	20,6	248	26,2	311	32,5	381	38,1	441	44,4	508	50,0	564
22”	558,8			22,2	294	28,6	373	34,9	451	41,3	526	47,6	600	54,0	671
24”	609,6	17,4	255	24,6	355	30,9	441	38,9	547	46,0	639	52,4	719	59,5	807
26”	660,4														
28”	711,2														
30”	762														
32”	812,8														
34”	863,6														
36”	914,4														

Asme b 36,10 pipe schedules
Wall= walthickness in mm
Wt = weights in kg/p/mtr

INTRODUCTION

A wide variety of steels and nickel-based alloys are used to make thermowells. There are no other materials which will stand up to all of the many service conditions which can be found across the industry.
It is important that the proper metal is used in the fabrication of a thermowell. Obviously an improper choice will lead to premature failure, while over-specifying leads to higher costs than necessary to do a given job.

The primary metals used in the fabrication of thermowells are: carbon steel, chrome molybdenum steels, stainless steels (304, 310, 316, 321, 347, 304L, 316L, 446), nickel-based alloys (Inconels, Incoloys, Hastelloys).

The main responsibility of thermowells is to protect the temperature sensor from corrosion or oxidation conditions found in the process, as well as mechanical stresses. Each of the previously mentioned materials provides different degrees of protection under various service conditions.
The following pages lists the type of materials with some recommendations for their use. As a general guide, a high chromium content is desirable for high temperature resistance to oxidation and sulfur attack. The presence of aluminum (1-2%) is also useful as a very resistant surface: ‘ilm of mixed chromium oxide/ aluminum oxide is formed.

GLOSSARY OF TERMS

Austenitic	:	Refers to the crystal structure of the 300 series stainless steel.
Carbide precipitation	:	The process where chromium carbides form and precipitate out in the steel. Carbon atoms combine with chromium atoms lead to local depletion of chromium, thereby reducing the available chromium to form a protective chromium oxide film. This allows localized inter granular attack from salts and acids. Carbide precipitation occurs when a 300 series stainless steel is held in the 800 °F range.
Carbide stabilized	:	In order to reduce the chance of carbon precipitation, certain 300 series stainless steel are stabilized with small amounts of titanium, tantalum of columbium which preferentially combine with the carbon leaving the chromium alone. This result is also accomplished by the ‘low carbon’ stainless steels, which have less carbon to combine with the chromium.
Carburizing atmospheres	:	Contain carbonaceous vapours (e.g. hydrocarbons). The present carbon can react with the alloys at high temperatures to produce metal carbides. This can result in embrittlement. Generally, high nickel content in an alloy is helpful in resisting carburizing although it will not completely prevent it.
Creep	:	At high temperatures the mechanical strength of metals falls off. Over time and at high temperatures metals will slowly stretch under an applied load and will fail at stress much smaller than would normally be expected.
Ferritic	:	Refers to the crystal structure of the 400 series stainless steel.
Inert atmospheres	:	Consist of inert gas such as argon. There is no problem with alloys in such an atmosphere. A variation of an inert atmosphere is no atmosphere at all – i.e. a vacuum. This is used increasingly for heat-treatment purposes.
Oxidizing atmospheres	:	Contain oxygen and will react with metals at elevated temperatures to produce oxides on the surface. The good high temperature performance of the heat-resisting alloys depends on the formation of a stable protective oxide film on the surface. The elements chromium and aluminium, when present in an alloy, form excellent protective films of chromium oxide and aluminium oxide.

Passivating	:	Involves immersing 300 series stainless steel in 10% nitric acid for 10-30 minutes. The acid removes any particles of iron which may have become embedded in the surface during processing but doesn't attack the stainless steel. Actually, being a strong oxidizing acid, the chromium oxide film is improved thereby increasing the steels ability to withstand corrosion.
Reducing atmospheres	:	Contain hydrogen of carbon compounds and will not form protective oxides on an alloy. If hydrogen is present, this may diffuse into thermowells and thermocouples. It produces 'green rot' attack, so called from the dark green surface colour produced, although this may not be very obvious. In the case of chromel-alumel thermocouples the 'green rot attack causes the chromed wire to become magnetic, which results in an erroneous lower output. This effect is easy to confirm with a magnet; if both wires are magnetic 'green rot' has occurred. (Actually this is not strictly a 'reducing' phenomenon. It occurs only when a very small amount of oxygen is present in an essentially reducing atmosphere. Under these conditions, preferential oxidation of the chromium in the alloy will occur.)
Stress-corrosion cracking	:	When a metal is subjected to both stress and corrosion at the same time, there is the possibility it may crack. Often stress-corrosion cracking occurs in the presence of chlorides.
Stress relief	:	A heat treating process, used to reduce internal stresses in a part to avoid stress corrosion cracking from occurring.
Sulphidizing atmospheres	:	Contain sulphur compounds, which often arise when coal or fuel oil is burned. The sulphur may be present as sulphur dioxide, which is the case under oxidizing conditions, or as hydrogen sulphide (H2S) under reducing conditions. The latter is worse as the atmosphere does not help the formation of protective oxide films. Alloys containing nickel (as almost all the commonly used high temperature alloys do) are subject to attack by sulphur because sulphur forms a low melting point compound with the nickel in the alloy. Alloys high in chromium (over about 18%) containing aluminium form an oxide film which offers resistance to sulphur under oxidizing conditions. To resist sulphur under reducing conditions, the best protection is an aluminized film.
Weld decay	:	Localized corrosion on each side of a weld caused by carbide precipitation.

STAINLESS STEELS

This group of metals forms an invisible chromium oxide which serves to resist oxidation and corrosive attack by chemicals and acids. To be effective, they need to have a minimum of 14% chromium. The 300 series stainless steel are known as 'austenitic' while the 400 series are known as 'ferritic'. Austenitic stainless steels do not become brittle at low temperature as ferritic steels do.

SS 304 : Also known as '18-8' (nominally 18% chromium, 8% nickel) is the most commonly specified austenitic stainless steel. SS 304 like other 300 series stainless steel is subject to 'carbide precipitation' in the area of 700-1,650 °F. This means that chromium forms carbides when SS 304 is held in/of is cooled slowly through the above temperature range. The net effect is a localized depletion of chromium around the carbides, which can lead to inter-granular corrosion from acids of other corrosives. This condition is especially apparent where parts are welded (leading to 'weld decay'). SS 304 has a maximum temperature rating for continuous service of 1,650 °F in air. Care must be taken as the strength falls off considerably at elevated temperatures. SS 304 is widely used as a thermowell material for lower temperature applications across industry since it is not affected by most organic and inorganic chemicals.

SS 310 : Has higher chromium and nickel (nominally 25% chromium and 20% nickel) improved high temperature characteristics. The SS 310 is subject to carbide precipitation in the 800 °F to 1,600 °F range. Maximum continuous service temperature in air is 2,100 °F. The SS 310 is used where good high temperature strength is needed or in carburizing/ reducing atmospheres.

SS 316 : Another very popular all purpose austenitic stainless steel. SS 316 has nominally 18% chromium and 12% nickel, but is modified with 2-3% molybdenum which improves its resistance to chlorides. SS 316 is subject to carbide precipitation in the 800-1,600 °F range.
Maximum continuous service temperature in air is 1,650 °F. Because of its increased corrosive resistance, SS 316 is used where improved corrosion resistance is required, especially in chlorides.

304L and 316L : Low carbon versions of SS 304 and SS 316. These alloys solve the problem of carbide precipitations since they have a very low carbon content (0.03% maximum instead of 0.08% maximum).

SPECIAL STAINLESS STEELS

Carpenter 20-Cb3 : A stainless steel having 20% chromium, 34% nickel, 2,5% copper and columbium and tantalum equal to 8 times the carbon content for carbide stabilization. This alloy has excellent resistance to corrosive conditions, especially to sulfuric acid.

NICKEL BASED ALLOYS

A. Incoloys, Inconels, Monel

A very important group of alloys is the nickel-based Inconels and Incoloys. These alloys have an excellent resistance to a corrosive attack by many aggressive chemicals. They also have an excellent resistance to oxidation at high temperatures and good high temperature strength. They typically contain 15-23% chromium to provide a protective oxide film. The Inconels contain 40-73% nickel, while the Incoloys contain 32-42% and 30-36% iron. Some grades contain a small amount of titanium or tantalum for improved high temperature strength and aluminium to improve the protective characteristics of the oxide film at elevated temperatures (a mixed chromium oxide/aluminium film).

Inconel 600 : High nickel 76%, high chromium 15.5%, for resistance to oxidizing and reducing atmospheres. I600 is used for several corrosive environments at high temperature.

Inconel 601 : High nickel 60.5%, high chromium 23.0%, plus 1.5% aluminium. Good high temperature properties. I601 provides an outstanding resistance to oxidation and a good resistance to carburizing and sulphur containing atmospheres.

Incoloy 800 : 32.5% nickel, 46.0% iron, 21% chromium. Resistance to oxidation and carburization at high temperatures. Resists sulphur attack and corrosion in many environments.

Incoloy 800H : 32.5% nickel, 46.0% iron, 21% chromium. Resistance to oxidation and carburization at high temperatures. Resists sulphur attack and corrosion in many environments.

Incoloy 800H : A special version of the above alloy with a small controlled amount of carbon for improved high temperature strength.

Monel 400 : 66% high nickel, 31% high copper. Monel provides a good resistance to corrosion in salt water. Not subject to chloride stress cracking. Monel is used for heat exchangers and for sulphuric acid applications.

B. Hastelloys

These nickel-based alloys are used for their excellent corrosion resistance under many severe conditions due to their high molybdenum content.

Hastelloy B : 61% nickel, 28% molybdenum. Excellent corrosion resistance to hydrochloric acid and to sulphuric, phosphoric and acetic acids and hydrogen chloride gas.

Hastelloy C : 54% nickel, 16% molybdenum, 15.5% chromium, 4% tungsten. Excellent corrosion resistance to many chemical environments, including ferric acid and cupric chlorides, contaminated mineral acids, and wet chlorine gas. Oxidation resistant to 1,900 °F.

Hastelloy X : 47% nickel, 9% molybdenum, 22% chromium, 0.5% tungsten. Good high temperature strength and resistance to oxidation to 2,200 °F. Also good for reducing conditions.

PROTECTION TUBE MATERIALS

Introduction

There are many applications across the industry where the temperature to be measured, is too high for the standard stainless steel and nickel-based alloy thermowell materials. All of the more common stainless steels and nickel-based alloys melt at/or before 2,550 °F/1,400 °C and become weak or soft at/or before approx. 2,200 °F/1,200 °C. In these applications a different material must be utilized.

There are two metals available which have a much higher melting point than the stainless steels or nickel-based alloys: tantalum 5,425 °F/2,996 °C and molybdenum 4,730 °F/2,610 °C. However, these metals have inherent problems that limit their use in high temperature service:

- they oxidize rapidly (tantalum above 530 °F/276 °C and molybdenum above 930 °F/499 °C), there fore they can't be used for thermowell materials except in strictly non-oxidizing atmospheres;
- they are very expensive to be used as a thermowell or protection tube material.

The solution is to use a non-metallic or ceramic type of protection tube material. There are a number of these type materials available for high temperature service, each with its own unique capabilities: fused quartz, cermet, silicon carbide, boron nitride, mullite and alumina.

While these materials exhibit varying degrees of high temperature capabilities there are disavantages to their use. Being almost completely made of ceramic, they are extremely brittle and can be broken quite easily by a mechanical shock. Also, most of these materials have a very poor resistance to 'thermal shock'. If a flame is applied suddenly to one side, it expands. Since the other side is cooler, it doesn't expand at the same rate. This leads to stresses which, if severe enough, will crack the protection tube. The lower co-efficient of thermal expansion' these materials have, the more resistance they exhibit to this thermal shock cracking.

The following is a discussion of each of the above referenced materials with some examples of their typical uses in industry.

Fused quartz

Pure silica, fused quartz, has a very low co-efficient of thermal expansion, giving it excellent resistance to thermal shock cracking. It is also a vey chemically inert material and resists attacks by many corrosive chemicals and liquid metals. An unfortunate limitation of fused quartz is, that it is a super cooled 'glass'. At about 2,000 °F (1,094 °C) it will devitrify so that it can't be used for service above this temperature. Also, any surface contamination will accelerate devitrification at high temperatures. (Devitrification refers to the fact that fused quartz will re-crystallize and can't be used above 2,000°F).

Because of fused quartz' excellent thermal shock resistance, it is often used in the metal casting industry as a 'disposable' thermocouple protection tube. The fused quartz tube is inserted into the melt and the temperature (used for control of the pouring temperature) is read. Due to its excellent thermal shock resistance, fuse quartz is able to withstand the sudden change from ambient to melt temperatures.

Cermet

Cermet is a mixture of 77% chromium oxide and 23% aluminum oxide. Made by the Union Carbide Company it is a dense, abrasion resistant material with a high thermal conductivity and a good resistance to wetting by many liquid metals. (Wetting is the degree at which a liquid metal will 'adhere' to a protection tube).
It resists sulphur gases under oxidizing conditions up to at least 2,000 °F (1,094 °C). Also, non-ferrous alloys such as copper, brass, zinc and lead do not wet cermet. It is not recommended for use in carburizing or nitrogen atmospheres, since the chromium in the cermet will form carbides or nitrides.

Cermet is somewhat sensitive to thermal shock and has a maximum service temperature in oxidizing conditions of 2,500 °F (1,370 °C).

Cermet finds use in copper and brass melting pots, and in abrasive atmospheres of elevated temperature where particles might damage a metal thermowell operating near its softening point.

Silicon carbide

Silicon carbide is another very inert material which resists attacks from many aggressive environments, such as sulphur gases. Having a low co-efficient of thermal expansion, it has an excellent resistance to thermal shock and a good thermal conductivity. The material is made by the Carborundum Company. Two types of silicon carbide are available:

- carbofrax 'A': about 90% silicon carbide with the balance being mainly silica;
- 'KT' silicon carbide: about 96% silicon carbide.

Thermowells of carbofrax are considerably less expensive than 'KT silicon carbide, but are not gas tight. However, they give excellent service at high temperatures up to 3,000 °F (1,649 °C). An inner alumina 'sleeve' is used to protect a platinum-rhodium thermocouple from contamination when it is the sensor of choice.
'KT' silicon carbide is used for special applications when high density gas tight thermowells are needed.
Silicon carbide is often used in the steel industry, due to its good thermal shock resistance and elevated temperature capabilities. It is used as a protection tube, which is inserted into a ladle to read the melt temperature.

Boron nitride

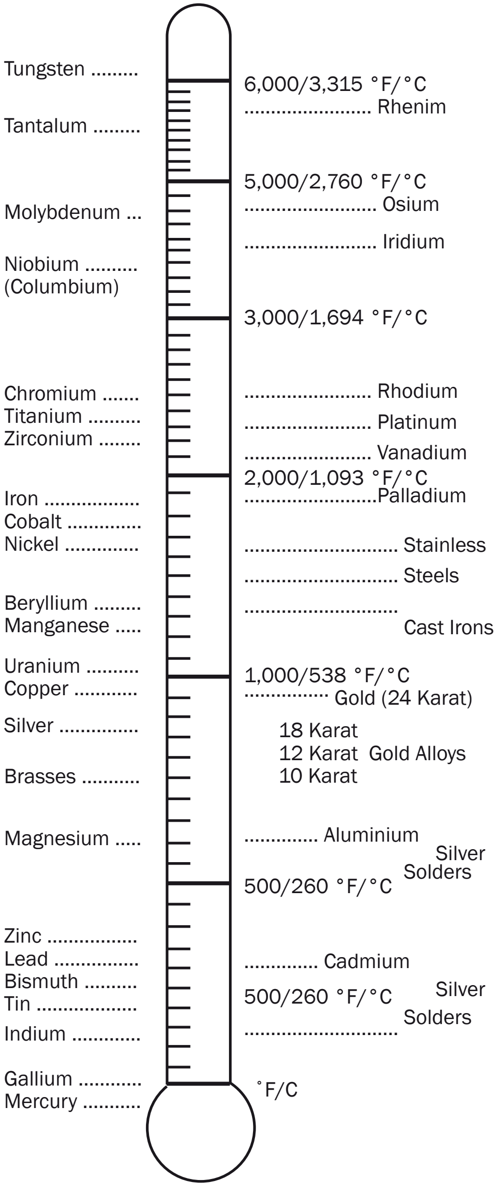
Boron nitride is a synthetic material made by the Carborundum Company which can be used in oxidizing atmospheres up to about 2,000 °F (1,094 °C) or in reducing of inert atmospheres up to about 5,000 °F (2,760 °C). It has a very low co-efficient of thermal expansion and hense excellent resistance to thermal shock. It is not wetted by many liquid metals. A big advantage is that it is machinable with ordinary tooling and has lubricating characteristics somewhat similar to graphite. Recent applications where boron nitride has been used include as an intermittent thermowell with a 'B' calibration thermocouple to measure pouring temperatures of cupro nickels.

Alumina and Mullite

Alumina (aluminum oxide) and mullite (a compound of alumina and silica) have been used for many years as thermowells for chromel-alumel and platinum-rhodium thermocouples. They can be used for high temperatures: 3,450 °F (1,900 °C) for high purity alumina and 3,100 °F (1,700 °C) for mullite. One problem with these materials: they are subject to thermal shock. They can crack if subjected to sudden or non-uniform, localized heating or cooling.

Mullite has a co-efficient of thermal expansion of about 2/3 of alumina and a consequently somewhat better resistance to thermal shock. Both materials are gas tight. Alumina, other than mullite, should be used with platinum-rhodium thermocouples for any conditions rather than oxidizing. The reason: the silicon can be reduced from the mullite and will contaminate platinum-rhodium thermocouples, thereby throwing them out of calibration.

Typical applications for alumina and mullite protection tubes include heat treatment furnaces operating at high temperatures, where little danger from thermal shock or from mechanical damage is involved. This type of protection tube is also widely used in the glass industry.

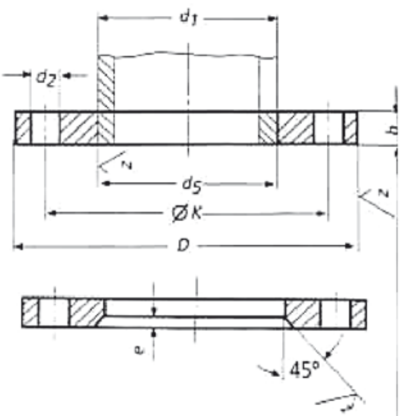

Tungsten ....
6,000/3,315 °F/°C
.... Rhenim
Tantalum ....
5,000/2,760 °F/°C
.... Osium
Molybdenum ...
.... Iridium
Niobium ....
(Columbium)
3,000/1,694 °F/°C
Chromium ....
Titanium ....
Zirconium ....
.... Rhodium
.... Platinum
.... Vanadium
2,000/1,093 °F/°C
........................Palladium
Iron ....
Cobalt ....
Nickel ....
.... Stainless
.... Steels
.... Cast Irons
Beryllium ....
Manganese .....
Uranium ....
Copper ....
1,000/538 °F/°C
.... Gold (24 Karat)
Silver ....
18 Karat
12 Karat Gold Alloys
10 Karat
Brasses ....
Magnesium .....
.... Aluminium
Silver
Solders
500/260 °F/°C
Zinc ....
Lead ....
Bismuth ....
Tin ....
.... Cadmium
500/260 °F/°C
Silver
Solders
Indium ....
....
Gallium ....
Mercury ....
°F/C

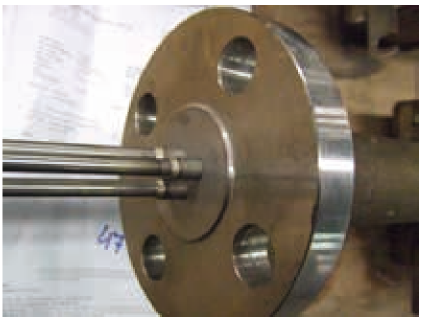
Summary table metallic thermowell materials				
Designation	**Nominal composition**	**Max. temp.**	**Meting range**	**Application notes (con´t.serv., air)**
SS 304	18 % Chromium 81 % Nickel	1,652 °F 900 °C	2,550-2,640 °F 1,399-1,449 °C	The general purpose austenitic SS. Subject to carbide precipitation in the 480 to 870 °C range. Corrosion resistant in the annealed conditions. Not affected by sterilizing solutions, foodstuffs, most dyestuffs, organic chemicals and many inorganic chemicals.
SS 310	25 % Chromium 20 % Nickel	2,100 °F 1,148 °C	2,550-2,640 °F 1,399-1,449 °C	Very high elevated temperature strength and scale resistance. Superior to 304 in much high temperature applications. Good resistance to carburizing and reducing environments. Subject to carbide precipitation in the 480 to 870 °C range.
SS 316	18 % Chromium 12 % Nickel 2-3% Molybdenum	1,650 °F 899 °C	2,550-2,550 °F 1,399-1,399 °C	Higher corrosion resistance than type 304. High creep strength. Withstands sulphurous acid compounds resists tendency to pit in phosphoric and acetic acids. Subject to carbide precipitation in the 426 to 815 °C range.
SS 321 **SS 347**	Similar to 304 but carbide stabilized	1,600 °F 871 °C	2,550-2,600 °F 1,399-1,426 °C	Carbide stabilized grade intended to prevent harmful precipitation of chromium carbides and the resulting susceptibility to inter granular corrosion. For corrosion conditions and intermittent heating and cooling applications between 426 to 815 °C range.

Summary table metallic thermowell materials				
Designation	**Nominal composition**	**Max. temp.**	**Meting range**	**Application notes (con´t.serv., air)**
Inconel 600	76 % Nickel 15,5 % Chromium	2,100 °F 1,148 °C	2,470-2,575 °F 1,354-1,412 °C	Good in several corrosive environments and at elevated temperatures. High hot strength and resistance to progressive oxidation.
Incoloy 800	32,5 % Nickel 46 % Iron 21 % Chromium	2,000 °F 1,093 °C	2,475-2,525 °F 1,357-1,385 °C	Good elevated temperature resistance to oxidation and carburization. Good sulphur and corrosion resistance.
Hastelloy B	61 % Nickel 28 % Molybdenum	2,200 °F 1,204 °C	2,300-2,470 °F 1,260-1,354 °C	Excellent corrosion resistance to hydrochloric, sulphuric phosphoric, and acetic acids. Excellent corrosion. Resistance to hydrogen chloride gas.
Hastelloy C	54 % Nickel 16 % Molybdenum 15,5 % Chromium 4 % Tungsten	2,200 °F 1,204 °C	2,300-2,470 °F 1,260-1,354 °C	Excellent corrosion resistance to many chemical environments, including ferric and cupric chlorides, contaminated mineral acids, wet chlorine gas. Oxidation resistance to 982 °C.
Hastelloy X	47 % Nickel 9 % Molybdenum 22 % Chromium 0,5 % Tungsten	2,200 °F 1,204 °C	2,300-2,470 °F 1,260-1,354 °C	Good high temperature strength and resistance to oxidations to 1,200 °C. Also good for reducing conditions.

SLIP-ON FLANGES

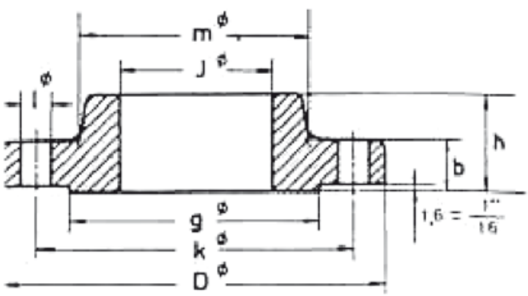
According to DIN EN 1092-1 type PN10 (DIN 2576)												
OD		**flange dimensions in mm**					**bolts**			**weight**	**grades**	
NW	d1 mm	d5 mm	D mm	b mm	k mm	e mm	st nr	draad thread	d2 mm	kg/st kg/pc	4301/4307 (304/304L)	4401/4404 (316/316L)
10	17,2	17,7	90	14	60	5	4	M 12	14	0,605	x	x
15	20	21	95	14	65	5	4	M 12	14	0,675	x	x
15	21,3	22	95	14	65	5	4	M 12	14	0,669	x	x
20	25	26	105	16	75	5	4	M 12	14	0,75	x	x
20	26,9	27,6	105	16	75	5	4	M 12	14	0,94	x	x
25	30	31	115	16	85	5	4	M 12	14	1,14	x	x
25	33,7	34,4	115	16	85	5	4	M 12	14	1,11	x	x
32	38	39	140	16	100	5	4	M 16	18	1,66	x	x
32	42,4	43,1	140	16	100	5	4	M 16	18	1,62	x	x
40	44,5	45,5	150	16	110	5	4	M 16	18	1,89	x	x
40	48,3	49	150	16	110	5	4	M 16	18	1,86	x	x
50	50,8	51,9	165	18	125	6	4	M 16	18	2,6	x	x
50	54	55,1	165	18	125	6	4	M 16	18	2,57	x	x
50	57	58,1	165	18	125	6	4	M 16	18	2,51	x	x
50	60,3	61,1	165	18	125	6	4	M 16	18	2,47	x	x
65	70	71,1	185	18	145	6	4	M 16	18	3,15	x	x
65	76,1	77,1	185	18	145	6	4	M 16	18	3	x	x



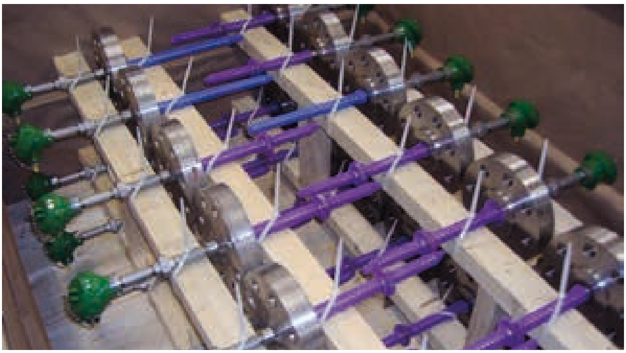


According to DIN EN 1092-1 type PN10 (DIN 2576)												
OD		flange dimensions in mm					bolts			weight	grades	
NW	d1 mm	d5 mm	D mm	b mm	k mm	e mm	st nr	draad thread	d2 mm	kg/st kg/pc	4301/4307 (304/304L)	4401/4404 (316/316L)
80	84	85,5	200	20	160	7	8	M 16	18	3,95	x	x
80	88,9	90,3	200	20	160	7	8	M 16	18	3,79	x	x
100	101,6	103,2	220	20	180	7	8	M 16	18	4,58	x	x
100	104	105,6	220	20	180	7	8	M 16	18	4,38	x	x
100	106	107,6	220	20	180	7	8	M 16	18	4,3	x	x
100	108	109,6	220	20	180	7	8	M 16	18	4,2	x	x
100	114,3	115,9	220	20	180	7	8	M 16	18	4,03	x	x
125	129	130,8	250	22	210	7	8	M 16	18	5,92	x	x
125	133	134,8	250	22	210	7	8	M 16	18	5,71	x	x
125	139,7	141,6	250	22	210	7	8	M 16	18	5,46	x	x
150	154	156,1	285	22	240	7	8	M 20	22	6,88	x	x
150	156	158,1	285	22	240	7	8	M 20	22	6,8	x	x
150	159	161,1	285	22	240	7	8	M 20	22	6,72	x	x
150	168,3	170,5	285	22	240	7	8	M 20	22	6,57	x	x
200	204	206,8	340	24	295	7	8	M 20	22	10,41	x	x
200	206	208,7	340	24	295	7	8	M 20	22	9,91	x	x
200	219,1	221,8	340	24	295	7	8	M 20	22	9,31	x	x
200	219,1	221,8	340	24	295	7	12	M 20	22	9,31	x	x
250	254	257,2	395	26	350	7	12	M 20	22	12,98	x	x
OD		flange dimensions in mm					bolts			weight	grades	
NW	d1 mm	d5 mm	D mm	b mm	k mm	e mm	st nr	draad thread	d2 mm	kg/st kg/pc	4301/4307 (304/304L)	4401/4404 (316/316L)
250	256	259,2	395	26	350	7	12	M 20	22	12,9	x	x
250	273	276,2	395	26	350	7	12	M 20	22	11,9	x	x
300	304	307,7	445	26	400	7	12	M 20	22	15,8	x	x
300	306	309,7	445	26	400	7	12	M 20	22	15,3	x	x
300	323,9	327,6	445	26	400	7	12	M 20	22	13,8	x	x
350	355,6	359,7	505	28	460	7	16	M 20	22	20,6	x	x
400	406,4	411	565	32	515	7	16	M 24	26	27,9	x	x
450	457,2	462,3	615	38	565	7	20	M 24	26	35,6	x	x
500	508	513,6	670	38	620	7	20	M 24	26	41,1	x	x
600	609,6	615,7	780	44	725	7	20	M 27	30	56,3	x	x
700	711	716,5	895	50	840	7	24	M 27	30	80,4	o	o
800	813	820	1015	56	950	7	24	M 27	30	113,2	o	o
900	914	921,5	1115	62	1050	7	28	M 33	36	138,3	o	o

According to ASTM-A 182 SO/RF 150 LBS												
OD	**flange dimensions in mm**							**bolts**		**weight**	**grades**	
NW	D mm	b mm	k mm	h mm	m mm	J mm	g mm	st nr	l mm	kg/st kg/pc	304/L	316/L
1/2"	88,9	11,1	60,3	15,9	30,2	22,3	34,9	4	15,9	0,5	x	x
3/4"	98,4	12,7	69,8	15,9	38,1	27,7	42,9	4	15,9	0,9	x	x
1"	107,9	14,3	79,4	17,5	49,2	34,5	50,8	4	15,9	0,9	x	x
1.1/4"	117,5	15,9	88,9	20,6	58,7	43,2	63,5	4	15,9	1,4	x	x
1.1/2"	127	17,5	98,4	22,2	65,1	49,5	73	4	15,9	1,4	x	x
2"	152,4	19,1	120,6	25,4	77,8	62	92,1	4	19	2,3	x	x
2.1/2"	177,8	22,2	139,7	28,6	90,5	74,7	104,8	4	19	3,2	x	x
3"	190,5	23,8	152,4	30,2	107,9	90,7	127	4	19	3,6	x	x
4"	228,6	23,8	190,5	33,3	134,9	116,1	157,2	8	19	5,9	x	x
5"	254	23,8	215,9	36,5	163,5	143,8	185,7	8	22,2	6,8	x	x
6"	279,4	25,4	241,3	39,7	192,1	170,7	215,9	8	22,2	8,6	x	x
8"	342,9	28,6	298,4	44,4	246,1	221,5	269,9	8	22,2	13,6	x	x
10"	406,4	30,2	361,9	49,2	304,8	276,4	323,8	12	25,4	19,5	x	x
12"	482,6	31,8	431,8	55,6	365,1	327,2	381	12	25,4	29	x	x
14"	533,4	34,9	476,2	57,1	400	259,2	412,7	12	28,6	41	x	x
16"	596,9	36,5	539,7	63,5	457,2	410,5	469,9	16	28,6	44,5	x	x
18"	635	39,7	577,8	68,3	504,8	461,8	533,4	16	31,7	59	x	x
20"	698,5	42,9	635	73	558,8	513,1	584,2	20	31,7	75	x	x
24"	812,8	47,6	749,3	82,5	663,6	616	692,1	20	34,9	99,8	x	x



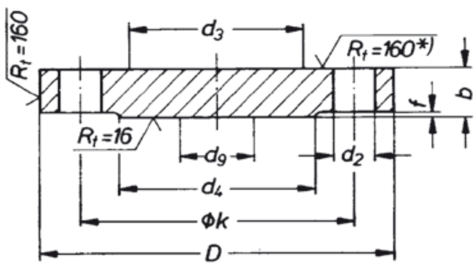
According to ASTM-A 182 SO/RF 300 LBS												
OD	**flange dimensions in mm**							**bolts**		**weight**	**grades**	
NW	D mm	b mm	k mm	h mm	m mm	J mm	g mm	st nr	l mm	kg/st kg/pc	304/L	316/L
1/2"	95,2	14,3	66,7	22,2	38,1	22,3	34,9	4	15,9	0,9	x	x
3/4"	117,5	15,9	82,5	25,4	47,6	27,7	42,9	4	19	1,4	x	x
1"	123,8	17,5	88,9	27	54	34,5	50,8	4	19	1,4	x	x
1.1/4"	133,3	19	98,4	27	63,5	43,2	63,5	4	19	1,8	x	x
1.1/2"	155,6	20,6	114,3	30,2	69,8	49,5	73	4	22,2	2,7	x	x
2"	165,1	22,2	127	33,3	84,1	62	92,1	8	19	3,2	x	x
2.1/2"	190,5	25,4	149,2	38,1	100	74,7	104,8	8	22,2	4,5	x	x
3"	209,5	28,6	168,3	42,9	117,5	90,7	127	8	22,2	5,9	x	x
4"	254	31,8	200	47,6	146	116,1	157,2	8	22,2	10	x	x
5"	279,4	34,9	234,9	50,8	177,8	143,8	185,7	8	22,2	12,7	e	e
6"	317,5	36,5	269,9	52,4	206,4	170,7	215,9	12	22,2	17,7	x	x
8"	381	41,3	330,2	61,9	260,3	221,5	269,9	12	25,4	26,3	x	x
10"	444,5	47,6	387,3	66,7	320,7	276,4	323,8	16	28,6	36,7	e	e
12"	520,7	50,8	450,8	73	374,6	327,2	381	16	31,7	52,2	e	e
14"	584,2	54	514,3	76,2	425,4	359,2	412,7	20	31,7	74,8	e	e
16"	647,7	57,2	571,5	82,5	482,6	410,5	469,9	20	34,9	86,2	e	e
18"	711,2	60,3	628,5	88,9	533,4	461,8	533,4	24	34,9	113	e	e
20"	774,7	63,5	685,8	95,2	587,4	513,1	584,2	24	34,9	143	e	e
24"	914,4	69,8	812,8	106,4	701,7	616	692,1	24	41,3	215	e	e



BLIND FLANGES

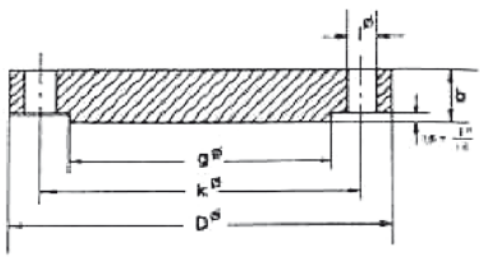
According to DIN EN 1092-1 type 05 PN64 (DIN 2527)										
OD	**flange dimensions in mm**				**bolts**			**weight**	**grades**	
NW	D mm	b mm	k mm	max d9	st nr	draad thread	d2 mm	kg/st kg/pc	4301/4307 (304/304L)	4401/4404 (316/316L)
50	180	26	135	-	4	M20	22	4,5	o	o
65	205	26	160	45	8	M20	22	5,7	o	o
80	215	28	170	60	8	M20	22	6,9	o	o
100	250	30	200	80	8	M24	26	10,1	o	o
125	295	34	240	105	8	M27	30	16	o	o
150	345	36	280	130	8	M30	33	23,5	o	o
(175)	375	40	310	155	12	M30	33	30,8	o	o
200	415	42	345	180	12	M33	36	39,7	o	o
250	470	46	400	220	12	M33	36	57,4	o	o
300	530	52	460	270	16	M33	36	81	o	o
350	600	56	525	310	16	M36	39	114	o	o
400	670	60	585	360	16	M39	42	153	o	o

Form E

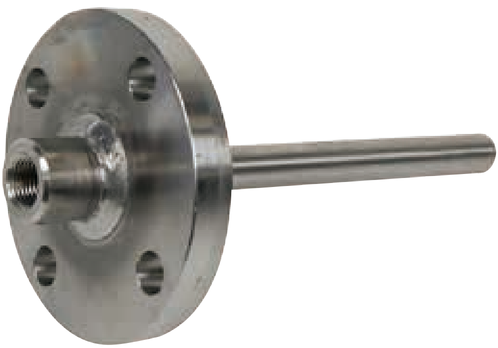


According to DIN 2527/E ND 100											
OD	**flange dimensions in mm**				**bolts**			**weight**	**grades**	
NW	D mm	b mm	k mm	max d9	st nr	draad thread	d2 mm	kg/st kg/pc	4301/4307 (304/304L)	4401/4404 (316/316L)
10	100	20	70	-	4	M12	14	1	o	o
15	105	20	75	-	4	M12	14	1,2	o	o
25	140	24	100	-	4	M16	18	2,7	o	o
32	155	24	110	-	4	M20	22	3,2	o	o
40	170	26	125	-	4	M20	22	4,1	o	o
50	195	28	145	-	4	M24	26	5,8	o	o
65	220	30	170	45	8	M24	26	8	o	o
80	230	32	180	60	8	M24	26	9,4	o	o
100	265	36	210	80	8	M27	30	14,3	o	o
125	315	40	250	105	8	M30	33	22,6	o	o
150	355	44	290	130	12	M30	33	31,8	o	o
(175)	385	48	320	155	12	M30	33	41,3	o	o
200	430	52	360	180	12	M33	36	56,1	o	o
250	505	60	430	210	12	M36	39	89,6	o	o
300	585	68	500	260	16	M39	42	11	o	o
350	655	74	560	300	16	M45	48	175	o	o

According to ASTM-A 182 BL/RF 150 LBS									
OD	**flange dimensions in mm**				**bolts**		**weight**	**grades**	
NW	D mm	b mm	k mm	g mm	st nr	l mm	kg/st kg / pc	304/L	316/L
1/2"	88,9	11,1	60,3	34,9	4	15,9	0,5	x	x
3/4"	98,4	12,7	69,8	42,9	4	15,9	0,9	x	x
1"	108	14,3	79,4	50,8	4	15,9	0,9	x	x
1.1/4"	117,5	15,9	88,9	63,5	4	15,9	1,4	x	x
1.1/2"	127	17,5	98,4	73	4	15,9	1,8	x	x
2"	152,4	19,1	120,6	92,1	4	19	2,3	x	x
2.1/2"	177,8	22,2	139,7	104,8	4	19	3,2	x	x
3"	190,5	23,8	152,4	127	4	19	4,1	x	x
4"	228,6	23,8	190,5	157,2	8	19	7,7	x	x
5"	254	23,8	215,9	185,7	8	22,2	9,1	x	x
6"	279,4	25,4	241,3	215,9	8	22,2	11,8	x	x
8"	342,9	28,6	298,4	269,9	8	22,2	21	x	x
10"	406,4	30,2	361,9	323,8	12	25,4	31,8	x	x
12"	482,6	31,8	431,8	381	12	25,4	49,9	x	x
14"	533,4	34,9	476,2	412,7	12	28,6	63,5	x	x
16"	596,9	36,5	539,7	469,9	16	28,6	81,6	x	x
18"	635	39,7	577,8	533,4	16	31,7	99,8	x	x
20"	698,5	42,9	635	584,2	20	31,7	129	x	x
24"	812,8	47,6	749,3	692,1	20	34,9	195	x	x

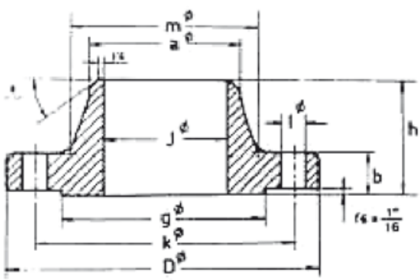


According to ASTM-A 182 BL/RF 300 LBS									
OD	**flange dimensions in mm**				**bolts**		**weight**	**grades**	
NW	D mm	b mm	k mm	g mm	st nr	l mm	kg/st kg /pc	304/L	316/L
1/2”	95,2	14,3	66,5	34,9	4	15,9	0,9	x	x
3/4”	117,5	15,9	82,5	42,9	4	19	1,4	x	x
1”	123,8	17,5	88,9	50,8	4	19	1,4	x	x
1.1/4”	133,3	19	98,4	63,5	4	19	1,8	x	x
1.1/2”	155,6	20,6	114,3	73	4	22,2	2,7	x	x
2”	165,1	22,2	127	92,1	8	19	3,6	x	x
2.1/2”	190,5	25,4	149,2	104,8	8	22,2	5,4	x	x
3”	209,5	28,6	168,3	127	8	22,2	7,3	x	x
4”	254	31,8	200	157,2	8	22,2	12,2	x	x
5”	279,4	34,9	234,9	185,7	8	22,2	15,9	e	e
6”	317,5	36,5	269,9	215,9	12	22,2	22,7	x	x
8”	381	41,3	330,2	269,9	12	25,4	36,7	x	x
10”	444,5	47,6	387,3	323,8	16	28,6	57	e	e
12”	520,7	50,8	450,8	381	16	31,7	84	e	e
14”	584,2	54	514,3	412,7	20	31,7	113	e	e
16”	647,7	57,2	571,5	469,9	20	34,9	134	e	e
18”	711,2	60,3	628,6	533,4	24	34,9	178	e	e
20”	774,7	63,5	685,8	584,2	24	34,9	229	e	e
24”	914,4	69,8	812,8	692,1	24	41,3	358	e	e



WELDING NECK FLANGES

According to ASTM-A 182 WN/RF 150 LBS													
OD		flange dimensions in mm							bolts		weight	grades	
NW	a mm	D mm	b mm	k mm	h mm	m mm	J mm	g mm	st nr	l mm	kg/st kg/pc	304/L	316/L
1/2"	21,3	88,9	11,1	60,3	47,6	30,2	15,8	34,9	4	15,9	0,9	x	x
3/4"	26,7	98,4	12,7	69,8	52,4	38,1	20,8	42,9	4	15,9	0,9	x	x
1"	33,5	107,9	14,3	79,4	55,6	49,2	26,7	50,8	4	15,9	1,4	x	x
1.1/4"	42,2	117,5	15,9	88,9	57,1	58,7	35,1	63,5	4	15,9	1,4	x	x
1.1/2"	48,3	127	17,5	98,4	61,9	65,1	40,9	73	4	15,9	1,8	x	x
2"	60,5	152,4	19,1	120,6	63,5	77,8	52,6	92,1	4	19,1	2,7	x	x
2.1/2"	73,2	177,8	22,2	139,7	69,8	90,5	62,7	104,8	4	19,1	3,6	x	x
3"	88,9	190,5	23,8	152,4	69,8	107,9	78	127	4	19,1	4,5	x	x
4"	114,3	228,6	23,8	190,5	76,2	134,9	102,4	157,2	8	19,1	6,8	x	x
5"	114,3	254	23,8	215,9	88,9	163,5	128,3	185,7	8	22,2	8,6	x	x
6"	168,4	279,4	25,4	241,3	88,9	192,1	154,2	215,9	8	22,2	10,9	x	x
8"	219,2	342,9	28,6	298,4	101,6	246,1	202,7	269,9	8	22,2	17,7	x	x
10"	273,1	406,4	30,2	362	101,6	304,8	254,5	323,8	12	25,4	23,6	x	x
12"	323,9	482,6	31,8	431,8	114,3	365,1	304,8	381	12	25,4	36,3	x	x
14"	355,6	533,4	34,9	476,2	127	400		412,7	12	28,6	50	x	x
16"	406,4	596,9	36,5	539,7	127	457,2		469,9	16	28,6	64	x	x
18"	457,2	635	39,7	577,8	139,7	504,8		533,4	16	31,8	68	x	x
20"	508	698,5	42,9	635	144,5	558,8		584,2	20	31,8	81,6	x	x
24"	609,6	812,8	47,6	749,3	152,4	663,6		692,1	20	34,9	118	x	x



According to ASTM-A 182 WN/RF 150 LBS														
OD		**flange dimensions in mm**							**bolts**		**weight**	**grades**	
NW	a mm	D mm	b mm	k mm	h mm	m mm	J mm	g mm	st nr	l mm	kg/st kg/pc	304/L	316/L
1/2”	21,3	95,2	14,3	66,7	52,4	38,1	15,8	34,9	4	15,9	0,9	x	x
3/4”	26,7	117,5	15,9	82,5	57,1	47,6	20,8	42,9	4	19,1	1,4	x	x
1”	33,5	123,8	17,5	88,9	61,9	54	26,7	50,8	4	19,1	1,8	x	x
1.1/4”	42,2	133,4	19,1	98,4	65,1	63,5	35,1	63,5	4	19,1	2,3	x	x
1.1/2”	48,3	155,6	20,6	114,3	68,3	69,8	40,9	73	4	22,2	3,2	x	x
2”	60,5	165,1	22,2	127	69,8	84,1	52,6	92,1	8	19,1	4,1	x	x
2.1/2”	73,2	190,5	25,4	149,2	76,2	100	62,7	104,8	8	22,2	5,4	x	x
3”	88,9	210	28,6	168,3	79,4	117,5	78	127	8	22,2	6,8	x	x
4”	114,3	254	31,8	200	85,7	146,1	102,4	157,2	8	22,2	11,3	x	x
5”	141,2	279,4	34,9	235	98,4	177,8	128,3	185,7	8	22,2	14,5	e	e
6”	168,4	317,5	36,5	269,9	98,4	206,4	154,2	215,9	12	22,2	19	x	x
8”	219,2	381	41,3	330,2	111,1	260,4	202,7	269,9	12	25,4	30,4	x	x
10”	273,1	444,5	47,6	387,3	117,5	320,7	254,5	323,8	16	28,6	41,3	e	e
12”	323,9	520,7	50,8	450,8	130,2	374,6	304,8	381	16	31,7	63,5	e	e
14”	355,6	584,2	54	514,3	142,9	425,4		412,7	20	31,7	81,6	e	e
16”	406,4	647,7	57,2	571,5	146,1	482,6		469,9	20	34,9	113	e	e
18”	457,2	711,2	60,3	628,6	158,8	533,4		533,4	24	34,9	145	e	e
20”	508	774,7	63,5	685,8	161,9	587,4		584,2	24	34,9	181	e	e
24”	609,6	914,4	69,8	812,8	168,3	701,7		692,1	24	41,3	263	e	e

APPLICATIONS / PROTECTION TUBE MATERIALS

Application		Protection tube material
Heat treatment		
• Annealing	: - up to 704 °C	Black steel
	- over 704 °C	Inconel 600, SS 446
• Carburizing hardening	: - up to 816 °C	Black steel, SS 446
	- 1,093 °C	Inconel 600, SS 446
	- over 1,093 °C	Ceramic
	- nitriding salts bath	SS 446
	- cyanide	Nickel (CP)
	- neutral	SS 446
	- high speed	Ceramic
Iron and Steel		
• Basic oxygen furnace		Quartz
• Blast furnace:		
- down comer		Inconel 600, SS 446
- stove dome		Silicon carbide
- hot blast main		Inconel 600
- stove trunk		Inconel 600
- stove outlet flue		Black steel
• Open hearth:		
- flues and stack		Inconel 600, SS 446
- checkers		Inconel 600, cermets
- waste heat boiler		Inconel 600, SS 446
• Billet heating slab heating		
and butt welding	: - up to 1,093 °C	Inconel 600, SS 446
	- over 1,093 °C	Silicon ceramic carbide
• Bright annealing batch:		
- top work temperature		Not required (use bare wire J T/C)
- bottom work temperature		SS 446
• Continuous furnace section:		
- forging		Silicon ceramic carbide
- soaking pits	: - up to 1,093 °C	Inconel 600
	- over 1,093 °C	Silicon ceramic carbide
Nonferrous materials		
• Aluminium melting		Cast iron (white-washed)
• Aluminium heat treating		Black steel
• Brass or bronze		Not required (use dip-type T/C)
• Lead		SS 446, black steel
• Magnesium		Black steel, cast iron
• Tin		Extra heavy carbon steel
• Zinc		Extra heavy carbon steel

Application	Protection tube material
Cement • Exit flues • Kilns, heating zone	 Inconel 600, SS 446 Inconel 600
Ceramic • Kilns • Dryers • Vitreous enamelling	 Ceramic and silicon carbide Silicon carbide, black steel Inconel 600, SS 446
Glass • Fore hearths and feeders • Tanks roof and wall • Flues and checkers	 Platinum thimbles Ceramic Inconel 600, SS 446
Paper • Digesters	 SS 316, SS 446
Petroleum • Cracking lines • Dewaxing • Towers • Transfer lines • Bridge wall	 SS 316 SS 304, SS 316, SS310, SS321 SS 304, SS 316, SS310, SS321 SS 304, SS 316, SS310, SS321 Inconel 600
Power • Coal-air mixtures • Flue gases • Pre heaters • Steam lines • Water lines • Boiler tubes	 SS 304 Black steel, SS 446 Black steel, SS 446 SS 347, SS 316 Low carbon steel SS 304, SS 310
Gas producers • Producer gas • Water gas : - carburettor - super heater	 SS 446 Inconel 600, SS 446 Inconel 600, SS 446
Incinerators : - up to 1,093 °C - over 1,093 °C	Inconel 600, SS 446 Ceramic, silicon carbide (secondary)

Application		Protection tube material
Food		
• Baking ovens		Black steel
• Char retort, sugar		Black steel
• Vegetables and fruit		SS 304
Chemical		
• Acetic acid	: - 10-50%, 21 °C	SS 304, Hastelloy C, Monel
	- 50%, 100 °C	SS 316, Hastelloy C, Monel
	- 99%, 21-100 °C	Hastelloy C, Monel
• Alcohol, ethyl, methyl	: 21-100 °C	SS 304
• Ammonia	: all concentration, 21-100 °C	SS 304, SS 316
• Ammonium chloride	: all concentration, 100 °C	SS 316, Monel
• Ammonium nitrate	: all concentration, 21-100 °C	SS 316
• Ammonium sulphate	: 10% to saturated, 100 °C	SS 316
• Barium chloride	: at 21 °C	Monel, Hastelloy C
• Barium hydroxide	: at 21 °C	Low carbon steel
• Barium sulphide		Nichrome, Hastelloy C
• Butadiene		SS 304
• Butane		SS 304
• Butyl acetate		Monel
• Butyl alcohol		Copper, SS304
• Calcium chlorate	: dilute 21 to 66 °C	SS 304
• Calcium hydroxide	: - 10 to 20%, 100 °C	SS 304, Hastelloy C
	- 50% at 100 °C	SS 304, Hastelloy C
• Carbolic acid	: all 100 °C	SS 316
• Chlorine gas	: - dry at 21 °C	SS 316, Monel
	- moist -7 to 100 °C	Hastelloy C
• Chromic acid	: 10 to 50% at 100 °C	SS 316, Hastelloy C
• Citric acid	: concentrated at 100 °C	SS 316, Hastelloy C
• Copper nitrite		SS 304, SS 316
• Copper sulphate		SS 304, SS 316
• Cyanogen gas		SS 304
• Dow therm		Low carbon steel
• Ether		SS 304
• Ethyl acetate		SS 304
• Ethyl chloride	: 21 °C	SS 304, low carbon steel
• Ethyl sulphate	: 21 °C	Monel
• Ferric chloride	: 5%, 21 °C to boiling	Tantalum, Hastelloy C
• Ferric sulphate	: 5%, 21 °C	SS 304
• Ferrous sulphate dilute	: 21 °C	SS 304
• Formaldehyde		SS 304, SS 316
• Freon		Monel
• Gallic acid	: 5%, 21 to 66 °C	Monel

Application		Protection tube material
• Gasoline	: 21 °C	SS 304
• Glucose	: 21 °C	SS 304
• Glycerin	: 21 °C	SS 304
• Hydrobromic acid	: 98%, 100 °C	Hastelloy B
• Hydrochloric acid	: - 1- 5%, 21 °C	Hastelloy C
	- 1-25%, 100 °C	Hastelloy B
• Hydrofluoric acid	: 60%, 100 °C	Hastelloy C, Monel
• Hydrogen peroxide	: 21 to 100 °C	SS 316, SS 304
• Hydrogen sulphide	: wet and dry	SS 316
• Iodine		Hastelloy C, tantalum
• Kerosene		SS 304
• Lactic acid		SS 316
• Magnesium chloride	: - 5%, 21 °C	Monel, nickel
	- 5%, 100 °C	Carpenter 20CB3
• Magnesium sulphate	: hot and cold	Monel
• Muratic acid		Hastelloy B
• Naphtha	: 21 °C	SS 304
• Natural gas	: 21 °C	SS 304, SS 316
• Nickel chloride	: 21 °C	SS 304
• Nickel sulphate	: hot and cold	SS 304
• Nitric acid	: - 5%, 21 °C	SS 304, SS 316
	- 20%, 21 °C	SS 304, SS 316
	- 50%, 100 °C	SS 304, SS 316
	- 65%, 100 °C	SS 316
	- concentrated, 100 °C	Tantalum
• Nitrobenzene		SS 304
• Oleic acid	: 21 °C	SS 316
• Oxalic acid	: - 5% hot, cold	SS 304
	- 10%, 100 °C	Monel
• Oxygen	: 21 °C	
• Steel		
• Palmitic acid		SS 316
• Pentane		SS 304
• Phenol		SS 304, SS 316
• Phosphoric acid	: - 1-5%, 21 °C	SS 304
	- 10%, 21 °C	SS 316
	- 10%, 100 °C	Hastelloy C
	- 30%, 21-100°C	Hastelloy B
	- 85%, 21-100°C	Hastelloy B
• Picric acid	: 21 °C	SS 304
• Potassium bromide	: 21 °C	SS 316
• Potassium carbonite	: 1% at 21 °C	SS 304, SS 316

Application		Protection tube material
• Potassium hydroxide	: - 5-25%, 21-100 °C	SS 304
	- 60% at 100 °C	SS 316
• Potassium nitrate		SS 304
• Potassium sulphate	: 21 °C	SS 304, SS 316
• Potassium sulphide	: 21 °C	SS 304, SS 316
• Propane		SS 304, low carbon steel
• Pyrogallic acid		SS 304
• Quinine sulphate	: dry	SS 304
• Seawater		Monel, Hastelloy C
• Salicylic acid		Nickel
• Sodium bicarbonate	: - all concentration, 21 °C	SS 304
	- 5% at 66 °C	SS 304, SS 316
• Sodium chloride	: - 5%, 21-66 °C	SS 316
	- saturated 21-100 °C	SS 316, Monel
• Sodium fluoride	: 5%, 21 °C	Monel
• Sodium hydroxide		SS 304, SS 316, Hastelloy C
• Sodium nitrate	: fused	SS 316
• Sodium sulphate	: 21 °C	SS 304, SS 316
• Sodium sulphide	: - 21 °C	SS 316
	- 30%, 66 °C	SS 304
• Sulphur dioxide	: - moist gas, 21 °C	SS 316
	- gas, 302 °C	SS 304, SS 316
• Sulphur	: - dry molten	SS 304
	- wet	SS 316
• Sulphuric acid	: - 5-90% at 21-100 °C	Hastelloy B
	- 90% above 100 °C	Hastelloy D
• Tannic acid	: 21 °C	SS 304, Hastelloy B
• Tartaric acid	: - 21 °C	SS 304
	- 66 °C	SS 316
• Toluene		SS 304, low carbon steel
• Turpentine		SS 304, SS 316
• Vinegar		SS 316
• Water distilled	: return condensate	SS 304
• Whiskey and wine		SS 304, nickel
• Xylene		Copper
• Zinc chloride		Monel, Hastelloy B
• Zinc sulphate	: - 5%, 21 °C	SS 304, SS 316
	- saturated, 21 °C	SS 304, SS 316

EUROPEAN IEC STANDARDS

European IEC specifications 144 & 529 define the degree of protection provided to electrical enclosures to safeguard personnel against electric shock an equipment within the enclosures from environmental contamination such as entry of water. This is expressed by the letters IP followed by two numbers.

NEMA AND IEC STANDARDS

In the USA, NEMA and UL have established a rating system for enclosures which provides different levels of protection. A direct comparison between IEC and NEMA is not possible but the following table gives an approximate guide.

IP Definition	Protection to IEC 144/855420	Protection to NEMA enclosure type	NEMA Definition
Protection against solid objects greater than 12 mm	IP 20	NEMA 1 (ventilated)	general purpose
Protection against solid objects greater than 2,5 mm	IP 30	NEMA 1	general purpose
Protection against solid objects greater than 12 mm and dripping water	IP 21	NEMA 2 (ventilated)	drip proof
Protection against solid objects greater than 2,5 mm and dripping water	IP 31	NEMA 2	drip proof
Protection against solid objects greater than 12 mm and dripping water	IP 24	NEMA 3R (ventilated)	rain proof sleet (ice) resistant outdoor use
Protection against solid objects greater than 2,5 mm and dripping water	IP 34	NEMA 3R	rain proof sleet (ice) resistant outdoor use
Protection against dust and splashing liquids	IP 54	-	-
Dusttight and protected against water jets	IP 65	NEMA 12	induct use dusttight & driptight
Dusttight and protected against heavy seas	IP 66	NEMA 35	dusttight driptight
Dusttight and protected against heavy seas	IP 66	NEMA 4	dusttight watertight
-	-	NEMA 4X	dusttight watertight corrosion resistant
Dusttight and protected against water entry at one meter immersion	IP 67	-	-
Dusttight and protected against heavy submersion	IP 68	NEMA 6	submersible watertight dusttight sleet (ice) resistant indoor & outdoor
Protection against sleet (ice) not specified by IEC	-	NEMA 13	oiltight & dusttight

Types of protection			
IEC/Europe		**North America**	
Zone 0	Exia	Div. 1 Zone 0 now recognised	
Zone 1	Exd-flameproof Exi-intrinsic safety ia&ib Exe-increased safety	Class I Div. 1	Type of protection: explosionproof purged intrinsic safety oil immersion
Zone 2	All types suitable for Zone 0 and 1 Type N, ExN or Exn N=BS 1998 n=EN1999	Class I Div. 2	Type of protection: All types suitable for Div. 1 and Non-incendive

ATEX approvals	
Type XPS1	Ex II 2G Exe II T6 to T1 for use in zone 1 and 2 according ATEX EN-60079-0-2006 and EN-60079-7-2007
Type XPS2	Ex II 2G Exia IIC T6 to T1 for use in zone 0, 1 and 2 according ATEX EN-60079-0-2006 and EN-60079-11-2007
Type XPS2	Ex II 2G Exib IIC T6 to T1 for use in zone 0, 1 and 2 according ATEX EN-60079-0-2006 and EN-60079-11-2007
Type XPS3	Ex II 2G Exd IIC T6 to T1 for use in zone 1 and 2 according ATEX EN-60079-0-2006 and EN-60079-1-2007
Type XPS4	Ex II 3G ExenA II T6 to T1 for use in zone 2 according ATEX EN-60079-0-2006 and EN-60079-15-2005

IEC/EX approvals	
Type XPS1	Exe II T6... T1 for use in zone 1 and 2
Type XPS2	Exia IIC T6...T1 for use in zone 0, 1 and 2
Type XPS2	Exib IIC T6...T1 for use in zone 0, 1 and 2
Type XPS3	Exd IIC T6...T1 for use in zone 1 and 2
Type XPS4	ExnA II T6... T1 for use in zone 2

SPECIFICATIONS

Solid Conductors		
Wire size AWG	Diameter mm	Circular mm
0	8,25	53,57
2	6,54	33,57
4	5,19	21,23
6	4,12	13,30
8	3,26	8,36
10	2,59	5,26
12	2,05	3,31
14	1,63	2,08
–	1,38	1,50
16	1,29	1,33
18	1,02	0,82
20	0,81	0,52
22	0,64	0,32
24	0,51	0,20
26	0,40	0,13
28	0,32	0,08
30	0,25	0,05
32	0,20	0,03
34	0,16	0,02
36	0,13	0,01
38	0,10	0,008
40	0,08	0,005

Stranded Conductors			
Wire size AWG	Stranding n x mm dia.	Diameter mm	Circular mm
12	7 x 0,81	2,44	3,65
12	19 x 0,45	2,37	3,10
–	50 x 0,26	2,20	2,50
14	7 x 0,64	1,85	2,28
14	16 x 0,40	1,85	2,08
14	19 x 0,36	1,85	1,95
–	48 x 0,20	1,70	1,50
16	7 x 0,51	1,52	1,44
16	19 x 0,29	1,47	1,24
–	7 x 0,43	1,30	1,00
–	32 x 0,21	1,38	1,00
17	19 x 0,25	1,35	0,95
18	7 x 0,40	1,22	0,90
18	16 x 0,25	1,19	0,82
18	19 x 0,25	1,24	0,97
–	24 x 0,21	1,20	0,75
20	7 x 0,30	0,95	0,52
20	16 x 0,20	0,93	0,50
20	19 x 0,20	0,94	0,62
24	7 x 0,20	0,61	0,23
24	19 x 0,13	0,61	0,24
26	7 x 0,16	0,48	0,14
28	7 x 0,13	0,38	0,07
30	7 x 0,10	0,30	0,057
32	7 x 0,08	0,22	0,034
34	7 x 0,06	0,19	0,022
36	7 x 0,05	0,15	0,014

The above listed dimensions are nominal values for comparison purposes only.

Thermo Electric standard wire sizes*	
Solid (t/c)	14, 16, 20, 24 and 30 AWG
Stranded	16,20 and 24 AWG (t/c) 14, 16, 18 and 20 AWG (Cu)

* Other sizes are available on request or as 'non standard' wire from stock.
For more information contact Doedijns Instrumentation (brand Thermo Electric).

18. INTERNATIONAL THERMOCOUPLE COLOUR CODING

THERMOCOUPLE COLOUR CODING

Thermocouple Extension Type		ANSI	BS	DIN	NFC	JIS	IEC
JX	+ Iron - Constantan ®						
KX	+ Chromel ® - Alumel ®						
WX / KCA	+ Iron - Copper Ni						
VX / KCB	+ Copper - Copper Ni						
TX	+ Copper - Constantan ®						
EX	+ Chromel ® - Constantan ®						
NX	+ Nicrosil ® - Nisil ®						
SX / RX	+ Copper - Alloy 11						
BX	+ Copper-S - Copper-E						

Multipoint produced on-site

THERMO ELECTRIC
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