KANTHAL®

THERMOCOUPLE, EXTENSION AND COMPENSATING ALLOYS

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INTRODUCTION AND GRADES

For many industrial heating processes, especially those performed at high temperatures, a thermocouple is the most accurate, convenient, and simple method of temperature measurement. In some cases, it is the only practical method.

Kanthal is a leading producer of thermocouple materials.

The modern thermocouple operates on Seebeck's principle. It states that when a circuit is created using two different metal conductors and one junction is at a higher temperature than the other, a current flows through the circuit. The resulting electromotive force (EMF) is proportional to the temperature difference between the two junctions.

Our base metal thermocouple alloys are engineered for reliable use in high-temperature environments up to 1,260°C (2,300°F). Kanthal offers a broad selection of thermocouple materials and configurations to support a wide range of industrial measurement needs. This portfolio allows customers to choose the most suitable combination for their process conditions, whether the priority is stability, durability, or consistent accuracy. Detailed information about the Kanthal® range of thermocouple alloys is provided on the following pages. Our extensive knowledge and expertise in this specialized field are available to support you with technical advice or assistance.

Kanthal alloys are supplied in accordance with internationally recognized standards such as ASTM and IEC. The tables below show the standard tolerances associated with these specifications. If older, non-equivalent standards are still in use, we can provide different EMF values upon request. The equivalent Kanthal alloys and combinations are well established and listed under recognized trademarks. Each entry is followed by the relevant code in brackets, with 'P' indicating the positive leg and 'N' indicating the negative leg.

STANDARDS AND NORMS

ASTM	(American Society for Testing and Materials) E 230
ANSI	(American National Standard Institute) MC 96.1
IEC	(European Standard by the International Electrotechnical Commission) 584 -1/2/3
DIN	(Deutsche Industrie Normen) EN 60584 -1/2
BS	(British Standards) 4937-1041, EN 60584 -1/2
NF	(Norme Française) EN 60584 -1/2 - NFC 42323 - NFC 42324
JIS	(Japanese Industrial Standards) C 1602 - C 1610
GOST	(Unification of the Russian Specifications) 3044

TYPES OF THERMOCOUPLE WIRES PRODUCED BY KANTHAL

WIRES COMPONENT THE THERMOCOUPLE

Code	Positive leg	Negative leg
N	Nicrosil (NP)	Nisil (NN)
K	Thermothal® P (KP)	Thermothal® N (KN)
E	Thermothal® P (EP)	Cuprothal® (EN)
J	Iron (JP)	Cuprothal® (JN)
T	Copper	Cuprothal® (TN)

STANDARD GRADE

This grade is calibrated across the entire operating temperature range, and the EMF (Electromotive Force) of the thermocouple wires meets the relevant standards or customer specifications. Each arm is calibrated against platinum, and the EMF values are indicated on the label of each coil or spool.

Thermothal® P and Thermothal® N wires, which are type K thermocouples, are available in either a bright or oxidized condition.

Additionally, the thermoelements used for type J thermocouples, including Cuprothal® (JN) and Iron (JP), are typically supplied in a bright annealed condition.

SPECIAL GRADE

All thermocouple combinations are available by selection to closer tolerances than normal (1/2 and ¼ tolerances) for applications requiring special accuracy. Tolerances for special grade material, which comes at an additional cost, are listed on the following pages. Extension grade material is also available; it follows the same tolerance limits as standard grade but is tested only up to 200°C (392°F).

For some applications, special tolerances of ± 0.25°C or ± 0.002 T (whichever is greater – where 'T' is the temperature) can be manufactured.

SHEATING GRADE

When thermocouples are required for integration into mineral-filled sheathed elements, it is essential to select alloys that meet specific electromotive force (EMF) requirements. The wire must conform to the following international standards:

JIS C 1605, ASTM E 608, E 585, and other significant standards. During the production of thermocouples for mineral-filled sheathed elements, the EMF value can change due to several factors, including:

- The preparation method and subsequent thermal treatments
- The type of sheath material used, such as stainless steel or nickel-chromium alloys that offer high-temperature resistance
- Insulation values

Sheathing grade is uncommon and often requires thermocouple material with an intentional EMF offset, calibrated to read more negative than the standard specification. This offset is not a separate grade. It is a customized adjustment that Kanthal can produce for specific customer applications where precise EMF behavior is critical.

OTHER SPECIAL FEATURES

OXIDIZED SURFACE

Kanthal's standard specification is for bright annealed material, and oxidized wire can be supplied on request for more demanding environments. Oxidized surfaces offer improved resistance in atmospheres containing hydrogen sulfide (H_2S) and carbon dioxide (CO_2). When additional protection is required, the wire can also be enclosed in ventilated sheaths. A small flow of clean air is introduced through a side vent at the cold junction and exits at the hot junction. Kanthal supplies both bright and oxidized wires in accordance with standard EMF requirements and customer-specific needs.

CALIBRATION

All types of thermocouples are calibrated to ensure that the EMF is accurate within the temperature ranges specified by international standards. If thermocouples are required for use in sub-zero temperatures, they must be specifically ordered for that purpose. Each thermoelectric alloy is individually calibrated against Pt 67, and the corresponding EMF values at various temperatures are displayed on the label.

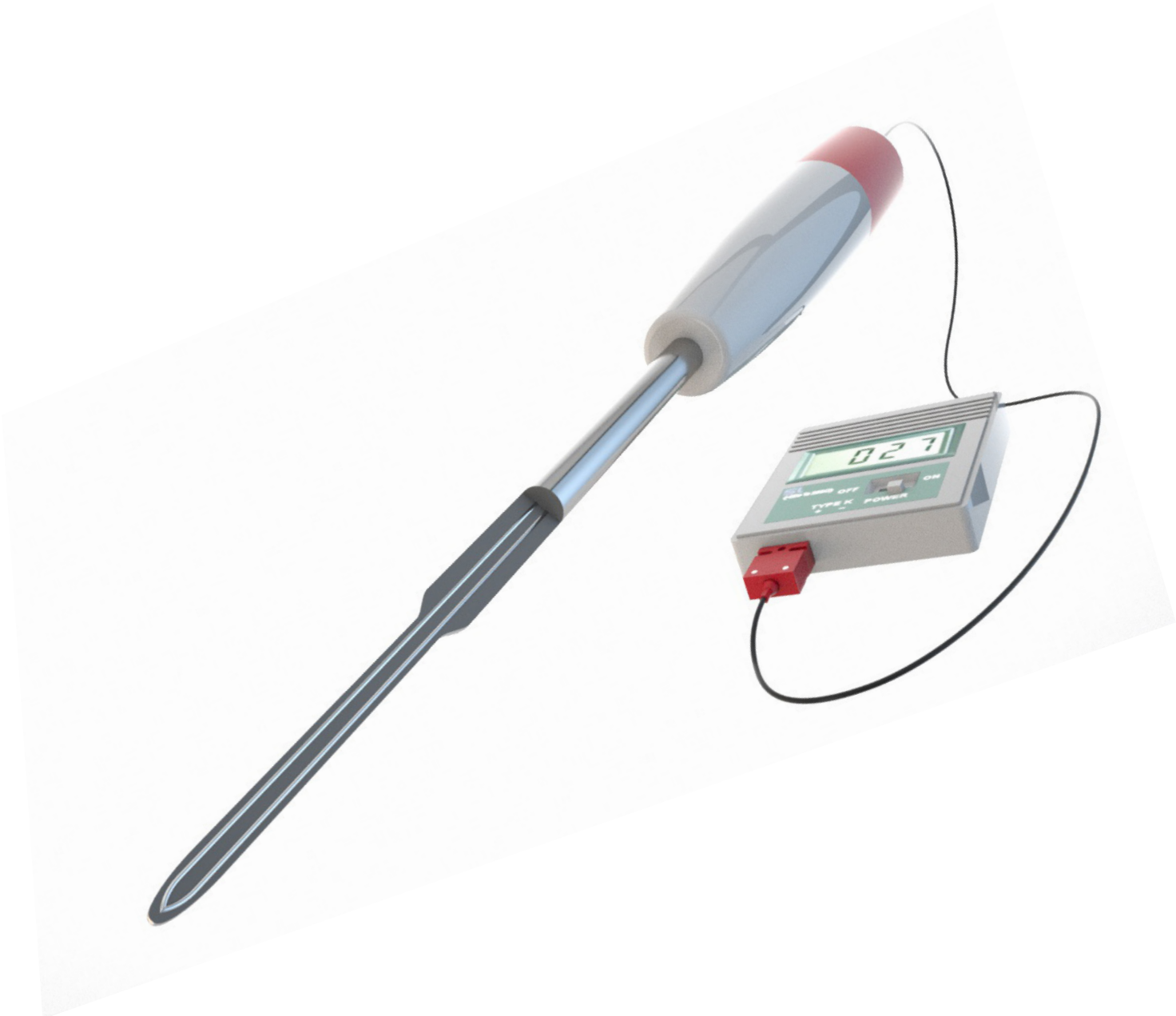
HARD AND HALF PROCESSING PRODUCTS (JOINTS)

Connecting thermocouples to compensation or extension cables often requires creating joints. To prevent inaccurate EMF readings, it is advisable to use the same alloy for the joint as for the thermocouple or cable, especially when the temperatures at the joints vary.

Kanthal's standard material is supplied fully annealed, but special mechanical properties can be provided on request when machining or other processing requirements call for them. Such processing can affect the EMF, so the finished product must be annealed to restore the correct EMF values.

For the bright annealing of Thermothal® P and Thermothal® N, the materials are heat-treated in a clean, reducing atmosphere free of sulfur gases and moisture.

THERMOCOUPLES



MOST USED THERMOCOUPLE COMBINATIONS

THERMOCOUPLE	THERMOELEMENT	ALLOY	WORKING ATMOSPHERE	TEMPERATURE RANGE, °C	
Type K	KP	Thermothal® P	Oxidizing	-200	+1,200
	KN	Thermothal® N	Inert	–	–
Type E	EP	Thermothal® P (EP)	Oxidizing	-200	+900
	EN	Cuprothal® (EN)	Inert	–	–
Type T	TP	Copper	Oxidizing, vacuum	-200	+350
	TN	Cuprothal® (TN)	Reducing, inert	–	–
Type J	JP	Iron (JP)	Oxidizing (limited use at high temp.)	-40	+750
	JN	Cuprothal® (JN)	Reducing, inert, vacuum	–	–
Type N	NP	Nicrosil	Oxidizing	-200	+1,200
	NN	Nisil	Inert	–	–

CHOICE OF THERMOCOUPLE

To find the best thermocouple material for the specific application, consider the temperature, working environment, and physical characteristics of the components involved.

One significant advantage of Type K thermocouples (Thermothal® P/Thermothal® N), constructed from two high-nickel alloys, is their effectiveness in both oxidizing and reducing environments. However, when using Type K in reducing environments, specific precautions must be taken, which are detailed in the following chapter.

Type J thermocouples (made from Iron (JP) and Cuprothal® (JN)) are also suitable for both oxidizing and reducing atmospheres.

Type T thermocouples (copper/Cuprothal® (TN)) are primarily used at room and cryogenic temperatures. For applications requiring a high thermoelectric output, Type E thermocouples (Thermothal® (EP)/Cuprothal® (EN)) are recommended.

MAXIMUM OPERATING TEMPERATURE

Operating thermocouples at maximum temperatures significantly reduces their lifespan, although it's difficult to specify exact durations.

PRINCIPAL FACTORS THAT AFFECT THE LIFE OF A THERMOCOUPLE

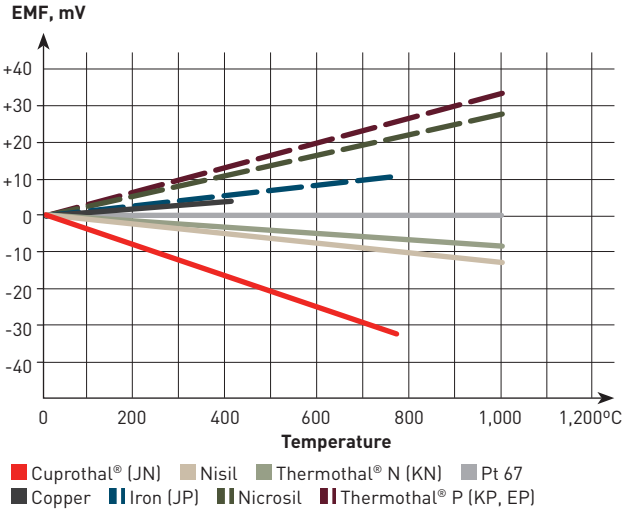
TEMPERATURE:
The lifespan of thermocouples decreases by about 50% with a 50°C (122°F) increase.

THERMAL CYCLING:
When thermocouples are subjected to thermal cycling from room temperature to above 500°C (932°F), their lifespan reduces by about 50% compared to those that operate continuously at a constant temperature.

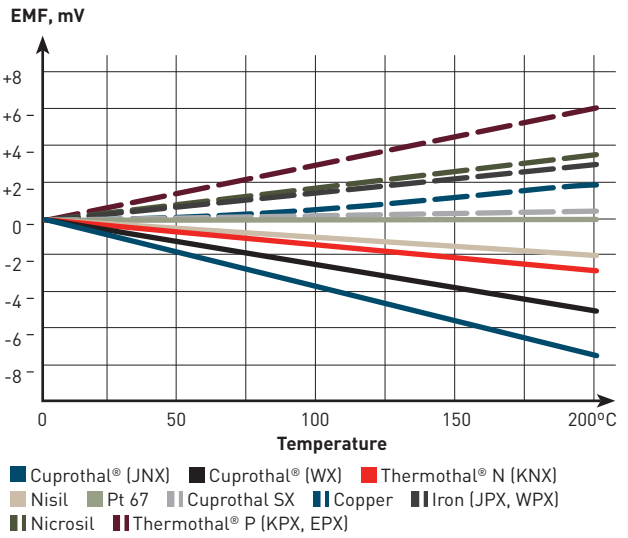
PROTECTION:
Covering thermocouples with a protective sheath and placing them in ceramic insulators significantly extends their lifespan.

The following table provides the recommended maximum temperatures for thermocouples used as bare and protected wires of different diameters, operating in air without thermal cycling.

NOMINAL EMF FOR THERMOCOUPLE ALLOYS VS. PT 67



NOMINAL EMF FOR THERMOCOUPLE EXTENSION AND COMPENSATING CABLES VS. PT 67



MAXIMUM TEMPERATURES RECOMMENDED FOR THERMOCOUPLES USED AS BARE AND PROTECTED WIRES

THERMOCOUPLE	TYPE	3.26 MM	1.63 MM	1.00 MM	0.80 MM	0.50 MM	0.30 MM	0.25 MM
Thermothal® P/ Thermothal® N (type K)	bare wire protected wire	1,050°C 1,150°C	930°C 1,080°C	900°C 1,050°C	860°C 970°C	800°C 910°C	750°C 860°C	710°C 820°C
Thermothal® P (EP)/ Thermothal® (EN) (type E)	bare wire protected wire	860°C 1,000°C	800°C 910°C	750°C 860°C	700°C 810°C	660°C 770°C	620°C 730°C	580°C 690°C
Copper/ Cuprothal® (TN) (type T)	bare wire protected wire	– –	400°C 450°C	360°C 410°C	320°C 370°C	280°C 370°C	250°C 330°C	220°C 270°C
Iron (JP)/ Cuprothal® (JN) (type J)	bare wire protected wire	760°C 760°C	760°C 760°C	720°C 760°C	680°C 760°C	650°C 760°C	600°C 710°C	560°C 670°C
Nicrosil/ Nisil (type N)	bare wire protected wire	1,100°C 1,250°C	1,010°C 1,180°C	960°C 1,110°C	930°C 1,040°C	890°C 1,000°C	840°C 950°C	800°C 910°C

Temperatures are given as a guide to obtain a satisfactory life before burn out of the thermocouple occurs. Checks on stability should be carried out at regular intervals.

PROPERTIES AND GRADES OF THERMOCOUPLE AND COMPENSATING ALLOYS

		THERMOTHAL® P (+)	THERMOTHAL® N (–)	CUPROTHAL® (EN), (JN), TN (–)	CUPROTHAL® WX (–)	CUPROTHAL® SX (–)
Nominal composition, %	Ni	90	95	44	43	3
	Cr	10	–	–	–	–
	Fe	–	–	+	2	–
	Cu	–	–	balance	balance	balance
	Other	+	AlMn- Si+	Mn+	Mn+	2 Mn
Approx. melting point, °C		1,430	1,400	1,210	1,210	1,080
Specific resistance at 20°C, micro-ohm cm		70.6	29.2	49.0	52.0	12.0
Density, g/cm^2		8.72	8.60	8.90	8.90	8.91
Temperature coefficient of resistance, ×10^{-6}/°C		300 20–100	1,900 20–100	60 20–100	100 20–100	1,500 20–100
Linear expansion coefficient, ×10^{-6}/°C		17 20–100	17 20–100	14 20–100	15 20–100	16 20–100
Thermal conductivity at 20°C Wm^{-1} °C^{-1}		19.2	29.7	21.2	21.0	–

(cont.)

(cont.)

		PLATINUM	IRON (+)	NICROSIL (+)	NISIL (–)	COPPER (+)	CUPROTHAL® CL (–)
Nominal composition, %	Ni	–	–	balance	balance	–	45.0
	Cr	–	–	14.2	–	–	–
	Fe	–	100	–	–	–	–
	Cu	–	–	–	–	100	balance
	Other	–	+	Si+	4.3 Si	–	–
Approx. melting point, °C		1,773	1,535	1,420	1,420	1,083	1,210
Specific resistance at 20°C, micro-ohm cm		10.6	13.0	100.0	36.5	1.72	49.0
Density, g/cm^3		21.45	7.86	8.5	8.58	8.92	8.90
Temperature coefficient of resistance, ×10^{-6}/°C		3,000 20–100	5,000 20–100	390 20–100	678 20–100	3,930 20–100	100 20–100
Linear expansion coefficient, ×10^{-6}/°C		89.0 20–100	11.7 20–100	17.0 20–100	17.0 20–100	16.6 20–100	14.0 20–100
Thermal conductivity at 20°C Wm^{-1} °C^{-1}		69.5	66.2	13.0	27.0	388.0	21.2

THERMOCOUPLE TYPES

NICROSIL / NISIL - TYPE N

For many years, Type K base metal thermocouples have been widely used for temperature measurements up to approximately 1,000°C (1,832°F), offering good calibration accuracy, stability, oxidation resistance, and a high thermal EMF at a reasonable price.

The development of Type N (Nicrosil/Nisil) thermocouples has introduced clear advantages for industrial temperature measurement. These include:

- Excellent resistance to EMF drift during long-term exposure to elevated temperatures
- High stability in the 250–550°C (482–1,022°F) range
- A significantly longer service life due to the enhanced oxidation resistance of the Nisil negative leg

Although the thermal EMF output of Nicrosil/Nisil is lower than that of Type K and may require instrumentation adjustments, Type N is widely used in industries such as aerospace, nuclear, and semiconductor, where long-term stability, accuracy, and extended service life are essential. Its consistent performance helps reduce inspection, maintenance, and calibration intervals in thermocouple-operated pyrometric systems.

Extension wires for Nicrosil/Nisil thermocouples are also available. The table below compares the EMF temperature characteristics of Nicrosil/Nisil with those of Pt 67 (as described in NIST Monograph 175), based on the International Temperature Scale of 1990 (ITS-90).

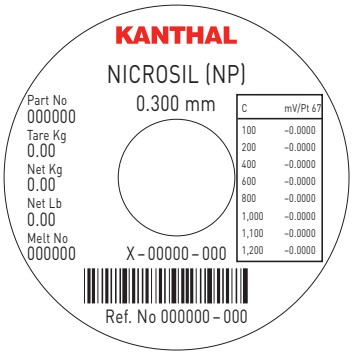
NICROSIL/NISIL EMF REFERENCE TABLE (MV), REFERENCE JUNCTION 0°C

°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.261	0.525	0.793	1.065	1.340	1.619	1.902	2.189	2.479	2.774
100	2.774	3.072	3.374	3.680	3.989	4.302	4.618	4.937	5.260	5.585	5.913
200	5.913	6.245	6.579	6.916	7.255	7.597	7.941	8.288	8.637	8.988	9.341
300	9.341	9.696	10.054	10.413	10.774	11.136	11.501	11.867	12.234	12.603	12.974
400	12.974	13.346	13.719	14.094	14.469	14.846	15.225	15.604	15.984	16.362	16.748
500	16.748	17.131	17.515	17.900	18.286	18.672	19.059	19.447	19.835	20.224	20.613
600	20.613	21.003	21.393	21.784	22.175	22.566	22.958	23.350	23.742	24.134	24.527
700	24.527	24.919	25.312	25.705	26.098	26.491	26.883	27.276	27.669	28.062	28.455
800	28.455	28.847	29.240	29.632	30.024	30.416	30.807	31.199	31.590	31.981	32.371
900	32.371	32.769	33.151	33.541	33.930	34.319	34.707	35.095	35.482	35.869	36.256
1,000	36.256	36.641	37.027	37.411	37.796	38.179	38.562	38.944	39.326	39.706	40.087
1,100	40.087	40.466	40.845	41.223	41.600	41.976	42.352	42.727	43.101	43.474	43.846
1,200	43.846	44.218	44.588	44.958	45.326	45.694	46.060	46.426	46.789	47.152	47.513
1,300	47.513	–	–	–	–	–	–	–	–	–	–

THERMOCOUPLES TYPES

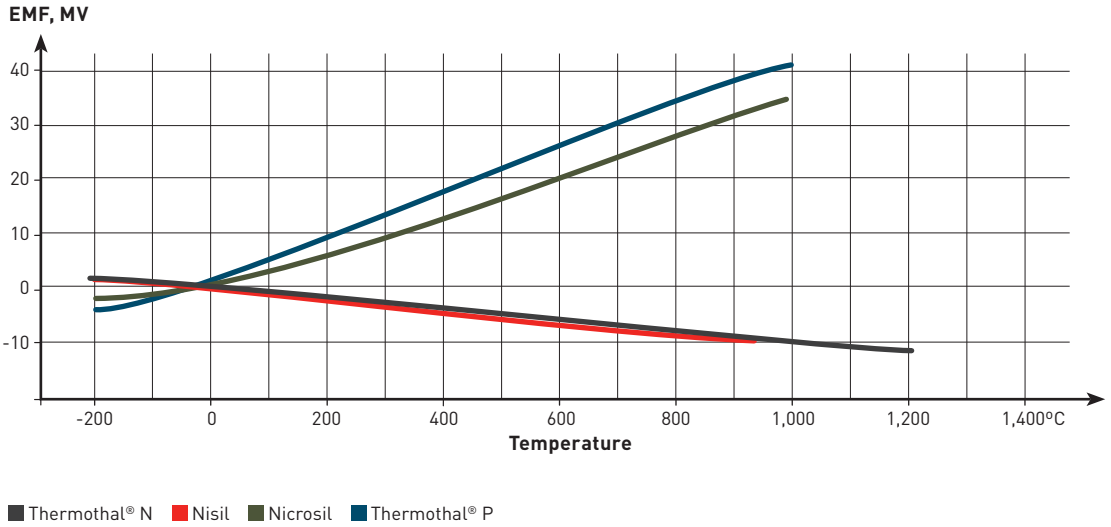
STANDARD EMF AGAINST PT 67, REFERENCE JUNCTION °C

TEMPERATURE °C	EMF, mV	
	NICROSIL LEG (POSITIVE)	NISIL LEG (NEGATIVE)
0	0.000	0.000
100	1.784	0.990
200	3.943	1.970
300	6.348	2.993
400	8.919	4.055
500	11.603	5.145
600	14.370	6.243
700	17.202	7.325
800	20.094	8.360
900	23.045	9.327
1,000	26.046	10.210
1,100	29.083	11.004
1,200	32.144	11.702
1,300	35.221	12.292



Labels used to identify Nicrosil and Nisil.

EMF COMPARISON OF NICROSIL, NISIL, THERMOTHAL® P AND THERMOTHAL® N VS. PT



THERMOTHAL® P / THERMOTHAL® N - TYPE K

Type K thermocouples are most used at temperatures exceeding 500°C (932°F) due to theirsuperior resistance to oxidation compared to other base metal thermocouples.

Thermothal® P and Thermothal® N thermocouples meet all necessary international standards. Each thermocouple element is manufactured to specific tolerances when paired with platinum. When single-leg material is specified, any Thermothal® P coil can be matched with any Thermothal® N coil to form a standard tolerance. Each coil undergoes testing at 200°C (392°F), 400°C (752°F), 600°C (1,112°F), 800°C (1,472°F), and 1,000°C (1,832°F) against Platinum 67, and each one comes with a tag indicating the EMF values compared to Pt 67.

The table on the next page lists the EMF characteristics of KP and KN against Pt 67, as outlined in NIST Monograph 175.

PRECAUTIONS IN THE USE OF TYPE K

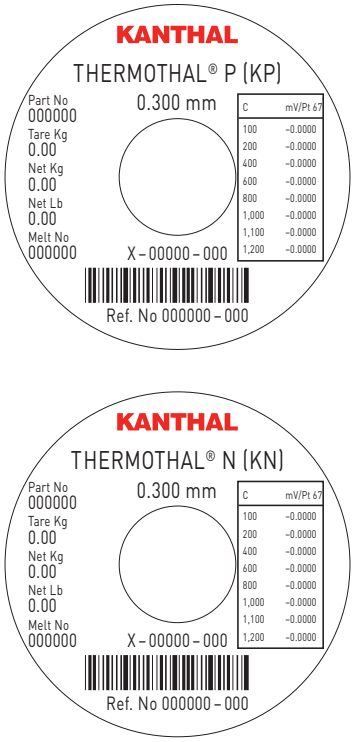
The following precautions should be taken when using type K thermocouples, as outlined in ASTM STP 470A.

Type K thermocouples offer superior resistance to oxidation compared to most other types, except type N. They are recommended for use in oxidizing or inert atmospheres. However, type K thermocouples should not be used directly or without protection in the following conditions:

- In environments with alternating oxidizing and reducing atmospheres.
- In atmospheres containing sulfur gases, which can lead to intergranular corrosion, embrittlement, and cracking of the negative leg (Thermothal® N).
- Any protective sheaths must be thoroughly cleaned to eliminate oils, fats, carbon-containing substances, and dirt.
- In a vacuum for extended periods, as chromium tends to evaporate from the positive leg (Thermothal® P), altering the thermoelectric EMF of the couple.
- In reducing atmospheres, such as hydrogen, dissociated ammonia, or carbon monoxide, which have low oxygen content.

In reducing atmospheres, the positive leg (90% nickel 10% chromium) develops green oxide called "Green rot" (Cr2O3) instead of the nickel-chromium oxide (NiO-Cr2O3). The development of the green oxide decreases the chromium content in Thermothal® P. This decreases its EMF, leading to a reduction in EMF output by up to 55%, especially within the range of 816°C to 1,038°C (1,501–1,900°F). This condition is also associated with the KP arm becoming magnetic due to the loss of chromium.

Using a suitable sheath material prevents corrosive gases from attacking the thermocouple. Sheaths with a small diameter should be avoided.



Labels used to identify Thermothal® P and Thermothal® N.

THERMOCOUPLES TYPES

THERMOTHAL® P (KP)/THERMOTHAL N (KN) EMF REFERENCE TABLE (MV), REFERENCE JUNCTION 0°C

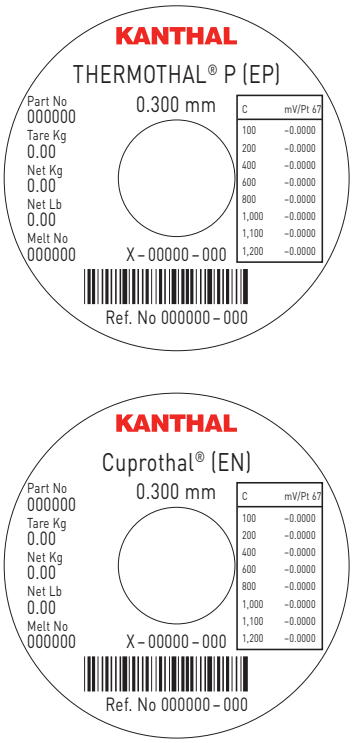
°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.397	0.798	1.203	1.612	2.023	2.437	2.851	3.267	3.682	4.096
100	4.096	4.509	4.920	5.328	5.735	6.138	6.540	6.941	7.340	7.739	8.139
200	8.139	8.539	8.940	9.343	9.747	10.153	10.561	10.971	11.382	11.795	12.209
300	12.209	12.624	13.040	13.457	13.875	14.293	14.713	15.133	15.554	15.975	16.397
400	16.397	16.820	17.243	17.667	18.091	18.516	18.941	19.366	19.792	20.218	20.644
500	20.644	21.071	21.497	21.924	22.350	22.776	23.203	23.629	24.055	24.480	24.906
600	24.906	25.330	25.755	26.179	26.602	27.025	27.447	27.869	28.290	28.710	29.129
700	29.129	29.548	29.965	30.382	30.798	31.214	31.628	32.041	32.453	32.865	33.275
800	33.275	33.685	34.093	34.501	34.908	35.313	35.718	36.121	36.524	36.925	37.326
900	37.326	37.726	38.124	38.522	38.918	39.314	39.708	40.102	40.494	40.885	41.276
1,000	41.276	41.665	42.053	42.440	42.826	43.211	43.595	43.978	44.359	44.740	45.119
1,100	45.119	45.497	45.873	46.249	46.623	46.996	47.367	47.737	48.105	48.473	48.839

STANDARD EMF AGAINST PT 67, REFERENCE JUNCTION °C

	EMF, mV	
TEMPERATURE °C	THERMOTHAL® P (KP) LEG (POSITIVE)	THERMOTHAL® N (KN) LEG (NEGATIVE)
0	0.000	0.000
100	2.814	1.283
200	5.970	2.168
300	9.323	2.886
400	12.764	3.633
500	16.214	4.431
600	19.618	5.287
700	22.951	6.178
800	26.205	7.070
900	29.386	7.940
1,000	32.499	8.777
1,100	35.544	9.575
1,200	38.508	10.330

THERMOTHAL® (EP) / CUPROTHAL® (EN) - TYPE E

Type E has the largest EMF output of any common thermocouple and is sometimes used in thermal generators (thermopiles). It is used up to 900°C (1,652°F) and has good stability from the cryogenic range up to 300°C (572°F). The positive arm of the couple is Thermothal® P, the same as type K thermocouple; the negative arm is Cuprothal® (EN).



Labels used to identify Thermothal® P (EP) and Cuprothal® (EN).

STANDARD EMF AGAINST PT 67, REFERENCE JUNCTION °C

TEMPERATURE °C	EMF, mV	
	THERMOTHAL® P (EP) LEG (POSITIVE),	CUPROTHAL® (EN) LEG (NEGATIVE)
0	0.000	0.000
100	2.814	3.505
200	5.970	7.457
300	9.323	11.713
400	12.764	16.182
500	16.214	20.792
600	19.618	25.475
700	22.951	30.161
800	26.205	34.812
900	29.386	39.401

THERMOTHAL® P (EP)/CUPROTHAL® (EN) EMF REFERENCE TABLE (MV), REFERENCE JUNCTION 0°C

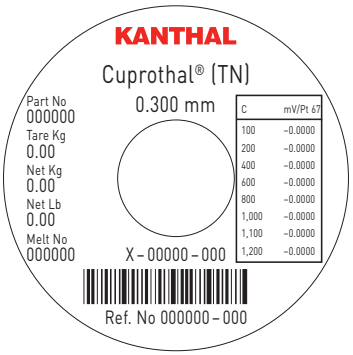
°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.591	1.192	1.801	2.420	3.048	3.685	4.330	4.985	5.648	6.319
100	6.319	6.998	7.685	8.379	9.081	9.789	10.504	11.224	11.951	12.684	13.421
200	13.421	14.164	14.912	15.664	16.420	17.181	17.945	18.713	19.484	20.257	21.036
300	21.036	21.817	22.600	23.386	24.174	24.964	25.757	26.552	27.348	28.146	28.946
400	28.946	29.747	30.550	31.354	32.159	32.965	33.772	34.579	35.388	36.196	37.005
500	37.005	37.815	38.624	39.434	40.244	41.053	41.862	42.671	43.479	44.286	45.093
600	45.093	45.900	46.705	47.510	48.313	49.116	49.917	50.718	51.517	52.315	53.112
700	53.112	53.908	54.703	55.497	56.289	57.080	57.870	58.659	59.446	60.232	61.017
800	61.017	61.801	62.583	63.364	64.144	64.922	65.698	66.473	67.246	68.017	68.787
900	68.787	69.554	70.319	71.083	71.844	72.603	73.360	74.115	74.869	75.621	76.373

COPPER / CUPROTHAL® (TN) - TYPE T

The combination of copper (as the positive element) and Cuprothal® (TN) (as the negative element) forms a thermocouple suitable for both laboratory and industrial settings, across a temperature range of -185°C to +370°C (-301°F to +698°F). It is crucial not to exceed this temperature range because copper has limited resistance to oxidation. Generally, we provide only the negative element (Cuprothal® (TN)), as any high-quality, pure electrolytic copper that conforms to ASTM Standard B3 is consistently uniform and stable in electromotive force (EMF) across different batches, especially at temperatures above -185°C (-301°F).

It's crucial to note that the negative element of the Thermothal® P (EP)-Cuprothal® (EN) and copper-Cuprothal® (TN) does not produce the same EMF output as Iron (JP)-Cuprothal® (JN). Therefore, Cuprothal® (EN) and Cuprothal® (TN) are not interchangeable with Cuprothal® (JN).

The EMF-temperature characteristics of copper/ Cuprothal® (TN) thermocouples are detailed below. If materials are needed for sub-zero temperature applications, it is essential to specify this when placing your order, as a special grade of Cuprothal® must be selected for such conditions.



Label used to identify Cuprothal® (TN).

STANDARD EMF AGAINST PT 67, REFERENCE JUNCTION °C

TEMPERATURE °C	EMF, mV	
	COPPER LEG (POSITIVE),	CUPROTHAL® (TN) LEG (NEGATIVE)
-200	-0.195	-5.408
-100	-0.369	-3.010
0	0	0
100	0.773	3.505
200	1.837	7.451
300	3.149	11.713
400	4.690	16.182

COPPER - CUPROTHAL® (TN) EMF REFERENCE TABLE (MV), REFERENCE JUNCTION 0°C

°C	0	10	20	30	40	50	60	70	80	90	100
-200	-5.603	-5.439	-5.261	-5.070	-4.865	-4.648	-4.419	-4.177	-3.923	-3.657	-3.379
-100	-3.379	-3.089	-2.788	-2.476	-2.153	-1.819	-1.475	-1.121	-0.757	-0.383	0.000
0	0.000	0.391	0.789	1.196	1.612	2.036	2.468	2.909	3.358	3.814	4.279
100	4.279	4.750	5.228	5.714	6.206	6.704	7.209	7.720	8.235	8.760	9.288
200	9.288	9.822	10.362	10.908	11.458	12.013	12.574	13.139	13.709	14.283	14.862
300	14.862	15.445	16.032	16.624	17.219	17.819	18.422	19.030	19.641	20.255	20.872

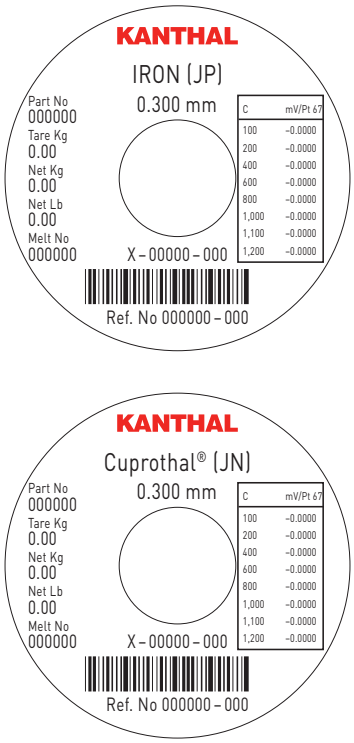
IRON (JP) / CUPROTHAL® (JN) - TYPE J

The Type J thermocouple is popular due to its high electromotive force (EMF) and low cost. It can operate in oxidizing environments up to approximately 760°C (1,400°F) and in reducing environments up to about 900°C (1,652°F). For high-temperature applications, larger wire diameters are recommended. It is important to note that a magnetic transformation occurs in iron at 770°C (1,418°F), and a crystallographic change happens at 900°C (1,652°F). These changes significantly affect the thermoelectric properties of iron.

Type J thermocouples should not be used in sulfurous atmospheres at temperatures above 500°C (932°F), and they are not recommended for use below freezing temperatures due to embrittlement issues.

Only a small part of the global iron wire production is used for thermocouple applications, causing producers to avoid controlling melts for specific EMF values.

Therefore, choosing the right melts of Cuprothal® that, when combined with iron, follow standardization curves and tolerances is essential. Kanthal provides the special iron needed for J thermocouples. It is also important to remember that Cuprothal® (JN) is not interchangeable with Cuprothal® (TN) or Cuprothal® (EN), nor can it be used with other types of iron.



Labels used to identify Iron (JP) and Cuprothal® (JN).

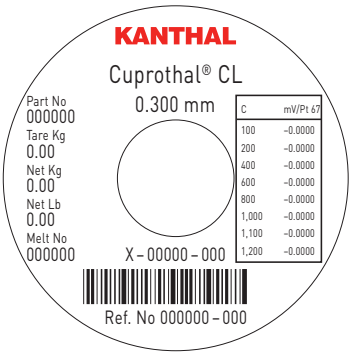
IRON (JP)/ CUPROTHAL® (JN) EMF REFERENCE TABLE (MV), REFERENCE JUNCTION 0°C

°C	0	10	20	30	40	50	60	70	80	90	100
0	0.000	0.507	1.019	1.537	2.059	2.585	3.116	3.650	4.187	4.727	5.269
100	5.269	5.814	6.360	6.909	7.459	8.010	8.562	9.115	9.669	10.224	10.779
200	10.779	11.334	11.889	12.445	13.000	13.555	14.110	14.665	15.219	15.773	16.327
300	16.327	16.881	17.434	17.986	18.539	19.091	19.642	20.194	20.745	21.297	21.848
400	21.848	22.400	22.952	23.504	24.057	24.610	25.164	25.720	26.276	26.834	27.393
500	27.393	27.953	28.516	29.080	29.647	30.216	30.788	31.362	31.939	32.519	33.102
600	33.102	33.689	34.279	34.873	35.470	36.071	36.675	37.284	37.896	38.512	39.132
700	39.132	39.755	40.382	41.012	41.645	42.281	42.919	43.559	44.203	44.848	45.494
800	45.494	46.141	46.786	47.431	48.074	48.715	49.353	49.989	50.622	51.251	51.877

On request, Kanthal can supply Cuprothal® (LN) that, combined with Iron (LP), meets the old German standard DIN 43710 for type L thermocouples.

CUPROTHAL® CL

Cuprothal® CL exhibits a very high EMF value against Pt 67, the highest among the various types of Cuprothal®. This is due to its low content of additional elements in its chemical makeup. In contrast, other Cuprothal® types require some additions to meet the EMF values specified by standards. Due to its high thermoelectric output, Cuprothal® CL is primarily used in the manufacture of thermocouples for detecting flames in gas burners, which are connected to safety devices.



Labels used to identify Cuprothal® CL.

DELIVERY FORMS

The wire is typically supplied in coils in a fully annealed condition, with a tensile strength ranging from 600 to 800 MPa.

CUPROTHAL® CL – EMF MINIMUM VALUES (MV) AGAINST PT 67, REFERENCE JUNCTION AT 0°C

TEMPERATURE °C	EMF MIN., MV
0	0
100	-4.00
200	-8.62
800	-38.68

EMF testing must be carried out on annealed material.

EMF TOLERANCES

STANDARD AND SPECIAL TOLERANCES

Unless otherwise specified, thermocouples, compensating materials, and extension materials are supplied to standard tolerances.

Upon request, materials can be provided with special tolerances. Each spool and coil is calibrated within a temperature range of 0°C (32°F) up to the maximum temperature indicated for each alloy combination (with maximum temperatures of 1,000°C (1,832°F), 1,100°C (2,012°F), and 1,200°C (2,192°F) available upon request).

Standard and special tolerances are detailed in the tables below.

AMERICAN STANDARDS ASTM E 230- ANSI MC 96.1

TYPE OF THERMOCOUPLE	TEMPERATURE RANGE, °C	TOLERANCE	
		STANDARD	SPECIAL
Thermothal® P (KP)/Thermothal® N (KN) (Type K)	from 0 to 1,250	±2.20°C or ±0.75%	–
Thermothal® P (EP)/Cuprothal® (EN) (Type E)	from 0 to 900	±1.70°C or ±0.50%	–
Copper/Cuprothal® (TN) (Type T)	from 0 to 350	±1.00°C or ±0.75%	–
Iron (JP)/Cuprothal® (JN) (Type J)	from 0 to 750	±2.20°C or ±0.75%	–
Nicrosil (NP)/Nisil (NN) (Type N)	from 0 to 1,300	±2.20°C or ±0.75%	–
Thermothal® P (KP)/Thermothal® N (KN) (Type K)	from 0 to 1,250	–	±1.10°C or ±0.40%
Thermothal® P (EP)/Cuprothal® (EN) (Type E)	from 0 to 900	–	±1.00°C or ±0.40%
Copper/Cuprothal® (TN) (Type T)	from 0 to 350	–	±0.50°C or ±0.40%
Iron (JP)/Cuprothal® (JN) (Type J)	from 0 to 750	–	±1.10°C or ±0.40%
Nicrosil (NP)/Nisil (NN) (Type N)	from 0 to 1,300	–	±1.10°C or ±0.40%

Tolerance is whichever is the greater value

EMF TOLERANCES

EUROPEAN STANDARDS IEC 584-2 (DIN EN 60584-2; BS EN 60584-2; JIS C 1602)

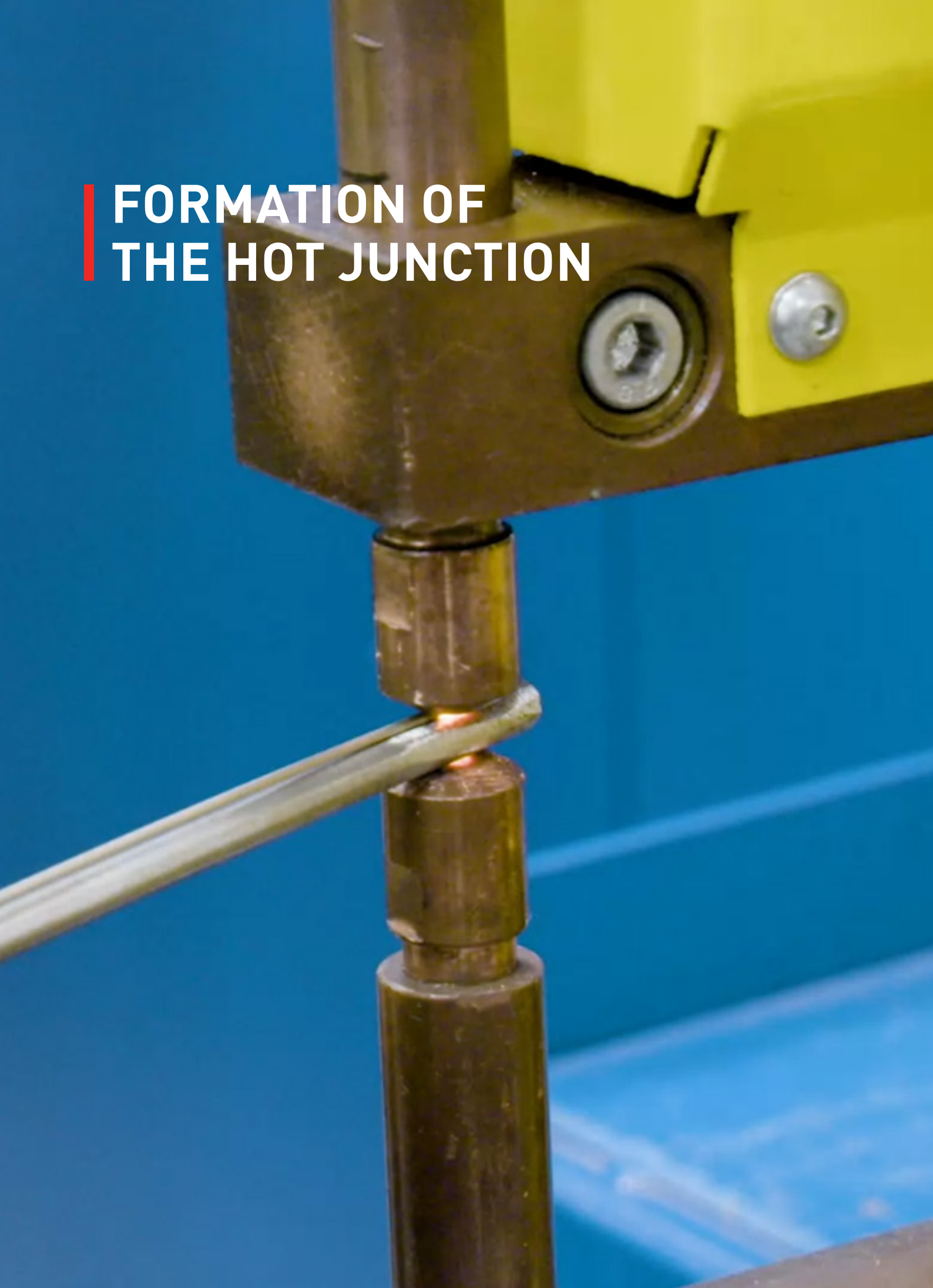
TYPE OF THERMOCOUPLE	TEMPERATURE RANGE °C	TOLERANCE		
		CLASS 1	CLASS 2	CLASS 3
Thermothal® P (KP)/Thermothal® N (KN) (Type K)	from -40 to 1,000	±1.5°C or ±0.40%	–	–
Thermothal® P (EP)/Cuprothal® (EN) (Type E)	from -40 to 800	±1.5°C or ±0.40%	–	–
Copper/Cuprothal® (TN) (Type T)	from -40 to 350	±0.5°C or ±0.40%	–	–
Iron (JP)/Cuprothal® (JN) (Type J)	from -40 to 750	±1.5°C or ±0.40%	–	–
Nicrosil (NP)/Nisil (NN) (Type N)	from -40 to 1,000	±1.5°C or ±0.40%	–	–
Thermothal® P (KP)/Thermothal® N (KN) (Type K)	from -40 to 1,200	–	±2.5°C or ±0.75%	–
Thermothal® P (EP)/Cuprothal® (EN) (Type E)	from -40 to 900	–	±2.5°C or ±0.75%	–
Copper/Cuprothal® (TN) (Type T)	from -40 to 350	–	±1.0°C or ±0.75%	–
Iron (JP)/Cuprothal® (JN) (Type J)	from -40 to 750	–	±2.5°C or ±0.75%	–
Nicrosil (NP)/Nisil (NN) (Type N)	from -40 to 1,200	–	±2.5°C or ±0.75%	–
Thermothal® P (KP)/Thermothal® N (KN) (Type K)	from -40 to +40	–	–	±2.5°C or ±1.5%
Thermothal® P (EP)/Cuprothal® (EN) (Type E)	from -40 to +40	–	–	±2.5°C or ±1.5%
Copper/Cuprothal® (TN) (Type T)	from -40 to +40	–	–	±1.0°C or ±1.5%
Nicrosil (NP)/Nisil (NN) (Type N)	from -200 to +40	–	–	±2.5°C or ±1.5%

Tolerance is whichever is the greater value

NOTE:
Thermocouple materials are typically supplied to meet the specified tolerances for temperatures above 200°C (392°F). They are not tested for compliance with low-temperature class 3 tolerances for types T, E, K, and N.

If thermocouples must meet class 3 requirements in addition to classes 1 or 2, this must be clearly specified at the time of order, as material selection may need adjustment.

FORMATION OF THE HOT JUNCTION



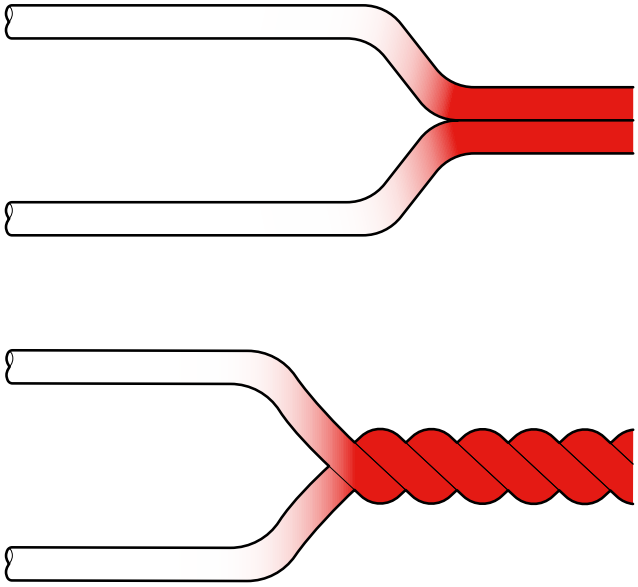
FORMATION OF THE HOT JUNCTION

To create the hot junction, a suitable method must be used to ensure a reliable electrical contact between the thermocouple wires.

At low temperatures, where copper or Cuprothal® (TN) couples are typically used, soft soldering or silver soldering can be employed.

For Thermothal® P/Thermothal® N and other combinations, welding is the only suitable method for making joints in high-temperature measurements.

Oxyacetylene welding is mostly used, but arc welding also produces good results.



OXYACETYLENE AND GAS WELDING

The ends of the wires must be cleaned by filing or grinding and then twisted together with two or three turns, as illustrated below. This process ensures good contact during welding and prevents any tension in the welded joint.

The wires are held vertically in a vice, and the flame is directed downward onto the twisted wires for welding. A good weld is achieved by a small droplet fusing the twisted ends. The gas flame should be adjusted depending on the wire diameter, and it is essential to use a neutral or reducing flame.

During welding, avoid overheating, as it can lead to embrittlement. With practice, satisfactory welding results can be achieved without using flux. However, if you encounter any difficulties, borax can be utilized as an alternative. Ensure that all borax is thoroughly removed from the metal after the weld has cooled down.

Rewelding is challenging; if the initial weld is inadequate, it is usually necessary to cut the wires and start a new weld.

ARC WELDING

The wires are cleaned and twisted, like the process used in gas welding. They are then secured in a vice connected to the positive terminal of a direct current (DC) power supply. A carbon electrode, acting as the negative terminal, is lightly touched to the twisted wires to create an arc that welds the ends of the wires. The required voltage varies based on the diameter; for a 3.2 mm wire, approximately 40 volts is needed.

No flux is needed in this type of welding. When the carbon electrode is replaced with a tungsten electrode, the process is known as TIG (Tungsten Inert Gas) welding, which is also commonly used for welding thermocouple materials. In this case, an inert gas is blown onto the welding joint to protect it from air contamination fully.

DISCHARGE CAPACITY WELDING

This welding method is used for small-diameter wires (up to 0.8 mm).

The ends of the thermoelement must be cleaned with emery paper, and the wires should be held in contact as shown in the picture below.

COMPENSATING AND EXTENSION GRADE ALLOYS

COMPENSATING AND EXTENSION GRADE ALLOYS

When connecting thermocouples to instruments, it's crucial to use a cable that has the same EMF output as the thermocouple. Using a mismatched cable can generate unwanted EMF at the junctions. The optimal solution is to use an extension cable made from the same material as the thermocouple. The tolerances for these cables are provided in the following tables.

In some instances, a more cost-effective alternative is to use compensating cables, which are made from different alloys than the thermocouple but are designed to have a similar output over a limited temperature range.

For example, copper/Cuprothal® (VNX) type KCB (VX) cable is compatible with Thermothal® P/Thermothal® N (type K) thermocouples.

Our Cuprothal SX alloy (RCA-SCA, RCB-SCB, SNX-RNX) is specifically used with copper to compensate for Pt/PtRh thermocouples (type S and R).

Both compensating and extension grades of wire are supplied in a bright annealed condition.

Below is a list of the principal Kanthal® compensating and extension cables.

AMERICAN STANDARD ANSI MC 96-1

TYPE OF THERMOCOUPLE	COMPENSATING OR EXTENSION CABLES	NOMINAL COMPOSITION OF THE CABLES	AMERICAN STANDARD ANSI MC 96-1			
			MV	AT TEMP °C.	TOLERANCE	
					STANDARD	SPECIAL
Thermothal® P (KP)/ Thermothal® N (KN) (Type K)	Thermothal® P (KPX)/ Thermothal® N (KNX) (KX)	Thermothal® P (KPX): 90% Ni - 10% Cr Thermothal® N (KNX): 95% Ni + Al-Mn-Si	4.096 8.139	100 200	±2.2°C from 0°C to 200°C	– –
Thermothal® P (KP)/ Thermothal® N (KN) (Type K)	Copper/ Cuprothal® (VNX) (VX)*	Copper: 100% Cu Cuprothal® (VNX): 44% Ni-balance Cu	4.096 –	100 –	±2.2° from 0°C to 100°C	– –
Thermothal® P (EP)/ Cuprothal® (EN) (Type E)	Thermothal® P (EPX)/ Cuprothal® (ENX) (EX)	Thermothal® P (EPX): 90% Ni-10% Cr Thermothal® N (KNX): 95% Ni M+Al-Mn-Si balance Cu	6.319 13.421	100 200	±1.7°C from 0°C to 200°C	– –
Copper/Cuprothal® (TN) (Type T)	Copper/Cuprothal® (TNX) (TX)	Copper: 100% Cu Cuprothal® (TNX): 44% Ni-balance Cu	4.279 –	100 –	±1°C from 0°C to 100°C	±0.5°C from 0°C to 100°C
Iron (JP)/Cuprothal® (JN) (Type J)	Iron (JPX)/ Cuprothal® (JNX) (JX)	Iron (JPX): 100% Fe Cuprothal® (JNX): 44% Ni-balance Cu	5.269 10.779	100 200	±2.2°C from 0°C to 200°C	±1.1°C from 0°C to 200°C
Pt/Pt 10% Rh Pt/Pt 13% Rh (Type S, R)	Copper/Cuprothal® SX (SX) (RX)	Copper: 100% Cu Cuprothal® SX: 3% Ni-Mn-balance Cu	0.646 1.441	100 200	±0.057 mV from 0°C to 200°C	– –
Nicrosil (NP)/Nisil (NN) (Type N)	Nicrosil (NPX)/ Nisil (NNX) (NX)	Nicrosil (NPX): 84% Ni - 14.2% Cr - Si Nisil (NNX): 95% Ni - 4.3% Si	2.774 5.913	100 200	±2.2°C from 0°C to 200°C	– –

*Type VX is not included in the recent American standard but it is still used

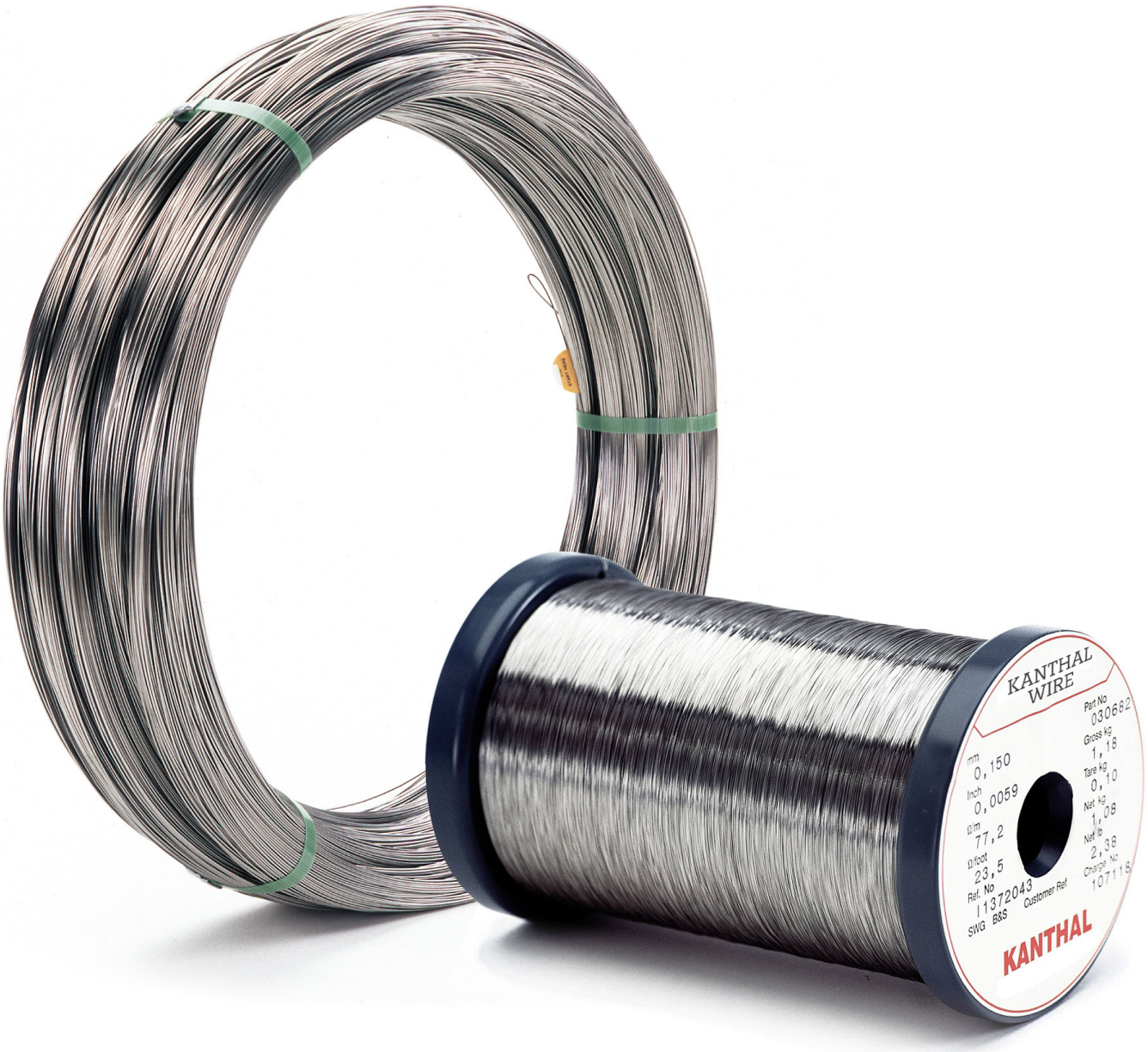
EUROPEAN STANDARD IEC 584-3 (DIN EN 60584-3; BS 4937; NFC 42324)

TYPE OF THERMOCOUPLE	COMPENSATING OR EXTENSION CABLES	NOMINAL COMPOSITION OF THE CABLES	EUROPEAN STANDARD IEC 584-3			
			MV	AT TEMP °C.	TOLERANCE	
					STANDARD	SPECIAL
Thermothal® P (KP)/ Thermothal® N (KN) (Type K)	Thermothal® P (KPX)/ Thermothal® N (KNX) (KX)	Thermothal® P (KPX): 90% Ni - 10% Cr Thermothal® N (KNX): 95% Ni + Al-Mn-Si	4.096 8.139	100 200	±2.5°C from -25°C to 200°C	±1.5°C from -25°C to 200°C
Thermothal® P (KP)/ Thermothal® N (KN) (Type K)	Iron (WPX)/ Cuprothal® (WX) (WNX) (KCA)	Iron (WPX): 100% Fe Cuprothal® WX (WNX): 43% Ni - 2% Mn 2% Fe - balance Cu	4.096 8.139	100 200	±2.5°C from 0°C to 150°C	
Thermothal® P (KP)/ Thermothal® N (KN) (Type K)	Copper/ Cuprothal® (VNX) (KCB)	Copper: 100% Cu Cuprothal® (VNX): 44% Ni-balance Cu	4.096 –	100	±2.2°C from 0°C to 100°C	
Thermothal® P (EP)/ Cuprothal® (EN) (Type E)	Thermothal® P (EPX)/ Cuprothal® (ENX) (EX)	Thermothal® P (EPX): 90% Ni-10% Cr Cuprothal® (ENX): 44% Ni-balance Cu	6.319 13.421	100 200	±2.5°C from -25°C to 200°C	±1.5°C from -25°C to 200°C
Copper/ Cuprothal® (TN) (Type T)	Copper/ Cuprothal® (TNX) (TX)	Copper: 100% Cu Cuprothal® (TNX): 44% Ni-balance Cu	4.279 –	100	±1°C from -25°C to 100°C	±0.5°C from -25°C to 100°C
Iron (JP)/ Cuprothal® (JN) (Type J)	Iron (JPX)/ Cuprothal® (JNX) (JX)	Iron (JPX): 100% Fe Cuprothal® (JNX): 44% Ni-balance Cu	5.269 10.779	100 200	±2.5°C from -25°C to 200°C	±1.5°C from -25°C to 200°C
Pt/Pt 10% Rh Pt/Pt 13% Rh (Type S, R)	Copper/ Cuprothal®SX RCA-SCA RCB-SCB	Copper: 100% Cu Cuprothal® SX: 3% Ni-Mn-balance Cu	– – 0.646 – – 0.646 1.441	– – 100 – – 100 200	±2.5°C from 0°C to 100°C ±5°C from 0°C to 200°C	
Nicrosil (NP)/ Nisil (NN) (Type N)	Nicrosil (NPX)/ Nisil (NNX) (NX)	Nicrosil (NPX): 84% Ni - 14.2% Cr - Si Nisil (NNX): 95% Ni - 4.3% Si	2.774 5.913	100 200	±2.5°C from -25°C to 200°C	±1.5°C from -25°C to 200°C

JAPANESE STANDARD JIS C 1610

			JAPANESE STANDARD JIS C 1610			
					TOLERANCE	
TYPE OF THERMOCOUPLE	COMPENSATING OR EXTENSION CABLES	NOMINAL COMPOSITION OF THE CABLES	MV	AT TEMP °C.	STANDARD	SPECIAL
Thermothal® P (KP)/ Thermothal® N (KN) (Type K)	Thermothal® P (KPX)/ Thermothal® N (KNX) (KX)	Thermothal® P (KPX): 90% Ni - 10% Cr Thermothal® N (KNX): 95% Ni + Al-Mn-Si	4.096 8.139	100 200	± 100 mV from -25°C to 200°C	± 60 mV from -25°C to 200°C
Thermothal® P (KP)/ Thermothal® N (KN) (Type K)	Iron (WPX)/ Cuprothal® (WX) (WNX) (KCA)	Iron (WPX): 100% Fe Cuprothal® WX (WNX): 43% Ni - 2% Mn 2% Fe - balance Cu	4.096 8.139	100 200	± 100 mV from 0°C to 150°C	
Thermothal® P (KP)/ Thermothal® N (KN) (Type K)	Copper/ Cuprothal® (VNX) (KCB)	Copper: 100% Cu Cuprothal® (VNX): 44% Ni-balance Cu	4.096 –	100	± 100 mV from 0°C to 100°C	
Thermothal® P (EP)/ Cuprothal® (EN) (Type E)	Thermothal® P (EPX)/ Cuprothal® (ENX) (EX)	Thermothal® P (EPX): 90% Ni-10% Cr Cuprothal® (ENX): 44% Ni-balance Cu	6.319 13.421	100 200	±200 mV from -25°C to 200°C	± 120 mV from -25°C to 200°C
Copper/ Cuprothal® (TN) (Type T)	Copper/ Cuprothal® (TNX) (TX)	Copper: 100% Cu Cuprothal® (TNX): 44% Ni-balance Cu	4.279 –	100	± 160 mV from -25°C to 100°C	±30 mV from -25°C to 100°C
Iron (JP)/ Cuprothal® (JN) (Type J)	Iron (JPX)/ Cuprothal® (JNX) (JX)	Iron (JPX): 100% Fe Cuprothal® (JNX): 44% Ni-balance Cu	5.269 10.779	100 200	± 140 mV from -25°C to 200°C	± 185 mV from -25°C to 200°C
Pt/Pt 10% Rh Pt/Pt 13% Rh (Type S, R)	Copper/ Cuprothal® SX RCA-SCA RCB-SCB	Copper: 100% Cu Cuprothal® SX: 3% Ni-Mn-balance Cu	– – 0.646 – – 0.646 1.441	– – 100 – – 100 200	±30 mV from 0°C to 100°C ± 60 mV from 0°C to 200°C	
Nicrosil (NP)/ Nisil (NN) (Type N)	Nicrosil (NPX)/ Nisil (NNX) (NX)	Nicrosil (NPX): 84% Ni - 14.2% Cr - Si Nisil (NNX): 95% Ni - 4.3% Si	2.774 5.913	100 200	± 200 mV from -25°C to 200°C	± 60 mV from -25°C to 200°C

DELIVERY FORMS



PACKAGING

Kanthal® branded materials are generally packaged as shown in the image. If necessary, the wire can also be custom-packed to meet individual specifications. For added protection, spools are wrapped in plastic film.

WIRE

Wire available on spools has a diameter of up to approximately 1.50 mm, as shown in the table.

For wires with a diameter of 1.50 mm and above, they are supplied in coils with an inner diameter of approximately 500 to 600 mm.

Wires ranging from 2 mm to 6 mm can be straightened in a semi-hard condition and supplied in 3 m lengths upon request. Wires larger than 6 mm and up to 10 mm are available only in oxidized or straightened form. Straight lengths are bundled together for supply. For any specific needs, contact Kanthal.

RIBBON

Ribbon is typically supplied on DIN 125 spools, with most ribbon delivered on 10 lb plastic spools. Ribbon sections with sizes of 0.3 mm² or larger are wound on DIN 100 spools. Upon request, the smallest ribbon sizes can be supplied on DIN 80 spools. Ribbon can also be supplied on DIN 100, 125, 355, 200, 80, and 160 spools.

All wire sizes and alloys can be supplied in oxidized form. Wire with diameters ⩾ 5 mm and up to 10.50 mm is available only in oxidized form.

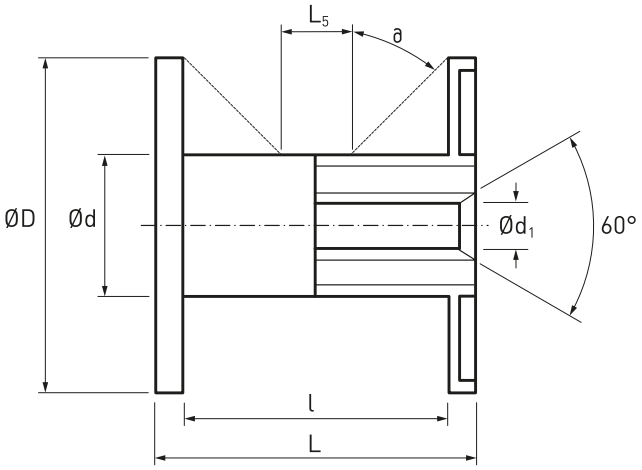
Straight and cut wire is available for diameters from 2.9 mm (0.114 in) to 4.775 mm (0.188 in), with cut lengths ranging from 12 into 144 in.

STRIP

Standard delivery is in coil form.

ROD

Available shaved or unshaved, depending on the alloy. For any specific needs, contact Kanthal.



Spool dimensions.

DIMENSIONS FOR DIFFERENT TYPE OF SPOOLS

SPOOL	TARE	SPOOL MEASUREMENTS MM (IN)					WIRE DIAMETER	CAPACITY APPROX.
NO.	G (LB)	D	D	D1	L	L	MM (IN)	KG (LB)
DIN 200	600 (1.32)	200 (7.87)	125 (4.92)	36 (1.42)	200 (7.87)	160 (6.30)	0.16–1.20 (0.006–0.047)	10 (22.00)
DIN 250	1,060 (2.31)	250 (9.84)	160 (6.30)	36 (1.42)	200 (7.87)	160 (6.30)	0.30–1.63 (0.012–0.064)	20 (44.10)
DIN 355	1,850 (4.08)	355 (13.98)	224 (8.82)	36 (1.42)	200 (7.87)	160 (6.30)	0.50–1.63 (0.022–0.064)	40 (88.20)

APPLICATION-DRIVEN THERMOCOUPLE SELECTION GUIDANCE

WIRE GEOMETRY AND CONSTRUCTION

Thermocouple performance is primarily governed by alloy composition and calibration; however, wire geometry and construction play an important role in mechanical durability, installation, and response time. The following guidance is intended to assist with selecting the appropriate construction for specific applications.

Round (Solid) Wire

Round solid wire is commonly used for general-purpose and static installations. It provides stable EMF performance and is suitable for applications with minimal vibration or mechanical movement.

Stranded Thermocouple Cable

Stranded construction offers improved flexibility and resistance to vibration and repeated bending. It is recommended for applications involving mechanical movement, thermal cycling, or vibration, such as moving assemblies or dynamic installations.

Flat / Strip Thermocouple

Flat or strip thermocouples provide improved surface contact and faster thermal response. These constructions are typically used for surface temperature measurement on heaters, platens, and tooling. Care should be taken to avoid excessive bending or mechanical stress.

Application Considerations

- Static installations → Solid round wire
- Vibration or movement → Stranded construction
- Surface temperature measurement or fast response → Flat/strip geometry

Wire geometry does not change nominal thermocouple EMF characteristics but may influence mechanical life, response time, and long-term stability depending on the application environment.

TOLERANCES


Toleransnivå:
Sök
Rensa
Skicka till M3
Data skickat till M3
Varde

Unless stated otherwise, all wire, strip, and ribbon are supplied fully annealed in a bright, matte, or oxidized finish. Please specify the desired type of finish when placing your order.

The standard tolerances for wire, straight lengths, and strip are provided below.

TOLERANCES ON DIMENSIONS OF COLD ROLLD RIBBON

Ribbon is normally specified with a resistance tolerance.

Upon request, a tolerance for width dimensions can be applied as shown in the table below.

TOLERANCES ON NOMINAL LENGTH FOR CUT AND STRAIGHTENED LENGTHS (RODS)

All diameters and lengths have a tolerance of -0% to +1% on the nominal length.

TOLERANCES ON DIAMETER OF WIRE

WIRE SIZE	MAX DEVIATION FROM NOMINAL VALUE, MM	MAX OVALITY MM
d	Tol = ±0.015·√d —	Tol = ±0.015·√d —

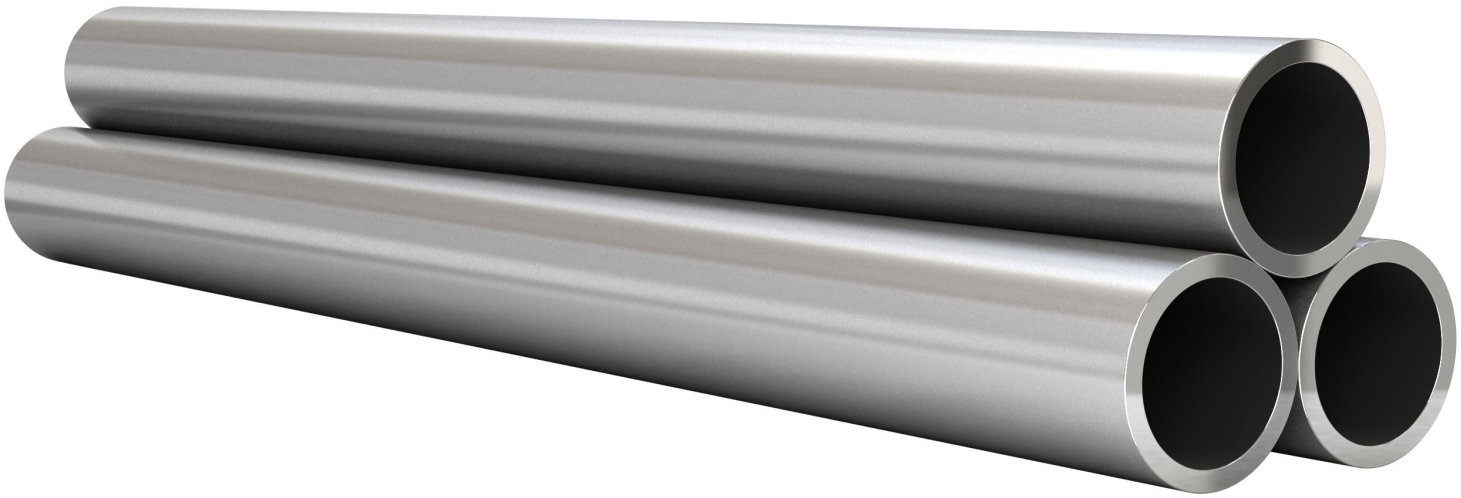
TOLERANCES ON DIAMETER OF STRAIGHT LENGTHS

DIAMETER, MM	TOLERANCE, MM
1.70 to 3.00	+0/- 0.060
3.01 to 6.00	+0/- 0.075
6.01 to 10.00	+0/- 0.090

TOLERANCES ON DIMENSIONS OF COLD ROLLED RIBBON

WIDTH, MM	THICKNESS, MM		
	0.07 – 0.20	0.20 – 0.50	0.50 – 0.80
0.5 – 1.5	+0.02 – 0.04	+0.01 – 0.03	–
1.5 – 2.5	+0.04 – 0.07	+0.03 – 0.04	+0.02 – 0.04
2.5 – 4.0	–	±0.08	+0.12

KANTHAL®
PROTECTION TUBES



METALLIC PROTECTION TUBES UP TO 1,400°C (2,552°F)

Kanthal® offers metallic protection tubes manufactured from high temperature resistant alloys such as Kanthal® AF/A1/D, Kanthal® APM/APMT, and Alkrothal®, with a maximum operating temperature in air of 1,400°C (2,552°F).

Kanthal® APM and Kanthal® APMT tubes are available in seamless/extruded form, while other tubes are available in seam-welded form. The seam-welded tubes are manufactured from Kanthal® strip material and feature a longitudinal weld seam. Small dimensions are typically used for protective tubes, ranging from Ø6 mm to Ø337 mm. Additional sizes are available upon request.

Kanthal® metallic tubes are supplied closed at one end and threaded at the other for the connection head. They can also be supplied in standard lengths with both ends open.

The advantages of using Kanthal® protection tubes for thermocouples include:

- They withstand temperatures up to 1,400°C (2,552°F), exceeding the limits of other metallic protection tubes by 150 to 200°C (302 to 392°F).
- They exhibit high resistance to damage from sulfur and carbon compounds.
- Their high-temperature resistance enables the production of tubes with thinner walls, increasing their service life. Thinner walls facilitate faster heat transmission, resulting in greater sensitivity to temperature variations.
- The aluminum oxide layer on the protection tube has a minimal tendency to flake off, thereby preventing contamination.

METALLIC PROTECTION TUBES

		OD		WALL THICKNESS		MAX. LENGTH	
ALLOY	PRODUCT FORM	MM	IN	MM	IN	MM	IN
Kanthal® D	Seam-welded tube	6.00	0.25	0.40	0.015	13,000	42.6
Kanthal® AF	Seam-welded tube	6.50	0.26	0.80	0.03	13,000	42.6
Kanthal® AF	Seam-welded tube	15.00	0.59	1.30	0.05	13,000	42.6
Kanthal® AF	Seam-welded tube	19.00	0.80	1.30	0.05	13,000	42.6
Kanthal® AF	Seam-welded tube	22.00	0.90	1.30	0.05	13,000	42.6
Kanthal® AF	Seam-welded tube	22.00	0.90	2.00	0.80	13,000	42.6
Kanthal® A-1	Seam-welded tube	15.00	0.59	1.00	0.04	13,000	42.6
Kanthal® APM	Seamless tube	26.67	1.05	2.87	0.11	13,000	42.6
Kanthal® APM	Seamless tube	33.40	1.31	3.38	0.13	13,000	42.6
Kanthal® APM	Seamless tube	40.00	1.57	3.00	0.12	13,000	42.6
Kanthal® APMT	Seamless tube	26.67	1.05	2.87	0.11	13,000	42.6
Kanthal® APMT	Seamless tube	33.40	1.31	3.38	0.13	13,000	42.6
Kanthal® APMT	Seamless tube	33.70	1.33	6.00	0.24	13,000	42.6
Alkrothal®	Seam-welded tube	35.00	1.38	1.50	0.06	13,000	42.6

Additional sizes are available upon request.

KANTHAL® SUPER PROTECTION TUBES UP TO 1,700°C (3,092°F)

These tubes are made of molybdenum disilicide, like our Kanthal® Super heating elements.

Kanthal® Super protection tubes have the following advantages:

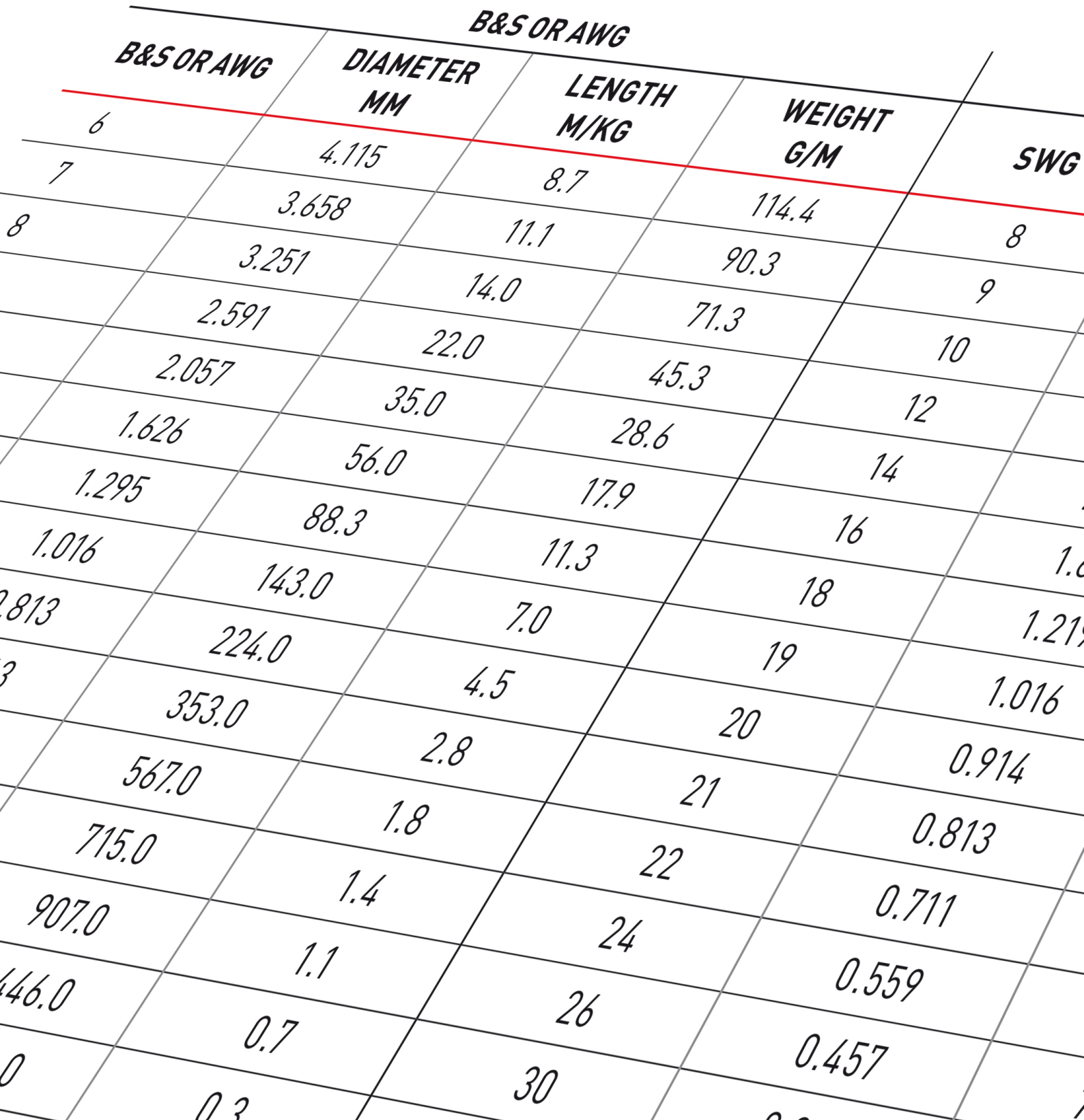
- The maximum operating temperature is 1,700°C (3,092°F).
- These protection tubes exhibit lower porosity and brittleness compared to ceramic alternatives, making them particularly suitable for high-temperature applications and corrosive furnace atmospheres.
- Under certain conditions, metallic protection tubes may be affected by electromagnetic oscillations, which can disrupt the functioning of the thermo-couple. However, Kanthal® Super protection tubes are designed to suppress these oscillations.

Kanthal® Super tubes can be supplied with one end closed and provided with a threaded tube fitting.

KANTHAL SUPER PROTECTION TUBES

OD	WALL THICKNESS	MAXIMUM LENGHT
MM	MM	MM
10	2.0	1,500
12	4.5	1,500
12	3.0	1,500
18	4.0	1,500
22	4.5	1,500

TABLES


B&S OR AWG
B&S OR AWG
DIAMETER MM
LENGTH M/KG
WEIGHT G/M
SWG
6
4.115
8.7
7
3.658
11.1
114.4
8
8
3.251
14.0
90.3
9
2.591
22.0
71.3
10
2.057
35.0
45.3
12
1.626
56.0
28.6
14
1.295
88.3
17.9
16
1.016
143.0
11.3
18
224.0
7.0
19
353.0
4.5
20
567.0
2.8
21
715.0
1.8
22
907.0
1.4
24
1.1
26
0.7
30

THERMOTHAL® P

B&S OR AWG

B&S OR AWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
6	4.115	8.6	116.0
7	3.658	10.9	91.6
8	3.251	13.8	72.4
10	2.591	21.8	46.0
12	2.057	34.5	29.0
14	1.626	55.2	18.1
16	1.295	87.1	11.5
18	1.016	141.0	7.1
20	0.813	221.0	4.5
22	0.643	353.0	2.8
24	0.511	559.0	1.8
25	0.455	705.0	1.4
26	0.404	895.0	1.1
28	0.320	1,426.0	0.7
32	0.203	3,543.0	0.3
36	0.127	9,053.0	0.1

SWG

SWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
8	4.064	8.8	113.1
9	3.658	10.9	91.6
10	3.251	13.8	72.4
12	2.642	20.9	47.8
14	2.032	35.4	28.3
16	1.626	55.2	18.1
18	1.219	98.3	10.2
19	1.016	141.0	7.1
20	0.914	175.0	5.7
21	0.813	221.0	4.5
22	0.711	289.0	3.5
24	0.559	467.0	2.1
26	0.457	699.0	1.4
30	0.315	1,472.0	0.7
34	0.234	2,667.0	0.4
36	0.193	3,920.0	0.3

METRIC

DIAMETER MM	LENGTH M/KG	WEIGHT G/M
10.00	1.5	684.90
8.00	2.3	438.30
7.00	3.0	335.60
6.00	4.1	246.60
4.70	6.6	151.30
4.00	9.1	109.60
3.90	9.6	104.20
3.26	13.7	72.80
3.20	14.3	70.10
3.00	16.2	61.60
2.50	23.4	42.80
2.30	27.6	36.20
2.05	34.7	28.80
2.00	36.5	27.40
1.63	55.0	18.20
1.50	64.9	15.40
1.40	74.5	13.41
1.29	87.7	11.41
1.20	101.0	9.86
1.15	110.0	9.06
1.13	114.0	8.75
1.00	146.0	6.85
0.81	223.0	4.49
0.64	356.0	2.81
0.63	368.0	2.72
0.60	406.0	2.47
0.51	561.0	1.78
0.50	584.0	1.71
0.45	721.0	1.39
0.40	913.0	1.10
0.32	1,426.0	0.70
0.30	1,622.0	0.62
0.25	2,336.0	0.43
0.20	3,650.0	0.27
0.18	4,507.0	0.22
0.10	14,601.0	0.07

THERMOTHAL® N

B&S OR AWG			
B&S OR AWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
6	4.115	8.7	114.4
7	3.658	11.1	90.3
8	3.251	14.0	71.3
10	2.591	22.0	45.3
12	2.057	35.0	28.6
14	1.626	56.0	17.9
16	1.295	88.3	11.3
18	1.016	143.0	7.0
20	0.813	224.0	4.5
22	0.643	353.0	2.8
24	0.511	567.0	1.8
25	0.455	715.0	1.4
26	0.404	907.0	1.1
28	0.320	1,446.0	0.7
32	0.203	3,593.0	0.3
36	0.127	9,179.0	0.1

SWG			
SWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
8	4.064	9.0	111.6
9	3.658	11.1	90.4
10	3.251	14.0	71.4
12	2.642	21.2	47.2
14	2.032	35.9	27.9
16	1.626	56.0	17.9
18	1.219	99.6	10.0
19	1.016	143.0	7.0
20	0.914	177.0	5.6
21	0.813	224.0	4.5
22	0.711	293.0	3.4
24	0.559	474.0	2.1
26	0.457	709.0	1.4
30	0.315	1,492.0	0.7
34	0.234	2,704.0	0.4
36	0.193	3,975.0	0.3

METRIC		
DIAMETER MM	LENGTH M/KG	WEIGHT G/M
10.00	1.5	675.40
8.00	2.3	432.30
7.00	3.0	331.00
6.00	4.1	243.20
4.70	6.7	149.20
4.00	9.3	108.10
3.90	9.7	102.70
3.26	13.9	71.78
3.20	10.1	69.17
3.00	16.5	60.79
2.50	23.7	42.22
2.30	28.0	35.73
2.05	35.2	28.39
2.00	37.0	27.02
1.63	55.7	17.95
1.50	65.8	15.20
1.40	75.5	13.24
1.29	89.0	11.24
1.20	101.0	9.86
1.15	110.0	9.06
1.13	114.0	8.75
1.00	146.0	6.85
0.81	223.0	4.49
0.64	356.0	2.81
0.63	368.0	2.72
0.60	406.0	2.47
0.51	561.0	1.78
0.50	584.0	1.71
0.45	721.0	1.39
0.40	913.0	1.10
0.32	1,426.0	0.70
0.30	1,622.0	0.62
0.25	2,336.0	0.43
0.20	3,650.0	0.27
0.18	4,507.0	0.22
0.10	14,805.0	0.07

CUPROTHAL® (EN), CUPROTHAL® (JN), CUPROTHAL (TN), CUPROTHAL® WX

B&S OR AWG

B&S OR AWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
6	4.115	8.4	118.4
7	3.658	10.7	93.9
8	3.251	13.5	73.9
10	2.591	21.3	46.0
12	2.057	33.8	29.6
14	1.626	54.1	18.5
16	1.295	85.3	11.7
18	1.016	139.0	7.2
20	0.813	216.0	4.8
22	0.643	346.0	2.9
24	0.511	548.0	1.8
25	0.455	691.0	1.5
26	0.404	877.0	1.1
28	0.320	1,397.0	0.7
32	0.203	3,472.0	0.3
36	0.127	8,870.0	0.1

SWG

SWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
8	4.064	8.7	115.4
9	3.658	10.7	93.5
10	3.251	13.5	73,9
12	2.642	20.5	48.8
14	2.032	34.7	28.9
16	1.626	54.1	18.5
18	1.219	96.3	10.4
19	1.016	138.6	7.2
20	0.914	171.2	5.8
21	0.813	216.0	4.6
22	0.711	283.0	3.5
24	0.559	457.8	2.2
26	0.457	685.0	1.5
30	0.315	1.4	0.7
34	0.234	2.6	0.4
36	0.193	3.8	0.3

METRIC

DIAMETER MM	LENGTH M/KG	WEIGHT G/M
10.00	1.4	699.00
8.00	2.2	447.40
7.00	2.9	342.50
6.00	4.0	251.60
4.70	6.5	154.40
4.00	8.9	111.80
3.90	9.4	106.30
3.26	13.5	74.29
3.20	14.0	71.58
3.00	15.9	62.91
2.50	22.9	43.69
2.30	27.0	36.98
2.05	34.0	29.38
2.00	35.8	27.96
1.63	53.8	18.57
1.50	63.6	15.73
1.40	73.0	13.70
1.29	86.0	11.63
1.20	99.0	9.86
1.15	108.0	9.06
1.13	112.0	8.75
1.00	143.0	6.85
0.81	218.0	4.49
0.64	349.0	2.81
0.63	360.0	2.72
0.60	397.0	2.47
0.51	550.0	1.78
0.50	572.0	1.71
0.45	707.0	1.39
0.40	894.0	1.10
0.32	1,397.0	0.70
0.30	1,590.0	0.62
0.25	2,289.0	0.43
0.20	3,577.0	0.27
0.18	4,415.0	0.22
0.10	4,306.0	0.07

IRON

B&S OR AWG

B&S OR AWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
6	4.115	9.6	104.5
7	3.658	12.1	82.6
8	3.251	15.3	65.2
10	2.591	24.1	41.4
12	2.057	38.3	26.1
14	1.626	61.3	16.3
16	1.295	96.6	10.4
18	1.016	157.0	6.4
20	0.813	245.0	4.1
22	0.643	392.0	2.6
24	0.511	620.0	1.6
25	0.455	783.0	1.3
26	0.404	992.0	1.0
28	0.320	1,582.0	0.6
32	0.203	3,931.0	0.3
36	0.127	10,043.0	0.1

SWG

SWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
8	4.064	9.8	102.0
9	3.658	12.1	82.60
10	3.251	15.3	65.2
12	2.642	23.2	43.1
14	2.032	39.2	25.5
16	1.626	61.3	16.3
18	1.219	109.0	9.2
19	1.016	157.0	6.4
20	0.914	194.0	5.3
21	0.813	245.0	4.2
22	0.711	320.0	3.1
24	0.559	518.0	1.9
26	0.457	776.0	1.3
30	0.315	1,633.0	0.6
34	0.234	2,958.0	0.3
36	0.193	4,349.0	0.2

METRIC

DIAMETER MM	LENGTH M/KG	WEIGHT G/M
10.00	1.6	617.30
8.00	2.5	395.10
7.00	3.3	302.50
6.00	4.5	222.20
4.70	7.3	136.40
4.00	10.1	98.77
3.90	10.7	93.89
3.26	15.2	65.61
3.20	15.8	63.21
3.00	18.0	55.56
2.50	25.9	38.58
2.30	30.6	32.66
2.05	38.6	25.94
2.00	40.5	24.69
1.63	61.0	16.40
1.50	72.0	13.89
1.40	82.7	12.10
1.29	97.3	10.27
1.20	112.0	8.89
1.15	122.0	8.16
1.13	127.0	7.88
1.00	162.0	6.17
0.81	247.0	4.05
0.64	395.0	2.53
0.63	408.0	2.45
0.60	450.0	2.22
0.51	623.0	1.61
0.50	648.0	1.54
0.45	800.0	1.25
0.40	1,012.0	0.99
0.32	1,582.0	0.63
0.30	1,800.0	0.56
0.25	2,592.0	0.39
0.20	4,050.0	0.25
0.18	5,000.0	0.20
0.10	16,199.0	0.06

CUPROTHAL® SX

B&S OR AWG

B&S OR AWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
6	4.115	8.4	118.5
7	3.658	10.7	93.6
8	3.251	13.5	74.0
10	2.591	21.3	47.0
12	2.057	33.8	29.6
14	1.626	54.0	18.5
16	1.295	85.2	11.7
18	1.016	138.0	7.2
20	0.813	216.0	4.6
22	0.643	346.0	2.9
24	0.511	547.0	1.8
25	0.455	690.0	1.5
26	0.404	876.0	1.1
28	0.320	1,390.0	0.7
32	0.203	3,468.0	0.3
36	0.127	8,860.0	0.1

SWG

SWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
8	4.064	8.7	115.6
9	3.658	10.7	93.6
10	3.251	13.5	74.0
12	2.642	20.5	48.9
14	2.032	34.6	28.9
16	1.626	54.0	18.5
18	1.219	96.0	10.4
19	1.016	138.0	7.2
20	0.914	171.0	5.9
21	0.813	216.0	4.6
22	0.711	283.0	3.5
24	0.559	457.0	2.2
26	0.457	684.0	1.5
30	0.315	1,440.0	0.7
34	0.234	2,610.0	0.4
36	0.193	3,836.0	0.3

METRIC

DIAMETER MM	LENGTH M/KG	WEIGHT G/M
10.00	1.4	699.80
8.00	2.2	447.90
7.00	2.9	342.90
6.00	4.0	251.90
4.70	6.5	154.60
4.00	8.9	112.00
3.90	9.4	106.40
3.26	13.5	74.37
3.20	14.0	71.66
3.00	15.9	62.98
2.50	22.9	43.74
2.30	27.0	37.02
2.05	34.0	29.41
2.00	35.8	27.99
1.63	53.8	18.59
1.50	63.5	15.75
1.40	72.9	13.72
1.29	85.9	11.65
1.20	99.0	10.08
1.15	108.0	9.25
1.13	112.0	8.94
1.00	143.0	7.00
0.81	218.0	4.59
0.64	349.0	2.87
0.63	360.0	2.78
0.60	397.0	2.52
0.51	549.0	1.82
0.50	572.0	1.75
0.45	706.0	1.42
0.40	893.0	1.12
0.32	1,396.0	0.72
0.30	1,588.0	0.63
0.25	2,286.0	0.44
0.20	3,573.0	0.28
0.18	4,410.0	0.23
0.10	14,290.0	0.07

NICROSIL

B&S OR AWG

B&S OR AWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
6	4.115	8.8	113.4
7	3.658	11.2	89.7
8	3.251	14.1	70.8
10	2.591	22.2	45.0
12	2.057	35.3	28.4
14	1.626	56.5	17.7
16	1.295	89.0	11.2
18	1.016	145.0	6.9
20	0.813	226.0	4.4
22	0.643	361.0	2.8
24	0.511	572.0	1.8
25	0.455	721.0	1.4
26	0.404	915.0	1.1
28	0.320	1,458.0	0.6
32	0.203	3,622.0	0.3
36	0.127	9,255.0	0.1

SWG

SWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
8	4.064	9.0	110.6
9	3.658	11.2	89.7
10	3.251	14.1	70.8
12	2.642	21.4	46.8
14	2.032	36.2	27.7
16	1.626	56.5	17.7
18	1.219	100.0	10.0
19	1.016	145.0	6.9
20	0.914	179.0	5.6
21	0.813	226.0	4.4
22	0.711	295.0	3.4
24	0.559	478.0	2.1
26	0.457	715.0	1.4
30	0.315	1,504.0	0.7
34	0.234	2,726.0	0.4
36	0.193	4,007.0	0.3

METRIC

DIAMETER MM	LENGTH M/KG	WEIGHT G/M
10.00	1.5	617.30
8.00	2.3	395.10
7.00	3.1	302.50
6.00	4.2	222.20
4.70	6.8	136.40
4.00	9.3	98.77
3.90	9.8	93.89
3.26	14.1	65.61
3.20	14.6	63.21
3.00	16.7	55.56
2.50	23.9	38.58
2.30	28.2	32.66
2.05	35.5	25.94
2.00	37.3	24.69
1.63	56.2	16.40
1.50	66.3	13.89
1.40	76.2	12.10
1.29	89.7	10.27
1.20	112.0	8.89
1.15	122.0	8.16
1.13	127.0	7.88
1.00	162.0	6.17
0.81	247.0	4.05
0.64	395.0	2.53
0.63	408.0	2.45
0.60	450.0	2.22
0.51	623.0	1.61
0.50	648.0	1.54
0.45	800.0	1.25
0.40	1,012.0	0.99
0.32	1,582.0	0.63
0.30	1,800.0	0.56
0.25	2,592.0	0.39
0.20	4,050.0	0.25
0.18	5,000.0	0.20
0.10	16,199.0	0.06

NISIL

B&S OR AWG

B&S OR AWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
6	4.115	8.8	114.1
7	3.658	11.1	90.2
8	3.251	14.0	71.2
10	2.591	22.1	45.2
12	2.057	35.1	28.5
14	1.626	56.1	17.8
16	1.295	88.5	11.3
18	1.016	144.0	7.0
20	0.813	225.0	4.5
22	0.643	359.0	2.8
24	0.511	568.0	1.8
25	0.455	717.0	1.4
26	0.404	909.0	1.1
28	0.320	1,449.0	0.7
32	0.203	3,601.0	0.3
36	0.127	9,201.0	0.1

SWG

SWG	DIAMETER MM	LENGTH M/KG	WEIGHT G/M
8	4.064	9.0	111.3
9	3.658	11.1	90.2
10	3.251	14.0	71.2
12	2.642	21.3	47.0
14	2.032	35.9	27.8
16	1.626	56.1	17.8
18	1.219	100.0	10.0
19	1.016	144.0	7.0
20	0.914	178.0	5.6
21	0.813	225.0	4.5
22	0.711	294.0	3.4
24	0.559	475.0	2.1
26	0.457	711.0	1.4
30	0.315	1,496.0	0.7
34	0.234	2,710.0	0.4
36	0.193	3,984.0	0.3

METRIC

DIAMETER MM	LENGTH M/KG	WEIGHT G/M
10.00	1.5	673.90
8.00	2.3	431.30
7.00	3.0	330.20
6.00	4.1	242.60
4.70	6.7	148.90
4.00	9.3	107.80
3.90	9.8	102.50
3.26	14.0	71.62
3.20	14.5	69.00
3.00	16.5	60.65
2.50	23.7	42.12
2.30	28.1	35.65
2.05	35.3	28.32
2.00	37.1	26.95
1.63	55.9	17.90
1.50	66.0	15.16
1.40	75.7	13.21
1.29	89.2	11.21
1.20	103.0	9.7
1.15	112.0	8.9
1.13	116.0	8.6
1.00	148.0	6.7
0.81	226.0	4.4
0.64	362.0	2.8
0.63	374.0	2.7
0.60	412.0	2.4
0.51	571.0	1.8
0.50	594.0	1.7
0.45	733.0	1.4
0.40	927.0	1.1
0.32	1,449.0	0.7
0.30	1,649.0	0.6
0.25	2,374.0	0.4
0.20	3,710.0	0.3
0.18	4,580.0	0.2
0.10	14,840.0	0.1

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