Wire

Wire in a wide range of alloys optimized for use in, for example, resistance, high-temperature and conductive applications.

The Kanthal range of alloys include, for example, resistance heating alloys, resistance alloys and soft conductive alloys.

Product forms available are:

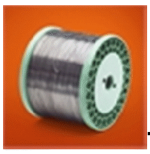
- round wire
- ribbon (flat wire)
- shaped wire
- stranded wire

The wire is supplied on spools, in coils, in pail pac or as straightened lengths and available with or without coating.

Kanthal wire products

**Resistance heating wire and resistance wire**

Resistance heating wire and resistance wire for a variety of heat generating and electronic applications.

**Thermocouple wire**

Wire and ribbon for thermocouples, extension leads and compensating cables.

Conductive wire

Round and flat conductive wire (magnet wire) in aluminium, copper clad aluminium, and copper.

Spray wire

Thermal spraying wire in a wide range of alloys for high-temperature corrosion protection, bonding layers and sealing.

The Kanthal program of round wire and ribbon (flat wire) includes a wide range of alloys, such as:

- iron-chromium-aluminium (FeCrAl) alloys
- nickel-chromium (NiCr) alloys
- nickel-iron (NiFe) alloys
- copper-nickel (CuNi) alloys
- nickel-cobalt (NiCo) alloys
- precious metals (e.g. gold, silver and platinum alloys)
- soft conductive alloys (e.g. aluminium, copper and copper-clad aluminium - CCA)
- stainless steels (e.g. ASTM 304 and ASTM 316)

Technical data for each individual alloy, such as chemical composition, is available in the datasheet for the respective grade.

Resistance heating wire and resistance wire

Round and flat resistance heating wire and resistance wire with bright annealed or oxidized surface, depending on size. Round resistance wire sizes up to 0.40 mm (0.0157 inch) are available with insulation and coating.

Kanthal resistance heating wire and resistance wire is characterized by consistent resistivity from delivery to delivery, facilitating trouble-free production.

Resistance heating alloys and resistance alloys

The wide Kanthal range of resistance heating alloys and resistance alloys in wire form makes it possible to select the most appropriate grade and size for each respective application, resulting in optimum end-product performance.

List of resistance heating alloys and resistance alloys

Type of alloy	Description
Kanthal and Alkrothal FeCrAl alloys*	High-resistivity iron-chromium-aluminium alloys for use up to 1400ºC (2550ºF).
Nikrothal NiCr alloys	High-resistivity nickel-chromium alloys for use up to 1250ºC (2280ºF).
Nifethal NiFe alloys	Low-resistivity nickel-iron alloys with high temperature coefficient of resistance for use up to 600ºC (1110ºF).
Cuprothal CuNi alloys	Medium- and low-resistivity copper-nickel alloys for use up to 600ºC (1110ºF).

* Kanthal FeCrAl alloys are available as both conventional resistance heating alloys and powder metallurgical alloys (Kanthal APM).

Product forms and size range

Round wire
0.010-12 mm (0.00039-0.472 inch)
Other sizes are available on request.

Ribbon (flat wire)
Thickness: 0.023-0.8 mm (0.0009-0.031 inch)
Width: 0.038-4 mm (0.0015-0.157 inch)
Width/thickess ratio max 40, depending on alloy and tolerance
Other sizes are available on request.

Stranded wire
Some resistance heating alloys and pure nickel are available as stranded wire.

Resistance tolerance

Standard resistance tolerance for wire is listed in the following table. Wire can be supplied to closer tolerance on request.
The data is valid at 20°C (68°F).

Wire size Ø mm (inch)	Resistance tolerance %
<0.127 (0.005)	+/- 8
>0.127 (0.005)	+/- 5

Delivery forms

Kanthal resistance wire is delivered on spools, in coils, in pail pac or as straightened lengths.

Insulation and coating

The Kanthal program includes a wide range of insulation coatings, bondable coatings and metallic coatings such as electroplating and anodizing. All coatings are available in various colors.

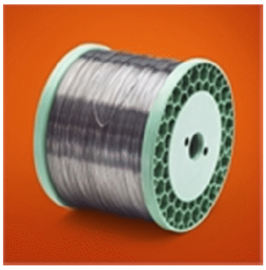
Marking

Each spool/package of wire is supplied with a label or tag showing alloy type, nominal size, tare and net weight, resistance W/m (W/ft), charge number and a reference number.

Stock program

We have a number of frequently used products in stock. Please contact us for details.

Thermocouple wire and strip



Thermocouple wire and thermocouple strip for use at temperatures up to 1260°C (2300°F). Kanthal thermocouple wire is supplied with bright or oxidized surface according to standard or special EMF requirements.

Each individual arm is calibrated against platinum and the EMF values are shown on each coil or spool.

The Kanthal product program for thermocouples includes:

- Thermocouple wire - round and flat
- Thermocouple strip
- **Extension leads/extension cables**
- **Compensating cables**
- Bunched wire
- **Thermocouple protection tubes**

Our program also includes a bi-filar side-by-side configuration in some size ranges.

Types of thermocouple wire

Code	Wires component the thermocouple	
	+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)

*Not produced by Sandvik

The most used thermocouple combinations

Size range

Wire: Kanthal thermocouple wire ranges from 0.05 to 8.0 mm (0.0019 to 0.315 inch). Wire in the size range 0.0254 mm to 0.51 mm (0.001 to 0.0201 inch) can be supplied with or without an insulating coating.

Strip: Standard sizes for thermocouple strip range from thickness 0.10 to 3.0 mm (0.0039 to 0.181 inch) and width from 4 to 195 mm (0.157 to 7.68 inch).

Standards

Kanthal thermocouple alloys are supplied according to the following standards shown below. Where older standards are still in use (which are not equivalent to those listed below), we can supply different EMF values upon request.

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

Conductive wire

Round and flat conductive wire (magnet wire) in aluminium, copper-clad aluminium and copper. The Kanthal program includes standard conductive wire sizes but also custom-designed sizes and resistance to meet specific design requirements. The wire is available with or without insulation or coating.

Size range

Round wire
0.023-1.27 mm (0.0009-0.050 inch)

Ribbon (flat wire) / Square wire
Thickness: 0.023-0.635 mm (0.0009-0.025 inch)
Width: 0.038-2.032 mm (0.0015-0.041 inch)
Width/thickess ratio max 40, depending on alloy and tolerance

Conductive wire alloys

Aluminium
The Kanthal program includes aluminium in three different conditions - bare aluminium, coated aluminium and anodized aluminum. The aluminum wire is used primarily as electrical conductors due to its inherent ability to rapidly dissipate heat and resist corrosion as well as its reduction in weight over other alloys. Kanthal aluminum wire is widely used for hard disk drive coils, audio speaker coils with heat resistant enamels and high strength bond coats.
List of aluminium alloys

Copper-clad aluminium (CCA)
Kanthal copper-clad aluminium (CCA) wire is available with 10% or 15% copper cladding over an aluminium wire core. CCA offers the inherent characteristics of aluminium while the copper cladding provides greater conduction of current and the ease of soldering of copper. Kanthal CCA wire is used for electrical contact material and conductors.
List of copper-clad aluminium (CCA)

Copper
Kanthal oxygen-free high-conductivity copper (OHFC) has excellent physical, electrical conductivity and thermal resistance properties. Copper is easily soldered, welded and plated for excellent corrosion resistance. The alloy CDA 10100 has a purity of 99.99%, CDA 10200 has 99.5% and ETP C11000 has 99.9%.
List of copper alloys

Insulation and coating

The Kanthal program includes a wide range of insulation coatings, bondable coatings and metallic coatings such as electroplating and anodizing. All coatings are available in various colors.

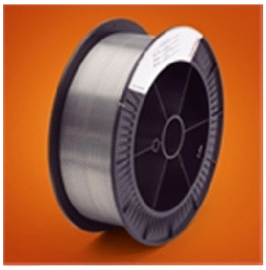
Delivery forms

Kanthal conductive wire can be supplied on a wide range of plastic spools with up to 15 kg (33 lbs) wire weight.

Typical applications for Kanthal conductive wire

- Audio voice coils
- Hard disk drive coils
- Motor coils
- Transformers
- Ignition coils
- Solar panel buses and tabs

Spray wire



Thermal spraying wire in a wide range of alloys for high-temperature corrosion protection, bonding layers, build-up coating and sealing.

Spray wire alloys

The Kanthal program of tspray wire includes the following types of alloys:

- FeCrAl and FeCrAlY alloys
- NiCr and NiCrFe alloys
- NiAl alloys
- NiFe alloys
- CuNi alloys

Sizes

Standard sizes are 1.20, 1.60 and 2.00 mm (0.0472, 0.0693 and 0.0787 inch). Other sizes can be offered on request. The standard delivery form is tight wound on SD 300K spools.

Typical applications

Kanthal thermal spraying wire is used in a variety of applications, such as:

- High-temperature oxidation protection used, for example, to resist gases in boiler atmospheres
- Coatings to resist heat and prevent scaling of conventional low alloy steels
- Bond coats for improving the adhesion of top coatings
- Coatings on moulds in the glass industry

Safety

Personnel working with thermal spraying should be aware of the hazards connected to the process. They should be familiar with the use of protection equipment for eyes, skin, hearing, respiratory system etc. Personnel should be familiar with safety regulations regarding the complete process, including spraying and the spray equipment used.

This product contains elements, which in certain combinations may be dangerous to your health. We provide Material Safety Data Sheets (MSDS) for this product, which should be read and understood before using the material.

Not following these instructions may be a danger to your health.

Wire insulations and coatings

The Kanthal program includes a wide range of insulation coatings, bondable coatings and metallic coatings such as electroplating and anodizing. All coatings are available in various colors.

Insulation coatings

Our program covers insulation coatings for temperatures up to 240°C (464°F). In addition to standard NEMA or JIS builds, we are capable of applying "Thin" and "Ultra-thin" builds of insulations. These builds are thinner than NEMA Type 1 and still meet the dielectric property and other requirements of NEMA Type 1.

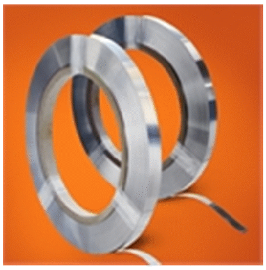
Bondable coatings

Bondable coatings can be applied to bare wire or as a second coat over the top of any of the insulations that are offered. The amount of coating applied can be standard NEMA or JIS build or thinner amounts as required. If a special coating or insulation is required we will work with you to develop a process for its use. We have, for example, developed low out-gassing, high-temperature, self-bondable coatings specifically designed for the hard disk drive industry to reduce contamination and deliver good resonance performance.

Metallic coatings

The Kanthal program includes several types of metallic coatings such as anodizing, electroplating and electropolishing. As a standard we offer gold-plated wire, nickel-plated wire and silver-plated wire, but also other types of electroplating can be manufactured on request. Additionally, we work with cladding and cladded alloys.

Strip



Strip in a wide range of materials optimized for use in electrical resistance and high-temperature applications. Standard sizes range from thickness 0.10 to 3.5 mm (0.0039 to 0.1378 inch) and width 4-195 mm (0.157-7.68 inch).

Kanthal strip is normally delivered in cold-rolled condition with ground surface and supplied in coils with an internal diameter of 400 mm (15.75 inch) or in straightened lengths.

Kanthal strip products

**Resistance heating strip**
Resistance heating strip for furnace heating elements and variety of other heat-generating applications.

**Thermocouple strip**
Strip for thermocouples, extension leads and compensating cables.

Resistance heating strip

Resistance heating strip for furnace heating elements and other heat-generating applications. The strip is normally delivered in cold-rolled condition with ground surface.

Our wide range of resistance heating alloys in strip form makes it possible to select the most appropriate grade and size for each respective application, resulting in optimum end-product performance. The consistent resistivity from delivery to delivery facilitates trouble-free production.

Size range

Thickness: 0.10-4 mm (0.00394-0.157 inch)
Width: 4-200 mm (0.157-7.874 inch)
Other sizes can be delivered on request.

Resistance heating alloys in strip form

Type of alloy	Description
Kanthal and Alkrothal FeCrAl alloys*	High-resistivity iron-chromium-aluminium alloys for use up to 1400ºC (2550ºF).
Nikrothal NiCr alloys	High-resistivity nickel-chromium alloys for use up to 300ºC (570ºF).
Cuprothal CuNi alloys	Medium- and low-resistivity copper-nickel alloys for use up to 150ºC (300ºF).

* Kanthal FeCrAl alloys are available as both conventional alloys and powder metallurgical alloys (Kanthal APM).

Resistance tolerance

Standard resistance tolerance for strip is ± 5%, but strip with closer resistance tolerance can be delivered on request.

Delivery forms

Kanthal resistance heating strip is supplied in coils with an internal diameter of Ø 400 mm or in straightened lengths.

Marking

Each coil of strip is supplied with a label or tag showing alloy type, nominal size, tara and net weight, resistance Ω/m (Ω /ft) and charge number

Thermocouple wire and strip

Thermocouple wire and thermocouple strip for use at temperatures up to 1260°C (2300°F). Kanthal thermocouple wire is supplied with bright or oxidized surface according to standard or special EMF requirements.

Each individual arm is calibrated against platinum and the EMF values are shown on each coil or spool.

The Kanthal product program for thermocouples includes:

- Thermocouple wire - round and flat
- Thermocouple strip
- **Extension leads/extension cables**
- **Compensating cables**
- Bunched wire
- **Thermocouple protection tubes**

Our program also includes a bi-filar side-by-side configuration in some size ranges.

Types of thermocouple wire

Code	Wires component the thermocouple	
	+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)

*Not produced by Sandvik

Size range

Wire: Kanthal thermocouple wire ranges from 0.05 to 8.0 mm (0.0019 to 0.315 inch). Wire in the size range 0.0254 mm to 0.51 mm (0.001 to 0.0201 inch) can be supplied with or without an insulating coating.

Strip: Standard sizes for thermocouple strip range from thickness 0.10 to 3.0 mm (0.0039 to 0.181 inch) and width from 4 to 195 mm (0.157 to 7.68 inch).

Standards

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JIS	(Japanese Industrial Standards) C 1602 - C 1610
GOST	(Unification of the Russian Specifications) 3044

350 Aluminum

General description

1350 Aluminum has a purity of 99-99.5%. 1350 Al has been widely used for disk drive coils and development of tethers with heat resistant enamels and high strength bond coatings.

Chemical composition

	Al %
Nominal composition	99.5

Mechanical properties

Yield strength	Tensile strength	Elongation
$R_{p0.2}$	**R_m**	**A**
MPa	**MPa**	**%**
166	186	1.2

Physical properties

Temperature factor of resistivity	
Temperature °C	**20-100**
Ct	0.00408

Density g/cm^3 (lb/in^3)	2.703 (0.097)
Electrical resistivity at 20°C Ωmm^2/m (Ω/cmf)	0.028 (16.78)
DC Conductivity vs Copper %	61.8

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Alkrothal 14

Alkrothal 14 is a ferritic iron-chromium-aluminium alloy (FeCrAl alloy) suitable for use at temperatures up to 1100°C (2010°F).

Alkrothal 14 is typically used for electrical resistance wire in low-temperature applications such as heating cables.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Fe %
Nominal composition					4.3	Bal.
Min	-	-	-	14.0	-	
Max	0.08	0.7	0.5	16.0	-	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	455	630	22	220
4.0	445	600	22	220
6.0	435	580	23	220

Young's modulus

Temperature °C	20	100	200	400	600	800	1000
GPa	220	210	205	190	170	150	130

Mechanical properties at elevated temperature

Temperature °C	900
MPa	30

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	1000
MPa	1.2	0.5

Physical properties

Density g/cm³	7.28
Electrical resistivity at 20°C Ω mm²/m	1.25
Poisson's ratio	0.30

Temperature factor of resistivity

Temperature°C	100	200	300	400	500	600	700	800	900	1000	1100
Ct	1.00	1.02	1.03	1.04	1.05	1.08	1.09	1.10	1.11	1.11	1.12

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/ K
20 - 250	11
20 - 500	12
20 - 750	14
20 - 1000	15

Thermal conductivity

Temperature °C	20
W/m K	16

Specific heat capacity

Temperature°C	20	200	400	600	800	1000
kJ kg^{-1} K^{-1}	0.46	0.63	0.72	1.00	0.80	0.73

Melting point °C	1500
Max continuous operating temperature in air °C	1100
Magnetic properties	The material is magnetic up to approximately 600°C (Curie point).
Emissivity - fully oxidized material	0.70

Aminide

Aminide wire is insulated with a Polyamide-imide insulation. It has excellent thermal endurance, solvent resistance.

Typical applications are within fractional and integral horse power motors(hermetic and open), automotive and hand tool armatures, dry type transformers.

Bond E1

Bonding instructions

Kanthal Bond E1 is a thermoplastic modified epoxy bondcoat. It will soften and reflow with the application of heat during or after coil winding. Bond E1 is typically applied as an overcoat over a Polyurethane or Polyester or Polyimide type insulation basecoat to make a bondable magnet wire. Such a wire will bond to itself when heat softens the overcoat on adjacent turns and the bondcoat flows together. Upon cooling, the overcoat will harden, which locks the turns in place. Bonding of wire coated with Bond E1 should be considered reversible in that a return to high temperature will once again soften the coating.

Bond E1 softens between 120°C and 140°C (248-284°F). Full Bond strength can be achieved at 10 minutes at 130°C. Additional time or higher temperatures may increse the effective bonding area between conductors, giving a modest increase in performance. Of course, service testing should be performed to verify the adequacy of the winding construction, the bonding process and outgassing properties.

The postbake cycle above refers to time at temperature. Ovens of force hot air stations may require additional time or higher temperatures to bring the wire up to the required bonding temperature.

Resistance heating of the winding by application of current is an efficent method of bonding. Wire temperatures up to 220°C (428°F) can be tolerated up to a few minutes. Again, it is up to the user to optimize the bonding process.

Limitations of bondable wire

Note that bondable magnet wire is ineffective across gaps in a winding, nor will it bond well unless adjacent conductors are in intimate contact. Fine wire, 0.073-0.38 mm (0.003-0.015 in.) and precision winding of coils allows one to realize the full benifits of bondable wire technology.

Bond MA

Bonding instructions

Bond MA is a thermoplastic polyamide; that is, it softens and flows with the applicatioon of heat. It is typically applied as an overcoat tover a Polyurethane or Polyester basecoat to make a bondable magnet wire. Such wire bonds to itself when heat softens the overcoat on adjacent turns and it flows together. Upon cooling, the overcoat hardens, locking the turns in place. Bonding of wire coated with Bond MA should be considered reversible in that a return to high temperature will again soften the coating.

Bond MA softens between 160 and 170°C (320-338°F). Fill bond strength can be achieved after one hour at 170°C (338°F). Additional time or higher temperatures may increase the effective bonding area between conductors, giving a modest increase in performance.

The bonding cycle above refers to time that the wire is at temperature. Ovens or forced hot air stations may require additional time or higher temperatures to bring the magnet wire up to the required bonding temperature.

Bonding of the wire can be accomplished by resistance heating after winding or by heating in an oven. Bonding is also possible by applicattion of hot air or solvents (such as methyl alcohol) to the wire during winding. For optimal results these coils should then be post baked after winding at 170°C (338°F) for one hour.

Limitations of bondable wire

Note that bondable magnet wire is ineffective across gaps in a winding, nor will it bond well unless adjacent conductors are in intimate contact. Fine wire and precision wound coils can take the most advantage of bondable technology.

Service temperature

The bond strength of the bonded windings decerase as a function of temperature. Bond MA will retain approximately 5-10% of its room temperature strength at 155-165°C (311-329°F). Service testing should be performed to verify the adequacy of the winding construction and the bonding process.

Bond XTC

Bonding instructions

Bond XTC is a high temperature thermoplastic polyamide bondcoat. It will soften and reflow with the application of heat during or after coil winding. Bond XTC is typically applied as an overcoat over a Polyurethane or Polyester type insulation basecoat to make a bondable magnet wire. Such a wire will bond to itself when heat softens the overcoat on adjacent turns and the bondcoat flows together. Upon cooling the overcoat will harden, which locks the turns in place. Bonding, if wire coated with Bond XTC should be considered reversilbe in that a return to high temperature will once again soften the coating.

If coils are postbaked at 180°C (356°F) for one hour, then the Bond XTC will maintain its room temperature strength until at least 140°C (284°F) and still have greater than 50% of its room temperature strength at 190°C (374°F). Postbaking of Bond XTC at lower temperatures for longer periods of time (such as 4 hours at 170°C (338°F)) is possible to optimize bond strength and coil outgassing properties. Of course, service testing should be performed to verify the adequacy of the winding constructions, the bonding process and outgassing properties.

Postbake cycle above refers to time at temperature. Ovens of forced hot air stations may require additional time or higher temperatures to bring the wire ip to the required bonding temperature.

Resistance heating of the windings by application of current is and efficent method of bonding wire temperatures up to 220°C (428°F) can be tolerated up to a few minutes. Again it is up to the user to optimize the bonding process.

Limitations of bondable wire

Note that bondable magnet wire is ineffective across gaps in a winding, nor will it bond well unless adjacent conductors are in intimate contact. Fine wire, 0.076-0.38mm (0.003-0.015 in.) and precision winding of coils allows one to realize the full benifits of bondable wire technology.

Bond XTS

Bonding instructions

Bond XTS is a high temperature thermoset epoxy bondcoat. It will soften and reflow with application of heat or after coil winding. Bond XTS can also be activated during coil winding with MEK solvent, Bond XTS exhibits low outgassing in specialized appolications.

Bond XTS is typically applied as an overcoat over Polyurethane or Polyester type insulation basecoat to make a bondable magnet wire. Such wire will bond to itself when heat softens the overcoat on adjacent turns and the bondcoat flows together. Upon cooling the overcoat will harden, which locks the turns in place.

If coils are postbaked at 180°C (356°F) for one to four hours, depending on the application then the Bond XTS will maintain its bond strength until at least 200°C (392°F).*

*Maximum bond strength is based on the temperature at which the adhesiv still retains 5-10% of its room temperature strength.

Postbaking of Bond XTS at lower temperatures for longer perioods of time to achieve optimal bond strength is possible, but this post bake cure cycle must be optimized by the coil winder. To gain an improvement on the bond strength requires that the wire coil be held together during the postbake process. Of course, service testing should be performed to verify the adequacy of the winding construction, the bonding process and outgassing properites.

The postbake cycle above refers to time at temperature. Ovens of forced hot air stations may require additional time or higher temperatures to bring the wire up to required bonding temperature. Resistance heating of the windings by application of current is an efficient method of bonding. Wire temperatures up to 220°C (428°F) can be tolerated for up to a few minutes. Again it is up to the user to optimize the bonding process.

Limitations of bondable wire

Note that bondable magnet wire is ineffective across gaps in a winding, nor will it bond well unless adjacent conductors are in intimate contact. Fine wire, 0.076-0.38mm (0.003-0.015 in.), and precision winding of coils allows one to realize the full benifits of bondable wire technology.

Bond-B

Bonding instructions

Bond-B us a thermoplastic polyvinylbutyral, that is, it softens and flows with the application of heat. It is typically applied as an overcoat over a polyester or polyesterimide basecoat to make a bondable magnet wire. Such wire bonds to itself when heat softens the overcoat on adjacent turns and it flows together. Upon cooling the overcoat hardens, locking the turns in place. Bond-B should be considered reversible in that a return to high temperature will again soften the coating.

Bond-B softens between 100 and 120°C (212-248°F). Full bond strength can be achieved after ten minutes at 120°C. Additional time or higher temperatures may increase the effective bonding area between conductors, giving a modest increase in performance.

The bonding cycle above refers to the time that the wire is at temperaure. Ovens or forced hot air stations will require additional time and/or high temperatures to bring the magnet wire up to bonding temperature. Motor laminations for example, represent a large heat sink that will greatly extend bonding time.

Resistance heating of the windings by the application of current is a more efficient and preferred method of bonding. Wire temperatures up to 200°C (392°F) can be tolerated for up to a few minutes with minimal outgassning.

Service temperature

The bond strength of bonded windings decreases as a function of temperature. Bond-B will retain approximately 5-10% of its room temperature bond strength at 90-100°C (194-212°F). Service testing should be performed to verify the adequacy of the winding construction and the bonding process.

Limitations of bondable wire

Note that bondable magnet wire is ineffective across gaps in a winding, nor will it bond well unless adjacent conductors are in intimate contact. Fine wire and precision wound coils can take the most advantage of bondable technology. Motor size wire applications must be carefully evaluated to determine whether bondable wire is appropriate.

C10100 and C10200

General description

Copper has excellent physcial, thermal properties and electrical conductivity. Copper is easily soldered, welded and plated for corrosion resistance. Gold plated pure copper is used when electrical condutivity is crucial and its application is critical to maintaining a stable resistance with minimal variation over the wire length.

Copper is available in three grades of Oxygen free (OF), Oxygen free electronic (OFE) and also in grade Electrolytic Tough Pitch (ETP), in both round and milled ribbon forms.

Chemical composition

	Cu %	**Ag%**
C10100 OFE **Oxygen free electronic**	99.99	-
C10200 OF **Oyxgen free**	99.99	min

Table represents nominal composition of each grade

Mechanical properties

	Tensile strength R_m	
	MPa	**ksi**
Hard	455	66
Anealed	220	32

Physical properties

Density g/cm³ (lb/in³)	8.94 (.323)
Electrical resistivity at 20°C Ωmm²/m	0.017
Temperature coefficient of resistance K^{-1}	+0.00397
Conductivity at 20°C (68°F)	Anealed 101% IACS min

Coefficient of thermal expansion

Temperature °C (°F)	**Thermal expansion 10^{-6}/K**
20-500 (68-932)	17.0

Thermal conductivity

Temperature °C (°F)	100 (212)
W m^{-1} K^{-1}	391

Specific heat capacity

Temperature °C (°F)	20
kJ kg^{-1} K^{-1}	0.385

Melting Point °C (°F)	1083 (1981)

Standards

Specifications	ASTM B170, 1, 2, 3, F-68, 272-grade 1 and 2

C11000 ETP

General description

Copper has excellent physcial, thermal properties and electrical conductivity. Copper is easily soldered, welded and plated for corrosion resistance. Gold plated pure copper is used when electrical condutivity is crucial and its application is critical to maintaining a stable resistance with minimal variation over the wire length.

Copper is available in three grades of Oxygen free (OF), Oxygen free electronic (OFE) and also in grade Electrolytic Tough Pitch (ETP), in both round and milled ribbon forms.

Chemical composition

	Cu %	**Ag%**
Nominal composition	99.99	min

Mechanical properties

	Tensile strength R_m	
	MPa	**ksi**
Hard	455	66
Anealed	240	35

Physical properties

Density g/cm³ (lb/in³)	8.89 (.321)
Electrical resistivity at 20°C Ωmm²/m	0.017
Temperature coefficient of resistance K^{-1}	+0.00393 to +0.00397
Conductivity at 20°C (68°F)	Annealed, 100% to 101.5% IACS min

Coefficient of thermal expansion

Temperature °C (°F)	**Thermal expansion 10^{-6}/K**
20-500 (68-932)	17.0

Thermal conductivity

Temperature °C (°F)	100 (212)
$W\ m^{-1}\ K^{-1}$	388

Specific heat capacity

Temperature °C (°F)	20
kJ kg^{-1} K^{-1}	0.385

Melting Point °C (°F)	1083 (1981)

Standards

Specifications	ASTM B 1, 2, 3, 250

Copper clad (10%) Aluminum

General description

Copper Clad (10%) Aluminum is a conductive wire with a 10% Copper cladding ove an aluminum core. Copper Clad Aluminum (CCA) is used for electrical contact material and conductors. CCA offers the inherent characteristics of aluminum while the copper cladding provides greater conduction of current and the ease of soldering copper.

Chemical composition

	Cu %	Al %
Nominal composition	15 (cladding)	99.3 (core)

Mechanical properties

	Tensile strength R_m	
	MPa	**ksi**
Hard	193	28
Anealed	110	16

Physical properties

Density g/cm^3 (lb/in^3)	3.32 (.120)
Electrical resistivity at 20°C $\Omega mm^2/m$ (Ω/cmf)	0.026 (15.90)
DC Conductivity vs Copper %	65

Copper Clad (15%) Aluminum

General description

Copper Clad (15%) Aluminum is a conductive wire with a 15% Copper cladding ove an aluminum core. Copper Clad Aluminum (CCA) is used for electrical contact material and conductors. CCA offers the inherent characteristics of aluminum while the copper cladding provides greater conduction of current and the ease of soldering copper.

Chemical composition

	Cu %	Al %
Nominal composition	15 (cladding)	99.3 (core)

Mechanical properties

	Tensile strength R_m	
	MPa	**ksi**
Hard	207	30
Anealed	138	20

Physical properties

Density g/cm³ (lb/in³)	3.63 (.131)
Electrical resistivity at 20°C Ωmm²/m (Ω/cmf)	0.026 (15.50)
DC Conductivity vs Copper %	67

Cuprothal

Cuprothal is an alloy used for the negative leg of the following types of thermocouples and compensating cables: E, J, T and KCB (VX). The alloy can be used at temperatures down to 20 K where its Seebeck coefficient is about 8 µV / K.

Thermocouple type E has the highest emf output of any common thermocouple and is for this reason used in thermal generators (thermopiles).

Cuprothal type T is matched with elecrolytic copper (ASTM standard B3). Thermocouple type T is both used in laboratory and industrial applications.

Cuprothal type KNCB (VNX) is matched with electrolytic copper when used in compensating cables for thermocouples type K.

Chemical composition

	Ni %	Mn %	Fe %	Co %	Cu %
Nominal composition	44.0	0.5	0.5	0.3	Bal.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
2.00	250	480	30	130

Physical properties

Density g/cm^3	8.9
Electrical resistivity at 20°C Ω mm^2/m	0.49

Temperature factor of resistivity

Temperature°C	100	200	300	400	500	600
Ct	1.002	1.002	1.001	1.005	1.017	1.037

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 100	14

Thermal conductivity

Temperature °C	20
W m^{-1} K^{-1}	21

Specific heat capacity

Temperature °C	20
kJ kg^{-1} K^{-1}	0.410

Melting point °C	1280
Magnetic properties	The material is non-magnetic

Recommended maximum continuous operating temperatures for type JN

Wire size Ø	3.26	1.63	1.00	0.50	0.25
Bare wire °C	760	760	720	650	560

Protected wire °C	760	760	760	760	670

Note that the indicated temperatures should be considered as guide values

Recommended maximum continuous operating temperatures for type EN					
Wire size Ø	3.26	1.63	1.00	0.50	0.25
Bare wire °C	890	800	750	660	580
Protected wire °C	1000	910	860	770	690

Note that the indicated temperatures should be considered as guide values

Thermoelectric properties

CUPROTHAL™JN - JNX

Nominal emf values vs Iron

Temperature °C	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**
mV	5.269	10.779	16.327	21.848	27.393	33.102	39.132	45.494

ITS 90 - Reference junction 0°C

CUPROTHAL™TNX - TN

Nominal emf values vs electrolytic copper (ASTM B3)

Temperature °C	**100**	**200**	**300**	**400**
mV	4.279	9.288	14.862	20.872

ITS 90 - Reference junction 0°C

CUPROTHAL™EN - ENX

Nominal emf values vs Thermothal P (KP)

Temperature °C	100	200	300	400	500	600	700	800	900	1000
mV	6.319	13.421	21.036	28.946	37.005	45.093	53.112	61.017	68.787	76.373

ITS 90 - Reference junction 0°C

CUPROTHAL™KNCB (VNX)

Nominal emf values vs electrolytic copper (ASTM B3)

Temperature °C	100
mV	4.096

ITS 90 - Reference junction 0°C

Cuprothal 10

Cuprothal 10 is a copper-nickel alloy (CuNi alloy) with low resistivity, suitable for low temperature resistances. The alloy is suitable for use at temperatures up to 300°C (570°F).

Wire in Cuprothal 10 is typically used as heating cables.

Chemical composition

	Ni %	Cu %
Nominal composition	6.0	Bal.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	**$R_{p0.2}$**	**R_m**	**A**
mm	**MPa**	**MPa**	**%**
1.00	110	280	30

Physical properties

Density g/cm³	8.9
Electrical resistivity at 20°C Ω mm²/m	0.10

Temperature factor of resistivity

Temperature °C	20	100	200	300
Ct	1.00	1.06	1.11	1.19

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x10^{-6}/K
20 - 100	16

Thermal conductivity

Temperature °C	20
W m^{-1} K^{-1}	90

Specific heat capacity

Temperature °C	20

kJ kg^{-1} K^{-1}	0.380

Melting point °C	1095
Max continuous operating temperature in air °C	300
Magnetic properties	The material is non-magnetic

Cuprothal 15

Cuprothal 15 is a copper-nickel alloy (CuNi alloy) with medium-low resistivity for low temperature resistances. The alloy is suitable for use at temperatures up to 400°C (750°F).

Curpothal 15 is typically used for heating cables, fuses, shunts, resistors and various types of controllers.

Chemical composition

	Ni %	Cu %
Nominal composition	11.0	Bal.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	**$R_{p0.2}$**	**R_m**	**A**
mm	**MPa**	**MPa**	**%**
1.00	130	300	30

Physical properties

Density g/cm^3	8.9
Electrical resistivity at 20°C Ω mm^2/m	0.15

Temperature factor of resistivity

Temperature °C	20	100	200	300	400
Ct	1.00	1.035	1.07	1.11	1.15

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x10^{-6}/K
20-100	16

Thermal conductivity

Temperature °C	20
W m^{-1} K^{-1}	60

Specific heat capacity

Temperature °C	20

kJ kg^{-1} K^{-1}	0.380

Melting point °C	1100
Max continuous operating temperature in air °C	400
Magnetic properties	The material is non-magnetic

Cuprothal 30

Cuprothal 30 is a copper-nickel alloy (CuNi alloy) with medium resistivity for medium-low temperature resistances. The alloy is suitable for use at temperatures up to 400°C (750°F)

Cuprothal 30 is typically used in heating cables, fuses, shunts, resistors and various types of controllers.

Chemical composition

	Ni %	Mn %	Cu %
Nominal composition	23.0	1.5	Bal.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.00	170	380	30	110
2.20	160	360	32	100

Physical properties

Density g/cm^3	8.9
Electrical resistivity at 20°C Ω mm^2/m	0.30

Temperature factor of resistivity

Temperature °C	20	100	200	300	400
Ct	1.00	1.02	1.03	1.04	1.06

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x10^{-6}/K
20-100	16

Thermal conductivity

Temperature °C	20
W m^{-1} K^{-1}	35

Specific heat capacity

Temperature °C	20
kJ kg^{-1} K^{-1}	0.370

Melting point °C	1150
Max continuous operating temperature in air °C	400
Magnetic properties	The material is non-magnetic

Cuprothal 49 and 49TC

Cuprothal 49 is a copper-nickel alloy (CuNi alloy) characterized by high electrical resistance, high ductility and non-corroding properties. It is suitable for use at temperatures up to 600°C (1110°F).

Typical applications for Cuprothal 49 are temperature-stable potentiometers, industrial rheostats and electric motor starter resistances.

The combination of negligible temperature coefficient and high resistivity makes the alloy particulary suitable for the winding of precision resistors.

Cuprothal 49 is manufactured from electrolytic copper and pure nickel. In finer wire sizes the alloy is designated as Cuprothal 49 TC.

Chemical composition

	Ni %	Mn %	Fe %	Cu %
Nominal Composition	44.0	1.0	0.5	Bal.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.00	250	480	30	130

Physical properties

Density g/cm³	8.9
Electrical resistivity at 20°C Ω mm²/m	0.49
Temperature coefficient of resistance K^{-1}	± 20 ppm (wire < 0.30 mm)
	± 60 ppm (wire > 0.30 mm)

Temperature factor of resistivity

Temperature °C	100	200	300	400	500	600
Ct	1.002	1.002	1.001	1.005	1.017	1.037

Coefficient of thermal expansion

Temperature °C	Thermal Expansion $X10^{-6}/K$
20-100	14

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Thermal conductivity	
Temperature °C	**20**
W m^{-1} K^{-1}	21.0

Specific heat capacity	
Temperature °C	**20**
kJ kg^{-1} K^{-1}	0.410

Melting point °C	1280
Max continuous operating temperature in air °C	600
Magnetic properties	The material is non-magnetic

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Cuprothal 5

Cuprothal 5 is a low resistivity copper-nickel alloy (CuNi alloy) for low temperature resistances. The alloy is suitable for use at temperatures up to 300°C (570°F).

Typical applications for Cuprothal 5 are heating cables in electric blankets and pillows.

Chemical composition

	Ni %	Cu %
Nominal composition	2.2	Bal.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	$R_{p0.2}$	R_m	A
mm	MPa	MPa	%
1.00	100	240	30

Physical properties

Density g/cm^3	8.9
Electrical resistivity at 20°C $\Omega\ mm^2/m$	0.05

Temperature factor of resistivity

Temperature°C	20	100	200	300
Ct	1.00	1.11	1.25	1.40

Coefficient of thermal expansion

Temperature °C	Thermal Expansion $x10^{-6}/K$
20 - 100	16.5

Thermal conductivity

Temperature °C	20
$W\ m^{-1}\ K^{-1}$	130

Specific heat capacity

Temperature °C	20

kJ kg^{-1} K^{-1}	0.380

Melting point °C	1090
Max continuous operating temperature in air °C	300
Magnetic properties	The material is non-magnetic

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Cuprothal SX

Cuprothal SX is an alloy used for the negative leg of compensating cables for thermocouple type S/R. Cuprothal SX must be matched with electrolytic copper (ASTM B3) to meet the reference standard.

Chemical composition

	Cu %	Ni %	Mn %
Nominal composition	Bal.	3.0	2.0

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	$R_{p0.2}$	R_m	A
mm	MPa	MPa	%
0.32	-	330	30

Physical properties

Density g/cm^3	8.91
Electrical resistivity at 20°C $\Omega\ mm^2/m$	0.12
Temperature factor of resistivity between 20°C and 100°C $10^{-6}/K$	1500

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x $10^{-6}/K$
20 - 100	16

Melting point °C	1080
Magnetic properties	The material is non-magnetic

Thermoelectric properties

Nominal emf values vs electrolytic copper (ASTM B3)

Temperature °C	100	200
mV	0.646	1.441

ITS 90 - Reference junction 0°C

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Cuprothal WX

Cuprothal WX is an alloy used for the negative leg of the compensating cable for thermocouples type K. Cuprothal WX must be matched with iron to meet the reference standards.

Chemical composition

	Cu %	Ni %	Fe %	Mn %
Nominal composition	Bal.	43.0	2.0	2.0

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	**$R_{p0.2}$**	**R_m**	**A**
mm	**MPa**	**MPa**	**%**
0.32	-	550	25

Physical properties

Density g/cm³	8.90
Electrical resistivity at 20°C Ω mm²/m	0.52
Temperature factor of resistivity between 20°C and 100°C 10^{-6}/K	100

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 100	15

Thermal conductivity

Temperature °C	Thermal conductivity W m^{-1} K^{-1}
20 - 100	21

Melting point °C	1210
Magnetic properties	The material is non-magnetic

Thermoelectric properties

Nominal emf values vs iron

Temperature °C	100	200
mV	4.096	8.139

ITS 90 - Reference junction 0°C

FEP

FEP coating is thin film applications of fluorinated ethylene propylene available in a variety of film thickness and colors. The following values are typical of the flouropolymer and should not be used as a specification.

Electrical Properties

Property	ASTM standard	Unit	Value
Dielectric constant	D150	MHz	2.1
Dielectric strength	D149	V/m	53
Dissipation factor	D150	MHz	0.0006
Arc resistance	D495	s	300
Volume resistivity	D257	Ω cm	$> 10^{18}$
Surface resistivity	D257	Ω/sq	$> 10^{16}$

Mechanical properties

Property	ASTM standard	Unit	Value
Specific gravity	D792		2.15
Tensile strength	D1457 D1708	MPa (psi)	23 (3.400)
Hardness	D2240	Shore D pencil	56 HB
Coefficient of friction **Static**	D1894	-	 0.2

Physical properties

Property	ASTM standard	Unit	Value
Melting point	D3418	°C (°F)	260 (500)
Max. operating temperature **Continuous** **Intermittent**		 °C (°F) °C (°F)	 204 (400) 232 (500)
Thermal conductivity		Bt in /(h ft² °F) W/ (m K)	1.4 0.20

Formvar

Formvar enamel is made from vinyl acetal resins produced as a smooth uniform film. Formvar has excellent mechanical properties such as abrasion resistance and flexibility. The film will withstand excessive elongation without rupture. When stressed during winding, Formvar has a tendency to craze upon contact with solvents such as toluene, naphtha, xylol, etc. Formvar can be removed mechanically or chemically during terminal preparation.
Typical applications are within motors, random and precision wound coils, oil filled and dry transformers, armature and generator winding where "tough" film may be required.

Electrical Properties

Property	NEMA MW-1000	ASTM D1696	IEC 851	JIS C 3003	MW-15-C
Dielectric strength at 25°C (77°F)	3.8.1.1	69-75	13-4.2, 3, 4	11.1	13.1 kV
Dissipation factor at 220°C (428°F)		107-114			0.05

Mechanical properties

Property	NEMA MW-1000	ASTM D1696	IEC 851	JIS C 3003	MW-15-C
Adherence and flexibility no snap 20% snap	3.3.1.1 3.3.1.1	141-148 141-148	8- 5.1.1	8.1 9.1	Pass 1d Pass 1d
% elongation at break	3.4.1.1	122-129	6-3.0		36
Mandrel at break	3.4.1.1	122-129			Pass 1d
Cut-through temperature	3.50.1.1	61.68			261°C (502°F)
Heat shock 20% stretch - ½ h at 200°C (392°F)	3.5.1.1	156-162	9-3.1	14.1	Pass 3d

Kanthal A

Kanthal A is a ferritic iron-chromium-aluminium alloy (FeCrAl alloy) suitable for use at temperatures up to 1350°C (2460°F). It is characterized by high resistivity and good oxidation resistance.

Kanthal A is typically used in industrial furnaces and home appliances. Examples of applications are elements embedded in ceramics for panel heaters, infrared heaters, warming plates, irons, ceramic pots, in cartridge heaters for liquid heating, storage heaters, in ceramic heaters for cooking plates, air guns, hobby kilns, radiators, in quartz tube heaters for space heating, toasters, toaster ovens, grills, industrial infrared dryers, coils on molded ceramic fibre for cooking plates with ceramic hobs.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Fe %
Nominal composition					5.3	Bal.
Min	-	-	-	20.5	-	
Max	0.08	0.7	0.5	23.5	-	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	$R_{p0.2}$	R_m	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	550	725	22	230
4.0	450	660	24	230

Mechanical properties at elevated temperature

Temperature °C	900
MPa	34

Ultimate tensile strength - deformation rate 6.2 x 10 $^{-2}$/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	1000
MPa	1.2	0,5

Physical properties

Density g/cm³	7.15
Electrical resistivity at 20°C Ω mm²/m	1.39
Poisson's ratio	0.30

Young's modulus

Temperature °C	**20**	**100**	**200**	**400**	**600**	**800**	**1000**
GPa	220	210	205	190	170	150	130

Temperature factor of resistivity

Temperature °C	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**
Ct	1.00	1.01	1.01	1.02	1.03	1.04	1.04	1.05	1.05	1.06	1.06	1.06	1.06

Coefficient of thermal expansion

Temperature °C	**Thermal Expansion x 10^{-6}/K**
20 - 250	11
20 - 500	12
20 - 750	14
20 - 1000	15

Thermal conductivity

Temperature °C	**50**	**600**	**800**	**1000**	**1200**
W m^{-1} K^{-1}	11	20	22	26	27

Specific heat capacity

Temperature °C	**20**	**200**	**400**	**600**	**800**	**1000**	**1200**
kJ kg^{-1} K^{-1}	0.46	0.56	0.63	0.75	0.71	0.72	0.74

Melting point °C	1500
Max continuous operating temperature in air °C	1350
Magnetic properties	The material is magnetic up to approximately 600°C (Curie point).
Emissivity - fully oxidized material	0.70

Kanthal A-1

Kanthal A-1 is a ferritic iron-chromium-aluminium alloy (FeCrAl alloy) suitable for use at temperatures up to 1400°C (2550°F).

Typical applications for Kanthal A-1 are electrical heating elements in high-temperature furnaces for heat treatment, ceramics, glass, steel, and electronics industries.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Fe %
Nominal composition					5.8	Bal.
Min	-	-	-	20.5	-	
Max	0.08	0.7	0.4	23.5	-	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	545	760	20	240
4.0	475	680	18	230

Mechanical properties at elevated temperature

Temperature °C	900	1000	1100	1200	1300
MPa	34	18	10	6	4

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	1000
MPa	1.2	0.5

Physical properties

Density g/cm³	7.10
Electrical resistivity at 20°C Ω mm²/m	1.45

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Poisson's ratio	0.30

Young's modulus							
Temperature °C	**20**	**100**	**200**	**400**	**600**	**800**	**1000**
GPa	220	210	205	190	170	150	130

Temperature factor of resistivity														
Temperature°C	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**	**1400**
Ct	1.00	1.00	1.00	1.00	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.05

Coefficient of thermal expansion	
Temperature °C	**Thermal Expansion x 10^{-6}/K**
20 - 250	11
20 - 500	12
20 - 750	14
20 - 1000	15

Thermal conductivity						
Temperature °C	**50**	**600**	**800**	**1000**	**1200**	**1400**
W m^{-1} K^{-1}	11	20	22	26	27	35

Specific heat capacity								
Temperature °C	**20**	**200**	**400**	**600**	**800**	**1000**	**1200**	**1400**
kJ kg^{-1} K^{-1}	0.46	0.56	0.63	0.75	0.71	0.72	0.74	0.80

Melting point °C	1500
Max continuous operating temperature in air °C	1400
Magnetic properties	The material is magnetic up to approximately 600°C (Curie point).
Emissivity - fully oxidized material	0.70

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Kanthal AE

Kanthal AE is a ferritic iron-chromium-aluminium alloy (FeCrAl alloy) suitable for use at temperatures up to 1300ºC (2370ºF). The alloy has exceptional form stability and life in spirals with large coil to wire diameter ratio.

Kanthal AE has been developed for conditions of extreme surface loads in fine wire dimensions. It contains trace elements which provides for an extremely well adhering oxide with good emissivity properties.

Typical applications for Kanthal AE are in fast-response elements for ceramic glass top hobs and quartz tube heaters. Due to the dense and well adhering oxide, the alloy is also suitable for applications using close wound coils.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Fe %
Nominal composition					5.3	Bal.
Min	-	-	-	20.5	-	
Max	0.08	0.7	0.4	23.5	-	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	MPa	MPa	%	Hv
1.0	520	720	20	230

Mechanical properties at elevated temperature

Temperature °C	900
MPa	34

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800
MPa	1.2

Physical properties

Density g/cm³	7.15
Electrical resistivity at 20°C Ω mm²/m	1.39
Poisson's ratio	0.30

Young's modulus

Temperature °C	**20**	**100**	**200**	**400**	**600**	**800**	**1000**
GPa	220	210	205	190	170	150	130

Temperature factor of resistivity

Temperature°C	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**
Ct	1.00	1.01	1.01	1.02	1.03	1.04	1.04	1.05	1.05	1.06	1.06	1.06	1.06

Coefficient of thermal expansion

Temperature °C	**Thermal Expansion x 10^{-6}/K**
20 - 250	11
20 - 500	12
20 - 750	14
20 - 1000	15

Thermal conductivity

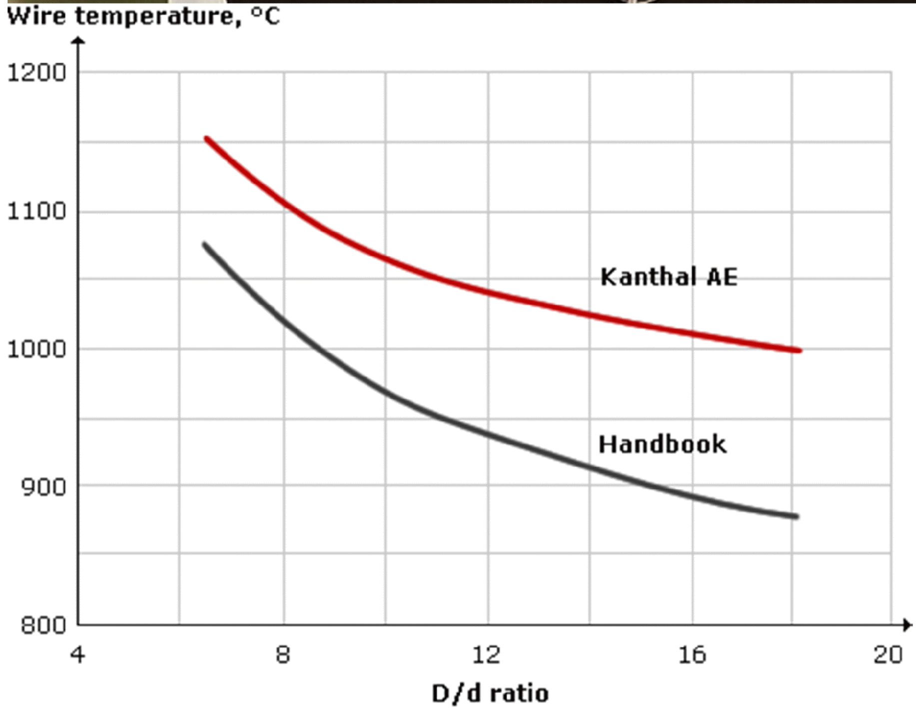
Temperature °C	**50**	**600**	**800**	**1000**	**1200**
$W\ m^{-1}\ K^{-1}$	11	20	22	26	27

Specific heat capacity

Temperature °C	**20**	**200**	**400**	**600**	**800**	**1000**	**1200**
$kJ\ kg^{-1}\ K^{-1}$	0.46	0.56	0.63	0.75	0.71	0.72	0.74

Melting point °C	1500
Max continuous operating temperature in air °C	1300
Magnetic properties	The material is magnetic up to approximately 600°C (Curie point).
Emissivity - fully oxidized material	0.70

Maximum permissible wire temperature versus coil to wire diameter ratio in supported elements of KANTHAL AE


Wire temperature, °C
1200
1100
1000
900
800
Kanthal AE
Handbook
4
8
12
16
20
D/d ratio

Kanthal AF

Kanthal AF is a high-temperature ferritic iron-chromium-aluminium alloy (FeCrAl alloy) suitable for use at temperatures up to 1300°C (2370°F). The alloy is characterized by excellent oxidation and life properties in combination with good form stability properties.
Kanthal AF is typically used in electrical heating elements in industrial furnaces and in the appliance industry.
Example of applications in the appliance industry are in open mica elements for toasters, hair dryers, in meander shaped elements for fan heaters and as open coil elements on fibre insulating material in ceramic glass top heaters in ranges, in ceramic heaters for boiling plates, coils on molded ceramic fibre for cooking plates with ceramic hobs, in suspended coil elements for fan heaters, in suspended straight wire elements for radiators, convection heaters, in porcupine elements for hot air guns, radiators, tumble dryers.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Fe %
Nominal composition					5.3	Bal.
Min	-	-	-	20.5	-	
Max	0.08	0.7	0.4	23.5	-	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	$R_{p0.2}$	R_m	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	500	700	23	230
4.0	475	680	18	230

Mechanical properties at elevated temperature

Temperature °C	900	1000	1100	1200	1300
MPa	37	20	12	6	4

Ultimate tensile strength - deformation rate 6.2 x 10^{-2} /min

Creep strength - 1% elongation in 1000 h

Temperature °C	1100	1200
MPa	1.7	0.3

Physical properties

Density g/cm³	7.15
Electrical resistivity at 20°C Ω mm²/m	1.39
Poisson's ratio	0.30

Young's modulus

Temperature °C	**20**	**100**	**200**	**400**	**600**	**800**	**1000**
GPa	220	210	205	190	170	150	130

Temperature factor of resistivity

Temperature°C	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**
Ct	1.00	1.01	1.01	1.02	1.03	1.04	1.04	1.05	1.05	1.06	1.06	1.06	1.06

Coefficient of thermal expansion

Temperature °C	**Thermal Expansion x 10^{-6}/K**
20 - 250	11
20 - 500	12
20 - 750	14
20 - 1000	15

Thermal conductivity

Temperature °C	**50**	**600**	**800**	**1000**	**1200**
W m^{-1} K^{-1}	11	20	22	26	27

Specific heat capacity

Temperature °C	**20**	**200**	**400**	**600**	**800**	**1000**	**1200**
kJ kg^{-1} K^{-1}	0.46	0.56	0.63	0.75	0.71	0.72	0.74

Melting point °C	1500
Max continuous operating temperature in air °C	1300
Magnetic properties	The material is magnetic up to approximately 600°C (Curie point).
Emissivity - fully oxidized material	0.70

Kanthal APM

Kanthal APM is an advanced powder-metallurgical, dispersion-strengthened, ferritic iron-chromium-aluminium alloy (FeCrAl alloy) suitable for use at temperatures up to 1425°C (2600°F).

Kanthal APM has good hot strength, giving good form stability of the heating elements with less need for element support. It has low tendency to ageing, low resistance change and long element life. Kanthal APM has an excellent surface oxide, which gives good protection in corrosive atmospheres as well as in atmospheres with high carbon potential, and no scaling. The combination of excellent oxidation properties and formstability makes the alloy unique.

Typical applications for Kanthal APM are in high temperature furnaces for firing of ceramics, heat treatment, in laboratory furnaces, in furnaces for electronic industries and in diffusion furnaces.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Fe %
Nominal composition					5.8	Bal.
Min	-	-	-	20.5	-	
Max	0.08	0.7	0.4	23.5	-	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
4.0	470	680	20	230

Mechanical properties at elevated temperature

Temperature °C	900	1000	1100	1200	1300
MPa	40	23	16	12	9

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	900
MPa	8.2	3.5

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Creep strength - 0.1% elongation in 1000 h

Temperature °C	1100	1200	1300	1400
MPa	2.3	1.2	0.7	0.4

Creep rupture strength

Time	800°C	1472°F	1000°C	1832°F	1200°C	2192°F	1400°C	2552°F
h	MPa	psi	MPa	psi	MPa	psi	MPa	psi
100	15.0	2176	5.6	812	3.3	478	1.3	189
1000	11.3	1640	3.4	478	1.6	232	0.5	72
10000	8.2	1190	2.2	320	0.7	100	0.2	30

The data in the tables apply to material with fine grain structure in the temperature range from 800°C to 900°C,
and to material with coarse grain structure in the temperature range from 1100°C to 1400°C.
In the delivery state KANTHAL APM always has a fine grain structure. After use for a certain period of time , the grain size becomes coarse.

Physical properties

Density g/cm^3	7.10
Electrical resistivity at 20°C Ω mm^2/m	1.45
Poisson's ratio	0.30

Young's modulus

Temperature °C	20	100	200	400	600	800	1000
GPa	220	210	205	190	170	150	130

Temperature factor of resistivity

Temperature°C	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
Ct	1.00	1.00	1.00	1.00	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.05

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x $10^{-6}/K$
20 - 250	11
20 - 500	12
20 - 750	14

20 - 1000	15
20-1200	16
20-1400	16

Thermal conductivity

Temperature °C	50	600	800	1000	1200	1400
$W\ m^{-1}\ K^{-1}$	11	20	22	26	27	35

Specific heat capacity

Temperature °C	20	200	400	600	800	1000	1200	1400
$kJ\ kg^{-1}\ K^{-1}$	0.46	0.56	0.63	0.75	0.71	0.72	0.74	0.80

Melting point °C	1500
Max continuous operating temperature in air °C	1425
Magnetic properties	The material is magnetic up to approximately 600°C (Curie point).
Emissivity - fully oxidized material	0.70

Kanthal APM, construction materials

Kanthal APM is an advanced powder-metallurgical, dispersion-strengthened, ferritic iron-chromium-aluminium alloy (FeCrAl alloy) for furnace temperatures up to 1250°C (2282°F).

The alloy offers a unique combination of excellent oxidation properties and form stability at high temperatures. Kanthal APM forms an excellent, non-scaling surface oxide, which gives good protection in most furnace environments, i.e. oxidizing, sulpidizing and carburizing gas, as well as against deposits of carbon, ash, etc.

Typical applications for Kanthal APM wire are in high-temperature structural parts in furnaces such as mesh belts, loaders, mounting systems for elements or insulation and loading baskets.

Chemical composition

	C %	Si %	Mn %	Mo %	Cr %	Al %	Fe %
Nominal composition	0.08	-	-	3.0	21.0	5.0	Balance
Min		0.7	0.4		20.5	-	
Max					23.5	-	

Mechanical properties

Wire size Ø	Yield strength $R_{p0.2}$	Tensile strength R_m	Elongation A	Hardness
mm	**MPa**	**MPa**	**%**	**Hv**
4.0	470	680	20	230

Mechanical properties at elevated temperature

Temperature °C	900	1000	1100	1200	1300
MPa	40	23	16	12	9

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	900
MPa	8.2	3.5

Creep strength - 0.1% elongation in 1000 h

Temperature °C	1100	1200	1300	1400
MPa	2.3	1.2	0.7	0.4

Creep rupture strength

Time	800°C / 1472°F		1000°C / 1832°F		1200°C / 2192°F		1400°C / 2552°F	
h	MPa	psi	MPa	psi	MPa	psi	MPa	psi
100	15.0	2176	5.6	812	3.3	478	1.3	189
1000	11.3	1640	3.4	478	1.6	232	0.5	72
10000	8.2	1190	2.2	320	0.7	100	0.2	30

The data in the tables apply to material with fine grain structure in the temperature range from 800°C to 900°C, and to material with coarse grain structure in the temperature range from 1100°C to 1400°C.
In the delivery state KANTHAL APM always has a fine grain structure. After use for a certain period of time, the grain size becomes coarse.

Physical properties

Density g/cm³	7.10
Electrical resistivity at 20°C Ω mm²/m	1.45
Poisson's ratio	0.30

Young's modulus

Temperature °C	20	100	200	400	600	800	1000
GPa	220	210	205	190	170	150	130

Temperature factor of resistivity

Temperature °C	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
Ct	1.00	1.00	1.00	1.00	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.05

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6} /K
20 - 250	11
20 - 500	12
20 - 750	14

20 - 1000	15
20-1200	16
20-1400	16

Thermal conductivity

Temperature °C	**50**	**600**	**800**	**1000**	**1200**	**1400**
W/(m K)	11	20	22	26	27	35

Specific heat capacity

Temperature °C	**20**	**200**	**400**	**600**	**800**	**1000**	**1200**	**1400**
kJ/(kg K)	0.46	0.56	0.63	0.75	0.71	0.72	0.74	0.80

Melting point °C	1500
Max continuous operating temperature in air °C	1425
Magnetic properties	The material is magnetic up to approximately 600°C (Curie point)
Emissivity - fully oxidized material Ɛ	0.70

Kanthal APMT

Kanthal APMT is an advanced powder-metallurgical, dispersion-strengthened, ferritic iron-chromium-aluminium alloy (FeCrAl alloy) with an addition of molybdenum. It is suitable for furnace temperatures up to 1250°C (2282°F).

Kanthal APMT offers a unique combination of excellent oxidation properties and form stability at high temperatures. The material forms an excellent, non-scaling surface oxide, which gives good protection in most furnace environments, i.e. oxidizing, sulpidizing and carburizing gas, as well as against deposits of carbon, ash, etc.

Typical applications for Kanthal APMT wire are in high-temperature structural parts in furnaces such as mesh belts, loaders, mounting systems for elements or insulation and loading baskets.

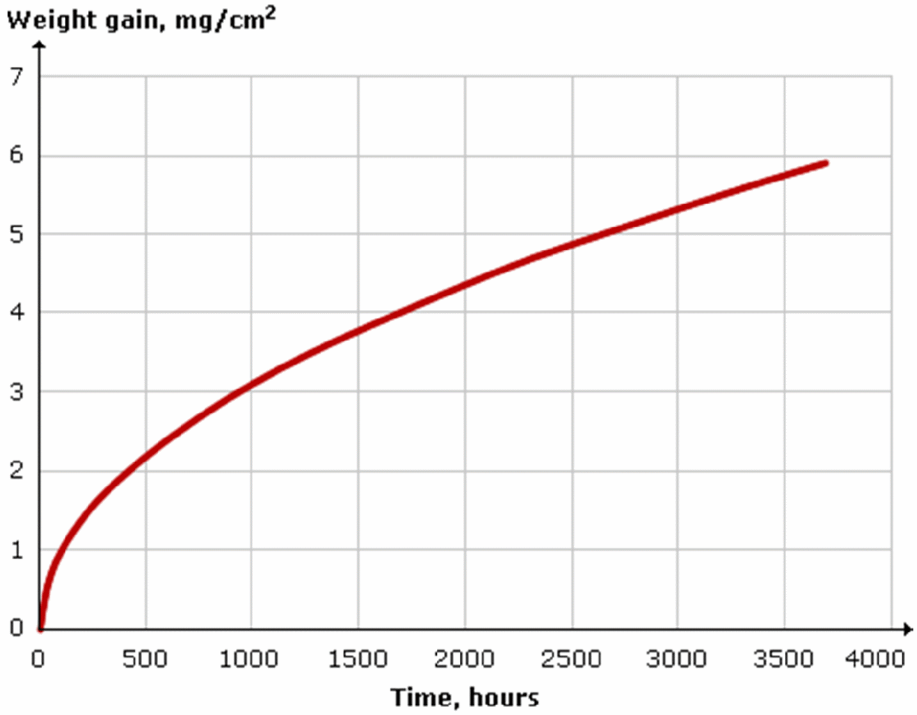
Chemical composition

	C %	Si %	Mn %	Mo %	Cr %	Al %	Fe %
Nominal composition				3.0	21.0	5.0	Balance
Min	-	-	-		20.5	-	
Max	0.08	0.7	0.4		23.5	-	

Corrosion resistance

Max recommended continuous operating temperature in air ºC 1250
Protective surface oxide Al_2O_3

Oxidation rate



Mechanical properties

Wire dimension Ø mm	Yield strength $R_{p0.2}$ MPa	Tensile strength R_m MPa	Elongation A %	Hardness Hv
1	730	961	14	
4	630	852	19	

Remark: The samples are taken in the longitudinal direction from tube in delivery condition.

Mechanical properties at elevated temperature

Temperature °C	600	800	1000	1200
MPa	420	120	42	16

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	1000	1100	1200
MPa	16	6.5	2.5	1.0

Secondary creep rate at various stress levels

Creep rate	Temperature/ Stress			
s^{-1}	800°C MPa	1000°C MPa	1100°C MPa	1200°C MPa
$1.0\ e^{-10}$	17	4	1.5	0.5
$1.0\ e^{-8}$	23	7.5	3	1.3
$1.0\ e^{-6}$	30	10.3	6	3

Creep rupture strength

Time	Temperature/ Stress			
h	800°C MPa	1000°C MPa	1100°C MPa	1200°C MPa
100	28	10	4	2.8
1000	21	7	3.2	1.6
10000	18	5	2	0.9

Physical properties

Density g/cm^3	7.25

Electrical resistivity at 20°C mm^2/m	1.40
Poisson's ratio	0.30

Young's modulus

Temperature °C	20	100	200	400	600	800	1000
GPa	220	210	205	190	170	150	130

Coefficient of thermal expansion

Temperature °C	20 - 250	20 - 500	20 - 750	20 - 1000	20 - 1200
CTE x 10^{-6}/K	12.4	13.1	13.6	14.7	15.4

Thermal conductivity

Temperature °C	50	600	800	1000	1200
W/(m K)	11	21	23	27	29

Specific heat capacity

Temperature °C	20	200	400	600	800	1000	1200
kJ/(kg K)	0.48	0.56	0.64	0.71	0.67	0.69	0.70

Melting point °C	1500
Magnetic properties	Ferromagnetic, Curie point approximately 600°C.

Emissivity - fully oxidized material ε	0.70

Temperature factor of resistivity

Temperature °C	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
C_t	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.02	1.03	1.03	1.03	1.03	1.04

Kanthal D

Kanthal D is a ferritic iron-chromium-aluminium alloy (FeCrAl alloy) suitable for use at temperatures up to 1300°C (2370°F). The alloy is used in home appliances as well as in industrial applications.

Typical applications in home appliances include metal sheathed tubular elements for dishwashers, elements embedded in ceramics for panel heaters, cartridge elements in metal dies, heating cables and rope heaters in defrosting and deicing elements, mica elements used in irons, quartz tube heaters for space heating, industrial infrared dryers, in coils on molded ceramic fibre for boiling plates with ceramic hobs, in bead insulated coils for panel heaters, in suspended coil elements for air heaters in laundry dryers.

In industrial applications Kanthal D is used in, for example, terminals to furnace elements, porcupine elements for air heating, and in furnace heating elements.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Fe %
Nominal composition					4.8	Bal.
Min	-	-	-	20.5	-	
Max	0.08	0.7	0.5	23.5	-	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	$R_{p0.2}$	R_m	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	485	670	23	230
4.0	450	650	18	230

Mechanical properties at elevated temperature

Temperature °C	900
MPa	34

Ultimate tensile strength - deformation rate 6.2×10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	900

MPa	1.2	0.5

Physical properties

Density g/cm³	7.25
Electrical resistivity at 20°C Ω mm²/m	1.35
Poisson's ratio	0.30

Young's modulus

Temperature °C	20	100	200	400	600	800	1000
GPa	220	210	205	190	170	150	130

Temperature factor of resistivity

Temperature°C	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Ct	1.00	1.01	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.07	1.07	1.08	1.08

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 250	11
20 - 500	12
20 - 750	14
20 - 1000	15

Thermal conductivity

Temperature °C	50	600	800	1000	1200
W m^{-1} K^{-1}	11	20	22	26	27

Specific heat capacity

Temperature °C	20	200	400	600	800	1000	1200
kJ kg^{-1} K^{-1}	0.46	0.56	0.63	0.75	0.71	0.72	0.74

Melting point °C	1500

Max continuous operating temperature in air °C	1300
Magnetic properties	The material is magnetic up to approximately 600°C (Curie point).
Emissivity - fully oxidized material	0.70

Kanthal LT

Kanthal LT is a ferritic iron-chromium-aluminium alloy (FeCrAl alloy) suitable for use at temperatures up to which 1100°C (2010°F).

Kanthal LT has been developed for low-temperature applications and can replace all low-temperature materials in home appliance applications.

The alloy is typically used in home appliances.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Fe %
Nominal composition					3.8	Bal.
Min	-	-	-	17.0	-	
Max	0.08	0.7	0.5	21.0	-	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	$R_{p0.2}$	R_m	A	
mm	MPa	MPa	%	Hv
1.0	550	750	16	230

Mechanical properties at elevated temperature

Temperature °C	900
MPa	34

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	1000
MPa	1.2	0,5

Physical properties

Density g/cm³	7.30
Electrical resistivity at 20°C Ω mm²/m	1.23

Poisson's ratio	0.30

Young's modulus

Temperature °C	**20**	**100**	**200**	**400**	**600**	**800**	**1000**
GPa	220	210	205	190	170	150	130

Temperature factor of resistivity

Temperature°C	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
Ct	1.00	1.02	1.03	1.04	1.05	1.08	1.09	1.10	1.11	1.11	1.12

Coefficient of thermal expansion

Temperature °C	**Thermal Expansion x 10^{-6}/K**
20 - 250	11
20 - 500	12
20 - 750	14
20 - 1000	15

Thermal conductivity

Temperature °C	**20**
W m^{-1} K^{-1}	16

Specific heat capacity

Temperature °C	**20**
kJ kg^{-1} K^{-1}	0.46

Melting point °C	1500
Max continuous operating temperature in air °C	1100
Magnetic properties	The material is magnetic up to approximately 600°C (Curie point).
Emissivity - fully oxidized material	0.70

Kanthal SW 010

General description

Kanthal SW 010 is a ferritic FeCrAl alloy wire developed for use in Arc and Flame Spray systems. The wire produces dense, well bonding coatings, resistant to high temperature oxidation and corrosion.

Typical applications are as bond coats in high temperature coating systems, protective coatings in high temperature atmospheres containing sulphur or carbon, protective coatings against scaling of conventional low alloy steels.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Fe %
Nominal composition						Bal.
Min	-	-	-	20.5	5.3	
Max	0.08	0.7	0.4	23.5	6.3	

Machining

Depending of surface finish requirements, the coating may be machined by turning or grinding. For rougher surface, turning using carbide tools, light cuts and efficient cooling to avoid overheating is recommended. Grinding in fine steps using cooling, light pressure and clean wheels gives smoother finish.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	$R_{p0.2}$	R_m	A
mm	MPa	MPa	%
1.6	830	930	5

Physical properties

Density g/cm³	7.10
Electrical resistivity at 20°C Ω mm²/m	1.45
Melting point	1500 °C
Magnetic Properties	The material is magnetic up to approximately 600 °C (the Curie point).
Dimension tolerance mm	+ 0/-0.05

Young's Modulus

Temperature °C	20
GPa	220

Typical coating properties

Summary of results obtained when spraying with a conventional Arc Spray gun, using varying spraying parameters.

Deposition efficiency (%)	62-78
Hardness HV (300g)	165-280
Surface roughness (µm)	11-16
Porosity (%)	1-6*
Oxides (%)	5-20*

*) These results are obtained when using air as spraying gas. Also nitrogen has been used, resulting in lower rates of porosity and oxides.

Safety

Personnel working with thermal spraying should be aware of the hazards connected to the process. They should be familiar with the use of equipment regarding, i.e. eye, skin, hearing and respiratory protection.

Personnel should be familiar with safety regulations regarding the complete process, including spraying and the spray equipment used. This product contains elements, which in certain combinations may be dangerous to your health. Material Safety Data Sheets are provided by Kanthal for this product, and should be read and understood before using the material.

Not following these instructions may danger your health.

Kanthal SW 030

General description

Kanthal SW 030 is a ferritic FeCrAl alloy wire developed for use in Arc and Flame Spray systems. The wire produces dense, well bonding coatings, resistant to high temperature oxidation.

Typical applications are as bond coats in high temperature coating systems, protective coatings against sulphur containing atmospheres, protective coatings against scaling of conventional low alloy steels.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Fe %
Nominal composition						Bal.
Min	-	-	-	20.5	4.3	
Max	0.08	0.7	0.5	23.5	5.2	

Machining

Depending of surface finish requirements, the coating may be machined by turning or grinding. For rougher surface, turning using carbide tools, light cuts and efficient cooling to avoid overheating is recommended. Grinding in fine steps using cooling, light pressure and clean wheels gives smoother finish.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	$R_{p0.2}$	R_m	**A**
mm	**MPa**	**MPa**	**%**
1.6	720	840	6

Physical properties

Density g/cm³	7.25
Electrical resistivity at 20°C Ω mm²/m	1.35
Melting point °C	1500
Magnetic properties	The material is magnetic up to approximately 600 °C (the Curie point).
Dimension tolerance mm	+0/-0.05

Young's Modulus

Temperature °C	**20**

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GPa	220

Typical coating properties

Summary of results obtained when spraying with a conventional Arc Spray gun, using varying spraying parameters.

Deposition efficiency (%)	65-75
Hardness HV (300g)	160-270
Surface roughness (µm)	12-17
Porosity (%)	1-6*
Oxides (%)	5-15*

*) These results are obtained when using air as spraying gas. Also nitrogen has been used, resulting in lower rates of porosity and oxides.

Safety

Personnel working with thermal spraying should be aware of the hazards connected to the process. They should be familiar with the use of equipment regarding, i.e. eye, skin, hearing and respiratory protection.

Personnel should be familiar with safety regulations regarding the complete process, including spraying and th spray equipment used. This product contains elements, which in certain combinations may be dangerous to your health. Material Safety Data Sheets are provided by Kanthal for this product, and should be read and understood before using the material.

Not following these instructions may danger your health.

Kanthal SW 100

General description

Kanthal SW 100 is a ferritic FeCrAlY alloy wire developed for use in Arc and Flame Spray systems. The trace elements added in this alloy improve the sprayed coatings protective properties. The wire produces dense, well bonding coatings, resistant to high temperature oxidation.

Typical applications are as bond coats in high temperature coating systems, protective coatings against sulphur or carbon containing atmospheres, protective coatings against scaling of conventional low alloy steels.

Chemical composition

	C %	Si %	Mn %	Cr %	Al %	Trace Elements	Fe %
Nominal composition						Y	Bal.
Min	-	-	-	20.5	4.7	-	
Max	0.08	0.7	0.4	23.5	5.7	-	

Machining

Depending of surface finish requirements, the coating may be machined by turning or grinding. For rougher surface, turning using carbide tools, light cuts and efficient cooling to avoid overheating is recommended. Grinding in fine steps using cooling, light pressure and clean wheels gives smoother finish.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	**$R_{p0.2}$**	**R_m**	**A**
mm	**MPa**	**MPa**	**%**
1.6	800	880	5

Physical properties

Density g/cm³	7.15
Electrical resistivity at 20°C Ω mm²/m	1.39
Melting point °C	1500
Magnetic properties	The material is magnetic up to approximately 600 °C (the Curie point).
Dimension tolerance mm	+ 0/-0.05

Young's Modulus

Temperature °C	**20**
GPa	220

Typical coating properties

Summary of results obtained when spraying with a conventional Arc Spray gun, using varying spraying parameters.

Deposition efficiency (%)	**70-80**
Hardness HV (300g)	**170-270**
Surface roughness (µm)	**8-18**
Porosity (%)	**1-6***
Oxides (%)	**3-14***

*) These results are obtained when using air as spraying gas. Also nitrogen has been used, resulting in lower rates of porosity and oxides.

Safety

Personnel working with thermal spraying should be aware of the hazards connected to the process. They should be familiar with the use of equipment regarding, i.e. eye, skin, hearing and respiratory protection.

Personnel should be familiar with safety regulations regarding the complete process, including spraying and th spray equipment used. This product contains elements, which in certain combinations may be dangerous to your health. Material Safety Data Sheets are provided by Kanthal for this product, and should be read and understood before using the material.

Not following these instructions may danger your health.

Disclaimer: Recommendations are for guidance only, and the suitability of a material for a specific application can be confirmed only when we know the actual service conditions. Continuous development may necessitate changes in technical data without notice. This datasheet is only valid for Kanthal materials.

Kanthal SW 200

General description

Kanthal SW 200 is an austenitic NiCr alloy developed for use in Arc and Flame Spray systems. The wire produces dense, well bonding coatings resistant to high temperature oxidation.

Typical applications are as protective coatings against corrosive gases, protection against scaling of conventional low alloy steels, build up coatings for dimensional restoration.

Chemical composition

	C %	Si %	Mn %	Cr %	Fe %	Ni %
Nominal composition						Bal.
Min	-	1.0	-	19.0	-	-
Max	0.10	1.7	1.0	21.0	2.0	-

Machining

Depending of surface finish requirements, the coating may be machined by turning or grinding. For rougher surface, turning using carbide tools, light cuts and efficient cooling to avoid overheating is recommended. Grinding in fine steps using cooling, light pressure and clean wheels gives smoother finish.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	**$R_{p0.2}$**	**R_m**	**A**
mm	**MPa**	**MPa**	**%**
1.6	950	1030	6

Physical properties

Density g/cm³	8.30
Electrical resistivity at 20°C Ω mm²/m	1.09
Melting point °C	1400
Magnetic Properties	Non magnetic
Dimension tolerance mm	+ 0/-0.05

Typical coating properties

Summary of results obtained when spraying with a conventional Arc Spray gun, using varying spraying parameters.

Deposition efficiency (%)	65-75
Hardness HV (300g)	170-280
Surface roughness (µm)	5-15
Porosity (%)	2-5
Oxides (%)	8-30

Safety

Personnel working with thermal spraying should be aware of the hazards connected to the process. They should be familiar with the use of equipment regarding, i.e. eye, skin, hearing and respiratory protection.

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Kanthal SW 210

General description

Kanthal SW 210 is an austenitic NiFeCr alloy developed for use in Arc and Flame Spray systems. The wire produces dense, well bonding coatings resistant to high temperature oxidation.

Typical applications are protective coatings against corrosive gases, protection against scaling of conventional low alloy steels, build up coatings for dimensional restoration.

Chemical composition

	C %	Si %	Mn %	Cr %	Ni %	Fe %
Nominal composition						Bal.
Min	-	1.0	-	14.0	57	-
Max	0.10	1.7	1.0	18.0	60	-

Machining

Depending of surface finish requirements, the coating may be machined by turning or grinding. For rougher surface, turning using carbide tools, light cuts and efficient cooling to avoid overheating is recommended. Grinding in fine steps using cooling, light pressure and clean wheels gives smoother finish.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	**$R_{p0.2}$**	**R_m**	**A**
mm	**MPa**	**MPa**	**%**
1.6	830	930	5

Physical properties

Density g/cm^3	8.20
Electrical resistivity at 20°C Ω mm^2/m	1.11
Melting point °C	1390
Magnetic Properties	Slightly magnetic
Dimension tolerance mm	+ 0/-0.05

Typical coating properties

Summary of results obtained when spraying with a conventional Arc Spray gun, using varying spraying parameters.

Deposition efficiency (%)	60-70
Hardness HV (300g)	160-230
Surface roughness (µm)	10-15
Porosity (%)	2-5
Oxides (%)	10-23

Safety

Personnel working with thermal spraying should be aware of the hazards connected to the process. They should be familiar with the use of equipment regarding, i.e. eye, skin, hearing and respiratory protection.

Personnel should be familiar with safety regulations regarding the complete process, including spraying and the spray equipment used. This product contains elements, which in certain combinations may be dangerous to your health. Material Safety Data Sheets are provided by Kanthal for this product, and should be read and understood before using the material.

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Kanthal SW 230

General description

Kanthal SW 230 is an austenitic FeNiCr alloy developed for use in Arc and Flame Spray systems. The wire produces dense, well bonding coatings resistant to high temperature oxidation.

Typical applications are protective coatings against corrosive gases, protection against scaling of conventional low alloy steels, build up coatings for dimensional restoration.

Chemical composition

	C %	Si %	Mn %	Cr %	Ni %	Fe %
Nominal composition						Bal.
Min	-	1.6	-	18.0	34	-
Max	0.10	2.5	1.0	21.0	37	-

Machining

Depending of surface finish requirements, the coating may be machined by turning or grinding. For rougher surface, turning using carbide tools, light cuts and efficient cooling to avoid overheating is recommended. Grinding in fine steps using cooling, light pressure and clean wheels gives smoother finish.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	$R_{p0.2}$	R_m	**A**
mm	**MPa**	**MPa**	**%**
1.6	860	950	6

Physical properties

Density g/cm^3	7.90
Electrical resistivity at 20°C Ω mm^2/m	1.04
Melting point °C	1390
Magnetic Properties	Non magnetic
Dimension tolerance mm	+ 0/-0.05

Typical coating properties

Summary of results obtained when spraying with a conventional Arc Spray gun, using varying spraying parameters.

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Deposition efficiency (%)	60-75
Hardness HV (300g)	160-240
Surface roughness (µm)	10-15
Porosity (%)	2-5
Oxides (%)	10-20

Safety

Personnel working with thermal spraying should be aware of the hazards connected to the process. They should be familiar with the use of equipment regarding, i.e. eye, skin, hearing and respiratory protection.

Personnel should be familiar with safety regulations regarding the complete process, including spraying and the spray equipment used. This product contains elements, which in certain combinations may be dangerous to your health. Material Safety Data Sheets are provided by Kanthal for this product, and should be read and understood before using the material.

Kanthal SW 782

General description

Kanthal SW 782 is an austenitic FeNi alloy wire developed for use in Arc and Flame Spray systems. The alloy has low resistivity and a high temperature coefficient of resistance.

Typical applications are as a coating in moulds in glass industry, or as a build up coating for dimensional restoration.

Chemical composition

	Ni %	Fe %
Nominal composition	52.0	Bal.

Machining

Depending of surface finish requirements, the coating may be machined by turning or grinding. For rougher surface, turning using carbide tools, light cuts and efficient cooling to avoid overheating is recommended. Grinding in fine steps using cooling, light pressure and clean wheels gives smoother finish.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	$R_{p0.2}$	R_m	A
mm	MPa	MPa	%
1.6	670	730	7

Physical properties

Density g/cm^3	8.20
Electrical resistivity at 20°C $\Omega\ mm^2/m$	0.37
Melting point °C	1435
Magnetic Properties	Magnetic up to approx. 530 °C (Curie point)
Dimension tolerance mm	+ 0/-0.05

Typical coating properties

Summary of results obtained when spraying with a conventional Arc Spray gun, using varying spraying parameters.

Deposition efficiency (%)	65-78
Hardness HV (300g)	130-215
Surface roughness (µm)	7-13

Porosity (%)	1-5*
Oxides (%)	15-22*

*) These results are obtained when using air as spraying gas. Also nitrogen has been used, resulting in lower rates of porosity and oxides.

Safety

Personnel working with thermal spraying should be aware of the hazards connected to the process. They should be familiar with the use of equipment regarding, i.e. eye, skin, hearing and respiratory protection.

Personnel should be familiar with safety regulations regarding the complete process, including spraying and th spray equipment used. This product contains elements, which in certain combinations may be dangerous to your health. Material Safety Data Sheets are provided by Kanthal for this product, and should be read and understood before using the material.

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Kanthal SW 806

General description

Kanthal SW 806 is an austenitic NiAl alloy wire developed for use in Arc and Flame Spray systems. The wire produces dense, well bonding coatings.

Typical applications are as bond coats, as protective coatings against high temperature oxidation, protective coatings against scaling of conventional iron base alloys, and as build up coatings for dimensional restoration.

Chemical composition

	Al %	Ni %
Nominal composition		Bal.
Min	4.5	
Max		

Machining

Depending of surface finish requirements, the coating may be machined by turning or grinding. For rougher surface, turning using carbide tools, light cuts and efficient cooling to avoid overheating is recommended. Grinding in fine steps using cooling, light pressure and clean wheels gives smoother finish.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	**$R_{p0.2}$**	**R_m**	**A**
mm	**MPa**	**MPa**	**%**
1.6	780	850	7

Physical properties

Density g/cm^3	8.20
Electrical resistivity at 20°C Ω mm^2/m	0.42
Melting point °C	1430
Magnetic Properties	Non magnetic
Dimension tolerance mm	+ 0/-0.05

Typical coating properties

Summary of results obtained when spraying with a conventional Arc Spray gun, using varying spraying parameters.

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Deposition efficiency (%)	60-70
Hardness HV (300g)	180-250
Surface roughness (µm)	15-28
Porosity (%)	3-7*
Oxides (%)	10-25*

*) These results are obtained when using air as spraying gas. Also nitrogen has been used, resulting in lower rates of porosity and oxides.

Safety

Personnel working with thermal spraying should be aware of the hazards connected to the process. They should be familiar with the use of equipment regarding, i.e. eye, skin, hearing and respiratory protection.

Personnel should be familiar with safety regulations regarding the complete process, including spraying and th spray equipment used. This product contains elements, which in certain combinations may be dangerous to your health. Material Safety Data Sheets are provided by Kanthal for this product, and should be read and understood before using the material.

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Kanthal SW 821

General description

Kanthal SW 821 is a copper-nickel alloy wire developed for use in Arc and Flame Spray systems. The wire produces dense, well bonding coatings. The coatings are resistant against corrosion, typically used in marine and certain chemical applications.

Chemical composition

	Ni %	Si %	Mn %	Fe %	Cu %
Nominal composition					Bal.
Min	63	-	-		
Max		0.5	1.25	2.50	

Machining

Depending of surface finish requirements, the coating may be machined by turning or grinding. For rougher surface, turning using carbide tools, light cuts and efficient cooling to avoid overheating is recommended. Grinding in fine steps using cooling, light pressure and clean wheels gives smoother finish.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	$R_{p0.2}$	R_m	**A**
mm	**MPa**	**MPa**	**%**
1.6	577	626	8

Physical properties

Density g/cm^3	8.8
Melting point °C	1350
Magnetic Properties	The material is slightly magnetic at room temperature
Dimension tolerance mm	+ 0/-0.05

Young's Modulus

Temperature °C	**20**
GPa	178

Typical coating properties

Properly sprayed the wire produces dense, well bonding coatings for oxidation and corrosion protection.

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Safety

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Personnel should be familiar with safety regulations regarding the complete process, including spraying and the spray equipment used. This product contains elements, which in certain combinations may be dangerous to your health. Material Safety Data Sheets are provided by Kanthal for this product, and should be read and understood before using the material.

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Manganina 43

Manganina 43 is a copper-manganese-nickel alloy (CuMnNi alloy) with very low thermal electromotive force (emf) compared to copper. The components, in which Manganina 43 is used, is normally operating at room temperature.

Manganina 43 is used for the manufacturing of resistance standards, precision wire wound resistors, potentiometers, shunts and other electrical and electronic components.

The alloy's low emf vs. copper makes it ideal for use in electrical circuits, especially D.C., where a spurious thermal emf could cause malfunctioning of electronic equipment. Due to the low operating temperature, the temperature coefficient of resistance is controlled to be low over a range of 15°C to 35°C.

Chemical composition

	Ni %	Mn %	Cu %
Nominal composition	4.0	11.0	Bal.

Mechanical properties

Wire size	Yield Strength	Tensile Strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.00	180	390	30	110

Physical properties

Density g/cm^3	8.4
Electrical resistivity at 20°C Ω mm^2/m	0.43
Temperature coefficient of resistance (15 - 35 °C) (x 10^{-6}/K)	0 ± 15

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 100	18

Thermal conductivity

Temperature °C	20
W m^{-1} K^{-1}	22

Specific heat capacity

Temperature °C	20
kJ kg^{-1} K^{-1}	0.410

Melting point °C	1020
Max continuous operating temperature in air °C	Room temperature
Magnetic properties	The material is non-magnetic

Nicrosil

Nicrosil is an alloy used for the positive leg of thermocouple type N. It offers higher thermoelectric stability in air above 1000°C (1830°F) and a better oxidation resistance in air than type E, J and K thermocouples.

Nicrosil alloy cannot be exposed to reducing or alternatively oxidizing and reducing atmospheres or to vacuum. This thermocouple is the most recent one among the different types covered by the international standards.

Chemical composition

	Ni %	Cr %	Si %
Nominal composition	Bal.	14.2	1.5

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	**$R_{p0.2}$**	**R_m**	**A**
mm	**MPa**	**MPa**	**%**
2.0	310	800	35

Physical properties

Density g/cm^3	8.53
Electrical resistivity at 20°C Ω mm^2/m	1.00
Temperature coefficient of resistance between 20°C and 100°C x 10^{-6}/K	90

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 100	17

Thermal conductivity

Temperature °C	20
W m^{-1} K^{-1}	13

Melting point °C	1420
Magnetic properties	The material is non-magnetic

Recommended maximum continuous operating temperature

Wire size Ø	3.26	1.63	1.00	0.50	0.25
Bare wire °C	1100	1010	960	890	800
Protected wire °C	1250	1180	1110	1000	910

Note that the indicated temperatures should be considered as guide values

Thermoelectric properties

Nominal emf values vs Nisil

Temp °C	mV
100	2.774
200	5.913
300	9.341
400	12.974
500	16.748
600	20.613
700	24.527
800	28.455
900	32.371
1000	36.256
1100	40.087
1200	43.846
1300	47.513

ITS 90 - Reference junction 0°C

Nifethal 42

Nifethal 42 is a nickel-iron alloy (NiFe alloy) with a quite low and constant thermal expansion factor up to 300°C (570°F). The alloy is suitable for use at temperatures up to 600°C (1110°F).
Typical applications for Nifethal 42 are in high-temperature thermostats in, for example, gas and electric stoves.

Chemical composition

	Ni %	Fe %
Nominal composition	42.0	Bal.

Mechanical properties

Wire size	Tensile strength
Ø	**R_m**
mm	MPa
5.8	Min 700

Physical properties

Density g/cm^3	8.12
Electrical resistivity at 20°C Ω mm^2/m	0.63

Coefficient of thermal expansion

Temperature °C	Thermal Expansion X10^{-6} /K
20-100	4.5

Thermal conductivity

Temperature °C	100
W m^{-1} K^{-1}	15

Specific heat capacity

Temperature °C	20
kJ kg^{-1} K^{-1}	0.50

Melting point °C	1425
Magnetic properties	The material is magnetic up to approximately 530°C (the Curie point).

Nifethal 70

General description

Nifethal 70 is an alloy with low resistivity and high temperature coefficient of resistance.

Typical applications for Nifethal 70 are in voltage regulators, timing devices, temperature sensitive resistors, temperature compensating devices and low temperature heating applications.

Chemical composition

	Ni %	Fe %
Nominal composition	72	Bal.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	**$R_{p0.2}$**	**R_m**	**A**
mm	**MPa**	**MPa**	**%**
0.5	340	640	30

Physical properties

Density g/cm^3	8.45
Electrical resistivity at 20°C Ω mm^2/m	0.20

Temperature factor of resistivity

Temperature °C	100	150	200	250	300	350	400	450	500	1000	1100
Ct	1.42	1.68	1.91	2.19	2.47	2.75	3.03	3.34	3.66	1.23	1.24

Coefficient of thermal expansion

Temperature °C	Thermal Expansion X10^{-6}/K
20-1000	15

Thermal conductivity

Temperature °C	20
W m^{-1} K^{-1}	17

Specific heat capacity

Temperature °C	20

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kJ kg^{-1} K^{-1}	0.52

Melting point °C	1430
Max continuous operating temperature in air °C	600
Magnetic properties	The material is magnetic up to approximately 610°C (the Curie point).

Nikrothal 20

General description

Nikrothal 20 is used at operating temperatures up to 1050°C (1920°F).

Typical applications for Nikrothal 20 are as terminals attached to nickel-chromium heating elements operating at relatively low temperatures and in other applications where the material is exposed to elevated temperature.

Chemical composition

	C %	Si %	Mn %	Cr %	Ni %	Fe %
Nominal composition						Bal.
Min	-	2.3	-	23.0	19.0	
Max	0.08	2.5	0.5	25.0	21.0	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	335	675	30	160
4.0	300	650	30	160

Mechanical properties at elevated temperature

Temperature °C	900
MPa	120

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	1000
MPa	20	4

Physical properties

Density g/cm^3	7.80

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Electrical resistivity at 20°C Ω mm²/m	0.95

Temperature factor of resistivity

Temperature°C	100	200	300	400	500	600	700	800	900	1000	1100
Ct	1.04	1.10	1.14	1.17	1.21	1.23	1.26	1.28	1.30	1.32	1.34

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 250	16
20 - 500	17
20 - 750	18
20 - 1000	19

Thermal conductivity

Temperature °C	20	100	200	300	400	500	600	700	800	900	1000
W m^{-1} K^{-1}	13	14	16	17	18	20	21	22	23	25	26

Specific heat capacity

Temperature °C	20	100	200	300	400	500	600	700	800	900	1000
kJ kg^{-1} K^{-1}	0.50	0.50	0.50	0.52	0.55	0.57	0.60	0.63	0.64	0.68	0.70

Melting point °C	1380
Max continuous operating temperature in air °C	1050
Magnetic properties	The material is non-magnetic
Emissivity - fully oxidized material	0.88

Nikrothal 30

General description

Nikrothal 30 is a cost-effective alloy for use as electric heating element material in domestic appliances and other electric heating equipment. It has good ductility after use, good corrosion resistance except in sulphur containing atmospheres and certain controlled atmospheres and excellent weldability. Nikrothal 30 can be used at operating temperatures up to 1050°C (1920°F).

Typical applications for Nikrothal 30 are solid hot plates, open coil heaters in HVAC systems , night-storage heaters, convection heaters, heavy duty rheostats and fan heaters. Nikrothal 30 is also used in heating cables and rope heaters in defrosting and de-icing elements, electric blankets and pads, car seats, baseboard heaters, floor heaters, resistors, etc.

Chemical composition

	C %	Si %	Mn %	Cr %	Ni %	Fe %	Trace Elements
Nominal composition						Bal.	Added
Min		1.6		20.0	30.0		
Max	0.15	2.5	1.0	22.0	33.0		

Mechanical properties

Wire size		Yield strength		Tensile strength		Elongation	Hardness
Ø		$R_{p0.2}$		R_m		A	
mm	inch	MPa	ksi	MPa	ksi	%	HV
1.0	0.04	340	49.3	675	97.9	35	180
4.0	0.16	300	43.5	650	94.3	30	160

Physical properties

Density	**g/cm^3**	7.80
	lb/in^3	0.282
Electrical resistivity at 20°C	**$\Omega\ mm^2/m$**	1.03
	Ω/cmf	620

Temperature factor of resistivity

Temperature °C	100	200	300	400	500	600	700	800	900	1000

Temperature °F	212	392	572	752	932	1112	1292	1472	1652	1832
Ct-value	1.03	1.07	1.11	1.14	1.17	1.19	1.21	1.23	1.24	1.26

Coefficient of thermal expansion

Temperature	Temperature	Thermal Expansion
°C	°F	x 10^{-6}/K
20 - 250	68 - 482	16
20 - 500	68 - 932	17
20 - 750	68 - 1382	18
20 - 1000	20 - 1832	19

Max continuous operating temperature in air	1050°C
	1920°F
Magnetic properties	The material is non-magnetic
Emissivity - fully oxidized material	0.88

Nikrothal 35/19 Cb

Nikrothal 35/19 Cb is a nickel-chromium alloy (NiCr alloy) with addition of niobium. The material is characterized by high mechanical strength at high temperatures.

Typical applications for Nikrothal 35/19 Cb are as wire in meshbelts.

Chemical composition

	C %	Si %	Mn %	Cr %	Ni %	Nb %	Fe %
Nominal composition						1.0	Bal.
Min	-	1.0	-	18.0	34.0	-	-
Max	0.15	3.0	1.0	21.0	37.0	-	-

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø mm	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	450	750	30	180

Mechanical properties at elevated temperature

Temperature °C	900
MPa	120

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	1000
MPa	20	4

Physical properties

Density g/cm³	7.90
Electrical resistivity at 20°C Ω mm²/m	1.04

Temperature factor of resistivity

Temperature°C	100	200	300	400	500	600	700	800	900	1000	1100

Ct	1.03	1.06	1.10	1.12	1.15	1.17	1.19	1.21	1.22	1.23	1.24

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 250	16
20 - 500	17
20 - 750	18
20 - 1000	19

Thermal conductivity

Temperature °C	20	100	200	300	400	500	600	700	800	900	1000	1100
$W\ m^{-1}\ K^{-1}$	13	14	15	16	18	19	21	22	24	25	26	28

Specific heat capacity

Temperature °C	20	100	200	300	400	500	600	700	800	900	1000	1100
$kJ\ kg^{-1}\ K^{-1}$	0.50	0.50	0.50	0.51	0.54	0.57	0.60	0.62	0.64	0.67	0.70	0.73

Melting point °C	1390
Max continuous operating temperature in air °C	1100
Magnetic properties	The material is non-magnetic
Emissivity - fully oxidized material	0.88

Nikrothal 40

General description

Nikrothal 40 is used as electric heating element material in domestic appliances and other electric heating equipment at operating temperatures up to 1100°C (2010°F). It has good ductility after use, good corrosion resistance except in sulphur containing atmospheres and certain controlled atmospheres and excellent weldability.

Typical applications for Nikrothal 40 are night-storage heaters, convection heaters, heavy duty rheostats and fan heaters. Nikrothal 40 is also used in heating cables and rope heaters in defrosting and de-icing elements, electric blankets and pads, car seats, baseboard heaters, floor heaters, resistors, etc.

Chemical composition

	C %	Si %	Mn %	Cr %	Ni %	Fe %
Nominal composition						Bal.
Min	-	1.6	-	18.0	34.0	
Max	0.10	2.5	1.0	21.0	37.0	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	340	675	35	180
4.0	300	650	30	160

Mechanical properties at elevated temperature

Temperature °C	900
MPa	130

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	1000
MPa	20	4

Physical properties

Density g/cm^3	7.90
Electrical resistivity at 20°C $\Omega\ mm^2/m$	1.04

Temperature factor of resistivity

Temperature°C	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
Ct	1.03	1.06	1.10	1.12	1.15	1.17	1.19	1.21	1.22	1.23	1.24

Coefficient of thermal expansion

Temperature °C	**Thermal Expansion x $10^{-6}/K$**
20 - 250	16
20 - 500	17
20 - 750	18
20 - 1000	19

Thermal conductivity

Temperature °C	**20**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
$W\ m^{-1}\ K^{-1}$	13	14	15	16	18	19	21	22	24	25	26	28

Specific heat capacity

Temperature °C	**20**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
$kJ\ kg^{-1}\ K^{-1}$	0.50	0.50	0.50	0.51	0.54	0.57	0.60	0.62	0.64	0.67	0.70	0.73

Melting point °C	1390
Max continuous operating temperature in air °C	1100
Magnetic properties	The material is non-magnetic
Emissivity - fully oxidized material	0.88

Nikrothal 60

General description

Nikrothal 60 can be used at operating temperatures up to 1150°C (2100°F). Nikrothal 60 has excellent hot strength, good oxidation properties and very good formability. Nikrothal 60 has good corrosion resistance except in sulphur containing atmospheres and certain controlled atmospheres. Nikrothal 60 is used as electric heating element material in domestic appliances and furnace applications up to high temperatures.

Typical applications for Nikrothal 60 are in metal sheathed tubular elements used in hot plates, grills, toaster ovens, storage heaters, etc and as suspended coils in air heaters used in clothes dryers, fan heaters, hand dryers.

Chemical composition

	C %	Si %	Mn %	Cr %	Ni %	Fe %
Nominal composition						Bal.
Min	-	1.0	-	14.0	57.0	
Max	0.10	1.7	1.0	18.0	60.0	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	370	730	35	180
4.0	300	700	30	160

Mechanical properties at elevated temperature

Temperature °C	900
MPa	100

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	1000
MPa	15	4

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Physical properties

Density g/cm^3	8.20
Electrical resistivity at 20°C Ω mm^2/m	1.11

Temperature factor of resistivity

Temperature°C	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**
Ct	1.02	1.04	1.05	1.06	1.08	1.09	1.09	1.10	1.10	1.11	1.12	1.13

Coefficient of thermal expansion

Temperature °C	**Thermal Expansion x 10^{-6}/K**
20 - 250	14
20 - 500	15
20 - 750	16
20 - 1000	17

Thermal conductivity

Temperature °C	**20**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
W m^{-1} K^{-1}	13	13	14	16	17	19	20	22	24	25	25	29

Specific heat capacity

Temperature °C	**20**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
kJ kg^{-1} K^{-1}	0.46	0.46	0.48	0.50	0.53	0.55	0.58	0.60	0.63	0.66	0.68	0.71

Melting point °C	1390
Max continuous operating temperature in air °C	1150
Magnetic properties	The material is slightly magnetic
Emissivity - fully oxidized material	0.88

Nikrothal 70

General description

The material is used for electrical heating in industrial furnaces. It is particularly well suited for reducing atmospheres, as it is not subject to "green root".

Chemical composition

	C %	Si %	Mn %	Cr %	Fe %	Ni %	Trace elements
Nominal composition						Bal.	Added
Min	-	0.5	-	29.0	-	-	
Max	0.15	2.0	1.0	32.0	5.0	-	

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	430	820	30	185
4.0	425	800	30	185

Physical properties

Density g/cm³	8.10
Electrical resistivity at 20°C Ω mm²/m	1.18

Temperature factor of resistivity

Temperature°C	100	200	300	400	500	600	700	800	900	1000	1100	1200
Ct	1.01	1.02	1.03	1.04	1.05	1.05	1.04	1.04	1.04	1.05	1.05	1.06

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 250	13.7
20 - 500	14.6
20 - 750	15.8
20 - 1000	17.1

Thermal conductivity

Temperature °C	20	100	200	300	400	500	600	700	800	900	1000	1100
$W\ m^{-1}\ K^{-1}$	13	13	14	15	17	19	20	22	24	26	28	29

Specific heat capacity

Temperature °C	20	100	200	300	400	500	600	700	800	900	1000	1100
$kJ\ kg^{-1}\ K^{-1}$	0.46	0.46	0.48	0.50	0.53	0.55	0.58	0.60	0.63	0.65	0.67	0.71

Melting point °C	1380
Max continuous operating temperature in air °C	1250
Magnetic properties	The material is non-magnetic
Emissivity - fully oxidized material	0.88

Nikrothal 80

General description

Nikrothal 80 is a high grade austenitic alloy. Due to its malleability and strength at high temperatures, Nikrothal 80 is especially suited for applications in the electrical appliance industry. In industrial furnace use Nikrothal 80 has many advantages due to its excellent mechanical properties in the hot state. Nikrothal 80 has superior life compared to competitive NiCr alloys because of the extremely good adhesion properties of the surface oxide.

Typical applications for Nikrothal 80 are flat irons, ironing machines, water heaters, plastic moulding dies, soldering irons, metal sheathed tubular elements, cartridge elements, etc.

Chemical composition

	C %	Si %	Mn %	Cr %	Ni %	Fe %	Trace elements
Nominal composition					Bal.		Added
Min	-	1.0	-	19.0	-	-	-
Max	0.10	1.7	1.0	21.0	-	2.0*	-

* Fe< 1.0 on request

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	420	810	30	180
4.0	300	725	30	160

Mechanical properties at elevated temperature

Temperature °C	900
MPa	100

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 1% elongation in 1000 h

Temperature °C	800	1000
MPa	15	4

Physical properties

Density g/cm^3	8.30
Electrical resistivity at 20°C Ω mm^2/m	1.09

Temperature factor of resistivity

Temperature°C	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**
Ct	1.01	1.02	1.03	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.06	1.07

Coefficient of thermal expansion

Temperature °C	**Thermal Expansion x 10^{-6}/K**
20 - 250	14.1
20 - 500	14.9
20 - 750	16.0
20 - 1000	17.2

Thermal conductivity

Temperature °C	**20**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
W m^{-1} K^{-1}	15	15	15	15	17	19	21	22	24	26	28	30

Specific heat capacity

Temperature °C	**20**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**
kJ kg^{-1} K^{-1}	0.46	0.46	0.48	0.50	0.52	0.54	0.56	0.60	0.63	0.65	0.67	0.70

Melting point °C	1400
Max continuous operating temperature in air °C	1200
Magnetic properties	The material is non-magnetic
Emissivity - fully oxidized material	0.88

Nikrothal 80/20 Cb

Nikrothal 80/20 Cb is a nickel-chromium alloy (NiCr alloy) with addition of niobium The material is characterized by high mechanical strength at high temperatures.

Typical applications for Nikrothal 80/20 Cb are as wire in meshbelts.

Chemical composition

	C %	Si %	Mn %	Cr %	Nb %	Ni %	Fe %
Nominal composition					1.0	Bal.	
Min	-	0.75	-	19.0	-	-	-
Max	0.3	1.50	2.5	21.0	-	-	1.0

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
1.0	400	800	30	190
4.0	350	750	30	170

Mechanical properties at elevated temperature

Temperature °C	900	1100
MPa	140	50

Ultimate tensile strength - deformation rate 6.2 x 10^{-2}/min

Creep strength - 0.5% elongation in 1000 h

Temperature °C	800
MPa	15

Physical properties

Density g/cm^3	8.30
Electrical resistivity at 20°C Ω mm^2/m	1.09

Temperature factor of resistivity

Temperature°C	100	200	300	400	500	600	700	800	900	1000	1100	1200

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Ct	1.01	1.02	1.03	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.06	1.07

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 250	14.1
20 - 500	14.9
20 - 750	16.0
20 - 1000	17.2

Thermal conductivity

Temperature °C	20	100	200	300	400	500	600	700	800	900	1000	1100
W m^{-1} K^{-1}	15	15	15	15	17	19	21	22	24	26	28	30

Specific heat capacity

Temperature °C	20	100	200	300	400	500	600	700	800	900	1000	1100
kJ kg^{-1} K^{-1}	0.46	0.46	0.48	0.50	0.52	0.54	0.56	0.60	0.63	0.65	0.67	0.70

Melting point °C	1400
Max continuous operating temperature in air °C	1200
Magnetic properties	The material is non-magnetic
Emissivity - fully oxidized material	0.88

Nikrothal LX

General description

Nikrothal LX has been developed for electronic components where a high resistivity together with a low temperature coefficient of resistance is required.

Chemical composition

	C %	Si %	Mn %	Cr %	Fe %	Al %	Ni %	Cu %
Nominal composition							Bal.	
Min	-	0.50	2.1	18.0	-	2.40	-	1.60
Max	0.02	0.70	2.3	20.0	0.10	2.60	-	1.80

Mechanical properties

Yield strength	Tensile strength	Elongation
$R_{p0.2}$	R_m	A
MPa	MPa	%
800-1200	950-1400	3-25

Physical properties

Density g/cm^3	8.30
Electrical resistivity at 20°C Ω mm^2/m	1.33

Temperature coefficient of resistance with reference to +25°C

Temperature range	Temperature coefficient of resistance	Temperature coefficient of resistance
°C	PPM/°C	PPM/°C
-55 - +250	-5 - +5	-10 - +10

Thermal electromotive force against Cu µV/°C	**+1.0**

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 300	14

Thermal conductivity

Temperature °C	**20**

W m^{-1} K^{-1}	15

Specific heat capacity	
Temperature °C	**20**
kJ kg^{-1} K^{-1}	0.46

Melting point °C	1390
Max continuous operating temperature in air °C	1150
Magnetic properties	The material is slightly magnetic
Emissivity - fully oxidized material	0.88

Nisil

Nisil is an alloy used for the negative leg of thermocouple type N. It offers higher thermoelectric stability in air above 1000°C (1830°F) and better oxidation resistance than type E, J and K thermocouples.

Nisil alloy cannot be exposed to sulphur-containing gases. This thermocouple is the most recent one among the different types covered by the international standards.

Chemical composition

	Ni %	Si %	Mg %
Nominal composition	Bal.	4.3	0.1

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation
Ø	$R_{p0.2}$	R_m	A
mm	MPa	MPa	%
2.00	300	680	33

Physical properties

Density g/cm³	8.585
Electrical resistivity at 20°C Ω mm²/m	0.365
Temperature coefficient of resistance between 20°C and 100°C x 10^{-6}/K	680

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 100	17

Thermal conductivity

Temperature °C	100
W m^{-1} K^{-1}	27

Melting point °C	1420
Magnetic properties	The material is non-magnetic

Recommended maximum continuous operating temperatures

Wire size Ø	3.26	1.63	1.00	0.50	0.25
Bare wire °C	1100	1010	960	890	800
Protected wire °C	1250	1180	1110	1000	910

Note that the indicated temperatures should be considered as guide values

Thermoelectric properties

Nominal emf values vs Nicrosil	
Temp °C	**mV**
100	2.774
200	5.913
300	9.341
400	12.974
500	16.748
600	20.613
700	24.527
800	28.455
900	32.371
1000	36.256
1100	40.087
1200	43.846
1300	47.513

ITS90- Reference junction 0°C

NRX 600

NRX 600 is a nickel-chormium alloy (NiCr alloy) for furnace temperatures up to 1150°C (2100°F)

Typical appliactions for NRX 600 are as conveyor belts in corrosive atmospheres for heat treatments of metals and ceramics.

Chemical composition

	Cr %	Ni %	Fe %
Nominal composition	15	77	7

Mechanical composition

Wire size	Yield strength	Tensile strength	Elongation
Ø	$R_{p0.2}$	R_m	A
mm	MPa	MPa	%
1.0	310	670	30

Physical properties

Density g/cm^3	8.55
Electrical resistivity at 20°C Ω mm^2/m	1.00

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 1000	16.7

Thermal conductivity

Temperature °C	100
$W\ m^{-1}\ K^{-1}$	11.9

Specific heat capacity

Temperature °C	20
$kJ\ kg^{-1}\ K^{-1}$	0.46

Melting point °C	1400
Max continuous operating temperature in air °C	1150

PAC-240

PAC-240 is a film insulation made of polyimide resins. It is a Class 240°C (465°F) thermal rated insulation with exceptional resistance to chemical solvents and burnout. The outstanding thermoplastic flow of over 400°C (750°F) and its ability to withstand excessive overloads extends the use of magnet wire in extreme conditions. ML is unaffected by prolonged exposure to varnish solvents and its compatible with virtually all systems.

Applied in the form of a polyamic acid solution, it is converted with heat to a continuous film with excellenet resistance to radiation,, chemicals and cyrogenic temperatures. PAC-240 meets the requirements of NEMA MW 16 and listed with Underwriters Laboratories

Typcial applications are within fractional and integral horsepower motors, high temperature continuous duty coils and relays, hermetic and sealed units, heavy duty hand tool motors, encapsulated coils, speaker voice coils.

Electrical Properties

Property	NEMA MW-1000	ASTM D1696	IEC 851	JIS 3003	
Dielectric strength at 25°C (77°F)	3.8.1.1	69-75	13-4.2, 3, 4	11.1	11.1 kV
Dissipation factor at 220°C (428°F) - 1 kHz		107-114			0.08

Mechanical properties

Property	NEMA MW-1000	ASTM D 1696	IEC 851	JIS C 3003	
Adhesion and flexibility no snap 20% snap	3.3.1.1 3.3.1.1	141-148 141-148	8- 5.1.1	8.1 9.1	
Cut-through temperature	3.50.1.1	61-68			>500°C (932°F)
Heat shock 20% stretch - ½ h at 260°C	3.5.1.1	156-162	9-3.1	14.1	Pass 3d

(500°F)					
Scrape resistance	3.59.1.1	170-177	11-6.1	10.2	1275g

Physical properties

Thermal endurance above 240°C (464°F)				
Hours at temperature	20000	10000	5000	1000
Temperature °C (°F)	242 (468)	270 (518)	280 (536)	315 (599)

Poly

Poly a fast running, general purpose, Class 155 polyurethane wire enamel. Suitable for monolithic or dual coat applications, it meets the requirements of NEMA MW 75, MW 80 (MW 79 on finer gauges) alse meets the requiremets of JIS C 3003 for "Pinhole" resistance.

Poly is available in clear and colored versions.

The primary benefit of the polyurethane is its easy solderability vs. the 180C tri-2-SOd solderable Polyester coating (2 seconds at 380°C vs. 5 seconds at 455°C)

Polyeurethane can be readily used on Copper, Aluminum and Copper-Clad Aluminum wires as a basecoat for the commonly applied thermoplastic bondcoats. It is a cost-effective insulation to be applied to wires that are used in the manufacture of precision coils, as it provides end users manufacturing benefits in handling and solderability.

Typical appliacations are within motors, R.F. coils, relay, encapsulated coils, ignition coils, solenoids, low voltage transformers, Multi layer and precision wound coils, speaker voice coils.

Electrical Properties

Property	NEMA MW-1000	ASTM D1676	IEC 851	JIS C 3003	(AWG 24)
Dissipation factor at 170°C (338°F) - 1 kHz		0.22			

Mechanical properties

Property	NEMA MW-1000	ASTM D1676	IEC 851	JIS C 3003	(AWG 24)
Adherence and flexibility	Pass 1d		Pass 1d		
Cut-through temperature	223°C (433°F)				
Heat shock 20% stretch - ½ h at 175°C (347°F)	Pass 3d				

Soldering properties

Property	NEMA	ASTM	IEC	JIS C	(AWG

	MW-1000	D1676	851	3003	24)
at 340°C (644°F) - without/ with flux	10.0/7.0 sec	10.0/7.0 sec	10.0/7.0 sec	10.0/7.0 sec	10.0/7.0 sec
at 360°C (680°F) - without/ with flux	4.0/3.0 sec	4.0/3.0 sec	4.0/3.0 sec	4.0/3.0 sec	4.0/3.0 sec
at 380°C (716°F) - without/ with flux	2.0/1.5 sec	2.0/1.5 sec	2.0/1.5 sec	2.0/1.5 sec	2.0/1.5 sec

R63C

General description

R63C is a Ni base alloy with high melting point and good conductivity. It also has low discharge potential as well as good corrosion resistance to C and S.

R63C is typically used as a spark plug electrode

Chemical composition

	Ni %	Si %	Mn %
Nominal composition	95	1	4

Mechanical properties

	Tensile strength R_m MPa
Min	440
Max	1200

Physical properties

Density g/cm^3	872
Electrical resistivity at 20°C Ω mm^2/m	0.22
Temperature coefficient of resistance (20- 250 °C) (x 10^{-6}/K)	3000

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 500	15.2

Thermal conductivity

Temperature °C	**100**
W m^{-1} K^{-1}	38.5

Specific heat capacity

Temperature °C	**20**
kJ kg^{-1} K^{-1}	0.203
Melting point °C	1430

Redi Ohm 180

Chemical composition

	Ni %	Cu %
Nominal composition	22	Bal

Mechanical properties

	Tensile strength R_m	
	MPa	**ksi**
Hard	689	100
Anealed	345	50

Physical properties

Density g/cm³ (lb/in³)	8.90 (.321)
Electrical resistivity at 20°C Ωmm²/m (Ω/cmf)	0.298 (180)

Coefficient of thermal expansion

Temperature °C (°F)	Thermal expansion 10^{-6}/K
20-500 (68-932)	15.9

Thermal conductivity

Temperature °C (°F)	100 (212)
W m^{-1} K^{-1}	29.0

Specific heat capacity

Temperature °C (°F)	20
kJ kg^{-1} K^{-1}	0.92

Melting point °C (°F)	1100 (2012)
Max continuous operating temp. °C (°F)	540 (1004)
Magnetic properties	Material is non-magnetic
Thermal E M F vs. Copper mV/°C	-.037

Redi Ohm 30

Chemical composition

	Ni %	Cu %
Nominal composition	2.0	Bal

Mechanical properties

	Tensile strength R_m	
	MPa	**ksi**
Hard	413	60
Anealed	206	30

Physical properties

Density g/cm^3 (lb/in^3)	8.90 (.321)
Electrical resistivity at 20°C Ωmm^2/m (Ω/cmf)	0.05 (30)

Coefficient of thermal expansion

Temperature °C (°F)	Thermal expansion 10 $^{-6}$/K
20-500 (68-932)	16.5

Thermal conductivity

Temperature °C (°F)	100 (212)
W m^{-1} K^{-1}	162

Specific heat capacity

Temperature °C (°F)	20
kJ kg^{-1} K^{-1}	0.92

Melting point °C (°F)	1100 (2012)
Max continuous operating temp. °C (°F)	200 (392)
Magnetic properties	Material is non-magnetic
Thermal E M F vs. Copper mV/°C	-.014

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Redi Ohm 60

Chemical composition

	Ni %	Cu %
Nominal composition	6.0	Bal

Mechanical properties

	Tensile strength R_m	
	MPa	ksi
Hard	482	70
Anealed	241	35

Physical properties

Density g/cm^3 (lb/in^3)	8.90 (.321)
Electrical resistivity at 20°C Ωmm^2/m (Ω/cmf)	0.1 (60)

Coefficient of thermal expansion

Temperature °C (°F)	Thermal expansion 10 $^{-6}$/K
20-500 (68-932)	16.3

Thermal conductivity

Temperature °C (°F)	100 (212)
W m^{-1} K^{-1}	90.7

Specific heat capacity

Temperature °C (°F)	20
kJ kg^{-1} K^{-1}	0.92

Melting point °C (°F)	1100 (2012)
Max continuous operating temp. °C (°F)	300 (572)
Magnetic properties	Material is non-magnetic
Thermal E M F vs. Copper mV/°C	-.022

Redi Ohm 650

Chemical composition

	Ni %	Cr %
Nominal composition	80	20

Mechanical properties

	Tensile strength R_m	
	MPa	**ksi**
Hard	1551	225
Anealed	689	100

Physical properties

Density g/cm³ (lb/in³)	8.41 (.304)
Electrical resistivity at 20°C Ωmm²/m (Ω/cmf)	1.08 (650)

Coefficient of thermal expansion

Temperature °C (°F)	Thermal expansion 10^{-6}/K
20-500 (68-932)	14.5

Thermal conductivity

Temperature °C (°F)	100 (212)
W m^{-1} K^{-1}	11.3

Specific heat capacity

Temperature °C	20
kJ kg^{-1} K^{-1}	.104

Melting point °C (°F)	1395 (2543)
Max continuous operating temp. °C (°F)	1100 (2012)
Magnetic properties	Material is non-magnetic
Thermal E M F vs. Copper mV/°C	+.006

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Redi Ohm 800

Redi-Ohm 800 (RO 800) is a Nickel Chromium, plus additions, alloy with high specific resistivity, low temperature coefficient and low thermal EMF against Cu. RO 800 is suitable for high value resistors and potentiometers for automotive and consumer electronics, as well as for testing and automatic control equipment. RO 800 is also used for heating elements and cables. RO 800 is available in sizes from 0.50 to 0.010 mm (0.020-0.0004 in), with temperature coefficients of ±20, ±10, ±5, ±0 to -5 ppm. Closer tolerances are available upon request. RO 800 meets the requirements of ASTM B-267, Standard Specification for Wire for Use in Wound Resistors, Alloy Class 1a and 1b.

Chemical composition

	Al %	Cr %	Cu %	Fe %	Mn %	Si %	Ni %
Nominal composition	3.5	20	<0.1	0.5	0.5	1.0	Bal.

Mechanical properties

	Tensile strength R_m	
	MPa	**ksi**
Hard	1700	250
Anealed	900	130

Physical properties

Density g/cm³ (lb/in³)	8.12 (.293)
Electrical resistivity at 20°C Ωmm²/m (Ω/cmf)	1.32 (800)

Coefficient of thermal expansion

Temperature °C (°F)	Thermal expansion 10^{-6}/K
20-100 (68-210)	14
20-400 (68-750)	15

Thermal conductivity

Temperature °C (°F)	100 (212)
$W\ m^{-1}\ K^{-1}$	13.1

Specific heat capacity

Temperature °C (°F)	20
kJ kg^{-1} K^{-1}	0.104

Melting point °C (°F)	1400 (2550)
Max continuous operating temp. °C (°F)	250 (480)
Magnetic properties	Material is non-magnetic
Thermal E M F vs. Copper mV/°C	0.001

Redi Seal

Chemical composition

	Ni %	Co %	Mn %	Fe %
Nominal composition	29	17	Bal.	Bal.

Mechanical properties

	Tensile strength R_m	
	MPa	**ksi**
Hard	1034	150
Anealed	517	75

Physical properties

Density g/cm³ (lb/in³)	8.36 (.302)
Electrical resistivity at 20°C Ωmm²/m (Ω/cmf)	0.49 (294)

Coefficient of thermal expansion

Temperature °C (°F)	Thermal expansion 10^{-6}/K
20-500 (68-932)	6.0

Thermal conductivity

Temperature °C (°F)	100 (212)
W m^{-1} K^{-1}	14.7

Specific heat capacity

Temperature °C (°F)	20
kJ kg^{-1} K^{-1}	0.123

Melting point °C (°F)	1450 (2642)
Max continuous operating temp. °C (°F)	450 (842)
Magnetic properties	Material is magnetic
Thermal E M F vs. Copper mV/°C	-.035

Redi-Iron 120

Chemical composition

	Ni %	Fe %
Nominal composition	70	30

Mechanical properties

	Tensile strength R_m	
	MPa	**ksi**
Hard	1034	150
Anealed	483	70

Physical properties

Density g/cm³ (lb/in³)	8.46 (.305)
Electrical resistivity at 20°C Ωmm²/m (Ω/cmf)	0.199 (120)

Coefficient of thermal expansion

Temperature °C (°F)	Thermal expansion 10^{-6}/K
20-500 (68-932)	15.0

Thermal conductivity

Temperature °C (°F)	100 (212)
W m^{-1} K^{-1}	28.9

Specific heat capacity

Temperature °C (°F)	20
kJ kg^{-1} K^{-1}	0.125

Melting point °C (°F)	1425 (2597)
Max continuous operating temp. °C (°F)	590 (1094)
Magnetic properties	Material is magnetic
Thermal E M F vs. Copper mV/°C	-.040

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Redi-Nickel 5000

Chemical composition

	Ni %
Nominal composition	99.5

Mechanical properties

	Tensile strength R_m	
	MPa	ksi
Hard	931	135
Anealed	414	60

Physical properties

Density g/cm³ (lb/in³)	8.90 (.322)
Electrical resistivity at 20°C Ωmm²/m (Ω/cmf)	0.01 (60)

Coefficient of thermal expansion

Temperature °C (°F)	Thermal expansion 10^{-6}/K
20-500 (68-932)	15.0

Thermal conductivity

Temperature °C (°F)	100 (212)
$W\ m^{-1}\ K^{-1}$	58.2

Specific heat capacity

Temperature °C (°F)	20
$kJ\ kg^{-1}\ K^{-1}$	0.113

Melting point °C (°F)	1450 (2642)
Max continuous operating temp. °C (°F)	500 (932)
Magnetic properties	Material is magnetic
Thermal E M F vs. Copper mV/°C	-.022

Redi-Nickel 6000

Chemical composition

	Ni %
Nominal composition	99.9

Mechanical properties

	Tensile strength R_m	
	MPa	ksi
Hard	689	100
Anealed	276	40

Physical properties

Density g/cm^3 (lb/in^3)	8.90 (.321)
Electrical resistivity at 20°C $\Omega mm^2/m$ (Ω/cmf)	0.07 (42)

Coefficient of thermal expansion

Temperature °C (°F)	Thermal expansion 10^{-6}/K
20-500 (68-932)	15.0

Thermal conductivity

Temperature °C (°F)	100 (212)
$W\ m^{-1}\ K^{-1}$	59.0

Specific heat capacity

Temperature °C (°F)	20
$kJ\ kg^{-1}\ K^{-1}$	0.13

Melting point °C (°F)	1450 (2642)
Max continuous operating temp. °C (°F)	500 (932)
Magnetic properties	Material is magnetic
Thermal E M F vs. Copper mV/°C	-.022

EL News

Electrolux Macedonia Palenzo

Thermocouple iron

Thermocouple iron is used for the positive leg of thermocouples type J, L, and it is also used as the positive leg of compensating cables type KCA (WX).

The alloy is transformed magnetically at 770°C (1420°F) and a crystallographic transformation occurs at 900°C (1650°F). Both transformations affect the thermoelectric properties of the alloy.

Iron can not be exposed to sulphur-containing atmospheres and to temperatures below zero. Thermocouple iron wire is supplied copper-coated to prevent oxidation.

Thermocouple type J and L are frequently used because of their high emf output and their low cost. Compensating cables of type KCA are used together with thermocouples of type K.

Chemical composition

	C %	Si %	Mn %	Fe %
Nominal composition	0.03	0.05	0.30	Bal.

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	$R_{p0.2}$	R_m	A	
mm	MPa	MPa	%	Hv
2.0	-	450	15	100

Physical properties

Density g/cm^3	7.86
Electrical resistivity at 20°C Ω mm^2/m	0.13
Temperature coefficient of resistance between 20°C and 100°C x 10^{-6}/K	5000

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 100	11.7

Thermal conductivity

Temperature °C	100
W m^{-1} K^{-1}	66.2

Specific heat capacity	
Temperature °C	**20**
kJ kg^{-1} K^{-1}	0.445

Melting point °C	1535
Magnetic properties	The material is magnetic

Recommended maximum continuous operating temperature

Wire size Ø	3.26	1.63	1.00	0.50	0.25
Bare wire °C	760	760	720	650	560
Protected wire °C	760	760	760	760	670

Note that the indicated temperatures should be considered as guide values

Thermoelectric properties

Iron is used as positive leg in thermocouples of type J, L and in compensating type KCA. The emf values vs the negative thermocouple leg are listed in the data sheets for the respective thermocouples.

Thermothal N

Thermothal N is an alloy used for the negative leg of thermocouples type K. Thermocouples type K have a good resistance to oxidation and better than other combinations of thermocouples. Thermothal N can not be exposed to atmospheres containing sulphur gases.

Chemical composition

	Ni %	Al %	Mn %	Si %	Co %
Nominal composition	Bal.	1.5	1.5	1.5	0.5

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	$R_{p0.2}$	R_m	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
2.0	250	550	35	120

Mechanical properties at elevated temperature

Temperatur	Yield strength	Tensile strength	Elongation
	$R_{p0.2}$	R_m	A_{50}
°C	**MPa**	**MPa**	**%**
100	253	563	42
300	224	551	36
500	203	481	41

Ultimate tensile strength - deformation rate 6.2 x 10^{-6} min^{-1}

Physical properties

Density g/cm³	8.60
Electrical resistivity at 20°C Ω mm²/m	0.292
Temperature coefficient of resistance between 20°C and 100°C x 10^{-6}/K	1900

Young's modulus

Temperature °C	20	100	300	500
GPa	194	91	61	42

Coefficient of thermal expansion

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Temperature °C	Thermal Expansion x 10^{-6}/K
20 - 100	17

Thermal conductivity

Temperature °C	100
W m^{-1} K^{-1}	29.7

Specific heat capacity

Temperature °C	20
kJ kg^{-1} K^{-1}	0.523

Melting point °C	1400
Magnetic properties	The material is magnetic

Recommended maximum continuous operating temperature

Wire size Ø	3.26	1.63	1.00	0.50	0.25
Bare wire °C	1050	930	900	800	710
Protected wire °C	1150	1080	1050	910	820

Note that the indicated temperatures should be considered as guide values

Thermoelectric properties

Nominal emf values vs Pt 67 - Reference junction 0°C

°C	100	200	300	400	500	600	700	800	900	1000	1100	1200
mV	-1.283	-2.168	-2.886	-3.633	-4.431	-5.287	-6.178	-7.070	-7.940	-8.777	-9.575	-10.330

Nominal emf values vs Thermothal P (ITS 90) - Reference junction 0°C

°C	100	200	300	400	500	600	700	800	900	1000	1100	1200
mV	4.096	8.139	12.209	16.397	20.644	24.906	29.129	33.275	37.326	41.276	45.119	48.838

hermothal P

Thermothal P is an alloy used for the positive leg of thermocouples type E or type K. Thermocouples of type K have good resistance to oxidation, and better than other base metal combinations. Thermocouples of type E have the largest emf output of any common thermocouple.

Thermothal P cannot be exposed to reducing or alternately oxidizing and reducing atmospheres or vacuum.

Chemical composition

	Ni %	Cr %	Si %
Nominal composition	Bal.	10.0	0.5

Mechanical properties

Wire size	Yield strength	Tensile strength	Elongation	Hardness
Ø	**$R_{p0.2}$**	**R_m**	**A**	
mm	**MPa**	**MPa**	**%**	**Hv**
2.0	220	580	35	140

Mechanical properties at elevated temperature

Temperatur	Yield strength	Tensile strength	Elongation
	$R_{p0.2}$	**R_m**	**A_{50}**
°C	**MPa**	**MPa**	**%**
100	272	596	41
300	244	594	39
500	217	563	39

Ultimate tensile strength - deformation rate 6.2 x 10^{-6} min^{-1}

Physical properties

Density g/cm^3	8.72
Electrical resistivity at 20°C Ω mm^2/m	0.706
Temperature coefficient of resistance between 20°C and 100°C x 10^{-6}/ K	300

Young's modulus

Temperature °C	20	100	300	500
GPa	200	132	68	48

Coefficient of thermal expansion

Temperature °C	Thermal Expansion x 10^{-6}/ K
20 - 100	17

Thermal conductivity

Temperature °C	100
W m^{-1} K^{-1}	19.2

Specific heat capacity

Temperature °C	20
kJ kg^{-1} K^{-1}	0.448

Melting point °C	1280
Magnetic properties	The material is non-magnetic

Recommended maximum continuous operating temperature

Wire size Ø	3.26	1.63	1.00	0.50	0.25
Bare wire °C	1050	930	900	800	710
Protected wire °C	1150	1080	1050	910	820

Note that the indicated temperatures should be considered as guide values

Thermoelectric properties

Nominal emf values vs Pt 67 - Reference junction 0°C

°C	100	200	300	400	500	600	700	800	900	1000	1100	1200
mV	2.814	5.970	9.323	12.764	16.214	19.618	22.951	26.205	29.386	32.499	35.544	38.508

Reference junction 0°C

Nominal emf values vs Thermothal N

°C	100	200	300	400	500	600	700	800	900	1000	1100	1200

mV	4.096	8.139	12.209	16.397	20.644	24.906	29.129	33.275	37.326	41.276	45.119	48.839

(ITS 90) - Reference junction 0°C

TRI-2-SOD

TRI-2-SOD magnet wire is insulated with a Class H modified polyester resin. It has excellent thermal endurance, solvent resistance and exhibits a low coefficient of friction to improve windability.

Typical applications are within appliance and tool motors, continuous operation coils, subfractional instrument and servo motors solenoids. speaker voice coils.

Electrical Properties

Property	NEMA MW 1000	ASTM D1696	IEC 851	JIS C 3003	
Dielectric strength at 25°C (77°F)	3.8.1.1	69-75	13-4.2, 3, 4	11.1	14.0 kV
Dissipation factor at 220°C (428°F)		107-114			0.05

Mechanical properties

Property	NEMA MW-1000	ASTM D1696	IEC 851	JIS C 3003	
Adherence and flexibility no snap 20% snap	3.3.1.1 3.3.1.1	141-148 141-148	8- 5.1.1	8.1 9.1	Pass 1d Pass 1d
% elongation at break	3.4.1.1	122-129	6-3.0		38
Mandrel at break	3.4.1.1	122-129			Pass 1d
Cut through temperature	3.50.1.1	61-68			306°C (583°F)
Heat shock 20% strecth - ½ h at 200°C (392°F)	3.5.1.1	156-162	9-3.1	14.1	Pass 3d


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