KANTHAL®

KANTHAL ALLOYS

A RESISTANCE MATERIALS HANDBOOK

Fe Iron	Cr Chromium	Al Aluminum
Ni Nickel	Cu Copper	Mn Manganese
Mo Molybdenum	Y Yttrium	

KANTHAL: A GLOBAL LEADER IN INDUSTRIAL HEATING TECHNOLOGY

This handbook is designed to provide foundational and product-specific data for resistance and resistance heating alloys used in electrical appliances and industrial furnaces. It includes guidelines for design, calculations, and applications, making it easier to choose the ideal alloy and design the optimal element for your needs.

For additional information, visit www.kanthal.com, where you can access product updates, detailed specifications, and downloadable datasheets. Kanthal alloys are offered in various grades and forms, including ready-to-install elements, systems, and precision wire available in very small sizes.

With extensive technical and commercial expertise available through our global offices, we are ready to assist with technical inquiries or collaborate on completely new solutions in our R&D facilities.

KANTHAL®

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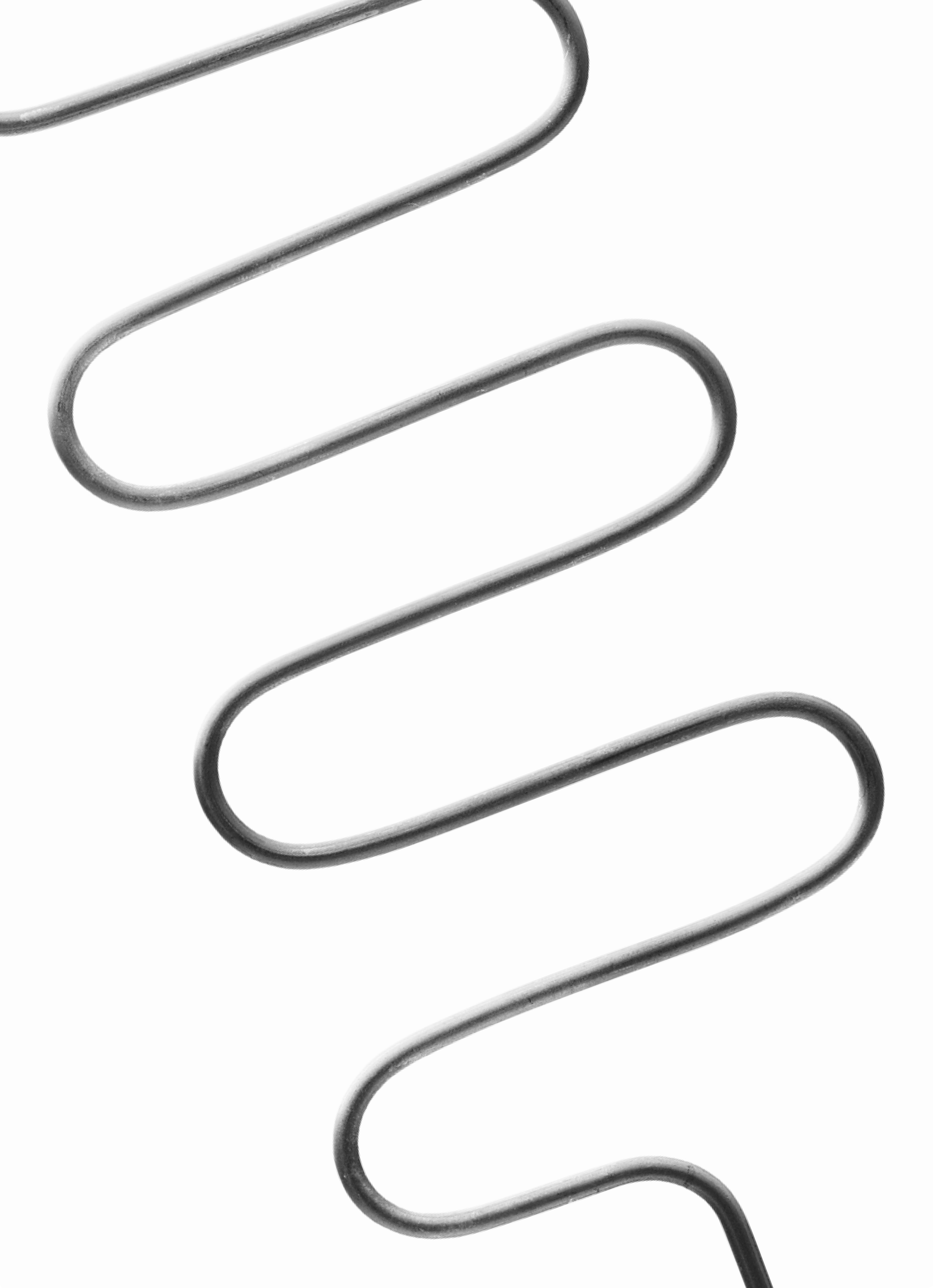

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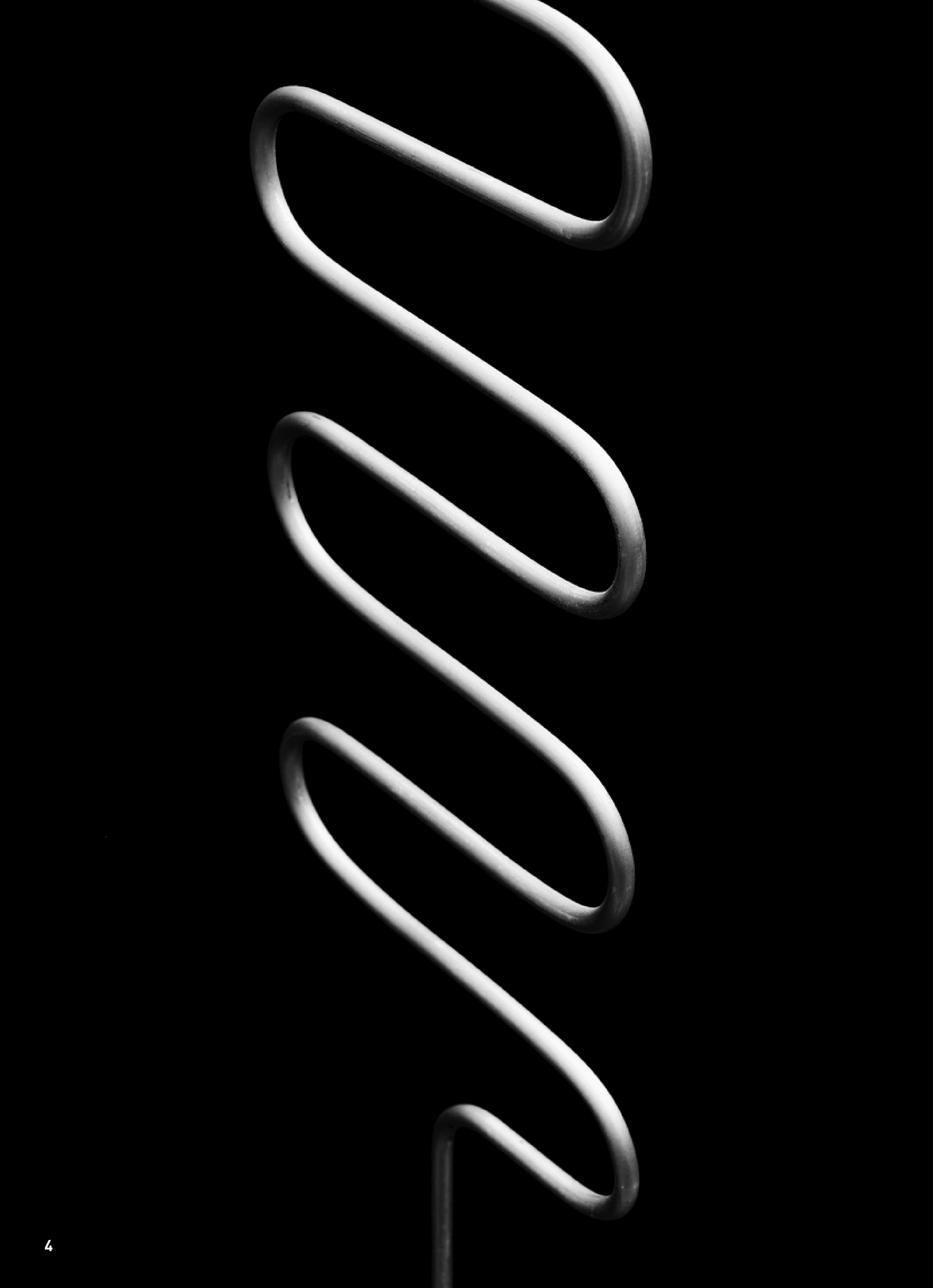


RESISTANCE HEATING ALLOYS

The electric resistance heating alloys manufactured by Kanthal AB can be broadly categorized into two main groups—Kanthal® iron-chromium-aluminum (FeCrAl) alloys and Nikrothal® nickel-chromium (NiCr) alloys.

Developed at the beginning of the 20th century, nickel-chromium found use as a heating element material in industrial furnaces and electric household appliances.

In the 1930s, Kanthal AB introduced a new electric resistance heating alloy called Kanthal®. When compared to Nikrothal®, Kanthal® has a longer lifespan and a higher maximum operating temperature.

The two main types of alloys have specific properties, each with its advantages and disadvantages. They are available in various grades and forms. In general, the Kanthal® range of alloys is superior to Nikrothal® in terms of performance and lifespan, making them a standard material choice for metallic heating elements in industrial furnaces.

However, Nikrothal® alloys may offer significant advantages if you require a heating element with excellent high-temperature mechanical properties. Nikrothal® alloys exhibit higher hot and creep strength compared to Kanthal® alloys which makes them better suited for suspended element designs.

For furnace users, switching to Kanthal® offers significant advantages, including higher maximum operating temperatures, reduced element material usage, and an extended lifespan.

FERRITIC ALLOYS

These alloys are known for their high electrical resistivity and exceptional resistance to high-temperature oxidation, making them ideal for use as electric heating elements and resistance materials in electronic equipment. Our range of FeCrAl alloys, branded as Kanthal®, can also be effectively utilized in non-electrical environments, such as ignitors or flame probes for gas burners.

TYPES OF KANTHAL® ALLOYS

KANTHAL® APM: UP TO 1,425°C (2,600°F)
Kanthal® APM is an electric resistance material that can improve performance at high temperatures. It addresses issues like bunching, creeping, sagging and oxide spallation that conventional metallic elements often face. Additionally, it can be used to explore new applications where metallic elements are currently not utilized.

Advantages of Kanthal® APM:

Improved hot strength, providing:
- Better form stability of the heating element
- Reduced need for element support
- Minimal resistance change (aging)
- Extended element life

Excellent oxide, providing:
- Effective protection in most atmospheres
- Minimal scaling and impurities
- Extended element lifespan

KANTHAL® A-1: UP TO 1,400°C (2,550°F)
The alloy is known for its high resistivity and excellent oxidation resistance.

Kanthal® A-1 is a high-temperature alloy used in applications involving ceramics, glass, steel, and electronics.

KANTHAL® AF: UP TO 1,300°C (2,370°F)
This alloy grade has improved creep strength and oxidation properties.

It is especially recommended where good form stability properties are required, particularly at high temperatures.

KANTHAL® D: UP TO 1,300°C (2,370°F)
Employed mainly in home appliances and industrial furnaces.

Its high resistivity and low density, combined with better heat resistance than austenitic alloys, make it suitable for many applications.

ALKROTHAL®: UP TO 1,100°C (2,010°F)
It is commonly specified for rheostats, braking resistors, etcetera.

It is also used as a heating wire for lower temperatures, such as heating cables.

PERFORMANCE METRICS OF FERRITIC ALLOYS

Creep rupture strength, sagging resistance, and elongation across Kanthal® APM and Kanthal® A-1 at high temperatures.

CREEP RUPTURE STRENGTH FOR INDUSTRIAL WIRE 4 MM

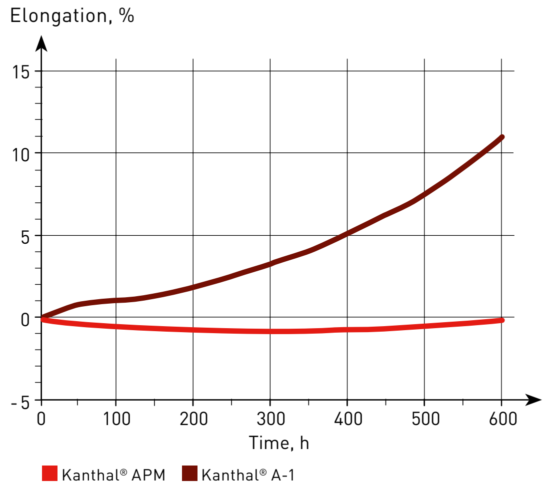
TIME, H	TEMPERATURE 1,000°C, MPA
100	5.6
1,000	3.4
10,000	2.2

TIME, H	TEMPERATURE 1,200°C, MPA
100	3.3
1,000	1.6
10,000	0.7

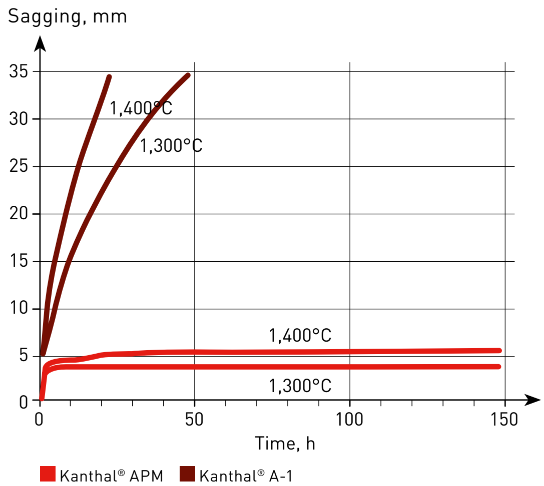
TIME, H	TEMPERATURE 1,400°C, MPA
100	1.3
1,000	0.5
10,000	0.2

Comparison between Kanthal® APM (top) and conventional FeCrAl (bottom) after 1,250 hours at max 1,225°C element temperature.

ELONGATION AT 1,300°C ELEMENT TEMPERATURE



SAGGING TEST DIAMETER 9.5 MM, 1,300°C AND 1,400°C, 300 MM BETWEEN SUPPORTS



ADVANTAGES OF KANTHAL® ALLOYS

HIGHER MAXIMUM OPERATING TEMPERATURE
Kanthal® A-1 can withstand temperatures up to 1,400°C (2,550°F) in air, compared to Nikrothal® 80, which can only handle up to 1,200°C (2,190°F).

HIGHER SURFACE LOAD CAPACITY
Due to higher maximum temperature, Kanthal® alloys can endure higher surface loads.

EXTENDED LIFESPAN
Kanthal® elements offer 2–4 times the lifespan of Nikrothal® alloys when operated in the air at the same temperature.

HIGHER ELECTRICAL RESISTIVITY
The greater resistivity of Kanthal® alloys allows for the use of materials with a larger cross-section, especially for thin wire applications. Additionally, Kanthal® alloys' resistivity is less affected by cold-working and heat treatment than that of Nikrothal® alloys.

HIGHER YIELD STRENGTH
The higher yield strength of Kanthal® alloys results in less deformation during wire coiling.

SUPERIOR OXIDATION PROPERTIES
The aluminum oxide (Al_2O_3) formed on Kanthal® alloys adheres better, is less contaminating, and serves as a more effective diffusion barrier and electrical insulator. It is also more resistant to carburizing atmospheres compared to the chromium oxide (Cr_2O_3) formed on Nikrothal® alloys.

LOWER DENSITY
Kanthal® alloys have a lower density than Nikrothal® alloys, allowing them to produce more elements from the same weight of material.

SIGNIFICANT WEIGHT SAVINGS
The combination of lower density and higher resistivity means that less material is required to achieve the same power output when using Kanthal® alloys instead of Nikrothal®. When converting from Nikrothal® to Kanthal®, either the wire diameter can remain constant while adjusting the surface load, or the surface load can remain constant while changing the wire diameter. This flexibility often leads to substantial weight and cost savings in various applications.

ENHANCED SULFUR RESISTANCE
Kanthal® alloys demonstrate superior corrosion resistance in hot conditions when exposed to sulfuric compounds or sulfur-containing contaminants on the wire surface, whereas Nikrothal® alloys are highly susceptible to damage under these conditions.

AUSTENITIC ALLOYS

Nickel-chrome (NiCr) alloys possess high mechanical strength that is maintained even at elevated temperatures, making them ideal for use as heat-resistant materials in various industrial processes. Kanthal's range of NiCr alloy products, branded as Nikrothal®, are also widely used as resistive heating elements in applications such as electric grills, tumble dryers, and blow-dryers.

TYPES OF NIKROTHAL® ALLOYS

NIKROTHAL® 80: UP TO 1,200°C (2,190°F)
It is a premium-quality alloy known for its high nickel content, which provides excellent workability and high-temperature strength.

Nikrothal® 80 is widely used in demanding applications within the electric appliance industry, particularly for tubular element applications.

NIKROTHAL® 60: UP TO 1,150°C (2,100°F)
It is suitable for a range of domestic and furnace applications and offers good corrosion resistance, excellent oxidation properties, and superior form stability, making it reliable for high-temperature use.

However, its corrosion resistance may be reduced in sulfur-containing atmospheres.

Typical applications for Nikrothal® 60 include use as suspended coils, where it is most commonly utilized, and less frequently in tubular heating elements.

NIKROTHAL® 40: UP TO 1,100°C (2,010°F)
The primary advantage of this alloy is its lower cost due to its reduced nickel content.

It is suitable for use in a variety of domestic appliances and general heating equipment where moderate temperatures are required.

NIKROTHAL® 70: UP TO 1,250°C (2,280°F)
Typical applications for Nikrothal® 70 include use as electrical heating elements in industrial furnaces.

This alloy is particularly well-suited for use in reducing atmospheres, as it is resistant to "green rot," a type of corrosion that affects some alloys in such environments.

ADVANTAGES OF NIKROTHAL® ALLOYS

HIGHER HOT AND CREEP STRENGTH
Nikrothal® alloys exhibit higher hot and creep strength compared to Kanthal® alloys. Although Kanthal® APM and Kanthal® AF have good form stability and are superior to other Kanthal® grades, they do not match the hot and creep strength of Nikrothal® alloys.

BETTER DUCTILITY AFTER USE
Nikrothal® alloys maintain their ductility even after prolonged use, ensuring flexibility and durability over time.

HIGHER EMISSIVITY
Fully oxidized Nikrothal® alloys have a higher emissivity than Kanthal® alloys. This means that at the same surface load, Nikrothal® alloys operate at a somewhat lower element temperature, enhancing efficiency in certain applications.

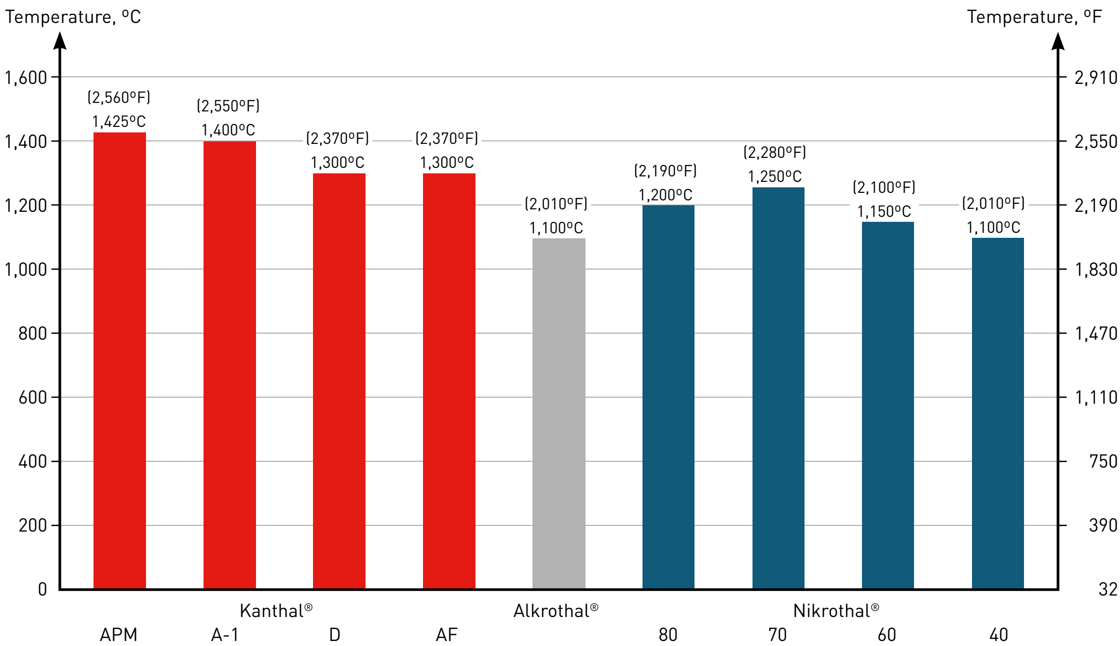
NON-MAGNETIC PROPERTIES
Nikrothal® alloys are generally non-magnetic, making them advantageous for low-temperature applications where non-magnetic materials are required. The exception to this is Nikrothal® 60, which is magnetic at low temperatures. In contrast, Kanthal® alloys become non-magnetic only when heated above 600°C (1,100°F).

BETTER WET CORROSION RESISTANCE
Nikrothal® alloys generally offer better corrosion resistance at room temperature than non-oxidized Kanthal® alloys, except in environments containing sulfur or certain controlled atmospheres.

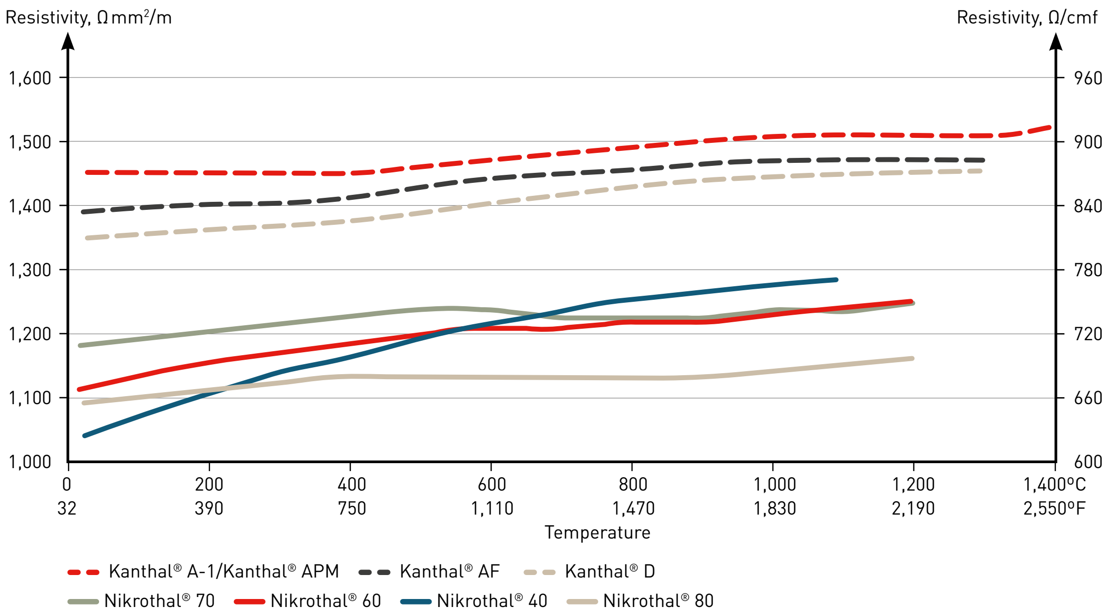
SUMMARY

Kanthal® and Nikrothal® alloys are designed for high temperatures: Kanthal® for oxidation resistance and longevity, Nikrothal® for creep strength and ductility.

MAXIMUM OPERATING TEMPERATURE PER ALLOY



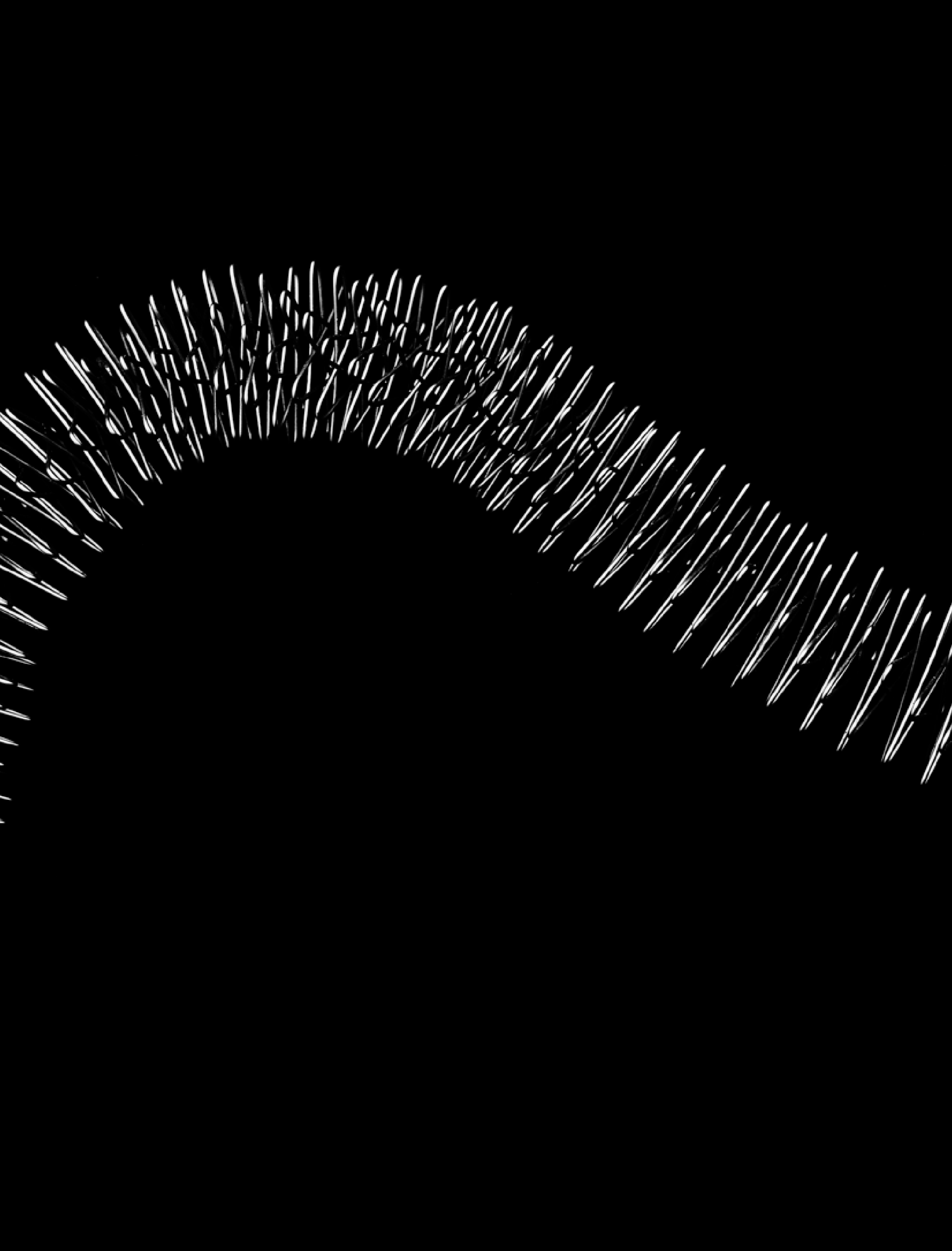
RESISTIVITY VS. TEMPERATURE



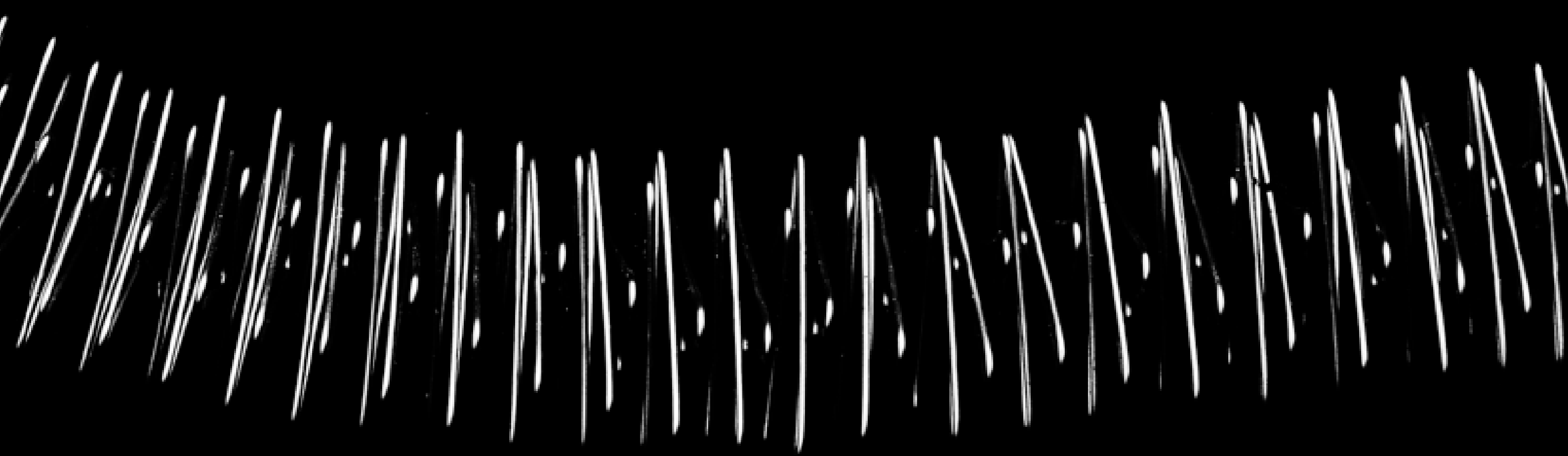
PRODUCT VARIETIES

Kanthal® and Nikrothal® alloys are available in specialized forms such as wire, strips, rods, and straightened wire. Alongside standard sizes (ranging from 0.10 to 3.5 mm in thickness and 4 to 205 mm in width), customized sizes can also be requested. These versatile forms ensure adaptability for high-temperature and resistance needs.

	ROD	WIRE	STRIP	STRAIGHTENED WIRE
Kanthal® APM	•	•	•	•
Kanthal® A-1	•	•	•	•
Kanthal® D	•	•	•	•
Kanthal® AF		•	•	•
Alkrothal®	•	•	•	•
Nikrothal® 80		•	•	•
Nikrothal® 70		•	•	•
Nikrothal® 60		•	•	•
Nikrothal® 40	•	•	•	•



PHYSICAL AND MECHANICAL PROPERTIES



Kanthal® and Nikrothal® alloys are generally available in wire, ribbon, or strip form, offering versatile solutions for various heating and resistance applications. Both types of alloys are known for their excellent physical and mechanical properties, including high tensile strength, good ductility, and resistance to oxidation and corrosion at elevated temperatures.

These alloys provide various options for designing and optimizing heating elements and components across several industrial and domestic applications.

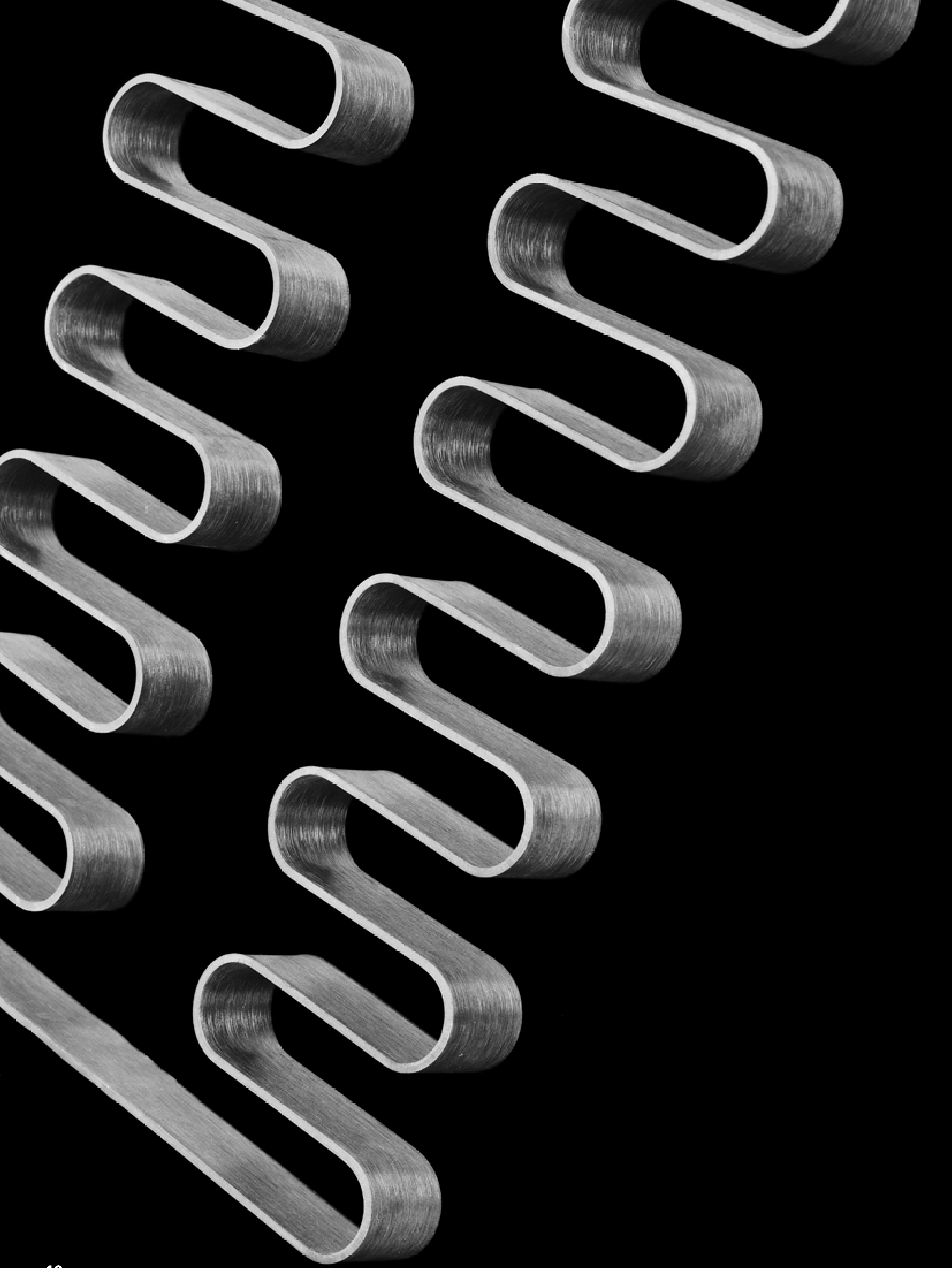
The physical and mechanical properties of the alloys are listed in the table on the next page.

PROPERTIES OVERVIEW

		KANTHAL® APM	KANTHAL® A-1	KANTHAL® AF	KANTHAL® D
Max continuous operating temp. (element temperature in air)	°C (°F)	1,425 (2,600)	1,400 (2,550)	1,300 (2,370)	1,300 (2,370)
Nominal composition (See Note), **%**	Cr Al Fe Ni	22 5.8 balance –	22 5.8 balance –	22 5.3 balance –	22 4.8 balance –
Density ρ	g/cm³ (lb/in³)	7.10 (0.256)	7.10 (0.256)	7.15 (0.258)	7.25 (0.262)
Resistivity at 20°C at 68°F	Ω mm²/m (Ω/cmf)	1.45 (872)	1.45 (872)	1.39 (836)	1.35 (812)
Temperature factor of the resistivity, Ct					
250°C (480°F)		1.00	1.00	1.01	1.01
500°C (930°F)		1.01	1.01	1.03	1.03
800°C (1,470°F)		1.03	1.03	1.05	1.06
1,000°C (1,830°F)		1.04	1.04	1.06	1.07
1,200°C (2,190°F)		1.05	1.04	1.06	1.08
Linear thermal expansion coefficient α, ×10-6/K					
20–100°C (68–210°F)		–	–	–	–
20–250°C (68–480°F)		11	11	11	11
20–500°C (68–930°F)		12	12	12	12
20–750°C (68–1,380°F)		14	14	14	14
20–1,000°C (68–1,840°F)		15	15	15	15
Thermal conductivity λ at 50°C at 122°F	W/m K (Btu in/ft2 h °F)	11 (76)	11 (76)	11 (76)	11 (76)
Specific heat capacity at 20°C at 68°F	kJ/kg K (Btu/lb °F)	0.46 (0.110)	0.46 (0.110)	0.46 (0.110)	0.46 (0.110)
Melting point (approx.)	°C (°F)	1,500 (2,730)	1,500 (2,730)	1,500 (2,730)	1,500 (2,730)
Mechanical properties* (approx.)					
Tensile strength	N/mm² (psi)	680** (98,600**)	680 (98,600)	700 (101,500)	670 (97,200)
Yield point	N/mm² (psi)	470** (68,200**)	545 (79,000)	500 (72,500)	485 (70,300)
Hardness	Hv	230	240	230	230
Elongation at rupture	%	20**	20	23	22
Tensile strength at 900°C at 1,650°F	N/mm² (psi)	40 (5,800)	34 (4,900)	37 (5,400)	34 (4,900)
Creep strength*					
at 800°C	N/mm²	8.2	1.2	–	1.2
at 1,470°F	(psi)	(1190)	(170)	–	(170)
at 1,000°C	N/mm²	–	0.5	–	0.5
at 1,830°F	(psi)	–	(70)	–	(70)
at 1,100°C	N/mm²	–	–	0.7	–
at 2,010°F	(psi)	–	–	(100)	–
at 1,200°C	N/mm²	–	–	0.3	–
at 2,190°F	(psi)	–	–	(40)	–
Magnetic properties		1)	1)	1)	1)
Emissivity, fully oxidized condition		0.70	0.70	0.70	0.70

Note: Composition listed is nominal. Actual composition may vary to meet standard electrical resistance and dimensional tolerances.
* The values given apply for sizes of approx. 1.0 mm diameter (0.039 in)
** 4.0 mm (0.157 in) Thinner gauges have higher strength and hardness values while the corresponding values are lower for thicker gauge
*** Calculated from observed elongation in a Kanthal standard furnace test. 1% elongation after 1000 hours
1) Magnetic (Curie point approx. 600°C (1100°F)) 2) Non-magnetic 3) Slightly magnetic

ALKROTHAL®	NIKROTHAL® 80	NIKROTHAL® TE	NIKROTHAL® 70	NIKROTHAL® 60	NIKROTHAL® 40
1,100 (2,010)	1,200 (2,190)	1,200 (2,190)	1,250 (2,280)	1,150 (2,100)	1,100 (2,010)
15 4.3 balance –	20 – – 80	22 – 9 balance	30 – – 70	16 – balance 60	20 – balance 35
7.28 (0.263)	8.30 (0.300)	8.10 (0.293)	8.10 (0.293)	8.20 (0.296)	7.90 (0.285)
1.25 (744)	1.09 (655)	1.19 (716)	1.18 (709)	1.11 (668)	1.04 (626)
1.02 1.05 1.10 1.11 –	1.02 1.05 1.04 1.05 1.07	1.04 1.06 1.06 1.07 1.07	1.02 1.05 1.04 1.05 1.06	1.04 1.08 1.10 1.11 –	1.08 1.15 1.21 1.23 –
– 11 12 14 15	– 15 16 17 18	– 14 15 16 17	– 14 15 16 17	– 16 17 18 18	– 16 17 18 19
16 (110)	15 (104)	14 (97)	14 (97)	14 (97)	13 (90)
0.46 (0.110)	0.46 (0.110)	0.46 (0.110)	0.46 (0.110)	0.46 (0.110)	0.50 (0.119)
1,500 (2,730)	1,400 (2,550)	1,380 (2,515)	1,380 (2,515)	1,390 (2,535)	1,390 (2,535)
630 (91,400)	810 (117,500)	800 (116,000)	820 (118,900)	730 (105,900)	675 (97,900)
455 (66,000)	420 (60,900)	390 (56,600)	430 (62,400)	370 (53,700)	340 (49,300)
220	180	190	185	180	180
22	30	30	30	35	35
30 (4,300)	100 (14,500)	– –	120 (17,400)	100 (14,500)	120 (17,400)
1.2 (170) 1 (140) – – – –	15 (2,160) 4 (560) – – – –	15 (2,160) 4 (560) – – – –	– – – – – – – –	15 (2,160) 4 (560) – – – –	20 (2,900) 4 (560) – – – –
1)	2)	2)	2)	3)	2)
0.70	0.88	0.88	0.88	0.88	0.88



DESIGN FACTORS

The design of an element is influenced by many factors, including the desired operating life, the required maximum operating temperature, and the environment in which it operates. Additionally, operating practices, such as the frequency of element temperature cycles or extended use at maximum temperatures can impact overall performance. This chapter will provide insights into these factors, covering both appliance-specific and furnace-specific considerations, with detailed calculations found in the "Design calculations" section on page 45.

GENERAL FACTORS AND FURNACE-SPECIFIC FACTORS

OPERATING LIFE

Element life is dependent on the alloy used, element temperature, element design, ambient atmosphere, heating cycle, type of element support, etc.

When heated, resistance-heating alloys form an oxide layer on their surface, which reduces further oxidation of the material. To accomplish this function, the oxide layer must be dense and resist the diffusion of gases as well as metal ions. It must also be thin and adhere well to the metal under temperature fluctuations. By carefully balancing the alloying elements, alloys with longer life, higher maximum operating temperatures, and improved high-temperature mechanical strength can be achieved.

The protective oxide layer on Kanthal® alloys, formed at temperatures above 1,000°C (1,830°F), consists mainly of alumina. The color is light grey, while at lower temperatures (below 1,000°C or 1,830°F), the oxide color becomes darker. The alumina layer has excellent insulating properties and good chemical resistance to most compounds.

Even with good adherence, some spalling (flaking off) of the oxide layer cannot be avoided. Damages to the oxide layer are repaired by the spontaneous formation of new oxide.

The oxide formed on Nikrothal® alloys consists mainly of chromium oxide. The color is dark, and its electrical insulating properties are inferior to those of alumina. The oxide layer on Nikrothal® alloys spalls and evaporates more easily than the tighter oxide layer that forms on Kanthal® alloys.

For a round wire, the ratio of volume to surface area is proportional to the diameter. Practically, this means that as the wire diameter increases, more alloying element is available per surface unit to form a new oxide. Thus, at a given temperature, thicker wires have longer lifetimes than thinner wires. Similarly, for strip elements, increased thickness leads to longer life.

To estimate the relative quality of a resistance alloy, a test method must be chosen that considers both oxidation rate and spalling. The method used at Kanthal is the Bash-test (ASTM B-76 and B-78). A 0.7 mm (0.0276 in) wire is electrically heated to a standardized temperature and cycled on and off every two minutes. The time to failure is recorded.

Results of such tests are given in the table on the following page, for Kanthal® and Nikrothal® alloys. In the table, the durability of Kanthal® A-1 wire at 1,200°C (2,190°F) is set at 100%, and the durability of the other alloys is related to that figure.

Numerous practical applications also show a much longer life for Kanthal® elements than for elements equipped with NiCr(Fe) wire.

The life of the resistance heating alloy is dependent on several factors, among them the most important are:
- Temperature
- Temperature cycling
- Contamination
- Alloy composition
- Trace elements and impurities
- Wire diameter
- Surface condition
- Atmosphere
- Mechanical stress
- Method of regulation

Since these are unique for each application it is difficult to give general guidelines of life expectations. Recommendations on some of the important design factors are given below.

CORROSION RESISTANCE

Corrosive or potentially corrosive substances can significantly reduce the lifespan of resistance-heating wires. Corrosion can be caused by perspiring hands, mounting or supporting materials, or various contaminants.

STEAM

Steam is particularly detrimental to wire life, with a more pronounced effect on Nikrothal® alloys than Kanthal® alloys.

HALOGENS

Halogens (fluorine, chlorine, bromine, and iodine) aggressively attack all high-temperature alloys, even at relatively low temperatures.

SULFUR

Sulfurous atmospheres also pose a threat; however, Kanthal® alloys demonstrate considerably better durability than nickel-based alloys in these environments. Kanthal® alloys are especially stable in oxidizing gases containing sulfur, but their service life is reduced in sulfurous reducing gases. Conversely, Nikrothal® alloys are more sensitive to sulfur.

RELATIVE DURABILITY VALUES IN %
KANTHAL® AND NIKROTHAL® ALLOYS
(ASTM-TEST WIRE 0.7 MM (0.028 IN))

ALLOY	1,100°C (2,010°F)	1,200°C (2,190°F)	1,300°C (2,370°F)
Kanthal® A-1	340	100	30
Kanthal® AF	465	120	30
Kanthal® D	250	75	25
Nikrothal® 80	120	25	–
Nikrothal® TE	130	25	–
Nikrothal® 60	95	25	–
Nikrothal® 40	40	15	–

Kanthal® A-1 at 1,200°C (2,190°F) is set at 100%

SALTS AND OXIDES

The salts of alkaline metals, boron compounds, etc. in high concentrations can harm resistance heating alloys.

METALS

Molten metals such as zinc, brass, aluminum, and copper can react with resistance alloys, necessitating protection from splashes of these metals.

CERAMIC SUPPORT MATERIAL

Ceramic support should be carefully selected when in direct contact with heating wires. Firebricks used for wire support should contain at least 45% alumina, and in high-temperature applications, sillimanite or high-alumina firebricks are recommended. The free silica (uncombined quartz) content should be minimized, and iron oxide (Fe_2O_3) content should be kept as low as possible, ideally below 1%. Additionally, water glass as a binder in cement should be avoided.

EMBEDDING COMPOUNDS

Most embedding compounds including ceramic fibers are suitable for Kanthal® and Nikrothal® is composed of alumina, alumina-silicate, magnesia, or zircon. For detailed information, refer to the table on “Maximum Wire Temperatures.”

MAXIMUM WIRE TEMPERATURES AS A FUNCTION OF WIRE DIAMETER WHEN OPERATING IN AIR

ALLOY	DIAMETER							
	0.15 – 0.40 MM °C	0.0059 – 0.0157 IN °F	0.41 – 0.95MM °C	0.0161 – 0.0374 IN °F	1.0 – 3.0 MM °C	0.039 – 0.18 IN °F	>3.0 MM °C	>0.118 IN °F
Kanthal® AF	900 – 1,100	1,650 – 2,010	1,100 – 1,225	2,010 – 2,240	1,225 – 1,275	2,240 – 2,330	1,300	2,370
Kanthal® D	925 – 1,025	1,700 – 1,880	1,025 – 1,100	1,880 – 2,010	1,100 – 1,200	2,010 – 2,190	1,300	2,370
Nikrothal® 80	925 – 1,000	1,700 – 1,830	1,000 – 1,075	1,830 – 1,970	1,075 – 1,150	1,970 – 2,100	1,200	2,190
Nikrothal® TE	925 – 1,000	1,700 – 1,830	1,000 – 1,075	1,830 – 1,970	1,075 – 1,150	1,970 – 2,100	1,200	2,190
Nikrothal® 60	900 – 950	1,650 – 1,740	950 – 1,000	1,740 – 1,830	1,000 – 1,075	1,830 – 1,970	1,150	2,100
Nikrothal® 40	900 – 950	1,650 – 1,740	950 – 1,000	1,740 – 1,830	1,000 – 1,050	1,830 – 1,920	1,100	0,010

FURNACE-SPECIFIC FACTORS

OPERATING LIFE AND MAXIMUM PERMISSIBLE TEMPERATURE

When heated, resistance heating alloys form an oxide layer on their surface, which helps to prevent further oxidation of the material. For this protective function to be effective, the oxide layer must be dense to resist the diffusion of gases, thin to avoid adding bulk, and strongly adhere to the metal even under temperature fluctuations.

The aluminum oxide layer formed on Kanthal® alloys excels in these qualities compared to the oxide formed on Nikrothal® alloys, resulting in a significantly longer operating life for Kanthal® heating elements.

The diagram below illustrates the comparative element lifespans.

This chapter offers general guidance on maximizing the operating life of heating elements.

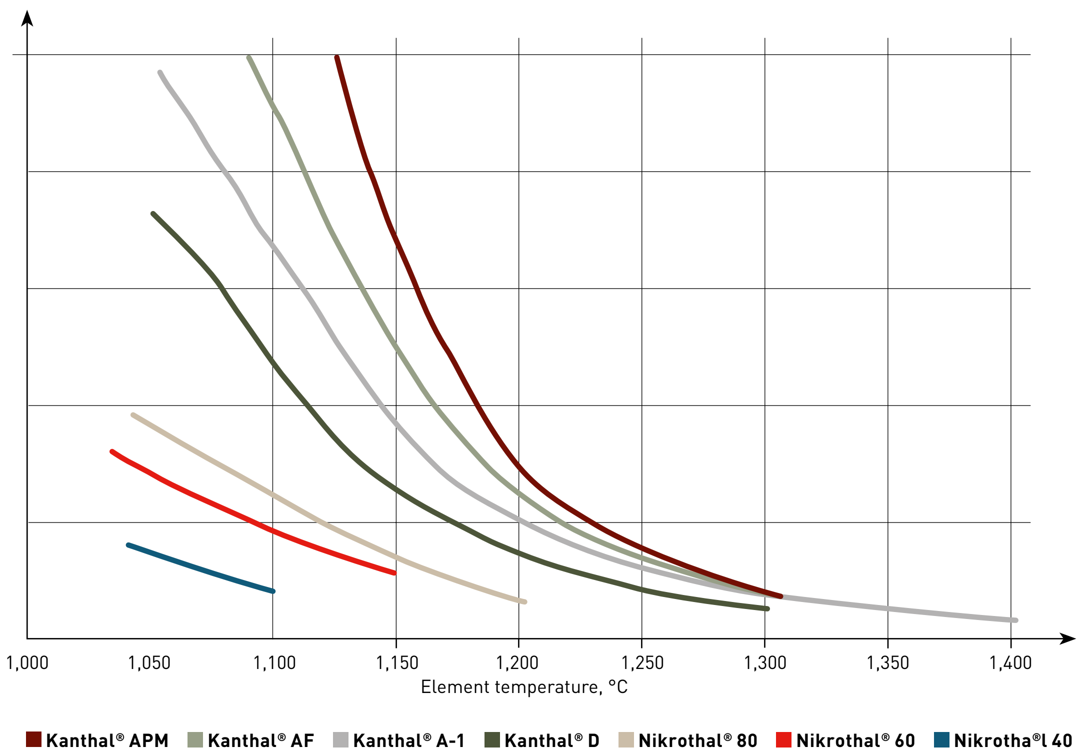
USE KANTHAL® ALLOYS

Heating elements made from Kanthal® alloys can last up to four times longer than those made from nickel-chromium materials. This advantage becomes more pronounced at higher operating temperatures.

AVOID TEMPERATURE FLUCTUATIONS

Rapid temperature fluctuations can reduce the operating life of heating elements. To minimize this effect, it is recommended to use electric control equipment that maintains a stable temperature, such as thyristors, which provide smooth and continuous control.

COMPARATIVE LIFE (KANTHAL® A-1 AT 1,200°C = 100%)



CHOOSE THICK ELEMENT MATERIAL

The thickness of the element material directly affects its lifespan. As the wire diameter increases, more alloying material is available per surface unit to form a protective oxide layer, resulting in longer element life at a given temperature. Consequently, thicker wires offer a longer lifespan than thinner ones. Similarly, for strip elements, increasing thickness enhances their durability. As a general guideline, a minimum wire diameter of 3 mm and a strip thickness of 2 mm is recommended to maximize element life.

ADJUST THE ELEMENT TEMPERATURE TO THE FURNACE ATMOSPHERE

The table in the following page shows common furnace atmospheres and their impact on the maximum operating temperature of heating elements. Nikrothal® should not be used in furnaces with a CO-containing protective gas atmosphere, as this can lead to "green rot" at temperatures between 800–950°C (1,472–1,652°F. In these situations, Kanthal alloys are recommended, provided the heating elements are pre-oxidized in the air at 1,050°C (1,922°F) for 7–10 hours. Reoxidation of the heating elements should also be performed at regular intervals.

AVOID CORROSION FROM SOLID SUBSTANCES, FLUIDS, AND GASES

Impurities in the furnace atmosphere, such as oil, dust, volatile compounds, or carbon deposits, can cause damage to heating elements. Sulfur is harmful to all nickel-based alloys, while chlorine, in any form, will attack both Kanthal® and Nikrothal® alloys. Additionally, splashes of molten metal or salt can also lead to damage to the heating elements.

Numerous practical applications also show a much longer life of Kanthal® elements.

FURNACE ATMOSPHERES

The lifespan of a resistance heating element relies on the continuous presence of a dense oxide layer that fully covers the element's surface. Corrosion occurs when specific compounds in the furnace atmosphere interfere with the formation or replenishment of this oxide layer. The greater the interference, the shorter the element's life, and the impact of corrosive compounds is often dependent on temperature.

AIR

The ability of resistance alloys to function in air at high temperatures depends entirely on the protective oxide layer formed on their surface. However, impurities in the air, such as fumes, gases, dust, and other contaminants from the furnace batch or insulation, can disrupt oxide formation. Poor ventilation may cause gases to escape along the terminals, leading to excessive corrosion and premature failure.

Under normal operating conditions, Nikrothal® alloys have a higher tendency for oxide spalling than Kanthal® alloys, which can be an issue when heating materials with sensitive surfaces, such as white porcelain. Additionally, ceramic supports can become contaminated, potentially causing creep currents that lead to premature element failure.

CONTROLLED ATMOSPHERES

In carbonaceous atmospheres, whether endothermic or exothermic, the alumina layer on Kanthal® alloys provides effective protection against the active components of these gas mixtures. Pre-oxidizing the elements in the air at 1,050°C (1,920°F) for seven to ten hours can significantly extend their life in these "protective" atmospheres. For maximum lifespan, the elements should be re-oxidized periodically based on operating conditions.

In contrast, the protective layer on Nikrothal® 80 Plus is not effective in exothermic and endothermic atmospheres; instead, selective chromium oxidation along the grain boundaries ("green rot") occurs, especially at low oxygen potential and element temperatures of 500-950°C (932-1,742°F). In such cases, Kanthal® alloys are recommended.

HYDROGEN AND NITROGEN ATMOSPHERES

Pure hydrogen does not harm Kanthal® or Nikrothal® alloys, but service life can be shortened if the gas mixture contains uncracked ammonia.

Very dry nitrogen, lacking in oxygen, can lead to the formation of aluminum nitride, limiting the maximum permissible temperature 1,050°C (1,920°F) for Kanthal® A-1 and 1,100°C (2,012°F) for Kanthal® AF. Conversely, the strong affinity of these alloys for oxygen can inhibit nitride formation in atmospheres of technically pure nitrogen, which typically contains some oxygen.

Kanthal® AF remains relatively stable in a pure nitrogen atmosphere at temperatures up to 1,250°C (2,280°F), provided controlled pre-oxidation is performed at the service temperature.

VACUUM

In a high vacuum, the oxide layer on Nikrothal® alloys decomposes at temperatures above 1,000°C (1,830°F), and the alloy components may vaporize, depending on the pressure and temperature.

MAXIMUM PERMISSIBLE TEMPERATURES IN VARIOUS ATMOSPHERES

	KANTHAL® A-1 AND KANTHAL® APM °C (°F)	KANTHAL® AF °C (°F)	KANTHAL® D °C (°F)	NIKROTHAL® 80 °C (°F)	NIKROTHAL® 70 °C (°F)	NIKROTHAL® 60 °C (°F)	NIKROTHAL® 40 °C (°F)
OXIDIZING							
Air. dry	1,400* (2,550)	1,300 (2,370)	1,300 (2,370)	1,200 (2,190)	1,250 (2,280)	1,150 (2,100)	1,100 (2,010)
Air. moist** (3% H2O)	1,200 (2,190)	1,200 (2,190)	1,200 (2,190)	1,150 (2,100)	1,150 (2,100)	1,100 (2,010)	1,050 (1,920)
N_2. Nitrogen***	1,200/1,050 (2,190/1,920)	1,250/1,100 (2,280/2,010)	1,150/1,000 (2,100/1,830)	1,250 (2,280)	1,250 (2,280)	1,200 (2,190)	1,150 (2,100)
Ar. Argon	1,400 (2,550)	1,400 (2,550)	1,300 (2,370)	1,250 (2,280)	1,250 (2,280)	1,200 (2,190)	1,150 (2,100)
Exothermic: 10% CO. 15% H_2. 5% CO2. 70% N2****	1,150 (2,100)	1,150 (2,100)	1,100 (2,010)	1,100 (2,010)	1,100 (2,010)	1,100 (2,010)	1,100 (2,010)
REDUCING							
Endothermic: 20% CO. 40% H_2. 40% N2****	1,050 (1,920)	1,050 (1,920)	1,000 (1,830)	1,100 (2,010)	1,100 (2,010)	1,100 (2,010)	1,100 (2,010)
H_2. Hydrogen	1,400 (2,550)	1,400 (2,550)	1,300 (2,370)	1,250 (2,280)	1,250 (2,280)	1,200 (2,190)	1,150 (2,100)
75%H2. 25%N2*****	1,200 (2,190)	1,200 (2,190)	1,100 (2,010)	1,100 (2,010)	1,100 (2,010)	1,100 (2,010)	1,100 (2,010)
VACUUM							
10-3 torr	1,150 (2,100)	1,200 (2,190)	1,100 (2,010)	1,100 (2,010)	1,100 (2,010)	1,000 (1,830)	900 (1,650)

* Max 1,425/2,530°C (2,597–4,586°F) for Kanthal® APM.
** Maximum temperature for the Nikrothal®alloy s will decrease with increasing water content and flowrate of gas.
*** The higher values apply for preoxidized material.
**** Please note the risk of "green root" corrosion on Nikrothal® alloys in carburizing atmospheres. Use of Kanthal alloys is preferred.
***** Ammonia or ammonia containing atmospheres will have a lower maximum permissible temperature.

In contrast, the protective oxide on Kanthal® alloys is more stable, and pre-oxidized elements can be operated at lower pressures and higher temperatures. At 5 × 10^{-4} torr and 1,100°C (2,010°F), Kanthal® elements have an excellent lifespan. However, if the element temperature reaches 1,150°C (2,100°F), it should be re-oxidized after 250 service hours; at 1,250°C (2,200°F), re-oxidation is needed after 100 hours (or at 1,050°C (1,920°F) after 5 hours).

CERAMIC SUPPORT MATERIALS

For electric furnaces, special consideration must be given to the ceramic supports that contact the heating elements directly. Firebricks used for element support should have an alumina content of at least 45%. In high-temperature furnaces, sillimanite or high-alumina firebricks are often recommended. The free silica (uncombined quartz) content should be minimized, as silica may react with the surface oxide at high temperatures. Iron oxide (Fe_2O_3) content should be kept as low as possible, preferably below 1%, and alkali oxides (Na_2O, K_2O, etc.) should remain below 0.1%.

Water glass, often used as a binder in cement, can negatively affect resistance heating materials and should be avoided.

Leakage and creep currents at high temperatures can attack contact points between the ceramic support and the heating element, potentially leading to premature failure. Therefore, support materials must have high insulating resistance at the service temperature.

EMBEDDING COMPOUNDS

Most embedding compounds, including ceramic fibers, are suitable for Kanthal® and Nikrothal® if composed of alumina, alumina-silicate, magnesia, or zirconia, and if the guidelines under "Ceramic support materials" are followed. Generally, commercially available products meet these criteria. When moistened cement is used with Kanthal® alloys, such as in heating panels, immediate drying is crucial to prevent corrosion from sulfuric impurities. Distilled water is preferred as a moistening agent because fluorinated or chlorinated tap water can cause corrosion. Likewise, degreasing solvents containing chlorine must be completely removed after cleaning element coils.

Certain cements can attack resistance heating materials. In enclosed environments, even traces of sulfur-containing contaminants can severely damage Nikrothal® wires at elevated temperatures. Boron compounds can attack both Kanthal® and Nikrothal® alloys at temperatures above 900°C (1,650°F).

Corrosion tests for embedding compounds should always be conducted before their use is specified.

ELEMENT TYPES

Kanthal offers its alloys in wire and strip form to provide design options allowing users to optimize performance for their specific application.

The mechanical strength of all metallic heating materials decreases with increasing temperature. Thick strip or wire elements generally provide a more stable design and a lower risk of deformation at high operating temperatures than thin wire spirals.

Operating life is also related to the cross-section of the element material, strip thickness, and wire diameter should be selected as large as possible, particularly for high-temperature applications.

Electric appliances equipped with heating elements are used in both domestic and industrial applications. Domestic applications include cooking, fluid heating, drying, ironing, space heating, and special purposes such as heating beds, aquariums, saunas, soldering irons, and paint strippers. Industrial applications involve processes such as heat treatment, hardening, and drying of inks, paints, and lacquers. Components like seats, motors, and rearview mirrors are frequently electrically heated in vehicles.

The appliance and the element must meet requirements concerning performance, cost of raw material and manufacture, lifespan, and safety. These requirements can sometimes conflict. For example, a long life and a high degree of safety require a low wire temperature, which results in a longer heating time and often higher raw material costs.

The lifespan of a well-designed element depends on the make and type of wire used. Our FeCrAl and NiCr(Fe) wires have excellent properties at high temperatures, offering the best possible lifespan. These wires are described and compared under "Physical and Mechanical Properties," on page 15. It is important to note that the lifespan of a wire increases with a larger wire diameter and a lower wire temperature.

ELEMENTS FOR ELECTRIC APPLIANCES

Elements for electric appliances can be grouped in various ways. If classified according to how the wire is mechanically supported, they can be divided into three groups: embedded, supported, and suspended elements.

THE EMBEDDED ELEMENT TYPE

The wire in the embedded element type is surrounded by solid or granular insulating material.

THE SUPPORTED ELEMENT TYPE

The wire, usually in coil form, is placed on the surface, in a groove, or a hole of the electrically insulating material. Kanthal® AF and Nikrothal® 80 are generally the most suitable materials. To avoid deformations in horizontal coils, the wire temperature should not exceed the values given in the diagram on this page.

THE SUSPENDED ELEMENT TYPE

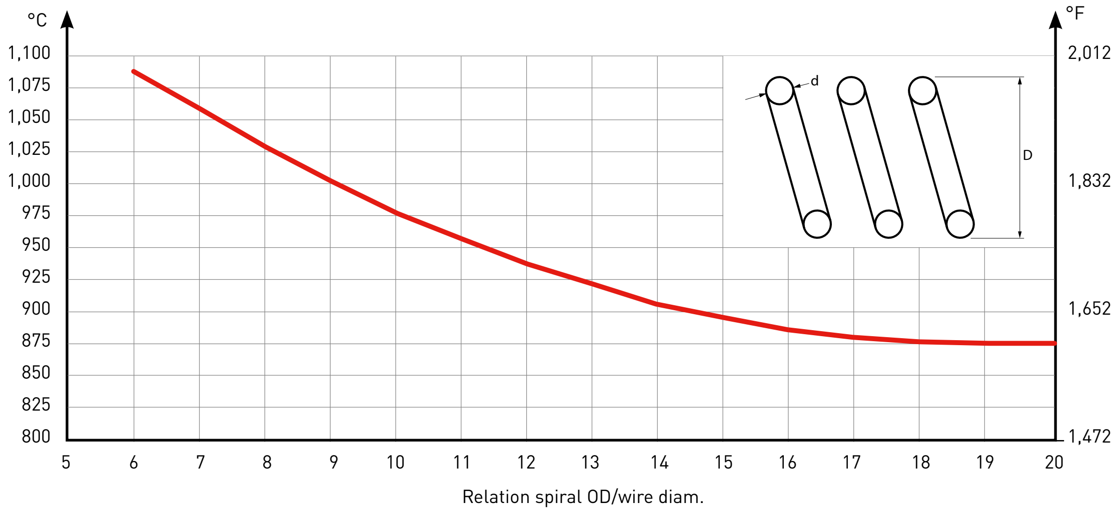
The wire is suspended freely between insulated points and is exposed to mechanical stress caused by its weight, spring force, and, in some cases, external spring forces. Nikrothal® 80 and Nikrothal® 60 are the most suitable materials.

COMPARISON OF EMBEDDED, SUPPORTED, AND SUSPENDED ELEMENTS FOR ELECTRIC APPLIANCES

	Element Type		
	Embedded	**Supported**	**Suspended**
Mounting of wire	Embedded in electrical insulation	Fully supported by electrical insulation	Supported at points only
Heat dissipation from wire	Conduction	Radiation Convection Conduction	Convection Radiation
Shape of wire	Round wire (Ribbon)	Round wire	Round wire (Ribbon)
Wire surface load, W/cm²	<=25	1-10	3-15*
Wire surface load, W/in²	6-160	6-65	20-100*
Hot strength of wire	Normally unimportant	Sometimes important	Often important
Access to ambient air	Limited	Rarely limited	No limitation
Electrical insulation requirements	Important for life and safety	Rarely a problem	Problem only when wire sags

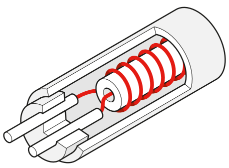
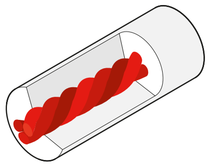
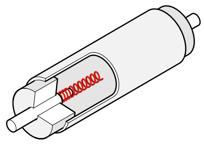
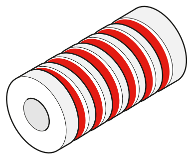
* If immersed in water, even higher surface load is possible depending of water velocity. 20-60 W/cm2, 130-390 W/in2

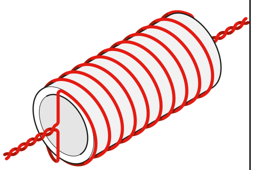
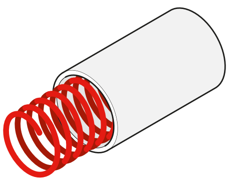
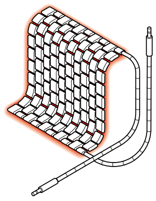
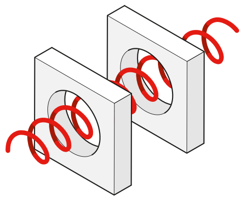
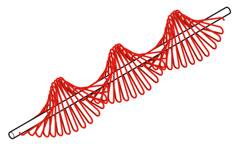
PERMISSIBLE D/d RATIOS AS A FUNCTION OF WIRE TEMPERATURE



OVERVIEW: APPLIANCE ELEMENT TYPES

Electric heating elements are classified as embedded, supported, or suspended. Each type balances performance, lifespan, safety, and cost, with alloy choice, wire size, and operating temperature key for durability and efficiency.

	EMBEDDED ELEMENTS			SUPPORTED ELEMENTS	
Element type	Cartridge elements, powder filled	Heating cables and rope heaters	Metal sheathed tubular element	Ceramic cartridge elements	
					
Characteristics	Straight wire or coil is wound on a threaded ceramic body and insulated by granular insulating material (MgO) from an enveloping metal tube. Terminals are at one end of the element. Elements are compressed when high-loaded.	Wire is wound on a fiberglass core and insulated by PVC or silicone rubber (higher temperatures). Fiberglass insulation permits even higher temperatures. Heating cables with straight or stranded wires, sometimes enclosed in aluminum tube, also occur.	The heating coil is insulated from the encasing metallic tube by granular material (MgO). The tube is compressed to a round oval or triangular shape. Terminals may be at either end or at one end of the element	Most common design consists of round ceramic bodies with longitudinal holes or grooves for heating coil. Elements are often in metallic tube with terminals at one end. Often provisions are made to avoid excessive sagging of the coil when the element is operating vertically.	
Recommended alloys	Nikrothal® 80 in straight wire elements. Kanthal® D in coiled wire elements.	Kanthal® D. Nikrothal® 40 and Nikrothal® 80.	Kanthal® D in elements with sheath temperature >700C (1.290F). Nikrothal® 80 in elements with sheath temperature >700C (1.290F)	Kanthal® A-1 or Kanthal® D for horizontally operating coils. Nikrothal® 80 (usually) for long vertically situated coils when sagging is a problem.	
Surface load	On tube: 10–25 W/cm2 (65–161 W/in2) for elements with straight wire. Other types: about 5 W/cm2 (32 W/in2).	Wire: <1 W/cm2 (<6 W/in2) on wire for PVC and silicone rubber, 2–5 W/cm2 (13–32 W/in2) for fiberglass insulation.	Wire: Normally 2-4 times the element surface load. Element: 2-25 W/cm^2 (13-161 W/inch^2)	Wire: 3–6 W/cm2 (20–40 W/in2). Element: 2–5 W/cm2 (19–39 W/in2).	
Typical applications	Metal dies, plates, refrigerators.	Defrosting and de-icing elements, electric blankets and pads, car seat heaters, baseboard heaters, floor heating.	Hot plates, domestic ovens, grills, deep fryers, immersion heaters, dishwashers, washing machines, radiators, storage heaters, air heaters, oil heaters.	Liquid heating, storage heaters.	

			SUSPENDED ELEMENTS	
Other ceramic elements	Quartz tube heaters	Bead insulated coils or stranded wire	Suspended coils	Porcupine elements
				
Coiled and straight wire is located on smooth ceramic tube or in grooves or holes of ceramic bodies of various shapes (plates, tubes, rods, cylinders, etc.).	Heating coil or porcupine shaped wire is placed inside quartz tube (or tube of glass ceramic). When the element is operating vertically or at an angle, the coil should be tight-wound and pre-oxidized. For horizontal use, the relative pitch is 1.2–2.0.	Heating coil, or stranded wire, is insulated by ceramic beads. With beads having two holes heating mats are made.	Wire coil is supported at intervals, e.g. by ceramic holders.	Heating conductor consists of hairpin-shaped wire bends protruding in all directions, with hole in center. Element is supported by central insulated rod or insulating tube around its circumference.
Kanthal® A-1, Kanthal® AF and Kanthal® D. Nikrothal® 80 (for pencil bars).	Kanthal® AF.	Kanthal® D. Nikrothal® 80 (for panel heaters).	Nikrothal® 80, Nikrothal® 60 and Nikrothal® 40	Kanthal® AF. Nikrothal® 80.
Wire: 3–9 W/cm2 (19–58 W/in2).	Wire: 2–8 W/cm2 (13–52 W/in2). Element: 4–8 W/cm2 (26–52 W/in2).	Wire: 1–8 W/cm2 (6–52 W/in2).	Wire: 7–8 W/cm2 in forced air, 3–4 W/cm2 in natural convection.	Wire: 4 W/cm2 (26 W/in2) in natural convection. For toasters: 12 W/cm2 (77 W/in2) in forced convection.
Boiling plates, air guns, hobby kilns, radiators	Space heating, infrared heaters, industrial infrared dryers etc.	Mats for in-situ annealing of welded parts, panel heaters.	Air heaters such as: laundry dryers, fan heaters, land dryers.	Hot air guns, radiators, convectors, tumble dryers, domestic ovens with forced convection.

ELEMENTS IN FURNACES

For determining the dimensions and forms of industrial elements, the main factors are furnace temperature, furnace power (which depends on the load and the heating rate), available voltage, and the physical size of the furnace chamber. These are discussed below.

FURNACE TEMPERATURE

The furnace temperature depends on the required charge temperature. The element temperature will exceed the furnace temperature by an amount determined by the element design.

FURNACE POWER

Furnace power is calculated by determining the amount of power needed to heat the charge to a predetermined temperature within a specific time, including furnace losses and a safety margin.

MODE OF OPERATION

For continuously operating furnaces, it is generally sufficient to calculate the power required for the actual charge, considering the normal efficiency for that type of furnace. Assuming an efficiency of 70-80% to cover losses from an electric furnace, and adding a safety margin, an adequate input value may be obtained.
For batch furnaces, required heat-up times and the heating capacity of the furnace must be considered when determining input power requirements. However, input power itself has minimal effect on energy consumption and efficiency. The decisive factor is heat losses, determined by the effectiveness of the insulation. A given mass requires the same amount of energy regardless of the total power.

The aim in selecting input power values is to provide sufficient power without being excessively high in relation to furnace size, as this would lead to unnecessarily high element temperatures, adversely affecting service life. LTM (low thermal mass) batch furnaces may require approximately 25% less input power.

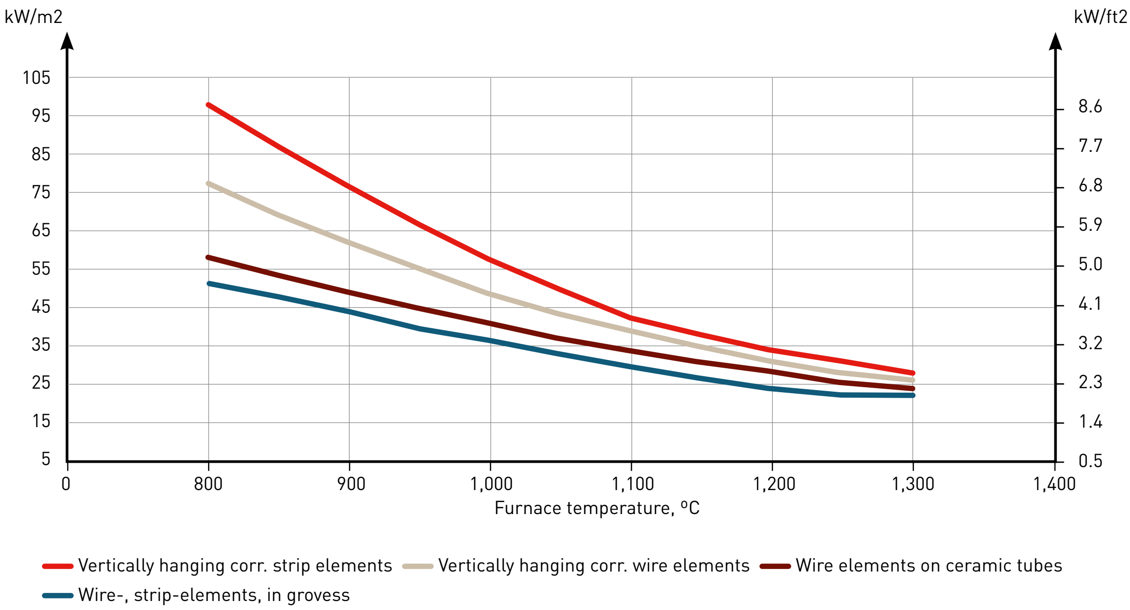
FURNACE VOLTAGE

Apart from small high-temperature furnaces, which usually operate on lower voltages via a transformer, most furnaces can be designed to operate at standard line voltage. The element thickness or cross-section also influences circuit design. For large cross-sections, furnace power should not be divided among too many parallel circuits. With three-phase AC power, a star (Y) configuration generally allows for larger cross-sections, while a delta (Δ) configuration requires smaller cross-sections. Therefore, elements in small furnaces should preferably be connected to a single-phase power source in series or through a low-voltage transformer.

FURNACE WALL LOADING

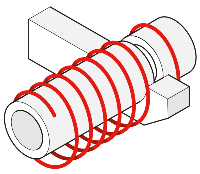
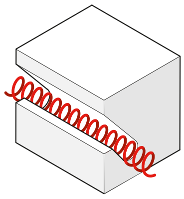
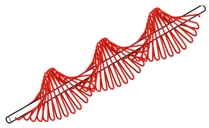
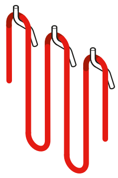
In designing resistance elements, element temperature and material cross-section are crucial, as they significantly affect service life. The goal is typically to achieve maximum element life. Important factors include power concentration on the furnace wall, specific surface load of the resistance material, and heat transfer conditions. The wall area is usually calculated as the length multiplied by the height or width of the element-carrying wall, roof, or bottom.

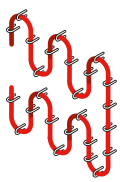
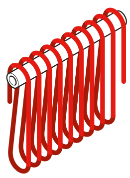
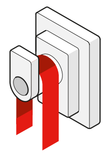
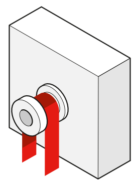
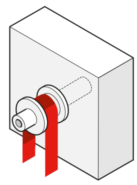
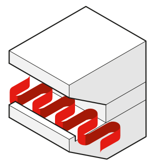
MAX RECOMMENDED WALL LOADING VERSUS FURNACE TEMPERATURE AND DIFFERENT ELEMENT CONFIGURATIONS



OVERVIEW: FURNACE ELEMENT TYPES

Furnace heating element systems include wire and strip configurations. Designed for temperatures up to 1,300°C (2,370°F), they optimize performance through precise surface load and wall loading parameters.

	WIRE ELEMENTS				
Element systems	Spiral	Spiral	Porcupine	Rod over bend	
Supports	Ceramic tubes	Grooves	Ceramic tubes	Metallic rods	
					
Material	Sillimanite	Chamotte grade 28	Sillimanite	Kanthal® APM	
Max. furnace temperature, °C	1,300	1,250	800	1,300	
Max. wall loading at 1,000°C furnace temperature, kW/m²	40	35	–	50	
Max. surface load at 1,000°C furnace temperature, W/cm²	3 – 4	3 – 4	–	5 – 6	
Wire diameter, d, mm	2.0 – 6,5	2.0 – 5.0	1.0 – 6.5	≥ 5.0	
Strip thickness, t, mm	–	–	–	–	
Strip width, w, mm	–	–	–	–	
Outer coil diameter, D, mm	12 – 14 d	5 – 6 d	–	–	
Max. loop length at 1,000°C furnace temperature, mm	–	–	–	250	
Min. pitch at max. loop length, mm	3d	2d	3d	40	

			STRIP ELEMENTS			
	Corrugated	Looped	Deep-corrugated	Deep-corrugated	Deep-corrugated	Corrugated
	Metallic staples	Ceramic tubes	Ceramic cup locks	Ceramic bushes	Ceramic tubes	Grooves
						
	U-shaped Kanthal® nails	Sillimanite	Cordierite or mullite	Cordierite or mullite	Sillimanite	Chamotte grade 28
	1,300	1,300	1,300	1,300	1,300	1,300
	50	60	60	60	60	20–40
	3–6	5–6	5–6	5–6	5–6	3–4
	2.0 – 5.0	≥ 5.0	–	–	–	–
	–	–	2.0–3.0	2.0–3.0	2.0–3.0	1.5–3.0
	–	–	8–12 t	8–12 t	8–12 t	8–12 t
	–	–	–	–	–	–
	100	250	250	250	250	2–3 w
	40	40	50	50	50	1.5 w

ELEMENT SUPPORT SYSTEMS

USE OF CERAMIC SUPPORT MATERIALS

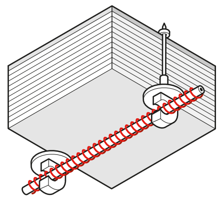
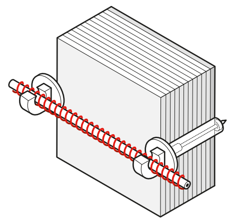
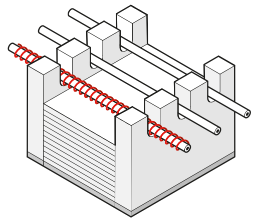
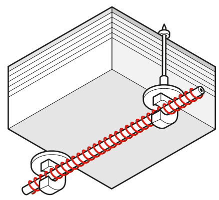
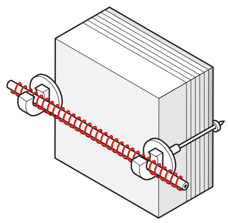
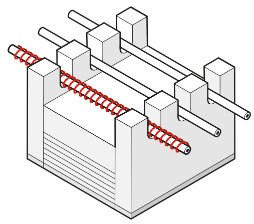
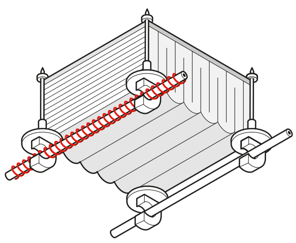
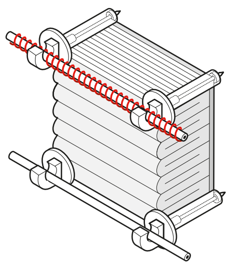
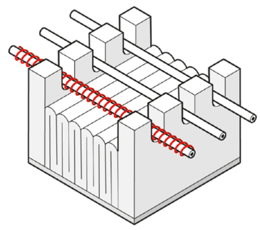
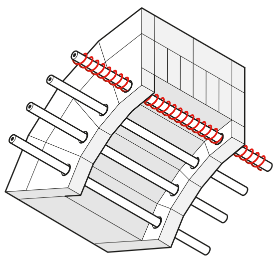
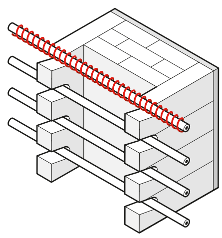
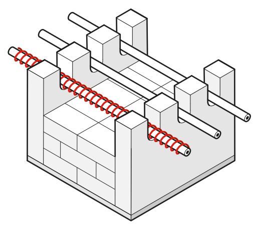
The ceramics used in furnace construction significantly affect furnace life, operating properties, and thermal efficiency. High-quality refractory element supports are crucial for the durability and operating life of heating elements. Only high-grade fireclay or sillimanite with an alumina content over 45%, iron oxide content under 1%, and minimal alkali content should be used. The ceramic support material must have high insulation resistance and withstand rapidly fluctuating thermal and mechanical stresses.

Heating elements are sensitive to impurities on ceramic supports, which may lead to creep currents that attack the elements and cause premature failure. These impurities may also react with the surface oxide, reducing element life. It is essential to keep the supporting bricks clean. After an element failure, any damaged brick should be replaced or coated with protective cement.

FURNACE INSULATION MATERIALS

In modern industrial furnaces, ceramic fiber insulation is commonly used, initially in “blankets” attached to the furnace using studs and washers. Over time, other fiber materials, such as panels and vacuum-formed modules, have been introduced, offering benefits like energy savings, quick furnace reaction, and lightweight design. Traditional brick lining, however, has advantages, such as superior mechanical properties.

WIRE: SPIRALS – FREE RADIATING

FIBER-BLANKET			
FIBER-VACUUM FORMED			
FIBER-STACKED			
BRICK			

WIRE: SPIRALS

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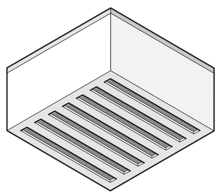
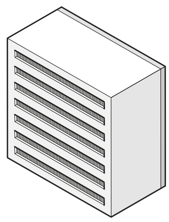
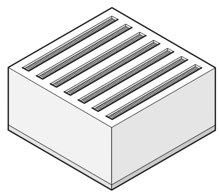
FIBER-VACUUM FORMED			
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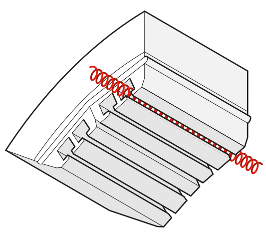
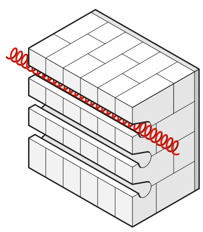
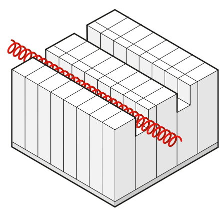
BRICK			

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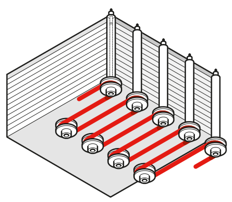
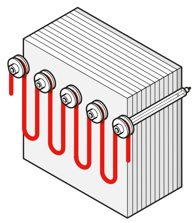
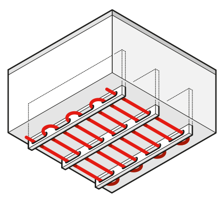
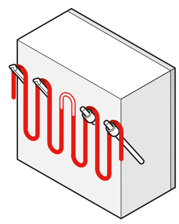
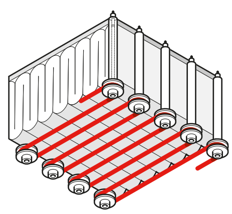
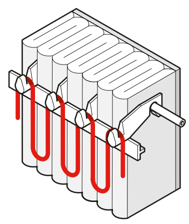
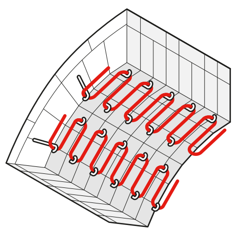
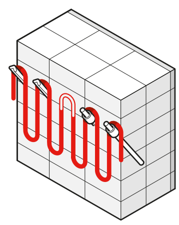
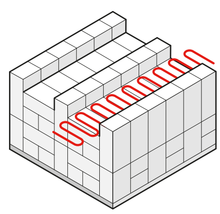
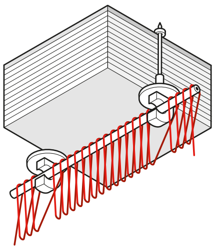
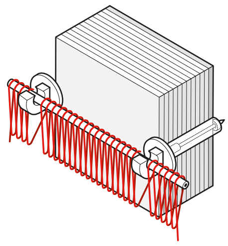
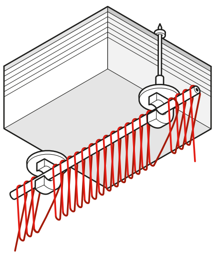
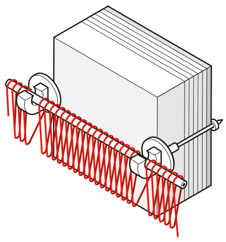
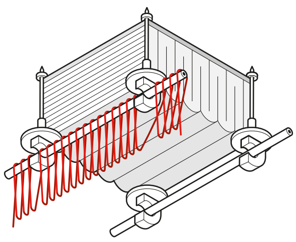
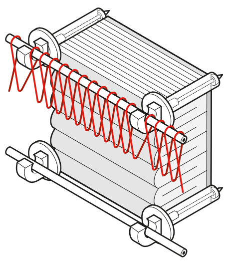
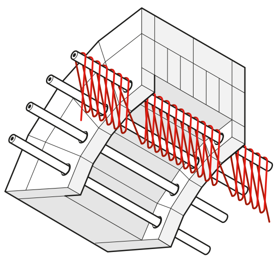
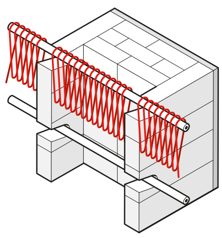
FIBER-BLANKET			
FIBER-VACUUM FORMED			
FIBER-STACKED			
BRICK			

WIRE: LOOP

FIBER-BLANKET			
FIBER-VACUUM FORMED			
FIBER-STACKED			
BRICK			

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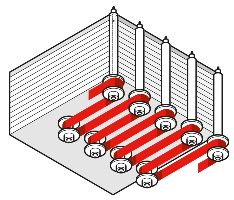
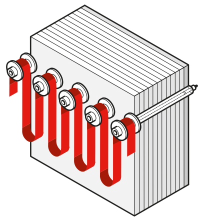
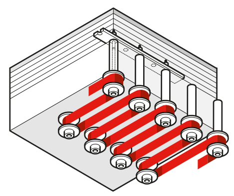
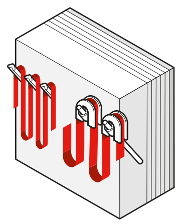
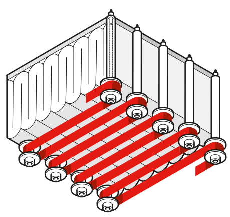
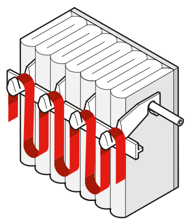
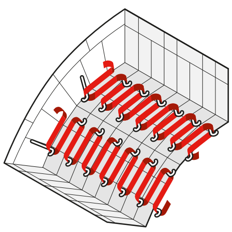
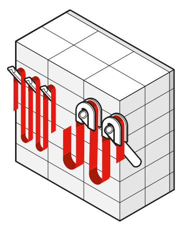
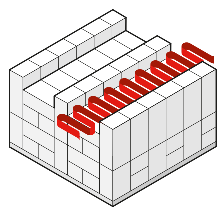
FIBER-BLANKET			
FIBER-VACUUM FORMED			
FIBER-STACKED			
BRICK			

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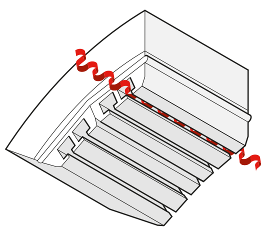
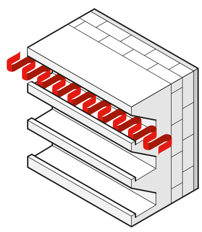
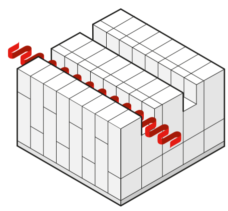
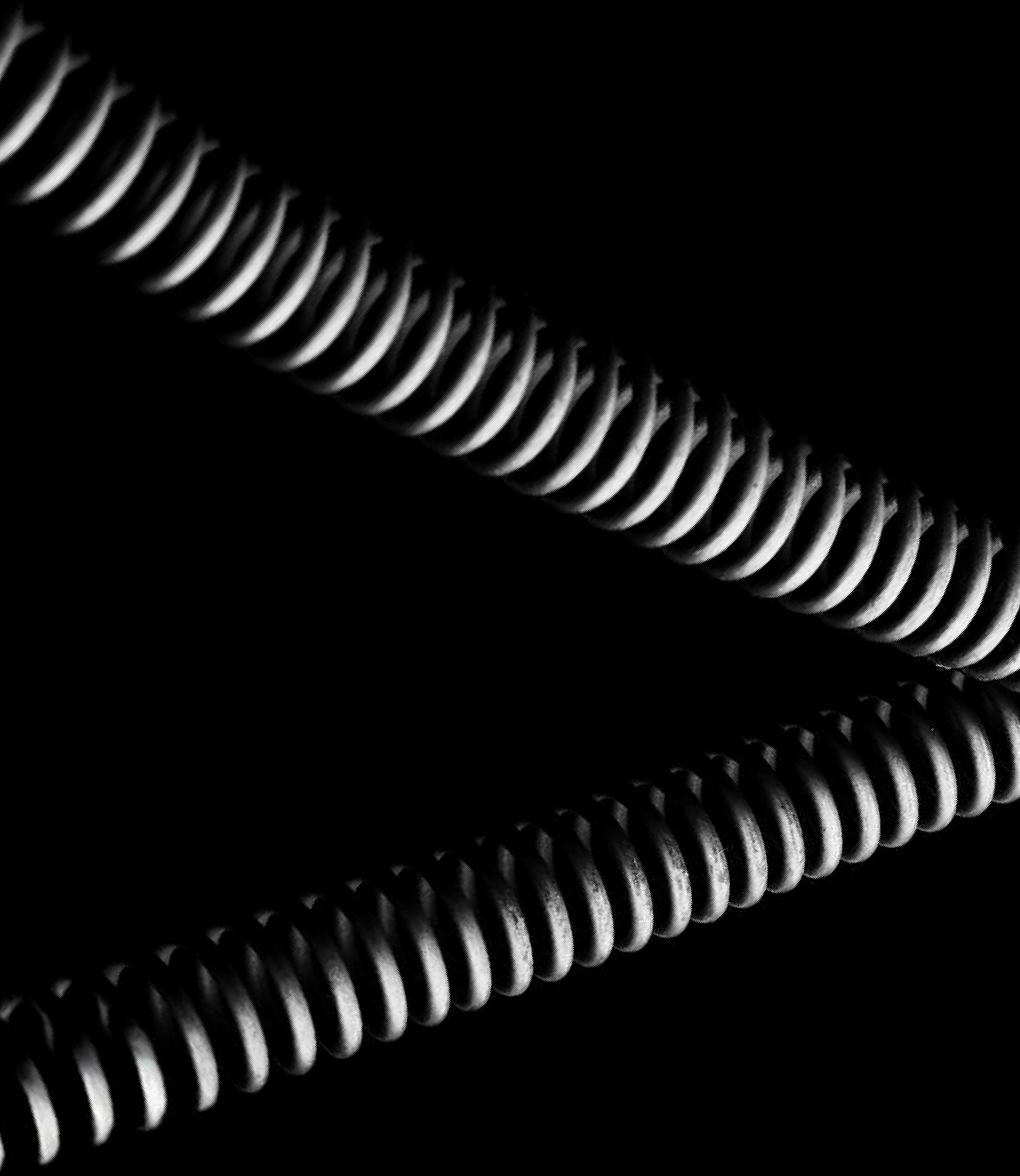
BRICK			



DESIGN CALCULATIONS AND STANDARD TOLERANCES

Accurate design calculations are critical for optimizing the performance and longevity of electric heating elements in both appliances and industrial furnaces.

This section provides a comprehensive guide to calculating key parameters, including wire diameter, surface load, resistance, and coil dimensions, while addressing factors like operating temperature, voltage, and element type.

By balancing these variables with material properties, designers can ensure optimal efficiency, reliability, and cost-effectiveness. Additionally, the chapter includes detailed guidelines for designing wire coil elements and outlines standard tolerances for wire dimensions and electrical resistance to ensure precision and consistency in manufacturing.

APPLIANCE CALCULATIONS

SUPPORTED WIRE

The typically used wire surface load, and in many cases, the element surface load is listed in the Appliance element types table, pages 30–31. The element surface load is defined as the rating divided by the part of the element surface that is close to the energized wire and therefore has an elevated temperature.

Usually, a range of surface loads rather than a single figure is provided in these tables. The choice within this range depends on the requirements for the element mentioned on page 28, as well as on the voltage, rating, and dimensions available. A high voltage and a low rating will result in a thin wire, which, at the same temperature, has a shorter life than a thick wire, and therefore will require a lower wire surface load.

WIRE TEMPERATURE

For embedded and supported element types, the wire temperature depends on both the wire and the element surface load. For suspended element types, the element surface load, in most cases, cannot be defined. In addition to the surface load, factors such as ambient temperature, heat dissipation conditions, and the presence and location of other elements will influence the wire temperature, which in turn affects the choice of wire and element surface loads.

SURFACE LOAD

When calculating an element, voltage, and rating are typically known. The wire surface load is then chosen per the figures listed in the table on page 30–31. The wire surface is found as the ratio between the rating and the wire surface load.

SURFACE AND RESISTANCE

After calculating the resistance in the cold state, the ratio between the surface and the resistance is determined. This ratio is listed for all wire types and dimensions in this handbook, enabling easy identification of the correct wire size from the tables.

COIL AND WIRE DIAMETER

The ratio between the coil and wire diameter (D/d) must be calculated to ensure that the coil can be easily manufactured. Ideally, this ratio should be within the range of 5 to 12. For supported elements, this ratio must be compared with the deformation curve in the graph on page 29. When the coil length and diameter are known, the coil pitch can be estimated using Formula (10) in the Appendix on page 141. It is normally 2 to 4 times the wire diameter. For quartz tube heaters, a smaller pitch is typically used. Preoxidized coils made from Kanthal® FeCrAl in such elements can be used with a slight coil.

For a straight wire on a threaded firebar and many suspended-type elements, the wire length is fixed. The resistance per meter can be calculated, and the wire size determined from the tables in this handbook. If this results in a high surface load with ribbon, a wider and thinner ribbon of the same cross-section can be chosen.

METAL SHEATHED TUBULAR ELEMENT

The calculation of a metal-sheathed tubular element is more complex because the resistance is reduced by 10 to 30% due to the compression of the element. For such elements, the tube surface load is first determined based on the intended use. The wire surface load is normally 2 to 4 times greater. After calculating the resistance from the rating and voltage, it must be increased by 10 to 30% to arrive at the resistance after coiling. The wire surface will become 2 to 7% smaller when the element is reduced. Even though the tube length is increased through compression by rolling, the tube surface often remains unchanged.

Example:
Tubular element for a broiler application
Element power rating: 2,000 W (P)
Voltage: 230 V (U)
Final tube diameter 8 mm
Final tube length 1,000 mm

As a first step it is of importance to find out the actual heating zone length.
If the terminal length inside the element tube is 2 × 50 mm the total coil length (L_e) will be:

$$L_e = 1{,}000 - (2 * 50) = 900\ mm$$

Coil hot resistance (R_T) can be calculated using the following equation:

$$R = \frac{U^2}{P} = \frac{230^2}{2{,}000} = 26.45\ \Omega$$

Tube surface load (p_{tube}) can be defined by:

$$P_{y,tube} = \frac{P}{A_{tube}} = \frac{P}{(\pi * d_{tube} * L_e * 0.01)} = \frac{2{,}000}{(\pi * 10 * 900 * 0.01)} = 7.07\ W/cm^2$$

For wire surface load (p_{wire}) inside tube, factor 3 is used as general rule of thumb:

$$p_{y,wire} = 3 * p_{y,tube} = 3 * 7.07 = 21.21 \approx 22\ \mathrm{W}/cm^2$$

Wire surface (A_C) can be calculated using the following equation:

$$p_{y,wire} = \frac{P}{A_c} => A_c = \frac{P}{p_{y,wire}} = \frac{2{,}000}{21.21} = 94.29 \approx 94\ cm^2$$

Kanthal's alloy Nikrothal® TE specifically designed for use in tubular elements is an excellent choice for this application and an average wire temperature of 900°C is expected. Due to temperature factor of resistance (Ct = 1,06 for Nikrothal® TE at 900°C) resistance at room temperature can be calculated by using the following equation:

$$R_T = C_t * R_{20} => R_{20} = \frac{R_T}{C_T} = \frac{26.45}{1.06} = 24.95 \approx 25\Omega$$

The ratio between wire surface area and resistance is:

$$\frac{A_c}{R_{20}} = \frac{94}{25} = 3.76\ cm^2/\Omega$$

The value 3.44 (cm2/Ω) for Nikrothal® TE is corresponding to a wire size of about 0.55 mm. We assume that a steel tube of initially 10 mm diameter is being used and can then expect a resistance reduction of about 30 % upon rolling. The resistance of the coil should therefore be close to 35 Ω.

The wire surface prior to compression is normally up to 7 % bigger, or 100 cm^2, and the ratio between wire surface and resistance 2.85 cm^2/Ω. The corresponding wire size is 0.50 mm.

Performing tests using calculated wire size is recommended aiming to verify element properties and influence from both coiling and reduction as a result of compression.

Example:
Suspended coil element for convection heater
Element power rating: 3,000 W (P)
Voltage: 230 V (U)
Coil length: 850 mm (L_e)

For a suspended element in a forced convection application the recommended wire surface load is normally ranging from 7 to 8 W/cm^2. For this element calculation example a suitable surface load at 8 W/cm^2 will be used.

The first thing to calculate is the total wire resistance needed. This is done in two steps by using the following calculations:

1. Coil hot resistance (R_T):

$$R = \frac{U^2}{P} = \frac{230^2}{300} = 17.63\ \Omega$$

Coil resistance at room temperature can be calculated by dividing the hot resistance (R_T) using the temperature factor (C_t). For this application design Nikrothal® 60 is a well proven alloy and at the expected temperature level 900°C the defined Ct value is 1.10.

2. Coil cold resistance (R_{20}):

$$R_{20} = \frac{R_T}{C_T} = \frac{17.63}{1.10} = 16.03\Omega$$

Wire surface area (A_C) is given by dividing element Power with the wire surface load:
$A_C = P / p = 3{,}000 / 8 = 375\ cm^2$

By using the result from surface area calculation, a suitable wire dimension can be found by calculating the surface area to cold resistance ratio, resistivity at room temperature (cm^2/Ω).

The ratio between wire surface and resistance is:

$$R_{20} = \frac{R_T}{C_T} = \frac{17.63}{1.10} = 16.03\Omega$$

Comparing the calculated value for resistivity at room temperature (cm^2/Ω) in the table for Nikrtohal® 60 shows that wire dimension Ø 1.0 mm is the closest match at 22.2 cm^2/Ω.

When wire dimension has been set the information on resistance per meter wire (Ω/m) is available from the Nikrothal® 60 table, hence total wire length can be calculated:

$$\frac{A_c}{R_{20}} = \frac{375}{16.03} = 23.39\ cm^2/\Omega$$

Wire surface load with selected wire dimension Ø 1.0 mm can be verified by the following calculation, as value surface area per meter (cm2/m) can be found in the Nikrothal® 60 table:

$$p_{y,wire} = \frac{P}{(cm^2/m) * L} = \frac{3{,}000}{31.4 * 11.6} = 8.21\ W/cm^2$$

The ratio between coil diameter and wire diameter (D/d) depends greatly on element design and wire temperature. For suspended element in this calculation outer coil diameter 15 mm is selected. This gives the following ratio:

$$\frac{D}{d} = \frac{15}{1} = 15$$

Coil pitch (s) can be found by using equation:

$$s = \frac{\pi * (D - d) * L_e}{L} = \frac{\pi * (15 - 1) * 850}{11.63} = 3.21mm$$

Use the following calculation to find out the number of element coil turns (W):

$$W = \frac{(1{,}000 * L)}{\pi * (D - d)} = \frac{(1{,}000 * 11.63)}{\pi * (15 - 1)} = 264\ turns$$

Close wound coil length (Lw) is given by number of coil turns times wire dimension:

$$L_w = W * d = 264 * 1 = 264$$

The streched coil length (Le) can now be calculated:

$$L = \frac{s}{d} * L_w = \frac{3.21}{1} * 264 = 847\ mm$$

Application tests to adjust and verify appropriate air flow settings is recommended and should always be considered in order to confirm element coil calculation and heating element properties in forced convection.

FURNACE CALCULATIONS

Designers of equipment using electric resistance heating materials must determine what material and form will satisfy specific heating requirements. The general approach is to start with the required operating temperature and power, the available voltage, and the space for the heating elements. A suitable material and element type is then selected (see 'Physical and Mechanical Properties,' page 15, and 'Design Factors,' page 19), followed by calculations for element parameters.

This section describes the relevant design calculations for spiral wire elements and corrugated strip and wire elements. (See the Appendix for detailed symbols, definitions, and formulas.)

ELEMENT SURFACE LOAD

Increased surface load results in a higher element temperature compared to its surroundings. Thus, the maximum permissible element temperature imposes a limit on surface load. The maximum permissible surface load decreases with increasing furnace temperature and depends on factors such as maximum element temperature, element deformation, and current limits.

Surface load affects element design in two opposing ways. If surface loading is reduced, a larger and more expensive element is required; however, such an element experiences slower material consumption, resulting in a longer life. The goal is to select a surface load that provides an optimal balance between service life and element cost.

The surface load of a heating element, p, is equal to its power, P, divided by its surface area, A:

$$p = P/A$$

In the metric system, surface load is usually expressed in W/cm^2, and the imperial system, in W/in^2. Element temperature is the major factor in the life of an element and is determined by its surrounding temperature and surface load. Since Kanthal® alloys can be operated at higher temperatures than Nikrothal® alloys, they can achieve higher surface loading with an equivalent or longer life than Nikrothal®.

There are three criteria for determining the maximum surface load:

- Element temperature
- Form stability (especially for Kanthal® alloys)
- Current

The more freely radiating the element form, the higher the maximum surface load. Therefore, the ROB (Rod Over Bend) type element can handle the highest load, followed by the corrugated strip element. The spiral type, being more concealed, has a lower maximum surface load. Spirals on tubes can carry a higher load than spirals in grooves.

The graphs in page 51, shows the recommended surface loads for Kanthal® and Nikrothal® alloys in industrial furnaces. Since Kanthal® alloys can be operated at higher temperatures than Nikrothal® alloys, a higher surface load can be accepted without jeopardizing element life. Element design is also crucial. The more freely radiating the element form, the higher the maximum surface load. Therefore, the ROB type element (corrugated heavy wire, mounted on the surface) can handle the highest load, followed by the corrugated strip element.

Coil elements on ceramic tubes can handle a higher load than coil elements in grooves. The values in the diagrams on page 51 are given for the following design conditions:

ELEMENT TYPES A (HEAVY WIRE) AND B (STRIP):
- Minimum strip thickness: 2.5 mm
- Minimum wire diameter: 5 mm
- Minimum pitch: 50 mm at maximum loop length and maximum surface load

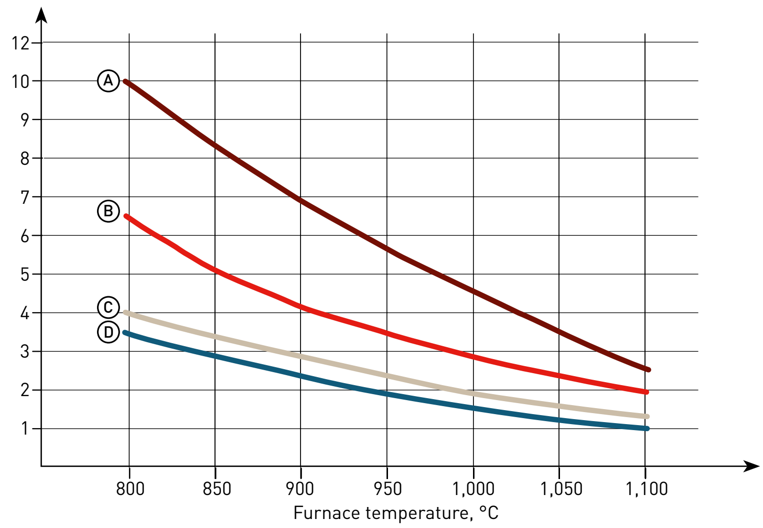
Maximum recommended loop length:
- < 900°C: 300 mm
- 1,000°C: 250 mm
- 1,100°C: 200 mm
- 1,200°C: 150 mm
- 1,300°C: 100 mm

For finer wire diameters and smaller strip thicknesses, lower surface loads and shorter loop lengths must be chosen to avoid element deformation and subsequent shorter element life.

ELEMENT TYPE C:
- Wire element on ceramic tube
- Minimum wire diameter: 3 mm

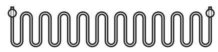
ELEMENT TYPE D:
- Wire and strip element in grooves
- Minimum wire diameter: 3 mm
- Minimum strip thickness: 2 mm

MAXIMUM RECOMMENDED SURFACE LOADS FOR NIKROTHAL® ALLOYS IN INDUSTRIAL FURNACES

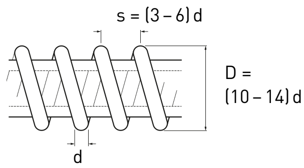


Ⓐ Freely radiating corrugated wire elements

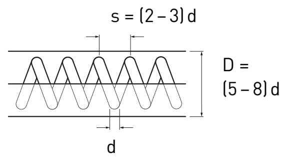
Ⓑ Freely radiating corrugated strip elements



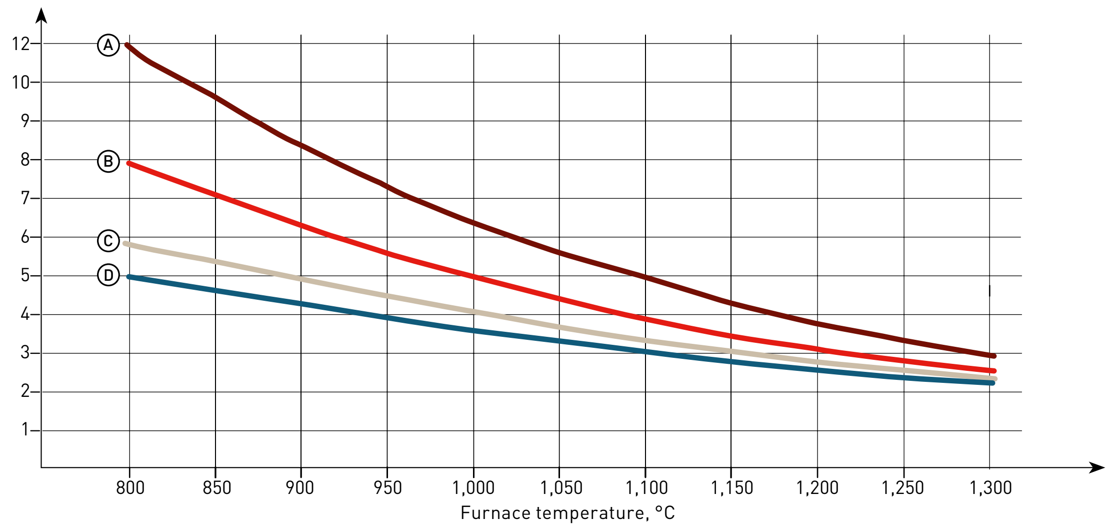
Ⓒ Spiral elements on ceramic tubes



Ⓓ Heating elements in grooves



MAXIMUM RECOMMENDED SURFACE LOADS FOR KANTHAL® A-1, KANTHAL® AF AND KANTHAL® APM ALLOYS IN INDUSTRIAL FURNACES



Note: The diagrams are valid for thyristor control. For on-off control lower surface loads should be chosen (about - 20%).

DESIGN OF WIRE ELEMENTS

CALCULATION OF WIRE DIAMETER

DIRECT CALCULATION METHOD

The diameter that will result in the desired surface load, given the electrical input data, can be calculated as:

$$d = \frac{1}{k_d} \sqrt[3]{I^2 \frac{\rho C_t}{p_s}}$$

where:
I = Current
ρ = Resistivity
C_t = Temperature factor
p_s = Surface load of heating element
k_d = Wire diameter form factor

For metric units, with ρ in Ω mm²/m and p_s in W/cm², k_d = 2.91, and d will be in mm.
For imperial units, with ρ in Ω circ. mil/ft and p_s in W/in², k_d = 335, and d will be in inch.

Example:
Power, W = 20 kW
Voltage, U = 220 V
Target surface load, ps = 4.0 W/cm2 (26 W/in²)
Wire temperature = 1,200°C (2,190°F)
Material = Kanthal® AF
Resistivity, ρ = 1.39 Ω mm²/m (836 Ω circ. mil/ft)
Temperature factor, Ct (1,200°C) = 1.06

First determine the current, I:

$$I = \frac{P}{U} = \frac{20{,}000}{220} = 90.9 \text{ A}$$

The diameter can then be calculated:

$$d = \frac{1}{2.91} \sqrt[3]{90.9^2 \frac{1.39 \times 1.06}{4.0}} = 4.98 \text{ mm } (0.196 \text{ in})$$

The nearest standard size is 5.0 mm (0.197 in). The actual surface load at this power and voltage will then be 3.95 W/cm² (25.5 W/in²).

TABLE LOOKUP METHOD

Wire diameter can alternatively be chosen using the ratio η, i.e. surface area, Ac, to cold resistance, R20. The ratio is presented as in the tables section, page 73.

Given the electrical data, element temperature, and target surface load, η can be calculated as:

$$\eta = \frac{A_c}{R_{20}} = I^2 \frac{C_t}{p_s}$$

where:
A_c = Surface area of the conducting wire
R_{20} = Cold resistance
I = Current
C_t = Temperature factor
p_s = Surface load of heating element

Having determined the target η, a suitable wire diameter can be selected from the tables. Whether this size actually suits the element concerned should be considered in relation to the operating conditions.

Example:

$$\eta = \frac{90.9^2 \times 1.06}{4.0} = 2{,}194 \frac{\text{cm}^2}{\Omega} \left(340 \frac{\text{in}^2}{\Omega}\right)$$

Under the η column in the table, the nearest value is 2,220 cm²/Ω (344 in²/Ω), giving a diameter of 5.0 mm (0.197 in). The actual surface load at this power and voltage will then be 3.95 W/cm² (25.5 W/in²).

CALCULATION OF WIRE LENGTH

Having determined wire type and diameter, the next stage in arriving at a spiral element is to calculate wire length. The first step is to determine the cold resistance, R_{20}, of the selected wire:

$$R_{20} = \frac{R_T}{C_t} = \frac{U^2}{PC_t}$$

where:
R_{20} = Cold resistance
R_T = Hot resistance
C_t = Temperature coefficient
U = Voltage
P = Power

The resistance per unit length, $R_{20/m}$, can be calculated as:

$$R_{20/m} = \frac{4\rho}{\pi d^2}$$

Alternatively, the resistance per meter (or per ft) has been precalculated for material and diameter combinations and can be found in the tables. From this, the wire length, ℓ, can be calculated as:

$$\ell = \frac{R_{20}}{R_{20/m}}$$

Example:
Wire diameter, d = 5.0 mm (0.197 in)
Power, P = 20 kW
Voltage, U = 220 V
Wire temperature = 1,200°C (2,190°F)
Material = Kanthal® AF
Resistivity, ρ = 1.39 Ω mm²/m (836 Ω circ. mil/ft)
Temperature factor, Ct (1,200°C) = 1.06

$$R_T = \frac{U^2}{P} = \frac{220^2}{20{,}000} = 2.42\ \Omega$$

$$R_{20} = \frac{R_T}{C_t} = \frac{2.42}{1.06} = 2.28\ \Omega$$

The resistance per unit length, $R_{20/m}$ is:

$$R_{20/m} = \frac{4 \times 1.39}{3.14 \times 5.0^2} = 0.0708\,\frac{\Omega}{m}\ \left(0.0216\ \frac{\Omega}{ft}\right)$$

The total wire length is:

$$\ell = \frac{2.28}{0.0708} = 32.2\ \text{m}\ (106\ \text{ft})$$

COIL ELEMENT DIMENSIONS

Having determined the wire diameter and length, the next step is to select the external diameter of the coil. Regarding values for the ratio of coil external diameter, D to wire diameter, d, see page 51.

Smaller ratios cause too great a winding strain on the wire; larger ratios produce a weaker, more flimsy coil.

For a given wire length, ℓ, the number of turns, w is:

$$w = \frac{\ell}{\pi(D - d)}$$

where the length should be converted to the same unit as diameter, e.g. from m to mm (multiply ℓ by 1,000) or ft to in (multiply ℓ by 12).

The close-wound coil length, L_w, is:

$$L_w = wd$$

Recommended values for the pitch, s, see page 51.

Stretched coil length can finally be calculated as:

$$L = \frac{s}{d}\,L_w$$

Example:
Wire diameter, d = 5.0 mm (0.197 in)
Wire length, ℓ = 32.2 m (106 ft)
Coil outer diameter, D = 27.5 mm (1.08 in)
Pitch, s = between 10 mm (0.394 in) and 20 mm (0.787 in)

$$w = \frac{32{,}200}{3.14 \times (27.5 - 5.0)} \approx 456$$

Close-wound coil length,

$$L_w = 456 \times 5.0 = 2{,}280 \text{ mm (89.8 in)}$$

Stretched length,

$$\text{min: } L = 2 \times 2{,}280 = 4{,}560 \text{ mm (180 in)}$$
$$\text{max: } L = 4 \times 2{,}280 = 9{,}120 \text{ mm (359 in)}$$

DESIGN OF CORRUGATED STRIP ELEMENTS

In designing corrugated strip elements, the procedure is first to determine the width, thickness, and length of the strip and then the corrugation parameters: pitch, depth (or height) of corrugation, etc. Instructions are given for both parallel and stretched corrugated elements.

Strip size depends on operating conditions centered around surface loading and on the type of alloy selected. In turn, selection of an alloy is based on the same parameters plus furnace atmosphere, heating/cooling cycles, and element temperature. For recommended values of surface load, see graphs in page 51.

Example:
Power, W = 12 kW
Voltage, U = 110 V
Target surface load, p_s = 1.0 W/cm^2 (6.45 W/in^2)
Material = Kanthal® A-1
Resistivity, ρ = 1.45 Ω mm^2/m (872 Ω circ. mil/ft)
Temperature factor, C_t (1,200°C) = 1.04

Table lookup method
An alternative method of calculating the strip section is calculate the surface area to cold resistance ratio and find a suitable strip dimension in the tables:

$$\eta = \frac{A_c}{R_{20}} = I^2 \frac{C_t}{p_s}$$

Example

$$\eta = \frac{109.1^2 \times 1.04}{1.0} = 12{,}400 \frac{\text{cm}^2}{\Omega} \left(1{,}920 \ \frac{\text{in}^2}{\Omega}\right)$$

The nearest standard size is 2.0 × 20 mm (0.079 × 0.79 in) with η = 12,100 cm^2/Ω (1875 in^2/Ω). The actual surface load at this power and voltage will then be 1.02 W/cm^2 (6.6 W/in^2). Note that a 0.7 × 35 mm (0.028 × 1.4 in) strip also has η = 12,100 cm^2/Ω (1875 in^2/Ω), but is much less appropriate since the thickness ideally should be at least 1.5 mm (0.06 in).

CALCULATION OF STRIP LENGTH
Having determined the strip width and thickness, the strip length, l, must be calculated. This requires an initial calculation of cold resistance, R_{20}:

$$R_{20} = \frac{R_T}{C_t} = \frac{U^2}{PC_t}$$

The resistance per unit length, $R_{20/m}$, can be calculated as:

$$\ell = \frac{R_{20}}{R_{20/m}}$$

Alternatively, the resistance per meter (or per ft) has been precalculated for material and diameter combinations and can be found in the tables. From this, the strip length, ℓ, can be calculated as:

$$R_{20/m} = \frac{\rho}{tb}$$

Example:
Strip dimensions, t × b = 2.0 × 20 mm (0.079 × 0.79 in)
Power, P = 12 kW
Voltage, U = 110 V
Material = Kanthal® A-1
Resistivity, ρ = 1.45 Ω mm^2/m (872 Ω circ. mil/ft)
Temperature factor, Ct (1,200 °C) = 1.04

$$R_T = \frac{U^2}{P} = \frac{110^2}{12{,}000} = 1.01\ \Omega$$

$$R_{20} = \frac{R_T}{C_t} = \frac{1.01}{1.04} = 0.97\ \Omega$$

The resistance per unit length, $R_{20/m}$ is:

$$R_{20/m} = \frac{1.39}{2 \times 20} = 0.0363\frac{\Omega}{m}\left(0.0110\ \frac{\Omega}{ft}\right)$$

The total wire length is:

$$\ell = \frac{0.97}{0.0363} = 26.7\ \text{m}\ (88\ \text{ft})$$

CORRUGATED ELEMENT DIMENSIONS

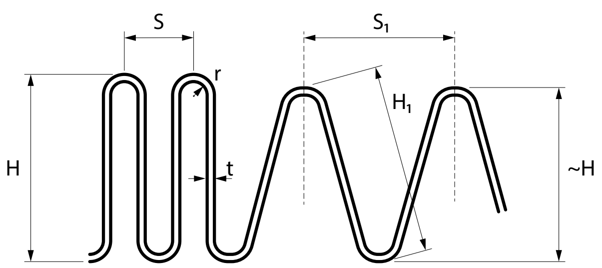
A corrugated element, with a parallel section and a stretched section, is shown in Fig. 1. As illustrated, the key design parameters for the element are the element (or corrugation) height, H, pitch, s, and bending radius, r. Other values necessary for element calculations are: Total element length, Le (given by the furnace design), and strip thickness, t, width, b, and length, ℓ.

Parallel Corrugated Element

When the loops are parallel, there is a geometrical relationship between r and s:

$$r = \frac{s - 2t}{4}; \quad s = 4r + 2t$$

FIGURE 1



The element length, L_e, after parallel corrugation is then:

$$L_e = \frac{\ell(2r + t)}{H + 1.14r - 0.43t}$$

Alternatively, if the element length is pre-determined, the element height can be calculated as:

$$H = \frac{\ell}{L_e}(2r + t) - 1.14r + 0.43t$$

Stretched Elements

Stretching a corrugated element so that the loops are no longer parallel reduces the danger of deformation. A stretched element may be calculated by the same method as a parallel element. That is: the total (stretched) element length, L_1, is given by the furnace design; t, b, and ℓ are determined by calculation. Element height, H, must be selected.
The pitch after stretching, s_1, (center-to-center distance between hooks for hanging elements) is:

$$s_1 = \frac{sL_1}{L}$$

The element height can be calculated by:

$$H = \frac{\ell}{L_e}(2r + t) - 1.14r + 0.43t$$

The height of a stretched element, H, will be somewhat lower than that with parallel loops.

$$H \simeq \sqrt{H_1 - \left(\frac{s_1}{2}\right)^2}$$

The difference in height will in most cases be small and may be neglected.

Example:
Strip dimensions, t × b = 2.0 × 20 mm (0.079 × 0.79 in)
Strip length: 26.7 m (88 ft)
Element length, L_e: 3.00 m (9.84 ft)
Ceramic support diameter, d_{sup}: 28 mm (1.1 in)
Ceramic support max permissible width: 33 mm (1.3 in)

A bending radius, r, of at least 14 mm (0.55 in) is needed for the strip to fit around the Ø28 mm (Ø1.1 in) ceramic supports. A slight clearance of 0.5 mm (0.02 in) should be added in addition to this.

$$r = \frac{d_{sup}}{2} + 0.5 = \frac{28}{2} + 0.5 = 14.5 \text{ mm } (0.57 \text{ in})$$

For parallel loops, the pitch, s, will then be:

$$s = 4r + 2t = 62 \text{ mm } (2.44 \text{ in})$$

The element height is then:

$$H = \frac{26.7}{3.00}(2 \times 14.5 + 2) - 1.14 \times 14.5 + 0.43 \times 2 =$$

$$260 \text{ mm } (10.2 \text{ in})$$

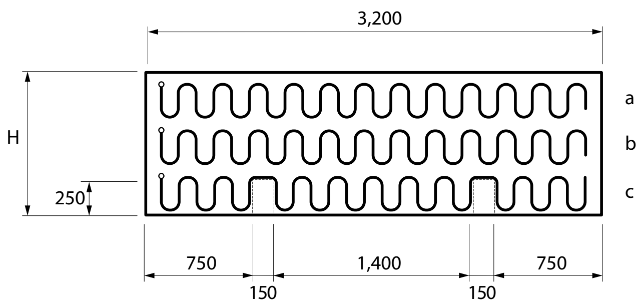
Check the dimensions:
t = 2 mm (0.079 in)
b = 20 mm (0.79 in) = 10 t
s = 62 mm (2.44 in) = 3.1 b
r = 14.5 mm (0.57 in) = 7.25 t
H = 260 mm (10.2 in)
>1.5 mm (>0.06 in)
(8–12) t
≤33 mm (1.3 in)
min. 50 mm (2.0 in)
min. (4–5) t
max. 150–400 mm (5.9–15.8 in)

All dimensions are within the recommended limits.

DESIGN OF FREELY RADIATING STRIP AND WIRE ELEMENTS

In order to show the element calculation methods for freely radiating wire and strip elements, a 200 kW fiber-lined furnace is chosen as a calculation example (see Fig. 2). The furnace is equipped with deep-corrugated elements mounted on ceramic hangers. In the first case, wire elements are used, and in the second case, strip elements. A comparison has been made at the end with strip elements of NiCr elements to show weight and cost savings by using Kanthal® AF.

FIGURE 2

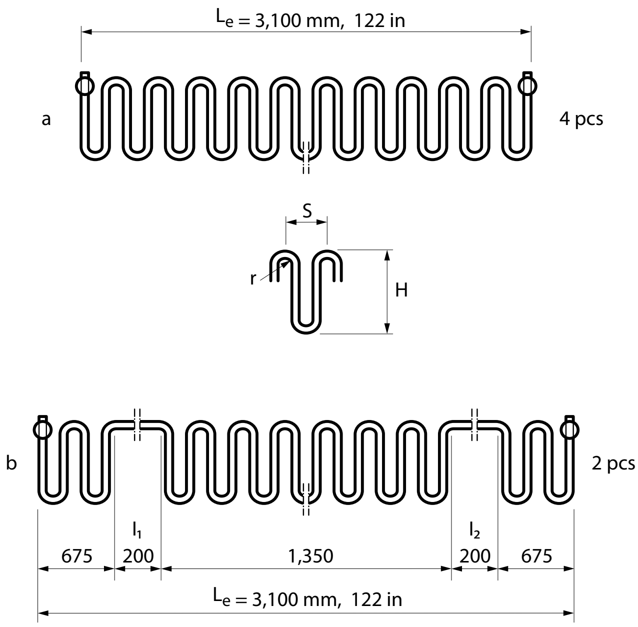


DEEP-CORRUGATED KANTHAL® AF WIRE ELEMENT

The element design is shown in Fig. 3. The furnace is equipped with four elements of type "a" and two elements of type "b".

FURNACE DATA
Power (total): 200 kW
Furnace temperature, T_f: 1,100°C (2,010°F)
Assumed element temperature, T_e (for calculations): 1,200°C (2,190 °F)
Number of 3-phase groups: 1
Power per phase: 66.67 kW
Voltage: 380 V
Current: 175.4 A
Resistance: 2.166 Ω
Number of elements in series: 2
Element length, L_e: 3.1 m (10.2 ft)

FIGURE 3



DATA PER ELEMENT
Power, P: 33.33 kW
Voltage, U: 190 V
Current, I: 175.4 A
Max surface load, p_s: 6.0 W/cm² (38.7 W/in²)
Resistance, hot, R_T: 1.083 Ω
Material: Kanthal® AF
Resistivity, ρ: 1.39 Ω mm²/m
Temperature factor, C_t (1,200°C): 1.06
Terminals: Round, ℓ_u, length 350 mm (13.8 in)

CALCULATION OF TERMINALS
Determine the appropriate terminal diameter to handle the current and maintain the lowest terminal temperature.

With the terminal length, ℓ_u, and diameter, d_u, decided, the resistance of the two terminals, R_u, (one per end) can be calculated:

$$R_u = 2 \times \frac{4\ell_u \rho}{\pi d^2}$$

$$R_u = 2 \times \frac{4 \times 0.35 \times 1.39}{3.14 \times 16^2} = 0.0048\ \Omega$$

CALCULATION OF WIRE DIAMETER
The preliminary wire diameter in mm (or in) is calculated as:

$$d = \frac{1}{k_d} \sqrt[3]{I^2 \frac{\rho C_t}{p_s}}$$

where k_d is 2.91 for metric units (or 335 for imperial). The diameter that would give a surface load of 6.0 W/cm² (38.7 W/in²) at full power is:

$$d = \frac{1}{2.91} \sqrt[3]{175.4^2 \frac{1.39 \times 1.06}{6.0}} = 6.74\ \text{mm}\ (0.265\ \text{in})$$

The closest standard dimension is 7.0 mm (0.276 in).

CALCULATION OF WIRE LENGTH

The cold resistance of the element, R_{20}, can be calculated as:

$$R_{20} = \frac{R_T}{C_t} - R_u$$

where R_u is the cold resistance of the two terminals combined.

$$R_{20} = \frac{1.083}{1.06} - 0.0048 = 1.017\ \Omega$$

The wire length, ℓ, can then be calculated as:

$$\ell = \frac{\pi d^2 R_{20}}{4\rho}$$

$$\ell = \frac{3.14 \times 7.0^2 \times 1.017}{4 \times 1.39} = 28.1\ \text{m}\ (92.2\ \text{ft})$$

Based on this diameter and length, and that the density of Kanthal® AF is 7.15 kg/cm³ (0.258 lb/in³), the wire weight will be 7.7 kg (17 lb).

SURFACE LOAD

The surface load can be calculated using:

$$p_s = \frac{I^2 C_t}{\eta}$$

where η for the selected wire dimension can be found in the table. For Ø7.0 mm Kanthal® AF it is 6,090 cm2/Ω.

$$p_s = \frac{175.4^2 \times 1.06}{6{,}090} = 5.35 \frac{\text{W}}{\text{cm}^2} \left(34.5 \frac{\text{W}}{\text{in}^2}\right)$$

An alternative is to use the formula:

$$p_s = \frac{I^2 \rho C_t}{24.67 \times d^3}\ (\text{metric})$$

$$p_s = \frac{I^2 \rho C_t}{3.77 \times 10^7 \times d^3}\ (\text{imperial})$$

BENDING RADIUS

A bending radius, r, of 9 mm (0.35 in) will be used in this example.

Maximum corrugation height

Three elements are suspended on a wall having a height of 1,000 mm (1,000/3 ≈ 333 mm per element [13.1 in/element]). Take into account that about 25% of this height per element should be reserved for clearance, leaving 75% of that height for the element.

$$H_{max} = 333 \times 0.75 = 250\ \text{mm}\ (9.84\ \text{in})$$

This number can be used as a preliminary height when calculating the number of pitches.

CALCULATION OF NUMBER OF PITCHES

The number of pitches is calculated as:

$$N = \frac{0.5 \times [\ell - (\ell_1 + \ell_2 + \cdots + \ell_n)]}{H + 1.14r - 0.43d}$$

where ℓ_1, ℓ_2, ... ℓ_n, are straight sections of the element.

Element type "a" (Fig. 3), no straight sections:

$$N = \frac{0.5 \times 28{,}100}{250 + 1.14 \times 9.0 - 0.43 \times 7.0} = 54.6 \approx 55$$

Since the maximum height was used in this calculation, the result must be rounded up to 55. With 55 pitches, the average pitch, s, will be:

$$s = \frac{L_e}{N} = \frac{3{,}100}{55} = 56\ \text{mm}\ \ (2.2\ \text{in})$$

Check that s ⩾ 4 r + 2 d

$$4r + 2d = 4 \times 9.0 + 2 \times 7.0 = 50\ \text{mm}\ (2.0\ \text{in}) \rightarrow \text{ok}$$

Element "b" (Fig. 3), two 200 mm long straight sections:

$$N = \frac{0.5 \times [28{,}100 - (200 + 200)]}{250 + 1.14 \times 9.0 - 0.43 \times 7.0} = 53.8 \approx 54$$

Rounding up, this gives 54 pitches. These 54 pitches need to be distributed over a total span of 2,700 mm (106.3 in), consisting of two 675 mm (26.6 in) wide outer parts, and the 1,350 mm (53.1 in) wide center part between the supporting beams (see Fig. 3).The outer parts correspond to ¼ of the span each and should thus contain approximately ¼ of the 54 pitches, and in the same way since the center part corresponds to ½ of the span, it should also have roughly half of the pitches. The exact numbers would be 13.5 pitches in the outer parts, and 27 pitches in the center. For a design using full pitches, the distribution will be 14 pitches in the outer parts and 26 in the center. The average pitch in the outer parts, s1, will thus be:

$$s_1 = \frac{675}{14} = 48 \text{ mm } (1.9 \text{ in})$$

and in the center:

$$s_2 = \frac{1{,}350}{26} = 52 \text{ mm } (2.0 \text{ in})$$

Check that s ⩾ 4 r + 2 d

$$4r + 2d = 4 \times 9.0 + 2 \times 7.0 = 50 \text{ mm } (2.0 \text{ in}) \rightarrow \text{not ok}$$

Note that the pitch in the outer parts will be less than 50 mm. As an alternative solution the furnace design can be revised by moving the 200 mm (7.0 in) ceramic supports inwards by 25 mm (1.0 in) (see Fig. 4). The average pitch in the outer parts then become:

$$s_1 = \frac{700}{14} = 50 \text{ mm } (2.0 \text{ in})$$

and in the center:

$$s_2 = \frac{1{,}300}{26} = 50 \text{ mm } (2.0 \text{ in})$$

Check that s ⩾ 4 r + 2 d

$$4r + 2d = 4 \times 9.0 + 2 \times 7.0 = 50 \text{ mm } (2.0 \text{ in}) \rightarrow \text{ok}$$

CALCULATION OF CORRUGATION HEIGHT

The element height, or corrugation height, is calculated as:

$$H = \frac{0.5 \times [\ell - (\ell_1 + \ell_2 + \cdots + \ell_n)]}{N} - 1.14r + 0.43d$$

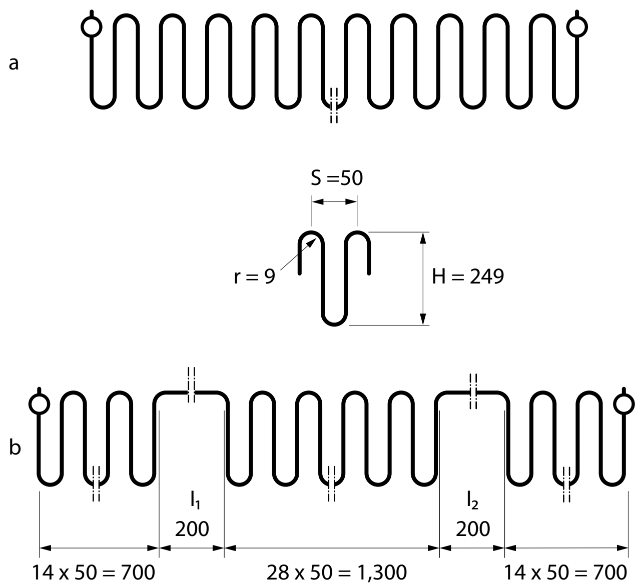
Element type "a" (Fig. 3), no straight sections:

$$H = \frac{0.5 \times (23{,}100)}{55} - 1.14 \times 9.0 + 0.43 \times 7.0 = 248 \text{ mm } (9.8 \text{ in})$$

Element "b" (Fig. 3), two 200 mm long straight sections:

$$H = \frac{0.5 \times [23{,}100 - (200 + 200)]}{54} - 1.14 \times 14.5 + 0.43 \times 2.5 = 249 \text{ mm } (9.8 \text{ in})$$

FIGURE 4

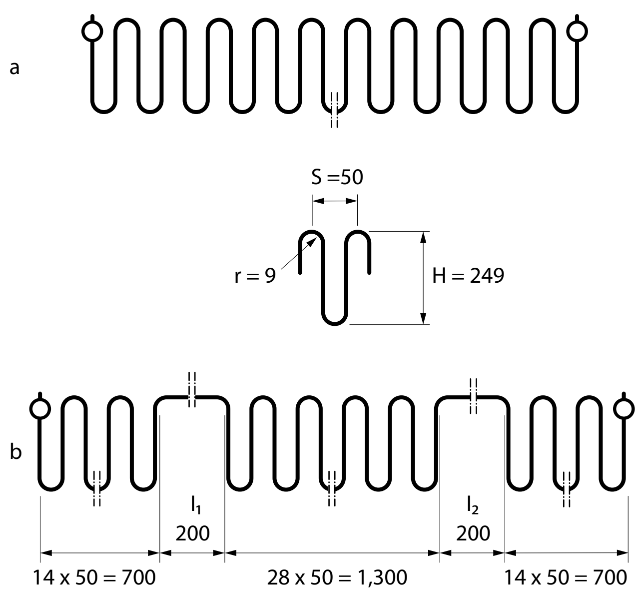


DEEP-CORRUGATED KANTHAL® AF STRIP ELEMENTS

The element design is shown in Fig. 5. The furnace is equipped with four elements of type "a" and two elements of type "b". As can be seen from the sketch, element "b" has two straight parts because of the supporting beams for the charge.

FURNACE DATA
Power (total): 200 kW
Furnace temperature, T_f: 1,100°C (2,010°F)
Assumed element temperature, T_e (for calculations): 1,200 °C (2,190 °F)
Number of 3-phase groups: 1
Power per phase: 66.67 kW
Voltage: 220 V
Current: 303 A
Resistance, hot: 0.726 Ω
Number of elements in series: 2
Element length, Le: 3.1 m (10.2 ft)

FIGURE 5



DATA PER ELEMENT
Power, P: 33.33 kW
Voltage, U: 110 V
Current, I: 303 A
Max surface load, p_s: 3.0 W/cm² (19.4 W/in²)
Resistance, hot, R_T: 0.363 Ω
Material: Kanthal® AF
Resistivity, ρ: 1.39 Ω mm²/m
Temperature factor, Ct (1,200°C): 1.06
Terminals: Round, length, ℓ_u: 350 mm (13.8 in)

CALCULATION OF TERMINALS
Determine the appropriate terminal diameter to handle the current and maintain the lowest terminal temperature.

With the terminal length, ℓ_u, and diameter, d_u, decided, the resistance of the two terminals, R_u, (one per end) can be calculated:

$$R_u = 2 \times \frac{4\ell_u \rho}{\pi d^2}$$

$$R_u = 2 \times \frac{4 \times 0.35 \times 1.39}{3.14 \times 20^2} = 0.0031\ \Omega$$

CALCULATION OF STRIP SIZE
The preliminary strip thickness is calculated as:

$$t = k_t \times \sqrt[3]{I^2 \frac{\rho \times C_t}{p_s}}, k_t = \sqrt[3]{\frac{1}{20n(1+n)}}$$

where n is the desired ratio of width/thickness. The version of kt above applies for the use of metric units. Aiming for a surface load of 3.0 W/cm² (19.4 W/in²), and n = 12 gives:

$$t = \sqrt[3]{\frac{1}{20 \times 12 \times (1+12)}} \times \sqrt[3]{303^2 \frac{1.39 \times 1.06}{3.0}} =$$

$$2.44\ \text{mm}\ (0.096\ \text{in})$$

The closest standard dimension is 2.5 mm thickness (0.10 in). Aiming for a 12 times wide strip means that

$$b = 12 \times 2.5 = 30\ \text{mm}\ (1.2\ \text{in})$$

CALCULATION OF STRIP LENGTH

The cold resistance of the element, R_{20}, can be calculated as:

$$R_{20} = \frac{R_T}{C_t} - R_u$$

where R_u is the cold resistance of the two terminals combined.

$$R_{20} = \frac{0.363}{1.06} - 0.0031 = 0.339\ \Omega$$

The strip length, ℓ, can then be calculated as:

$$\ell = \frac{R_{20} tb}{\rho}$$

$$\ell = \frac{0.339 \times 2.5 \times 30}{1.39} = 18.3\ \text{m (60 ft)}$$

Based on this width, thickness and length, and that the density of Kanthal® AF is 7.15 kg/cm³ (0.258 lb/in³), the strip weight will be 9.8 kg (21.6 lb).

SURFACE LOAD

The surface load can be calculated using:

$$p_s = \frac{I^2 C_t}{\eta}$$

where n for the selected strip dimension can be found in the table. For 2.5 × 30 mm Kanthal® AF it is 35,100 cm²/Ω.

$$p_s = \frac{303^2 \times 1.06}{35{,}100} = 2.77 \frac{W}{cm^2} \left(17.9 \frac{W}{in^2}\right)$$

An alternative is to use the formula:

$$p_s = \frac{1}{20n(1+n)} I^2 \frac{\rho C_t}{t^3}\ \text{(metric)}$$

$$p_s = \frac{\pi}{96 \times 10^6 \times n(1+n)} I^2 \frac{\rho C_t}{t^3}\ \text{(imperial)}$$

which gives the same result.

BENDING RADIUS

Ceramic supports to be used have a diameter of 28 mm (1.1 in) and permit a maximum strip width of 33 mm (1.3 in). This gives a minimum bending radius, r, of 14 mm (0.55 in). Add 0.5 mm (0.02 in) for clearance, giving:

$$r = \frac{28}{2} + 0.5 = 14.5\ \text{mm (0.57 in)}$$

MAXIMUM CORRUGATION HEIGHT

Three elements are suspended on a wall having a height of 1,000 mm (1,000/3 ≈ 333 mm per element [13.1 in/element]). Take into account that about 25% of this height per element should be reserved for clearance, leaving 75% of that height for the element.

$$H_{max} = 333 \times 0.75 = 250\ \text{mm (9.84 in)}$$

This number can be used as a preliminary height when calculating the number of pitches.

CALCULATION OF NUMBER OF PITCHES

The number of pitches is calculated as:

$$N = \frac{0.5 \times [\ell - (\ell_1 + \ell_2 + \cdots + \ell_n)]}{H + 1.14r - 0.43t}$$

where ℓ_1, ℓ_2, ... ℓ_n, are the lengths of straight sections of the element.

Element type "a" (Fig. 5), no straight sections:

$$N = \frac{0.5 \times 18{,}300}{250 + 1.14 \times 14.5 - 0.43 \times 2.5} = 34.45 \approx 35$$

Since the maximum height was used in this calculation, the result must be rounded up to 35. With 35 pitches, the average pitch, s, will be:

$$s = \frac{L_e}{N} = \frac{3{,}100}{35} = 89\ \text{mm (3.5 in)}$$

Check that s ⩾ 4 r + 2 t:

$$4r + 2t = 4 \times 14.5 + 2 \times 2.5 = 63\ \text{mm (2.5 in)} \rightarrow \text{ok}$$

Element "b" (Fig. 5), two 200 mm long straight sections:

$$N = \frac{0.5 \times [18{,}300 - (200 + 200)]}{250 + 1.14 \times 14.5 - 0.43 \times 2.5} = 33.72 \approx 34$$

These 34 pitches will be distributed as 9 pitches in the outer parts and 16 in the center in this example. The average pitch in the outer parts, s_1, will thus be:

$$s_1 = \frac{675}{9} = 75 \text{ mm (3.0 in)}$$

and the average pitch in the center, s_2, will be:

$$s_2 = \frac{1{,}350}{16} = 84 \text{ mm (3.3 in)}$$

Check that s ⩾ 4 r + 2 t:

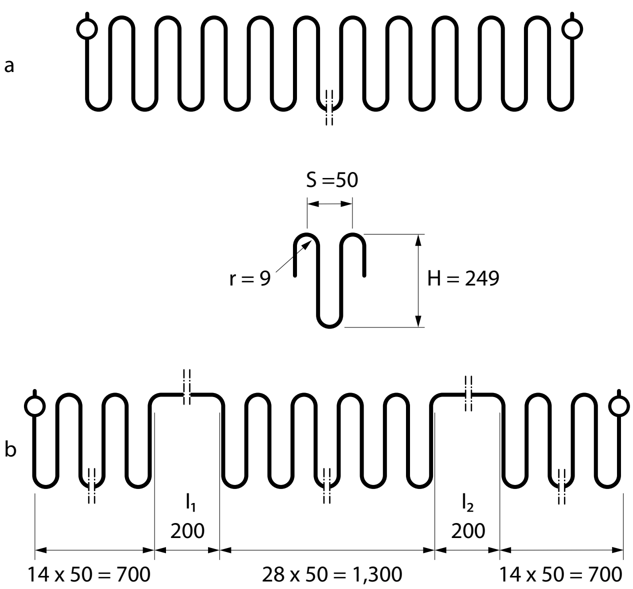
$$4r + 2t = 4 \times 14.5 + 2 \times 2.5 = 63 \text{ mm (2.5 in)} \rightarrow \text{ok}$$

CALCULATION OF CORRUGATION HEIGHT

The element height, or corrugation height, is calculated as:

$$H = \frac{0.5[\ell - (\ell_1 + \ell_2 + \cdots + \ell_n)]}{N} - 1.14r + 0.43t$$

FIGURE 6



Element type "a" (Fig. 6), no straight sections:

$$H = \frac{0.5 \times (18{,}300)}{35} - 1.14 \times 14.5 + 0.43 \times 2.5 =$$

$$246 \text{ mm (9.7 in)}$$

Element "b" (Fig. 6), two 200 mm long straight sections:

$$H = \frac{0.5 \times [18{,}300 - (200 + 200)]}{34} - 1.14 \times 14.5 + 0.43 \times 2.5 =$$

$$248 \text{ mm (9.8 in)}$$

Check maximum corrugation height according to the recommendation. In this case height was limited to a maximum of 250 mm to fit in the furnace with the desired clearance.

CALCULATION OF ELEMENT TEMPERATURE

Element temperature, T_e, in °C is calculated as:

$$T_e = -273 + \sqrt[4]{\frac{p_s}{\varepsilon\delta \times 5.67 \times 10^{-12}} + (T_f + 273)^4}$$

where ε is the emissivity of the strip, δ is a form factor, and T_f is the furnace temperature. The emissivity, ε, is 0.70 for Kanthal® alloys, and 0.88 for Nikrothal® alloys.

The form factor, δ, is calculated as:

$$\delta = \frac{b + t + \frac{s}{2} - \sqrt{\frac{s^2}{4} + b^2}}{b + t}$$

For this calculation, use the smallest pitch, s, in the design, which will likely be the hottest position. In this case, the smallest pitch is 75 mm, representing the outer parts of the bottom row (element type “b”).

$$\delta = \frac{30 + 2.5 + \frac{75}{2} - \sqrt{\frac{75^2}{4} + 30^2}}{30 + 2.5} = 0.676$$

The calculated element temperatures will thus be:

$$T_e = -273 + \sqrt[4]{\frac{2.77}{0.70 \times 0.676 \times 5.67 \times 10^{-12}} + (1{,}100 + 273)^4} =$$

$$1{,}190 \text{ °C (2,170 °F)}$$

which is acceptable for Kanthal® AF.

COMPARISON BETWEEN NIKROTHAL® 80 AND KANTHAL® AF

The comparison has been made under the following assumed conditions: The same power, hot resistance, and cross sections for terminal and strip.

$$p_s = \frac{I^2 C_t}{\eta} = 303^2 \times \frac{1.07}{44,700} = 2.2 \frac{W}{cm^2} \left(14.2 \frac{W}{in^2}\right)$$

where η and C_t are looked up in the tables. Ct was looked up for 1,200 °C, i.e. 100 °C higher than the furnace temperature to take into account that the element is always hotter. The resistance per unit length, R_ℓ, used below for calculation of length, can also be found in the tables for the chosen strip dimension of Nikrothal® 80.

$$R_u = 2 \times \frac{4\ell_u \rho}{\pi d^2} = 2 \times \frac{4 \times 0.35 \times 1.09}{3.14 \times 20^2} = 0.0024\ \Omega$$

$$R_{20} = \frac{R_T}{C_t} - R_u = \frac{0.363}{1.07} - 0.0024 = 0.0337\ \Omega$$

$$\ell = \frac{R_{20}}{R_{20/m}} = \frac{0.337}{0.0145} = 23.2\ \text{m}\ (76.1\ \text{ft})$$

The density of Nikrothal® 80 is 8.30 g/cm^3 (0.30 lb/in^3), which gives a strip weight of 14.4 kg (31.8 lb).

For elements of type "a":

$$N = \frac{0.5 \times 23,200}{250 + 1.14 \times 14.5 - 0.43 \times 2.5} = 43.70 \approx 44$$

$$s = \frac{3,100}{44} = 70\ \text{mm}\ (2.8\ \text{in})$$

$$H = 0.5 \times \frac{23,200}{44} - 1.14 \times 14.5 + 0.43 \times 2.5 = 248\ \text{mm}\ (9.8\ \text{in})$$

For elements of type "b":

$$N = \frac{0.5 \times [23,200 - (200 + 200)]}{250 + 1.14 \times 14.5 - 0.43 \times 2.5} = 42.95 \approx 43$$

Distributed as 11 pitches per outer side, and 21 in the center region:

$$s_1 = \frac{675}{11} = 61.4\ \text{mm}\ (2.4\ \text{in});\ s_2 = \frac{1,350}{21} = 64\ \text{mm}\ (2.5\ \text{in})$$

$$H = 0.5 \times \frac{[23,200 - (200 + 200)]}{43} - 1.14 \times 14.5 + 0.43 \times 2.5 = 250\ \text{mm}\ (9.8\ \text{in})$$

Calculation of element temperature, s = 61.4 mm (2.4 in):

$$\delta = \frac{30 + 2.5 + \frac{61.4}{2} - \sqrt[2]{\frac{61.4^2}{4} + 30^2}}{30 + 2.5} = 0.624$$

The emissivity, ε, for Nikrothal® alloys is 0.88.

$$T_e = -273 + \sqrt[4]{\frac{2.2}{0.88 \times 0.624 \times 5.67 \times 10^{-12}} + (1,100 + 273)^4} = 1,164\ °\text{C}\ (2,130\ °\text{F})$$

ELEMENT "A" - COMPARISON TABLE STRIP 30 X 2.5 MM (1.2 X 0.1 IN)

	KANTHAL® AF	NIKROTHAL®
Power, kW	33.33	33.33
Hot resistance, Ω	0.363	0.363
Element height, mm (in)	246 (9.7)	250 (9.8)
Strip length, m (ft)	18.3 (61.9)	23.2 (76.1)
Strip weight. kg (lbs)	9.8 (21.6)	14.4 (31.8)
Number of supports	34	43

The strip length is 21% shorter and the element weight is 32% less with Kanthal® AF compared with Nikrothal® 80. The number of supporting pins is reduced by 21% with Kanthal® AF.

STANDARD TOLERANCES

Standard tolerances for wire are provided below. Size tolerances do not apply to material manufactured to resistance tolerances and vice versa.

TOLERANCES ON ELECTRICAL RESISTANCE

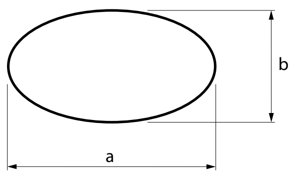
- Resistance of Wire at 20°C (68°F)
- Diameter ⩽ 0.127 mm (0.005 in): ± 8%
- All dimensions > 0.127 mm (0.005 in): ± 5%

TOLERANCES ON DIMENSIONS

TOLERANCES ON DIAMETER OF WIRE ACCORDING TO THE EN 10 218-2 T4 STANDARD

WIRE SIZE	MAX DEVIATION FROM NOMINAL VALUE		MAX OVALITY	
	MM	IN	MM	IN
d	Tol = ±0.015·√d	(Tol = ±0.002976·√d)	Tol ⩽ 0.015·√d	(Tol ⩽ 0.002976·√d)

Max ovality = a − b



DELIVERY FORMS

To prevent transport damage, all goods are securely packed in either cardboard boxes or wooden cases, with appropriate internal protection.

Resistance heating alloys are available in a variety of delivery forms, including wire spools, pails, coils, and strips, to cater to diverse customer requirements. Each delivery form is designed to optimize handling and storage, with standardized sizes and lengths detailed for convenience. Surface finishes, dimensions, and resistance tolerances are carefully controlled, with the option for closer tolerances upon request. This chapter outlines the available delivery forms and specifications, ensuring reliability and ease of use for various applications.

RESISTANCE HEATING ALLOYS – KANTHAL®, ALKROTHAL® AND NIKROTHAL®

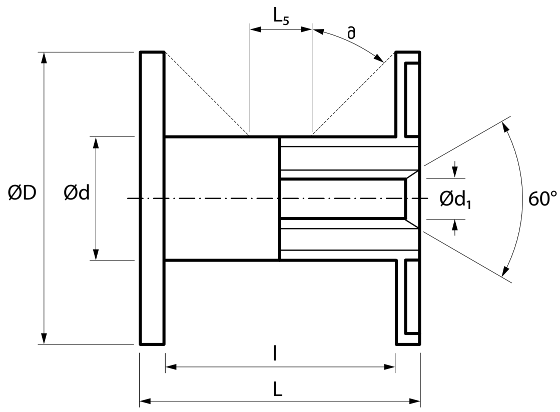
WIRE

Wire with a diameter of ≤1.63 mm (0.064 in) is delivered on spools, as shown in the figure. Each spool contains a single continuous length of wire.

Wire sizes ranging from 0.40 mm to 1.63 mm (0.016–0.064 in) can also be supplied in round pail packs (drums), as shown in the table below.

Wire with a diameter greater than 1.65 mm (0.065 in) is typically supplied in coils with an inner diameter of approximately 500–600 mm (19.7–23.6 in).

Wire with a diameter of less than 1.82 mm can be supplied on standard spools. Each spool holds one continuous length of wire.



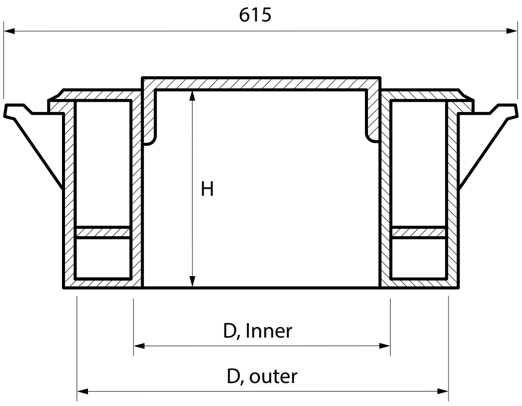
Spool (B 1, B 2, B 4).

TYPES OF WIRE SPOOLS

SPOOL	TARE	SPOOL MEASUREMENTS, MM (IN)					WIRE DIAMETER	CAPACITY APPROX.
NO.	G (LB)	D	D	D1	L	L	MM (IN)	KG (LB)
B 1	100 (0.22)	75 (2.95)	40 (1.57)	16 (0.63)	120 (4.72)	100 (3.94)	0.10 – 0.19 (0.004 – 0.007)	1 (2.2)
B 2	115 (0.25)	90 (3.54)	40 (1.57)	16 (0.63)	120 (4.72)	100 (3.94)	0.20 – 0.24 (0.008 – 0.009)	2 (4.4)
B 4	180 (0.40)	120 (4.72)	50 (1.97)	16 (0.63)	120 (4.72)	100 (3.94)	0.25 – 1.00 (0.010 – 0.039)	4 (8.8)
DIN 200	600 (1.32)	200 (7.87)	125 (4.92)	36 (1.42)	200 (7.87)	160 (6.30)	0.16 – 1.20 (0.006 – 0.047)	10 (22.0)
DIN 250	1,050 (2.31)	250 (9.84)	160 (6.30)	36 (1.42)	200 (7.87)	160 (6.30)	0.30 – 1.63 (0.012 – 0.064)	20 (44.1)
DIN 355	1,850 (4.08)	355 (13.98)	224 (8.82)	36 (1.42)	200 (7.87)	160 (6.30)	0.50 – 1.63 (0.022 – 0.064)	40 (88.2)

TYPES OF WIRE PAILS (DRUM PACK)

PAIL NO.	TARE G (LB)	PAIL MEASUREMENTS, MM (IN) D, OUTER	D, INNER	HEIGHT	MATERIAL	WIRE DIAMETER MM (IN)	CAPACITY APPROX. KG (LB)
P 50	2,600 (5.7)	508 (20.0)	330 (13.0)	150 (5.9)	plastic	0.40–1.63 (0.016–0.064)	33 (73)
P 100	3,500 (7.7)	508 (20.0)	330 (13.0)	250 (9.8)	plastic	0.40–1.63 (0.016–0.064)	50 (110)
P 200	8,500 (18.7)	500 (19.7)	300 (11.8)	520 (20.5)	cardboard	0.80–1.63 (0.031–0.064)	160–240 (352–529)
P 350	10,000 (22.0)	500 (19.7)	300 (11.8)	820 (32.3)	cardboard	0.80–1.63 (0.031–0.064)	250–400 (551–882)



Pail pack.

STRIP

Available in coils with an internal diameter of approximately 400 mm (15.7 in). The lengths specified in the table are typically supplied, though larger coils are available upon request.

STRIP LENGTH

STRIP THICKNESS		LENGTH (APPROX.) KANTHAL®		NIKROTHAL®	
mm	in	m	ft	m	ft
3.0	0.12	65	213	90	295
2.5	0.10	80	262	105	344
2.0	0.08	100	327	130	425
1.5	0.06	135	442	175	573
1.0	0.04	200	655	260	851
0.5	0.02	400	1,309	500	1,636

SURFACE FINISH

Element materials are available with the following surface finishes. Some finishes may not be available in certain markets. For full details, please contact your local supplier.

DELIVERY TOLERANCES

Cold-drawn round wire is supplied with a resistance tolerance of ±5% per length. Cold-rolled strip is also supplied with a resistance tolerance of ±5% per length. Wire and strip can be supplied with closer tolerances upon request.

IMPORTANT
Tolerances on dimensions and resistance per unit length must not be specified simultaneously.

FORMS OF SURFACE FINISH

QUALITY	BRIGHT ANNEALED		OXIDIZED ANNEALED		PICKLED		GRINDED	
	MM	INCH	MM	INCH	MM	INCH	MM	INCH
Kanthal® A-1 Wire	<2.3	<0.090	≥1.02	≥0.040	>5.01	≥0.197	–	–
Kanthal® A-1 Strip	≥0.1 - 3.0	≥0.003 - 0.118	≥0.1 - 3.0	≥0.003 - 0.118	–	–	≥0.1 - 3.0	≥0.003 - 0.118
Kanthal® AF Wire	<2.3	<0.090	≥1.02	≥0.040	>5.01	≥0.197	–	–
Kanthal® AF Strip	≥0.1 - 3.0	≥0.003 - 0.118	≥0.1 - 3.0	≥0.003 - 0.118	–	–	≥0.1 - 3.0	≥0.003 - 0.118
Kanthal® D Wire	<2.3	<0.090	≥1.02	≥0.040	>5.01	≥0.197	–	–
Kanthal® D Strip	≥0.1 - 3.0	≥0.003 - 0.118	≥0.1 - 3.0	≥0.003 - 0.118	–	–	≥0.1 - 3.0	≥0.003 - 0.118
Alkrothal® Wire	<2.3	<0.090	≥1.02	≥0.040	>5.01	≥0.197	–	–
Alkrothal® Strip	≥0.1 - 3.0	≥0.003 - 0.118	≥0.1 - 3.0	≥0.003 - 0.118	–	–	≥0.1 - 3.0	≥0.003 - 0.118
Nikrothal® 80 Wire	<5.0	<0.196	≥1.02	≥0.040	>5.01	≥0.197	–	–
Nikrothal® 80 Strip	≥0.1 - 3.0	≥0.003 - 0.118	≥0.1 - 3.0	≥0.003 - 0.118	–	–	≥0.1 - 3.0	≥0.003 - 0.118
Nikrothal® 60 Wire	<5.0	<0.196	≥1.02	≥0.040	>5.01	≥0.197	–	–
Nikrothal® 60 Strip	≥0.1 - 3.0	≥0.003 - 0.118	≥0.1 - 3.0	≥0.003 - 0.118	–	–	≥0.1 - 3.0	≥0.003 - 0.118
Nikrothal® 40 Wire	<5.0	<0.196	≥1.02	≥0.040	>5.01	≥0.197	–	–
Nikrothal® 40 Strip	≥0.1 - 3.0	≥0.003 - 0.118	≥0.1 - 3.0	≥0.003 - 0.118	–	–	≥0.1 - 3.0	≥0.003 - 0.118

TABLES
METRIC UNITS

KEY TO THE TABLES, METRICS

The columns in the charts have the following values, to be used as indicated:

Ω/m, 20°C	Given the length of wire or strip, the resistance per element at 20°C can easily be calculated. If the service temperature is to be considered, it must be multiplied by the factor Ct.
cm2/m	The radiation area can be calculated from the length of wire or strip per element. Taken with output, it also shows the appropriate surface load (W/cm2).
g/m	Given the length of wire or strip per element, the exact weight of the individual element can be calculated.
cm2/Ω, 20°C	This property, defined by Kanthal, gives the proper choice of dimension together with the aimed power, voltage, temperature and the recommended surface load.

KANTHAL® A-1, WIRE

WIRE DIMENSIONS AND PROPERTIES

Resistivity: 1.45 Ω*mm²/m

Density: 7.10 g/cm³

To obtain resistivity at working temperature, multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	0.99	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.04

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
10.00	0.0185	17,016.56	557.633	314	78.540
9.90	0.0188	16,511.15	546.536	311	76.977
9.80	0.0192	16,015.85	535.550	308	75.430
9.70	0.0196	15,530.55	524.677	305	73.898
9.60	0.0200	15,055.16	513.914	302	72.382
9.50	0.0205	14,589.57	503.264	298	70.882
9.40	0.0209	14,133.68	492.724	295	69.398
9.30	0.0213	13,687.39	482.297	292	67.929
9.20	0.0218	13,250.59	471.980	289	66.476
9.10	0.0223	12,823.19	461.776	286	65.039
9.00	0.0228	12,405.07	451.682	283	63.617
8.90	0.0233	11,996.15	441.701	280	62.211
8.80	0.0238	11,596.31	431.831	276	60.821
8.70	0.0244	11,205.46	422.072	273	59.447
8.60	0.0250	10,823.48	412.425	270	58.088
8.50	0.0256	10,450.29	402.890	267	56.745
8.40	0.0262	10,085.78	393.466	264	55.418
8.30	0.0268	9,729.85	384.153	261	54.106
8.20	0.0275	9,382.39	374.952	258	52.810
8.10	0.0281	9,043.30	365.863	254	51.530
8.00	0.0288	8,712.48	356.885	251	50.265
7.90	0.0296	8,389.83	348.019	248	49.017
7.80	0.0303	8,075.24	339.264	245	47.784
7.70	0.0311	7,768.62	330.620	242	46.566
7.60	0.0320	7,469.86	322.089	239	45.365
7.50	0.0328	7,178.86	313.668	236	44.179
7.40	0.0337	6,895.52	305.360	232	43.008
7.30	0.0346	6,619.73	297.162	229	41.854
7.20	0.0356	6,351.40	289.077	226	40.715
7.10	0.0366	6,090.41	281.103	223	39.592
7.00	0.0377	5,836.68	273.240	220	38.485
6.90	0.0388	5,590.09	265.489	217	37.393
6.80	0.0399	5,350.55	257.849	214	36.317
6.70	0.0411	5,117.95	250.321	210	35.257
6.60	0.0424	4,892.19	242.905	207	34.212
6.50	0.0437	4,673.17	235.600	204	33.183
6.40	0.0451	4,460.79	228.406	201	32.170
6.30	0.0465	4,254.94	221.324	198	31.172
6.20	0.0480	4,055.52	214.354	195	30.191
6.10	0.0496	3,862.44	207.495	192	29.225
6.00	0.0513	3,675.58	200.748	188	28.274
5.90	0.0530	3,494.84	194.112	185	27.340

KANTHAL® A-1, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
5.80	0.0549	3,320.13	187.588	182	26.421
5.70	0.0568	3,151.35	181.175	179	25.518
5.60	0.0589	2,988.38	174.874	176	24.630
5.50	0.0610	2,831.13	168.684	173	23.758
5.40	0.0633	2,679.50	162.606	170	22.902
5.30	0.0657	2,533.37	156.639	167	22.062
5.20	0.0683	2,392.66	150.784	163	21.237
5.10	0.0710	2,257.26	145.040	160	20.428
5.00	0.0738	2,127.07	139.408	157	19.635
4.90	0.0769	2,001.98	133.888	154	18.857
4.80	0.0801	1,881.90	128.479	151	18.096
4.70	0.0836	1,766.71	123.181	148	17.349
4.60	0.0872	1,656.32	117.995	145	16.619
4.50	0.0912	1,550.63	112.921	141	15.904
4.40	0.0954	1,449.54	107.958	138	15.205
4.30	0.0998	1,352.94	103.106	135	14.522
4.20	0.1047	1,260.72	98.366	132	13.854
4.10	0.1098	1,172.80	93.738	129	13.203
4.00	0.1154	1,089.06	89.221	126	12.566
3.90	0.1214	1,009.41	84.816	123	11.946
3.80	0.1279	933.73	80.522	119	11.341
3.70	0.1349	861.94	76.340	116	10.752
3.60	0.1425	793.92	72.269	113	10.179
3.50	0.1507	729.58	68.310	110	9.621
3.40	0.1597	668.82	64.462	107	9.079
3.30	0.1695	611.52	60.726	104	8.553
3.20	0.1803	557.60	57.102	101	8.042
3.10	0.1921	506.94	53.589	97	7.548
3.00	0.2051	459.45	50.187	94	7.069
2.90	0.2195	415.02	46.897	91	6.605
2.80	0.2355	373.55	43.718	88	6.158
2.70	0.2533	334.94	40.651	85	5.726
2.60	0.2731	299.08	37.696	82	5.309
2.50	0.2954	265.88	34.852	79	4.909
2.40	0.3205	235.24	32.120	75	4.524
2.30	0.3490	207.04	29.499	72	4.155
2.20	0.3814	181.19	26.989	69	3.801
2.10	0.4186	157.59	24.592	66	3.464
2.00	0.4615	136.13	22.305	63	3.142
1.90	0.5114	116.72	20.131	60	2.835
1.80	0.5698	99.24	18.067	57	2.545
1.70	0.6388	83.60	16.116	53	2.270

KANTHAL® A-1, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
1.60	0.7212	69.70	14.275	50	2.011
1.50	0.8205	57.43	12.547	47	1.767
1.40	0.9419	46.69	10.930	44	1.539
1.30	1.0924	37.39	9.424	41	1.327
1.20	1.2821	29.40	8.030	38	1.131
1.10	1.5258	22.65	6.747	35	0.950
1.00	1.8462	17.02	5.576	31	0.785
0.90	2.2793	12.41	4.517	28	0.636
0.80	2.8847	8.71	3.569	25	0.503
0.70	3.7677	5.84	2.732	22	0.385
0.60	5.1283	3.68	2.007	19	0.283
0.50	7.3848	2.13	1.394	16	0.196
0.40	11.5387	1.09	0.892	13	0.126
0.30	20.5133	0.46	0.502	9	0.071
0.20	46.1549	0.14	0.223	6	0.031
0.10	184.6197	0.02	0.056	3	0.008

KANTHAL® A-1, STRIP

STRIP DIMENSIONS AND PROPERTIES

Resistivity: 1.45 Ω*mm²/m

Density: 7.10 g/cm³

To obtain resistivity at working temperature, multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	0.99	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.04

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
50	3.0	0.0097	1,060	109,655	1,065
50	2.5	0.0116	1,050	90,517	888
50	2.0	0.0145	1,040	71,724	710
50	1.8	0.0161	1,036	64,303	639
50	1.5	0.0193	1,030	53,276	533
50	1.2	0.0242	1,024	42,372	426
50	1.0	0.0290	1,020	35,172	355
50	0.7	0.0414	1,014	24,476	249
50	0.5	0.0580	1,010	17,414	178
50	0.4	0.0725	1,008	13,903	142
50	0.3	0.0967	1,006	10,407	107
40	3.0	0.0121	860	71,172	852
40	2.5	0.0145	850	58,621	710
40	2.0	0.0181	840	46,345	568
40	1.8	0.0201	836	41,512	511
40	1.5	0.0242	830	34,345	426
40	1.2	0.0302	824	27,277	341
40	1.0	0.0363	820	22,621	284
40	0.7	0.0518	814	15,719	199
40	0.5	0.0725	810	11,172	142
40	0.4	0.0906	808	8,916	114
40	0.3	0.1208	806	6,670	85
35	3.0	0.0138	760	55,034	746
35	2.5	0.0166	750	45,259	621
35	2.0	0.0207	740	35,724	497
35	1.8	0.0230	736	31,978	447
35	1.5	0.0276	730	26,431	373
35	1.2	0.0345	724	20,971	298
35	1.0	0.0414	720	17,379	249
35	0.7	0.0592	714	12,064	174
35	0.5	0.0829	710	8,569	124
35	0.4	0.1036	708	6,836	99
35	0.3	0.1381	706	5,112	75
30	3.0	0.0161	660	40,966	639
30	2.5	0.0193	650	33,621	533
30	2.0	0.0242	640	26,483	426
30	1.8	0.0269	636	23,686	383
30	1.5	0.0322	630	19,552	320
30	1.2	0.0403	624	15,492	256
30	1.0	0.0483	620	12,828	213
30	0.7	0.0690	614	8,892	149
30	0.5	0.0967	610	6,310	107

KANTHAL® A-1, STRIP

(cont.)

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
30	0.4	0.1208	608	5,032	85
30	0.3	0.1611	606	3,761	64
25	3.0	0.0193	560	28,966	533
25	2.5	0.0232	550	23,707	444
25	2.0	0.0290	540	18,621	355
25	1.8	0.0322	536	16,634	320
25	1.5	0.0387	530	13,707	266
25	1.2	0.0483	524	10,841	213
25	1.0	0.0580	520	8,966	178
25	0.7	0.0829	514	6,203	124
25	0.5	0.1160	510	4,397	89
25	0.4	0.1450	508	3,503	71
25	0.3	0.1933	506	2,617	53
20	3.0	0.0242	460	19,034	426
20	2.5	0.0290	450	15,517	355
20	2.0	0.0363	440	12,138	284
20	1.8	0.0403	436	10,825	256
20	1.5	0.0483	430	8,897	213
20	1.2	0.0604	424	7,018	170
20	1.0	0.0725	420	5,793	142
20	0.7	0.1036	414	3,997	99
20	0.5	0.1450	410	2,828	71
20	0.4	0.1813	408	2,251	57
20	0.3	0.2417	406	1,680	43
18	3.0	0.0269	420	15,641	383
18	2.5	0.0322	410	12,724	320
18	2.0	0.0403	400	9,931	256
18	1.8	0.0448	396	8,849	230
18	1.5	0.0537	390	7,262	192
18	1.2	0.0671	384	5,720	153
18	1.0	0.0806	380	4,717	128
18	0.7	0.1151	374	3,250	89
18	0.5	0.1611	370	2,297	64
18	0.4	0.2014	368	1,827	51
18	0.3	0.2685	366	1,363	38
15	3.0	0.0322	360	11,172	320
15	2.5	0.0387	350	9,052	266
15	2.0	0.0483	340	7,034	213
15	1.8	0.0537	336	6,257	192
15	1.5	0.0644	330	5,121	160
15	1.2	0.0806	324	4,022	128
15	1.0	0.0967	320	3,310	107

KANTHAL® A-1, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
15	0.7	0.1381	314	2,274	75
15	0.5	0.1933	310	1,603	53
15	0.4	0.2417	308	1,274	43
15	0.3	0.3222	306	950	32
12	3.0	0.0403	300	7,448	256
12	2.5	0.0483	290	6,000	213
12	2.0	0.0604	280	4,634	170
12	1.8	0.0671	276	4,111	153
12	1.5	0.0806	270	3,352	128
12	1.2	0.1007	264	2,622	102
12	1.0	0.1208	260	2,152	85
12	0.7	0.1726	254	1,471	60
12	0.5	0.2417	250	1,034	43
12	0.4	0.3021	248	821	34
12	0.3	0.4028	246	611	26
10	2.5	0.0580	250	4,310	178
10	2.0	0.0725	240	3,310	142
10	1.8	0.0806	236	2,930	128
10	1.5	0.0967	230	2,379	107
10	1.2	0.1208	224	1,854	85
10	1.0	0.1450	220	1,517	71
10	0.7	0.2071	214	1,033	50
10	0.5	0.2900	210	724	36
10	0.4	0.3625	208	574	28
10	0.3	0.4833	206	426	21
8	2.0	0.0906	200	2,207	114
8	1.8	0.1007	196	1,946	102
8	1.5	0.1208	190	1,572	85
8	1.2	0.1510	184	1,218	68
8	1.0	0.1813	180	993	57
8	0.7	0.2589	174	672	40
8	0.5	0.3625	170	469	28
8	0.4	0.4531	168	371	23
8	0.3	0.6042	166	275	17
7	1.5	0.1381	170	1,231	75
7	1.2	0.1726	164	950	60
7	1.0	0.2071	160	772	50
7	0.7	0.2959	154	520	35
7	0.5	0.4143	150	362	25
7	0.4	0.5179	148	286	20
7	0.3	0.6905	146	211	15
6	1.5	0.1611	150	931	64

KANTHAL® A-1, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η $CM^2/Ω$ 20°	WEIGHT G/M
6	1.2	0.2014	144	715	51
6	1.0	0.2417	140	579	43
6	0.7	0.3452	134	388	30
6	0.5	0.4833	130	269	21
6	0.4	0.6042	128	212	17
6	0.3	0.8056	126	156	13
5	1.2	0.2417	124	513	43
5	1.0	0.2900	120	414	36
5	0.7	0.4143	114	275	25
5	0.5	0.5800	110	190	18
5	0.4	0.7250	108	149	14
5	0.3	0.9667	106	110	11

KANTHAL® AF, WIRE

WIRE DIMENSIONS AND PROPERTIES

Resistivity: 1.39 Ω*mm^2/m

Density: 7.15 g/cm^3

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	0.99	1.00	1.01	1.01	1.02	1.03	1.03	1.04	1.05	1.05	1.06	1.06	1.06	1.06	1.06

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
10.00	0.0177	17,751.09	561.560	314	78.540
9.90	0.0181	17,223.86	550.385	311	76.977
9.80	0.0184	16,707.18	539.322	308	75.430
9.70	0.0188	16,200.94	528.372	305	73.898
9.60	0.0192	15,705.03	517.533	302	72.382
9.50	0.0196	15,219.34	506.808	298	70.882
9.40	0.0200	14,743.77	496.194	295	69.398
9.30	0.0205	14,278.21	485.693	292	67.929
9.20	0.0209	13,822.56	475.304	289	66.476
9.10	0.0214	13,376.70	465.028	286	65.039
9.00	0.0218	12,940.54	454.863	283	63.617
8.90	0.0223	12,513.97	444.811	280	62.211
8.80	0.0229	12,096.87	434.872	276	60.821
8.70	0.0234	11,689.14	425.045	273	59.447
8.60	0.0239	11,290.69	415.330	270	58.088
8.50	0.0245	10,901.39	405.727	267	56.745
8.40	0.0251	10,521.14	396.237	264	55.418
8.30	0.0257	10,149.84	386.858	261	54.106
8.20	0.0263	9,787.38	377.593	258	52.810
8.10	0.0270	9,433.66	368.439	254	51.530
8.00	0.0277	9,088.56	359.398	251	50.265
7.90	0.0284	8,751.98	350.469	248	49.017
7.80	0.0291	8,423.81	341.653	245	47.784
7.70	0.0298	8,103.96	332.949	242	46.566
7.60	0.0306	7,792.30	324.357	239	45.365
7.50	0.0315	7,488.74	315.877	236	44.179
7.40	0.0323	7,193.17	307.510	232	43.008
7.30	0.0332	6,905.47	299.255	229	41.854
7.20	0.0341	6,625.56	291.113	226	40.715
7.10	0.0351	6,353.31	283.082	223	39.592
7.00	0.0361	6,088.62	275.164	220	38.485
6.90	0.0372	5,831.39	267.359	217	37.393
6.80	0.0383	5,581.51	259.665	214	36.317
6.70	0.0394	5,338.87	252.084	210	35.257
6.60	0.0406	5,103.37	244.615	207	34.212
6.50	0.0419	4,874.89	237.259	204	33.183
6.40	0.0432	4,653.34	230.015	201	32.170
6.30	0.0446	4,438.61	222.883	198	31.172
6.20	0.0460	4,230.58	215.864	195	30.191
6.10	0.0476	4,029.16	208.956	192	29.225
6.00	0.0492	3,834.23	202.161	188	28.274
5.90	0.0508	3,645.70	195.479	185	27.340

KANTHAL® AF, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
5.80	0.0526	3,463.45	188.909	182	26.421
5.70	0.0545	3,287.38	182.451	179	25.518
5.60	0.0564	3,117.37	176.105	176	24.630
5.50	0.0585	2,953.34	169.872	173	23.758
5.40	0.0607	2,795.16	163.751	170	22.902
5.30	0.0630	2,642.73	157.742	167	22.062
5.20	0.0655	2,495.94	151.846	163	21.237
5.10	0.0680	2,354.70	146.062	160	20.428
5.00	0.0708	2,218.89	140.390	157	19.635
4.90	0.0737	2,088.40	134.830	154	18.857
4.80	0.0768	1,963.13	129.383	151	18.096
4.70	0.0801	1,842.97	124.049	148	17.349
4.60	0.0836	1,727.82	118.826	145	16.619
4.50	0.0874	1,617.57	113.716	141	15.904
4.40	0.0914	1,512.11	108.718	138	15.205
4.30	0.0957	1,411.34	103.832	135	14.522
4.20	0.1003	1,315.14	99.059	132	13.854
4.10	0.1053	1,223.42	94.398	129	13.203
4.00	0.1106	1,136.07	89.850	126	12.566
3.90	0.1164	1,052.98	85.413	123	11.946
3.80	0.1226	974.04	81.089	119	11.341
3.70	0.1293	899.15	76.878	116	10.752
3.60	0.1366	828.19	72.778	113	10.179
3.50	0.1445	761.08	68.791	110	9.621
3.40	0.1531	697.69	64.916	107	9.079
3.30	0.1625	637.92	61.154	104	8.553
3.20	0.1728	581.67	57.504	101	8.042
3.10	0.1842	528.82	53.966	97	7.548
3.00	0.1966	479.28	50.540	94	7.069
2.90	0.2104	432.93	47.227	91	6.605
2.80	0.2257	389.67	44.026	88	6.158
2.70	0.2428	349.39	40.938	85	5.726
2.60	0.2618	311.99	37.961	82	5.309
2.50	0.2832	277.36	35.097	79	4.909
2.40	0.3073	245.39	32.346	75	4.524
2.30	0.3346	215.98	29.707	72	4.155
2.20	0.3657	189.01	27.179	69	3.801
2.10	0.4013	164.39	24.765	66	3.464
2.00	0.4425	142.01	22.462	63	3.142
1.90	0.4903	121.75	20.272	60	2.835
1.80	0.5462	103.52	18.195	57	2.545
1.70	0.6124	87.21	16.229	53	2.270

KANTHAL® AF, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
1.60	0.6913	72.71	14.376	50	2.011
1.50	0.7866	59.91	12.635	47	1.767
1.40	0.9030	48.71	11.007	44	1.539
1.30	1.0472	39.00	9.490	41	1.327
1.20	1.2290	30.67	8.086	38	1.131
1.10	1.4626	23.63	6.795	35	0.950
1.00	1.7698	17.75	5.616	31	0.785
0.90	2.1849	12.94	4.549	28	0.636
0.80	2.7653	9.09	3.594	25	0.503
0.70	3.6118	6.09	2.752	22	0.385
0.60	4.9161	3.83	2.022	19	0.283
0.50	7.0792	2.22	1.404	16	0.196
0.40	11.0613	1.14	0.898	13	0.126
0.30	19.6645	0.48	0.505	9	0.071
0.20	44.2451	0.14	0.225	6	0.031
0.10	176.9803	0.02	0.056	3	0.008

KANTHAL® AF, STRIP

STRIP DIMENSIONS AND PROPERTIES

Resistivity: 1.39 Ω* mm²/m

Density: 7.15 g/cm³

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	0.99	1.00	1.01	1.01	1.02	1.03	1.03	1.04	1.05	1.05	1.06	1.06	1.06	1.06	1.06

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
50	3.0	0.0093	1,060	114,388	1,073
50	2.5	0.0111	1,050	94,424	894
50	2.0	0.0139	1,040	74,820	715
50	1.8	0.0154	1,036	67,079	644
50	1.5	0.0185	1,030	55,576	536
50	1.2	0.0232	1,024	44,201	429
50	1.0	0.0278	1,020	36,691	358
50	0.7	0.0397	1,014	25,532	250
50	0.5	0.0556	1,010	18,165	179
50	0.4	0.0695	1,008	14,504	143
50	0.3	0.0927	1,006	10,856	107
40	3.0	0.0116	860	74,245	858
40	2.5	0.0139	850	61,151	715
40	2.0	0.0174	840	48,345	572
40	1.8	0.0193	836	43,304	515
40	1.5	0.0232	830	35,827	429
40	1.2	0.0290	824	28,455	343
40	1.0	0.0348	820	23,597	286
40	0.7	0.0496	814	16,397	200
40	0.5	0.0695	810	11,655	143
40	0.4	0.0869	808	9,301	114
40	0.3	0.1158	806	6,958	86
35	3.0	0.0132	760	57,410	751
35	2.5	0.0159	750	47,212	626
35	2.0	0.0199	740	37,266	501
35	1.8	0.0221	736	33,358	450
35	1.5	0.0265	730	27,572	375
35	1.2	0.0331	724	21,876	300
35	1.0	0.0397	720	18,129	250
35	0.7	0.0567	714	12,585	175
35	0.5	0.0794	710	8,939	125
35	0.4	0.0993	708	7,131	100
35	0.3	0.1324	706	5,333	75
30	3.0	0.0154	660	42,734	644
30	2.5	0.0185	650	35,072	536
30	2.0	0.0232	640	27,626	429
30	1.8	0.0257	636	24,708	386
30	1.5	0.0309	630	20,396	322
30	1.2	0.0386	624	16,161	257
30	1.0	0.0463	620	13,381	215
30	0.7	0.0662	614	9,276	150
30	0.5	0.0927	610	6,583	107

KANTHAL® AF, STRIP

(cont.)

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η $CM^2/Ω$ 20°	WEIGHT G/M
30	0.4	0.1158	608	5,249	86
30	0.3	0.1544	606	3,924	64
25	3.0	0.0185	560	30,216	536
25	2.5	0.0222	550	24,730	447
25	2.0	0.0278	540	19,424	358
25	1.8	0.0309	536	17,353	322
25	1.5	0.0371	530	14,299	268
25	1.2	0.0463	524	11,309	215
25	1.0	0.0556	520	9,353	179
25	0.7	0.0794	514	6,471	125
25	0.5	0.1112	510	4,586	89
25	0.4	0.1390	508	3,655	72
25	0.3	0.1853	506	2,730	54
20	3.0	0.0232	460	19,856	429
20	2.5	0.0278	450	16,187	358
20	2.0	0.0348	440	12,662	286
20	1.8	0.0386	436	11,292	257
20	1.5	0.0463	430	9,281	215
20	1.2	0.0579	424	7,321	172
20	1.0	0.0695	420	6,043	143
20	0.7	0.0993	414	4,170	100
20	0.5	0.1390	410	2,950	72
20	0.4	0.1738	408	2,348	57
20	0.3	0.2317	406	1,753	43
18	3.0	0.0257	420	16,317	386
18	2.5	0.0309	410	13,273	322
18	2.0	0.0386	400	10,360	257
18	1.8	0.0429	396	9,231	232
18	1.5	0.0515	390	7,576	193
18	1.2	0.0644	384	5,967	154
18	1.0	0.0772	380	4,921	129
18	0.7	0.1103	374	3,390	90
18	0.5	0.1544	370	2,396	64
18	0.4	0.1931	368	1,906	51
18	0.3	0.2574	366	1,422	39
15	3.0	0.0309	360	11,655	322
15	2.5	0.0371	350	9,442	268
15	2.0	0.0463	340	7,338	215
15	1.8	0.0515	336	6,527	193
15	1.5	0.0618	330	5,342	161
15	1.2	0.0772	324	4,196	129
15	1.0	0.0927	320	3,453	107

KANTHAL® AF, STRIP

(cont.)

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
15	0.7	0.1324	314	2,372	75
15	0.5	0.1853	310	1,673	54
15	0.4	0.2317	308	1,329	43
15	0.3	0.3089	306	991	32
12	3.0	0.0386	300	7,770	257
12	2.5	0.0463	290	6,259	215
12	2.0	0.0579	280	4,835	172
12	1.8	0.0644	276	4,289	154
12	1.5	0.0772	270	3,496	129
12	1.2	0.0965	264	2,735	103
12	1.0	0.1158	260	2,245	86
12	0.7	0.1655	254	1,535	60
12	0.5	0.2317	250	1,079	43
12	0.4	0.2896	248	856	34
12	0.3	0.3861	246	637	26
10	2.5	0.0556	250	4,496	179
10	2.0	0.0695	240	3,453	143
10	1.8	0.0772	236	3,056	129
10	1.5	0.0927	230	2,482	107
10	1.2	0.1158	224	1,934	86
10	1.0	0.1390	220	1,583	72
10	0.7	0.1986	214	1,078	50
10	0.5	0.2780	210	755	36
10	0.4	0.3475	208	599	29
10	0.3	0.4633	206	445	21
8	2.0	0.0869	200	2,302	114
8	1.8	0.0965	196	2,031	103
8	1.5	0.1158	190	1,640	86
8	1.2	0.1448	184	1,271	69
8	1.0	0.1738	180	1,036	57
8	0.7	0.2482	174	701	40
8	0.5	0.3475	170	489	29
8	0.4	0.4344	168	387	23
8	0.3	0.5792	166	287	17
7	1.5	0.1324	170	1,284	75
7	1.2	0.1655	164	991	60
7	1.0	0.1986	160	806	50
7	0.7	0.2837	154	543	35
7	0.5	0.3971	150	378	25
7	0.4	0.4964	148	298	20
7	0.3	0.6619	146	221	15
6	1.5	0.1544	150	971	64

KANTHAL® AF, STRIP

(cont.)

WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
DIMENSIONS				DESIGN NUMBERS	
6	1.2	0.1931	144	746	51
6	1.0	0.2317	140	604	43
6	0.7	0.3310	134	405	30
6	0.5	0.4633	130	281	21
6	0.4	0.5792	128	221	17
6	0.3	0.7722	126	163	13
5	1.2	0.2317	124	535	43
5	1.0	0.2780	120	432	36
5	0.7	0.3971	114	287	25
5	0.5	0.5560	110	198	18
5	0.4	0.6950	108	155	14
5	0.3	0.9267	106	114	11

KANTHAL® APM, WIRE

WIRE DIMENSIONS AND PROPERTIES

Resistivity: 1.45 Ω* mm²/m

Density: 7.10 g/cm³

To obtain resistivity at working temperature, multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	0.99	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.04

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
10.00	0.0185	17,016.56	557.633	314	78.540
9.90	0.0188	16,511.15	546.536	311	76.977
9.80	0.0192	16,015.85	535.550	308	75.430
9.70	0.0196	15,530.55	524.677	305	73.898
9.60	0.0200	15,055.16	513.914	302	72.382
9.50	0.0205	14,589.57	503.264	298	70.882
9.40	0.0209	14,133.68	492.724	295	69.398
9.30	0.0213	13,687.39	482.297	292	67.929
9.20	0.0218	13,250.59	471.980	289	66.476
9.10	0.0223	12,823.19	461.776	286	65.039
9.00	0.0228	12,405.07	451.682	283	63.617
8.90	0.0233	11,996.15	441.701	280	62.211
8.80	0.0238	11,596.31	431.831	276	60.821
8.70	0.0244	11,205.46	422.072	273	59.447
8.60	0.0250	10,823.48	412.425	270	58.088
8.50	0.0256	10,450.29	402.890	267	56.745
8.40	0.0262	10,085.78	393.466	264	55.418
8.30	0.0268	9,729.85	384.153	261	54.106
8.20	0.0275	9,382.39	374.952	258	52.810
8.10	0.0281	9,043.30	365.863	254	51.530
8.00	0.0288	8,712.48	356.885	251	50.265
7.90	0.0296	8,389.83	348.019	248	49.017
7.80	0.0303	8,075.24	339.264	245	47.784
7.70	0.0311	7,768.62	330.620	242	46.566
7.60	0.0320	7,469.86	322.089	239	45.365
7.50	0.0328	7,178.86	313.668	236	44.179
7.40	0.0337	6,895.52	305.360	232	43.008
7.30	0.0346	6,619.73	297.162	229	41.854
7.20	0.0356	6,351.40	289.077	226	40.715
7.10	0.0366	6,090.41	281.103	223	39.592
7.00	0.0377	5,836.68	273.240	220	38.485
6.90	0.0388	5,590.09	265.489	217	37.393
6.80	0.0399	5,350.55	257.849	214	36.317
6.70	0.0411	5,117.95	250.321	210	35.257
6.60	0.0424	4,892.19	242.905	207	34.212
6.50	0.0437	4,673.17	235.600	204	33.183
6.40	0.0451	4,460.79	228.406	201	32.170
6.30	0.0465	4,254.94	221.324	198	31.172
6.20	0.0480	4,055.52	214.354	195	30.191
6.10	0.0496	3,862.44	207.495	192	29.225
6.00	0.0513	3,675.58	200.748	188	28.274
5.90	0.0530	3,494.84	194.112	185	27.340

KANTHAL® APM, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM^2/Ω	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
5.80	0.0549	3,320.13	187.588	182	26.421
5.70	0.0568	3,151.35	181.175	179	25.518
5.60	0.0589	2,988.38	174.874	176	24.630
5.50	0.0610	2,831.13	168.684	173	23.758
5.40	0.0633	2,679.50	162.606	170	22.902
5.30	0.0657	2,533.37	156.639	167	22.062
5.20	0.0683	2,392.66	150.784	163	21.237
5.10	0.0710	2,257.26	145.040	160	20.428
5.00	0.0738	2,127.07	139.408	157	19.635
4.90	0.0769	2,001.98	133.888	154	18.857
4.80	0.0801	1,881.90	128.479	151	18.096
4.70	0.0836	1,766.71	123.181	148	17.349
4.60	0.0872	1,656.32	117.995	145	16.619
4.50	0.0912	1,550.63	112.921	141	15.904
4.40	0.0954	1,449.54	107.958	138	15.205
4.30	0.0998	1,352.94	103.106	135	14.522
4.20	0.1047	1,260.72	98.366	132	13.854
4.10	0.1098	1,172.80	93.738	129	13.203
4.00	0.1154	1,089.06	89.221	126	12.566
3.90	0.1214	1,009.41	84.816	123	11.946
3.80	0.1279	933.73	80.522	119	11.341
3.70	0.1349	861.94	76.340	116	10.752
3.60	0.1425	793.92	72.269	113	10.179
3.50	0.1507	729.58	68.310	110	9.621
3.40	0.1597	668.82	64.462	107	9.079
3.30	0.1695	611.52	60.726	104	8.553
3.20	0.1803	557.60	57.102	101	8.042
3.10	0.1921	506.94	53.589	97	7.548
3.00	0.2051	459.45	50.187	94	7.069
2.90	0.2195	415.02	46.897	91	6.605
2.80	0.2355	373.55	43.718	88	6.158
2.70	0.2533	334.94	40.651	85	5.726
2.60	0.2731	299.08	37.696	82	5.309
2.50	0.2954	265.88	34.852	79	4.909
2.40	0.3205	235.24	32.120	75	4.524
2.30	0.3490	207.04	29.499	72	4.155
2.20	0.3814	181.19	26.989	69	3.801
2.10	0.4186	157.59	24.592	66	3.464
2.00	0.4615	136.13	22.305	63	3.142
1.90	0.5114	116.72	20.131	60	2.835
1.80	0.5698	99.24	18.067	57	2.545
1.70	0.6388	83.60	16.116	53	2.270

KANTHAL® APM, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
1.60	0.7212	69.70	14.275	50	2.011
1.50	0.8205	57.43	12.547	47	1.767
1.40	0.9419	46.69	10.930	44	1.539
1.30	1.0924	37.39	9.424	41	1.327
1.20	1.2821	29.40	8.030	38	1.131
1.10	1.5258	22.65	6.747	35	0.950
1.00	1.8462	17.02	5.576	31	0.785
0.90	2.2793	12.41	4.517	28	0.636
0.80	2.8847	8.71	3.569	25	0.503
0.70	3.7677	5.84	2.732	22	0.385
0.60	5.1283	3.68	2.007	19	0.283
0.50	7.3848	2.13	1.394	16	0.196
0.40	11.5387	1.09	0.892	13	0.126
0.30	20.5133	0.46	0.502	9	0.071
0.20	46.1549	0.14	0.223	6	0.031
0.10	184.6197	0.02	0.056	3	0.008

KANTHAL® APM, STRIP

STRIP DIMENSIONS AND PROPERTIES

Resistivity: 1.45 Ω* mm²/m

Density: 7.10 g/cm³

To obtain resistivity at working temperature, multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	0.99	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.04

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
50	3.0	0.0097	1,060	109,655	1,065
50	2.5	0.0116	1,050	90,517	888
50	2.0	0.0145	1,040	71,724	710
50	1.8	0.0161	1,036	64,303	639
50	1.5	0.0193	1,030	53,276	533
50	1.2	0.0242	1,024	42,372	426
50	1.0	0.0290	1,020	35,172	355
50	0.7	0.0414	1,014	24,476	249
50	0.5	0.0580	1,010	17,414	178
50	0.4	0.0725	1,008	13,903	142
50	0.3	0.0967	1,006	10,407	107
40	3.0	0.0121	860	71,172	852
40	2.5	0.0145	850	58,621	710
40	2.0	0.0181	840	46,345	568
40	1.8	0.0201	836	41,512	511
40	1.5	0.0242	830	34,345	426
40	1.2	0.0302	824	27,277	341
40	1.0	0.0363	820	22,621	284
40	0.7	0.0518	814	15,719	199
40	0.5	0.0725	810	11,172	142
40	0.4	0.0906	808	8,916	114
40	0.3	0.1208	806	6,670	85
35	3.0	0.0138	760	55,034	746
35	2.5	0.0166	750	45,259	621
35	2.0	0.0207	740	35,724	497
35	1.8	0.0230	736	31,978	447
35	1.5	0.0276	730	26,431	373
35	1.2	0.0345	724	20,971	298
35	1.0	0.0414	720	17,379	249
35	0.7	0.0592	714	12,064	174
35	0.5	0.0829	710	8,569	124
35	0.4	0.1036	708	6,836	99
35	0.3	0.1381	706	5,112	75
30	3.0	0.0161	660	40,966	639
30	2.5	0.0193	650	33,621	533
30	2.0	0.0242	640	26,483	426
30	1.8	0.0269	636	23,686	383
30	1.5	0.0322	630	19,552	320
30	1.2	0.0403	624	15,492	256
30	1.0	0.0483	620	12,828	213
30	0.7	0.0690	614	8,892	149
30	0.5	0.0967	610	6,310	107

KANTHAL® APM, STRIP

(cont.)

WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	DESIGN NUMBERS η CM²/Ω 20°	WEIGHT G/M
	DIMENSIONS				
30	0.4	0.1208	608	5,032	85
30	0.3	0.1611	606	3,761	64
25	3.0	0.0193	560	28,966	533
25	2.5	0.0232	550	23,707	444
25	2.0	0.0290	540	18,621	355
25	1.8	0.0322	536	16,634	320
25	1.5	0.0387	530	13,707	266
25	1.2	0.0483	524	10,841	213
25	1.0	0.0580	520	8,966	178
25	0.7	0.0829	514	6,203	124
25	0.5	0.1160	510	4,397	89
25	0.4	0.1450	508	3,503	71
25	0.3	0.1933	506	2,617	53
20	3.0	0.0242	460	19,034	426
20	2.5	0.0290	450	15,517	355
20	2.0	0.0363	440	12,138	284
20	1.8	0.0403	436	10,825	256
20	1.5	0.0483	430	8,897	213
20	1.2	0.0604	424	7,018	170
20	1.0	0.0725	420	5,793	142
20	0.7	0.1036	414	3,997	99
20	0.5	0.1450	410	2,828	71
20	0.4	0.1813	408	2,251	57
20	0.3	0.2417	406	1,680	43
18	3.0	0.0269	420	15,641	383
18	2.5	0.0322	410	12,724	320
18	2.0	0.0403	400	9,931	256
18	1.8	0.0448	396	8,849	230
18	1.5	0.0537	390	7,262	192
18	1.2	0.0671	384	5,720	153
18	1.0	0.0806	380	4,717	128
18	0.7	0.1151	374	3,250	89
18	0.5	0.1611	370	2,297	64
18	0.4	0.2014	368	1,827	51
18	0.3	0.2685	366	1,363	38
15	3.0	0.0322	360	11,172	320
15	2.5	0.0387	350	9,052	266
15	2.0	0.0483	340	7,034	213
15	1.8	0.0537	336	6,257	192
15	1.5	0.0644	330	5,121	160
15	1.2	0.0806	324	4,022	128
15	1.0	0.0967	320	3,310	107

KANTHAL® APM, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
15	0.7	0.1381	314	2,274	75
15	0.5	0.1933	310	1,603	53
15	0.4	0.2417	308	1,274	43
15	0.3	0.3222	306	950	32
12	3.0	0.0403	300	7,448	256
12	2.5	0.0483	290	6,000	213
12	2.0	0.0604	280	4,634	170
12	1.8	0.0671	276	4,111	153
12	1.5	0.0806	270	3,352	128
12	1.2	0.1007	264	2,622	102
12	1.0	0.1208	260	2,152	85
12	0.7	0.1726	254	1,471	60
12	0.5	0.2417	250	1,034	43
12	0.4	0.3021	248	821	34
12	0.3	0.4028	246	611	26
10	2.5	0.0580	250	4,310	178
10	2.0	0.0725	240	3,310	142
10	1.8	0.0806	236	2,930	128
10	1.5	0.0967	230	2,379	107
10	1.2	0.1208	224	1,854	85
10	1.0	0.1450	220	1,517	71
10	0.7	0.2071	214	1,033	50
10	0.5	0.2900	210	724	36
10	0.4	0.3625	208	574	28
10	0.3	0.4833	206	426	21
8	2.0	0.0906	200	2,207	114
8	1.8	0.1007	196	1,946	102
8	1.5	0.1208	190	1,572	85
8	1.2	0.1510	184	1,218	68
8	1.0	0.1813	180	993	57
8	0.7	0.2589	174	672	40
8	0.5	0.3625	170	469	28
8	0.4	0.4531	168	371	23
8	0.3	0.6042	166	275	17
7	1.5	0.1381	170	1,231	75
7	1.2	0.1726	164	950	60
7	1.0	0.2071	160	772	50
7	0.7	0.2959	154	520	35
7	0.5	0.4143	150	362	25
7	0.4	0.5179	148	286	20
7	0.3	0.6905	146	211	15
6	1.5	0.1611	150	931	64

KANTHAL® APM, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η $CM^2/Ω$ 20°	WEIGHT G/M
6	1.2	0.2014	144	715	51
6	1.0	0.2417	140	579	43
6	0.7	0.3452	134	388	30
6	0.5	0.4833	130	269	21
6	0.4	0.6042	128	212	17
6	0.3	0.8056	126	156	13
5	1.2	0.2417	124	513	43
5	1.0	0.2900	120	414	36
5	0.7	0.4143	114	275	25
5	0.5	0.5800	110	190	18
5	0.4	0.7250	108	149	14
5	0.3	0.9667	106	110	11

KANTHAL® APMT, WIRE

WIRE DIMENSIONS AND PROPERTIES

Resistivity: 1.40 Ω* mm^2/m

Density: 7.25 g/cm^3

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	1.00	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.03	1.03	1.03	1.04	1.04

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
10.00	0.0178	17,624.29	569.414	314	78.540
9.90	0.0182	17,100.83	558.082	311	76.977
9.80	0.0186	16,587.84	546.865	308	75.430
9.70	0.0189	16,085.22	535.761	305	73.898
9.60	0.0193	15,592.85	524.772	302	72.382
9.50	0.0198	15,110.63	513.896	298	70.882
9.40	0.0202	14,638.46	503.134	295	69.398
9.30	0.0206	14,176.22	492.486	292	67.929
9.20	0.0211	13,723.83	481.952	289	66.476
9.10	0.0215	13,281.16	471.531	286	65.039
9.00	0.0220	12,848.11	461.225	283	63.617
8.90	0.0225	12,424.58	451.033	280	62.211
8.80	0.0230	12,010.46	440.954	276	60.821
8.70	0.0236	11,605.65	430.989	273	59.447
8.60	0.0241	11,210.04	421.138	270	58.088
8.50	0.0247	10,823.52	411.401	267	56.745
8.40	0.0253	10,445.99	401.778	264	55.418
8.30	0.0259	10,077.34	392.269	261	54.106
8.20	0.0265	9,717.47	382.874	258	52.810
8.10	0.0272	9,366.27	373.592	254	51.530
8.00	0.0279	9,023.64	364.425	251	50.265
7.90	0.0286	8,689.46	355.371	248	49.017
7.80	0.0293	8,363.64	346.431	245	47.784
7.70	0.0301	8,046.07	337.605	242	46.566
7.60	0.0309	7,736.64	328.893	239	45.365
7.50	0.0317	7,435.25	320.295	236	44.179
7.40	0.0326	7,141.79	311.811	232	43.008
7.30	0.0334	6,856.15	303.441	229	41.854
7.20	0.0344	6,578.23	295.184	226	40.715
7.10	0.0354	6,307.93	287.041	223	39.592
7.00	0.0364	6,045.13	279.013	220	38.485
6.90	0.0374	5,789.74	271.098	217	37.393
6.80	0.0385	5,541.64	263.297	214	36.317
6.70	0.0397	5,300.74	255.610	210	35.257
6.60	0.0409	5,066.91	248.037	207	34.212
6.50	0.0422	4,840.07	240.577	204	33.183
6.40	0.0435	4,620.10	233.232	201	32.170
6.30	0.0449	4,406.90	226.000	198	31.172
6.20	0.0464	4,200.36	218.883	195	30.191
6.10	0.0479	4,000.38	211.879	192	29.225
6.00	0.0495	3,806.85	204.989	188	28.274
5.90	0.0512	3,619.66	198.213	185	27.340

KANTHAL® APMT, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
5.80	0.0530	3,438.71	191.551	182	26.421
5.70	0.0549	3,263.90	185.003	179	25.518
5.60	0.0568	3,095.11	178.568	176	24.630
5.50	0.0589	2,932.24	172.248	173	23.758
5.40	0.0611	2,775.19	166.041	170	22.902
5.30	0.0635	2,623.85	159.948	167	22.062
5.20	0.0659	2,478.12	153.969	163	21.237
5.10	0.0685	2,337.88	148.104	160	20.428
5.00	0.0713	2,203.04	142.353	157	19.635
4.90	0.0742	2,073.48	136.716	154	18.857
4.80	0.0774	1,949.11	131.193	151	18.096
4.70	0.0807	1,829.81	125.783	148	17.349
4.60	0.0842	1,715.48	120.488	145	16.619
4.50	0.0880	1,606.01	115.306	141	15.904
4.40	0.0921	1,501.31	110.238	138	15.205
4.30	0.0964	1,401.25	105.285	135	14.522
4.20	0.1011	1,305.75	100.445	132	13.854
4.10	0.1060	1,214.68	95.718	129	13.203
4.00	0.1114	1,127.95	91.106	126	12.566
3.90	0.1172	1,045.46	86.608	123	11.946
3.80	0.1234	967.08	82.223	119	11.341
3.70	0.1302	892.72	77.953	116	10.752
3.60	0.1375	822.28	73.796	113	10.179
3.50	0.1455	755.64	69.753	110	9.621
3.40	0.1542	692.71	65.824	107	9.079
3.30	0.1637	633.36	62.009	104	8.553
3.20	0.1741	577.51	58.308	101	8.042
3.10	0.1855	525.05	54.721	97	7.548
3.00	0.1981	475.86	51.247	94	7.069
2.90	0.2120	429.84	47.888	91	6.605
2.80	0.2274	386.89	44.642	88	6.158
2.70	0.2445	346.90	41.510	85	5.726
2.60	0.2637	309.76	38.492	82	5.309
2.50	0.2852	275.38	35.588	79	4.909
2.40	0.3095	243.64	32.798	75	4.524
2.30	0.3370	214.43	30.122	72	4.155
2.20	0.3683	187.66	27.560	69	3.801
2.10	0.4042	163.22	25.111	66	3.464
2.00	0.4456	140.99	22.777	63	3.142
1.90	0.4938	120.89	20.556	60	2.835
1.80	0.5502	102.78	18.449	57	2.545
1.70	0.6168	86.59	16.456	53	2.270

KANTHAL® APMT, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
1.60	0.6963	72.19	14.577	50	2.011
1.50	0.7922	59.48	12.812	47	1.767
1.40	0.9095	48.36	11.161	44	1.539
1.30	1.0548	38.72	9.623	41	1.327
1.20	1.2379	30.45	8.200	38	1.131
1.10	1.4732	23.46	6.890	35	0.950
1.00	1.7825	17.62	5.694	31	0.785
0.90	2.2007	12.85	4.612	28	0.636
0.80	2.7852	9.02	3.644	25	0.503
0.70	3.6378	6.05	2.790	22	0.385
0.60	4.9515	3.81	2.050	19	0.283
0.50	7.1301	2.20	1.424	16	0.196
0.40	11.1408	1.13	0.911	13	0.126
0.30	19.8059	0.48	0.512	9	0.071
0.20	44.5634	0.14	0.228	6	0.031
0.10	178.2535	0.02	0.057	3	0.008

KANTHAL® APMT, STRIP

STRIP DIMENSIONS AND PROPERTIES

Resistivity: 1.40 Ω* mm²/m

Density: 7.25 g/cm³

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	1.00	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.03	1.03	1.03	1.04	1.04

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
50	3.0	0.0093	1,060	113,571	1,088
50	2.5	0.0112	1,050	93,750	906
50	2.0	0.0140	1,040	74,286	725
50	1.8	0.0156	1,036	66,600	653
50	1.5	0.0187	1,030	55,179	544
50	1.2	0.0233	1,024	43,886	435
50	1.0	0.0280	1,020	36,429	363
50	0.7	0.0400	1,014	25,350	254
50	0.5	0.0560	1,010	18,036	181
50	0.4	0.0700	1,008	14,400	145
50	0.3	0.0933	1,006	10,779	109
40	3.0	0.0117	860	73,714	870
40	2.5	0.0140	850	60,714	725
40	2.0	0.0175	840	48,000	580
40	1.8	0.0194	836	42,994	522
40	1.5	0.0233	830	35,571	435
40	1.2	0.0292	824	28,251	348
40	1.0	0.0350	820	23,429	290
40	0.7	0.0500	814	16,280	203
40	0.5	0.0700	810	11,571	145
40	0.4	0.0875	808	9,234	116
40	0.3	0.1167	806	6,909	87
35	3.0	0.0133	760	57,000	761
35	2.5	0.0160	750	46,875	634
35	2.0	0.0200	740	37,000	508
35	1.8	0.0222	736	33,120	457
35	1.5	0.0267	730	27,375	381
35	1.2	0.0333	724	21,720	305
35	1.0	0.0400	720	18,000	254
35	0.7	0.0571	714	12,495	178
35	0.5	0.0800	710	8,875	127
35	0.4	0.1000	708	7,080	102
35	0.3	0.1333	706	5,295	76
30	3.0	0.0156	660	42,429	653
30	2.5	0.0187	650	34,821	544
30	2.0	0.0233	640	27,429	435
30	1.8	0.0259	636	24,531	392
30	1.5	0.0311	630	20,250	326
30	1.2	0.0389	624	16,046	261
30	1.0	0.0467	620	13,286	218
30	0.7	0.0667	614	9,210	152
30	0.5	0.0933	610	6,536	109

KANTHAL® APMT, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η $CM^2/Ω$ 20°	WEIGHT G/M
30	0.4	0.1167	608	5,211	87
30	0.3	0.1556	606	3,896	65
25	3.0	0.0187	560	30,000	544
25	2.5	0.0224	550	24,554	453
25	2.0	0.0280	540	19,286	363
25	1.8	0.0311	536	17,229	326
25	1.5	0.0373	530	14,196	272
25	1.2	0.0467	524	11,229	218
25	1.0	0.0560	520	9,286	181
25	0.7	0.0800	514	6,425	127
25	0.5	0.1120	510	4,554	91
25	0.4	0.1400	508	3,629	73
25	0.3	0.1867	506	2,711	54
20	3.0	0.0233	460	19,714	435
20	2.5	0.0280	450	16,071	363
20	2.0	0.0350	440	12,571	290
20	1.8	0.0389	436	11,211	261
20	1.5	0.0467	430	9,214	218
20	1.2	0.0583	424	7,269	174
20	1.0	0.0700	420	6,000	145
20	0.7	0.1000	414	4,140	102
20	0.5	0.1400	410	2,929	73
20	0.4	0.1750	408	2,331	58
20	0.3	0.2333	406	1,740	44
18	3.0	0.0259	420	16,200	392
18	2.5	0.0311	410	13,179	326
18	2.0	0.0389	400	10,286	261
18	1.8	0.0432	396	9,165	235
18	1.5	0.0519	390	7,521	196
18	1.2	0.0648	384	5,925	157
18	1.0	0.0778	380	4,886	131
18	0.7	0.1111	374	3,366	91
18	0.5	0.1556	370	2,379	65
18	0.4	0.1944	368	1,893	52
18	0.3	0.2593	366	1,412	39
15	3.0	0.0311	360	11,571	326
15	2.5	0.0373	350	9,375	272
15	2.0	0.0467	340	7,286	218
15	1.8	0.0519	336	6,480	196
15	1.5	0.0622	330	5,304	163
15	1.2	0.0778	324	4,166	131
15	1.0	0.0933	320	3,429	109

KANTHAL® APMT, STRIP

(cont.)

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
15	0.7	0.1333	314	2,355	76
15	0.5	0.1867	310	1,661	54
15	0.4	0.2333	308	1,320	44
15	0.3	0.3111	306	984	33
12	3.0	0.0389	300	7,714	261
12	2.5	0.0467	290	6,214	218
12	2.0	0.0583	280	4,800	174
12	1.8	0.0648	276	4,258	157
12	1.5	0.0778	270	3,471	131
12	1.2	0.0972	264	2,715	104
12	1.0	0.1167	260	2,229	87
12	0.7	0.1667	254	1,524	61
12	0.5	0.2333	250	1,071	44
12	0.4	0.2917	248	850	35
12	0.3	0.3889	246	633	26
10	2.5	0.0560	250	4,464	181
10	2.0	0.0700	240	3,429	145
10	1.8	0.0778	236	3,034	131
10	1.5	0.0933	230	2,464	109
10	1.2	0.1167	224	1,920	87
10	1.0	0.1400	220	1,571	73
10	0.7	0.2000	214	1,070	51
10	0.5	0.2800	210	750	36
10	0.4	0.3500	208	594	29
10	0.3	0.4667	206	441	22
8	2.0	0.0875	200	2,286	116
8	1.8	0.0972	196	2,016	104
8	1.5	0.1167	190	1,629	87
8	1.2	0.1458	184	1,262	70
8	1.0	0.1750	180	1,029	58
8	0.7	0.2500	174	696	41
8	0.5	0.3500	170	486	29
8	0.4	0.4375	168	384	23
8	0.3	0.5833	166	285	17
7	1.5	0.1333	170	1,275	76
7	1.2	0.1667	164	984	61
7	1.0	0.2000	160	800	51
7	0.7	0.2857	154	539	36
7	0.5	0.4000	150	375	25
7	0.4	0.5000	148	296	20
7	0.3	0.6667	146	219	15
6	1.5	0.1556	150	964	65

KANTHAL® APMT, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η CM^2/Ω 20°	WEIGHT G/M
6	1.2	0.1944	144	741	52
6	1.0	0.2333	140	600	44
6	0.7	0.3333	134	402	30
6	0.5	0.4667	130	279	22
6	0.4	0.5833	128	219	17
6	0.3	0.7778	126	162	13
5	1.2	0.2333	124	531	44
5	1.0	0.2800	120	429	36
5	0.7	0.4000	114	285	25
5	0.5	0.5600	110	196	18
5	0.4	0.7000	108	154	15
5	0.3	0.9333	106	114	11

KANTHAL® D, WIRE

WIRE DIMENSIONS AND PROPERTIES

Resistivity: 1.35 Ω* mm^2/m

Density: 7.25 g/cm^3

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	0.99	1.00	1.01	1.02	1.02	1.03	1.04	1.05	1.06	1.06	1.07	1.07	1.08	1.08	1.08

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
10.00	0.0172	18,277.05	569.414	314	78.540
9.90	0.0175	17,734.20	558.082	311	76.977
9.80	0.0179	17,202.21	546.865	308	75.430
9.70	0.0183	16,680.97	535.761	305	73.898
9.60	0.0187	16,170.36	524.772	302	72.382
9.50	0.0190	15,670.28	513.896	298	70.882
9.40	0.0195	15,180.62	503.134	295	69.398
9.30	0.0199	14,701.27	492.486	292	67.929
9.20	0.0203	14,232.12	481.952	289	66.476
9.10	0.0208	13,773.05	471.531	286	65.039
9.00	0.0212	13,323.97	461.225	283	63.617
8.90	0.0217	12,884.75	451.033	280	62.211
8.80	0.0222	12,455.29	440.954	276	60.821
8.70	0.0227	12,035.49	430.989	273	59.447
8.60	0.0232	11,625.22	421.138	270	58.088
8.50	0.0238	11,224.39	411.401	267	56.745
8.40	0.0244	10,832.88	401.778	264	55.418
8.30	0.0250	10,450.58	392.269	261	54.106
8.20	0.0256	10,077.38	382.874	258	52.810
8.10	0.0262	9,713.17	373.592	254	51.530
8.00	0.0269	9,357.85	364.425	251	50.265
7.90	0.0275	9,011.30	355.371	248	49.017
7.80	0.0283	8,673.41	346.431	245	47.784
7.70	0.0290	8,344.07	337.605	242	46.566
7.60	0.0298	8,023.18	328.893	239	45.365
7.50	0.0306	7,710.63	320.295	236	44.179
7.40	0.0314	7,406.30	311.811	232	43.008
7.30	0.0323	7,110.08	303.441	229	41.854
7.20	0.0332	6,821.87	295.184	226	40.715
7.10	0.0341	6,541.56	287.041	223	39.592
7.00	0.0351	6,269.03	279.013	220	38.485
6.90	0.0361	6,004.17	271.098	217	37.393
6.80	0.0372	5,746.89	263.297	214	36.317
6.70	0.0383	5,497.06	255.610	210	35.257
6.60	0.0395	5,254.58	248.037	207	34.212
6.50	0.0407	5,019.33	240.577	204	33.183
6.40	0.0420	4,791.22	233.232	201	32.170
6.30	0.0433	4,570.12	226.000	198	31.172
6.20	0.0447	4,355.93	218.883	195	30.191
6.10	0.0462	4,148.54	211.879	192	29.225
6.00	0.0477	3,947.84	204.989	188	28.274
5.90	0.0494	3,753.72	198.213	185	27.340

KANTHAL® D, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
5.80	0.0511	3,566.07	191.551	182	26.421
5.70	0.0529	3,384.78	185.003	179	25.518
5.60	0.0548	3,209.74	178.568	176	24.630
5.50	0.0568	3,040.84	172.248	173	23.758
5.40	0.0589	2,877.98	166.041	170	22.902
5.30	0.0612	2,721.03	159.948	167	22.062
5.20	0.0636	2,569.90	153.969	163	21.237
5.10	0.0661	2,424.47	148.104	160	20.428
5.00	0.0688	2,284.63	142.353	157	19.635
4.90	0.0716	2,150.28	136.716	154	18.857
4.80	0.0746	2,021.29	131.193	151	18.096
4.70	0.0778	1,897.58	125.783	148	17.349
4.60	0.0812	1,779.01	120.488	145	16.619
4.50	0.0849	1,665.50	115.306	141	15.904
4.40	0.0888	1,556.91	110.238	138	15.205
4.30	0.0930	1,453.15	105.285	135	14.522
4.20	0.0974	1,354.11	100.445	132	13.854
4.10	0.1023	1,259.67	95.718	129	13.203
4.00	0.1074	1,169.73	91.106	126	12.566
3.90	0.1130	1,084.18	86.608	123	11.946
3.80	0.1190	1,002.90	82.223	119	11.341
3.70	0.1256	925.79	77.953	116	10.752
3.60	0.1326	852.73	73.796	113	10.179
3.50	0.1403	783.63	69.753	110	9.621
3.40	0.1487	718.36	65.824	107	9.079
3.30	0.1578	656.82	62.009	104	8.553
3.20	0.1679	598.90	58.308	101	8.042
3.10	0.1789	544.49	54.721	97	7.548
3.00	0.1910	493.48	51.247	94	7.069
2.90	0.2044	445.76	47.888	91	6.605
2.80	0.2192	401.22	44.642	88	6.158
2.70	0.2358	359.75	41.510	85	5.726
2.60	0.2543	321.24	38.492	82	5.309
2.50	0.2750	285.58	35.588	79	4.909
2.40	0.2984	252.66	32.798	75	4.524
2.30	0.3249	222.38	30.122	72	4.155
2.20	0.3551	194.61	27.560	69	3.801
2.10	0.3898	169.26	25.111	66	3.464
2.00	0.4297	146.22	22.777	63	3.142
1.90	0.4761	125.36	20.556	60	2.835
1.80	0.5305	106.59	18.449	57	2.545
1.70	0.5948	89.80	16.456	53	2.270

KANTHAL® D, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
1.60	0.6714	74.86	14.577	50	2.011
1.50	0.7639	61.69	12.812	47	1.767
1.40	0.8770	50.15	11.161	44	1.539
1.30	1.0171	40.15	9.623	41	1.327
1.20	1.1937	31.58	8.200	38	1.131
1.10	1.4206	24.33	6.890	35	0.950
1.00	1.7189	18.28	5.694	31	0.785
0.90	2.1221	13.32	4.612	28	0.636
0.80	2.6857	9.36	3.644	25	0.503
0.70	3.5079	6.27	2.790	22	0.385
0.60	4.7746	3.95	2.050	19	0.283
0.50	6.8755	2.28	1.424	16	0.196
0.40	10.7430	1.17	0.911	13	0.126
0.30	19.0986	0.49	0.512	9	0.071
0.20	42.9718	0.15	0.228	6	0.031
0.10	171.8873	0.02	0.057	3	0.008

KANTHAL® D, STRIP

STRIP DIMENSIONS AND PROPERTIES

Resistivity: 1.35 Ω* mm²/m

Density: 7.25 g/cm³

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	0.99	1.00	1.01	1.02	1.02	1.03	1.04	1.05	1.06	1.06	1.07	1.07	1.08	1.08	1.08

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
50	3.0	0.0090	1,060	117,778	1,088
50	2.5	0.0108	1,050	97,222	906
50	2.0	0.0135	1,040	77,037	725
50	1.8	0.0150	1,036	69,067	653
50	1.5	0.0180	1,030	57,222	544
50	1.2	0.0225	1,024	45,511	435
50	1.0	0.0270	1,020	37,778	363
50	0.7	0.0386	1,014	26,289	254
50	0.5	0.0540	1,010	18,704	181
50	0.4	0.0675	1,008	14,933	145
50	0.3	0.0900	1,006	11,178	109
40	3.0	0.0113	860	76,444	870
40	2.5	0.0135	850	62,963	725
40	2.0	0.0169	840	49,778	580
40	1.8	0.0188	836	44,587	522
40	1.5	0.0225	830	36,889	435
40	1.2	0.0281	824	29,298	348
40	1.0	0.0338	820	24,296	290
40	0.7	0.0482	814	16,883	203
40	0.5	0.0675	810	12,000	145
40	0.4	0.0844	808	9,576	116
40	0.3	0.1125	806	7,164	87
35	3.0	0.0129	760	59,111	761
35	2.5	0.0154	750	48,611	634
35	2.0	0.0193	740	38,370	508
35	1.8	0.0214	736	34,347	457
35	1.5	0.0257	730	28,389	381
35	1.2	0.0321	724	22,524	305
35	1.0	0.0386	720	18,667	254
35	0.7	0.0551	714	12,958	178
35	0.5	0.0771	710	9,204	127
35	0.4	0.0964	708	7,342	102
35	0.3	0.1286	706	5,491	76
30	3.0	0.0150	660	44,000	653
30	2.5	0.0180	650	36,111	544
30	2.0	0.0225	640	28,444	435
30	1.8	0.0250	636	25,440	392
30	1.5	0.0300	630	21,000	326
30	1.2	0.0375	624	16,640	261
30	1.0	0.0450	620	13,778	218
30	0.7	0.0643	614	9,551	152
30	0.5	0.0900	610	6,778	109

KANTHAL® D, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η $CM^2/Ω$ 20°	WEIGHT G/M
30	0.4	0.1125	608	5,404	87
30	0.3	0.1500	606	4,040	65
25	3.0	0.0180	560	31,111	544
25	2.5	0.0216	550	25,463	453
25	2.0	0.0270	540	20,000	363
25	1.8	0.0300	536	17,867	326
25	1.5	0.0360	530	14,722	272
25	1.2	0.0450	524	11,644	218
25	1.0	0.0540	520	9,630	181
25	0.7	0.0771	514	6,663	127
25	0.5	0.1080	510	4,722	91
25	0.4	0.1350	508	3,763	73
25	0.3	0.1800	506	2,811	54
20	3.0	0.0225	460	20,444	435
20	2.5	0.0270	450	16,667	363
20	2.0	0.0338	440	13,037	290
20	1.8	0.0375	436	11,627	261
20	1.5	0.0450	430	9,556	218
20	1.2	0.0563	424	7,538	174
20	1.0	0.0675	420	6,222	145
20	0.7	0.0964	414	4,293	102
20	0.5	0.1350	410	3,037	73
20	0.4	0.1688	408	2,418	58
20	0.3	0.2250	406	1,804	44
18	3.0	0.0250	420	16,800	392
18	2.5	0.0300	410	13,667	326
18	2.0	0.0375	400	10,667	261
18	1.8	0.0417	396	9,504	235
18	1.5	0.0500	390	7,800	196
18	1.2	0.0625	384	6,144	157
18	1.0	0.0750	380	5,067	131
18	0.7	0.1071	374	3,491	91
18	0.5	0.1500	370	2,467	65
18	0.4	0.1875	368	1,963	52
18	0.3	0.2500	366	1,464	39
15	3.0	0.0300	360	12,000	326
15	2.5	0.0360	350	9,722	272
15	2.0	0.0450	340	7,556	218
15	1.8	0.0500	336	6,720	196
15	1.5	0.0600	330	5,500	163
15	1.2	0.0750	324	4,320	131
15	1.0	0.0900	320	3,556	109

KANTHAL® D, STRIP

(cont.)

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
15	0.7	0.1286	314	2,442	76
15	0.5	0.1800	310	1,722	54
15	0.4	0.2250	308	1,369	44
15	0.3	0.3000	306	1,020	33
12	3.0	0.0375	300	8,000	261
12	2.5	0.0450	290	6,444	218
12	2.0	0.0563	280	4,978	174
12	1.8	0.0625	276	4,416	157
12	1.5	0.0750	270	3,600	131
12	1.2	0.0938	264	2,816	104
12	1.0	0.1125	260	2,311	87
12	0.7	0.1607	254	1,580	61
12	0.5	0.2250	250	1,111	44
12	0.4	0.2813	248	882	35
12	0.3	0.3750	246	656	26
10	2.5	0.0540	250	4,630	181
10	2.0	0.0675	240	3,556	145
10	1.8	0.0750	236	3,147	131
10	1.5	0.0900	230	2,556	109
10	1.2	0.1125	224	1,991	87
10	1.0	0.1350	220	1,630	73
10	0.7	0.1929	214	1,110	51
10	0.5	0.2700	210	778	36
10	0.4	0.3375	208	616	29
10	0.3	0.4500	206	458	22
8	2.0	0.0844	200	2,370	116
8	1.8	0.0938	196	2,091	104
8	1.5	0.1125	190	1,689	87
8	1.2	0.1406	184	1,308	70
8	1.0	0.1688	180	1,067	58
8	0.7	0.2411	174	722	41
8	0.5	0.3375	170	504	29
8	0.4	0.4219	168	398	23
8	0.3	0.5625	166	295	17
7	1.5	0.1286	170	1,322	76
7	1.2	0.1607	164	1,020	61
7	1.0	0.1929	160	830	51
7	0.7	0.2755	154	559	36
7	0.5	0.3857	150	389	25
7	0.4	0.4821	148	307	20
7	0.3	0.6429	146	227	15
6	1.5	0.1500	150	1,000	65

KANTHAL® D, STRIP

(cont.)

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
6	1.2	0.1875	144	768	52
6	1.0	0.2250	140	622	44
6	0.7	0.3214	134	417	30
6	0.5	0.4500	130	289	22
6	0.4	0.5625	128	228	17
6	0.3	0.7500	126	168	13
5	1.2	0.2250	124	551	44
5	1.0	0.2700	120	444	36
5	0.7	0.3857	114	296	25
5	0.5	0.5400	110	204	18
5	0.4	0.6750	108	160	15
5	0.3	0.9000	106	118	11

NIKROTHAL® 80, WIRE

WIRE DIMENSIONS AND PROPERTIES

Resistivity: 1.09 Ω* mm^2/m

Density: 8.30 g/cm^3

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	1.00	1.01	1.02	1.03	1.04	1.05	1.04	1.04	1.04	1.04	1.05	1.06	1.07	1.09	1.10

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
10.00	0.0139	22,636.71	651.880	314	78.540
9.90	0.0142	21,964.37	638.908	311	76.977
9.80	0.0145	21,305.49	626.066	308	75.430
9.70	0.0148	20,659.91	613.354	305	73.898
9.60	0.0151	20,027.51	600.773	302	72.382
9.50	0.0154	19,408.15	588.322	298	70.882
9.40	0.0157	18,801.69	576.002	295	69.398
9.30	0.0160	18,207.99	563.811	292	67.929
9.20	0.0164	17,626.93	551.752	289	66.476
9.10	0.0168	17,058.37	539.822	286	65.039
9.00	0.0171	16,502.16	528.023	283	63.617
8.90	0.0175	15,958.18	516.355	280	62.211
8.80	0.0179	15,426.28	504.816	276	60.821
8.70	0.0183	14,906.34	493.408	273	59.447
8.60	0.0188	14,398.21	482.131	270	58.088
8.50	0.0192	13,901.77	470.984	267	56.745
8.40	0.0197	13,416.87	459.967	264	55.418
8.30	0.0201	12,943.37	449.080	261	54.106
8.20	0.0206	12,481.16	438.324	258	52.810
8.10	0.0212	12,030.07	427.699	254	51.530
8.00	0.0217	11,589.99	417.204	251	50.265
7.90	0.0222	11,160.78	406.839	248	49.017
7.80	0.0228	10,742.29	396.604	245	47.784
7.70	0.0234	10,334.40	386.500	242	46.566
7.60	0.0240	9,936.97	376.526	239	45.365
7.50	0.0247	9,549.86	366.683	236	44.179
7.40	0.0253	9,172.94	356.970	232	43.008
7.30	0.0260	8,806.06	347.387	229	41.854
7.20	0.0268	8,449.11	337.935	226	40.715
7.10	0.0275	8,101.93	328.613	223	39.592
7.00	0.0283	7,764.39	319.421	220	38.485
6.90	0.0291	7,436.36	310.360	217	37.393
6.80	0.0300	7,117.71	301.430	214	36.317
6.70	0.0309	6,808.28	292.629	210	35.257
6.60	0.0319	6,507.96	283.959	207	34.212
6.50	0.0328	6,216.61	275.420	204	33.183
6.40	0.0339	5,934.08	267.010	201	32.170
6.30	0.0350	5,660.24	258.731	198	31.172
6.20	0.0361	5,394.96	250.583	195	30.191
6.10	0.0373	5,138.10	242.565	192	29.225
6.00	0.0386	4,889.53	234.677	188	28.274
5.90	0.0399	4,649.10	226.920	185	27.340

NIKROTHAL® 80, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
5.80	0.0413	4,416.69	219.293	182	26.421
5.70	0.0427	4,192.16	211.796	179	25.518
5.60	0.0443	3,975.37	204.430	176	24.630
5.50	0.0459	3,766.18	197.194	173	23.758
5.40	0.0476	3,564.47	190.088	170	22.902
5.30	0.0494	3,370.09	183.113	167	22.062
5.20	0.0513	3,182.90	176.268	163	21.237
5.10	0.0534	3,002.78	169.554	160	20.428
5.00	0.0555	2,829.59	162.970	157	19.635
4.90	0.0578	2,663.19	156.517	154	18.857
4.80	0.0602	2,503.44	150.193	151	18.096
4.70	0.0628	2,350.21	144.000	148	17.349
4.60	0.0656	2,203.37	137.938	145	16.619
4.50	0.0685	2,062.77	132.006	141	15.904
4.40	0.0717	1,928.29	126.204	138	15.205
4.30	0.0751	1,799.78	120.533	135	14.522
4.20	0.0787	1,677.11	114.992	132	13.854
4.10	0.0826	1,560.14	109.581	129	13.203
4.00	0.0867	1,448.75	104.301	126	12.566
3.90	0.0912	1,342.79	99.151	123	11.946
3.80	0.0961	1,242.12	94.132	119	11.341
3.70	0.1014	1,146.62	89.242	116	10.752
3.60	0.1071	1,056.14	84.484	113	10.179
3.50	0.1133	970.55	79.855	110	9.621
3.40	0.1201	889.71	75.357	107	9.079
3.30	0.1274	813.50	70.990	104	8.553
3.20	0.1355	741.76	66.753	101	8.042
3.10	0.1444	674.37	62.646	97	7.548
3.00	0.1542	611.19	58.669	94	7.069
2.90	0.1650	552.09	54.823	91	6.605
2.80	0.1770	496.92	51.107	88	6.158
2.70	0.1904	445.56	47.522	85	5.726
2.60	0.2053	397.86	44.067	82	5.309
2.50	0.2221	353.70	40.743	79	4.909
2.40	0.2409	312.93	37.548	75	4.524
2.30	0.2623	275.42	34.484	72	4.155
2.20	0.2867	241.04	31.551	69	3.801
2.10	0.3147	209.64	28.748	66	3.464
2.00	0.3470	181.09	26.075	63	3.142
1.90	0.3844	155.27	23.533	60	2.835
1.80	0.4283	132.02	21.121	57	2.545
1.70	0.4802	111.21	18.839	53	2.270

NIKROTHAL® 80, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
1.60	0.5421	92.72	16.688	50	2.011
1.50	0.6168	76.40	14.667	47	1.767
1.40	0.7081	62.12	12.777	44	1.539
1.30	0.8212	49.73	11.017	41	1.327
1.20	0.9638	39.12	9.387	38	1.131
1.10	1.1470	30.13	7.888	35	0.950
1.00	1.3878	22.64	6.519	31	0.785
0.90	1.7134	16.50	5.280	28	0.636
0.80	2.1685	11.59	4.172	25	0.503
0.70	2.8323	7.76	3.194	22	0.385
0.60	3.8551	4.89	2.347	19	0.283
0.50	5.5513	2.83	1.630	16	0.196
0.40	8.6739	1.45	1.043	13	0.126
0.30	15.4203	0.61	0.587	9	0.071
0.20	34.6958	0.18	0.261	6	0.031
0.10	138.7831	0.02	0.065	3	0.008

NIKROTHAL® 80, STRIP

STRIP DIMENSIONS AND PROPERTIES

Resistivity: 1.09 Ω* mm^2/m

Density: 8.30 g/cm^3

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	1.00	1.01	1.02	1.03	1.04	1.05	1.04	1.04	1.04	1.04	1.05	1.06	1.07	1.09	1.10

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
50	3.0	0.0073	1,060	145,872	1,245
50	2.5	0.0087	1,050	120,413	1,038
50	2.0	0.0109	1,040	95,413	830
50	1.8	0.0121	1,036	85,541	747
50	1.5	0.0145	1,030	70,872	623
50	1.2	0.0182	1,024	56,367	498
50	1.0	0.0218	1,020	46,789	415
50	0.7	0.0311	1,014	32,560	291
50	0.5	0.0436	1,010	23,165	208
50	0.4	0.0545	1,008	18,495	166
50	0.3	0.0727	1,006	13,844	125
40	3.0	0.0091	860	94,679	996
40	2.5	0.0109	850	77,982	830
40	2.0	0.0136	840	61,651	664
40	1.8	0.0151	836	55,222	598
40	1.5	0.0182	830	45,688	498
40	1.2	0.0227	824	36,286	398
40	1.0	0.0273	820	30,092	332
40	0.7	0.0389	814	20,910	232
40	0.5	0.0545	810	14,862	166
40	0.4	0.0681	808	11,861	133
40	0.3	0.0908	806	8,873	100
35	3.0	0.0104	760	73,211	872
35	2.5	0.0125	750	60,206	726
35	2.0	0.0156	740	47,523	581
35	1.8	0.0173	736	42,539	523
35	1.5	0.0208	730	35,161	436
35	1.2	0.0260	724	27,897	349
35	1.0	0.0311	720	23,119	291
35	0.7	0.0445	714	16,049	203
35	0.5	0.0623	710	11,399	145
35	0.4	0.0779	708	9,094	116
35	0.3	0.1038	706	6,801	87
30	3.0	0.0121	660	54,495	747
30	2.5	0.0145	650	44,725	623
30	2.0	0.0182	640	35,229	498
30	1.8	0.0202	636	31,508	448
30	1.5	0.0242	630	26,009	374
30	1.2	0.0303	624	20,609	299
30	1.0	0.0363	620	17,064	249
30	0.7	0.0519	614	11,829	174
30	0.5	0.0727	610	8,394	125

NIKROTHAL® 80, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
30	0.4	0.0908	608	6,694	100
30	0.3	0.1211	606	5,004	75
25	3.0	0.0145	560	38,532	623
25	2.5	0.0174	550	31,537	519
25	2.0	0.0218	540	24,771	415
25	1.8	0.0242	536	22,128	374
25	1.5	0.0291	530	18,234	311
25	1.2	0.0363	524	14,422	249
25	1.0	0.0436	520	11,927	208
25	0.7	0.0623	514	8,252	145
25	0.5	0.0872	510	5,849	104
25	0.4	0.1090	508	4,661	83
25	0.3	0.1453	506	3,482	62
20	3.0	0.0182	460	25,321	498
20	2.5	0.0218	450	20,642	415
20	2.0	0.0273	440	16,147	332
20	1.8	0.0303	436	14,400	299
20	1.5	0.0363	430	11,835	249
20	1.2	0.0454	424	9,336	199
20	1.0	0.0545	420	7,706	166
20	0.7	0.0779	414	5,317	116
20	0.5	0.1090	410	3,761	83
20	0.4	0.1363	408	2,994	66
20	0.3	0.1817	406	2,235	50
18	3.0	0.0202	420	20,807	448
18	2.5	0.0242	410	16,927	374
18	2.0	0.0303	400	13,211	299
18	1.8	0.0336	396	11,771	269
18	1.5	0.0404	390	9,661	224
18	1.2	0.0505	384	7,610	179
18	1.0	0.0606	380	6,275	149
18	0.7	0.0865	374	4,323	105
18	0.5	0.1211	370	3,055	75
18	0.4	0.1514	368	2,431	60
18	0.3	0.2019	366	1,813	45
15	3.0	0.0242	360	14,862	374
15	2.5	0.0291	350	12,041	311
15	2.0	0.0363	340	9,358	249
15	1.8	0.0404	336	8,323	224
15	1.5	0.0484	330	6,812	187
15	1.2	0.0606	324	5,350	149
15	1.0	0.0727	320	4,404	125

NIKROTHAL® 80, STRIP

(cont.)

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
15	0.7	0.1038	314	3,025	87
15	0.5	0.1453	310	2,133	62
15	0.4	0.1817	308	1,695	50
15	0.3	0.2422	306	1,263	37
12	3.0	0.0303	300	9,908	299
12	2.5	0.0363	290	7,982	249
12	2.0	0.0454	280	6,165	199
12	1.8	0.0505	276	5,469	179
12	1.5	0.0606	270	4,459	149
12	1.2	0.0757	264	3,488	120
12	1.0	0.0908	260	2,862	100
12	0.7	0.1298	254	1,957	70
12	0.5	0.1817	250	1,376	50
12	0.4	0.2271	248	1,092	40
12	0.3	0.3028	246	812	30
10	2.5	0.0436	250	5,734	208
10	2.0	0.0545	240	4,404	166
10	1.8	0.0606	236	3,897	149
10	1.5	0.0727	230	3,165	125
10	1.2	0.0908	224	2,466	100
10	1.0	0.1090	220	2,018	83
10	0.7	0.1557	214	1,374	58
10	0.5	0.2180	210	963	42
10	0.4	0.2725	208	763	33
10	0.3	0.3633	206	567	25
8	2.0	0.0681	200	2,936	133
8	1.8	0.0757	196	2,589	120
8	1.5	0.0908	190	2,092	100
8	1.2	0.1135	184	1,621	80
8	1.0	0.1363	180	1,321	66
8	0.7	0.1946	174	894	46
8	0.5	0.2725	170	624	33
8	0.4	0.3406	168	493	27
8	0.3	0.4542	166	366	20
7	1.5	0.1038	170	1,638	87
7	1.2	0.1298	164	1,264	70
7	1.0	0.1557	160	1,028	58
7	0.7	0.2224	154	692	41
7	0.5	0.3114	150	482	29
7	0.4	0.3893	148	380	23
7	0.3	0.5190	146	281	17
6	1.5	0.1211	150	1,239	75

NIKROTHAL® 80, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η $CM^2/Ω$ 20°	WEIGHT G/M
6	1.2	0.1514	144	951	60
6	1.0	0.1817	140	771	50
6	0.7	0.2595	134	516	35
6	0.5	0.3633	130	358	25
6	0.4	0.4542	128	282	20
6	0.3	0.6056	126	208	15
5	1.2	0.1817	124	683	50
5	1.0	0.2180	120	550	42
5	0.7	0.3114	114	366	29
5	0.5	0.4360	110	252	21
5	0.4	0.5450	108	198	17
5	0.3	0.7267	106	146	12

NIKROTHAL® 70, WIRE

WIRE DIMENSIONS AND PROPERTIES

Resistivity: 1.18 Ω* mm²/m

Density: 8.10 g/cm³

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	1.05	1.06	1.07	1.08	1.09	1.05	1.05	1.05	1.04	1.05	1.05	1.06	1.06	1.07	1.07

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
10.00	0.0150	20,910.18	636.173	314	78.540
9.90	0.0153	20,289.13	623.513	311	76.977
9.80	0.0156	19,680.49	610.980	308	75.430
9.70	0.0160	19,084.16	598.575	305	73.898
9.60	0.0163	18,499.99	586.297	302	72.382
9.50	0.0166	17,927.86	574.146	298	70.882
9.40	0.0170	17,367.66	562.122	295	69.398
9.30	0.0174	16,819.25	550.226	292	67.929
9.20	0.0178	16,282.51	538.456	289	66.476
9.10	0.0181	15,757.30	526.814	286	65.039
9.00	0.0185	15,243.52	515.300	283	63.617
8.90	0.0190	14,741.03	503.912	280	62.211
8.80	0.0194	14,249.70	492.652	276	60.821
8.70	0.0198	13,769.42	481.519	273	59.447
8.60	0.0203	13,300.04	470.513	270	58.088
8.50	0.0208	12,841.46	459.635	267	56.745
8.40	0.0213	12,393.55	448.883	264	55.418
8.30	0.0218	11,956.17	438.259	261	54.106
8.20	0.0223	11,529.20	427.762	258	52.810
8.10	0.0229	11,112.53	417.393	254	51.530
8.00	0.0235	10,706.01	407.150	251	50.265
7.90	0.0241	10,309.53	397.035	248	49.017
7.80	0.0247	9,922.97	387.047	245	47.784
7.70	0.0253	9,546.19	377.187	242	46.566
7.60	0.0260	9,179.07	367.453	239	45.365
7.50	0.0267	8,821.48	357.847	236	44.179
7.40	0.0274	8,473.31	348.368	232	43.008
7.30	0.0282	8,134.42	339.016	229	41.854
7.20	0.0290	7,804.68	329.792	226	40.715
7.10	0.0298	7,483.98	320.695	223	39.592
7.00	0.0307	7,172.19	311.725	220	38.485
6.90	0.0316	6,869.18	302.882	217	37.393
6.80	0.0325	6,574.83	294.166	214	36.317
6.70	0.0335	6,289.01	285.578	210	35.257
6.60	0.0345	6,011.59	277.117	207	34.212
6.50	0.0356	5,742.46	268.783	204	33.183
6.40	0.0367	5,481.48	260.576	201	32.170
6.30	0.0379	5,228.53	252.497	198	31.172
6.20	0.0391	4,983.48	244.545	195	30.191
6.10	0.0404	4,746.21	236.720	192	29.225
6.00	0.0417	4,516.60	229.022	188	28.274
5.90	0.0432	4,294.51	221.452	185	27.340

NIKROTHAL® 70, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
5.80	0.0447	4,079.83	214.008	182	26.421
5.70	0.0462	3,872.42	206.692	179	25.518
5.60	0.0479	3,672.16	199.504	176	24.630
5.50	0.0497	3,478.93	192.442	173	23.758
5.40	0.0515	3,292.60	185.508	170	22.902
5.30	0.0535	3,113.04	178.701	167	22.062
5.20	0.0556	2,940.14	172.021	163	21.237
5.10	0.0578	2,773.76	165.468	160	20.428
5.00	0.0601	2,613.77	159.043	157	19.635
4.90	0.0626	2,460.06	152.745	154	18.857
4.80	0.0652	2,312.50	146.574	151	18.096
4.70	0.0680	2,170.96	140.531	148	17.349
4.60	0.0710	2,035.31	134.614	145	16.619
4.50	0.0742	1,905.44	128.825	141	15.904
4.40	0.0776	1,781.21	123.163	138	15.205
4.30	0.0813	1,662.51	117.628	135	14.522
4.20	0.0852	1,549.19	112.221	132	13.854
4.10	0.0894	1,441.15	106.941	129	13.203
4.00	0.0939	1,338.25	101.788	126	12.566
3.90	0.0988	1,240.37	96.762	123	11.946
3.80	0.1040	1,147.38	91.863	119	11.341
3.70	0.1097	1,059.16	87.092	116	10.752
3.60	0.1159	975.59	82.448	113	10.179
3.50	0.1226	896.52	77.931	110	9.621
3.40	0.1300	821.85	73.542	107	9.079
3.30	0.1380	751.45	69.279	104	8.553
3.20	0.1467	685.18	65.144	101	8.042
3.10	0.1563	622.94	61.136	97	7.548
3.00	0.1669	564.57	57.256	94	7.069
2.90	0.1786	509.98	53.502	91	6.605
2.80	0.1916	459.02	49.876	88	6.158
2.70	0.2061	411.58	46.377	85	5.726
2.60	0.2223	367.52	43.005	82	5.309
2.50	0.2404	326.72	39.761	79	4.909
2.40	0.2608	289.06	36.644	75	4.524
2.30	0.2840	254.41	33.654	72	4.155
2.20	0.3104	222.65	30.791	69	3.801
2.10	0.3407	193.65	28.055	66	3.464
2.00	0.3756	167.28	25.447	63	3.142
1.90	0.4162	143.42	22.966	60	2.835
1.80	0.4637	121.95	20.612	57	2.545
1.70	0.5199	102.73	18.385	53	2.270

NIKROTHAL® 70, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM^2/Ω	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
1.60	0.5869	85.65	16.286	50	2.011
1.50	0.6677	70.57	14.314	47	1.767
1.40	0.7665	57.38	12.469	44	1.539
1.30	0.8890	45.94	10.751	41	1.327
1.20	1.0433	36.13	9.161	38	1.131
1.10	1.2417	27.83	7.698	35	0.950
1.00	1.5024	20.91	6.362	31	0.785
0.90	1.8548	15.24	5.153	28	0.636
0.80	2.3475	10.71	4.072	25	0.503
0.70	3.0662	7.17	3.117	22	0.385
0.60	4.1734	4.52	2.290	19	0.283
0.50	6.0097	2.61	1.590	16	0.196
0.40	9.3901	1.34	1.018	13	0.126
0.30	16.6936	0.56	0.573	9	0.071
0.20	37.5606	0.17	0.254	6	0.031
0.10	150.2423	0.02	0.064	3	0.008

NIKROTHAL® 70, STRIP

STRIP DIMENSIONS AND PROPERTIES

Resistivity: 1.18 Ω* mm^2/m

Density: 8.10 g/cm^3

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	1.05	1.06	1.07	1.08	1.09	1.05	1.05	1.05	1.04	1.05	1.05	1.06	1.06	1.07	1.07

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
50	3.0	0.0079	1,060	134,746	1,215
50	2.5	0.0094	1,050	111,229	1,013
50	2.0	0.0118	1,040	88,136	810
50	1.8	0.0131	1,036	79,017	729
50	1.5	0.0157	1,030	65,466	608
50	1.2	0.0197	1,024	52,068	486
50	1.0	0.0236	1,020	43,220	405
50	0.7	0.0337	1,014	30,076	284
50	0.5	0.0472	1,010	21,398	203
50	0.4	0.0590	1,008	17,085	162
50	0.3	0.0787	1,006	12,788	122
40	3.0	0.0098	860	87,458	972
40	2.5	0.0118	850	72,034	810
40	2.0	0.0148	840	56,949	648
40	1.8	0.0164	836	51,010	583
40	1.5	0.0197	830	42,203	486
40	1.2	0.0246	824	33,519	389
40	1.0	0.0295	820	27,797	324
40	0.7	0.0421	814	19,315	227
40	0.5	0.0590	810	13,729	162
40	0.4	0.0738	808	10,956	130
40	0.3	0.0983	806	8,197	97
35	3.0	0.0112	760	67,627	851
35	2.5	0.0135	750	55,614	709
35	2.0	0.0169	740	43,898	567
35	1.8	0.0187	736	39,295	510
35	1.5	0.0225	730	32,479	425
35	1.2	0.0281	724	25,769	340
35	1.0	0.0337	720	21,356	284
35	0.7	0.0482	714	14,825	198
35	0.5	0.0674	710	10,530	142
35	0.4	0.0843	708	8,400	113
35	0.3	0.1124	706	6,282	85
30	3.0	0.0131	660	50,339	729
30	2.5	0.0157	650	41,314	608
30	2.0	0.0197	640	32,542	486
30	1.8	0.0219	636	29,105	437
30	1.5	0.0262	630	24,025	365
30	1.2	0.0328	624	19,037	292
30	1.0	0.0393	620	15,763	243
30	0.7	0.0562	614	10,927	170
30	0.5	0.0787	610	7,754	122

NIKROTHAL® 70, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
30	0.4	0.0983	608	6,183	97
30	0.3	0.1311	606	4,622	73
25	3.0	0.0157	560	35,593	608
25	2.5	0.0189	550	29,131	506
25	2.0	0.0236	540	22,881	405
25	1.8	0.0262	536	20,441	365
25	1.5	0.0315	530	16,843	304
25	1.2	0.0393	524	13,322	243
25	1.0	0.0472	520	11,017	203
25	0.7	0.0674	514	7,623	142
25	0.5	0.0944	510	5,403	101
25	0.4	0.1180	508	4,305	81
25	0.3	0.1573	506	3,216	61
20	3.0	0.0197	460	23,390	486
20	2.5	0.0236	450	19,068	405
20	2.0	0.0295	440	14,915	324
20	1.8	0.0328	436	13,302	292
20	1.5	0.0393	430	10,932	243
20	1.2	0.0492	424	8,624	194
20	1.0	0.0590	420	7,119	162
20	0.7	0.0843	414	4,912	113
20	0.5	0.1180	410	3,475	81
20	0.4	0.1475	408	2,766	65
20	0.3	0.1967	406	2,064	49
18	3.0	0.0219	420	19,220	437
18	2.5	0.0262	410	15,636	365
18	2.0	0.0328	400	12,203	292
18	1.8	0.0364	396	10,873	262
18	1.5	0.0437	390	8,924	219
18	1.2	0.0546	384	7,029	175
18	1.0	0.0656	380	5,797	146
18	0.7	0.0937	374	3,994	102
18	0.5	0.1311	370	2,822	73
18	0.4	0.1639	368	2,245	58
18	0.3	0.2185	366	1,675	44
15	3.0	0.0262	360	13,729	365
15	2.5	0.0315	350	11,123	304
15	2.0	0.0393	340	8,644	243
15	1.8	0.0437	336	7,688	219
15	1.5	0.0524	330	6,292	182
15	1.2	0.0656	324	4,942	146
15	1.0	0.0787	320	4,068	122

NIKROTHAL® 70, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η CM^2/Ω 20°	WEIGHT G/M
15	0.7	0.1124	314	2,794	85
15	0.5	0.1573	310	1,970	61
15	0.4	0.1967	308	1,566	49
15	0.3	0.2622	306	1,167	36
12	3.0	0.0328	300	9,153	292
12	2.5	0.0393	290	7,373	243
12	2.0	0.0492	280	5,695	194
12	1.8	0.0546	276	5,052	175
12	1.5	0.0656	270	4,119	146
12	1.2	0.0819	264	3,222	117
12	1.0	0.0983	260	2,644	97
12	0.7	0.1405	254	1,808	68
12	0.5	0.1967	250	1,271	49
12	0.4	0.2458	248	1,009	39
12	0.3	0.3278	246	751	29
10	2.5	0.0472	250	5,297	203
10	2.0	0.0590	240	4,068	162
10	1.8	0.0656	236	3,600	146
10	1.5	0.0787	230	2,924	122
10	1.2	0.0983	224	2,278	97
10	1.0	0.1180	220	1,864	81
10	0.7	0.1686	214	1,269	57
10	0.5	0.2360	210	890	41
10	0.4	0.2950	208	705	32
10	0.3	0.3933	206	524	24
8	2.0	0.0738	200	2,712	130
8	1.8	0.0819	196	2,392	117
8	1.5	0.0983	190	1,932	97
8	1.2	0.1229	184	1,497	78
8	1.0	0.1475	180	1,220	65
8	0.7	0.2107	174	826	45
8	0.5	0.2950	170	576	32
8	0.4	0.3688	168	456	26
8	0.3	0.4917	166	338	19
7	1.5	0.1124	170	1,513	85
7	1.2	0.1405	164	1,167	68
7	1.0	0.1686	160	949	57
7	0.7	0.2408	154	639	40
7	0.5	0.3371	150	445	28
7	0.4	0.4214	148	351	23
7	0.3	0.5619	146	260	17
6	1.5	0.1311	150	1,144	73

NIKROTHAL® 70, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η CM^2/Ω 20°	WEIGHT G/M
6	1.2	0.1639	144	879	58
6	1.0	0.1967	140	712	49
6	0.7	0.2810	134	477	34
6	0.5	0.3933	130	331	24
6	0.4	0.4917	128	260	19
6	0.3	0.6556	126	192	15
5	1.2	0.1967	124	631	49
5	1.0	0.2360	120	508	41
5	0.7	0.3371	114	338	28
5	0.5	0.4720	110	233	20
5	0.4	0.5900	108	183	16
5	0.3	0.7867	106	135	12

NIKROTHAL® 60, WIRE

WIRE DIMENSIONS AND PROPERTIES

Resistivity: 1.11 Ω* mm^2/m

Density: 8.20 g/cm^3

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	1.01	1.02	1.03	1.05	1.06	1.08	1.09	1.09	1.10	1.11	1.11	1.12	1.13	1.13	1.14

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
10.00	0.0141	22,228.84	644.026	314	78.540
9.90	0.0144	21,568.62	631.210	311	76.977
9.80	0.0147	20,921.61	618.523	308	75.430
9.70	0.0150	20,287.66	605.965	305	73.898
9.60	0.0153	19,666.65	593.535	302	72.382
9.50	0.0157	19,058.45	581.234	298	70.882
9.40	0.0160	18,462.92	569.062	295	69.398
9.30	0.0163	17,879.92	557.019	292	67.929
9.20	0.0167	17,309.33	545.104	289	66.476
9.10	0.0171	16,751.01	533.318	286	65.039
9.00	0.0174	16,204.82	521.661	283	63.617
8.90	0.0178	15,670.64	510.133	280	62.211
8.80	0.0183	15,148.33	498.734	276	60.821
8.70	0.0187	14,637.76	487.464	273	59.447
8.60	0.0191	14,138.79	476.322	270	58.088
8.50	0.0196	13,651.29	465.309	267	56.745
8.40	0.0200	13,175.12	454.425	264	55.418
8.30	0.0205	12,710.16	443.670	261	54.106
8.20	0.0210	12,256.27	433.043	258	52.810
8.10	0.0215	11,813.32	422.546	254	51.530
8.00	0.0221	11,381.17	412.177	251	50.265
7.90	0.0226	10,959.68	401.937	248	49.017
7.80	0.0232	10,548.74	391.826	245	47.784
7.70	0.0238	10,148.20	381.843	242	46.566
7.60	0.0245	9,757.93	371.990	239	45.365
7.50	0.0251	9,377.79	362.265	236	44.179
7.40	0.0258	9,007.66	352.669	232	43.008
7.30	0.0265	8,647.40	343.202	229	41.854
7.20	0.0273	8,296.87	333.863	226	40.715
7.10	0.0280	7,955.95	324.654	223	39.592
7.00	0.0288	7,624.49	315.573	220	38.485
6.90	0.0297	7,302.37	306.621	217	37.393
6.80	0.0306	6,989.46	297.798	214	36.317
6.70	0.0315	6,685.61	289.103	210	35.257
6.60	0.0324	6,390.70	280.538	207	34.212
6.50	0.0335	6,104.59	272.101	204	33.183
6.40	0.0345	5,827.16	263.793	201	32.170
6.30	0.0356	5,558.25	255.614	198	31.172
6.20	0.0368	5,297.75	247.564	195	30.191
6.10	0.0380	5,045.52	239.642	192	29.225
6.00	0.0393	4,801.43	231.850	188	28.274
5.90	0.0406	4,565.34	224.186	185	27.340

NIKROTHAL® 60, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM^2/Ω	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
5.80	0.0420	4,337.11	216.651	182	26.421
5.70	0.0435	4,116.63	209.244	179	25.518
5.60	0.0451	3,903.74	201.967	176	24.630
5.50	0.0467	3,698.32	194.818	173	23.758
5.40	0.0485	3,500.24	187.798	170	22.902
5.30	0.0503	3,309.36	180.907	167	22.062
5.20	0.0523	3,125.55	174.145	163	21.237
5.10	0.0543	2,948.68	167.511	160	20.428
5.00	0.0565	2,778.60	161.007	157	19.635
4.90	0.0589	2,615.20	154.631	154	18.857
4.80	0.0613	2,458.33	148.384	151	18.096
4.70	0.0640	2,307.86	142.265	148	17.349
4.60	0.0668	2,163.67	136.276	145	16.619
4.50	0.0698	2,025.60	130.415	141	15.904
4.40	0.0730	1,893.54	124.684	138	15.205
4.30	0.0764	1,767.35	119.080	135	14.522
4.20	0.0801	1,646.89	113.606	132	13.854
4.10	0.0841	1,532.03	108.261	129	13.203
4.00	0.0883	1,422.65	103.044	126	12.566
3.90	0.0929	1,318.59	97.956	123	11.946
3.80	0.0979	1,219.74	92.997	119	11.341
3.70	0.1032	1,125.96	88.167	116	10.752
3.60	0.1091	1,037.11	83.466	113	10.179
3.50	0.1154	953.06	78.893	110	9.621
3.40	0.1223	873.68	74.449	107	9.079
3.30	0.1298	798.84	70.134	104	8.553
3.20	0.1380	728.39	65.948	101	8.042
3.10	0.1471	662.22	61.891	97	7.548
3.00	0.1570	600.18	57.962	94	7.069
2.90	0.1680	542.14	54.163	91	6.605
2.80	0.1803	487.97	50.492	88	6.158
2.70	0.1939	437.53	46.950	85	5.726
2.60	0.2091	390.69	43.536	82	5.309
2.50	0.2261	347.33	40.252	79	4.909
2.40	0.2454	307.29	37.096	75	4.524
2.30	0.2672	270.46	34.069	72	4.155
2.20	0.2920	236.69	31.171	69	3.801
2.10	0.3205	205.86	28.402	66	3.464
2.00	0.3533	177.83	25.761	63	3.142
1.90	0.3915	152.47	23.249	60	2.835
1.80	0.4362	129.64	20.866	57	2.545
1.70	0.4890	109.21	18.612	53	2.270

NIKROTHAL® 60, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
1.60	0.5521	91.05	16.487	50	2.011
1.50	0.6281	75.02	14.491	47	1.767
1.40	0.7211	61.00	12.623	44	1.539
1.30	0.8363	48.84	10.884	41	1.327
1.20	0.9815	38.41	9.274	38	1.131
1.10	1.1680	29.59	7.793	35	0.950
1.00	1.4133	22.23	6.440	31	0.785
0.90	1.7448	16.20	5.217	28	0.636
0.80	2.2083	11.38	4.122	25	0.503
0.70	2.8843	7.62	3.156	22	0.385
0.60	3.9258	4.80	2.318	19	0.283
0.50	5.6532	2.78	1.610	16	0.196
0.40	8.8331	1.42	1.030	13	0.126
0.30	15.7033	0.60	0.580	9	0.071
0.20	35.3324	0.18	0.258	6	0.031
0.10	141.3296	0.02	0.064	3	0.008

NIKROTHAL® 60, STRIP

STRIP DIMENSIONS AND PROPERTIES

Resistivity: 1.11 Ω* mm^2/m

Density: 8.20 g/cm^3

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	1.01	1.02	1.03	1.05	1.06	1.08	1.09	1.09	1.10	1.11	1.11	1.12	1.13	1.13	1.14

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η $CM^2/Ω$ 20°	WEIGHT G/M
50	3.0	0.0074	1,060	143,243	1,230
50	2.5	0.0089	1,050	118,243	1,025
50	2.0	0.0111	1,040	93,694	820
50	1.8	0.0123	1,036	84,000	738
50	1.5	0.0148	1,030	69,595	615
50	1.2	0.0185	1,024	55,351	492
50	1.0	0.0222	1,020	45,946	410
50	0.7	0.0317	1,014	31,973	287
50	0.5	0.0444	1,010	22,748	205
50	0.4	0.0555	1,008	18,162	164
50	0.3	0.0740	1,006	13,595	123
40	3.0	0.0093	860	92,973	984
40	2.5	0.0111	850	76,577	820
40	2.0	0.0139	840	60,541	656
40	1.8	0.0154	836	54,227	590
40	1.5	0.0185	830	44,865	492
40	1.2	0.0231	824	35,632	394
40	1.0	0.0278	820	29,550	328
40	0.7	0.0396	814	20,533	230
40	0.5	0.0555	810	14,595	164
40	0.4	0.0694	808	11,647	131
40	0.3	0.0925	806	8,714	98
35	3.0	0.0106	760	71,892	861
35	2.5	0.0127	750	59,122	718
35	2.0	0.0159	740	46,667	574
35	1.8	0.0176	736	41,773	517
35	1.5	0.0211	730	34,527	431
35	1.2	0.0264	724	27,395	344
35	1.0	0.0317	720	22,703	287
35	0.7	0.0453	714	15,759	201
35	0.5	0.0634	710	11,194	144
35	0.4	0.0793	708	8,930	115
35	0.3	0.1057	706	6,678	86
30	3.0	0.0123	660	53,514	738
30	2.5	0.0148	650	43,919	615
30	2.0	0.0185	640	34,595	492
30	1.8	0.0206	636	30,941	443
30	1.5	0.0247	630	25,541	369
30	1.2	0.0308	624	20,238	295
30	1.0	0.0370	620	16,757	246
30	0.7	0.0529	614	11,616	172
30	0.5	0.0740	610	8,243	123

NIKROTHAL® 60, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
30	0.4	0.0925	608	6,573	98
30	0.3	0.1233	606	4,914	74
25	3.0	0.0148	560	37,838	615
25	2.5	0.0178	550	30,968	513
25	2.0	0.0222	540	24,324	410
25	1.8	0.0247	536	21,730	369
25	1.5	0.0296	530	17,905	308
25	1.2	0.0370	524	14,162	246
25	1.0	0.0444	520	11,712	205
25	0.7	0.0634	514	8,104	144
25	0.5	0.0888	510	5,743	103
25	0.4	0.1110	508	4,577	82
25	0.3	0.1480	506	3,419	62
20	3.0	0.0185	460	24,865	492
20	2.5	0.0222	450	20,270	410
20	2.0	0.0278	440	15,856	328
20	1.8	0.0308	436	14,141	295
20	1.5	0.0370	430	11,622	246
20	1.2	0.0463	424	9,168	197
20	1.0	0.0555	420	7,568	164
20	0.7	0.0793	414	5,222	115
20	0.5	0.1110	410	3,694	82
20	0.4	0.1388	408	2,941	66
20	0.3	0.1850	406	2,195	49
18	3.0	0.0206	420	20,432	443
18	2.5	0.0247	410	16,622	369
18	2.0	0.0308	400	12,973	295
18	1.8	0.0343	396	11,559	266
18	1.5	0.0411	390	9,486	221
18	1.2	0.0514	384	7,472	177
18	1.0	0.0617	380	6,162	148
18	0.7	0.0881	374	4,245	103
18	0.5	0.1233	370	3,000	74
18	0.4	0.1542	368	2,387	59
18	0.3	0.2056	366	1,781	44
15	3.0	0.0247	360	14,595	369
15	2.5	0.0296	350	11,824	308
15	2.0	0.0370	340	9,189	246
15	1.8	0.0411	336	8,173	221
15	1.5	0.0493	330	6,689	185
15	1.2	0.0617	324	5,254	148
15	1.0	0.0740	320	4,324	123

NIKROTHAL® 60, STRIP

(cont.)

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
15	0.7	0.1057	314	2,970	86
15	0.5	0.1480	310	2,095	62
15	0.4	0.1850	308	1,665	49
15	0.3	0.2467	306	1,241	37
12	3.0	0.0308	300	9,730	295
12	2.5	0.0370	290	7,838	246
12	2.0	0.0463	280	6,054	197
12	1.8	0.0514	276	5,371	177
12	1.5	0.0617	270	4,378	148
12	1.2	0.0771	264	3,425	118
12	1.0	0.0925	260	2,811	98
12	0.7	0.1321	254	1,922	69
12	0.5	0.1850	250	1,351	49
12	0.4	0.2313	248	1,072	39
12	0.3	0.3083	246	798	30
10	2.5	0.0444	250	5,631	205
10	2.0	0.0555	240	4,324	164
10	1.8	0.0617	236	3,827	148
10	1.5	0.0740	230	3,108	123
10	1.2	0.0925	224	2,422	98
10	1.0	0.1110	220	1,982	82
10	0.7	0.1586	214	1,350	57
10	0.5	0.2220	210	946	41
10	0.4	0.2775	208	750	33
10	0.3	0.3700	206	557	25
8	2.0	0.0694	200	2,883	131
8	1.8	0.0771	196	2,543	118
8	1.5	0.0925	190	2,054	98
8	1.2	0.1156	184	1,591	79
8	1.0	0.1388	180	1,297	66
8	0.7	0.1982	174	878	46
8	0.5	0.2775	170	613	33
8	0.4	0.3469	168	484	26
8	0.3	0.4625	166	359	20
7	1.5	0.1057	170	1,608	86
7	1.2	0.1321	164	1,241	69
7	1.0	0.1586	160	1,009	57
7	0.7	0.2265	154	680	40
7	0.5	0.3171	150	473	29
7	0.4	0.3964	148	373	23
7	0.3	0.5286	146	276	17
6	1.5	0.1233	150	1,216	74

NIKROTHAL® 60, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η CM^2/Ω 20°	WEIGHT G/M
6	1.2	0.1542	144	934	59
6	1.0	0.1850	140	757	49
6	0.7	0.2643	134	507	34
6	0.5	0.3700	130	351	25
6	0.4	0.4625	128	277	20
6	0.3	0.6167	126	204	15
5	1.2	0.1850	124	670	49
5	1.0	0.2220	120	541	41
5	0.7	0.3171	114	359	29
5	0.5	0.4440	110	248	21
5	0.4	0.5550	108	195	16
5	0.3	0.7400	106	143	12

NIKROTHAL® 40, WIRE

WIRE DIMENSIONS AND PROPERTIES

Resistivity: 1.04 Ω *mm²/m

Density: 7.90 g /cm³

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	1.00	1.03	1.06	1.10	1.12	1.15	1.17	1.19	1.21	1.22	1.24	1.24	1.25	1.25	1.25

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
10.00	0.0132	23,725.01	620.465	314	78.540
9.90	0.0135	23,020.35	608.117	311	76.977
9.80	0.0138	22,329.79	595.894	308	75.430
9.70	0.0141	21,653.18	583.795	305	73.898
9.60	0.0144	20,990.37	571.820	302	72.382
9.50	0.0147	20,341.23	559.969	298	70.882
9.40	0.0150	19,705.61	548.242	295	69.398
9.30	0.0153	19,083.38	536.640	292	67.929
9.20	0.0156	18,474.38	525.161	289	66.476
9.10	0.0160	17,878.48	513.807	286	65.039
9.00	0.0163	17,295.53	502.576	283	63.617
8.90	0.0167	16,725.40	491.470	280	62.211
8.80	0.0171	16,167.93	480.488	276	60.821
8.70	0.0175	15,622.99	469.630	273	59.447
8.60	0.0179	15,090.44	458.896	270	58.088
8.50	0.0183	14,570.12	448.286	267	56.745
8.40	0.0188	14,061.91	437.800	264	55.418
8.30	0.0192	13,565.65	427.438	261	54.106
8.20	0.0197	13,081.21	417.200	258	52.810
8.10	0.0202	12,608.44	407.087	254	51.530
8.00	0.0207	12,147.21	397.097	251	50.265
7.90	0.0212	11,697.36	387.232	248	49.017
7.80	0.0218	11,258.75	377.491	245	47.784
7.70	0.0223	10,831.25	367.873	242	46.566
7.60	0.0229	10,414.71	358.380	239	45.365
7.50	0.0235	10,008.99	349.011	236	44.179
7.40	0.0242	9,613.94	339.766	232	43.008
7.30	0.0248	9,229.43	330.646	229	41.854
7.20	0.0255	8,855.31	321.649	226	40.715
7.10	0.0263	8,491.44	312.776	223	39.592
7.00	0.0270	8,137.68	304.028	220	38.485
6.90	0.0278	7,793.88	295.403	217	37.393
6.80	0.0286	7,459.90	286.903	214	36.317
6.70	0.0295	7,135.61	278.527	210	35.257
6.60	0.0304	6,820.85	270.274	207	34.212
6.50	0.0313	6,515.48	262.146	204	33.183
6.40	0.0323	6,219.37	254.142	201	32.170
6.30	0.0334	5,932.37	246.262	198	31.172
6.20	0.0344	5,654.33	238.507	195	30.191
6.10	0.0356	5,385.13	230.875	192	29.225
6.00	0.0368	5,124.60	223.367	188	28.274
5.90	0.0380	4,872.62	215.984	185	27.340

NIKROTHAL® 40, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η CM²/Ω	WEIGHT G/M	AREA (SURFACE) CM²/M	AREA (CROSS SECT) MM²
5.80	0.0394	4,629.03	208.724	182	26.421
5.70	0.0408	4,393.71	201.589	179	25.518
5.60	0.0422	4,166.49	194.578	176	24.630
5.50	0.0438	3,947.25	187.691	173	23.758
5.40	0.0454	3,735.84	180.927	170	22.902
5.30	0.0471	3,532.11	174.288	167	22.062
5.20	0.0490	3,335.93	167.774	163	21.237
5.10	0.0509	3,147.15	161.383	160	20.428
5.00	0.0530	2,965.63	155.116	157	19.635
4.90	0.0552	2,791.22	148.974	154	18.857
4.80	0.0575	2,623.80	142.955	151	18.096
4.70	0.0599	2,463.20	137.061	148	17.349
4.60	0.0626	2,309.30	131.290	145	16.619
4.50	0.0654	2,161.94	125.644	141	15.904
4.40	0.0684	2,020.99	120.122	138	15.205
4.30	0.0716	1,886.30	114.724	135	14.522
4.20	0.0751	1,757.74	109.450	132	13.854
4.10	0.0788	1,635.15	104.300	129	13.203
4.00	0.0828	1,518.40	99.274	126	12.566
3.90	0.0871	1,407.34	94.373	123	11.946
3.80	0.0917	1,301.84	89.595	119	11.341
3.70	0.0967	1,201.74	84.942	116	10.752
3.60	0.1022	1,106.91	80.412	113	10.179
3.50	0.1081	1,017.21	76.007	110	9.621
3.40	0.1145	932.49	71.726	107	9.079
3.30	0.1216	852.61	67.569	104	8.553
3.20	0.1293	777.42	63.536	101	8.042
3.10	0.1378	706.79	59.627	97	7.548
3.00	0.1471	640.58	55.842	94	7.069
2.90	0.1575	578.63	52.181	91	6.605
2.80	0.1689	520.81	48.644	88	6.158
2.70	0.1816	466.98	45.232	85	5.726
2.60	0.1959	416.99	41.943	82	5.309
2.50	0.2119	370.70	38.779	79	4.909
2.40	0.2299	327.97	35.739	75	4.524
2.30	0.2503	288.66	32.823	72	4.155
2.20	0.2736	252.62	30.030	69	3.801
2.10	0.3003	219.72	27.362	66	3.464
2.00	0.3310	189.80	24.819	63	3.142
1.90	0.3668	162.73	22.399	60	2.835
1.80	0.4087	138.36	20.103	57	2.545
1.70	0.4582	116.56	17.931	53	2.270

NIKROTHAL® 40, WIRE

(cont.)

DIAMETER MM	RESISTANCE PER METER Ω/M	η $CM^2/Ω$	WEIGHT G/M	AREA (SURFACE) CM^2/M	AREA (CROSS SECT) MM^2
1.60	0.5173	97.18	15.884	50	2.011
1.50	0.5885	80.07	13.960	47	1.767
1.40	0.6756	65.10	12.161	44	1.539
1.30	0.7835	52.12	10.486	41	1.327
1.20	0.9196	41.00	8.935	38	1.131
1.10	1.0944	31.58	7.508	35	0.950
1.00	1.3242	23.73	6.205	31	0.785
0.90	1.6348	17.30	5.026	28	0.636
0.80	2.0690	12.15	3.971	25	0.503
0.70	2.7024	8.14	3.040	22	0.385
0.60	3.6782	5.12	2.234	19	0.283
0.50	5.2967	2.97	1.551	16	0.196
0.40	8.2761	1.52	0.993	13	0.126
0.30	14.7130	0.64	0.558	9	0.071
0.20	33.1042	0.19	0.248	6	0.031
0.10	132.4169	0.02	0.062	3	0.008

NIKROTHAL® 40, STRIP

STRIP DIMENSIONS AND PROPERTIES

Resistivity: 1.04 Ω* mm²/m

Density: 7.90 g/cm³

To obtain resistivity at working temperature. multiply by factor C_t in following table.

°C	20	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
C_T	1.00	1.03	1.06	1.10	1.12	1.15	1.17	1.19	1.21	1.22	1.24	1.24	1.25	1.25	1.25

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
50	3.0	0.0069	1,060	152,885	1,185
50	2.5	0.0083	1,050	126,202	988
50	2.0	0.0104	1,040	100,000	790
50	1.8	0.0116	1,036	89,654	711
50	1.5	0.0139	1,030	74,279	593
50	1.2	0.0173	1,024	59,077	474
50	1.0	0.0208	1,020	49,038	395
50	0.7	0.0297	1,014	34,125	277
50	0.5	0.0416	1,010	24,279	198
50	0.4	0.0520	1,008	19,385	158
50	0.3	0.0693	1,006	14,510	119
40	3.0	0.0087	860	99,231	948
40	2.5	0.0104	850	81,731	790
40	2.0	0.0130	840	64,615	632
40	1.8	0.0144	836	57,877	569
40	1.5	0.0173	830	47,885	474
40	1.2	0.0217	824	38,031	379
40	1.0	0.0260	820	31,538	316
40	0.7	0.0371	814	21,915	221
40	0.5	0.0520	810	15,577	158
40	0.4	0.0650	808	12,431	126
40	0.3	0.0867	806	9,300	95
35	3.0	0.0099	760	76,731	830
35	2.5	0.0119	750	63,101	691
35	2.0	0.0149	740	49,808	553
35	1.8	0.0165	736	44,585	498
35	1.5	0.0198	730	36,851	415
35	1.2	0.0248	724	29,238	332
35	1.0	0.0297	720	24,231	277
35	0.7	0.0424	714	16,820	194
35	0.5	0.0594	710	11,947	138
35	0.4	0.0743	708	9,531	111
35	0.3	0.0990	706	7,128	83
30	3.0	0.0116	660	57,115	711
30	2.5	0.0139	650	46,875	593
30	2.0	0.0173	640	36,923	474
30	1.8	0.0193	636	33,023	427
30	1.5	0.0231	630	27,260	356
30	1.2	0.0289	624	21,600	284
30	1.0	0.0347	620	17,885	237
30	0.7	0.0495	614	12,398	166
30	0.5	0.0693	610	8,798	119

NIKROTHAL® 40, STRIP

(cont.)

	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
30	0.4	0.0867	608	7,015	95
30	0.3	0.1156	606	5,244	71
25	3.0	0.0139	560	40,385	593
25	2.5	0.0166	550	33,053	494
25	2.0	0.0208	540	25,962	395
25	1.8	0.0231	536	23,192	356
25	1.5	0.0277	530	19,111	296
25	1.2	0.0347	524	15,115	237
25	1.0	0.0416	520	12,500	198
25	0.7	0.0594	514	8,649	138
25	0.5	0.0832	510	6,130	99
25	0.4	0.1040	508	4,885	79
25	0.3	0.1387	506	3,649	59
20	3.0	0.0173	460	26,538	474
20	2.5	0.0208	450	21,635	395
20	2.0	0.0260	440	16,923	316
20	1.8	0.0289	436	15,092	284
20	1.5	0.0347	430	12,404	237
20	1.2	0.0433	424	9,785	190
20	1.0	0.0520	420	8,077	158
20	0.7	0.0743	414	5,573	111
20	0.5	0.1040	410	3,942	79
20	0.4	0.1300	408	3,138	63
20	0.3	0.1733	406	2,342	47
18	3.0	0.0193	420	21,808	427
18	2.5	0.0231	410	17,740	356
18	2.0	0.0289	400	13,846	284
18	1.8	0.0321	396	12,337	256
18	1.5	0.0385	390	10,125	213
18	1.2	0.0481	384	7,975	171
18	1.0	0.0578	380	6,577	142
18	0.7	0.0825	374	4,531	100
18	0.5	0.1156	370	3,202	71
18	0.4	0.1444	368	2,548	57
18	0.3	0.1926	366	1,900	43
15	3.0	0.0231	360	15,577	356
15	2.5	0.0277	350	12,620	296
15	2.0	0.0347	340	9,808	237
15	1.8	0.0385	336	8,723	213
15	1.5	0.0462	330	7,139	178
15	1.2	0.0578	324	5,608	142
15	1.0	0.0693	320	4,615	119

NIKROTHAL® 40, STRIP

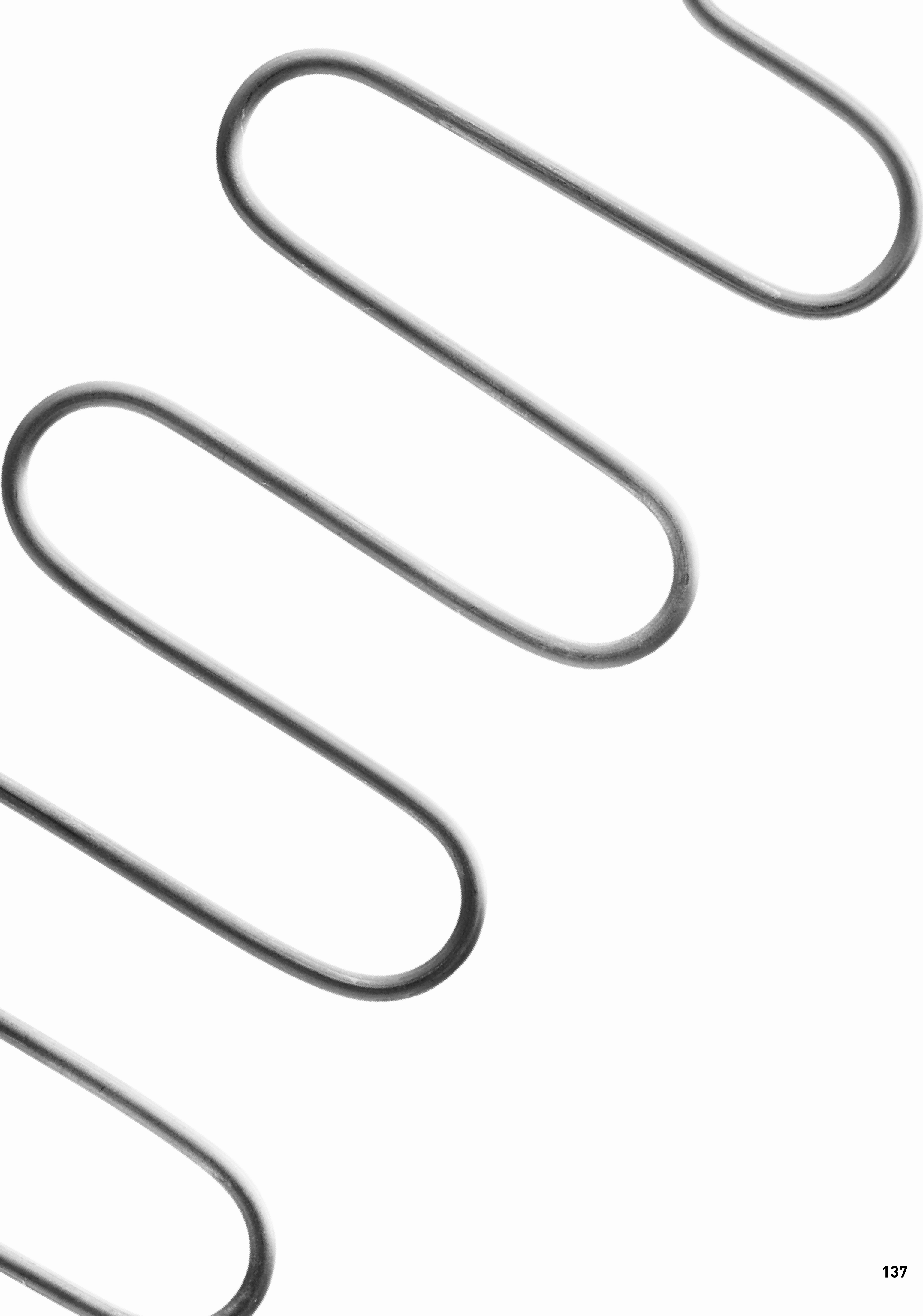
(cont.)

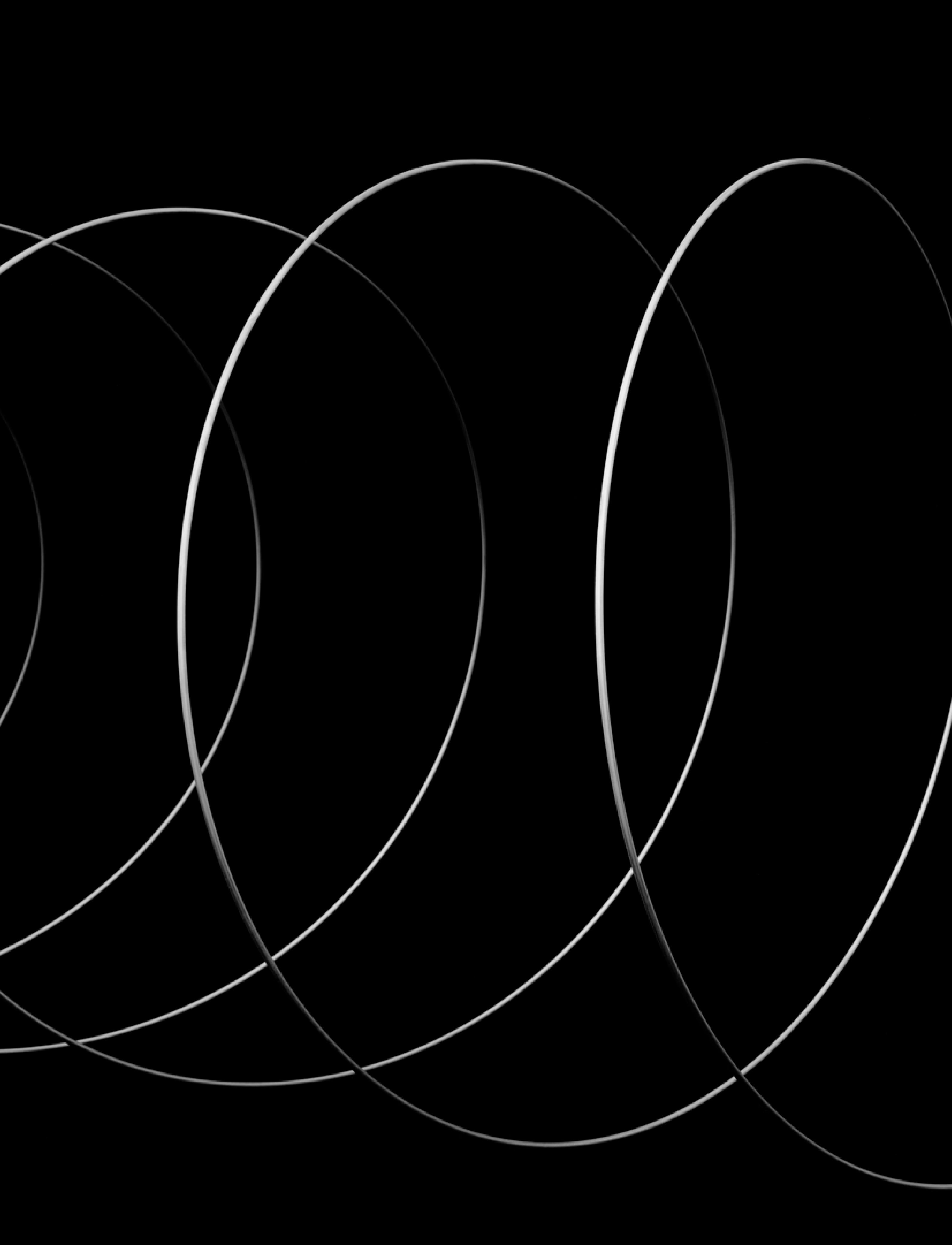
	DIMENSIONS			DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM^2/M	η $CM^2/Ω$ 20°	WEIGHT G/M
15	0.7	0.0990	314	3,170	83
15	0.5	0.1387	310	2,236	59
15	0.4	0.1733	308	1,777	47
15	0.3	0.2311	306	1,324	36
12	3.0	0.0289	300	10,385	284
12	2.5	0.0347	290	8,365	237
12	2.0	0.0433	280	6,462	190
12	1.8	0.0481	276	5,732	171
12	1.5	0.0578	270	4,673	142
12	1.2	0.0722	264	3,655	114
12	1.0	0.0867	260	3,000	95
12	0.7	0.1238	254	2,052	66
12	0.5	0.1733	250	1,442	47
12	0.4	0.2167	248	1,145	38
12	0.3	0.2889	246	852	28
10	2.5	0.0416	250	6,010	198
10	2.0	0.0520	240	4,615	158
10	1.8	0.0578	236	4,085	142
10	1.5	0.0693	230	3,317	119
10	1.2	0.0867	224	2,585	95
10	1.0	0.1040	220	2,115	79
10	0.7	0.1486	214	1,440	55
10	0.5	0.2080	210	1,010	40
10	0.4	0.2600	208	800	32
10	0.3	0.3467	206	594	24
8	2.0	0.0650	200	3,077	126
8	1.8	0.0722	196	2,714	114
8	1.5	0.0867	190	2,192	95
8	1.2	0.1083	184	1,698	76
8	1.0	0.1300	180	1,385	63
8	0.7	0.1857	174	937	44
8	0.5	0.2600	170	654	32
8	0.4	0.3250	168	517	25
8	0.3	0.4333	166	383	19
7	1.5	0.0990	170	1,716	83
7	1.2	0.1238	164	1,325	66
7	1.0	0.1486	160	1,077	55
7	0.7	0.2122	154	726	39
7	0.5	0.2971	150	505	28
7	0.4	0.3714	148	398	22
7	0.3	0.4952	146	295	17
6	1.5	0.1156	150	1,298	71

NIKROTHAL® 40, STRIP

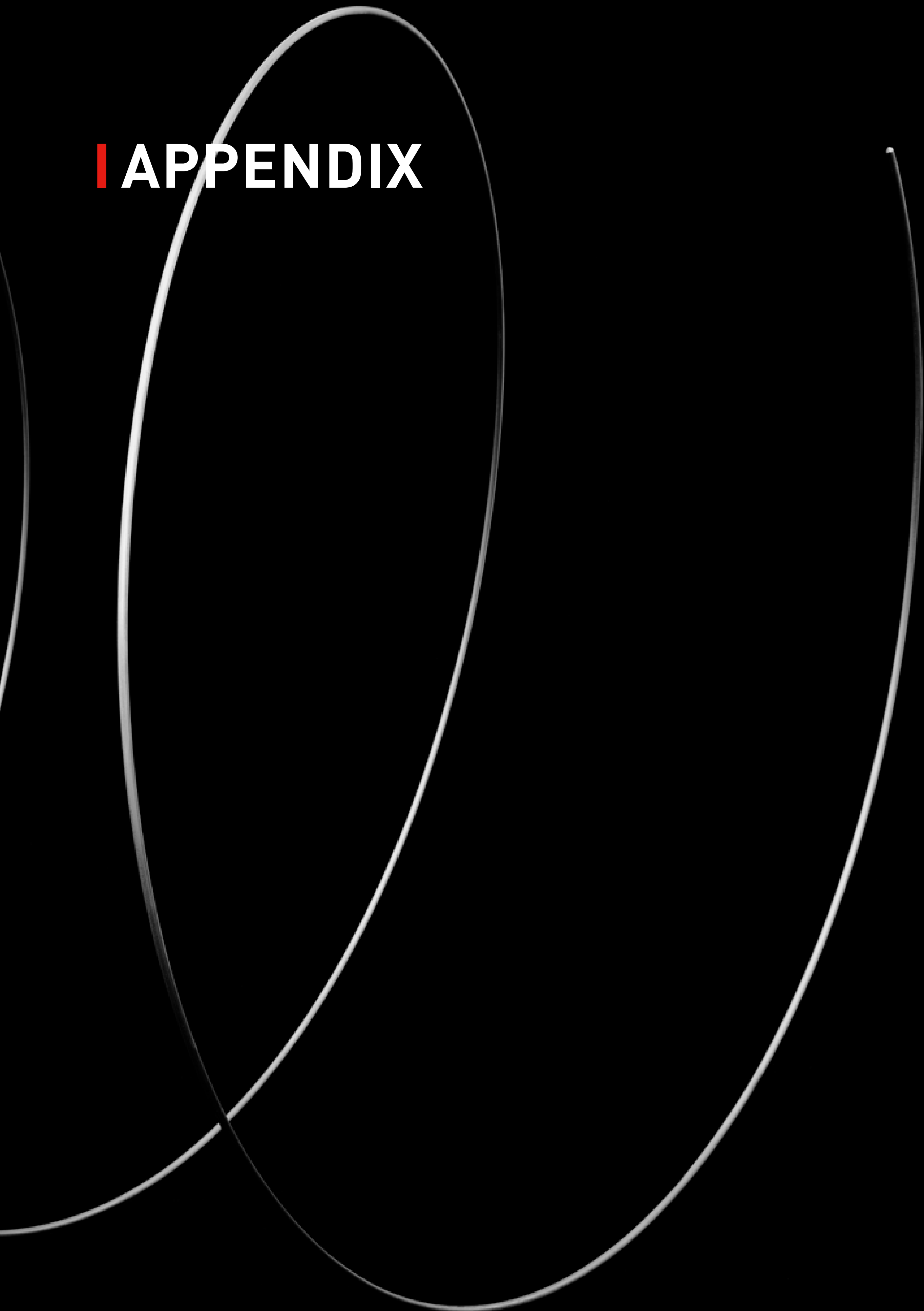
(cont.)

DIMENSIONS				DESIGN NUMBERS	
WIDTH MM	THICKNESS MM	RESISTANCE PER M	RESISTANCE CM²/M	η CM²/Ω 20°	WEIGHT G/M
6	1.2	0.1444	144	997	57
6	1.0	0.1733	140	808	47
6	0.7	0.2476	134	541	33
6	0.5	0.3467	130	375	24
6	0.4	0.4333	128	295	19
6	0.3	0.5778	126	218	14
5	1.2	0.1733	124	715	47
5	1.0	0.2080	120	577	40
5	0.7	0.2971	114	384	28
5	0.5	0.4160	110	264	20
5	0.4	0.5200	108	208	16
5	0.3	0.6933	106	153	12





APPENDIX



LIST OF SYMBOLS

The symbols used adhere to internationally approved standards.
The following symbols are applied:

SYMBOL	MEANING	UNIT FOR CALCULATION METRIC	IMPERIAL
A_C	Surface area of heating conductor	cm^2	in^2
b	Width (ribbon or strip)	mm	in
C_t	Temperature factor (ratio of resistivity at operating temperature to resistivity at room temperature)		
d	Wire diameter	mm	in
D	Outer coil diameter	mm	in
I	Current	A	A
L	Length of heating conductor	m	ft
L_e	Coil length	mm	in
n	Number of turns		
p	Surface load of heating element	W/cm^2	W/in^2
P	Power	W	W
q	Cross-sectional area of heating conductor	mm^2	in^2
r	Relative pitch		
R_T	Resistance at working temperature	Ω	Ω
R_{20}	Resistance at room temperature (20°C, 68°F)	Ω	Ω
s	Pitch	mm	in
t	Thickness (ribbon or strip)	mm	in
T	Temperature	K, °C	K, °F
U	Voltage	V	V
α	Temperature coefficient of resistivity	K^{-1}	$°F^{-1}$
γ	Density (old marking)	g/cm^3	lb/in^3
ρ	Resistivity	$Ω\ mm^2/m$	Ω/smf Ω/cmf*
10	Balancing factor used in the formulas makes possible that the values can be used with units of section 1: e.g. wire diameter, d, in millimeter (mm) or inch (in) is different from length of heating conductor, l, in meter (m) or foot (ft)		

FORMULAS AND DEFINITIONS

The following formulas and definitions apply to all applications:

DEFINITION: Resistivity, ρ $\Omega mm^2/m$ (Ω/cmf)

The resistance of a conductor, R_{20}, is directly proportional to its length, L and inversely proportional to its cross-sectional area, q:

$$R_{20} = \rho \frac{\ell}{q} \quad \Omega \quad [1]$$

The proportional constant, ρ is defined as the resistivity of the material and is temperature dependent. The unit of ρ is $\Omega mm^2/m$ (Ω/cmf).

DEFINITION: Temperature factor, C_t

Resistivity or change in resistance with temperature, is non-linear for most resistance heating alloys. Hence, the temperature factor, C_t, is often used instead of temperature coefficient. C_t is defined as the ratio between the resistivity or resistance at some selected temperature T °C and the resistivity or resistance at 20°C (68°F).

$$R_T = C_t R_{20} \quad \Omega \quad [2]$$

$$C_t = \frac{R_T}{R_{20}} \quad [3]$$

$$C_t = 1 + (T - 20)\alpha \quad [4]$$

DEFINITION: Surface load, p W/cm^2 (W/in^2)

The surface load of a heating conductor, p, is its power, P, divided by its surface area, A_c.

$$p = \frac{P}{A_c} \quad W/cm2\ (W/in2) \quad [5]$$

Wire

$$A_c = \pi dL \times 10 \quad \text{(metric) [6]}$$

$$A_c = \pi dL \times 12 \quad \text{(imperial) [6]}$$

Strip

$$A_c = 2(b + t)L \times 10 \quad \text{(metric) [7]}$$

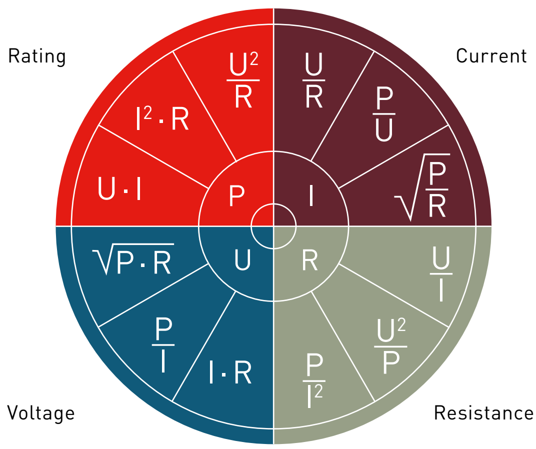
$$A_c = 2(b + t)L \times 12 \quad \text{(imperial) [7]}$$

General formulas

$$U = R_T I \quad V \quad [8]$$

$$P = UI \quad W \quad [9]$$

Combining equations [8] and [9] gives:



Combining equations [2], [5], [8] and [9] gives:

$$\eta = \frac{A_c}{R_{20}} = \frac{I^2 C_t}{p} \quad cm2/\Omega\ (in2/\Omega) \quad [10]$$

The ratio $\frac{A_c}{R_{20}}$, used for determining wire, strip or ribbon size, is tabulated for all alloys in the handbook for 'Resistance heating alloys and systems for industrial furnaces'.

DEFINITION: Cross sectional area, q mm² (in²)

Round wire

$$q = \frac{\pi}{4} d^2 \quad \text{mm2 (in2)} \quad [11]$$

Combining equations [1], [5], [6] and [11] gives the wire diameter, d:

$$d = \sqrt[3]{\frac{4\rho P}{\pi^2 p R_{20}}} \quad \text{mm (in)} \quad [12]$$

$$d = \sqrt[3]{\frac{4}{10\pi^2} \frac{\rho P}{p R_{20}}} \quad \text{(metric)} \quad [12]$$

$$d = \sqrt[3]{\frac{4}{15.28 \times 10^6 \times \pi^2} \frac{\rho P}{p R_{20}}} \quad \text{(imp.)} \quad [12]$$

Example:

ρ = 1.35 Ω mm²/m (812 Ω/cmf) for Kanthal® D (according to section 2)
P = 1,000 W
p = 8 W/cm² (51.6 W/in²)
R = 40 Ω

Strip

$$q = bt \quad \text{mm2 (in2)} \quad [13]$$

DEFINITION: Number of turns, n

$$N = \frac{L_e}{s} \quad [15]$$

DEFINITION: Coil pitch, s mm (in)

A round wire is often wound as a coil. For calculating coil pitch, s, the equation [16] applies:

$$\left[\frac{\pi(D-d)}{s}\right]^2 + 1 = \left(\frac{\ell}{L_e}\right)^2 \Rightarrow$$

$$s = \frac{\pi(D-d)}{\sqrt{\left(\frac{\ell}{L_e}\right)^2 - 1}} \quad \text{mm} \quad [16]$$

$$s = \frac{\pi(D-d)}{\sqrt{\left(\frac{1,000 \times \ell}{L_e}\right)^2 - 1}} \quad \text{(metric) [16']}$$

$$s = \frac{\pi(D-d)}{\sqrt{(\frac{12 \times \ell}{L_e})^2 - 1}} \quad \text{(imperial) [16']}$$

When the pitch, s, is small relatively to coil diameter, D, and wire diameter, d.

Than $\frac{s}{\pi (D-d)} << L$, so that equation [16] can be simplified to:

$$s = \frac{\pi(D-d)L_e}{\ell} \quad \text{mm (in)} \quad [17]$$

DEFINITION: Relative pitch, r

The ratio s/d is often used. It is called the relative pitch or the stretch factor, and may affect the heat dissipation from the coil.

$$r = \frac{s}{d} \quad [18]$$

The ratio D/d is essential for the coiling operation, as well as the mechanical stability of the coil in a hot state.

FORMULAS FOR VALUES IN TABLES

In the chapter "Tables," the values for surface area, weight, and resistance of each material and dimension are calculated per meter. Additionally, cross-sectional area and area per ohm (Ω) are presented. The formulas below include unit corrections:

Metric units
Resistance per meter, $R_{20/m}$ Ω/m
Based on equation [1]

Wire

$$R_{20/m} = \frac{4\rho}{\pi d^2} \quad [1']$$

Strip

$$R_{20/m} = \frac{\rho}{bt} \quad [1']$$

Weight per meter, m_m g/m

$$m = \text{volume} \times \gamma = q\ell \times \gamma => m_m = q\gamma$$

Wire

$$m_m = \frac{\pi d^2 \gamma}{4} \quad [19]$$

Strip

$$m_m = bt\gamma \quad [19]$$

Surface area per meter, $A_{C/m}$ cm²/m
Based on equation [6] respectively [7]

Wire

$$A_{C/m} = 10 \times \pi d \quad [6']$$

Strip

$$A_{C/m} = 10 \times 2(b + t) \quad [7']$$

Cross sectional area, q mm²
Based on equation [11], [13] respectively [14]

Wire

$$q = \frac{\pi}{4} d^2 \quad [11']$$

Strip

$$q = bt \quad [13']$$

Surface area per Ω cm²/Ω
Combining [1'] and [6'] respectively [1'] and [7']

Wire

$$\eta = \frac{A_{C/m}}{R_{20/m}} = \frac{10 \times \pi d \times q}{\rho} = \frac{10 \times \pi^2 d^3}{4\rho}$$

Strip

$$\eta = \frac{A_{C/m}}{R_{20/m}} = \frac{10 \times 2(b + t) \times bt}{\rho} = \frac{20(b + t)bt}{\rho}$$

Other equations which could be helpful

Length per kilo, L_{kg} m/kg
Based on equation [19] → $L_{kg} = \frac{1{,}000}{m_m}$

Wire

$$L_{kg} = \frac{1{,}000 \times 4}{\pi d^2 \gamma} = \frac{4{,}000}{\pi d^2 \gamma} \quad [19']$$

Strip

$$L_{kg} = \frac{1{,}000}{bt\gamma} \quad [19']$$

Resistance per kilo, R_{kg} Ω/kg
Combining [1'] and [19]→

$$R_{kg} = 1{,}000 \times \frac{R_{20/m}}{m_m} = 1{,}000 \times \frac{R}{q} \times \frac{1}{q\gamma} = \frac{1{,}000 \times R}{q^2 \gamma}$$

Wire

$$R_{kg} = \frac{1{,}000 \times \rho}{\left(\frac{\pi d^2}{4}\right)^2 \gamma} = \frac{16{,}000 \times \rho}{\pi^2 d^4 \gamma}$$

Strip

$$R_{kg} = \frac{1{,}000 \times \rho}{b^2 t^2 \gamma}$$

Relationship between metric and imperial units

1 Ω mm²/m (μΩm)		= 601.54 Ω/cmf
1 Ω mm²/m (μΩm)		= 472.44 Ω/smf
1 Ω/smf		= 1.2732 Ω/cmf
1 inch (in)	= 1000 mil	= 0.0254 m
1 foot (ft)	= 12 in	= 0.3048 m
1 mil	= 0.001 inch	= 0.0254 mm
1 W/cm²		= 6.45 W/in²
1 W/in²		= 0.155 W/cm²

Imperial units
ρ'_{wire} = Ω/cmf respectively
ρ''_{strip} = Ω/smf

Resistance per foot, $R_{20/ft}$ Ω/ft
Based on equation [1]

Wire

$$R_{20/ft} = \frac{\rho'}{10^6 \times d^2} \quad [1']$$

Strip

$$R_{20/ft} = \frac{\rho''}{10^6 \times bt} \quad [1']$$

Weight per foot, m_m lb/ft
m = volume · γ = q · l · γ → m_{ft} = q · γ

Wire

$$m = \text{volume} \times \gamma = q\ell \times \gamma \Rightarrow m_{ft} = q\gamma \quad [19']$$

Strip

$$m_{ft} = \frac{12 \times \pi d^2 \gamma}{4} = 3 \times \pi d^2 \gamma \quad [19']$$

Surface area per foot, $A_{C/ft}$ in²/ft
Based on equation [6] respectively [7]

Wire

$$A_{C/ft} = 12 \times \pi d \quad [6']$$

Strip

$$A_{C/ft} = 12 \times \pi d \quad [7']$$

Cross sectional area, q in²
Based on equation [11], [13] respectively [14]

Wire

$$q = \frac{\pi}{4} d^2 \quad [11']$$

Strip

$$q = bt \quad [13']$$

Surface area per Ω in²/Ω
Combining [1'] and [6'] respectively [1'] and [7']

Wire

$$\frac{A_{C/ft}}{R_{20/ft}} = \frac{12 \times 10^6 \times \pi d \times q}{\rho'} = \frac{3 \times 10^6 \times \pi^2 d^3}{\rho'}$$

Strip

$$\frac{A_{C/ft}}{R_{20/ft}} = \frac{12 \times 10^6 \times 2(b+t) \times bt}{\rho''} = \frac{24 \times 10^6 \times (b+t) bt}{\rho''}$$

Other equations which could be helpful

Length per pound, L_{lb} ft/lb
Based on equation [19] → $L_{lb} = \frac{1}{m_{ft}}$

Wire

$$L_{lb} = \frac{4}{12 \times \pi d^2 \gamma} = \frac{1}{3 \times \pi d^2 \gamma} \qquad [19']$$

Strip

$$L_{lb} = \frac{1}{12 \times bt\gamma} \qquad [19']$$

Resistance per pound, R_{lb} Ω/lb
Combining [1'] and [19]→

$$R_{lb} = \frac{R_{20/ft}}{m_{ft}} = \frac{\rho}{q \cdot q \cdot \gamma} = \frac{\rho}{q^2 \cdot \gamma}$$

Wire

$$R_{lb} = \frac{\rho'}{3 \times 10^6 \times \pi d^2 \times d^2 \gamma} = \frac{\rho'}{3 \times 10^6 \times \pi d^4 \gamma}$$

Strip

$$R_{lb} = \frac{\rho''}{12 \times 10^6 \times b^2 t^2 \gamma}$$

DESIGN CALCULATIONS FOR HEATING ELEMENTS

In this section, an element is defined as a combination of heating wire and any supporting or connecting materials. Electrical appliances equipped with heating elements are used in both domestic and industrial applications.

Domestic applications include functions such as cooking, fluid heating, drying, ironing, space heating, and specialized uses like heating beds, aquariums, saunas, soldering irons, and paint strippers.

Industrial applications include functions such as heat treatment, hardening, and drying of inks, paints, and lacquers. In vehicles, heating elements are used for seats, engines, and rearview mirrors.

The device and the heating element must meet performance, raw material, manufacturing cost, life expectancy, and safety requirements. Often, these requirements conflict. A longer lifespan and increased safety require a lower wire temperature, leading to longer heating times and higher raw material costs.

Designs for domestic and industrial applications must ensure safety and avoid harm to individuals or property damage. Safety specifications vary by market and can influence the design and temperature limitations of the device and its elements.

The lifespan of a well-designed element depends on the make and type of wire used. Our FeCrAl and NiCr(Fe) wires excel at high temperatures and offer the longest lifespan. Remember, wire life increases with a thicker wire and lower operating temperature.

WIRE TEMPERATURE
For embedded or supported element types, wire temperature is influenced by both the wire and the element's surface load. For suspended elements, surface load typically cannot be defined. In addition to surface load, factors such as ambient temperature, heat dissipation, and the presence or position of other elements will affect wire temperature, which in turn influences the selection of the wire and element surface load.

SURFACE LOAD
When designing an element, the voltage and power rating are typically known. The surface load of the heating element is calculated by dividing the power rating by the surface area of the energized wire. A range of surface loads, rather than a single value, is usually listed in the tables. Selection within this range depends on the element's requirements, as well as the available voltage, power rating, and dimensions.

For example, high voltage and low power ratings result in a thinner wire, which has a shorter lifespan at the same temperature. Therefore, a lower wire surface load is required. The wire surface area is calculated as the ratio of the power rating to the wire surface load.

SURFACE AND RESISTANCE
Once the cold-state resistance is calculated, the ratio of surface area to resistance is determined. This ratio is listed for all wire types and dimensions in this handbook allowing for easy selection of the correct wire size.

COIL PARAMETERS
The ratio of coil diameter to wire diameter (D/d) must be calculated to ensure the coil can be manufactured easily. The recommended ratio (D/d) ranges from 5 to 12. For supported elements, this ratio should be compared to the deformation curve on page 29.

When both coil length and diameter are known, the coil pitch (s) can be estimated using the formula [17] in the Appendix. The coil pitch is typically 2 to 4 times the wire diameter (d). For quartz tube heaters, a smaller pitch is usually applied. Pre-oxidized coils made from Kanthal® FeCrAl can be tightly wound in such elements.

For straight wire on a threaded ceramic rod or many suspended elements, the wire length is fixed. The resistance per meter can then be calculated, and the appropriate wire size can be selected from the handbook.

METAL-SHEATHED TUBULAR ELEMENT
Calculating a metal-sheathed tubular element is more complex, as the resistance is reduced by 10 to 30% due to the compression of the element. First, determine the tube surface load based on the element's use. The wire surface load is typically 2 to 4 times higher. After calculating resistance from the power rating and voltage, increase the resistance by 10 to 30% to account for coiling. The wire surface area decreases by 2 to 7% after compression. Since tube length increases due to compression during rolling, the tube surface area usually remains unchanged.

EXAMPLES

Tubular element for a flat iron	
Rating, P	1,000 W
Voltage, U	220 V
Final tube diameter	8 mm (0.315 in)
Final tube length	300 mm (11.8 in)

If the terminal length inside the tube is 2 × 25 mm the coil length (L_e) will be
L_e = 300 mm – (2 × 25 mm) = 250 mm (9.8 in).

Hot resistance based on equation [8] and [9]

$$R = \frac{U^2}{P} = \frac{220^2}{1{,}000} = 48.4\ \Omega$$

Tubes surface load based on equation [5]

$$p_{tube} = \frac{P}{A_{tube}} = \frac{P}{0.01 \times \pi d_{tube} \times L_e} = \frac{1{,}000}{0.01 \times \pi \times 8 \times 250} = 15.91\ \mathrm{W/cm^2}\ (103\ \mathrm{W/in^2})$$

$$p_{wire} = 3 \times p_{tube} \qquad [20]$$

Wire surface load inside tube. Factor 3 is used as a rule of thumb:

$$p_{tube} = \frac{P}{A_{tube}} = \frac{P}{0.01 \times \pi d_{tube} \times L_e} = \frac{1{,}000}{0.01 \times \pi \times 8 \times 250} = 15.91\ \mathrm{W/cm^2}\ (103\ \mathrm{W/in^2})$$

Wire surface based on equation [5]

$$p_{wire} = 3 \times p_{tube} = 3 \times 15.91 = 47.74 \approx 48\ \mathrm{W/cm^2}\ (309\ \mathrm{W/in^2})$$

Kanthal® D is a sensible choice and an average wire temperature of 700°C (1,290°F) likely. Due to temperature factor of resistance C_t = 1.05 for Kanthal® D.

Resistance at room temperature based on equation [2]

$$R_T = C_t R_{20} \Rightarrow R_{20} = \frac{R_T}{C_t} = \frac{48.4}{1.05} = 46.09 \approx 46.1\ \Omega$$

The ratio between wire surface and resistance is:

$$\eta = \frac{A_c}{R_{20}} = \frac{20.83}{46.1} = 0.452\ \mathrm{cm^2/\Omega}\ \ (0.070\ \mathrm{in^2/\Omega})$$

This is corresponding to a wire size of about 0.3 mm (0.012 in).

We assume that a steel tube of initially 9.5 mm (0.37 in) diameter is being used and can then expect a resistance reduction of about 30% upon rolling.

The resistance of the coil should therefore be about 65.3 Ω. The wire surface prior to compression is 7% bigger, or 22.5 cm^2 (3.49 in^2), and the ratio between wire surface and resistance 0.34 cm^2/Ω (0.053 in^2/Ω).

The corresponding wire size is 0.26 mm (0.01 in). Tests with this wire size have to be made in order to check the resistance reduction as a result of compression.

Coil suspended on a Mica-cross, element for a hair dryer

Rating, P	350 W
Voltage, U	55 V
Length of coil, l	250 mm (9.8 in)
Coil outer diameter, D	6 mm (0.236 in)

For this application a surface load, p, of 7 W/cm^2 (45.16 W/in^2) is reasonable.

Wire surface based on equation [5]

$$p = \frac{P}{A_c} \Rightarrow A_c = \frac{P}{p} = \frac{350}{7} = 50\ \text{cm}^2\ (7.75\ \text{in}^2)$$

Assuming a wire temperature of 600°C (1,110°F) and choosing Kanthal D with an C_t value of 1.04.

Hot- and cold resistance based on combining equations [8], [9] and [2]

$$R_T = \frac{U^2}{P} = \frac{55^2}{350} = 8.64\ \Omega$$

$$R_{20} = \frac{R_T}{C_t} = 8.31\ \Omega$$

By calculating the surface area to cold resistance ratio, a suitable wire dimension is found, combining [1'] and [6'], [7']

Wire

$$\frac{A_c}{R_{20}} = \frac{50\ \text{cm}^2}{8.31\ \Omega} = 6.01\ \text{cm}^2/\Omega\ \ (0.93\ \text{in}^2/\Omega$$

According to table for Kanthal D Ø 0.70 mm (0.0276 in) has an surface area to resistance ratio of 6.27 cm^2/Ω (0.97 in^2/Ω).

D/d ratio has to be considered since too low as well as too high values will create problems in the coiling process. Verifying the geometry of the coil, suitable values for the D/d ratio should be between 6 and 12. In this case:

$$\frac{D}{d} = \frac{6\ \text{mm}}{0.7\ \text{mm}} = 8.6$$

Length of wire is calculated as the ratio between resistance needed and resistance per meter (table on page 48, Kanthal D, d = 0.7 mm)

$$R_{20/m} = 3.51\ \Omega/\text{m}$$

Wire length:

$$\ell = \frac{R_{20}}{R_{20/m}} = \frac{8.31\ \Omega}{3.51\ \ \Omega/\text{m}} = 2.367\ \text{m}$$

Coil pitch, s, based on equation [17]

$$s = \frac{\pi(D-d)L_e}{\ell} = \frac{\pi(7-0.7)\times 250}{2370} = 2.09\ \text{mm}$$

Relative pitch based on equation [18]

$$r = \frac{s}{d} = \frac{2.09}{0.7} = 2.98$$

Surface load based on [5]

$$p = \frac{P}{A_{C/m}\ell} = \frac{350}{22 \times 2.37} = 6.7\ \text{W/cm}^2$$

MISCELLANEOUS CONVERSION FACTORS

TO CONVERT FROM	TO	MULTIPLY BY
BTU	Kilo-calorie	0.25200
BTU	Foot-pound	778.17
BTU	Joules	1054.0
BTU	Kilowatt-hour	0.00029307
Calorie	Joule	4.1840
Centigrade	Fahrenheit	(1.8 x °C) + 32
Circular mil	Square centimeter	0.000005067
Circular mil	Square inch	0.0000007854
Circular mil	Square mil	0.78540
Cubic centimeter	Cubic inch	0.061024
Dyne	Gram	0.0010197
Dyne	Newton	0.00001
Dyne	Pound	0.0000022481
Fahrenheit	Centigrade	0.555 x (°F - 32)
Gallon (US) (liquid)	Liter	3.7854
Gallon (UK) (liquid)	Liter	4.54
Gallon	Pint (liquid)	8
Gallon	Quart (liquid)	4
Gram	Ounces (US) (fluid)	0.035274
Gram	Ounce (troy)	0.032151
Gram	Pound	0.0022046
Gram/centimeter	Pound/inch	0.0055997
Gram/cubic centimeter	Ounce/gallon	133.5
Gram/cubic centimeter	Pound/cubic foot	62.428
Horsepower	Kilowatt	0.7457
Inch	Centimeter	2.54
Inch	Mil	1,000
Joule	Newtonmeter	1
Joule	Kilo-calorie	0.00023866
Kilogram	Carat	5,000
Kilogram	Pound	2.2046
Kilogram	Pounds (troy)	2.6792
Kilogram	Tons (short)	0.0011023
Kilogram	Ton (long)	0.00098421
Kilo-calorie	Kilo-newtonmeter	4.1868
Kilo-newtonmeter	Kilowatt-hour	0.00027
Kilowatt	BTU/minute	56.878
Kilowatt-hour	BTU	3413

TO CONVERT FROM	TO	MULTIPLY BY
Kilowatt-hour	Kilo-calorie	860
Kilowatt-hour	Joule	3,600,000
Liter	Cubic inch	61.023
Liter/minute	Gallon/second	0.0044029
Meter	Inch	39.370
Meter	Yard	1.0936
Microinch	Micrometer	25.4
Microinch	Millimeter	0.0254
Micrometer	Inch	0.000039370
Mile	Foot	5,280
Millimeter	Mil	39.370
Newton	Pound-force	0.22481
Ohm-circular mil/foot	Ohm-square mil/foot	1.273
Ohm-circular mil/foot	Ohm-square millimeter/meter	0.00166
Ohm-circular mil/foot	Microohm centimeter	0.16624
Ounce	Pound	0.0625
Ounces (US) (fluid)	Cubic inch	1.8047
Ounces (US) (fluid)	Liter	0.02957
Ounce (troy)	Gram	31.10
Ounce (troy)	Grain	480
Ounce (troy)	Pounds (troy)	0.083333
Pound	Gram	453.59
Pound	Grain	7,000
Pound	Kilogram	0.45359
Pounds (troy)	Grain	5760
Pounds (troy)	Gram	373.24
Pounds (troy)	Pound	0.82286
Square centimeter	Square inch	0.15500
Square foot	Square meter	0.092903
Square inch	Square centimeter	6.45
Square meter	Square foot	10.76
Square millimeter	Circular mil	1973.5
Square mil	Circular mil	1.2732
Square mil	Square centimeter	0.0000064516
Square mil	Square inch	0.000001
Stone	Pound	14
Watt	Foot-pound/minute	44.254
Watt	Kilo-calorie/minute	0.014331

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Alleima's quality management systems are approved by internationally recognized organizations. We hold certificates such as the ASME Quality Systems Certificate as a materials organization, along with ISO 9001, ISO/TS 16949, ISO 17025, and PED 97/23/EC approvals. We also have product and shop approvals from bodies like T.V, JIS, DNV, and Lloyd's Register.

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Environmental awareness, health, and safety are integral to our business and prioritized in all our operations. We hold ISO 14001 and OHSAS 18001 approvals.

Recommendations are for guidance only, and the suitability of a material for a specific application can only be confirmed when the actual service conditions are known. Continuous development may result in changes to technical data without notice.

This document applies only to Kanthal® materials. Other materials that meet the same international specifications may not necessarily possess the same mechanical and corrosion properties described here.

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