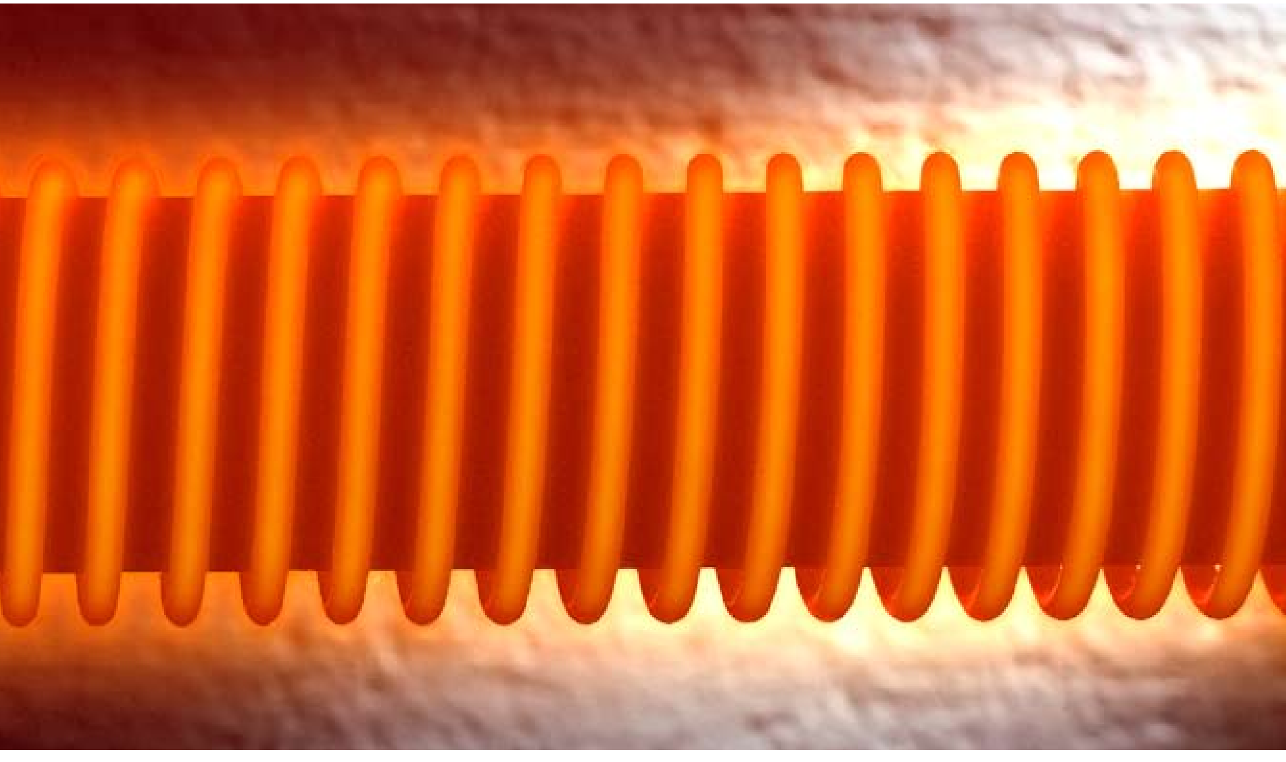
Resistance Heating Alloys and Systems for Industrial Furnaces



KANTHAL

Catalogue 1-A-5B-3 US 11-07-3000

Resistance Heating Alloys and Systems for Industrial Furnaces

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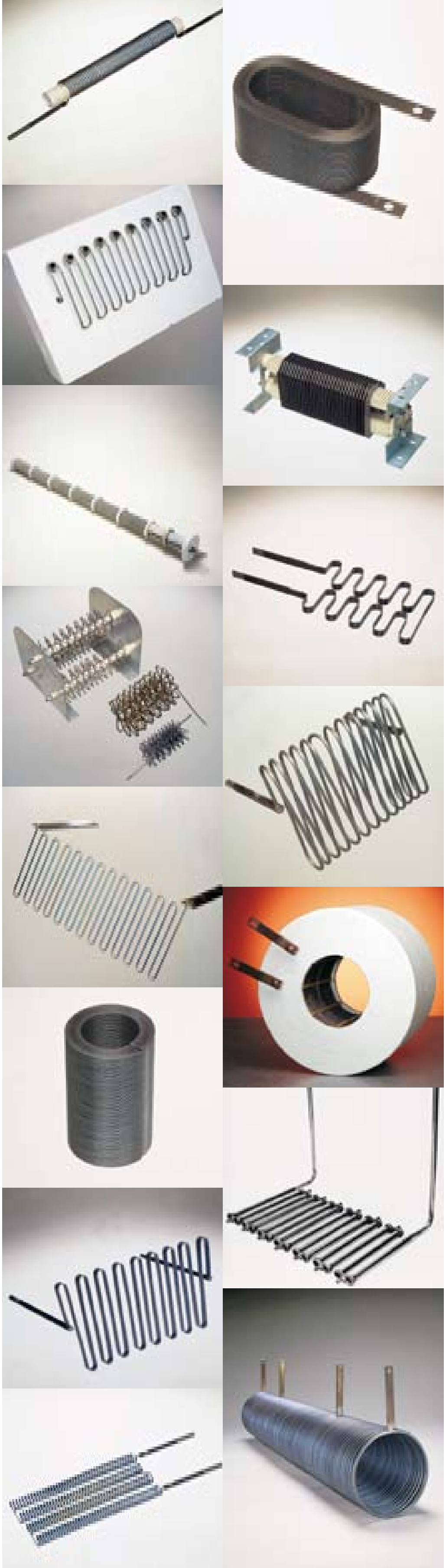


Metallic Heating Elements from Kanthal

This booklet contains technical data for our resistance heating alloys KANTHAL and NIKROTHAL.

We also include some instructions for the calculation and design of heating elements for industrial furnaces as well as examples of support systems and insulation. Out of the KANTHAL PM (powder metallurgical/production route) group tubes are only shortly described, detailed information is found in KANTHAL PM tubes handbook.

The latest product- and application information is found on **www.kanthal.com**.

We can assist you:

- in choosing suitable element material, element type, support system and insulation,
- by supplying complete heating elements ready for installation,
- in upgrading both electrical and gas heated furnaces by delivering technical solutions based on latest material technology rendering maximum productivity and economy
- to replace radiant tubes with KANTHAL APM tubes in both gas- and electrically heated furnaces and to supply complete recuperative burner systems (ECOTHAL® – SER).

Our modern workshops have developed considerable experience in manufacturing heating elements and can manufacture to any specifications.

Our delivery times are short and our service objectives are high.

KANTHAL or NIKROTHAL?

There are two main types of electric resistance alloys. Nickel-chromium (e.g. 80 Ni, 20 Cr) called NIKROTHAL was developed around the beginning of the 20th century and was soon used as heating element material in industrial furnaces as well as in electric household appliances.

In the thirties Kanthal introduced a new resistance heating alloy (called KANTHAL) based on iron-chromium-aluminum with a longer life and a higher maximum operating temperature than nickel-chromium. Kanthal manufactures both types of alloys under the names NIKROTHAL (nickel-chromium) and KANTHAL (iron-chromium-aluminum).

The two main types of alloys have their own specific properties, with advantages and disadvantages, and are supplied in many different grades and forms.

In general KANTHAL type alloy is superior to NIKROTHAL in respect of performance and life and is therefore nowadays a standard material choice when it comes to metallic heating elements for industrial furnaces.

The NIKROTHAL alloy may have special advantages if you need a heating element having very good mechanical properties in the hot state. KANTHAL APM has, however, creep strength at elevated temperatures in the same level as NIKROTHAL.

For the furnace user, using KANTHAL results in less amount of material at a lower price and also – a longer life. Table 1 shows an example of weight saving – and lower cost – obtained by using KANTHAL instead of nickel-chromium alloys. This lower element weight will also result in considerable cost savings regarding support system, because fewer suspension hooks are necessary.

The most important advantages with KANTHAL type alloy are:

- Higher maximum temperature of 2600°F compared to 2280°F
- Longer life (2–4 times)
- Higher surface load
- Higher resistivity
- Lower density
- No spalling oxide, which may contaminate the goods and the furnace and also cause short circuit or failure of elements and gas burners.

Weight saving based on same wire diameter:

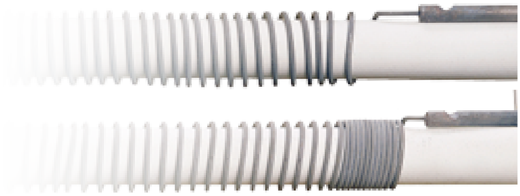
[lb]
$$\frac{98-65}{98} = 33\%$$

Element Data	NIKROTHAL	KANTHAL
Furnace temperature [°F]	1830	1830
Element temperature [°F]	1955	2025
Hot resistance [R_w]	3.61	3.61
Temperature factor [C_t]	1.05	1.06
Cold resistance [R_{20}]	3.44	3.41
Wire diameter [in]	0.217	0.217
Surface load [W/in²]	19.9	25.7
Wire length [ft] 3 elements	738	573
Wire weight [lb] 3 elements	98	65

Table 1 A 120 kW furnace equipped with R.O.B. elements. 3 elements of 40 kW each, 380 V.

KANTHAL APM Heating Material

KANTHAL APM is a resistance material which can be used to improve the performance at high temperatures, where conventional metallic elements are getting problems like bunching, creeping, oxide spallation and to open up new applications where metallic elements are not used today.



Comparison between KANTHAL APM (top) and conventional FeCrAl after 1250 h at max 2240°F element temperature.

The Great Advantages of KANTHAL APM are:

Improved hot strength, giving:

- much better form stability of the heating element
- less need for element support
- low resistance change (ageing)
- longer element life

Excellent oxide, giving:

- good protection in most atmospheres, especially corrosive atmospheres
- no scaling and impurities
- a longer element life

Creep Rupture Strength for Industrial Wire 0.16 in

Time [h]	Temp. 1830°F [psi]
100	724
1000	449
10000	304

Time [h]	Temp. 2190°F [psi]
100	478
1000	232
10000	87

Time [h]	Temp. 2550°F [psi]
100	188
1000	72

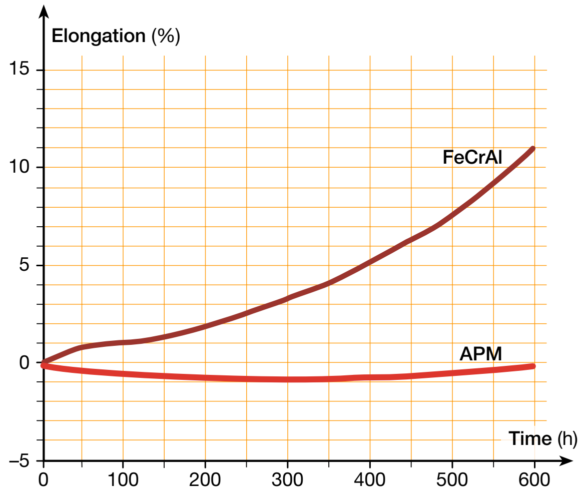


Fig. 1 Elongation at 2370°F element temperature.

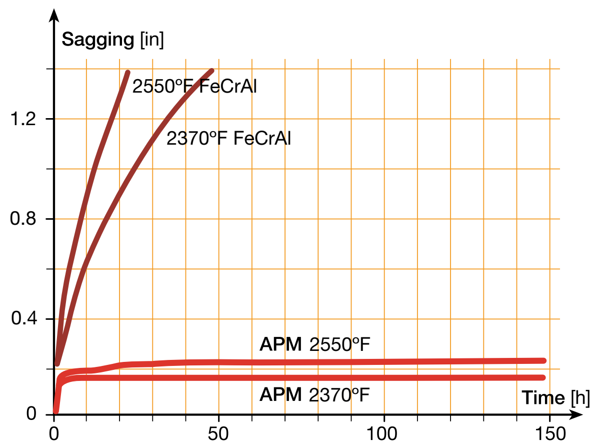


Fig. 2 Sagging test dia. 0.37 in, 2370°F and 2550°F, 300 in between supports.

Physical and Mechanical Properties

KANTHAL and NIKROTHAL alloys are generally available in wire, ribbon or strip form. Physical and mechanical properties of the alloys are listed in Table 2. C_t factor see page 23 and following.

		KANTHAL APM	KANTHAL A-1	KANTHAL AF	KANTHAL D	NIKROTHAL 80	NIKROTHAL 70	NIKROTHAL 60	NIKROTHAL 40
Max continuous operating temp.	**[°F]**	2600	2550	2370	2370	2190	2280	2100	2010
Nominal composition	**% Cr**	22	22	22	22	20	30	15	20
	Al	5.8	5.8	5.3	4.8	–	–	–	–
	Fe	Balance	Balance	Balance	Balance	–	5 %	Balance	Balance
	Ni	–	–	–	–	Balance	Balance	60	35
Resistivity at 68°F	**[Ω/cmf]**	872	872	836	842	655	704	668	626
Density	**[lb/in^3]**	0.256	0.256	0.259	0.262	0.300	0.296	0.296	.0285
Coefficient of	**68–1380°F**	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}	18×10^{-6}
thermal expansion, K^{-1}	**68–1830°F**	15×10^{-6}	15×10^{-6}	15×10^{-6}	15×10^{-6}	17×10^{-6}	17×10^{-6}	17×10^{-6}	19×10^{-6}
Thermal conductivity at 68°F	**[$W\,in^{-1}\,F^{-1}$]**	0.18	0.18	0.18	0.18	0.21	0.18	0.18	0.18
Specific heat capacity at 68°F	**[$Btu\,lb^{-1}\,F^{-1}$]**	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.119
Melting point	**[°F]**	2730	2730	2730	2730	2550	2515	2535	2535
Mechanical properties (approx.)*									
Tensile strength	**[psi]**	99000	99000	99000	95000	118000	119000	106000	98000
Yield point	**[psi]**	68000	69000	69000	66000	61000	63000	54000	49000
Hardness	**[Hv]**	230	230	230	230	180	185	180	180
Elongation at rupture	**[%]**	20	18	18	18	30	30	35	35
Tensile strength at 1650°F	**[psi]**	5800	4900	5400	4900	15000	17000	15000	17000
Creep strength at 1470°F	**[psi]**	1600	870	1200	870	2200	2200	2200	2900
at 1830°F	**[psi]**	490	145	220	145	580	580	580	580
Magnetic properties		Magnetic (Curie point 1100°F)				Non	Non	Slightly	Non
Emissivity, fully oxidized condition		0.70	0.70	0.70	0.70	0.88	0.88	0.88	0.88

*) The values given apply for wire sizes of 0.16 in diameter for Kanthal alloys and of 0.04 in for NIKROTHAL alloys.

Table 2 KANTHAL and NIKROTHAL basic data.

Furnace Wall Loading

Figure 3 shows the maximum recommended wall loading for four different element types. Please note that the furnace wall loading depends on both element type and element surface load. The lower the surface load, the longer the element life will be. (For description of the element types, see page 9).

When elements are placed on the base of a furnace, special attention must be paid to avoid overheating of the elements. For example, with a hearth plate having a thermal conductivity of (λ) = 0.014 W in^{-1} F^{-1} and thickness of 0.63 in *(at a power concentration on the bottom surface of 1.4 kW/ft²)* a temperature drop of 435°F is obtained through the plate. The total temperature difference between the base elements and the furnace temperature would thus be about 705°F. This imposes a furnace operating temperature of 1830°F even when using the high-temperature KANTHAL A-1 alloy, since the element temperature will be about 2505°F.

The example illustrates the significance of choosing a hearth plate of a material having good thermal conductivity, for example silicon carbide or heat-resistant steel. Beside measuring the temperature in the furnace chamber, it may also be advisable to measure the temperature of the base elements by a separate thermocouple.

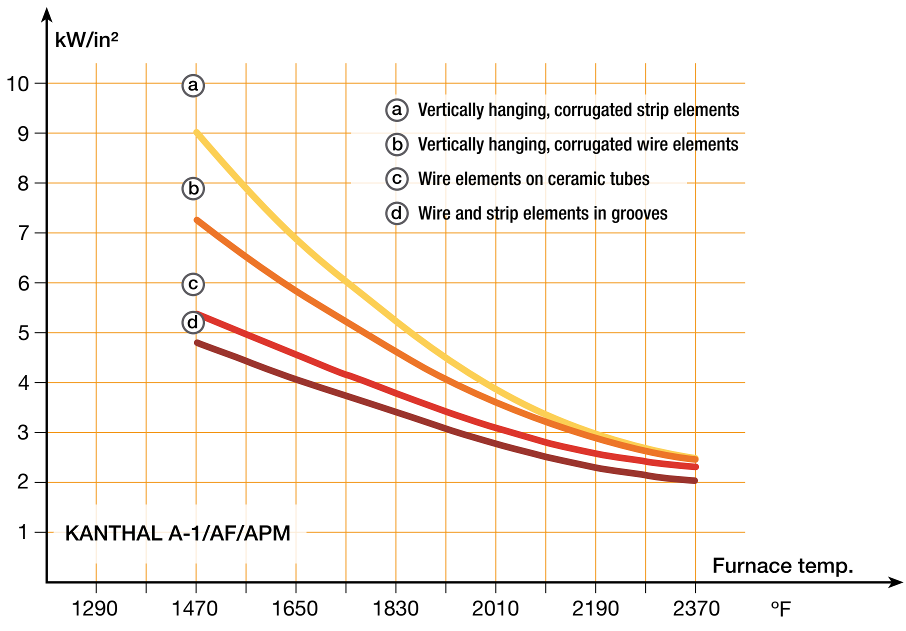


Fig. 3 Maximum recommended wall loading as a function of furnace temperature for different element types.

Element Surface Load

Since KANTHAL alloys can be operated at higher temperatures than NIKROTHAL alloys, a higher surface load can be accepted without jeopardizing the life. Element design is also of great importance. The more freely radiating the element form, the higher the maximum surface load can be. Therefore the R.O.B. (Rod Over Bend) type element (corrugated heavy wire, mounted on the surface), can be loaded the highest, followed by the corrugated strip element.

Spiral elements on ceramic tubes can be loaded higher than spiral elements in grooves. The values in Figure 4 are given for the following design conditions:

Element types a (heavy wire) and b (strip): Strip thickness min. 0.1 in. Wire diameter min. 0.2 in. Pitch min. 1.97 in at maximum loop length and maximum surface load.

Maximum recommended loop length:

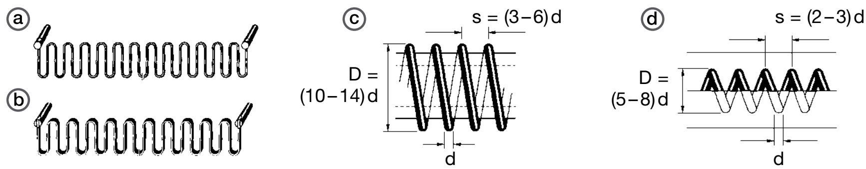
<1650°F	11.8 in
1830°F	9.8 in
2010°F	7.9 in
2190°F	5.9 in
2370°F	3.9 in

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. Wire diameter min. 0.12 in.

Element type d: Wire and strip element in grooves. Wire diameter min. 0.12 in, strip thickness min. 0.8 in.

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



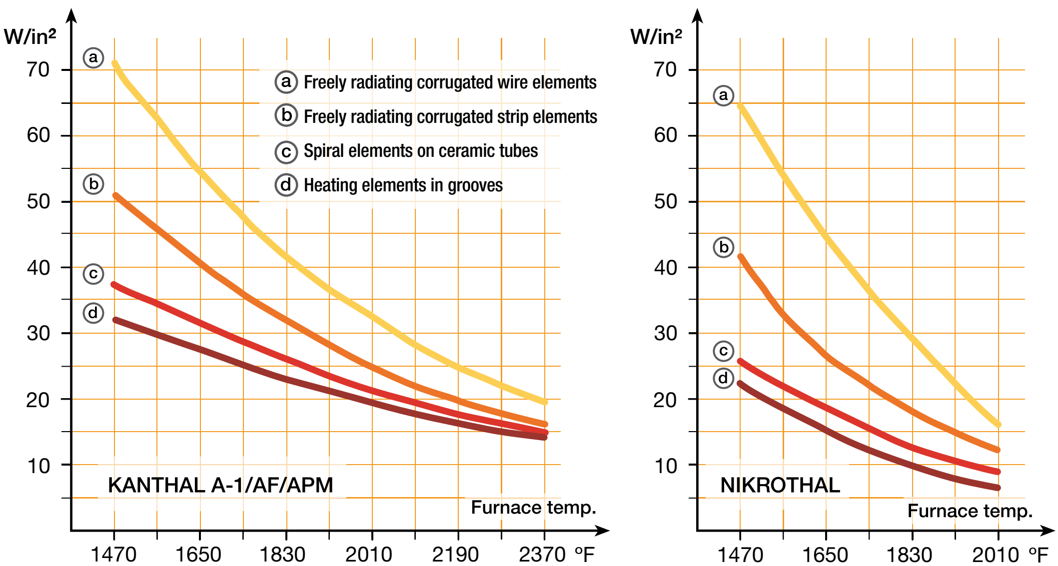


Fig. 4 Maximum recommended surface loads for KANTHAL and NIKROTHAL alloys in industrial funaces.

Operating Life and Maximum Permissible Temperature

When heated, resistance heating alloys form an oxide layer on their surface, which prevents further oxidation of the material. To accomplish this function the oxide layer must be dense and resist the diffusion of gases. It must also be thin and adhere to the metal under temperature fluctuations.

In these respects the aluminum oxide formed on KANTHAL alloys is might be even better than the oxide formed on NIKROTHAL alloys, which contributes to the much longer operating life of Kanthal heating elements. Figure 5 shows the comparative element life.

Below you will find some general advice to obtain as long element life as possible.

Use KANTHAL Alloys

Heating elements made of KANTHAL alloys have 2–4 times longer life than heating elements made of nickel-chromium material. The higher the temperature, the greater the difference.

Avoid Temperature Fluctuations

The operating life of the heating elements will be reduced by rapid temperature fluctuations. It is therefore advisable to choose an electric control equipment, which gives as even a temperature as possible, e.g. by using thyristors.

Choose Thick Element Material

The material thickness has a direct relationship to the element life, in that, as the wire diameter is increased, more alloying element is available per surface unit to form a new oxide. Thus, at given temperature, thicker wires will give a longer life than thinner wires. Accordingly, for strip elements, increased thickness gives a longer life. As a general rule, we recommend min. 0.12 in wire diameter and 0.8 in strip thickness.

Adjust the Element Temperature to the Furnace Atmosphere

Table 3 shows some common furnace atmospheres and their influence on the maximum operating temperature of the heating elements. NIKROTHAL should not be used in furnaces having a CO-containing protective gas atmosphere due to the risk of "green rot" at 1470–1740°F.

In such cases KANTHAL alloys are recommended, provided the heating elements are preoxidized in air at 1920°F for 7–10 hours. Reoxidation of the heating elements should be carried out at regular intervals.

Avoid Corrosion from Solid Substances, Fluids and Gases

Impurities in the furnace atmosphere, for instance oil, dust, volatiles or carbon deposits can damage the heating elements.

Sulphur is harmful to all nickel alloys. Chlorine in different forms will attack both KANTHAL and NIKROTHAL alloys. Splashes of molten metal or salt may also damage the heating elements.

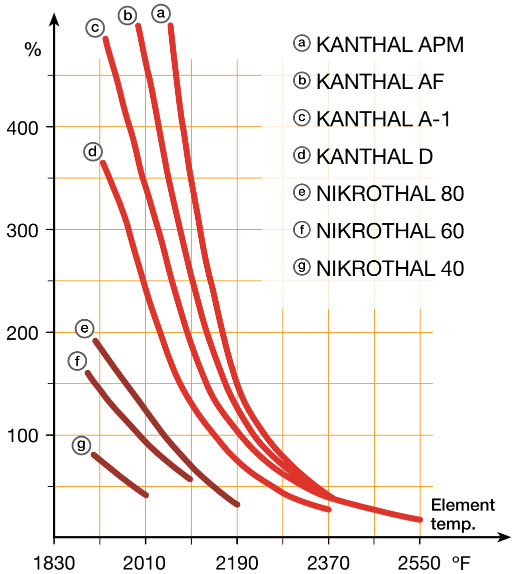


Fig. 5 Comparative life (KANTHAL A-1 at 2190°F = 100%)

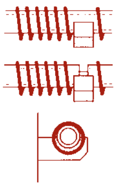
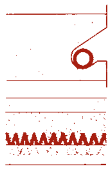
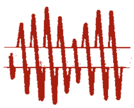
	KANTHAL A-1 and APM [°F]	KANTHAL AF [°F]	KANTHAL D [°F]	NIKROTHAL 80 and 70 [°F]	NIKROTHAL 60 [°F]	NIKROTHAL 40 [°F]
Oxidizing:						
Air, dry	2550[a]	2370	2370	2190[d]	2100	2010
Air, moist	2190	2190	2190	2100	2010	1920
Neutral:						
N_2, Nitrogen[b]	2190	2280	2100	2280	2190	2100
Ar, Argon	2550[a]	2370	2370	2280	2190	2100
Exothermic:						
10 CO, 15 H_2, 5 CO_2, 70 N_2	2100	2100	2010	2010[c]	2010	2010
Reducing:						
Endothermic:						
20 CO, 40 H_2, 40 N_2	1920	1920	1830	2010[c]	2010	2010
H_2, Hydrogen	2550[a]	2370	2370	2280	2190	2100
Cracked ammonia:[e]						
75 H_2, 25 N_2	2190	2190	2010	2280	2190	2100
Vacuum:						
10^{-3} torr	2100	2190	2010	1830	1650	1650

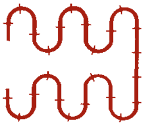
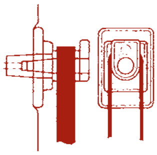
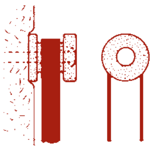
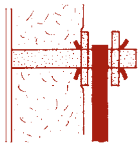
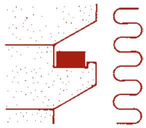
a) Max 2600°F for APM
b) The higher values apply for pre-oxidized material.
c) Please note risk of “green rot” formation in carburizing atmospheres. Use KANTHAL AF or NIKROTHAL 70.
d) 2280°F for NIKROTHAL 70.
e) An atmosphere created by cracked ammonia, that contains uncracked ammonia, will lower the max. permissible temperature.

Table 3 Maximum permissible temperatures in various atmospheres.

Key Data for Kanthal Elements

Table 4

		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. furnance temperature	**[°F]**	2370	2280	8147000	2370
Max. wall loading at 1830°F furnace temperature	**[kW/ft²]**	3.7	3.3	–	4.6
Max. surface load at 1830°F furnace temperature	**[W/in²]**	19–26	19–26	–	32–39
Wire diameter (d)	**[in]**	0.08–0.26	0.08–1.97	0.04–0.26	≥1.97
Strip thickness (t)	**[in]**	–	–	–	–
Strip widht (w)	**[in]**	–	–	–	–
Outer coil diameter (D)	**[in]**	(12–14) d	(5–6) d	–	–
Max. loop length at 1830°F furnace temperature	**[in]**	–	–	–	9.8
Min. pitch at max. loop length	**[in]**	3d	2d	3d	1.57

		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
2370	2370	2370	2370	2370	2370
4.6	5.6	5.6	5.6	5.6	1.9–3.7
19–39	32–39	32–39	32–39	32–39	19–26
0.08–1.97	≥1.97	–	–	–	–
–	–	0.08–0.12	0.08–0.12	0.08–0.12	0.06–0.12
–	–	(8–12) t	(8–12) t	(8–12) t	(8–12) t
–	–	–	–	–	–
3.9	9.8	9.8	9.8	9.8	(2–3) w
1.57	1.57	1.97	1.97	1.97	1.5 w

Kanthal TUBOTHAL – the Most Powerful Metallic Element System

Kanthal TUBOTHAL is an ideal electric element used in combination with PM tubes because of its great advantages, such as – very high power – long life – low weight – easy to design to existing power controls and supply. Combined with APM tubes, a "maintenance free system" is obtained with high reliability and with no need to remove elements, clean or rotate tubes, if correctly designed.

The variety of applications where the TUBOTHAL system can be used is vast. The main areas of use are in heat treatment, aluminum and steel industry furnaces.

The high loading capabilities of both TUBOTHAL elements and KANTHAL APM tubes can be exploited to the full in new furnaces and conversions from traditional radiant tube designs. In both cases, higher power and/or higher temperatures can be obtained, or a similar output can be achieved with fewer assemblies installed, leading to improved furnace flexibility and lower costs. The longer life obtained with the TUBOTHAL system, ensures highly reliable production and uninterrupted furnace operation.

TUBOTHAL element assemblies are available in a wide range of standard diameters, to suit the sizes of tubes currently available. In principle, the length of element is virtually unlimited, but the practicalities of packing, shipping and installation may impose restrictions on the usable length. TUBOTHAL elements are suitable for both horizontal and vertical installations.

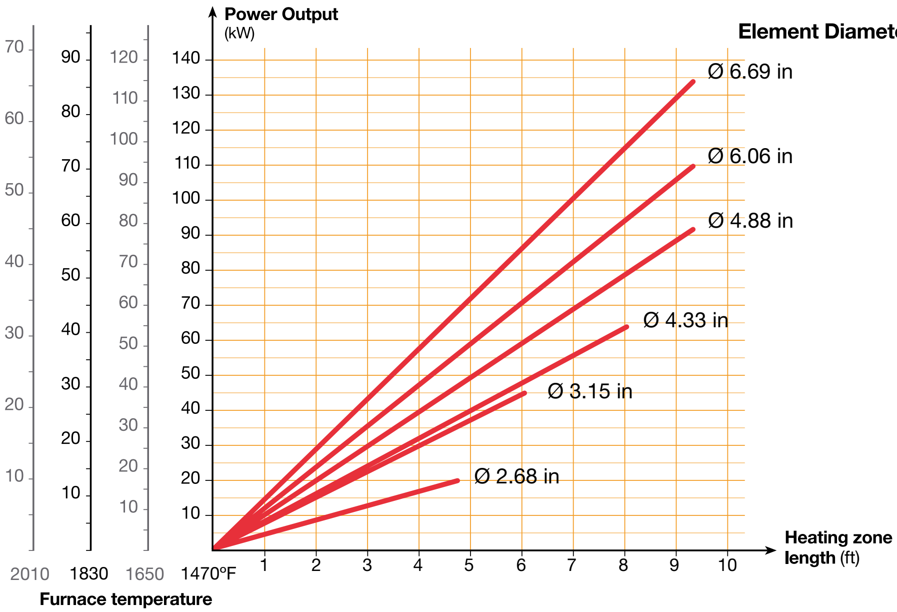


Fig. 13 Maximum design power outputs for all standard element diameters at different furnace temperatures.

Normally, horizontal tubes are simply supported at both ends. With very long radiant tubes, it may be necessary to provide supports along the tube length. KANTHAL APM rod has proved ideal for fabricating suitable support systems, hooks, etc.

Higher Power Output

TUBOTHAL elements will operate at a far higher power output than standard designs of radiant tube elements. A single TUBOTHAL assembly may be capable of replacing up to three heaters of a more conventional design, leading to major savings in replacement and maintenance costs.

In other cases, a change to TUBOTHAL, combined with uprated power input to the existing furnace, has resulted in improved furnace capacity at a much lower cost compared to a completely new furnace.

Fitting a few TUBOTHAL assemblies in an existing furnace can increase productivity by over 50 %, in some cases.

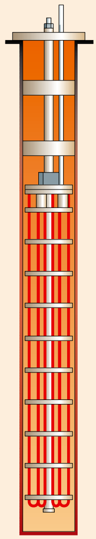
The power output for standard TUBOTHAL elements is a function of element diameter, effective heating length and operating temperature of the furnace. Figure 11, illustrates suggested maximum design power outputs for all standard element diameters, at furnace temperatures between 1470°F and 2010°F.

Power Supply

Although individual elements can operate at a voltage lower than that of the supply. In multiple element installations, groups of elements can be series – connected directly to the main voltage without the need of transformers. There is no significant ageing of the APM elements, so a variable voltage supply is not required. On/off control can be used, but three-term control, using fast or slow, cycle fired thyristors, will ensure a more stable element temperature and a longer element life, as well as offering better control of the furnace temperature.

Kanthal TUBOTHAL Benefits

- Very high power levels
- Long life
- "Maintenance free", longer service intervals
- Low ageing
- Low element weight
- Low thermal mass
- Standardised product for fast delivery and reliability
- Design flexibility
- KANTHAL PM tubes can also be used for gas heated solutions based on that the system is well prepared for changes depending on energy prices.



Vertical and horizontal TUBOTHAL element systems.

KANTHAL PM Material

The Kanthal family of high temperature materials is aimed initially at the manufacture of resistance wire and strip for electric furnace applications. KANTHAL PM (Powder metallurgy) tubes, APM and APMT, are seamless and produced by extrusion. KANTHAL PM tubes are suitable for a wide range of temperatures and atmospheres, covering many applications and processes in various industries.

KANTHAL PM materials are based on the well-known Kanthal FeCrAl alloy, the basis for electric elements in many different types of kiln and furnace for over 70 years. The PM materials are produced by an Advanced Powder Metallurgy process route. The PM alloys maintain all of the benefits of the traditional Kanthal alloys and add many more. The most obvious benefit is the higher mechanical strength achieved by dispersion strengthening.

KANTHAL APMT is a further development of KANTHAL APM, designed for specially demanding applications. The alloy has the same excellent high temperature corrosion resistance as APM, but with even higher strength.

More Power, Longer Life Less Maintenance
Kanthal metallic PM material has been successfully used for many years in the form of wire, strip, radiant and protection tubes. Used mainly in the heat treatment, steel and aluminum industries, KANTHAL PM tubes contribute to much higher furnace productivity by offering more power, less maintenance and longer service life.

KANTHAL PM tube range includes APM suitable for most types of processes, and APMT, an alloy with improved hot strength for extra demanding horizontal applications. KANTHAL PM tubes are suited to both gas and electrically heated furnaces.

Extra High Temperature
Can operate at temperatures up to 2280°F.

High Loading Potential
At a furnace temperature of 1830°F, the loading can be more than double that of NiCr and FeNiCr tubes. This allows more flexible furnace designs and conversion of existing heating systems to higher furnace power. Fewer tubes are needed for the same power rating.

Less Maintenance
The oxide is non-spalling, hence no scaling and no impurities inside the tube to contaminate the heating element or gas burner. No need for downtime to clean the tubes. No scaling on the outside and no contamination of the goods in the furnace.

Long Life

When heated, KANTHAL PM materials form an aluminum oxide (Al_2O_3) scale that protects the alloy from further corrosion and prolongs the service life, compared with ordinary NiCr or FeNiCr tubes.

No Tube Carburization

The alumina oxide protects the alloy from carburization in high carbon-potential atmospheres.

KANTHAL PM materials withstand coking and metal dusting.

No Weak Spots

Tubes are extruded, so there are no welded seams, eliminating a source of potential failure.

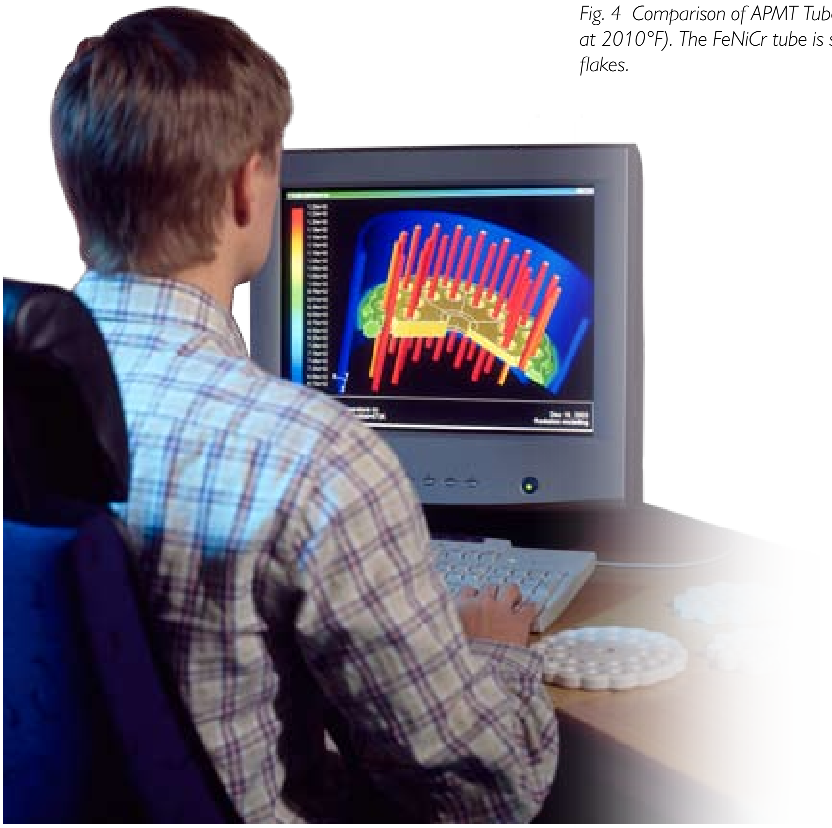
Excellent Form Stability

Excellent form stability even at elevated temperatures.

Low Weight

KANTHAL PM tubes weigh less than equivalent NiCr and FeNiCr tubes of the same dimension.

Fig. 4 Comparison of APMT Tube vs. Fe-35Ni-25Cr (after 2300 h at 2010°F). The FeNiCr tube is severely contaminated with oxide flakes.



Gas Fired Systems

Straight Through Tubes

In its simplest form, a radiant tube consists of a straight tube, with the burner fitted at one end and the exhaust chamber at the outlet. These straight through tubes, although simple and relatively inexpensive, are inherently inefficient, as the temperature of the exhaust gases is significantly higher than the furnace temperature, and the majority of the energy of combustion is lost to the surroundings.

Radiant Tubes for Recuperative Systems – SER Burner Systems

The majority of burners in use today are of a single ended design, where the burner and exhaust chamber are situated on the same side of the furnace. With these designs, the exhaust gases can be used to pre-heat the air required for combustion. This results in a major improvement in system efficiency, by exhausting only low temperature gases into the atmosphere. Common designs are U, W, and P shaped tubes, but these are gradually being replaced by less expensive and lighter single-ended recuperative burners, SER. With this design, the recuperator is integrated within the tube. Recovery of heat from the exhaust gases takes place within the furnace wall, minimising heat loss in the process.

Modern, high efficiency SER burner systems offer efficiencies in excess of 80 % and are highly cost effective compared with direct fired systems and straight through designs of radiant tubes. The inherent reliability and temperature capability of KANTHAL PM tubes make them an ideal partner and the preferred choice for the most modern burner systems.

With SER burners, the limiting factor in the design is normally the inner tube, which operates at a significantly higher temperature than the outer tube. Even in low temperature applications, the inner tube temperature can exceed the practical maximum for Ni-Cr materials, especially when the burner output is high. This has imposed severe limitations on the output of radiant tube designs.

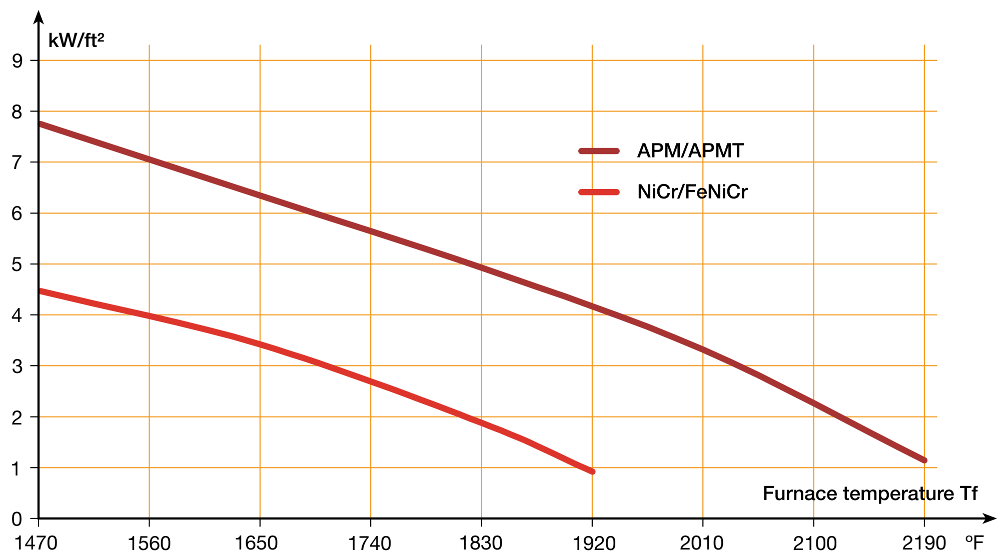


Fig. 10 Power output SER-burner systems.

KANTHAL PM radiant tubes however, are capable of far higher operating temperatures than NiCr. This has allowed burner manufacturers to exploit the higher outputs of modern designs to the full, dissipating the same power input in the furnace with fewer tubes, or uprating the input to existing systems (Figure 10). The potential benefits, in terms of productivity and installed costs, are immense and the use of KANTHAL PM materials has extended the temperature range of radiant tube assemblies.

Silicon Carbide Inner Tubes

Silicon carbide can be combined with KANTHAL PM tubes in gas applications, where the temperature is higher or the power loading is higher than metallic tubes can endure. SER burner systems that work at very high temperature or high loading can be designed with a ceramic flame tube (inner). The flame tube is the part in the system that works at the highest temperature, often 210–390°F warmer than the outer tube. As outer tubes, KANTHAL PM tubes can work under tougher conditions than other metallic tubes and have better resistance to thermal shock than ceramic tubes. Flanges, end caps and support systems are much cheaper and easier to install for metallic systems compared to ceramic.

Vertical SER

Straight through

Horizontal SER


KANTHAL

KANTHAL APM-Tubes Standard Product Range

OD [in]	Wall thickness [in]	Weight APM [lbs/ft]	Weight APMT [lbs/ft]	Max. length [ft]	APM standard stock	APMT standard stock
1.05	0.11	1.02		42.6	•	
1.31	0.13	1.52		42.6	•	
1.33	0.24	2.49		34.4	•	
1.57	0.12	1.67		42.6	•	
2.00	0.25	4.23	4.29	23.0	•	•
2.38	0.15	3.31		26.2	•	
2.52	0.16	3.60	3.65	23.0	•	•
2.95	0.18	4.76	4.83	39.4	•	•
3.27	0.20	5.85	5.93	39.4	•	•
3.50	0.22	6.85	6.99	39.4	•	•
3.94	0.20	7.12	7.26	37.7	•	•
4.29	0.20	7.79		32.8	•	
4.53	0.22	9.00	9.14	26.2	•	•
5.04	0.22	10.08		39.4	•	
5.75	0.24	12.57		31.2	•	
6.06	0.24	13.30	13.51	26.2	•	•
6.46	0.24	14.25		23.0	•	
7.01	0.31	20.36		21.3	•	
7.80	0.35	25.47		16.4	•	

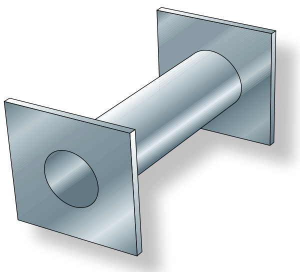
Tolerances

Tubes ≤ OD 1.97 in

OD	± 1.5 %, min ± 0.030 in
Wall thickness	± 15 %, min ± 0.024 in
Straightness	Max height of arc 0.12 in/39.37 in

Tubes > OD 1.97 in

OD	± 1 %
Wall thickness	± 15 %
Straightness	Max height of arc 0.12 in/39.37 in



PM tubes are also successfully used as muffles in sintering and mesh belt furnaces.

KANTHAL A-1

Wire Standard Stock Items. Strip Manufactured to Order.

Resistivity 872 Ω/cmf. Density 0.256 lb/in^3. To obtain resistivity at working temperature, multiply by factor C_t in following table.

°F	68	210	390	570	750	930	1110	1290	1470	1650	1830	2010	2190	2370	2550
C_t	1.00	1.00	1.00	1.00	1.00	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.05

Wire (at 68°F)

Dim. B&S	Resistance [Ω/ft]	Weight [lbs/1000 ft]
00	0.0064	317
0	0.0083	255
1	0.0104	202
2	0.0131	160
3	0.0166	127
4	0.0209	101
5	0.0264	79.8
6	0.0332	63.3
7	0.0419	50.2
8	0.0528	39.8
9	0.0666	31.6
10	0.0840	25.1
11	0.106	19.8
12	0.134	15.8
13	0.168	12.5
14	0.212	9.91
15	0.268	7.87
16	0.338	6.23
17	0.425	4.95
18	0.537	3.92

Strip (at 68°F)

Width [in]	Thickness [in]	Resistance [Ω/ft]	Weight [lbs/1000 ft]
1/2	0.04	0.0343	61.4
3/4	0.04	0.0228	92.2
1	0.04	0.0171	123
1/2	0.06	0.0228	92.2
3/4	0.06	0.0152	138
1	0.06	0.0114	184
1/2	0.08	0.0171	123
3/4	0.08	0.0114	184
1	0.08	0.0086	246
3/4	0.10	0.0091	230
1	0.10	0.0069	307
1 1/2	0.10	0.0046	461
1	0.12	0.0057	369
1 1/2	0.12	0.0038	553
1 3/4	0.12	0.0028	645

For minor dimensions please contact Kanthal directly. Contact information can be found on the back cover.

KANTHAL APM

Wire Standard Stock Items. Strip Manufactured to Order.

Resistivity 872 Ω/cmf. Density 0.256 lb/in³. To obtain resistivity at working temperature, multiply by factor C_t in following table.

°F	68	210	390	570	750	930	1110	1290	1470	1650	1830	2010	2190	2370	2550
C_t	1.00	1.00	1.00	1.00	1.00	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.04	1.05

Wire (at 68°F)

Dim. B&S	Resistance [Ω/ft]	Weight [lbs/1000 ft]
8.25*	0.0083	255
6.00	0.0156	135
5.50	0.0186	113
5.00	0.0225	93.7
4.50	0.0278	75.9
4.25	0.0312	67.7
4.00	0.0352	60.0
3.50	0.0460	45.9
3.00	0.0626	33.8
2.50	0.0901	23.4
2.00	0.141	15.0
1.50	0.250	8.44
1.00	0.563	3.75

*B&S 0

Strip (at 68°F)

Width [in]	Thickness [in]	Resistance [Ω/ft]	Weight [lbs/1000 ft]
1/2	0.04	0.0343	61.4
3/4	0.04	0.0228	92.2
1	0.04	0.0171	123
1/2	0.06	0.0228	92.2
3/4	0.06	0.0152	138
1	0.06	0.0114	184
1/2	0.08	0.0171	123
3/4	0.08	0.0114	184
1	0.08	0.0086	246
3/4	0.10	0.0091	230
1	0.10	0.0069	307
1 1/2	0.10	0.0046	461
1	0.12	0.0057	369
1 1/2	0.12	0.0038	553
1 3/4	0.12	0.0028	645

For minor dimensions please contact Kanthal directly. Contact information can be found on the back cover.

KANTHAL AF

Wire Standard Stock Items. Strip Manufactured to Order.

Resistivity 836 Ω/cmf. Density 0.259 lb/in³. To obtain resistivity at working temperature, multiply by factor C_t in following table.

°F	68	210	390	570	750	930	1110	1290	1470	1650	1830	2010	2190	2370	2550
C_t	1.00	1.00	1.01	1.01	1.02	1.03	1.04	1.04	1.05	1.05	1.06	1.06	1.06	1.06	1.07

Wire (at 68°F)

Dim. B & S	Resistance [Ω/ft]	Weight [lbs/1000 ft]
00	0.0063	324
0	0.0079	257
1	0.0100	204
2	0.0126	161
3	0.0159	128
4	0.0200	101
5	0.0253	80.5
6	0.0319	63.8
7	0.0402	50.6
8	0.0507	40.2
9	0.0639	31.8
10	0.0805	25.2
11	0.102	20.0
12	0.128	15.9
13	0.162	12.6
14	0.204	10.0
15	0.257	7.93
16	0.324	6.28
17	0.408	4.99
18	0.515	3.95

Strip (at 68°F)

Width [in]	Thickness [in]	Resistance [Ω/ft]	Weight [lbs/1000 ft]
1/2	0.04	0.0328	61.9
3/4	0.04	0.0219	92.2
1	0.04	0.0164	124
1/2	0.06	0.0219	92.9
3/4	0.06	0.0146	139
1	0.06	0.0109	186
1/2	0.08	0.0164	124
3/4	0.08	0.0109	186
1	0.08	0.0082	248
3/4	0.10	0.0088	232
1	0.10	0.0066	310
1 1/2	0.10	0.0044	464
1	0.12	0.0055	372
1 1/2	0.12	0.0036	558
1 3/4	0.12	0.0028	650

For minor dimensions please contact Kanthal directly. Contact information can be found on the back cover.

NIKROTHAL 80

Wire Standard Stock Items. Strip Manufactured to Order.

Resistivity 655 Ω/cmf. Density 0.300 lb/in^3. To obtain resistivity at working temperature, multiply by factor C_t in following table.

°F	68	210	390	570	750	930	1110	1290	1470	1650	1830	2010	2190
C_t	1.00	1.01	1.02	1.03	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.06	1.07

Wire (at 68°F)

Dim. B&S	Resistance [Ω/ft]	Weight [lbs/1000 ft]
00	0.00533	377
0	0.00621	298
1	0.00783	237
2	0.00988	188
3	0.0125	149
4	0.0157	118
5	0.0198	93.6
6	0.0250	74.2
7	0.0315	58.9
8	0.0397	46.7
9	0.0501	37.0
10	0.0630	29.4
11	0.0797	23.3
12	0.100	18.5
13	0.127	14.7
14	0.160	11.6
15	0.201	9.22
16	0.254	7.30
17	0.320	5.80
18	0.404	4.59

Strip (at 68°F)

Width [in]	Thickness [in]	Resistance [Ω/ft]	Weight [lbs/1000 ft]
1/2	0.04	0.0257	72
3/4	0.04	0.0172	178
1/2	0.6	0.0172	108
3/4	0.6	0.0114	162
3/4	0.8	0.0086	216
1	0.8	0.0064	288
1 1/4	0.8	0.0052	360
1	0.10	0.0052	360
1 1/2	0.10	0.0034	540
1 3/4	0.10	0.0029	630
1	0.125	0.0041	450
1 1/2	0.125	0.0028	675
1 3/4	0.125	0.0024	788

For minor dimensions please contact Kanthal directly. Contact information can be found on the back cover.

NIKROTHAL 70

Wire Standard Stock Items. Strip Manufactured to Order.

Resistivity 709 Ω/cmf[1]. Density 0.296 lb/in^3. To obtain resistivity at working temperature, multiply by factor C_t in following table.

°F	68	210	390	570	750	930	1110	1290	1470	1650	1830	2010	2190
C_t	1.00	1.01	1.02	1.03	1.04	1.05	1.05	1.04	1.04	1.04	1.05	1.05	1.06

Wire (at 68°F)

Dim. B&S	Resistance [Ω/ft]	Weight [lbs/1000 ft]
00	0.00533	368
0	0.00673	291
1	0.00848	231
2	0.0107	183
3	0.0135	145
4	0.0169	116

For minor dimensions please contact Kanthal directly. Contact information can be found on the back cover.

Terminals

Resistance and Weight Data.

Material	Resistivity [Ω/cmf]	Specific gravity [lb/in³]
KANTHAL APM	872	0.256
KANTHAL A-1	872	0.256
KANTHAL D	812	0.262

KANTHAL A-1

Dimension [in]	Resistance [Ω/ft]	Weight [lb/ft]
3/8	0.0062	0.340
1/2	0.0035	0.605
5/8	0.0022	0.945
3/4 (APM only)	0.00155	1.36

KANTHAL D

Dimension [in]	Resistance [Ω/ft]	Weight [lb/ft]
3/8	0.0058	0.347
1/2	0.0033	0.630
5/8	0.0021	0.965
3/4	0.0014	1.39

Kanthal – a World-Renowned Name Within the Field of Electric Heating

Since the early thirties, Kanthal has developed market leading, electric resistance alloy products and materials.

Our R&D efforts have always been directed at improving our materials to function fully at ever higher temperatures.

The centre for production, product development and metallurgy is in Hallstahammar, Sweden, whilst sales and production finishing plants are located around the world, close to our customers and operated through our subsidiaries and local representatives.

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The Sandvik Group is a global high technology enterprise with 41,700 employees and annual sales of approximately SEK 72 billion. Sandvik's operations are concentrated on its three core businesses of Sandvik Tooling, Sandvik Mining and Construction and Sandvik Materials Technology. Sandvik spends about 4 percent of is turnover on research and development.

Kanthal is a part of the business area Sandvik Materials Technology – a world-leading manufacturer of high-value-added products in advanced stainless steels, special alloys, metallic and ceramic resistance materials, as well as process plants and sorting systems.

As a member of the Sandvik Group, Kanthal has got full access to world-class competence within materials and process technology, as well as Sandvik Materials Technology's R&D-center in Sweden, which is one of the most distinguished in the world. Through Sandvik's global sales organisation Kanthal is represented in 130 countries.

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West facility in Hallstahammar, Sweden

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KANTHAL

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