

ELEKTRIFIZIERUNG VON THERMOPROZESSEN

5. FREIBERGER FEUERFEST-SYMPOSIUM
2023-04-24

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CONTENT

KANTHAL - AN ALLEIMA COMPANY

HEATING SYSTEMS PRODUCT PORTFOLIO FOR TPT

DECARBONIZING THE STEEL SECTOR

Alleima. A world-leading advanced materials company

High value-added products in advanced stainless steels and special alloys as well as products for industrial heating

Revenues

20,669

SEK M, 2023

Recycled steel

80%

in products

Originates from

1862

FTE's

~6,500

Sales

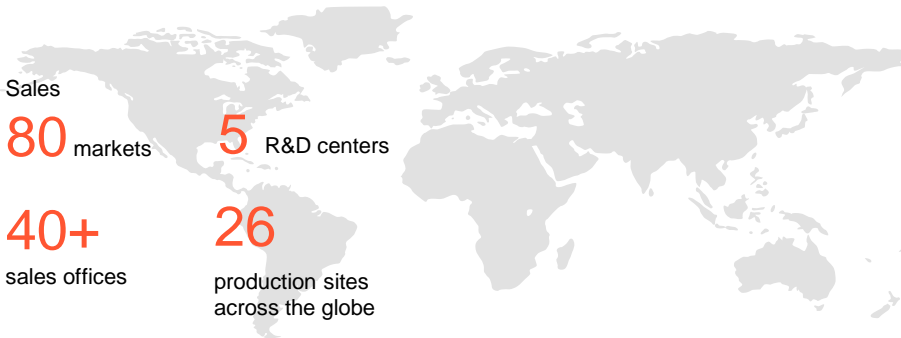
80 markets

5 R&D centers

40+

sales offices

26

production sites
across the globe

Customer segments



Industrial

Chemical and
Petrochemical

Oil and Gas



Industrial Heating



Consumer



Nuclear

Mining and
Construction

Transportation



Medical

Hydrogen and
Renewable energy

Europe

49%

Americas

2...

APAC

20%

Other

9%





KANTHAL
HEATING SYSTEMS
PRODUCT PORTFOLIO FOR TPT

KANTHAL®

FROM MELT TO FINISHED PRODUCT

With full control of the whole production chain – from raw material to finished product – we can ensure uniform and high-quality products

Melting

Ingot rolling

Billet rolling

Wire drawing

Powder-based
manufacturing

Ceramic:
 SiC , MoSi_2

Heating systems
incl. insulation

Process gas
heaters

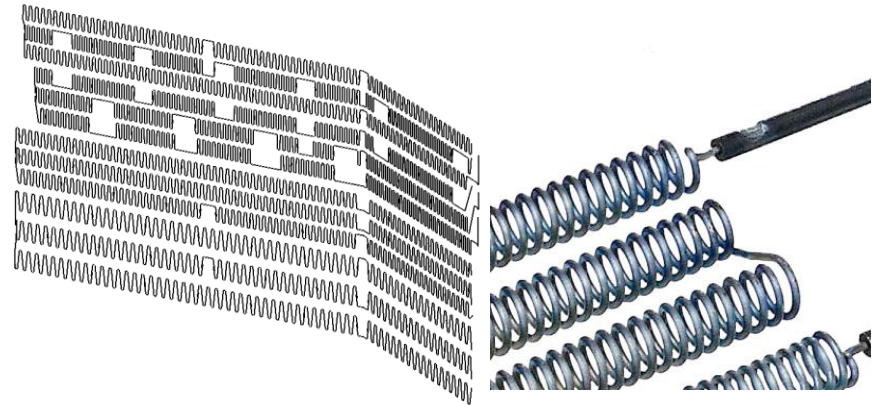
METALLIC ELEMENTS

THE CORE OF INDUSTRIAL HEAT

Wall loading 50 kW/m² @ T_f = 1,000°C

FeCrAl Alloys	T _{max} (°C)	Shapes
AF	1300	Wire, strip, SW tubes
A-1	1400	Wire, strip
APM	1425	Wire, strip, SL tubes

NiCr Alloys	T _{max} (°C)	Shapes
N40	1100	Wire
N70	1200	Wire, strip
N80	1250	Wire, strip

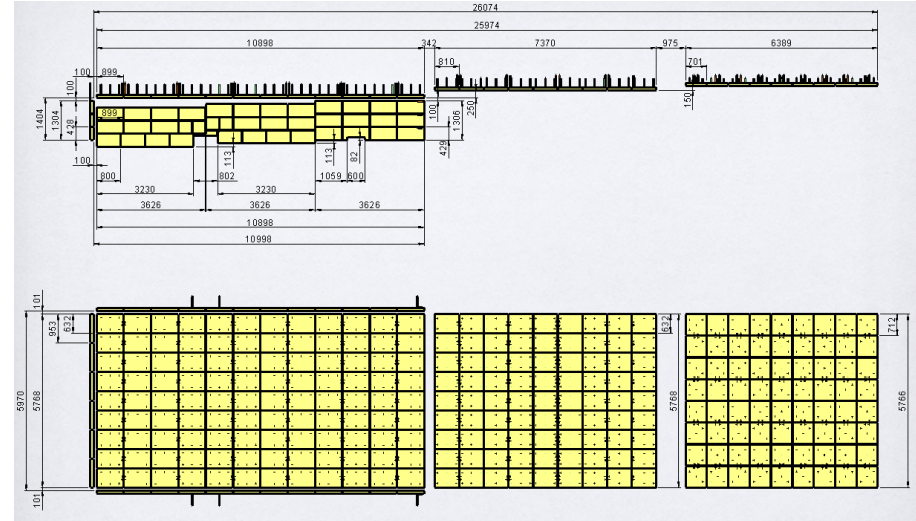


KANTHAL®

FIBROTHAL ©

HEATING + INSULATION IN ONE SYSTEM

- Modular designs – (almost) no limitations in shape
- Wall loading up to 100 kW/m²
- Typical insulation thickness 125 + 175 mm (for $T_f = 1100^\circ\text{C}$)



Case Re-heating kiln

Electrical Power 5 MW

Dimensions 26 x 5 x 1.6 m

KANTHAL®

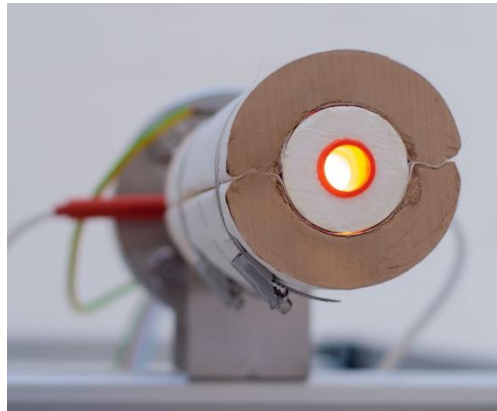
PROCESS GAS HEATERS

Direct heat, excellent process control.



PORCUPINE HEATING SYSTEMS

- 300...800°C
- < 0.1 bar_g
- Air (or non-dangerous gases)



KANTHAL FLOW HEATER / PROTHAL FH

- 800...1100°C
- 3.5 ... 800 kW
- 0...40 bar_g
- Clean Air, N₂, H₂, Syngases, ...

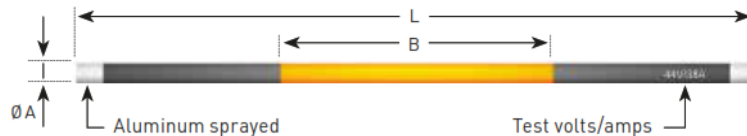


PROTHAL DH / PROTHAL NH

- 600...1,000°C
- 120... 2,000 kW
- 0..10 bar_g
- Air, N₂, H₂, Syngases, ...

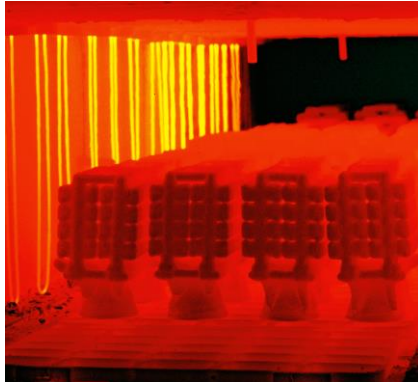
GLOBAR - SILICON CARBIDE ELEMENTS

- Typical temperature range 600...1600°C
- Higher loading compared to metallic elements
- Self stabilizing
- Multishank designs
- Ideal in continuous operation
- Typical diameter range 10...55 mm
- Heated length B up to 3.500 mm

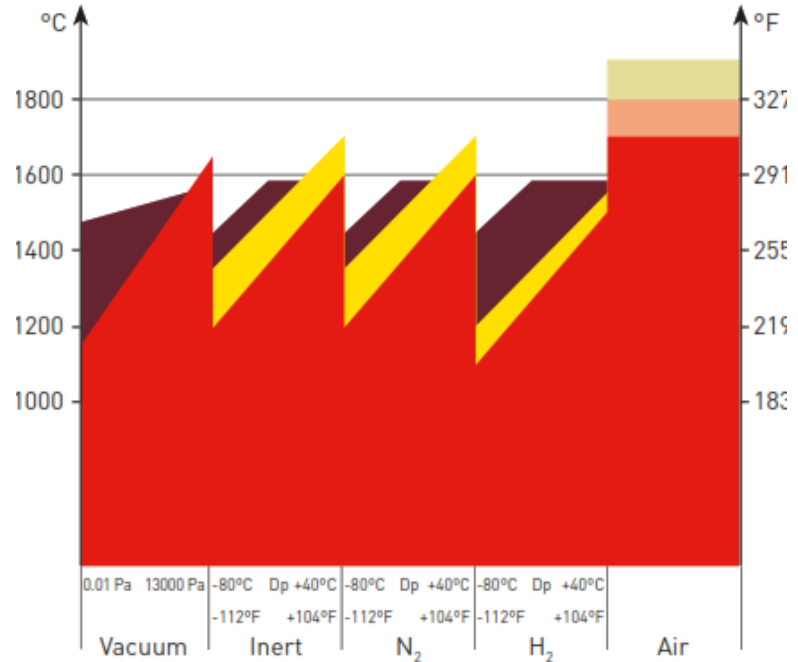


KANTHAL SUPER©

- Up to 1850°C element temperature
- > 2x higher loading than ME or SiC
- Fast thermal cycling possible without element degradation
- Longest life of all heating elements



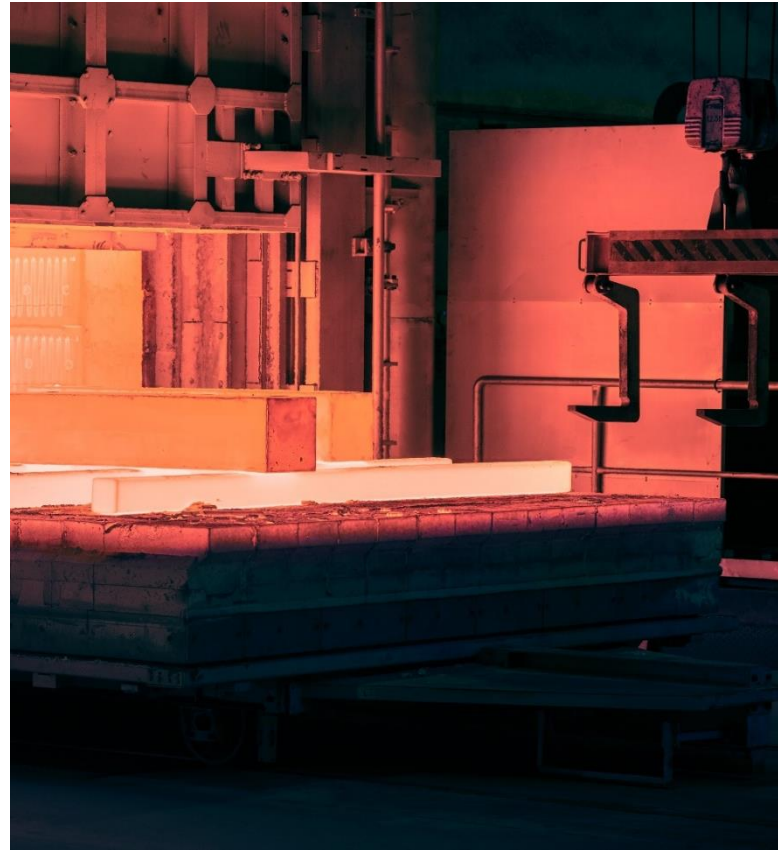
MAX TEMPERATURE IN DIFFERENT ATMOSPHERES



- Kanthal® Super ER
- Kanthal® Super RA
- Kanthal® Super 1700
- Kanthal® Super 1800
- Kanthal® Super 1900, Kanthal® Super HT, Kanthal® Super NC

ELECTRIFICATION BENEFITS

- 1) High efficiency (> 95% possible)
- 2) Excellent temperature control: $\pm 1^\circ\text{C}$
- 3) Reduction of CO₂ emissions, zero if renewable energy is used
- 4) Elimination thermal NO_x and SO_x emissions
- 5) Safer and quieter production environment

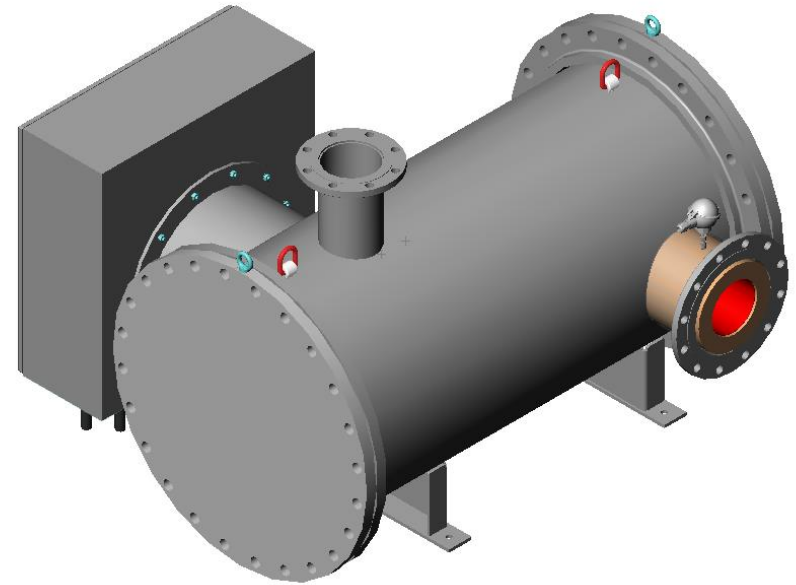


DECARBONIZING THE STEEL SECTOR

GAS PRE-HEATING PRIMARY STEEL

Process gas heater specification

Power	10 x 540 kW
Medium	Air
Operating pressure	3.9 barg
Flow rate	333...1666 m ³ /h
Inlet temperature	20...150°C
Outlet temperature	850°C
Dimensions	DN700 x 1500
Weight	1200 kg
Commissioning	2025



LADLE AND TUNDISH HEATING

- Heating of tundishes and ladles in secondary steelmaking drying and pre-heating processes
- Current state: Gas-fired, open burners with low overall efficiency, noisy and generating CO₂-emissions
- Challenges with power density, heating times and heating bottom of large ladles
- Electrification with ceramic heating solutions (SiC, MoSi₂) – *Remove emissions, quieter, Temperature control*



RE-HEATING FURNACES

1250-1300°C

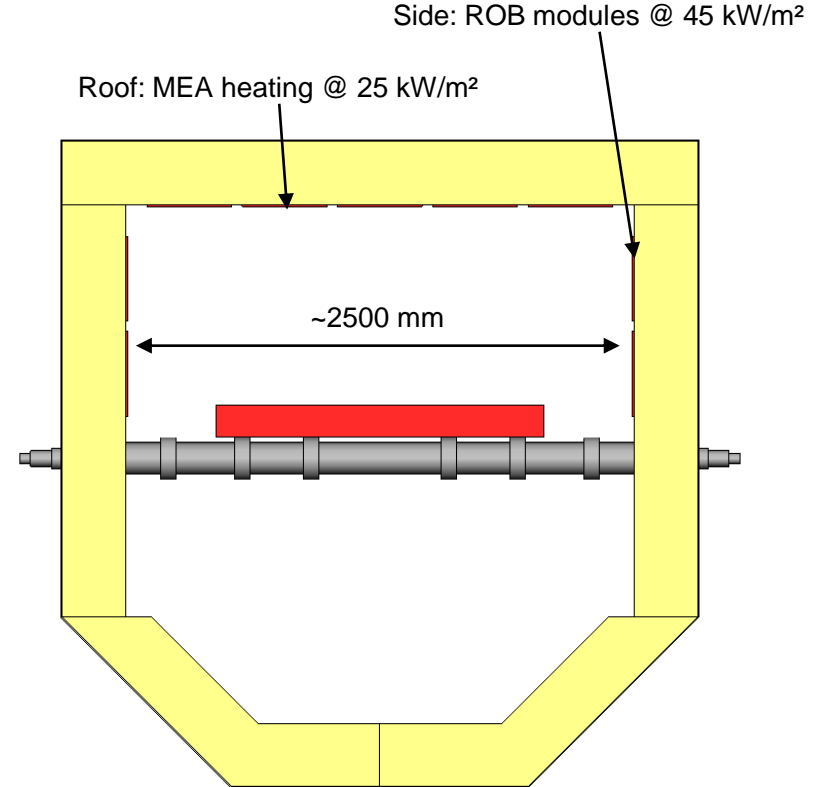
- Heating of slabs, billets and other product forms prior to forming operations.
- Typically, gas fired with large power requirement (10-50 MW per furnace), high power density and temperature (1250°C).
- Proven heating solutions validated on smaller scale (Kanthal® Super, Globalar® SiC).
- Capable of high-power density (80-100 kW/m²)
- Scale-up and develop for continuous 24/7 operation
- Remove emissions, higher thermal efficiency, improved yield (controlled atmosphere)



SLAB RE-HEATING

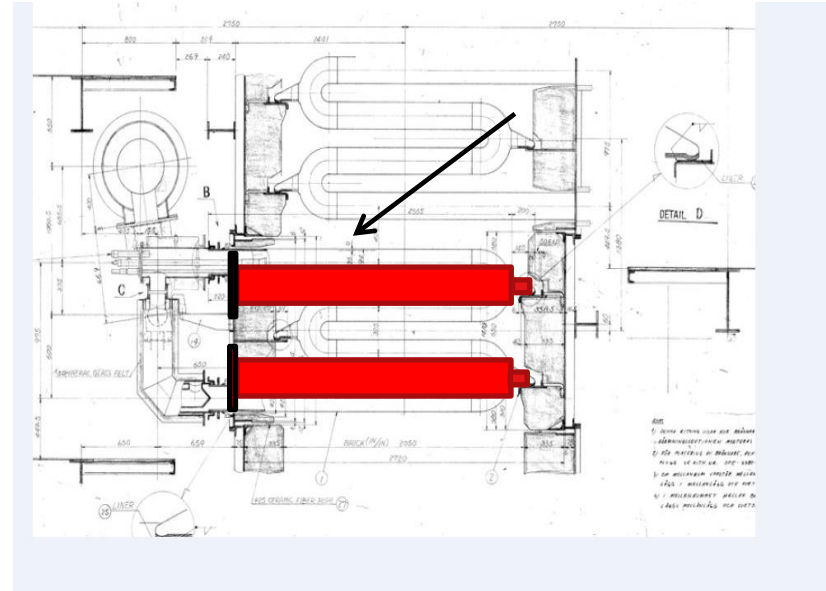
FIBROTHAL specification

Furnace type	Roller hearth kiln
Dimensions	2.5 x 120 m
Heating power	> 10 MW
Atmosphere	Air
Furnace temperature	1150°C
Heating system	FIB ROB (side) FIB MEA (roof)
Commissioning	2025



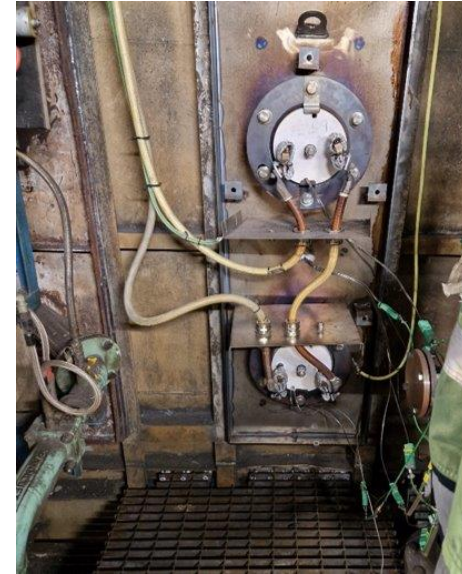
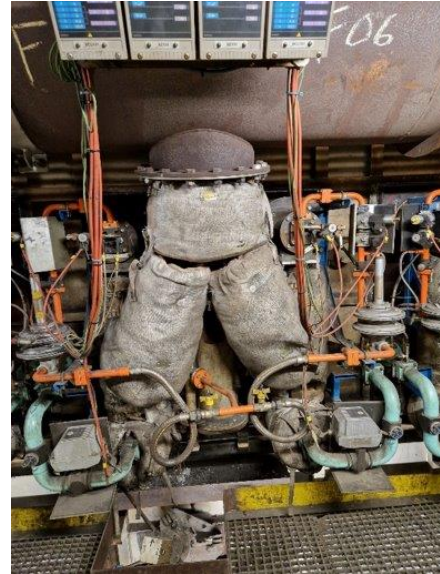
CURRENT HEATING SOLUTION

- Continuous furnaces for annealing and galvanizing of steel strip
- Atmosphere: 95% N 2-5% H₂, Temperature around 1000°C
- Heated with gas burners in Ni-Cr radiant tubes (W, U, P-type)
- Large power requirement (100-200 kW per burner) or 20-30 MW per furnace



ELECTRIFICATION OF CONTINUOUS ANNEALING

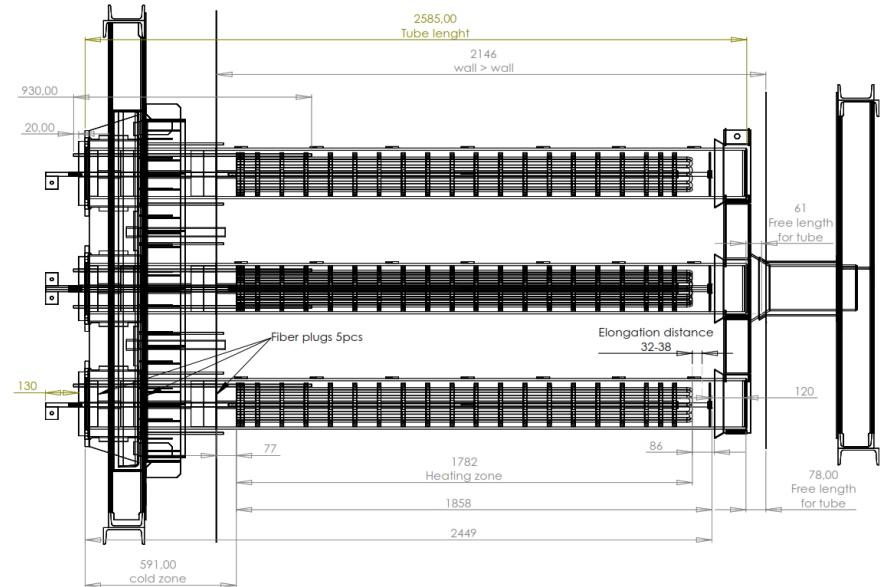
- Replace W, U, P-type gas burners with 2-3 electric heating units (eg. Tubothal® and Kanthal® radiant tube)
- Successful conversions for multiple customers, for annealing of steel strip
- Eliminate emissions
- Lower maintenance and higher productivity
- Higher efficiency
- Better process control



Example of replacement, traditional gas burner (left)
and electric solution (right)

VERTICAL STRIP ANNEALING LINE

- 90 x 44 kW = 4 MW installed heating power
- Tf: 930 °C
- Installation location: Central Europe
- Energy saving potential: >20 %



FUTURE OPPORTUNITIES

- SMART combination of
 - Radiation / convection
 - Hybrid heating: Resistive heating / induction / combustion (H₂)
- Upscaling into higher megawatt range
- Retrofit and Greenfield solutions might look different
- Technology development: PGH for higher temperatures

CHANCEN

- Eine Vielzahl der Thermoprozessanlagen lässt sich elektrisch beheizen.
- Bis 1200°C werden bereits Anlagen im Megawatt-Bereich elektrifiziert (Retrofit und Neuanlagenbau).
- Für den Bereich > 1200°C sind MW-Konzepte in der Entwicklung / Adaptierung.
- Hybride Beheizungskonzepte bieten zusätzliche Chancen.

VORAUSSETZUNGEN

- Konsequenter Ausbau regenerativer Energien und der E-Netze → wettbewerbsfähige Preise!
- Speichertechnologie realisieren!
- Internationaler Ansatz – Deutschland alleine kann das Klima nicht retten, aber wir können Technology-Leader sein.





THANK YOU!
THE FUTURE OF
HEATING TECHNOLOGY
– IT'S ELECTRIC

CONTACT

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1 May 2024

KANTHAL[®]

APPENDIX

KANTHAL AND NIKORTHAL BASIC DATA


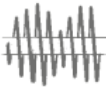

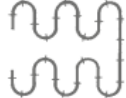

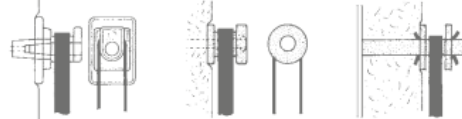
		KANTHAL®	KANTHAL®				NIKORTHAL®			
		APM	A-1	AF	D	80	70	60	40	
Max continuous operating temp. °C		1425	1400	1300	1300	1200	1250	1150	1100	
Nominal composition, %	Cr	22	22	22	22	20	30	15	20	
	Al	5.8	5.8	5.3	4.8	–	–	–	–	
	Fe	balance	balance	balance	balance	–	5%	balance	balance	
	Ni	–	–	–	–	balance	balance	60	35	
Resistivity at 20°C, Ωmm ² m ⁻¹		1.45	1.45	1.39	1.35	1.09	1.18	1.11	1.04	
Density, g/cm ³		7.10	7.10	7.15	7.25	8.3	8.1	8.2	7.9	
Coefficient of thermal expansion, K ⁻¹	20–750°C	14×10 ⁻⁶	14×10 ⁻⁶	14×10 ⁻⁶	14×10 ⁻⁶	16×10 ⁻⁶	16×10 ⁻⁶	16×10 ⁻⁶	18×10 ⁻⁶	
	20–1000°C	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 20°C, Wm ⁻¹ K ⁻¹		13	13	13	13	15	13	13	13	
Specific heat capacity at 20°C, KJkg ⁻¹ K ⁻¹		0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.50	
Melting point, °C		1500	1500	1500	1500	1400	1380	1390	1390	

Mechanical properties [approx.]*

Tensile strength, N mm ⁻²	680	680	680	650	810	820	730	675	
Yield point, N mm ⁻²	470	475	475	450	420	430	370	340	
Hardness, Hv	230	230	230	230	180	185	180	180	
Elongation at rupture, %	20	18	18	18	30	30	35	35	
Tensile strength at 900°C, N mm ⁻²	40	34	37	34	100	120	100	120	
Creep strength at 800°C	11	6	8	6	15	15	15	20	
	at 1000°C	3.4	1	1.5	1	4	4	4	
Magnetic properties	magnetic (curie point 600°C)					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 4 mm diameter for the Kanthal alloys and of 1 mm for the Nikrothal alloys

KEY DATA FOR KANTHAL ELEMENTS

	WIRE ELEMENTS						STRIP ELEMENTS		
Element systems	Spiral	Spiral	Porcupine	Rod over bend	Corrugated	Looped	Deep-corrugated	Deep-corrugated	Deep-corrugated
Supports	Ceramic tubes	Grooves	Ceramic tubes	Metallic rods	Metallic staples	Ceramic tubes	Ceramic cup locks	Ceramic bushes	Ceramic tubes
									
Material	Sillimanite	Chamotte grade 28	Sillimanite	Kanthal® APM	U-shaped Kanthal® nails	Sillimanite	Cordierite or mullite	Cordierite or mullite	Sillimanite
Max. furnace temperature, °C	1300	1250	800	1300	1300	1300	1300	1300	1300
Max. wall loading at 1000°C furnace temperature, kW/m ²	40	35	-	50	50	60	60	60	60
Max. surface load at 1000°C furnace temperature, W/cm ²	3-4	3-4	-	5-6	3-6	5-6	5-6	5-6	5-6
Wire diameter, d, mm	2.0-6,5	2.0-5.0	1.0-6.5	≥ 5.0	2.0-5.0	≥ 5.0	-	-	-
Strip thickness, t, mm	-	-	-	-	-	-	2.0-3.0	2.0-3.0	2.0-3.0
Strip width, w, mm	-	-	-	-	-	-	8-12 t	8-12 t	8-12 t
Outer coil diameter, D, mm	12-14 d	5-6 d	-	-	-	-	-	-	-
Max. loop length at 1000°C furnace temperature, mm	-	-	-	250	100	250	250	250	250
Min. pitch at max. loop length, mm	3d	2d	3d	40	40	40	50	50	50

TECHNICAL DATA OF FIBROTHAL HEATING MODULES

	F-3/LS	F-17/LS	F-19	F-14	F-BIO
Classification temp. °C (°F)*	1260 [2300]	1400 [2550]	1500 [2730]	1600 [2910]	1300 [2370]
Maximum continuous duty temperature, °C [°F]	1150 [2100]	1300 [2370]	1400 [2550]	1550 [2820]	1000 [1830] [in clean air]**
Density approx. kg/m ³ [lb/ft ³]	200 [12.48]	200 [12.48]	200 [12.48]	250 [15.61]	180–200 [11.24–12.48]
Linear shrinkage, % [24 hours at max. continuous duty temperature]	3/<1	4.5/<2	4.5	3.5	<2
Guide analysis, %:	Al ₂ O ₃ 46 SiO ₂ 54	50 50	67 33	77 23	CaO+MgO 18–20 70–80 others <3
Thermal conductivity, W/m-K***					
at 200°C [390°F]	0.07	0.07	0.07	–	0.08
at 400°C [750°F]	0.10	0.10	0.10	0.09	0.10
at 600°C [1110°F]	0.14	0.14	0.14	0.13	0.14
at 800°C [1470°F]	0.21	0.21	0.20	0.19	0.21
at 1000°C [1830°F]	0.28	0.29	0.28	0.24	0.28
at 1200°C [2190°F]	–	0.41	0.39	0.35	–
at 1300°C [2370°F]	–	0.49	0.46	0.39	–
at 1400°C [2550°F]	–	–	0.54	0.46	–
at 1500°C [2730°F]	–	–	–	0.54	–
at 1600°C [2910°F]	–	–	–	–	–

* Classification temperature of the fibers used

** The max. cont. duty temp. is reduced to 1000°C (1830°F) furnace temp. in H₂ atmosphere (also contents of it)

*** Measuring method: calorimeter

Fiber free versions see Moduthal™ brochure

For F-Bio products it is absolutely necessary to know the final application. Please contact our technical sales office for advice.