FIBROTHAL®
Handbook

Heating and Insulation Systems

KANTHAL®

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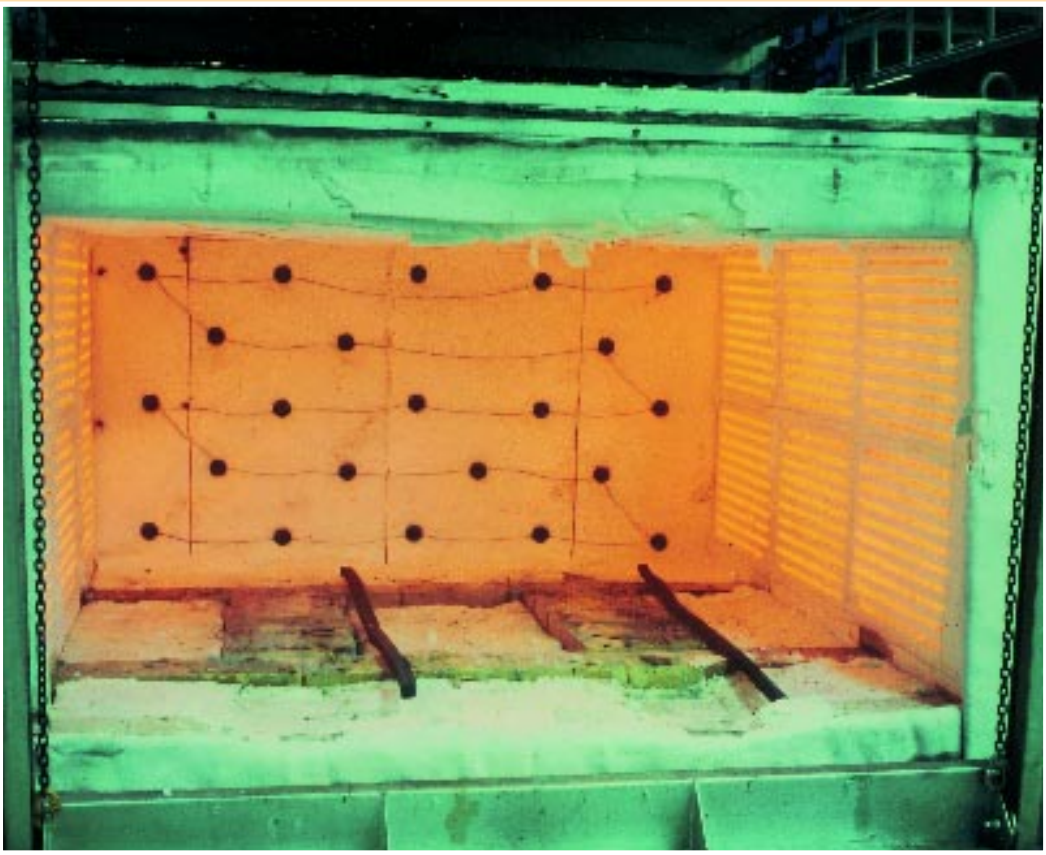


Fig. 1. FIBROTHAL-Heating modules with embedded heating elements

Introduction

1

Lightweight construction has become the norm in many industrial furnaces, with the use of ceramic fibres (KF) up to furnace temperatures of 1800˚C.

The low thermal mass and thermal conductivity of the ceramic fibre furnace linings mean that you can build industrial furnaces which, depending on the type and mode of operation, contribute significantly to energy saving, higher output and better availability.

In the electrically heated furnace, however, it is very expensive and time consuming to combine ceramic fibres, such as for example blankets or folding blocks, with electric heating elements. This has led to the product concept which we introduced on to the market in 1978 under the name FIBROTHAL®.

Today the name FIBROTHAL covers a family of products consisting of vacuum-formed ceramic fibre components, with or without electric heating elements.

1 Today, under the registered trademark FIBROTHAL we supply:

Fig. 2. Heating modules with embedded heating elements made of KANTHAL alloys for a maximum element temperature of 1150˚C

Fig. 3. RAC tubes with embedded but virtually free-radiating heating element, for a maximum element temperature of 1300˚C

Fig. 4. Meanderthal module with free-radiating heating elements for a maximum element temperature of 1300˚C, mainly for roof heating and tilting furnaces

Fig. 5. ROB with free-radiating heating elements for a maximum element temperature of 1300˚C, mainly for wall and floor heating

Fig. 6. Muffles with embedded heating elements made of KANTHAL alloys for a maximum element temperature of 1150˚C

Fig. 7. Insulation parts of vacuum-formed fibre in the most varied shapes for application temperatures up to 1800˚C

Fig. 8. FibroSiC are unsupported roof insulating parts, which are strengthened by SiC tubes

KF-Modules

2

	F-3/LS	F-17/LS	F-19	F-14	HT1750	HT1800
Classification temp. (°C)*	1260	1400	1500	1600	1600	1600
Max. continuous duty temperature (°C)	1150	1300	1400	1550	1750	1800
Density (kg/m^3) approx.	200	200	200	250	320	320
Linear shrinkage (%) (24 hours at maximum continuous duty temp.)	3.5/<1	4.5/<1	4.5	3.5	<4	<4***
Guide analysis (%): Al_2O_3	46	50	57	77	90	90
SiO_2	54	50	43	23	10	10
Thermal conductivity (W/mk)** at 200 °C	0.07	0.07	0.07	—	—	—
at 400 °C	0.10	0.10	0.10	0.09	0.16	0.19
at 600 °C	0.14	0.14	0.14	0.13	0.17	0.20
at 800 °C	0.21	0.21	0.20	0.19	0.19	0.22
at 1000 °C	0.28	0.29	0.28	0.24	0.22	0.24
at 1200 °C	—	0.41	0.39	0.35	0.26	0.27
at 1300 °C	—	0.49	0.46	0.39	0.28	0.29
at 1400 °C	—	—	0.54	0.46	0.30	0.31
at 1500 °C	—	—	—	0.54	0.32	0.33
at 1600 °C	—	—	—	—	0.35	0.35

* Classification temperature of the fibres used
** Measuring method F3, F17, F19, F14: calorimeter
Measuring method for HT 1750/1800: resistance wire – parallel (to 1400°C)
*** At 1700°C: <1%

Chemical Properties: the KF-modules possess high resistance to chemicals, including most acids, with the exception of hydrofluoric acid, phosphoric acid and strong bases. Wetting with water and oil has no influence on the properties of the ceramic fibres themselves. After drying or evaporation the thermal and physical properties are restored. Care must however be taken when they are fitted with heating elements because of possible corrosion.

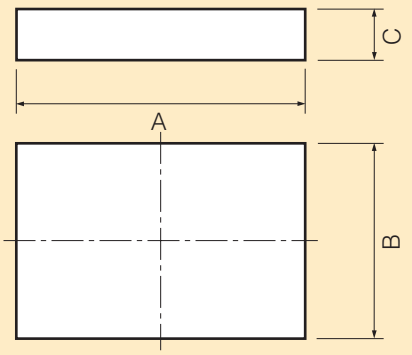
Table 1. Technical data of ceramic fibre modules

2 Tolerances

Electrical Resistance: R_k ±5%

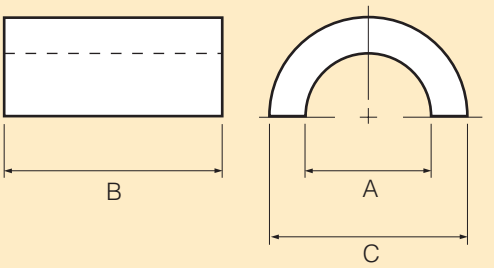
Module Dimensions

The following tolerances apply to the vacuum-formed insulation with or without heating element.



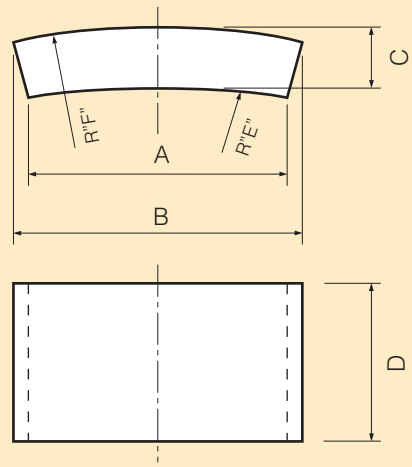
A,B	C, with machining on	
	one surface	two surfaces
≤ 700 ±3 >700 ±5	±5 +5/-10	±3 ±3

Fig. 9. FIBROTHAL Panels



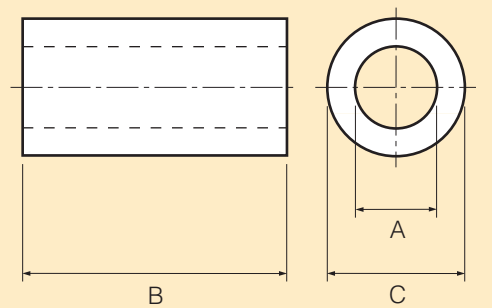
A		B	C	
≤ 200	+4	±3	≤350	±5
>200/ ≤350	+6		>350	±10
>350	+10			

Fig. 10. FIBROTHAL Half-cylinders



A,B and D		C	R "E"	R "F"
≤ 700	±3	±5	±5	±5
>700	±5		±10	±10

Fig. 11. FIBROTHAL Shells



A	B	C
+8/-2	+10/-5	±10

Fig. 12. FIBROTHAL Tubes

Atmospheres

2

Furnace atmosphere	Max. element temperature, KANTHAL heating elements	Max. element temperature, FIBROTHAL	Remarks
H_2	1400 °C	1000 °C	H_2 increases heat throughput of FIBROTHAL 3-4 times.
N_2	1200 °C preoxidised	1150 °C preoxidised	FIBROTHAL heating modules without heating elements up to maximum duty temperature.
N	don't use	don't use	
Endogas	1050 °C preoxidised	1050 °C preoxidised	Pay attention to carbon deposition! Better with gas-tight muffle.
Exogas	1150 °C preoxidised	1050 °C preoxidised	Pay attention to carbon deposition! Better with gas-tight muffle.
Sulphur	approx. 1000 °C	—	Does not withstand sulphur pentoxide.
Chlorine, fluorine, alkali	attacks all types of resistance alloys	attacks all types of resistance alloys	FIBROTHAL can be used without elements below 900˚C.
Vacuum < 10^{-3} hPa	1150 °C preoxidised	800 - 850 °C	Vacuum higher than 10^{-3} bar will take too long to evacuate the fibre block. Better with vacuum-tight muffle.
Pressurised	1400 °C	1250 °C	FIBROTHAL can be used in gas or air-tight furnaces only.
Scale	see remarks	see remarks	Spray scale from heat-resistant parts is usually satisfactorily tolerated, iron oxide scale attacks KANTHAL - fit cover.
Vapours	see remarks	see remarks	Vapours must not form condensates from salts or oxides, otherwise electrical bridges will be formed.
Gas velocity	see remarks	see remarks	FIBROTHAL withstands high gas velocities up to 50 m/s. Pay attention to butt joints with ceramic fibre blankets.

Fig. 13. Maximum permissible element temperatures in various furnace atmospheres

2 Power limitation

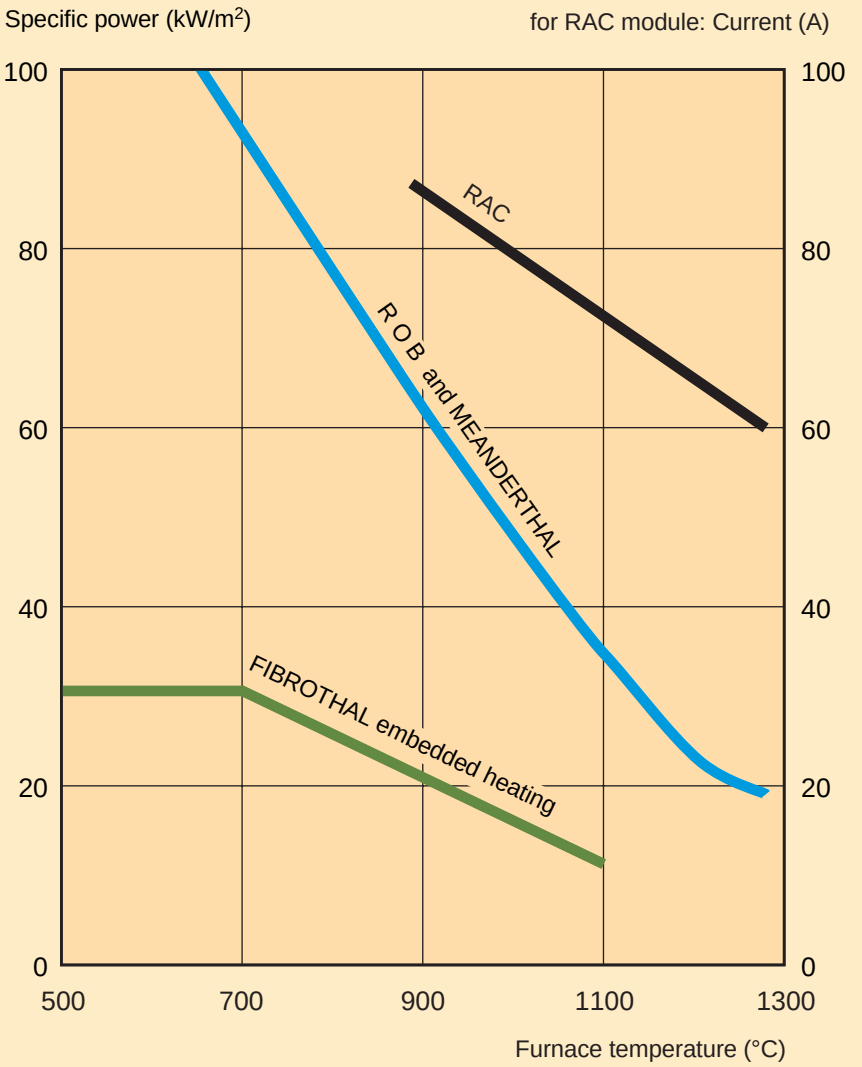


Fig. 14. shows for the various heating module designs the maximum recommended load in relation to the furnace temperature

3

Technical Data, Standard Range

Heating modules

FIBROTHAL Standard Heating Modules are manufactured with embedded heating elements, two principles being followed.

Principle I

With this method the KANTHAL A-1 heating wires (diameter < 3.5 mm) are embedded in the ceramic fibre module made of F3 fibre. The maximum element temperature is 1150°C.

For optimum heat radiation:

- The heating wire is made with oval cross-section
- Part of the face of the heating wire is bare
- The inside of the heating wires is largely free of ceramic fibres

This design is protected by patent.

Panels and half-cylinders are manufactured according to this principle.

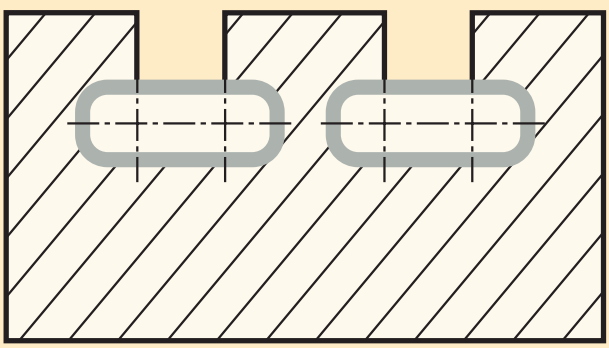


Fig. 15. Embedding principle

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Principle II

With this method – used exclusively for heating tubes – a heating wire of KANTHAL A-1 (diameter 5 mm) is formed to fit into a ceramic fibre module of F17 fibre with ceramic spacers. In this case the heating element lies on the surface of the insulation and is virtually free-radiating. The maximum element temperature is 1300˚C.

A complete range of moulds is available for manufacturing the standard modules. There are therefore no mould costs in this case.

In the new edition of this brochure the previous voltages have been converted to the Eurovoltage (400/230 V). The modules can however also be operated with the voltages previously used (380/220 V or 415/240 V).

If low power is required, the modules can also be operated at lower voltages. Higher power is also possible if allowance is made for the maximum wall loading (see Fig. 14).

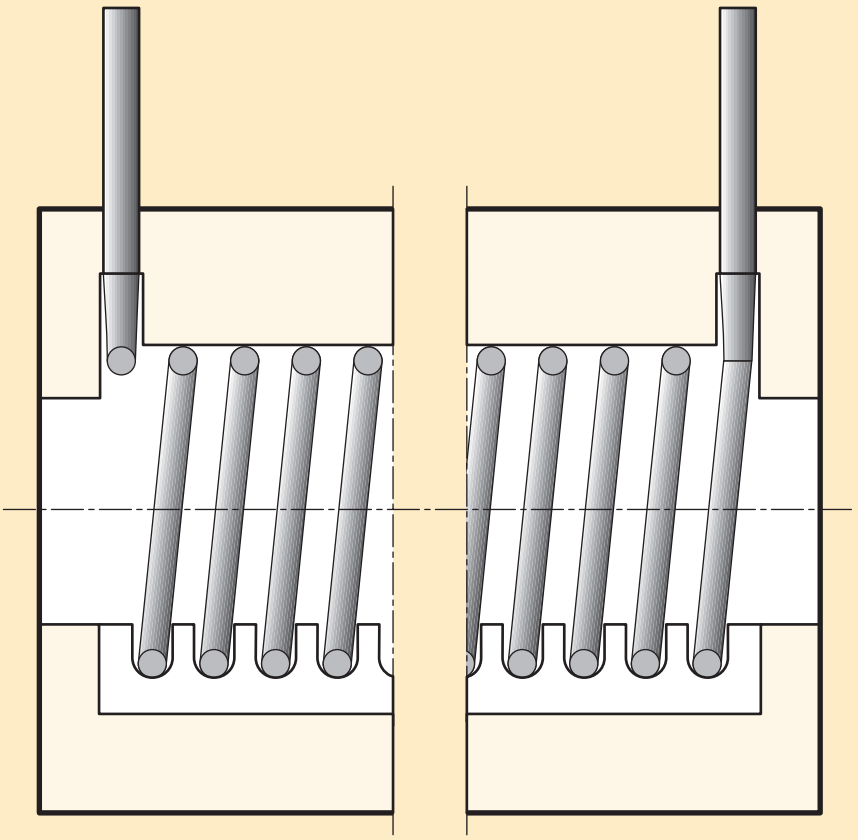

Fig. 16. RAC forming principle

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Panels

The heating surface is the surface which accomodates the heating element.

The standard module dimensions are based on the heated surface dimensions plus the minimum required unheated edge area. Panels can be manufactured to a maximum width or length of 1050 mm.

Unheated edges can be manufactured to any dimension as long as the overall panel dimension does not exceed the maximum width or length already specified. Standard modules can also be supplied with additional 125 mm unheated edges on either the width or length (type SL; SB).

If modules are to be attached to roofs or side walls, there is a design available with ceramic cup assembly mountings. For roofs in particular we recommend additional element anchorage using ceramic cement pins.

The standard design of connections is in the form of threaded rod M8 x 75 mm long at the back of the module. Other connection designs are available on request, e. g. flexible leads (see accessoroies).

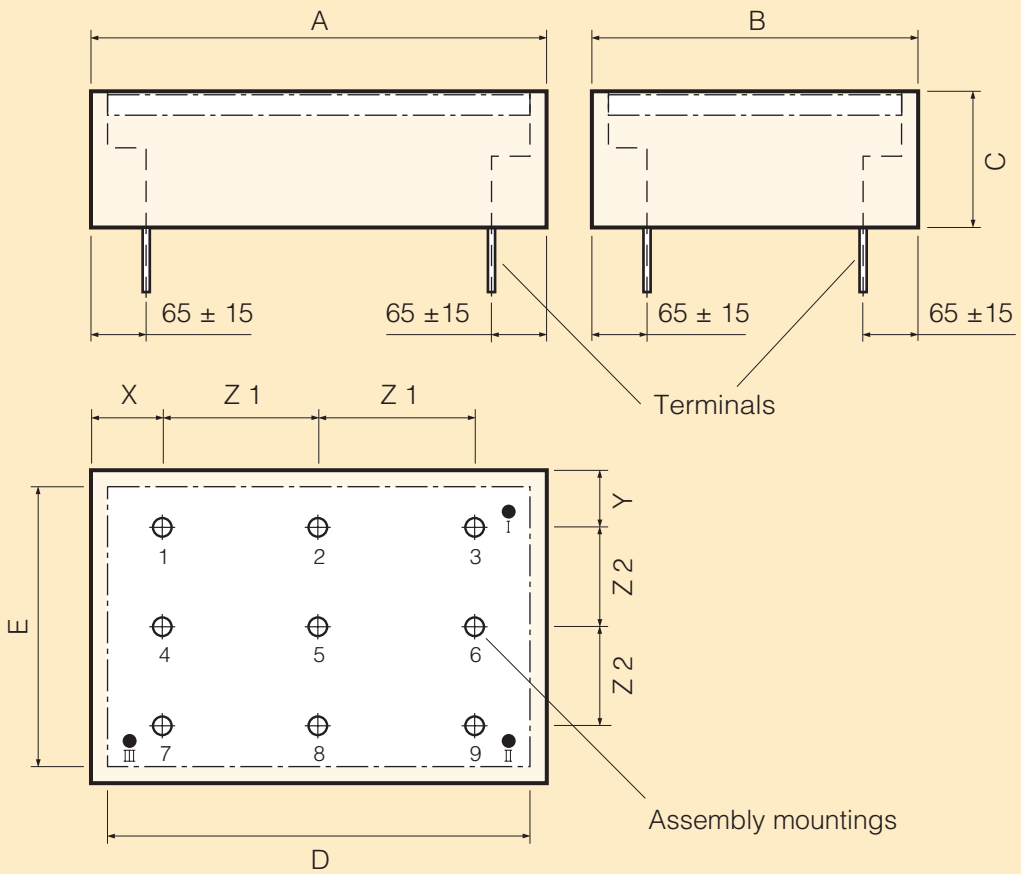

Fig. 17. FIBROTHAL Standard panels

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FIBROTHAL Heating Panels

Type designation	Part No.	Standard dim.	Heated area	Power	Voltage	Resistance	Term. arr.	Assembly	Grid dim.		Approx.
		A x B x C	D x E			R20	Position	Nos.	X/Z1	Y/Z2	weight
		mm	mm	W	V	Ohm		Pcs./Pos.	mm		kg
PAS 300/225/57.5	80030004	300x225x125	270x195	1050	57.5	3.03	I - III	-	-		2.1
PAS 300/225/57.5 S	80030007	300x225x125	270x195	1050	57.5	3.03	I - III	1 / 5	150/0	112/0	2.1
PAS 300/225/57.5 D	80030010	300x225x125	270x195	1050	57.5	3.03	I - III	2 / 1-9	75/75	92/21	2.1
PAS 300/225/57.5 SL	80030011	550x225x125	270x195	1050	57.5	3.03	I - III	-	-		3.5
PAS 300/225/57.5 SB	80030012	300x475x125	270x195	1050	57.5	3.03	I - III	-	-		3.9
PAS 375/225/57.5	80030016	375x225x125	335x195	1350	57.5	2.35	I - III	-	-		2.7
PAS 375/225/57.5 S/D	80030019	375x225x125	335x195	1350	57.5	2.35	I - III	2 / 1-9	75/112	92/21	2.7
PAS 375/225/57.5 SL	80030021	625x225x125	335x195	1350	57.5	2.35	I - III	-	-		4.1
PAS 375/225/57.5 SB	80030022	375x475x125	335x195	1350	57.5	2.35	I - III	-	-		5
PAS 450/300/100	80030026	450x300x125	410x250	2100	100	4.58	I - II	-	-		4.2
PAS 450/300/100 S/D	80030029	450x300x125	410x250	2100	100	4.58	I - II	2 / 4-6	100/125	150/0	4.2
PAS 450/300/100 SL	80030031	700x300x125	410x250	2100	100	4.58	I - II	-	-		6.1
PAS 450/300/100 SB	80030032	450x550x125	410x250	2100	100	4.58	I - II	-	-		7
PAS 450/300/115	80030036	450x300x125	410x250	2100	115	6.06	I - II	-	-		4.2
PAS 450/300/115 S/D	80030039	450x300x125	410x250	2100	115	6.06	I - II	2 / 4-6	100/125	150/0	4.2
PAS 450/300/115 SL	80030041	700x300x125	410x250	2100	115	6.06	I - II	-	-		6.1
PAS 450/300/115 SB	80030042	450x550x125	410x250	2100	115	6.06	I - II	-	-		7
PAS 450/300/133	80030046	450x300x125	410x250	2100	133	8.1	I - III	-	-		4.5
PAS 450/300/133 S/D	80030049	450x300x125	410x250	2100	133	8.1	I - III	2 / 1-9	100/125	131/19	4.5
PAS 450/300/133 SL	80030051	700x300x125	410x250	2100	133	8.1	I - III	-	-		5.9
PAS 450/300/133 SB	80030052	450x550x125	410x250	2100	133	8.1	I - III	-	-		6.9

Table 2. Standard FIBROTHAL heating panel designs

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FIBROTHAL Heating Panels

Type designation	Part No.	Standard dim.	Heated area	Power	Voltage	Resistance	Term. arr.	Assembly	Grid dim.		Approx.
		A x B x C	D x E			R20	Position	Nos.	X/Z1	Y/Z2	weight
		mm	mm	W	V	Ohm		Pcs./Pos.	mm		kg
PAS 450/375/115	80030056	450x375x125	410x325	2700	115	4.9	I - II	-	-		4.5
PAS 450/375/115 S/D	80030059	450x375x125	410x325	2700	115	4.9	I - II	2 / 4-6	100/125	187/0	4.5
PAS 450/375/115 SL	80030061	700x375x125	410x325	2700	115	4.9	I - II	-	-		7.7
PAS 450/375/115 SB	80030062	450x625x125	410x325	2700	115	4.9	I - II	-	-		8.2
PAS 450/375/133	80030066	450x375x125	410x325	2700	133	6.3	I - II	-	-		5.3
PAS 450/375/133 S/D	80030069	450x375x125	410x325	2700	133	6.3	I - II	2 / 4-6	100/125	187/0	5.3
PAS 450/375/133 SL	80030071	700x375x125	410x325	2700	133	6.3	I - II	-	-		7.7
PAS 450/375/133 SB	80030072	450x625x125	410x325	2700	133	6.3	I - II	-	-		8
PAS 600/450/200	80030076	600x450x125	550x405	4200	200	9.16	I - II	-	-		8.7
PAS 600/450/200 S	80030079	600x450x125	550x405	4200	200	9.16	I - II	2 / 4-6	150/150	225/0	8.7
PAS 600/450/200 D	80030082	600x450x125	550x405	4200	200	9.16	I - II	4 / 1-3-7-9	150/150	100/125	8.7
PAS 600/450/200 SL	80030083	850x450x125	550x405	4200	200	9.16	I - II	-	-		11.5
PAS 600/450/200 SB	80030084	600x700x125	550x405	4200	200	9.16	I - II	-	-		12.5
PAS 600/450/230	80030088	600x450x125	550x405	4200	230	12.11	I - II	-	-		8.6
PAS 600/450/230 S	80030091	600x450x125	550x405	4200	230	12.11	I - II	2 / 4-6	150/150	225/0	8.6
PAS 600/450/230 D	80030094	600x450x125	550x405	4200	230	12.11	I - II	4 / 1-3-7-9	150/150	100/125	8.6
PAS 600/450/230 SL	80030095	850x450x125	550x405	4200	230	12.11	I - II	-	-		11.4
PAS 600/450/230 SB	80030096	600x700x125	550x405	4200	230	12.11	I - II	-	-		12.3
PAS 750/450/200	80030100	750x450x125	700x405	5400	200	7.12	I - III	-	-		11.1
PAS 750/450/200 S	80030103	750x450x125	700x405	5400	200	7.12	I - III	2 / 4-6	143/232	225/0	11.1
PAS 750/450/200 D	80030106	750x450x125	700x405	5400	200	7.12	II - III	6 / 1-2-3-7-8-9	100/126	100/125	11.1
PAS 750/450/200 SL	80030107	1000x450x125	700x405	5400	200	7.12	I - III	-	-		14
PAS 750/450/200 SB	80030108	750x700x125	700x405	5400	200	7.12	I - III	-	-		15.8

Table 2. Standard FIBROTHAL heating panel designs

3

FIBROTHAL Heating Panels

Type designation	Part No.	Standard dim.	Heated area	Power	Voltage	Resistance	Term. arr.	Assembly	Grid dim.		Approx.
		A x B x C	D x E			R20	Position	Nos.	X/Z1	Y/Z2	weight
		mm	mm	W	V	Ohm		Pcs./Pos.	mm		kg
PAS 750/450/230	80030112	750x450x125	700x405	5400	230	9.42	I - III	-	-		15.4
PAS 750/450/230 S	80030115	750/450x125	700x405	5400	230	9.42	I - III	2/4-6	143/232	225/0	15.4
PAS 750/450/230 D	80030118	750x450x125	700x405	5400	230	9.42	II - III	6/1-2-3-7-8-9	100/126	100/125	15.4
PAS 750/450/230 SL	80030119	1000x450x125	700x405	5400	230	9.42	I - III	-	-		13.5
PAS 750/450/230 SB	80030120	750x700x125	700x405	5400	230	9.42	I - III	-	-		15.4
PAS 900/600/400	80030124	900x600x125	825x540	8400	400	18.32	II - III	-	-		17.4
PAS 900/600/400 S	80030127	900x600x125	825x540	8400	400	18.32	II - III	2 / 4-6	198/252	300/0	17.5
PAS 900/600/400 D	80030130	900x600x125	825x540	8400	400	18.32	II - III	6/1-2-3-7-8-9	156/147	150/150	17.4
PAS 900/600/400 SB	80030131	900x850x125	825x540	8400	400	18.32	II - III	-	-		23
PAS 900/750/400	80030135	900x750x125	825x680	10800	400	14.25	II - III	-	-		22.3
PAS 900/750/400 S	80030138	900x750x125	825x680	10800	400	14.25	II - III	2 / 4-6	198/252	375/0	22.3
PAS 900/750/400 S	80030141	900x750x125	825x680	10800	400	14.25	II - III	9 / 1...9	156/147	100/138	22.3
PAS 900/750/400 S	80030142	900x1000x125	825x680	10800	400	14.25	II - III	-	-		27.9

Table 2. Standard FIBROTHAL heating panel designs

3

Half-Cylinders

For horizontal operation the upper half shell should be designed for the pin system (for explanation see heating panels).

The connections are designed as standard in the form of threaded bolts M8 x 75 mm long on the back of the module. Other connection designs are available on request, e.g. flexible leads (see accessories).

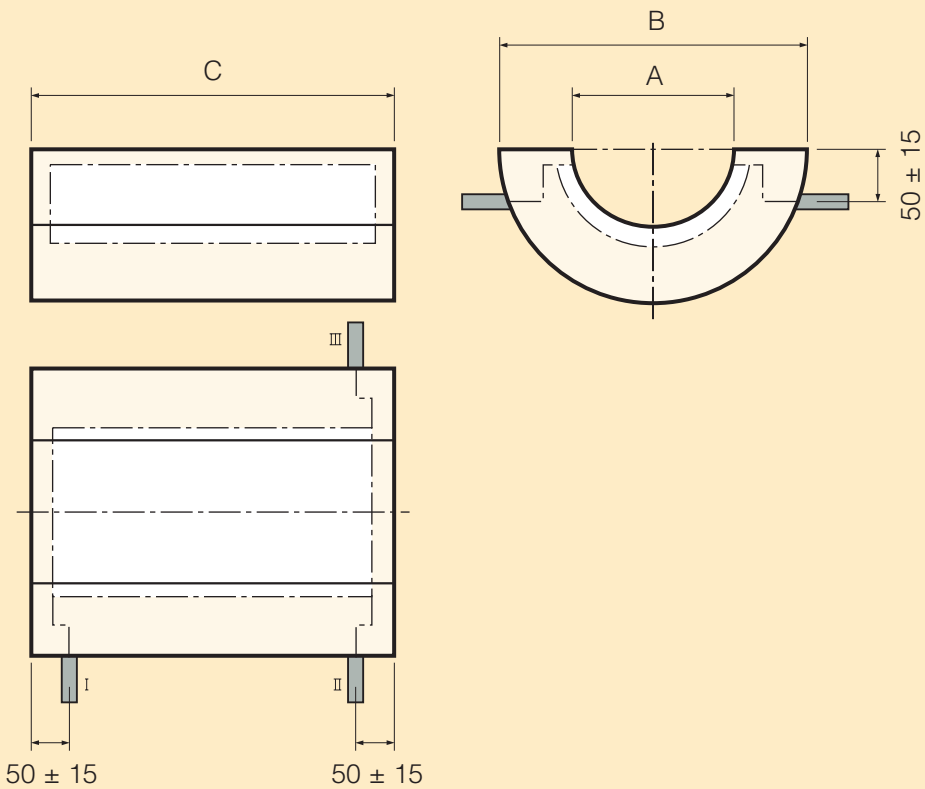

Fig. 18. FIBROTHAL Standard half-cylinders

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FIBROTHAL Half-Cylinders

Type designation	Part No.	Ø i.d.	Ø o.d.	Length	Power	Voltage	Resistance	Terminal arr.	Approx.
		A	B	C			R20		weight
		mm	mm	mm	W	V	Ohm	Position	kg
HAS 70/250/57.5	80030256	70	220	250	450	57.5	7.06	I - III	1
HAS 70/500/115	80030260	70	220	500	900	115	14.13	I - II	1.9
HAS 100/250/57.5	80030264	100	250	250	650	57.5	4.89	I - II	1.2
HAS 100/300/57.5	80030268	100	250	300	750	57.5	4.24	I - III	1.5
HAS 100/500/115	80030272	100	250	500	1300	115	9.78	I - II	2.4
HAS 100/600/115	80030276	100	250	600	1500	115	8.48	I - III	3
HAS 150/250/57,5	80030280	150	300	250	950	57.5	3.35	I - II	1.7
HAS 150/300/57,5	80030284	150	300	300	1150	57.5	2.76	I - II	2
HAS 150/500/115	80030288	150	300	500	1900	115	6.69	I - II	3.4
HAS 150/600/115	80030292	150	300	600	2300	115	5.53	I - III	4.1
HAS 200/250/57,5	80030296	200	350	250	1250	57.5	2.54	I - III	2.2
HAS 200/300/57,5	80030300	200	350	300	1500	57.5	2.12	I - II	2.7
HAS 200/500/115	80030304	200	350	500	2500	115	5.09	I - III	4.5
HAS 200/600/115	80030308	200	350	600	3000	115	4.24	I - III	5.3
HAS 250/375/115	80030312	250	450	375	2350	115	5.41	I - II	5.3
HAS 250/400/115	80030316	250	450	400	2500	115	5.09	I - II	5.3
HAS 250/750/200	80030320	250	450	750	4700	200	8.18	I - III	10.7
HAS 250/750/230	80030324	250	450	750	4700	230	10.82	I - III	10.4
HAS 250/800/230	80030328	250	450	800	5000	230	10.17	I - II	11

Table 3. Standard FIBROTHAL half-cylinder designs

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FIBROTHAL Half-Cylinders

Type designation	Part No.	Ø i.d.	Ø o.d	Length	Power	Voltage	Resistance	Terminal arr.	Approx.
		A	B	C			R20		weight
		mm	mm	mm	W	V	Ohm	Position	kg
HAS 300/375/115	80030332	300	500	375	2800	115	4.54	I - II	6.1
HAS 300/400/115	80030336	300	500	400	3000	115	4.24	I - II	6.5
HAS 300/750/230	80030340	300	500	750	5600	230	9.08	I - III	13
HAS 300/800/230	80030344	300	500	800	6000	230	8.48	I - II	12.9
HAS 350/500/200	80030348	350	600	500	4400	200	8.74	I - III	11.5
HAS 350/500/230	80030352	350	600	500	4400	230	11.56	I - III	11.5
HAS 350/600/230	80030356	350	600	600	5300	230	9.6	I - III	13.5
HAS 350/750/230	80030360	350	600	750	6600	230	7.71	I - III	17
HAS 350/800/230	80030364	350	600	800	7000	230	7.27	I - III	17.7
HAS 400/500/200	80030368	400	650	500	5000	200	7.69	I - III	13
HAS 400/500/230	80030372	400	650	500	5000	230	10.17	I - III	13
HAS 400/600/200	80030376	400	650	600	6000	200	6.41	I - II	14.8
HAS 400/600/230	80030380	400	650	600	6000	230	8.48	I - III	15.2
HAS 400/750/400	80030384	400	650	750	7500	400	20.51	I - II	18.5
HAS 400/900/400	80030388	400	650	900	9000	400	17.09	I - III	21.7
HAS 450/600/400	80030392	450	700	600	6800	400	22.62	I - III	15.8
HAS 450/900/400	80030396	450	700	900	10200	400	15.08	I - II	26.1
HAS 500/600/400	80030400	500	750	600	7500	400	20.51	I - II	17.1
HAS 500/900/400	80030404	500	750	900	11300	400	13.61	I - II	27.3

Table 3. Standard FIBROTHAL half-cylinder designs

3

Tubes

For the power connections (strip 20 x 3) you can choose between radial (Design A) and face variants (Design B).

Because of the high current levels a flexible wire connection is not possible.

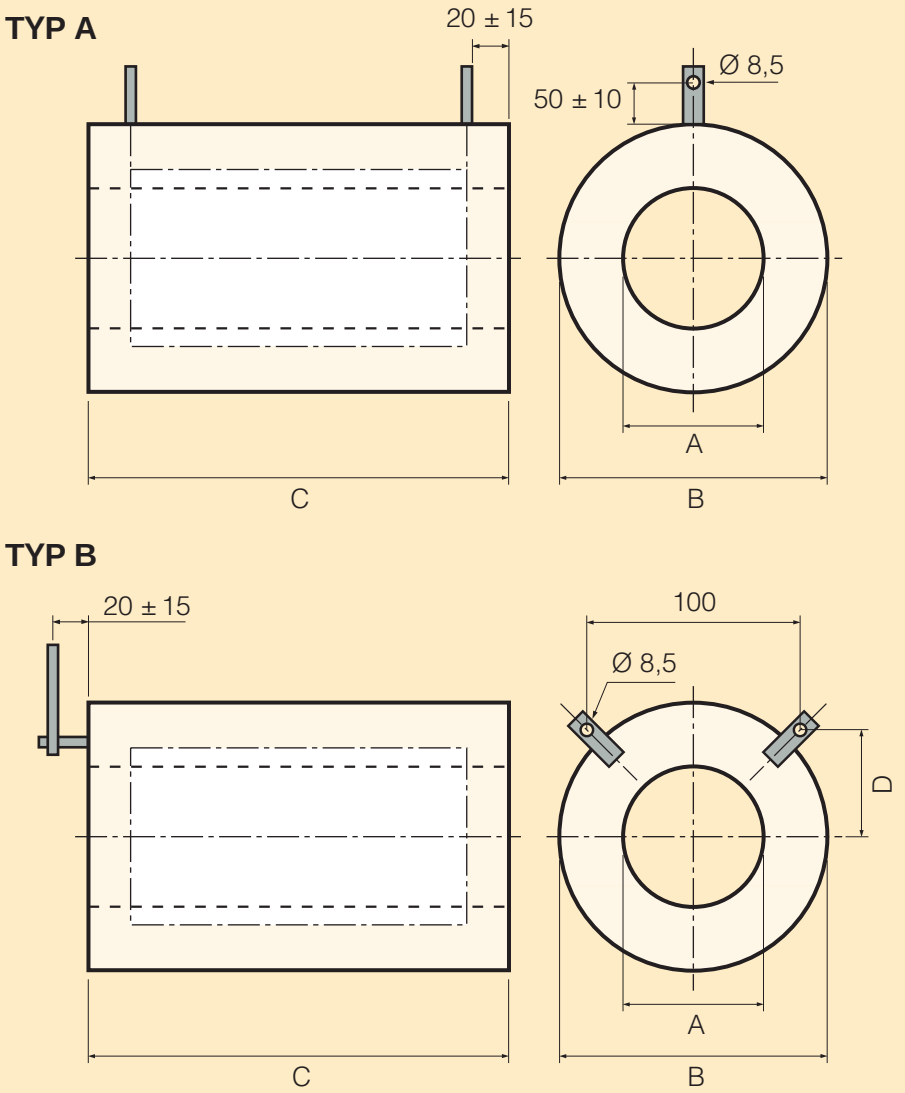

Fig. 19. FIBROTHAL Standard tubes

3

FIBROTHAL Tube

Type designation	Type A	Type B	Dimensions	Dimensions	Length	Terminal	Voltage	Voltage	Voltage	Resistance	Weight
			Øi.d.	Øo.d.		arr.	Power	Power	Power		
			A	B	C	D	at 60 A	at 72 A	at 85 A	R20	
			mm	mm	mm	mm	V	V	V	Ohm	kg
	Part No.	Part No.					W	W	W		
RAC 40/200	80030147	80030153	40	160	220	105	15.8 950	19 1369	22.5 1909	0.253	1.6
RAC 40/500	80030158	80030164	40	160	520	105	40 2398	48 3455	56.7 4818	0.639	3.8
RAC 70/200	80030169	80030175	70	240	220	135	25 1500	30 2161	35.5 3014	0.4	2.9
RAC 70/500	80030180	80030186	70	240	520	135	63.1 3786	75.8 5454	89.5 7608	1.008	6.9
RAC 100/200	80030191	80030197	100	270	220	150	34.1 2049	41 2952	48.4 4117	0.546	3.6
RAC 100/500	80030202	80030208	100	270	520	150	86.2 5170	103.5 7450	122.2 10391	1.377	8.5
RAC 150/200	80030213	80030219	150	350	220	215	49.4 2963	59.3 4269	70.1 5955	0.789	5.1
RAC 150/500	80030224	80030230	150	350	520	215	127 7620	152.5 10979	180.2 15314	2.03	12.5
RAC 200/200	80030235	80030241	200	450	220	240	64.6 3878	77.6 5587	91.7 7793	1.033	7.7
RAC 200/500	80030246	80030252	200	450	520	240	163.1 9787	195.8 14101	231.4 19669	2.607	18.7

Table 4. Standard FIBROTHAL tube designs

3

Insulating Parts

FIBROTHAL insulating parts are available in the same standard dimensions as the heating modules. The standard range also includes insulating end pieces which fit the outside diameters of the half-cylinders and tubes. If necessary these end pieces can also be supplied drilled to the size of the work tube. The standard thickness is 125 mm; other dimensions are also available.

FIBROTHAL end piece range

Outside diameter mm	Thickness mm	Weight kg
160	125	0,5
220	125	0,9
240	125	1,1
300	125	1,2
350	125	2,4
450	125	3,9
500	125	4,9
600	125	7,0
650	125	8,2
700	125	9,6
750	125	11,0

Table 5. FIBROTHAL Standard KANTHAL End pieces

Modules to special design

4

Over and above the standard range we offer an extensive special range of different heating systems. With these all furnace sizes and designs can in principle be created. The following systems are available:

- Module with embedded heating
- ROB in panel and shell design
- Meander systems
- Special tube modules
- Muffles
- Insulating parts

An extensive range of forming moulds is available for the manufacture of the special modules. Nevertheless, for special designs a proportion of the mould costs may be charged.

Modules with embedded heating

These modules can be used for almost all furnace layouts. In addition to panels for furnaces with flat walls we manufacture many different module designs for cylindrical surfaces, such as for example tubes up to 500 mm diameter and half-cylinders up to 650 mm diameter. For larger inside diameters shell modules (1/3, 1/4, 1/6 shells, etc.) are used. The design corresponds in principle to that of the standard panels or half-cylinders. The maximum element temperature is also 1150˚C.

Advantages of this system:

1. The heating element is directly incorporated into the module and requires no additional mountings
2. Shape and dimensions and electrical data variable within wide limits
3. Terminal voltages of the modules correspond to mains voltage or fractions of it
4. Easy interchangeability of the modules, if the furnace is suitably designed, during operation also
5. No limitation on the installation position

4

ROB in panel and shell design

The ROB system consists of FIBROTHAL insulation modules with built-in mounting system and meander-shaped heating elements of round wire, the element legs mainly running next to each other in V-form. Both KANTHAL and NIKROTHAL alloys can be used here.

Advantages of this system:

1. Free-radiating heating element up to 1300˚C element temperature.
2. Heating element change possible.
3. Long heating element length over several modules possible, therefore far fewer terminals are required.
4. Larger heating conductor cross-section can be installed; this results in longer element working life.
5. High power concentrations can be installed (see Fig. 14).

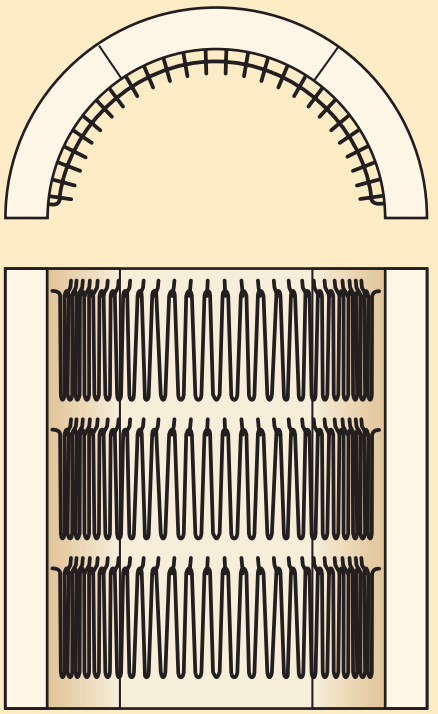

Fig. 20. ROB in panel design

4

Meander systems

Under this designation we supply various designs, which differ basically only in the mounting system for the heating elements. The special feature of these heating elements is that the element legs in principle run parallel to each other. Here again KANTHAL and NIKROTHAL alloys are used.

Meanderthal (System 1)

The heating element mountings consist of special ceramic parts, which are anchored in the ceramic fibre module. Ceramics for particular pitch values are available. The design can also be supplied as a panel.

Advantages of this system:

1. Free-radiating heating element up to 1300˚C element temperature.
2. Heating element change possible.
3. Larger heating conductor cross-sections can be installed; this results in longer element working life.
4. High power concentrations can be installed (see Fig. 14).
5. No limitation on the installation position; also suitable for tilting furnaces.

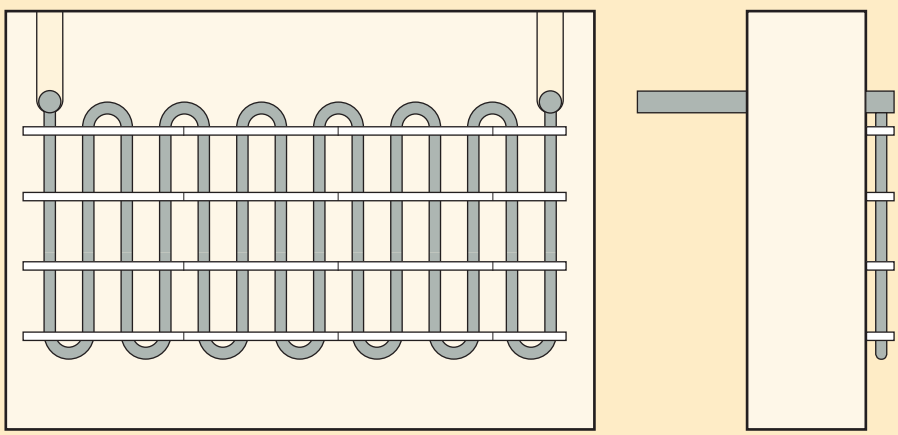

Fig. 21. Meander modules

4

Meanderthal (System 2)

The heating element mountings consist of metallic, hairpin-shaped parts, which are anchored in the ceramic fibre module.

Advantages of this system:

1. Free-radiating heating element up to 1300˚C element temperature.
2. Larger heating conductor cross-sections can be installed; this results in a longer element working life.
3. High power concentrations can be installed (see Fig. 14).
4. No limitation on the installation position; also suitable for tilting furnaces
5. Variable heating element pitch values.
6. Also suitable for round furnaces.

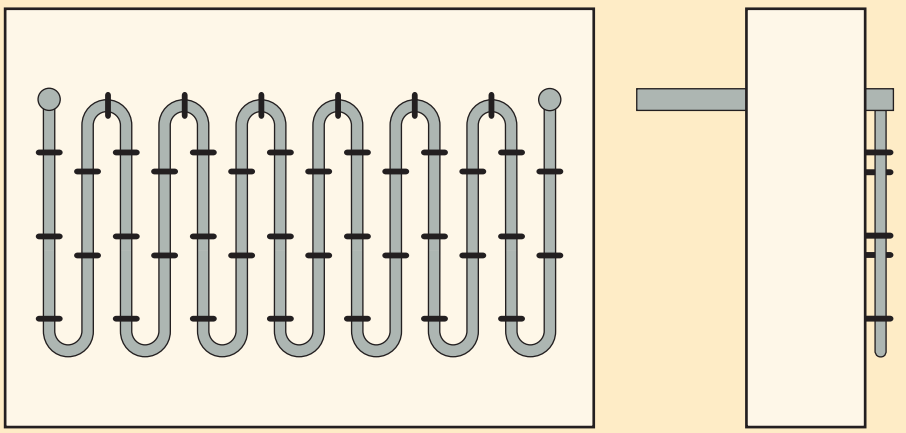

Fig. 22. Meanderthal module, System 2

4

Special Tube Modules

These modules, usually multi-zone, correspond in their design to the RAC tubes (see Principle II, Fig. 16). The maximum inside diameter is 400 mm; lengths up to approx. 2000 mm can be manufactured. If required these heating tubes can also be supplied with a sheet metal shell. Depending on the requirements the alloys KANTHAL A1, AF or APM are used.

Advantages of the system:

1. High temperature uniformity.
2. Precise temperature profiles can be achieved.
3. High power concentration (see Fig. 14)
4. Can be installed in any position.

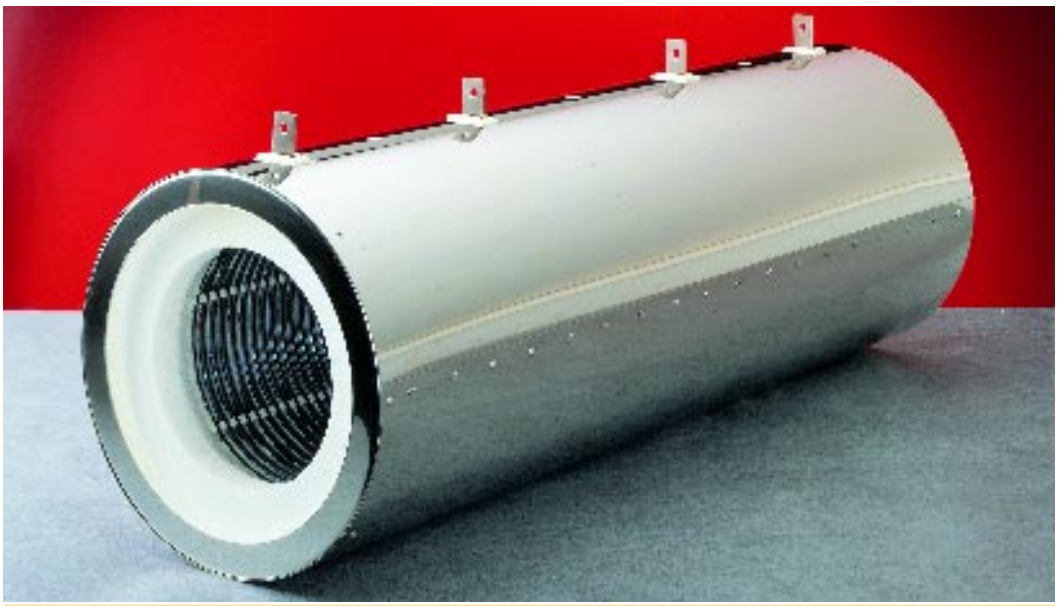

Fig. 23. Heating cassette (diffusion annealing tube)

4

Muffles

Monoblock ceramic fibre modules with embedded heating element, can be used for laboratory and small chamber furnaces. These can be heated on up to four sides. Maximum element temperature 1150˚C. Matching door modules can be supplied.

Advantages of this system:

1. Short assembly times.
2. Short heating up times.
3. Uniform temperature distribution in the furnace interior.
4. Rapidly and easily replaced.

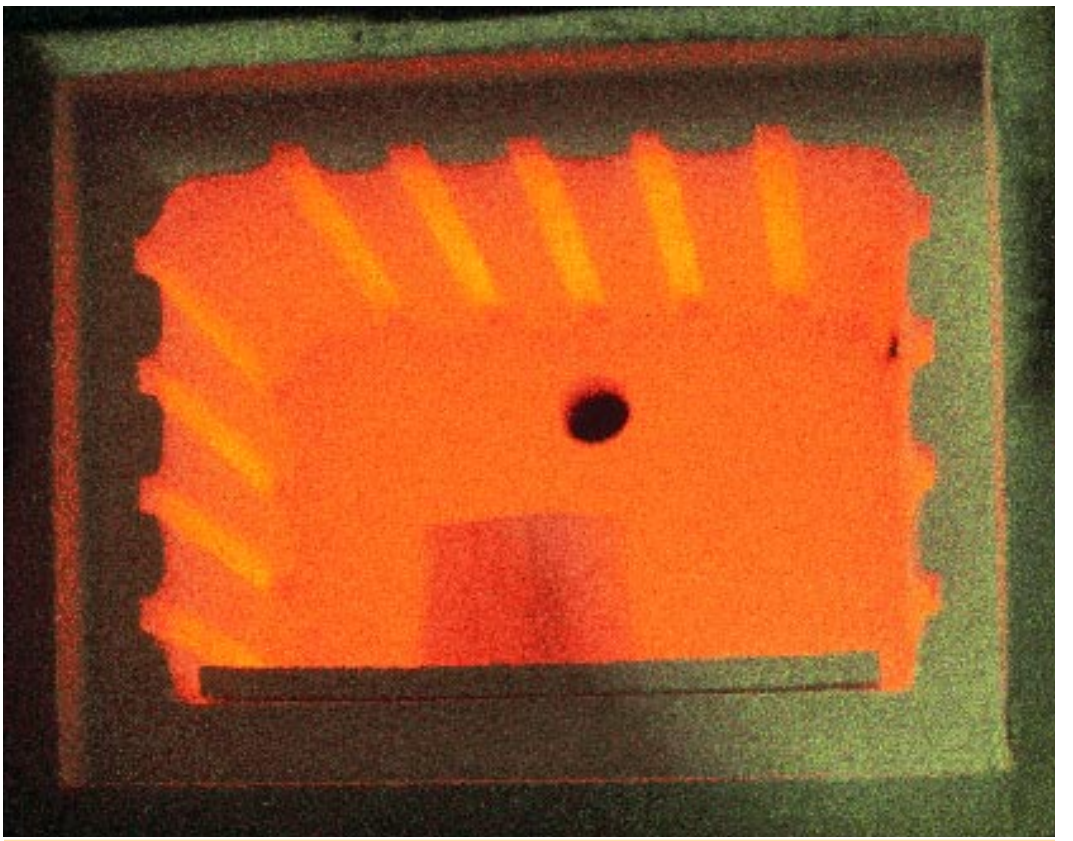

Fig. 24. FIBROTHAL Muffle in laboratory furnace

4

Insulating parts

Insulating parts to special designs can be supplied in the same dimensions as the heating modules described in the preceding section.

FibroSiC, unsupported roof modules

The further development of our FIBROTHAL system, in particular with the objective of achieving self-supporting, easy-to-assemble roof insulation, has led to the combination of ceramic fibre insulation modules and SiC tubes.

This design, introduced under the type designation FibroSiC, can be used for spans up to 2 200 mm at Tf = 1200˚C.

Advantages of this system:

1. Unsupported up to 2200 mm at furnace temperature 1200°C.
2. Easy to assemble.
3. Economic design, since no other roof support is needed.

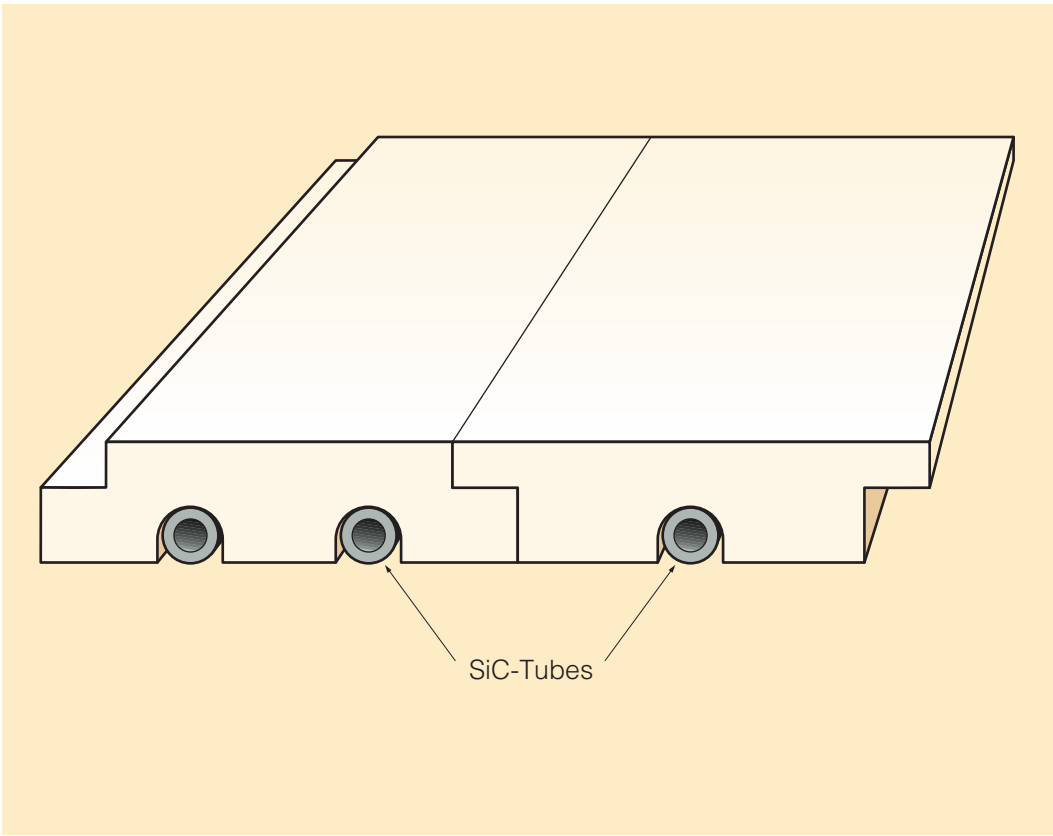

Fig. 25. FibroSiC

4

FIBROTHAL HT 1750/1800

For continuous operating temperatures above 1600˚C conventional ceramic fibre modules cannot fulfil the requirements. This has led to the development of the high temperature fibre ceramic, which because of a special production method can also be supplied in complicated geometrical shapes with homogeneous structure. High quality Al_2O_3 fibres are used in its manufacture. Because organic components are avoided no combustion products are produced even when the material is first used. Because of the special production methods the ceramic fibres are arranged fully isotropically in the module. This prevents de-lamination and displacement both under transient and gradient temperature load.

Advantages of this system:

1. Maximum operating temperature 1750°C and 1800°C respectively.
2. Complicated shapes possibility.
3. No de-lamination.
4. Homogeneous structure.
5. Limited shrinkage.
6. Very good insulation properties.

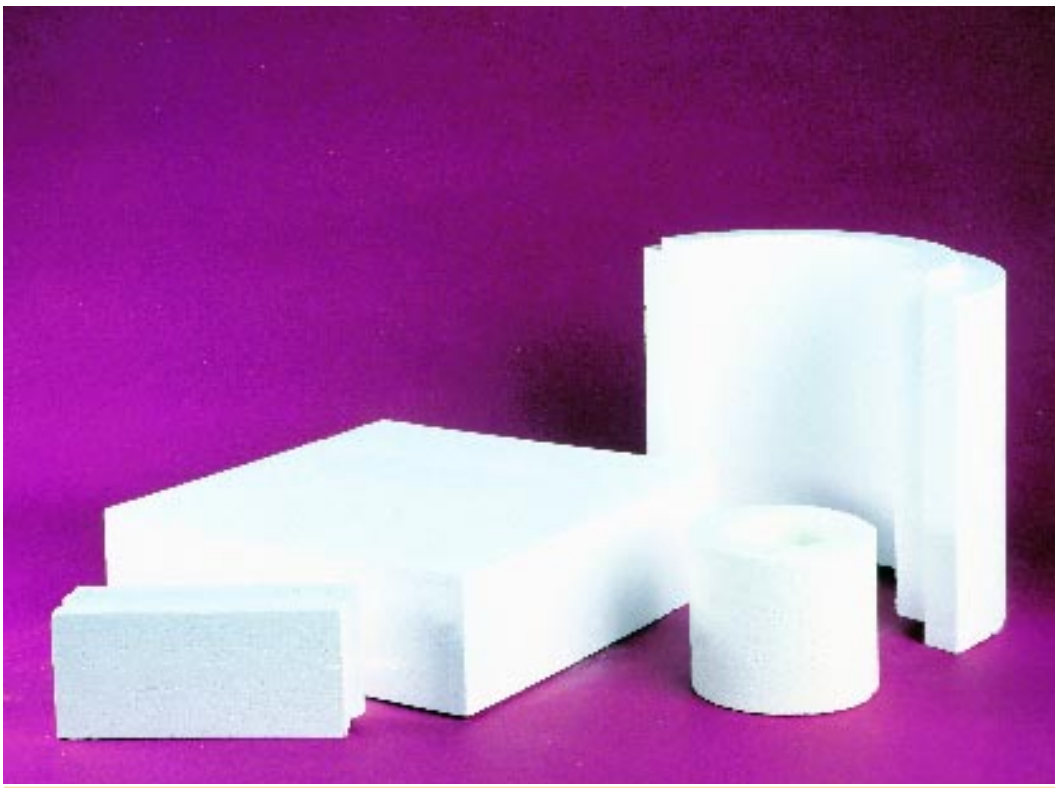

Fig. 26. FIBROTHAL HT1750/1800 Modules

FIBROTHAL High Temperature Modules

4

Form	Part No.	Dimensions* mm			Weight kg
Panels		**L**	**B**	**H**	
PAO 250-124-64	80030405	250	124	64	0,6
PAO 500-400-50	80030406	500	400	50	3,2
PAO 500-400-60	80030407	500	400	60	3,8
PAO 500-400-70	80030408	500	400	70	4,5
PAO 500-400-80	80030409	500	400	80	5,1
PAO 500-400-90	80030410	500	400	90	5,8
PAO 500-400-100	80030411	500	400	100	6,4
PAO 500-400-110	80030412	500	400	110	7,0
PAO 500-400-120	80030413	500	400	120	7,7
PAO 500-400-130	80030414	500	400	130	8,3
PAO 500-400-140	80030415	500	400	140	9,0
PAO 500-400-150	80030416	500	400	150	9,6
PAO 500-500-50	80030417	500	500	50	4,0
PAO 500-500-60	80030418	500	500	60	4,3
PAO 500-500-70	80030419	500	500	70	5,6
PAO 500-500-80	80030420	500	500	80	6,4
PAO 500-500-90	80030421	500	500	90	7,2
PAO 500-500-100	80030422	500	500	100	8,0
PAO 500-500-110	80030423	500	500	110	8,8
PAO 500-500-120	80030424	500	500	120	9,6
PAO 500-500-130	80030425	500	500	130	10,4
PAO 500-500-140	80030426	500	500	140	11,2
PAO 500-500-150	80030427	500	500	150	12,0
PAO 560-560-70	80030428	560	560	70	7,0
PAO 560-560-80	80030429	560	560	80	8,0
Tongue and groove formats					
PAO 295-133-64 NF	80030430	295	133	64	0,8
PAO 500-133-64 NF	80030431	500	133	64	1,4
PAO 500-250-80 NF	80030432	500	250	80	3,2
PAO 500-250-110 NF	80030433	500	250	110	4,4
PAO 800-250-80 NF	80030434	800	250	80	5,1
PAO 800-250-110 NF	80030435	800	250	110	7,0
Half-cylinder					
HAO 500-300-400	80030436	ø 500/300		L = 400	8,0
Tube					
RAO 200-120-200	80030437	ø 200/120		L = 200	1,3

HT 1750 ±2%, HT 1800 ca. -5%

Table 6. FIBROTHAL HT Standard Range

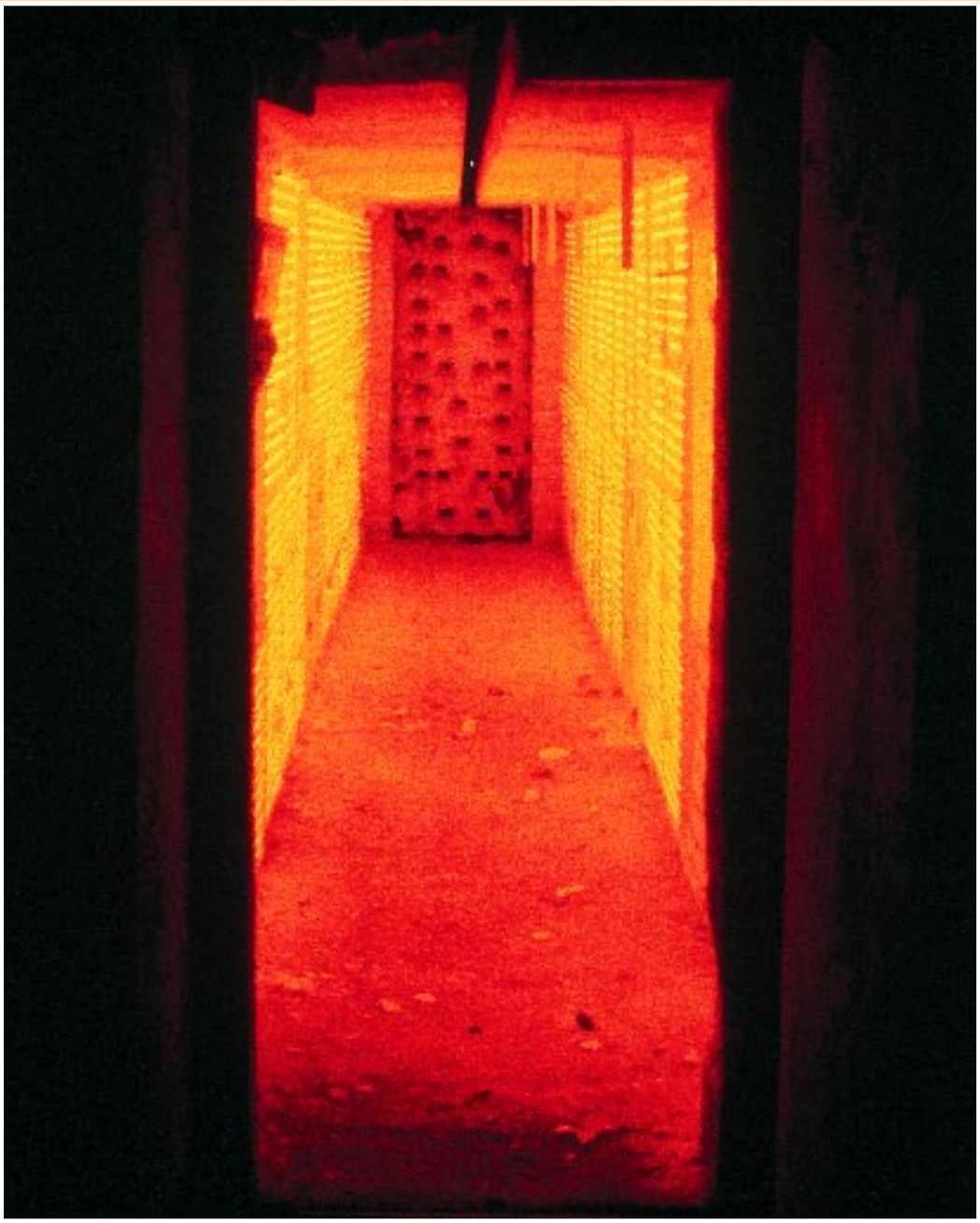

Fig. 27. FIBROTHAL modules in a suspended monorail furnace

Accessories

5

Flexible bead-insulated connecting leads

Only for modules with embedded heating!

The lead consists of NIKROTHAL 40 and is multi-twisted. The choice of the necessary cross-section depends on the power consumption of the FIBROTHAL module. The diagrams below can be used to select the correct lead dimensions. Remember, however, that the temperatures at the terminals must never exceed 200˚C.

It is also necessary to note that the temperature of the lead in the back insulation, in particular the welded connection to the terminal, should not exceed 800˚C. The lead temperature is due to the combination of inherent heating caused by the passing current (see Figs. 28 and 29) and the temperature of the insulation.

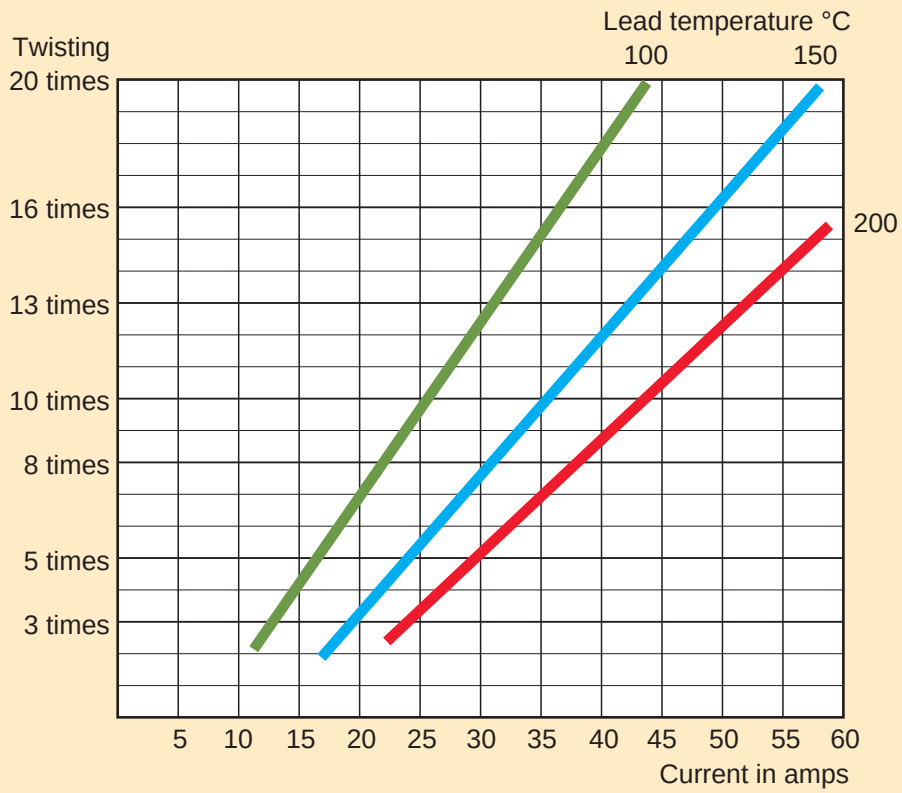

Fig. 28. Leads bead-insulated in air

5

Number of twists:	(x- times)	3	5	6	8	10	13
Outside diameter of the twisted lead:	(mm)	3.5	4.5	5	6.5	7	8.5
Outside diameter of the insulating beads:	(mm)	11	11	11	14	14	14

Table 7. Twisted Connecting Leads

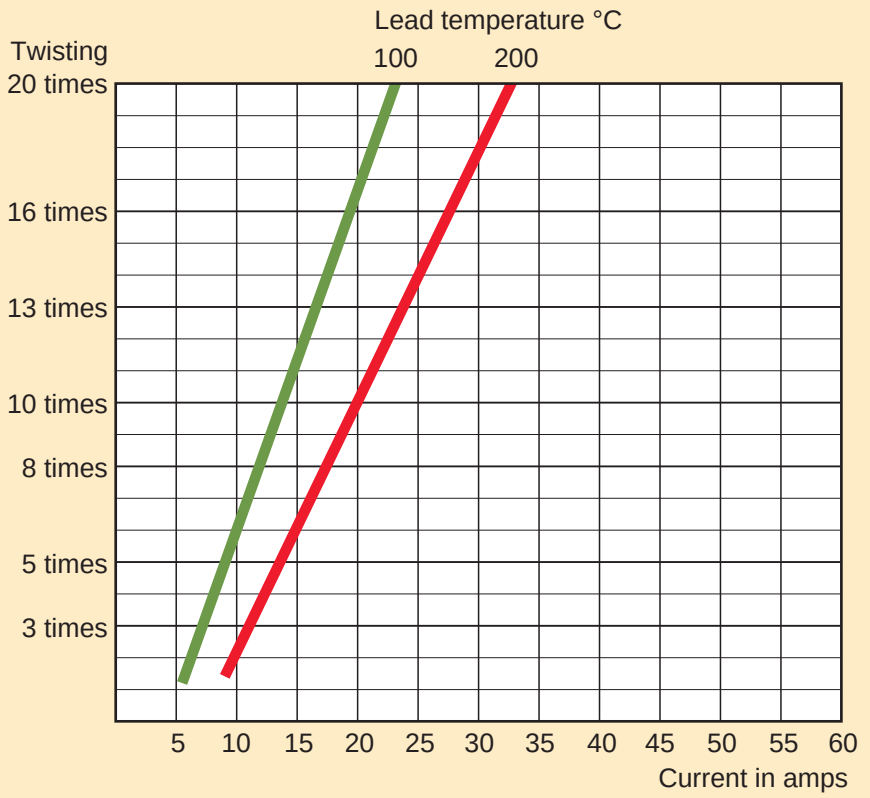

Fig. 29. Leads bead-insulated in Fibrothal

5

FIBROTHAL insulating blankets

for compensating for module and furnace tolerances and shrinkage, dimensions: 1/4" x 300 mm wide

Protection tubes for thermocouples

diameter 7/5 mm x desired length, both ends open

FIBROTHAL Adhesive

for bonding FIBROTHAL modules together

FIBROTHAL hardener

for hardening machined surfaces

FIBROTHAL cement

for patching up damaged FIBROTHAL Modules

FIBROTHAL repair kit

consisting of: FIBROTHAL adhesive, hardener, powder, wool and felt

FIBROTHAL Mounting

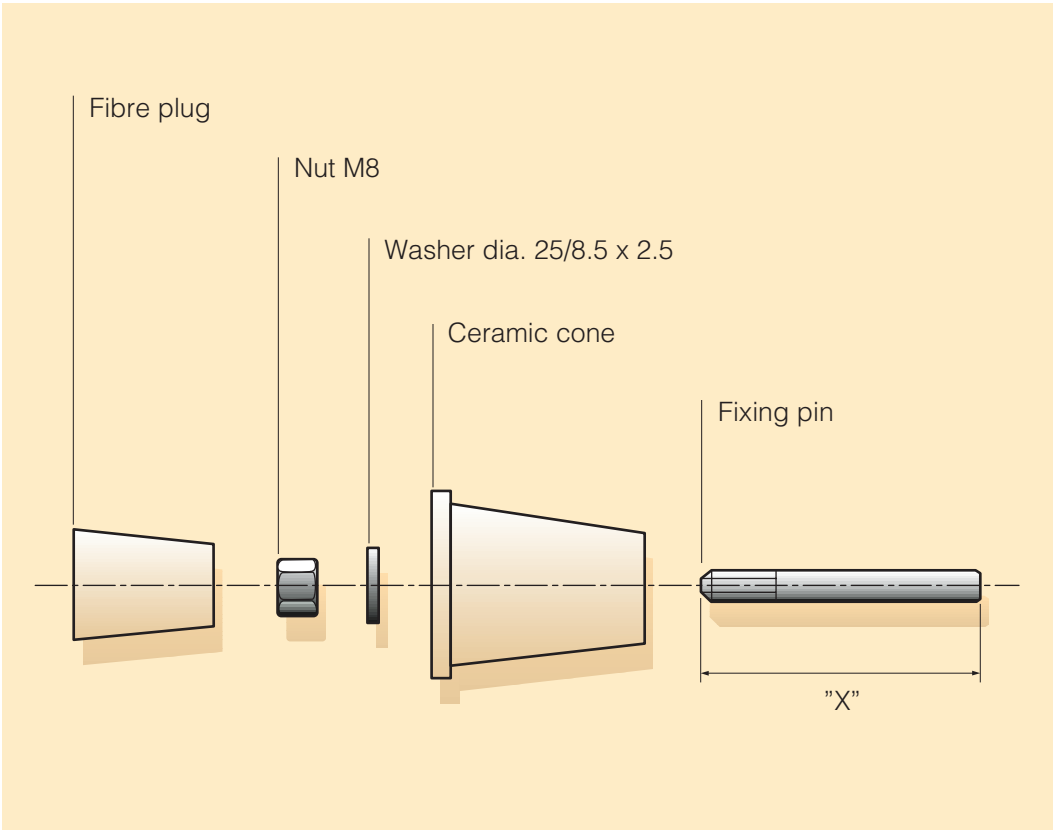

Fig. 30. FIBROTHAL Mountings

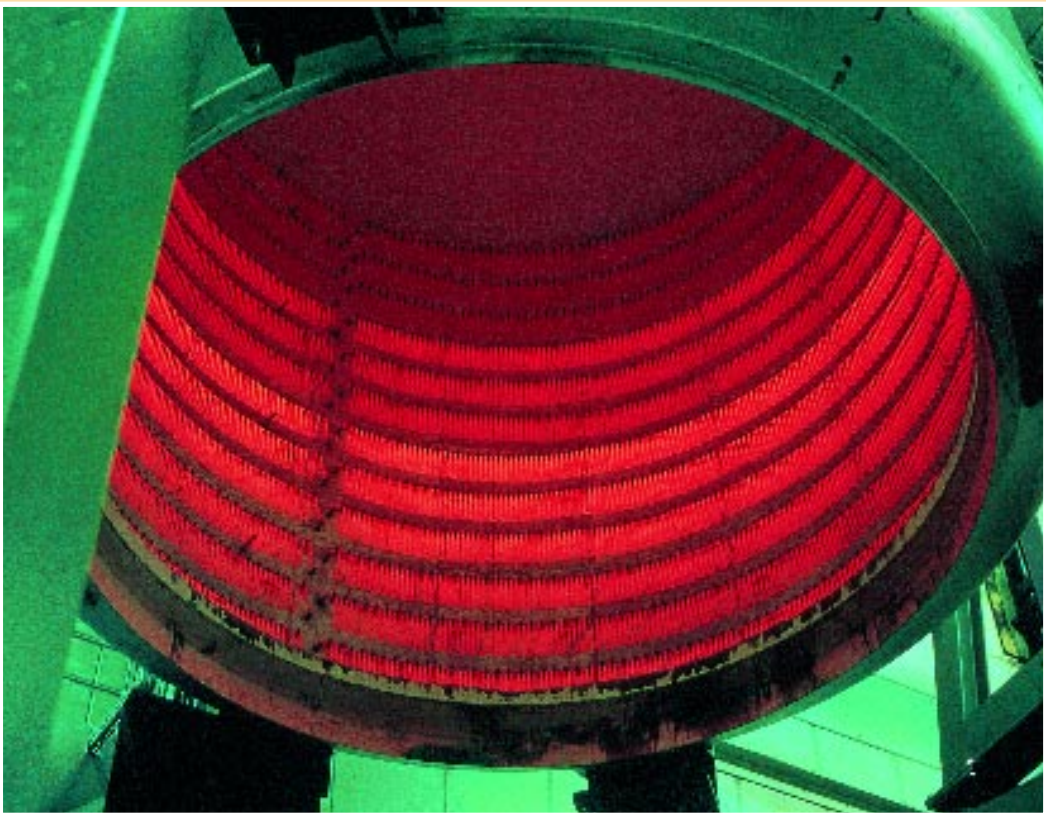

Fig. 31. ROB-Modules in a Bell furnace

Assembly

6

For relatively small furnaces, such as tube furnaces with RAC modules, FIBROTHAL half-cylinders or third cylinders and muffle or chamber furnaces with FIBROTHAL panel modules, usually no special measures are necessary for the mounting or fixing of the FIBROTHAL modules, because they are self-supporting and/or self-stabilising inside the furnace body.

Attaching the FIBROTHAL modules

For attaching the FIBROTHAL modules in larger furnace installations, we recommend the FIBROTHAL mounting (see Accessories). For certain furnace designs it is possible to use a minimum of mountings, sometimes even none, because the modules support each other in a similar way as the blocks of a vault.

Examples of this are shown in Figs. 32, A to C. With this assembly it is essential that the modules can be assembled or inserted from the outside or from above. To reduce the assembly times and therefore costs, we can supply completely pre-assembled module rings.

If the design makes assembly of the modules from the furnace interior necessary, we recommend the tried and tested module combination as per Fig. 32, D.

This design consists of the module types A+B, in which the modules ”B” are held by the modules ”A”. In most cases it is sufficient to fix the modules ”A” with the mountings.

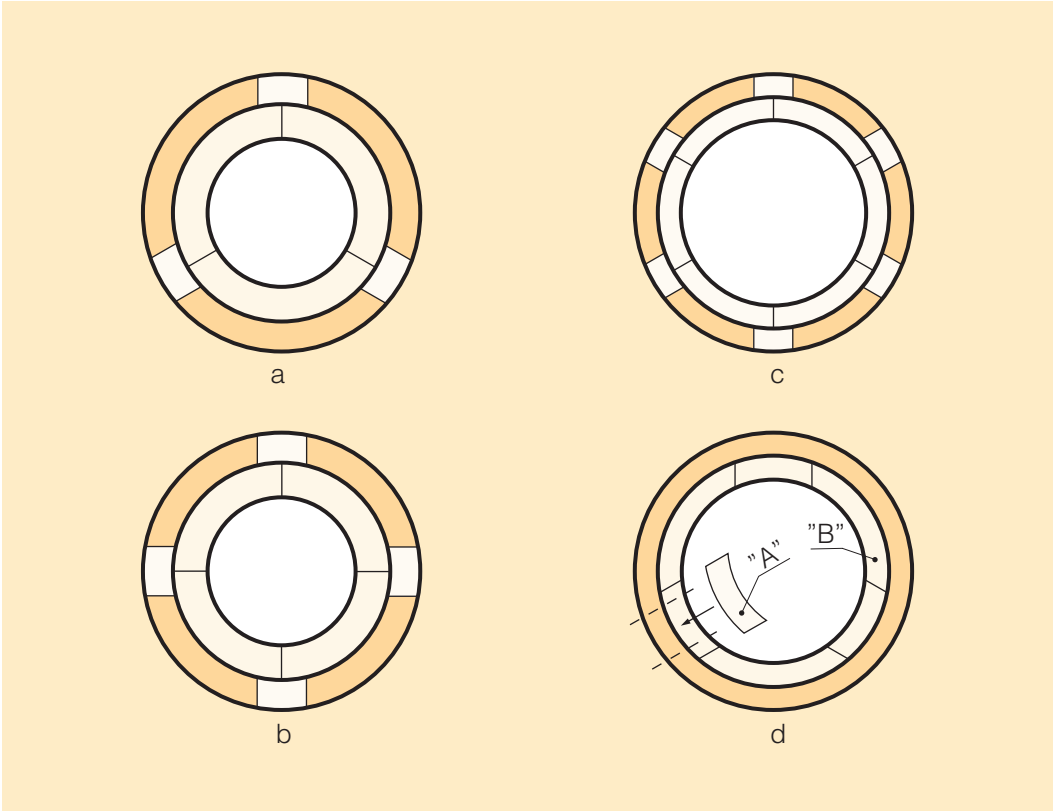

Fig. 32. Module installation situations A-D

6

Sealing the Joints

To compensate for furnace and module tolerances, and for shrinkage of the module inside, but also to prevent radiation losses through the module gaps, we recommend fitting a double folded layer of ceramic fibre felt (see Accessories) between the FIBROTHAL modules. The ceramic fibre felt should project by at least 25 mm from the front of the module. This projection serves to compensate for the thermal module shrinkage.

Welding on the Heating Element

If welding has to be carried out, e.g. between the terminal and the heating element, we recommend using the TIG method. Welding filler is usually not necessary. Please follow our welding instructions.

Further information for design and assembly will be found in our Ideas Book and the Assembly Instructions.

Overview of the Heating Systems

7

The Table below is intended for quick reference to the various heating systems.

	FIBROTHAL Panels	FIBROTHAL Shells	FIBROTHAL Tubes	RAC	R O B	Meanderthal System 1	Meanderthal System 2
Vertical installation	X	X	X	X	X	X	X
Horizontal installation	XD	X	X	X	–	X	X
Floor installation	X	X	n.a.	n.a.	X	X	X
Suitable for round furnaces	O	X	X	X	X	O	X
Element change possible	–	–	–	–	X	X	O
Free-radiating heating	–	–	–	X	X	X	X
Element quality A-1	X	X	X	X	X	X	X
AF	X	X	X	X	X	X	X
APM	X	X	X	X	X	X	X
N80/N60	–	–	–	–	X	X	X
Max. element temperatur °C A-1, AF, APM	1150	1150	1150	1300	1300	1300	1300
Max. element temperatur °C N80/N60	–	–	–	–	1100/1050	1100/1050	1100/1050

X = possible
D =pin system recommended in certain circumstances
O = sometimes possible (customer information necessary)
– = not possible
n.a. = not applicable

Table 8. Selection criteria for heating systems

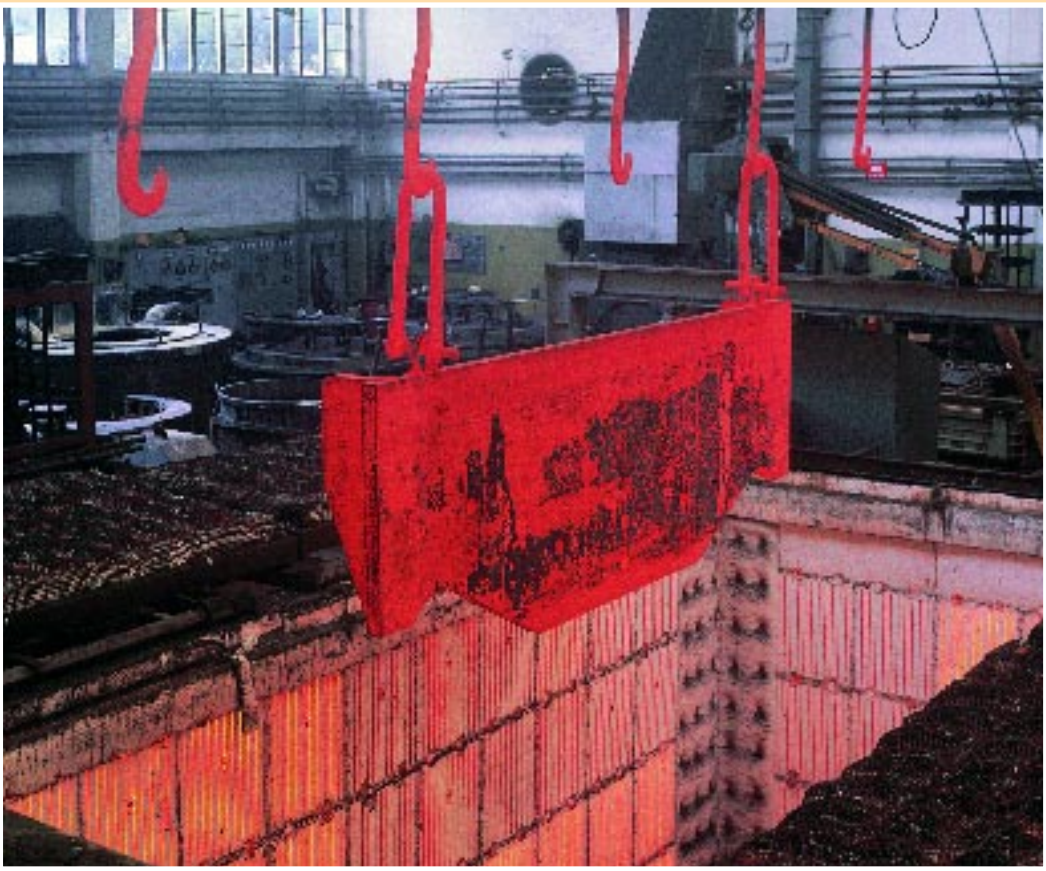

Fig. 33. FIBROTHAL heating modules installed in a shaft furnace

Voltage and power conversion for standard modules

8

Calculation example

Assumption

For a chamber furnace 6 FIBROTHAL heating panels with dimensions 750 x 450 x 125 are necessary. The required furnace should have a power rating of approx. 25 kW.

For this duty the FIBROTHAL heating module PAS 750/450/230 (Table 2) can be chosen. According to the Table the standard data are 5400 Watts at 230 Volts supply voltage with a cold resistance of 9.42 Ohms (hot resistance approx. 4% higher = 9.8 Ohms). 6 heating modules would therefore give a total installed furnace power of 32.4 kW (2 three-phase groups; star connection).

Calculation of the modified power per Fibrothal heating panel

$$\text{Power per heating panel (P)} = \frac{\text{required furnace power (P)}}{\text{Quantity of Heating Modules}}$$

$$\text{Power per heating panel (P)} = \frac{25\ (\text{kW})}{6} = 4170\ (\text{W})$$

Calculation of the new supply voltage (U)

$$U = \sqrt{P \times R_w}$$

$$U = \sqrt{4170\ (\text{W}) \times 9.8\ (\Omega)} = 202{,}15\ (\text{V})$$

U = 202.15 Volts

In this case it is advisable to select 1 three-phase group in delta connection with two heating modules in series, i.e. each module is connected to 200 Volts.

Calculation of the power (P) per FIBROTHAL Heating Module at 200 volts supply voltage

$$P = \frac{U^2}{R_w}$$

$$\frac{200^2\ (\text{V}^2)}{9.8\ (\Omega)} = 4082\ (\text{W})$$

P = 4082 Watts

The total furnace power is therefore 6 x 4082 Watts = 24489 Watts.

The temperature factor which contributes to the change in the heating resistance can be neglected for the calculation illustrated above, because with the element alloy KANTHAL A-1 it is max. 4%.

Fig. 34. FIBROTHAL modules used in a conveyor belt furnace

KANTHAL

KANTHAL AB
P O Box 502
S-734 27 Hallstahammar, Sweden
Tel: +46 220 216 00 Telex: 40967
Telefax: +46 220 169 82, 211 93