TUBES MEASUREMENTS/REGULATIONS

for Thermoelements

W. HALDENWANGER
Technische Keramik GmbH & Co. KG

A member of the Morgan Crucible Company Plc

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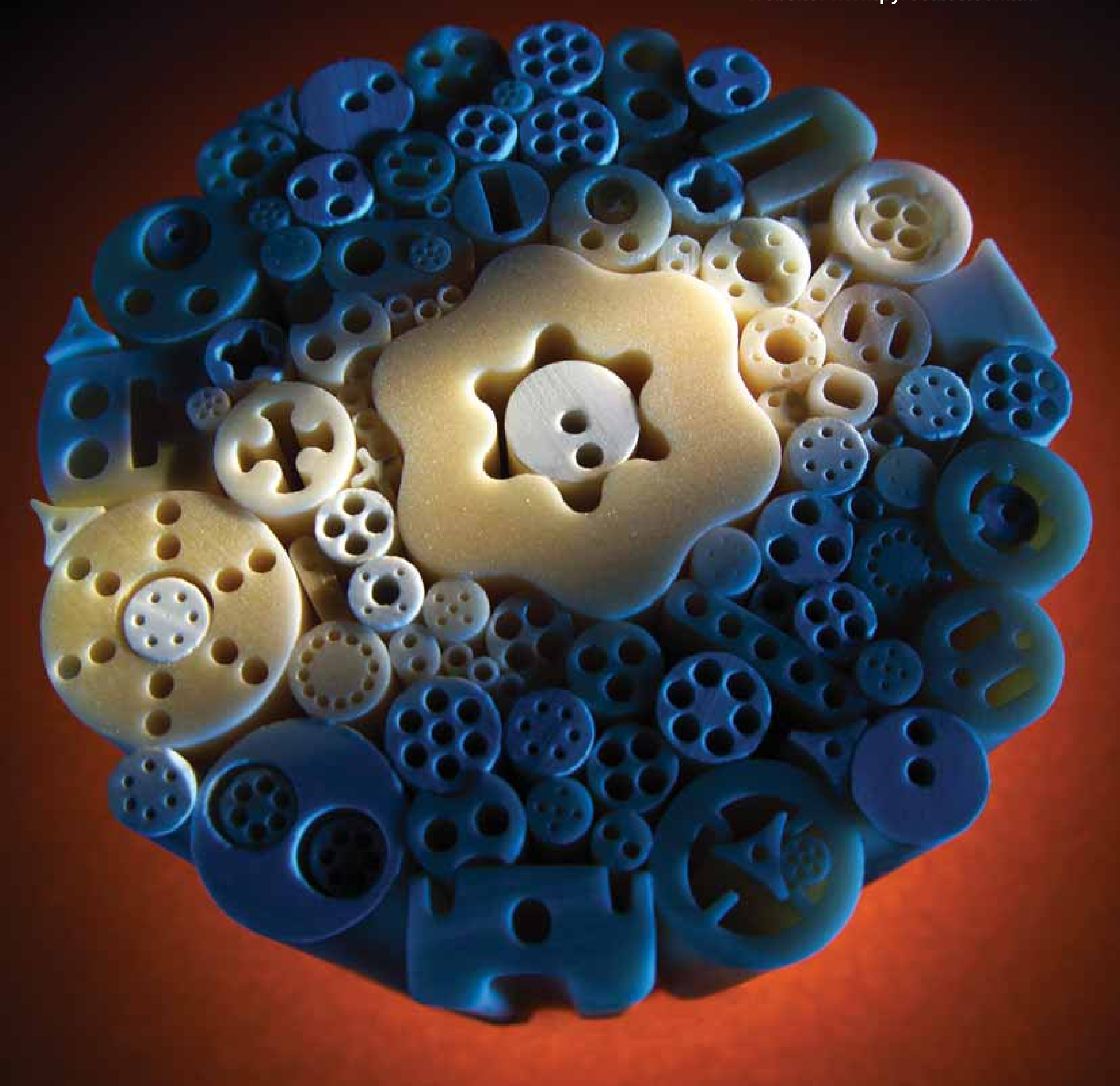
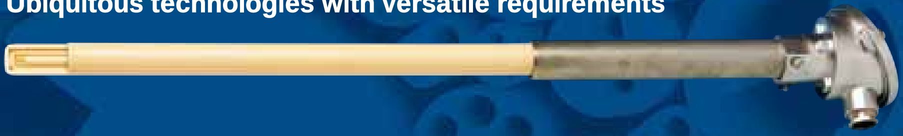


Pyrosales
Total Sensor Solutions

MEASUREMENTS, CONTROLS, REGULATIONS

Ubiquitous technologies with versatile requirements



Whether in research and development, in modern industrial production or even in the home – there is no area in which measurements, control processes and regulations are not required. Today, there are constantly increasing demands for data accuracy. At the same time, the operating conditions for measuring and regulation instruments are becoming consistently stricter, resulting from, for example, temperature change endurance or aggressive mediums.

Owing to their competent high-tech material, technical ceramics made by W. HALDENWANGER have a tradition of performing strikingly well in a variety of extreme applications. This brochure shows a selection of possible applications within measurement and control technology and delivers important information for engineering and construction of ceramic components.

Aluminium oxide ceramic is commonly used to protect delicate sensors which are in constant contact with, for example, corrosion and other damaging processing substances.

Plugs for control lines in nuclear power plants are subject to high radiation; here, synthetic materials were not, or only partially resistant. However, our Alsint 99.7 components are resistant. These Alsint 99.7 components are also faultless in radioactive contaminated areas. As a result of the extreme working temperatures, modern measuring methods such as DTA and DTC require ceramic sheath tubes and other ceramic components – specifically ultrapure Alsint 99.7 is used with DTA and DTC. Laser tubes made of Alsint 99.7 are also used to control the motion sequences of the He-Ne Lasers in harsh operating conditions.

Sheath tubes made of various ceramic materials such as Alsint 99.7, Pythagoras, Sillimantin 60 NG, Sillimantin 60, SiC, Halsic-R and Halsic-I, as well as insulation rods made of Alsint 99.7 or Pythagoras, are applied in the field of temperature measurement.

Within the processes of controlled engineering, corrosion and abrasion, in connection with high temperatures, can result in extreme operational demands which metallic regulation carrying capacities can not withstand. In such cases, Alsint 99.7 or Zirconia components ensure reliable operations.

Technical ceramics reveals its strengths when other materials have long failed to fulfil necessary requirements. The diversity of design and utilization are therefore nearly limitless.

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ALSINT 99.7		PYTHAGORAS		SILLIMANTIN 60
Type C 799 according to DIN EN 60672 Al_2O_3-content 99.7 %		Type C 610 according to DIN EN 60672 Al_2O_3-content approx. 60 %, Alkali-content 3 %		Type C 530 according to DIN EN 60672 Al_2O_3-content 73 – 75 %
Outer / Inner Ø in mm	Outer / Inner Ø in mm	Outer / Inner Ø in mm	Outer / Inner Ø in mm	Outer / Inner Ø in mm
0.8 x 0.3	12.0 x 8.0	0.8 x 0.3	14.0 x 10.0	15 x 10
1.3 x 0.7	12.7 x 8.9	1.3 x 0.7	15.0 x 10.0	20 x 15
1.6 x 1.0	14.0 x 10.0	1.6 x 1.0	15.0 x 11.0	22 x 17
1.8 x 1.2	15.0 x 10.0	1.8 x 1.2	16.0 x 12.0	24 x 19
2.0 x 1.0	17.0 x 12.0	2.0 x 1.0	17.0 x 12.0	26 x 18
2.7 x 1.7	17.0 x 13.0	2.7 x 1.7	17.0 x 13.0	28 x 22
3.0 x 2.0	17.5 x 11.1	3.0 x 2.0	17.5 x 11.1	30 x 23
4.0 x 2.0	20.0 x 15.0	4.0 x 2.0	20.0 x 15.0	
5.0 x 3.0	24.0 x 18.0	5.0 x 3.0	24.0 x 19.0	
6.0 x 4.0	25.4 x 19.1	6.0 x 4.0	25.4 x 19.1	
8.0 x 5.0	26.0 x 20.0	8.0 x 5.0	26.0 x 18.0	
9.0 x 6.0	28.0 x 22.0	9.0 x 6.0	26.0 x 20.0	
9.6 x 6.4	30.0 x 23.0	10.0 x 6.0	28.0 x 22.0	
10.0 x 6.0		10.0 x 7.0	30.0 x 23.0	
10.0 x 7.0		12.0 x 8.0		
max. length 3500 mm depending on outer Ø		max. length 3500 mm depending on outer Ø		max. length 3500 mm depending on outer Ø

SILICON CARBIDE		HALSIC-R		HALSIC-I
fine and course structure, SiC-content approx. 70 and 90 %, clay-bound		According to DIN EN 12212 recrystallized SiC, SiC-content ≥ 99 %		According to DIN EN 12212, reaction-bound, Si-infiltrated SiC, SiC-concentration approx. 90 %, Si-free content ca.10 %
Outer / Inner Ø in mm	Outer / Inner Ø in mm	Outer / Inner Ø in mm	Outer / Inner Ø in mm	Outer / Inner Ø in mm
17 x 12	30 x 23	20 x 10	34 x 24	20 x 13
20 x 12	33 x 28	22 x 12	35 x 25	22 x 15
20 x 15	35 x 27	25 x 15	38 x 25	25 x 18
22 x 17	40 x 32	30 x 15	40 x 30	27 x 20
24 x 19	45 x 25	30 x 20	45 x 35	30 x 20
26 x 18	45 x 35	32 x 22	50 x 38	45 x 35
26 x 20	50 x 25			
max. length 2000 mm depending on outer Ø		max. length 2100 mm depending on outer Ø		max. length 2100 mm depending on outer Ø

Dimensions not included in the table can be custom made upon request.
All of the following tubes are available: both ends open, one end closed, both ends open with flange, one end closed with flange. Tolerances are in compliance with DIN 40 680. Customized tolerances upon request.

Morgan
MorganAdvancedCeramics

2-BORE AND 4-BORE INSULATION RODS

Tools available

Insulation rods made of Alsint 99.7 or Pythagoras are used to insulate inserted thermal wires. In accordance with DIN 43725, Pythagoras insulation rods can be heated to temperatures up to 2732°F/1500°C. For higher temperatures, we recommend Alsint 99.7 insulation rods.

ALSINT 99.7 TYPE C 799						PYTHAGORAS TYPE C 610					
2-bore rods			4-bore rods			2-bore rods			4-bore rods		
* O Ø/B Ø	O Ø/B Ø	O Ø/B Ø	* O Ø/B Ø	O Ø/B Ø	O Ø/B Ø	* O Ø/B Ø	O Ø/B Ø	O Ø/B Ø	* O Ø/B Ø	O Ø/B Ø	O Ø/B Ø
1.2 0.2	5.2 0.2	7.9 1.8	1.5 0.3	5.5 1.3	10.0 1.8	1.1 0.3	5.1 1.5	8.5 2.5	1.5 0.3	4.9 1.1	8.7 2.2
1.2 0.3	5.2 1.6	8.0 2.0	1.7 0.4	5.6 1.0	10.0 3.1	1.2 0.2	5.1 1.9	8.7 2.3	1.7 0.4	4.9 1.4	8.8 2.5
1.4 0.3	5.2 1.7	8.2 1.8	2.3 0.5	5.6 1.3	10.2 2.7	1.2 0.3	5.2 1.7	9.0 2.0	2.1 0.5	5.1 1.2	9.1 2.5
1.7 0.3	5.2 1.8	8.2 2.5	2.4 0.5	5.6 1.5	10.3 2.3	1.4 0.3	5.2 1.9	9.1 2.4	2.3 0.5	5.2 1.1	9.2 2.1
1.9 0.6	5.4 1.3	8.3 1.6	2.4 0.6	5.7 1.2	10.5 1.1	1.5 0.4	5.4 1.8	9.2 2.8	2.3 0.6	5.2 1.3	9.3 2.8
2.0 0.3	5.5 1.5	8.4 2.9	2.6 0.6	5.8 1.2	10.5 1.5	1.6 0.3	5.4 1.9	9.4 2.9	2.4 0.6	5.3 1.0	9.4 1.8
2.0 0.4	5.5 1.8	8.5 1.3	2.7 0.5	5.8 1.5	10.7 2.5	1.8 0.6	5.5 0.9	9.7 2.7	2.5 0.5	5.3 1.1	9.4 3.0
2.0 0.6	5.5 1.9	8.7 2.5	2.7 0.6	5.9 1.5	11.6 2.5	1.9 0.6	5.5 1.1	9.7 3.7	2.5 0.6	5.3 1.2	9.5 1.5
2.1 0.6	5.5 2.0	8.7 2.6	2.7 0.7	6.0 1.3	11.7 3.5	2.0 0.6	5.5 1.8	9.8 3.7	2.5 0.7	5.4 1.1	9.8 1.1
2.3 0.5	5.7 1.1	8.8 1.5	2.8 0.7	6.0 1.4	11.7 3.7	2.1 0.5	5.5 1.9	9.9 3.9	2.6 0.6	5.5 1.2	9.8 1.4
2.7 0.8	5.7 1.8	8.9 0.5	2.9 0.7	6.1 1.8	11.8 3.5	2.1 0.6	5.6 1.5	10.2 2.7	2.7 0.6	5.5 1.5	10.0 2.4
2.9 0.5	5.8 1.4	8.9 2.5	3.2 0.7	6.2 1.7	11.8 3.8	2.6 0.8	5.6 1.8	10.2 3.8	2.8 0.8	5.6 1.5	10.4 3.0
3.0 0.7	5.8 2.0	9.0 1.6	3.3 0.8	6.3 1.7	11.9 3.9	2.7 0.5	5.7 1.9	10.3 3.2	3.0 0.7	5.7 1.2	10.9 2.5
3.1 1.0	5.9 1.0	9.1 2.5	3.5 0.9	6.4 1.2	12.6 3.6	2.9 0.7	5.9 0.9	10.4 3.0	3.1 0.8	5.8 1.6	11.0 3.4
3.2 1.1	5.9 1.2	9.3 2.4	3.6 0.7	6.4 1.6	12.9 4.1	3.0 1.1	5.9 1.8	10.4 3.8	3.3 0.9	5.8 1.7	11.0 3.5
3.3 1.1	5.9 1.8	9.3 3.0	3.6 1.1	6.5 1.7	13.3 3.1	3.1 1.1	5.9 2.0	10.5 3.0	3.4 0.6	5.9 1.7	11.0 3.6
3.4 1.1	5.9 1.9	9.6 2.1	3.8 0.8	6.6 1.5	13.3 3.5	3.2 1.0	6.0 1.0	10.6 3.5	3.4 1.0	6.0 1.2	11.1 3.7
3.6 0.5	5.9 2.0	9.7 2.5	3.8 1.0	6.6 2.0	14.2 3.6	3.4 0.5	6.0 1.5	10.7 2.5	3.4 1.2	6.0 1.6	11.2 3.8
3.6 0.8	6.0 1.5	9.8 2.9	3.9 0.7	6.7 1.0	14.3 3.5	3.4 0.8	6.0 2.0	10.7 3.7	3.5 0.8	6.1 1.5	11.5 3.3
3.7 1.1	6.0 1.8	10.0 2.3	4.0 1.0	6.7 1.9	15.8 3.8	3.5 1.1	6.3 1.5	10.9 1.5	3.5 1.0	6.1 1.7	11.8 3.5
3.7 1.2	6.1 1.9	10.0 3.1	4.0 1.1	7.0 1.5	16.9 4.6	3.5 1.2	6.3 1.8	11.0 3.0	3.6 0.8	6.2 1.5	12.5 3.0
3.8 1.1	6.2 1.0	10.0 3.8	4.1 0.7	7.8 1.5		3.7 1.1	6.4 0.9	11.5 3.0	3.7 0.7	6.2 2.0	12.5 3.4
3.9 1.2	6.2 1.8	10.2 1.5	4.1 0.8	7.8 2.0		3.8 0.5	6.4 1.4	11.5 3.3	3.7 0.9	6.3 1.0	12.5 3.8
4.0 0.8	6.2 2.0	10.2 2.7	4.2 0.7	7.9 1.5		3.8 0.8	6.4 2.4	11.7 4.0	3.8 0.6	6.7 1.8	13.0 3.5
4.0 1.0	6.3 0.9	10.3 2.8	4.2 0.8	8.0 2.3		3.8 0.9	6.5 1.0	11.9 1.1	3.8 0.9	7.3 1.5	13.2 3.6
4.1 0.5	6.3 1.8	10.9 2.7	4.2 1.2	8.3 1.7		3.9 0.9	6.5 1.6	12.0 3.9	3.8 1.1	7.3 1.9	13.2 4.0
4.1 0.9	6.4 1.0	10.9 3.9	4.3 0.7	8.3 1.8		3.9 1.2	6.5 1.9	12.8 4.5	3.9 0.6	7.4 1.5	13.4 3.4
4.1 1.0	6.4 1.5	11.1 3.1	4.3 0.8	8.3 2.3		4.0 1.3	6.5 2.2	13.0 2.4	3.9 0.8	7.8 1.7	14.2 4.0
4.2 1.2	6.4 2.1	11.1 3.9	4.3 1.2	8.4 1.9		4.2 1.2	6.8 2.2	14.1 4.5	3.9 1.1	7.8 2.3	14.8 3.7
4.3 1.3	6.7 1.5	11.3 3.6	4.5 1.3	8.4 2.2		4.2 1.3	7.0 1.1	14.2 4.5	4.0 0.7	7.9 1.9	15.0 3.6
4.3 1.4	6.7 1.8	11.4 2.5	4.6 1.0	8.5 1.5		4.2 1.6	7.0 2.6	15.3 4.8	4.0 1.1	7.9 2.2	15.8 4.5
4.4 1.3	6.8 0.9	11.6 1.5	4.7 0.7	8.5 2.5		4.3 1.2	7.1 2.4	17.7 4.0	4.0 1.2	8.0 1.8	
4.5 1.2	6.8 1.5	12.2 3.3	4.8 0.8	8.6 1.8		4.4 0.9	7.2 2.4	18.3 4.1	4.1 0.7	8.0 2.3	
4.6 1.0	6.8 2.4	12.2 3.4	4.8 1.0	8.6 1.9		4.4 1.0	7.4 1.8		4.2 1.3	8.0 2.4	
4.6 1.2	6.9 1.0	12.3 3.0	4.8 1.1	8.6 2.0		4.4 1.3	7.5 1.9		4.3 0.9	8.0 2.5	
4.7 1.0	6.9 1.6	12.5 4.1	4.8 1.2	8.6 2.3		4.5 1.0	7.7 1.7		4.4 0.7	8.1 1.5	
4.7 1.1	6.9 2.2	12.6 1.2	4.8 1.5	8.8 1.2		4.5 1.5	7.7 2.4		4.5 0.8	8.1 1.7	
4.7 1.3	7.0 1.6	13.6 4.6	5.0 1.1	8.8 1.5		4.6 1.6	7.8 1.6		4.5 0.9	8.1 1.8	
4.7 1.5	7.0 2.0	13.8 2.5	5.0 1.2	8.8 1.8		4.7 1.4	8.2 1.5		4.5 1.1	8.1 1.9	
4.8 1.0	7.2 2.3	15.0 4.6	5.1 1.0	9.1 2.1		4.7 1.7	8.2 2.4		4.5 1.2	8.1 2.3	
4.8 1.5	7.4 2.6	15.1 4.6	5.2 1.2	9.4 2.5		4.9 1.6	8.2 2.6		4.5 1.5	8.2 1.5	
4.9 1.7	7.5 1.1	15.9 3.3	5.2 1.3	9.6 2.9		4.9 1.7	8.4 0.5		4.7 1.1	8.2 1.8	
5.0 1.4	7.6 2.4	16.3 4.9	5.4 1.2	9.7 2.6		4.9 1.8	8.4 2.5		4.7 1.2	8.3 1.2	
5.0 1.8	7.7 2.5		5.5 1.2	9.9 2.8		5.1 1.2	8.5 1.6		4.8 0.9	8.5 1.5	

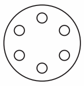
** O Ø = Outer diameter in mm* *B Ø = Bore diameter in mm*

MULTI-BORE INSULATION RODS

Tools available

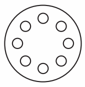
ALSINT 99.7 TYPE C 799 / PYTHAGORAS TYPE C 610

6-bore rods



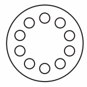
* O Ø	6 x B Ø	O Ø	6 x B Ø
1.5	0.25	1.5	0.25
4.0	0.75	4.0	1.10
4.4	1.00	4.5	1.10
5.0	1.10	5.1	1.20
6.0	1.20	6.0	1.10
8.0	1.20	7.5	1.20

8-bore rods



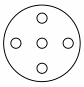
* O Ø	8 x B Ø	O Ø	8 x B Ø
4.2	0.75	4.0	0.75
4.8	0.80	4.5	0.80
6.0	0.55	5.0	0.60
6.4	1.00	6.0	1.00
7.5	0.80	7.0	0.80
12.7	2.10	12.0	2.00

10-bore rods



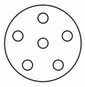
* O Ø	10 x B Ø	O Ø	10 x B Ø
5.3	0.40	5.0	0.40
5.5	0.80	5.2	0.80
5.7	0.65	5.4	0.65
6.0	0.75	5.6	0.75
7.0	1.10	6.5	1.10
8.0	0.70	7.5	0.70

5-bore rods with centre bore



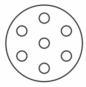
* O Ø	5 x B Ø	O Ø	5 x B Ø
2.7	0.35	2.6	0.35
4.5	0.5	4.3	0.5
9.4	1.0	8.7	1.0

6-bore rods with centre bore



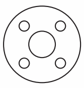
* O Ø	6 x B Ø	O Ø	6 x B Ø
2.1	0.4	2.0	0.4
4.9	0.55	4.6	0.55
5.4	1.1	5.0	1.1

7-bore rods with centre bore



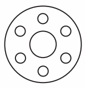
* O Ø	7 x B Ø	O Ø	7 x B Ø
2.0	0.25	1.9	0.25
3.2	0.3	3.0	0.3
17.0	4.0	16.0	3.7

5-bore rods with centre bore and 4 smaller bores



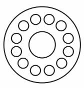
* O Ø	CB Ø	4 x B Ø	O Ø	CB Ø	4 x B Ø
3.0	0.9	0.30	2.8	0.9	0.50
4.0	1.5	0.75	4.5	1.2	0.75
5.0	2.4	0.75	7.7	2.9	1.20
8.5	4.0	0.80	8.0	3.7	0.80
9.0	3.2	1.15	9.2	4.0	1.10

7-bore rods with centre bore and 6 smaller bores



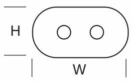
* O Ø	CB Ø	6 x B Ø	O Ø	CB Ø	6 x B Ø
3.7	1.8	0.45	3.5	1.7	0.45
4.0	1.8	0.45	4.0	1.7	0.75
5.0	1.8	0.75	5.0	1.8	0.70
11.0	4.3	2.10	10.4	4.0	2.00
13.3	4.4	2.40	12.5	4.1	2.30

13-bore rods with centre bore and 12 smaller bores



* O Ø	CB Ø	12 x B Ø	O Ø	CB Ø	12 x B Ø
8.6	4.4	0.3	7.7	4.1	0.3
9.6	2.1	1.2	9.0	1.9	1.2
9.6	2.1	1.1	9.0	2.0	1.1

Oval 2-bore rods

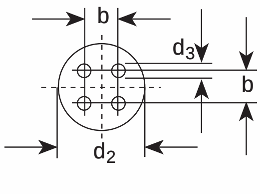


W	/	H	x	B Ø	W	/	H	x	D Ø
3.0	/	2.0	x	0.7	2.3	/	1.4	x	0.7
4.5	/	3.0	x	1.5	3.0	/	2.0	x	1.0
7.5	/	5.0	x	2.2	4.0	/	2.7	x	1.0
11.5	/	7.2	x	3.9	4.6	/	3.3	x	1.5
12.0	/	8.0	x	4.0	11.5	/	6.3	x	4.2

** O Ø = Outer diameter in mm   B Ø = Bore diameter in mm   CB Ø = Centre bore diameter in mm*

DIN MEASUREMENTS

Measurements for ceramic sheath tubes and insulation components for thermoelements according to DIN 43724 and DIN 43725



Materials for insulation rods
C 610 or C 799
DIN EN 60672

4-bore insulation rods according to DIN 43725			Wire Ø	1-bore insulation rods according to DIN 43725			Wire Ø
Outer Ø (d_2) in mm	Bore Ø (d_3) in mm	Length in mm	Ø in mm	Outer Ø (d_1) in mm	Inner Ø in mm	Length in mm	Ø in mm
5.5	1.2	205 275 380 560 770 1060 1460 2060	≤ 0.8	2.7 ± 0.2	1.7	5, 10, 25, 50	1.0 and 1.38
8.5	1.5		≤ 0.8	4.0 ± 0.3	2.0	5, 10, 25, 50	1.38
				6.0 ± 0.3	4.0	5, 10, 25, 50	3.0

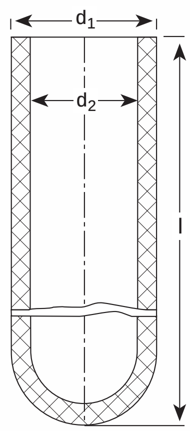


TABLE 1: ceramic sheath tubes DIN 43724

DIN EN 60672	Outer Ø (d_1) in mm	Inner Ø (d_2) in mm	Length (L) in mm	Thermal shock resistance	Permeability	Max. permissible continuous temp.
C 610	10	7	200, 270, 375, 530, 740, 1030	medium to good	gastight	2732 °F 1500 °C
	15	11	530, 740, 1030, 1430, 2030			
	24	19	530, 740, 1030, 1430			
C 530	26	18	530, 740, 1030, 1430	very good	porous	2912°F/1600°C
C 799	10	6	200, 270, 375, 530	medium	gastight	2912 °F 1600 °C
	15	10	530, 740, 1030			
	24	18	530, 740, 1030, 1430			

DESIGN

Unglazed. Admissible tolerance of the wall thickness is in compliance with DIN 40680 Part 1, degree of accuracy: Coarse. Admissible deflection is in compliance with DIN 40680 Part 2, degree of accuracy: Fine, with the following specifications: A straight rod, diameter 0.8 x (d1-2s), must be able to be inserted to the bottom of the sheath tube. The rounded bottom of the sheath tube uniformly becomes the cylindrical section of the sheath tube.

REQUIREMENTS

Thermal shock resistance:
No visible damage after test implementation.

Dimensional stability: Original straightness after test implementation.

Gastightness: No air is released during testing: only valid for the sheath tubes labelled gastight in Table 1.

TESTS

Thermal shock resistance:
The sheath tube is inserted with the closed end into a 40 mm internal diameter tube furnace at a constant rate (Table 2). The furnace is heated to the maximum permissible continuous temperature of the sheath tube. The sheath tube must not come in contact with the tube furnace, therefore a vertical setup of the tube furnace is recommended. After a minimum of 20 minutes holding time, the sheath tube is removed at the same rate and is hung freely in order to cool in calm air.

TABLE 2

Diameter d1 in mm	Insertion rate cm/min
10	100
15	50
24 and 26	1

Dimensional stability:
The sheath tube is horizontally clamped into the tube furnace used for thermal shock resistance testing and is then heated to the maximum permissible continuous temperature. This procedure lasts for 30 minutes.

Gastightness:
The sheath tube is exposed to an inner overpressure of 2 bar, and then submersed in water for one minute.

Note: The tests should be conducted in the abovementioned order. The thermal shock resistance tests and dimensional stability tests can be conducted simultaneously when the tube furnace is setup horizontally.

GUIDELINES

for the selection of sheath tube materials according to DIN 43724, Paragraph 7:

- Alkalis- and hydrofluoric acid-free gases up to 2732 °F / 1500 °C: Type C 610
- Contact with alkali vapours up to 2732 °F / 1500 °C: Type C 799
- Gases of all kinds, if inner tubes are gas-tight, up to 2912 °F / 1600 °C: Type C 530
- Melting glass up to 2732 °F / 1500 °C: Type C 799

(not general specifications; reference values only)

TOLERANCES ACCORDING TO DIN 40680

W. HALDENWANGER
Technische Keramik GmbH & Co. KG

A member of the Morgan Crucible Company Plc

Diameter and deflection tolerances without grinding according to DIN 40680

Nominal Ø or length in mm	Accuracy (admissible tolerances in mm) coarse	medium
up to 4	± 0.4	± 0.15
above 4 up to 6	± 0.6	± 0.20
above 6 up to 8	± 0.7	± 0.25
above 8 up to 10	± 0.8	± 0.30
above 10 up to 13	± 1.0	± 0.35
above 13 up to 16	± 1.2	± 0.40
above 16 up to 20	± 1.2	± 0.45
above 20 up to 25	± 1.5	± 0.50
above 25 up to 30	± 1.5	± 0.55
above 30 up to 35	± 2.0	± 0.60
above 35 up to 40	± 2.0	± 0.65
above 40 up to 45	± 2.0	± 0.70
above 45 up to 50	± 2.5	± 0.80
above 50 up to 55	± 2.5	± 0.90
above 55 up to 60	± 2.5	± 1.00
above 60 up to 70	± 3.0	± 1.20
above 70 up to 80	± 3.5	± 1.40
above 80 up to 90	± 4.0	± 1.60
above 90 up to 100	± 4.5	± 1.80
above 100 up to 110	± 5.0	± 2.00
above 110 up to 125	± 5.5	± 2.20
above 125 up to 140	± 6.0	± 2.50
above 140 up to 155	± 6.5	± 2.80
above 155 up to 170	± 7.0	± 3.00
above 170 up to 185	± 7.5	± 3.40
above 185 up to 200	± 8.0	± 3.80
above 200 up to 250	± 9.0	± 4.20
above 250 up to 300	± 10.0	± 4.60
above 300 up to 350	± 11.0	± 5.00
above 350 up to 400	± 12.0	± 5.50
above 400 up to 450	± 13.0	± 6.10
above 450 up to 500	± 14.0	± 6.80
above 500 up to 600	± 15.0	± 7.60
above 600 up to 700	± 16.0	± 8.30
above 700 up to 800	± 17.5	± 9.00
above 800 up to 900	± 19.0	± 9.50
above 900 up to 1000	± 20.0	± 10.00
above 1000	± 0.02 · d	± 0.01 · d

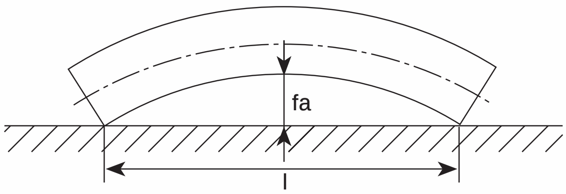
Nominal length in mm	Accuracy (admissible deflection fa in mm) coarse	medium
up to 30	1.7	0.15
above 30 up to 40	1.8	0.20
above 40 up to 50	1.9	0.25
above 50 up to 60	2.0	0.30
above 60 up to 70	2.1	0.35
above 70 up to 80	2.1	0.40
above 80 up to 90	2.2	0.45
above 90 up to 100	2.3	0.50
above 100 up to 110	2.4	0.55
above 110 up to 125	2.5	0.65
above 125 up to 140	2.6	0.70
above 140 up to 155	2.7	0.80
above 155 up to 170	2.9	0.85
above 170 up to 185	3.0	0.90
above 185 up to 200	3.1	1.00
above 200 up to 250	3.5	1.25
above 250 up to 300	3.9	1.50
above 300 up to 350	4.3	1.75
above 350 up to 400	4.7	2.00
above 400 up to 450	5.1	2.25
above 450 up to 500	5.5	2.50
above 500 up to 600	6.3	3.00
above 600 up to 700	7.1	3.50
above 700 up to 800	7.9	4.00
above 800 up to 900	8.7	4.50
above 900 up to 1000	9.5	5.00
above 1000	1.5 + 0.8 % · l	0.5 % · l

Please contact us for stricter tolerances.

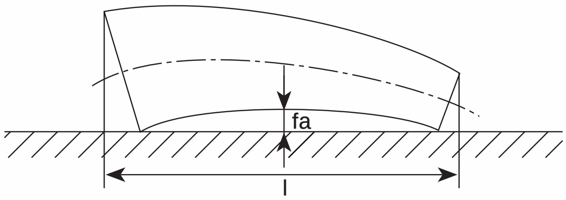
Manufacturing process	Degree of accuracy coarse	medium
Casted, turned, extruded for parts with an envelope size of 30 mm and higher	Common application	
Extruded for parts with an envelope size up to 30 mm, non-metered pressed, metered semi-moist pressed, metered dry pressed, white machined		Common application

Accuracy	coarse		medium	
DIN EN 60672 Type	C 610	C 799	C 610	C 799
Manufacturing processes				
Casted	•	•		
Turned	•			
Extruded envelope size 30 mm and higher	•	•		
Extruded envelope size up to 30 mm			•	•
Non-metered pressed			•	
Metered semi-moist pressed		•		
Metered dry pressed				•
White machined			•	•

The values for accuracy: Course are not applicable to the first manufacturing. Special agreements are required.
• Customary manufacturing process



Deflection of a cylindrical formed part



Deflection of a non-cylindrical formed part

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