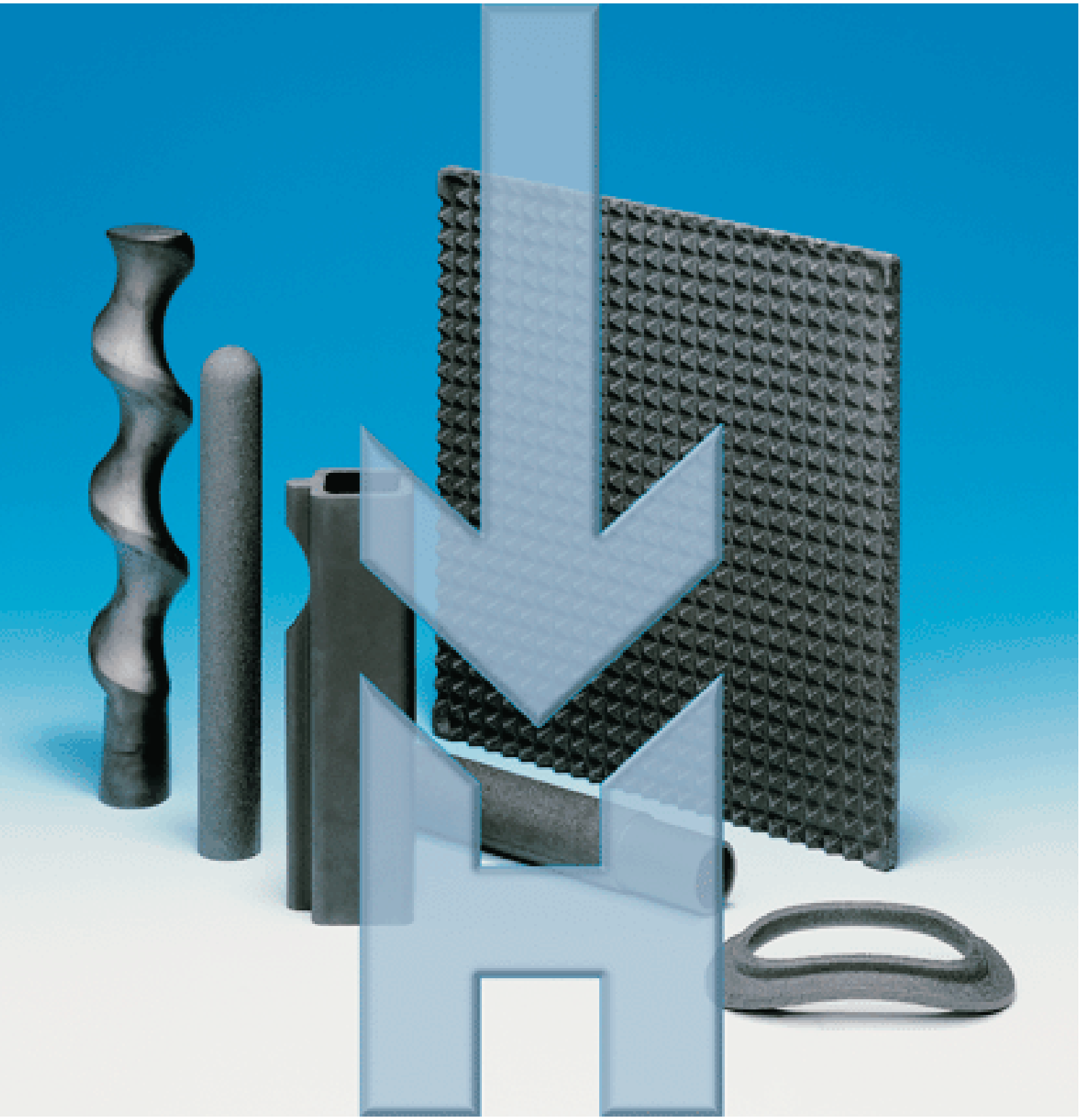
HALDENWANGER

Halsic-R/-RX/-I/-S



Morgan
morganadvancedceramics

HALSIC is the name for four exceptional high-performance ceramics from the material group silicon carbide (SiC) made by W. HALDENWANGER. They have the following common characteristics: absolute dimensional stability despite very high mechanical strain in high temperature applications - very good thermal shock resistance - extremely high corrosion resistance - low specific weight.

Halsic-R

- recrystallized silicon carbide (RSiC)
- compact SiC matrix with open porosity
- classic ceramic for high temperature constructions
- large sized components possible
- reliable bonding of coatings
- application temperatures: 1600 °C (oxidizing) and approx. 2000 °C (under protective atmosphere)
- resistant against strong acids and alkalis

Halsic-I

- silicon infiltrated reaction bonded silicon carbide (SiSiC)
- reaction bonded SiC matrix, free of pores, with residual metallic silicon
- high temperature ceramic for highest mechanical loads
- extremely good oxidation resistance
- large sized components possible
- application temperatures: up to 1350 °C
- corrosion resistant against strong acids and alkalis

Halsic-RX

- chemically doped recrystallized silicon carbide ($RSiC_{doped}$)
- compact SiC matrix with open porosity
- very good oxidation resistance
- multiple increased life time compared to Halsic-R
- ideal material for porcelain fast firing
- large sized components possible
- reliable bonding of coatings
- application temperatures: up to 1650 °C (oxidizing)

Halsic-S

- pressureless sintered silicon carbide (SSiC)
- dense sintered SiC matrix with very low percentage of closed pores
- high temperature ceramic for extreme mechanical loads
- extremely good oxidation resistance
- application temperatures: up to 1600 °C
- corrosion resistant against strong acids and alkalis

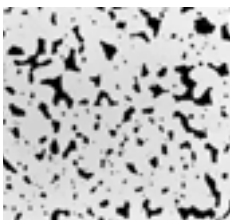
HALSIC MATERIALS

Physical properties* of W. HALDENWANGER Halsic materials					
	Units	**Halsic-R** RSiC recrystallized	**Halsic-RX** $RSiC_{doped}$ chemically doped	**Halsic-I** SiSiC reaction bonded silicon infiltrated	**Halsic-S** SSiC pressureless sintered
Contents: SiC metallic Si	vol %	≥ 99	≥ 99 [1]	88 - 92 12 - 8	≥ 99
Bulk density 20 °C	$g \cdot cm^{-3}$	2.7	2.7	3.1	3.1
Water absorption	weight %	5	5	≤ 0.1	≤ 0.1
Flexural strength at 20 °C [2]	MPa	80 - 100	80 - 100	240 - 280	350 - 400
Flexural strength at 1300 °C [3]	MPa	90 - 110	90 - 110	250 - 300	370 - 420
Thermal expansion 20 - 1.000 °C, linear	$10^{-6} \cdot K^{-1}$	4.5	4.5	4.3	5,0
Thermal conductivity 200 °C [4]	$W \cdot m^{-1} \cdot K^{-1}$	35	35	100	124
Thermal conductivity 1200 °C [4]	$W \cdot m^{-1} \cdot K^{-1}$	26	26	32	33
Young's modulus, static 20 °C	GPa	280	280	370	420_{dyn}
Thermal shock resistance	-	very good	very good	very good	very good
Maximum working temperature [5]	°C	approx. 1600 [6] approx. 2000 [7]	approx. 1650 [6]	approx. 1350	approx. 1600

* *The physical properties stated above result from test specimens. These values can only be used as a reference to technical products and other forms and dimensions.*

1) incl. chemical doping agents, 2) 4 point flexural strength, 3) 3 point flexural strength, 4) laser flash method, 5) depending on mechanical load and atmosphere, 6) in oxidizing atmosphere, 7) in protective atmosphere

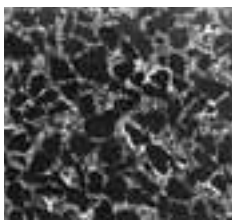
Halsic-R



recrystallized SiC
compact SiC matrix with the typically open and comparatively coarse pore structure

Halsic-R (RSiC) 200 µm ⊢⊣

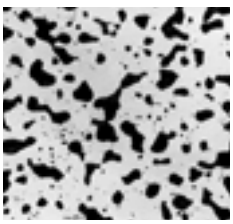
Halsic-I



reaction bonded silicon infiltrated SiSiC
SiSiC micro structure free of pores with reaction bonded SiC matrix (grey) and infiltrated metallic silicon (white)

Halsic-I (SiSiC) 50 µm ⊢⊣

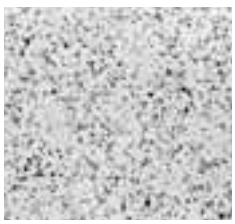
Halsic-RX



recrystallized and doped SiC
Matrix of a supporting beam after approx. 2000 cycles in a porcelain fast firing application (1420 °C, 5-7 h cold-cold): completely intact SiC matrix with rounded pores

Halsic-RX ($RSiC_{dot}$) 200 µm ⊢⊣

Halsic-S



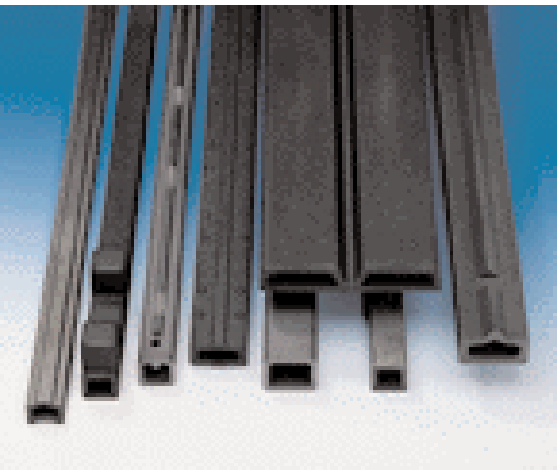
pressureless sintered SSiC
SiC micro structure with closed porosity and a characteristically very fine distribution of pores

Halsic-S (SSiC) 50 µm ⊢⊣

HALSIC - PRODUCT GROUPS

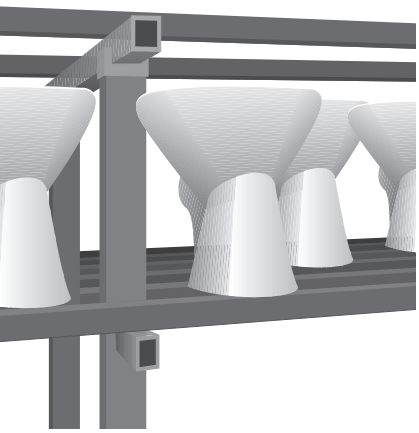
Beams and profiled supports

Beams and profiled supports in the quality Halsic-I are preferably used for single- and multilayered firing of larger ceramic components up to a temperature of 1350 °C (e.g. sanitary ware, high tension insulators, bricks, larger stone ware or earthenware, etc.). Beams and profiles can be used up to a temperature of approx. 1600 °C for Halsic-R or 1650 °C for Halsic-RX (e.g. porcelain industry, technical ceramics, etc.)



Hollow profiled supports in the above mentioned qualities can be produced in different cross-sections and up to a length of 3500 mm. They are used as single supports with high load carrying ability, system-building structures for kiln cars or as load support components for furnace and mechanical engineering. The possibility of a long free span of Halsic beams enables to optimize the usable setting space in the kiln.

The combination of different materials for the setups in kilns, such as a) cordierite posts, Halsic-I beams and cordierite batts for the sanitary ware firing – b) cordierite posts, Halsic-I profile beams and Sillimantin tubes for the brick industry – c) oxide bonded SiC pillars and Halsic-RX beams for the insulator production, etc., lead to sophisticated and economic solutions.



Rollers and tubes

Halsic-I rollers can be used up to temperatures of 1350 °C, those made of Halsic-R to 1600 °C and Halsic-RX even up to 1650 °C. Due to their high load bearing ability they can be used in roller kilns for the production of sanitary ware, porcelain, heavy clayware and technical ceramics even at very high temperatures and in highly oxidizing atmospheres at the same time.

In applications of heat treatment of metals and sintering of metal powder compacts, whereby silicon carbide and metal are in direct contact, precautionary measures are required. At temperatures above 900 °C, SiC in contact with various alloys will react chemically and the reaction process will damage or destroy the SiC as well as the metal. This is facilitated by the formation of low melting eutectica. This process is largely independent of the furnace atmosphere, although extremely low oxygen levels as under strongly reducing conditions and in inert atmospheres can increase the severity of the attack. To prevent such reactions from taking place, the SiC-surface can be plasma coated (see also page 6: surface treatment). In addition structural SiC-parts carrying a mechanical load, can be combined with and protected by oxide ceramics less susceptible to attack than SiC. They perfectly complete the roller programme of **W. HALDENWANGER**. With a total of 10 different materials you find the worlds widest range of ceramic rollers. These materials are: **Sillimantin 60, Sillimantin 65, Sillimantin 60 NG, Quarzgut (fused silica), Pythagoras and Korund-Mullit (corundum-mullite), Halsic-I, Halsic-R, Halsic-RX and plasma coated Halsic.**

In order to insert the rollers into the mechanical drive systems their ends can be ground and/or drilled (round or elongated holes, slots, etc.). Standard rollers in the described materials can be manufactured in diameters from 20 to 60 mm and lengths of over 3300 mm.

Tubes with a closed end in the qualities Halsic-I/Halsic-S (impervious) and Halsic-R/Halsic-RX (porous) can be used e.g. as thermocouple protection sheaths or radiant heater tubes. These tubes can also be supplied with a flange. Tubes with aligned bores are used as burner or cooling tubes.

Batts and plate setters

Kiln furniture made of Halsic-R and Halsic-RX has an excellent dimensional stability and due to its high thermal conductivity is especially suitable for fast firing cycles. In general, batts have rectangular shapes, yet in the porcelain production setting rings and plate setters are being increasingly used.

Batts can be manufactured in dimensions of over 3000 cm^2 and have a thickness of 5 to 8 mm depending on their size. Halsic-R and Halsic-RX kiln furniture is completely free of any grain fall. If required they can be supplied with a coating on one or on both sides. With the development of Halsic-RX we have succeeded in providing a material which has a life several times longer than the standard RSiC.

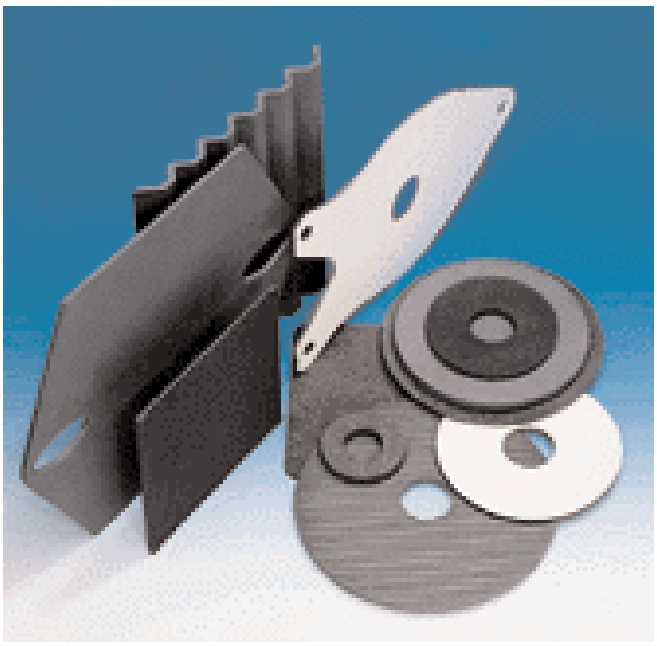
For special applications we supply Halsic batts with reinforced corners and with holes for the mechanical connection of batts in a roller kiln (porcelain fast firing). Apart from this we manufacture batts with a rim on one or on all sides.

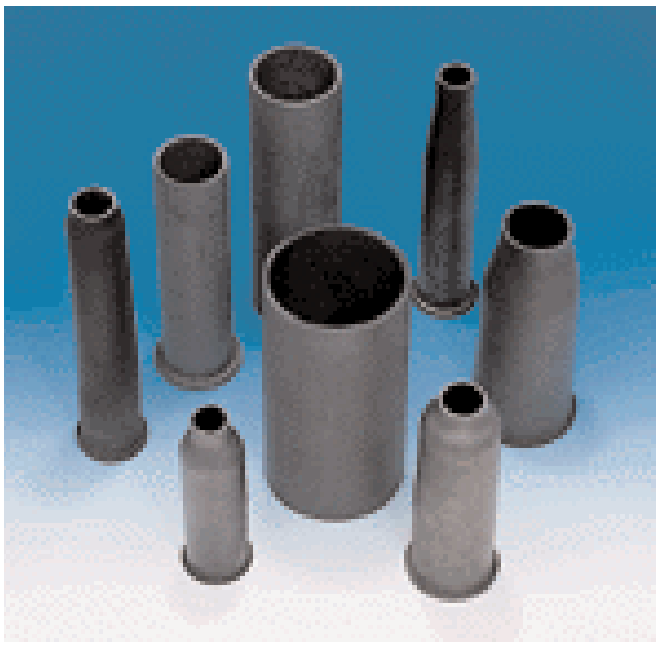
For applications which require an extreme flatness and surface finish we can also supply ground batts.

Special parts

In addition to the described standard product geometries our materials can be manufactured in a large variety of different shapes and sizes with our different production techniques. According to the application and the temperature the impervious materials Halsic-I (1350 °C) and Halsic-S (1600 °C) or the porous materials Halsic-R (1600 °C) and Halsic-RX (1650 °C) are available.

Typical applications for Halsic special parts in the area of industrial engineering are parts for burners, heat exchangers and high temperature construction components, not to forget the use in mechanical engineering if the operating conditions require a material possessing a resistance against temperature, oxidation, corrosion or abrasion. Furthermore Halsic materials have a very good mechanical strength, excellent thermal conductivity, extreme hardness and outstanding thermal shock resistance.





ADDITIONAL TREATMENT / QUALITY CONTROL

Mechanical treatment

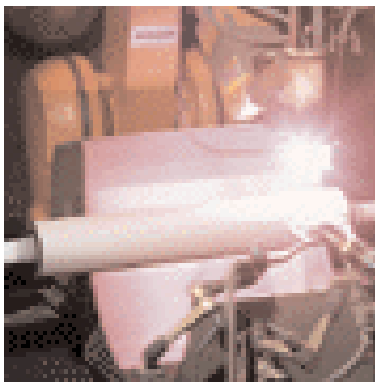
Products made of Halsic special materials are used as construction components for furnace and mechanical engineering, as kiln furniture for automated kilns or as mechanical components. In order to meet the required tight tolerances of the finished products, Halsic products often have to undergo mechanical machining. This can be done either before the firing in the green stage or after the firing, by using diamond tools.

Machining: grinding

The most common machining methods are cutting into length, grinding, drilling and slotting. Furthermore we do cylindrical and surface grinding, as well as finishing of surfaces.

Surface treatment

In some applications SiC materials can show undesired reactions when they have contact with certain products during firing, the furnace atmosphere or molten metal. It is possible to avoid this by protecting Halsic products against chemical reactions. This is done by a special surface treatment: applying a ceramic protective coating by dipping, painting, spraying or applying a ceramic protection layer by atmospheric plasma coating.



Plasma coating

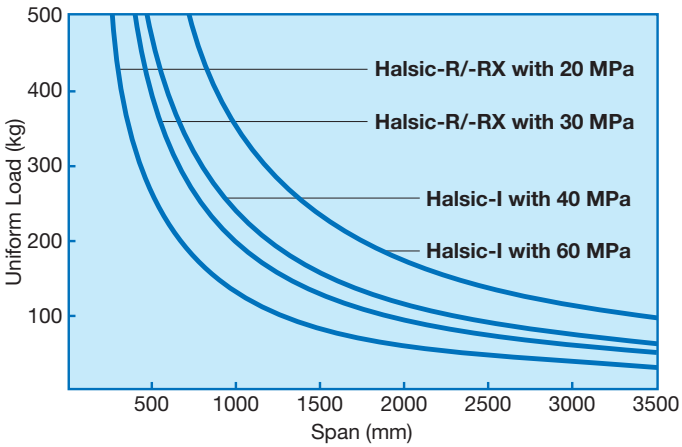
Calculation of kiln furniture constructions

The use of Halsic kiln furniture requires careful calculation for all supporting components. We carry out these static calculations for our customers and together with them we determine the required cross-sectional dimensions of the components for their specific application.

Contrary to metals, ceramic materials have a wider range in their physical properties. Thus an increased factor of safety is necessary. Depending on the application a multiple factor of safety is used for the dimensioning of beams and rollers which will be shown by an example.

The load diagram shows the interdependence of the loaded length to the span based on a maximum flexural strength of 20 and 30 MPa for Halsic-R/RX and 40 and 60 MPa for Halsic-I. The lower flexural strength values will give an increased safety factor for the component.

Load diagram (beam cross section 40 x 40 mm)



Quality management system

The consistent high standard of our Halsic products is guaranteed by a comprehensive quality management. It corresponds to the international standard ISO EN 9001 and has been certified accordingly.

TÜV
DIN EN ISO 9001
Registrier-Nr. 12 100 6316

TEMPERATURE MEASUREMENT

Thermocouple protection sheaths

The increased requirements in the field of temperature measurement at elevated temperatures under extreme conditions has lead to the development of protection sheaths made of high purity SiC materials. They are the porous materials Halsic-R and Halsic-RX and the impervious materials Halsic-I and Halsic-S. Thermocouple protection sheaths in these qualities allow a long service life even under tough applications due to their excellent properties.

Common material properties

- very good resistance against erosion and corrosion
- high mechanical strength
- very high thermal resistance

Halsic-I:		1350 °C
Halsic-R:	(oxidizing atmosphere)	1600 °C
Halsic-R:	(protective atmosphere)	> 2000 °C
Halsic-RX:	(oxidizing atmosphere)	1650 °C
Halsic-S:		1600 °C

- excellent thermal conductivity
- outstanding thermal shock resistance
- very good oxidation resistance
- very good resistance against acids
- good resistance against alkalis

Application examples

Thermocouple protection sheaths for temperature measurement within extensive dust pollution, corrosive surroundings and high temperatures:

- boilers and furnaces of all kind
- flue gas channels
- firing chambers
- flue gas desulfurizing and free from NO_X plants.

Thermocouple protection sheaths for temperature measurement in molten metals:

- tin
- lead
- zinc
- aluminium (only applicable with a plasma coating)

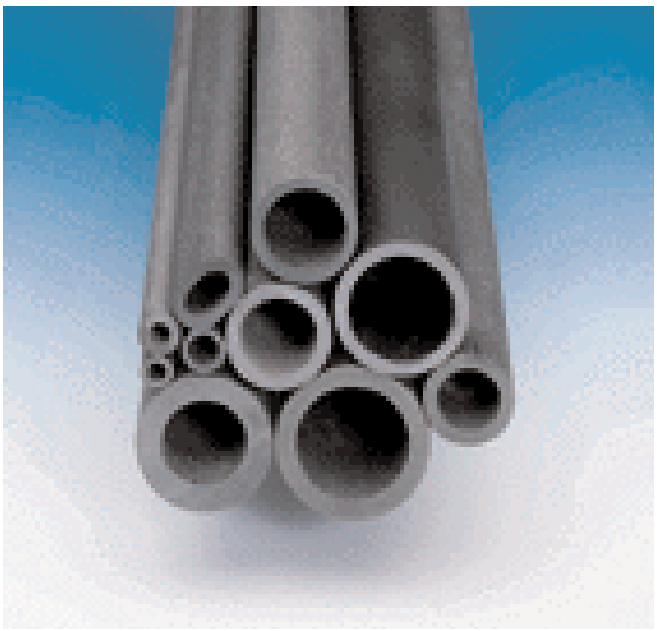


Table with standard dimensions

Outer sheath **Halsic-R Halsic-RX** O Ø x I Ø mm	maximum lengths **Halsic-R Halsic-RX** mm	Outer sheath **Halsic-I** O Ø x I Ø mm	maximum lengths **Halsic-I** mm
20 x 10	1350	20 x 13	2000
25 x 15	1800	25 x 18	2000
30 x 20	1850	30 x 20	2000
34 x 24	2100	34 x 24	2250
40 x 28	2250	40 x 30	2500
55 x 41	2250	55 x 42	2500
60 x 46	2250	60 x 46	2500

Different diameters and lengths can be made on request.