

**>> Kalenborn Offers  
Optimized Wear Protection**

**for Plant Components  
and Pipe Systems**



# >> Why Wear Protection?

## Reduce Costs and Avoid Downtime



The transport of bulk materials in many basic industries and in coal fired power stations is associated with heavy wear of the system components. Not only is the original equipment investment lost, plant shutdowns and production losses combine to destroy the capital base of the company.

This is unacceptable in today's competitive world markets. The solution to the problem is reliable wear protection. The selection of the appropriate material is of vital importance as well as its correct application.

Kalenborn have been dedicated to plant protection since originally developing fused cast basalt for wear reduction and cost savings.

Starting with fused cast basalt more than eighty years ago, a wide range of wear resistant materials has been developed with each material offering special characteristics. The materials are valuable, but the knowledge from experience gathered all over the world in many branches of industry is just as important.

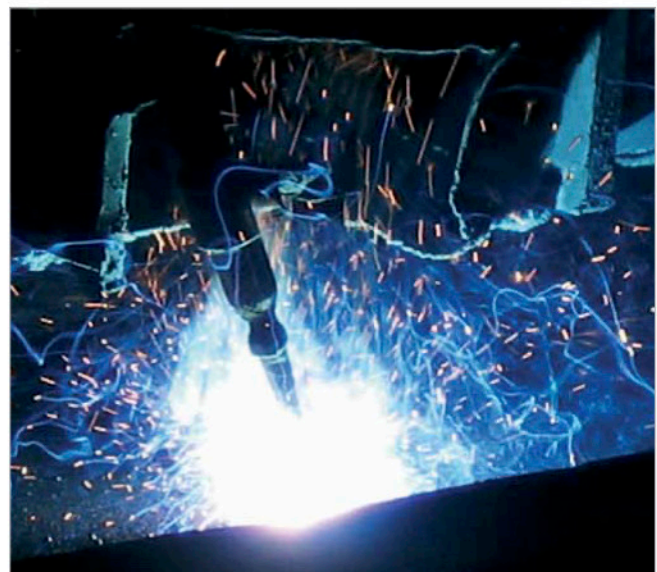
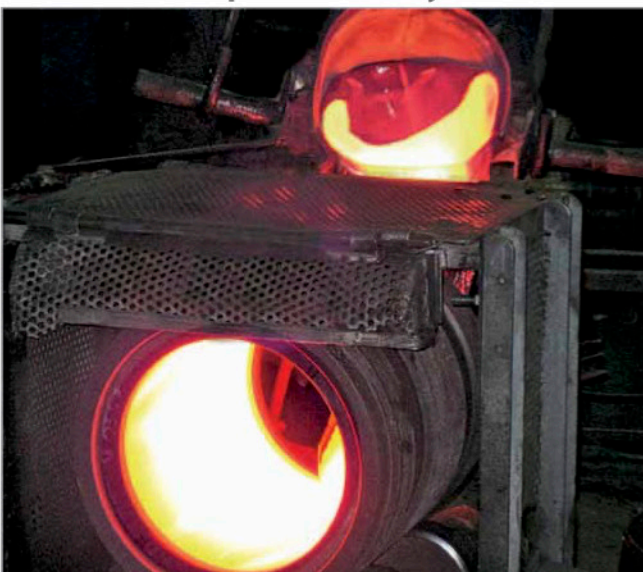
**The highest cost in many situations is the lost production time due to unplanned outages.**

**The money saved by using low cost steel components can result in a much higher cost later.**

**Abrasion resistant pipes and plant components save money as repair frequency is greatly reduced and production time is increased.**

**In some instances, a single avoided repair will pay for the added abrasion protection.**

## Efficient wear protection by ceramic and metallic materials



# >> The Wear Protection People

## Design, Manufacture, Delivery and Installation of Tailor-Made Wear Resistant Linings

### Design

Kalenborn's engineers can design customized, cost saving solutions for new or existing equipment.

All the details of the solution come from a single source: starting with advice on application, measurements on site, design services, manufacture of the lining through to proper installation.

### Manufacturing

The foundation of the abrasion resistant systems offered by

Kalenborn consists of different materials with individual characteristics:

- ABRESIST fused cast basalt
- KALCOR zirconium corundum
- KALOCER high alumina ceramics
- KALSICA silicon carbide ceramics
- KALCERAM hard ceramics
- KALMETALL metal wear protection
- KALCRET hard compound
- KALPOXY hard compound

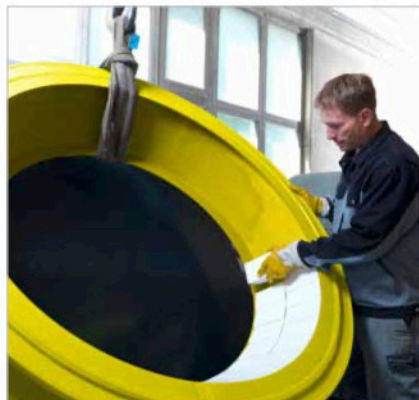
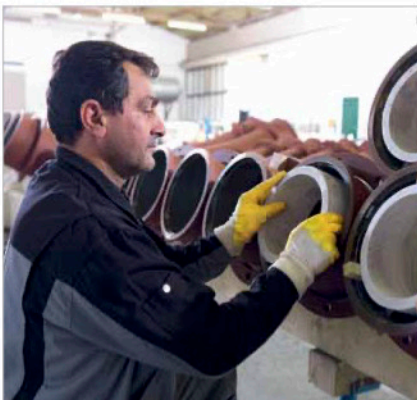
### Installation and Erection

Proper installation and erection require knowledge based on a wide range of experience. Installation of the engineered wear resistant linings can be performed or supervised by Kalenborn specialists in our workshops or on site all over the world.

### Which Material for Which Task?

Wear protection has to be matched to each application. The better the material and the installation method have been adapted to the specific problem, the more durable and economical the solution.

Which material will be most suitable is determined after all the factors are known. There is no magic formula or calculation principle, but knowledge based on 90 years of practical experience of Kalenborn.



# >> Kalenborn All Over the World

## Services Rendered for Many Branches of Industry, Active on all Continents

Kalenborn offers a complete array of wear protection materials to achieve acceptable service lifetimes.

In addition, Kalenborn has extensive experience in the field of slide promotion. Interruptions of material flow inside of bunkers and silos must be avoided and Kalenborn covers the entire material range with plastics as well as metallic and ceramic materials.

Kalenborn can supply a tailor-made solution for almost any particular problem. Our experts are prepared to be of assistance.



### Coal Fired Power Plants

Plant components are subject to substantial wear in coal storage and coal transport systems. This includes coal pulverizing and injection into the boiler, dust collection and ash removal including fly ash and bottom ash. The situation is similar for limestone and gypsum in desulphurization systems.



### Iron and Steel Industry

Critical systems of the iron and steel industry are the raw material storage and processing at the sinter plant, coke plant and blast furnace operation. Comprehensive wear protection is also an absolute must for steel making and in the rolling mills.



### Cement Industry

Endangered plant systems are raw material storage and processing. This includes pulverizing and feeding into the rotary kiln as well as handling of coal, clinker, additives and cement.



### Further Industries

Kalenborn are active in a wide range of industries and these include:

- chemical industry
- coal mines
- foundries
- glass works
- loading and unloading plants
- mineral processing
- ore beneficiation
- ore mines
- recycling plants
- steel works
- waste incinerating plants

Pictures:  
Top left: Steag / Voerde  
Top right: Stahlzentrum / Rogesa  
Bottom left: Lafarge-Zement

## Worldwide Organization

The headquarters of the company are located in Germany at the original production site of fused cast basalt. From here the company organizes international sales and supplies the various products for most applications.

Affiliated or associated companies are responsible for regional markets.

In addition, Kalenborn has set up a close network of regional representatives and cooperating companies that ensure contact with our customers.



Around the world, we are readily available to attend to your needs. The Kalenborn Group offers its international customers a local, well-connected network of experts everywhere.

### > USA

Kalenborn Abresist, USA

Kalenborn Technologies, USA

### > CANADA

Kalenborn Canada

### > BRASIL

Kalenborn do Brasil

### > FRANCE

Kalenborn France

### > GERMANY

Kalenborn Kalprotect, Germany

### > POLAND

Kalenborn Delma, Poland

Kalenborn OSW, Poland

Kalenborn Bazalt, Poland

### > HUNGARY

Kalenborn Refmon, Hungary

### > SINGAPORE

Kalenborn Asia, Singapore

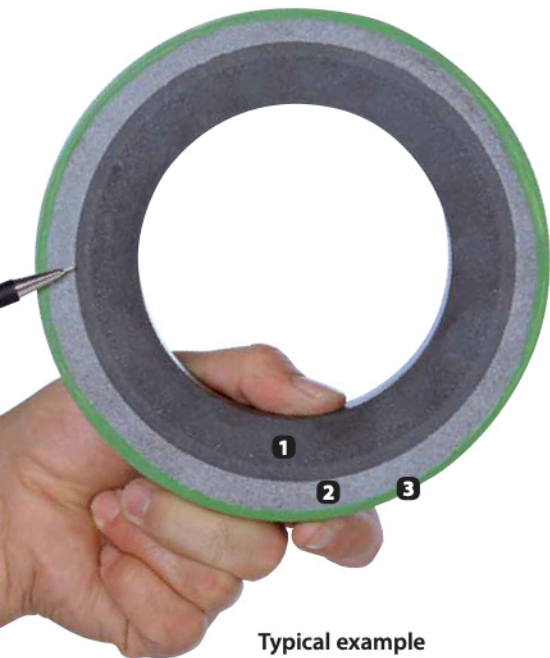
### > PHILIPPINES

Kalenborn Weartech Philippines

# >> Pipes and Pipe Bends

## Proper Protection for Hydraulic and Pneumatic Conveying Lines

A wide range of different materials with different characteristics can be chosen to protect against wear. Pipe linings made of mineral, ceramic or metallic materials have proven to work well.



Typical example of a ceramic lining:

- 1 Lining
- 2 Mortar
- 3 Steel

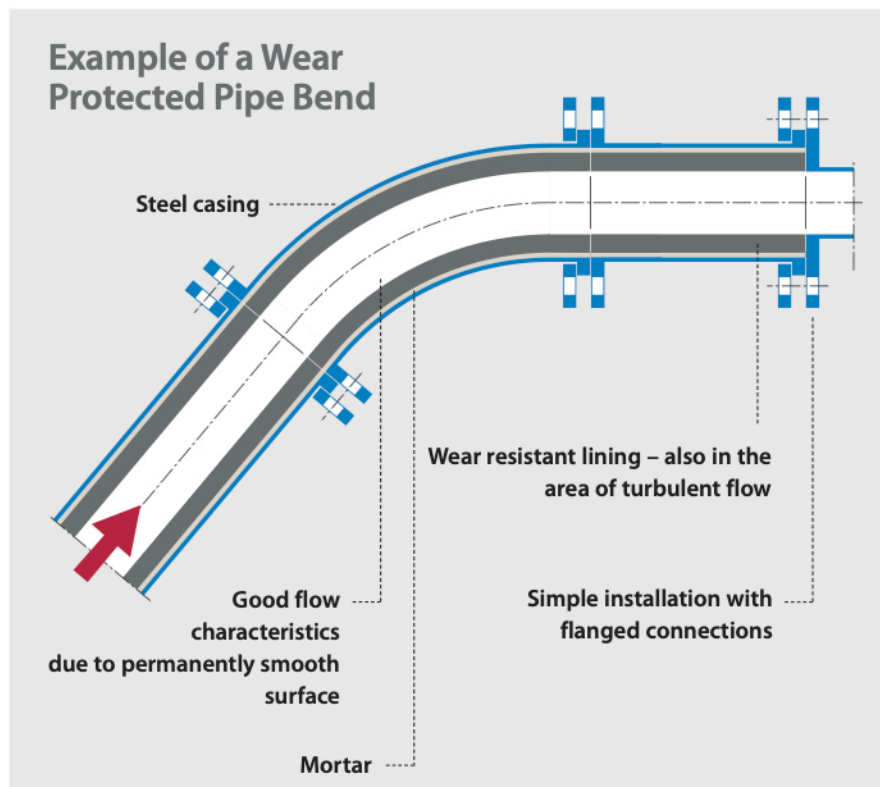
### Clear Advantages:

- long lifetime
- maintenance free operation
- no operation interruption
- no production losses
- no contamination of the conveyed materials due to abrasion, mixture or oxidation
- physiologically harmless, suitable for food products
- smooth surface to achieve good flowability and to avoid plugs
- reduced pressure losses and lower energy cost

To achieve both technical and economical wear protection, many factors have to be taken into account. The choice needs to be based on the application.

The best solution for long life and economical abrasion protection depends upon the proper selection of the lining material as well as knowledge of the expected cost.

### Example of a Wear Protected Pipe Bend



# >> Application Examples



The entire length of a hydraulic pipeline needs to be protected against abrasion. Under typical conveying conditions and general operating procedures, ABRESIST has proven to be extremely effective.



To reduce the severe abrasion of the bends in pneumatic systems, abrasion resistant piping components with internal linings – such as ABRESIST – should be used.

Because of continuing turbulence in the straight sections after bends, abrasion resistant pipes should be installed. Recommended length: 10 times the inside diameter or 1 – 2 meters.

## Examples in Hydraulic Conveying

Industry	Material
blast furnace plants	slag
chemical industry	caustic solutions with solids
coal fired power stations	bottom ash
hard coal mining	raw coal
hard coal washeries	heavy media with solids
phosphate plants	phosphate ore
potassium & salt industry	potassium salts, kieserite, salts
quartz & gravel plants	gravel, sand
refuse incineration	non-combustible residue, slag
rolling mills, continuous casting plants	sintered material, mill scale
sewage treatment plants	sewage sludge

## Examples in Pneumatic Conveying

Industry	Material
aluminum plants	calcined alumina, bauxite, electrode carbon
abrasive plants	abrasives
blast furnace plants	sintered material, lime, lime-oxygen mixture, packing compound, pulverized coal
cement plants	clinker dust, cement, blast furnace slag, fly ash
chemical plants	caustic lime, lime dust, fertilizer
coal fired power stations	pulverized coal, quick coke, fly ash, ash, slag, pyrite
coal mines	coal dust, tailings for backfilling
foundries	quartz sand, molding sand
glass works	feldspar, quartz, kaolin, nepheline, cullet
grinding mills and animal feed	cocoa beans, corn, sunflower seeds, cereals
ore mines	concentrate, tailings
breweries, malting plants	hops, malt, rice
mineral wool & insulation products	production waste, saw waste, perlite, stone dust
refuse incineration, vacuum refuse collection	industrial and domestic refuse
steel plants	carbon and limestone injection
technical carbon plants	technical carbon, graphite for electrodes

# >> Production and Conveying Systems

## Proper Protection for Long Lifetime and Troublefree Operation

Abrasive wear occurs, in particular, when hard and sharp edged bulk materials are moved. But the material to be conveyed cannot be altered to reduce the problem. Therefore, protective measures have to be implemented for the protection of the system components.

A wide range of materials with varying characteristics is available to protect against wear. Pipe linings made of mineral, ceramic and metallic materials have proven to work well.

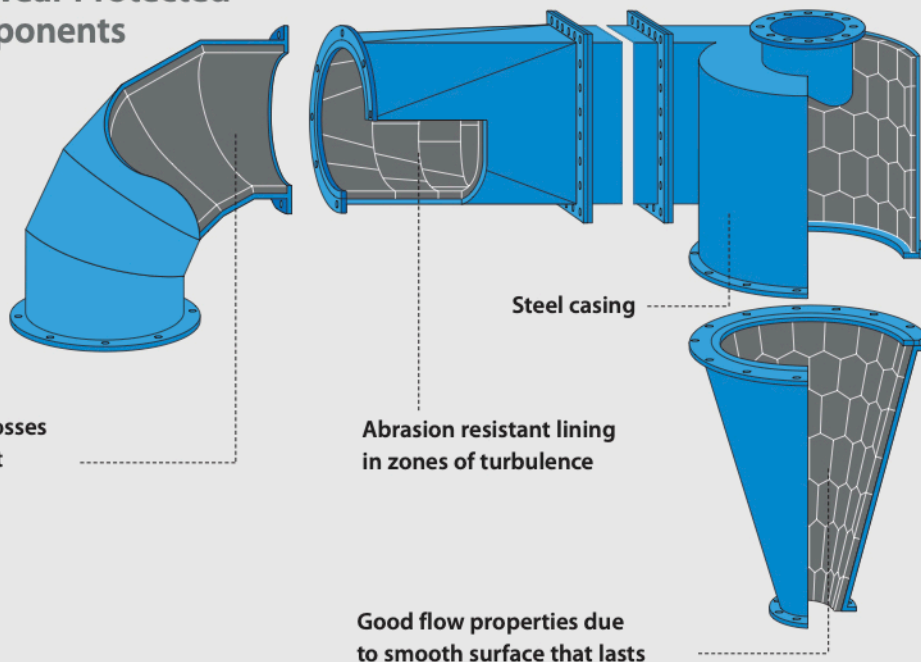
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- no production losses
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- physiologically harmless, suitable for food products
- smooth surface to achieve good flowability and to avoid plugs
- reduced pressure losses and lower energy cost



KALCOR lining of a hopper in the sinter dust collector of a steel mill

### Principle of Wear Protected System Components



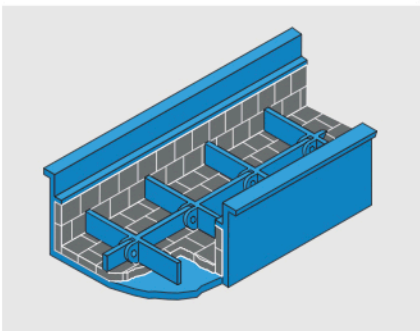
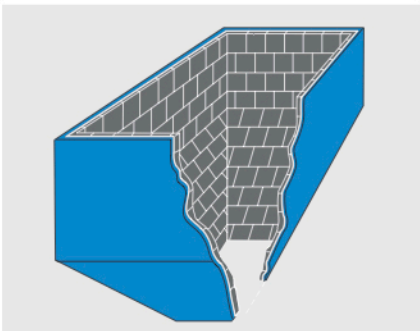
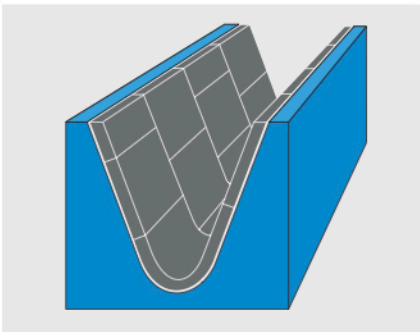
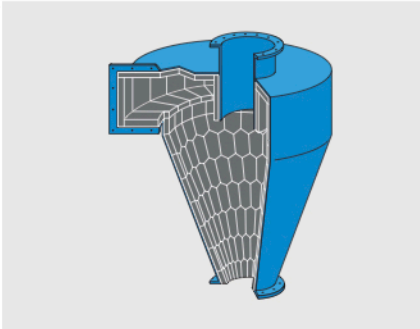
Reduced pressure losses and low energy cost

Abrasion resistant lining in zones of turbulence

Good flow properties due to smooth surface that lasts



# >> Application Examples



Typical system components with wear protection lining

The large rocks handled in quarries and mines are not the only problems for conveying and processing systems.

In modern process plants, characterized by high throughput rates and conveying velocities, even apparently harmless materials cause significant wear.

Here is a list of typical abrasion problem components:

- ash pipelines
- belt discharge chutes
- bunker spirals
- bunkers
- channels
- chutes
- circulating air separators
- continuous flow conveyors
- cyclones
- dissolving tanks
- drying sections
- dust collecting equipment
- dust collecting pipes
- fans
- flue gas ducts
- flumes
- gravel release tunnels
- hoppers of rotary dryers
- hydrocyclones
- launders
- mixer troughs
- pipe bends
- pipes
- pneumatic backfill lines
- prilling tower bottoms
- pulpers
- receivers
- screw conveyor troughs
- separators
- settling basins
- shaft spirals
- sifters
- silos
- sinter troughs
- tailings lines
- tanks
- thickeners
- tubular chain conveyors
- turbo separators
- vibrating troughs
- washing drums

# >> ABRESIST Linings

## Wear Resistant Fused Cast Basalt for Friction Induced Abrasion

ABRESIST fused cast basalt has been used successfully for years as a universal material for abrasion protection. Depending on the application and geometry, it can be used with temperatures up to 350 °C / 662 °F. Installed as original equipment, ABRESIST is an excellent solution to wear problems before they start.

During the manufacture of ABRESIST, selected natural basalt is melted and cast into molds, then moved into an annealing furnace. Due to the casting process, precise cylinders from 40 to 525 mm internal diameter can be produced for pipes and bends. Special tile shapes are engineered for larger pipe diameters and other equipment.

ABRESIST has an extremely hard and smooth surface. The material is corrosion resistant to most acids and alkalis. This makes ABRESIST very effective for pipelines where abrasion and corrosion occur together.

The idea to melt stone is age-old. However, melting of basalt only started with lab tests at the end of the 19th century. The development was hardly successful beyond this stage due to crystallization problems and inadequate application tests.

However, by the early 1920's our company successfully produced a basalt based abrasion resistant material. Today, under the trade name ABRESIST, fused cast basalt has become a proven product worldwide.

### ABRESIST

**Fused cast basalt is a mineral based wear protection material for plant components when the conveying material produces friction induced abrasion.**

**Installation: cylinders or shaped components. In special cases epoxies or synthetic mortars may be used due to strong mechanical stresses and/or vibration. Where higher temperatures are concerned, potassium silicate mortar may be used for installation. Mechanical fixing is feasible as well.**

**Application temperature: up to approximately 350 °C / 662 °F depending on application and geometry.**

**Advantages: highly abrasion resistant, smooth surface that lasts, no corrosion.**



Fly ash pipelines in a coal fired power station



Hydraulic ash conveying pipe being manufactured at the Abresist Kalenborn Corporation plant in Indiana, USA



Flumes and hoppers of any shape can be lined with abrasion resistant ABRESIST



Coke bunker in the iron and steel industry



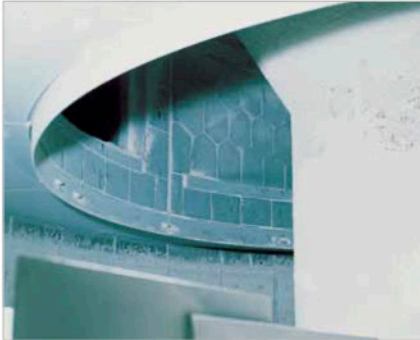
Raw material hopper in a German blast furnace plant

Worldwide ash removal pipes lined with ABRESIST reach lifetimes of more than 30 years. This US power plant operates more than 10,000 meters of 294 mm ID pipes.



Irrigation wear protected by ABRESIST

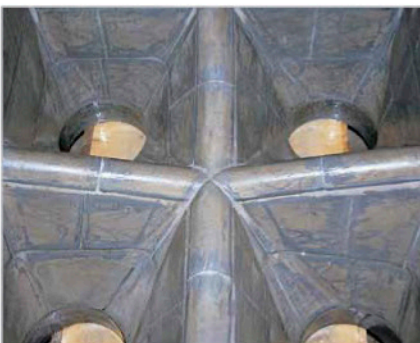
# >> ABRESIST Linings



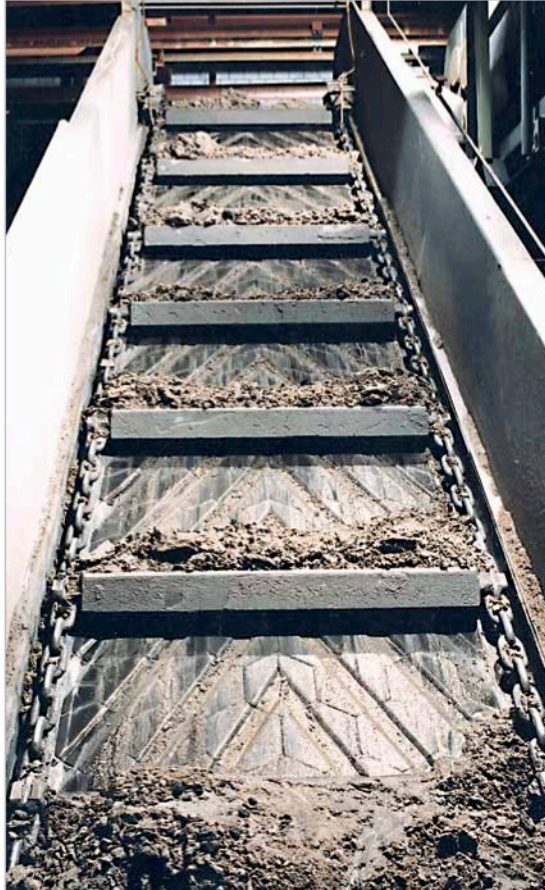
ABRESIST lining of an air separator



Waste paper bales are mixed for paper recycling in pulpers. Since the bales contain considerable impurities the pulper bottom is durably protected with ABRESIST.



Hoppers of any shape for material discharge are fitted with ABRESIST as wear protection



Chain conveyor for wet ash removal in a power plant. Drains cast into the lining reduce the undesired carrying of water to the discharge zone thereby lowering the water consumption rate.

Quite often screw-type elevators are used for transport in waste water treatment plants. Continued proper functioning of the annular gap requires its being protected against wear. ABRESIST is successfully used for that purpose even at diameters of 3,000 mm and 15,000 mm length.





Separator components provided with ABRESIST wear protection



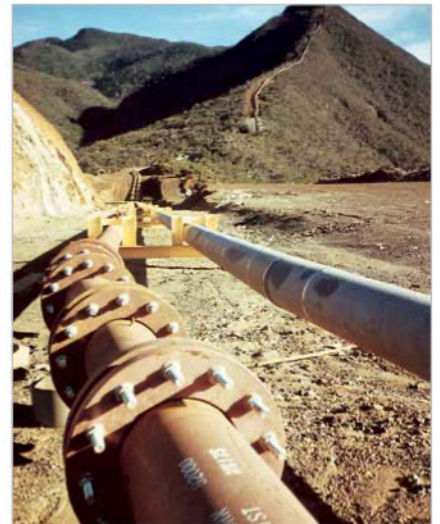
Combi-sorter made of high-grade steel used by the paper industry – protected from wear by fused cast basalt tiles



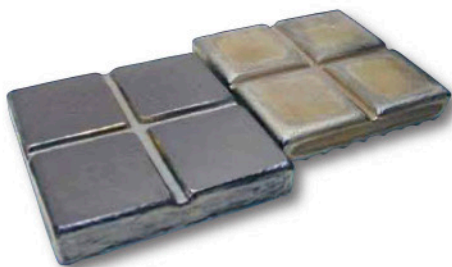
Fused cast basalt has performed well on automobile test tracks all over the world. Here, skid tiles are laid in Switzerland.



The bends and straight extension sections of the feed pipes to cement silos have been lined with ABRESIST



ABRESIST pipe for hydraulic ore transport



ABRESIST skid tiles at the right showing their natural surface; skid tiles with polished surface at the left to ensure a minimum friction coefficient

# >> KALCOR Linings

## Zirconium Corundum Wear Protection for High Temperature and Abrasion Resistance

With the growing knowledge of preventive wear protection the demand for durable materials with extended service life has increased.

KALCOR, a zirconium corundum was developed for extreme abrasion resistance and high temperatures up to 1.000 °C / 1.832 °F.

Alumina and zirconia are formed into tiles, shaped components and cylinders. This shape capability allows KALCOR to be manufactured into many different components demanded by various industries.

### KALCOR

**Material of alumina and zirconia for plant components, where extreme wear and/or high temperatures occur.**

**Installation: cylinders or shaped components in cement mortar or special setting compounds. Mechanical fixing is also possible.**

**Application temperature: up to approximately 1.000 °C / 1.832 °F depending on application and geometry.**

**Advantages: highly abrasion resistant, temperature resistant, corrosion resistant.**

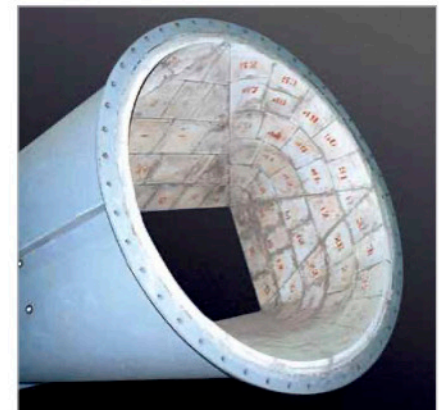
KALCOR lined pipes



High temperature wear protection in a dedusting cyclone of a blast furnace plant in Europe



Wear protection for high temperatures involves problems due to thermal stress between the outer steel component and the rigid lining. These problems can be solved by using KALCOR as wear protection material and the right mechanical fixing method: bolted connections or welded steel inserts. Example: drying drum in a chemical plant at 800 °C / 1.472 °F.



KALCOR protection easily applied in high wear areas: special cast shapes or cut components (diamond tipped tools only)

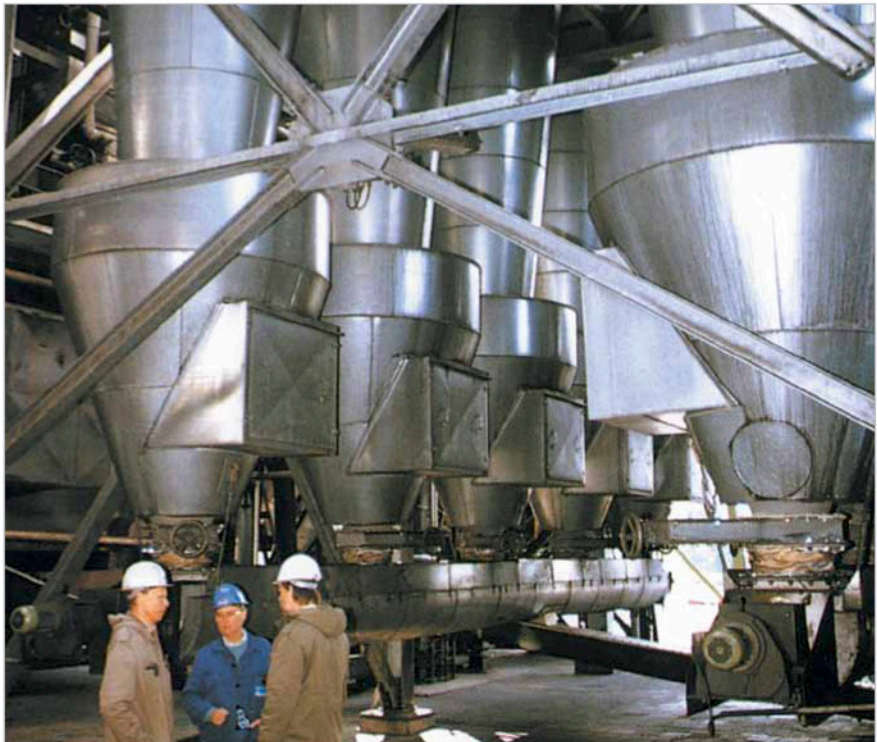
Even surfaces of complicated structure can be safely protected against wear by KALCOR

KALCOR bend with special deflectors to distribute the conveying stream of coal



# >> KALCOR Linings

Flue gas dust collector for dust removal from petroleum coke calciner in an oil refinery at temperatures up to 450 °C / 842 °F: 10 cyclones incl. immersion pipes, supply channels and raw-gas bends have been lined with abrasion resistant KALCOR (top illustrations – right and left)



Pipe branching in pneumatic conveying pipe lined with KALCOR



Pulverized coal distributor with reliable KALCOR lining to ensure trouble-free operation

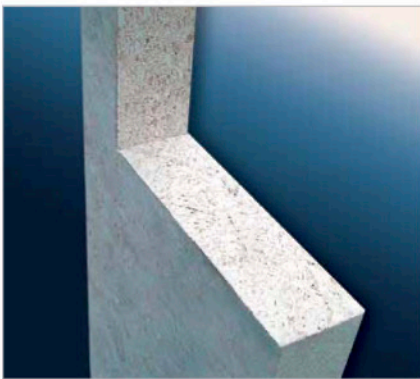
Pulverized coal bends lined with KALCOR zirconium corundum and welded-on unlined transition sections



# >> KALCOR-S Linings

## Wear Resistant and Temperature Resistant

Wear protection materials are steadily improving. Important considerations include the best possible adaptation and the specific application conditions. KALCOR-S zirconium corundum material has been engineered for good abrasion resistance and high temperature resistance up to 1.250 °C / 2.282 °F.



The structure of KALCOR-S is practically free of voids

KALCOR-S is produced by cold forming aluminum oxide and zirconium oxide raw materials into tiles, shaped elements and cylinders and then sintering. This allows the production of elements tailored to a variety of system component geometries.



No problem with KALCOR-S: thin wall cylinders

### KALCOR-S

**Sintered material made of aluminum and zirconium oxide for system components that are subject to both intense wear and high temperatures.**

**Installation: tubular and/or shaped elements are laid in cement mortar or special setting materials. Mechanical fixing systems are feasible in other cases.**

**Application temperature: up to approximately 1.250 °C / 2.282 °F - depending on the specific service conditions and geometry.**

**Advantages: highly wear resistant, temperature resistant, good thermal shock resistance.**



Asymmetric cross section of a pipe with KALCOR-S lining



# >> KALOCER Linings

## Extreme Abrasion Resistant High Alumina Ceramics

KALOCER is a member of the oxide family of ceramics, with aluminum oxide as the main component. Extremely high abrasion resistance is achieved by careful selection of the particle size and distribution.

Most tiles or cylinders are formed by pressing a dry powder of the ceramic. Machining of ceramic prior to kiln firing or slip-casting allows the manufacture of components with geometrically difficult shapes.

KALOCER can be manufactured in very thin tiles. This is an advantage when existing plant components have to be lined and space or weight are of critical importance.



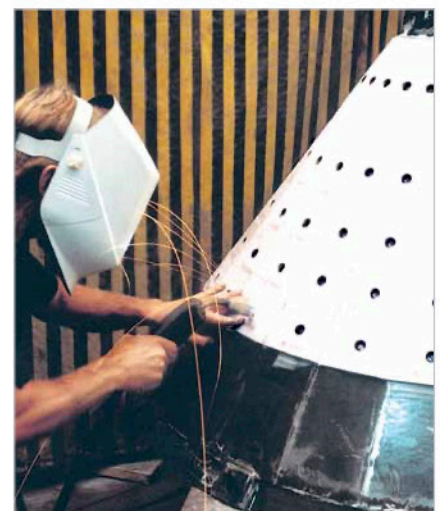
### KALOCER

**High alumina ceramics for plant components with extreme wear and/or temperature conditions. For thin linings or for smooth surfaces.**

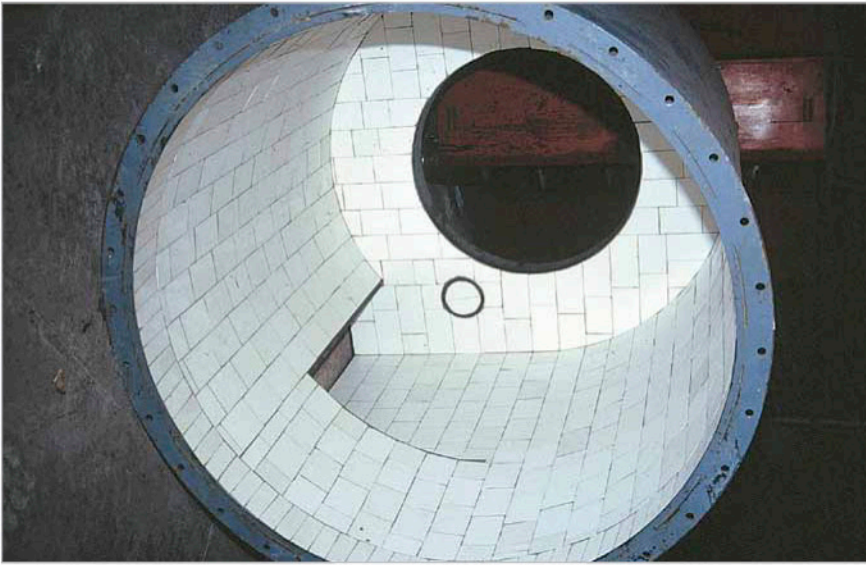
**Installation: pipes, shaped components, or thin tiles laid in KALFIX synthetic mortar. KALOCER tiles vulcanized into rubber mats for installation by gluing are available. Mechanical fixing by welding is also possible.**

**Application temperature: up to 1.000 °C / 1.832 °F depending on application and geometry.**

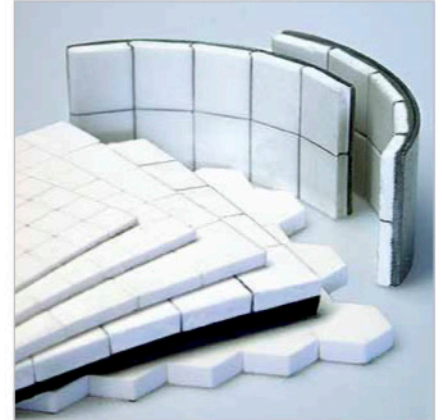
**Advantages: highly wear resistant, smooth surface that lasts, no corrosion, available from 1.5 mm thickness.**



**Mechanically fixed special tiles of KALOCER protect the cone against wear even in case of thermal shock stress**



Lining of a cyclone handling diatomaceous earth lined with 6 mm thick KALOCER tiles; the epoxy setting is resistant up to 180 °C / 356 °F



Kalenborn offers KALOCER mosaics in different sizes: square, hexagonal or special design from 1.5 mm to 12 mm thickness. Mosaics can be supplied with book ends. Vulcanized solutions are available.



Skip collection chute with KALOCER lining installed at a European blast furnace plant; the shaped elements are up to 50 mm thick and some have been cut three-dimensionally



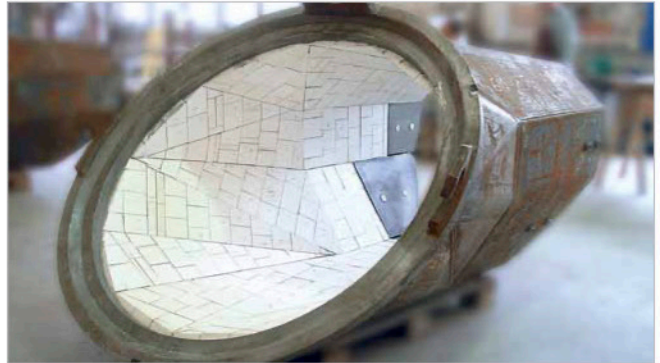
Agitators and mixers subject to extreme wear can be durably protected with KALOCER tiles shaped to the specific equipment design

# >> KALOCER Linings

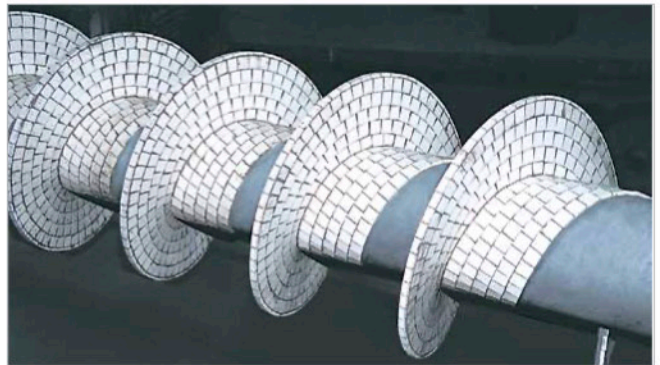
Chute for blast furnace lining in a European plant; the KALOCER lining is 50 mm thick



Octagonal hopper in a steel plant; the 50 mm thick KALOCER tiles have been three-dimensionally shaped and cut



Highly abrasion resistant KALOCER pipes to transport ore sludge in a mine in the Far East



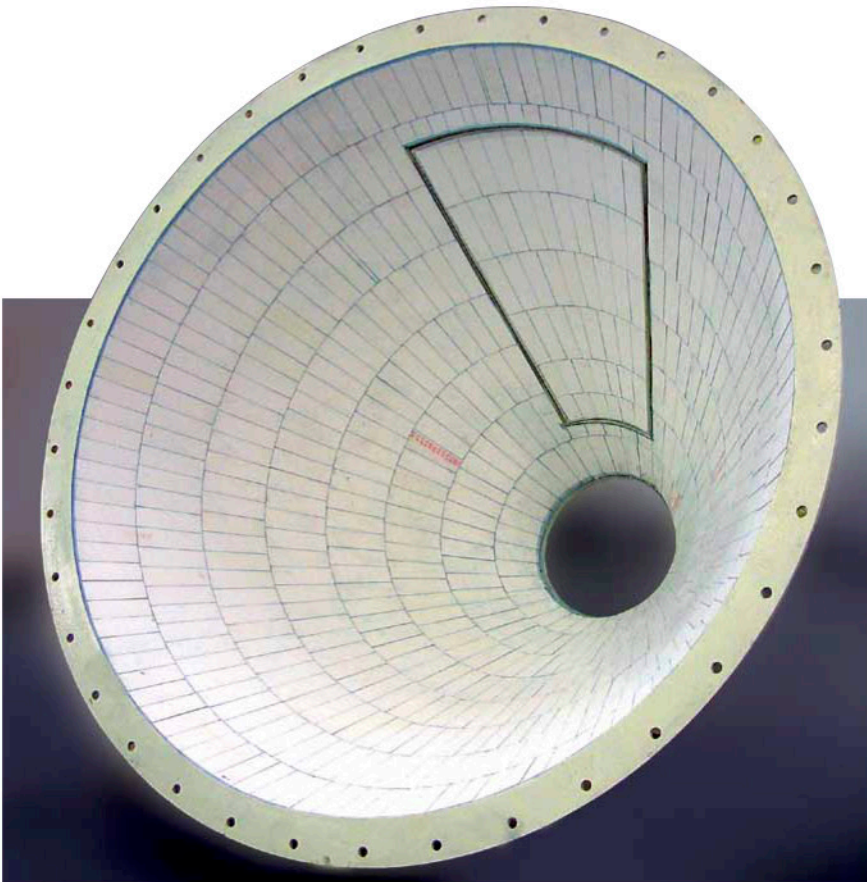
Screw lined with high alumina ceramics operated in a potash plant



KALOCER lining of a mill for superfine grinding of coloured pigments



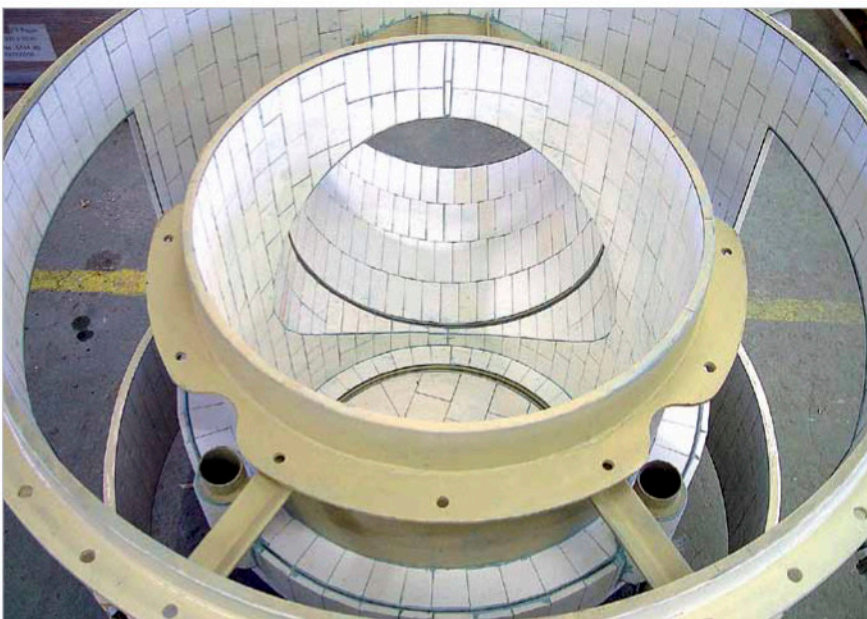
KALOCER pipe bricks are an economic alternative for lining pipes and bends



Solid protection of an outlet cone with precise fitting of the manhole



Lining a cyclone inlet with KALOCER; the arch shape enables fixing radial shaped elements in KALFIX setting compound whereas the headwall requires mechanical fixing by means of weld sleeves and ceramic caps



Precisely cut and fitted KALOCER lining in a separator system assures trouble-free operation



KALOCER mosaics of 1.5 to 12 mm allow flexible use; they are fixed by KALFIX epoxy setting compound

# >> KALSICA Linings

## Silicon Carbide Ceramics with Extremely High Temperature Abrasion Resistance

Outstanding resistance against wear and thermal shock is achieved with KALSICA. KALSICA is part of the silicon carbide ceramics group and available in different qualities:

- Silicon infiltrated silicon carbide (KALSICA-S)
- Nitride bonded silicon carbide (KALSICA-N and -P)

High precision can be achieved in manufacturing KALSICA shapes, formed by pressing or casting, then sintering in a reactor kiln.

Wall thickness from 2 mm for the shaped components is another advantage of using KALSICA wear protection linings.

### KALSICA

**Silicon carbide ceramics for plant components for extreme wear, high temperature and/or thermal shock.**

**Installation: individual shapes and components laid in mortar on synthetic resin or mineral base or in temperature and acid resistant based mastics. Mechanical fixing is also possible.**

**Application temperature: up to 1.000 °C / 1.832 °F depending on application and geometry.**

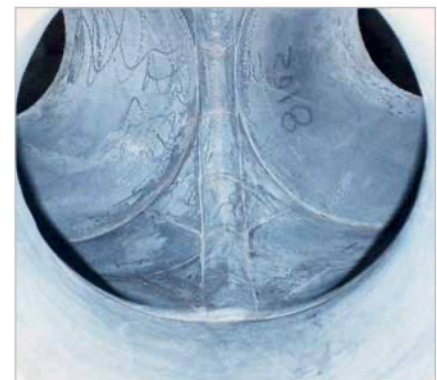
**Advantages: highly abrasion resistant, resistant to thermal shocks and manufactured to close tolerances.**



KALSICA hydro-cyclone for magnesite processing without steel jacket



For extreme wear in pneumatic transport



KALSICA lined pipe transition



1,200 mm diameter  
KALSICA-N cyclones guarantee  
reliable operation: the system  
separates silicon sand at  
temperatures up to 300 °C / 572 °F



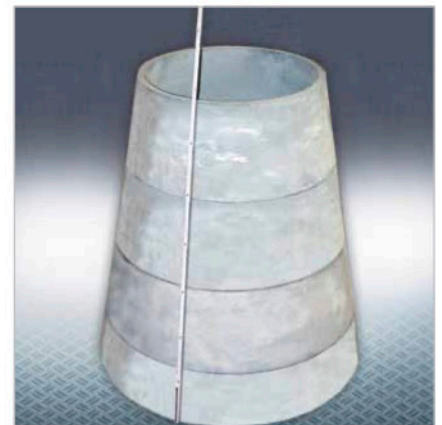
Pulverized coal distributor made of  
KALSICA-N installed in a power station



Guide vanes of a separator made  
of KALSICA-A operated within a coal  
pulverizer



Burner cone for a power station made  
of KALSICA-N



KALSICA-N lining for a  
cyclone handling silane dust;  
major cone diameter 1,200 mm;  
wall thickness 30 mm

# >> KALCRET Linings

**Hard Compound can be Cast, Trowelled or Sprayed-on to Achieve a Jointless Lining**



Trowelling

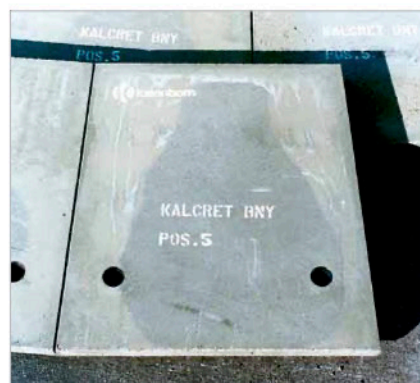
KALCRET hard compound is the general term for cement-bonded wear protecting materials. These are made from inorganic materials of high hardness and good wear resistance. The high density is attained by a well balanced particle size distribution of the individual components. The pores between the cement particles are filled with superfine particles of micro and nano silica.

## Prefabricated Shaped Elements

KALCRET hard compound has performed well in practice as prefabricated shaped elements. Tiles and shaped elements are prefabricated at the Kalenborn plant and equipped with common attachment hardware, such as steel corner inserts.



Casting



Prefabricated shaped elements made of KALCRET allow short installation times



Spraying

## KALCRET

**Cement bonded hard compound for a jointless lining of plant components where high wear and temperature occur.**

**Installation: by trowelling, casting or spraying.**

**Application temperature: up to 1.200 °C / 2.192 °F depending on application and geometry.**

**Advantages: highly wear resistant, strong and jointless lining, highly temperature resistant.**

**KALCRET allows wear protection of components with complicated geometry.**

## Prefabricated Pipes and Bends

Pipes and pipe bends lined with KALCRET can be produced with an inside diameter of more than 40 mm. Inside diameters up to 600 mm are lined with castable KALCRET whereas the use of trowelled-on KALCRET is more economical for inside diameters beyond 600 mm.

KALCRET pipe bend – prefabricated – with asymmetric cross section





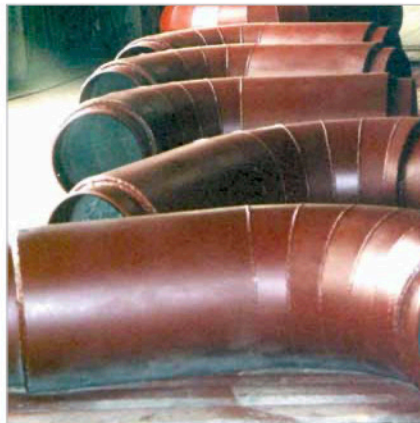
Scrubber inlet in a steel plant lined with sprayed-on KALCRET-BTS hard compound



Separator of a cement mill lined with KALCRET-BNX, up to 3,200 mm diameter



Reliable protection of the dust collecting pipe of a clinker cooler with KALCRET-BNY fitted as prefabricated shaped elements with integrated insulation



Prefabricated KALCRET bends for pulverized coal in a power station

Sinter dust transport pipe in a German cement plant

# >> Spraying with KALCRET

## Hard, Abrasion Resistant and Quickly Applied



Kalenborn spraying technology

KALCRET-S can be sprayed on large surfaces quickly at rates of more than 5 m<sup>2</sup>/hour. Spraying can be done horizontally and vertically. It can even be worked overhead and enables the lining of complicated surfaces without difficulty.

Investigations have shown that the properties of sprayed-on linings do not differ practically from these of comparable vibration compacted linings.

The addition of steel or other fibers has positive effects on strength and structural stability. The types of fibers are chosen with due regard to the specific thermal, chemical and corrosive stress. The fibers are added to the mixture during the spraying process.



Overhead working possible without difficulty

### Advantages of KALCRET-S:

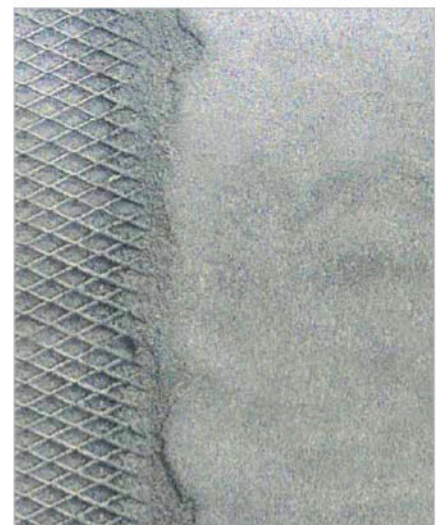
- time-tested wear protection compound
- excellent abrasion values as defined in ASTM
- homogeneous structure with little porosity
- smooth surfaces obtained by reworking
- minimum setting time
- short installation time due to high application rate beyond 5 m<sup>2</sup>/hour
- overhead working
- homogeneous, jointless and intensely compacted sprayed-on layer
- variable thickness options, preferably from 20 to 100 mm



Kalenborn spraying machine



Homogeneous structure



Reinforcement and wire mesh, smooth surface

# >> KALCERAM Linings

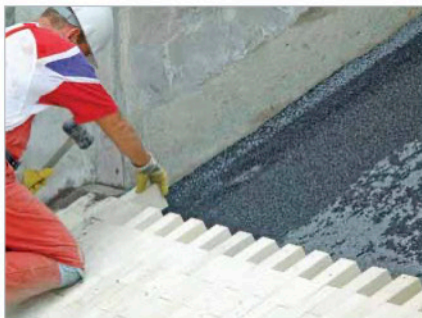
## Hard Ceramics with Good Sliding Properties

KALCERAM hard ceramics is particularly suitable where moderate abrasion is encountered and the extreme wear resistance of high quality linings cannot be economically justified.

For this reason KALCERAM is used in some system components in coal fired power stations, refuse incineration plants, coking plants, processing plants, potash mines,

steel works, chemical plants, quarries, ceramic factories, glass works, cement works, lime plants, etc.

Particular emphasis is placed on the abrasion resistance of the product. That is why KALCERAM is so different from other commercially available ceramic products.



High temperature KALCERAM-K chute in a coking plant provides good sliding properties even at high temperatures

Even conical surfaces can be lined as required with cut KALCERAM tiles



## KALCERAM

**Hard ceramics for plant components subject to moderate wear, e.g. coal bunkers and chutes, fine coal troughs, thickeners and chain conveyors.**

**Installation: made-to-measure tiles are laid either in cement mortar or KALFIX synthetic mortar.**

**Application temperature: up to approximately 350 °C / 662 °F (KALCERAM), up to approx. 1.000 °C / 1.832 °F (KALCERAM-K).**

**Advantages: average abrasion resistance, smooth surface, KALCERAM-K also shows good temperature resistance.**



Chutes lined with KALCERAM are a solution that lasts, e.g. for bag loading systems in cement plants

# >> KALMETALL Linings

## Metal Wear Protection with High Hardness and Impact Strength

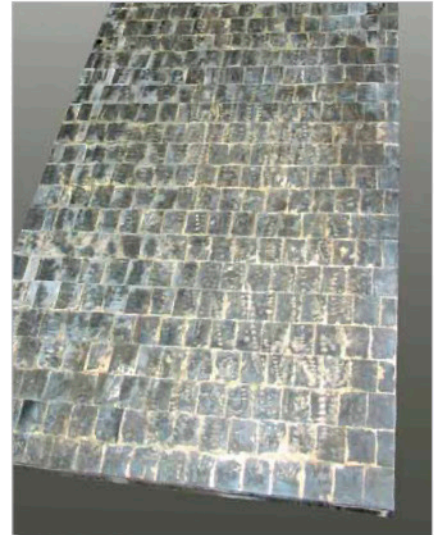
Kalenborn offer the complete array of metallic wear protection highlighted by long lifetime, flexible application, good impact resistance, relatively low weight and economic price/performance ratio.

### The Kalenborn program:

- KALMETALL-C hard casting
- KALMETALL-HB hard steel
- KALMETALL-HM hard metal
- KALMETALL-S hard metal spraying
- KALMETALL-W hard overlay welding



Mixer blade with KALMETALL-HM and KALOCER combined lining



KALMETALL-HM used to protect a vertical roller mill



### KALMETALL-C

Hard castings of varying alloys and properties matched to the specific abrasion and impact wear requirements.

**Installation:** made-to-measure shaped elements in setting compounds; mechanical fixing and self-supporting structures are also possible.

**Application temperature:** up to approximately 350 °C / 662 °F depending on application and geometry.

**Advantages:** high wear resistance with satisfactory impact strength or high impact strength with satisfactory wear resistance, economic in case of series production.

# >> Various Alloys of KALMETALL-C Hard Casting



Asphalt mixers are subject to significant wear; they are effectively protected by KALMETALL-C



Shaft flight of KALMETALL-C proven in use for hard coal mining

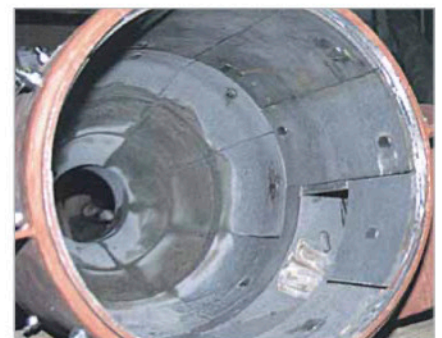
Pulverized coal pipe armored with hard casting KALMETALL-C



Rotors for turbines made of KALMETALL-C 155



Typical applications of KALMETALL-C hard casting are pipe systems; here a pulverized coal pipe of a power station in South East Asia



Cyclone used in a soil decontamination system – effectively protected with KALMETALL-C

# >> KALMETALL-W Linings

**Hard Overlay Welding Services, Standard Plates and Complete Plant Components**



KALMETALL-W incorporates several hard overlay welded steel systems that consist of a tough basic body and hard overlay welding.

The base metal provides the strength of the system. Depending on the specific application, it is made of standard or special steels.

The hard overlay welding is the wear layer. It consists of a C-Cr-Fe system with primarily chromium carbides. The carbides provide the extreme hardness of the overlay welding. Depending on the composition of the alloy, the hardness may be up to 820 HV.

## Welding Service

Kalenborn offers individual overlay welding for a variety of elements and components. KALMETALL-W allows Kalenborn to be a specialist in the regeneration of grinding systems.

## Hard Overlay Welded Plates

Standard plates are offered at varying qualities, thicknesses and dimensions. Special components can be custom fabricated any time. Components of self-supporting structures are characterized by low weight and high economy.

## KALMETALL-W

Hard overlay welded steel systems that consist of a tough basic body and the hard overlay welding.

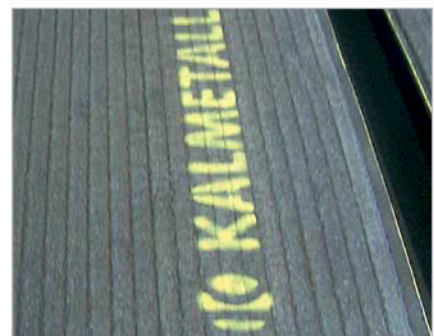
**Installation:** by overlay welding or use of standard plates to fabricate complete structures.

**Application temperature:** up to approximately 750 °C / 1.382 °F depending on application and geometry.

**Advantages:** high wear resistance and high impact strength combined with optimal adaptation to the customer's requirements.



Kalenborn welding service, regeneration of a grinding table



Hard overlay welded standard plates



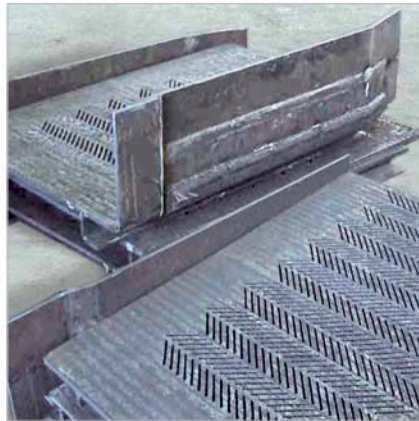
Separating cones of cement classifiers made of KALMETALL-W 100 as self-supporting structures



Pressure equalizing pipe set up near a blast furnace; the base metal has a thickness of 30 mm, the thickness of KALMETALL-W 100 hard overlay welding measures 6 mm; 450 mm diameter



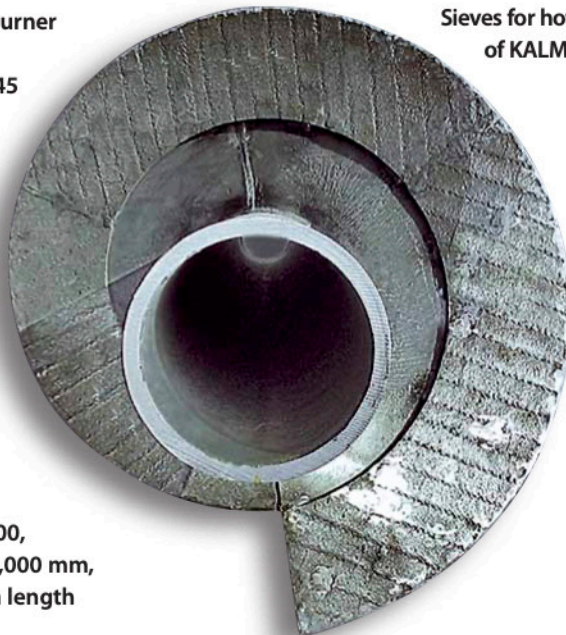
Pulverized coal burner lined with KALMETALL-W 145



Sieves for hot sinter made of KALMETALL-W 145



Pipe armored with KALMETALL-W 100 installed in a dust collecting system; inside diameter 400 mm, system thickness 8 + 5 mm

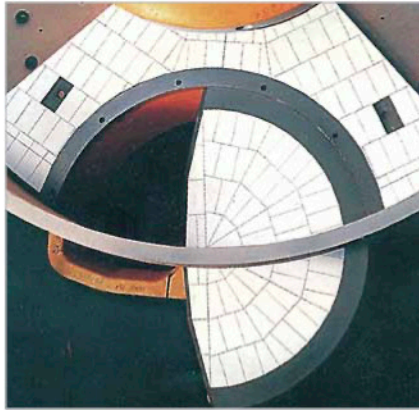


Screw conveyor protected with KALMETALL-W 100, diameter up to 2,000 mm, up to 10,000 mm length

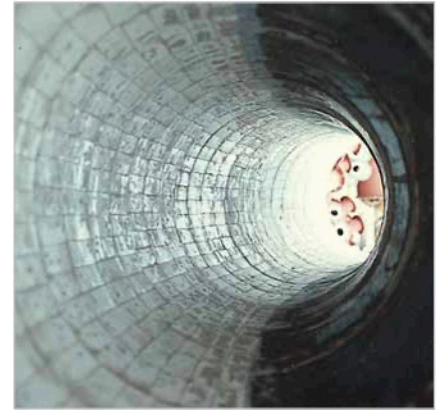
# >> Combined Linings

**More Economical due to Similar Lifetimes For all Plant Components**

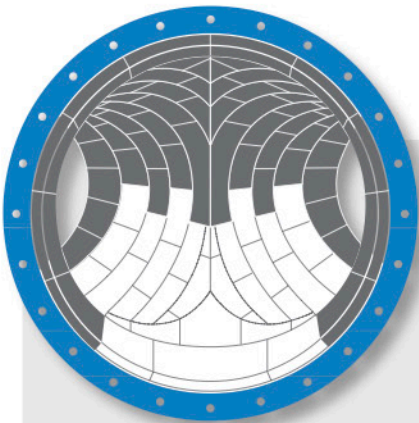
High conveying speeds and abrasive materials cause wear in material handling systems. However, the wear is of varying intensity in different areas. This is where a combination of the different wear resistant linings proves successful. Designed on the basis of prior successful experience, components can achieve similar lifetimes without some failing prematurely or other excessively protected.



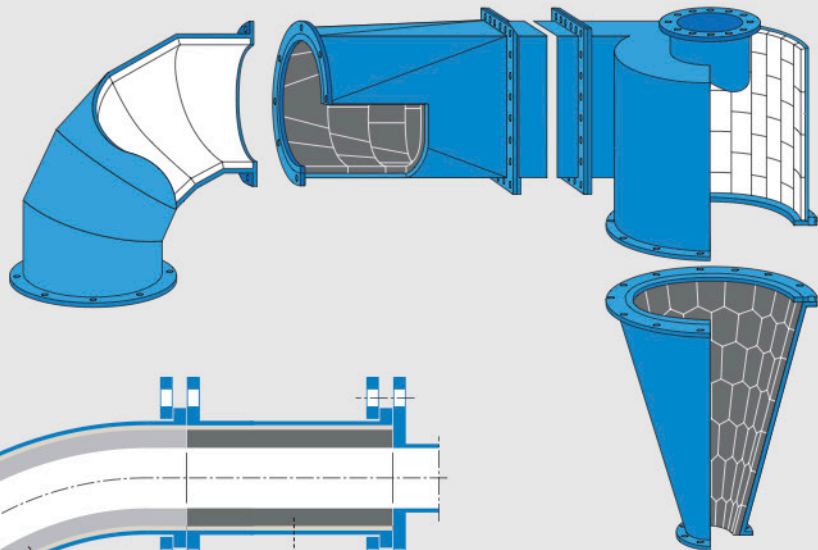
KALOCER bottom of a concrete mixer for extreme stress, KALMETALL-W in the area of the discharge gate



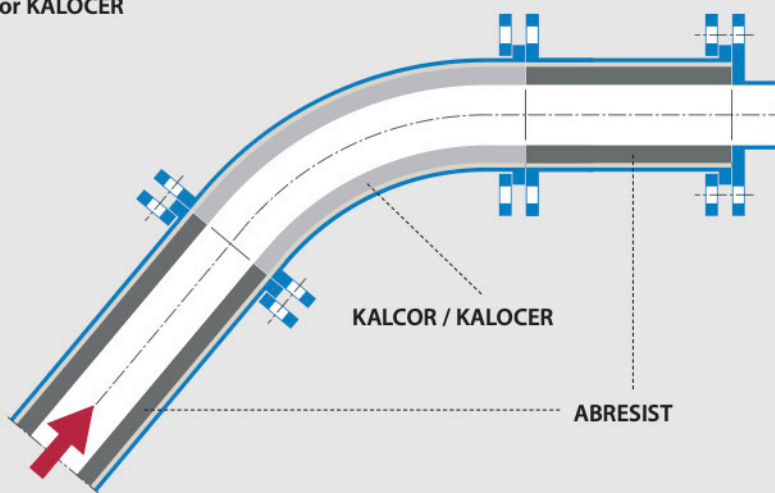
Pipe bend with ABRESIST and KALOCER combined lining



Reliable Lining of pipe unions and transition sections by a combination of ABRESIST or KALCRET with KALCOR or KALOCER



In case of specific applications combinations of Kalenborn wear protection materials may be suitable, e.g. ABRESIST, KALCOR, KALOCER, KALCRET or KALMETALL



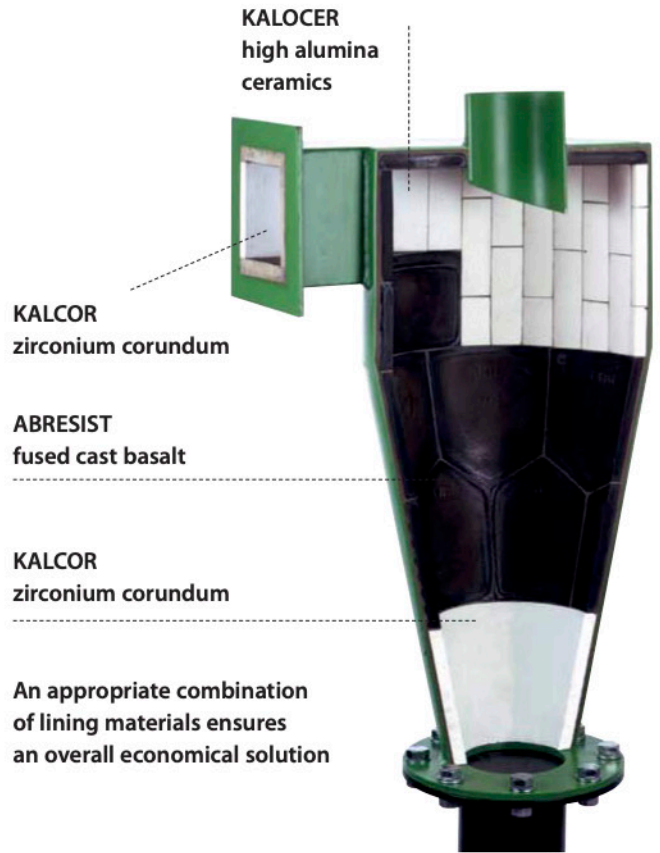




Discharge device for abrasive sludge from a mixer tank as a combination of KALCOR, KALOCER and high-grade steel



ABRESIST lining combined with KALCOR deflectors and an inspection device



Abrasive sinter particles impinge on the KALCOR lining at 250 °C / 482 °F and at high velocity – combined with ABRESIST results in an economical solution



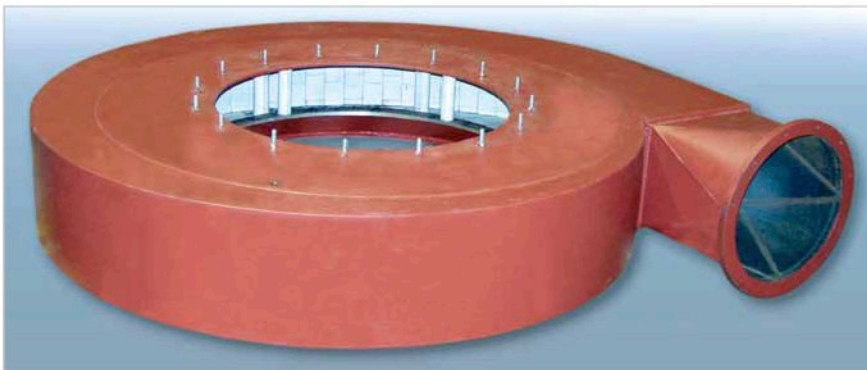
Combination of KALCOR and ABRESIST in a pulverized coal pipe in Europe

# >> Combined Linings

Use in a shredder system for plastic waste:  
KALMETALL-C and KALCRET



Immersion pipe of a cyclone  
for separating granulated blast  
furnace slag in the cement industry;  
KALCRET and KALMETALL-W



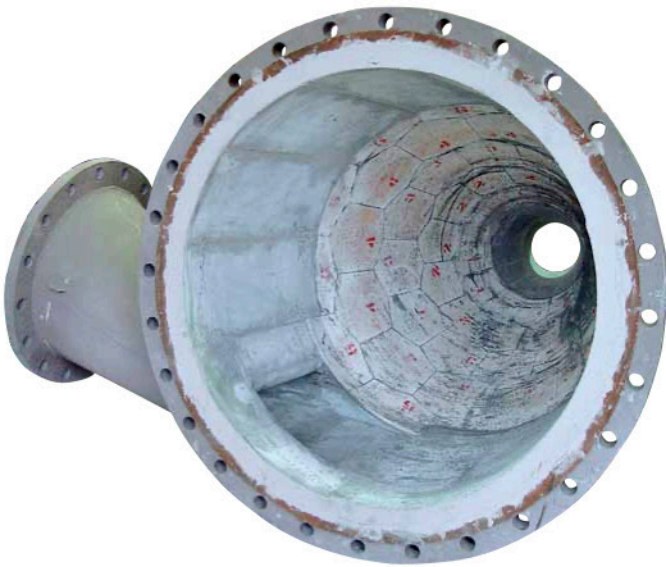
Separator inlet housing designed  
as self-supporting structure made of  
KALMETALL-W and KALOCER  
subject to extreme stress



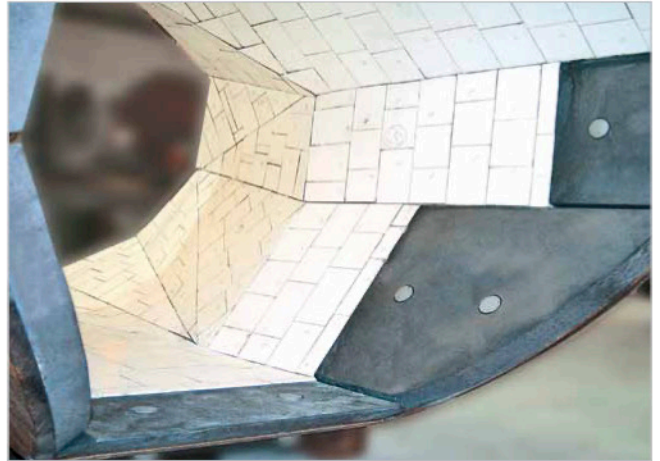
Pulverized coal distributor boxes protected with  
KALCOR for large surface lining and KALOCER  
to offer maximum wear resistance



Drum mixer for concrete lined with KALOCER high alumina  
ceramics; mixer tools made of KALMETALL-C hard casting  
and/or KALEN-PU plastics



Effective protection of a cyclone processing silica sand: KALCOR zirconium corundum and KALSICA silicon carbide ceramics



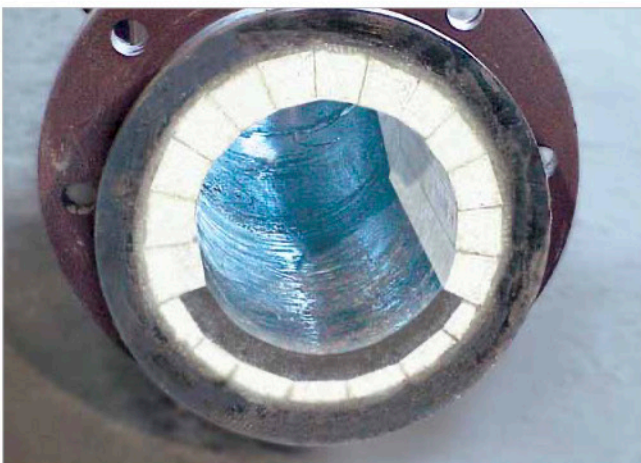
Octagonal hopper subjected to impact stress lined with three-dimensionally cut KALOCER shaped elements as well as KALMETALL-C shapes, each 50 mm thick



Kalenborn deviation pot with ABRESIST and KALOCER – the badly worn parts can be replaced



Coke wharf protected with KALCERAM-K on the sliding surface, with KALSICA-N in the zone of high wear and with KALMETALL-C in the area of impact stress



Impact protection in an extrados: KALMETALL-HM combined with KALOCER laid out as pipe brick

# >> Design Details

## Individual Fixing Alternatives Depending on Conditions and Processes

### Installation and Erection

A precondition for effective wear protection is proper installation.

Appropriate installation and erection of the lining depend on material conveyed, application, equipment, design and installation position. It also depends on whether sliding or impact wear prevail, temperature or thermal shock stress, corrosive or acid exposure is present.

ABRESIST, KALCOR, KALOCER and KALSICA normally are laid in cement mortar or special setting compounds.

Higher temperatures require additional measures like mechanical fixing, f.e. especially if the subsurface has different thermal expansion than the wear protection lining.

Special fixing systems have to be used for KALMETALL. Details are available in the relevant brochures.



Kalenborn offer a complete program of proven KALFIX setting compounds



Setting in cement mortar



Potassium silicate based mortars are used in case of high thermal stress

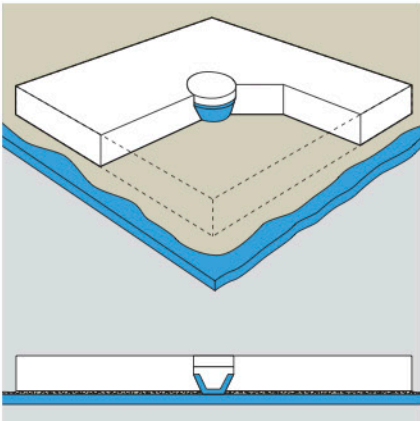


Use of synthetic resins



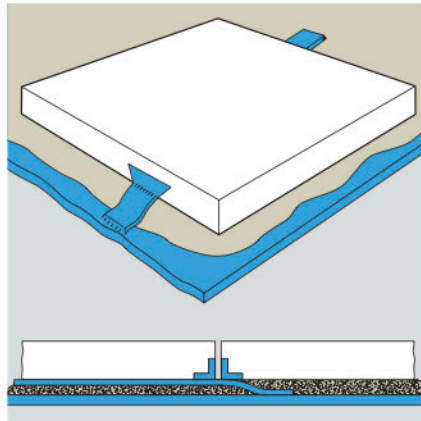
Mechanical fixing to meet special requirements

# >> Mechanical Fixings and High Temperature Applications



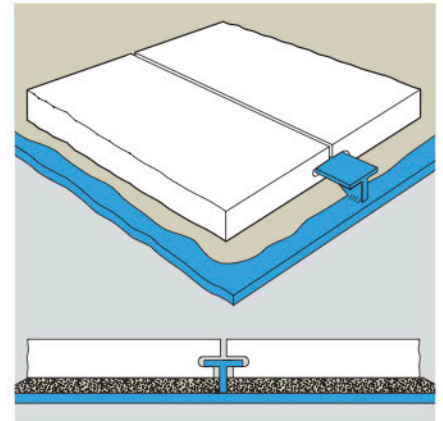
## Tile with Hole

These are usually fastened to vertical and overhanging steel surfaces by means of countersunk bolts, conical weld sleeves or weld studs.



## Tile with Steel Corner Inserts and Weld Straps

This mechanical fastening method enables installing the lining to steel surfaces by welding.

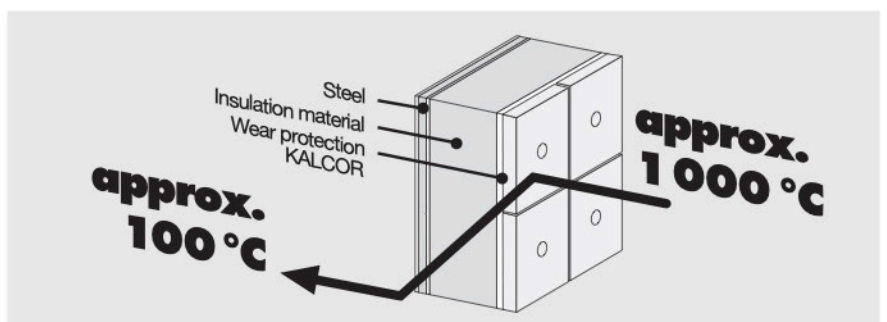


## Tile with Groove

This method has proved useful as well and allows the fastening of linings to steel surfaces by welding.

## High Temperature Applications up to 1.000 °C / 1.832 °F

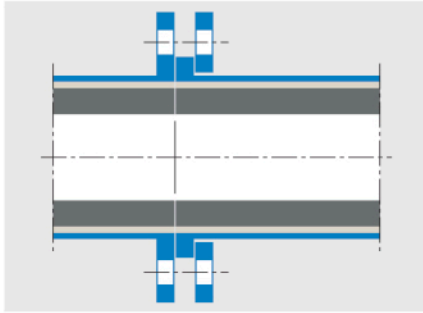
KALCOR, KALOCER and KALSICA are wear protective materials capable of withstanding high temperatures. A wide range of mechanical fixing methods and design details permit finding cost effective wear protection for any application. Moreover, KALCRET hard compound can be installed by casting, trowelling or spraying.



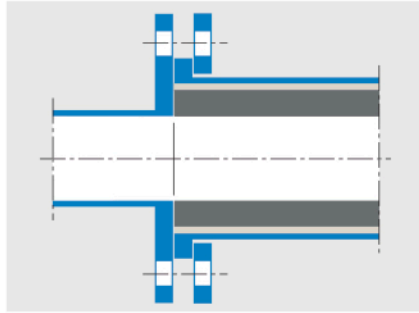
# >> Flanges and other Joints

## Flange Joints

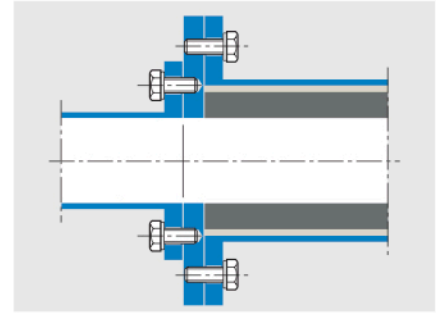
The connection of wear resistant pipes to each other or to regular steel pipes can be done with fixed and/or loose flanges.



Lined pipes can be connected to each other easily with a fixed collar and a loose turnable flange on one end.



A weld-on counter flange with larger bolt circle diameter on the unlined pipe is a proven solution to connect pipes.



Unlined pipes, pumps or fittings can be connected with a lined pipe using an adapter flange.

## Gaskets

The recommended dimensions of pipe gaskets are as follows:

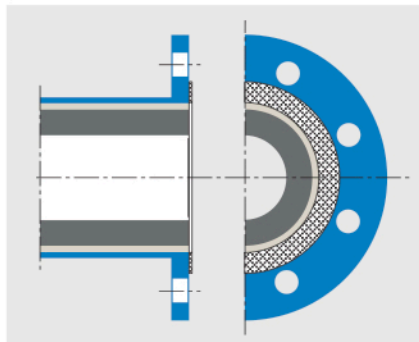
outside diameter  $\triangleq$  outside diameter of the collar

inside diameter  $\triangleq$  outside diameter of the steel pipe

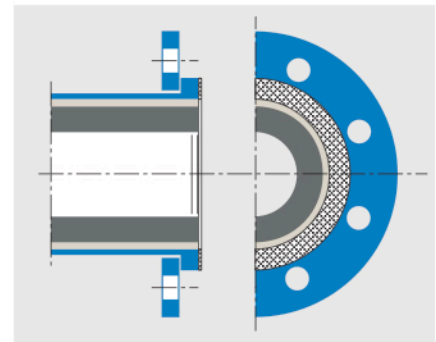
Minimum gasket thickness: 2 mm.

The material depends on the specific conditions. All known gasket materials can be used.

Other sealing systems are possible.



ABRESIST pipe with a fixed flange

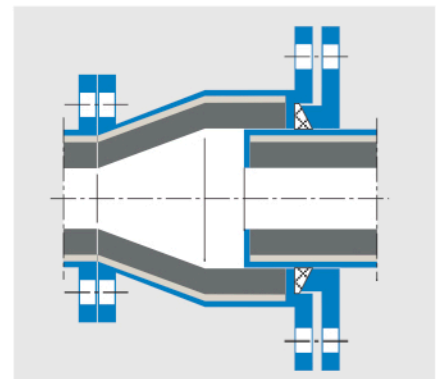


ABRESIST pipe with a fixed collar and turnable flange

## Expansion Joint Sections

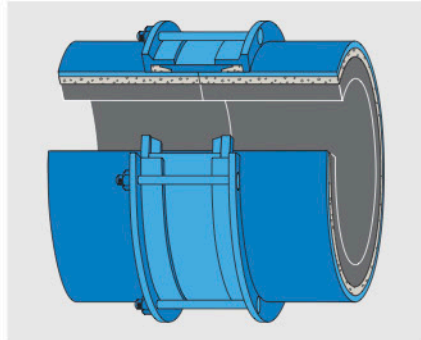
For longer pipelines wear resistant lined expansion joints of various designs are available to compensate for changes in length.

Expansion joints in a hydraulic bottom ash pipeline

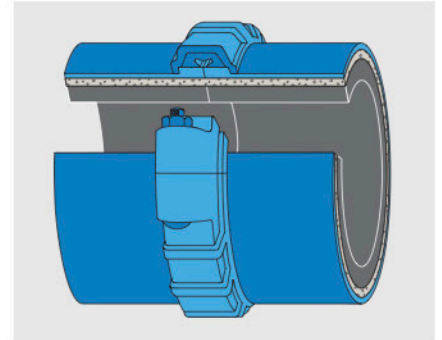


## Couplings

Wear protected pipes can be connected by any known coupling system.



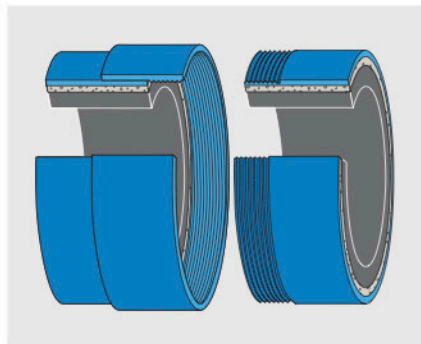
Coupling with radial restraint



Coupling with axial restraint

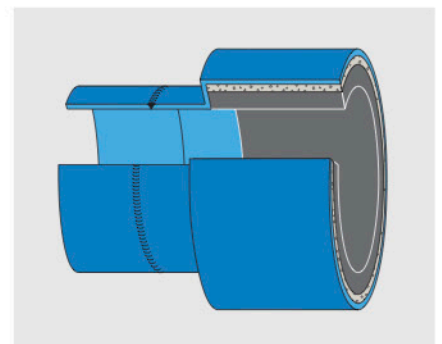
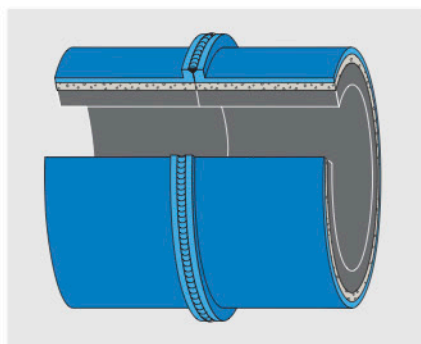
## Threaded Joint

When a pipeline is stressed by tension, e.g. when vertically suspended, threaded joints can be used.



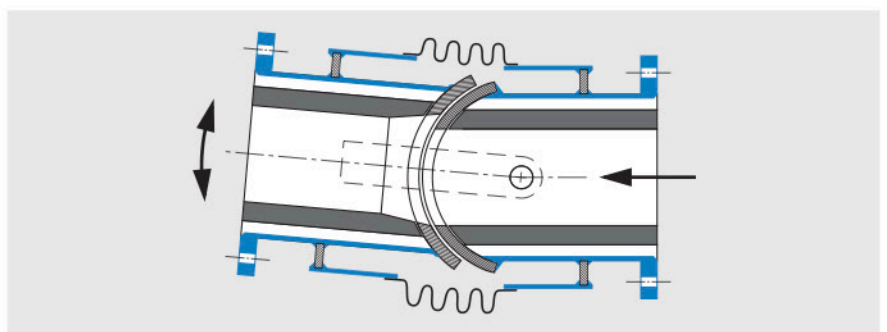
## Welded Connections

When flanged connections and couplings are not the answer, it is possible to connect wear resistant pipes by a welded connection.



## Joint Couplings

Special joint couplings to compensate for difference in level and length.



# >> Wear Protection Systems

## Flexible Bends, Ceramics-Rubber Bonding and more ...

### KALFLEX Bends

KALFLEX is flexible piping that can be easily installed with standard flanges. The core elements of the system are abrasion resistant segments that fit into each other. The segments are capable of moving in relation to each other, providing the desired flexibility.

The segments are enclosed in a rubber jacket containing a fabric insert, producing the needed stability and tightness.

### Abrasion Resistant KALMETALL-C Hard Casting

The wear resistant segments are made of KALMETALL-C hard casting, resistant against both impact and sliding wear. The segments have diameters between 19 and 200 mm.

### KALOCER in Case of Maximum Wear

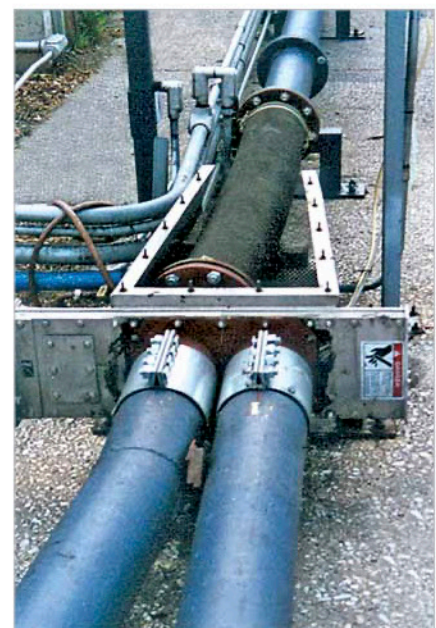
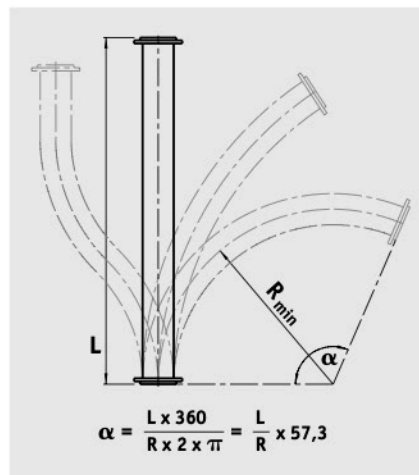
The segments can be made of high alumina ceramics if they have to withstand very harsh conditions concerning sliding wear. The inside diameter ranges from 50 to 125 mm. For design reasons collars and flanges are made of hard casting and/or steel.

### Advantages:

- inside diameter ranging from 19 to 200 mm
- maximum temperature 110 °C / 230 °F
- pressure up to 10 bar
- preventive stockkeeping
- useful for diverter valves
- used as vibration reducing element
- used as expansion joint
- well suited in case of narrow space
- compensation of load cells



KALFLEX used as flexible pipe bend



KALFLEX as part of a diverter valve in the USA

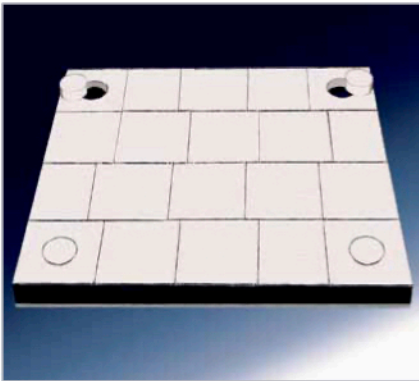


## KERAFLEX Ceramics Rubber Bonding

KERAFLEX is ceramic or overlay welded tile vulcanized into rubber mats. The ceramic tiles can be of varying thickness up to 50 mm.

### Advantages:

- impact resistant ceramic elements
- very hard and wear resistant surface
- impact resistant thanks to the rubber layer matched to the specific application and the optimal vulcanization



The KERAFLEX system



KERFALEX lining of a bin set up in a bulk material handling plant

## Kalenborn Deviation Pots

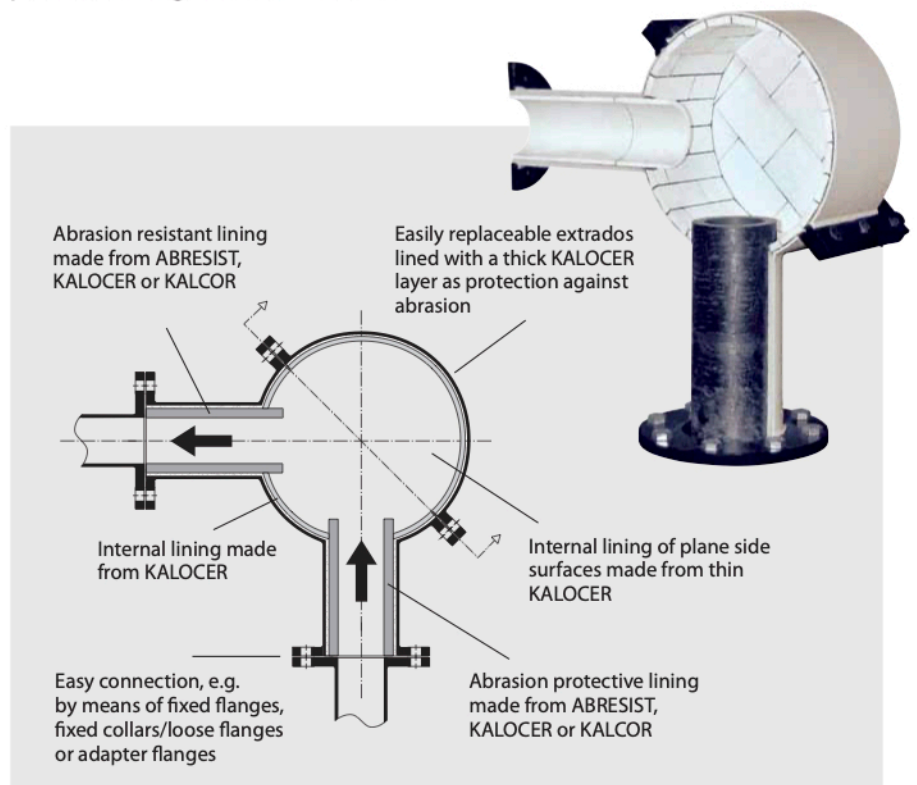
In pneumatic conveying systems an abrupt deviation of the material flow or discontinuous conveying frequently increases wear resulting in operational failures and costly repairs or replacements.

Kalenborn's deviation pot with a wear resistant lining displays a completely different behavior. It withstands the extra stress and permits relining whenever needed.

Lining materials normally used include ABRESIST fused cast basalt and highly wear resistant KALOCER high alumina ceramics.

### Advantages:

- standard sizes
- special solutions feasible any time
- wear protection materials selected based on the specific stress



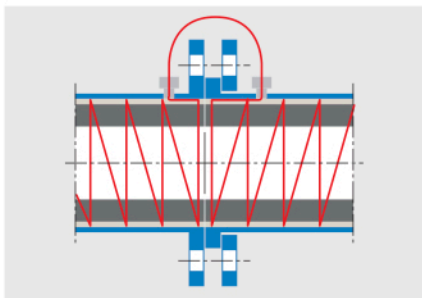
# >> Wear Protection Systems

## KALDETECT Wear Detection

For critical cases Kalenborn offer systems that monitor possible wear in the lining. This gives the operator early information for taking necessary action. Important and necessary, e.g. in pneumatic conveying lines to prevent toxic or environmentally harmful substances from being released.



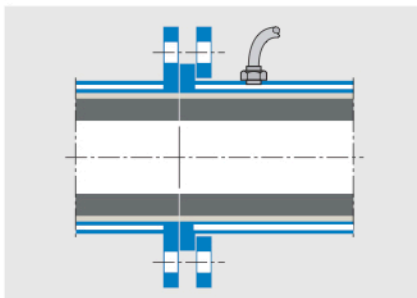
KALDETECT installed in a German waste incineration plant



### Electrical Wear Detection

The wear resistant lining is fitted on the OD with a low voltage electrical circuit. If the wear resistant lining wears through due to abrasion in the pipeline, the electrical circuit will be interrupted. This will sound an alarm and – combined with a suitable evaluation system – will indicate the pipe section concerned or the plant can be automatically shut down.

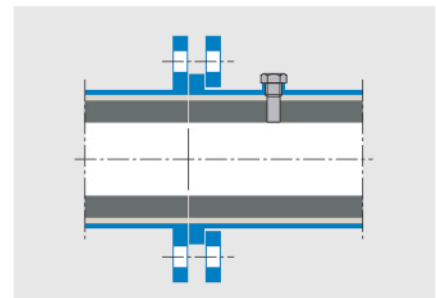
The electrical wear detection is available for all of the wear resistant materials of Kalenborn.



### Pneumatic Wear Detection

The steel casing is twin-walled. Changes in the pressure level in the space between the two parts caused by a leak will activate an indicator or alarm or the plant can be shut down – similar to the electrical wear detection.

This system can be used for single pipes, complete pipelines or any mechanical plant.



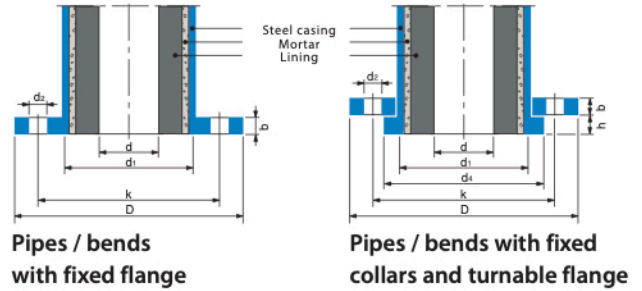
### Mechanical Wear Detection

The support structure and wear resistant lining are fitted with a bore hole. The length of the indicator pin monitors the thickness or condition of the protective lining when removed and inspected.

Additionally, a serrated wear measuring tape can be placed in a continuous groove of the abrasion resistant lining. The width of the visible saw tooth is an indication of the condition of the protective lining.

# >> Pipes & Bends

**Kalenborn Company**  
**Standard Rd 6a**  
**(Extract, Issue 05/2010)**



**Designation of pipe bend:** Inside diameter (d) 60 mm, radius (r) 1,000 mm, angle (a) 90° as defined in Kalenborn company standard Rd 6a:  
 • pipe bend Rd 6a id 60; r 1,000; 90°

**Dimensional tolerances:**  
 The dimensional tolerances specified in the Kalenborn company standard Rd 6a are in accordance with DIN EN 1092-1, DIN 1626, DIN ISO 13920 degree of accuracy A (but length tolerance up to 1,000 mm ± 2mm, up to 2,000 mm ± 3 mm, greater length ± 4 mm).

**Materials for pipes and flanges:**  
 Unalloyed structural steel S235 JR; other material specifications feasible on request.

**Corrosion protection (external surfaces):**  
 • surface preparation: DIN EN ISO 12944-4 / DIN EN ISO 8501-1 – St 2 (manually cleaned)  
 • coating system: zinc phosphate primer, red brown (similar to RAL 3011) – NDFT 40 µm; suitable as transport protection.

Other surface preparation methods or coating systems are feasible.

**Flanges:** Straight pipes with fixed flanges, pipe bends with fixed collars and turnable flanges. Other designs and other fixing systems on request.

**Recommended gasket geometry:**  
 • outside Ø = outside Ø of the collar (d<sub>4</sub>)  
 • inside Ø = outside Ø of the steel pipe (d<sub>1</sub>)  
 • thickness ≥ 2 mm

**Other standards:** Kalenborn offer solutions for piping operating at higher pressures, higher temperatures and other specifications (incl. Pressure Equipment Directive PED 97/23/EG; AD2000 etc.).

Pipes and bends		Flanges					Rings	
Lining inside diameter mm	Steel casing outside diameter * mm	Flange outside diameter mm	Bolt circle diameter mm	Number of holes	Holes diameter mm	Flange thickness mm	Ring outside diameter mm	Ring thickness mm
d	d <sub>1</sub>	D	k		d <sub>2</sub>	b	d <sub>4</sub>	h
40	127	220	180	8	18	16	158	15
50	139,7	234	187	8	18	16	166	15
55	139,7	234	187	8	18	16	166	15
60	139,7	234	187	8	18	16	166	15
65	159	254	207	8	18	16	186	15
70	159	254	207	8	18	16	186	15
75	159	254	207	8	18	16	186	15
80	159	254	207	8	18	16	186	15
88	159	254	207	8	18	16	186	15
95	168,3	269	222	8	18	16	201	15
100	177,8	275	228	8	18	18	207	16
107	193,7	286	240	8	18	18	219	16
110	193,7	286	240	8	18	18	219	16
113	193,7	286	240	8	18	18	219	16
120	193,7	300	253	8	18	18	232	17
125	193,7	313	266	8	22	18	241	17
132	219,1	313	266	8	22	18	241	17
146	219,1	327	280	8	22	18	255	17
150	219,1	327	280	8	22	18	255	17
162	244,5	347	300	8	22	18	275	17
170	255	372	323	8	22	19	298	18
175	255	372	323	8	22	19	298	18
178	255	372	323	8	22	19	298	18
183	255	372	323	8	22	19	298	18
190	273	404	353	8	22	19	328	18
200	273/290	404	353	8	22	19	328	18
205	273/290	404	353	8	22	19	328	18
225	315	430	379	12	22	19	354	18
242	323,9/345	460	410	12	22	24	382	19
250	323,9/345	460	410	12	22	24	382	19
260	355,6	490	440	12	22	24	413	19
275	355,6	490	440	12	22	24	413	19
280	355,6	490	440	12	22	24	413	19
294	385	516	465	12	22	24	440	19
300	385/406,4	516	465	12	22	24	440	19
311	406,4	516	465	12	22	24	440	19
325	420	545	495	12	22	24	470	24
350	435	568	517	16	22	24	490	24
375	457	588	537	16	22	24	510	24
400	485	618	567	16	22	28	535	24
430	515	648	592	16	22	28	565	24
450	540	668	618	20	22	29	585	24
475	590	730	688	20	22	29	650	28
500	590	730	688	20	22	29	650	28
525	610	755	705	20	22	29	670	28
610	711	860	810	24	26	29	775	28

\*First figure for pipes, second figure for bends

Technical changes and errors are reserved

# >> Materials at a Glance



## ABRESIST Fused Cast Basalt

ABRESIST is a basalt based wear protection for plant components in which the material to be conveyed predominantly causes friction induced abrasion in bunkers, troughs, chutes, chain conveyors, mixers, separators, pipes, pipe bends, cyclones, etc.

**Installation:** the shaped cast tiles are laid in cement mortar. To meet special requirements other setting materials may be used, such as KALFIX synthetic mortar or potassium silicate based mortar for higher temperatures.

**Application temperature:** up to approximately 350 °C / 662 °F.

**Advantages:** high abrasion resistance, lasting smooth surface, no corrosion.



## KALCOR Zirconium Corundum

KALCOR is a material composed of alumina and zirconia. It is recommended for particularly high abrasion and/or thermal stress, e.g. in cyclones and separators, in chutes for hot sinter or clinker, for mixers, pipelines, etc.

**Installation:** the shaped cast tiles are laid either in cement mortar or special setting materials. Mechanical fixing is possible as well.

**Application temperature:** up to approximately 1.000 °C / 1.832 °F.

**Advantages:** high abrasion resistance, high temperature stability, resistant to impact and corrosion.



## KALOCER High Alumina Ceramics

Special high alumina ceramics for system components exposed to extreme wear and/or thermal stresses for which thin linings or smooth surfaces are required, such as in circulating air separators, cyclones, screw centrifuges, vibrating chutes, fans, fan blades, etc.

**Installation:** shaped elements or thin tiles laid in epoxy mortar. KALOCER tiles are also vulcanized into rubber mats to be fastened by adhesive. Mechanical fixing is possible as well.

**Application temperature:** up to approximately 1.000 °C / 1.832 °F.

**Advantages:** high abrasion resistance, high temperature stability, resistant to impact and corrosion. Available in thicknesses from 1.5 mm.



## KALMETALL Metallic Wear Protection

Metallic wear protection is offered in various qualities. It is particularly suitable as protection against sliding and impact wear. The range includes hard castings as well as overlay weldings.

**Installation:** Made-to-measure castings laid in setting compounds or mechanically fixed. Plates with overlay welding are fixed mechanically or designed as self-supporting structure.

**Application temperature:** up to approx. 350 °C / 662 °F (hard castings), up to 750 °C / 1.382 °F (hard overlay weldings).

**Advantages:** highly wear resistant and resistant against impact wear, castings economic upon series production, overlay weldings characterized by good adaptability.



## KALCRET Hard Compound

Cement bonded hard compound for continuous lining of plant components where high wear and temperature occur, e.g. troughs, chutes, bunkers, cyclones, etc.

**Installation:** by trowelling, casting or spraying.

**Application temperature:** up to approximately 1.200 °C / 2.192 °F.

**Advantages:** high wear resistance and compressive strength, jointless lining and highly temperature resistant.

## DGC SOUTH AFRICA

DICKINSON FURNANCE SERVICES (PTY) LTD  
DICKINSON INDUSTRIES (PTY) LTD

T +27 (0) 16 421 3720  
F +27 (0) 16 422 1038  
E sales@dgrpint.com

10 Smuts Avenue, Vereeniging  
P.O. Box 63, Vereeniging, South Africa, 1930

www.dgrpint.com

## DGC AFRICA

DICKINSON COPPERBELT SERVICES LTD  
DGC AFRICA (DRC) S.A.S  
DGC STAFFING SOLUTIONS

T +260 76 183 2470 (Zambia)  
E sales@dgc-africa.com

OFFICES:  
Mufulira, Zambia  
Lubumbashi, Democratic Republic of

www.dgc-africa.com

## INTERNATIONAL

DGC INTERNATIONAL LTD

T +230 403 2500  
E sales@dgrpint.com  
2nd Floor, The AXIS, 26 Bank Street,  
Cybercity, Ebene, 722201, Mauritius



Ask Kalenborn Abresist for further information

## Kalenborn Abresist

PO Box 38, 5541 North State Road 13, Urbana, IN 46990

Phone (800) 348-0717 • Sales Fax (260) 774-3832  
email: info@abresist.com • www.kalenborn.us

