

Stainless steels





Deutsche Edelstahlwerke

Over 160 years of expertise

Deutsche Edelstahlwerke is a leading producer and processor of special steel long products with an unique product range worldwide. The stainless-, acid- and heat-resistant steel segment alone comprises over 200 grades which meet diverse requirements depending on the application. We give high priority not only to the quality of our products but also to the economic efficiency of their production. Our research and development, production and consulting departments work together closely to ensure these standards.

Over 160 years of expertise and modern production facilities form the basis for the outstanding quality of our products, which we continuously develop together with our customers.



Stainless steel – versatile and economical

Compared to many other materials, stainless steels possess good corrosion resistance which withstands even mechanical or abrasive stress. This property is produced by a passive layer on the surface which regenerates again and again. Its high compressive strength and great toughness even at low temperatures make stainless steel an optimal material which can be easily machined and even welded.

We supply the right material for every requirement:

- » high-alloy austenitic steels containing molybdenum are the recommended choice for high corrosive stress, particularly at elevated temperatures
- » hardenable and wear-resistant steels for edge retention and resistance to high wear stress

- » austenitic steels, soft martensitic steels or hardenable steels provide sub-zero toughness
- » high-temperature and heat-resistant steels which stand up to thermal and mechanical stresses and are resistant to brittleness

Top quality, individualised services and direct proximity to the customer are just some of our strengths. Our experts are happy to advise you.

Further information about our stainless-, acid- and heat-resistant steels can be found in our brochures "Steels for Oil- and Gas-Exploration" and "Providing special steel solutions in aerospace".

Forming and processing of stainless-, acid- and heat-resistant steels

Hot-forming

Forging and rolling

We produce semi-finished products for hot-forming in different versions. Every method of hot-forming – from open die forging or standard-pressed parts made with forging hammers to forming using Hatebur technology – can be implemented economically and suited to your requirements using our primary material.

Welding

Stainless-, acid- and heat-resistant steels can generally be welded, using different techniques depending on the material (e.g. condenser resistance welding, friction welding, welding with or without additional material, laser welding, electron beam welding) and using different types of finishing treatments if required. Detailed information about this can be found in our data sheets. We are also happy to advise you personally.

Cold forming

Cold massive forming

Cold massive forming has many advantages: high productive capacity, excellent utilisation of materials and thus a high economy of scale as well as high dimensional and shape accuracy.

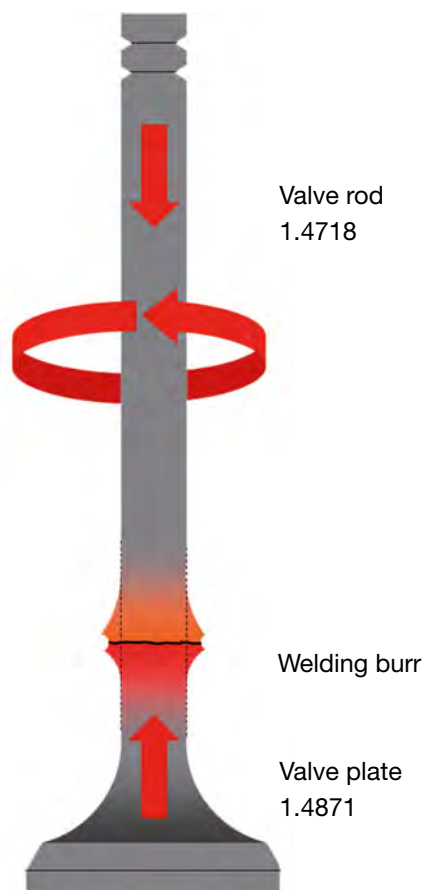
Cold forging

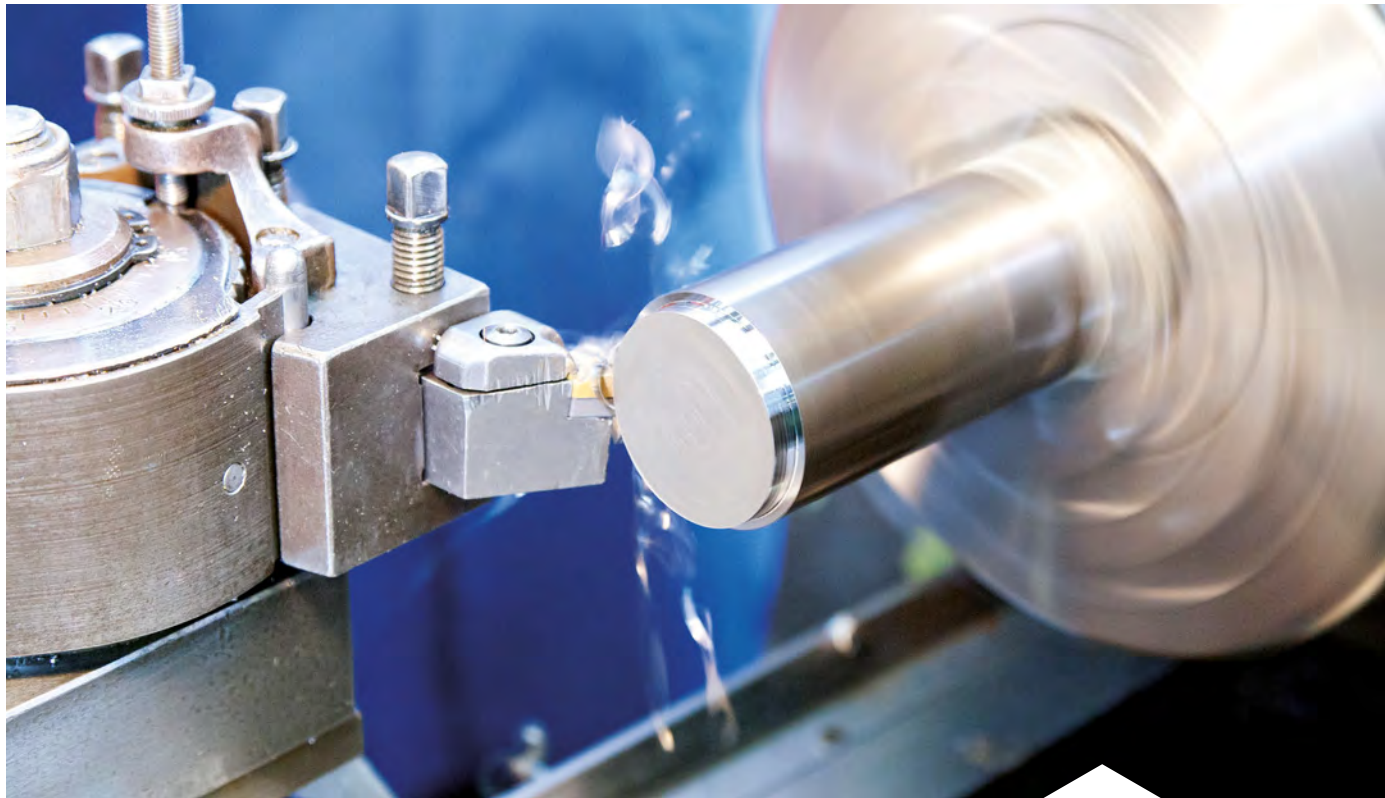
In this process, workpieces are formed using considerable pressure in a moulding press between a heading tool and a die. If the die is tapered, the process is called tapering. The workpiece lengthens and its circumference is reduced. If there is a cavity between the inside of the die and the heading tool, a cavity equivalent to the shape of the heading tool is created in the workpiece. This is referred to as cup extrusion due to the penetration of a heading tool into the primary material.

Drawing

We produce a large variety of stainless-, acid and heat-resistant steels as drawn steels. With the aid of drawing lubricants (e.g. stearate, oil), the (wire) rod is drawn through a drawing die at room temperature for the purpose of reducing its diameter and increasing its strength. During this process, the material is subjected to work hardening that affects materials differently. Compared to wire rod, drawn wire has closer diameter tolerances as well as a higher resistance.

Outlet valve produced by friction welding





Machining

Due to their varying microstructures and strengths as delivered, stainless steels have clearly divergent machining behaviours. For example, soft, ferritic steels require different machining parameters than high strength, quenched and tempered martensitic steels with strengths over 1300 MPa. With austenitic steels, lubrication and work hardening of the material must generally be avoided, so totally different machining parameters are required. In order to control machining within the material standards, conditions which enhance machining are offered for many materials (our Niro-Cut variants). However, this is not possible for all materials due to the required corrosion properties as well as the extremely high mechanical demands even at low temperatures. For high-speed machining and for a very high machining volume, stainless freecutting steels such as Corrodur 4005, Corrodur 4104 and Acidur 4305 are suitable; however due to their high sulphur content, their application is limited.

We would like to help you select suitable materials for your requirements and implement your machining projects.

Supply versions

Depending on the type of forming and their surface requirements, our customers can obtain the material in a hot-rolled black condition, in a ground state or if round bar steel is desired, as a peeled product. Depending on the material and process, we supply steel untreated in different states of heat treatment (e.g. quenched and tempered or cold sawable). Depending on the material, we also produce raw billets or raw ingots.

We are also happy to advise you on suitable processes for your requirements.



Stainless-, acid- and heat-resistant steels - An important material for industrial and everyday applications

Automotive industry

Leading suppliers of the automotive industry use our material in many different areas of their production. In addition, we also provide advice in the selection of material for new developments. Martensitic materials such as Acidur 4057 and Acidur 4418 play a major role in the production of high-pressure fuel injection systems in petrol engines. You can find many different types of our steel in automobile and commercial vehicle exhaust systems – from forging material to very thin wire which is installed as steel wool in catalytic converters. High-quality material is selected for the production of intake and outlet valves in engines because hot corrosion can occur here. Our product range includes stainless heat-resistant steels which are resistant to hot corrosion even under difficult fuel conditions.

The range of dimensions includes thin, quenched and tempered valve rods 5 mm in diameter through to primary materials for forging.

Besides these obvious applications, frequently there are also unseen applications in the automotive industry that are not associated with stainless materials at all, such as screw connections in petrol pipes or in engine management as well as braking system components.

Also soft magnetic materials such as locking mechanisms, servo motors and stainless springs are used in automobiles. Even in automobile surroundings, such as multi-storey car parks, stainless steels have become indispensable in structures and furnishings due to aggressive road salting.

Material	Code designation	Properties/Applications
Electrodur 4105	X6CrMoS17	Engine: fuel injection systems
Corrodur 4034	X46Cr13	Chassis frame: brakes, hand brakes Steering systems: pins and pistons for lorry steering systems
Acidur 4509	X2CrTiNb18	Exhaust: flanges, brackets, catalytic converters
Acidur 4301	X5CrNi18-10	Safety: airbags, servo motors, headrests
Acidur 4418	X4CrNiMo16-5-1	Engine: fuel injection systems



Power generation industry

Energy is precious. So even power generation itself needs to be efficient. We supply the necessary primary material: for example, for seamless boiler tubes. Our product range includes not only the major materials according to national and international standards but also material variants that we have developed or enhanced with our customers.

For turbine blades we offer materials to be forged into blades and profiles for machining. Flanges and safety screws are made using materials developed especially for the energy sector.

We meet high purity and homogeneity requirements with harmonised remelting processes such as electroslag remelting (ESR), electroslag remelting under inert gas and vacuum arc remelting (VAR).

The energy industry is growing and in particular it must continue developing a new ecology awareness. We support our customers and welcome their suggestions for (further) development of materials. This enables our products to be even more suited to your demands.

Material	Code designation	Properties/Applications
Acidur 4550	X6CrNiNb18-10	Round tubes for seamlessly rolled tubes
Pyrodur 4903	X10CrMoVNb9-1	Round tubes for seamlessly rolled tubes
Pyrodur 4923	X22CrMoV12-1	Turbine blade steel
Acidur 4404	X2CrNiMo17-12-2	Flanges
Pyrodur 4980	X6NiCrTiMoVB25-15	Safety screws
Pyrodur 4913	X19CrMoVNb11-1	Pins, screws

Construction

Stainless-, acid- and heat-resistant steels produced by Deutsche Edelstahlwerke fulfil all the requirements defined for materials in the construction sector. Thermal separation and insulation of balconies is provided by special thermal insulation elements (Isokorb). Glass fronts and roofing are stabilised in outdoor areas with gauze wire. Additional building protection is provided, for example, by lightning conductors and pigeon control netting made of Deutsche Edelstahlwerke steels. In bearing safety areas in building, bridge and tunnel construction, stainless steel guarantees maximum stability and longlasting reliability. Typical concrete flaking due to carbonation is prevented by the use of stainless steels in concrete construction.

In addition, stainless steel is much more durable than other materials and metals during fires. Therefore it is expected that stainless steels will be used increasingly, ensuring better compliance with fire protection regulations.

Blank rods are available up to 12 m long – also in strength classes > S460 – for large-area, non-bearing facades, supporting and bracing structures.

To avoid the need for welding, especially on decorative building components, more and more often stainless steels are being glued or screwed in place. Stainless fastening elements are available for this purpose, in high strength classes up to S880.

Material	Code designation	Properties/Applications
Acidur 4362 Acidur 4571	X2CrNiN23-4 X6CrNiMoTi17-12-2	Ribbed rolled finish for Isokorb
Acidur 4362 Acidur 4401 Acidur 4571	X2CrNiN23-4 X5CrNiMo17-12-2 X6CrNiMoTi17-12-2	Wall anchors (plug anchors, L-anchors, waved L-shaped anchors, Z-anchors in cavity wall/clinker, tension anchors/rods)
Acidur 4571	X6CrNiMoTi17-12-2	Lightning conductors (according to DIN EN 50164 T2 (VDE 0185-305-2:2013-02) for the use of lightning arrestors and grounding systems according to DIN VDE 0151 in the ground, size: 10.0 mm in diameter)
Acidur 4571 Acidur 4362	X6CrNiMoTi17-12-2 X2CrNiN23-4	Ribbed reinforced steel
Acidur 4301 Acidur 4401	X5CrNi18-10 X5CrNiMo17-12-2	In size range 1.3 mm to 1.6 mm in diameter for pigeon control netting (to stop birds landing on buildings)
Acidur 4301	X5CrNi18-10	In size range 10 mm to 12 mm in diameter for filled rods of staircase railings
Acidur 4301	X5CrNi18-10	Roof hooks: nails for fastening roof slates
Acidur 4401 Acidur 4462 Acidur 4301 Acidur 4307	X5CrNiMo17-12-2 X2CrNiMoN22-5-3 X5CrNi18-10 X2CrNi18-9	Gauze wire for outside facades, glass fastening elements, tension wires, tension rods (for stabilisation of glass facades and roofing; on request: compliance with the certification of the building authorities Z-30.3-6)
Acidur 4509 Acidur 4511	X2CrTiNb18 X3CrNb17	Stabilised ferritic steels for brick trowels





Food industry

Hygiene has top priority in the food industry. Because stainless-, acid- and heat-resistant steels are particularly suited to meet this requirement, they are used in the food production and processing industries. Stainless steels are used especially in meat cutters, beverage bottling plants and storage tanks, and they also play a major role in the water supply chain because high-grade steel is tasteless, corrosion-resistant and microbiologically safe.

A large variety of stainless steels are used in water management thanks to their low maintenance requirements and long life. Stainless steel is required for preparation, storage and distribution of drinking water. The chloride concentration must be con-

sidered when selecting the material for preparation. Depending on its concentration, the materials Acidur 4404, Acidur 4462 or Acidur 4521 are possible options.

While taking into account standards that may exist, our materials are suitable even for salted foodstuffs at temperatures up to 100 °C and withstand corrosive attack. When produced and processed correctly, stainless steels do not affect or promote nickel allergies. Other components such as chromium are not transmitted to foodstuffs, either. Therefore, stainless steel is preferable in the food industry not only for hygienic reasons but also due to its neutral behaviour with other materials.

Material	Code designation	Properties/Applications
Acidur 4057	X17CrNi16-2	Conveyor belts
Acidur 4116	X50CrMoV15	Meat cutters
Acidur 4301	X5CrNi18-10	Bottle closures, meat hooks
Acidur 4404	X2CrNiMo17-12-2	Stirring units, flanges, grates / strainers
Acidur 4542	X5CrNiCuNb16-4	Portioning nozzles
Acidur 4404 Acidur 4462 Acidur 4521	X2CrNiMo17-12-2 X2CrNiMoN22-5-3 X2CrMoTi18-2	Water management: drinking water preparation, storage and distribution



Chemical industry

Highly developed chemical processes require stainless steels which meet many different requirements regarding corrosion resistance under pressure and at elevated temperatures. Various stainless steels from our range of materials can be used here. If there is a risk of stress corrosion cracking, ferritic steels or Duplex steels can be implemented, e.g. Acidur 4521 in neutral cooling water with a moderate chloride ion content, or Acidur 4462 when the corrosive burden is higher. Steels containing molybdenum, such as Acidur 4404, Acidur 4435 or Acidur 4529, offer effective protection against pitting corrosion. These austenitic steels are resistant to intercrystalline corrosion (even when welded) and are therefore excellent for a number of applications, e.g. as welded containers.

Selective corrosion occurs mainly in carbamide production and nitric acid processing. For the first medium, Acidur 4429 is particularly well suited, while Acidur 4306 can be used in nitric acid.

Acidur 4462 has proven its value in contact with acid gas, a natural gas contaminated with CO, CO₂ and H₂S that can also contain substantial quantities of highly corrosive chloride.

The various types of chloride-induced corrosion are naturally one of the most critical issues for stainless steels. Because very different concentrations and temperatures occur depending on the application, it is strongly recommended to consult us about your particular applications.

Medical technology

Hygiene and precision play a special role in the medical industry. Both factors are essential for successful and responsible work in this sector. Our stainless-, acid- and heat-resistant steels provide a solid basis to achieve them. Our steels are used in medical applications ranging from implant materials and surgical instruments to infusion needles.

The selection of the material depends on how long the steel will have contact with the human body. If contact will be brief, standard steels are generally used, such as Corrodur 4021, Acidur 4122, Acidur

4117, Acidur 4301 and Acidur 4404.

They are used for various applications in the medical technology field, in particular for forceps, scissors, tweezers, chisels, spoons and scalpels. For implants, only specially approved materials can be used, including Acidur 4441.

Highest purity of materials, excellent polishability, long-lasting edge retention and suspension properties, not to mention fatigue strength and wear resistance, are all essential requirements for products in the medical technology sector.

Material	Code designation	Properties/Applications
Acidur 4441	X2CrNiMo18-15-3	Implant materials
Corrodur 4021 Acidur 4116 Acidur 4117 Acidur 4122	X20Cr13 X50CrMoV15 X38CrMoV15 X39CrMo17-1	Surgical instruments
Acidur 4116	X50CrMoV15	Infusion needles
Acidur 4404	X2CrNiMo17-12-2	Disinfection baskets, bone pins



Fastening elements

For formed parts such as screws, pins, dowels and nuts, it is important that they can be processed by cold massive forming, cold extrusion or cold upsetting. We produce material qualities especially adapted to these applications. Not only the required forming procedures and the geometry of the components, but also the properties of the material to be formed are important.

Therefore we ensure that these steels meet the highest requirements especially with regard to chemical composition, purity, microstructure, strength and surface quality.

Where high strength is required, a low hydrogen content is ensured by means of degassing.

Material	Code designation	Properties/Applications
Acidur 4301	X5CrNi18-10	Screws
Acidur 4307	X2CrNi18-9	
Acidur 4567	X3CrNiCu18-9-4	
Acidur 4571	X6CrNiMoTi17-12-2	Pins
Acidur 4016	X6Cr17	
Corrodur 4006	X12Cr13	Dowels
Acidur 4113	X6CrMo17-1	
Acidur 4462	X2CrNiMoN22-5-3	Nuts

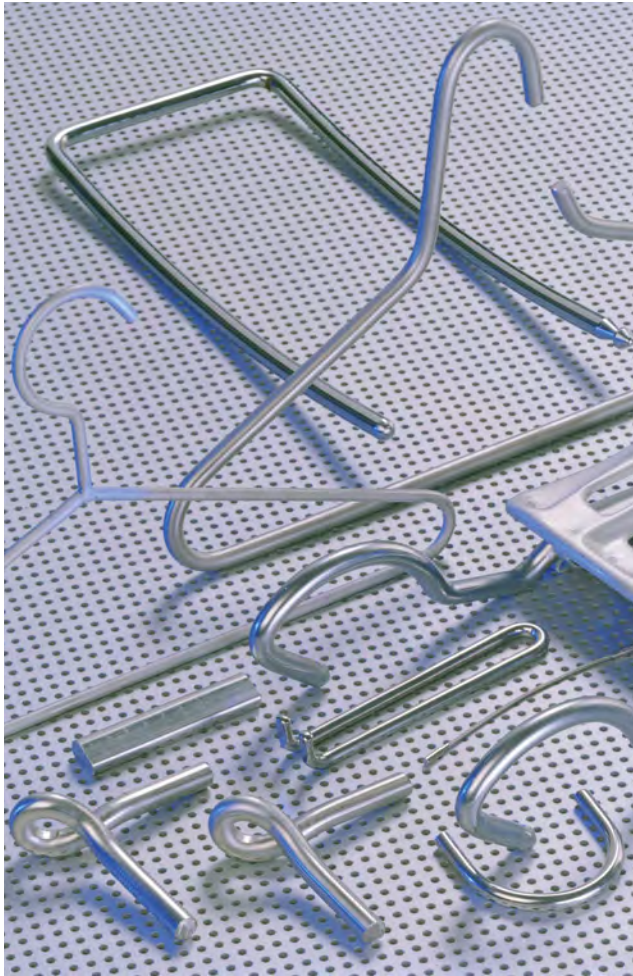


Everyday applications

In everyday life, stainless steels form the basis for functional and durable objects used in many different areas. For example, horizontal bars, coat hangers, door/furniture handles and tension springs as well as binding wire are made of stainless-, acid- and heat-resistant steels. Split pins made of stainless steel used as retaining elements

in machine and vehicle construction make everyday life safer. The jewellery industry is also using our stainless- and acid-resistant steel. It is antiallergenic according to EU guidelines and therefore suitable for allergy sufferers who have been unable to wear jewellery before now.

Material	Code designation	Properties/Applications
Acidur 4016	X6Cr17	Coat hangers
Acidur 4310	X10CrNi18-8	Spring wire for tension springs
Acidur 4301 Acidur 4016	X5CrNi18-10 X6Cr17	Retaining clips Binding wire (soft-annealed, strength approx. 400 - 450 MPa)
Acidur 4301 Acidur 4305	X5CrNi18-10 X8CrNiS18-9	Door/furniture handles
Acidur 4301	X5CrNi18-10	Pot handles (special requirements regarding grain size and the surface)
Acidur 4404	X2CrNiMo17-12-2	Fashion jewellery, art, split pins
Corrodur 4021	X20Cr13	Horizontal bars (annealed)
Acidur 4301 Acidur 4307 Acidur 4401 Acidur 4404	X5CrNi18-10 X2CrNi18-9 X5CrNiMo17-12-2 X2CrNiMo17-12-2	Wire rod and bar steel for threaded rods or threaded pins
Acidur 4301 Acidur 4016	X5CrNi18-10 X6Cr17	Bicycle spokes (high strength requirements and good straightening)
Acidur 4567	X3CrNiCu18-9-4	Socket screws



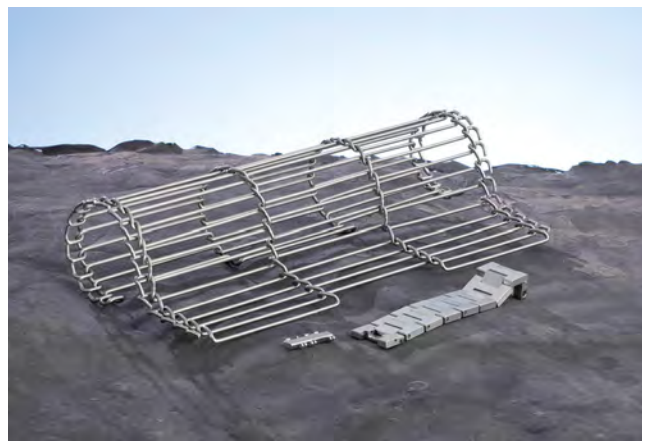


Precision mechanics/clocks

Corrosion-resistant steels used in precision mechanics must combine a range of properties. In addition to ease of cutting, wear resistance of surfaces and very high purity grade requirements are essential in the production and use of components which can be fractions of millimetres in size. With a wide range of analysis variants (e.g. Acidur 4435) and electroslag remelting or vacuum arc remelting options, even the highest quality requirements can be met without any problem.

Strainers/filters

Our product line also includes spring steels or high-grade steel wire with high strength and thin cross-sections made of austenitic steels. Material selection depends, however, on the respective application, i.e. to which extent the material will be thermally stressed or must meet food industry specifications. Filter elements, e.g. for high chloride concentrations in swimming pool equipment can be manufactured from our primary material.



Chains

Chains made of stainless-, acid- and heat-resistant wire are used in many areas, such as ovens in cement mills, hoisting devices, anchor chains, chain conveyors. The required material, strength and dimensions depend on the respective intended use. One unique steel is the heat-resistant duplex steel Permodur 4872. It is available in the modified versions 85 MA, 105 MA and 115 MA, which are produced especially for different requirements with regard to resistance to scaling.

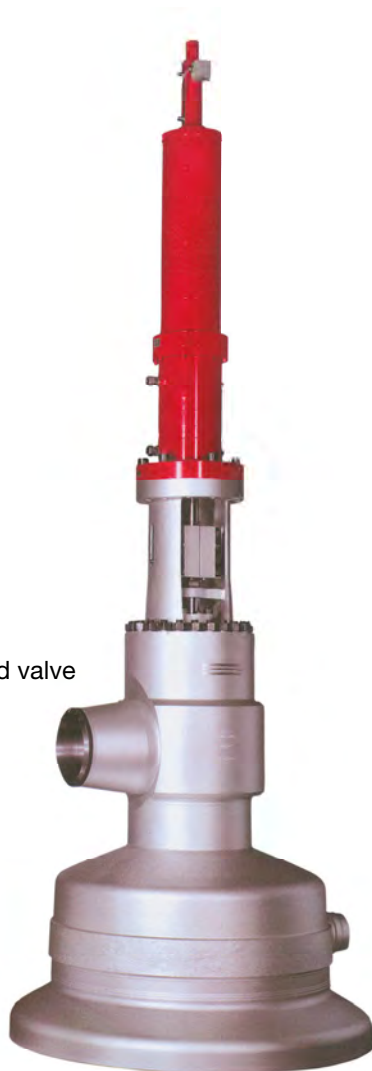
Stainless ball bearings

We supply primary material for stainless ball bearings in a wide range of variable dimensions. It meets wear and corrosion resistance requirements and features an extremely high purity, which guarantees long bearing life. We even supply primary remelted material for anti-friction bearings in a wide range of dimensions.

Solenoid valves

Solenoid valves are triggered by a current-induced magnetic field. This magnetic field moves corrosion-resistant steel with special magnetic properties. The material Electrodur 4105 is the classic choice for such applications. Excellent permeabilities and low coercive field strengths are adjusted by special analysis variants and annealing processes.

Solenoid valve



Load cells

(Load sensing equipment)

Tiny filigree strain gauges are frequently used to gauge forces. Because these sensors would be destroyed when exposed to a force, they are fitted into components made of corrosion-resistant steel. The steel withstands the active forces and defined elongation resulting from this. This enables the sensor to generate a processable signal. To enable precise gauging, the steel must react to an active force with reversible elongation across its entire width. For this purpose we supply steels such as Acidur 4542 with special analysis and states of heat treatment.

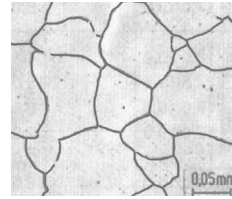
Shafts, spindles, screws and piston rods

Our materials Corrodur 4021 and Acidur 4057 are used to produce motor shafts used for the construction of electric motors. The latter is very popular in the area of naval shafts, pump shafts and as a material for piston rods. Also used in the area of naval shafts: Acidur 4542, Acidur 4418, Acidur 4404 and Acidur 4462. Piston rods are often also produced using Acidur 4006. These grades are therefore also used for screw spindles.

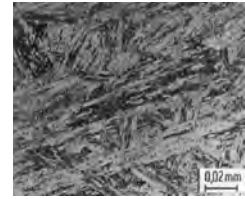
In these or other application areas, whenever long rods with strict specifications for straightness and low internal stress are required for a low-warp processing, we can provide our specialist knowledge to help you choose the right product.

Material groups

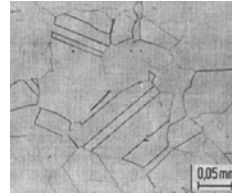
According to their chemical composition, stainless steels are classified into four groups based on their respective structural state. Depending on their chemical composition and heat treatment, the microstructures are referred to as ferritic, martensitic, austenitic or austenitic-ferritic (duplex).



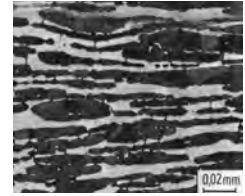
Ferritic



Martensitic



Austenitic



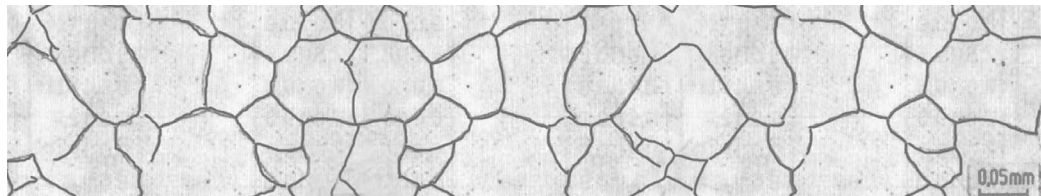
Duplex

Ferritic steels

Ferritic steels are characterised by a Cr content of 13 – 17 % and a C content < 0.07 %. These steels are not transformable by heat treatment and are therefore neither hardenable nor heat-treatable. During welding and heat treatment they have a tendency towards grain growth which leads to cold brittleness when the cross-sections are large.

Properties

- » good corrosion resistance
- » resistant to stress corrosion cracking
- » only thin cross-sections can be welded
- » good warm and cold formability
- » magnetic
- » cannot be hardened by heat treatment
- » low thermal expansion coefficient
- » high thermal conductivity
- » more economical than austenitic steels



OVERVIEW OF COMMERCIAL CARBON FERRITIC STEELS AND THEIR APPLICATIONS

Material	Code designation	Properties / Applications
Corrodur 4003	X2CrNi12	Constructional steel up to -60 °C
Acidur 4016 Acidur 4511	X6Cr17 X3CrNb17	Mechanical engineering, food industry with medium corrosive stress
Corrodur 4512	X2CrTi12	Mechanical engineering, fastening elements and automotive industry with low corrosive stress
Acidur 4521	X2CrMoTi18-2	General mechanical engineering for corrosive stress

Martensitic steels

By the addition of carbon (C content > 0.1 %), ferritic steels develop a martensitic structure (hardening) when cooled quickly. Because martensitic steel is brittle and has a tendency towards tension cracking, this material must be tempered after hardening to make the steel storable and machinable. Carbon martensitic steels have a high hardness and are corrosion-resistant. However, they possess only a low level of toughness at low temperatures.

Properties

- » good corrosion resistance
- » not susceptible to stress corrosion cracking
- » limited capacity for welding
- » moderate warm and cold formability
- » magnetic
- » can be hardened by heat treating
- » low thermal expansion coefficient
- » high thermal conductivity
- » more economical than austenitic steels
- » lends itself to machinability



OVERVIEW OF COMMERCIAL CARBON MARTENSITIC STEELS AND THEIR APPLICATIONS

Material	Code designation	Properties/Applications
Electrodur 4005	X12CrS13	Lends itself well to machining, softly magnetic, low corrosion resistance
Corrodur 4006	X12Cr13	Turbine blades, water pump shafts
Corrodur 4021	X20Cr13	Constructional steel, resistant to neutral waters
Corrodur 4034	X46Cr13	Steel for anti-friction bearings, wear parts
Acidur 4057	X17CrNi16-2	Constructional steel, wear-resistant, hardenable shafts
Corrodur 4104	X14CrMoS17	Machining steel, constructional steel
Durapur 4112	X90CrMoV18	Hardenable, wear-resistant (limited availability as electroslag variant)
Acidur 4116	X50CrMoV15	Cutlery steel
Acidur 4122	X39CrMo17-1	Constructional steel, shaft material
Corrodur 4037	X65Cr13	Wear parts

Soft martensitic steels

The hardness of soft martensitic steels, also known as nickel martensitic steels, is increased by adding nickel and not carbon. The advantage of this is that these steels possess not only a high degree of hardness and good corrosion resistance but also good toughness values at low temperatures.

Properties

- » good corrosion resistance
- » not susceptible to stress corrosion cracking
- » can be welded conditionally
- » moderate warm and cold formability
- » magnetic
- » can be hardened by heat treating
- » low thermal expansion coefficient
- » high thermal conductivity
- » good toughness at low temperatures

OVERVIEW OF COMMERCIAL SOFT MARTENSITIC STEELS AND THEIR APPLICATIONS

Material	Code designation	Properties/Applications
Acidur 4313	X3CrNiMo13-4	Constructional steel
Acidur 4418	X4CrNiMo16-5-1	Constructional steel, high strength and corrosion-resistant

Precipitation-hardening martensitic steels

In addition to carbon martensitic steels and soft martensitic steels, there are also martensitic steels whose hardness is increased by the formation of precipitations. The properties of these so-called precipitation-hardening martensitic steels are similar to those of soft martensitic steels.

Properties

- » good corrosion resistance
- » not susceptible to stress corrosion cracking
- » limited capacity for welding
- » moderate warm and cold formability
- » magnetic
- » can be hardened by heat treating
- » low thermal expansion coefficient
- » high thermal conductivity
- » more economical than austenitic steels
- » good toughness at low temperatures

OVERVIEW OF COMMERCIAL PRECIPITATION-HARDENING MARTENSITIC STEELS AND THEIR APPLICATIONS

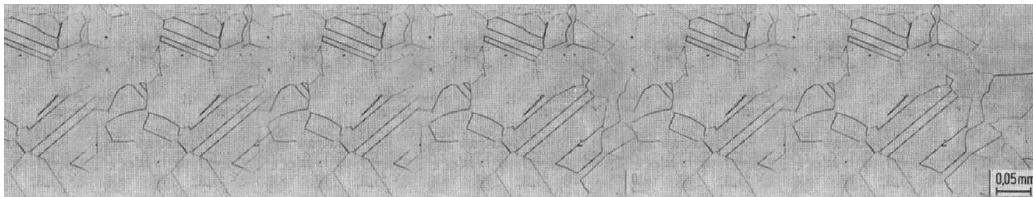
Material	Code designation	Properties/Applications
Acidur 4542	X5CrNiCuNb16-4	High strength hardenable steel, corrosion resistance like Acidur 4057
Acidur 4545	X5CrNiCuNb15-5	Pumps and valves for high-pressure systems, readings recorders, aerospace industry
Acidur 4548	X5CrNiCuNb17-4-4	Structural parts for aviation industry, food and petrochemical industries

Austenitic steels

The standard austenitic steel is Acidur 4301. It has a C content $\leq 0.07\%$, a Cr content of 18 % and a Ni content of 8 %. The ferritic structure is transformed into an austenitic structure by adding nickel. The chloride resistance of these steels is increased by the addition of Mo $\geq 2\%$. Acidur 4404 is an example of this type of steel with the respective Mo content. Austenitic steels are not hardenable; their strength can only be increased by cold forming.

Properties

- » very good corrosion resistance, but susceptible to stress corrosion cracking
- » easy to weld
- » very good warm and cold formability
- » non-magnetic
- » cannot be hardened by heat treatment
- » higher thermal expansion coefficient
- » low thermal conductivity
- » great toughness even at low temperatures



OVERVIEW OF COMMERCIAL AUSTENITIC STEELS AND THEIR APPLICATIONS

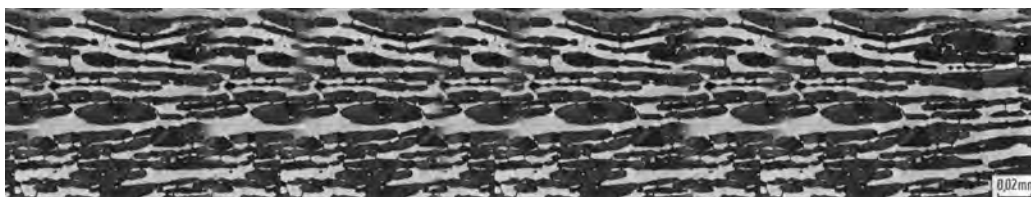
Material	Code designation	Properties/Applications
Acidur 4301	X5CrNi18-10	Standard austenitic steel ("V2A")
Acidur 4305	X8CrNiS18-9	Standard austenitic steel, machining steel
Acidur 4307	X2CrNi18-9	Like Acidur 4301, for welded thick components
Acidur 4310	X10CrNi18-8	Spring steel
Acidur 4401	X5CrNiMo17-12-2	Like Acidur 4301, but more corrosion-resistant
Acidur 4404	X2CrNiMo-17-12-2	Like Acidur 4401, but for welded components
Acidur 4441	X2CrNiMo18-15-3	Implant steel
Acidur 4529	X1NiCrMoCuN25-20-6	Highly corrosion-resistant austenitic steel for tensile stress
Acidur 4539	X1NiCrMoCu25-20-5	Austenitic steel, highly corrosion-resistant, Chloride-resistant, for wristbands
Acidur 4541	X6CrNiTi18-10	Like Acidur 4301, can be welded, stabilised
Acidur 4550	X6CrNiNb18-10	Like Acidur 4301, Nb-stabilised for aerospace industry
Acidur 4567	X3CrNiCu18-9-4	Like Acidur 4301, but cold up-setting steel
Acidur 4571	X6CrNiMoTi17-12-2	Like Acidur 4401, stabilised for welded thick cross-sections

Duplex steels

Duplex steels are a combination of ferritic and austenitic steels. Their microstructure consists of 50 % ferrite and 50 % austenite. This combination of structures produces a steel with very good corrosion resistance and a high basic strength.

Properties

- » very good corrosion resistance
- » not susceptible to stress corrosion cracking
- » easy to weld
- » moderate warm and cold formability
- » structures: 50:50 ferrite / austenite
- » cannot be hardened by heat treatment
- » moderate thermal expansion coefficient
- » moderate thermal conductivity
- » non-magnetic due to ferrite content
- » resistant to chloride



OVERVIEW OF COMMERCIAL DUPLEX STEELS AND THEIR APPLICATIONS

Material	Code designation	Properties/Applications
Acidur 4362	X2CrNiN23-4	Construction industry, bent components, shipbuilding, mechanical engineering
Acidur 4462	X2CrNiMoN22-5-3	Constructional steel, chloride-resistant
Acidur 4410	X2CrNiMoN25-7-4	Construction steel, highly corrosion-resistant
Acidur 4460	X4CrNiMoN27-5-2	Marine, fishing industry

Steels with special physical properties

In modern technology, not only the mechanical properties and corrosion resistance of steels is important but also their interaction with electromagnetic fields/their magnetisability.

Stainless-, acid- and heat-resistant steels from Deutsche Edelstahlwerke:

- » Non-magnetic: According to the definition of pertinent standards, non-magnetic austenitic steels belong to the group of steels with special physical properties. These steels are used wherever magnetic flow to a system must be excluded. The non-magnetic behaviour of these steels is measured using a permeability unit (magnetic permeability). The closer the value is to 1.00 (as with wood, aluminium or paper), the more non-magnetic the behaviour of the steels.

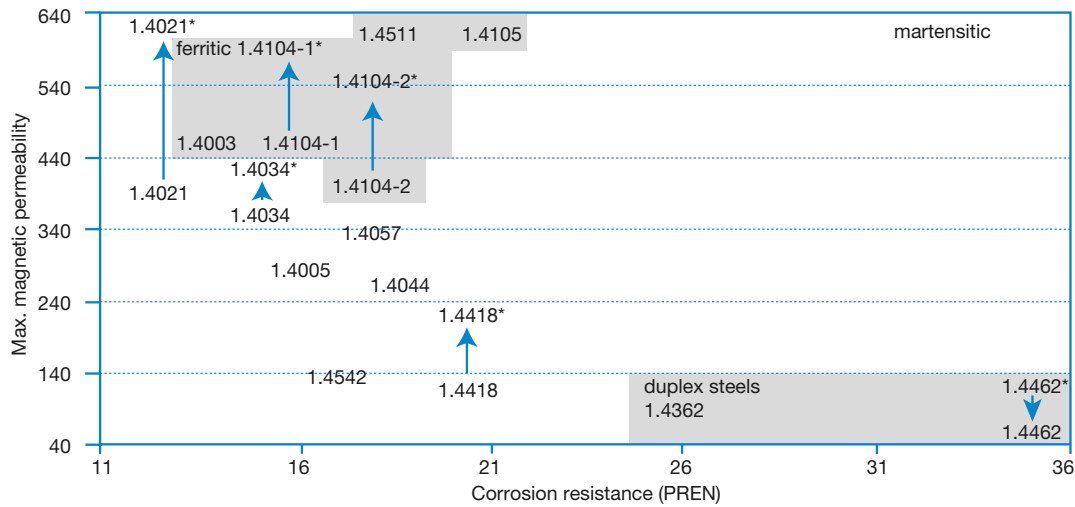
Also in a cold-worked machined state they are non-magnetic with permeabilities up to $< 1.02 \mu\text{m REL}$. Non-magnetic behaviour can be supported by high nickel, nitrogen or manganese contents which act as austenite stabilisers. Basically, many stainless austenitic steels are comparably non-magnetic. However, a disadvantage of these steels is that their non-magnetic behaviour is negatively influenced by cold working. An advantage of non-magnetic steels is also their comparably high basic strengths.

- » Magnetically soft-ferritic steels: Ferritic steels are used in electric motors and valves. Wherever magnetisability and corrosion resistance are equally important. For these steels, it is important that magnetic reversal losses in service are very low in the final state.

- » Magnetically hard-martensitic steels: Magnetically hard-martensitic steels can be used as permanent magnets or wherever high strength is relevant.
- » Mixed: Steels with a mixed microstructure (martensitic, austenitic, ferritic-austenitic) possess lower magnetisability which corresponds to the proportion of the magnetisable phase.

Throughout the development of the product and with the aid of our technical customer support service, we work closely with our customers to find the best solution with regard to costs, corrosion resistance, mechanical stress, machinability and magnetisability.

MAGNETISABILITY AND CORROSION RESISTANCE OF THE MOST COMMON STAINLESS STEELS



*as supplied and after special heat treatment

OVERVIEW OF THE MOST IMPORTANT STEELS WITH SPECIAL PHYSICAL PROPERTIES

Material	Code designation	Properties/Applications
Magnadur 501	X3MnCrNiMoN20-13	High strength ¹
Magnadur 601	X3MnCrN19-16	High strength ¹
Magnadur 3964	X2CrNiMnMoNNb21-16-5-3	Corrosion-resistant ¹
Magnadur 3974	X3CrNiMnMoNNb23-17-6-3	Resistant in sea water ¹
Magnadur 3952	X4CrNiMoN18-14	Permeability $\mu_r \leq 1.02$, Corrosion-resistant
Corrodur 4003	X2CrNi12	Softly magnetic, coercitive field strength < 160 A/m
Electrodur 4105	X6CrMoS17	Softly magnetic, coercitive field strength < 120 A/m
Magnadur 3813	X40MnCrN19	Motors, transformers, high strength
Magnadur 3816	X8CrMnN18-18	Motors, transformers, high strength

¹ permeability $\mu_r \leq 1.01$

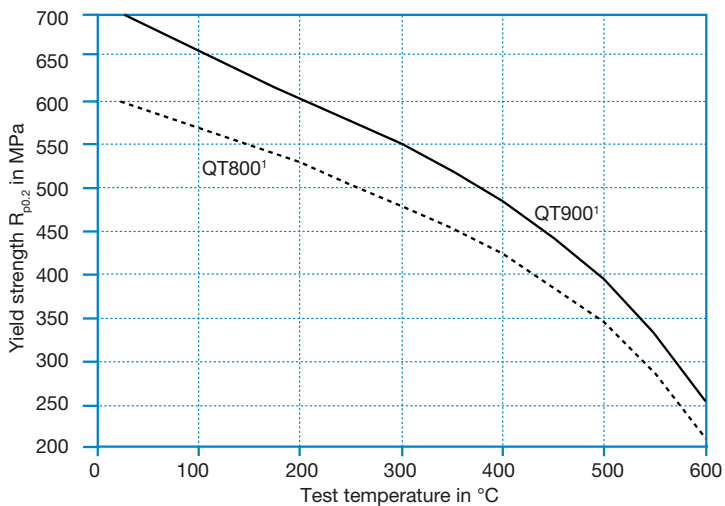
Creep-resistant steels

Creep-resistant steels are used in applications where forces are transmitted at high temperatures. At higher service temperatures ranging from 450 °C to 600 °C, mainly heat-treatable 12 % chromium steels are used. These steels possess satisfactory long-time thermal resistance properties and good resistance to scaling in this temperature range.

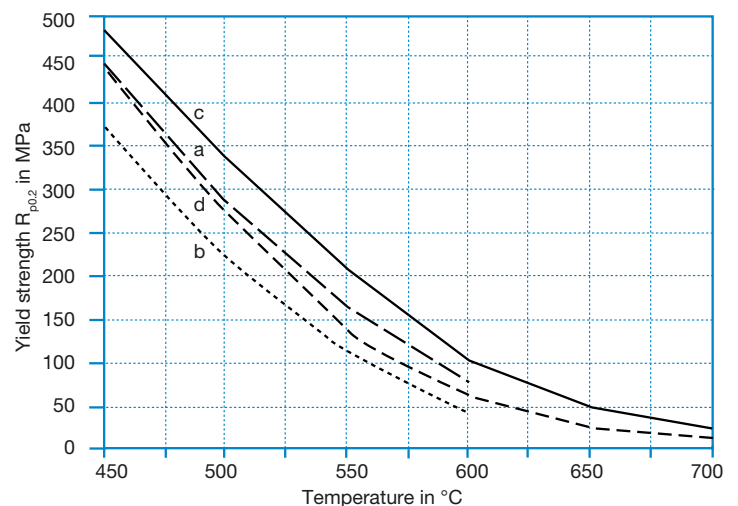
Creep-resistant austenitic chromium-nickel steels are used at higher service temperatures up to 750 °C (e.g. Pyrodur 4980). The good long-time thermal resistance properties of these steels are achieved by adding refractory carbide formers such as niobium, titanium or vanadium or by precipitation hardening.

Pyrodur 4938 is used in turbine manufacturing for blades, discs, shafts and screws at temperatures of approximately 550 °C. It is also used for studs in steam power plants where a good relaxation behaviour is required.

YIELD STRENGTH AND CREEP STRENGTH OF PYRODUR 4923 AT ELEVATED TEMPERATURES



¹ Index stands for minimum strength



a: creep strain limit with 1 % elongation in 10,000 hours
 b: creep strain limit with 1 % elongation in 100,000 hours
 c: creep strength in 10,000 hours
 d: creep strength in 100,000 hours

Material	Code designation	Properties/Applications
Pyrodur 4903	X10CrMoVNb9-1	Turbines in general
Pyrodur 4913	X19CrMoVNbN11-1	Studs in steam power plants
Pyrodur 4922	X20CrMoV12-1	Turbine shafts
Pyrodur 4923	X22CrMoV12-1	Turbine blades
Pyrodur 4938	X11CrNiMoV12-3	Blades, discs, shafts, screws in turbine manufacturing
Pyrodur 4980	X6NiCrTiMoVB25-15	Screws

Heat-resistant steels

Compared to conventional stainless steels, stainless heat-resistant steels possess higher contents of the alloys carbon, silicon and aluminium. They are special steels for thermal stress at temperatures ranging from 600 °C to 1,150 °C. One of their main properties is their resistance to permanent scaling allowing for different gases. Material selection depends on the existence of sulphurous oxidating, reducing or nitrogenous gases or the danger of carbonisation in the intended application. We can recommend various ferritic or austenitic steels in consideration of the existing temperature and gas media. The main alloying elements form a thick and adhesive surface layer at high temperatures. This surface layer prevents further penetration of reaction products into the surface. For these steels, the scaling resistance is tested, i.e. scaling loss must not be greater than 2 g/m² per hour in a 120 h test. Our customers can choose from ferritic, austenitic and duplex steels.

Our technical customer support service can help you choose the right material. Common ferritic materials with appropriate heat resistance include Permodur 4713, Permodur 4724 and Permodur 4742.

Permodur 4742 is characterised in particular by its resistance to sulphurous exhaust gases and is scale resistant in the temperature range between 800 °C and 1,000 °C. These grades are used, for example, in nozzles for high-temperature applications. Examples of austenitic and heat-resistant steels are Permodur 4878, Permodur 4828 and Permodur 4841. Permodur 4841 is characterised by its excellent strength properties at high temperatures up to 1,050 °C. A typical property of this steel is a low resistance to reducing or oxidising sulphurous gases. Permodur 4841 is used e.g. in apparatus construction for high-temperature applications or in the chemical industry. We recommend Permodur 4872 when comparably high creep strength and use of temperatures ranging from 1,000 °C to 1,150 °C are also required. Temperatures ranging from 450 °C to 700 °C should be avoided due to the risk of brittleness.

Permodur 4872 is a heat-resistant duplex steel which possesses good strength properties and scaling resistance at temperatures ranging up to 1,150 °C, thanks to its two-phase structure. This steel is used particularly in sulphurous exhaust gases and simultaneously carbonising conditions and e.g. as cement chain steel.

Material	Code designation	Properties/Applications
Permodur 4713	X10CrSiAl7-1-1	Furnace construction, resistant < 800 °C
Permodur 4724	X10CrSiAl13-1-1	Furnace construction, resistant < 850 °C
Permodur 4742	X10CrSiAl18-1-1	Furnace construction, resistant 800 - 1,000 °C
Permodur 4828	X15CrNiSi20-12-2	Furnace construction, resistant 800 - 1,000 °C
Permodur 4841	X15CrNiSi25-21	Furnace construction, resistant 1,050 °C
Permodur 4872	X25CrMnNi25-9-7	Cement chains, furnace construction, resistant < 1,150 °C
Permodur 4878	X12CrNiTi18-10	Furnace construction, resistant < 850 °C

**Environmental aspects**

Our customers' satisfaction is very important to us, and so is the environment. High-grade steel production is itself a recycling process, because the base material for the product is scrap metal which is remelted and thus recycled. We strictly ensure the responsible use of resources during the production of our high-grade steels – a commitment which we have incorporated in our corporate policy. Compliance with these standards is checked in regular audits by our company's dedicated environmental department.

By using stainless-, acid- and heat-resistant steels, our customers are also doing something to protect the environment:

- » no coatings are required
- » high-recycling rate
- » extended life of the component, costly repairs or replacements avoided
- » environmentally harmful substances are not released



Certifications

We have a top-class quality management system. Our company has numerous certifications, naturally including standard certificates such as ISO TS 16949, ISO 14001, ISO 9001 and QS 9000.

We additionally have numerous certifications from the aerospace and automotive industries. The spectrum is completed by certifications from building inspection authorities, power station certifications and certificates for pressure vessel construction.

The Deutsche Edelstahlwerke Production System (DPS) helps our employees in our plants to streamline workflows and processes optimally. Our customers also benefit from this, because the DPS enables us to supply high-quality products in a timely manner.

General note (liability)

Printing errors, omissions and changes excepted. Product-specific data sheets have priority over the information provided in this brochure. The desired performance characteristics are binding only if they are exclusively agreed upon at the conclusion of the contract.

Storage facility

In addition to diverse production facilities, we have a well-stocked central warehouse. We currently maintain a stock of about 20 materials from our stainless-, acid- and heat-resistant steel range.

The product range includes bar steel and blank steel in a range of sizes from 5 mm to 500 mm in diameter. Our numerous saw lines enable our customers to obtain processed material just in time. In addition to standard materials we also supply Niro-Cut variants which possess better machining properties by comparison. Our storage facility is adjusted to match market needs at regular intervals. This way we ensure that the right products for our customers are always in stock. Your experience and needs are very important to us. Please feel free to tell us about them so we can continue to improve our service for you.



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