Applications for Stainless Steel Long Products

A guide to unlocking all the properties of stainless

ISSF
INTERNATIONAL STAINLESS STEEL FORUM

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Stainless steel is often associated with corrosion resistance... and quite rightly. However, stainless steel can do much more thanks to its other properties. These include:

- Physical attributes such as electrical and thermal conductivity and magnetism
- Ability to withstand large temperature ranges
- Strength and toughness
- Aesthetics
- Environmental advantages
- Fire resistance.

The examples in this booklet illustrate just some of the many uses for stainless steel long products. Such a wide variety of applications and processing routes call for over 200 stainless grades, a complexity inherent to long products.

What is a Stainless Long Product?

Stainless steel long products include any stainless steels obtained from the hot rolling of blooms and ingots to produce semis, bars and wire.

Semis, also called billets, have a square cross-section with round edges. They are almost entirely used for either hot forging (valve bodies for instance) or hot re-rolling by independent re-rollers.

Bars

Bars with a diameter above 20 mm are usually produced directly by hot rolling. They are then heat treated, descaled, straightened and usually machined or ground to achieve the required tolerance and surface finish.

Bars with a diameter between 5 and 20 mm are usually manufactured by straightening hot rolled, annealed and pickled wire rod. Drawing benches allow direct conversion of wire rod to bright drawn bars and may require further grinding depending on the tolerance required.

Bars with a diameter below 5 mm require a further cold-drawing operation. Most of the bars are machined into a wide variety of parts, some of them very complex with tight tolerances.

Wire Rod

Hot rolled wire rod in irregular wound coils is heat treated, then pickled in acid baths to remove the black oxide layer. Hot rolled wire rod diameter ranges from 5 to 32 mm. Broadly speaking, there are three main applications for wire rod:

- Cold or warm heading for the production of fasteners or cutlery. If used to make cutlery, some stainless grades require hot forging.
- Conversion to bars (see above)
- Drawn wire is obtained by drawing coil-to-coil on single or multi-pass machines (up to 14 passes) followed by annealing as required. This results in a wire of the desired diameter and mechanical properties. For fine wire (roughly below 0.8mm) more multi-pass drawing and annealing cycles are necessary to achieve the required properties. Ultra-fine wire (down to about 0.015 mm) can be obtained using appropriate re-melted stainless steel grades.

Door Handles

Why stainless?

- Aesthetics
- Smooth touch
- Feeling of sturdiness.

Fabrication process:

Drawn or ground bars are bent, machined and polished.

Grade:

EN: 1.4301 (AISI: 304).

Manufacturer:

Tecosur SA, Spain (tecosur.com).

Along with their elegant look, these stainless steel door handles provide a smooth touch and feeling of sturdiness.

Image courtesy of Tecosur SA, Spain.

Mont Blanc Tunnel Cladding Anchors

Why stainless?

Fire resistance.

Fabrication process:

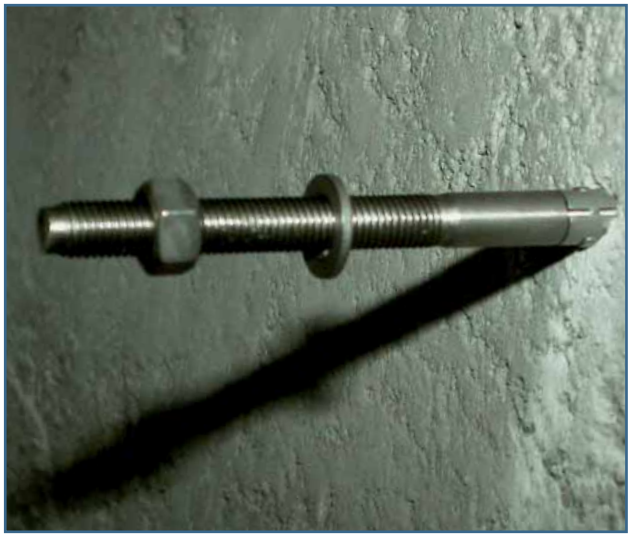
Anchors are created by making a skin pass on a wire rod, straightening, cutting to length and cold threading.

Grade:

EN: 1.4404 (AISI: 316L).

Manufacturer:

G&B Fissaggi, Italy (gebfissaggi.com)



The Mont Blanc tunnel between Italy and France was the scene of a terrible fire in March 1999 which claimed many lives. The tunnel re-opened following three years of extensive work to repair the damage caused by the blaze.

Safety precautions in the tunnel are now extremely tight. Particular attention is paid to the fire resistance of all components in the tunnel.

The Italian National Roads Authority has published a circular which contains directives for the construction of tunnels. Stainless steel, thanks to its characteristic stability and resistance to high temperatures, is cited as the material of choice for the fabrication tunnel components such as smoke extraction fans and lighting systems.

The system used to anchor the fibre cement cladding panels that line the Mont Blanc tunnel is now composed of 16 mm stainless anchors. The anchors have been tested to ensure they maintain their support function for at least two hours at 1,000° C.

Images courtesy of Centro Inox, Italy

Glass Facade “Spiders”

Why stainless?

- Good mechanical properties
- Low maintenance
- Aesthetics.

Fabrication process:

Forged or cast body. Fastening elements machined from bar.

Grade:

EN: 1.4542 (AISI: 630) and EN: 1.4462 (ASTM: F51).

Manufacturer:

Not available.

The glass panels on the façade are held in place by high strength “spiders” which carry the weight of the glass.

Although their primary function is mechanical, their appearance does not detract from the overall elegance of the structure. They are expected to last as long as the building itself without any risk of damage or collapse.

Post-tension Tie Rods

Why stainless?

- Good mechanical properties
- Durability.

Fabrication process:

Not available.

Grade:

EN: 1.4057 (AISI: 431), EN: 1.4301 (AISI: 304) and EN: 1.4401 (AISI: 316).

Manufacturer:

GeodaG Sistemi Srl, Italy (geodag.com)

The great Roman theatre, the symbol of Verona, dates back to the first half of the 1st Century AD. It was once one of the most important open air opera theatres in the Roman Empire.

Recent restoration work involved the construction of new covering for the central orchestra pit, an underground room and the underground sewage tunnels.

The new covering slab is structurally supported by a system of roof struts and post-tension tie rods. These minimise strains and deformation from loads placed on top. The post tension system used, comprising stainless steel bars, guarantees structural safety, quality and durability.

Images courtesy of Centro Inox, Italy

Clockwise from above: the lower part of the tie rods, detail of the head, and the upper part of the tie rods.

Nedujinja Shrine Bridge

Why stainless?

- Good mechanical properties
- Durability.

Fabrication process:

Shaped and welded stainless steel rebar.

Grade:

EN: 1.4005 (AISI: 420).

Manufacturer:

NSSC Hikari, Japan (ns-sc.co.jp)

In the reconstruction of the bridge at the Nedujinja Shrine, grade 410 stainless steel rebar was chosen for its durability as a reinforcement material in concrete structures.

A ferritic grade was selected over an austenitic grade because of its low thermal expansion properties and low cost. About 1.2 tons of stainless steel was used in the bridge.

Images courtesy of JSSA, Japan.

Decorative Mesh

Why stainless?

- Aesthetics
- Suitability for harsh weather conditions
- Low maintenance.

Fabrication process:

Wire rod, drawn into wire, annealed and woven.

Grade:

EN: 1.4401 (AISI: 316).

Manufacturer:

Not available.

The architect chose stainless steel for the cladding of this building because of its aesthetic qualities, both by the day and by night.

Images courtesy Ugitech SA, France.

Cable Anchoring Heads

Why stainless?

- Fire resistance
- Good mechanical properties.

Fabrication process:

Bent and threaded stainless steel bar.

Grade:

EN: 1.4301 (AISI: 304).

Manufacturer:

Cogne Acciai Speciali, Italy (cogne.com).

In April 2002, a light aircraft hit the Pirelli skyscraper in Milan, Italy. At least five people were killed in the accident and more than 30 injured.

The top floors of the 30-storey building caught fire. In particular, serious damage was caused to the 26th and 27th floors. The planking of the 26th floor took on a concave shape, bending more than 25 cm, while the floor of the upper story took on a slightly convex shape.

Restoration of the structure involved inserting a group of post-stretched cables. The anchoring of the heads of the active-reinforcement cables (or noses) against the core of the beam in reinforced concrete was done by means of 28 mm threaded stainless steel bars with a yield stress of > 800 MPa.

Above: The Pirelli Building after restoration.
Below: Details of the anchoring heads.

Images courtesy of Centro Inox, Italy.

Tensegrity® Glass Beams

Why stainless?

- Aesthetics
- Good mechanical properties.

Fabrication process:

Cut and threaded bars.

Grade:

EN: 1.4401 (AISI: 316).

Manufacturer:

Experiment of Professor Ing. M. Froli and Dr. Ing. L. Lani, Deptartment of Structural Engineering , University of Pisa, Italy (unipi.it).

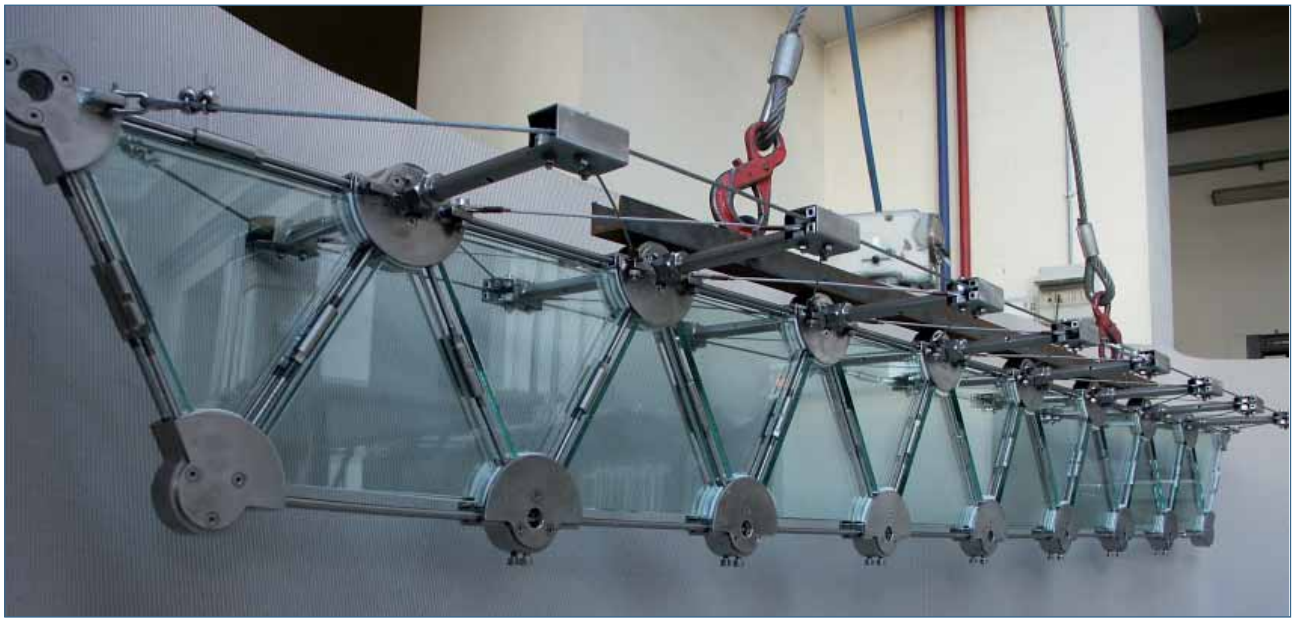
A new type of glass panel beam has been developed at the University of Pisa, Italy. The basic concept involves preventing and guiding glass fracture by breaking it into triangular modular elements. The elements are connected to each other by applying a pre-stress in the form of pre-tensioned stainless steel cables or bars. The glass is predominately subject to compression. The final collapse of the structure depends on the ductility of the steel.

The structure relies on the principle of tensile integrity, or Tensegrity as it is better known. Tensegrity refers to the integrity of structures as being based in a synergy between balanced tension and compression components.

All ancillary are made of stainless steel. This is for both aesthetic and durability reasons.

Prototypes are currently being tested at the University of Pisa.

Images courtesy of Centro Inox, Italy.



Mesh Cladding

Why stainless?

- Aesthetics
- Resistant to harsh weather
- Maintenance-free.

Fabrication process:

Wire rod is drawn into a wire with suitable diameter and mechanical properties, then woven into mesh.

Grade:

EN: 1.4401 (AISI: 316).

Manufacturer:

Cambridge Architectural Inc, USA (cambridgearchitectural.com).

The carpark at Winnipeg International Airport is wrapped in metal fabric, dramatically differentiating the exterior of the newly constructed garage. This was the first airport project in Canada, and one of the first in North America to target Leadership in Energy and Environmental Design (LEED) Certification.

The metal mesh provides a durable, long-lasting and virtually maintenance-free cladding solution as for the parking structure.

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System was developed by the United States Green Building Council (USGBC) in 1998. It provides a suite of standards for environmentally sustainable construction.

Images courtesy of Cambridge Architectural Inc.

Guardrail Cables

Why stainless?

- Aesthetics
- Good mechanical properties.

Fabrication process:

Wire rod is drawn into high strength wire, then twisted into cables.

Grade:

EN: 1.4401 (AISI: 316) and EN: 1.4310 (AISI: 302).

Manufacturer:

Not available.

Initially used on yachts, these guardrail cables have found new uses in buildings and other public spaces. They enable elegant designs and still admit the maximum amount of light.

Insulating Connectors

Why stainless?

- Durable
- Good mechanical properties.

Fabrication process:

Bending and forming stainless steel rebar.

Grade:

EN: 1.4462 (ASTM: F51) and EN: 1.4362.

Manufacturer:

Ancon Building Products, UK (ancon.co.uk).

Images courtesy of Ancon Building Products, UK.

The connector is a structural component used to join external concrete balconies to internal concrete floor slabs. Stainless steel reinforcement bars provide the load transfer and have a long service life. Rigid chlorofluorocarbon-free polystyrene insulation offers improved thermal protection. The connectors are easy to handle and to install.

Stainless steel provides the required strength, corrosion resistance and maintenance-free life in all weather conditions.

This system improves the thermal insulation of buildings by avoiding cold bridging, thereby reducing heat losses and improving comfort inside.

Clockwise from top: balcony connectors in place before concrete is poured, connectors awaiting installation of the balcony, detail of insulated balcony connector.

Aircraft Landing Gear Components

Why stainless?

- No coatings required
- Good mechanical properties.

Fabrication process:

Components are obtained by hot forging, heat treatment and machining.

Grade:

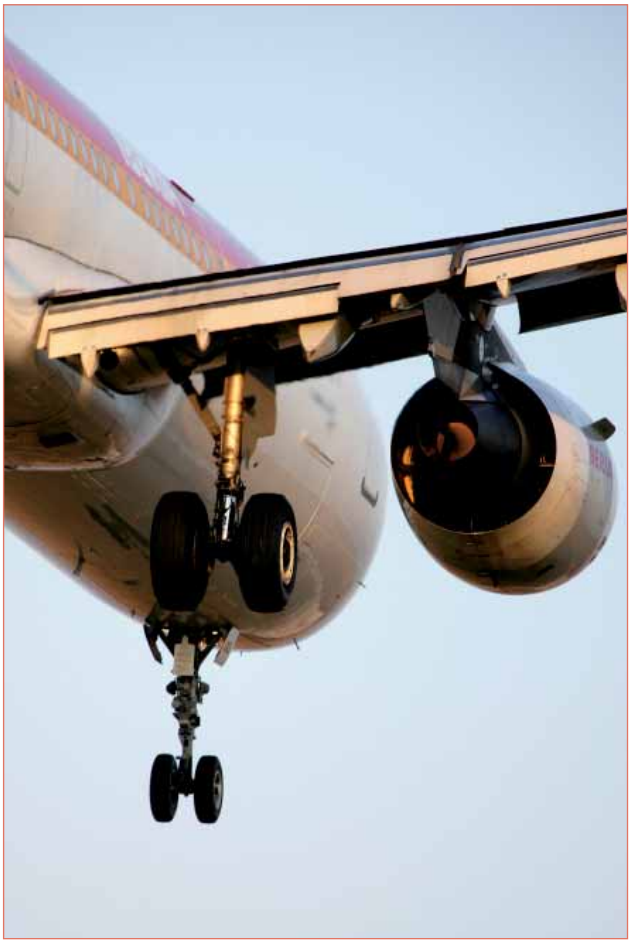
EN: 1.4548 (AISI 630) re-melted and
EN: 1.4545 (AMS 5659, ASTM 564).

Manufacturer:

Not available.

Aircraft landing gear components are subject to extreme stress during both take-off and landing.

Re-melted martensitic stainless steels are preferred over engineering steels for parts of the landing gear of commercial aircraft. The re-melted martensitic stainless as provides good mechanical properties, while avoiding the need of cadmium-plating, which is now banned because of its toxicity.



Intake and Exhaust Valves

Why stainless?

Good mechanical properties at high temperatures.

Fabrication process:

Hot forging or extrusion, machining, heat treatment, final grinding.

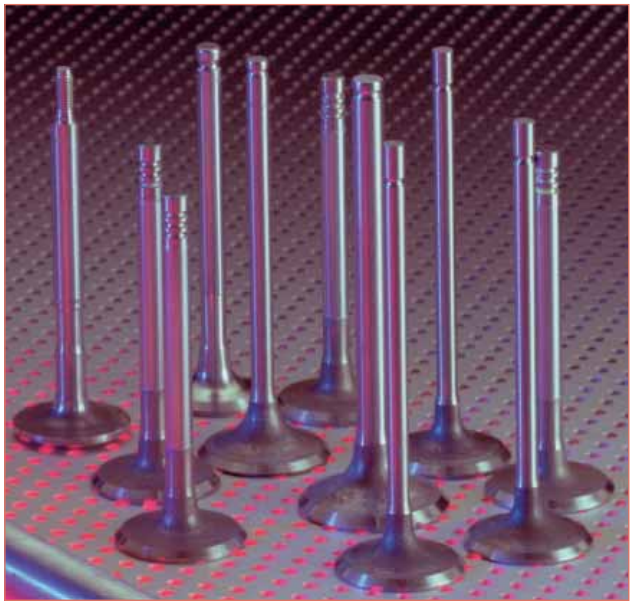
Grade:

Exhaust: Austenitic grades such as EN 1.4882 and 1.4871.

Intake and shaft: Martensitic grades such as EN 1.4718.

Manufacturer:

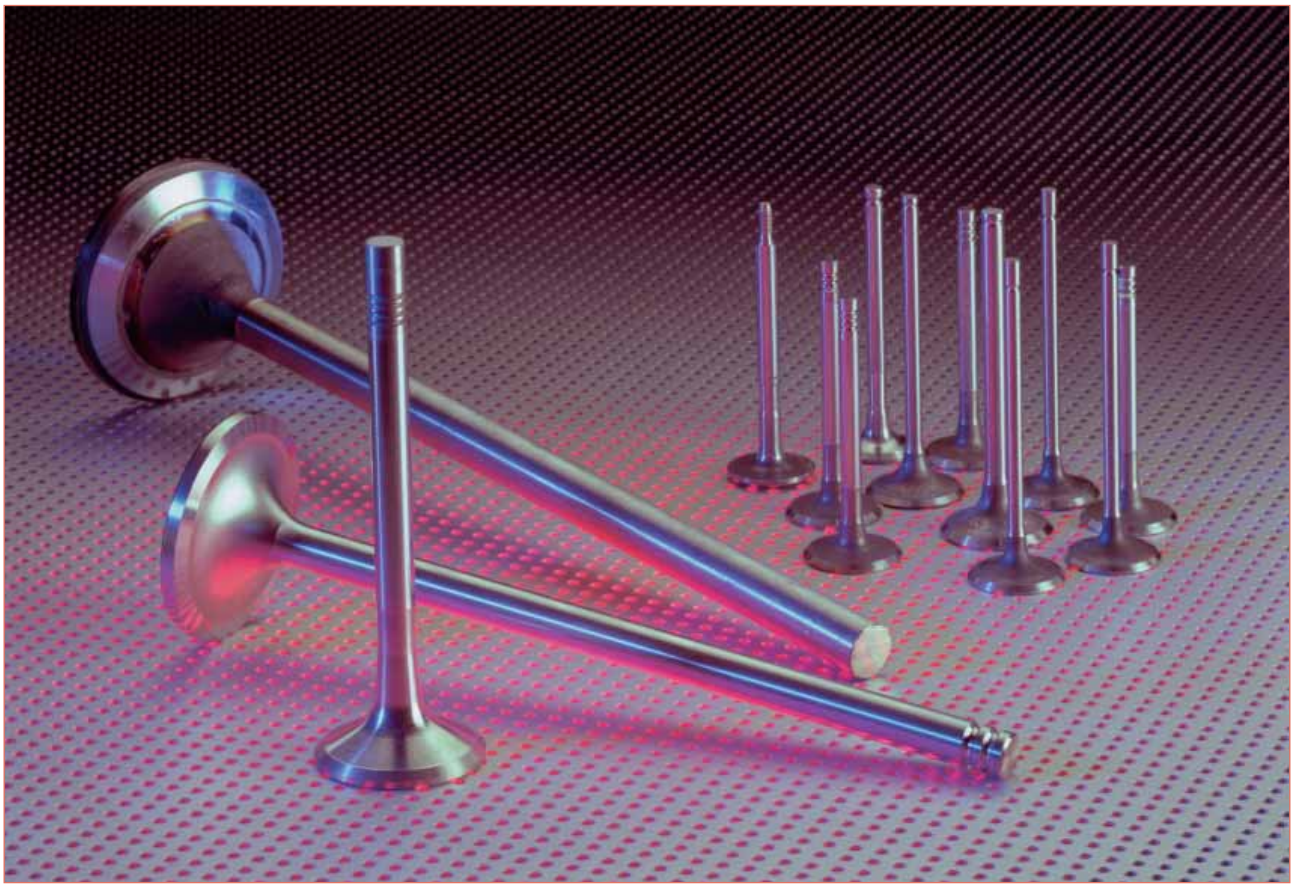
Not available.



Exhaust valves in combustion engines operate at high temperatures. However, the gas temperature of intake valves is much lower.

This dictates the use of different stainless grades for the intake and exhaust valves. Stainless steel provides optimum performance at the lowest cost.

Image courtesy of Deutsche Edelstahlwerke GmbH, Germany.



High Pressure Hydrogen Tank Components

Why stainless?

- Does not become brittle after long exposure to hydrogen
- Durability.

Fabrication process:

Not applicable.

Grade:

Modified EN: 1.4435 (AISI: 316L).

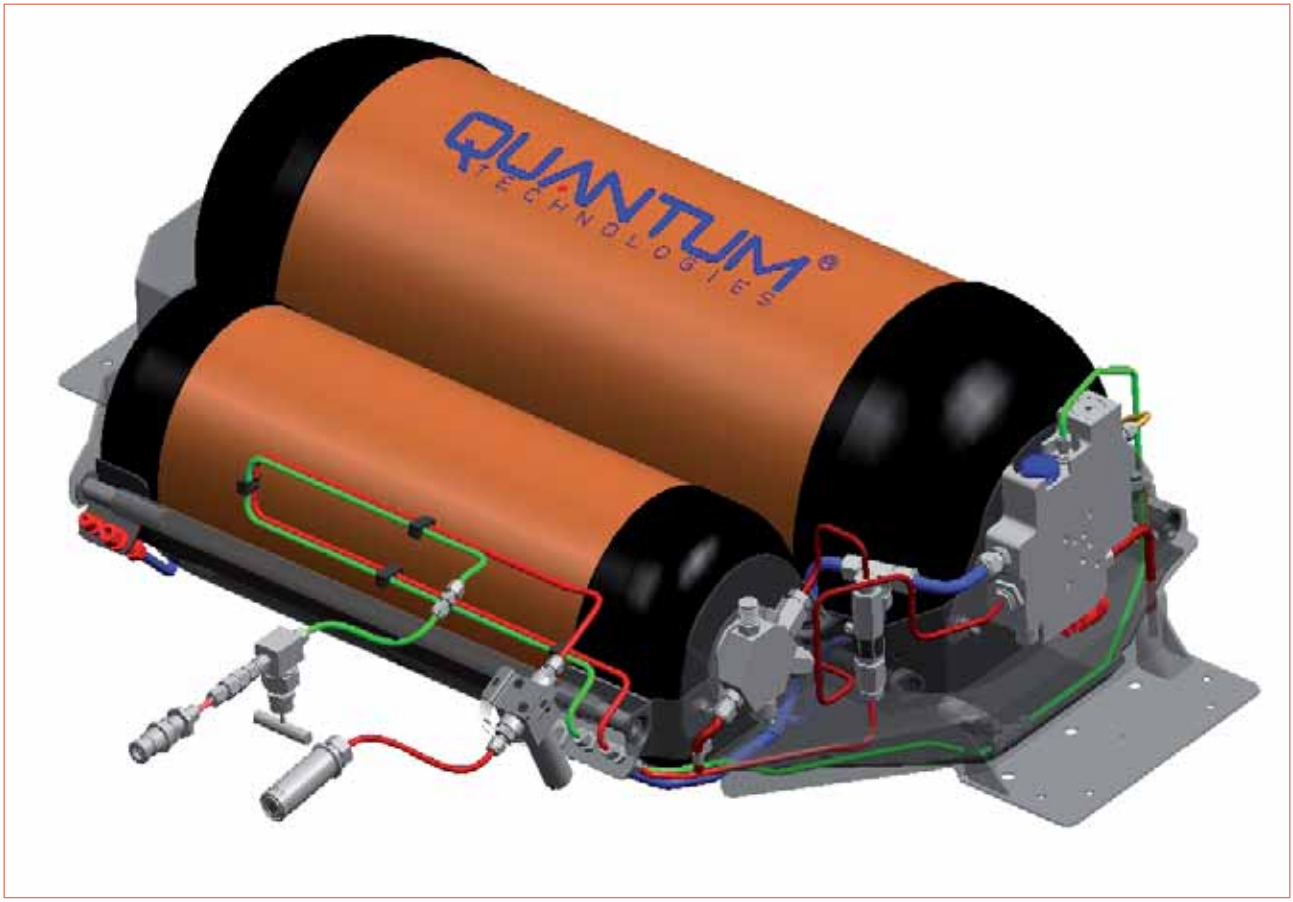
Manufacturer:

Not available.

Hydrogen-powered cars will require high pressure (+700 bar) hydrogen tanks. The tanks must be reliable under all conditions and at temperatures ranging between -60 and +60° C.

One of the major challenges is to find materials that can resist the effect of hydrogen which can make them brittle. Special austenitic stainless steels meet this requirement and have the high strength required for this application.

Image courtesy of Adam Opel GmbH, Germany.



Stainless Steel Wool

Why stainless?

Oxidation resistance (hot gases).

Fabrication process:

The wool is obtained by placing static cutting tools on moving wire to produce a continuous chip. The stainless steel chips are then used to make stainless wool which is then pre-formed in various shapes such as sleeves to produce high performance silencers.

Grade:

EN: 1.4113 (AISI: 434).

Manufacturer:

Nuova Temas, Italy (nuovatemas.it).

Silencer wool is used in automotive exhausts to reduce noise emissions from the vehicle.

Stainless competes with glass and direct-cast metallic fibres in this application.

Images courtesy of Nuova Temas, Italy.

Heating Elements

Why stainless?

- Electrical conductivity
- Oxidation resistance.

Fabrication process:

Hot rolled wire rod is drawn and annealed in successive steps into small diameter wire. This is then be wound to form heating elements for electrical appliances.

Grade:

Fe-Cr-Al stainless steels.

Manufacturer:

Kanthal AB, Sweden (kanthal.com).

Ferritic-chromium-aluminium stainless steels combine a controlled electrical resistivity with outstanding oxidation resistance. The oxidation resistance is a result of the high chromium and aluminum content in the stainless.

The heating elements are used in many domestic applications such as toasters and hair dryers.

They also have industrial uses in fan heaters and industrial furnaces.

For more demanding applications, and particularly at higher temperatures, nickel-chromium alloys or ceramics are used (for example, SiC, MoSi2).

Images courtesy of Kanthal AB, Sweden.

Magnetic Resonance Imaging

Why stainless?

Non magnetic.

Fabrication process:

Not applicable.

Grade:

Austenitic stainless steels.

Manufacturer:

Not available.

Magnetic Resonance Imaging (MRI) is a powerful medical imaging technique. MRI is based on the physical and chemical principles of nuclear magnetic resonance (NMR), a technique used to gain information about the nature of molecules.

During a MRI scan, a strong magnetic field aligns the nuclear magnetisation of (usually) hydrogen atoms in water in the body. The use of non-magnetic materials in the equipment is therefore mandatory. A computer interprets the data, and creates images that display the different resonance characteristics of different tissue types. Trained medical staff can examine the resulting image and use the information to diagnose many different types of medical conditions within the human body.

Surgical Implants

Why stainless?

- Biocompatibility
- Good mechanical properties.

Fabrication process:

Cold or hot forging, followed by machining and polishing.

Grade:

EN: 1.4441 (ISO-5832-1) and
EN: 1.4472 (ISO-5832-9).

Manufacturer:

Not available.

Stainless steel, together with titanium and cobalt-based alloys, is widely used for surgical implants such as hip and knee joints, fasteners, and plates. These implants may either be temporary or permanent.

The stainless is re-melted to ensure a high level of purity for optimum biocompatibility and mechanical properties. Stainless steel is also the preferred material for all surgical, dental and medical tools and equipment.

Images courtesy of Ugitech SA, France.

Generator End Ring

Why stainless?

- Non magnetic
- Good mechanical properties.

Fabrication process:

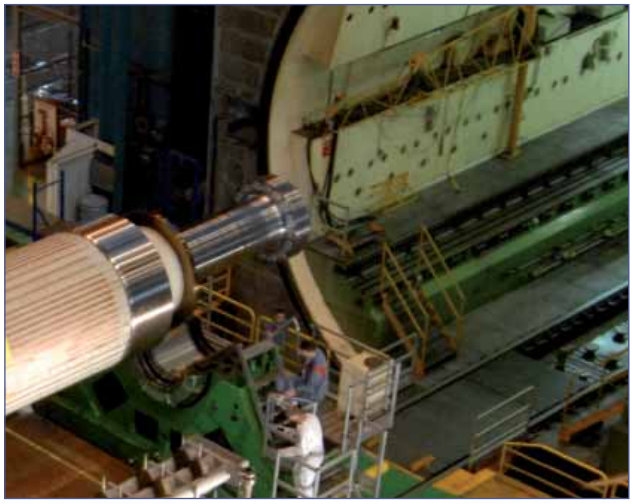
The ring, with a bore of between 0.6 and 1.6 m, is obtained by forging, heat treating and machining.

Grade:

DIN: 1.3816.

Manufacturer:

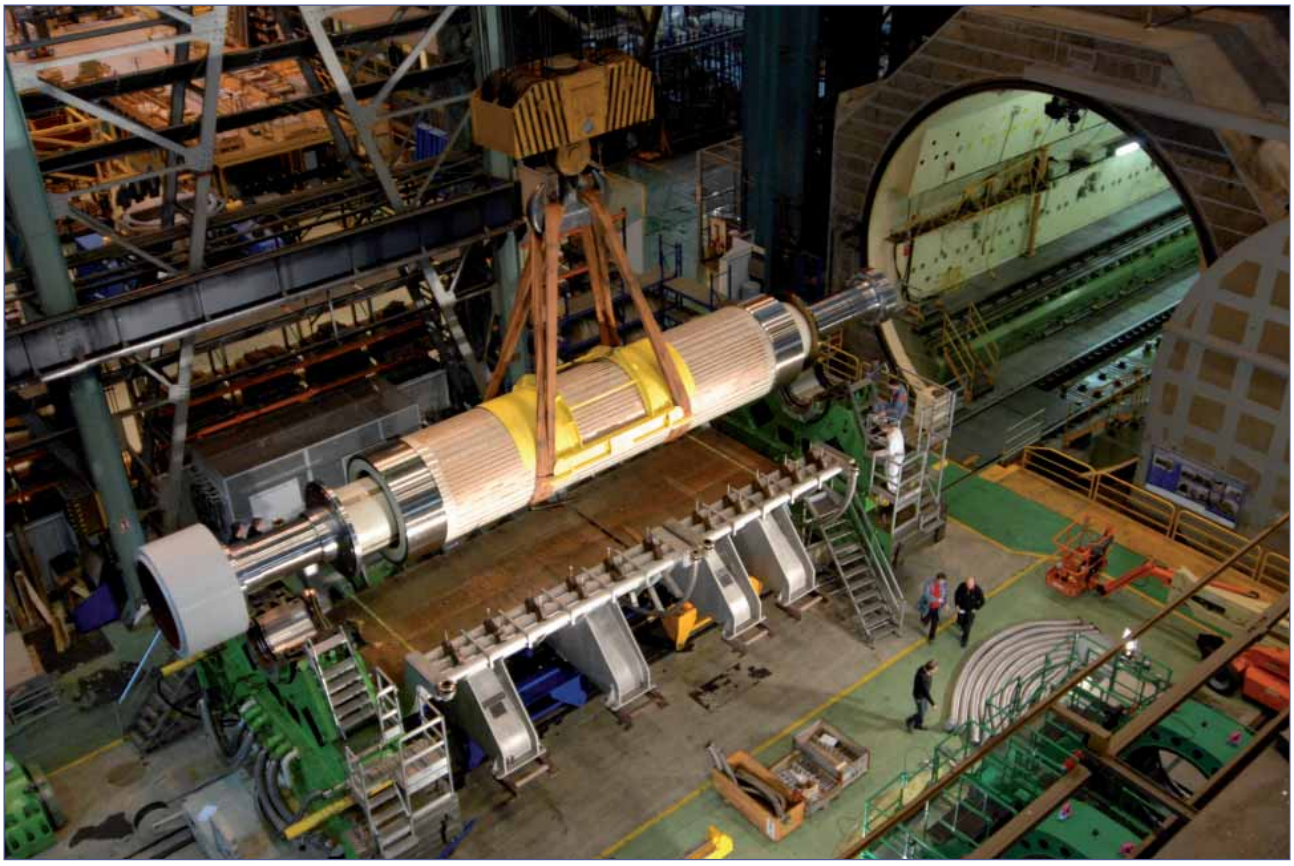
Alstom Power SA, Switzerland (alstom.ch).



The diameter of the end ring of a turbo generator can be between 0.5 and 1.6 metres. The end ring must pass stringent tests to ensure it can operate without deformation at speeds ranging from 3,000 to 3,600 revolutions per minute. A 20% overspeed test is also conducted before the end rings are passed for use.

Non-magnetic stainless steel reduces the losses in the ring that are caused by eddy currents and thermal stresses. The steel also possess a high yield strength in order to avoid plastic deformation due to the high stresses produced by the shrink-fit and centrifugal forces

Image courtesy of Alstom Switzerland SA, Switzerland.



Steam Turbine Blades

Why stainless?

Good mechanical properties at elevated temperatures.

Fabrication process:

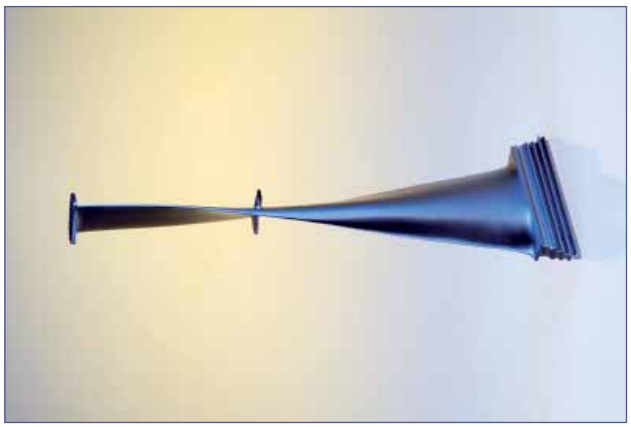
Large blades are forged from billets, machined, then heat-treated. Small blades are heat-treated and machined from flat bars.

Grade:

Proprietary 0.2C 13Cr Nb V super martensitic stainless steels.

Manufacturer:

Alstom Power SA, Switzerland (alstom.ch).



Coal, gas and nuclear powerplants produce electricity by heating water to create steam. The steam is driven through turbine blades at very high pressure. The blades drive the turbine which generates electricity.

The typical operating temperature of the steam is around 600° C. The blades must be tough and resistant to creep, stress, corrosion and cracking. The super-martensitic stainless steels used in these blades are perfect for use in this application.

Images courtesy of Alstom Power SA, Switzerland and Deutsche Edelstahlwerke, Germany.

Cryogenic Valve for Liquid Natural Gas (LNG)

Why stainless?

- Good mechanical properties at cryogenic temperatures
- Dimensional stability during thermal cycling.

Fabrication process:

Cast body and butterfly. Stem is machined from bar.

Grade:

For body and disk: EN: 1.4307 (ASTM: A351 CF3M).

For stem: EN: 1.4401 (ASTM: A182 F316).

Manufacturer:

Velan SAS, France (velan.fr).

This valve operates at cryogenic temperatures, in harsh weather conditions.

Dimensional stability is required during cycles ranging from ambient temperature to liquid natural gas temperatures (usually -196° C) to avoid leakage. Perfect reliability is essential.

Images courtesy of Velan SAS, France.

Clockwise from top right: 107 cm (42 inch) valve; valve at the LNG terminal in Bilbao, Spain; tapped valve after testing in liquid nitrogen.

For more information about stainless steel, please contact one of our long product producing members, your local stainless steel development association (SSDA) or ISSF.

ISSF Long Product Producers

Aichi Steel Corporation - aichi-steel.co.jp

Baoshan Iron and Steel Co. (Special Steel Branch) - shno1steel.com

Böllinghaus - boellinghaus.de

Carpenter Technologies - cartech.com

Cogne Acciai Speciali S.p.A - cogne.com

Daido Steel Co., Ltd. - daido.co.jp

Deutsche Edelstahlwerke GmbH - dew-stahl.com

Gerdau Aços Especiais Piratini - gerdau.com.br/gerdauacosespeciais

JSC Dneprospetsstal - dss.com.ua

Nippon Steel and Sumikin Stainless Corporation (NSSC) - ns-sc.co.jp

North American Stainless (NAS) - northamericanstainless.com

Outokumpu Oyj - outokumpu.com

Panchmahal Steel Limited (PSL) - panchmahalsteel.co.in

POSCO Specialty Steel Co. Ltd. - poscoss.co.kr

Roldan S.A. - acerinox.com

Taiyuan Iron and Steel (Group) Company Ltd. - tisco.com.cn

Ugitech S.A. - ugitech.com

Viraj Group - viraj.com

Walsin Lihwa Corporation - walsin.com

Yieh United Steel Corporation (YUSCO) - yusco.com.tw

Stainless Steel Development Associations

Africa

Southern Africa Stainless Steel Development Association (SASSDA) - sassda.co.za

Asia and Oceania

Australian Stainless Steel Development Association (ASSDA) - assda.asn.au

Indian Stainless Steel Development Association (ISSDA) - stainlessindia.org

Japan Stainless Steel Association (JSSA) - jssa.gr.jp

Korea Iron and Steel Association (KOSA) - kosa.or.kr

New Zealand Stainless Steels Development Association (NZSSDA) - hera.org.nz/nzssda/Default.htm

PASDER (Paslanmaz Celik Kullanimini Gelistirme Ve Yayginlastirma Dernegi) - turkpasder.com

Stainless Steel Council of China Specialist Steel Enterprises Association (CSSC) - cssc.org.cn

Taiwan Steel and Iron Industries Association (TSIIA) - tsiia.org.tw

Thai Stainless Steel Development Association (TSSDA) - tssda.org

Europe

British Stainless Steel Association (BSSA) - bssa.org.uk

Cedinox - cedinox.es

Centro Inox - centroinox.it

Edelstahl-Vereinigung e.V - stahl-online.de

Euro Inox - euro-inox.org

Eurofer - eurofer.org

Informationsstelle Edelstahl Rostfrei (ISER) - edelstahl-rostfrei.de

Institut de Développement de l'Inox (ID Inox) - idinox.com

Jernkontoret - jernkontoret.se

Polska Unia Dystrybuturów Stali (PUDS) - puds.pl

Special Steel and Alloys Consumers and Suppliers Association. (USSA) - ussa.ru

Swiss Inox - swissinox.ch

Union de Empresas Siderúrgicas (UNESID) - unesid.org

South America

Nucleo Inox - nucleoinox.org.br

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