Stainless Steel Explained

Stainless steel is the name given to a wide range of steels which have the characteristics of greatly enhanced corrosion resistance over conventional mild and low alloy steels.

The enhanced corrosion resistance of stainless steel essentially comes from the addition of at least 11% chromium, however most stainless steels commonly used contain around 18% chromium. Other significant alloying elements include nickel and for superior corrosion resistant properties, molybdenum.

For ACO Building Drainage applications, the principal properties of stainless steel may be summarised as follows:

- Durable and corrosion resistant in highly aggressive environments.
- Hygienic, easily cleaned surfaces.
- Aesthetically attractive surface finish.
- Good forming and fabrication characteristics.
- Excellent strength and resistance to oxidisation at high temperatures.

All these make stainless steel an obvious first choice material for demanding applications.

Stainless Steel Families

Stainless steel is used across a wide spectrum of engineering applications and this has led to the development of the vast range of different types of stainless steels that are now available.

Austenitic Stainless Steel is the most widely used and encompasses the generic 304 and 316 grades of material. These materials are used in the ACO Building Drainage manufacturing process and are ideal for applications including food processing, leisure, dairy, brewing, pharmaceutical, chemical and petrochemical industries.

304 grade stainless steels contain around 18% chromium and 10% nickel and provides excellent corrosion resistance. For applications where superior corrosion resistance properties are required under extreme conditions particularly where chlorides are involved, 316 grade stainless steels are used and contain around 17% chromium, 12% nickel and 2.2% molybdenum.

Unlike all other grades of stainless steels, austenitic grades are non-magnetic and as a consequence magnetic particles are not attracted to the system surfaces which otherwise would encourage both contamination and corrosion.

Ferritic, Martensitic and bluplex stainless steels are unsuitable for drainage products.

Stainless Steel Corrosion Resistance

The single most important property of stainless steels and the reason for their existence and widespread use, is their natural corrosion resistance. In spite of their name, stainless steels can both ‘stain’ and corrode if used incorrectly.

The reason for the good corrosion properties is due to the formation of a very thin, invisible oxide film that forms on the surface of the material in oxidising environments such as the atmosphere and water.

This film is a chromium-rich oxide which protects the steel from attack in aggressive environments. As chromium is added to a steel, a rapid reduction in the corrosion rate is observed because of this protective film. In order to obtain a compact and continuous passive film, a chromium content of at least 11% is required. Passivity increases fairly rapidly with increasing chromium content up to about 17% chromium.

The most important alloying element is therefore chromium, but a number of other elements including nickel, molybdenum and nitrogen also contribute to the corrosion resistance properties of stainless steels. Other alloying elements may also be added to enhance the corrosion resistance in particular environments.

Stainless steels must oxidise in order to form the passive, chromium-rich oxide film. Stainless steels have a very strong tendency to passivate and only a small amount of oxidising agents are needed for passivation - air and water are sufficient to passivate stainless steels and indeed, this oxide film is spontaneously regenerated when exposed to oxygen. An important factor to note is that the passive film is self-healing, so when the material is cut or machined or, should chemical or mechanical damage occur, the passive film will ‘heal’ or re-passivate in oxidising environments - unlike a painted finish on mild steel.

Selection of the correct grade of material for each application is an important factor in the design process. It is important to note that even 316 grades of stainless steel are not immune to all kinds of chemical attack; use of reducing solutions such as hydrochloric and sulphuric acids particularly when in concentrated and/or hot form, requires careful consideration. See corrosion resistance chart on pages 46 and 47.

Stainless Steel Finishing Processes

A stainless steel finish should appear clean, smooth and faultless. This is obvious when the steel is used for such purposes demanding stringent hygiene or decorative trim applications, but a fine surface finish is also crucial in respect to its corrosion resistant properties.

The corrosion resistance properties of stainless steel are achieved by the spontaneous formation of a very thin chromium-rich oxide layer over the surface of the material. Unfortunately, surface defects and imperfections introduced during the manufacturing process may drastically disturb the self healing process of the passive layer and subsequently reduce the corrosion resistance of the material.

In the manufacturing process it is welding that creates the greatest challenge to corrosion resistance.

Untreated Stainless Steel

After welding stainless steel, a bluish high temperature oxide film can be seen which has substantially inferior corrosion protection properties compared to the original passive layer. Immediately beneath this blue oxide film is a thin layer of chromium depleted metal which makes the metal surface susceptible to corrosion. Post weld treatment is, therefore, very important to restore the corrosion protection properties and is effectively achieved by removing the blue high temperature oxide film and chromium depleted layer to restore the surface of the material. This 'cleaning' is essentially a controlled corrosion process using chemicals, this will restore not only its original corrosion resistance performance but also the high quality aesthetics.

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ACO Pickle Passivation Plant

All ACO Building Drainage products are subjected to specialised treatment to ensure the material retains the maximum resistance to corrosion.

The chemical processing methods used in the ACO Building Drainage process are pickle passionate and eltropolishing. ACO resources include the largest pickle passivation plant in Europe.

Pickle Passivation

The standard ACO Building Drainage manufacturing process uses the pickle passivation chemical finishing process to restore the products to their full optimum corrosion resistant state without damaging the surface finish. This is considered the best method for cleaning welded joints.

Pickle Passivation is a two-phase process. Pickling removes both the bluish high temperature oxide film and the chromium depleted layer and is achieved by placing the components in a pickling bath containing a mixture of nitric acid and hydrofluoric acid.

The second phase is passivation and in many ways is similar to the pickling process. During this process the components are placed in a bath containing only nitric acid. This treatment strengthens the passive layer and also removes any iron impurities that may have become embedded in the surface of the stainless steel during the manufacturing process.

This treatment is important where mechanical cleaning of the components has taken place with the use of wire brushes, grinding wheels and files where iron particles from other materials may contaminate the stainless steel surface.

Electropolishing

Electropolishing is ideal for producing a uniform, highly reflective lustre with an extremely smooth finish even on the most complex product contours. This is a well proven method of polishing and is achieved by an electro-chemical process which is essentially the reverse of electroplating.

The components are immersed in a bath of electrolyte containing phosphoric acid where the components become the anode of a direct current electrical circuit. The process is characterised by the selective attack on the surface of the components whereby upstanding roughnesses are preferentially dissolved and will yield a progressively smoother, brighter surface.

For pharmaceutical and food processing industries, bacterial resistance is considerably improved by the electropolishing process.

Certain gratings within the ACO Building Drainage range are electropolished as standard. All stainless steel products can be electropolished if required to special order.

Corrosion Resistance Chart

Reagent	Stainless Steel 304	Stainless Steel 316	EPDM	Neoprene Gasket	Viton Gasket
Acetic Acid 20%	●	●	●	?	●
Acetic Acid 80%	●	●	●	X	●
Acetone	●	●	●	●	X
Alcohol (Methyl or Ethyl)	●	●	●	●	?
Aluminium Chloride	?	?	●	●	●
Aluminium Sulphate	●	●	●	●	●
Ammonia Gas (Dry)	●	●	~	●	~
Ammonium Chloride	?	?	●	●	●
Ammonium Hydroxide	●	●	●	●	●
Ammonium Nitrate	●	●	●	●	●
Ammonium Phosphate	●	●	●	●	●
Ammonium Sulphate	?	●	●	●	●
Ammonium Sulphide	●	●	~	~	~
Amyl Chloride	●	●	X	~	?
Aniline	●	●	?	X	●
Barium Chloride	●	●	●	●	●
Barium Hydroxide 10%	~	~	●	●	●
Barium Sulphate	●	●	●	●	●
Barium Sulphide	~	~	●	●	●
Beer	●	●	●	●	●
Beet Sugar Liquors	●	●	●	●	●
Benzene	●	●	X	X	●
Benzoic Acid	●	●	X	●	●
Bleach -12.5%Active C1	~	~	●	X	X
Boric Acid	●	●	●	●	●
Bromic Acid	?	?	~	~	~
Bromine Water	X	X	~	X	~
Butane	●	●	X	●	●
Calcium Carbonate	●	●	●	●	●
Calcium Chloride	X	?	●	●	●
Calcium Hydroxide	?	●	●	●	●
Calcium Hypochlorite	X	?	?	X	●
Calcium Sulphate	●	●	●	~	●
Cane Sugar Liquors	~	~	●	●	●
Carbon Acid	~	~	●	●	●
Carbon Bisulphide	●	●	X	X	●
Carbon Dioxide	●	●	●	●	●
Carbon Monoxide	●	●	●	●	●

Reagent	Stainless Steel 304	Stainless Steel 316	EPDM	Neoprene Gasket	Viton Gasket
Carbon Tetrachloride	?	?	X	X	●
Caustic Potash	●	●	●	~	●
Caustic Soda	●	●	●	●	●
Chloride (Dry)	?	?	●	X	●
Chloride (Wet)	X	X	X	X	?
Chloraocetic Acid	~	●	?	X	●
Chlorobenzene	●	●	X	X	●
Chloroform	?	?	X	X	●
Chrome Acid 50%	X	X	?	X	●
Chromic Acid 10%	●	●	X	X	●
Citric Acid	?	●	●	●	●
Copper Chloride	X	X	●	●	●
Copper Cyanide	●	●	●	●	●
Copper Nitrate	●	●	~	●	●
Copper Sulphate	●	●	●	●	●
Cottonseed Oil	~	~	X	●	●
Cresol	~	~	X	X	X
Cyclohexanone	?	●	●	X	X
Cyclorexanol	~	~	X	●	X
Dimethyleanine	~	~	?	●	●
Dionylphalate	~	~	?	X	X
Disodium Phosphate	~	~	●	X	●
Distilled Water	●	●	●	●	●
Ethyl Acetate	●	●	?	X	X
Ethylene Chloride	●	●	X	X	?
Ethylene Glycol	●	●	●	●	●
Fatty acids (Cb)	●	●	X	?	●
Ferric Sulphate	●	●	●	●	●
Fluorene Gas (wet)	X	X	●	X	?
Formaldehyde (37%)	●	●	●	●	●
Formic Acid (90%)	X	●	●	●	?
Freon 12	●	●	●	●	●
Fruit Juices and Pulp	?	●	~	●	●
Furfural	●	●	X	X	X
Gasoline (Refined)	●	●	X	●	●
Glucose	●	●	●	●	●
Glycerine	●	●	●	●	●

The corrosion resistance information contained within this table is indicative only.

All data is based on reactions noted at an ambient temperature of 20°C. Higher temperatures will generally reduce the corrosion resistance of the materials.

Please contact ACO Building Drainage if guarantees are required of specific material suitability.

We shall arrange for tests to be undertaken with the reagent to establish the chemical resistance of the materials. Other gasket and sealing ring materials are available. Please contact us for further information.

- ● Recommended
- ? Suitable. However, contact ACO Building Drainage for further advice.
- X Not recommended
- ~ No data available