

Stainless steel: the cost competitive corrosion solution

Columbus Stainless, the only fully integrated, technologically advanced, single site stainless steel producer in Africa, outlines the common stainless steel grades and uses and highlights the value of the material for the manufacturing industry.

When choosing metals for longevity and low maintenance, stainless steels become the obvious choice. This is because of their characteristic corrosion resistance, giving long life in various aggressive environments whilst maintaining their original properties and aesthetic appearance.

Corrosion can be defined as the gradual destruction of materials through chemical reactions with the environment. Corrosion degrades the useful properties of metals and structures, compromising strength and structural integrity as a result of mass loss and eventual perforation.

Most metals and metal alloys tend to revert back to their natural stable states on exposure to moisture in air. For example, carbon steels are made up of iron and a combination of other alloying elements. Without any surface protection, the corrosion reaction tends to form a coating of rust (iron-oxide), which is brittle and exfoliates, exposing a new fresh surface of steel to be attacked by the surrounding environment. If this cycle is allowed to continue, it will have a destructive effect on equipment and structures.

Stainless steel has a unique advantage in that a thin, tenacious and self-repairing passive chromium oxide layer forms on the surface of the steel. This oxide layer gives

the steel its characteristic corrosion resisting properties in most environments. Due to its corrosion resistance, stainless steel, which must contain a minimum of 10.5% chromium for a passive layer to form, is mainly used with an uncoated mill finish, since no additional protective coating systems are needed for corrosion protection.

Columbus Stainless produces the three main families of stainless steel standard and utility: ferritic, austenitic and duplex stainless steel, as outlined below.

Ferritic steels and 3CR12

Ferritic stainless steels are commonly known as plain chromium steels. Ferritic stainless steel grades contain at least 10.5% chromium, with additional alloying elements for improved corrosion resistance, strength and weldability added for the various grades. Common grades include 430, 409, 441 and 444.

Standard ferritic grades such as 430 are used mainly for aesthetic applications, cutlery, cookware as well as applications roofing, cladding and decorative trims. Grade 441, which contains additional alloying elements such as niobium and titanium for stabilisation and higher strength at high temperatures, is mainly used in robust applications – in the automotive industry for exhaust pipes and

catalytic converters, for example.

Molybdenum containing ferritic grades such as 436 and 444 exhibit higher pitting and general corrosion resistance. Because ferritic stainless steel grades are resistant to stress corrosion cracking, they are used in applications where their austenitic equivalents (eg, 304 and 316) cannot be used, hot water systems being an example.

The utility ferritic stainless steel, 3CR12®, is a low cost utility ferritic stainless steel developed by Columbus Stainless and used widely throughout the South African mining industry as a cost effective solution to corrosion in a wide range of structural applications. It has excellent properties in wet-abrasion conditions as a result of its superior strength, moderate corrosion resistance and good slideability.

Applications are widespread and include materials handling environments in mines and coal washing plants. It is used for applications such as ore cars and wagons, chutes and launders, as well as shaft steel work, chimney stacks, ducting, roofing and cladding; poultry and piggery buildings; walkway products, including grating, hand rails and stairs; electrical boxes; and security fencing. It is also widely used in sewage processing plants and for municipal water storage tanks.

3CR12® coal wagons and life cycle costing

In 1985, trial coal wagons were manufactured out of 3CR12 with a hot rolled and annealed (HRA) surface finish. These wagons are used



to transport coal between Ermelo and Richards Bay. They have a payload of 80 t and make the journey roughly five times a week.

Before 3CR12, the wagons were made from Cor-Ten, but these only lasted 8-12 years, with refurbishment required after five years. Over the years, many inspections of these coal wagons have been conducted. Of particular note is a study done in 2012, after 27 years of service. The wall thickness of the coal wagons was measured using extensive ultrasonic thickness measurements. Steel wagons recorded corrosion-abrasion wear rate of 160 µm/yr, while a metal loss of 10 µm/yr was recorded for 3CR12 wagons in the same application.

From these measurements, these 3CR12 coal wagons have a predicted total life of 65 years, while steel wagons have to be replaced roughly eight times in this period, significantly increasing costs and potential lost production time.

Austenitic and duplex stainless steel

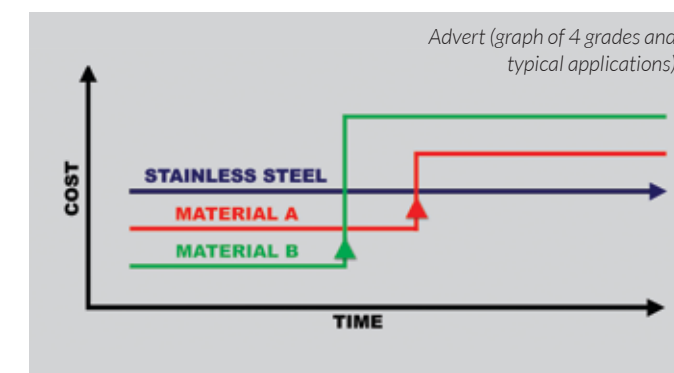
Austenitic stainless steel grades are a family of steels that contain iron alloyed with chromium and nickel for improved properties. They have excellent formability and fabricability and exhibit good strength properties under cryogenic and very high temperature conditions. These grades are used extensively in the food and beverage and petrochemical industries for high temperature applications, for their excellent oxidation resistance.

Standard austenitic grades contain high contents of chromium and nickel. A typical example is grade 304, which is very successful in applications demanding high hygienic performance, such as in agriculture, for abattoirs, dairy processing and meat handling equipment; food and beverage storage tanks; catering and hospitality utensils, food processing equipment and cold storage facilities; and health care applications for medical equipment and surgical tools. The regulatory safety requirement in these industries is that there must be no measurable chemical reaction between the metal surface and the food-grade product, that is, the product may not be contaminated with any metallic constituents or corrosion products.

Molybdenum containing austenitic grades, including 316, exhibit increased general and localised corrosion protection and are used in more aggressive environments. Main applications include the manufacture of tank containers for the bulk transportation of chemicals, gases and corrosive liquids; processing tanks in the chemical and petrochemical industries, and pressure vessels.

Heat resisting austenitic stainless steels (309 and 310S) contain much higher chromium and nickel contents than standard austenitic grades for improved high-temperature oxidation resistance and they can maintain reasonable strength at very high temperatures. They are successfully used for heat exchangers and heating elements; burners and combustion chambers, and electrical elements.

Duplex stainless steel grades contain a mixed microstructure of austenite and ferrite. They have characteristic high strength, resistance to stress corrosion cracking and superior corrosion resistance. Popular grades include the lean duplex, 2304, and the standard duplex grade, 2205. These are successfully being used in the paper, pulp, chemical,



petrochemical and mining industries for various processing equipment and storage tanks. Their superior corrosion resistance can withstand even harsh marine environments.

Stainless steel for local manufacturing

South Africa boasts a wide variety of large industries, including power generation, mining, farming and manufacturing. Fundamental to supporting these diverse industries is the steel industry. Stainless steel has proven itself to be a multi-functional and adaptable metal and a successful choice in many application where it offers excellent value to the manufacturing and end-user industries. Stainless steel remains a cost competitive, low maintenance material that contributes to long-term sustainability; being manufactured using mostly recycled metals and 100% recyclable at the end of its life. Columbus Stainless is proud to have contributed to the development of this material over five decades and will continue to do so as Africa and the world grows. Indeed the future of manufacturing is Stainless. □



SOLUTIONS TO CORROSION THROUGH INDUSTRY EXPERTISE

Multi Alloys has earned a reputation as a specialist – a leading supplier of nickel alloys, duplex and high alloy stainless steel, titanium, and other niche products. Our extensive stockholding represents our understanding of and commitment to our customers. We pride ourselves on adding value through experience.

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