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A service provided by the
British Stainless Steel Association

Stainless Steels for the Food Processing Industries

Introduction

Stainless steels are widely used in food and beverage manufacturing and processing industries for manufacture, bulk storage and transportation, preparation and presentation applications.
Depending on the grade of stainless steel selected, they are suitable for most classes of food and beverage products.

Stainless steels used in food processing

Most containers, pipework and food contact equipment in stainless steels is manufactured from either 1.4301 (304) or 1.4401 (316) austenitic stainless steels. The 17% chromium ferritic stainless steel 1.4016 (430) is also used widely for such applications as splashbacks, housings and equipment enclosures, where corrosion resistance requirements are not so demanding.

The "316" grades (1.4401 / 1.4404) are often referred to as *the* "food" grades.
There is no known official classification for this and so, depending on the application, the equally common 1.4301 and 1.4016 types may be suitable for food processing and handling, bearing in mind that in general terms the corrosion resistance ranking of grades can be taken as: -

1.4401/1.4404 (316) > 1.4301 (304) > 1.4016 (430)

In addition to these non-hardenable types (1.4301 & 1.4401 are "austenitic" and 1.4016 is "ferritic") higher strength "duplex" types 1.4362 (2304) and 1.4462 (2205) are also available and are useful for "warm" conditions (i.e. over 50°C) where stress corrosion cracking (SCC) can be a problem e.g. in brewery sparge tanks.

Hardenable "martensitic" type stainless steels are widely used for cutting & grinding applications, especially as knives.

Table 1 summarises the grades and some of the typical applications.

Corrosion Hazards to Stainless Steels in Food Processing

If the grade of stainless steel is correctly specified for the application, corrosion should not be encountered.
The types of corrosion to which stainless steels can be susceptible are summarised below, as this can be useful in identifying problems due to wrong grade selection or inappropriate use of equipment.

Pitting/Crevice Corrosion

Stainless steels can be susceptible to localised corrosion
Microscopic defects in the protective “passive” oxide surface layer can give rise to corrosion in the presence of halogen ions, particularly chlorides. Local breakdown of the passive layer can occur at the site of such defects. This form of attack can prevent the re-formation of the passive layer and so pitting or crevice corrosion occurs. Pitting corrosion is characterised by local deep pits on free surfaces. Crevice corrosion is occurs in narrow, solution-containing crevices or sharp re-entrant features in a structure in which the passive film may be more readily weakened and broken-down. Examples of potential sites for crevice corrosion are under washers, flanges and soil deposits or growths on the stainless steel surface.

Both crevice and pitting corrosion occur most readily in aqueous chloride-containing solutions.
Although attack can occur in neutral conditions, acidic conditions and increases in temperature promote pitting and crevice corrosion.
Corrosion can also occur in environments containing other halogen ions (e.g. bromides and fluorides) but this is much less likely.

Stress Corrosion Cracking

“SCC” is a localised form of corrosion characterised by the appearance of cracks in materials subject to both stress and a corrosive environment. It usually occurs in the presence of chlorides at temperatures generally above 50°C

Intergranular Corrosion

"IGC" or “ICC” (known in the past as “weld decay”) is the result of localised attack, generally in a narrow band around heat affected zones of welds, where chromium has been lost or tied-up as carbides in grain boundary areas.
The result is that this “sensitised” region can suffer localised attack.
This is most common in the “standard” carbon austenitics and is avoided by the low (0.030% maximum) types 1.4307, 1.4404 etc or by using the “stabilised” types such as 1.4541 (321), which contains titanium.

Galvanic Corrosion

This form of attack would not normally be expected in food processing unless the service environment was particularly aggressive.
It occurs when two or more dissimilar metals are electrically connected and exposed to a corrosive environment (e.g. a mild steel/stainless steel couple in seawater).

Surface finish & condition is very important to the successful application of stainless steels
Smooth surfaces not only promote good cleansibility but also reduce the risk of corrosion
High quality mechanical finishes or electropolished finishes should be considered.

Cleaning of Stainless Steel Equipment

Effective cleaning is essential in maintaining the integrity of the process and in prevention of corrosion. The choice of cleaning method and the frequency of its application depends on the nature of the process, the food being processed, the deposits formed, hygiene requirements etc. The following cleaning methods are suitable in conjunction with stainless steel equipment.

Water and Steam

Vessels and equipment can sometimes be flushed clean with cold water, hot water or steam.

Mechanical Scrubbing

Hard and adherent deposits can be removed with stainless steel wool, Scotchbrite sponges or emery cloth dipped in mineral spirits. Care must be exercised to avoid iron- or chloride-containing cleaning materials

Scouring Powder and Detergents

Any chloride free scouring powders and detergents may be used provided sufficient care is taken not to scratch the visible surfaces. (Under aggressive conditions roughened surfaces can be more susceptible to corrosion) Soda, borax and sodium perborate are also good cleaners. If a light polishing effect is required, a paste of magnesium oxide or finely crushed pumice in water can be used.

Alkaline Solutions

Solutions containing soda, ammonia or ammonium hydroxide can be used for removing grease & fats.

These are not harmful to stainless steels.

Organic Solvents

Acetone, mineral spirits, ether, and alcohol can be used to remove grease or other non-water soluble substances as alternatives to ammonia or hydroxide solutions.

Nitric Acid

Most stainless steels are safe in contact with a wide range of concentrations of nitric acid.

Washing with nitric acid can be used freely and can increase the “passivity” of the stainless steel.

Nitric acid can also be used to remove iron contamination from stainless steel surfaces, thus preventing “rust staining” effects.

Rinsing

Vessels and equipment must be rinsed after the use of cleaning agents. While flushing or rinsing with water is usually adequate, it may be necessary to rinse the equipment with a neutralising solution (e.g. soda). Residual traces of benzene, mineral spirits, etc may be removed by rubbing with chalk dust, which is also useful in removing fingerprints and other grease marks.

Disinfection of Stainless Steel Equipment

Chemical disinfectants are often more corrosive than cleaning agents and care must be exercised in their use.

Hypochlorites

Hypochlorites, chloramine and other disinfectants can liberate free chlorine, which can often cause pitting.
This usually occurs with a steam phase or a liquid surface.

Sodium hypochlorite or potassium hypochlorites are often used in commercial sterilising agents. If these substances are used with stainless steel, the duration of the treatment should be kept to minimum and followed by thorough rinsing with water. At higher temperatures, chloride-containing sterilising agents should not be used with stainless steel.
Milton solutions (hypochlorite & chloride) can be very aggressive to stainless steels.
Hypochlorite solutions are not suitable for use with plate-type pasteurisers and experience has shown that, even with the plates cooled prior to treatment, sufficient heat can be retained in the framework to cause pitting.

Tetravalent ammonium salts

Tetravalent ammonium salts are much less corrosive than hypochlorites, even when halogens are present in their formulation. On the rare occasions where corrosion has been observed with these materials, it is the chloride compound that has been identified as the cause.

Iodine Compounds

Iodine compounds may be used for the disinfection of stainless steel.
Their application in the food industry is limited by the tendency to taint the product.

Nitric acid

Even at low concentrations, nitric acid has a strong bactericidal action and can be a low cost disinfectant for stainless steel equipment, especially in dairies and pasteurising equipment.

Maintenance of equipment

Stainless steel equipment often contains gaskets or other components that can absorb or retain fluids. These liquids may be become concentrated by evaporation and corrosion may ensue. Equipment should be disassembled occasionally for thorough cleaning. If the disassembled equipment exhibits corrosion (crevice corrosion usually), then the corroded surfaces should be cleaned.
If corrosion is severe painting or coating can be considered, but replacement should be considered as the localised attack can propagate once started.
More information on care and maintenance of stainless steel is available in SSAS Information Sheet No. 7.20

Table 1 - Typical Applications of Stainless Steels used in Food Preparation

Grade	Type	Typical Application
1.4028 (420) 1.4116	Martensitic	Spatulas and palette knives Cooks and Professional Knives
1.4016 (430)	Ferritic	Table surfaces, equipment cladding, panel (ie components requiring little formability or weldability). Used for moderately corrosive environments (e.g. vegetables, fruits, drinks, dry foods, etc)
1.4301 (304) 1.4401 (316) 1.4539 (904L)	Austenitic	Vats, bowls, pipework, machinery parts (i.e. components requiring some formability or weldability). Corrosion resistance superior to 430. Components used with more corrosive foods (e.g. meat/blood, foods with moderate salt contents), which are frequently cleaned, with no stationery solids and not under excessive stress. Used with corrosive foods (e.g. hot brine with solids which act as crevice forms, stagnant and slow moving salty foods)
1.4362 (2205) 1.4462 (2304)	Duplex	Used with corrosive foods (e.g. hot brine with solids, stagnant and slow moving salty foods). Higher strength than 904L, which gives design and weight savings. Good resistance to stress corrosion cracking in salt solutions at elevated temperatures
1.4547 (254 SMO)	Super Austenitic	Used with corrosive foods (e.g. hot brine with solids, which act as crevice formers, stagnant and slow moving salty foods). Good resistance to stress corrosion cracking in salt solutions at elevated temperatures. Used in steam heating and hot work circuits, hot water boilers, etc

Before commencing any task ensure that you have received the appropriate health and safety literature from the supplier and fully understand it. If in doubt seek advice.

This Information Sheet is based on a draft supplied by Avesta Sheffield Ltd.