Selection of 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. Guidlelines on the Materials of Construction for Equipment in Contact with Food have been published by the European Hygiene Engineering and Design Group (EHEDG). This includes an extenive section on stainless steels. Copies of these Guidelines can be ordered from this website.

Stainless steels used in food processing

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

In addition to these non-hardenable austenitic and ferritic types higher strength 'duplex' types, such as grades 1.4362 and 1.4462 are useful for 'warm' conditions (i.e. over 50ï¿½C) where stress corrosion cracking (SCC) can be a corrosion risk, such as in brewery sparge tanks.

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

Is 316 type the only stainless steel that is classed as the 'food' grade

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 grades 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 types) > 1.4301 (304 types) > 1.4016 (430 types)

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.
Surface finish and 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.

The types of corrosion to which stainless steels can be susceptible are summarised below. This can be useful in identifying problems due to wrong grade selection or inappropriate use of equipment.

Pitting and Crevice Corrosion
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.

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. Examples of potential sites for crevice corrosion are under washers, flanges and soil deposits or growths on the stainless steel surface.

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 50ï¿½C.

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. This is more likely to occur in the 'standard' carbon austenitics. The risk of IC attack is virtually eliminanted if the low carbon (0.030% maximum, eg 1.4307) or the 'stabilised' (eg 1.4541) types are selected.

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 cleaning methods listed are suitable for stainless steel equipment.

Water and Steam
Mechanical Scrubbing
Scouring Powder and Detergents
Alkaline Solutions
Organic Solvents
Nitric Acid

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 cause pitting.
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.

Tetravalent ammonium salts
Tetravalent ammonium salts are much less corrosive than hypochlorites, even when halogens are present in their formulation.

Iodine Compounds
Iodine compounds may be used for the disinfection of stainless steel.

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 food process 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.

Typical applications of the various stainless steel types

Types	Typical Applications
420 (martensitic)	Cooks and professional knives, spatulas etc
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).
304 (austenitic)	Vats, bowls, pipework, machinery parts (i.e. components requiring some formability or weldability). Corrosion resistance superior to 430.
316	Components used with more corrosive foods (e.g. meat/blood, foods

(austenitic)	with moderate salt contents), which are frequently cleaned, with no stationary solids and not under excessive stress.
1.4539 (austenitic)	Used with corrosive foods (e.g. hot brine with solids that act as crevice forms, stagnant and slow moving salty foods).
1.4462 (duplex)	Used with corrosive foods (e.g. hot brine with solids, stagnant and slow moving salty foods). Higher strength than austenitics. Good resistance to stress corrosion cracking in salt solutions at elevated temperatures.
6%Mo. types (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