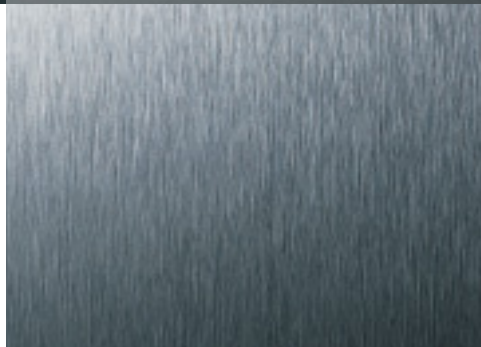
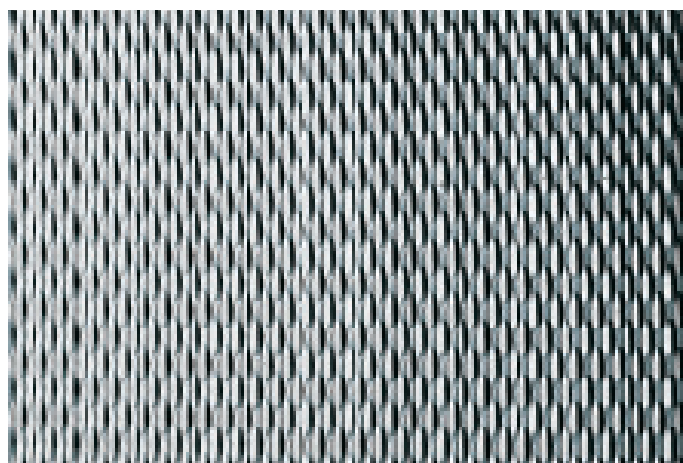


Which Stainless Steel Should I Specify for Exterior Applications?

Stainless steel is one of the most durable materials used in architecture. However, stainless steel is not one material; there are many different types with different properties and, most importantly, different levels of corrosion resistance. If an appropriate stainless steel grade, surface finish, and design are selected and if it is properly maintained, its appearance will remain virtually unchanged over its life. The most commonly used architectural grades are Types 304 (UNS S30400, EN 1.4301) and 316 (UNS S31600, EN 1.4401). Type 304 is suitable for most interior and mildly corrosive exterior applications. If the site is more aggressive, molybdenum-containing Type 316 or an even more corrosion resistant stainless steel may be necessary to avoid corrosion and staining.



Filling out the adjoining form will help you to evaluate the aggressiveness of a particular site and to make a successful material selection. Questions that should be asked when assessing a site are:

1. Will the wind blow salt or pollution toward the site?
2. Is there any corrosion or staining on existing architectural metals near the site?

If the pollution or salt exposure levels in the environment cannot be determined by site examination alone, laboratory testing of an unwashed material sample from the site area can determine the type and concentration of surface contaminants. It is important not to disturb the surface when collecting the sample, because, this could remove or alter the surface deposits.

Select all of the items on the following list that describe the site, design and maintenance schedule. Add up the points and calculate the total site score. Selecting smooth surface finishes, regular manual cleaning or heavy rain-washing, and avoiding sheltered components will reduce the potential corrosiveness of an environment. Surface roughness should be below R_a 20 micro-inches (0.5 microns or micrometers) with a clean-cut finish.

Stainless Steel Selection Based On Site Score

Score

- 0 to 2** Type 304 is the most economical choice.
- 3** Type 316 is the most economical choice.
- 4** Type 317L (UNS S31703, EN 1.4438) or a higher grade of stainless steel is suggested.
- 5+** A higher grade of stainless steel such as 2205 (UNS S32205, EN 1.4462), 904L (UNS N08904, EN 1.4539), 317LMN (UNS S31726, EN 1.4439), a super duplex or a 6% molybdenum austenitic stainless steel may be needed. The advice of a stainless steel corrosion specialist is suggested.

Table 1: Estimated Site and Design Score

Points	Section 1: Environment (select only the one highest applicable score)	Score
	Rural	
0	Very low or no pollution	
	Urban Pollution (light industry, automotive exhaust)	
0	Low	
2	Moderate	
3	High**	
	Industrial Pollution (aggressive gases, soot, iron oxides, chemicals, etc.)	
3	Low or moderate	
4	High **	
	Section 2: Coastal and/or Deicing Salt Exposure (if there is salt exposure, select only the one highest applicable score)	Score
	Coastal or Marine Salt Exposure only	
1	Low (>1.6 to 16 km) (1 to 10 miles from salt water) *	
3	Moderate (30 m to 1.6 km (100 ft to 1 mile) from salt water)	
4	High (<30 m or 100 ft from salt water)	
5	Marine (some salt spray or occasional splashing) **	
10	Severe Marine (regular splashing or immersion) **	
	Deicing Salt Exposure only (distance from road or floor)	
0	No chlorides were detected on a sample from the site and no change in exposure conditions is expected	
0	Traffic levels on nearby roads are too low to generate road mist or wind levels are too low to carry chlorides to the site and no deicing salt is used on sidewalks	
1	Very low (≥ 180 m (600 ft) or 12 floors from salt source) *	
2	Low (30 to 180 m (100 to 600 ft) or up to 12 floors from salt source)*	
3	Moderate (<30 m (100 ft) or 3 floors from salt source) *	
4	High (Direct application or splash zone) **	
	Exposed to Both Coastal and Deicing Salt **	
	Section 3: Local Weather Pattern (select only one)	Score
-1	Temperate or cold climates, regular heavy rain (not sheltered)	
-1	Hot or cold climates with typical humidity below 50%	
0	Temperate or cold climate, occasional heavy rain (not sheltered)	
0	Tropical or subtropical, wet, regular or seasonal very heavy rain (not sheltered)	
1	Temperate climate, infrequent rain, humidity above 50%	
1	Regular very light rain or frequent fog	
2	Hot, humidity above 50%, very low or no rainfall ***	
	Section 4: Design Considerations (Select all that apply)	Score
0	Boldly exposed for easy rain cleaning	
0	Vertical surfaces with a vertical or no finish grain	
-1	Surface finish roughness $\leq R_a$ 0.5 μ m or 20 μ in	
1	Surface finish roughness $> R_a$ 0.5 μ m up to 1 μ m (20 μ in to 40 μ in)	
2	Surface finish roughness $> R_a$ 1 μ m or 40 μ in	
1	Sheltered location	
1	Horizontal surfaces or unsealed crevices	
1	Horizontal finish grain orientation	
	Section 5: Maintenance Schedule (select only one)	Score
0	Not washed	
-1	Washed at least annually	
-2	Washed four or more times per year	
-3	Washed at least monthly	
	Total Score	Total Score

* A sample from the site should be tested to determine if chlorides are present. Some locations of this type are exposed to chlorides but others are not.

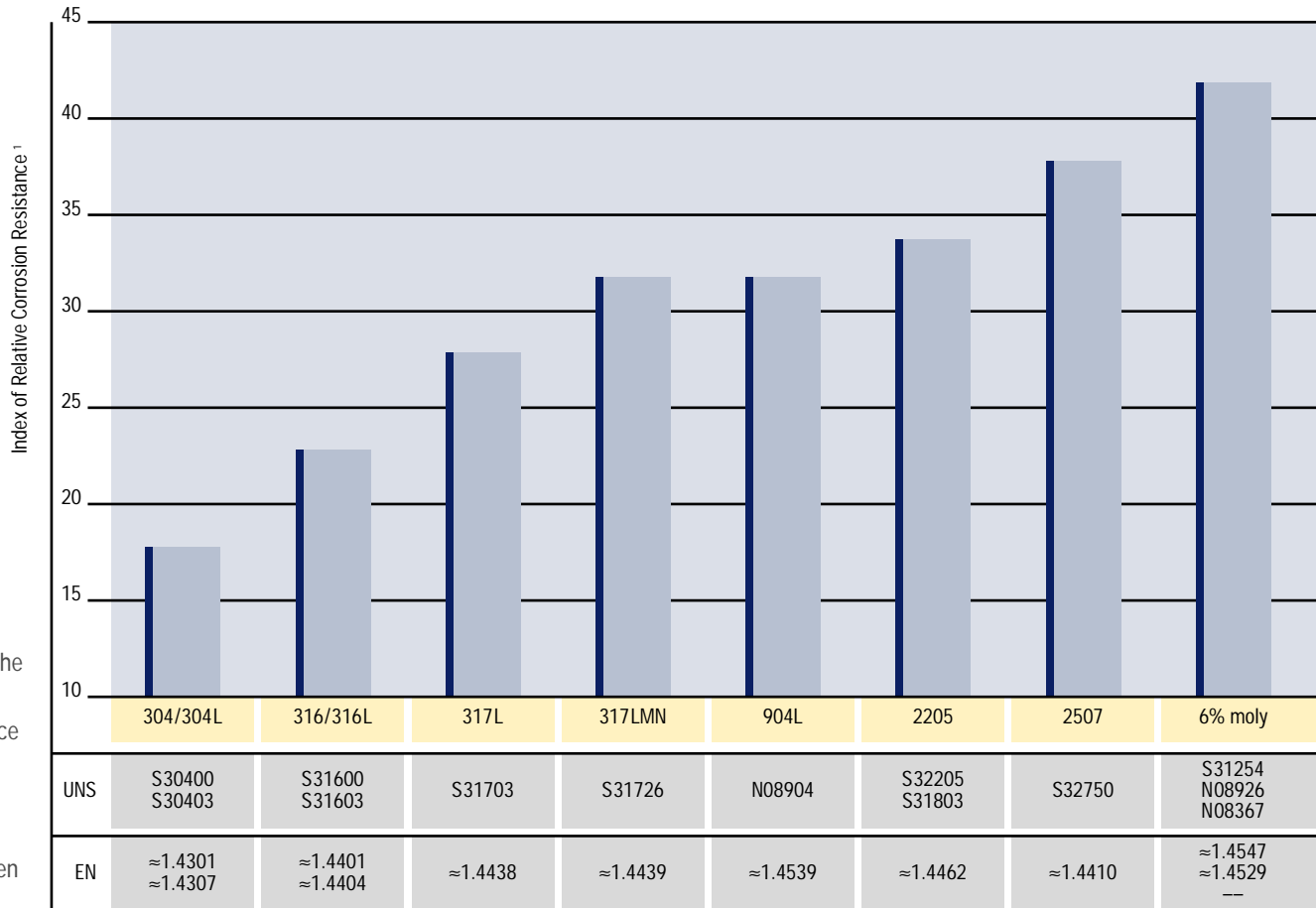
** Potentially a highly corrosive location. Have a stainless steel corrosion expert evaluate the site.

*** If there is also salt or pollution exposure, have a stainless steel corrosion expert evaluate the site.

Corrosion Resistance of Stainless Steels

The composition of a stainless steel has a significant impact on its corrosion resistance. The chromium content in the widely used Type 304 stainless steel is about 18%. This stainless steel does not contain any significant levels of molybdenum or nitrogen. Increasing the chromium, molybdenum and nitrogen content increases the corrosion resistance of stainless steels. Figure 1 shows different stainless steel grades and their pitting corrosion resistance using a common index of relative corrosion resistance.

Figure 1
The index shows the improving pitting corrosion resistance of stainless steels with increasing chromium, molybdenum and nitrogen content.¹



In architectural applications, corrosive environments include those with deicing salt exposure, coastal regions and areas of industrial or heavy urban pollution. The constituents that make these environments corrosive include chlorides from either sea or deicing salts (sodium, potassium and calcium chlorides) and acid rain from exhaust gas condensates generated by power- or chemical plants and cars.

If sufficient chloride levels are present on a stainless steel surface and if the atmosphere is moist, small pits can form leaving unsightly rust on the surface. Moderate to high humidity, fog, or light misty rain supply enough moisture for salt to become corrosive. Corrosion can be avoided by either removing salts or chlorides from the stainless steel surface by thorough washing or by selecting a stainless steel that is corrosion resistant enough to withstand salt exposure. In geographical areas with heavy rain falls, boldly exposed stainless steel surfaces may not need any further treatment to wash-off corrosive deposits from the surface. In other geographical areas or sheltered spots manual washing may be necessary.

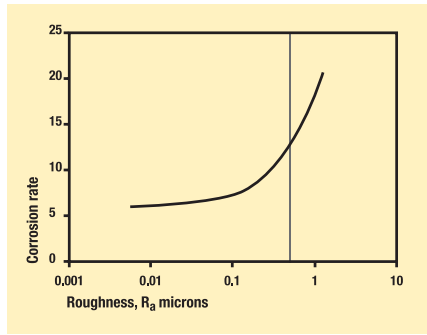
Surface chloride levels can increase significantly with closer proximity to the salt water body, road, or other sources, and over time without heavy rain or manual cleaning of the surface. Stainless steels that are resistant to seawater at ambient temperatures include 2507 super duplex stainless steel and any of the 6% molybdenum super austenitic stainless steels.

Effect of Surface Roughness and Other Design Features

A very smooth surface finish makes it difficult for contaminants to adhere. If they do adhere, they can be washed off more easily from smoother surfaces. A rough surface accumulates more contaminants and the microscopic pockets on the surface make it more difficult for heavy rain and manual washing to remove them. Therefore, a smooth surface finish provides protection against corrosion and staining, and a rough surface finish promotes corrosion and staining.

Figure 2

There is a rapid increase in corrosion rate when the surface roughness is above R_a 20 micro inches (0.5 microns or micrometers).²



and staining. Without regular cleaning, the dirt on horizontal surfaces can look unsightly even without corrosive contaminants. The surfaces immediately below horizontal areas are often streaked with dirty drip marks. Therefore, horizontal surfaces should be avoided unless regular natural or manual cleaning is likely.

Crevice corrosion can occur when water and contaminants remain in tight gaps. Gaps can be avoided by using welded connections or by applying an appropriate sealant.

Maintenance and Cleaning

If a stainless steel is susceptible to corrosion by chlorides or pollution, those substances have to remain on the surface of the stainless steel long enough and in sufficient concentration to initiate corrosion. Frequent cleaning by heavy rain or manual washing prevents corrosive compound accumulation and corrosion. The frequency of manual cleaning required for maintaining a pristine appearance depends on the site environment, surface finish, design, and potential for rain cleaning. If the stainless steel does not provide adequate corrosion resistance, a rough finish is selected, there are horizontal, sheltered surfaces, or there are crevices, then more frequent cleaning will be required. If Type 304 is exposed to coastal environments, deicing salt or aggressive pollution, it may be necessary to clean it four or more times per year to maintain an attractive appearance.

If an appropriate stainless steel, finish and design are selected and there is adequate rain cleaning, an installation may remain attractive over many years of service without manual cleaning. For a pristine appearance, it may only be necessary to thoroughly clean occasionally to remove adherent dirt and hydrocarbons. There are numerous examples of well-designed stainless steel structures, which are rarely or never cleaned.

When cleaning is required, a mild chloride-free detergent, water and degreaser solution are usually sufficient. To remove adherent dirt or staining, a chloride free 200-mesh or finer calcium carbonate powder, or oxalic acid may be used without damaging most finishes. Cleaners with abrasives are not appropriate for colored and other delicate finishes. Some household and "stainless steel" cleaners will damage architectural finishes and should be tested in an inconspicuous location before use.

Abrasive pads and abrasive cleaners that will change the finish should be avoided. Steel wool should never be used on stainless steel because particles will embed in the surface and cause staining of the stainless steel as the transferred iron rusts.

Where Can I Get More Information?

The International Molybdenum Association (IMOA) in the UK has developed case studies on specific architectural applications and environments that can provide more insight into selecting the correct stainless steel (www.imoa.info, Phone: +44-20-8742 2274). The Nickel Development Institute (NiDI) publication No. 11 024, *Stainless Steels in Architecture, Building and Construction: Guidelines for Corrosion Prevention* provides detailed information about evaluating the environment and selecting an appropriate stainless steel. If a stainless steel with more corrosion resistance than Type 316 is needed, request the IMOA publication *Practical Guidelines for Fabrication of Duplex Stainless Steels* and NiDI publication 11 021 *High Performance Stainless Steels* (www.stainlessarchitecture.org; Phone: +1-416-591-7999). Examples of buildings and structures that have performed well over time can be found in the NiDI publication 11 023, *Timeless Stainless Architecture* and the Euro Inox publication, *Stainless Steel Facades*, Building Series, Volume 2 (info@euro-inox.org or www.euro-inox.org).

1 Expressed through their Pitting Resistance Equivalent, $PRE = \%Cr + 3,3*\%Mo + 16*\%N$

2 Surface finishes of stainless steels, Bulletin of the International Dairy Federation No 189, 1985, p3 - 12

International Molybdenum Association
2 Baron's Gate · 33 Rothschild Road · London W4 5HT · UK
Tel: +44 20 87 42 22 74 · Fax: +44 20 87 42 73 45
e-mail: info@imoa.info · www.imoa.info