

Case Study 01 Stainless Steel Handrails and Street Furniture

Moderate Urban Pollution

Moderate to High Deicing Salt Exposure

In downtown Chicago, Illinois, USA, this Type 316 (UNS S31600, EN 1.4401, SUS 316) stainless steel bench and handrail are in pristine condition after five years of service (**Figure A**). The handrail is adjacent to a sidewalk and about 1 meter (a few feet) from a busy road where deicing salt is used. The bench is in an adjoining park.

Type 316 contains 2% molybdenum, which improves pitting and crevice corrosion resistance. This is particularly helpful in preventing salt damage. The use of Type 316, a smooth surface finish, and natural rain and maintenance cleaning keep this street furniture attractive despite the severe environment.



Figure A Specification of Type 316 stainless steel, a smooth finish and a design that takes advantage of rain washing keep this bench and handrail beautiful. (Photo credit – Paul Pittsford)



Figure B Type 304 stainless steel with a rough finish was the wrong choice for handrails exposed to deicing salt laden road mist. Cleaning will remove the staining but it will reappear every year. (Photo credit – TMR Stainless)

In contrast, Type 304 (UNS S30400, EN 1.4301, SUS 304) stainless steel handrails were corroded and badly stained after only one winter in Pittsburgh, Pennsylvania, USA (**Figure B**). The railings were installed the preceding autumn. Type 304 does not contain molybdenum and is therefore more susceptible to chloride corrosion than Type 316.

The railings are located approximately 90 meters (300 feet) uphill from a busy highway. No deicing salt was used on the steps beside the railing. Wind has carried road mist, laden with deicing salts, up the hill and, deposited it on the railings.

The tubing was purchased with a mill finish. During fabrication, a coarse abrasive pad was applied to the surface producing a rough, directional, brushed appearance. The same procedure was used for the bar. Only the small diameter rods have a smooth finish which is why they have significantly less corrosion.

Salt and corrosive pollutants more readily adhere to rough surfaces and even regular heavy rain may not completely remove deposits. The use of rough surface finishes increases the probability of corrosion damage.

Stainless Steel Selection Criteria

The IMOA publication, *Which Stainless Steel Should Be Specified for Exterior Applications?*, provides stainless steel selection assistance. The site and design scores below are based on the guidelines in that brochure. Copies can be obtained at www.imoa.info or by calling IMOA +44 20 8742 2274

Section 1: Environment	Score = 2
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Both sites are surrounded by office buildings and are exposed to a moderate level of urban pollution. Chicago and Pittsburgh have almost identical average sulfur dioxide (0.012 and 0.014 ppm respectively) and air borne (PM10) particulate levels (35 and 40 $\mu\text{g}/\text{m}^3$ respectively). By itself, this pollution level is not high enough to corrode Type 304 or Type 316, but it may cause deterioration of other architectural metals. If higher levels of urban pollution are present, Type 316 or a more corrosion resistant stainless steel might be required.

Section 2: Deicing Salt Exposure	Chicago Score = 3 (bench) and 4 (railing)	Pittsburgh Score = 2
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In many colder climates such as Chicago and Pittsburgh, deicing salt is used to melt ice and snow on roads and sidewalks. Salt becomes corrosive when air temperatures are above freezing.¹ The Chicago project is in close proximity to the road. The railing can be splashed by salt-laden water but the benches are not subject to splashing so their scores are lower. The railings in Pittsburgh are about 90 meters (300 feet) uphill from a busy highway and the wind blows the deicing salt-laden mist uphill. Road salt has been measured on surfaces as far as 200 meters (650 feet) from a busy road.²

Section 3: Local Weather Pattern	Chicago Score = -1	Pittsburgh Score = -1
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Chicago and Pittsburgh have temperate climates with average temperatures ranging from about -7°C to 29°C (9°F to 85°F). Rainfall is fairly evenly distributed throughout the warmer months and average annual precipitation levels are 840 mm (33 inches) in Chicago and 940 mm (37 inches) in Pittsburgh. Both cities have storms with heavy rain combined with high wind levels that wash away surface deposits and neither application is sheltered.

Section 4: Design Considerations	Chicago Score = 0 to -1	Pittsburgh Score = 2
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In both designs, crevices are sealed and the designs generally encourage rain-washing. The Chicago benches have some sheltered areas and the railings have some horizontal surfaces. The smooth finish in Chicago retains less salt and it is more easily washed off by rain, but this advantage does not help in the sheltered areas under the benches where corrosive deposits can accumulate giving them a higher score. Salt adheres to the rough finish ($> R_a$ 1 μm or 40 μin) in Pittsburgh and rain cleaning is less effective. This increases the score. A smooth finish is defined as a surface roughness that is less than or equal to R_a 0.5 μm or 20 μin .

Section 5: Maintenance Schedule	Chicago Score = -1	Pittsburgh Score = 0
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The Chicago application is washed annually after the last snowfall to remove salt deposits. The railings in Pittsburgh had not been washed since their installation the previous year when this photo was taken.

Stainless Steel Selection	Total:	Chicago Score = 3	Pittsburgh Score = 5
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Type 316 is usually the most cost effective solution for street level applications where deicing salt is used, particularly if a smooth surface finish is specified and salt deposits are washed off manually after the last snowfall of the season or if heavy rains can wash the surface. The Chicago bench and railing scores differ in two of the evaluation categories above but both have a total score of 3 making Type 316 an appropriate material choice.

Type 304 will stain and corrode when exposed to deicing salt. Refinishing the railing to obtain a smooth finish which minimizes deicing salt accumulation ($\leq R_a$ 0.5 μm or 20 μin) could reduce the Pittsburgh score to a 2, indicating that 304 can be considered. Alternatively, the railing could be cleaned regularly. Even with a smoother finish, there may be some corrosion staining of Type 304 over time and occasional cleaning may be required. If airborne dust in the warmer months contains measurable salt levels, more frequent cleaning may be necessary.

- 1 Calcium chloride becomes corrosive at 0°C (32°F) and 45% humidity and sodium chloride becomes corrosive at 10°C (50°F) and 76% humidity. Both chlorides are used in deicing products.
- 2 A series of scientific studies on deicing salt aerosols at the Royal Military College of Canada found measurable chloride corrosion on metal samples as far as 200 meters (656 feet) from Highway 401. Under certain conditions, salt may be carried even farther.

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