DESIGNER

HANDBOOK

STAINLESS

STEEL

ARCHITECTURAL

FACTS

Rising to a height of 630 feet, Jefferson National Expansion Memorial in St. Louis, Mo., is faced with Type 304 stainless steel plates with a polished finish. Because of stainless' resistance to corrosion and weathering, the gleam of the catenary arch, visible for over 30 miles, will be permanent.

Architect:
Eero Saarinen.

Cover:
Society Tower, Cleveland, OH

The Society Tower project has a penthouse covered in panels of stainless steel, making the roof a distinctive cap. The panel system consists of 22-gauge stainless steel for both the exterior and interior. Most panels have a pattern which was applied by Rigidized Metals Corporation of Buffalo, NY. The customer was Flower City Architectural Metals, Glen Cove, NY, and the panels were manufactured by E.G. Smith of Pittsburgh, PA.

Architect:
Kendall/Heaton Associations, Inc.
and Cesar Pelli & Associates

WHY DESIGN IN STAINLESS STEEL?

Stainless steel is a series of steel alloys which includes at least 10.5 percent chromium. Most grades used in architecture also include a percentage of nickel, and manganese, molybdenum, or other elements may be added for special characteristics. Because of its appearance, strength and high corrosion resistance, stainless steel is finding increasingly wide use in architecture for both exterior and interior applications. This fact sheet has been prepared to give architects and architectural students most of the basic data they will need to put stainless steel to work effectively. The fact sheet provides information on the characteristics of the metal, the forms in which it is available, alloys and finishes most commonly specified for architectural purposes, and suggestions on design and maintenance.

Stainless steel has certain inherent advantages that make it ideal for a wide variety of architectural applications. Chief among these is its resistance to corrosion. Under normal conditions, stainless is unlikely to corrode, pit, tarnish, or deteriorate in any other way. There is no need to compensate for loss of strength due to deterioration, and replacement costs are virtually non-existent.

From the esthetic viewpoint, stainless is notable for its inherent beauty and the ease with which it blends with other materials. It has a subtle sheen which does not overwhelm or intrude on other design and color elements; rather, it complements, reflects and highlights surrounding materials. Because of its corrosion resistance, its appearance is permanent, and there is no danger of corrosion products streaking or staining other materials.

Stainless is among the strongest of metals. Tensile strengths of 75,000 to 125,000 psi (or higher if needed) often allow the use of gauges much lighter than are usually needed in other metals. Sturdy design elements, fabricated from thin sheets of stainless, can combine light weight with strength.

A corollary of stainless' high life expectancy is the ease with which it can be maintained. In an urban or industrial atmosphere all that is generally needed is a washing with detergent and water or with one of the commercial stainless steel cleaners. This can often be handled in the course of the regular window washing operation. In many circumstances, however, washing can be left to the action of rain and wind, with no fear that the metal will deteriorate. Savings that accrue from the low cost of maintaining stainless can make up any difference in cost that may appear between components made of stainless and other materials. Result: in the long run, stainless is one of the most economical of architectural metals.

The Specialty Steel Industry of North America has a life cycle costing computer diskette program available free of charge that will compare stainless with other materials.

Stainless steel is produced in virtually all standard metal forms and sizes, plus many special shapes. Sheet and strip stainless are the products most often formed into architectural components. The designation strip is used for widths of metal less than 24 inches, while sheet refers to 24 inch and greater widths. Sheet and strip forms are available in practical architectural thicknesses from .010 inch and up (or as low as .001 inch for special applications). Heavier plate material is also available, over 10 inches in width and 3/16 inch and over in thickness.

Stainless steels are also produced in the form of tubing—round, oval, square, rectangular and hexagonal, both welded and seamless. Welded tubing is made up to 30 inches in diameter, seamless up to 8 inches. Other available forms include bars and rods of similar shapes as well as wire and extrusions.

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ALLOY TYPE DESIGNATIONS

304 is the basic chromium-nickel austenitic stainless steel and has been found suitable for the widest range of applications in all kinds of architectural work. It is the most readily available in a variety of forms. This type is easy to form and fabricate with excellent resistance to corrosion from exposure to weather. It is the grade which is normally used for exterior architectural applications.

304L is a low carbon variation of 304 having slightly higher corrosion resistance. It is sometimes specified where extensive welding of heavy sections will be done.

316 offers more corrosion resistance through the addition of molybdenum. This type is desirable where severe corrosion conditions exist, such as heavy industrial atmospheres and marine environments.

316L is a low carbon variation of 316. It is sometimes specified where extensive welding of heavy sections will be done.

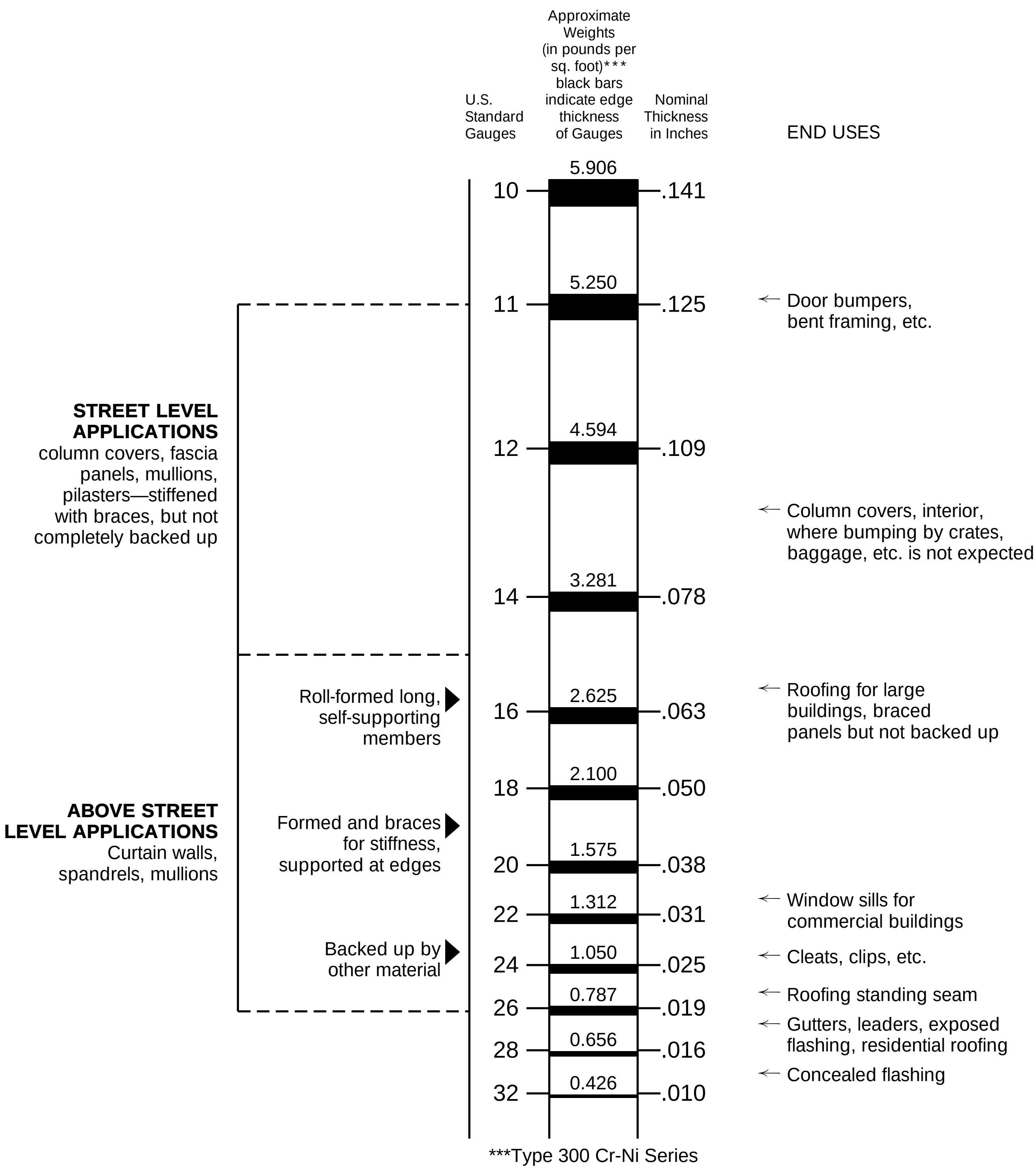
430 is a chromium ferritic stainless steel with lower corrosion resistance than the 300 series. It is principally employed for interior use.

305 and **410** are used for bolts, nuts, screws, and other fasteners.

PRODUCT FORMS

Item	Description	Dimensions		
		Thickness	**Width**	**Diameter or Size**
Sheet	Coils and cut lengths: Mill finishes Nos. 1, 2D & 2B Pol. finishes Nos. 3, 4, 6, 7 & 8	 under 3/16" (4.76 mm) " " "	 24" (609.6 mm) & over all widths	—
Strip	Cold finished, coils or cut lengths Pol. finishes Nos. 3, 4, 6, 7 & 8	under 3/16" (4.76 mm) " " "	under 24" (609.6 mm) all widths	—
Plate	Flat rolled or forged	3/16" (4.76 mm) & over	over 10" (254 mm)	—
Bar	Hot finished rounds, squares, octagons and hexagons	—	—	1/4" (6.35 mm) & over
	Hot finished flats	1/8" (3.18 mm) to 8" (203 mm) incl.	1/4" (6.35 mm) to 10" (254 mm) incl.	—
	Cold finished rounds, squares, octagons and hexagons	—	—	over 1/8" (3.18 mm)
	Cold finished flats	1/8" (3.18 mm) to 4½" (114 mm)	3/8" (9.53 mm) to 4½" (114 mm)	—
Wire	Cold finishes only: (In coil) Round, square, octagon, hexagon, flat wire	under 3/16" (4.76 mm)	under 3/8" (9.53 mm)	—
Pipe & Tubing	Several different classifications, with differing specifications, are available. For information on standard sizes consult your local Steel Service Center or the SSINA.			
Extrusions	Not considered “standard” shapes, but of potentially wide interest. Currently limited in size to approximately 6½" (165.1 mm) diameter, or structurals.			

THICKNESS OF STAINLESS STEEL USED IN ARCHITECTURAL APPLICATIONS



SHEET FINISH DESIGNATIONS

The SSINA has a handbook available free of charge on the "Finishes for Stainless Steel."

Unpolished Finish (Rolled) No. 1†	A dull finish produced by hot rolling to the specified thickness, followed by annealing and descaling.
Unpolished Finish (Rolled) No. 2D*†	A dull finish produced by cold rolling to the specified thickness, followed by annealing and descaling. May also be accomplished by a final light roll pass on dull rolls.
Unpolished Finish (Rolled) No. 2B*†	A bright finish commonly produced in the same way as No. 2D finish except that the annealed and descaled sheet receives a final light cold roll pass on polished rolls. This is a general purpose cold rolled finish, and is more readily polished than the No. 1 or No. 2D finishes.
Bright Annealed	A bright, cold rolled, highly reflective mirror-like appearance. Often specified for architectural applications.
Polished Finish No. 3†	An intermediate polished finish generally used where a semi-polished surface is required for subsequent finishing operations following fabrication.
Polished Finish No. 4†	A general purpose bright polished finish obtained with a 120-150 mesh abrasive, following initial grinding with coarser abrasives.
Polished Finish No. 6†	A soft satin finish having lower reflectivity than No. 4 finish. It is produced by Tampico brushing the No. 4 finish in a medium of abrasive and oil.
Polished Finish No. 7†	A highly reflective finish produced by buffing a surface which has first been finely ground with abrasives, but "grit" lines are not removed.
Polished Finish No. 8†	The most reflective finish commonly produced. It is obtained by polishing with successively finer abrasives, then buffing extensively with a very fine buffing compound to remove essentially all "grit" lines.
Specials	A wide variety of polished, embossed, patterned, textured, engraved and coated finishes are available on special inquiry.

* No. 1 and 2 finishes for strip (widths under 24") approximate No. 2D and 2B sheet finishes respectively, in the corresponding alloy types.
† As designated in the Steel Products Manual "Stainless and Heat Resisting Steels," AIME.

BAR AND PLATE FINISH DESIGNATIONS

CONDITIONS & FINISHES FOR BAR

Conditions	Surface Finishes*
1. Hot worked only	(a) Scale not removed (excluding spot conditioning) (b) Rough turned** (c) Pickled or blast cleaned and pickled
2. Annealed or otherwise heat treated	(a) Scale not removed (excluding spot conditioning) (b) Rough turned (c) Pickled or blast cleaned and pickled (d) Cold drawn or cold rolled (e) Ground (f) Polished
3. Annealed and cold worked to high tensile strength***	(d) Cold drawn or cold rolled (e) Ground (f) Polished

* Surface finishes (b), (e) and (f) are applicable to round bars only.
** Bars of the 4XX series stainless steels which are highly hardenable, such as Types 414, 420, 420F, 431, 440A, 440B and 440C, are annealed before rough turning. Other hardenable grades, such as Types 403, 410, 416 and 416Se, may also require annealing depending on their composition and size.
*** Produced in Types 302, 303Se, 304 and 316.

For more information on finishes refer to the Architectural Metal Products Division of the National Association of Architectural Metal Manufacturers "Finishes for Stainless Steel" AMP 503-88.

CONDITIONS & FINISHES FOR PLATE

Condition and Finish	Description and Remarks
Hot rolled	Scale not removed. Not heat treated. Plates not recommended for final use in this condition.*
Hot rolled, annealed or heat treated	Scale not removed. Use of plates in this condition is generally confined to heat resisting applications. Scale impairs corrosion resistance.*
Hot rolled, annealed or heat treated, blast cleaned or pickled	Condition and finish commonly preferred for corrosion resisting and most heat resisting applications.
Hot rolled, annealed descaled and temper passed	Smoother finish for specialized applications.
Hot rolled, annealed descaled cold rolled, annealed, descaled, optionally temper passed	Smooth finish with greater freedom from surface imperfections than the above.
Hot rolled, annealed or heat treated, surface cleaned and polished	Polished finishes: refer to sheet finishes.

* Surface inspection is not practical on plates which have not been pickled or otherwise descaled.

DESIGNING IN STAINLESS STEEL

The SSINA has a designer handbook available free of charge called "The Selection & Use of Stainless Steel."

As with any material used in building, the cost of stainless steel construction varies depending on design requirements and solutions. Costs will be higher for elaborate, unique or complex detailing than for simplified, standardized designs. Thus stainless structures can range from quite costly to most economical. The following recommendations will be helpful in achieving economy in stainless steel designs:

1. Design hollow sections in shapes which can be fabricated by common sheet metal techniques (see below). Simple straight-line bends are easy to form; avoid short return bends or jogs, which make fabrication difficult.
2. Reduce gauge. Research reveals that Type 304 stainless steel sheet, for example, has at least three times greater tensile strength than aluminum sheet. Architects can take advantage of this strength by reducing gauges.
3. Metal thickness can be reduced by designing formed sections, or by using textured or die-pressed sheet for broad areas.
4. Design self-framing units to eliminate the need for structural steel backup, which adds weight and cost.
5. Where possible, incorporate commercial parts and details standardized by fabricators. Elaborate custom detailing naturally costs more.

JOINING CONSIDERATIONS

Stainless steels are readily welded, and, unlike most other materials, the work area can be blended for uniformity of appearance when polished finishes are used. Spot welding, on the other hand, has little effect on the surface, and refinishing is minimized or completely eliminated.

When fasteners are used, these should always be of stainless steel. Corrosion products from non-stainless fasteners can streak and mar the entire installation.

Fasteners which go through a metal face must be located carefully so that there will be no distortion when they are pulled tight. Otherwise, extra gauge will be needed to resist distortion.

Other means of preventing "dimpling" are the placement of reinforcing pads under screw heads, and the use of a hat channel on the inside of a metal component. In the latter case, the nut is fastened to the hat channel so that the pull of the fastener is distributed over a large area of the metal face.

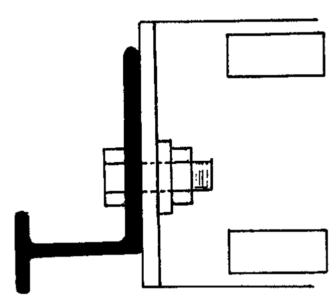
The SSINA has a handbook available free of charge on the "Selection of Stainless Steel Fasteners."

The Fresno City Hall, Fresno, California, features the second largest stainless steel roof in the U.S., over two acres of stainless steel. Stainless also used for interior applications. The fabricator and installer was Zahner Architectural Metals of Kansas City, Kansas.

Architect:
Arthur Erickson

Both the 3-story landside building and the X-shaped airside building of the Pittsburgh International Airport feature an airy concourse with 80-ft. radius barrel roofs of terne-coated stainless steel. Each roof is 150 squares of .015 terne-coated type 304 stainless steel (TCS). Panels for the standing seam roof were 24" wide and 126" long. TCS is manufactured by Follansbee Steel, Follansbee, WV and was applied by General Roofing Company, Bridgeville, PA.

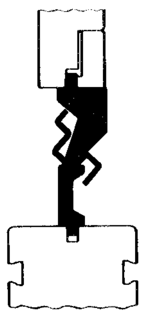
Architect:
Katselas & Associates



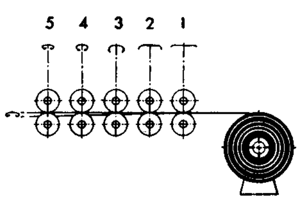
After failure of the original anchoring systems, 43,000 new granite panels have been installed on the Amoco Building, Chicago, IL. using a stainless steel stone veneer anchoring system. The devices (as illustrated) are bolted to adjustment clips, which are attached to studs that are welded to the building's structural frame. Stainless steel was selected for its strength, durability and resistance to corrosion and wind fatigue.

Stainless steel was used for the column covers and storefronts as well as the mullion cladding for the I.B.M. Building in Kansas City. The fabricator was Zahner Architectural Metals of Kansas City, Kansas.

Architect:
Black & Veach



Typical power break forming tooling. Dies shown in blue.



Stages of formation in typical roll forming operation.

FABRICATION METHODS

Stainless steel can be fabricated by all standard methods used for metal including casting, machining, stamping, spinning and extruding. The most widely used methods for the fabrication of architectural components of sheet and strip metal are brake forming and roll forming.

Brake forming is a manually fed bending operation utilizing a relatively simple hand or power-operated brake press. Although designs must be simple, formation can be on one, two, or (to a limited extent) three planes. This is the most economical method if a small number of pieces are to be formed.

Roll forming is an automated, continuous process using special roller-die equipment. This is the most economical method for forming a large quantity of pieces, and is widely used in manufacturing stock window and curtain wall framing components.

In recent years the cost of stainless steel components has been decreasing to the point where it is competitive with other metals. This is partly due to increased use of roll forming equipment by fabricators of stainless steel components. Equally responsible is the growing tendency of architects and specification writers to write performance type rather than construction type specs. Specifications which require stainless sections as thick as aluminum ones put an unnecessary cost disadvantage on the stronger stainless. Performance type specs are based on putting strength where it is needed. The result: stainless steel's greater strength is used to full advantage, thus reducing costs.

The SSINA has available free of charge a handbook on the "Fabrication of Stainless Steel."

DESIGNING FOR MINIMUM MAINTENANCE

Design considerations can assist stainless steel's superior wear and corrosion-resisting characteristics in reducing long-term maintenance costs. On exterior applications out of easy reach, where airborne dirt accumulations cannot be prevented, good design can reduce maintenance requirements. In this connection, the following suggestions are offered:

1. Use the smoothest finish, whether flat or textured, that will provide the desired appearance and necessary rigidity.
2. When textures or patterns are indicated, use impressions in the vertical direction. Horizontal shapes collect more dirt, can cause uneven streaking.
3. Avoid designs that concentrate flow of water on an exterior surface. Massive overhangs that project beyond lower building areas should be avoided to prevent streaking with dirt-laden water. These massive overhangs will also shield surfaces below from the natural cleaning action of rain.
4. Avoid or minimize flat horizontal surfaces such as window sills and soffits, or channel dirt drainage through drips and weep holes. Drainage should be confined to the rear of panels.
5. In designing joints, provide drainage for water that may penetrate. Joint faces should include a device to eliminate capillary action.
6. Eliminate drainage from other materials, such as chloride-bearing cements, slag roofs and other corrosive materials.
7. Avoid direct contact between stainless steels and other less corrosion-resistant metals such as carbon steel and zinc. Under certain conditions, e.g. in the extended presence of poorly drained contaminated water, electrolytic action may result and the less corrosion-resistant metal may suffer accelerated corrosion through galvanic attack.

TO ELIMINATE DISTORTION

Whenever a light gauge reflective material is used over a broad area, optical distortion or, "oil canning," may be a problem. Any of the following steps can be taken to avoid oil canning when designing in stainless:

1. Use slight concave panels to eliminate all flat reflective surfaces.
2. Back light gauge stainless sheet with a stiff material.
3. Use a panel with a shallow, die-pressed design.
4. Break up the reflective surface by using textured stainless steel or by using a less reflective finish, or a combination of finishes.
5. Specify a relatively heavy gauge, so there will be no danger of buckling.

Stainless Steel *The Value Option*®

EFFECTIVE CLEANING METHODS

Job	Cleaning Agents*	Comments
Routine Cleaning	Warm Water, Soap, Ammonia, Detergent	Apply with sponge or soft cloth. Can be used on all finishes.
Fingerprints and Smears	3M Stainless Steel Cleaner and Polish, Arcal 20, Lac-O-Nu, Lumin Wash, O'Cedar Cream Polish, Stainless Shine	Provides barrier film to minimize fingerprints. Can be used on all finishes.
Stubborn Stains and Discoloration	3M Stainless Steel Cleaner and Polish, Allchem Concentrated Cleaner, Samae, Twinkle, Cameo Copper Cleaner, Grade FFF or Grade F Italian Pumice, Whiting or talc, Liquid Nu Steel, Copper's or Revere Stainless Steel Cleaner, Household Cleaners, Lumin Cleaner, Zud Restoro, Sta-Clean, Highlite, Allen Polish, Penny-Brite, Copper-Brite	Rub lightly, using dry damp cloth, in the direction of polish lines on the stainless steel.
Grease and Blood Burnt-on or Baked-on Foods	Scotch-Brite Power Pad 2001, Easy-Off, De-Grease-It, 4% to 6% hot solution of such agents as tri-sodium polyphosphate, 5% to 15% caustic soda solution	Excellent removal on acids, all finishes. Particularly useful where rubbing is not practical.
Grease and Oil	Any good commercial detergent or caustic cleanser.	Apply with sponge or soft cloth in direction of polish lines.

*NOTE: Use of proprietary names is intended only to indicate a type of cleaner and does not constitute an dorsement. Omission of any proprietary cleanser does not imply its inadequacy. All products should be used in strict accordance with instructions on package.

Galvanic Corrosion. This is one potential hazard the designer should recognize when the detail calls for dissimilar metals (any metals) to be in contact with each other.

In a corrosive medium, the dissimilar metals form short-circuited electrodes, which establish an electro-chemical cell. This action results in the dissolution of the anodic electrode, whereas the cathode remains unattacked. The potential varies with the position of the metals and alloys on the following galvanic series chart. The closer to the bottom of the list a metal is, the more anodic it is, and it will suffer accelerated corrosion when coupled with a metal listed above it. The farther apart the metals are on this list, the greater the corrosive action on the anode metal.

The relative mass of each metal must also be considered. A large mass of the less noble metal weakens the potential for galvanic action. For instance, stainless steel in contact with a structural steel system does not appreciably affect the structural steel in terms of galvanic corrosion.

No problems occur when stainless steel screws are used to assemble an aluminum window. The use of aluminum screws in a stainless steel window can cause serious corrosion problems with the screws. This occurs when the dissimilar metals are in contact with each other. An insulator between the two solves the problem.

Contact Corrosion. A small piece of carbon steel, scale, copper, or foreign material lodged on stainless steel may be sufficient to destroy passivity at the point of contact and cause pitting. Contact corrosion can easily be prevented by ensuring that stainless building components are clean and free from scale, small particles of metal, etc.

GALVANIC SERIES OF METALS AND ALLOYS IN SEAWATER[a]

Gold
Monel
Stainless type 316
Stainless type 304
Stainless type 430
Silver
Aluminum bronze
Copper
Red brass
Yellow brass
Muntz metal
Cast iron
Alloy steel
Low steel
Aluminum 5052
Aluminum 6063
Aluminum 6061
Aluminum 3003
Alclad 3003
Zinc
Magnesium

[a] The series proceeds from more noble (at the top) cathodic to less noble anodic metals and alloys.

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