Stainless Steel - *the modern material with a 60 year track record.*

The term "stainless steel" is used to describe over one hundred different stainless steels, with each one tailor-made to give outstanding performance in specific applications. The key to successful use is understanding the application and then specifying the correct type from the six generally associated with Architectural and Building products.

Grade Typical Chemical Composition

430	17% Cr		0.07% C	
304L	18% Cr	10.0% Ni	0.03% C	
304	18% Cr	10.0% Ni	0.06% C	
316L	17% Cr	12.0% Ni	0.03% C	2.5% Mo
316	17% Cr	12.0% Ni	0.06% C	2.5% Mo
2205	22% Cr	5.5% Ni	0.03% C	3.0% Mo

Why do stainless steels resist corrosion?

All metals react with oxygen in the air to form a film of oxide on the surface. The oxide formed on ordinary steel allows the oxidation to continue producing the typical rusty appearance. However,- because stainless steels contain more than 11 % chromium, the characteristics of the oxide are changed. Further oxidation is prevented and if the film is accidentally removed, a new one forms to continue the protection.

In practice, stainless steel contain at least 18% chromium. The most frequently used grades also contain at least 8% nickel.

Typical Uses

Type 430 stainless steel performs reasonably well indoors, but steels containing nickel are required for satisfactory service outdoors. Type 304 is widely used for curtain walling, side walling, roofing etc. but Type 316 stainless steel is preferable for coastal regions and locations where atmospheric pollution is a problem. Guidance on selection can be obtained from the companion brochure "Advantages for Architects".

The European specification Eurocode 3 Part 1.4, will include Grades 304L, 316L and 2205 for structural applications.

Product forms

Stainless steel is produced in virtually all standard metal forms and sizes, plus many special shapes and castings. The most commonly used products are made from thin sheet and strip.

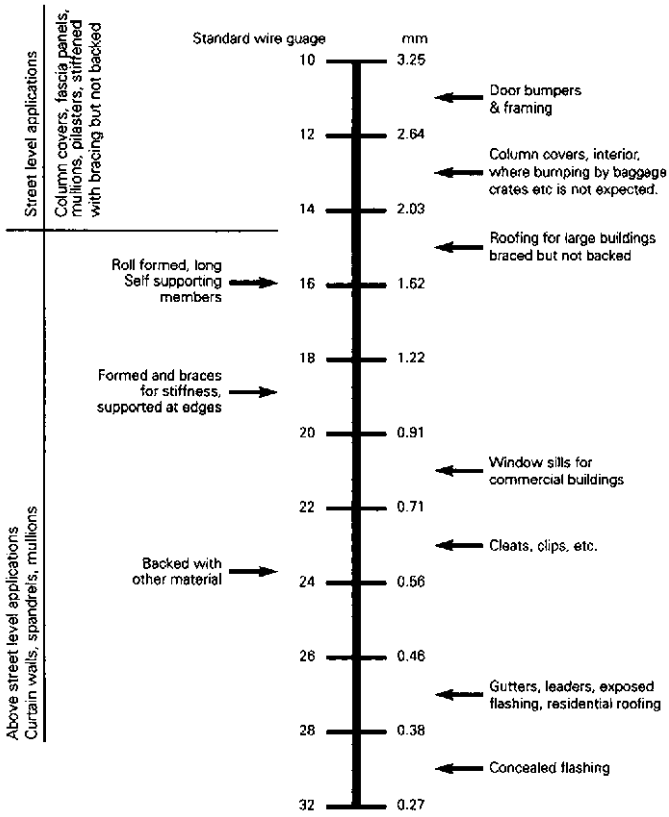
Surface appearance

A wide range of commercial surface finishes is available. The surface can be highly reflective or matt; smooth, brushed or embossed; painted, coloured or even coated with terne alloy to produce an appearance similar to lead.

Fabrication

Techniques used for welding, forming and cutting ordinary carbon steel can be used for stainless steel, but adjustments in equipment settings and recognition of the higher strength of stainless steel will be required. When these differences are accommodated, stainless steel can be readily fabricated.

Thickness of Stainless Steel used in Architectural applications



Design

For over 60 years, architects have used stainless steel to produce permanent expressions of their design concepts. Some, such as the Chrysler Building in New York City, are highly visible, but there are many other external and interior applications where stainless steel plays a less dramatic but vital role in the aesthetics and performance of a building. Stainless steel's role as a long life, high integrity structural material is recognised by design codes such as the American Society of Civil Engineers standard ANSI/ASCE - 8 - 90 "Specification for the Design of Cold Formed Stainless Steel Structural Members" and the "Design Manual for Structural Stainless Steel" published by the Nickel Development Institute in conjunction with Euro Inox.

Future

Stainless steel already has many ideal characteristics required for an architectural material - but its development continues.

Existing types have been improved to give even better performance and new steels are being marketed to meet the demands of advanced architectural applications.

Maintenance and Cleaning

Introduction

For over half a century, stainless steel has provided architects with the means to produce a permanent expression of their design concepts. This visual permanency is due to the material's excellent resistance to corrosion allowing the surface to retain its original appearance indefinitely. Over the same time period, the surface appearance options for stainless steel have been continuously increasing. Consequently, it is not surprising that stainless steel has been specified with confidence by generations of architects for so many indoor and outdoor applications (1).

However, like any other building material, stainless steel may become soiled in service by the deposition of airborne dirt, by accidental damage or through acts of vandalism.

This brochure provides guidance on cleaning techniques that are appropriate for typical service situations. Some aspects of design that can simplify cleaning and minimise maintenance costs are also indicated.

P L Decletey

Built in 1929, the Chrysler Building's tower and gargoyles are clad with chromium - nickel stainless steel, S 30200, using batten roll and standing seam techniques. Although they have only been cleaned twice in nearly seventy years, they continue to make their gleaming statement on the New York skyline.

Design

(a) General

Considering maintenance and cleaning aspects during the design of a building can have a major effect on future ownership costs. For instance, irrespective of the material selected for the envelope, the cleaning requirements of a building can be greatly influenced by the success achieved in designing out opportunities for dirt to collect and by optimising the effectiveness of rain washing.

Some guide lines are :

- The total area of horizontal surfaces should be minimised. In addition to looking unsightly, the dust and dirt collected on them could also produce streaking on lower areas when it is subsequently washed off by rain. If an embossed stainless steel is used for these locations, it is preferable to select one that has a continuous path between the embossing to allow the surface to drain freely.
- The beneficial effect of rain should be optimised by ensuring that rain washing occurs as uniformly as possible. Concentrating or directing the flow of rain water down the wall of a building must be avoided, in order to prevent localised streaking. Similarly, the size of any overhangs should be chosen such that the higher ones project further than the lower ones, and the design should avoid introducing areas that would be sheltered from the rain.
- Cleaning should be made as easy as possible and excessively complex contours should be avoided. Special attention should be given to any features, canopies or soffits located at low levels where they are readily visible from the street. Obviously, facilities for doing the cleaning should be specified, e.g. gondolas and external water points on large buildings.

(b) ***Stainless steel***

When stainless steel is used, the cleaning requirements can be minimised by selecting the most appropriate type of steel for the location. In general, stainless steels containing at least 18% chromium and 8% nickel should be specified, but detailed guidance is available (2). It is also good practice to identify locations that are potentially more likely to get soiled or damaged by passing traffic and accommodate this in the design.

Some specific design aspects are :

- The type of surface specified together with the local environment and the aesthetic requirements will influence the cleaning regime. A guide to the commercially available surface finishes is given in a companion brochure (2). If a hairline or number 4 type of finish is chosen, it is preferable to have the "grain" running vertically for ease of drainage. As might be expected, rough surfaces tend to retain airborne dirt more than smooth ones, but the high reflectivity of the latter may be undesirable for aesthetic reasons. However, many embossed surfaces combine the inherent smoothness of a bright annealed surface with "micro indentations" to offer a low reflectivity, lustrous sheen. Alternatively, coloured and painted surfaces combine a smooth surface with low reflectivity and colour.

- Joints should be designed to permit minimum dirt accumulation. Capillary action should also be eliminated by using a sealant or having a gap large enough to permit speedy draining.

- The detail should include provision for avoiding galvanic corrosion by using clips and fasteners made from stainless steel or by electrically insulating stainless steel from components made from other metals.

- The design should avoid the possibility of drainage from other materials contaminating the stainless steel surface, e.g. carbon steel, weathering steel, chloride-bearing cements, mastics and sealants, etc.

- It is important to consider the effect of abrasion and soiling in locations where pedestrian traffic is high. In such locations, a bright annealed or polished surface will show scratches more than an embossed, hairline or number 4 type of finish. A 2B or 2D finish is not recommended because their surfaces are very susceptible to finger marking and scratches are impossible to rectify without completely altering the surface appearance.

- In locations where mechanical damage is likely to occur, it is prudent to consider using a detachable type of fixing system to permit economical panel replacement.

- As with other fully finished materials, the design specification should include means to preserve the surface during transportation, storage and erection. Dry storage under cover is preferred, particularly if an absorptive wrapping such as cardboard has been used, otherwise this might stain the surface.

- Precautions should be taken to prevent people walking on the steel, but if it is necessary to walk on the surface, soft soled shoes should be specified. Similarly, if sheets are to be removed from a stack, they should not be slid over each other. It is better to turn them from the stack and lift them off.

- Although good working practices are adopted on most building sites, the possibility of accidental damage is always present. For instance, splashing by mud, cement or mortar from adjacent work is not unknown. Consequently, a plastic film is often specified to protect the surface and also stop airborne dirt depositing on it. This can minimise, or in many instances completely avoid, the cost of an initial clean. Some architects specify that the artefacts are placed in a loose plastic "bag". Alternatively, the practice in some countries is to specify that a plastic film be stuck on the surface before delivery to site. However, if an adhesive plastic film is specified then it should be obtained from a technically competent manufacturer who can advise on the choice of film material, type of adhesive and guarantee the maximum time that can be allowed before stripping. The reason is that prolonged exposure to heat and sun-light can make stripping difficult and cause adhesive to be retained on the stainless steel surface - producing a major increase in cleaning costs.

Cleaning and Maintenance

Although there are a few exceptions, such as industrial roofing, most building components, whether located inside or outside, require cleaning at some time.

In practice, there are three main types of cleaning situations :

(1) Initial cleaning prior to handing over to the client.

(2) Routine cleaning during service.

(3) Exceptional cleaning caused by vandalism, accidents or neglect.

"Bare" Stainless Steel

The objective is to restore the original appearance of the component and, in this respect, the surface hardness and good resistance to corrosion of stainless steel are valuable assets that can be exploited during cleaning.

(a) Initial Cleaning.

In common with many other building materials, stainless steel arrives on site with its surface in the finished condition.

If an adhesive plastic film has been used to protect the surface, it should be kept in place as long as possible, so that the dust and debris generated during construction settle on it instead of on the steel's surface. For instance, in the case of curtain walling, stripping the plastic film is left until just before the building is "handed over." By starting to strip the film at the top of the building and working down to the base any dirt and debris falls to the protected lower layers and the pristine surface is exposed for the client. In the past, there were occasions when the stainless steel's surface might retain a small amount of adhesive after stripping (3). Nowadays, improvements in film and adhesive technology make this very unlikely, particularly if the adhesive plastic film has been obtained from a technically competent producer and their

D J Cochrane

Although it is interesting to see that stainless steel was able to accommodate the foibles of the Art Deco period when this canopy was erected at the Savoy Hotel in London, the re-entrant angles and sheltered regions of the design are not the sort of thing that make cleaning easy.

However, the chromium - nickel stainless steel, S 30400, still looks as good as it did when installed in the early 1930's, in spite of having lived through the notoriously polluted atmosphere in London during the first half of this century.

advice on usage has been followed. However, if there is a need to check whether adhesive retention has occurred, this can be done by visual inspection. If adhesive is present, a four stage cleaning procedure has been suggested by Smit (3).

1 Pre-clean the surface with a slow-evaporating solvent that is compatible with water and has low toxicity. Rub the solvent onto the surface with a cloth or brush it on with a long-fibre nylon brush, using light strokes. Wipe the solvent off with a clean cloth before it has dried in order to avoid merely spreading the residue around.

2 Clean the surface by wiping or brushing with a detergent solution.

3 Rinse with water at ambient temperature.

4 Dry, using a squeegee if possible.

The type of solvent required will depend on the adhesive used. It has been reported that methylene ethylene ketone could be suitable for rubber resin and methanol for acrylic type adhesives (4). However, advice should be taken from the plastic film manufacturer. Obviously, any associated health, safety and environmental aspects must be followed.

If the stainless steel surface has not been protected, then an initial cleaning may be required before handing over. A typical procedure would be:

1 Rinse with water to remove loose dirt.

2 Wash with water containing soap, detergent or 5% ammonia, using a soft, long-fibre brush if necessary.

3 Rinse with water.

4 If required, remove the water with a squeegee, using overlapping strokes, working from top to bottom.

When cleaning hairline or number 4 type of surface finishes it is essential that the cleaning movement should be in the same direction as the "grain".

(b) Routine cleaning.

The quality of the environment and the aesthetic standard required will obviously influence the frequency of routine cleaning.

For outside locations, rain can wash a well designed building quite effectively, but it is usual to supplement this natural process by routinely washing the stainless steel once or twice a year. For instance, a stainless steel curtain wall may be washed at the same time as the windows.

However, in those parts of the world where severe environmental situations exist, such as coastal regions with high temperatures, high humidity and air pollution, then washing three or four times a year may be required if a high aesthetic standard is demanded.

The cleaning procedure used for initial cleaning can be adopted.

In some locations heavier soiling may occur due to local conditions, such as splashing at ground level in winter from an adjacent road surface. In such cases, pressure jet cleaning with hot water in spring to remove material adhering to the surface, followed by rubbing with a mild-abrasive cleaner recommended for stainless steel, a water rinse and drying is usually adequate. (Normal domestic cleaners should be avoided as they usually contain harsh abrasives that will alter the surface appearance.. Many also contain chlorine compounds which, if left on the surface, may cause corrosion.) Alternatively, advice on proprietary cleaning systems can be obtained from local specialists.

If the surface has a hairline or number 4 type of finish it is important to rub in the direction of the "grain".

(c) Vandalism, accidents and remedial cleaning.

Graffiti, using marker pens, brush or spray painting is becoming a major problem in some areas of the world. Fortunately, the corrosion resistance of stainless steel can be used to advantage, allowing most solvents and chemical paint removers to be used. However, advice should be taken on the most appropriate type to use for the particular paint involved and the location. For instance, some proprietary chemicals may attack mastics and sealing strips. Obviously, the surface and any joints should be well washed with water after using any chemicals.

Removing paint by scraping should not be attempted, as this will damage the surface. A suitable non-metallic abrasive pad may be used in combination with a paint remover, but care

should be taken to avoid "polishing" the surface locally. Never use pads that have been used on carbon steel or the surface of the stainless steel will become contaminated with carbon steel particles, leading to rust staining. Steel wool must not be used on stainless steel for the same reason.

Vandalism by scratching with a knife or similar implement is also encountered. Unfortunately, it is difficult to polish scratches out on brightly polished stainless steel. Some removal can be achieved on a No. 4 surface finish, by rubbing suitable abrasive cloths and Scotchbrite pads in the direction of the "grain". Removal from embossed material is impossible, but the harder surface produced by the embossing plus the irregular surface tends to minimise the visual impact of the attack.

Splashing with cement or mortar is perhaps the most common accidental damage encountered on a building site. As with any building material, splashes should be washed off with adequate amounts of water before they set. If this is not done, it will be very difficult or even impossible to remove the dry, solidified material without marking the stainless steel surface. Proprietary cleaners used to remove mortar from tiles must not be used, as they normally contain strong chemicals that would etch the stainless steel. A combination of power washing and cautious mechanical methods may be used to remove the bulk of the splash, followed by cleaning with a mild-abrasive cleaning compound designed for stainless steel. An attempt should then be made to remove any scratches produced by the removal treatment.

Contamination by carbon steel may also occur accidentally on site due to scuff marks from hand tools, deposition of dust from abrasive cutting wheels, spray from oxy-acetylene burning and prolonged contact with carbon steel components e.g. spare roof bolts left on the surface, etc. The outcome is that the carbon steel rusts, producing brown stains. In extreme cases, the rust particles may be associated with surface pitting. Extensive carbon steel contamination is difficult to rectify on site. However, most accidents produce localised rust stains which may be removed using proprietary gels, or a 10% phosphoric acid solution, followed by rinsing with an ammonia solution and then cold water or by wetting the stain with an oxalic acid solution for up to 15 minutes, followed by a cold water rinse and drying.

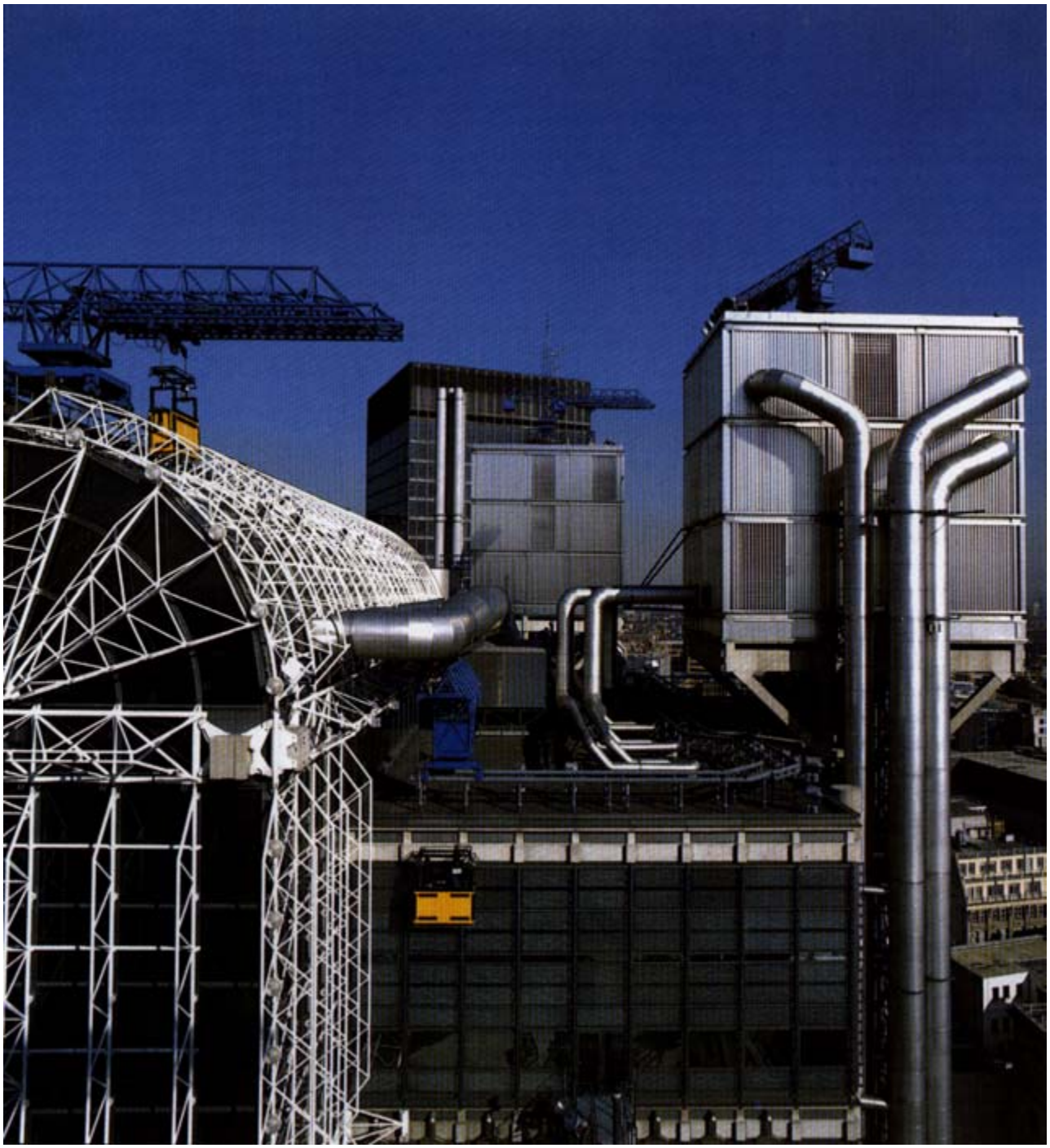
H H Lawson

This office building attached to the front of the General Electric Turbine Manufacturing Plant in Schenectady, New York, was constructed in 1948, with additions being made in 1966. In spite of being cleaned very infrequently since erection it still looks good, as you can see from this photograph taken on the 25th October 1993.

Alternatively, small areas may be treated with a "rubbing block", consisting of a suitably fine abrasive in a hard rubber or plastic filler. In all cases, however, tests should be done on an inconspicuous region to determine whether the treatment produces any unacceptable change in surface appearance.

Contamination by oil and grease requires careful removal to avoid leaving a thin film on the surface that would produce coloured rings. The majority of the oil or grease should be removed with a solvent such as acetone, benzene, or alcohol, applied with a sponge or cloth. (The Montreal Protocol will phase out many proprietary solvents based on 1.1.1 Trichloroethane by the end of 1995, but, at the time of writing, chemical companies are developing alternatives.) This could then be followed by washing with a detergent solution, rinsing with water and allowing to dry.

Contamination by finger marking in high traffic areas may require regular cleaning to maintain a satisfactory aesthetic standard. Solvents could be used, but a mild-abrasive domestic cleaner or a non-volatile proprietary stainless steel cleaning agent would be more suitable for confined, indoor locations. The suppression of finger marking may be achieved by rubbing the surface with "baby oil" or spraying with an aerosol oil.



Photographic credit Phil Starling/Intercity Magazine

John Young, the Partner within the Richard Rogers Partnership in charge of The Lloyd's of London Building design team, confirms that knowledge of modern cleaning techniques and their provision is an essential item to be considered in the early stage of design, (6). The building has nineteen separate systems to help the cleaners keep the building looking good.

Not surprising, when you consider that there are 322,800 sq. ft. of embossed chromium - nickel stainless steel, S 31600, and a further 204,440 sq. ft. of glass, anodised aluminium window frames and painted mild steel plus 50 miles of pipes and ducts to keep clean.

Although regular cleaning is the best way to retain the appearance of stainless steel, it is still possible largely to restore the surface if it has been neglected. A typical remedial treatment could be :

1 Wash loose dirt from the surface with water containing detergent.

2 Rub the surface with a paste containing 200 mesh calcium carbonate or a suitable, proprietary mild-abrasive cleaning paste e.g. as used to restore car paintwork.

3 Wipe off the moist paste.

4 Rinse with water.

Other very effective methods using complex, proprietary mixtures of surfactants and other chemicals are also offered by commercial cleaning companies.

Coloured/Painted Stainless Steel

Although the substrate will have the intrinsic robustness of stainless steel, the colouring system applied to the surface will be more delicate. Many of the cleaning techniques used for bare stainless steel must therefore not be used on coloured/ painted stainless steel.

Painted stainless steels commonly use Pvf2 and polyester paint systems. However, other systems may be encountered, consequently it is only possible to make general remarks on the maintenance and cleaning of painted stainless steel. Specific advice must be taken from the suppliers or competent cleaning companies.

Because coloured stainless steel depends on a thickened oxide film to generate the colour, great care must be taken to avoid damaging the surface. Site repair is impossible.

(a) Initial Cleaning.

It is assumed that the surface will have been protected during delivery, storage on site and erection.

In the case of thin film paint systems, an adhesive plastic film may have been used to protect the surface. In such instances it is vital that the recommended maximum time before stripping is not exceeded, in order to avoid the potential problem of adhesive retention. If the advice is adhered to, it is not usual to wash the surface. However, if the time period is exceeded and adhesive needs to be removed, the solvents used for bare stainless steel may attack the paint. Advice must be taken from both the film and painted stainless steel supplier, or a competent, specialist cleaning company.

(b) Routine cleaning.

The four-stage cleaning regime suggested for the routine cleaning of bare stainless steel can be adopted, but special care must be taken not to damage the surface. This is particularly important when dealing with heavily soiled, painted stainless steel. For instance, pressure jet cleaning may damage the paint and hosing with water containing a detergent is preferable. If the soiling still remains, gentle rubbing with a soft cloth sprinkled with fine calcium carbonate powder, i.e. 200 mesh or finer, could be tried - but this could take the gloss off the paint if done too vigorously or too frequently. Overall, it is advisable to seek help from the painted stainless steel producer or a specialist cleaning company.

(c) Vandalism, accidents and remedial cleaning.

Techniques exist to remove paint and ink marks from coloured and painted stainless steels, but any attempt to remove this type of graffiti should be left to specialist cleaning companies, otherwise the surface may be irrevocably damaged.

Graffiti scratches on painted stainless steel have the same visual effect as on painted carbon steel, but the advantage is that the scratch mark does not subsequently enlarge by corrosion. Obviously, it is possible to re-paint the scratched area and restore the surface of painted stainless steel. In the case of coloured stainless steel, however, site rectification is not possible as the colour depends on the electrolytic production of an oxide film.

Mortar and cement splashes should be washed off immediately, as satisfactory removal when dry is impossible. In the extreme, stainless steel wool could be used to remove the accretion from painted stainless steel, but this would also remove the paint and re-painting the affected area would be required.

Oil stains should not be removed with an organic solvent like thinners as this could upset the colour tone. It is preferable to use a soft cloth wetted with a neutral detergent diluted with hot water, followed by a cold water rinse and drying with a soft cloth.

It is obviously important to avoid scratching the surface. A metallic brush or coarse abrasive compound should never be used and ideally, iron particles should be removed before they start to rust, by wiping gently with a soft cloth.

Large scale, remedial cleaning should be done by a competent, specialist cleaning company.

Summary

Maintenance and cleaning aspects must be considered early in the design of any architectural project. If visual appearance is irrelevant, as in industrial roofing, then the emphasis will be on maintenance rather than cleaning. In this respect it is pertinent to note that stainless steel performs well (5).

Where aesthetic standards are important, it is fortunate that the type of stainless steels used in architecture, buildings and construction are exactly the same as used by the chemical industry to resist corrosion in many parts of their production plants. A wide range of effective cleaning reagents can therefore be used, making restoration of surface appearance relatively easy - if the correct procedure is adopted.

In the case of painted and coloured stainless steel, the cleaning regime is controlled by the characteristics of the colouring system. Unfortunately, although similar types of stainless steel are used throughout the world, it is possible to encounter many different types of paint systems. Consequently, it is difficult to give specific advice and help should be sought from the suppliers or specialist cleaning companies.

You are advised to contact your local stainless steel information centre for up-to-date information on proprietary cleaning agents and companies offering cleaning services in your area.

Footnotes

The health, safety and environmental requirements associated with the chemicals and procedures mentioned in this brochure must be determined before use. This also includes disposal of the waste water/spent acid solutions, plastic film, etc.

It has been assumed that clean, potable water is available for cleaning. If this is not correct, then consideration should be given to the effect of any impurities in the water on the cleaned surface, e.g. a mineral/dry residue content that is high enough to deposit excessive amounts of solids on evaporation, organic matter and soil in suspension. Similarly, sea water should not be used in view of its high chloride content.

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