

Stainless Steel – Surface Finishes

Introduction

Surface finish is an important element in any specification of stainless steel regardless of the intended use. For those applications where appearance is important, finish is a design element and must be specified. In non-decorative applications the surface finish may have implications for friction, wear, maintenance or corrosion resistance and must, therefore, also be carefully chosen and clearly specified.

The choice of finish should never be left to the supplier, or the specification loosely worded, such as "Type 304 with a 180 grit finish". The finish should be properly identified by a standard industry designation or by a trade name, e.g. OPTISHEEN®.

Finishes and Design

There are a wide range of decorative finishes available; therefore, it is important to pay close attention to the selection of the most appropriate finish for the application required. For highly visible applications the appearance of stainless steel is a critical design element and a misunderstanding of the wrong finish can alter the desired effect. In commercial and hygienic applications, such as restaurants and hospitals, properly finished stainless steel is easier to keep clean. In consumer products, such as catering equipment, the lustre from a well polished sheet of stainless steel has strong sales appeal.

In addition to the visual appearance of polished stainless steel there are a number of functional considerations. In sanitary applications correctly polished stainless steel not only looks good but it helps to reduce the risk of bacteria being retained by the material.

In aggressive environments, such as in the nuclear or offshore industries, a correctly polished stainless steel surface has a better resistance to corrosion than a surface that is roughly or badly polished. A smooth surface is less susceptible to an accumulation of deposits and stainless, which often become focal points for localised corrosion. All stainless steel finishes perform better when cleaned and maintained and details of correct cleaning procedures may be found in our publication, "The Cleaning and Maintenance of Stainless Steel".

Finishes and Fabrication

Some fabrication operations, such as grinding prior to painting or gluing, may require a rough surface finish but, generally speaking, a smooth, well finished sheet requires less physical effort than a coarse, rough one when it comes to blending. Certain finishes are more difficult to recreate by hand than others, causing fabrication difficulties; this is especially true of the "special" finishes which cannot be easily replicated in a fabrications workshop. For this reason the fine satin finish (such as OPTISHEEN®) is popular and practical for fabrication shops around the world.

Types of Finish

Stainless steel is available in a wide variety of standard and special finishes. The majority of finishes can be divided into three categories: mill finishes, mechanically polished finishes and special finishes. In each case the finishes are described under either their appropriate British Standard number (BS 1449 Part 2) or the name by which they are commonly known. In some instances a finish may commonly be known by several names, leading to some misunderstandings (see *Finish Variations*).

Satin Finish Variations

Finishes described by a particular industry designation, i.e. No. 4 finish, may still vary from supplier to supplier and even from batch to batch from the same supplier. In the case of mill finishes, this may be the result of differing manufacturing conditions. In the case of satin polished finishes, it is probably due to wear of the abrasive belts used in these processes. One way to overcome these problems is to specify a proprietary brand name finish, such as OPTISHEEN®, which has a guaranteed consistency.

Failing this, reference should be made to a supplied finish of at least 30 mm square to show up all the characteristics of the finish and against which the final product can be judged. The customer should define and agree acceptable levels of variations from the standard to minimise the problems caused by belt wear and consequent changes in finish.

BS EN 10088-2 / 10028-7 Finishes

BS EN Finish	Old BS Finish	Description		
Hot Rolled				
1C	0	Hot rolled, heat treated, not descaled		
1E	1	Hot rolled, heat treated, mechanically descaled		
1D	1	Hot rolled, heat treated, pickled		
1U	-	Hot rolled, not heat treated, not descaled		
Cold Rolled				
2C	-	Cold rolled, heat treated, not descaled		
2E	-	Cold rolled, heat treated, mechanically descaled		
2D	2D	Cold rolled, heat treated, pickled		
2B	2B	Cold rolled, heat treated, pickled, skin passed		
2R	2A / (BA)	Cold rolled, bright annealed		
2Q	-	Cold rolled, hardened and tempered, scale-free		
Special Finishes*				
BS EN Finish	Old BS Finish	Description	Typical Grit	Typical R _a
1G or 2G	-	Ground Grit	120	2.5 to 2.0 μ
1J or 2J	3B	Brushed - Unidirectional	180	1.2 to 1.0 μ
1J or 2J	4	Dull Polished – Unidirectional	240	0.6 μ
1K or 2K	5	Satin polished – Unidirectional	320	0.5 Max
1P or 2P	7	Bright polished – Non-Directional with a high degree of image clarity	600	0.1 μ
1P or 2P	8	Mirror Finish – Non-Directional with a very high degree of image clarity	800	0.05 μ
1M or 2M	-	Patterned		
2L	-	Coloured		
2W	-	Corrugated		
1S or 2S	-	Surface Coated (Metallic coatings such as tin, lead or aluminium)		
<p>*Note: Special finishes indicate hot rolled (1) and cold rolled (2) sheets, e.g.: Ground polished hot rolled sheets = 1G / Ground polished cold rolled sheets = 2G</p>				

Mill Finishes

The majority of mill finishes have a dull or matt finish which is not suitable as a decorative finish for most products or applications. They are suitable, however, where appearance is not important or where further finishing is to take place.

Stainless steel is polished by mills in a range of forms, e.g. sheet, plate, bar & tube, but all finishes may not be available on all forms. It is important, therefore, to check that the finish is available in the form required.

1D / 1E – Hot Rolled Plate

Hot rolled, softened (annealed) with the surface de-scaled. The surface remains rough and heavily pitted and subsequent finishing is limited to heavy grinding. It can be used where uniformity and smoothness of finish are not important and where a heavy ground surface is acceptable.

Typical uses include gas turbine parts, incinerators, kiln liners and oil burner parts.

2D

This material is cold rolled followed by softening and de-scaling. The effect of cold rolling the material is to produce a smoother, less pitted surface. The surface is not only smooth but of matt grain appearance. Used where a better surface is required or subsequent processing/finishing is necessary.

Typical uses include car exhaust systems, furnace parts, builders' hardware and petrochemical equipment.

2B

The material is cold rolled, softened and de-scaled as in the case of the 2D finish and then receives a final light pass on polished rolls called a 'skin pass' or 'pinch pass'. The material remains grey in appearance but the effect of this final pass on polished rolls is to produce a smoother, brighter surface than the 2D finish. This is the general purpose, cold rolled finish and it is suitable for a wide range of applications where stainless steel is specified. It is also suitable for a wide range of subsequent polishing processes such as satin finishing. Typical uses for a standard 2B finish include non-decorative or functional sheet metal products, industrial refrigeration equipment, chemical plant and plumbing fixtures.

2R (Bright Annealed)

This finish is also produced by cold rolling and de-scaling but in this case the final annealing is done in a controlled atmosphere furnace. The effect of annealing without the presence of oxygen is to produce a reflective surface on the stainless steel and it is often used in preference to a 2B finish where reflectivity is important, such as catering equipment. The very smooth surface also makes this surface highly suitable for further finishing processes such as mirror polishing and chrome plating.

Typical uses include architectural components, food processing equipment, chute liners, general hardware and catering equipment. Problems can occur in use since the very smooth, highly reflective surface is prone to scratching. Also different batches can be markedly different in appearance.

Acid Treatments

De-scaling

Scale (high temperature oxides) can be removed by immersion in suitable acid solutions. Paste style de-scaling solutions are also available for localised treatment on large structures or components.

Passivation / Removing Ferrous Contamination

Stainless steel can pick up carbon from machine beds, tools, racks, etc., which can result in unsightly rust staining. This can be removed by using dilute nitric acid and this is sometimes called "calcination" because of the ability of oxidation acids to accelerate the formation of acid film. Etching operations are conducted on stainless steel by dry or wet methods.

Wet Etching

The wet methods use strong acidic solutions, typically nitric/hydrochloric and nitro/hydrofluoric acid solutions.

The extent and depth of the etching can be controlled by the type of solution and by limiting the contact times of the etching solution. Etching is, to a considerable extent, an art and a skill which is acquired through experience as well as extensive experimentation.

Polished Finishes

The term “polished” defines a range of finishes which generally are of two types, either: (a) satin or grained or (b) brightened and mirror polished. Polishing improves appearance and consistency, make cleaning easier and aids practicality to fabricate and repair/blend after welding and to mask minor damage. Satin Polished stainless steel is practical in use, widely available, relatively low cost and the most commonly used.

Ground – 1G Hot Rolled / 2G Cold Rolled

A coarse but uniform finish, generally obtained using abrasive belts and grits. Usually applied to hot rolled material and generally not to material under 2.5 mm thick. Often used to recover a rough surface prior to further polishing or texturing. This coarse finish can lead to tears and laps in the surface layer, resulting in potential corrosion problems due to localised oxygen starvation, which prevents the formation of the natural protective oxide film that endows stainless steel with its corrosion resistance.

Typical uses include food processing equipment, scientific apparatus and brewing equipment.

Dull Buffed – EN No. 2J for Cold Rolled

A semi-dull finish with a uniform grain generally applied to the supplied surface of the mill finish stainless steel. No pre-grinding is involved, so only the smoother mill finishes such as 2A or 2B can be used. This finish is obtained using a bristle type brush or fine abrasives. It is used where a dull, but even, finish is required and where appearance is not critical.

1J for Hot Rolled / 2J for Cold Rolled

Obtained using fine abrasives or a series of successively finer abrasives if surface defects have to be removed. A smooth, soft polish is produced which has a low level of reflectivity and uni-directional texture. The surface is normally applied to No. 2 D and No. 1 mill finish or to 2A or 2B when removal of all defects is essential. This finish is used for a variety of engineering applications where an even matt ground surface is the main criterion. This finish suffers from problems of consistency and is also harder to keep clean due to the dry-ground nature of the polishing process.

Typical uses include dairy equipment, bus shelters and lorry components.

(OPTISHEEN®) – Satin Polish –

1K for Hot Rolled / 2K for Cold Rolled

OPTISHEEN® is a fine satin finish with an attractive lustre and smooth texture. It is produced using fine abrasives and a special cutting compound, giving it a clean, smooth “wet” cut surface. The smooth surface ensures minimal entrapment of surface debris from polishing or in use, making it suitable for most applications, especially architectural and catering uses. It is also easier to clean due to its long, shallow grain and less prone to staining in external or critical applications. The finer grain blends more easily after fabrications than coarser finishes which require more physical effort. The “wet” cut abrasive system ensures a high degree of consistency from sheet to sheet and grit size can be adjusted to maintain the correct levels of roughness and reflectivity. This finish has a pleasing appearance and is pleasant to the touch, making it suitable for a vast range of products or components.

Typical uses include catering equipment, lifts, shop fronts, architectural panels, restaurant equipment, control panels and luggage handling equipment.

Bright Polished – 2P for Cold Rolled

A bright reflective finish which is achieved by bright buffing using a soft mop and suitable polishing compound. The process involved no pre-grinding and, as such, relies on the material having a good, defect-free surface. This type of finishing will not remove surface defects but is essentially an enhancement of the mill surface. This finish is generally more reflective than the bright annealed finish but the degree of brightness or reflectivity may vary according to application or cost considerations.

It is used for architectural applications as well as in the catering trade.

Mirror Polished – 1P for Hot Rolled / 2P for Cold Rolled

A very reflective finish achieved by pre-grinding and then finally bright buffing as for the No. 7 finish. Pre-grinding enables removal of surface defects and is essential on coarse mill finishes such as No. 2D or No. 1. The process is also necessary if the No. 7 bright polished finish is not of sufficient reflectivity but, as it is far more expensive than the No. 7, it is only used when absolutely necessary.

It is used for decorative surfaces and food conveyors where a particularly smooth finish is required.

Special Finishes

There are a wide range of special finishes that can be applied to stainless steel which are used when the standard mill or polished finishes are not suitable. These finishes may be used for decorative purposes or on fabricated components that cannot be polished in the normal way.

Electroplating or Electrodeposition

In this instance metal is deposited onto the stainless steel. This process is undertaken for aesthetic reasons, to increase the surface hardness or to enhance the solderability to improve lubrication and avoid seizing, to eliminate bi-metallic contact. Some typical applications of plating on stainless are:

Copper - For lubrication in cold heading and spring making to reduce galling and scaling.

Nickel - Most usually in combination with copper as a basis for chromium plating.

Chromium - For colour matching as a car trim and to preserve finish on press plates.

Gold & Silver - For decorative effect on panels.

Textured, Patterned

This finish is the deep patterned effect by rolling the sheets of stainless steel between two hard, engraved rollers. The most common patterns are "leather" effect and "linen" effect, although others are available. Some of the textures are claimed to increase the strength and rigidity of the material. This material is mainly used where a high resistance to vandalism and damage is required, for example car-park lifts.

Colouring

The colouring of stainless steel can be achieved by chemical surface treatment which actually modifies the surface oxide film on the metal. A range of colours is available, including bronze, gold and blue. The coloured finish is attractive but susceptible to finger-marks, which results in a colour change and is not hard-wearing, and this should be considered when deciding on the use. The process uses acidic solution which, due to the variances in composition of the stainless and the process variables, can be guaranteed to be the same every time.

Metal Spraying

A thin layer of metal can be applied to stainless steel by a means of spraying. The metals used are usually lead or tin, because coated stainless steel is cheaper than the pure lead or tin.

Paint / Enamel

A tougher colour surface can be achieved using paint, stove enamel or vitreous enamel. These finishes are usually baked onto the surface to provide a hard coloured surface. The finishes have to be applied to clean de-scaled stainless steel that is also free from solvents and grease and they can be used for a wide range of applications.

The strength of the bond to the surface can depend on the surface texture. For this reason it is usually advisable to roughen the surface prior to painting. Paint also has the advantage of being easy to confine to limited areas by the use of masking.

Electro Polishing

This process is particularly suited to components or small pieces of stainless steel. The finish is uniform, highly reflective and smooth. The process involves immersing the stainless steel in an electrolyte bath in which the metal acts as an anode, removing a layer of metal and smoothing the surface. Good results can only be achieved on material that already has a good surface.

Blast or Dry Etching

This finish is achieved using fine abrasives which are fired at the stainless steel in a stream of compressed air. This achieves a uniform, matt grey finish on components and fabricated parts such as castings. It can also be used selectively for decorative purposes. Only iron-free abrasives can be used to avoid contamination and these can be filtered to remove any traces of dirt.

Changes in surface texture produce marked differences in light reflectivity and, as a result, contrasting effects can be obtained. Such contrasts are most pronounced when the etching is done on polished or buffed finishes.

Barrel / Vibratory Finishes

This is a similar process to base etching inasmuch that also other media fine abrasives are used to finish the material. In these cases, however, the abrasives are vibrated against the metal or tumbled with their components in a barrel type container. The same points apply regarding the type of abrasive as for base etching and its main use is the same, which is for the finish of components.