Technical Bulletin

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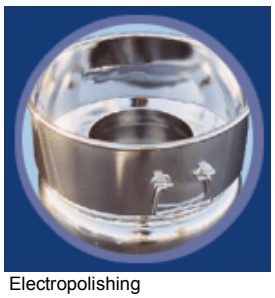
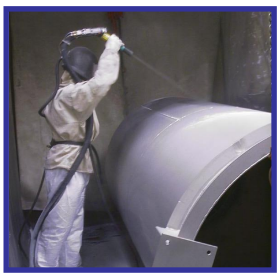
SURFACE FINISHES FOR STAINLESS STEEL

The stainless steel properties are obtained by a unique composition of the alloy in which chromium plays the leading role. Chromium combines with oxygen to produce an extremely fine impenetrable film of chromium oxide, which protects the underlying material. When this film of chromium oxide is present the stainless steel is corrosion resistant in which case we may call the metal passive. In those places in which the film is damaged and other forms of contamination prevent the passive film from reforming naturally, then corrosion can take place. All the beneficial properties of stainless steel can be destroyed during the fabrication process and unless the correct stainless steel finish is specified then corrosion and staining can occur whilst in service causing dissatisfaction with the end product or even worse, failure of a critical system.

To prepare the surface and protect the stainless steel against corrosion, a number of methods and means exist. Here we should distinguish the chemical methods (pickling and electropolishing) and the mechanical methods (blasting with glass or ceramic beads, and automatic or manual grinding and polishing). To choose the right finish type it is important to have an overview of the *limitations,* resulting surface *quality* and *costs*. Table 1 gives an overview of differences between these techniques most commonly used. The finishes are complementary to one another and often a combination of finishes will be specified in order to obtain a suitable end product. Some are carried out pre fabrication and others post fabrication.


Electropolishing


Ceramic bead blasting


Automatic polishing

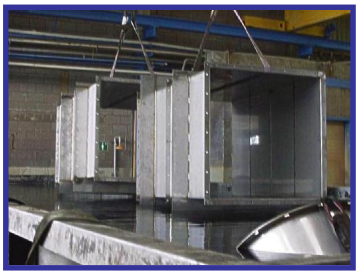

Pickling by immersion

Table 1: Surface finishes for stainless steel

Method	means	only austenitic steel	only plate, sheet or tube	chance shadow forming	no inside	inside with difficulty	not too big for bath	no crevices or boxed section	removal (µm)	roughening	makes surface uniform	roughness Ra (µm)	chance contamination as Fe	price indication (€/m^2 plate)
Electropolishing	bath	X		X		X	X	X	50-20	↓	X	0.3-0.2		40-300
Pickling	bath	X					X	X	3-1	↑		~0.5		10-25
Pickling	spray, paste	X							3-1	↑		~0.5		~20
Bead blasting	ceramic				X				100-30	↑	X	2.0-0.8		10-20
Bead blasting	glass				X				100-30	↑	X	3.0-1.5	X	5-15
Grinding, brushing, polishing	automatic		X		X				100-30	↑↓	X	5-0.05	X	2-20
Grinding, brushing, polishing	manual				X				100-30	↑↓	X	5-0.05	X	20-60

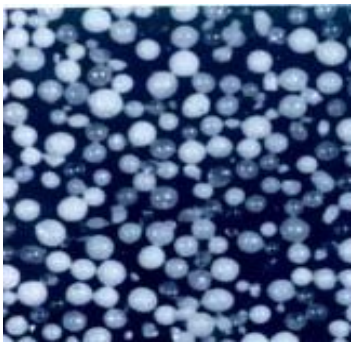
Note: Roughness of chemically treated surface is based on starting with a pre finished surface or cold rolled 2B.

Material and structure limitations:

- Generally only *austenitic stainless steels* are electropolished or pickled. Other steel types require special electrolytes or pickle liquids with increased costs to change baths.
- Automatic mechanical polishing is only standard for *plate, sheet and tube material*.
- Electropolishing can have problems in obtaining a uniform finish due to the possibility of *shadow formation* in the corners or areas which are out of reach for the electric field.
- Also with mechanical methods *closed corners* (< 90 degrees) are generally difficult to treat. The mechanical methods are generally unsuitable to treat the inside, unlike the chemical methods although electropolishing requires product adjusted electrodes for the inside.
- With pickling in a bath or electropolishing, the size is limited to the *bath size*. Alternatively very large items can be spray pickled and large vessels can be electropolished by part filling the vessel and using an internal cathode and the rotation method.
- Using chemical methods, the structure should be free of *crevices* because of the difficult removal of pickling acids after the treatment. Similarly, *boxed sections* or enclosed stainless steel fabrications should not be immersed because of the risk of acid entrapment. The chemical can seep into the weld. It is always advised that boxed sections are either provided with drain holes or alternatively spray pickled and not immersed.
- The *removal of material* is important in relation with measure tolerances. Generally only with pickling the removal of material can be neglected.

Resulting surface quality:

- The *surface roughness*. All methods increase the surface roughness, except electropolishing and mechanical polishing. Surfaces polished like a mirror have an extremely low surface roughness (Ra ≤ 0.3 µm) and a reduced capacity to hold dirt particles. This makes them less sensitive for corrosion and easy to clean. Only pickling cannot make the surface uniform, but it can maintain a uniform look.
- *Embedding of contamination*. With chemical methods oxides and other contamination are removed from the surface whereas with mechanical methods it is possible to rub in earlier-removed material, polishing material or grind material. All kinds of contamination and especially foreign iron can act as corrosion source, especially in a wet environment. Therefore, mechanically cleaned surfaces should preferably be used in dry applications with regular cleaning.
- *Glass versus ceramic bead blasting*: The high hardness combined with the round structure of the ceramic beads makes it with recycling easy to separate from contamination. Glass particles easily splinter, leading to a higher surface roughness and after recycling with insufficient separation leading to contamination of the surface. Ceramic bead blasting is often preceded with pickling to prevent contamination of the blasting material. It is also common practice to passivate bead-blasted material chemically by immersion in a passivation bath. These double treatments increase the price.



Ceramic beads

Costs:

- For comparison, a rough *price indication* is given for plate and sheet material. More complex and smaller structures require more handling which increases the price. Electropolishing gives the best quality (low roughness without contamination) at highest costs. Good quality (without contamination but higher roughness) is obtained with pickling and ceramic bead blasting. Relatively lowest quality (contaminated) at low costs is obtained with glass bead blasting (high roughness) and mechanical polishing (high to low roughness). However, the best choice of method or combination of methods depends on the application with given limitations.

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