

# Technical Bulletin

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## STAINLESS STEEL SURFACES IN THE WFI PIPES AND EQUIPMENT FIELD

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*The component's  
value is assured  
by its surface*



## STAINLESS STEEL SURFACES IN THE WFI PIPES AND EQUIPMENT FIELD

One characteristic of WFI-quality, ultra-pure water, is that of acting very aggressively towards stainless steel surfaces in tube lines and containers. This is even more significant if the ultra-pure water qualities in question are degassed and heated or where ultra-pure steam is being created or piped. In the recent past, there have been more and more reports on the observation of rouging effects or else of significant (resulting) corrosion with these types of systems. These reports have primarily dealt with materials systems based on 1.4571 (316 Ti) or 1.4404/1.4435 (316L).

In supposing a material to have been produced in accordance with specifications and to have been properly processed and to have been welded free of defects, it seems important to ascertain the relevant material and surface properties. Combined, these give a material and surface profile from the viewpoint of the operator of the equipment:

- Corrosion prevention and prevention of rouging – and further effects of corrosion;
- Prevention of particle and ion generation from the surface to WFI medium;
- Prevention of germ contamination on the surface and in the "material depressions" near the surface
- Assurance of optimal and pore-deep cleaning after sterilization (e.g. using the CIP method).

These requirements, very generally formulated in mathematical and physical terms as they are, guarantee the operator non-catalytic use of the WFI medium without any adverse effect at all without making any changes to:

- \*) Conductivity/resistance*
- \*) Ion content (above all heavy metals.)*
- \*) Particle content (all types)*
- \*) TOC content*
- \*) Germ load (pyrogens, etc.).*

If one now attempts to translate these general requirements into criteria for technical equipment which are suitable for production technology and which are measurable, then this becomes very problematic. The roughness parameters Ra, Rz, etc. commonly used by the technologist are, of course, not even remotely suited for describing these physical and chemical mechanisms, which can sometimes be very complex.

Using the three-part observation method specified according to:

- \*) *Topography*
- \*) *Morphology*
- \*) *Energy level*

of the surrounding metal surface and, as required, the

- \*) *Boundary layer effects with a flow*

The results are as following for mechanically and electrochemically processed surfaces:

	<i>mechanically processed (cold-drawn or mechanically ground) Mat. 1.4435</i>	<i>electrochemically polished 350 - 400 A min./dm<sup>2</sup> Mat. 1.4435</i>
<i>Topography</i>	despite favorable Ra value in fact generally jagged (grid measurement) and thus very large real surface in cavernous form;	absolute minimum of the real surface; closed and "tight"
<i>Morphology</i>	relatively impure surface with various inclusions from tools (e.g. grinders etc.) and segregated areas with free ferrite and martensite;	pure, unadulterated austenitic structure due to stress-free surface removal;
<i>Energy level</i>	considerable stored energy from prior forming and machining process	standard energy level of alloy
<i>Boundary layer</i>	increased boundary layer volume due to "depressions" in the topography	minimum boundary layer volume

From this comparison the following can be deduced for the formal set of operator requirements.

### **1. Corrosion behavior:**

Particularly due to the morphological conditions, the electropolished surface is far superior to the mechanically processed one and ensures anti-corrosion stability (e.g. rouging) primarily because an unadulterated chromium oxide passivation layer can form on properly electropolished surfaces and allows the necessary anti-corrosion Cr/Fe ratio  $> 1.5$  to be achieved with certainty by means of special conditioning measures when passivating the surface. Observed thus, the Ra value has a very secondary significance as against the morphology of the surface.

The actual make-up of the topography shows, particularly in the "shallows", a concomitant effect in terms of corrosion behavior, with the electropolished surface likewise offering clear advantages here.

### **2. Particle generation:**

In this connection, primarily the morphological state of the surface is also decisive; likewise the closed topography of the surface.

In both cases, the electropolished surfaces exhibit much more favorable and calculable conditions.

### **3. Germ contamination:**

Here, the closed topography and the minimal boundary layer volume are decisive for preventing lasting germ contamination.

### **4. Cleanability:**

For this surface property, closed topography, energy level and minimal boundary layer volume are equally responsible.

This set of factors shows that for WFI equipment technology, the combination of electro-chemically polished surfaces and the right material is particularly important in creating optimal and, above all, calculable conditions and that the Ra value is of less fundamental importance than the much more important surface morphology (clean passivation layers with a Cr/Fe-Ratio  $> 1.5$ ). These requirements are met demonstrably and guaranteed with Safetron electropolished (also in the longitudinal weld area).

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# Technical Bulletin

## Procedures for the treatment of metal surfaces

- ▶ Electrochemical polishing
- ▶ Electrochemical and chemical deburring
- ▶ Chemical polishing
- ▶ Chemical pickling
- ▶ Passivation
- ▶ Derouging and professional repassivation

All services can be carried out on the premises of the customer

## Development and supply of

- ▶ chemicals for pickling, electropolishing and passivation of metal surfaces
- ▶ chemicals for derouging and repassivation of stainless steel surfaces
- ▶ turnkey constructions/equipments for the chemical and electrochemical surface treatment of metals

## Technical consultation

- ▶ for the surface treatment of
  - Stainless steel (i.e. 1.4435 / 1.4404 / 316l, 1.4539 / 904l, etc.)
  - Nickel and Nickel Alloys (i.e. Alloy 59, Hastelloy, Inconel)
  - Aluminium
  - Copper
  - Niobium
  - Titanium
  - Zirkonium
  - C-steel
- ▶ for apparatus, tubes and fittings in the food, beverage, chemical, cosmetic and pharmaceutical industries, bio and medical technology, plant, refrigeration and heat technology
- ▶ for surface treatment specifications for apparatus and tube systems
- ▶ concerning corrosion of stainless steel

## Further services

- ▶ Colouring of stainless steel
- ▶ Clean room treatment
- ▶ Waste water technology
- ▶ Research & Development

**We are member of VDMA, EHEDG und ISPE**

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