Stainless Steel Passivation

Definition: **Passivation** is a non-electrolytic finishing **process** that makes **stainless steel** more rust-resistant. The **passivation process** typically uses nitric or citric acid to remove free iron from the surface. This results an inert, protective oxide layer that is less likely to chemically react with air and cause corrosion.

By chemically removing free irons from the surface of stainless steel, the passivation process adds a thin oxide "film" layer. Less iron at the surface means more chromium. More chromium means a thicker chromium oxide surface when the stainless steel is exposed to air (oxygen). And that thicker, chemically non-reactive surface means more protection against rust.

Per common passivation specifications, passivation is "the removal of exogenous iron or iron compounds from the surface of stainless steel by means of a chemical dissolution, most typically by a treatment with an acid solution that will remove the surface contamination, but will not significantly affect the stainless steel itself." Further, states passivation is "the chemical treatment of stainless steel with a mild oxidant, such as a nitric acid solution, for the purpose of enhancing the spontaneous formation of the protective passive film."

Therefore, a "mild oxidant", such as a nitric acid or citric acid (mineral or organic acid solution), removes the excess iron and associated contaminants from the surface of the stainless steel and allows the formation of a chromic oxide layer when exposed to air, which thus leads to stainless steel's corrosion-resistant properties.

Why passivate stainless steel?

To answer this question, let's look at what stainless steel is first. Stainless steels are naturally corrosion-resistant, which might suggest that passivating them would be unnecessary; however, stainless steel is not entirely impervious to corrosion. Stainless steel derives its corrosion resistant properties from its chromium content. The chromium, in the presence of air (oxygen), forms a thin film of chromium oxide which covers the surface of the stainless steel. Chromium oxide is inert or "passive" by nature, and chromium in the material gives stainless steel its corrosion-resistant properties.

Under ideal conditions, pure, cleaned stainless steel (SS) forms an inert, oxide film when exposed to oxygen in the atmosphere which protects the SS from corrosion.
Under realistic, normal conditions, any of the following can inhibit the formation of the oxide film which protects stainless steel from corrosion:

- **foreign material in a manufacturing environment**
- **sulfides added to the stainless steel for improved machinability**
- **particles of iron from cutting tools or during the welding process being transferred to the surface of the stainless steel parts**
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Therefore, these contaminants need to be removed down to the surface grain boundaries / structure of the stainless steel surface. This removal and oxide growth process is called passivation.

How does the passivation process work?

Many passivation specifications exist to instruct on the proper process to passivate stainless steel, titanium and other materials, some of which are listed below. Common to nearly all the specifications are:

- cleaning the surface from any contaminants listed above
- chemical treatment via immersion in an acid bath (typically nitric or citric acid)
- testing of the newly passivated stainless steel surface to ensure effectiveness of the process steps

This chemical treatment simply augments/expedites the naturally occurring process when the material is exposed to oxygen in the atmosphere. It simply helps to "grow" the inert, oxide layer faster and thicker than found naturally.

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