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Citric Acid Passivation of Stainless Steel

An alternative product for passivation...

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For many years, the stainless steel industry has abided by the requirements of Federal Standards to use potentially hazardous nitric acid baths for passivation. Although some industries have successfully used citric acid, most of the market in the U.S. uses nitric acid.

Citric acid is organic, safe and easy to use. When formulated correctly, citric acid provides excellent performance at considerable cost savings. This acid is the same acid found in oranges and other citrus fruits. It is used extensively in soda and other foods. More than 99% of the citric acid sold in the U.S. is used in food and beverage products. It is also used in cleaners and disinfectants.

The concept of passivation of stainless steel with citric acid is not new. It was developed years ago in the beverage industry in Germany, where it was necessary to provide containers that were free of iron on the surface. Iron causes a bad taste in the beverage, and the nitric acid passivation systems could not provide the degree of passivation required.

Other industries have only recently started using citric acid. There are a number of reasons for this, including the government standard QQP3C. This specification has been the standard of the passivation industry in the U.S., and it required the use of nitric acid or nitric acid in combination with sodium dichromate.

There was little incentive to get rid of nitric acid, since it provided products that met the specification. Recently, however, there has been an incentive. The Defense Department has cancelled QQP35C in favor of a new ASTM Standard for passivation, A967.

The U.S.EPA and other local regulators recognize the relative safety of citric acid formulations to the environment. Citric acid is biodegradable and rinse waters can go to drain if they meet local pH regulations.

When formulated correctly, citric acid produces excellent results in passivation of almost any stainless steel product. It is used for cleaning, brightening and passivation of other metals as well. Some industries using citric acid include fasteners, medical devices, semi-conductors, automotive and aerospace.

Citric acid emits no NO_x vapors that can be harmful to the atmosphere. Nitrogen oxides aid in the production of smog, whereas citric acid does not.

Citric acid does not require special handling equipment or safety devices for employees. Also, the systems do not corrode other equipment and structures.

There is also no need for hazardous waste removal. The formulations remove the free iron and iron oxides without removing significant amounts of nickel, chromium or other heavy metals. Waste removal costs are reduced or eliminated. Raw materials are stored as nonhazardous chemicals.

Because citric acid efficiently removes iron from the surface, much lower concentrations are required than when using nitric acid. Typical solutions range from 4 to 10% citric acid by weight. Because of the high reactivity with free iron and low reactivity with other metals, it is generally safe to leave the parts in the bath longer than necessary.

Typical times in the passivation bath are generally less than those for nitric acid. Line speeds can run up to five times faster in some cases. This allows passivation at room temperature or using a low amount of heat.

Tests run using citric acid in the semi conductor industry showed that the chrome oxide ratio of the surface of stainless steel is as high as 12.5: 1.

Although citric removes free iron from work surfaces of stainless steel, it will not produce the desired results wherever etching is needed. It also does not perform as well as nitric or nitric/hydrofluoric solutions at removing extreme heat-hardened scale. It also cannot remove copper and nickel coatings in drawing lubrications.

Test data show that citric acid equals or exceeds the performance of nitric acid in salt spray (B117), copper sulfate, palladium chloride, boiling water and high humidity testing. Data from the semiconductor industry show that the top 25 to 30 angstroms of the surface is highly chromium enriched. This is what provides the corrosion resistance.

Citric acid provides passivation of stainless steel while providing worker and environmental safety, versatility, ease of use, less maintenance and lower costs.

The standard of acceptance is whether the product passes the test, not whether the process meets a standard. The objective should always be to provide low cost parts that are the best they can be without adversely affecting workers or the environment.