NUTS & BOLTS

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Special This Issue!

Here's the inside scoop on how we can help you with the problem of corrosion in stainless steels...

Contrary to popular belief, "stainless" steel is not stainless, and is subject to rust! However, there are measures you can take to prevent it.

Here are some of the questions we answer:

- ✓ What is passivation?
- ✓ What is passivation testing?
- ✓ Where does surface iron come from anyway?
- ✓ What is sensitization?
- ✓ How about heat treating and weld heat affected zone?
- ✓ Machining etc...

Our Philosophy

New Hampshire Materials Laboratory *has one goal—to help you solve your technical problems at a reasonable cost. Tests help, but are not always enough.*

Our team of dedicated and experienced professionals has both the skills and the backup facilities to serve in the following:

- Failure Analysis
- Material Certification & Compliance
- New Product Testing
- Mechanical Properties
- Tensile and Compression Testing
- Heat Treat problems and Verification
- Reverse Engineering
- Weld & Life Testing
- SEM & EDS

N.H. Materials Laboratory Inc.

Looking BEYOND the expected...

Rusting by Stainless Steels

Background

The cost of corrosion to U.S. Industries and the American public is currently estimated at $170 billion per year. Although corrosion is only nature's method of recycling, or of returning a metal to it's lowest energy form, it is an insidious enemy that destroys our cars, our plumbing, our bridges, our engines, our cars and our factories. One area we would not expect to find corrosion would be so-called "Stainless Steels". Contrary to popular belief, Stainless Steel is neither stainless nor is it free from rust. Too often users are surprised to find rust deposits and corrosion in what was assumed to be a rust-free material. In many instances the presence of rust can lead to catastrophic failure of a part or at least lead to cosmetic blemishes. The following is a discussion of what causes Stainless to "rust" and what measures to take to prevent it.

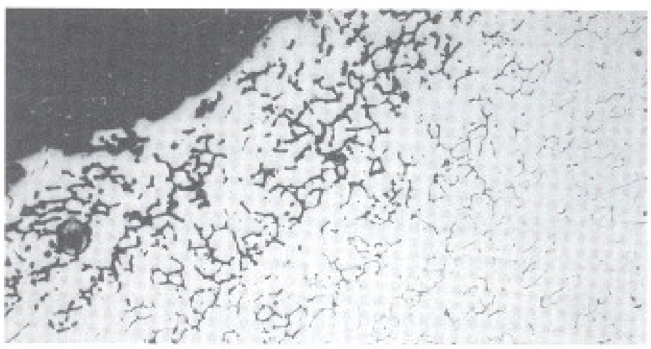

FIGURE 1: Selective corrosion of minor phase of stainless steel due to poor casting practices.

Messed Up Surface Chemistry...

All of the stainless steels rely on a tight, continuous film of iron-chromium oxide for their apparent corrosion resistance. When the film is damaged, if it promptly reforms then all is well. However, when something happens that prevents the formation of that tight, continuous film of oxide then your parts can rust. This vulnerable weak spot in the oxide may be aggressively attacked if it is the small area anode of a galvanic corrosion cell.

Think of it in terms of messed up surface chemistry: a thin film of iron, or embedded iron particles, or increased carbon in either a thin film or microstructure faults. In effect, anything that reduces or dilutes the chromium, either in a spot or across the surface, may cause rust. The oxide film is barely able to provide protection at 10.5% chromium. At 17-20% chromium in the austenitic stainless the film becomes reasonably reliable. The ferritic stainless steels with 26-29% chromium can form more effective surface oxide films.

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A method of cleaning the iron rich sites to insure a uniform surface film is the *passivation process.*

What is Passivation?

An ambiguous description—the passivation process does not make the stainless steel passive! It is a very misleading name. It is actually the last step in the cleaning process and it is directed at removing iron-rich surface films.

Passivation is a dip in dilute nitric acid.

The different stainless steel families require different dilutions. For example, the less corrosion resistant stainless steels require some added sodium dichromate along with more concentrated acid. (See Metals Handbook, v 13, p552, 9th ed. for the different recipes or call us with your fax number and we'll send you a copy.)

Passivation can remove surface films of iron. It doesn't usually remove embedded particles, contamination from weld spatter, and can't undo sensitization.

There's No Substitute for Cleaning...

Never assume that passivation is a substitute for cleaning. Unless the parts are scrupulously clean, the dip in nitric acid won't work and may cause trouble. Gassing at particles of dirt prevents passivation at that point. Then, if there are chlorides in the dirt, they will contaminate the passivating solution and your parts may be grievously attacked—all of them! And *you* get to pay for the disposal of all that ruined nitric acid!

So it pays to remove all of the visible dirt, chips, etc., then clean in hot caustic, and water rinse before passivating. (Your quality control program needs to dwell on assuring the effectiveness of the cleaning before passivating.) A dip in weak caustic and a final wash end the process.

What is Passivation Testing?

If passivation is about removing iron, then passivation testing is testing for iron.

For the 400 series, a 24-hour soak in a 100% humidity chamber at 35° C will reveal the iron. The 300 series can be tested by following the ASTM A380 recipes. This is a test in which an acid copper sulfate solution is applied and in a few minutes copper plates out onto the iron-rich areas. Other useful recipes and instructions appear in ASTM A262, A763 and Fed Spec QQ-P-35B.

Where Does Surface Iron Come From?

The most important way to prevent rusting is to keep the surface clean. Weld spatter is the kiss of death, since under each bead it leaves a metallurgically bonded spot of metal having diluted chromium on the stainless.

It's all about dust control

A grinding wheel that has been contaminated by carbon or tool steel will embed steel particles and will smear iron across the surface. The grinder will irrevocably embed any grinding dust from a nearby station or which drifts down from the ceiling beams. Grinding coolant that has been circulated through a machine running carbon or tool steels is a major contributer

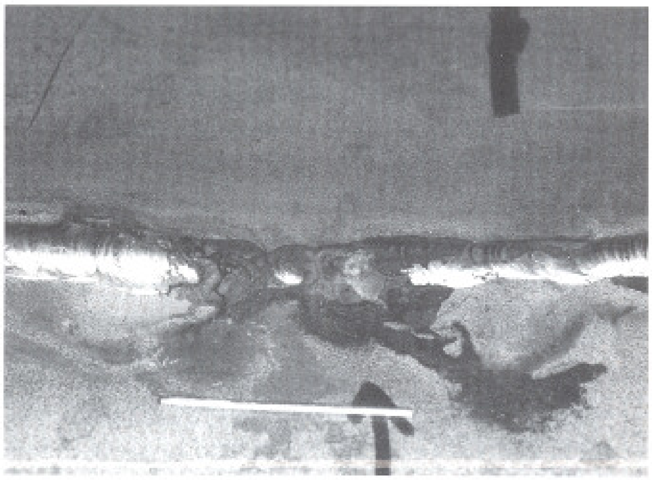

FIGURE 2: Weld corrosion of stainless steel weld caused by lack of proper cleaning and preparation resulting in rusting of surface oxides

when it comes to permanently contaminating the next piece of stainless. It pretty much means that stainless steel grinding must be in its own room, with its own dust control and coolant systems, completely isolated from other ferric materials being processed.

Grit blasters for stainless must contain only ceramic media, and absolutely no steel shot. If a grit blaster has ever been used on carbon or tool steel it can never be used on stainless. We have seen a large inventory of ceramic grit ruined when someone went into the shop on a weekend and "cleaned up" his motorcycle frame using the grit blaster that was dedicated to stainless.

How about Heat Treating and Weld Heat Affected Zone?

Sensitization is the phenomenon of precipitation of chromium carbide particles along the grain boundaries, which depletes the chromium in the adjacent grains. Not only is the metal embrittled, but also, in a thin band along the grains and grain boundaries the chromium has been reduced so the protective film is ineffective and galvanic corrosion proceeds on a microscopic scale. You may observe rust along the tracery of the grain boundaries, or you may see an overall film of rust.

If, before welding or heat treatment, oil and grease are not completely removed, then at elevated temperatures, the extra carbon may react with the metal to form chromium carbides, and away we go again. In the adjacent metal the chromium is depleted, and the metal surface can no longer form a good oxide film. It's important to thoroughly clean all the surfaces to be welded in order to remove any oils or greases that may be present.

Machining etc.

During blanking, shearing, and punching, if the tool wears, where has the tool's steel gone? Of course, the particles of steel have become embedded in the stainless! Rusting of edges will follow. If the wear rates are low then only an occasional part will fail the passivation test.

In stamping, drawing, wire forming, and a host of such operations, if the tool wears then particles of steel have been embedded.

Never share these tools with carbon steels.

Ceramic and carbide tools contain no iron so they won't transfer any iron particles to the stainless.

It's an open question whether machining coolant can be shared. It depends on whether the particular operation embeds particles of steel in the surface of the stainless. And never, ever, let shared coolant dry on the surface of a stainless part!

Take Heart...

We have seen manufacturers that couldn't get their work to pass a passivation test. Then, through diligent attention to the details described above, as well as some changes in shop culture, they turned it around to the point that, if the parts don't pass passivation the fault surely is in the hands of their metal suppliers.

People at NHML...

Connie LeBlanc is the Office Manager at NHML and the one that really runs the place. Connie hails from Wtchita, Kansas and she adds her midwestern charm to the company. Her lovely voice is the one you'll first hear when you call in. Her main hobbies are collecting Purchase Orders and practicing her New England accent.

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