NUTS & BOLTS

VOLUME 14
WINTER 2000

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Stainless Anyone?

Picking the right stainless steel can be a challenge. This month we review some of the properties of this popular metal.

We examine relative hardness, corrosion resistance, rolling contact noise and strength along with failure mode.

We'll tell you:

- ✓ Which stainless is the hardest
- ✓ Which alloy has the highest corrosion resistance
- ✓ What stainless would you choose for low rolling contact fatigue strength
- ✓ Which alloy has the best pitting resistance

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...

Choosing a Stainless Steel for Hardness and Corrosion Resistance

Background

Of all the steel alloys, stainless steel is probably the least understood. Selecting the right stainless for your application can be perplexing. This article is an attempt to clear the air and to give some insight into the differences between various stainless steel alloys. Hopefully it will assist the designer to select the most appropriate material for specific applications.

The focus of this issue is on the stainless steels and related alloys that combine a high degree of hardness, corrosion resistance, low cost and availability. It is intended for the designer who needs to specify material on the drawing.

If additional information relative to the metallurgical details is needed, please call or contact us by e-mail, Lab@NHML.com.

52100

The alloy is homogeneous so that all of the chromium is available for corrosion resistance. The alloy melts clean and heat treats beautifully so high cycle

fatigue strength is good and the alloy supports high rolling contact stress. Good quality stock is easily purchased. QC requires checking decarb in as-received stock, and after heat treating checking decarb and grain size.

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420

The alloy has good corrosion resistance and pretty good hardness. However, it heat treats with a coarse grain, which makes it somewhat unpredictable and reduces the fatigue strength and rolling contact stress. It is moderately easy to purchase good quality. QC requires monitoring segregation and grain size after heat treating.

440C

It is hard. The alloy has big, blocky, primary carbides. The matrix chromium is only a little higher than H13's so its corrosion resistance is only a little better than H13. The primary carbides make for noisy rolling contact, markedly lower rolling contact fatigue strength, fairly good compressive strength, and poor tensile properties. There are very consistent supplies of good quality. QC requires monitoring the heat treater's results for excessive austenite grain boundary precipitation, prior austenite grain size, primary carbide particle size and retained austenite.

H13

Not as clean as **52100** so its rolling contact fatigue strength isn't quite as high but its higher chromium gives pretty good corrosion resistance. Hard to buy good quality and hard to heat treat well. QC requires monitoring incoming steel for segregation and monitoring the heat treater's results for austenite grain size and precipitation in the austenite grain boundaries.

17-4PH

This compromise has better corrosion resistance, good toughness when properly heat treated, and lower hardness. Coarse grain can be a problem.

Commercial stocks seem to be good quality. QC requires monitoring the heat treater's results for austenite grain size, precipitation in the austenite grain boundaries and through-thickness hardness. Hardness after the solutionizing heat treatment needs to be checked, which is the usual as-purchased condition for small quantities. Segregation can be a problem.

Hard Worked 304

High hardness and strength with pretty good corrosion resistance are available in heavily cold worked type **304.** It has much less toughness than annealed 304 but it is right up there with the other hard stainless steels. Wire, small bars and small strip dimensions are available. Quality control includes surface finish, which can be scaly on a microscopic scale.

Other hard stainless steels include:

- **416** for improved pitting resistance
- **440A** and **440B** for better homogeneity than **440C** but still suffer from primary carbides.
- **17-7PH** for more of the same as compared to **17-4PH**

The growing family of fully densified powder metals gives great opportunities for combining all the properties except affordability. In a critical application, where the metal cost can be absorbed, be sure to look over what's available. We see these fully densified powder metals in a frustratingly limited range of small bar stock sizes.

An example of compacted powder metal bar stock is Crucible Materials Corporation's **CPM T440V** which has 17% chromium along with other good things. The powder process keeps the carbides fine as long as the heat treater doesn't mess it up during final heat treating after machining. The heat treater's results must be monitored for carbide and grain size or the product isn't any better than the regular ingot and strand cast mill product.

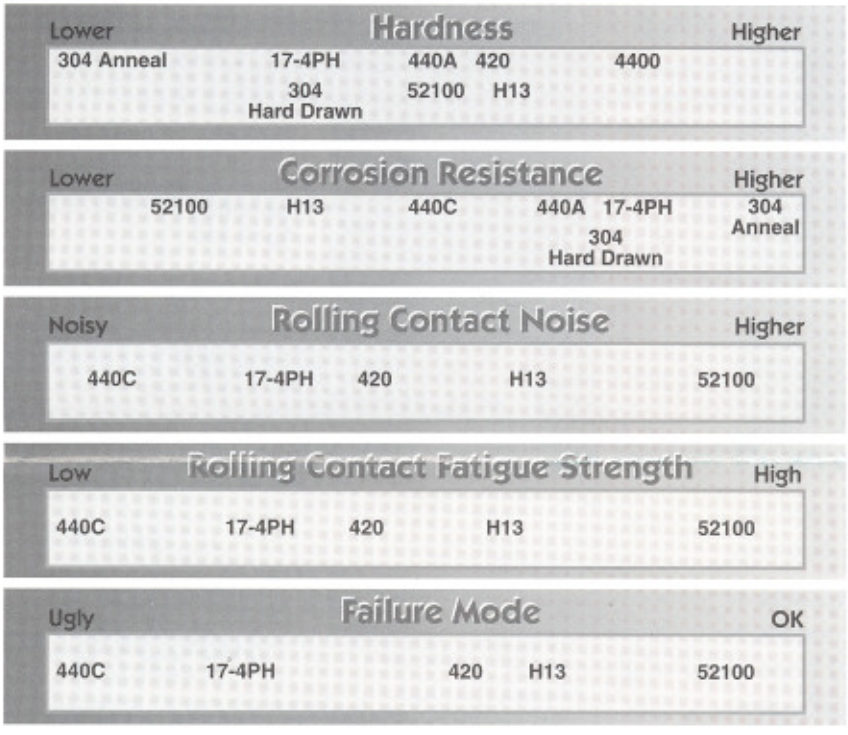


FIGURE 1: Comparitive Properties: various stainless steel alloys

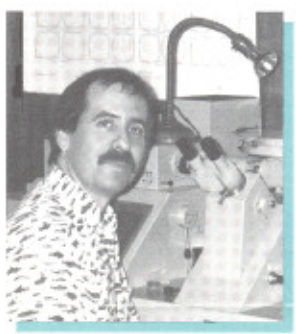
Some warnings regarding the heat treaters' culture:

Heat treaters are pre-programmed to deliver the hardness range specified in the purchase order. Unfortunately, hardness alone doesn't cut it in the hard stainless steels. You must additionally put numbers on the microstructural stuff which is listed above. If you don't, then expect unreliable wear, unreliable fracture toughness, unreliable fatigue, and sometimes unreliable corrosion resistance. And without having called them out you can't even reject the lot when failures occur.

Except for the **440** family of stainless steels, a messed up heat treating lot can often be re-heat treated. Accumulated decarb and distortion can be problems the second time around.

Remember that the hardenable stainless steels have very poor thermal conductivity. At least while getting the bugs out of the heat treating process, keep track of part location on the furnace racks. Edge parts will heat faster and have the longest time at temperature. **Result:** more distortion, better homogeneity, larger grain size, probably a faster cool down, etc. Center parts or parts shadowed from atmosphere circulation: less distortion, more segregation, finer grain size, failure to make the hardness specifications.

These alloys require that furnace racks need to be packed much more loosely and bigger circulating blowers are needed. There's a lot of merit to paying the price for a few percent of the high heat transfer gasses: hydrogen or helium or both. And finally, heat treaters love to heat treat but they hate to keep records! You need good records as to which furnace was used, number of parts per rack, strip chart record, thermocouple location, and atmosphere pressure and composition. We have long observed that the customers that consistently hold their heat treaters' hands are the ones that get consistent results. It seems to take about six months to work out the bugs and to convince the heat treater that you really mean what you say.

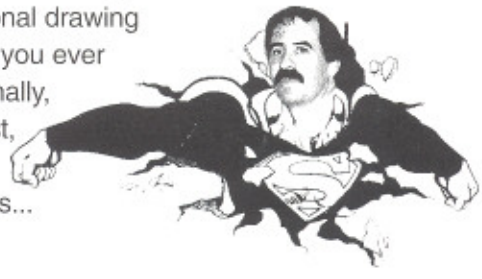


People at NHML...

Introducing Tim Kenney, Our Laboratory Director. Part-time carpenter, geologist, gourmet and world-traveler, Tim also knows more about materials than anyone really ought to know.

Although originally born in New Hampshire, somehow Tim lost his way, and now resides in Maine with his wife and son.

Our photo depicts Tim hard at work at our Neophot 21 Metallograph, and while we don't delve into his personal life, his wife Kerry insisted that we also attach this additional drawing of "Super Tim". If you ever talk to Tim personally, ask about his vast, albeit strange, collection of ducks...



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