

## Stainless Steel vs. Carbon Steel Tools by Marty Weiser

### What is Stainless Steel?

Generally stainless steel(SS) is made by adding at least 10% chromium (Cr) to iron. The SS then forms a chrome sesquioxide-based surface oxide that sticks to the SS and prevents further corrosion. This locks the material into the ferrite phase which is body-centered cubic (BCC) and is moderately strong and not terribly ductile.

Nickel (Ni) is often added to SS to convert the structure to the much more ductile austenite phase and to add resistance to high temperature oxidation. One of the most common grades of SS contains 18% Cr and 8% Ni and is used in everything from industrial piping to spoons and forks. In the US, this is known as type 303- or 304- SS.

### The Role of Carbon in Steel

Carbon is often added to steel to increase its hardness. Adding as little as 0.5% carbon can make a huge difference in the hardness of the steel. However, the increased hardness comes with a disadvantage-it is much less ductile. Careful control of the heat treatment allows one to control the trade off between hardness and ductility, but, if you make a mistake, you can end up with a blade that won't hold an edge or one that shatters if you drop it. Very high quality Japanese steel tools often laminate a piece of high ductility, low-carbon steel to a thin layer of low ductility, high-carbon steel to give a blade with a hard cutting edge and a reasonably ductile body.

Cast irons, listed as having 2-5% carbon, are generally too brittle to make good cutting tools. However, they do make wonderful machine tools since they are extremely dimensionally stable.

### Problems with Carbon in Stainless Steel

If you look up the definition of steel you will find something along the lines of "an iron alloy containing more than 0.1% carbon". If you look up the composition of most SS you will find that the carbon content is limited to less than 0.1%. Therefore, SS is technically not a steel. Why is the carbon content of SS limited? Well, if you mess up the heat treatment the carbon likes to combine with the Cr to form chromium carbide which has the formula  $\text{Cr}_23\text{C}_6$ . This compound forms along the grain boundaries (not defined here) and robs the regions along the grain boundaries of Cr. However, Cr was added to the material to make it corrosion resistant so if you remove it the SS is no longer stainless. That is why the carbon concentration of SS is limited. So SS does not contain much carbon to make sure that it remains stainless. What is the result? Carbon is responsible for making steels hard so they hold a really nice cutting edge. Therefore, SS is not very hard and makes lousy cutting tools. Well not really. Metallurgists figured that a metal that was both stainless and held a decent cutting edge would be great so they developed some SS that held a fairly good cutting edge. In the US, these are the 400 series SS.

The key is that, through careful control of the composition and heat treatment, you can create a metal that is a good compromise between corrosion resistance and hardness. However, if you make a mistake in either one you end up with a material that is too hard (brittle) or too soft (won't hold an edge). Generally, cheap SS tools such as knives err on the side of too soft while high quality tools generally are right on or err on the side of too hard.

### **In summary:**

SS is a misnomer (it is neither a steel nor completely stainless). Good SS bonsai tools are expensive because they are difficult to make. I suggest that good quality carbon-steel tools will hold a better edge and last as long or longer than much higher-priced SS tools.