Three Reasons Why Mechanical Properties of Cold-Drawn Steel Can Vary

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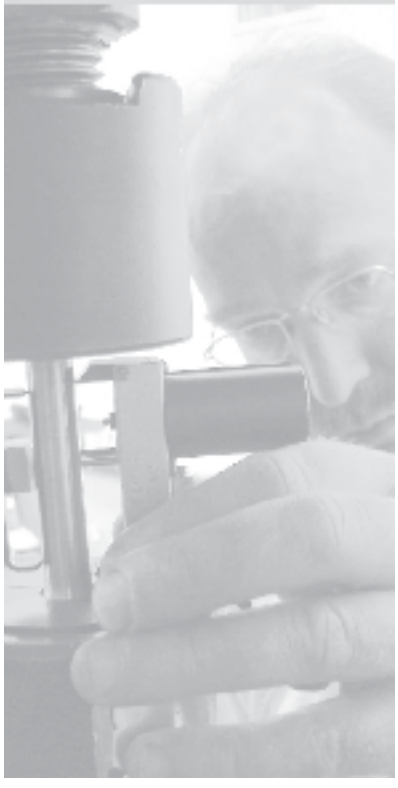
Why do the mechanical properties on different shipments of the same size and grade of steel vary so much?

To answer this, lets look at Grade 1018, a non-free machining grade that we may encounter in our shops.



We'll pull it until it's two pieces.

A cold-drawn, 1018 steel bar of 1-inch diameter typically has a Tensile Strength (TS) of 64,000 psi; Yield Strength (YS) of 54,000 psi; percent Elongation in 2-inch (%EL) of 15 percent; and percent Reduction of Area (%RA) of 40 percent. (According to Information Report SAE J 1397, Estimated Mechanical Properties and Machinability of Steel Bars.) Note that these are estimated values, not minimums.

Your mileage (properties) may vary. Here are three reasons why:

1. The original melt and cast process can affect chemical makeup. Basic Oxygen Furnace (BOF) steels are made from a high percentage of new metal and thus have lower levels of residual elements from scrap that could strengthen the material. Also, BOF steels tend to run lower levels of nitrogen, which is a ferrite strengthener. So, BOF Melt steels tend to be on the low side of mechanical properties like tensile and yield, and a bit higher ductility (%RA and %EL in 2-inch).

2. The mechanical properties of cold-drawn steel are affected by the amount of cold work. This can come about in two different ways. The first way is as the bar size ordered gets smaller, given a standard draft, the percentage of cold work increases. This increase in the percentage of cold work increases the mechanical properties of tensile and yield strength and can decrease the ductility somewhat.

The second way can be when different vendors use a different "drafting practice" resulting in a different amount of cold work to make the same size. Typical draft may be to use hot-roll sized 1/16-inch over the final size for drawing. Another vendor may choose 3/32-inch oversize. And, in rare cases, a company might use 1/8-inch to assure exceeding, not just meeting, minimum yield strength.

3. The final steps of straightening and polishing can relax the steel. The amount of cold work done in straightening the bars can relax the steel because the force is applied transverse to the original drawing. So, a supplier using a two-roll straightener, all other things being equal, might produce bars with a different final set of properties than one using a train of planishing discs to get the bar commercially straight.

So what values could you expect to encounter in Grade 1018 steel when looking at all of these effects? We've seen 3/8-inch 1018 with tensile strength in the high 80,000s; yield strength in the high 70,000s; %EL in 2-inch as high as 26; and %RA as high as 65.

In 4-inch Grade 1018, we've seen TS as low as 58,000 psi; YS of about 42,000 psi; %EL in 2-inch of 12 percent; and %RA of 35 percent.

The process path generally can explain the properties received. It also explains why those mechanical properties you receive are sometimes so far from what you expect.