

# STAMPING JOURNAL

EXPERTISE TO HELP METAL STAMPERS FORM THEIR FUTURE

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## Special Training Section

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# Stamping 101: Material guidelines

*Properties and characteristics that affect formability*

**B**aking a cake requires the right amount of the right ingredients, added at the right time, and baked at the optimal time and temperature. Sheet metal production is not that different. Literally hundreds of different "flavors" of metals are available, each with its own blend of physical, chemical, and surface properties and characteristics.

### Strengthening Metals

Pure elements are relatively soft and malleable. When you move a carpet, it takes a

lot of force to pull the carpet from one end. However, if you first create a little wave or ripple and propagate that through the carpet, it becomes much easier to move. Metal forming on the atomic scale is similar.

Atomically, a pure metal can be pictured like a 3-D network of racked billiard balls all the same size. The gaps in the atomic structure, called dislocations, are necessary for metal flow. As these dislocations propagate in the workpiece, any deviations from the homogeneous pure matrix element will require more effort for the dislocations to move around it. All pure elements are relatively soft and malleable for this reason.

To make a steel alloy, for example, some of the iron billiard balls would need to be replaced with ones made of manganese (Mn), silicon (Si), phosphorus (P), titanium (Ti), and so forth, which are similar but not identical in size to the iron balls. The disruption in the pure iron atomic lattice caused by these alloying additions is responsible for what is known as *solid solution hardening*.

Even though all the balls touch, small gaps exist between them, called *interstices*. This is where small elements like carbon and nitrogen fit (see **Figure 1**). When some alloys are heat-treated, these small elements combine with larger ones and precipitate out of the matrix, creating more obstacles to metal flow, resulting in higher strength associated with *precipitation hardening*. *Work hardening*, also known as *strain hardening*, occurs when many dislocations "pile up" together, and more force needs to be applied to move them apart to continue metal flow.

### Ultralow Carbon Steels

**Steel** is, by minimal definition, an alloy of iron and up to 2 percent carbon (if it is more than 2 percent, the alloy is *cast iron*). Carbon is small enough to fit into the interstices of a primarily iron matrix, making it an "intersti-

tial element" in steel. If the steel alloy has an ultralow carbon level (typically less than 50 parts per million), most of these gaps will not be occupied and, therefore are sometimes described as interstitial-free (IF) steel. These IF steels are almost pure iron, and as a result are very formable. As such, they can be described as *extra-deep-drawing steel* (EDDS). Achieving this low carbon level does not occur using conventional steel processing. Instead, the molten steel must be put under a vacuum that decarburizes it by removing carbon monoxide, as well as other gases like hydrogen and nitrogen. This process is called *vacuum degassing*, and it is done in the production of vacuum degassed interstitial-free steels (VD-IF).

### Mild and Higher-strength Steels

**Mild steel** (also known as *drawing steel*) contains about 0.04 percent carbon and 0.25 percent manganese, along with several other elements in much smaller quantities. Even with all the alloying, these low-carbon steels are still about 99.5 percent iron. Increasing the alloying typically leads to an increase in strength, a decrease in formability and more challenging weldability (higher carbon equivalent). High-strength steels (carbon-manganese); conventional high-strength, low-alloy steels (HSLA); and advanced high-strength steels (AHSS) such as dual-phase (DP) and transformation-induced plasticity (TRIP) steels have different balances of strength, formability, and weldability based on their different chemistries and processing at the steel mill. Knowing the characteristics

## The Training Issue