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MATERION

TECHNICAL TIDBITS

MATERION PERFORMANCE ALLOYS

In harmony with your supplier? –
A brief discussion of the tradeoffs involved when trying to tweak properties of standard materials.

- **Elastic Strain**
- **Plastic Strain**
- **Stress Relaxation**
- **Stress Relaxation Resistance**
- **Initial Stress Level**

The next issue of Technical Tidbits will discuss process capability.

TUNING AND **CUSTOMIZING PROPERTIES**

Often, design engineers end up with designs that push the limits of materials.

For example, they may end up needing a material with properties at the upper ends of all the specification ranges. They may then contact their supplier to ask to purchase material that is in the upper end of all property specifications. How likely is this to happen?

Let's look at an example of a material that has a yield strength specification of 160 to 195 ksi and a tensile elongation in 2 inches of 1 to 8%. The upper right chart of Figure 1 below shows the actual distribution of measurements, with histograms of each variable along the respective axis. Both yield strength and elongation are centered at the middle of their respective specification ranges, although the total distribution appears to be an ellipse stretching from upper left to lower right indicating interdependence of the properties. If the two variables were truly independent of each other and normally distributed, you would expect the combined distribution to be circular in nature, with greatest measurement density at the center gradually diminishing toward the edges.

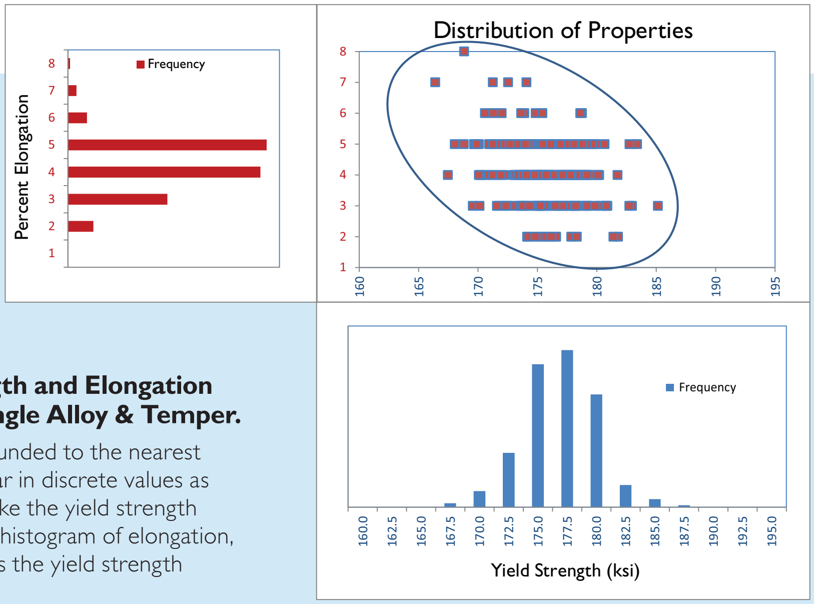

Figure 1. Yield Strength and Elongation Distributions for a Single Alloy & Temper.
Note that elongation is rounded to the nearest percent, so the data appear in discrete values as opposed to a continuum like the yield strength data. The left diagram is a histogram of elongation, the bottom diagram shows the yield strength distribution.

So, if you want a material that has a yield strength of 190 ksi and a tensile elongation of 7%, both values would technically be within specification. You might think that random chance might create a statistical outlier that is on the high side of both strength and elongation. The problem with this thinking is that strength and elongation are not independent variables. Any mechanism that increases the hardness of the material reduces ductility and any means to increase the ductility reduces strength. This is the underlying, fundamental metallurgical reason why there are no measurements in the upper right corner of the specification ranges. The strength/ductility relationship follows predictable patterns. While a processing error may result in a piece of metal ending up in the lower left corner (thus having to be melted as scrap), there is little chance of an outlier miraculously appearing in the upper right corner.

TUNING AND **CUSTOMIZING PROPERTIES** (CONTINUED)

Figure 2 below lends further proof that yield strength and elongation are interrelated. By plotting different tempers of the same material on one chart, you can see that the strength/elongation tradeoff carries across all tempers. No data points appear in the upper right corners of any of the tempers, indicating the difficulty in achieving such an unlikely property combination. You can ask your supplier to provide material at the upper end of the range for strength, but you will have to sacrifice elongation and ductility. Or you can improve elongation at the expense of strength. When asking your supplier to customize properties, you will have to be aware of all the trade-offs involved and that it may not be physically possible to get the desired combination of properties.

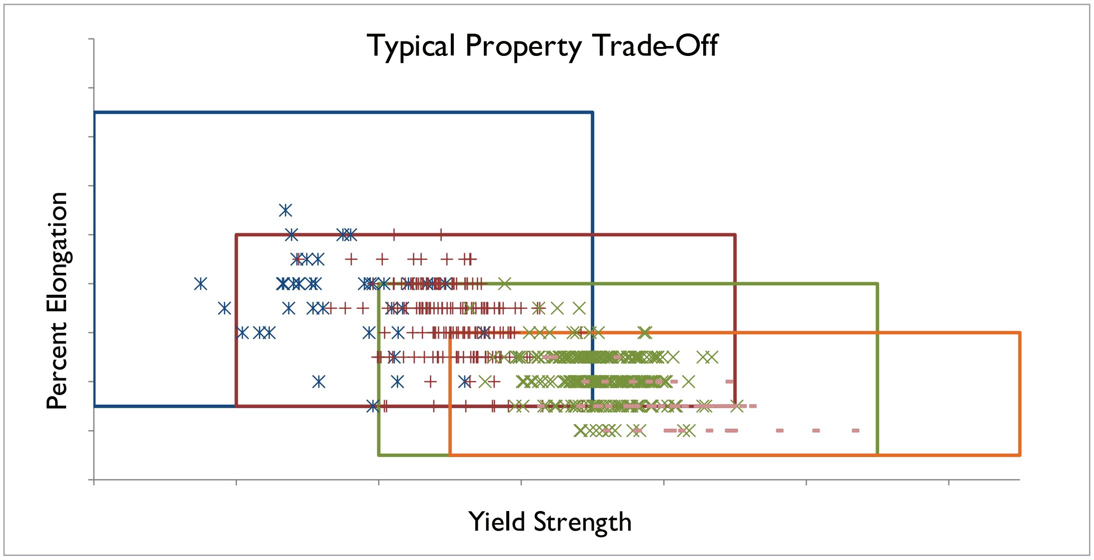

Figure 2. Yield Strength – Percent Elongation Continuum for Multiple Tempers of the Same Material.

Plotting the data for multiple tempers of the same alloy confirms that higher yield strength accompanies lower elongation, and vice versa. The solid lines indicate the specification limits for each temper and individual measurements are shown by the markers of corresponding color. Note the lack of outliers in both the upper right and lower left corners.

This illustrates an important point in material selection, that all material selection involves some kind of trade-off. Such examples include strength (yield/tensile/fatigue) vs. ductility (elongation, reduction of area), strength vs. conductivity (electrical and thermal), strength vs. toughness, etc. This brings us to the most well-known trade-off: material performance and reliability vs. material cost. In order to get better combination of properties, and thus a more reliable material your supplier will need to use more expensive raw materials and perform more processing on them, resulting in a higher sales price. If you will forgive the following semi-facetious list, there is also the additional tradeoff where lower priced materials can save purchasing costs but increase the cost of poor quality, such as warranty claims, recalls, lawsuits, brand damage, government fines, ended careers, lost reputation, death and injury, etc.

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Please contact your local sales representative for further information on material hardness or other questions pertaining to Materion or our products.

Health and Safety

Handling copper beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on copper beryllium, contact Materion Performance Alloys or your local representative.

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