MATERION BRUSH PERFORMANCE ALLOYS
TECHNICAL TIDBITS

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Strip vs. Wire

Is your world flat or round? – A discussion on the relative merits of strip versus flat or round wire for use in electronic connectors.

- **Slitting**
- **Rollover**
- **Shear**
- **Fracture/ Break**
- **Burr**
- **Drawing**
- **True Strain**

The next issue of Technical Tidbits will discuss the spring contact performance differences of round and rectangular cross sections.

Previous editions of Technical Tidbits have focused on how to select the proper alloy and temper of base metals for use in electrical and electronic connectors. This is an important decision, although there are many more design choices that must be made. Miniaturization demands small spring contacts, which are often formed from wire (flat or round), or stamped and formed from strip. This issue of Technical Tidbits focuses on the differences between strip and wire, and how to choose the proper form.

Sometimes it is very easy to make the choice. Certain alloys and tempers are available only as strip, and others are available only as wire. Wire is usually available in longer coils than strip, while strip is available in much larger widths than flat wire. However, wire has tighter width tolerances than strip. Wire does not offer the same design flexibility that strip does. For example, if the part to be stamped has a great deal of surface area, wire may not be wide enough to meet the demand. Furthermore, if a contact has a very irregular cross section with several bends in both the longitudinal and transverse directions, then strip is the material of choice. On the other hand, if the contact is a simple shape with constant cross section, then wire will work perfectly.

Narrow width strip must be **slit** from the much wider coils that are produced by copper mills. At each slit edge, there are four features of interest. **Rollover** is the area at the top (beginning) of the slit that has been crumpled downward by the slitting knife. **Shear** is the area that has been sheared into a straight edge by the knife. The last part of the slit edge will be literally torn out of the cross section. This area is termed **fracture** or **break**. A **burr** is a small, sharp ridge of material extending from the bottom of the fracture zone. Since burrs can break off, possibly even resulting in connector shorts, finished contacts are often chemically or physically deburred, at an additional cost. The left side of figure 1 demonstrates the features of the slit edge, while the right side compares the cross sectional shapes of wire and strip. Note that the edge features are exaggerated in the figure for clarity. The sizes of the rollover, shear, and break zones, as well as the size of the burrs, depend on the clearance between, and vertical overlap of, the slitting knives. It is important to note that these features appear on the edges of stamped parts as well.

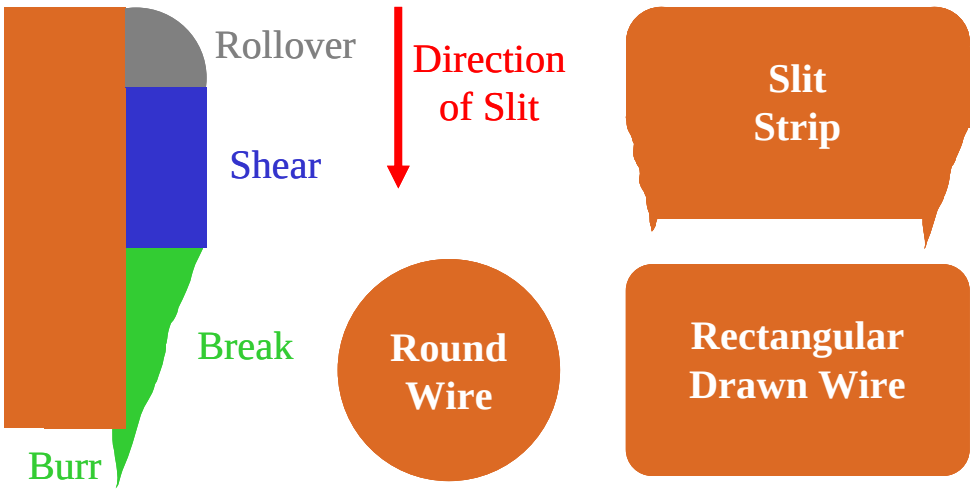

Figure 1. Shape differences between drawn wire and slit strip.

Strip vs. Wire (continued)

Slitting operations will impart cold work and residual stress to the edges of the strip. These stresses can create problems such as die exit twist or camber when the strip is stamped. If the width to thickness ratio is less than 5:1, strip may even show shape problems before stamping, since the residual slitting stresses will be present across a substantial portion of the cross section. These stresses will be compounded by the residual stresses induced by forming operations, unless the final processing step is a heat treatment to stress relieve or age harden the material.

Round wire is **drawn** to the proper gauge, and flat wire may be drawn or rolled from the top, bottom, and sides to the proper width and thickness. In either case, there is no slitting involved. This means that wire will not have the residual stresses from slitting that are present in strip. Since the residual stresses can negatively impact the performance of electrical contacts, wire may offer a slight advantage. However, any forming operations performed on the wire to shape it into the contact will also create residual stress. There will always be some residual stress present, unless the stress is relieved by heat treatment.

Wire and strip are processed differently. One consequence is that equivalent alloys and tempers can show completely different properties in strip and in wire. For example, 1/4 hard (H01 temper) C26000 brass wire has a 57 ksi yield strength, a 70 ksi tensile strength, and a 20% elongation. In strip form, 1/4 hard (H01 temper) C26000 brass has a 40 ksi yield strength, a 54 ksi tensile strength, and 43% elongation. This discrepancy comes from the definition of H01 temper as being a 10.9% reduction in strip thickness or wire diameter. The **true strain** associated with these reductions is twice as much in round wire as in the rectangular strip, so 1/4 hard wire has undergone twice as much strain hardening as 1/4 hard strip. Not only are material properties dependent upon the alloy and temper, they are also dependent on the product form! Therefore, in order to properly specify a material on a print, the designer has to name the alloy, temper, and product form (if it is not obviously an application for strip or wire.) It is certainly not enough to specify merely "brass", "phosphor bronze", or "beryllium copper" on a print. Unfortunately, the author has seen many prints where this is done.

Strip offers several advantages over wire, including greater design flexibility and a generally lower cost in large widths. However, there are some applications where wire will perform better, especially when narrow, regular cross sections are required. Wire will show lower residual stresses and will have a better shaped edge than strip. Strip and wire a processed differently, so they cannot be directly substituted for one another. Product form can be equally important in determining properties as alloy and temper.

Written by Mike Gedeon of Brush Performance Alloys Customer Technical Service Department. Mr. Gedeon's primary focus is on electronic strip for the telecommunications and computer markets with emphasis on Finite Element Analysis (FEA) and material selection.

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References:

ASM Handbook V. 2 – Properties and Selection: Non-Ferrous Alloys and Special Purpose Materials ©1990 ASM International Materials Park, OH

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