

## Resistance Welding – Quality Assurance Issues “Appearances are Deceiving-2” By David Steinmeier

### The Problem

Many manufacturing companies employing resistance welding processes to join metal parts use visual criteria to pass or fail welded parts.

Regardless of who does the inspection, the operator or a trained quality assurance inspector, the visual inspection process cannot predict weld quality in terms of weld peel or pull strength. Relying on visual inspection virtually guarantees unnecessary product scrap and welded products that will fail in the field.

### Why Visual Inspection Doesn't Work

Visual inspection techniques fail to measure weld quality for the simple reason that the welded interface area between the welded parts is not visible. Cross-sectioning the welded parts will show the bond length at only one point in space, but not across the entire bond area.

Heat balance problems can cause one part to heavily melt while the other part hardly heats up. This imbalance results in a weak weld that is not visible to the operator or inspector.

### When Visual Inspection is Useful

Welding a connector onto closely spaced output terminals of an electronic assembly has the potential to create short circuits between adjacent terminals that are comprised of weld splash particles. Visual inspection can identify these shorted terminals for rework.

### Visual Inspection Techniques

Visual inspection techniques primarily fall into three categories: a) weld mark size and shape, b) degree of surface discoloration, and c) degree of “sparking” or expulsion.

### Weld Mark Criteria

Resistance welding leaves a “footprint” or surface mark that is created by the electrode. The amount of heat generated in the part and at the interface between the part and electrode tip determines the size and shape of the final weld mark.

### Weld Mark Criteria Example

Consider the following weld mark inspection example. A very small wire is resistance welded to a stainless steel pin at one end of the wire and to a large stainless steel header at the opposite end of the wire. The machine operators use photographs to identify “cold”, “good”, and “hot” welds. It is important to note that the photographic criteria were not based on any correlation between actual peel strength.

Peel strength was assumed to be a function of the minor diameter dimension (“Y” in Figure 1) because as the electrode degraded, the shape of the minor diameter changed. To prove or disprove this assumption, new and used electrodes were used to make a series of test welds. Key dimensions defining the weld mark were measured. Each weld was then peel tested. All of the dimensional data and peel test data were then analyzed to see if a correlation existed between any weld dimension (appearance) and the peel strength.

Figure 1 shows the welded wire profile and corresponding dimensions used in the analysis.

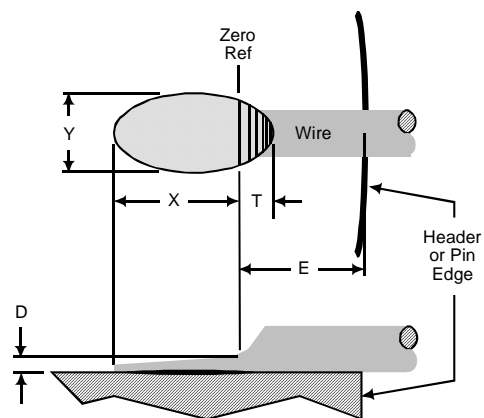


Figure 1 - Welded wire dimensions.

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Figures 2 and 3 show a scatter plot of the weld mark's minor diameter for both the header and pin welds versus peel strength for a *worn out* electrode and a *new* electrode respectively. Note that each set of data points falls primarily in a horizontal plane, indicating a lack of strong correlation with the peel strength.

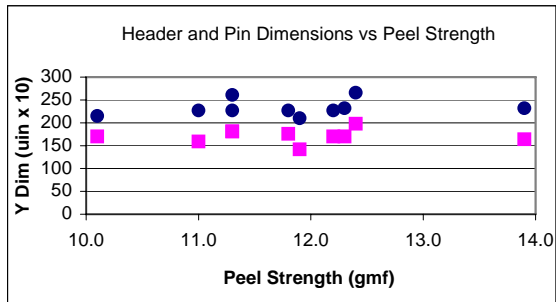


Figure 2 – *Worn* Electrode Header (Rounds) and Pin (Squares).

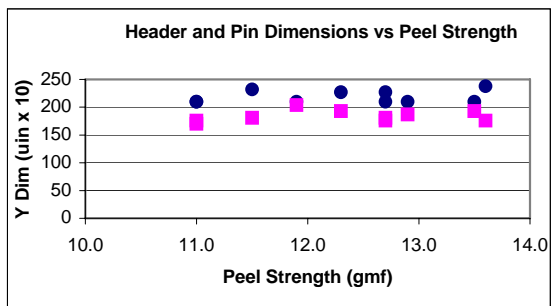


Figure 3 – *New* Electrode Body (Rounds) and Pin (Squares)

A comprehensive regression analysis showed no correlation between *any* dimension, new or worn electrode and peel strength. Therefore, visual inspection of each weld represents an economic loss to manufacturing and does not create any quality assurance for the end customer.

## Weld Surface Discoloration Criteria

Gauging the degree of weld surface discoloration is also pointless since the spread and intensity of the surface discoloration depend both on the external and internal heat generated by the welding process. Discoloration doesn't represent the weld condition between the parts interface.

## Weld “Sparking” Criteria

Many manufacturers use weld “sparking” or material expulsion to judge resistance weld quality. The operators are told that more “sparking” represents a stronger weld. In reality, the sparks come from bits of over-heated electrode tip and parts material. “Sparking” creates voids in the weld area, substantially reducing the weld strength.

Consider the following battery pack welding application. The 90° peel test strength of interconnecting tab weld was about 1 dN with the established welding process that produced heavy “sparking”. After optimizing the weld energy and weld force, all “sparking” was eliminated. The peel strength rose to an average of 5 dN, and the electrode life improved by a factor of three times or more. “Sparking” is a contra-indicator of weld quality.

## What’s a Manufacturer to Do?

Since weld appearance, discoloration, and sparking are useless measures of resistance weld quality, how can a six-sigma oriented manufacturer ensure reliable resistance welds?

Fortunately, there are three possible solutions:

1. Periodically sample weld quality by using peel or pull testing.
2. Periodically sample weld quality by sectioning welded parts to monitor weld penetration.
3. Monitor peak weld current, voltage, force, and displacement for a possible correlation with weld strength.

## Conclusion

Visual resistance welding inspection increases manufacturing costs without assuring weld quality. Limit visual inspection to examine potential electrical short circuits caused by weld splash particles.

Use statistically based destructive testing, sectioning, and weld monitor parameters that actually correlate with weld quality.