

## Weld Monitoring Primer for Micro Resistance Welding - Update

### The “Holy Grail”

The “Holy Grail” of weld monitoring for micro resistance welding is to find one or more real time welding parameters that strongly correlate with the weld quality in terms of pull or peel strength of the welded parts.

### Reality Update

Weld monitoring instrumentation has improved, but the “unknown” weld monitor parameters that closely correlate with the actual weld quality have yet to be discovered. Weld monitor parameters such as peak weld current, voltage, force, and displacement are useful for identifying macro changes in weld quality, but cannot explain the large variations in weld quality that occur during a normal production run.

### Then Why Bother with Weld Monitoring?

When properly utilized, weld monitoring can successfully screen out weak welds. However, weld monitoring cannot be used to predict the exact weld strength of each weld due to the large process variance. Both Figures 1 and 2 illustrate the weld monitoring dilemma caused by these large process variances. For example, Figure 1 shows that given a weld current of 0.550 KA, the pull strength can range from 19 to 34 lbs. Figure 2 shows that given a weld displacement or “set down”, of 0.0030 inches, the pull strength can range from 19 to 35 lbs.

The success of weld monitoring depends to a very large degree upon the definition of weld quality. A minimum “weld quality” requirement of 35 lbs demands that the weld current never drops below 0.670 KA or the weld displacement never drops below 0.0057 inches. However, the yield for this high level of “weld quality” is less than 1%.

If the minimum “weld quality” requirement is 15 lbs, then a minimum weld current of 0.470 KA or a minimum 0.0013 inches of weld displacement will ensure a yield of almost 100%. Thus for a minimum weld quality level of 15 lbs, weld monitoring does offer significant economic benefits by ensuring that the welding process does not drift below a minimum limit.

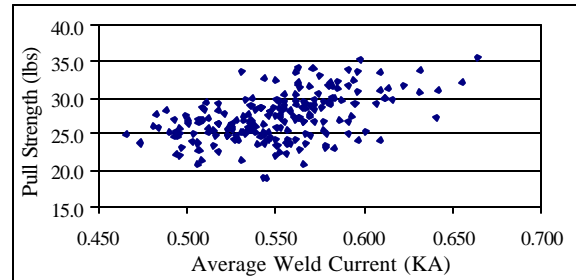


Figure 1 - Pull strength versus weld current.

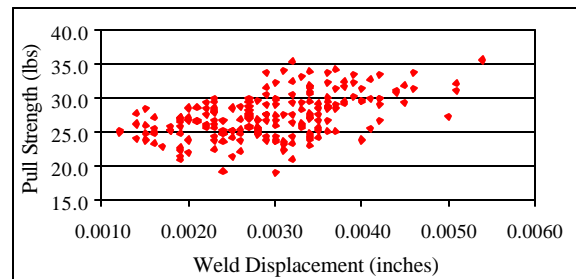


Figure 2 - Pull strength versus weld displacement.

### Weld Quality Variation Sources

Weld quality variation sources in suspected order of importance include: parts interface conditions, sensor signal-to-noise ratio problems, and inconsistent pull or peel test methods.

On a microscopic basis, differences in interface electrical resistance between the electrode tips and parts and between the parts may be the prime source of weld quality variance. Additionally, electrode tip wear and oxide buildup over time shift the average weld quality and increase the process variance.

Weld monitor sensors for weld voltage, force, and displacement are not optimally placed due to physical limitations. Sub-optimal placement results in poor signal-to-noise performance, potentially masking valuable weld quality information.

Finally, pull or peel test methods that lack fixtures for providing consistent pull or peel test geometry and the lack of constant pull or peel force rate control add to the weld quality variance.

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## Weld Monitoring - Electrical Parameters

Weld voltage and current comprise the basic welding electrical parameters. All other electrical parameters such as resistance and power are calculated from these two parameters. Common measurement techniques include: peak, root-mean-square (RMS), average, and time integration. Peak measurements are more sensitive to potential changes in the welding process and noise spikes. RMS, average, and integration measurements filter out the noise spikes, but may mask potential weld quality information.

The type of welding power supply automatically narrows the choice of weld monitor parameter. Monitor the weld current when using constant voltage welding. Monitor the weld voltage when using constant current welding. Monitor both weld voltage and weld current when using constant power welding or when using a non-feedback power supply.

## Weld Monitoring - Mechanical Parameters

Weld force and weld displacement constitute the prime mechanical welding parameters. Weld nugget size measurement requires X-ray or destructive cross-sectioning. Visual weld appearance inspection, while very popular, is totally useless due to the complete lack of correlation between visual appearance and weld strength.

Electrode impact on the parts controls the initial interface resistance between the electrode and parts and between parts. Weld force may or may not correlate with weld quality. At best, weld force may correlate with the average electrode life and average weld strength. However, weld force measurements will not predict the exact weld strength for each weld.

Displacement monitoring measures the distance that the parts compress into each other during welding. Displacement monitoring may work with most “soft” materials such as nickel and stainless steel, but is ineffective when used on hard materials such as carbon steel, molybdenum, and tungsten. Displacement may or may not correlate with the average weld strength, but will not predict the exact weld strength for each weld.

## Sensor Types

The user must make the proper weld monitor sensor selection to ensure signal sensitivity, accuracy, and resolution. Weld current can be measured anywhere in the power supply weld current circuit using a

current coil, precision resistor, or Hall Effect Device to convert current to a voltage representing the weld current. The precision resistor offers the best resolution, accuracy, and waveform preservation. Weld force is best measured with a load cell. Weld displacement can be measured using capacitance, inductive, magnetic, optical, and resistive sensors.

## Installation

The improper installation of a weld monitor sensor can negate the measurement capabilities of even the best and most sensitive weld monitor sensors. Weld voltage must be monitored as close to the electrode tips as possible, especially when using high resistance electrodes such as molybdenum or tungsten, which drop appreciable voltage and thus decrease the measurement sensitivity. The distance from each electrode tip to the parts should be as short as possible and must remain constant.

Weld force and displacement sensors must be in direct line with electrodes in order to produce the best signal-to-noise ratio. Figure 3 shows the best location for each sensor type.

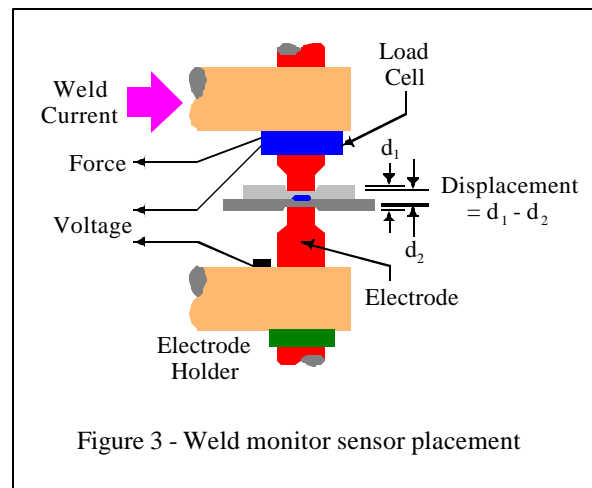


Figure 3 - Weld monitor sensor placement

## Conclusions

Weld monitoring can be a valuable tool in identifying macro changes to your resistance weld process. Care must be taken to ensure that the weld monitor sensors are deployed to produce the best signal-to-noise ratio response. Finally and most important, correlation studies must be conducted to verify that the chosen weld monitor parameters really correlate with weld quality not just over several welds, but over the time span of many production runs and electrode changes.