BY DONALD F. MAATZ JR.

**Q: We are resistance spot welding on galvanized coated parts and experiencing what we consider to be short electrode life. We start each production run with welds that barely meet their size requirements but finish with expulsion so severe we end up destroying the electrode face. We are hesitant to change the weld schedule due to the small initial weld size and have instead focused on the current stepper, to little effect. The water flow, electrode cap size, weld force, secondary current, and weld time are all in line with RWMA guidelines. Any ideas would be appreciated.**

A: Your question intrigues me. If it is assumed that all other aspects of your resistance spot welding (RSW) application are within acceptable industry norms, and that you are welding parts with a coating that is not too detrimental (they all are to a certain extent) to the electrode caps, you may actually have a current stepper boost issue. However, as I will illustrate, this boost issue may be of a very different kind than you realize. But, before we move forward, the following caveat must be understood: This discussion is really relevant only for automotive-grade coated steel products, with

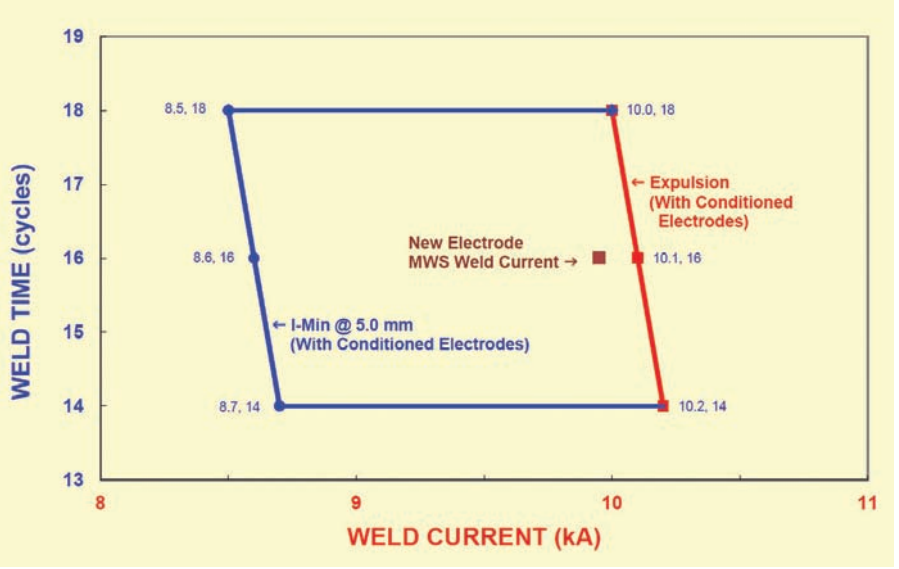


*Fig. 1 — A resistance spot weld lobe.*

the assumption that you are referring to hot-dipped galvanized parts for your application. I say this as other automotive grade coatings (electro-galvanized, galvanneal, etc.) do exhibit this behavior but typically to a lesser degree. The welding of any other material substrate (stainless, etc.), or grade of galvanized coating (i.e., commercial, military, etc.) on steel, falls outside of the realm of this article's applicability. Again, please note that for this discussion, all aspects of the RSW process are correct for the application being discussed. The important elements of material weldability; part presentation; weld gun capability, configuration, and condition; electrode alignment, cooling, stack-up ratio; plus the actual weld schedule itself, are suitable for the application. If this were not the case, we would not be able to correctly evaluate the application for electrode wear and weld performance over the course of a production run.

To help answer your question, we must first understand what would occur if we were spot welding and did not have a current stepper boost feature on our weld control. As each weld is made, the act of applying the scheduled weld time and secondary current, combined with the application of the needed weld force, physically degrades the condition of the electrode contact face. Some in the industry refer to this as mushrooming. This degradation may be subtle and barely noticeable even after many welds, or it may be dramatic, occurring very quickly in the production run. As an example, when the RSW process is used on bare steel and the parts are free of dirt and lightly coated with a known benign oil, it may be possible to make many thousands of welds before the electrode caps are no longer able to produce a weld of acceptable quality. On the other hand, I have seen coatings that acted so aggressively as a wear agent that the electrode caps were essentially ruined and required maintenance after less than a few dozen welds. The most common electrode maintenance activity involves renewing the contact face geometry either by dressing the electrode cap, or replacing it.

The current stepper is a feature of the weld control and was created as a means to help increase the number of welds between electrode maintenance cycles. It accomplishes this by adjusting the secondary current in a programmed manner so that the current density (amps/unit area) remains relatively consistent as the electrode cap contact face area increases with every weld. The early weld controls

only permitted the addition of current at discrete intervals, and a plot of their profile over time looked like a set of steps, hence the name. A more modern weld control permits a customized profile plot (e.g., boost of 1 amp/weld). However, despite the fact the profile is a sloped line and no longer looks like a set of stairs, the name has stuck. As an aside, there has been movement at the OEM level away from utilizing the boost feature of current steppers and strictly using them as a counter to trigger a maintenance activity. This no-boost, dress early, dress often philosophy has merit but really needs to be the subject of a separate discussion.

An examination of your application reveals you may be dealing with — at least for the first portion of your production run — a large variance with your electrode contact face resistance. I say this based on your statement that the welds initially were almost unacceptably small at the start of a production run but grew so hot over time that expulsion ensued. This is a phenomenon that we have seen frequently and have illustrated with an additional data point in a weld lobe plot (see Fig. 1 and also the March 2012 RWMA Q&A for more details on weld lobes). What is unique about this particular weld lobe plot is that it details the secondary current value when a new set of electrodes produces a weld that meets the requirements of minimum weld size (MWS). However, once the electrodes had been conditioned (Ref. 1), the secondary current required to achieve a weld at MWS (I-Min) was substantially lower. Additionally, the new electrode MWS current is only slightly lower than the conditioned electrode expulsion current (I-Max). From a production standpoint, this represents a real problem as the electrodes are exhibiting a very dynamic break-in behavior due to variance with their contact face resistance.

The situation detailed in our example weld lobe is a result of the electrode cap surface contact resistance changing rapidly over the initial 30–100 welds of their life cycle. Once the weld-to-weld variability of the surface contact resistance has been greatly reduced, the effect of electrode face geometry (see the May 2009 RWMA Q&A for more details on electrode geometry) becomes the dominant driving force for the weld lobe results. A potential fallout from this dynamic behavior is that the published results for this weld lobe would be of minimal value unless they were confirmed by a Weld Lobe Point Verification. The Weld Lobe Point Verification test validates a specific set of welding parameters as to its ability to consistently produce welds of acceptable quality. The test is conducted by establishing the weld point within the lobe that is to be validated. For typical automotive grade materials, the validation point is usually 500–1000 A beneath the expulsion current for a given weld time and utilizes electrodes configured to mimic a production environment (i.e., out of the box without conditioning or stabilization). The welding portion of the validation consists of a series of peel coupons (typically 30 or more) at the desired validation point. All peeled test welds should be greater than minimum weld size, and ideally exhibit no expulsion.

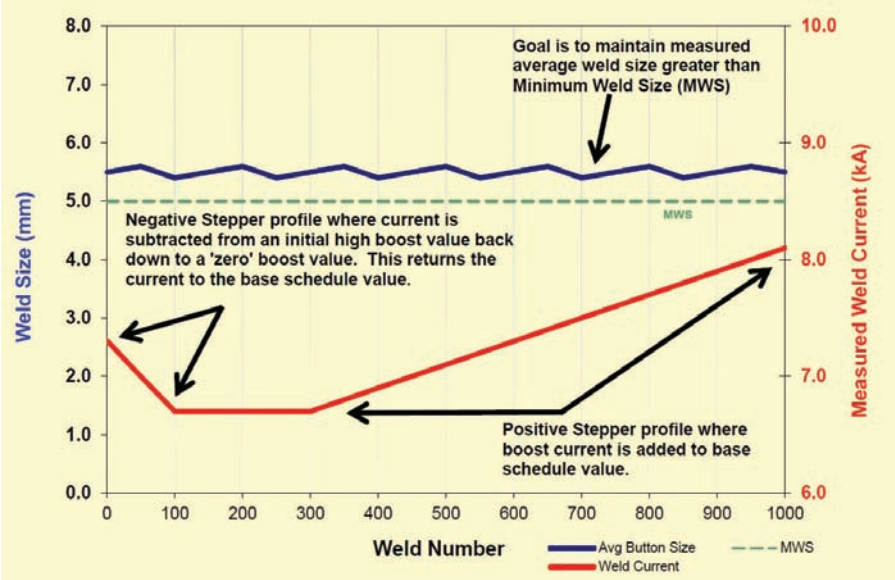


*Fig. 2 — A resistance spot weld current stepper boost profile.*

One possible solution to your issue is to employ a negative stepper boost profile — Fig. 2. As detailed in the example, this type of boost profile permits the utilization of a higher initial starting secondary current with new electrode caps that quickly fades back to a baseline value more suitable for conditioned electrode caps. Once the electrode caps begin to exhibit normal wear, a positive value of boost can be programmed, thus prolonging the time between electrode maintenance cycles. While it will take a bit of experimentation on your part, you should find that your RSW process will be more robust and cost effective by employing this alternative boost strategy.

The RSW process can be very robust, even on coated materials. However, in order to achieve that robustness there are many variables that must be considered, addressed if they are out of compliance, documented for reference, and, finally, maintained for the life cycle of the part.♦

*Acknowledgment*

I would like to thank James W. Dolfi, former AWS Detroit Section, D8D and Auto/Steel Partnership (ASP) Joining Committee chairman, for his invaluable perspective on the welding of coated materials.

*References*

1. AWS D8.9:2012, *Test Methods for Evaluating the Resistance Spot Welding Behavior of Automotive Sheet Steel Materials.* Miami, Fla.: American Welding Society.

*DONALD F. MAATZ JR. is a laboratory manager, RoMan Engineering Services. He is past chairman of the AWS Detroit Section, serves on the D8D and D8.9 Automotive Welding committees, is an advisor to the C1 Resistance Welding Committee, is an AWS CWI, and is vice chairman of the Certified Resistance Welding Technician working group. He is a graduate of The Ohio State University with a BS in Welding Engineering. This article would not have been possible were it not for the assistance from members of the RoMan team. Send your comments/questions to Maatz at* dmaatz@romaneng.com, *or to Donald F. Maatz Jr., c/o* Welding Journal, *8669 NW 36 St., #130, Miami, FL 33166.*