

Q: My company is relatively new to resistance spot welding, and we are looking at efficiency improvements that would require running multiple part combinations on a single tool. With an eye toward minimizing potential changeover miscues, we would like to utilize a single welding electrode for all of our spot welds, if possible. Unfortunately, after a review of the many electrode combinations that might work, we came away slightly concerned about the wide variety available. Are there any rules or guidelines that could aid us in this endeavor?

A: This is a fairly common question within the industry as companies look to standardize and/or minimize the number of welding consumables, including electrodes, they stock for a given process. To help determine an answer, it will be helpful to consider the function of the electrode within the resistive welding process and then attempt to provide a few basic guidelines on proper selection.

The successful execution of any resistance welding operation, however simple or complicated, is dependent upon the proper functioning of the electrodes. The high level of development that has occurred (and is still occurring) with the various resistive joining processes has made it more evident than ever that good welding is a precision process. A properly designed welding machine includes a capable electrical system, robust mechanical system, and precise control system. The function of the electrodes is to conduct the current and withstand the high forces so as to maintain a uniform contact area, thus ensuring the proper relationship of current, time, and force required for a successful weld.

To answer your question regarding electrode selection and whether or not it is possible for one size to fit all, it is beneficial to start by discussing the basic parameters that affect every weld: current, time, and force. Other themes important to the discussion are electrode materials and contact face geometry. As you did not detail the specifics of the substrates involved, this discussion is generic in nature but should provide enough information on the selection of resistance spot welding electrodes to reach the correct conclusion for your particular application.

Weld Force. The force required for a particular weld influences many aspects of electrode design and construction, particularly the electrode taper size, body diameter, and cooling cavity to contact face distance. The welding operation subjects

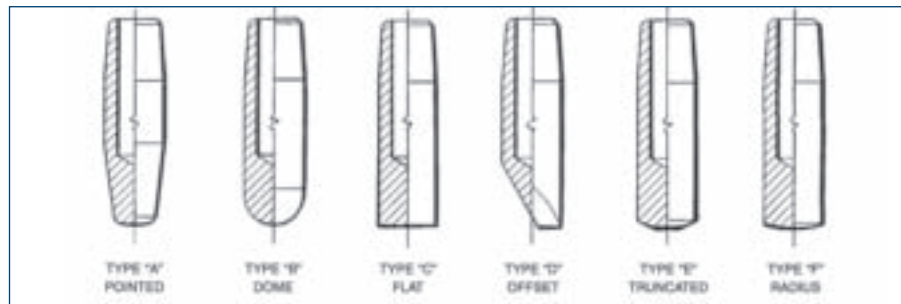


Fig. 1 — Standard spot welding electrodes. (Illustration courtesy of the RWMA.)

the electrodes to stresses that are often of considerable magnitude, and they must be capable of withstanding these stresses at elevated temperatures without excessive deformation. This is no easy task when one considers that many resistance spot welds are made between 500 and 1700 pounds. The majority of the electrode design requirements have been proven over time and subsequently incorporated as industry standards. Specifically, AWS D8.6, ISO-5821, and RWMA Bulletin 16 may be referenced for the recommended or standardized designs. The electrode design constraints mandated by force are a critical area where a compromise in the electrode selection process may occur. For example, if one application requires a higher weld force than another, the electrode selected must be capable of withstanding the greater force condition.

Weld Current and/or Weld Time. The secondary welding current and time required to achieve a spot weld are rarely, if ever, considered when selecting an electrode. The primary reason for this is that the vast majority of spot welding electrodes are cooled in some fashion, thus rendering them with excellent electrical and thermal capacities. This results in the required weld force being a much larger factor in electrode design selection than either current or time.

Electrode Material. An in-depth discussion on the proper selection of electrode materials should be left for another time as this is potentially a very application-specific area of resistance welding. There are many excellent sources of information on this topic and a good place to start is the *Resistance Welding Manual* or one of the many electrode suppliers listed in the RWMA Directory (files.aws.org/rwma/docs/webdir-09.pdf). One point to keep in mind is that electrodes generally have a higher thermal conductivity than that of the metals being welded, so for a starting point consider

electrodes constructed of RWMA Class-1 and Class-2 copper as these alloys compose the majority of the usage within the industry.

Electrode Geometry. The selection of the contact face geometry is the most critical aspect of electrode selection that must be considered. To help facilitate this selection, several aspects of the weld must be considered. These include the required weld size, substrate gauge, and surface quality requirements. One important physical characteristic to remember is that the contact face geometry, weld size, and substrate gauge should all trend in the same direction. More to the point, a welding process that attempts to utilize a larger contact face to weld both a thick and thin section will most likely struggle on the thin stack-up. This is a very important point to keep in mind when selecting the electrode for your application. Other items such as substrate type and coating, while important for determining the actual weld schedule (force, etc.) and influencing the potential life of the electrode, do not have the impact on achieving the initial weld that the required weld size, substrate gauge, and surface quality do.

Figure 1 illustrates six of the many standard electrode nose geometries available.

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Each of these geometries has its own benefits and limitations, and supporters and detractors. Type A, B, and E geometries are most commonly used for general welding applications. Type C and F geometries are typically used where minimal surface marking is required. Type D geometry permits access in limited spaces. The following general guidelines should help with the selection process:

- **Type A.** Good general design. The selection of the contact face diameter is important so that it is compatible with the desired weld size and the substrate gauge. The design is able to support weld sizes larger than $4\sqrt{\text{GMT}}$ (governing metal thickness) when a properly sized contact face is utilized for a particular substrate gauge.
- **Type B.** Also a good general design. Type B will typically result in more indentation than Types A or E due to its spherical shape; it is not able to support very large weld sizes. As a rule of thumb, do not expect to sustain weld sizes larger than $4\sqrt{\text{GMT}}$. It is a good candidate for robotic dressing.
- **Type C.** Utilized for improved weld surface quality. Has the potential to wear quickly when welded on coated materials and should be dressed off-line in order to renew properly.
- **Type D.** Utilized when a weld has to be made close to an upturned flange or corner. The offset loading associated with the Type D design is hard on the electrode taper. The basic rules regarding Types A and E contact face diameters also apply to the Type D electrode contact face.
- **Type E.** Another good general design available in different rake angles. The 30- and 45-deg designs are the most popular. These designs are also a good candidates for robotic dressing. As with the Type A electrode, the selection of the contact face diameter is important so that it is compatible with the desired weld size and substrate gauge.
- **Type F.** Utilized for improved weld surface quality. May also be used when welding very thick stack-ups or aluminum, depending on the face radius specified. A properly sized Type F can support very large weld sizes ($>5.5\sqrt{\text{GMT}}$) when used with robust schedules and capable equipment. Also while possible, this geometry is not a good candidate for robotic dressing.

For further information on electrode selection, AWS C1.1:2000, *Recommended Practices for Resistance Welding*, may also be a beneficial reference.

So to attempt to answer your question: Are there industry standard electrode designs available that are very versatile and capable of welding many different stack-ups? The answer is yes if due considera-

tion is given to the required weld force and a suitable geometry is selected. However, even the best standard electrode can become unsuitable under a variety of circumstances. Another way to look at this problem is to think of the spark plugs in your car. While different types of spark plugs may work, there is most likely an optimal design that works best, but just as there is not a spark plug made that will allow my pickup truck to sit on the pole at the Indy 500, there is not a single elec-

trode capable of making all types of resistance spot welds. ♦

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