

Designing Ring Projections for Hermetic Sealing

Tips for success and solutions for overcoming challenges

Ring projections, also known as annular projections, are used in the electronic packaging industry to hermetically seal electronic, transistor outline (TO) and, more recently, rectangular packages. For successful ring projection design, be sure to use the right pneumatic weld head controller, weld head, and power supply, and carefully develop a weld schedule. Consider incorporating both visual indicators and weld monitors into your process to ensure reliability of a hermetic seal. And for overcoming less than perfect designs, check for post-weld defects and take preventive actions to avoid them.

BASIC DESIGN CONCEPTS

Ring projections are usually coined into the drawn cap material, but may be machined or chemically etched into the package header or lid. The projection must be on either the cap or the header, never on both. The projection directs the heat, which must be directed to only one predetermined location. **Figure 1** shows two examples of such projections on a cap, and **Figure 2** illustrates how the projections look on a header.

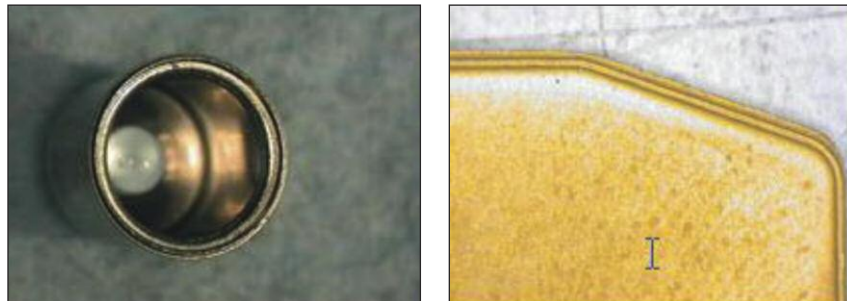


Figure 1 – Projections on a package cap



Figure 2 – Projections on the package header

The typical height for projections used in electronic packaging applications ranges from 0.006-0.010 inches. The projection height must be co-planar or flat within 0.002 inches to ensure even heat distribution between the two mating parts. Otherwise, there could be a non-hermetic seal caused by uneven heat distribution between the mating parts. With uneven heat distribution there will be insufficient heat in some sections of the weld joint resulting in a “cold weld,” and overheated sections, which will result in material expulsion in some sections of the weld joint. **Figure 3** illustrates the proper projection specifications for resistance welding.

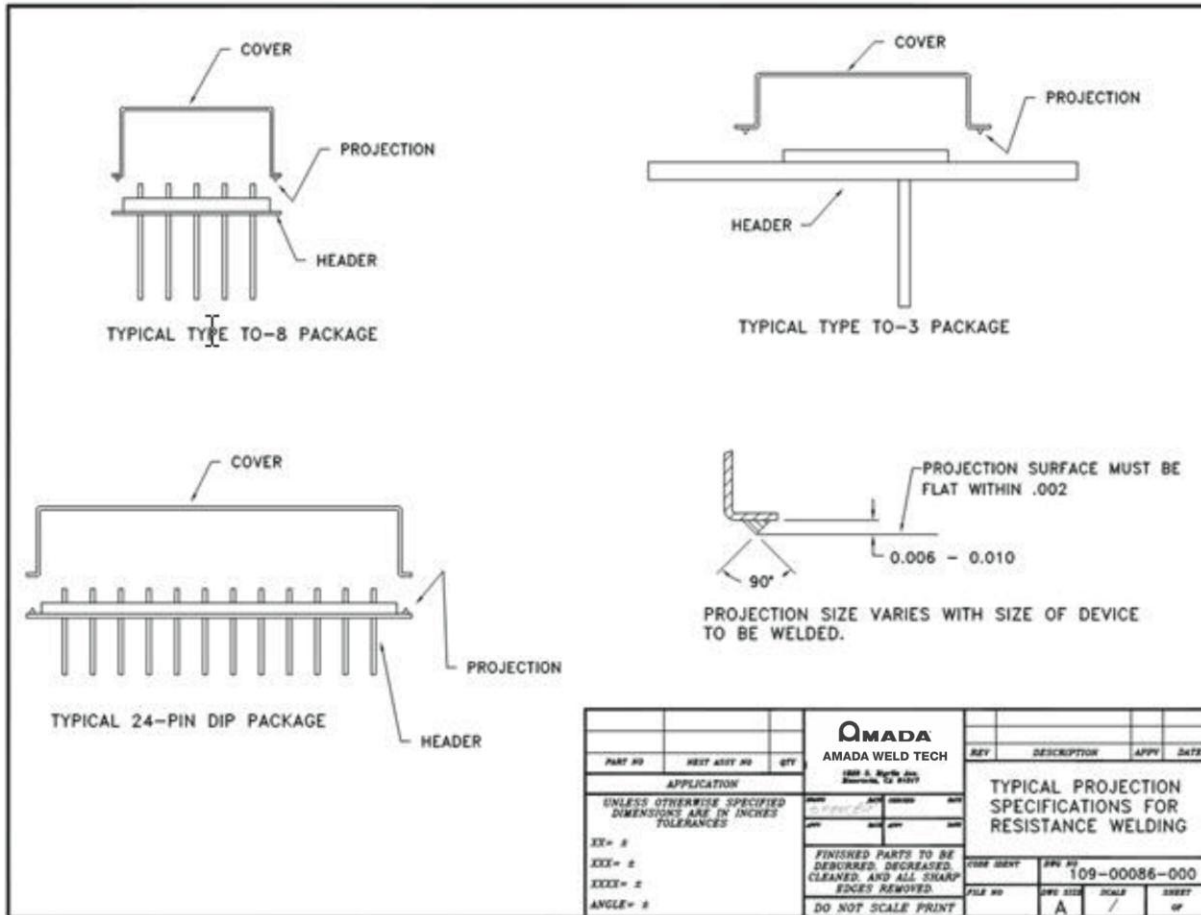


Figure 3 – Projection specifications

USE THE RIGHT WELD HELD CONTROLLER, WELD HEAD, AND POWER SUPPLY

The most important factor in ensuring a good hermetic seal is to use the most appropriate pneumatic weld head controller, weld head, and power supply. One example of a system recommended for most hermetic projection welding applications is AMADA WELD TECH’s CD-P and CD-A Series Capacitive Discharge Projection Welding Systems. This single station production system is complete with a capacitive discharge weld power supply, a high efficiency SS-100A pneumatic weld head

controller, and a KN-200A weld head. The KN-200A die set weld head design ensures that top and bottom electrodes are always aligned. The high efficiency SS-100A pneumatic weld head controller ensures the preset weld force is achieved before sending a weld signal to the capacitor discharge power supply to fire.

The right power supply is extremely important for ensuring repeatable results. The most cost effective approach is to select a power supply that can handle the largest package size to be welded. As the package size increases (as measured in linear inches), more weld energy is needed. In most cases, a power supply that can handle a very high energy range can be adjusted downward to deal with smaller packages. One caveat – the highest energy models like the CD-P9000A may not have good enough resolution to deal with extremely small packages that may require less weld energy (300 joules or less).

For a small transistor outline packages, like the T018 and T056 (caps with diameters ranging from .150 to .25 inches), we recommend the CD-A capacitive discharge welder CD-A1000A (adjustable from 0 to 999 joules), which offers a short, high energy weld pulse, localizes heat in the weld zone, reducing heat build-up in sensitive microelectronic packages. For larger packages, up to .50 in diameter like the T08, a CD-P3000A can be used. For T03 packages (.770 in diameter) a CD-P6000A system would be recommended.

Recently, there has been a significant increase in the number of larger rectangular packages, measuring up to 5 linear inches. These typically contain modules with different components, including transistors, relays, and photonic components. For these types of modular packages, a power supply with an energy range of 9000 to 12000 joules is recommended.

Refer to **Table 1** for typical welding applications showing recommended power supplies ranging from the 1000 to 12000 joules and linear length of the projection it can handle.

TYPICAL ELECTRONIC DEVICES AND CAPACITOR DISCHARGE POWER SUPPLIES IN THE MARKET													
DEVICE TYPE	T0-56	T0-18	T0-46	T0-5	T0-39	T0-37	T0-8	T0-66	T0-3	14 DIP	24 DIP	RELAYS	HYBRIDS
PROJECTION LINEAR LENGTH (mm)	0.49" (12.5)	0.7" (17.8)	0.7" (17.8)	1" (25.4)	1" (25.4)	1.1" (27.2)	1.6" (40.6)	1.9" (48.3)	2.8" (71.1)	2.4" (61.0)	3.3" (83.8)	4" (101.6)	5" (127.0)
CD POWER SUPPLY MAXIMUM OUTPUT													
1000 JOULES	X	X	X	X	X	X							
3000 JOULES		X	X	X	X	X	X	X					
6000 JOULES			X	X	X	X	X	X	X	X			
9000 JOULES				X	X	X	X	X	X	X	X	X	
12000 JOULES				X	X	X	X	X	X	X	X	X	X

LEGEND: "X" - WELDABLE

Table 1 – Projection welding matrix by application

WELD SCHEDULE DEVELOPMENT IS KEY TO SUCCESS

The proper weld schedule is a delicate balance between force, heat, and weld current. Developing a weld schedule is a methodical procedure, which consists of making sample welds and evaluating the results. The first weld should be made at low energy settings. Gradual adjustments are then made to each of the welding parameters, one at a time, until good weld penetration is achieved. Since increasing energy can result in material expulsion inside the package, a good technique is to start by making a weld, then opening it to check for possible material expulsion, and then tweaking the weld schedule accordingly.

Using a capacitive discharge power supply means the pulse duration is fixed, so only force and energy can be adjusted. Increasing force would eliminate material expulsion, but could flatten out the projection, making it useless. To check if the force is too high, consider performing a weld cycle with the weld power turned off and inspecting the projection; if it is flattened or digging into the mating part, the force is too high and should be lowered.

The quality and flatness of the projection ring is a key factor in achieving a hermetic seal. Bowed cap flanges and uneven projection height can cause failure. Increasing the weld force can compensate for cap flatness and uneven projection ring height issues to some degree. However, be careful not to use excessive force; as mentioned earlier, this can flatten the projection or dig into the mating part, which will eliminate the effectiveness of the projection you've worked so hard to create. Also, keep in mind that when you increase the force, you decrease the contact resistance between the cap and the header. In this case, increase weld energy to achieve a successful weld. **Figure 4** is a side view of a rectangular header with uneven projection height. **Figure 5** shows a bowed cap flange defect.

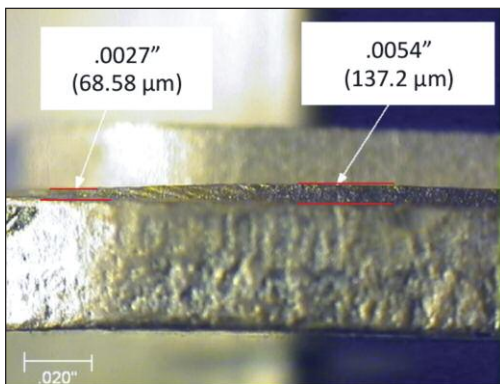


Figure 4 – Header with uneven projection height

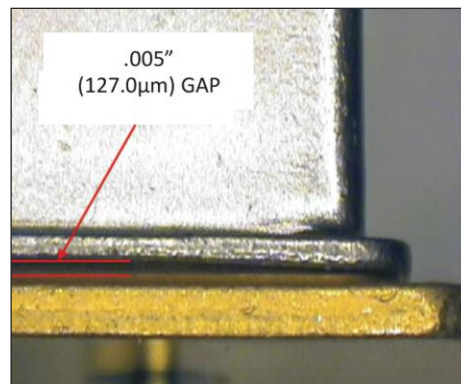


Figure 5 – Bowed cap flange defect

USE BOTH VISUAL INDICATORS AND WELD MONITORS TO ENSURE RELIABILITY OF A HERMETIC SEAL

While most welded packages generally undergo Military Standard gross and fine leak tests to guarantee hermetic seals, a visual confirmation of a continuous nickel fillet along the perimeter of the cap is a good indicator of a hermetic seal. A fillet may not be present where the projection is far from the outer edge; in those cases, consider visual monitoring of the projection collapse. Welded samples are also subjected to destructive testing to check the reliability of the weld joint; using a pull tester with a force gauge, welded strength can be measured while mechanically separating the cap from the header. Cross sectioning can also be performed to investigate the quality and nature of the weld joint. **Figure 6** shows examples of cross-sectioned projection-welded caps to headers.

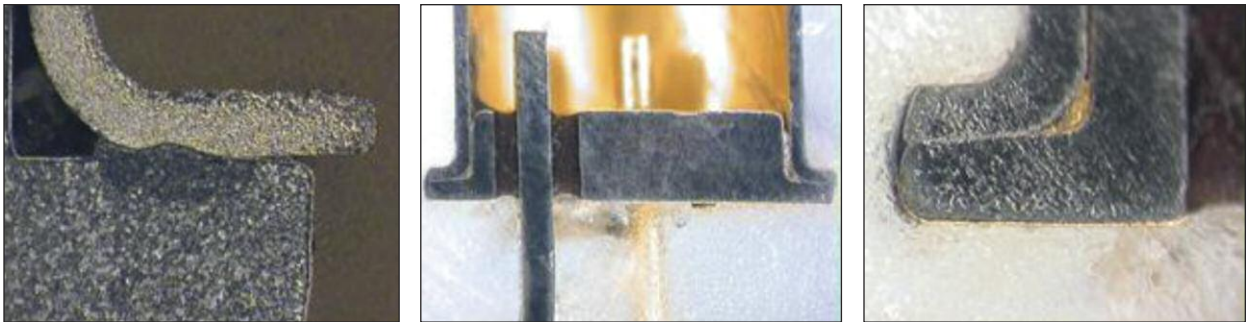


Figure 6 – Cross sections of projection-welded caps

While visual indicators give a fairly good idea of weld success, consider installing weld checkers or weld monitors on the weld head to measure actual current, resistance, and projection collapse during welding; these are very useful tools for process development and production monitoring. Rather than a feeling or guess, monitors give you an objective, numerical way of tracking current and projection collapse. Such tools are excellent for developing the best possible weld schedule.

For example, AMADA WELD TECH's Advanced Data Analysis Monitor provides graphical viewing of seven key resistance welding variables, including current, voltage, power, resistance, displacement, force, and cover gas flow. The instrument monitors not only what happens during the weld, but also before weld monitoring is triggered, giving a 360-degree view of the process. For process development, the tool can be used for welding evaluation and research, studies, process optimization, and process validation.

Another option is the MM-400A Weld Monitor, which shows numerical results with upper and lower reject limits; a programmable weld counter shows the ratio of in/out of limits welds. The MM-400A measures current, voltage, force and displacement. The electrical data can be used to confirm that the weld resistance change is consistent, and the mechanical data (weld displacement) verifies the expected deformation has occurred. This data can be used to indicate process drift, troubleshoot and ultimately provide data that a process is in control.

CHECK FOR POST-WELD DEFECTS AND TAKE PREVENTIVE ACTION TO AVOID THEM

After successfully designing the projection and achieving a hermetic seal, an important final step is investigating potential post-weld defects, including particle impact noise detection (PIND) failure and glass feedthrough cracking.

Particle impact noise detection (PIND) failure generally occurs due to material expulsion trapped inside the package during the projection welding process. **Figure 7** shows evidence of a ball-like material expulsion inside the package after mechanically separating the cap from the header. In most cases, this material expulsion can be eliminated by either increasing the weld force or decreasing the weld energy.

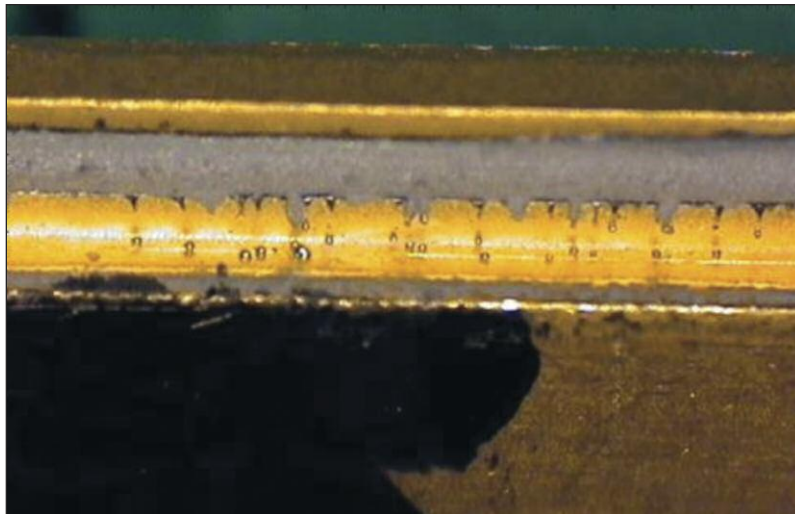


Figure 7 – Material expulsion example

If you encounter fine leak failure during weld schedule development, investigate the possibility of glass feedthrough cracking. Electronic packages, including TO packages, oscillators, modules, and photonics, have feedthroughs surrounded by glass that can be cracked during the welding process, thus compromising the seals. **Figure 8** shows a fine leak failure due to hairline cracks in the glass feedthrough. These defects are caused by excessive heat or sudden impact as the weld head comes into contact with the parts. Avoid them by adjusting the weld head's down speed and decreasing the weld pulse duration.



Figure 8 – Leak failure from glass feedthrough crack

Finding the best manufacturing solution for a particular hermetic sealing application can be a challenging process. Wherever possible, it is important to do a thorough evaluation of specific processes to ensure they provide a comprehensive application solution. For example, AMADA WELD TECH offers application laboratories that provide assistance on part design, material selection, and maximizing component manufacturability.

