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COLD-WELDING INFORMATION

Many devices produced in the electronic, cryogenic, laser and high-vacuum industries are connected to vacuum pumping stations by ductile metal tabulation. This method provides a low-cost, reliable connection which is bakeable to 600° C and requires only a small amount of space. To eliminate the need for expensive valves when separating these devices from manifolds, tabulation can be sealed and severed in a single, simple operation with a pinch-off press. The HY-series pinch-off tools produce a permanent, bilateral seal in ductile metal tubing by symmetrically collapsing, cold welding and severing tabulation with no loss of vacuum or pressure.

A great deal of research data on cold-welding originated from NASA reports of accidental cold-welding in outer space. Conditions for these "accidents" were perfect: the materials were of the highest purity, surfaces superbly machined and thoroughly cleaned, and placed in the high vacuum of space. Even a small amount of exerted force would bring atoms close enough together to form a metallurgical bond or cold weld. A good pinch-off is no accident; the correct conditions must be created.

Tubular Selection

The most commonly used metal for pinch-off is OFHC (**O**xygen **F**ree, **H**igh **C**onductivity) copper. ASTM B68-83, B75-84, B133-83 and B170-82 (CDA-101) give the specifications, chemistry and state of ductility for billet-certified 99.99% pinch-off grade copper. Because the material undergoes a deformation of approximately 350% during pinch-off, it is important that the materials be bright annealed at 650° C to 850° C for 30 minutes in a dry hydrogen atmosphere.

Another commonly used material is high-purity nickel: "A" Nickel, NI 270, NI 200 or 99.4% nickel (ASTM-B161). This material offers several advantages: Minimal outgassing during bake-out and pinch-off, minimal oxidation and higher temperature bakeability. As with copper, nickel tabulation must be fully annealed at 1150° C for 30 minutes before pinch-off. Good results also can be obtained with aluminum (annealed 3003 H14, 98%, classified non-heat treatable), pure iron, gold, platinum, silver and columbium.

The cold-welded area will be work hardened during pinch-off and micrographs will show a dense, elongated grain structure. The size or length of the cold-welded area depends on: Material, type, annealing, cleanliness, wall thickness and radius of the pinch-off anvil inserts.

Preparation for Pinch-Off

Tubulation I.D. must be totally free of contamination at the weld point. Sonic or mechanical cleaning rather than chemical cleaning prior to pump down yields the best cold-welds. The O.D. of the tubing should be polished with 320-grit emery cloth to remove any oxide crystals. Oxides are harder than the base metal and can interfere with the cold-welding process.

The lapped tungsten carbide anvil inserts of the pinch-off jaws must be cleaned before each pinch-off. Often a very thin ribbon of the work-hardened metal remains on the jaw insert and must be removed. Any contamination pressed into the metal at the weld point can injure the cold-welded seal. The pinch-off is a cold extrusion and a lubricant can be used to aid the material flow. A clean #10 machine oil works well on most metals.

During the pinch-off, hand or hydraulic pressure must be applied evenly until the tubing severs suddenly. Any interruption of this process while the material is in a plastic state will result in an incomplete cold weld. Hydraulic pumps, whether hand-powered, air booster or electric, provide reliable service and assure the best results. Leaks are likely to occur if the pinch-off phase is incomplete and the tubing needs to be wiggled apart.

After the Pinch-Off

Various methods have been developed to check the finished device for leakage. Vacuum insulation time rates and electric resistance measurements can be avoided if a sample tube is carried through the entire process, then subjected to a helium leak test or microscopic examination and used for comparative analysis. Process procedures should be duplicated precisely, since changes as subtle as bending a piece of copper tubing will change its grain structure and work-harden the piece considerably. Even more significant changes in grain size, crystal structure and ductility will occur during any thermal processes such as brazing, bake-out, soldering or welding.

The cold-welded stub should be protected with a plastic cap or a Varian Torr Seal* resin after the pinch-off, as it is a delicate seal and razor sharp. (*Registered trade mark of Varian, Inc.)

Pinch-Off Press Selection

Choosing the correct Pinch-Off tool for any particular application depends on many factors. Contact Custom Products & Services, Inc. for more information.

TYPICAL TUBE DEFORMATION

Model Number	TUBING DIA (x 0.035" wall)	ELONGATION (per side)	FLARE (Razor Edge)	DISTORTION (min. stub length)
HY-125	1/8"	.050: (1/8")	.170"	.125"
HY-187	3/16"	.050: (1/8")	.250"	.187"
HY-250	¼"	.050: (1/8")	.350"	.250"
HY-500	½"	.055" (3/16")	.750"	.500"