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Title: Confined Tube Crimp Using Portable Hand Tools

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Confined Tube Crimp Using Portable Hand Tools

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ABSTRACT

The Lawrence Radiation Laboratory developed handheld tools that crimp a 1/16 inch OD tube, forming a leak tight seal[1] (see Figure 1). The leak tight seal forms by confining the 1/16 inch OD tubing inside a die while applying crimp pressure. Under confined pressure, the tube walls weld at the crimp. The purpose of this study was to determine conditions for fabricating a leak tight tube weld.

The equipment was used on a trial-and-error basis, changing the conditions after each attempt until successful welds were fabricated. To better confine the tube, the die faces were polished. Polishing removed a few thousandths of an inch from the die face, resulting in a tighter grip on the tubing wall. Using detergent in an ultrasonic bath, the tubing was cleaned. Also, the time under crimp pressure was increased to 30 seconds. With these modifications, acceptable cold welds were fabricated.

After setting the conditions for an acceptable cold weld, the tube was TIG welded across the crimped face.

INTRODUCTION

A vacuum tight, structurally sound weld is needed for a 1/16-inch OD stainless steel tubing. Lawrence Radiation Laboratory developed a hand-held set of jaws for crimping 1/16-inch tubes (Figure 1).[2] From these drawings, die blocks and cutters for 1/16-inch tubing were fabricated (Figure 2).

DISCUSSION

The crimper works by compressing the tube between cutters while confining in a die block. The gap between the cutters is the primary adjustment for the crimping tool. A screw at the end of the jaw sets this depth.

Preliminary operations discovered a design flaw in the hand-held crimper. While making a crimp, the jaw handles had unlimited travel, transmitting all the leveraged force applied by the operator to the cutters. This allowed the operator to apply more force than the material strength. This resulted in cracked cutters and broken die-blocks (Figure 3).

Adding handle stops to the jaw handles provided a solution to this problem (Figure 4). With this design change, excess force transmits to the stops rather than the cutters. An additional advantage is that the handle stops make the cutter force consistent from one crimp to the next.

WR quality tubing made from type 316 stainless steel was used for this experiment.[3] Micrographs of the polished cross sections provided the data for assessing quality of the tube welds.

Helium leak checks were performed on the first set of crimps confirmed the formation of a leak tight seal. However, the leak check data tells little about crimp quality. Cutting the tube with a pair of wire cutters yields a leak tight seal, but a low quality crimp.

The gap between the cutters was measured by inserting a feeler gage between the cutters with the jaws closed. We began by making crimps with a gap of 0.0015 inches between the cutter points. There was no expectation of making an acceptable crimp under these conditions. These initial crimps showed that the die block, cutters, jaws and tubing aligned.

Manufacturing experience showed that, for fusion welding to occur, there must not be a gap between the cutters. In fact, fusion welding requires a compression of the cutters by a substantial amount. Experience with manufacturing shows that the best welds are produced with the cutters compressed by as much as 0.010-inches.

Crimp samples were differentiated into three series for experimentation

Series 1:

After making the initial crimps with a positive gap between the cutters, the adjustment screw was tightened by 1/8th turn (see Figure 2). The adjustment screw has course threads spaced by about 1/16th inch. Consequently, a 1/8th turn moved the cutters about 0.008-inches toward the center. Closing the jaws under these conditions would load the cutter points with the leveraged force of the handles. Without a piece of tubing to distribute this load, closing the crimper handles would most likely result in a repeat of the damage illustrated in Figure 3. With the cutters adjusted so that the cutter points make contact, a spacer was placed between the handles to prevent them from inadvertently closing (see Figure 2).

Figure 5 shows an example of the first crimps made under these conditions. Examination of these crimps indicated that it was possible to make a better crimp, so these crimps were not subjected to metallographic analyses. The adjustment screw was turned another 1/8-turn and a set of ten crimps were made. Figure 6 shows an example of one of the ten crimps made under these conditions.

Each crimp from Series 1 was fitted with a 1/16-inch Swagelok® fitting and helium leak checked.[4] The crimps were found to leak at a rate of less than 1×10^{-9} std cc/sec. Five of the ten crimps were submitted for metallographic analyses (Figure 7).
Crimps under Series 1 conditions showed a lack of bonding across fusion zone. The metal did weld toward the cut end and there was no detectable leak.

Series 2:

Crimp samples in series two were subject to further alteration of the crimping tool. In the interest of obtaining better results, the cutter adjustment screw was tightened another 3/8 turn (Figure 8).

Of the ten crimps made in Series 2, the last five were submitted for metallography. One of the samples was lost during preparation; therefore only four micrographs were prepared. Micrographs 2 and 3 represent examples where fusion welding occurred almost throughout the area of contact. However, one of the four crimps did not weld along the fusion zone (Figures 11 and 12).

Micrographs 2 through 5 show that the cut zone was extruded to a thickness of several thousands of an inch (Figures 9-12). Applying more force by adjusting the cutters would most likely result in a failure of the crimper materials.

Series 3:

Close examination of the crimper revealed a possible cause for the lack of bond shown in Micrographs 4 and 5 (Figures 11 and 12). In this design, the die block slides back-and-forth, or floats, along the cutters (see Figures 2 and 3). This allows the crimp to self center without making adjustments. Any binding of the die block on the cutters results in an off-center crimp that places the weld zone under shear force rather than compression. Under shear, the centerline slips and no weld forms.

Corrective actions were taken as follows.

1. The die block was lubricated with graphite. This noticeably reduced the resistance of the "floating" design.
2. The die block top was tightened finger-tight. In all previous crimps, the top plate was tightened snuggly with a wrench. Finger tighten the bolts also reduced the resistance of the die block movement along the cutter.
3. With the tube in place and before making the crimp, the die block was moved along the cutters so that the anvil side of the cutters made contact with the tube. Under this arrangement, each crimp began from the same starting point.

Ten crimps were made using the above corrective actions. All of the crimps formed a weld along the fusion zone and Micrographs 6 and 7 are representative of these crimps (Figures 13, 14, and 15).

CONCLUSION

High quality crimps were produced by taking care to allow the die block to slide freely along the cutters. The die block top was affixed finger tight.

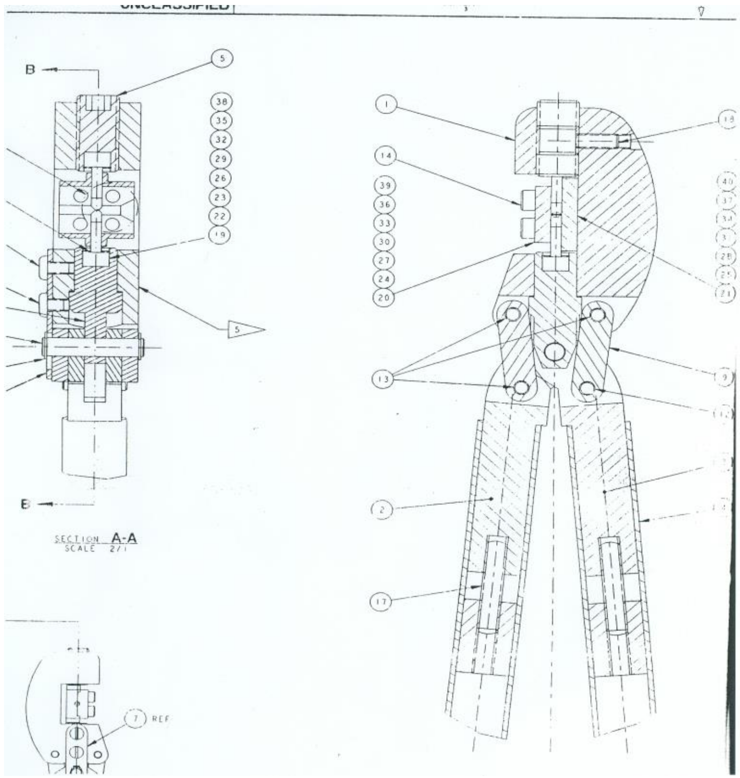

Figure 1: Hand-Held Crimper Drawing

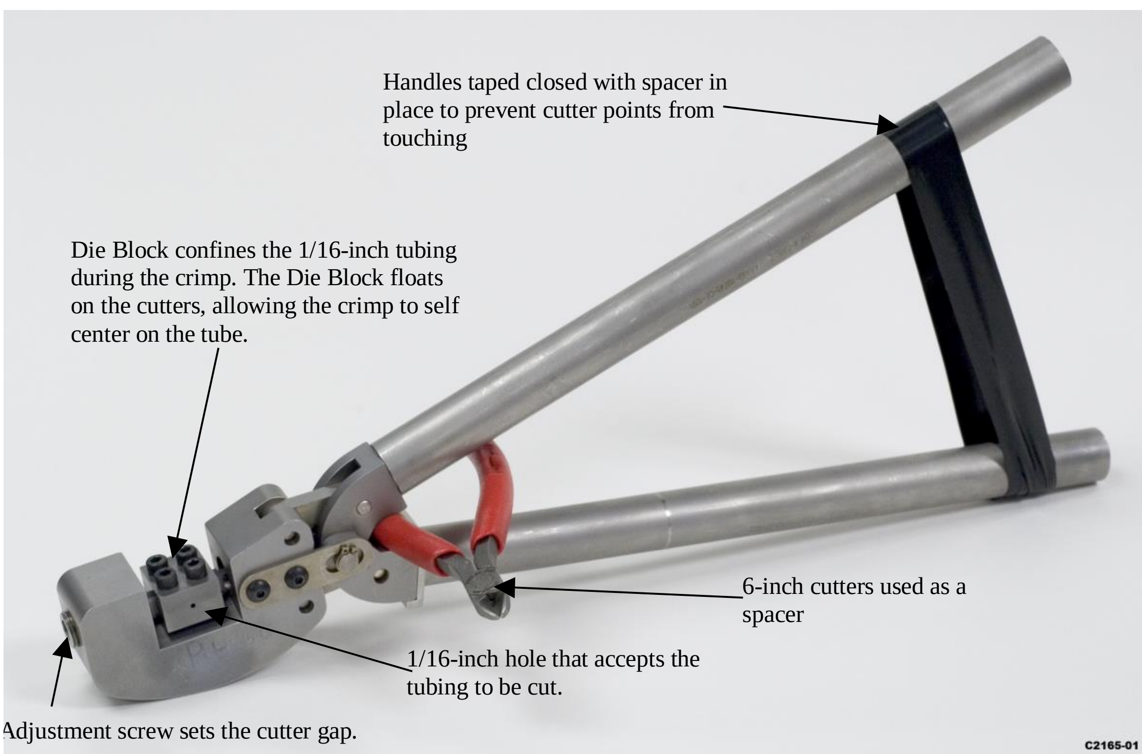

Figure 2: Hand-Held Crimper

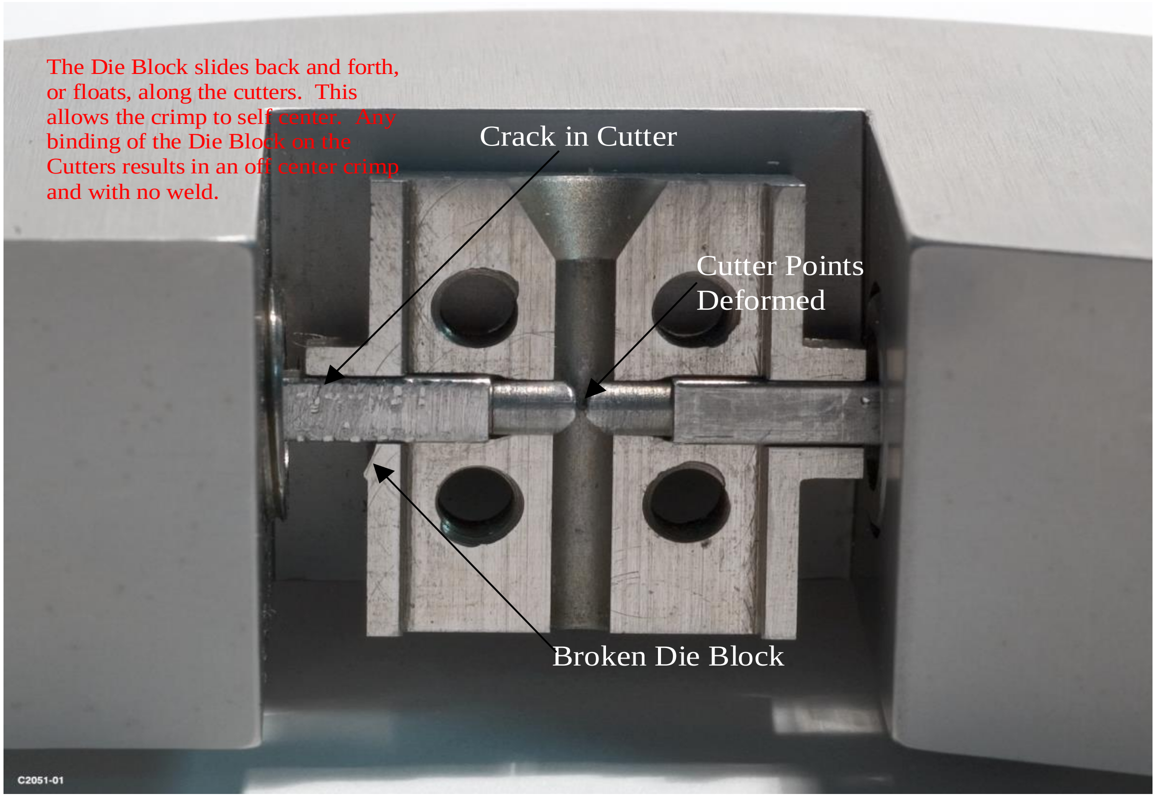

Figure 3: Crack Cutters and Broken Die Block

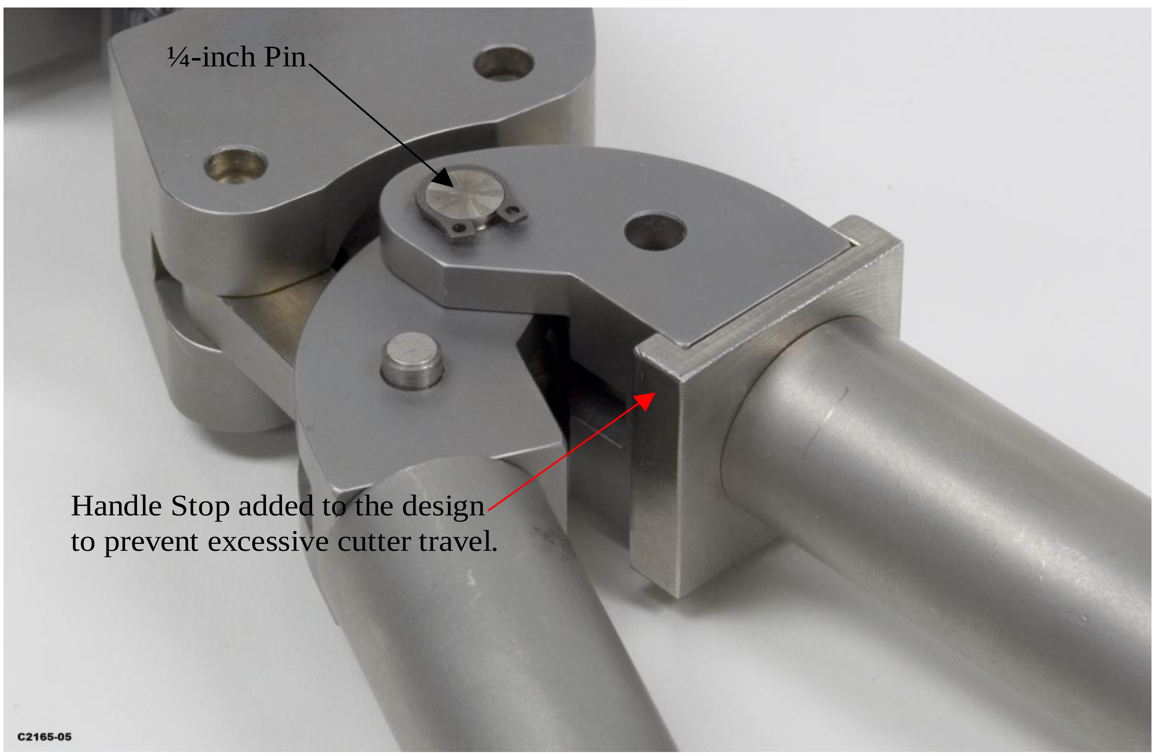

Figure 4: Handle Stop

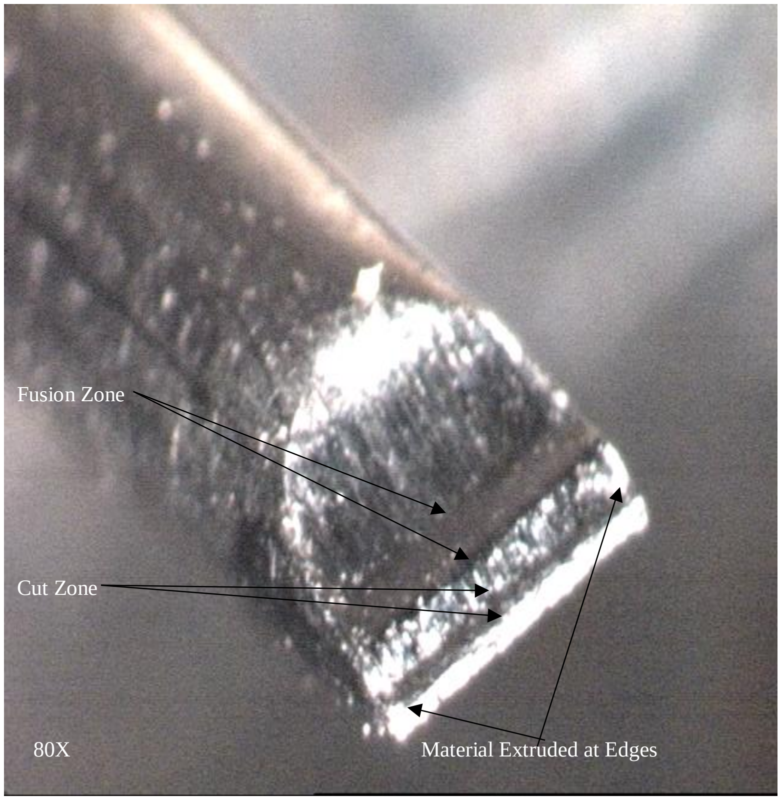

Figure 5: First Attempted Crimp, Not Submitted for Metallography

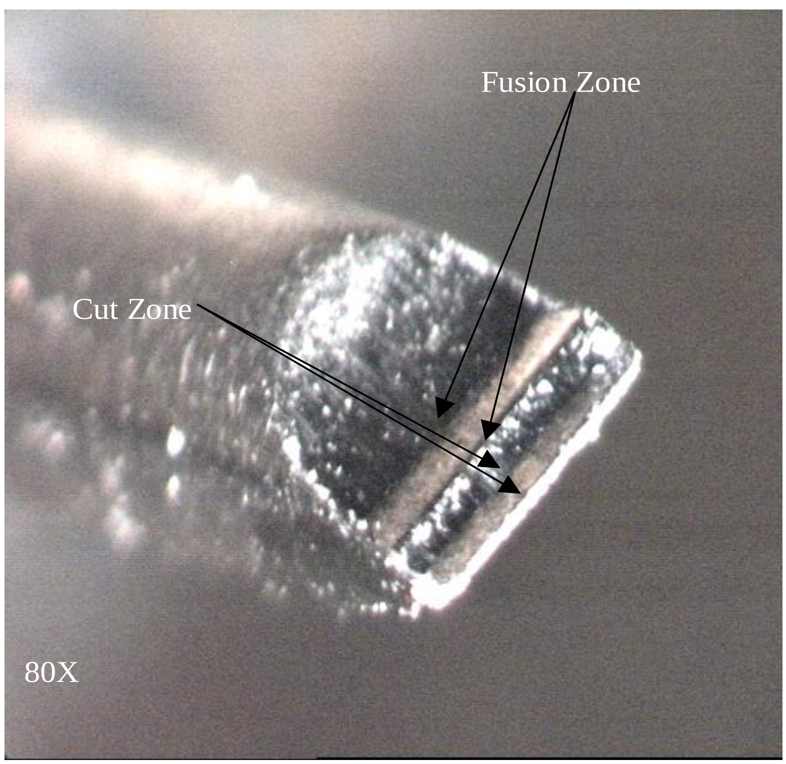

Figure 6: Series 1 Crimp, Submitted for Metallography

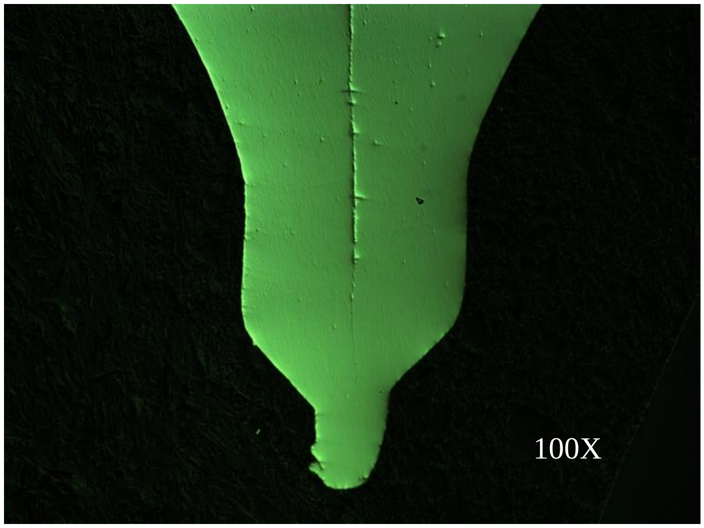

Figure 7: Micrograph 1, Series 1, Sixth Crimp

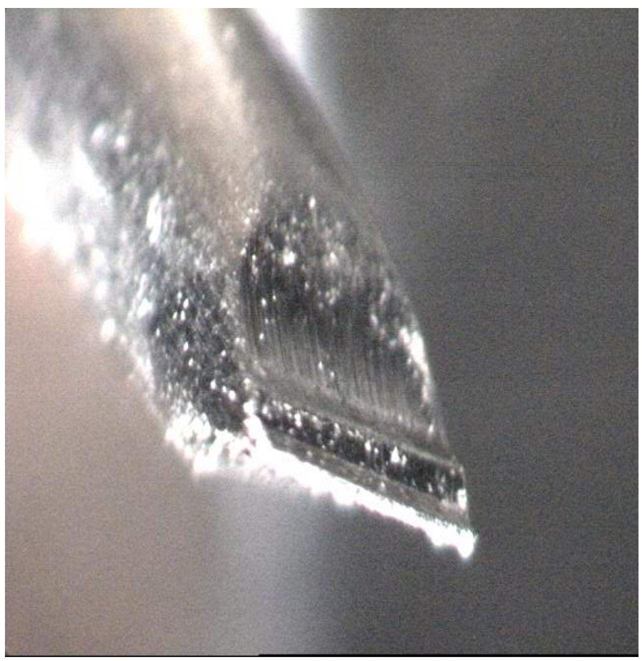

Figure 8: Series 2, Submitted for Metallography

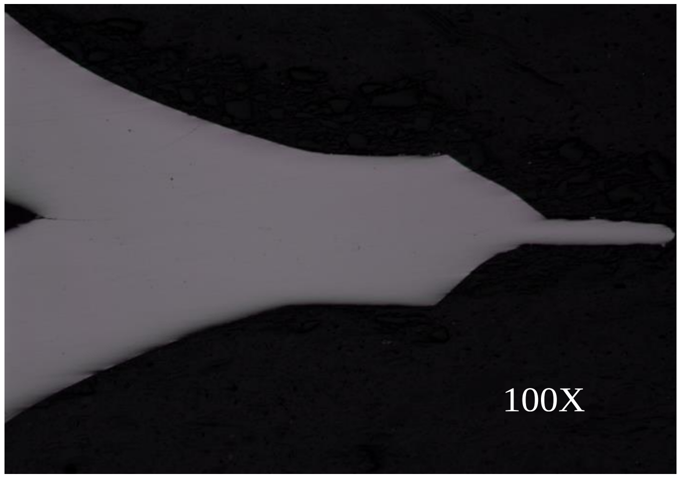

Figure 9: Micrograph 2, Series 2, Crimp 9

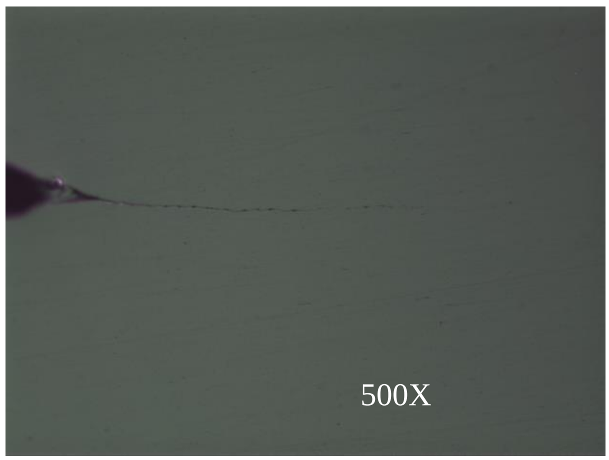

Figure 10: Micrograph 3, Series 2, Crimp 9

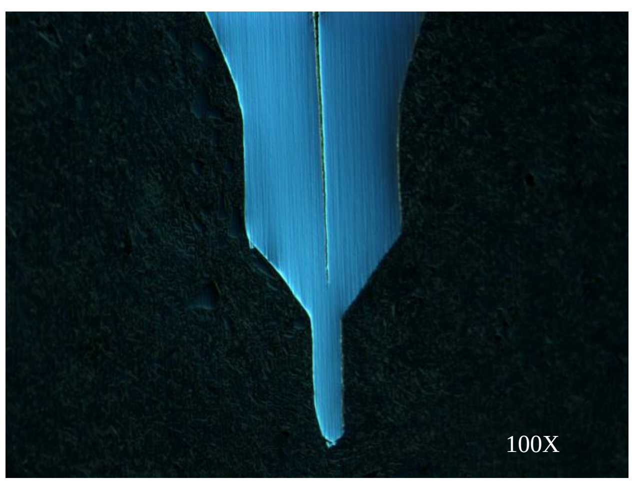

Figure 11: Micrograph 4, Series 2, Crimp 8

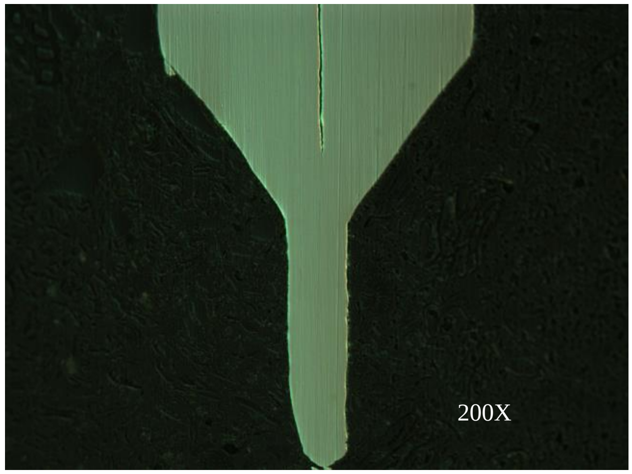

Figure 12: Micrograph 5, Series 2, Crimp 8

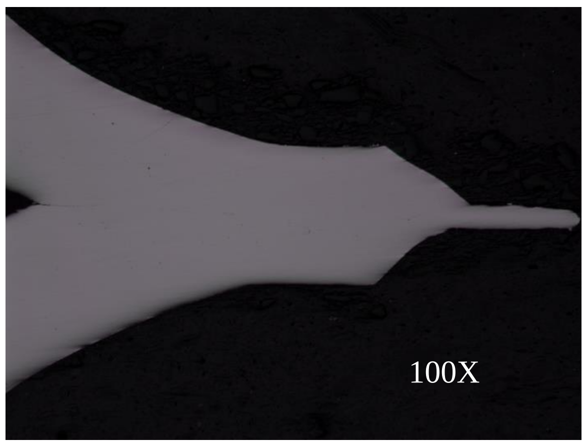

Figure 13: Micrograph 6, Series 3, Crimp 10

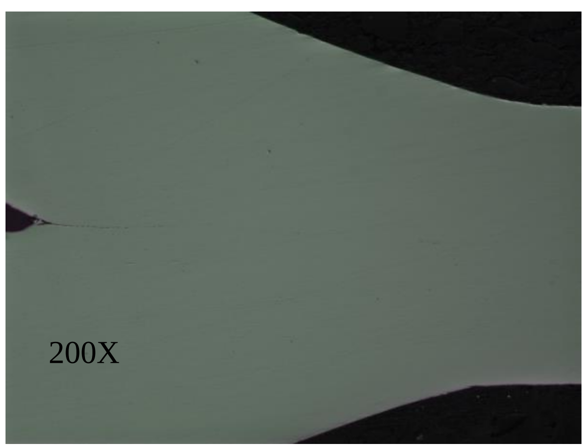

Figure 14: Micrograph 7, Series 3, Crimp 10

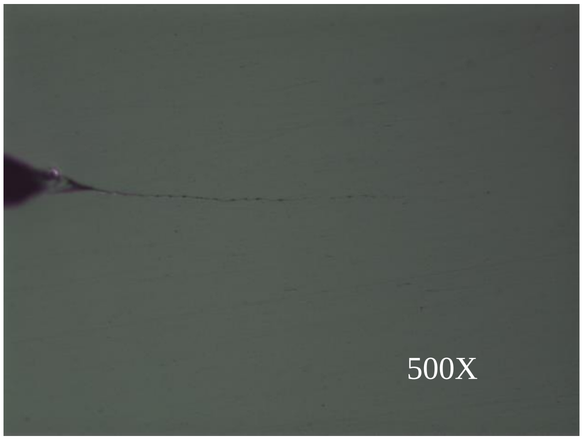

Figure 15: Micrograph 8, Series 3, Crimp 10

References and Notes:

[1] Lawrence Radiation Laboratory drawing number AAA69-119745-OF, "Field Tooling, Pinch Off, Pinch Off Assembly (U)

[2] Lawrence Radiation Laboratory drawing number AAA69-119745-OF, "Field Tooling, Pinch Off, Pinch Off Assembly (U)

[3] "Tubing, Seamless, Corrosion Resistant Steel Type 316, High Purity (U)", Los Alamos National Laboratory, Weapon Engineering ESA-WE, MS C936, Document Number 2Y-59391.

[4] Swagelok Southwest Co., 602-268-4848, info@Arizona.swagelok.com, 4926 E. Beverly Rd.Phoenix, AZ 85044.