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Welding Nightmare III – Need for Qualified Welders and Procedures

By

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Introduction

Welder and Procedure Qualification is often overlooked in production welding, often leading to in-service problems with weldments months, or even years later. Doing welder and procedure qualification can be quite expensive, specifically for large, heavy duty welded assemblies. This case study involved torque tube to a flange welds. I personally had approximately 100 hours involved in the examination of the welds involved in this assembly. The cost of failure of one of these assemblies was very high, and usually resulted in damage to auxiliary equipment, and also posed an extreme hazard to operating personnel. There had been several costly failures prior to my evaluating the quality of the welds.

Visual Examination

Figure 1 – Tube and Flange Assembly

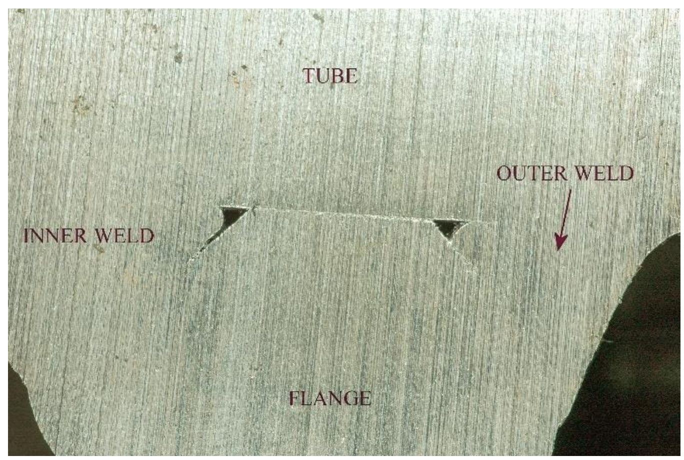

Figure 2 – Lack of Fusion in Weld Roots

The tube-flange assembly is shown in Figure 1. The assembly was quartered to permit easier evaluation and examination. The weld required a cover pass; that appears to be missing.

Figure 2 is the band saw cross section of the weld. (I believe that this was the first time one of these welds had been cut open.) It was immediately apparent that the underlying problem in this weld was lack of fusion at the weld root. Also, the engineered design was for weld penetration to the bottom of the grooves.

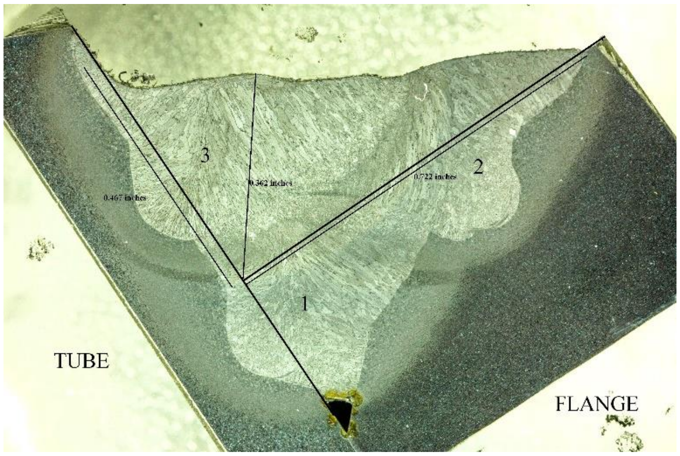

Figure 3 – Inner Fillet Weld with Measurements

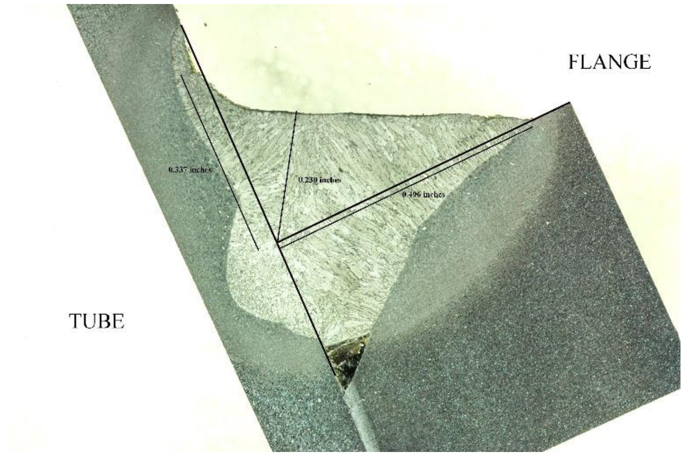

Figure 4 – Outer Fillet Weld with Measurements

The polished and etched section of the inner fillet weld is shown in Figure 3. The reason the weld did not penetrate to the root as intended was because the root pass arc was centered on the tube and not the root. This is a very common problem in welded assemblies and is an operator error. It is likely that the weld operator had not recently passed a qualification test for this type of weld. The outer fillet weld is shown in Figure 4. The same root pass condition was found with this weld. These two welds were classified as partial penetration butt welds, and the operator doing the welding should have recently qualified for partial penetration butt welds.

Additional problems associated with the inner fillet weld is that the arc of pass two was centered in the flange steel and not the weld metal. The arc of pass three was centered on the tube material instead of within the root pass weld metal. The effective throat in Figure 3, as defined by the design, was supposed to have been 0.50 inches, but was measured at 0.362 inches. The cover pass was missing.

The effective throat of the outer fillet weld was measured at 0.23 inches which is much less than the specified 0.50 inches. The cover pass was missing on this weld.

Metallographic Examination

The magnification shown for the photos is the magnification at which the photos were taken. The photos shown in this report may be smaller or larger in size than the originals.

The tube steel was an SAE 1026 steel that was silicon and aluminum killed. The aluminum acts as a grain refiner, up to a point. The heat affected zone of the tube associated with the inner weld is shown in Figure 5. The grain size was determined to be ASTM 2.5, which is a coarse grain size. Grain sizes in steel at larger than ASTM 5 have much poorer fatigue resistance and lower fracture toughness than grain sizes smaller than ASTM 5. (ASTM grain size 0 is very large, and ASTM grain size 13 is very fine.)

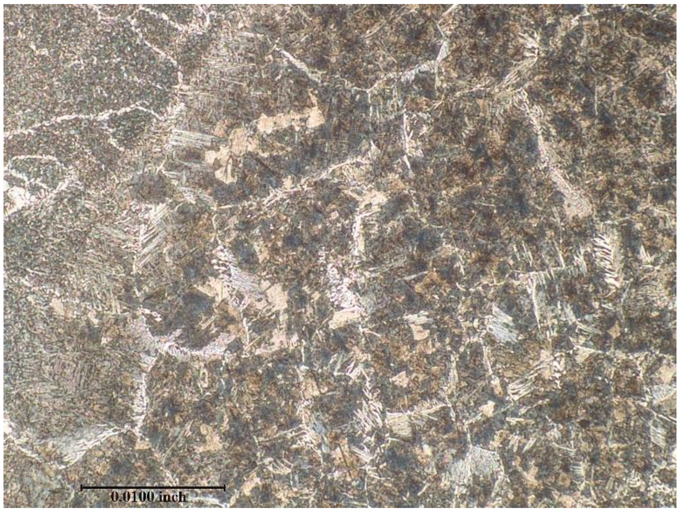

Figure 5 – 100X Coarse Grain in Tube HAZ Inner Weld

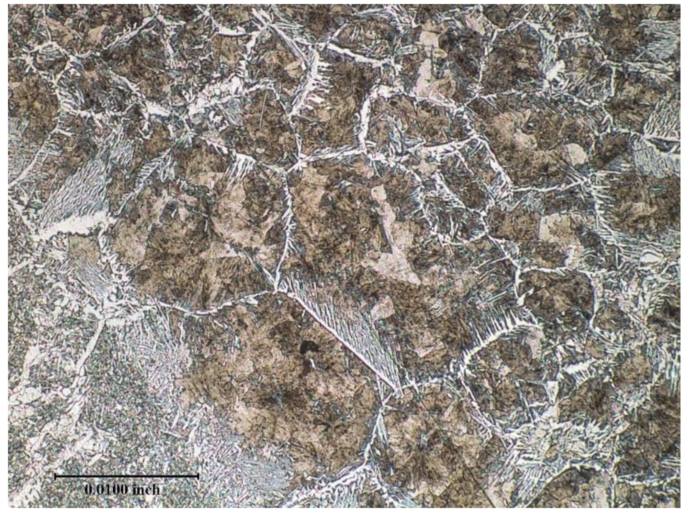

Figure 6 – 100X Coarse Grain in Tube HAZ Outer Weld

With proper weld pass sequencing and positioning, it is possible to maintain fine grain sizes in the weld heat affected zones. That was not done in this case.

Weld repair of damaged and broken equipment has many more unknowns than OEM equipment. Most weld repair shops do not have qualified welders and procedures, which results in repeated failures of the equipment and occasionally full loss of use of the equipment and possibly injury of operators.

Taking the extra time and expense to insure that a welder, procedure, and setup are doing what was intended is well worth the effort and expense. For quality control, non-destructive testing, such as x-ray and ultrasound, should be used to insure the integrity of the welds.