AL-6XN® WELDING RECOMMENDATIONS

AL-6XN alloy is easy to weld using similar parameters as Type 316L stainless steel, including travel speed (IPM) and weld current. It is common to use a weld insert ring for additional alloying when orbital or manual welding in the field.

USE WELD INSERT RINGS

When using weld insert rings for orbital or manual welding, never use filler wire in place of weld insert rings for sanitary tubing. Welding techniques that apply filler wire to the weld face risk the possibility of insufficient alloying in the weld root.

The alloy of the insert ring must have a higher molybdenum content than the AL-6XN to compensate for alloy dilution on cooling. Typically, Alloy C-22 (13% Mo) is used. If Alloy C-22 is not available, Alloy 625 (9% Mo) or Alloy C-276 (15% Mo) may be substituted. CSI stocks C-22 weld insert rings.

PLACE THE WELD INSERT RING AND FUSION WELD

The weld insert ring should be placed between the two sections and fusion-welded as usual. The weld current must be increased slightly to compensate for increased thickness due to the insert ring.

USE INERT GAS FOR WELD COVER AND BACKING

Inert gases such as helium may be used, although argon is more common. In some applications, the addition of 3-5% nitrogen to shielding gas can help compensate for the loss of nitrogen during welding.

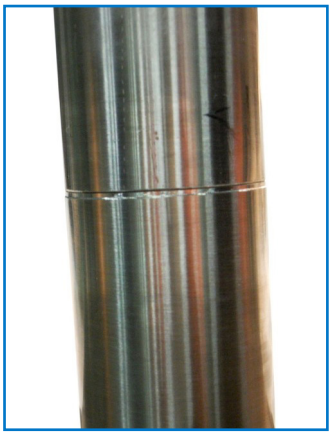
REMOVE HEAT TINTS

The weld heat-affected zone (HAZ) should be no darker than a light straw color. A color-free silver weld and heat-affected zone are best. Any darker weld heat tints must be removed before placing in service. Dark blue and black heat tints are the most susceptible to corrosion. Remove these tints by using abrasives followed by acid cleaning or passivation. A poorly cleaned surface may be just as susceptible to corrosion attacks as the original heat tint.

NOTE: When the temperature of the metal is below the dew point, allow it to warm above the condensation temperature to prevent moisture condensate on the surface, which can cause heat tint.

WELD INSERT RINGS

RING WELDED BETWEEN SECTIONS



ORBITAL WELD

HEAT TINTS REMOVED

AL-6XN® WELDING RECOMMENDATIONS

WELDING PROCEDURES (WITH FILLER)

When welding AL-6XN, metallurgical changes occur in the weld pool that must be considered when developing welding procedures. For most installations of AL-6XN piping systems, the process of post-weld annealing is not feasible. The practice of adding an alloy filler, called over-alloying the weld, is required to improve the corrosion resistance of these welds.

Over-alloying replenishes elements in the weld pool that have previously segregated during the melting and re-solidification process. The as-solidified weld has dendrite cores that are depleted of chromium and molybdenum. These elements are essential in the material's ability to resist localized corrosion attacks. To compensate for the depleted elements, filler metals with high molybdenum content are needed to increase the molybdenum to levels above 6%.

CSI evaluated several alloys that could assist in the addition of molybdenum to the weld pool. We found that the 13% molybdenum content of Hastelloy C-22 worked well for over-alloying welds in AL-6XN.

AUTOGENOUS WELDING PROCEDURES (WITHOUT FILLER)

The as-solidified weld of autogenous welding has dendrite cores that are depleted of chromium and molybdenum. These regions of the weld are more susceptible to localized corrosion; consequently, autogenous welding can be used with the following precautions:

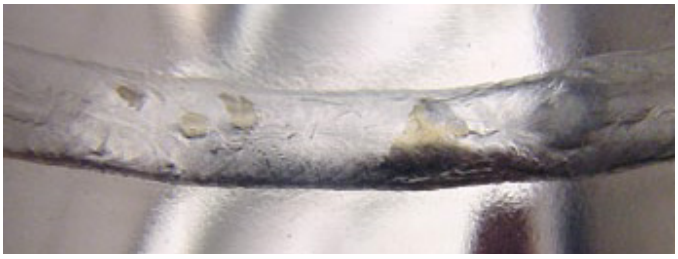
- Post-weld heat treatment is required. Anneal temperature above 2150°F (1180°C) followed by rapid cooling in a controlled atmosphere.
- The heat treatment duration for annealing must be sufficient to re-homogenize the weld segregation.
- Using mixed gases with a nitrogen volume of 3-5% for weld shielding can help improve properties of corrosion resistance.
- The ASTM G48-C critical pitting temperature test may be used to assess the quality of autogenously welded and annealed AL-6XN.

In the event that neither over-alloying nor heat treatment of the weld occurs, the exposure conditions must be carefully reviewed to determine if autogenous welds are satisfactory. Autogenous AL-6XN welds are more resistant to corrosion than similar welds in types 316L, 317L, and 904L.

WELD APPEARANCE

Weld appearance can be somewhat misleading when visually compared to hygienic welds made in 316L stainless steel. A typical AL-6XN weld has non-uniform freeze lines and oxide islands in the weld bead. These oxide islands appear as a thin film, having a varying color with tints from gray to dark brown that adhere to the surface. The appearance of "light" and "dark" spots on both the inside and the outside of the weld is typical. The heat-affected zone (HAZ) can also have discoloration and is generally a little darker than conventional 316L welds.

ACCEPTABLE WELD MADE IN AL-6XN ELECTROPOLISHED TUBING



ACCEPTABLE WELD MADE IN AL-6XN MECHANICALLY POLISHED TUBING