

SEA-CURE®

Common Practice For Welding Stainless Tubes Into Clad or Monolithic Tubesheets



FABRICATION DATA

SCOPE

This procedure covers the commonly used procedures for seal or structural welding Plymouth SEA-CURE® Stainless tubing to either alloy clad carbon steel or monolithic alloy tubesheets.

TUBESHEET SELECTION

Proper selection of the tubesheet alloy for use in high conductivity water depends on the conductivity and chloride content of the solution to which the SEA-CURE® Tubing/tubesheet combination is exposed. A more highly alloyed tubesheet is required because of the highly cathodic nature of SEA-CURE® Stainless Steel. In general the tubesheet must be more highly alloyed in chromium, molybdenum and nickel as the chloride/conductivity increases. The most commonly used tubesheet materials, starting from the mildest chloride/conductivity condition and progressing to the most severe are: Alloy 825, Alloy 904L, 254SMO, 25-6Mo, AL-6XN, 1925hMo, Alloy 625 and Alloy C-276. In general this selection follows the increasing PRE Number, which is $PREN = \%Cr + 3.3(\%Mo) + 16(\%N)$.

Choice of a clad or monolithic tubesheet generally depends on economics and availability. Carbon steel or low alloy stainless steel may be clad either by weld overlay, explosive or roll bonding. Before selection of a cladding technique the resulting surface must be evaluated to assure that no secondary phases, such as chi or sigma, are present that may adversely affect the corrosion resistance of the clad surface. A monolithic tubesheet may be the most economical for thinner or low pressure applications.

GENERAL

The tubesheet holes should be clean and dry prior to pushing the tubes. This will minimize contamination of the weld and outgassing during welding. Tungsten Inert Gas (TIG) welding normally is used to make the welds. The portion of the tube to be welded must be in close contact with the tubesheet hole, but the heated residual gas must be able to escape so blowouts or porosity are not created in the weld.

Generally, no filler alloy is used in making the welds. If a filler is required use Alloy 825, Incoloy 135 or Alloy 625. The more highly alloyed the filler alloy, the lower the weld toughness.

It is essential to develop an individual procedure for welding SEA-CURE® Stainless to each tubesheet alloy, thickness of tubesheet, tube wall thickness and tube ligament spacing. This procedure must include the use of rolling or drift punching to obtain contact of the two surfaces, the required extension or in some cases recess of SEA-CURE® Stainless from the tubesheet, the position of the welding torch, amperage, voltage, weld speed and the proper gas mixture.

Good welding practice includes: low power input with small electrodes, multiple passes as section size increases and interpass cooling to below 200° F (100° C). Oxygen, nitrogen and carbon contamination must be minimized and precautions used to avoid the loss of stabilizing elements from the molten weld metal.

Following the final rolling-in of the tube after welding the weld and heat affected zone, especially in the tubesheet, are inspected using dye penetrant testing. In general, cracking can be eliminated by adjustment of the set-up conditions or welding parameters. Such a change will produce a "super duplex" structure in the weld and maintain the proper alloy balance in the tubesheet heat affected zone.

GENERAL PROCEDURE

More than 300,000 SEA-CURE® Stainless tube – tubesheet welds are in trouble-free service today and more are being added monthly. This is the general procedure used to produce the welds:

1. Bring the working weld area of the tube and tubesheet into close proximity using either a drift punch or partial roll. Avoid the use of brass, bronze or any tooling that has been in contact with copper, zinc or aluminum as these elements will cause embrittlement in the heat affected zones. Allowance must be made to allow any residual heated gas to escape during welding to prevent weld blowout or porosity.
2. Thoroughly clean and dry the surfaces to be welded. Remember, both SEA-CURE® Stainless and the highly alloyed tubesheet alloys, like titanium and zirconium, are extremely sensitive to carbon, sulfur, oxygen and nitrogen contamination. These contaminants will reduce corrosion resistance and cause brittleness in the welds. Purge the weld area, including the tube-tubesheet gap with inert gas to prevent formation of oxides or nitrides on the heated metal.
3. TIG weld. Use sufficient cover gas to yield a clear weld with no evidence of a blue or black color. SEA-CURE® Stainless and the highly alloyed tubesheet materials are exactly like titanium or zirconium in that even a light blue color will result in accelerated corrosion. Make sure the gap is saturated with argon before striking the arc. Position the weld electrode so it melts the SEA-CURE® Stainless preferentially and provides a weld nugget large enough to give the required pull-out strength. The resulting microstructure should be that of a “super duplex” stainless steel.
4. Expand the tube into the tubesheet hole following the procedure in the Plymouth Tube Fabrication Data Bulletin “Common Practice for Roller Expanding and Flaring”. Use five roll expanders with sufficient lubrication. Do not over-roll and do not expand past the end of the tubesheet, stopping within ¼ - 1/8 inch of the end. Verify the position with an ID eddy current probe.
5. Dye check the weld to verify that cracking has not occurred, usually in the tubesheet base metal. If any cracks are present, grind out and back-fill with Incoloy 135 wire, then re-dye check.
6. Examine the weld and heat affected areas for evidence of blue or black coloration. If even the slightest coloration exists, blast the surface clean with glass beads or aluminum oxide blasting media. **DO NOT USE SILICON CARBIDE.** Make sure the surface is absolutely clean since any blue or black oxide will adversely affect the corrosion resistance.

INSPECTION

Dye check inspection for cracking and/or porosity generally is sufficient for verifying the quality of the welds. Use of the ID eddy current probe is sufficient to verify the extent of roller expansion so the roll-in does not extend beyond the end of the tubesheet.

FOR FURTHER ASSISTANCE:

Plymouth Tube Co. Inside Sales is prepared to offer clarification on these procedures.

Just call 262-642-8201, or FAX your questions to 262-642-8486

Attention: Inside Sales or e-mail sales@plymouth.com.

