Use of Explosion Welding Process for Tube Plugging

Section IX, (Circulate to Sections I, IV, VIII Div 1 & Div 2, and XII for adoption consideration.)

Inquiry: Under what conditions may the Explosion Welding process be used for Tube Plugging?

Reply: It is the opinion of the Committee that the Explosion Welding process may be used for Tube Plugging, when the following conditions are met.

1. General Requirements
   The requirements below shall only be used to qualify the welding procedure and welding operator performance qualification, using the explosion welding process for the plugging of tubes, when permitted by the referencing code, standard, or specification.

2. Welding Procedure Qualification
   (a) The Welding Procedure Specification shall be used for tube plugging with the explosion welding process shall be qualified as set forth in QW-200.1 and QW-200.2.
   (b) Essential Variables
      (1) a change in the P-Number classification of any of the materials being joined. This includes the tube and plug materials. When the plug also joins to either the tubesheet or cladding, these materials shall be included. a change in the P-Number classification for any of the materials included in the explosion weld joint, including the tube, plug, tubesheet, and tubesheet cladding when applicable.
      (2) if the plug is welded to the tube, a decrease in the nominal tube wall thickness of 10% or more (if the plug is welded to the tube).
      (3) a change in the plug wall nominal thickness.
(4) a decrease in the proximity of two plugs to be simultaneously joined by explosion welding.
(5) any increase in the number of plugs to be simultaneously joined by explosion welding.
(6) a change in the type of explosive to be used for welding.
(7) a change of 10% or more in the explosive charge mass to be used for welding.
(8) a decrease of 15% or more in the tubesheet ligament.
(9) the deletion of cleaning of the tube plug or hole contact surfaces, or a change in the cleanliness requirements (including surface oxide removal) for such surfaces prior to explosion welding, a change in the cleanliness requirements for the tube, plug, or hole contact surfaces, including surface oxide removal, prior to explosion welding.
(10) any change in the nominal plug geometry.
(11) a change of 10% or more in the clearance (stand-off) between the tube or hole and the plug in the bonding area.
(12) the addition or deletion of the use of adjacent hole packing material support bars used to prevent distortion during the welding process.
(13) a change in the tubesheet cladding metal, when the explosive charge is installed within one tube diameter of the cladding metal.
(14) for tube plugging, a change in the tube-to-tubesheet welding procedure when the explosive charge is installed within one tube diameter of the tube-to-tubesheet weld [see (e)(1)(-c)].

(c) Nonessential Variables
(1) when the plug is not joined to the tubesheet, a change in the P-Number of tubesheet material for tube plugging (when plug is not joined to the tubesheet).

(d) Supplementary Essential Variables
(1) There are no Supplementary Essential Variables.

(e) Procedure Qualification Specimens
(1) Test Assembly
(-a) The procedure qualification shall be made on a test assembly that replicates the conditions to be used in production with respect to position, tube hole pattern, and the essential variables listed in this Subparagraph. The procedure qualification test shall be performed using a mockup replicating the production weld position, tube hole pattern, and other essential variables listed in this subparagraph.
(-b) The test assembly tubesheet thickness shall be as thick as the production tubesheet, except that it need not be more than 1 in. (25 mm) greater than the length of the explosion plug.
(-c) When the explosive charge is to be placed less than one tube diameter from cladding or a tube-to-tubesheet weld, the qualification test assembly shall include cladding or tube-to-tubesheet welds, as applicable.
(-d) The minimum of ten (10) explosion welds shall be required for procedure qualification.
(2) Examination of Test Assembly
(-a) When explosion welds between plugs and cladding or tube-to-tubesheet welds are required per (e)(1)(-c), such cladding and tube-to-tubesheet welds shall be examined by the liquid penetrant method and shall meet the requirements of Section V, Article 6 and shall apply the acceptance standards of QW-195.2. Explosion welds between plugs and cladding or tube-to-tubesheet welds which are performed as required in (2)(e)(1)(-c) shall be examined by the liquid penetrant examination method in accordance with Section V, Article 6 and meet the acceptance criteria of QW-195.2.
(-b) Each plug weld and tube-to-tubesheet weld (when applicable) shall be sectioned...
longitudinally to reveal two cross-sectional faces, 180-deg apart. After polishing and etching the faces, each explosion weld joint area shall be metallographically examined at 10× or greater magnification for the length of the explosion bonding interface. The bonding interface shall be considered acceptable if there is a minimum of five times the nominal tube wall thickness of continuous bond weld between the plug and tube or tubesheet on each cross-sectioned face. Each tube-to-tubesheet weld examination (if applicable) shall be considered acceptable if it is free from explosively-produced cracks as determined visually using 10× magnification.

(-c) Ligament distortion caused by explosion welding is unacceptable when the resulting adjacent tube I.D. is less than the outside diameter of the tube plug.

(-d) The procedure shall be considered qualified when all ten (10) of the required explosion tube plug welds are found to be acceptable. The procedure is qualified when all ten (10) of the required explosion welded tube plugs meet the requirements of (a) thru (c) above.

3. Welding Operator Performance Qualification

Tube plugging by explosion welding shall be performed by welding operators who have been qualified following the required tests below: Tube plugging by explosion welding shall be performed by welding operators whose performance has been qualified as follows:

(a) Required Tests. The welding operator shall prepare (if applicable), install, and weld a minimum of five plugs in conformance with an explosion plug Welding Procedure Specification. Acceptance of these plug welds qualifies the operator for welding with all other explosion plug welding procedures. The welding operator shall be qualified for explosion plug welding after successfully preparing a mockup consisting of a minimum of five explosion plug welds following a qualified explosion plug Welding Procedure Specification that meet the test acceptance criteria in (2) above.

(b) Examination of Test Assembly. The five plugs shall be examined in accordance with the requirements of QW-193.2 and shall meet these the given applicable acceptance standards.

(c) Renewal of Qualification. Renewal of qualification shall be performed in accordance with QW-193.2 and QW-322.

4. This Case number shall be recorded on the welding procedure specification, procedure qualification record, and welding operator performance qualification.

(d) This Case number shall be shown on the Manufacturer’s Data Report when used for new Construction applications.