

WELDING OF INTERNALLY CLAD PIPING

ES-47

*Prepared by
Pipe Fabrication Institute Engineering Committee*



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USA
5901 Coastal Hwy #27
Ocean City, MD. 21842

CANADA
200-3633 Blvd Des Sources
D.D.O. QC Canada H9B 2K4

WEBSITE
www.pfi-institute.org

WELDING OF INTERNALLY CLAD PIPING

1. Scope

- 1.1. This standard provides best practices for engineers, fabricators and installers for purchasing and assembly of pipe and fitting (piping components) that are internally clad with a corrosion-resistant or other metallic cladding.
 - 1.1.1. Piping components may consist of carbon or low alloy steel that has been manufactured by concentric forging of an internal liner made of stainless steel, nickel or nickel alloy or other metal in which the manufacturing process metallurgically bonds the cladding to the external piping component. Piping components may also be manufactured by the application of weld metal overlay by arc welding or other welding process such as explosion welding.

2. Cladding Material

- 2.1. The desired chemical analysis of the cladding must be established by the purchaser and stated in the specifications. When cladding is applied by metallurgical bonding, identification of the grade or UNS number of the cladding material satisfies this need. When the cladding will be applied by welding, the fabricator will determine the welding filler metal that must be used to achieve the desired chemical composition of the cladding since this decision depends on the welding process that the fabricator will use; accordingly, owners and their engineers are generally discouraged from specifying the filler metal that is to be used when cladding is to be applied by welding.
- 2.2. If in site verification of the composition of weld buildup is required, the extent of such verification shall be specified by the customer. Verification shall be performed in accordance with PFI ES-42, Standard for Positive Material Identification of Piping Components using Portable X-Ray Emission Type Equipment.

3. Materials

- 3.1. The cladding should be a minimum of 1/8 inch (3mm) thickness regardless of the thickness of the pipe components themselves.
- 3.2. When piping system components are supplied by the owner or someone other than the fabricator, those components should be purchased in

accordance with this standard. If components do not meet this standard, the fabricator may have to add weld metal and machine the component ends to make the component suitable for shop and field welding; alternatively, the purchaser may wish to purchase components with square ends and have the fabricator prepare the ends. If cut lengths and fittings are supplied, the length of the fittings may not conform to standard ASME B16 dimensions, and pipe will have to be trimmed to achieve the required assembly or system dimensions.

- 3.3. When the butt welds between clad pipe components are going to be radiographed or ultrasonically examined by the fabricator or installing contractor, the ends of each component shall be radiographed or ultrasonically examined for a distance of not less than the greater of 3 inches or 1.5 times the thickness of the pipe from the end. Acceptance criteria shall be the same as will be required for the butt weld that will be made between components. The internal surface of the cladding shall be sufficiently smooth that it does not interfere with proper interpretation or radiographs or ultrasonic examination signals.
- 3.4. For elevated temperature service, it should be recognized that differential thermal expansion will cause elevated stress at the transition between different types of materials (e.g., at carbon to stainless steel transitions). The customer shall be responsible for selection of filler metals to be used for welds joining clad pipe and fittings to each other and for overall suitability of such joints for the intended service conditions.

4. Weld End Preparation and Welding

- 4.1. Since pipe fittings that have been clad may not comply with the standard length dimensions shown in the applicable ASME B16 standard, it may be necessary for the fabricator to measure each fitting prior to cutting pipe to achieve the correct dimensions in completed subassemblies.
- 4.2. For field welds and for pipe that is too small to weld from the cladding side, the weld end shall be machined as shown in Figure 1 and fit-up as shown in Figure 2.

- 4.3. Where ends to be welded together are available for dimensional verification, the inside dimensions of both ends shall be measured and compared. Based on the measured dimensions, the fabricator shall determine the bore dimension so that the internal misalignment of the ends to be joined will not exceed 1/16 in.
- 4.3.1. Where simply machining the weld end does not result in an extended root face (TIG lip) that consists of only the cladding material, the fabricator shall add weld metal to the end on the inside diameter and on the end of the pipe sufficient to ensure that the extended land is cladding material or suitable weld metal. The consumables and techniques used shall be such that the surfaces that will be exposed to the working fluid in the pipe in service are of the chemical analysis specified by the customer. On thin pipe, it may be possible to build up the ends sufficiently that a simple 35 to 40° bevel with a small root face will ensure that the wetted surfaces of the joint are of the required chemical analysis after the weld has been made.
- 4.3.2. Buildup of the weld end shall be made with filler metal that matches the corrosion-resistance or other critical properties of the cladding material.
- 4.3.3. If the butt weld will be examined by radiography or ultrasonic methods, it is recommended that any weld buildup be similarly examined prior to making the weld or prior to shipping if the weld will be made in the field. When random radiography or ultrasonic examination is specified, it is not known which welds will be selected for examination prior to making the weld, therefore, it is recommended that 100% of any weld buildup should be examined.
- 4.3.4. If liquid penetrant examination is required for the cladding surface and weld buildup has been performed, the liquid penetrant examination shall be repeated on the final surfaces prior to fit-up.
- 4.3.5. Buttwelds shall be made with the filler metal specified by the customer. The root pass will usually be welded using GTAW or GMAW. The balance of the weld can be completed using any suitable process
- 4.4. Where ends to be welded together are not available for dimensional verification or where ends will match equipment or other parts, the engineer shall provide the bore dimension. It is recommended that the bore dimension be in accordance with PFI ES-21 less 0.25 inches. This will ensure that the minimum wall thickness of substrate is present and provide for approximately 1/8 inch (3mm) of cladding material. When this approach is used, it may be necessary for the cladding to be machined back from the substrate or it may be necessary to add sufficient cladding weld metal deposited to the weld end and inside surface to ensure that the extended land is all cladding material or equivalent weld metal after machining.
- 4.5. Verification of the presence of stainless steel or nickel/nickel alloy cladding on the inside surface of the pipe can be verified by swabbing the surface with a solution of copper sulfate in water. Any bare steel will quickly develop a copper deposit. Any copper deposits should be removed with a flapper wheel or aluminum oxide embedded in nylon wheels. Wire brushing is prohibited for removal of copper deposits since the wire brush simply smears the copper around instead of removing it. The presence of cladding can also be verified using PMI in accordance with PFI ES-42.
- 4.6. For shop welds where the pipe is large enough to weld from both sides (i.e., it is large enough that a welder can climb inside and weld the cladding side comfortably, typically NPS 36 (DN 900) and larger), the following applies:
 - 4.6.1. The cladding should be stripped back from the substrate material and beveled so that welding can be done from both sides of the joint. See Figure 3. Where cladding is stripped back, the remaining substrate wall thickness shall be measured to verify that the thickness satisfies the minimum design thickness requirements. Confined space precautions shall be observed whenever the cladding process requires personnel to enter the pipe.
 - 4.6.2. The inside of the joint is welded to flush with the end preparation below the cladding level. After the outside has been backgouged to sound metal, the remainder of the inside weld should be completed using an appropriate filler metal to match the corrosion-resistance or other critical properties of the cladding material. See Figure 4. Any surface examinations such as liquid penetrant examination that are required should be completed at this time.
 - 4.6.3. The remainder of the weld should be completed from the outside if that has not already been completed.