TIP 0402-20

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GTAW root pass welding of 6% molybdenum austenitic stainless steel pipe – open root joint with hand-fed filler

Introduction

Much useful attention has been given to overcoming the corrosion problem encountered in the root bead of a 6% molybdenum austenitic stainless steel pipe weld *(1)*. Sound procedures have been developed and reported for orbital welds with consumable inserts and for manual GTAW welds with consumable inserts *(2)*. This TIP provides guidelines for making a corrosion-resistant root pass using GTAW and hand-fed filler metal. The TIP is intended to be used as a guide in establishing welding procedures and acceptance criteria, not as a specification.

Scope

This TIP contains guidelines for the open root joint welding of 6% molybdenum austenitic stainless steel pipe with the gas tungsten arc welding (GTAW) process and hand-fed filler metal. These guidelines include welding procedure specification elements designed to provide root pass welds enriched in molybdenum. The higher molybdenum content filler metal compensates for molybdenum segregation in the cast weld metal. The standard filler metal for 6% Mo stainless steel is a nickel-base alloy with a nominal 9% or greater molybdenum content. However, for mills that have a near neutral chlorine dioxide stage effluent, an iron base filler metal with high Cr and Mo content is preferred. The guidelines describe welding joint designs, weld fit-up, and tacking practices that allow adequate filler metal addition in the root pass. Other elements of typical root pass welding procedure are also described.

The guidelines may be used as a basis for developing welding procedures agreeable to the owner and piping fabricator. The agreement should cover the quality control measures and any standards that may be involved. All welding procedures, welder, and welding operators should be qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code or other applicable jurisdictional code requirements.

Safety precautions

Any welding process requires appropriate safety precautions, techniques, and safety equipment (helmet, shields, gloves, etc.). Normal manufacturing safety precautions apply. Some companies require welding permits. Check with the appropriate department at your organization.

This TIP may require the use, disposal, or both of chemicals that may present serious hazards to humans. Procedures for the handling of such substances are set forth on Material Safety Data Sheets that must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this technical information paper, the user should determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

the same type filler metal used for the root pass weld. They should be of medium thickness and 13 to 16 mm (0.5 to 0.6 in.) long with tapered ends. Such tacks can be fused into the root weld without grinding, producing a weld that will pass radiographic inspection. Tack welds should be spaced not to exceed 75 to 100 mm (3 to 4 in.) centers or a minimum number of tacks by pipe size: 4 tacks for 50 to 100 mm (2 to 4 in.) pipe, 6 tacks for 150 to 200 mm (6 to 8 in.) pipe, 10 tacks for 250 to 300 mm (10 to 12 in.) pipe. Tacks described are small but generally large enough so they will not break during welding of the root. During tack welding, spacers made of short lengths of suitable diameter alloy filler wire are helpful to maintain the desired gap. Any cracked or defective tack welds should be ground out. Hot ends of the tack welds should be tapered to aid in fusing into the root weld.

The need to maintain a proper root opening during root pass welding is two-fold. First, a consistent and uniform gap aids the welder in producing the optimum inner diameter (I.D.) root contour. When the joint closes up, there is a tendency toward concave roots rather than the desired slightly convex contour. The other reason for a uniform root opening is that it allows adequate filler metal addition to obtain the optimum molybdenum enriched root pass chemical composition. As the joint closes, it is difficult to melt a proper amount of filler metal into the weld root.

A major objective of this TIP is to provide guidelines that will ensure a sound, corrosion-resistant root pass. It is essential that there be sufficient mixing in the molten weld pool before solidification to avoid zones of incompletely mixed filler and base metal which have lower corrosion resistance. The objective is to maintain a molten weld pool for a long enough time to ensure complete mixing before solidification.

Figure 1 shows the root opening or “D” dimension is determined by the wire diameter. The wire diameter is usually 1.6 or 2.4 mm (0.062 or 0.094 in.). For the keyhole method, the root opening D is slightly smaller than the wire diameter. For the continuous feeding method, the root opening is equal to or larger than the wire diameter, depending upon the individual technique the shop has developed to ensure complete mixing before solidification.

Cleaning before welding

The weld joint and 50 to 75 mm (2 to 3 in.) on each side should be free of oil, grease, machining lubricants, and other contaminants prior to welding. Improper cleaning can cause weld defects such as cracks, porosity, and lack of fusion, and could reduce the weld corrosion resistance. A typical procedure to remove oil or grease includes:

- Removing excess contaminants by wiping with clean cloth
- Swabbing weld area with an organic solvent such as aliphatic petroleum, acetone etc.
- Avoiding chlorinated hydrocarbons which can be deleterious to stainless steel
- Removing all solvent by wiping with a clean, dry cloth.

Filler metals

The filler metal for the root pass should have a minimum of 9% molybdenum to compensate for the reduced corrosion resistance resulting from weld metal microsegregation. Recent data indicates that nickel base alloys may have appreciable corrosion rates in the range of 0.0762 to 0.508 mm/yr (3 to 20 mils/yr) in chlorine hydroxide stage environments in those mills that elect to add sodium hydroxide to neutralize the acidic environment instead of carrying the tower environment through to the vat. In these particular mills, the nickel base filler metal welds may corrode at substantially greater rates than the 6% Mo base metal. For mills that neutralize the chlorine dioxide stage effluent with sodium hydroxide, a higher iron content filler metal, such as ERNiCrMo-11, has become the preferred filler metal for this particular service. Nickel base filler metals normally used for welding 6% Mo include:

UNS Number	ANSI/AWS A5.14
N06625	ERNiCrMo-3
N10276	ERNiCrMo-4
N06022	ERNiCrMo-10
N06059	ERNiCrMo-12
N06686	ERNiCrMo-14

3. Annual Book of ASTM Standards, Vols. 01.01 and 02.04, ASTM, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428.

4. "Recommended Practices for Root Pass Welding of Pipe Without Backing," ANSI/AWS D10.11-87, published by the American Welding Society.

5. "The Back Purging and Welding Requirements for Fabrication of HASTELLOY alloy Pipe Systems," published by Haynes, Inc., Kokomo, IN 46902.

References

1. "Fabrication Procedures for Rolled Alloys AL 6XN," Rolled Alloys, Temperance, MI.

2. "Guidelines for the welded fabrication of nickel-containing stainless steels for corrosion resistant services," Nickel Development Institute Reprint No. 11 007.

3. "How to Weld Avesta 254 SMO," Avesta Welding Info No. 9029, published by Avesta Stainless Inc., Schaumburg, IL.

Additional information

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