Suggested Field Welding Procedure (GTAW) for Coiled Tubing Grades HS70, HS80, HS90, HS110

This guideline may be used to qualify weld procedures for all gauges and grades of Tenaris coiled tubing up to and including HS-110”. The success or failure of butt welds on coiled tubing is highly dependent on the skill of the welding personnel, the type of welding equipment used, the method of heat extraction during welding, and the level of non-destructive examination after the weld is complete. Caution should be exercised when using strings containing butt welds because the quality of the weld affects the yield strength and the resistance to environmental cracking. As with all welding procedures, Tenaris Coiled Tubes recommends qualifying a weld procedure by mechanical testing samples prior to welding on actual strings.

Two things must be considered prior to welding coiled tubing: the welding equipment and the welding personnel. These two variables dictate joint design, alignment clamp design, and chill block design.

Joint Design
Typically a square butt weld will be used for tubing which is less than or equal to 0.125” thick and a “V” groove will be used for heavier wall tubing. However, the decision to use a square butt joint versus a “V” groove should be based on the available welding equipment and skill of the operator. For instance, an automatic orbital welding machine may be capable of a full-penetration weld in a single-pass on 1.25” OD X 0.156” wall coil tubing. However, in the field where less sophisticated equipment is available, such tubing may be considered “heavy-gauge” and a multiple pass, “V” groove procedure would be used. When utilizing a “V” groove procedure, the bevel angle may vary from 30° to 45° depending on the amount of penetration the equipment and/or operator is capable of. A good rule of thumb for V-groove welds is a 37° bevel with a 1/16” gap and a 1/32”-1/16” land. For manual square groove butt welds, Tenaris Coiled Tubes recommends using a 1/32” to 1/16” gap between tube ends.

Alignment clamps
Using an orbital welding machine will also dictate the shape of the alignment clamp: low clearance alignment clamps may be used with automatic equipment whereas a manual weld will require more access to the entire girth of the weld. The alignment clamps should ensure proper alignment of the axis and gap maintenance during welding.

Chill blocks
Standard chill blocks for manual welding should be made from copper material, 3” - 4” long, 3/8” (minimum) thick and the ID of the chill block should match the...
OD of the pipe. The thicker the chill block, the more heat it will extract; chill blocks measuring 0.5” - 1.0” thick are often used in the field. The end of the chill block may be beveled at a 30° to 45° angle for easier access. Chill blocks for orbital welding equipment will have to be custom designed and tested to ensure proper heat extraction. Tenaris Coiled Tubes recommends that all HS-90™ and HS-110™ strings be welded while using water-cooled chill blocks for heat extraction. In addition, water-cooled chill blocks should be used on lower grades of coiled tubing with wall thicknesses greater than and including 0.190”. Standard chill blocks may be used on lower grades with wall thicknesses less than 0.190” however, caution should be used as lower yield strengths may exist. Water or ethylene glycol circulation may be applied with running tap water or a 5 gallon bucket with a small pump. Soldering or brazing a copper tube to the back end of the chill block will provide an adequate couple between the chill block and the water source as shown below.

Below is a step-by-step procedure for welding coiled tubing

1. Straighten both ends of tubing to be welded. Cut ends of tubing square or machine a bevel using a beveling tool, grinder, or file. Deburr all cut edges.

2. If the tubing is wet inside, place a small amount of soluble tissue or toilet paper about 12” from the end of the tube to stop seepage.

3. Using a small flat/curved tip chisel, or a small round/curved file, taper/remove the inside weld bead 0.25” - 0.5” from the end of the tube. A chisel ground with a curve similar to the ID of the pipe works best for this procedure. Extreme care should be taken not to nick or cut the ID of the pipe. If a nick or cut is made into the tube wall, or any of the pipe wall is filed off, cut that section off and start over. It may be necessary to remove the bead before doing the final weld preparation in step 1.

4. Polish the end of the tube using emery cloth or a fine wire brush about 2 inches back from the end on the O.D. and about 1 inch back from the end on the I.D. The final appearance should be smooth shiny metal on the O.D. and I.D. of the tube. Circumferential grooves and grinding marks significantly decrease fatigue life and should be polished smooth using emery cloth or a fine wire brush. Please assure that all sand paper and emery cloth is NOT aluminum oxide.

5. Use alcohol or other appropriate degreasing agent to clean the inside and outside of the tube. Assure that the surfaces near the weld prep are clean and dry. Do not use gasoline. Avoid contaminating the clean surfaces during alignment in step 6. Re-clean if necessary after alignment.

6. Position tube ends in a fixture so that the ends are butted together. Use a straight edge (at least 8 inches long) to assure alignment on all axes. In order to maintain the proper gap width, use a small piece of weld consumable between the two pipes during the alignment process. It is also recommended that you leave the spacer wire in while welding the first side of the tube to prevent the gap from closing. Remove the spacer before welding the other side.

NOTE: It is extremely important to assure that the tubes are butted squarely and the tube lengths adjacent to the weld are straight.

7. Position chill blocks (heat sinks) on either side of the joint to be welded. For groove welds, the chill blocks may be moved to the edge of the groove during the root pass, and then moved approximately 3/16” away from the edge during subsequent passes. Chill blocks for material thicker than 0.190” or grades greater than HS-80' should be water-cooled for maximum heat extraction. For square butt welds, the chill blocks should be placed about 3/16” from the edge of the tube. See the “Chill Block” section on page 1 for more information on chill block design.

8. Wind curtains shall be positioned to insure there is no air movement in the vicinity of the weld during the welding process, which could interrupt the cover gas.

9. The full penetration weld shall be accomplished using the GTAW (a.k.a. TIG) process with high frequency start and a 3/32-inch thoriated tungsten electrode. Scratch starting may contaminate the weld and is not recommended. A 75% Helium/25% Argon shielding gas mixture works well for this type of full penetration weld. Welding parameters should be DCEN, 50-100 AMPS, 9-15 VOLTS, and 1-2.5 ipm, however these may vary slightly based on the welding machine you are using. 100% Argon shielding gas is suitable but will require higher amperages for full penetration, and may increase HAZ (Heat Affected Zone) hardnesses. Tenaris Coiled Tubes recommends using AWS ER70S-2 or ER70S-6 1/16-inch diameter weld consumable for all welds on HS-90’ grade tubing and below. (continued)
For HS-110’ coiled tubing, Precision Tube Technology recommends using AWS ER80SD-2 1/16” filler material. The weld shall be made using a single-pass stringer bead with a 0.25 - 0.50 inch overlap on the start and stop. Proper cleaning between each pass is recommended for heavier tubing. A small amount of oscillation may be necessary to assure tie in of both sides of the weld. However, large amounts of oscillation should be avoided as wide beads tend to decrease fatigue resistance of the string.

10. Remove chill blocks and allow to cool to touch after each pass. When using water-cooled chill blocks, leave blocks in place, and allow blocks to cool to touch before proceeding.

11. After the weld is complete, remove chill blocks and dress the weld bead to within -0.000/+0.005 in of the tube surface. The finish shall be smooth with no nicks or cuts. Note: do not remove material from the parent tube surface. Factory welds are dressed with a small hand grinder to remove the cap of the weld, and then filed smooth with a flat file. Final finishing is done with emery cloth until smooth. It is necessary to remove the cap prior to radiography to ensure a full penetration weld.

12. It is vital that X-rays be made of each weld. A procedure following ASME Section V, Article 2 using the double-wall, double-viewing technique for complete coverage and capable of very high quality (2T-hole #7 penetrrometer) is recommended for detecting small defects. Experience has shown that lack of penetration and even very small defects can lead to sudden failure. Welds are rejectable for any defect: porosity, undercut, lack of penetration, lack of fusion, cracks or underfill.

**Recommended Equipment and Supplies**

**Equipment/Tools:**
- High frequency start GTAW machine:
  - 150 Amp minimum, remote pedal control
- Beveling Machine, 4” Grinder, or File
- Rounded Chisel
- Hammer
- Fine Wire Brush (Round)
- Drill/Die Grinder
- Alignment Clamp
- Straight-Edge
- Wire Cutters
- Flat File (Finishing OD)
- Portable Bandsaw or Hacksaw
- Copper Chill Blocks
  (Water Bucket and Pump if Required for water cooling)

**Supplies**
- 3/32” Thoriated Tungsten
- ER70S-2 or ER70S-6 (HS-90’ and below) or ER80SD-2 (HS-110’) Weld Consumable
- Leather Gloves
- Welding Hood
- Protective windshield or Tarp
- Alcohol/Degreasing Agent
- Lint Free Rag
- Emery Cloth
- Tissue Paper