Hygienic Welding: How Do You Know When It’s Right?

3-A SSI Education Program – Hygienic Design Integrity for the Future
Milwaukee, WI May 17, 2016

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**D18 Committee on Welding in Sanitary Applications**

**SCOPE**: Responsible for creating and revising standards on welding in sanitary applications.

- **AWS D18.2:2009**, *Guide to Weld Discoloration Levels on Inside of Austenitic Stainless Steel Tube*
- **AWS D18.3/D18.3M:2015**, *Specification for Welding of Tanks, Vessels, and Other Equipment in Sanitary (Hygienic) Applications*
Goals of D18.1, D18.2 & D18.3

In General the Goals are:

• Qualification requirements for Weld Procedures & Welder/Welding Operator Performance
• Guidance for judging root welds of tubes from OD appearance
• Weld visual acceptance criteria
• Illustration of weld discoloration levels
Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications

1. Scope and Responsibilities
2. Normative References
3. Definitions
4. Qualification
5. Fabrication Practices
6. Visual Examination Requirements
7. Documentation
• Procedure Qualification
  - A written qualified Welding Procedure Specification (WPS), in accordance with AWS B2.1, for each weld
  - Acceptance criteria includes:
    Visual examination in accordance with Section 6, 2 transverse tensile tests, and 2 root-bend and 2 face-bend tests

• Performance Qualification
  - Welder/Welding operator performance qualification shall be in accordance with AWS B2.1
material preparation – square cut edges, cutting flash and burrs removed

• joint fit up – butt joints should have zero root opening

• no filler metal – unless connections require it because of fit-up problems, such as wall thickness, diameter or alignment or base metals, such as 2205 or 254 SMO, that require overmatching filler metal

• weld finishing – if visual examination requirements of section 6 not met, weld shall be finished to a max Ra of 32 micro inch (0.8 micron)

• tack welds – shall meet discoloration requirements of 6.2.3.3 (AWS D18.2)

• preconstruction weld samples (PWS)
  - 3 welds made by each welder to aid in evaluating production welds
OD of welds examined by welder & inspector, to be consistent with PWS and Visual Examination Requirements of Section 6. This gives confidence that the inside weld surface is acceptable without an internal examination.
AWS D18.1: Section 6-Visual Examination Requirements Section

- Welds not meeting OD standards examined by borescope or other suitable means
  - Welds shall be full penetration
  - No cracks, undercut, crevices, or embedded or protruding material
  - No excessive discoloration (AWS D18.2)
- Slag-like surface imperfections >1/16” are unacceptable and those <1/64” shall be disregarded; while no more than 4 imperfections are allowed in any 4 linear inches of weld
  - Manual or Orbital GTAW (TIG), which does not use flux, is preferred due to fear of introduction of slag/flux inclusions
AWS D18.1: Section 6-Visual Examination Requirements on Product Contact Surface
Guide to Weld Discoloration Levels on Inside of Austenitic Stainless Steel Tube

The Sample Numbers refer to the amount of oxygen (ppm) in the purging gas:

- No.1 – 10
- No.2 – 25
- No.3 – 50
- No.4 – 100
- No.5 – 200
- No.6 – 500
- No.7 – 1000
- No.8 – 5000
- No.9 – 12500
- No.10 – 25000

Note: Welds on type 304L SS showed no significant difference in heat tint color from type 316L.
Heat Tint - Acceptance Limits

• Typically 4 and greater is unacceptable, unless otherwise agreed upon
• Acceptable limits could vary with end application service
• An acceptance level should be identified by number rather than ppm of oxygen, because amount of discoloration and its appearance can be influenced by factors other than oxygen, such as:
  - Moisture in backing gas or on surface increases discoloration
  - Contaminants such as hydrocarbons on the surface prior to welding increase discoloration
  - Hydrogen in backing gas decreases discoloration
  - Metal surface finish can affect appearance
Specification for Welding of Tanks, Vessels, and Other Equipment in Sanitary (Hygienic) Applications

1. Scope and Responsibilities
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AWS D18.3: Section 4-Welding Qualification

• Procedure Qualification
  - A written qualified Welding Procedure Specification (WPS), in accordance with AWS B2.1, for each weld
  - Acceptance criteria includes:
    Visual examination in accordance with Section 6,
    Tensile and bend tests in accordance with AWS B2.1

• Performance Qualification
  - Welder/Welding operator performance qualification shall be in accordance with AWS B2.1
• Prevent/minimize iron contamination by:
  - Stainless steel and nickel alloys shall be stored and fabricated separately from that of carbon steel
  - Cleaning or use of flexible isolation barriers (such as cardboard, paper or plastic) to prevent iron pickup from forming equipment
  - Tools or abrasive materials that have previously been used on carbon steel shall not be used on stainless steel or nickel alloys
• Members to be welded shall be brought into correct alignment and held by suitable devices or tack welds
  - Tack welds shall be free of cracks, porosity and discoloration
  - Tack welds shall be fully consumed by subsequent welding or shall be removed
AWS D18.3: Section 6-Visual Examination Requirements

• Welders/Welding Operators shall examine each weld they make. Supervisors or Quality Control/Assurance Personnel shall examine a representative portion of the welds to verify that work is satisfactory.

• Acceptable and unacceptable weld profiles are identified in Figure 2 of the specification.

• Welds that require finishing shall also be examined in the finished condition.

• Ultimately, welds shall not contain any discontinuity open to the surface such as cracks, undercut, crevices, porosity, pits or embedded or protruding materials.
AWS D18.3: Section 6-Visual Examination Requirements

(A) DESIRABLE FILLET WELD PROFILES

(B) ACCEPTABLE FILLET WELD PROFILES

(C) UNACCEPTABLE FILLET WELD PROFILES

- INSUFFICIENT THROAT
- EXCESSIVE CONVEXITY
- EXCESSIVE UNDERCUT
- OVERLAP
- INSUFFICIENT LEG
- INADEQUATE PENETRATION
AWS D18.3: Section 6 - Visual Examination Requirements

(D) ACCEPTABLE GROOVE WELD PROFILE

- EXCESSIVE REINFORCEMENT
- UNDERFILL
- EXCESSIVE UNDERCUT
- OVERLAP

(E) UNACCEPTABLE GROOVE WELD PROFILES
### Flux welding processes can be used because welds are easy to inspect and slag/flux imperfections can be easily removed and welds repaired
Manual vs Automatic Orbital Tube Welding

• Orbital welds have more consistent root weld beads and practically free from heat tint
• Short projects may favor manual welding
• Manual welders better able to accommodate poorer fit-up conditions
By means of AWS D18.1/18.2/18.3 these criteria give confidence that all surfaces, whether product or non-product surfaces, are acceptable.