



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

*3-A SSI Education Program – Hygienic Design Integrity for the Future
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D18 Committee on Welding in Sanitary Applications

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

- **AWS D18.1/D18.1M:2009,**
Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) 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

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

QW-482 (Rev. 3)

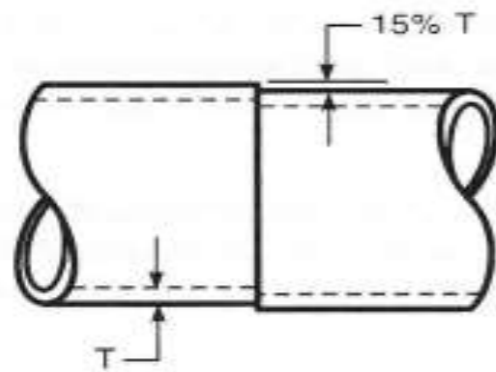
WPS No. 1111 Rev.

POSITIONS (QW-482) Residual or Groove: 3G Welding Position: 1 <input checked="" type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> Positional or Fillet: N/A		POSTWELD HEAT TREATMENT (QW-482) Temperature Range: W/RT V/ INSULATION Time Range: WARM TO TOUCH						
PREHEAT (QW-482) Preheat Temp., Min.: 200* Interpass Temp., Min.: 500* Postheat Maintenance: CHECK EACH LAYER (Continuous or periodic heating where applicable should be recorded)		GAS (QW-482) Shielding Gas: N/A Gas Flow Rate: N/A Gas Composition: N/A						
ELECTRICAL CHARACTERISTICS (QW-482) Current AC or DC: DC Polarity: SP Amperage (Range): 85-120 Voltage (Range): 19-22 (Amperage and voltage range should be recorded for each electrode size, position, and thickness etc. This information may be listed in a table form similar to that shown below.) Tungsten Electrode Size and Type: N/A Make of Metal Trolley for GMAW: N/A Electrode Wire feed speed range: N/A								
TECHNIQUE (QW-482) Shield or Shield Back: STANDARD AND WEAVE Other or Gas Cup Size: N/A Shield and Tackling Coating (Brazing, Coating, etc.): CLEAN EACH PASS WITH WIRE BRUSH OR BUFFER Method of Back Chipping: N/A Qualification: N/A Contact Taper to Work Distance: N/A Multiple or Single Electrode: MULTIPASS Travel Speed (Range): 8"-12" Penetration: N/A Other: N/A								
Weld Layer	Process	Filler Metal		Current		Voltage Range	Travel Speed Range	D.P. (e.g., Penetration, Contamination, Hot Pass, Addition, Technique, Tackling Angle, Etc.)
		Class	Size	Test Pos.	Amperage Range			
1	SRM	E-6011	1/8"	DCRP	85-120	19-22	6"-10"	N/A
2	SRM	E-7018	3/32"	DCRP	85-120	19-22	6"-10"	N/A
3	SRM	E-7018	1/8"	DCRP	85-120	19-22	6"-10"	N/A
4	SRM	E-7018	1/8"	DCRP	85-120	19-22	8"-12"	N/A
5	SRM	E-7018	1/8"	DCRP	85-120	19-22	8"-12"	N/A

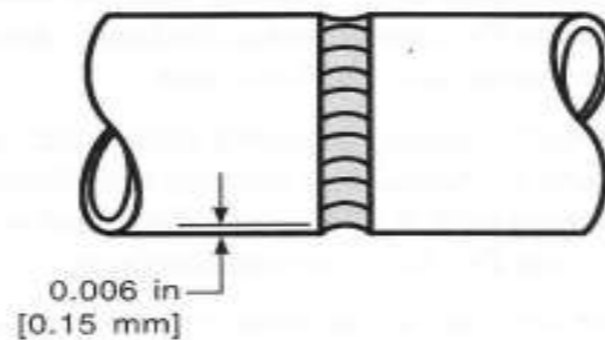
- Material Preparation – square cut edges, cutting flash and burrs removed
- Joint Fit Up – butt joints should have zero root opening
- No Filler Metal – unless connections require it because of fit-up problems, such as wall thickness, diameter or alignment or base metals, such as 2205 or 254 SMO, that 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

AWS D18.1: Section 6-Visual Examination Requirements Section

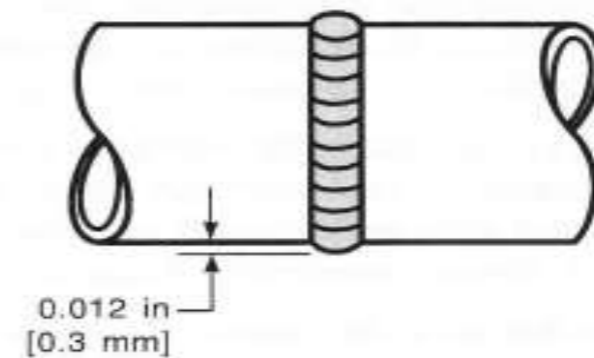
- OD of welds examined by welder & inspector, to be consistent with PWS and Visual Examination Requirements of Section 6. This gives confidence that the inside weld surface is acceptable without an internal examination



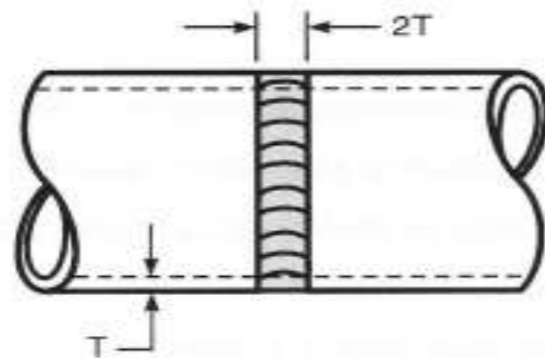
(A)
MAXIMUM MISALIGNMENT
15% OF TUBE
WALL THICKNESS



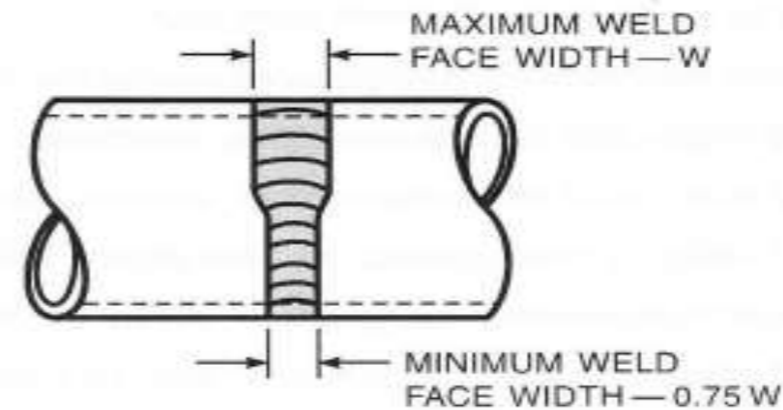
(B)
NONPRODUCT
CONTACT SURFACE —
MAXIMUM CONCAVITY



(C)
NONPRODUCT
CONTACT SURFACE —
MAXIMUM CONVEXITY



(D)
MINIMUM FACE WIDTH FOR
MANUAL WELDING — 2T

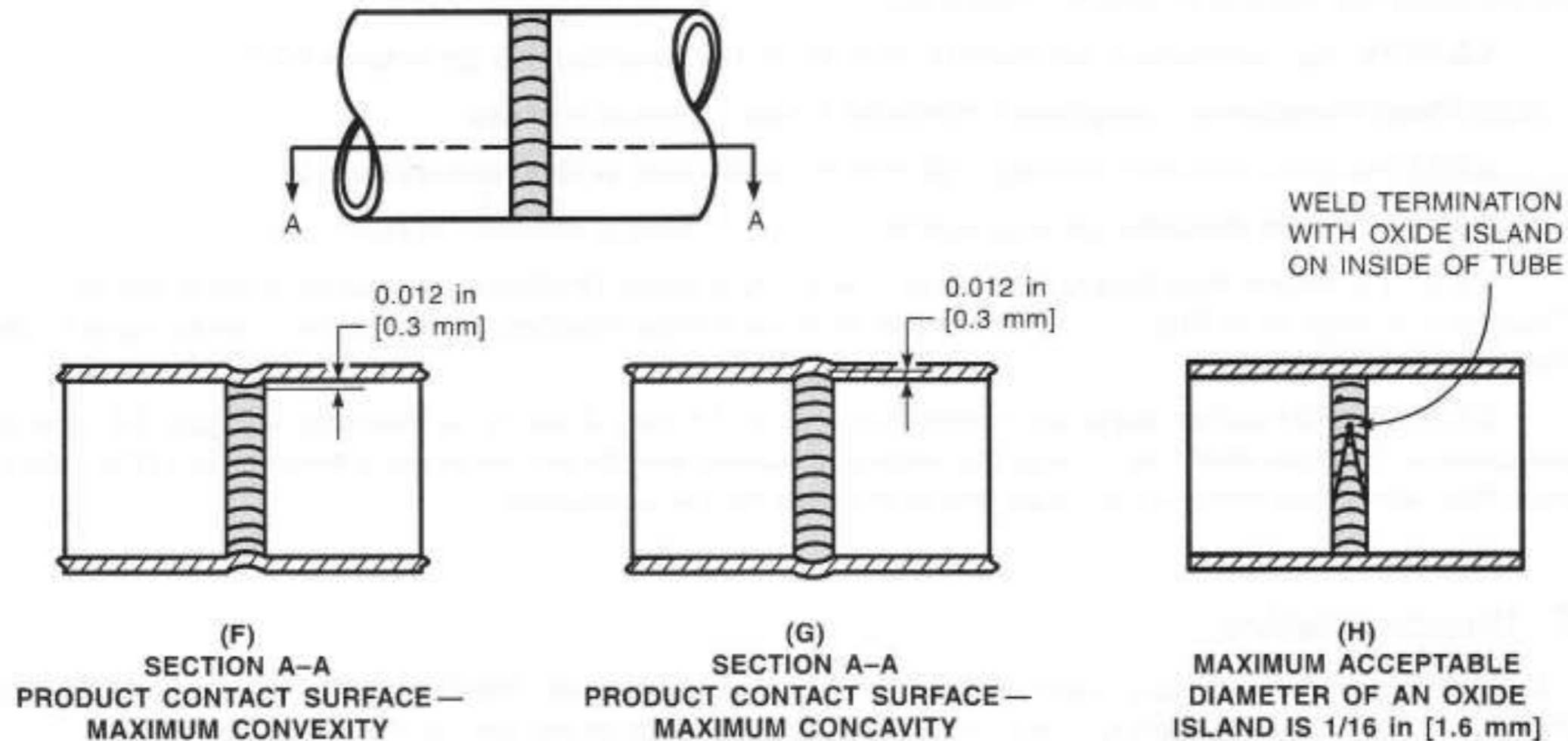


(E)
MINIMUM FACE WIDTH FOR
MANUAL WELDING — 75% OF W
WHERE W = MAXIMUM FACE WIDTH

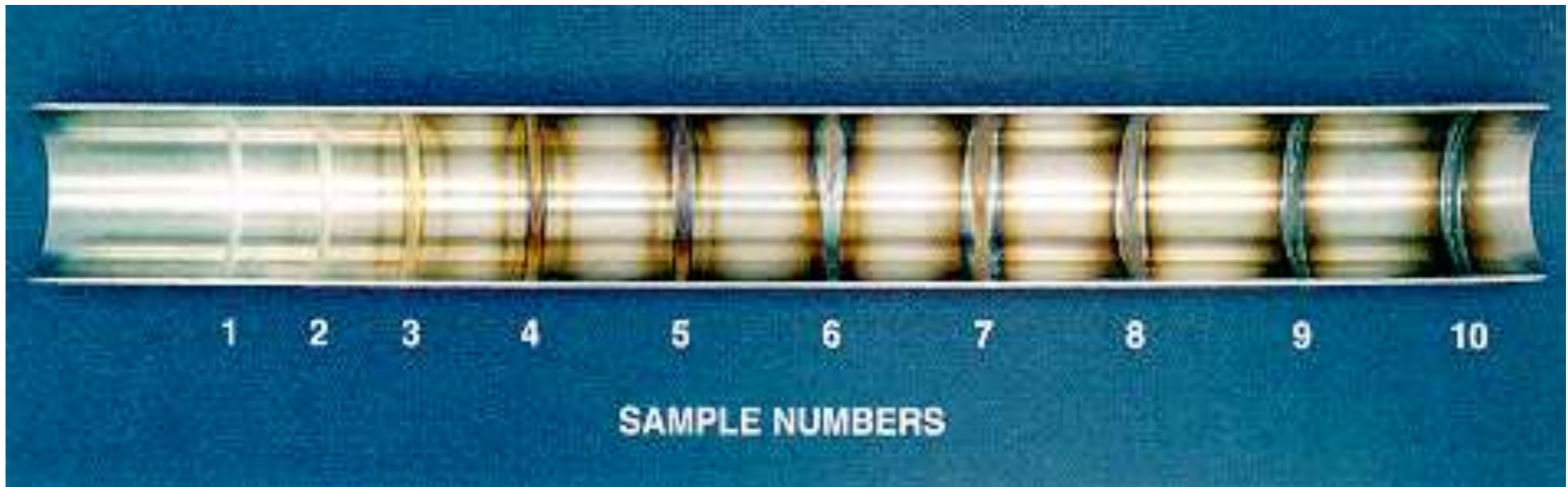
AWS D18.1: Section 6-Visual Examination Requirements Section

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

Note: Welds on type 304L SS showed no significant difference in heat tint color from type 316L.

- 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

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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,
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

QW-482 (Back) WPS No. 1111 Rev. _____

POSITIONS COVERED: 3G Position(s) of Groove: 10, X Position(s) of Root: N/A		POSTWELD HEAT TREATMENT (PWHT): Temperature Range: WRAP W/ INSULATION Time Range: WARM TO TOUCH					
PROJECT (QW-482): Process Temp. Min.: 200° Increase Temp. Max.: 500° Preheat Minimum: CHECK EACH LAYER (Continuum or special heating where applicable should be recorded)		GAS (QW-482): Shielding Gas: Cooled Preheat: N/A Drying: N/A Trailing: N/A Backing: N/A					
ELECTRICAL CHARACTERISTICS (QW-482): Current AC or DC: DC Polarity: SP Amps (Range): 85-120 Volts (Range): 19-22 (Range and volt range should be recorded for each electrode size, position, and thickness, etc. This information may be listed in a tabular form similar to that shown below.)							
Tungsten Electrode Size and Type: N/A Mode of Metal Transfer to GMAW: N/A Electrode Wire feed speed range: N/A							
TECHNIQUE (QW-482): Stringer or Weave: STRINGER AND WEAVE Other or See QW-482: N/A Hold and Insulate During Striking, Counting, etc.: CLEAN EACH END WITH WIRE BRUSH OR BUFFER Method of Back Chipping: N/A Guidance: N/A Contact Tube to Work Diameter: N/A Multiple or Single Electrodes: MULTIPASS Multiple or Single Electrodes: SINGLE Travel Speed (ft/min): 8"-12" Peening: N/A Other: N/A							
Weld Layer	Process	Filler Metal		Current		Travel Speed Range	D/Pe
		Class	Size	Type	Amps Range		
1	SMW	E-6011	1/8"	DCRP	85-120	19-22	6"-10"
2	SMW	E-7018	3/32"	DCRP	85-120	19-22	6"-10"
3	SMW	E-7018	1/8"	DCRP	85-120	19-22	6"-10"
4	SMW	E-7018	1/8"	DCRP	85-120	19-22	8"-12"
5	SMW	E-7018	1/8"	DCRP	85-120	19-22	8"-12"

- 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



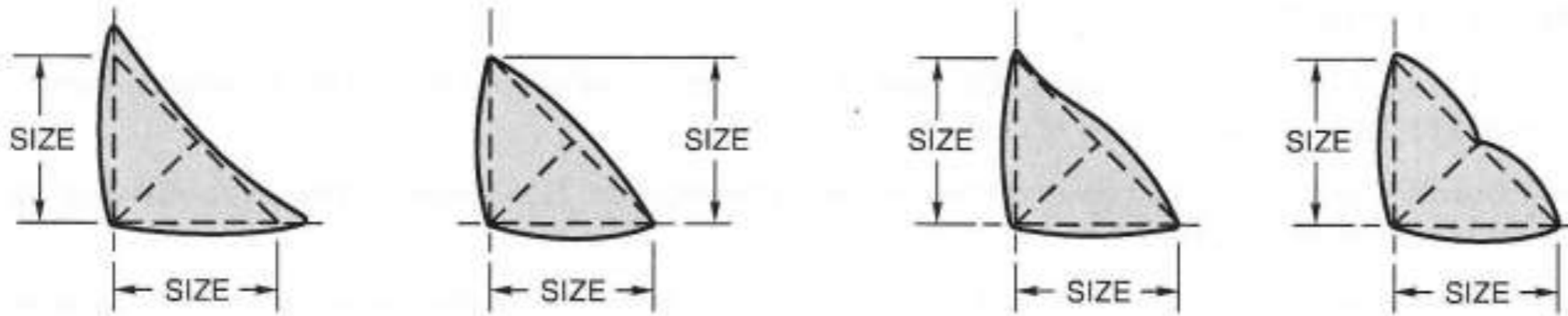
- Members to be welded shall be brought into correct alignment and held by suitable devices or tack welds
 - Tack welds shall be free of cracks, porosity and discoloration
 - Tack welds shall be fully consumed by subsequent welding or shall be removed



AWS D18.3: Section 6-Visual Examination Requirements

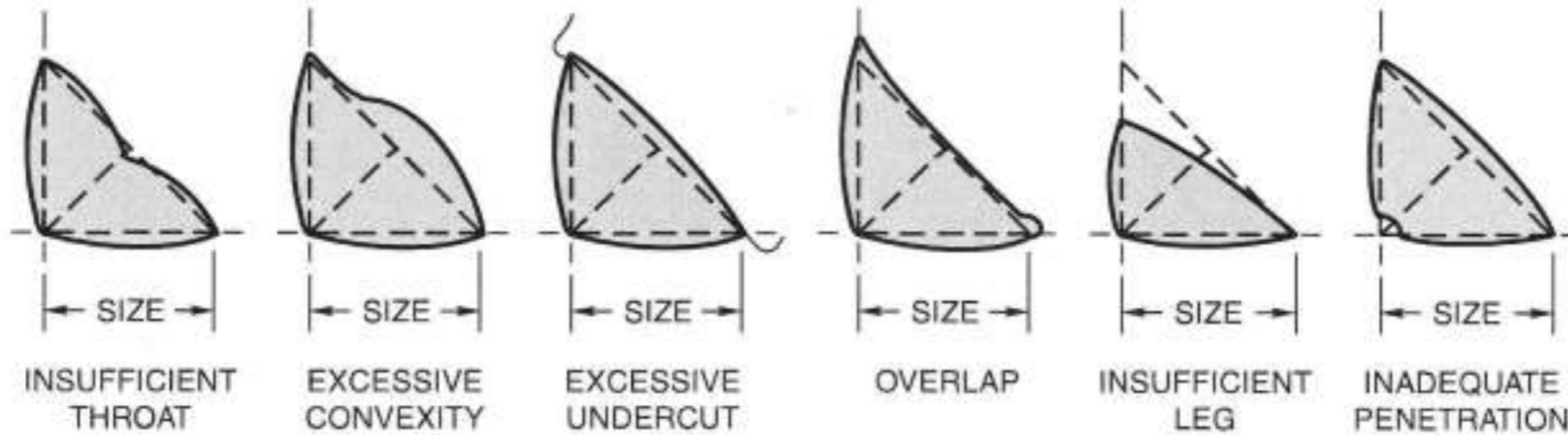
- Welders/Welding Operators shall examine each weld they make. Supervisors or Quality Control/Assurance Personnel shall examine a representative portion of the welds to verify that work is satisfactory
- Acceptable and unacceptable weld profiles are identified in Figure 2 of the specification
- Welds 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



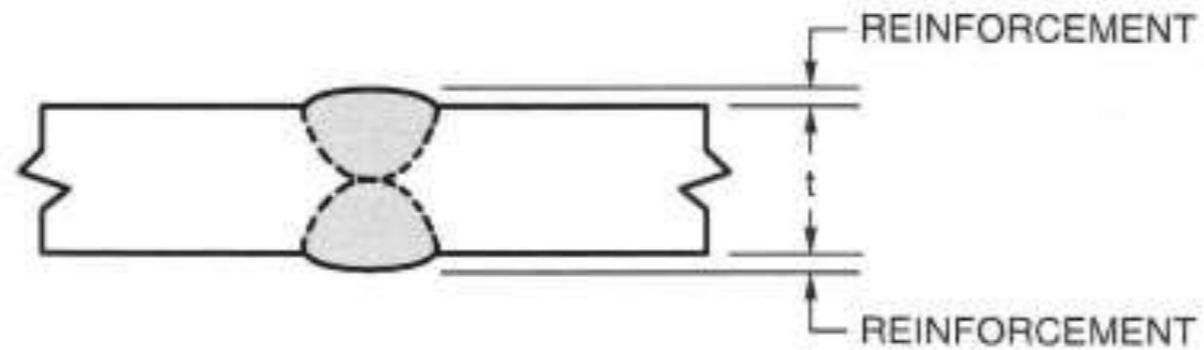
(A) DESIRABLE FILLET WELD PROFILES

(B) ACCEPTABLE FILLET WELD PROFILES

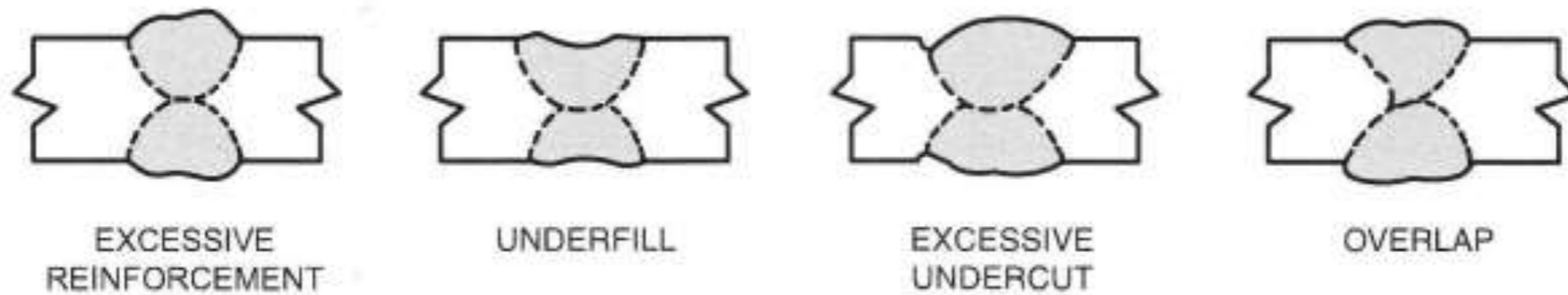


(C) UNACCEPTABLE FILLET WELD PROFILES

AWS D18.3: Section 6-Visual Examination Requirements



(D) ACCEPTABLE GROOVE WELD PROFILE



(E) UNACCEPTABLE GROOVE WELD PROFILES

		Flux Process	Shop Suitable
GTAW	Gas Tungsten Arc Welding	No	Yes
GMAW	Gas Metal Arc Welding	No	Yes
PAW	Plasma Arc Welding	No	No
LBW	Laser Beam Welding	No	No
EBW	Electron Beam Welding	No	No
SMAW	Shielded Metal Arc Welding	Yes	Yes
FCAW	Flux-Cored Arc Welding	Yes	Yes
SAW	Submerged Arc Welding	Yes	Yes

Flux welding processes can be used because welds are easy to inspect and slag/flux imperfections can be easily removed and welds repaired

- 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