

Structural Welding Code—Sheet Steel

1. General Provisions

1.1 Scope

This welding code covers arc welding of structural sheet/strip steels, including cold formed members (hereafter collectively referred to as *sheet steel*) which are equal to or less than 3/16 in. (0.188 in./4.8 mm) in nominal thickness. See Annex D, Tables D1 and D2 for gage numbers and equivalent thicknesses.

Three weld types unique to sheet steel, arc spot, arc seam, and arc plug welds, are included in this code.

1.1.1 Applicable Materials. This code is applicable to the welding of structural sheet steels to other structural sheet steels or to supporting structural steel members.

1.1.2 General Stipulations. The fundamental premise of the code is to provide general stipulations applicable to any situation. Acceptance criteria for production welds different from those specified in the code shall be permitted for a particular application, provided they are suitably documented by the proposer and approved by the Engineer. These alternate acceptance criteria shall be based upon evaluation of suitability for service using past experience, experimental evidence, or engineering analysis considering material type, service load effects, and environmental factors.

1.1.3 Approval. All references to the need for approval shall be interpreted to mean approval by the Engineer, defined as the duly designated person who acts for and in behalf of the owner on all matters within the scope of this code. Deviations from code requirements shall require the Engineer's approval.

1.2 Sheet Steel Base Metal

1.2.1 Specified Base Metals. Sheet steel base metals to be welded under this code shall conform to the requirements of the latest edition of one of the specifications

listed below, or any sheet steel qualified in conformance with 1.2.2. Any combination of these steels may be welded together. These steels may also be welded to any of the steels listed in the latest edition of ANSI/AWS D1.1, *Structural Welding Code—Steel*.

(1) Specification for Sheet Steel, Zinc-Coated (Galvanized) by the Hot-Dip Process. Structural Physical Quality (A653 SQ Grades 33, 37, 40, and 80).

(2) Specification for Hot-Rolled Steel Sheet and Strip. Structural Quality (ASTM A570).

(3) Specification for Steel Sheet and Strip, Hot-Rolled and Cold-Rolled, High Strength, Low Alloy, with Improved Corrosion Resistance (ASTM A606).

(4) Specification for Steel Sheet and Strip, Hot-Rolled or Cold-Rolled, High Strength, Low Alloy Columbium or Vanadium, or both (ASTM A607 Grades 45, 50, 55, 60, 65, and 70).

(5) Specification for Steel, Cold-Rolled Sheet, Carbon Structural (ASTM A611).

1.2.2 Other Base Metals. When a steel other than those covered in 1.2.1 is approved under the provisions of the project or product specification, and such a steel is proposed for welded construction, the weldability of the steel and the WPS for welding it shall be established by qualification in conformance with the requirements of section 4 and such other requirements as prescribed by the Engineer.

1.2.3 Minimum Yield Point. The provisions of this code are intended for use with sheet steel having a minimum specified yield point equal to or less than 80 000 psi (550 MPa).

1.3 Welding Processes

1.3.1 Approved Processes. This code provides for welding with the shielded metal arc welding (SMAW), gas

metal arc welding (GMAW), flux cored arc welding (FCAW), gas tungsten arc welding (GTAW), or submerged arc welding (SAW) welding processes. (*Note: Any variation of gas metal arc welding (GMAW), including short-circuiting transfer, is acceptable.*)

1.3.2 Stud Welding. When stud welding through the flat portion of decking or roofing onto supporting structural members, the WPS shall conform to section 7 of this code and section 7 of ANSI/AWS D1.1.

1.3.3 Other Processes. Other welding processes may be used when approved by the Engineer. In such case, the Engineer shall specify any additional qualification requirements necessary to assure satisfactory joints for the intended service.

1.4 Weld Metal Requirements

1.4.1 Matching Filler Metals. When using the indicated weld process, the filler metals listed in Table 1.1 provide a weld joint with strengths matching that of the base metal.

1.4.2 Other Base Metal–Filler Metal Combinations. Base metal–filler metal combinations other than those described in 1.4.1 shall be permitted when evaluated and approved by the Engineer. When base metals of dissimilar strengths are welded, the filler metal tensile strength shall be equal to or greater than that of the lowest tensile strength base metal.

1.4.3 Manufacturer’s Certification. When requested by the Engineer, the contractor shall furnish an electrode manufacturer’s certification stating that the electrode will meet the requirements of the classification.

1.4.4 Electrodes for Shielded Metal Arc Welding (SMAW)

1.4.4.1 AWS Specification. Electrodes for SMAW shall conform to the requirements of the latest edition of ANSI/AWS A5.1, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*, or to the requirements of ANSI/AWS A5.5, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*.

1.4.4.2 Low-Hydrogen Electrode Control. This control shall be for sheet steel that is welded to a primary structural member which is thicker than 1/4 in. (6.4 mm). All electrodes having low-hydrogen coverings conforming to ANSI/AWS A5.1 shall be purchased in hermetically-sealed containers or shall be dried for at least two hours between 500°F (260°C) and 800°F (425°C) before they are used. Electrodes having low-hydrogen coverings conforming to ANSI/AWS A5.5 shall be purchased in hermetically-sealed containers or shall be dried at least

one hour at temperatures between 700°F (370°C) and 800°F (430°C) before being used. Electrodes shall be dried prior to use if the hermetically-sealed container shows evidence of damage.

Immediately after the opening of the hermetically-sealed container or removal of the electrode from a drying oven, electrodes shall either be used or stored in ovens held at a temperature of at least 250°F (120°C). E70XX and E70XX-X electrodes that are not used within four hours or E80XX-X electrodes that are not used within two hours after the opening of the hermetically-sealed container or the removal of the electrodes from a drying or storage oven shall be redried before use. Electrodes that have been wet shall not be used.

1.4.4.3 Melting Rate. A good measure of welding current can be provided by the melting rate (M) of the electrode.

$$M = \frac{\text{Inches of electrode melted}}{\text{Time in minutes}}$$

The application of this method is described in detail in the Commentary, C1.4.4.3.

1.4.5 Submerged Arc Welding (SAW)

1.4.5.1 AWS Specification. The bare electrodes and fluxes used in combination for SAW shall conform to the requirements of the latest edition of ANSI/AWS A5.17, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*, or to the requirements of the latest edition of ANSI/AWS A5.23, *Specification for Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*.

1.4.5.2 Flux. Flux used for submerged arc welding shall be dry and free of contamination from dirt, mill scale, oils, or other foreign material. All flux shall be purchased in packages that can be stored, under normal conditions, for at least six months without such storage affecting its welding characteristics or weld properties. Flux from damaged packages shall be discarded or shall be dried at a minimum temperature of 250°F (120°C) for one hour before use. Flux shall be placed in the dispensing system immediately upon the opening of a package, or if used from an opened package, the top 1 in. (25 mm) shall be discarded. Flux that has been wet shall not be used.

1.4.6 Gas Metal Arc Welding, Flux Cored Arc Welding (FCAW), and Gas Tungsten Arc Welding (GTAW) Filler Metals

1.4.6.1 AWS Specification. The filler metals and shielding for GMAW, FCAW or GTAW shall conform to the requirements of the latest edition of ANSI/AWS A5.18, *Specification for Carbon Steel Filler Metals for*

Table 1.1
Matching Filler Metal Requirements¹ (see 1.4.1)

ASTM Steel Specification		Minimum Yield Point		Minimum Tensile Strength		AWS Filler Metal Specifications
		ksi	MPa	ksi	MPa	
A653SQ	Gr 33	33	230	45	310	SMAW AWS A5.1 E60XX, E70XX
	Gr 37	37	255	52	360	
	Gr 40	40	275	55	380	
A570	Gr 30	30	205	49	340	SMAW A5.5 E70XX-X
	Gr 33	33	230	52	360	
	Gr 36	36	250	53	365	SAW AWS A5.17 F6AX-EXXX or F7AX-EXXX
	Gr 40	40	275	55	380	
	Gr 45	45	310	60	415	SAW AWS A5.23 F6AX-EXXX-XX or F7AX-EXXX-XX
	Gr 50	50	345	65	450	
A606		45	310	65	450	GMAW AWS A5.18 ER70S-X
A607	Gr 45	45	310	60	415	GTAW AWS A5.18 ER70S-X
	Gr 50	50	345	65	450	
A611	Gr A	25	175	42	290	FCAW AWS A5.20 E6XT-X or E7XT-X
	Gr B	30	205	45	310	
	Gr C	33	230	48	335	FCAW AWS A5.29 E7XTX-X or E6XTX-X
	Gr D	40	275	52	360	
A607	Gr 55	55	380	70	485	SMAW AWS A5.1 E70XX
						SMAW AWS A5.5 E70XX-X
						SAW AWS A5.17 F7AX-EXXX
						SAW AWS A5.23 F7AX-EXXX-XX
						GMAW AWS A5.18 ER70S-X
						FCAW AWS A5.20 E7XT-X
						FCAW AWS A5.29 E7XTX-X
GTAW AWS A5.18 ER70S-X						
A653SQ	Gr 80	80	550	82	570	SMAW AWS A5.5 [Note 2] E80XX-X
A607	Gr 60	60	415	75	515	SAW AWS A5.23 F8AX-EXXX-XX
	Gr 70	70	485	85	585	
A611	Gr E	80	550	82	565	GMAW AWS A5.28 [Note 2] ER80S-X
						FCAW AWS A5.29 [Note 2] E8XTX-X
						GMAW AWS A5.28 [Note 2] ER80S-X

Notes:

- Low hydrogen electrodes shall be used when required by ANSI/AWS D1.1. See 1.4.4.2 of ANSI/AWS D1.3-98.
- Filler metals of alloy groups B3, B3L, B4L, B5, B5L, B6, B6L, B7, B7L, B8, B8L, or B9 in ANSI/AWS A5.5, A5.28, or A5.29 are not prequalified for use in the as-welded condition.

Gas Metal Arc Welding or ANSI/AWS A5.28, Specification for Low Alloy Steel Filler Metals for Gas Shielded Arc Welding, ANSI/AWS A5.20, Specification for Carbon Steel Electrodes for Flux Cored Arc Welding, or ANSI/AWS A5.29, Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding, as applicable.

1.4.6.2 Shielding Media. A gas or gas mixture used for shielding in GMAW, FCAW, when required, or GTAW, shall be of a welding grade having a dew point of -40°F (-40°C) or lower. When requested by the Engineer, the gas manufacturer shall furnish certification that the gas or gas mixture meets the procurement specification and will meet the dew point requirement.

1.5 Weld Types

1.5.1 Square-Groove Welds in Butt Joints. This type of weld is restricted to the welding of sheet steel to sheet steel in all positions of welding.

1.5.2 Fillet Welds. This type of weld may be used in all positions of welding involving sheet steel to sheet steel or a sheet steel to a supporting structural member.

1.5.2.1 Fillet Welds in Lap and T-joints. Fillet welds in lap and T-joints may be used in all positions (see Table 1.2) involving a sheet steel to sheet steel or a sheet steel to a supporting structural member.

Note: When fillet welding sheet steel to a supporting structural member, measures shall be taken to prevent underbead cracking.

1.5.3 Flare-Groove Welds. This type of weld may be used in all positions involving the following:

- (1) Two sheet steels for flare-V and flare-bevel grooves
- (2) A sheet and a supporting structural member for flare-bevel groove (see Table 1.2)

1.5.4 Arc Spot Welds. This type of weld is a spot weld made by an arc welding process in which the weld is made without preparing a hole in either member. These welds are restricted to the welding of sheet steel to supporting structural member in the flat position. (See Table 1.2) *Note: Neither the thickness of a single sheet nor the combined thickness of two sheets welded to the thicker supporting structural members shall exceed 0.15 in. (3.7 mm).*

1.5.5 Arc Seam Welds. An arc seam weld is made without preparing a slot in either member.

These welds are restricted to the welding of joints involving:

- (1) Sheet to sheet in the flat or horizontal position
- (2) Sheet to thicker supporting structural member in the flat position (see Table 1.2)

1.5.6 Arc Plug Welds. An arc plug weld is made by filling a circular hole in an outer member or members.

These welds may be used in all positions involving the following:

- (1) Multiple layers of sheet steels
- (2) Multiple layers of sheet steels and a thicker supporting structural member

1.6 Definitions

The welding terms used in this specification shall be interpreted in accordance with definitions given in the latest edition of ANSI/AWS A3.0, *Standard Welding Terms and Definitions*, supplemented by Annex C of this specification.

Table 1.2
Welding Positions¹ and Restrictions for WPS (see 1.5.3)

	Square-Groove Weld in Butt Joint	Fillet Weld	Flare-Bevel- Groove Weld	Flare-V- Groove Weld	Arc Spot Weld	Arc Seam Weld	Arc Plug Weld
Sheet to Sheet	F H V OH	F H V OH	F H V OH	F H V OH	— — — —	F H — —	F H V OH
Sheet to Supporting Member	— — — —	F H V OH	F H V OH	— — — —	F — — —	F — — —	F H V OH

Note 1: Positions of welding: F = flat, H = horizontal, V = vertical, OH = overhead.