



Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)¹

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1. Scope*

1.1 This specification covers cold-formed welded carbon steel hollow structural sections (HSS) for welded or bolted construction. These shapes are utilized in but not limited to the following applications: buildings, bridges, towers, cranes, sign supports and poles, off-shore production and drilling platforms, roll-over protective structures (ROPS), falling object protective structures (FOPS), and amusement rides.

1.2 This HSS is produced in welded sizes with a periphery of 88 in. [2235 mm] or less, and a specified nominal wall thickness of 0.148 in. [3.8 mm] or greater and 0.875 in. [22 mm] or less.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. The inch-pound units shall apply unless the “M” designation of this specification is specified in the order.

1.4 The text of this specification contains notes and footnotes that provide explanatory material. Such notes and footnotes, excluding those in tables and figures, do not contain any mandatory requirements.

2. Referenced Documents

2.1 *ASTM Standards*:²

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

2.2 *Military Standard*:³

MIL-STD-129 Marking for Shipment and Storage

2.3 *Federal Standards*:⁴

Fed. Std. No. 123 Marking for Shipment

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products

2.4 *AIAG Standard*:⁵

B-1 Bar Code Symbology Standard

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology **A941**.

4. Ordering Information

4.1 Orders for material under this specification shall contain information concerning as many of the following items as are required to describe the desired material adequately:

4.1.1 Quantity (feet [metres] or number of lengths),

4.1.2 Name of material (cold-formed HSS),

4.1.3 Size (outside diameter and wall thickness for round HSS, and outside dimensions and wall thickness for square and rectangular HSS),

4.1.4 Length (random, multiple, specific; see **12.4**),

4.1.5 End condition (see **17.3**),

4.1.6 Burr removal (see **17.3**),

4.1.7 Certification (see Section **19**),

4.1.8 ASTM specification designation and year of issue,

4.1.9 End use,

4.1.10 Special requirements,

4.1.11 Bar coding (see **20.3**),

4.1.12 Packing, Marking and Loading (see Section **21**), and

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://dodssp.daps.dla.mil>.

⁴ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

⁵ Available from Automotive Industry Action Group (AIAG), 26200 Lahser Rd., Suite 200, Southfield, MI 48033, <http://www.aiag.org>.

4.1.13 Supplementary requirement, if any, including the additional requirement called for in the supplementary requirement.

5. Process

5.1 The steel shall be made by one or more of the following processes: open-hearth, basic-oxygen, or electric furnace.

5.2 When steels of different grades are sequentially strand cast, the steel producer shall identify the resultant transition material and remove it using an established procedure that positively separates the grades.

6. Manufacture

6.1 HSS shall be made from flat-rolled steel by the electric-resistance-welding process. The longitudinal butt joint of welded tubing shall be welded across its thickness. No transverse coil splices are permitted in the furnished product.

6.2 Stress relief or annealing is permissible. If heat treatment is performed mechanical testing shall be conducted after heat treatment.

NOTE 1—Welded HSS is normally furnished without removal of the inside flash.

7. Heat Analysis

7.1 Each heat analysis shall conform to the requirements specified in **Table 1** for heat analysis.

7.2 The maximum permissible carbon equivalent shall be 0.45 %. The carbon equivalent shall be based upon the heat analysis. The required heat analysis and the carbon equivalent shall be reported. The carbon equivalent shall be calculated using the following formula:

$$CE = C + (Mn)/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

8. Product Analysis

8.1 When product tests are conducted the HSS shall conform to the requirements of **Table 1** for product analysis.

8.2 If product analyses are made, they shall be made using test specimens taken from two lengths of HSS from each lot of 500 lengths, or fraction thereof, or two pieces of flat-rolled stock from each lot of a corresponding quantity of flat-rolled stock. Methods and practices relating to chemical analysis shall

be in accordance with Test Methods, Practices, and Terminology **A751**. Such product analyses shall conform to the requirements specified in **Table 1** for product analysis.

8.3 If both product analyses representing a lot fail to conform to the specified requirements, the lot shall be rejected.

8.4 If only one product analysis representing a lot fails to conform to the specified requirements, product analyses shall be made using two additional test specimens taken from the lot. Both additional product analyses shall conform to the specified requirements or the lot shall be rejected.

9. Tensile Requirements

9.1 The material, as represented by the test specimen, shall conform to the requirements as to tensile properties prescribed in **Table 2**.

10. Charpy V-Notch (CVN) Impact Requirements

10.1 The material, as represented by the test specimen, shall conform to the minimum average CVN Impact Value of 25 ft-lb at 40°F [34 Joules at 4°C], based on full-size longitudinal test specimens. (See Test Methods and Definitions **A370** for acceptance criteria for subsize specimens.)

11. Flattening Test

11.1 The flattening test shall be made on round HSS. A flattening test is not required for square and rectangular HSS.

11.2 For round HSS, a test specimen at least 4 in. [100 mm] in length shall be flattened cold between parallel plates in three steps, with the weld located 90° from the line of direction of force. During the first step, which is a test for ductility of the weld, no cracks or breaks on the inside or outside surfaces of the test specimen shall be present until the distance between the plates is less than two-thirds of the specified outside diameter of the tubing. For the second step, no cracks or breaks on the inside or outside parent metal surfaces of the test specimen, except as provided for in **11.4**, shall be present until the distance between the plates is less than one-half of the specified outside diameter of the tubing. During the third step, which is a test for soundness, the flattening shall be continued until the test specimen breaks or the opposite walls of the test specimen meet. Evidence of laminated or unsound material or of incomplete weld that is revealed during the entire flattening test shall be cause for rejection.

11.3 Surface imperfections not found in the test specimen before flattening, but revealed during the first step of the flattening test, shall be judged in accordance with **Section 17**.

TABLE 1 Chemical Requirements

Element	Composition, %	
	Heat Analysis	Product Analysis
Carbon, max	0.26	0.30
Manganese, max	1.35	1.40
Phosphorus, max	0.035	0.045
Sulfur, max	0.035	0.045
Aluminum, min	.015 acid soluble OR .020 total Al content	...
Silicon	≤0.04 or 0.15 ≤ Si ≤ 0.25	<0.07 or 0.13 ≤ Si ≤ 0.28

Notes:

(1) For each reduction of 0.01 percentage point below the specified maximum for carbon, an increase of 0.06 percentage point above the specified maximum for manganese is permitted, up to a maximum of 1.50% by heat analysis and 1.60% by product analysis.

(2) Where an ellipsis (...) appears in the table, requirements have not been defined.

TABLE 2 Tensile Requirements

Round and Shaped HSS	
	Grade A
Yield Strength, psi [MPa]	50,000 [345] – 70,000 [485]
Tensile Strength, psi [MPa], min.	65,000 [450]
Elongation in 2 in. [50 mm], min. % ^A	21

^A The minimum elongation values specified apply only to tests performed prior to shipment of the tubing.



11.4 When low D -to- t ratio HSS are tested, the strain imposed due to geometry is unreasonably high on the inside surface at the 6 and 12 o'clock locations. Cracks at these locations shall not be cause for rejection if the D -to- t ratio is less than 10.

12. Permissible Variations in Dimensions

12.1 Outside Dimensions:

12.1.1 *Round HSS*—The outside diameter shall not vary more than ± 0.5 %, rounded to the nearest 0.005 in. [0.1 mm], from the specified outside diameter for specified outside diameters 1.900 in. [48 mm] and smaller, and ± 0.75 %, rounded to the nearest 0.005 in. [0.1 mm], from the specified outside diameter for specified outside diameters 2.00 in. [50 mm] and larger. The outside diameter measurements shall be made at positions at least 2 in. [50 mm] from the ends of the HSS.

12.1.2 *Square and Rectangular HSS*—The outside dimensions, measured across the flats at positions at least 2 in. [50 mm] from the ends of the HSS shall not vary from the specified outside dimensions by more than the applicable amount given in **Table 3**, which includes an allowance for convexity or concavity.

12.2 *Wall Thickness*—The minimum wall thickness shall be 95 % of the specified wall thickness. The maximum wall thickness, excluding the weld seam, shall be not more than 10 % greater than the specified wall thickness. For square and rectangular tubing the wall thickness requirements shall apply only to the centers of the flats.

12.3 *Mass*—On the basis that the density of rolled steel is 0.2836 lb/in.³ [7850 kg/m³] and that the outside radius of corners of rectangular HSS are 2 times the specified thickness, the actual mass of an individual length of HSS shall not deviate from the mass specified by more than -3.5 % or $+10$ %.

12.4 *Length*—HSS is normally produced in random lengths 5 ft [1.5 m] and over, in multiple lengths, and in specific lengths. Refer to Section 4. When specific lengths are ordered, the length tolerance shall be in accordance with **Table 4**.

TABLE 3 Permissible Variations in Outside Flat Dimensions for Square and Rectangular HSS

Specified Outside Large Flat Dimension, in. [mm]	Permissible Variations Over and Under Specified Outside Flat Dimensions, ^A in. [mm]
2½ [65] or under	0.020 [0.5]
Over 2½ to 3½ [65 to 90], incl	0.025 [0.6]
Over 3½ to 5½ [90 to 140], incl	0.030 [0.8]
Over 5½ [140]	0.01 times large flat dimension

^A The permissible variations include allowances for convexity and concavity. For rectangular HSS having a ratio of outside large to small flat dimension less than 1.5, and for square HSS, the permissible variations in small flat dimension shall be identical to the permissible variations in large flat dimension. For rectangular HSS having a ratio of outside large to small flat dimension in the range of 1.5 to 3.0 inclusive, the permissible variations in small flat dimension shall be 1.5 times the permissible variations in large flat dimension. For rectangular HSS having a ratio of outside large to small flat dimension greater than 3.0, the permissible variations in small flat dimension shall be 2.0 times the permissible variations in large flat dimension.

TABLE 4 Length Tolerances for Specific Lengths of Structural HSS

	22 ft [6.5 m] and Under		Over 22 ft [6.5 m]	
	Over	Under	Over	Under
Length tolerance for specific lengths, in. [mm]	½ [13]	¼ [6]	¾ [19]	¼ [6]

12.5 *Straightness*—The permissible variation for straightness of HSS shall be ⅛ in. times the number of feet [10 mm times the number of metres] of total length divided by 5.

12.6 *Squareness of Sides*—For square and rectangular structural HSS, adjacent sides shall be square (90°), with a permissible variation of $\pm 2^\circ$ max.

12.7 *Radius of Corners*—For square and rectangular structural HSS, the radius of each outside corner of the section shall be as noted in the table below.

TABLE 5 Corner Radii

Thickness, t , in. [mm]	Corner Radius
$t \leq 0.400$ [10.2 mm]	1.6 t to 3.0 t
$t > 0.400$ [10.2 mm]	1.8 t to 3.0 t

12.8 *Twist*—For square and rectangular structural HSS, the permissible variations in twist shall be as given in **Table 6**. Twist shall be determined by holding one end of the HSS down on a flat surface plate, measuring the height that each corner on the bottom side of the HSS extends above the surface plate near the opposite ends of the HSS, and calculating the twist (the difference in heights of such corners), except that for heavier sections it shall be permissible to use a suitable measuring device to determine twist. Twist measurements shall not be taken within 2 in. [50 mm] of the ends of the HSS.

13. Special Shape HSS

13.1 The availability, dimensions, and tolerances of special shape structural HSS shall be subject to inquiry and negotiation with the manufacturer.

14. Number of Tests

14.1 The term “lot” shall apply to all HSS of the same specified size and specified wall thickness that are produced from the same heat of steel.

14.2 One tension test as specified in Section 16 shall be made from a length of HSS representing each lot.

TABLE 6 Permissible Variations in Twist for Square and Rectangular HSS

Specified Outside Large Flat Dimension, in. [mm]	Maximum Permissible Variations in Twist per 3 ft of Length [Twist per Meter of Length]	
	in.	[mm]
1½ [40] and under	0.050	[1.3]
Over 1½ to 2½ [40 to 65], incl	0.062	[1.6]
Over 2½ to 4 [65 to 100], incl	0.075	[1.9]
Over 4 to 6 [100 to 150], incl	0.087	[2.2]
Over 6 to 8 [150 to 200], incl	0.100	[2.5]
Over 8 [200]	0.112	[2.8]



14.3 One set of CVN tests as specified in Section 16 shall be made from a length of HSS representing each lot.

14.4 The flattening test, as specified in Section 11, shall be made on one length of round HSS from each lot.

15. Retests

15.1 If the results of the mechanical tests representing any lot fail to conform to the applicable requirements specified in Sections 9, 10, and 11, the lot shall be rejected or retested using additional HSS of double the original number from the lot. The lot shall be acceptable if the results of all such retests representing the lot conform to the specified requirements.

15.2 If one or both of the retests specified in 15.1 fail to conform to the applicable requirements specified in Sections 9, 10, and 11, the lot shall be rejected or, subsequent to the manufacturer heat treating, reworking, or otherwise eliminating the condition responsible for the failure, the lot shall be treated as a new lot and tested accordingly.

16. Test Methods

16.1 Tension test specimens shall conform to the applicable requirements of Test Methods and Definitions A370, Annex A2.

16.2 Tension test specimens shall be full-size longitudinal test specimens or longitudinal strip test specimens. Any longitudinal strip test specimens shall be taken from a location at least 90° from the weld and shall be prepared without flattening in the gage length. Longitudinal strip test specimens shall have all burrs removed. Tension test specimens shall not contain surface imperfections that would interfere with proper determination of the tensile properties.

16.3 The yield strength corresponding to the 0.2 % strain offset method shall be determined.

16.4 CVN Impact test specimens shall conform to the applicable requirements of Test Methods and Definitions A370. Subsize specimens are permitted in accordance with Test Methods and Definitions A370.

16.5 CVN Impact test specimens shall be longitudinal. They shall be taken from a location at least 90° from the weld.

17. Inspection

17.1 All HSS shall be inspected at the place of manufacture to ensure conformance to the requirements of this specification.

17.2 All HSS shall be free from defects and shall have a workmanlike finish.

17.2.1 Surface imperfections shall be classed as defects when their depth reduces the remaining wall thickness to less than 95 % of the specified wall thickness. It shall be permissible for defects having a depth not in excess of $3\frac{1}{3}$ % of the specified wall thickness to be repaired by welding, subject to the following conditions:

17.2.1.1 The defect shall be completely removed by chipping or grinding to sound metal,

17.2.1.2 The repair weld shall be made using a low hydrogen welding process, and

17.2.1.3 The projecting weld metal shall be removed to produce a workmanlike finish.

17.2.2 Surface imperfections such as handling marks, light die or roll marks, or shallow pits are not considered defects provided that the imperfections are removable within the specified limits on wall thickness. The removal of such surface imperfections is not required. HSS shall be free of protruding metal on the outside surface of the weld seam.

17.3 Unless otherwise specified in the purchase order, structural HSS shall be furnished with square cut ends, with the burr held to a minimum. When so specified in the purchase order, the burr shall be removed on the outside diameter, inside diameter, or both.

18. Rejection

18.1 It shall be permissible for the purchaser to inspect HSS received from the manufacturer and reject any HSS that does not meet the requirements of this specification, based upon the inspection and test methods outlined herein. The purchaser shall notify the manufacturer of any HSS that has been rejected, and the disposition of such HSS shall be subject to agreement between the manufacturer and the purchaser.

18.2 It shall be permissible for the purchaser to set aside any HSS that is found in fabrication or installation within the scope of this specification to be unsuitable for the intended end use, based on the requirements of this specification. The purchaser shall notify the manufacturer of any HSS that has been set aside. Such HSS shall be subject to mutual investigation as to the nature and severity of the deficiency and the forming or installation, or both, conditions involved. The disposition of such HSS shall be subject to agreement between the manufacturer and the purchaser.

19. Certification

19.1 When specified in the purchase order or contract, the manufacturer shall furnish to the purchaser a certificate of compliance stating that the product was manufactured, sampled, tested, and inspected in accordance with this specification and any other requirements designated in the purchase order or contract, and was found to meet all such requirements. Certificates of compliance shall include the specification number, year of issue, and manufacturer. If testing is not performed by manufacturer, then the name of the testing agency shall be on the certification in addition to the items previously stated.

19.2 When specified in the purchase order or contract, the manufacturer shall furnish to the purchaser test reports for the product shipped that contain the heat analyses and the results of the tension tests and CVN Impact tests required by this specification and the purchase order or contract.

19.3 A signature or notarization is not required on certificates of compliance or test reports; however, the documents shall clearly identify the organization submitting them. Notwithstanding the absence of a signature, the organization submitting the document is responsible for its content.

19.4 A certificate of compliance or test report printed from, or used in electronic form, from an electronic data interchange

(EDI) shall be regarded as having the same validity as a counterpart printed in the certifying organization's facility. The content of the EDI transmitted document shall conform to any existing EDI agreement between the purchaser and the manufacturer.

20. Product Marking

20.1 Except as noted in 20.2, each length of structural HSS shall be legibly marked to show the following information: manufacturer's name, brand, or trademark; the specification designation (year of issue not required); and grade letter.

20.2 For structural HSS having a specified outside diameter or large flat dimension of 4 in. [100 mm] or less, it shall be permissible for the information listed in 20.1 to be marked on a tag securely attached to each bundle.

20.3 *Bar Coding*—In addition to the requirements in 20.1 and 20.2, the manufacturer shall have the option of using bar coding as a supplementary identification method. When a specific bar coding system is specified in the purchase order, that system shall be used.

21. Packing, Marking, and Loading

21.1 When specified in the purchase order, packaging, marking, and loading shall be in accordance with Practices A700.

22. Government Procurement

22.1 When specified in the contract, marking for shipment of such materials shall be in accordance with Federal Std. No. 123 for civil agencies and MIL-STD 129 or Federal Std. No. 183 if continuous marking is required.

22.2 *Inspection*—Unless otherwise specified in the contract, the manufacturer shall be responsible for the performance of all applicable inspection and test requirements specified herein. Except as otherwise specified in the contract, the manufacturer shall use its own or any other suitable facilities for the performance of such inspections and tests.

23. Keywords

23.1 bridges; buildings; steel tube; welded construction; welded hollow structural sections

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified in the purchase order.

S1. Heat Treatment

S1.1 HSS shall be heat treated at a temperature of 850° F [450° C] or higher, followed by cooling in air. The product marking and certification or test report shall include S1.1 in addition to the requirements in Sections 19 and 20.

S2. Alternate Charpy V-notch Test

S2.1 The material, as represented by the test specimen, shall conform to the minimum average CVN Impact Value and test temperature specified on the purchase order, based on full-size longitudinal test specimens. (See Test Methods and Definitions A370 for acceptance criteria for subsize specimens.)

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue (A1085–13) that may impact the use of this standard. (Approved November 15, 2015.)

(1) Revised Table 1 Silicon content.

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