



RELIABLE TUBE Inc.



HSS

METHODS TO CHECK DIMENSIONAL TOLERANCES ON HOLLOW STRUCTURAL SECTIONS

HSS: TECHNICAL BROCHURE





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All excerpts from ASTM A500 are formatted with a gray background as seen here.

FOREWARD

The following is published as a guide for the purchaser of hollow structural sections (HSS). Methods of checking dimensional tolerances, stipulated in Section 11 of ASTM A500-20,* are discussed in detail. When checking tolerances for ASTM A847, ASTM A1085, ASTM A1065 or other material, the permissible variations may differ from what is given here; however, the method of measurement is the same. For additional information, please contact the HSS manufacturer or the Steel Tube Institute.

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OUTSIDE DIMENSIONS

MEASURING ROUND TUBING



11. PERMISSIBLE VARIATIONS IN DIMENSIONS

11.1 Outside Dimensions:

11.1.1 Round Structural Tubing—The outside diameter shall not vary more than $\pm 0.5\%$, 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 $\pm 0.75\%$, rounded to the nearest 0.005 in. [0.1 mm], from the specified outside diameter for specified outside diameters 2.00 in. [5 cm] and larger. The outside diameter measurements shall be made at positions at least 2 in. [5 cm] from the ends of the tubing.

TOOLS

To perform this measurement, you'll need outside micrometers of a suitable size to check the round HSS.

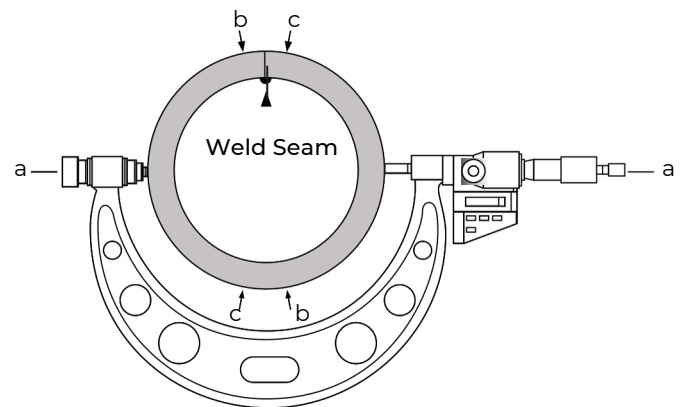


METHOD

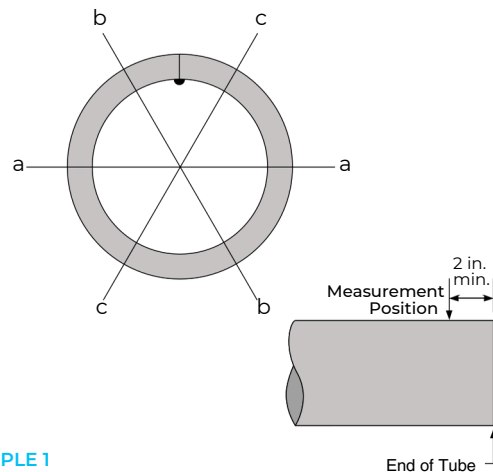
Refer to Example 1 for a typical application.

- 1 Measure at a position at least 2 inches from either end of the HSS.
- 2 Outside diameter measurements should be made at a point 90 degrees to the weld line (direction a-a, Diagram 1) and at points on either side of the weld line (directions b-b and c-c). Each measurement shall be considered individually.
- 3 Outside diameter measurements are not taken directly on the weld line. Application of the outside diameter tolerance to a measurement taken directly on the weld line must be specified by the customer.

DIAGRAM 1



EXAMPLE 1



EXAMPLE 1

Round HSS size is 7 in. O.D.

Specification: O.D. tolerance = 7 in. \times 0.0075 = 0.0525 = 0.053 in.

Measured dimensions: a-a, b-b, c-c: = 7. + 0.053 = 7.053 in. maximum
= 7. - 0.053 = 6.947 in. minimum



OUTSIDE DIMENSIONS

MEASURING SQUARE AND RECTANGULAR TUBING

TOOLS

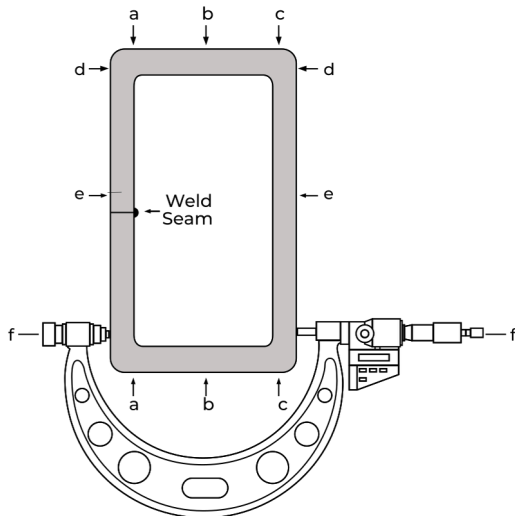
- 1 Outside micrometer of a suitable size to check the square or rectangular HSS.
- 2 Calipers and/or measuring tapes are not suitable.

METHOD

Refer to Example 2 for a typical application.

- 1 Measure at a position at least 2 inches from either end of the HSS.
- 2 Each side of the square or rectangular HSS requires measurements across the flats in order to ascertain not only the size but convexity or concavity as well. These measurements should be made near the start of the outside corner radii (directions a-a, c-c, d-d and f-f, Diagram 2) and near the center of the flats (directions b-b and e-e, Diagram 2). The measurement across the flat containing the weld should be made at a point on either side of the weld line. Each measurement shall be considered individually.
- 3 Measurements across the flats are not taken directly on the weld line. Application of Table 3 tolerances to a measurement taken directly on the weld line must be specified by the customer.
- 4 Note the tolerance for the small side of a rectangle is given by Table 3, Footnote A.
- 5 Allowance for concavity or convexity of HSS walls is included in these outside dimension tolerances.

DIAGRAM 2



11.1.2 Square and Rect angular St ructural T ubing—

The outside dimensions, measured across the flats at positions at least 2 in. [5 cm] from the ends of the tubing, 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.

TABLE 3 PERMISSIBLE VARIATIONS IN OUTSIDE FLAT DIMENSIONS FOR SQUARE AND RECTANGULAR STRUCTURAL TUBING

Specified Outside Large Flat Dimension, in. [mm]	Permissible Variations Over and Under Specified Outside Flat Dimensions, A in. [mm]
2 1/2 [65] or under	0.020 [0.5]
Over 2 1/2 to 3 1/2 [65 to 90], incl	0.025 [0.6]
Over 3 1/2 to 5 1/2 [90 to 140], incl	0.030 [0.8]
Over 5 1/2 [140]	0.01 times large flat dimension

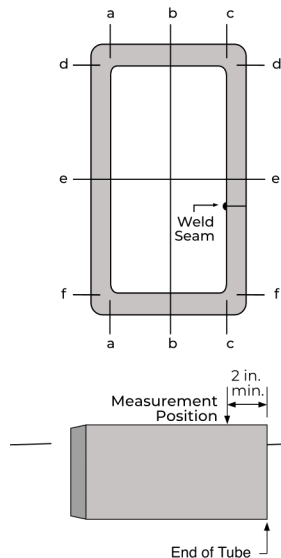
^A The permissible variations include allowances for convexity and concavity. For rectangular tubing having a ratio of outside large to small flat dimension less than 1.5, and for square tubing, the permissible variations in small flat dimension shall be identical to the permissible variations in large flat dimension. For rectangular tubing 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 tubing 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 3, FOOTNOTE A

Large Flat Dimension, LF	LF/SF < 1.5	1.5 ≤ LF/SF ≤ 3.0	LF/SF > 3.0
LF ≤ 2.5 in.	SF: ± 0.020 in.	SF: ± 0.030 in.	SF: ± 0.040 in.
2.5 in. < LF ≤ 3.5 in.	SF: ± 0.025 in.	SF: ± 0.038 in.	SF: ± 0.050 in.
3.5 in. < LF ≤ 5.5 in.	SF: ± 0.030 in.	SF: ± 0.045 in.	SF: ± 0.060 in.
LF > 5.5	SF: ± 0.01SF	SF: ± 0.015*SF	SF: ± 0.02*SF

LF = Large Flat Dimension, SF = Small Flat Dimension

EXAMPLE 2



Rectangular HSS size is 12 in. x 4 in.

Specification: Large side tolerance = 12 in. x 0.01 = 0.12 in.
Small side: ratio of side dimensions = 12/4 = 3 therefore tolerance = 1.5 x 0.12 = 0.18 in.

Measured dimension:
Large side at a-a, b-b and c-c = 12 + 0.12 = 12.12 in. maximum = 12 - 0.12 = 11.88 in. minimum

Small side at d-d, e-e and f-f = 4 + 0.18 = 4.18 in. maximum = 4 - 0.18 = 3.82 in. minimum

WALL THICKNESS

MEASURING ROUND HOLLOW STRUCTURAL SECTIONS



11.2 Wall Thickness—The minimum wall thickness excluding the weld seam of welded tubing if supplied with the inside flash not being removed shall be not more than 10 % less than the specified wall thickness. If the welded tubing is supplied with the inside flash removed, then the weld seam shall be included in the wall thickness measurement and shall be not more than 10 % less than the specified wall thickness. The maximum wall thickness, excluding the weld seam of welded tubing, 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.

TOOLS

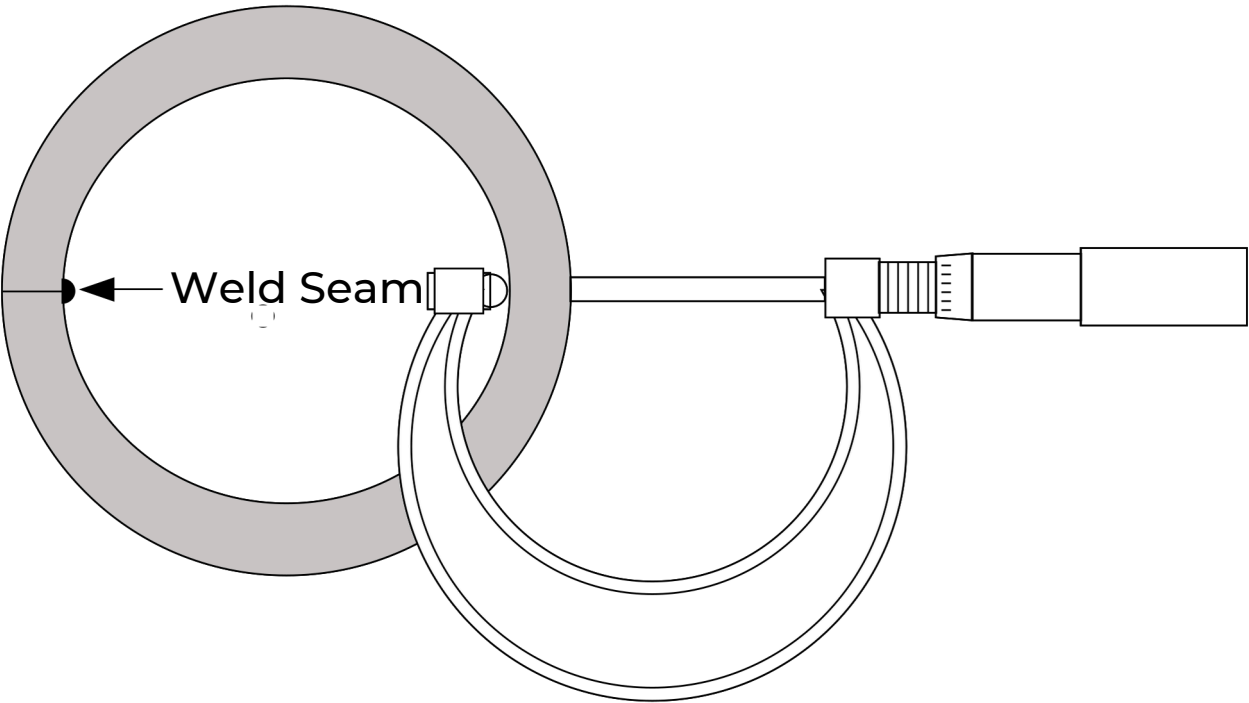
To perform this measurement, you'll need an outside micrometer spherical anvil type 0-1 inch range (various styles).

METHOD

Refer to Diagram 3 for a typical application.

Due to thickening caused by the manufacturing process and the presence of an inside weld bead, measurements shall not be taken in the area of the weld seam. Any other area of the HSS can be measured.

DIAGRAM 3



WALL THICKNESS

MEASURING SQUARE AND RECTANGULAR HOLLOW STRUCTURAL SECTIONS



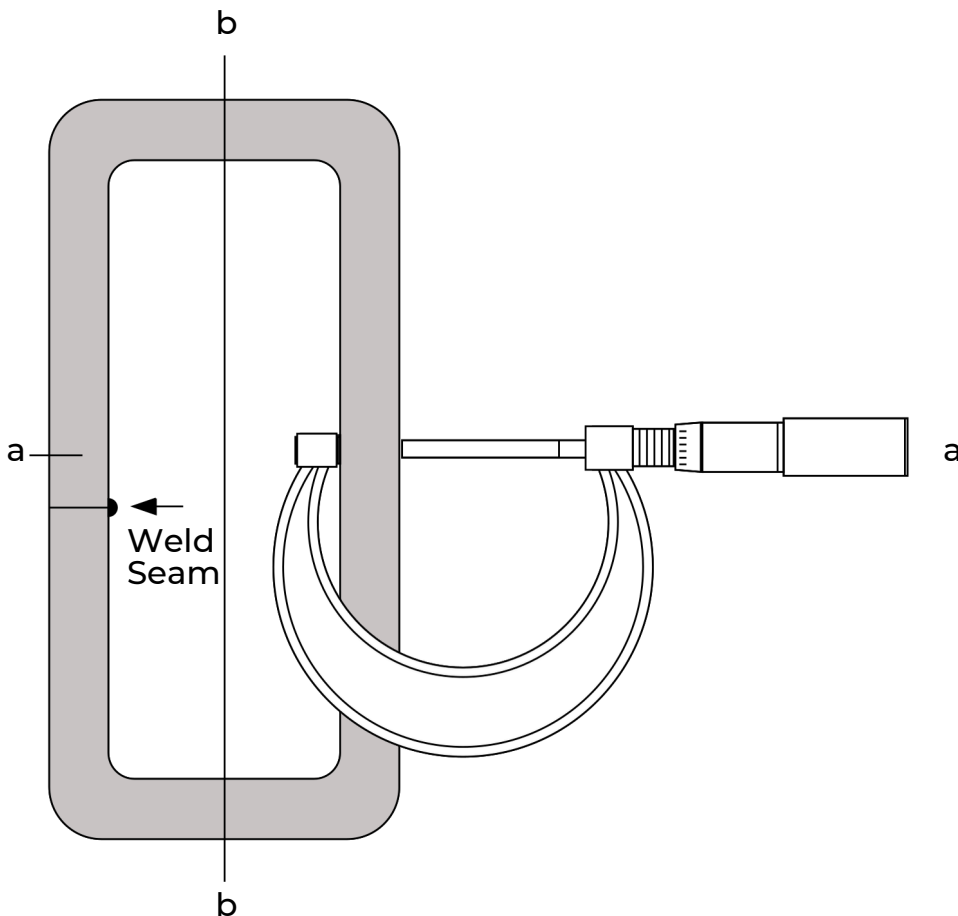
TOOLS

To perform this measurement, you'll need outside micrometers flat anvil type 0-1 inch range (various styles).

METHOD

- 1 Due to thickening caused by the manufacturing process and the presence of an inside weld bead, measurements shall not be taken in the area of the weld seam.
- 2 Measure in the center of a flat across from the weld line on direction a - a , Diagram 4 , or in the center of either flat on direction b-b.

DIAGRAM 4



LENGTH AND STRAIGHTNESS



MEASURING LENGTH

11.3 Length—Structural tubing 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.

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:

4.1.7 Length (random, multiple, specific; see 11.3),

Table 4 Length Tolerances for Specific Lengths of Structural Tubing

	22 ft [6.5 m] and Under		Over 22 ft [6.5 m]	
	Over	Under	Over	Under
Length tolerance for specific lengths, in. [mm]	1/2 [13]	1/4 [6]	3/4 [19]	1/4 [6]

TOOLS

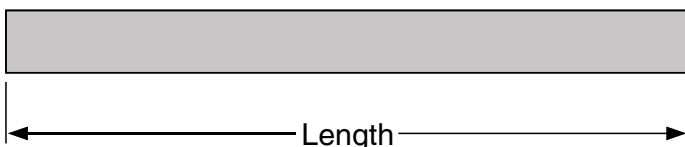
To perform this measurement, you'll need a tape measure or other suitable device to check length.

METHOD

Refer to Example 3 for a typical application.

- 1 Ensure that the HSS ends have minimal burrs or are burr-free.
- 2 Measure overall length with a suitable measuring device and note the following:
 - a For standard mill lengths, available from producing mills or steel service centers, the measured length tolerances will be all on the plus side and nothing under. The plus side tolerances will vary depending on the producer's capability.
 - b For specified mill lengths, the measured length must meet the requirements stipulated in Table 4.

EXAMPLE 3



Customer specified mill length is 25 feet.
Specification: From Table 4, over length tolerance is equal to 3/4 in. From Table 4, under length tolerance is equal to 1/4 in.
Measured Length: L = 25 ft. plus 3/4 in. = 25' - 3/4" Maximum
Measured Length: L = 25 ft. minus 1/4 in. = 24' - 11 3/4" Minimum

MEASURING STRAIGHTNESS

11.4 Straightness—The permissible variation for straightness of structural tubing shall be 1/8 in. times the number of feet [10 mm times the number of metres] of total length divided by 5.

TOOLS

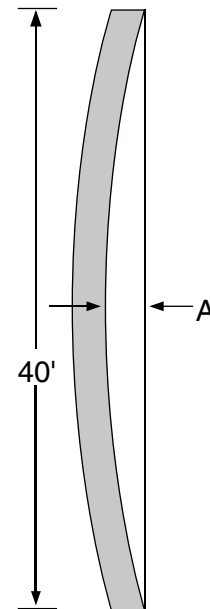
- 1 String line or piano wire of sufficient length to span the length of the HSS.
- 2 Tape measure or other suitable measuring device.

METHOD

Refer to Example 4 for a typical application.

- 1 Remove all burrs from both ends of the HSS being measured.
- 2 String a line from one end of the HSS to the other on the bowed side and pull tight.
- 3 Measure the maximum distance between the inside of the line and the face of the HSS. While the maximum distance will most often occur at the center of the HSS, this may not always be the case.

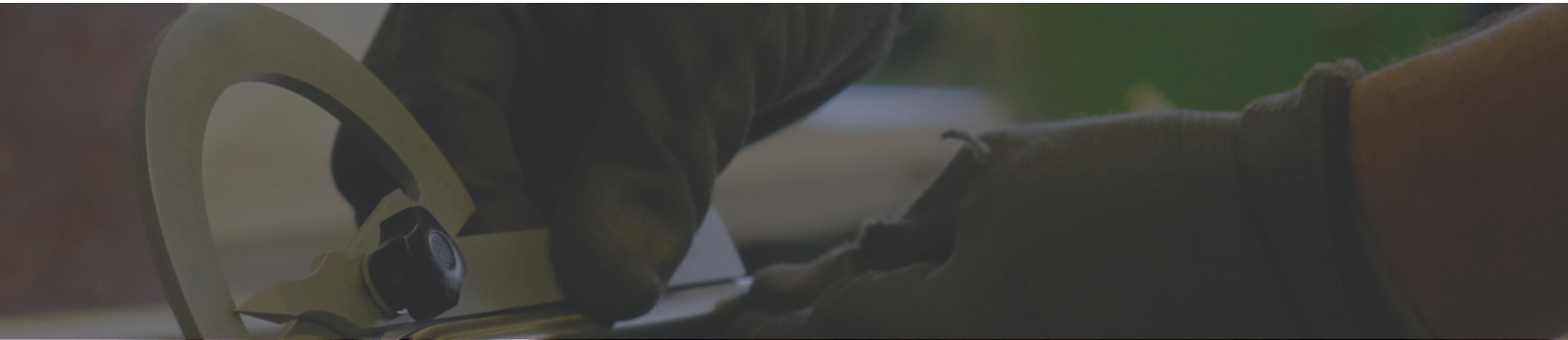
EXAMPLE 4



Section length is 40 feet.
Specification: Maximum permissible variation for straightness = 1/8 in. x number of feet of total length divided by 5.

A = 1/8 in. x 40 ft./5 ft. = 1.00 in. Therefore, the maximum variation in this case would be 1.00 in.

SQUARENESS OF SIDES



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

TOOLS

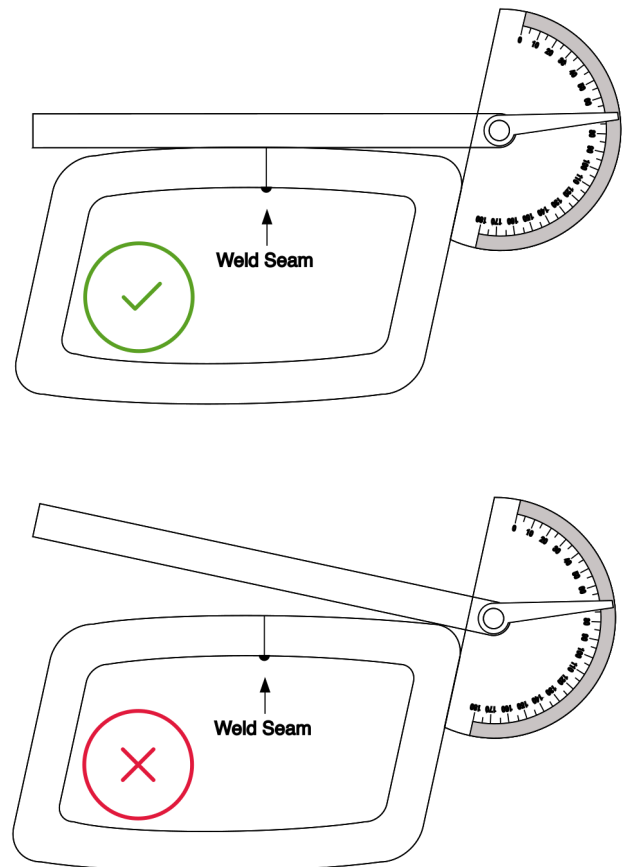
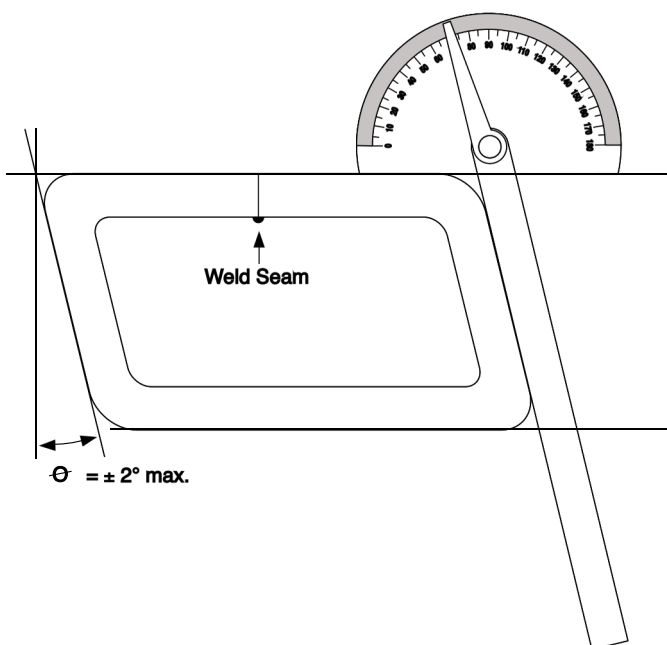
To perform this measurement, you'll need a protractor (various styles).

METHOD

- 1 Place the protractor on one surface of the square or rectangular HSS to be measured. See Diagram 5.
- 2 Adjust the protractor to measure the variation from 90 degrees.
- 3 Make sure that the squareness measurement is not affected by any convexity or concavity that may be present on the surfaces being checked. See Diagram 6.

DIAGRAM 6

DIAGRAM 5



CORNER RADIUS

MEASURING WITH RADIUS GAUGES



NOTE: The outside corner radius of hollow structural sections is not a manufacturing-controlled parameter. Variations from corner to corner can be expected.

These variations are the result of the method of the manufacturer, the machinery used to produce the product, and the internal specifications of a particular producer. Upon agreement between customer and manufacturer, maximum outside corner radii smaller than that allowed by the specification may be available.



11.6 Corner Radius—For square and rectangular structural tubing, the radius of each outside corner of the section shall not exceed three times the specified wall thickness.

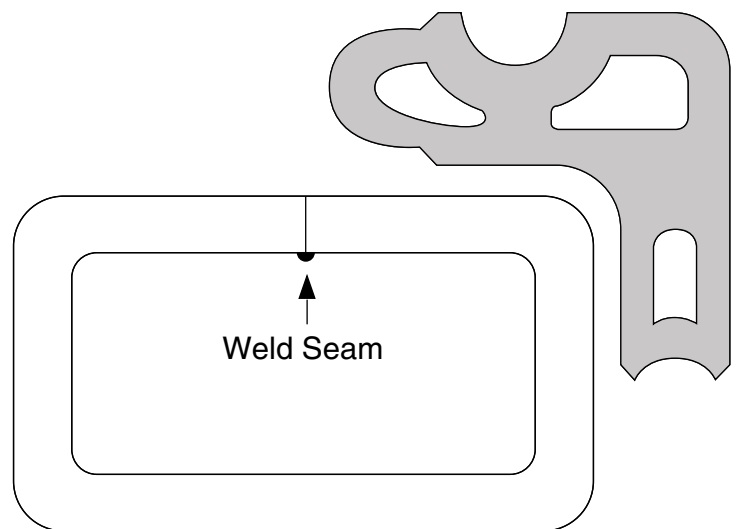
TOOLS

To perform this measurement, you'll need radius gauges (Method 1) See Diagram 7.

METHOD 1

- 1 Multiply the specified wall thickness of the HSS to be checked by three. This is the maximum outside corner radius allowed by the specification.
- 2 Select the radius gauge that corresponds to the maximum outside corner radius allowed by the specification.
- 3 Apply the gauge to each corner of the HSS being tested and note the fit. See Diagram 7.
- 4 If the gauge is too big or too small, remeasure with the next gauge size up or down until a good fit is obtained. A good fit is obtained when the gauge conforms to the profile of the HSS corner.
- 5 Note the gauge size and ascertain that each of the four corners is within the specification tolerance. Each measurement shall be considered individually

DIAGRAM 7



CORNER RADIUS

MEASURING WITH RULER AND STRAIGHT EDGE



TOOLS

To perform this measurement, you'll need a ruler and straight edge (Method 2). See Diagram 8.

METHOD 2

Refer to Example 5 for a typical application.

- 1 Multiply the specified wall thickness of the HSS to be checked by three. This is the maximum outside corner radius allowed by the specification.
- 2 Select a steel rule with graduations or a scale fine enough to give the desired accuracy.
- 3 Apply a rule to the one side of the corner to be measured and a straight edge to the other side. See Diagram 8.
- 4 Ascertain where the corner starts (tangent) on the side with the rule and measure from the start of the corner to the straight edge.
- 5 Note the reading and ascertain that it is within the specification tolerance.
- 6 Repeat the procedure on the same corner interchanging the ruler and the straight edge.
- 7 Repeat the procedure with the other three corners.
- 8 Make sure that the corner radius measurement is not affected by convexity or concavity that may be present on the surfaces adjacent to the corner being checked. For the concave case, the straight edge should be long enough to span the width of the HSS. See Diagram 9. For the convex case, the ruler and straight edge will not be practical and the radius gauge method should be used.

Example 5: Rectangular HSS size 8 in. x 4 in. x 0.500 in.
Specification: Outside corner radius = 3 in. x 0.500 in. = 1.500 in. maximum
Measured dimension: $n = 1.500$ in. maximum

DIAGRAM 8

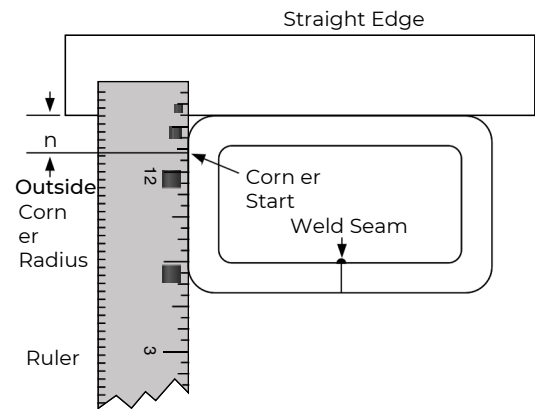
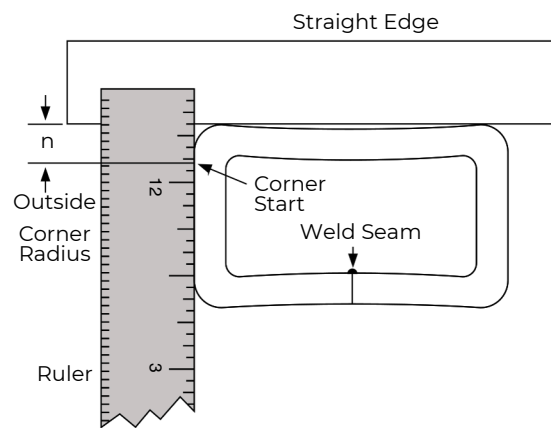
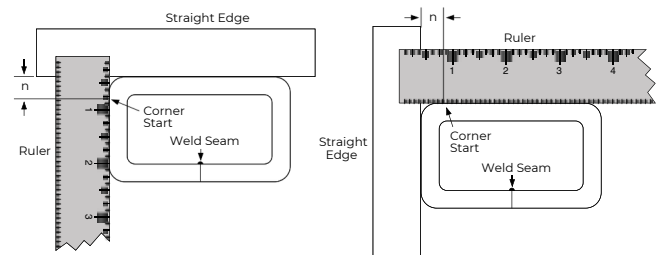


DIAGRAM 9



EXAMPLE 5

At the same corner, interchange ruler and straight edge.



TWIST

MEASURING WITH THICKNESS GAUGES

11.7 Twist—F or square and rectangular structural tubing, the permissible variations in twist shall be as given in Table 5.

Twist shall be determined by holding one end of the tubing down on a flat surface plate, measuring the height that each corner on the bottom side of the tubing extends above the surface plate near the opposite ends of the tubing, 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. [5 cm] of the ends of the tubing.

TABLE 5 PERMISSIBLE VARIATIONS IN TWIST FOR SQUARE AND RECTANGULAR STRUCTURAL TUBING

Specified Outside Large Flat Dimension, in. [mm]	Maximum Permissible Variations in Twist per 3 ft of Length [Twist per Metre of Length]
1 1/2 [40] and under	0.050 [1.3]
Over 1 1/2 to 2 1/2 [40 to 65], incl	0.062 [1.6]
Over 2 1/2 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]

TOOLS

- 1 Surface plate or other flat surface.
- 2 Feeler or thickness gauges (see Diagram 10) or other suitable measuring device.

METHOD

Refer to Example 6 for typical application.

- 1 Remove burrs from both ends of the HSS to be measured.
- 2 Hold down one end of the square or rectangular HSS on the flat surface plate with the bottom side of the HSS parallel to the surface. See Diagram 11.
- 3 Measure the height above the flat surface of each corner of the bottom side at the far end of the HSS. See Diagram 12. The difference in the measurements of these two corners is the twist or variation with respect to axial alignment of the section.
- 4 The measurements should be made with a suitable measuring device at points at least 2 inches from the end of the HSS.

DIAGRAM 10

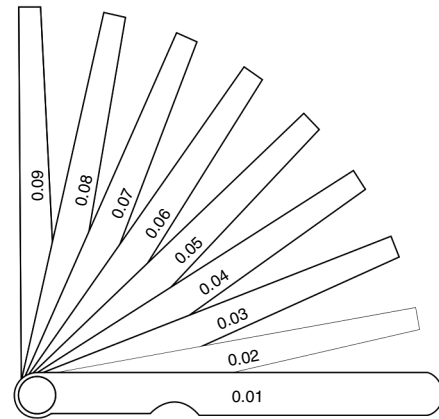


DIAGRAM 11

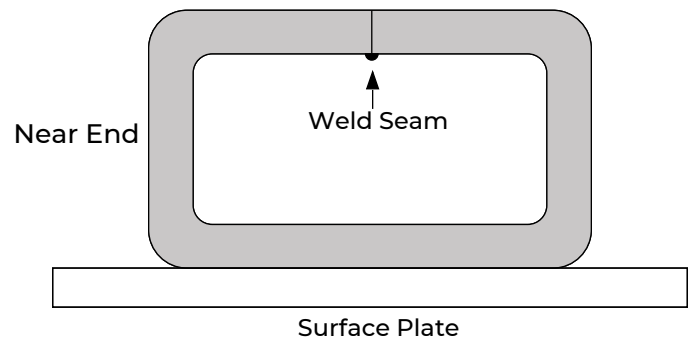
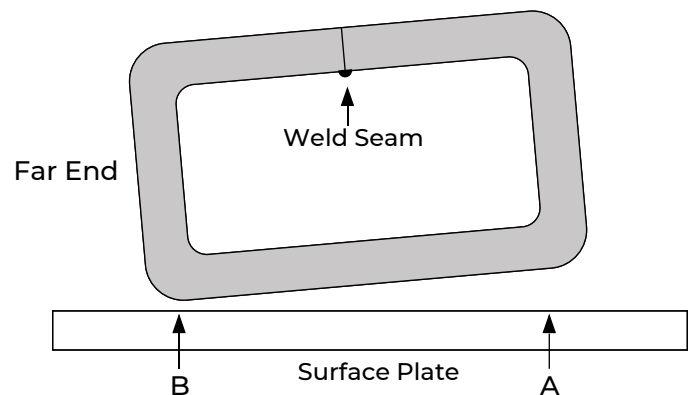
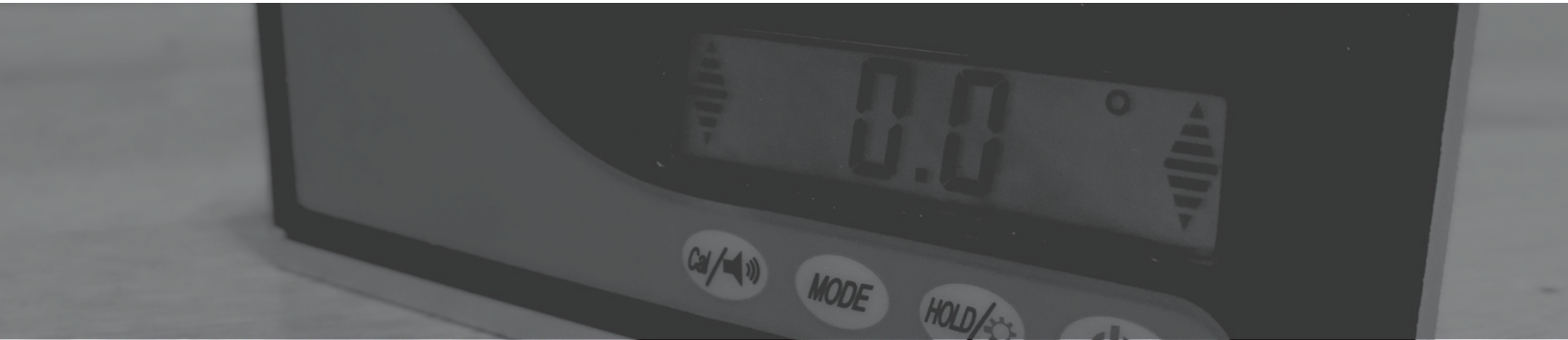


DIAGRAM 12



TWIST

MEASURING WITH DIGITAL PROTRACTOR



TOOLS

To perform this measurement, you'll need a digital protractor. See Diagram 13.

METHOD

Refer to Example 6 for typical application.

- 1 After calibrating the protractor at one end (2 inches from the end of the member), a reading can be taken at the opposite end of the member.
- 2 The following table converts the allowable twist given in Table 5 into degrees.

PERMISSIBLE TWIST (DEGREES)

Large Flat Dimensions (in.)	Length (Ft)				
	10	20	30	40	60
1 1/2	7.8	15.4	22.5	28.9	39.6
2	5.9	11.7	17.2	22.5	31.8
3	4.8	9.5	14.0	18.4	26.6
4	3.6	7.1	10.6	14.0	20.6
6	2.8	5.5	8.3	10.9	16.2
8	2.4	4.8	7.1	9.5	14
10	2.1	4.3	6.4	8.5	12.6
12	1.8	3.6	5.3	7.1	10.6
14	1.5	3.1	4.6	6.1	9.1
16	1.3	2.7	4.0	5.3	8.0
18	1.2	2.4	3.6	4.7	7.1
20	1.1	2.1	3.2	4.3	6.4
22	1.0	1.9	2.9	3.9	5.8
24	0.9	1.8	2.7	3.6	5.3

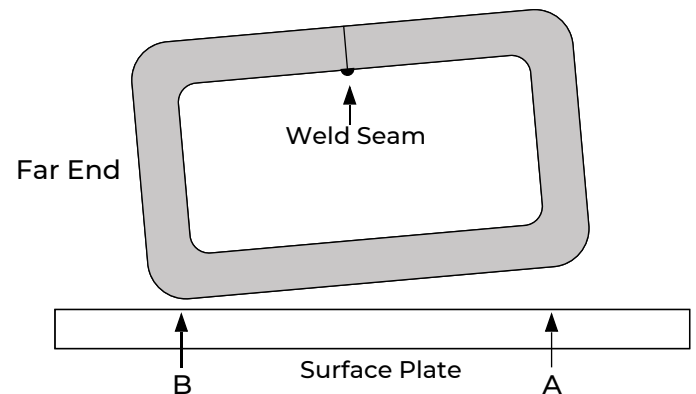
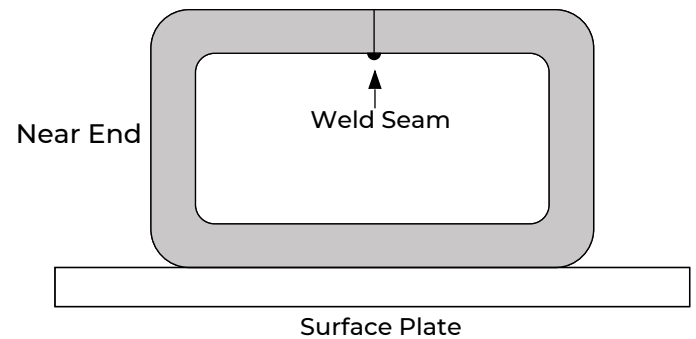
EXAMPLE 6

Rectangular tube size 8 in. x 4 in. x 30 ft. length.

Measuring Twist with Thickness Gauges

Specification: Allowable Twist = $0.100/3 \text{ ft.} \times 30 \text{ ft.} = 1.000 \text{ in. max.}$

Measured dimension: A minus B $\leq 1.000 \text{ in.}$



Measuring Twist With Digital Protractor
Specification: Allowable Twist: 7.1 degrees

DIAGRAM 13

