HSS

METHODS TO CHECK DIMENSIONAL TOLERANCES ON HOLLOW STRUCTURAL SECTIONS

HSS: TECHNICAL BROCHURE
TABLE OF CONTENTS

1-2 Outside Dimensions
3-4 Wall Thickness
5 Length and Straightness
6 Squareness of Sides
7-8 Radius Corners
9-10 Twist
11 STI Member Producers

FOREWORD

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 ±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. [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).
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
Round HSS size is 7 in. O.D.
Specification: O.D. tolerance = 7 in. x 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

EXAMPLE 1

Steel Tube Institute Methods to Check Dimensional Tolerances on Hollow Structural Sections steeltubeinstitute.org
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.
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

EXAMPLE 2

Rectangular HSS size is 12 in. x 4 in.

**Specification:**

Large side tolerance = 12 in. x 0.12 = 1.44 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 = a + 0.12 = 12.12 in. maximum
= a – 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

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

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

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**TABLE 3, FOOTNOTE A**

<table>
<thead>
<tr>
<th>Large Flat Dimension, LF</th>
<th>LF/SF &lt; 1.5</th>
<th>1.5 ≤ LF/SF ≤ 3.0</th>
<th>LF/SF &lt; 3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF ≤ 2.5 in.</td>
<td>SF: ± 0.020 in.</td>
<td>SF: ± 0.030 in.</td>
<td>SF: ± 0.040 in.</td>
</tr>
<tr>
<td>2.5 in. &lt; LF ≤ 3.5 in.</td>
<td>SF: ± 0.025 in.</td>
<td>SF: ± 0.038 in.</td>
<td>SF: ± 0.050 in.</td>
</tr>
<tr>
<td>3.5 in. &lt; LF ≤ 5.5 in.</td>
<td>SF: ± 0.030 in.</td>
<td>SF: ± 0.045 in.</td>
<td>SF: ± 0.060 in.</td>
</tr>
<tr>
<td>LF &gt; 5.5</td>
<td>SF: ± 0.015SF</td>
<td>SF: ± 0.02SF</td>
<td>SF: ± 0.02SF</td>
</tr>
</tbody>
</table>

\[ LF = \text{Large Flat Dimension}, \ SF = \text{Small Flat Dimension} \]
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**

1. Outside micrometer spherical anvil type 0-1 inch range (various styles).
2. Point micrometer 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.
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
METHOD

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.

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.
11.5 Squareness of Sides—For square and rectangular structural tubing, adjacent sides shall be square (90°), with a permissible variation of ±2° 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 5**

**DIAGRAM 6**
**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.

**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.

**DIAGRAM 7**

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

MEASURING WITH THICKNESS GAUGES

11.7 Twist—For 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>
<thead>
<tr>
<th>Specified Outside Large Flat Dimension, in. [mm]</th>
<th>Maximum Permissible Variations in Twist per 3 ft of Length [Twist per Metre of Length]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1/2 [40] and under</td>
<td>0.050 [1.3]</td>
</tr>
<tr>
<td>Over 1 1/2 to 2 1/2 [40 to 65], incl</td>
<td>0.062 [1.6]</td>
</tr>
<tr>
<td>Over 2 1/2 to 4 [65 to 100], incl</td>
<td>0.075 [1.9]</td>
</tr>
<tr>
<td>Over 4 to 6 [100 to 150], incl</td>
<td>0.087 [2.2]</td>
</tr>
<tr>
<td>Over 6 to 8 [150 to 200], incl</td>
<td>0.100 [2.5]</td>
</tr>
<tr>
<td>Over 8 [200]</td>
<td>0.112 [2.8]</td>
</tr>
</tbody>
</table>

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.
**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)**

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

**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 ft. x 30 ft. = 1.000 in. max.

Measured dimension: A minus B ≤ 1.000 in.
STI MEMBER PRODUCERS

**Atlas Tube Inc.**
1855 East 122nd St.
Chicago, IL 60633
(800) 733-5683
atlastube.com

**Hannibal Industries**
3851 South Santa Fe Ave.
Los Angeles, CA 90058
(323) 588-4261
hannibalindustries.com

**HW Metals**
19480 SW 118th Ave.
Tualatin, OR 97062
(503) 692-1690
hwmetals.com

**Maruichi American Corporation**
11529 Greenstone Ave.
Santa Fe Springs, CA 90670
(562) 903-8600
macsfs.com

**Maruichi Leavitt Pipe & Tube**
1717 115th St.
Chicago, IL 60643
(773) 239-7000
maruchi-leavitt.com

**Maruichi Oregon Steel Tube**
8735 North Harborage St.
Portland, OR 97203
(503) 737-1200
most.us.com

**Nucor Tubular Products**
6226 West 74th St.
Chicago, IL 60638
(708) 496-0380
nucortubular.com

**Searing Industries Inc.**
8901 Arrow Route
Rancho Cucamonga, CA 91730
(909) 948-3030
searingindustries.com

**Vest Inc.**
6023 Alcoa Ave.
Vernon, CA 90058
(800) 421-6370
vestinc.com

**Valmont Industries Inc.**
28800 Ida St.
Valley, NE 68064
(402) 359-2201
valmonttubing.com