METHODS TO CHECK DIMENSIONAL TOLERANCES ON HOLLOW STRUCTURAL SECTIONS
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.

*Excerpts from ASTM A500 reprinted with permission from ASTM A500/A500M-20, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard can be obtained from ASTM International at www.astm.org.
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). 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
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
OUTSIDE DIMENSIONS

MEASURING SQUARE AND RECTANGULAR TUBING

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

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
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

![Diagram showing measurement of wall thickness on a square or rectangular hollow section.]
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

<table>
<thead>
<tr>
<th>Length Tolerance for Specific Lengths, in. [mm]</th>
<th>22 ft [6.5 m] and Under</th>
<th>Over 22 ft [6.5 m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over</td>
<td>Under</td>
<td>Over</td>
</tr>
<tr>
<td>1/2</td>
<td>1/4</td>
<td>3/4</td>
</tr>
</tbody>
</table>

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

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

**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 5](image-url)
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. Each measurement shall be considered individually.

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.

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**

*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.

<table>
<thead>
<tr>
<th>PERMISSIBLE TWIST (DEGREES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Flat Dimension (in.)</td>
</tr>
<tr>
<td>1 1/2</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td>18</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>22</td>
</tr>
<tr>
<td>24</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.

DIAGRAM 13
Measuring Twist With Digital Protractor
Specification: Allowable Twist: 7.1 degrees