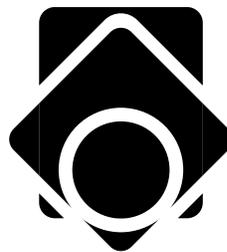


**Recommended  
Methods to Check  
Dimensional  
Tolerances on  
Hollow Structural  
Sections (HSS)  
Made to  
ASTM A500**



**Steel Tube  
Institute**  
OF NORTH AMERICA



The following is published as a guide for the purchaser of hollow structural sections (HSS). Methods of checking dimensional tolerances, stipulated in Section 10 of ASTM A500 - 93\*, are discussed in detail. For additional information, please contact the HSS manufacturer or The Steel Tube Institute of North America.

\* Excerpts from ASTM "Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes" have been reprinted with their permission.

## 10. Permissible Variations in Dimensions

### 10.1 Outside Dimensions:

**10.1.1 Round Structural Tubing**—The outside diameter shall not vary more than plus or minus 0.5% rounded to the nearest 0.005 in. (0.13 mm) of the nominal outside diameter size specified, for nominal outside diameters 1.900 in. (48.26 mm) and smaller; and plus or minus 0.75% rounded to the nearest 0.005 in. (0.13 mm) of the nominal outside diameter for nominal outside diameters 2.00 in. (50.8 mm) and larger. The outside diameter measurements shall be made at positions at least 2 in. (50.8 mm) from either end of the tubing.

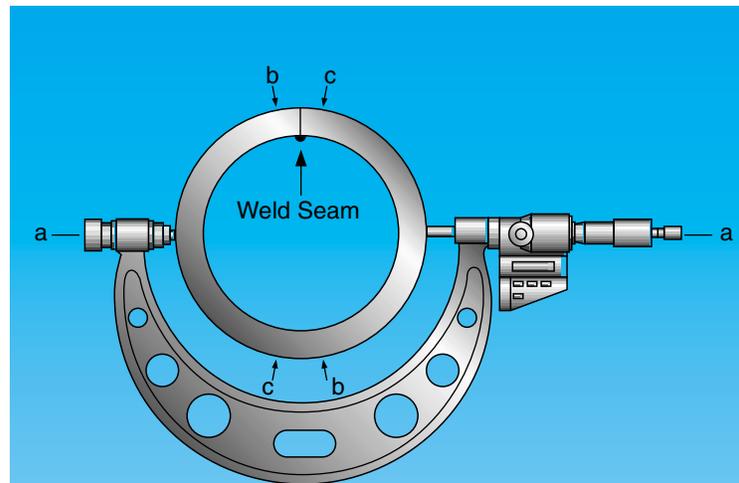
### Tools:

1) Outside micrometers of a suitable size to check the round HSS.

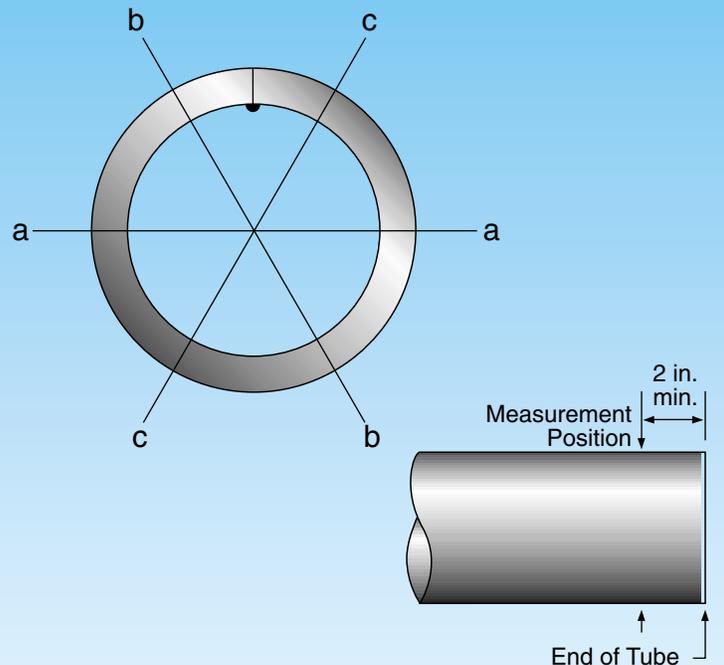
### Method:

- 1) Measure at a position at least 2 in. 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 normally 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.

Refer to Example 1 for a typical application.



### EXAMPLE 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

**10.1.2 Square and Rectangular Structural Tubing—**  
*The specified dimensions, measured across the flats at positions at least 2 in. (50.8 mm) from either end of the tubing and including the allowance for convexity or concavity, shall not exceed the tolerances shown in Table 3.*

**TABLE 3** Outside Dimension Tolerances for Square and Rectangular Structural Tubing

Outside Large Flat Dimension in. (mm)	Large Flat Dimension Tolerance <sup>a</sup> , plus and minus in. (mm)
2-1/2 (63.5) or under	0.020 (0.51)
Over 2-1/2 to 3-1/2 (63.5 to 88.9), incl.	0.025 (0.64)
Over 3-1/2 to 5-1/2 (88.9 to 139.7), incl.	0.030 (0.76)
Over 5-1/2 (139.7)	0.01 times large flat dimension

<sup>a</sup>Tolerances include allowance for convexity or concavity. For rectangular tubing having a ratio of outside large to small flat dimension less than 1.5, and for square tubing, the tolerance on small flat dimension shall be identical to the large flat dimension tolerance. For rectangular tubing having a ratio of outside large to small flat dimension in the range of 1.5 to 3.0 inclusive, the tolerance on small flat dimension shall be 1.5 times the large flat dimension tolerance. For rectangular tubing having a ratio of outside large to small flat dimension greater than 3.0, the tolerance on small flat dimension shall be 2.0 times the large flat dimension tolerance.

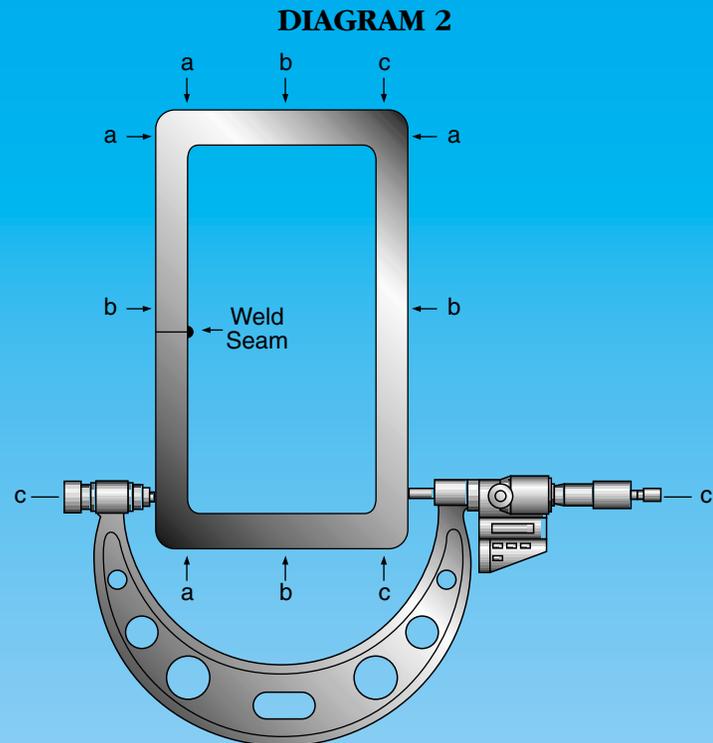
**Tools:**

- 1) Outside micrometer of a suitable size to check the square or rectangular HSS.

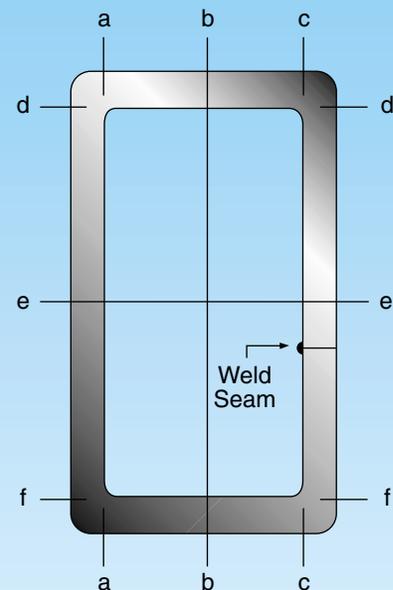
**Method:**

- 1) Measure at a position at least 2 in. 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), and near the center of the flats (directions b-b and e-e). 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 normally 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.

Refer to Example 2 for a typical application.



**EXAMPLE 2**



**Example 2: Rectangular HSS size is 12 in. x 4 in.**  
**Specification: Large side tolerance = 12 in. x .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 @ a-a, b-b and c-c**  
 = 12. + 0.12 = 12.12 in. maximum  
 = 12. - 0.12 = 11.88 in. minimum

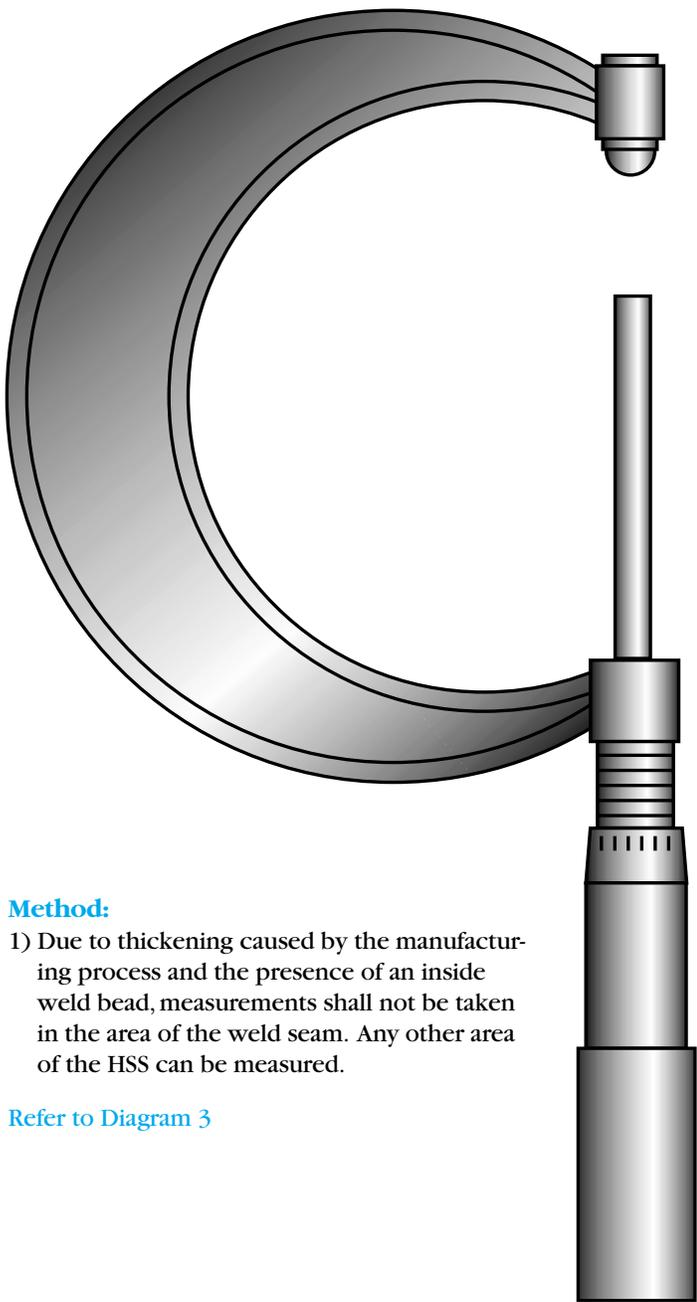
**Small side @ d-d, e-e and f-f**  
 = 4. + 0.18 = 4.18 in. maximum  
 = 4. - 0.18 = 3.82 in. minimum

**10.2 Wall Thickness** — *The minimum wall thickness at any point of measurement on the tubing shall be not more than 10% less than the nominal wall thickness specified. The maximum wall thickness, excluding the weld seam of welded tubing, shall be not more than 10% greater than the nominal wall thickness specified. The wall thickness on square and rectangular tubing is to be measured at the center of the flat.*

Round Hollow Structural Sections:

**Tools:**

- 1) Outside micrometer spherical anvil type 0-1" range (various styles)
- 2) Point micrometer 0-1" 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. Any other area of the HSS can be measured.

Refer to Diagram 3

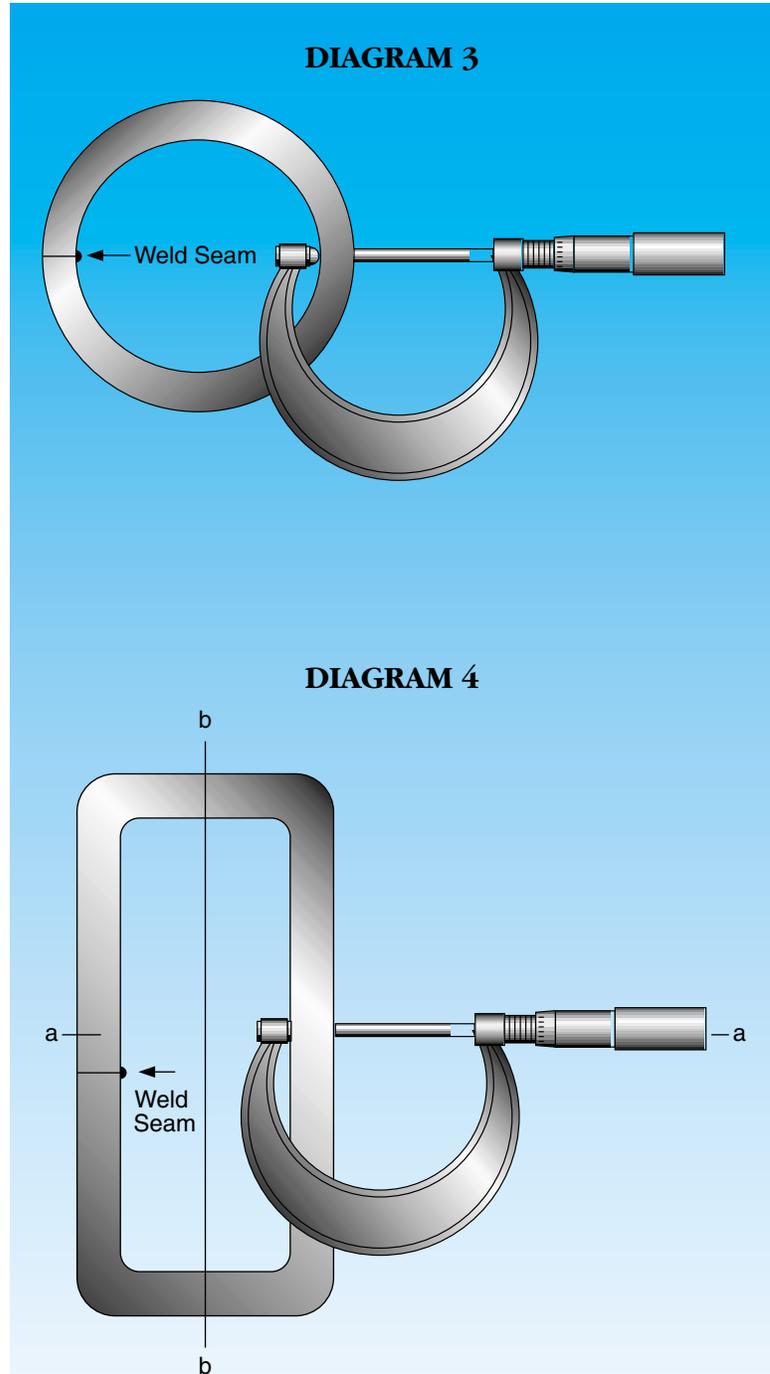
Square and Rectangular Hollow Structural Sections:

**Tools:**

- 1) Outside micrometer flat anvil type 0-1" 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.



**10.3 Length** — Structural tubing is normally produced in random mill lengths 5 ft. (1.5m) and over, in multiple lengths, and in specified mill lengths. Refer to Section 3. When specified mill lengths are ordered, the length tolerance shall be in accordance with Table 4.

**Section 3. Ordering Information**

3.1 Orders for material under this specification should include the following, as required, to describe the desired material adequately.

3.1.6 Length (speciflc or random, see 10.3)

**TABLE 4 Specified Mill Length Tolerances for Structural Tubing**

		Over 22 to 44 ft. (6.7 to 13.4 m), incl.	
		Over	Under
<b>Length tolerance for specified mill length, in. (mm)</b>			
Over	Under	Over	Under
1/2 (12.7)	1/4 (6.4)	3/4 (19.0)	1/4 (6.4)

**Tools:**

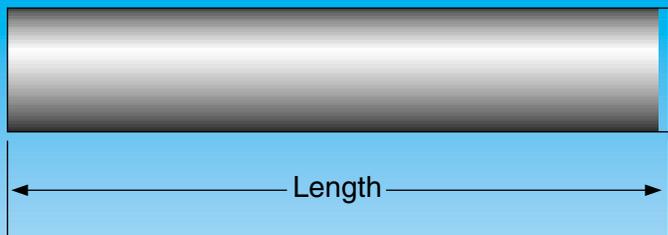
1) Tape measure or other suitable device to check length.

**Method:**

- 1) Ensure that the HSS ends 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.

Refer to Example 3 for a typical application.

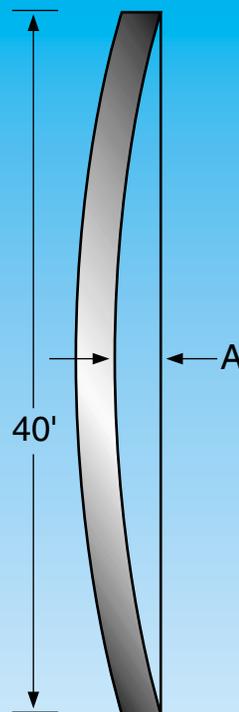
**EXAMPLE 3**



**Example 3: Customer specified mill length is 25 ft.**  
**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' – 0 3/4" Maximum  
 Measured Length, L = 25 ft. minus 1/4 in. = 24' – 11 3/4" Minimum

**EXAMPLE 4**



**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.**

**10.4 Straightness**—The permissible variation for straightness of structural tubing shall be 1/8 in. times the number of feet (10.4 mm times the number of meters) 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:**

- 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 the line stands off the HSS. While the maximum distance will most often occur at the center of the HSS, this may not always be the case.

Refer to Example 4 for a typical application.

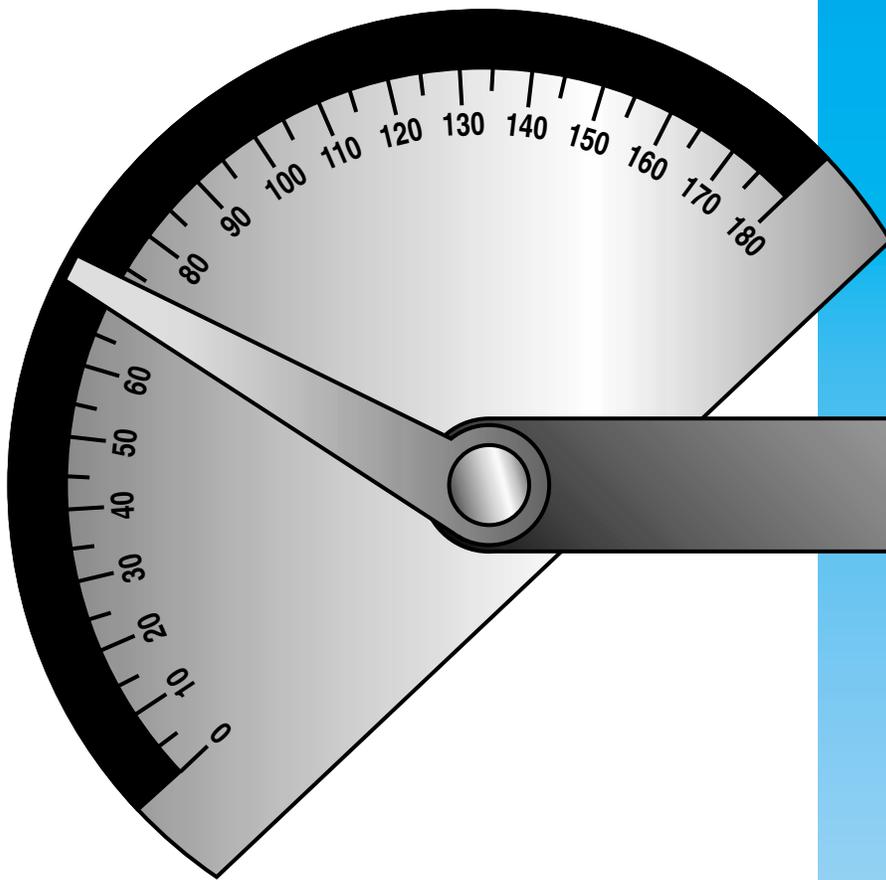


DIAGRAM 5

**10.5 Squareness of Sides**—For square and rectangular structural tubing, adjacent sides may deviate from 90 degrees by a tolerance of  $\pm 2$  degrees max.

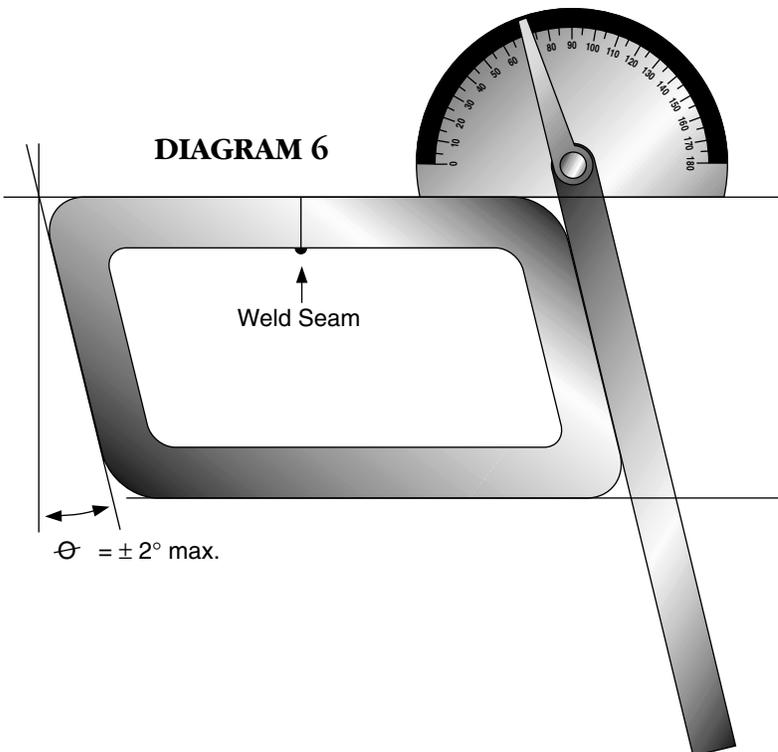
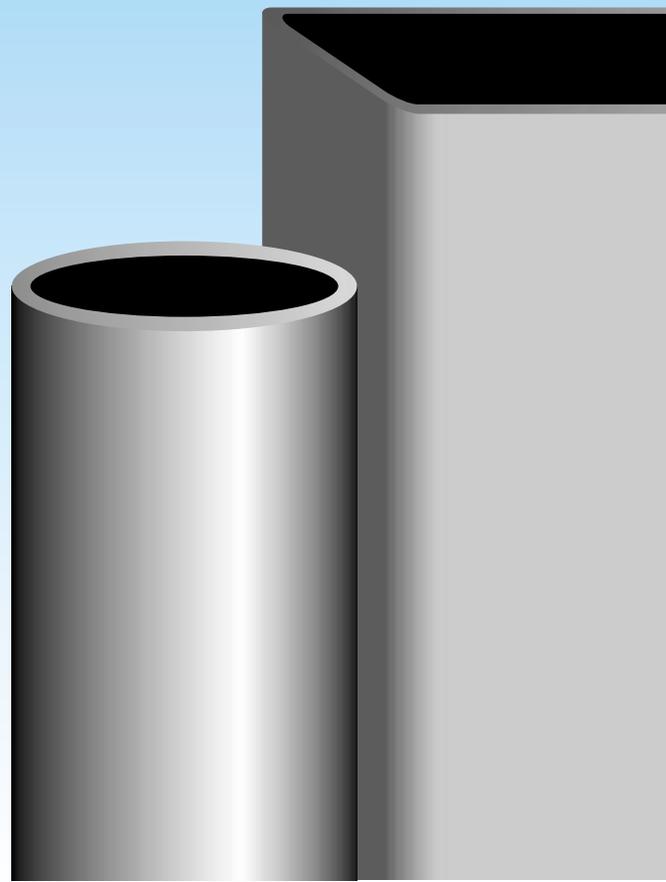


DIAGRAM 6

Weld Seam

$\theta = \pm 2^\circ \text{ max.}$



**Tools:**

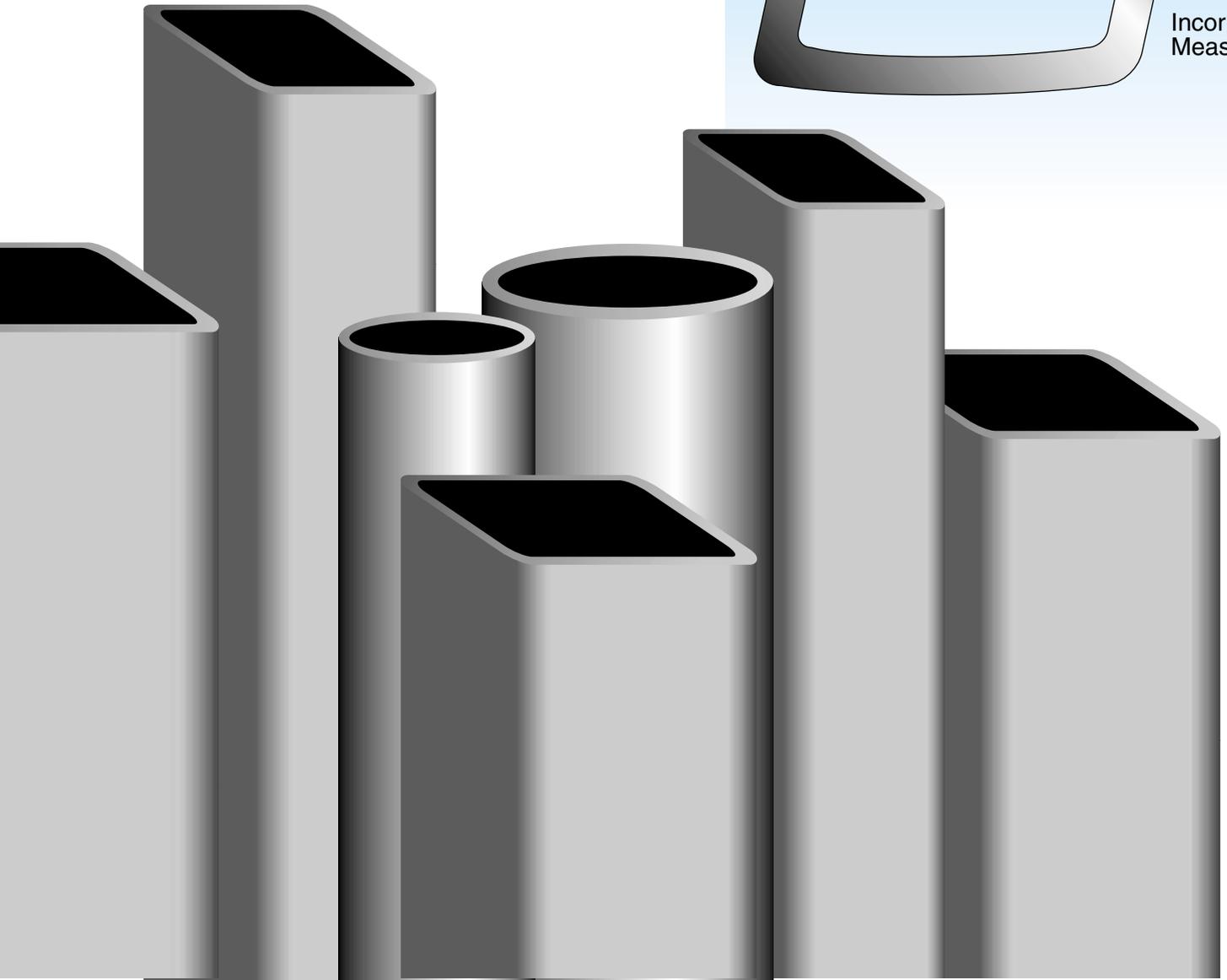
1) Protractor (various styles), Diagram 5

**Method:**

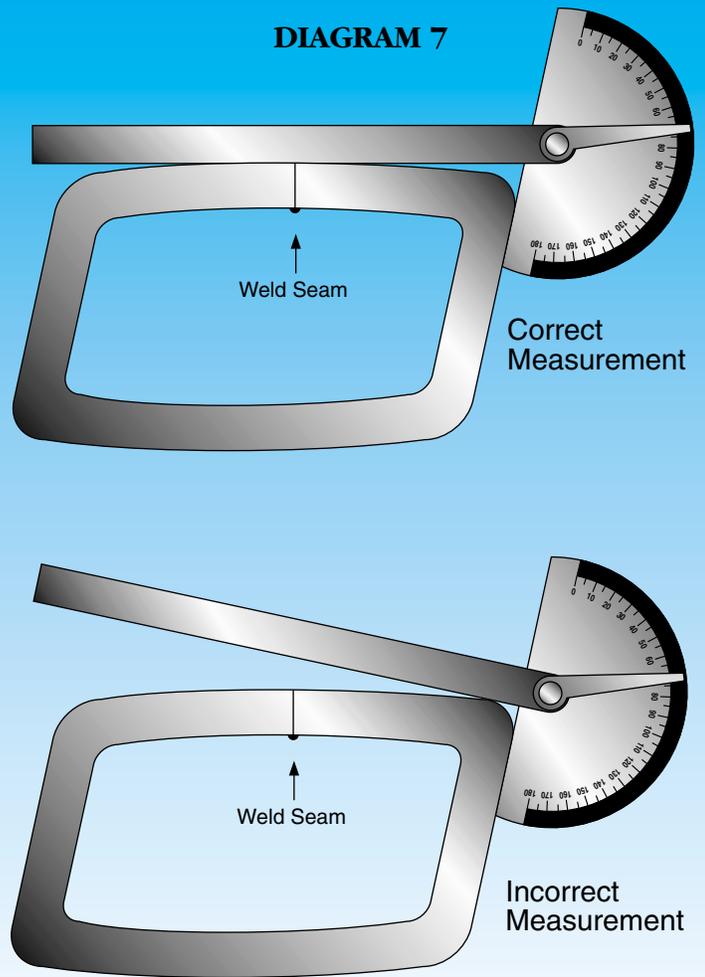
- 1) Place the protractor on one surface of the square or rectangular HSS to be measured, Diagram 6
- 2) Adjust the protractor to measure the variation from 90 degrees.

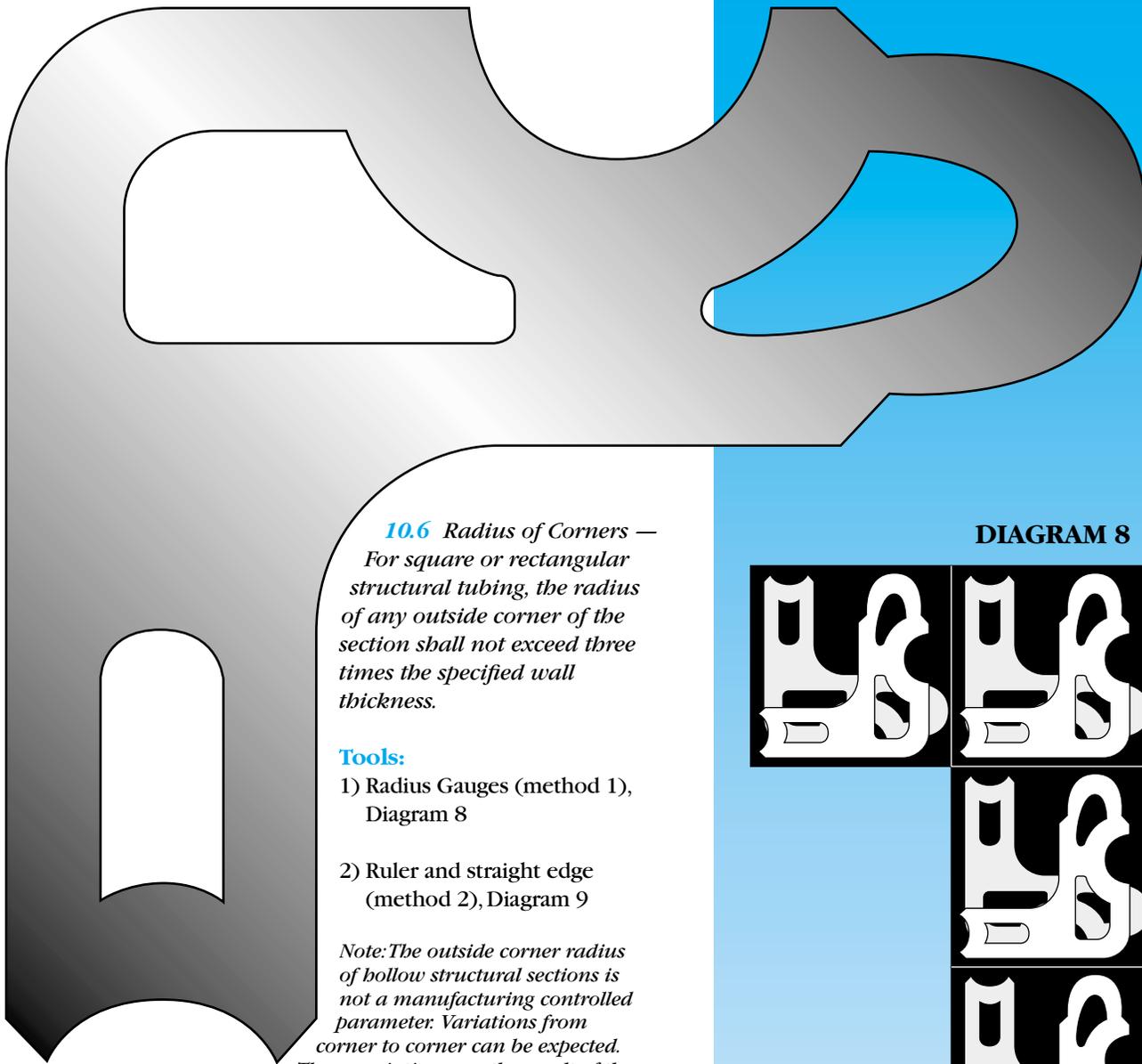


- 3) Make sure that the squareness measurement is not affected by any convexity or concavity that may be present on the surfaces being checked. Diagram 7



**DIAGRAM 7**





**10.6 Radius of Corners** —  
 For square or rectangular structural tubing, the radius of any outside corner of the section shall not exceed three times the specified wall thickness.

**Tools:**

- 1) Radius Gauges (method 1), Diagram 8
- 2) Ruler and straight edge (method 2), Diagram 9

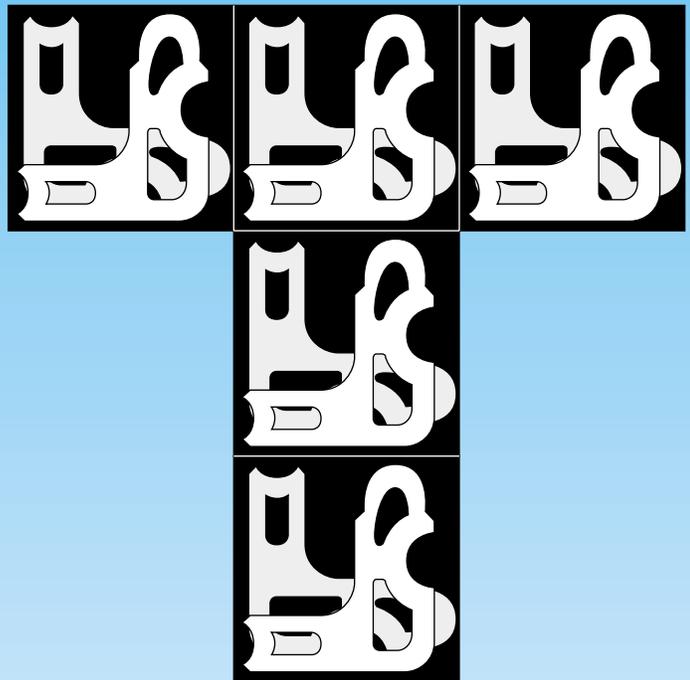
*Note: The outside corner radius of hollow structural sections is not a manufacturing controlled parameter. Variations from corner to corner can be expected. These variations are the result of the*

*method of manufacture, 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.*

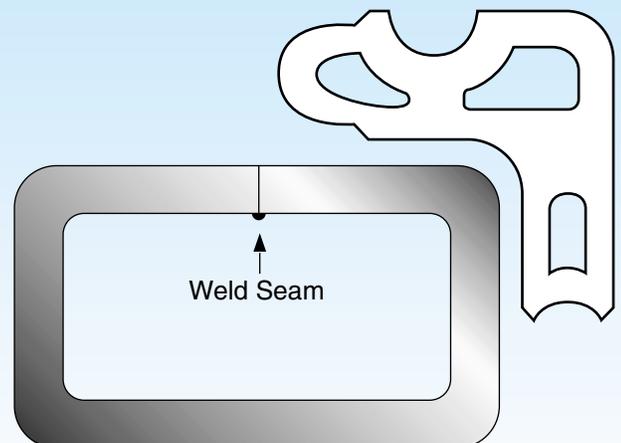
**Method #1:**

- 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, Diagram 10.
- 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 8**



**DIAGRAM 10**



**DIAGRAM 9**



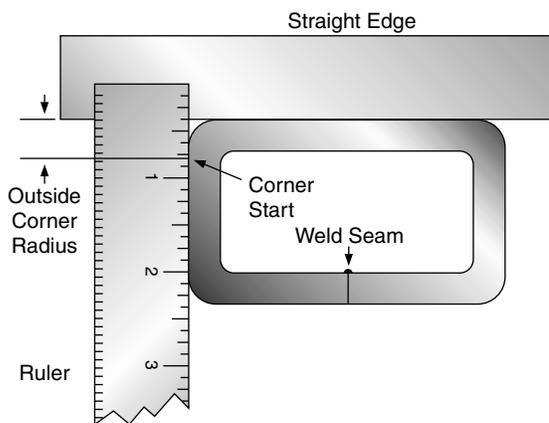
**STRAIGHT EDGE**

**METHOD #2:**

- 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, Diagram 11.
- 4) Ascertain where the corner starts 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, Diagram 12. For the convex case the ruler and straight edge will not be practical and the radius gauge method should be used.

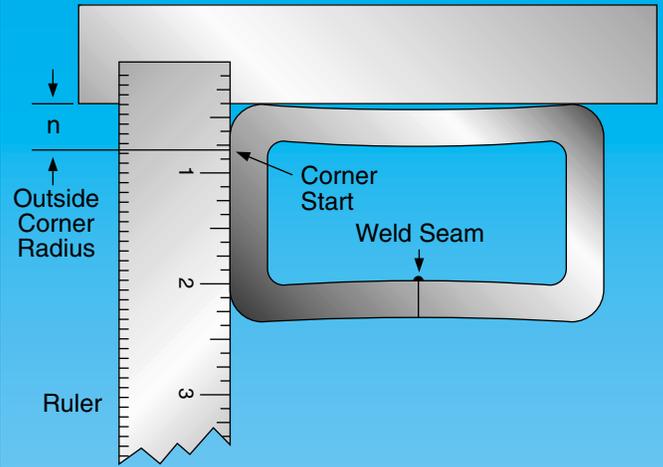
Refer to Example 5 for a typical application.

**DIAGRAM 11**



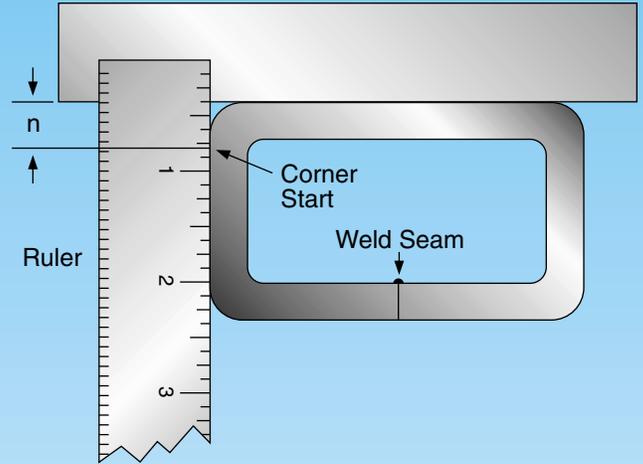
**DIAGRAM 12**

Straight Edge

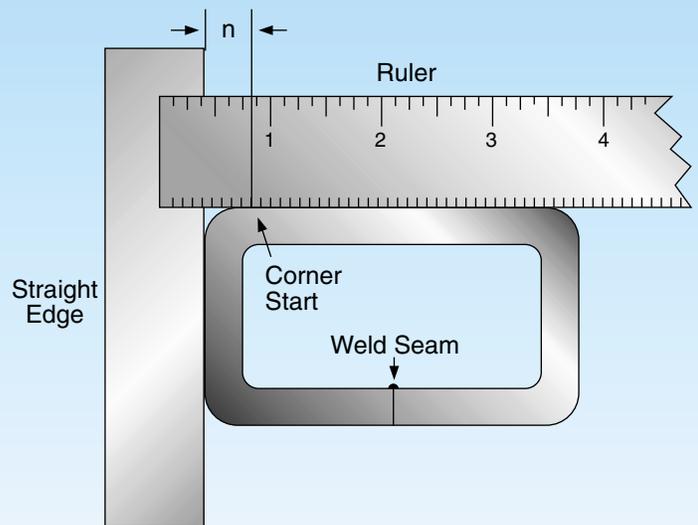


**EXAMPLE 5**

Straight Edge



At the same corner, interchange ruler and straight edge.



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

**10.7 Twist** — The tolerance for twist or variation with respect to axial alignment of the section, for square and rectangular structural tubing, shall be as shown in Table 5. Twist is measured either by holding down one end of a square or rectangular tube on a flat surface plate with the bottom side of the tube parallel to the surface plate and noting the difference in height above the surface plate of the two corners at the opposite end of the bottom side of the tube or by measuring this difference on the heavier sections by a suitable measuring device. The difference in height of the corners shall not exceed the values in Table 5. Twist measurements are not to be taken within 2 in. (50 mm) of either end of the product.

**Tools:**

- 1) Surface plate, Diagram 13, or other flat surface.
- 2) Feeler or thickness gauges, Diagram 14, or other suitable measuring device.

**Method:**

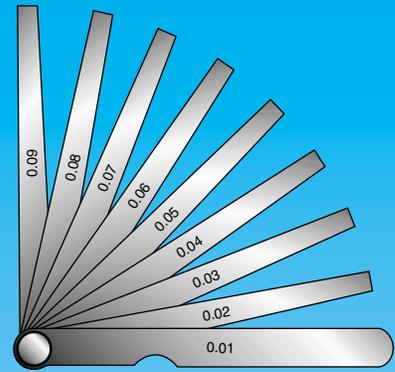
- 1) Remove burrs from both ends of the HSS to be measured.
- 2) Hold down one end of the square or rectangular HSS on the flat surface plate with the bottom side of the HSS parallel to the surface, Diagram 15.
- 3) Measure the height, above the flat surface, of each corner of the bottom side at the far end of the HSS, Diagram 16. 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 in. from the end of the HSS.

Refer to Example 6 for a typical application.

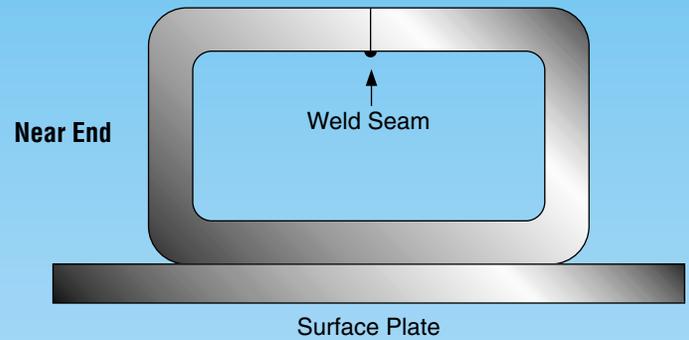
**DIAGRAM 13**



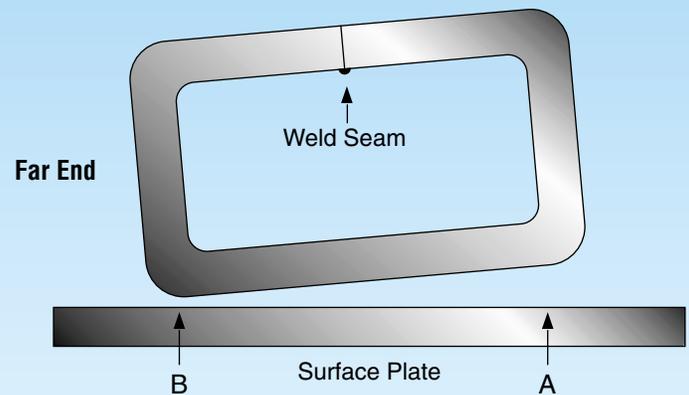
**DIAGRAM 14**



**DIAGRAM 15**

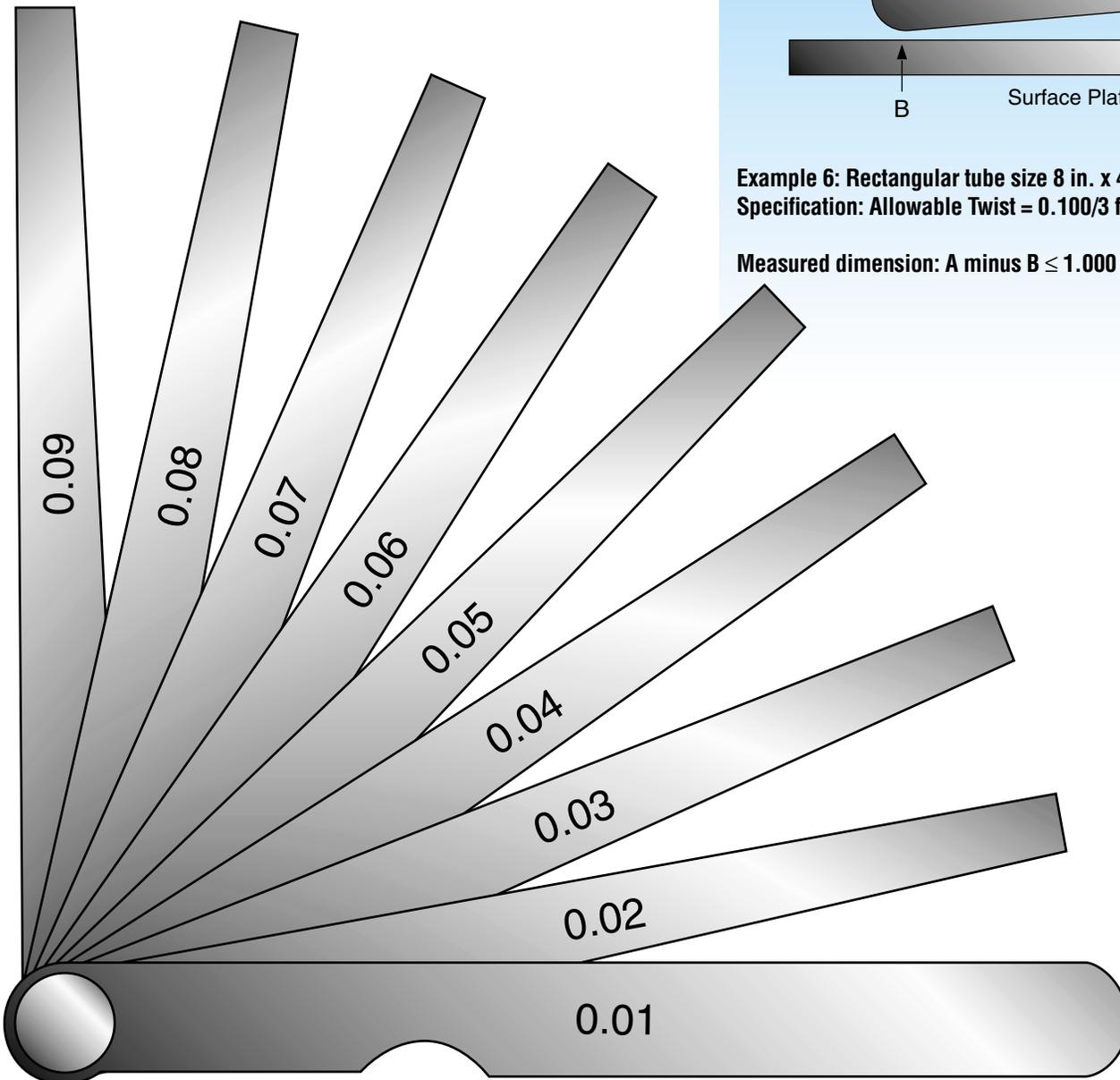


**DIAGRAM 16**

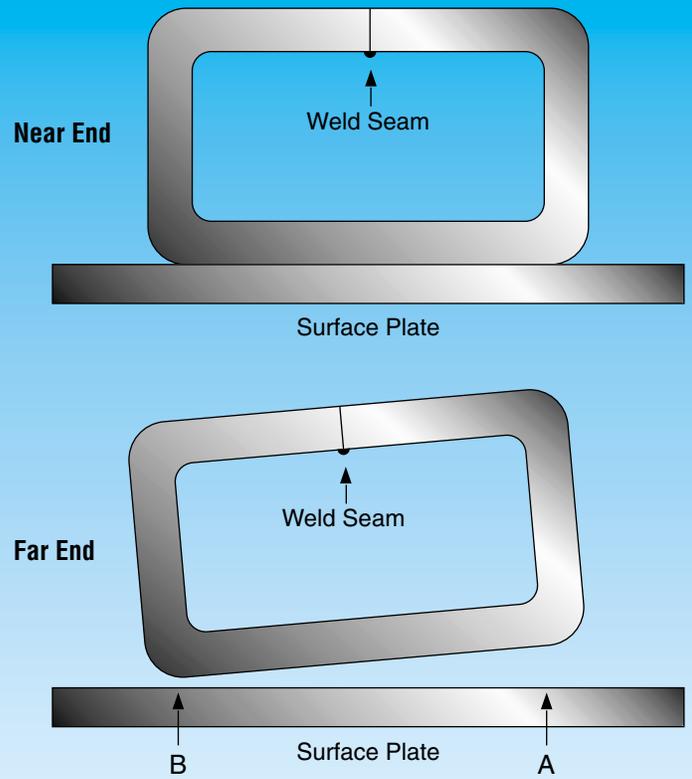


**TABLE 5** *Twist Tolerances for Square and Rectangular Structural Tubing*

Specified Dimension of Longest Side, in. (mm)	Maximum Twist in the First 3 ft. (1 m) and in each additional 3 ft.	
	in.	mm
1 1/2 (38.1) and under	0.050	1.39
Over 1 1/2 to 2 1/2 (38.1 to 63.5), incl.	0.062	1.72
Over 2 1/2 to 4 (63.5 to 101.6), incl.	0.075	2.09
Over 4 to 6 (101.6 to 152.4), incl.	0.087	2.42
Over 6 to 8 (152.4 to 203.2), incl.	0.100	2.78
Over 8 (203)	0.112	3.11



**EXAMPLE 6**



Example 6: Rectangular tube size 8 in. x 4 in. x 30 ft. length  
 Specification: Allowable Twist = 0.100/3 ft. x 30 ft. = 1.000 in. max.

Measured dimension: A minus B ≤ 1.000 in.

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---

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