# OVALITY ALLOWANCES for THIN-WALL TUBING

Ovality is an issue that is pervasive in thin-wall tubing. It can affect fit-up when preparing to butt weld two tube ends together if it is excessive. It is most prominent in seam welded tubes but is also present in seamless and welded + drawn tubes despite the manufacturer's best efforts. Ovality is a result of inherent residual stresses present after final manufacturing processes. One of the factors affecting the magnitude of ovality is the wall thickness-to-outside diameter (t:d) ratio. Thin-wall tubes are more susceptible to ovality than are tubes with higher t:d ratios. Tubes having higher t:d ratios are inherently stiffer, both axially and circumferentially.

Various product standards impose limits on maximum allowable ovality values to minimize problems in fabrication. Most of those standards address ovality allowances for thin-wall tubes as a special case, with different tolerances than those established as general requirements for the full range of OD sizes covered by a given specification.

Thin-wall tubing is defined in various ASTM Standards as tubes having specified wall thickness that is 3% or less than the specified OD dimension, or with a specified wall thickness of 0.020" or less.

The following is excerpted from **ASTM A1016/A1016M-21 Standard Specification for General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel, and Stainless Steel Tubes.** Similar verbiage is found in **ASTM B751-21 Standard Specification For General Requirements For Nickel And Nickel Alloy Welded Tube.** The requirements of ASTM A1016 are applicable to ASTM A213, A249, A269, A270, A554, A789 and other Tubular Product Specifications, including tubes manufactured to ASME BPE requirements. The requirements of ASTM B751 are applicable to, among others, ASTM B626, B676 and B704 Tubular Product Specifications.

**10. Permitted Variations in Outside Diameter**

10.1 Except as provided in 10.2.1, 10.3, and 25.10.4, variations from the specified outside diameter shall not exceed the amounts prescribed in Table 3.

10.2 Thin-wall tubes usually develop significant ovality (out-of-roundness) during final annealing, or straightening, or both. Thin-wall tubes are defined as those with a specified wall 3 % or less than the specified OD, or with a wall specified as 0.020 in. [0.5 mm] or less.

10.2.1 The diameter tolerances of Table 3 are not sufficient to provide for additional ovality expected in thin-wall tubes, and, for such tubes, are applicable only to the mean of the extreme (maximum and minimum) outside diameter readings in any one cross section. However, for thin wall tubes the difference in extreme outside diameter readings (ovality) in any one cross section shall not exceed the following ovality allowances:

| Outside Diameter, in. [mm] | Ovality Allowance |
|---|---|
| 1 [25.4] and under | 0.020 [0.5] |
| Over 1 [25.4] | 2.0 % of specified outside diameter |

(*Note: 10.3 addresses seamless tubes, 25.10.4 addresses products that failed NDE.)*

As noted in 10.2.1, ovality, or deviation from roundness, is defined as the difference between the largest diameter and the smallest diameter at a single tube cross section along the length of a round tube. It is expressed as a single value and not a range. It is not expressed as a +/- value from a nominal base value.

And as also noted in 10.2.1, the mean or average cross section diameter must be within the tolerances of Table 3. ASTM does not specify the number of measurements needed to determine the mean diameter, but United Industries recommends that 4 diagonals at approximately 45° intervals be measured to calculate the mean diameter.

Examples of specified wall thickness + specified OD that are thin-wall (T), and maximum allowed ovality for thin-wall tubes of indicated diameter.

| Wall/OD (in) | 1 | 1.5 | 2 | 2.5 | 3 | 4 | 6 | 8 |
|---|---|---|---|---|---|---|---|---|
| 0.035 | | T | T | T | T | T | T | T |
| 0.048 | | | T | T | T | T | T | T |
| 0.065 | | | | T | T | T | T | T |
| 0.083 | | | | | T | T | T | T |
| 0.095 | | | | | | T | T | T |
| 0.108 | | | | | | T | T | T |
| 0.120 | | | | | | T | T | T |
| | | | | | | | | |
| Max Allowed Ovality (in) | 0.020 | 0.030 | 0.040 | 0.050 | 0.060 | 0.080 | 0.120 | 0.160 |

It should be noted that ovality is typically observed at or near the end of a tube. In products made by United, OD measurements made ¼" or more from the end (depending on OD) are typically within the applicable general OD tolerance range, e.g. as specified in Table 3 of A1016. Because ovality is dependent on levels of residual stress, and residual stresses are somewhat uniform throughout the length of a tube, trimming the end is unlikely to significantly improve ovality. If the end is trimmed by ¼" or more, to a point within the acceptable OD size range, the "new end" will exhibit ovality similar to the "original end".

Experience has shown that a good rule of thumb for estimating ovality in thin-wall tubes ranges from 0.010" per inch of OD for sizes ≤1.50", to 0.020" per inch of OD for 6" and 8" OD's.
Care must be taken in handling and storage of thin-wall tube as it's ovality may be significantly adversely affected when not adequately supported or excessive weight is applied from above.

Thin-wall considerations are similar for pipe subject to the requirements of ASTM A999, except that the maximum allowable ovality at a cross section is defined as 1.5% of the specified OD size.

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