

### STAINLESS STEEL TUBE FOR THE FOOD INDUSTRY

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This commentary note compares the various specifications, all of which are from time to time considered alternatives for food process line service -

AS 1528.1-2001	“Specification for tubes (stainless steel) for the food industry”
ASTM A249M-08	“Specification for welded austenitic steel boiler, superheater, heat exchanger, and condenser tubes”
ASTM A269-08	“Specification for seamless & welded austenitic stainless steel tubing for general service”
ASTM A270-03a	“Specification for seamless & welded austenitic and ferritic/austenitic stainless steel sanitary tubing”
ASTM A554-08a	“Specification for welded stainless steel mechanical tubing”

The revision years noted above are those used for this comparison; ASTM specifications are revised very regularly and changes both major and minor are made. The comparisons are all based on the metric unit versions of each standard. Some reference is also made to the general specification ASTM A1016M-08.

AS1528 was revised in 2001 (after many years of disuse) by key stake-holders in the Australian tube industry and food manufacturing industries, under the auspices of the Australian Stainless Steel Development Association (ASSDA). AS 1528 is unique in that it covers all the associated fittings, in addition to the tube ...

- AS1528.1 - "Tubes"
- AS1528.2 - "Screwed Couplings"
- AS1528.3 - "Butt Weld Tube Fittings"
- AS1528.4 - "Clamp Liners with Gaskets"

At time of writing AS 1528 is in the process of a timely revision, expected to include endorsement as a joint AS/NZS standard.

### SPECIFICATION COMPARISON

#### 1. Material

All specifications call for the common grades 304, 304L, 316 and 316L. Most specifications allow a number of other stainless steel grades as well. AS1528.1 permits all grades of austenitic and duplex stainless steel listed in ASTM A240, so the possibilities are very extensive.

#### 2. Manufacture

All specifications require fusion welded tube without filler metal (in practice this permits standard tube production using TIG, plasma or other processes such as laser welding). AS 1528, A269 and A270 also cover seamless product, if requested, although this is rarely required.

#### 3. Dimensional Tolerances

##### 3.1 Wall Thickness

A249M requires  $\pm 10\%$  of nominal - no standard nominal thicknesses are stipulated.

A269 requires  $\pm 10\%$  of nominal for sizes over  $\frac{1}{2}$ " - no nominal thicknesses are stipulated.

A270 requires  $\pm 12.5\%$  of nominal - no nominal thicknesses are stipulated.

A554 requires  $\pm 10\%$  of nominal - no nominal thicknesses are stipulated.

AS 1528.1 specifies standard nominal thicknesses of 1.6mm for all ODs except 2.0mm for 203.2mm OD; other non-standard thicknesses can be specified by purchasers. The standard tolerance is +nil, -0.10mm. The all-minus tolerance recognises the usual practice for tube, to all specifications, to be produced towards the lower limit of the tolerance range. A range of between 1.52 and 1.58mm is typical. Slightly wider tolerances apply to the complimentary tube fittings covered by the other parts of AS 1528.

### 3.2 Outside Diameter

for standard inch series OD tube sizes, each specification requires -

Outside Diameter Tolerances (mm)					
Diameter	A249M	A269	A270	A554	AS 1528.1
25.4	$\pm 0.15$	$\pm 0.13$	$\pm 0.13$	$\pm 0.13$	$\pm 0.13$
38.1	$\pm 0.15$	$\pm 0.25$	$\pm 0.20$	$\pm 0.20$	$\pm 0.25$
50.8	$\pm 0.25$	$\pm 0.25$	$\pm 0.20$	$\pm 0.28$	$\pm 0.25$
63.5	$\pm 0.25$	$\pm 0.25$	$\pm 0.25$	$\pm 0.30$	$\pm 0.25$
76.2	$\pm 0.38$	$\pm 0.25$	$\pm 0.25$	$\pm 0.36$	$\pm 0.25$
101.6	+0.38/-0.64	$\pm 0.38$	$\pm 0.38$	$\pm 0.51$	$\pm 0.38$

- A249M tolerances for OD given in ASTM A1016M
- A554 tolerances for the standard "AW" condition of weld bead not removed.
- AS1528.1 also covers OD sizes 12.7, 19.0, 31.8, 127.0, 152.4 and 203.2mm

Ovality is a measure of the out-of-round, usually measured as the difference between the largest and smallest OD dimensions at a single cross-section of the tube; for most products there is no ovality allowance beyond the OD tolerance. The ASTM specifications do however make provision for extra ovality in "thin walled" tube, defined differently in each standard, as follows.

A249M Tubes with WT <3% of OD (OD 63.5mm and over for 1.6mm WT) can have ovality of 2.0%.

A269 1.6mm WT tube in all above sizes can have ovality twice the diameter tolerance.

A270 Extra provision for ovality only for diameters over 101.6mm.

A554 Ovality tolerance of double OD tolerance applies to tubes 63.5mm OD and above for 1.6mm WT.

AS 1528.1 allows ovality of up to double the OD tolerance for all sizes.

All the above specifications that allow extra ovality for thin wall tube still require the mean OD to be within their respective OD tolerances.

All these tube specifications give limits for OD and Wall Thickness – the Inside Diameter is not separately specified, even although from the hygiene point of view there may be some logic in doing so.

### 4. Surface Finish

A249 and A269 both require surfaces "free of scale" – the mandatory annealing of the tube is normally done in a controlled atmosphere and this "bright annealed" finish is stated to be acceptable.

A270 requires selection of both internal and external surfaces. The possible conditions range from a "mill finish" (ie. the strip's 2B finish, without any subsequent polishing), to abrasive polishing with 80, 120, 180 or 240 grit, to special polishing and electropolishing. Surface finishes may also be specified in terms of Ra values, but no limits are given in the specification.

A554 requires only "free of scale" and implies a "direct off mill" finish as standard. Clause 12.2 does allow - "If special surface conditioning is required, they shall be stated in the order". Thus a large proportion of A554 tube used in the Australian market is supplied in the externally abrasive polished condition, in the range of about 180 - 320#, or with a very highly buffed surface, typically stated as 600#, or proprietary finishes such as the highly reflective "Ultrabrite".

AS1528.1 specifies the external surface "as-produced" or "buff polished", as agreed. The internal surface

is required to be 2B finish, quoted as typically 0.3µm Ra. Work done by Atlas Steels indicates that for 1.6mm 2B coil (the starting material for welded tube) the typical roughness is 0.10 - 0.20 µm Ra; this would be expected to be degraded slightly in the manufacture of tube. With weld bead rolling it would be expected that the finish of the weld would also be similar to that of the parent tube.

## 5. Weld Bead

The food industry generally requires a tube with no weld bead remnant on the inside surface if the intended service is handling product.

A249M requires that at least the weld be cold worked after welding and before final heat treatment.

A269 does not require or allow for any weld bead control or cold working.

A270 makes no mention of weld bead, other than for “heavily cold worked” tube.

A554 can be supplied with the weld bead left on, but in recent years Australasian manufacturers of As Welded tube have made internal weld bead rolling a fairly routine procedure; this therefore complies with the "Bead Removed" option of A554. (Weld bead rolling is not generally possible in sizes below about 31.8mm, although sizes down to 20mm or even smaller can be hammer swaged by some manufacturers). Despite this practice “bead removed” is not a requirement for standard “AW” tube to ASTM A554.

AS1528.1 requires removal of the weld bead (except in the small sizes where the procedure is not possible). There is also a requirement that the internal surface be smooth, with no lack of weld penetration and no crevices adjacent to welds. This requirement addresses the heart of the issue - freedom from sites for product or bacterial build-up.

## 6. Heat Treatment

A249M, A269 and A270 all require that ... “all material shall be furnished in the heat treated condition”. Heat treatment is annealing (also referred to as solution treatment or solution annealing). In practice this is not a common requirement for food industry tube unless it requires significant bending or flaring.

A554 is normally supplied “as welded”, ie. no heat treatment after tube forming (although the tube will be produced from strip which has itself been annealed just prior to the final cold roll). There is the possibility of calling for A554 tube in the annealed condition, but this is never done - annealed tube (“As Welded Annealed” or AWA) is more usually specified to ASTM A269.

AS1528.1 allows either annealed or un-annealed conditions to be specified by the purchaser, although in practice un-annealed is standard.

## 7. Mechanical Properties

A249M is intended for critical environments in boilers or heat exchangers, so extensive mechanical testing is required. Full tensile and hardness testing is standard, as are flattening, flange and reverse bend.

A269 requires no tensile testing, but does require hardness tests, plus flange and reverse flattening.

A270 requires a reverse flattening test only.

A554 requires no mechanical testing as standard.

AS1528.1 requires no mechanical testing, but does require the tube to be made from strip compliant with ASTM A240 - which itself has tensile test requirements.

## 8. Non-Destructive Inspection

A249, A269, A270 and AS1528.1 all require 100% hydrostatic or eddy current testing.

A554 includes the possibility of NDT as a supplementary requirement, but this is not usual for A554 tube.

### WHICH SPECIFICATION?

ASTM A249/A249M is written for heat exchangers. It does specify weld bead removal, but this can be met from other standards, without unnecessarily calling up the stringent mechanical testing of A249. The annealing mandatory in A249 will not be required for most food applications. A high cost option.

ASTM A269 again requires tube in the annealed condition. Conversely, it does not specify internal weld bead removal, which generally is a food industry requirement. A269's main positive aspect is that it is frequently a stock item. It will prove uncompetitive against un-annealed tube.

ASTM A270 also has problems in that it requires the tube in the annealed condition, and says nothing about weld bead. Not normally stocked in Australasia.

ASTM A554 in its usual supply condition is intended for mechanical or structural applications, not for pressure containment and not for sanitary use. The lack of weld non-destructive testing reduces the reliability and lack of weld bead removal reduces cleanability vital for food applications.

AS1528.1 is by far the safest option ... and the most cost-effective. It is specifically directed at food industry applications, specifying the features necessary to ensure high integrity lines for hygienic applications without requiring high cost additional mechanical testing. Annealing is possible if required and surface finishes can be further specified. Batch traceability marking – considered essential to validate many food and pharmaceutical plants - is mandatory. Another key benefit is the existence of matching specifications for associated tube fittings.

### REFERENCES FOR FURTHER READING

Refer to the individual specifications for full details of requirements. Note that ASTM specifications are revised frequently; current revisions should be checked. ASTM specifications can be purchased through their website at [www.astm.org](http://www.astm.org). Australian Standards are available at [www.saiglobal.com](http://www.saiglobal.com).

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