

एक्सपान्डेड ट्यूब से ट्यूबशीट जोड़ों के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR EXPANDED TUBE TO TUBESHEET JOINTS

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Abbreviations:

ASME	American Society of Mechanical Engineers
API	American Petroleum Institute
ID	Inside diameter
OD	Outside diameter
SS	Stainless steel
TEMA	Tubular Exchangers Manufacturers Association

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1.0 SCOPE

This specification covers the minimum requirements of expanded tube-to-tubesheet joints for shell & tube heat exchangers and air coolers. It is the fabricator's responsibility to furnish sound, leak free joints. For the purpose of this specification, the term "joints" shall be construed to mean "tube-to-tube sheet joints".

2.0 APPLICABLE CODES

The latest edition of the following Codes and Standards shall be complied with:-

- a) ASME Sec. VIII Div. 1 (Code)
- b) TEMA for tubular exchangers
- c) API 661 for aircoolers.

3.0 JOINT CONFIGURATION

Joint with two grooves as per 7-15-0006 shall be used unless specified otherwise.

4.0 PROCEDURE TESTING

4.1 Procedure testing is required to be carried out in any of the following cases:-

- a) Authorised Inspector of Purchaser or EIL requires it to be carried out.
- b) There are no previously established procedures for Fr values (Factor of Reliability) in the last five years with the same combination of tube and tubesheet material, outside diameter (OD) and thickness of tubes, tube hole groove detail and length of expansion (excluding contact expansion).
- c) Code or specification or the equipment drawing requires it to be carried out.
- d) The length of expansion in the job is less than existing qualification length of expansion of same materials, tube size, tube hole groove detail. However, if qualification exists for length of expansion of 51 mm or more for the same combination of materials, size of tubes, tube hole grooving details, and the length of expansion for the job is 51 mm or more, the procedure testing need not be repeated. The length of expansion to be considered excludes any contact expansion.
- e) If previously established procedure of the fabricator is to be used, Authorised Inspector has the option of asking for a demonstration of the procedure to satisfy himself of its accuracy or to confirm the suitability of the expanding equipment or control unit. With time, the equipment used for expansion may change its characteristics and Authorised Inspector may like to check this by actual procedure tests.

4.2 Procedure test shall demonstrate % thinning vs machine setting and shear load test as per the requirements given below.

4.2.1 A sample tubesheet of same material and thickness as required for the job shall be drilled and/or reamed to achieve the required surface finish as per clause 6.0 and grooved as per 7-15-0006. Tube hole dimensions shall be as specified in clause 6.0 and as far as possible tube holes shall be prepared to cover the complete range of tolerance allowed. Tubesheet thickness used for procedural testing shall be as per item drawing or specification except that it need not exceed 55 mm. Diameter of tube holes drilled in the sample tubesheet shall be measured accurately. Hardness of tubesheet shall be measured and reported.

- 4.2.2 At least eight tubes from the same heat shall be selected with extreme tolerances as far as obtainable from the given lot of tubes to the satisfaction of the Authorised Inspector. The OD, inside diameter (ID) & hardness of these selected tubes shall be measured and reported.
- 4.2.3 One of these tubes shall be selected and positioned in the tube hole and assembly held in the same position as shall be adopted for production. Tube expander to be used for production shall be set at an estimated low value and tube shall be expanded inside the tube hole. Expander setting shall be increased until the thinning is in the range of 8-10% for all materials, except for non-ferrous and stainless steel, in which case it shall be 6-8%. In no case shall the % thinning exceed the values given in clause 8.1. The thinning figures are to finally such that these can result in achieving the required Fr value. It shall be the fabricator's responsibility to ensure the same.
- Percentage thinning is defined as follows:

$$\% \text{ thinning} = \left[\frac{1 - (D_h - ID_f)}{(OD - ID_i)} \right] * 100$$
 Where
 D_h = Tube hole diameter in tubesheet
 ID_f = ID of tube after complete expansion
 OD = OD of tube before expansion
 ID_i = ID of tube before expansion.
- 4.2.4 Expander setting thus found shall be tested on the remaining tubes and thinning shall be checked to be within the range specified above. Results of these tests (reporting combination number and % thinning achieved and various diameters used for calculation of thinning) shall be reported to the Authorised Inspector.
- 4.2.5 Samples prepared above, shall be cut in two halves along the axis of the tubes to show the flow of metal into the grooves. These cut-sections shall be presented to the Authorised Inspector who shall check the samples for flow of metal into the grooves and also check the expansion length. Authorised Inspector's approval shall be obtained on the same.
- 4.2.6 Fabricator is advised to satisfy himself that settings reported and to be used in the production shall be the best for the job, will enable him to achieve the required Fr value and give workmanship guarantee for the equipment. Authorised Inspector's approval shall in no way relieve the fabricator of his responsibility and guarantee to supply the equipment as per the conditions of the purchase order.
- 4.2.7 Shear load tests shall be carried out as per Appendix-A of Code. Fr value of the joint shall be established and shall be demonstrated to be greater than or equal to Fr (test) required as per Appendix-A Table A-2 of Code. For nonferrous and stainless steel combination of tubes & tubesheet a minimum Fr value of 0.7 shall be achieved. Actual value shall be reported in the test reports.

5.0 CARE OF TUBES

- 5.1 Ends of the tubes (tubesheet thickness + 100 mm) shall be subjected to careful visual inspection. These shall be cleaned to remove scales, rust, grease and dirt and should subsequently be cleaned by using a suitable sulfide free and chloride free solvent to get rid of oil and grease. The solvent should be non-residue forming and should not lead to any possible fire hazard. The area should be defect free and should have no scoring marks, rough surface etc. No repair is permitted on defective tubes unless approved by Authorised Inspector. In case a repair is done using an approved procedure, the tube dimensions after repair shall be within limits laid down by the tube material specification, otherwise the tube shall be discarded.
- 5.2 At least 10% tubes (subject to a minimum of 20 tubes per shell) shall be tested for hardness at the tube manufacturer's shop (This shall be taken care during sub-ordering). The hardness

measured should not be greater than the maximum hardness reported in the mockup. Tubes with greater hardness shall be rejected. Further hardness testing shall be done, if required by Authorised Inspector.

6.0 TUBE HOLES IN TUBESHEETS

Tube holes in tubesheets shall be drilled as per TEMA special close fit for shell and tube exchangers and as per API 661 special close fit for air coolers. For example, metric tube of size 20 mm OD, the nominal size of tube holes shall be 20.20 mm with tolerances as ± 0.05 mm, for 25 mm OD tubes, nominal size of holes shall be 25.25 mm with tolerances as ± 0.05 mm and so on.

Tube holes in tubesheets shall be drilled or drilled and reamed to final size and surface finish. Grooves shall be machined in the tube holes as per 7-15-0006. Tube holes shall have no burrs or scoring marks and shall be circular with parallel sides and normal to the tubesheet surface. Longitudinal and spiral scratches are not permitted. Edges of the tube holes shall be deburred and chamfered as per the figure in 7-15-0006. Tube holes shall have surface finish to 63 AARH or better & shall be cleaned prior to assembly.

7.0 ASSEMBLY AND EXPANSION

7.1 Care shall be taken during assembly to avoid scoring of tube holes in tubesheet or outer surface of the tubes. The tubes shall be positioned so that their projection from the tubesheet is as per 7-15-0006. For vertical shell & tube exchangers, the tubes are required to be flush with top tubesheet unless specified otherwise.

7.2 Tube expanders used by the fabricator shall be electronically or pneumatically or hydraulically controlled type and shall be in good condition and shall have the Authorised Inspector's approval. The tube expanders shall have 'stops' to prevent the rollers approaching nearer than 3 mm to the back of the tube sheet.

7.3 Expansion of tube into tubesheet shall be done as per the established procedure.

7.4 Tubes shall be expanded for the full thickness of the tubesheet leaving 3 mm (minimum) at the backside face of the tubesheet. However, for tubesheet thickness more than 55 mm, the expansion may be limited to 51 mm from the tube side face and remaining portion to be contact expanded leaving 3 mm (minimum) to 6 mm (maximum) at the back of tubesheet. Contact expansion shall have thinning of 3 - 5% which shall be ensured by measuring the ID of tubes.

7.5 Care shall be taken to avoid any distortion of the tubesheet or gross deformation of the ligaments. It is suggested that tubes be expanded systematically in small, diametrically opposite groups. The tube expansion shall be uniform on the whole expanded length. There shall be no abrupt transition at junction with unexpanded zone.

7.6 A check shall be made of the percentage thinning on tubes selected by Authorised Inspector and the results recorded and compared against percentage thinning figures of the procedure test.

8.0 TESTING

8.1 After expansion of all joints is completed on the job tubesheet, tubesheet face and the internal surfaces of the tubes to a length of about 15 mm shall be thoroughly cleaned. Any grease or oil shall be suitably removed using proper solvent or steam jets. These joints shall then be subjected to pneumatic air-soap solution test of 1.25 kg/cm² (g). Leaking tubes shall be further expanded, in the presence of Authorised Inspector after the reasons for the leakage are

ascertained and accepted by the Authorised Inspector. If the % thinning is greater than 15% for carbon steel and low alloy steel combinations and 12% for non ferrous and stainless steel combinations, then the defective tube shall be replaced and re-expanded.

- 8.2 Joints shall also be subjected to hydrostatic leakage test at a test pressure indicated in the drawings or requisition for at least one hour. Leaking tube, if any, may be further expanded keeping the guide lines given above in view.

9.0 INSPECTION

Inspection of the equipment shall be carried out as per the purchase order by the Authorised Inspector. For expanded tube to tubesheet joints, following stages of inspection shall be observed and reported:

- a) Agreement regarding expansion procedure. If procedure testing is to be carried out, then all preparations, cut samples, test results etc. shall be inspected by the Authorised Inspector.
- b) Inspection of tube ends. Special attention shall be paid to tube dimensions & hardness. These shall be within the specified tolerances.
- c) Approve any repair procedure to rectify defective tube end.
- d) After tube holes in the tubesheet have been drilled, and / or reamed and grooved, all tube holes shall be given a careful check for:
 - i) Tube layout pattern and locations.
 - ii) Tube holes meeting requirements of clause 6.0 above. Also it is to be checked that grooves in tube holes are located properly and of required dimensions.
 - iii) Minimum ligament width as per TEMA or API as applicable.
- e) Check the tube projection before expansion is to be started.
- f) Agree to the sequence of expanding tubes into the tubesheet holes.
- g) Check for distortion of tubesheet and thinning of tubes after expansion is complete.
- h) Witness pneumatic & hydrostatic testing.