

वेल्डेड ट्यूब से ट्यूबशीट जोड़ों
के लिए मानक विनिर्देश

**STANDARD SPECIFICATION FOR
WELDED
TUBE TO TUBESHEET JOINTS**

6-15-0003

Abbreviations:

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
OD	Outside diameter
TEMA	Tubular Exchangers Manufacturers' Association
TIG	Tungsten inert gas shielded arc

CONTENTS

- 1.0 SCOPE
 - 2.0 APPLICABLE CODES AND STANDARDS
 - 3.0 WELDING PROCESS AND JOINT DETAIL
 - 4.0 WELDING PROCEDURE QUALIFICATION
 - 5.0 WELDERS QUALIFICATION
 - 6.0 PREPARATION OF TUBES AND TUBESHEET
 - 7.0 WELDING
 - 8.0 EXAMINATION OF JOINTS
 - 9.0 TUBE EXPANDING
 - 10.0 REPAIRS
 - 11.0 TEST AND REPAIR REPORTS
-
- APPENDIX-1 - JOINT DETAILS
 - APPENDIX-2 - DETAILS OF TEST SPECIMENS

1.0 SCOPE

- 1.1 This specification covers minimum requirements for the welding and testing of tube to tubesheet joints of shell and 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 terms "joints" shall be construed to mean "tube-to-tube sheet joints".

2.0 APPLICABLE CODES AND STANDARDS

The latest edition of the following codes and standards shall be complied with:

- a) ASME Section VIII Division I
- b) ASME Section V
- c) ASME Section IX
- d) TEMA for tubular exchangers
- e) API 661 for aircoolers
- f) AWS

3.0 WELDING PROCESS AND JOINT DETAIL

- 3.1 Manual or automatic Tungsten Inert Gas shielded Arc (TIG) welding shall be used. All joints shall be made by using minimum two weld passes. The first pass should be preferably made without filler wire to ensure root fusion. The second or final pass shall be with filler wire. Any other welding process can be used only after obtaining written approval from the Authorised Inspector.
- 3.2 Joint detail shall be as indicated on the Purchaser drawings by giving reference to figure numbers in Appendix-1 of this specification. In absence of any Purchaser drawings or indication regarding type of joint, Figure 2 or Figure 3 shall be used depending upon whether tube thickness is ≥ 2 mm or < 2 mm respectively.

4.0 WELDING PROCEDURE QUALIFICATION

- 4.1 Welding Procedure Specification shall be compiled by the Fabricator and submitted to the Authorised Inspector for approval before the qualification tests are performed. Mock up test shall commence only after approval is obtained from the Authorised Inspector.
- 4.2 Welding procedure qualification test is required to be carried out if :-

- a) Authorised Inspector requires the test to be carried out.
- b) There exists no previous qualification tests within last three years for the proposed combination of tube and tubesheet P number and group number (as per ASME Section IX), tube outside diameter (OD), tube thickness, tubesheet thickness, tube pitch, tube pitch pattern, welding procedure and joint detail. All other factors remaining same, the procedure test need not be repeated if the job tubesheet thickness exceeds 40 mm and qualification exists for 40 mm or higher tubesheet thickness.

For plug type air coolers additional procedure qualification test is required to be performed for any of the following conditions:

- i) The job has lower clearances between tube and any of the header plates like top/bottom/end/stiffener/pass partition plate compared to earlier tests.
 - ii) The job has lower plug size for the same tube size compared to earlier tests.
-

- iii) The job has higher plugsheet thickness compared to earlier tests.
- c) Code or requisition or bid document requires the test to be carried out.
- 4.3 If required as per 4.2 above, the Fabricator shall perform a procedure qualification test, at least two weeks before the scheduled beginning of production. Procedure shall be qualified for the same hand position as is being proposed for production. Procedure test shall consist of the welding of nine tubes for square pitch and eight tubes, (three, two and three tubes per row arrangement) if on a triangular pitch. This shall be done for each set of combination of tube and tubesheet P number and group number, welding procedure, joint detail, tube OD, tube thickness, tube pitch, tube pitch pattern, tubesheet thickness. Additionally for air cooler, tests shall be done for each tube size with lowest plug size, lowest clearance between tube and any of the header plates, and the lowest plugsheet thickness to be used on the job. Thickness of the tubesheet used for procedure testing shall be same as used for job, except that for carbon steel and austenitic stainless steel materials, it need not exceed 40 mm, unless otherwise indicated. Refer Appendix-2 of this specification for test specimen details.
- 4.4 The following data report (six copies) shall be furnished for review to Authorised Inspector with the weld samples as outlined below.
 - a) Complete details of welding procedure employed indicating various machine settings, welding rods, inert gas composition & purities, flow rate, weld sequence etc.
 - b) Mechanical properties and chemical composition of tubesheet, tubes and filler metal.
 - c) The hardness of the weld, the tube, the tubesheet heat affected zone and the tubesheet base metal after each pass.
 - d) The complete test sample shall be cut (by sawing) as per Appendix 2 of this specification. These shall then be subjected to various tests etc. as outlined below:
 - i) Section 1 shall be polished, etched and microphotographed for examination of depth of weld, penetration and definition of boundaries. The minimum leak path of each weld shall be not less than the nominal thickness of the tube. The weld leg shall also be measured and shall be minimum 1.4 times the nominal thickness of the tube.
 - ii) Section 2 (two specimens) shall be subjected to tear test. These specimens shall be tongue bent to show the extent of weld penetration. The underside of the weld shall show evidence of adequate & uniform weld penetration.
 - iii) A section 10 mm thick containing the tube end welds shall be sawed from section 3 and radiographed for weld quality. The radiograph shall be submitted to Authorised Inspector. No cracks or crack like or visual defects are acceptable. Acceptance shall be as per Appendix 4 of ASME Section VIII Division 1. In case the radiograph is not acceptable, welding procedures shall be suitably modified so that proper weld and acceptable radiographs are obtained. These shall be proved by retests.
 - iv) Section 4 shall be etched and polished and given to Authorised Inspector.
 - e) A tension strength test shall be carried out as per ASME Section VIII Division I Appendix A. This strength test shall be performed at room temperature for each combination set of tube and tubesheet P number and group number, tube OD, tube thickness and joint detail. The breaking loads shall be at least equal to the load required for breaking the tube using the minimum specified ultimate tensile strength

of tube as indicated in certificates issued by the tube supplier. When tube material is to a specification which does not call for mechanical tests to be performed, ultimate tensile strength of the tube material shall be considered as four times the allowable stress at room temperature as indicated by the ASME Section II Part D, or other relevant code. Failure of the test piece at the weld shall not be a cause for rejection in case the minimum strength is attained, but the fracture should be examined for any evidence of faulty workmanship.

- 4.5 Fabricator is advised to satisfy himself that the procedures employed are the best for the job and would enable him to 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.

5.0 WELDERS QUALIFICATION

The purpose of this operator qualification test is to demonstrate that both the welding operator and the welding machines are capable of producing satisfactory joints. Once welding procedures have been qualified as above, welding operators employed on welding shall be required to prove their ability by making test samples similar to that prescribed above for welding procedure qualification. Welding operators may be qualified based on para 4.4 d (i), 4.4 d (ii), and 4.4 d (iii) above only, provided same welding machines & welding procedures are used. This welding operator qualification test should also be carried out if the welding operator has not executed similar welding six months prior to production. Repeat tests may be called for in the course of manufacture to determine the consistency of operator or machine to produce sound welds.

6.0 PREPARATION OF TUBES AND TUBESHEET

- 6.1 Tubeholes shall be to special close fit tolerance as per TEMA for shell and tube exchangers and as per API 661 for air coolers. Tube holes shall be free from any burns and the bundle side edge of tube holes shall be chamfered or radiused. Tube holes shall have smooth finish to 63 AARH.
- 6.2 Prior to assembly, the tubesheet and tube ends (inside and outside for a distance equal to the tubesheet thickness + 30 mm) shall be cleaned and degreased to free from dirt, grease etc. It is essential that the solvent used for degreasing be chloride free and sulfide free and non residue forming. The solvent should not lead to any possible fire hazard.
- 6.3 The tubes shall be positioned in the tubesheets by 30° tapered drift pin.
- 6.4 Before welding tube to tubesheet, the tubesheets shall be heated to a temperature as required to remove any last traces of moisture or solvent which may remain after the cleaning operation. Any specific requirement for application of preheat shall be established as a part of the welding procedure qualification test and should account for increased restraint offered by the larger assembly during production.

7.0 WELDING

Tubes shall be individually welded, using the procedure approved by the Authorised Inspector. Systematic welding procedure shall be adopted so as to result in minimum tubesheet distortion. All tubes are to have initial pass completely cleaned as necessary, visually examined and tested as per para 8.1 below, if required, before subsequent layers are applied. Welds shall be suitably finished and any spillage or spatter on tubesheet removed. Spillage of weld metal into the bores of tube is not permitted.

8.0 EXAMINATION OF JOINTS

- 8.1 Joints shall be subjected to air-soap solution test after first weld pass with air at 1.25 kg/cm² (g). Procedures outlined in ASME Section V, Article 10 shall be followed.
- 8.2 After completion of welding, the tubesheet face, the welds and internal tube surfaces to a distance of 25 mm beyond the fusion line must be cleaned thoroughly by wire brushing and examined carefully for surface defects. Defects such as cracks, surface breaking porosity, slag inclusions and lack of fusion are not acceptable.
- 8.3 After the visual inspection, a liquid penetrant examination in accordance with ASME Section VIII Division I, Appendix-8 & Section V, Article 6 shall be done. Before conducting this test, the faces of the carbon steel tubesheets shall be cleaned thoroughly by wire brush and solvents to remove all weld slag, rust and scale.
- 8.4 When specified on the drawings or requisition, a halide test shall be performed after the tests as per para 8.1, 8.2, and 8.3 above have been successfully completed. Procedures for halide test shall be as per ASME Section V, Article 10, Appendix - III Halogen diode detector probe test.
- 8.5 After the final tube expanding (refer para 9.0) has been completed, the liquid penetrant examination as outlined in para 8.3 above shall be repeated.
- 8.6 Whenever a halide test has been specified, an envelope test shall also be done as a further test for leaks after final tube expanding. For this test, tubesheets shall be securely wrapped in plastic sheets and the shell allowed to remain under test pressure with halogen tracer, for a period of 10 to 12 hours. Then with the detection set at a maximum sensitivity, the probe shall be inserted through the plastic cover at the bottom of the tubesheets and readings taken to observe if any leakage has occurred.
- 8.7 Final acceptance hydraulic pressure test shall be conducted after tube expansion at hydrotest pressure for at least one hour.

9.0 TUBE EXPANDING

After the tests outlined in 8.1, 8.2, 8.3, and 8.4 have been successfully completed and all leaking welds repaired, the tubes shall be "contact expanded" with a PARALLEL type expander. Contact expanding is intended to bring the tube OD into contact with the tube hole. Contact expanding shall begin 12 mm from the tubesheet face and extend to 3 mm from the back face. The contact expansion shall have thinning of 3-5% which shall be ensured by measuring the inside diameter of tubes.

10.0 REPAIRS

If leaks are found during any of the above testing procedures these shall be reported to the Authorised Inspector and after obtaining his approval, repairs shall be made by removing the defects down to sound parent metal and repeating the qualified weld procedures. All weld repairs shall be retested in accordance with procedures outlined in para 8.0 above.

11.0 TEST AND REPAIR REPORTS

Test and repair reports shall be included in the Data Folder. These reports shall also indicate the number of leaks discovered on each test and the extent of the repair done.

APPENDIX 1 - JOINT DETAILS

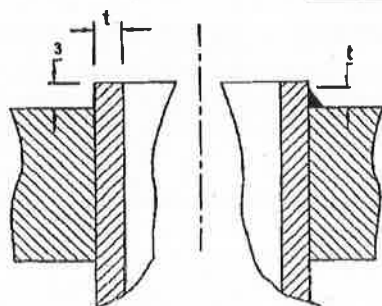


FIG-1

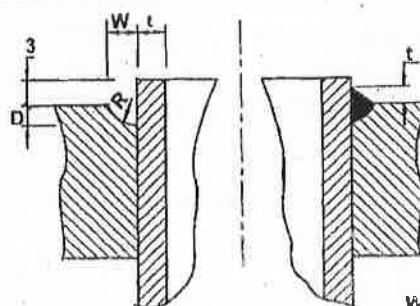


FIG-2

$W = t$
 $R = t$
 $D = t$ FOR $t \leq 3$
 AND
 $\approx 0.8t$ FOR $t > 3$

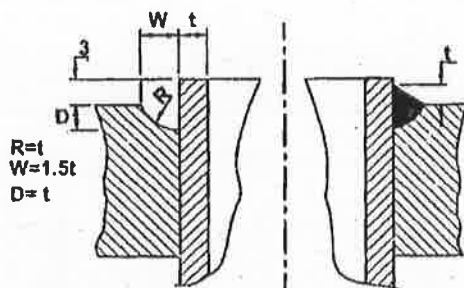


FIG-3

$R = t$
 $W = 1.5t$
 $D = t$

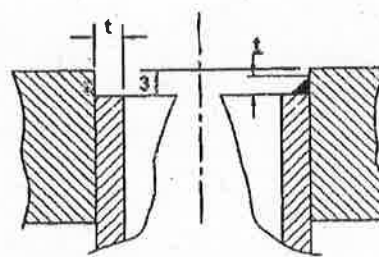


FIG-4

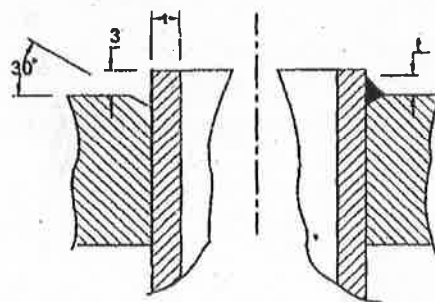
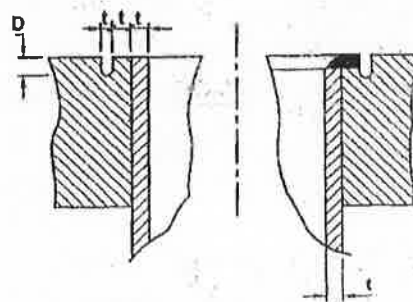


FIG-5



$D = 1.5t$ TO $2t$

FIG-6

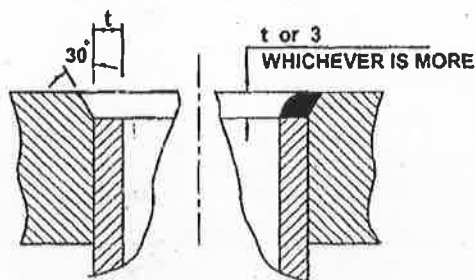


FIG-7

APPENDIX 2 - DETAILS OF TEST SPECIMENS

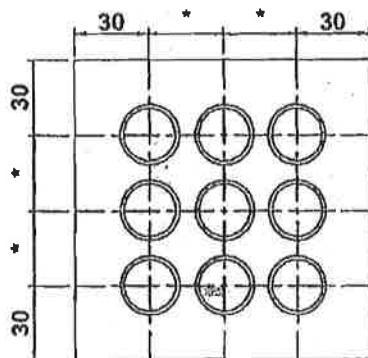


FIG-11

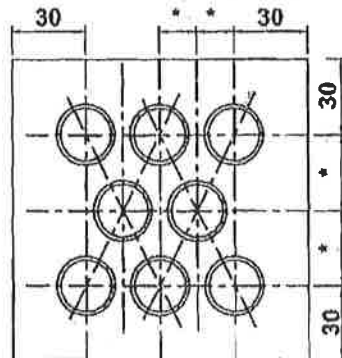
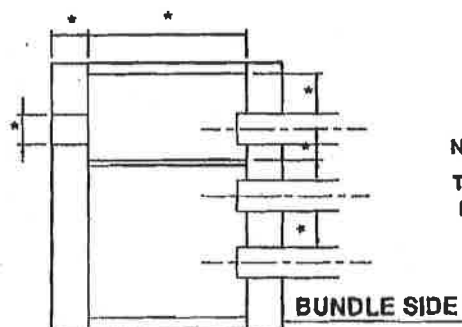


FIG-12



NOTE:-

THE MOCKUP ASSEMBLY SHOULD HAVE THE DIMENSIONS/THICKNESS MARKED '*' AS PER JOB

FIG-13 FOR PLUG TYPE AIRCOOLERS

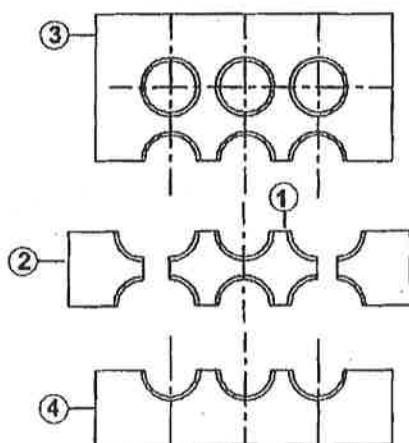


FIG-14

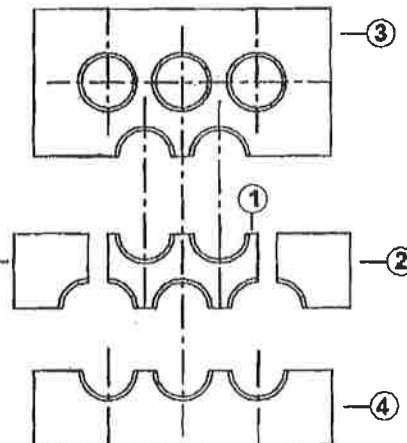


FIG-15

LEGEND

- 1. FOR MICROPHOTOGRAPHIC EXAMINATION
- 2. FOR TEAR TEST
- 3. FOR RADIOGRAPHIC EXAMINATION

एक्सपान्डेड ट्यूब से ट्यूबशीट जोड़ों
के लिए मानक विनिर्देश

**STANDARD SPECIFICATION FOR
EXPANDED
TUBE TO TUBESHEET JOINTS**

6-15-0004

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

CONTENTS

- 1.0 SCOPE
 - 2.0 APPLICABLE CODES
 - 3.0 JOINT CONFIGURATION
 - 4.0 PROCEDURE TESTING
 - 5.0 CARE OF TUBE
 - 6.0 TUBE HOLES IN TUBESHEET
 - 7.0 ASSEMBLY AND EXPANSION
 - 8.0 TESTING
 - 9.0 INSPECTION
-

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:

$$\% \text{ thinning} = [1 - (D_h - ID_r) / (OD - ID_i)] * 100$$

Where

D_h = Tube hole diameter in tubesheet

ID_r = 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.

आवश्यक कठोरता के लिए
मानक विनिर्देश

STANDARD SPECIFICATION

FOR

HARDNESS REQUIREMENT

6-15-0091

Abbreviations:

ASTM	:	American Society for Testing & Materials
BHN	:	Brinell Hardness Number
HAZ	:	Heat Affected Zone
PWHT	:	Post Weld Heat Treatment

Static Equipment Standards Committee

Convenor : Mr. A.K. Malik

Members : Mr. R.K. Gulati
Mr. P. Khanna
Ms V. Bharathi
Mr. K. Anjaneyulu
Mr. Chandra Kant (Inspection)
Mr. G.K. Iyer (Construction)
Mr. Ratan Lal (Project)

CONTENTS

1.0	SCOPE	4
2.0	HARDNESS REQUIREMENTS.....	4
3.0	WELDING QUALIFICATION TEST	4
4.0	PRODUCTION TEST	4
5.0	APPROVAL.....	5

362-

1.0 SCOPE

This specification covers general requirement of hardness of base metal, weld and heat-affected-zone (HAZ) and is applicable to all C-½ Mo, Cr-Mo steels and other materials whenever asked for in drawings/ specifications/standards. All testing shall be done in accordance with ASTM A450 after PWHT.

2.0 HARDNESS REQUIREMENTS

Hardness in base metals, weld and heat affected zone as per ASTM E10 shall not exceed the following:

For P1 materials	- 200 BHN ✓
For P3 & P4 materials	- 225 BHN
For P5 & P6 materials	- 235 BHN

3.0 WELDING QUALIFICATION TEST

3.1. For each welding procedure qualification six tests shall be made, three in weld metal and three in HAZ. Hardness requirements shall be as per cl. 2.0 above.

3.2. In addition to the requirement of 3.1 above, Vickers Micro hardness test shall be made on a full cross-section at 25 mm intervals beginning at 3 mm from the top surface with 5 kg load or with a load approved by the authorized inspector. Tests shall be made at each level for each of the following locations as per ASTM E 92:

Three tests shall be made in the weld metals, two tests in HAZ and one test in the base metal in accordance with Fig.1 and the hardness shall not exceed the following in base metal, weld metal and HAZ.

✓ For P1 materials	- 210 VHN
For P3 & P4 materials	- 237 VHN
For P5 & P6 materials	- 247 VHN

4.0 PRODUCTION TEST

✓ 4.1 All pressure containing weld metals are to be checked for hardness of weld and HAZ after PWHT but before hydro-test. The hardness shall not exceed the value stipulated.

✓ 4.2 Each longitudinal seam shall be checked both internally and externally near the center and at one end.

✓ 4.3 Each circumferential weld shall be checked at four locations approximately 90° apart, both internally and externally.

✓ 4.4 Each nozzle weldments shall be checked at two locations, 180° apart, both internally and externally.

5.0 APPROVAL

In case the hardness as obtained on production test is more than the limit specified in 2.0 above, the vendor shall submit the corrective procedure to lower the hardness in writing to EIL and/or authorized inspection agency for review/approval.

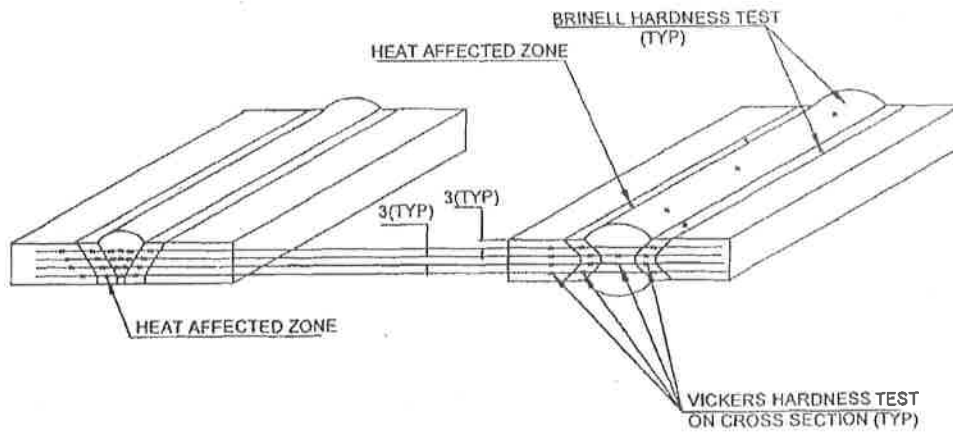


FIG.1- HARDNESS REQUIREMENT ON TEST COUPONS

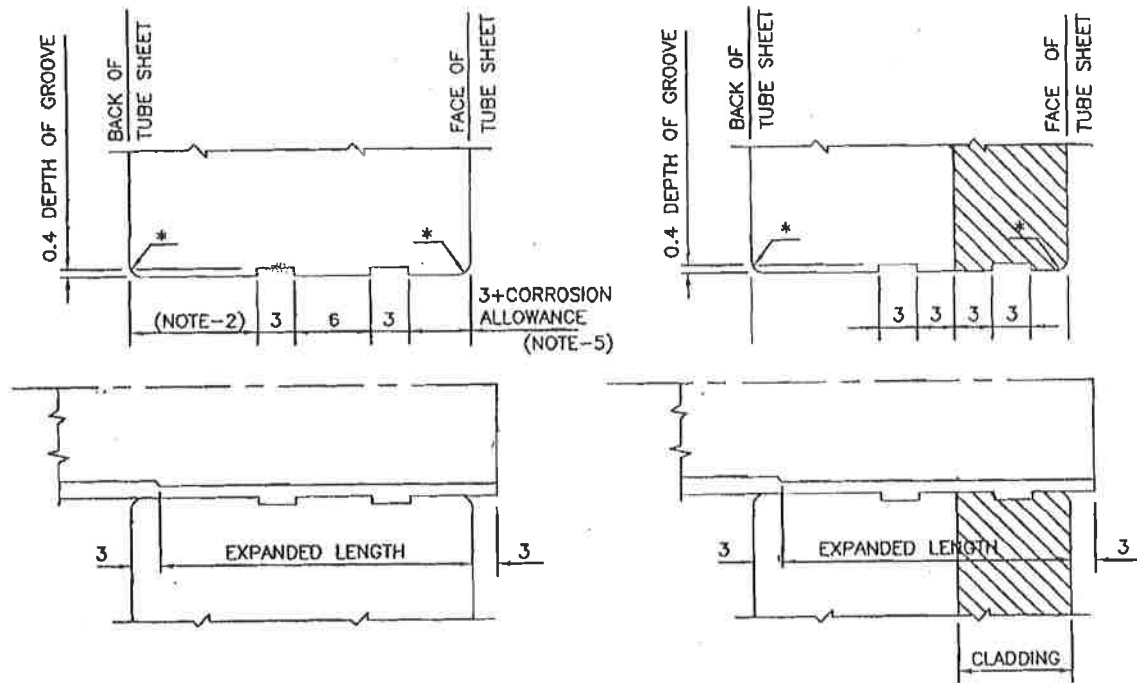


FIG.-1

FIG.-2

NOTES :-

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. FOR TUBESHEET THICKNESS WHERE THE GAP BETWEEN 2ND GROOVE & BACK OF TUBE SHEET IS LOWER THAN 6 mm DELETE 2ND GROOVE.
3. FOLLOW SPECIAL CLOSE FIT AS PER TEMA / API 661 UNLESS SPECIFIED OTHERWISE.
4. FOR CORROSION ALLOWANCE LESS THAN 4 mm., INCREASE THIS DIMENSION TO TUBE SHEET THICKNESS MINUS 18 mm. BUT NOT TO EXCEED 7 mm.
- * 5. CHAMFER (1X45°) OR RADIUS (R=1).