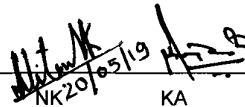


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के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR  
WELDED  
TUBE TO TUBESHEET JOINTS

5	20 05 19	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION		KA	KJH	RKT
4	07 06 13	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	TK	KA	RKT/SC	DM
3	28 01 08	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	KA	PK	AKM	VC
2	01 09 99	REVISED AND REISSUED AS STANDARD SPECIFICATION	HN	PK	RKA	AS
1	04 05 89	ISSUED AS STANDARD SPECIFICATION	RKA	BSG	VKM	RNS
Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
Approved by						

**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

**Static Equipment Standards Committee**

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## 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 air coolers
- 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  $\geq 2$  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/cm<sup>2</sup> (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

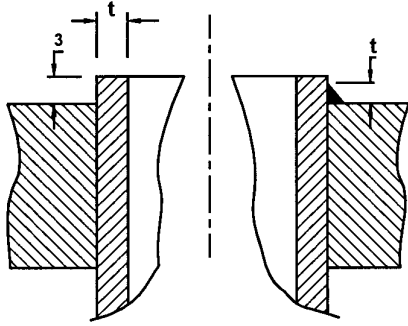


FIG-1

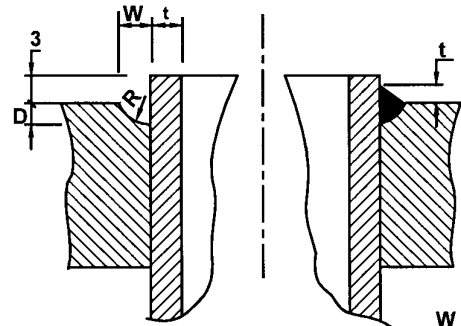


FIG-2

$W = t$   
 $R = t$   
 $D = t$  FOR  $t \leq 3$   
AND  
 $= 0.6t$  FOR  $t > 3$

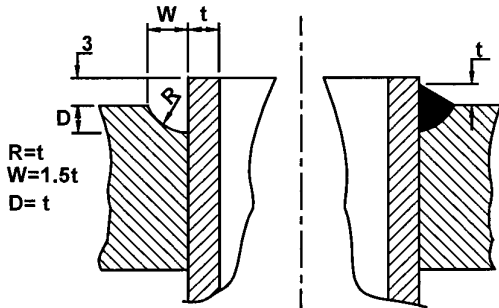


FIG-3

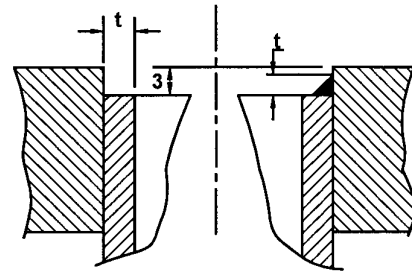


FIG-4

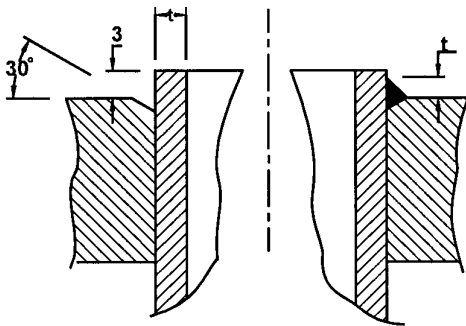
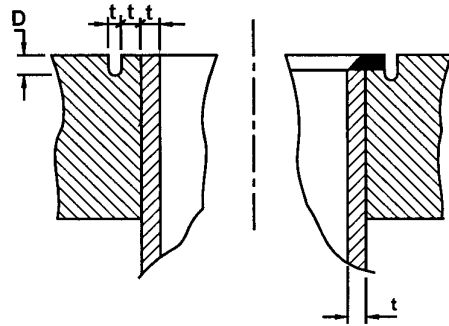


FIG-5



$D = 1.5t$  TO  $2t$

FIG-6

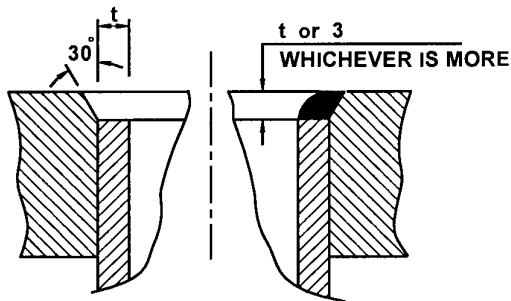
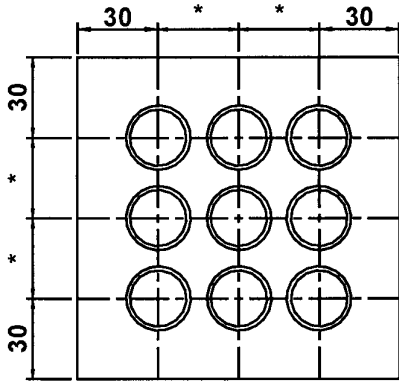


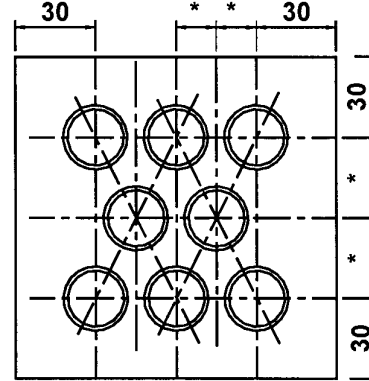
FIG-7



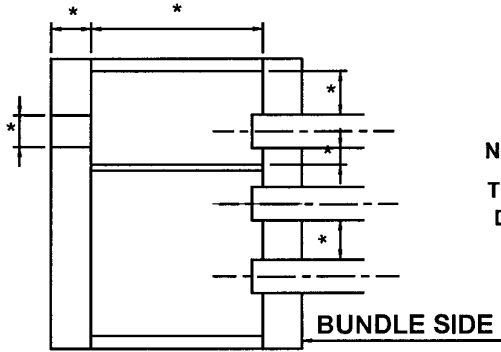
**APPENDIX 2 - DETAILS OF TEST SPECIMENS**



**FIG-11**



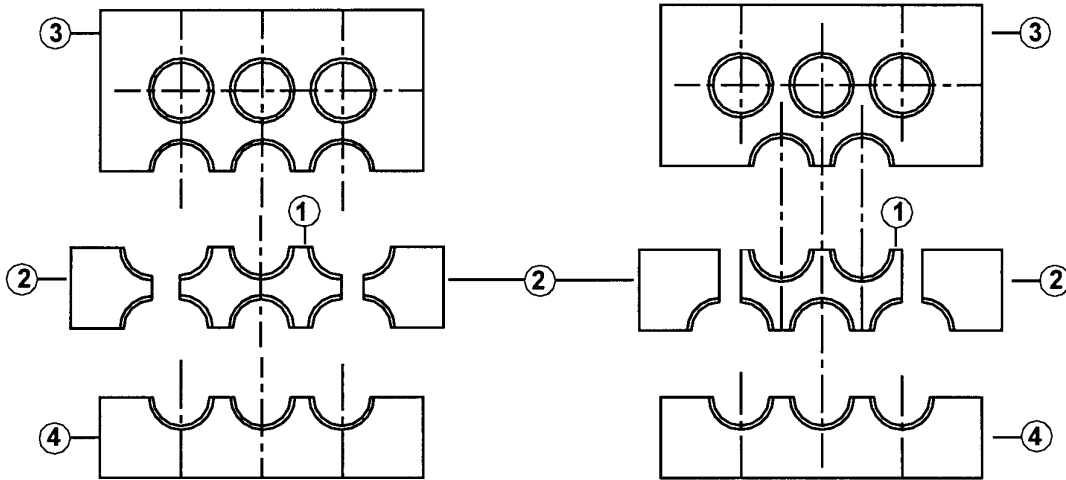
**FIG-12**



**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