INSPECTION & TEST PLAN FOR SHELL AND TUBE HEAT EXCHANGER

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Tabulation of Revised Pages

Page	Revision								Page	Revision								Page	Revision							
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1. Purpose

The inspection and test plan is an engineering document, which defines the type and extent of CONTRACTOR and CLIENT involvement in each phase of fabrication, control and testing requirements and inspection.

The inspection and test plan may under no circumstances be used as a substitute for the VENDOR's Quality Manual and/or Quality Control Plan. The VENDOR shall in any case conduct all the tests required by contractual documents, specifications, codes and standards, and keep the relevant documentation.

CONTRACTOR and CLIENT shall be entitled to send their inspectors to attend inspection in the VENDOR’s workshop.

This inspection and test plan shall be used as a basis for the definition of the material inspection plan during pre-inspection meeting.

2. Applicable Documents

ASME Sec. II	Material
ASME Sec. VIII Div. 1	Rules for Construction of Pressure Vessels
ASME Sec. VIII Div. 2	Rules for Construction of Pressure Vessels, Alternative Rules
ASME Sec .V	Non-Destructive Examination
ASME Sec. IX	Welding and Brazing Qualifications
TEMA Standard	Tubular Exchanger Manufacturers Associations
API 660	Shell & Tube Heat Exchangers
BS EN 10204 (3.1)	Material Certificates

All Standards and Specifications listed in the Requisition

3. Definitions

3.1 General definitions

Site	The lands and other places in or through which the works provided by the OWNER for the purpose of the CONSTRUCTION CONTRACT
Shall	Mandatory requirements
Should	Recommended or advisory requirements
May	Optional
Approved	Approved by OWNER

3.2 Abbreviations

Abbreviation	Meaning
NDT	None Destructive Test
WPS/PQR	Welding Procedure Specification/Procedure Qualification Record
VQCP	Vendor's Quality Manual and Quality Control Plan
ITP	Inspection and Test Plan
TPI	Third Party Inspector
PIM	Pre Inspection Meeting

4. General Requirements

The VENDOR shall inspect all the manufactured items to ensure that materials and workmanship are in accordance with applicable codes, standards and specifications indicated in the relevant Purchase Order.

All the manufactured items shall be inspected according to CONTRACTOR'S requirements. However, the acceptance of any work and/or release of them by the CONTRACTOR shall in no way relieve the VENDOR of any responsibility for carrying out all the provisions of the codes and specifications.

The CONTRACTOR and CLIENT or their authorized Inspectors/Representatives shall have free access at all reasonable time to all shops of the VENDOR or Sub-VENDOR for inspection/witnessing of work.

5. Definition of CONTRACTOR and CLIENT / TPI Involvement

The nature of CONTRACTOR and CLIENT involvement is indicated against each activity of fabrication and testing by means of the letters H, W, SW, R and A with the following definitions:

H: (Hold) Point
The VENDOR cannot carry out the specified controls and tests without CONTRACTOR and CLIENT attendance and witnessing. The VENDOR must notify CONTRACTOR by fax of the dedicated inspection activity at least twenty (20) Calendar days in advance and consequently CLIENT will be informed by CONTARACTOR. The VENDOR cannot deviate from this rule unless written approval has been given by CONTRACTOR.

W:(Witness)
The VENDOR must notify CONTRACTOR of the dedicated inspection activity at least twenty (20) Calendar days in advance and consequently CLIENT will be informed by CONTARACTOR. Although CONTRACTOR and CLIENT witnessing is not mandatory.

If CONTRACTOR does not elect to be present, the VENDOR may proceed with his own inspection, provided controls and test records are made available to CONTRACTOR for review.

SW: (Spot Witness)

Spot Witness denotes to random attendance of inspector without any invitation from the VENDOR and without advance notification by the CONTRACTOR to the VENDOR.

R: (Review) – Review of Documents

The VENDOR has either to submit to CONTRACTOR for review and comments the documents required prior to the performance of the dedicated activity or to transmit or make available for the review of CONTRACTOR the result of the controls and tests conducted, as the case may be. Consequently CLIENT will be informed by CONTARACTOR.

A: (Approval) – Approval of Documents

The VENDOR has either to submit to CONTRACTOR for comments and approvals the documents required prior to the performance of the dedicated activity or to transmit or make available for the approval of CONTRACTOR the result of the controls and tests conducted, as the case may be. VENDOR is not allowed to proceed the work before receipt of CONTRACTOR approval on the required documents.

Levels of Inspection:

Inspection levels shall be based on the criticality and complexity of the equipment, as determined by engineering.

Level 1: Full scope inspection

In addition to the visits required for formal witness points, the inspector shall visit the VENDOR on a regular basis to monitor work in progress. The frequency of visits will depend on the complexity and size on the order and the quality history of the VENDOR.

Level 1*: Modified Full scope inspection

The visits required for formal witness points are to be performed.

Level 2: Limited Scope Inspection

The inspector shall visit the VENDOR to inspect a limited number of pre-determined witness points.

Level 3: Final inspection prior to Shipment

The inspector shall provide specific instructions to the VENDOR defining the activities to be witnessed or the details to be verified.

Level 4: No source inspection required.

The inspector shall review and accept VENDOR’s certifications, test reports and QC data book documentation.

Level of inspection for this particular ITP is considered as level '1' or '1*'. Level of inspection of Long Lead Items are exception and in any case are being treated as level '1'.

6. VENDOR's Quality Manual and Quality Control Plan (VQCP)

The VENDOR's Quality Control Plan is a document, which defines in a chronological manner the list of the operations, controls and tests in accordance with his own "know-how" and with the requirements specified in CONTRACTOR's requisition.

The VENDOR must issue a Quality Control Plan for each type or category of material and component and the following information shall be clearly specified against each operation:

Reference documents (drawings, procedures, etc …)
Acceptance criteria (code, etc …)
Recording documents for control and tests.

Involvement of the Quality Control department of the VENDOR and/or his Sub-VENDOR.

The VQCP will have to include all CONTRACTOR and CLIENT inspection activities defined in inspection and test plan as well as all inspection activities scheduled by the third party inspection company.

For component of inspection levels 1 and 2 the VENDOR's VQCP shall be submitted compulsorily to CONTRACTOR and CLIENT for comments before the Pre-Inspection Meeting or starting the manufacturing. Vendor's Quality Manual shall also be submitted to CONTRACTOR upon request.

7. Inspection Activities

For detail of inspection activities, see relevant inspection and test plan in attachment # 1 as minimum requirements which shall be finalized during PIM.

8. Attachments

8.1 Attachment #1: ITP for Shell and Tube Heat Exchanger (3 Sheets)

8.2 Attachment #2: Test Sequence Standards with reference to TEMA Type of Shell and Tube Heat Exchangers (13 Sheets)

Attachment # 1

ITP for Shell and Tube Heat Exchanger

(3 Sheets)

Table: Inspection Activities

INSPECTION ACTIVITIES	APPLICABLE DOCUMENTS	CONTRACTOR	CLIENT / TPI
VENDOR's Quality Control Plan	VENDOR's Document	R	R
Pre-Inspection Meeting	Agenda	H	H
Material Test Certificate	BS EN 10204 (3.1)	R	R
Checking The Material With Requirements of Requisition	Requisition	W	W
Inspection of Sub Ordered Components	Requisition	W	W

INSPECTION ACTIVITIES	APPLICABLE DOCUMENTS	CONTRACTOR	CLIENT / TPI
Material identifications and markings	VENDOR's Approved Procedure	W	W
Storage of materials and welding consumables	VENDOR's Approved Procedure	R	R
WPS/PQR	Design Code, ASME Sec IX	R/A	R
Welder's Qualifications (Note 1)	ASME Sec. IX	R/A	R
NDT Personnel's Qualification	Design Code, ASME Sec V, ASNT Lev.II or eqv.	R/A	R
Material Traceability	VENDOR's Approved Procedure	W	W
Dimensional check (before forming & rolling)	Approved Drawings	W	W
Cutting, Forming, Rolling, Punching, Drilling, Tacking and Fit up	Approved Drawings	W	W
Inspection of Back Gouged portions of edges prepared for welding by MT or PT	Design Code, ASME Sec V	W	W
Tube Expanding / Tube to tubesheet Welding	Approved Drawings	W	W
Tube to Tubesheet joint test (Notes 5)	Approved Procedure	W	W
Welding	Design Code, ASME Sec IX	W	R
Bundle Assembly	Approved Drawings	W	R
Confirmation of NDT Results VT, RT, UT, MT, PT (Review of all Radiographs)	Design Code, ASME Sec V	W/A	R
Preparation of Production Test Plate	Requisition	W	R
Mechanical Testing of Production Test Plate	ASME Sec II, Requisition	W	R

INSPECTION ACTIVITIES	APPLICABLE DOCUMENTS	CONTRACTOR	CLIENT / TPI
Chemical Analysis of Production Test Plate	ASME Sec II, Requisition	W	R
Execution of Major Repair	Requisition	W	W
Completeness check	Approved Drawings	H	H
PWHT/ Stress Relieve (Note 2)	Design Code	R/A	R
NDTafter PWHT/ Stress Relieve	Requisition	R/A	R
Roughness checking (Flange Facing, Internal Surface, etc.)	Approved Drawings	W	R
Confirmation of Hardness Measurement in Final Condition, if applicable	Design Code, ASME Sec V	W	R
Final Visual and Dimensional Check	Approved Drawings and Standards	H	W
Reinforcing Pad air-soap test	Requisition	W	W
Leakage Test/Hydrotest	Requisition	H	H
Complete Draining and drying, N2/VPT/desiccant filling, (which applicable)	Requisition	W	W
Surface Preparation, Anti-Corrosion / Painting	Requisition	W	W
Pickling & Passivation (where applicable)	Requisition	W	W
Name plate, Cleanliness, Tagging and Marking	Requisition	W	W
Auxiliary Items (Spare Parts, Bolts, Nuts, etc.)	Requisition	W	W
Packing / Preparation for Shipment	Requisition	W	W
Check Identification and Destination Marking	Requisition	W	R

INSPECTION ACTIVITIES	APPLICABLE DOCUMENTS	CONTRACTOR	CLIENT / TPI
Pre Shipment Inspection (PSI) Including Packing, Marking and Review of Documents	Requisition	H	H
Non Conformities Treatment	Requisition	W	W
NDT Documents	Design Code, ASME Sec V	R/A	R
Documentations	Requisition	A	W/R
Control of Packing List	-	H	W
Deviations	-	H	W/R
Final Inspection / Data Book	Requisition	H/A	W/R
Release Note	-	H	H

Notes:

1- If Inspector doubts welder's ability, Inspector may request Welder for new qualification test.
2- Inspector has right to request VENDOR to witness if he/she deems necessary.
3- All shop tests shall be done by VENDOR or his SUB-VENDOR.
4- Qualification of sub-VENDORs shall be approved by CONTRACTOR.
5- For lethal / toxic services: Hold Point of CONTRACTOR to be considered.

Attachment # 2

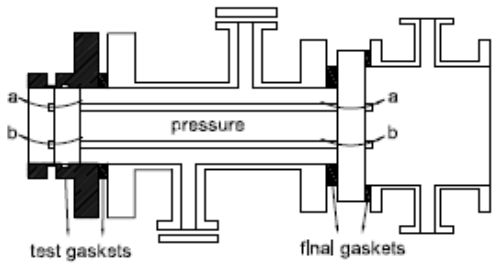
Test Sequence Standards with reference to TEMA Type of Shell and Tube Heat Exchangers

(13 Sheets)

Hydrostatic test procedure and test ring requirement for Shell and Tube Heat Exchangers: U tube, Floating head and Fixed Tubesheet are as specified sketches.

Fig. 1-1 : Standard for Floating Head Exchangers

Figure 1



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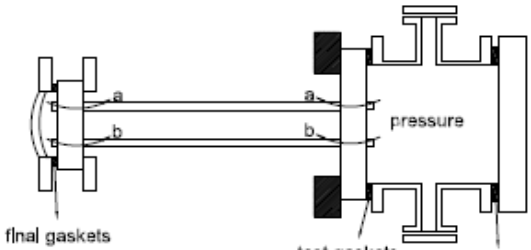


Case 1- Shell pressure ≥ bundle pressure

Tests made : Figs 1,3,4

Elements tested:

Fig. 1 - Extra tubular space

a. Tube to tube-sheet joints
b. Tube failure

Fig 3 - Test of removable head

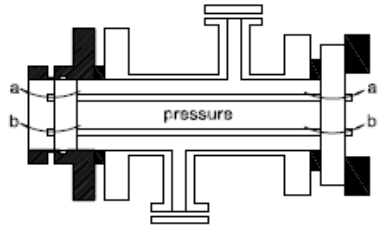
g. Channel
h. Gasket between channel and channel cover
f. Gasket between channel and tube-sheet
d. Floating head cover to tube-sheet

Fig 4 - Test of shell

j. Gasket between shell cover and shell
l. Gasket between channel and tube-sheet
c. Shell + cover

Fig. 1-2: Standard for Floating Head Exchangers (Continued)

Figure 1



All gaskets are final gaskets

Figure 2

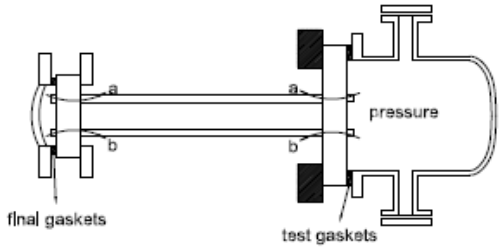
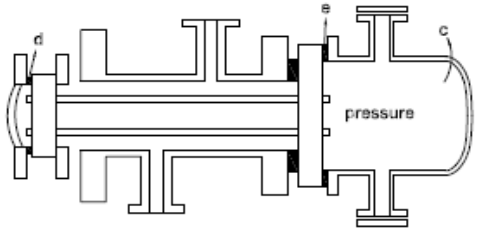
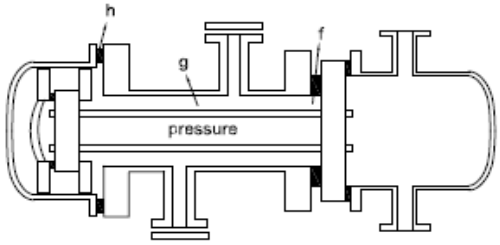


Figure 3



All gaskets are final gaskets

Figure 4



All gaskets are final gaskets

Case 1- Shell pressure ≥ bundle pressure

Tests made : Figs 1,3,4

Elements tested:

Fig. 1 - Extra tubular space

a. Tube to tube-sheet joints
b. Tube failure

Fig 3 - Test of channel and floating head

c. Channel
d. Gasket between channel and channel cover
e. Gasket between channel and tube-sheet

Fig 4 - Test of shell cover

f. Gasket between shell cover and shell
g Gasket between channel and tube-sheet
h. Shell + cover

Case 2- bundle pressure > shell pressure

Test made: Figs. 1 (as per floating head 1), 2,3,4

Elements tested:

Fig. 1 - See Case 1

Fig. 2 - Intratubular space

a. Tube to tube-sheet joints
b. Tube failure

Fig. 3 - See Case 1

Fig. 4 - See Case 1

Notes:

(1) For tubes welded to the tube-sheet, a dye-penetrant examination or test with ammonia must be conducted before and after the hydraulic test to locate any cracking.

Fig. 1-3: Standard for Floating Head Exchangers (Continued)

Case 1- Shell pressure ≥ bundle pressure

Tests made : Figs 1,3,4

Elements tested:

Fig. 1 - Extra tubular space

Figure 1

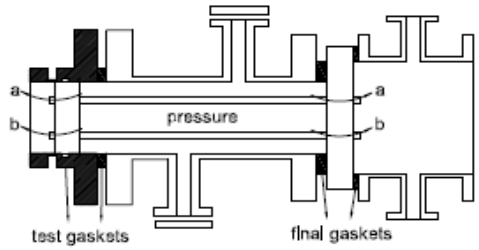


Figure 2

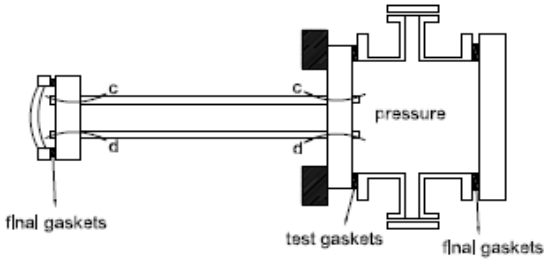
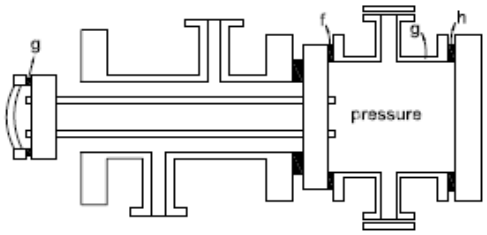
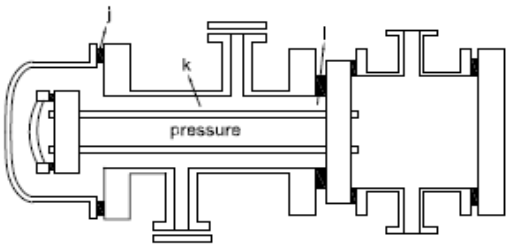


Figure 3



All gaskets are final gaskets

Figure 4



All gaskets are final gaskets

Fig. 1-4: Standard for Floating Head Exchangers (Continued)

Case 1- Shell pressure ≥ bundle pressure

Tests made : Figs 2,4 (Note 1)

Elements tested:

Figure 1

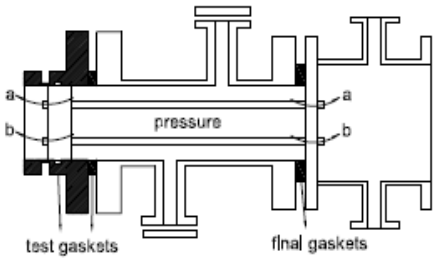
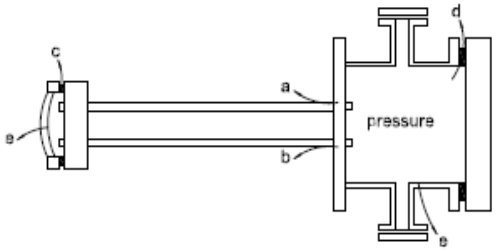
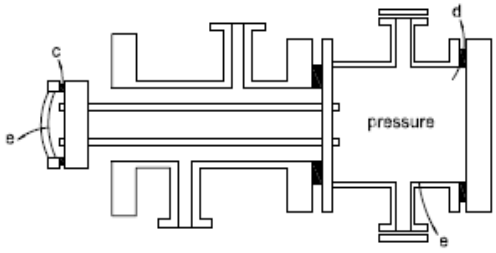


Figure 2



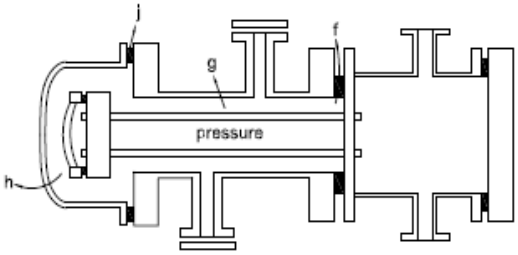
All gaskets are final gaskets

Figure 3



All gaskets are final gaskets

Figure 4



All gaskets are final gaskets

Fig. 1-5: Standard for Floating Head Exchangers (Continued)

Figure 1

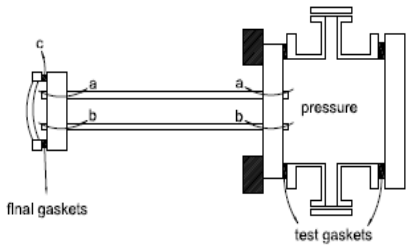
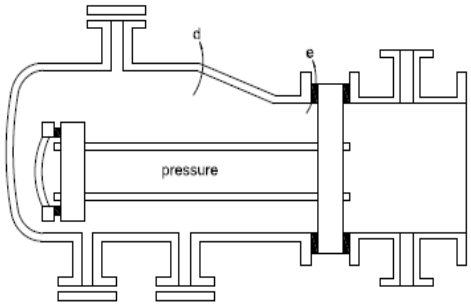
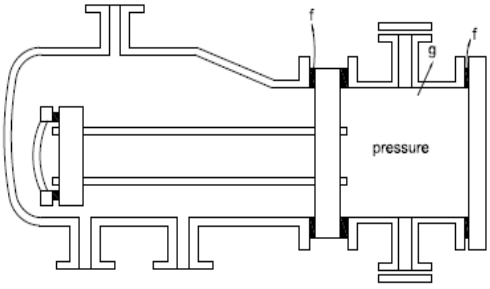


Figure 2



All gaskets are final gaskets

Figure 3



All gaskets are final gaskets

In all cases:

Tests made : Figs. 1,2,3

Elements tested:

Fig. 1 - Extra tubular space
- a. Tube to tube-sheet joints
- b. Tube failure
- c. Floating head and gasket

Fig 2 - Extra tubular space
- d. Shell
- e. Gasket between shell and tube-sheet

Fig 3 - Test of channel
- f. Gasket between channel cover and channel
  Gasket between channel and tube-sheet
- g. Test of channel

Notes:

(1) If the shell pressure is higher than the channel Pressure, continue test 1 to the shell pressure if possible so as to check a, b and c.

(2) For tubes welded to the tube-sheet, a dye-penetrant examination or test with ammonia must be conducted before figure 1 test and after figure 2 test to check the welds and. locate any cracks.

Fig. 1-6: Standard for Floating Head Exchangers (Continued)

Figure 1

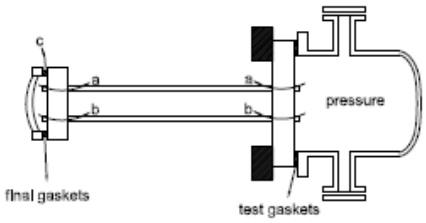


Figure 2

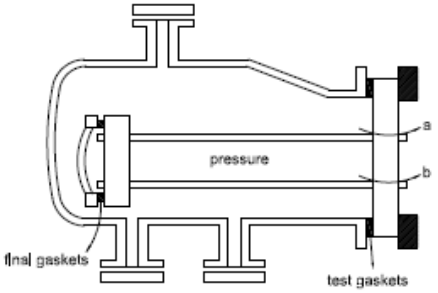
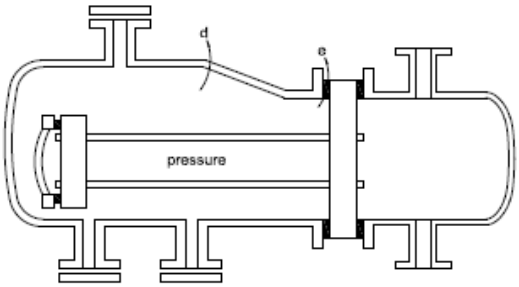
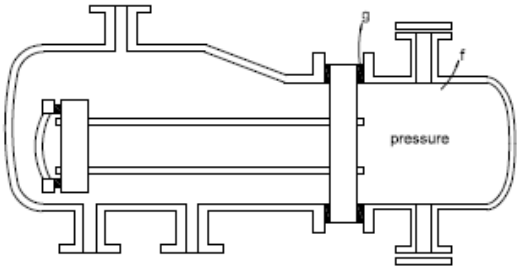


Figure 3



All gaskets are final gaskets

Figure 4



All gaskets are final gaskets

In all cases:

Tests made : Figs. 1,3,4 (in the case of welded tubes, test 2 shall also be made).

Elements tested:

Fig. 1 - Intratubular space
- a. Tube to tube-sheet joints
- b. Tube failure
- c. Floating head and gasket

Fig 2 - Extra tubular space
- a. Tube to tube-sheet joints
- b. Tube failure

Fig 3 - Testing of shell
- d. Shell
- e. Gasket between shell and tube-sheet

Fig 4- Testing of channel
- f. Testing of channel
- g. Gasket between channel and tube-sheet

Notes:

(1) For tubes welded to the tube-sheet, a dye-penetrant examination or test with ammonia must be conducted before figure 1 test and after figure 2 test to check the welds and locate any cracks.

Fig. 2-1: Standard for U-Tube Exchangers

Figure 1

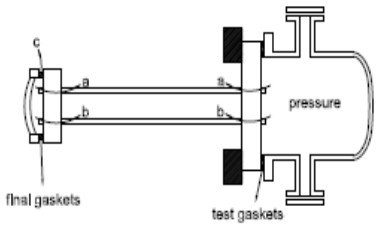
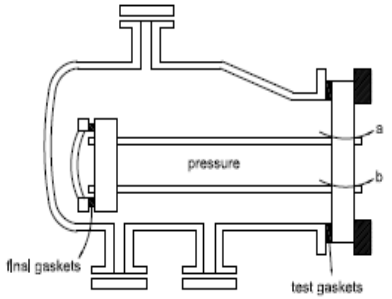


Figure 2



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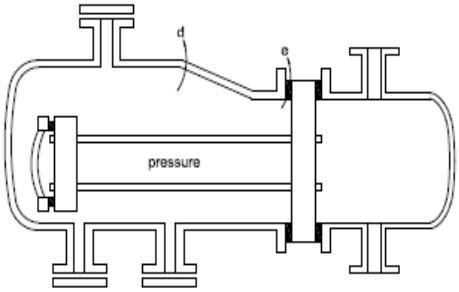
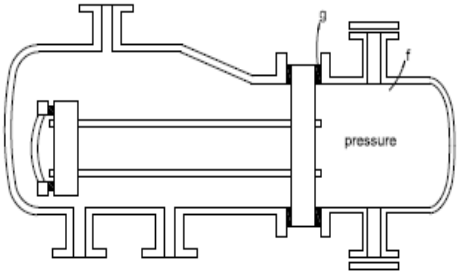


All gaskets are final gaskets

Figure 4



All gaskets are final gaskets

Tests made : Fig. 1,2 (Note 2),3,4

Elements tested:

Fig. 1 - Intratubular space
- a. Tube to tube-sheet joints
- b. Tube failure

Fig 2 - Extra tubular space
- g. Shell
- h. Test of Gasket between shell and tube-sheet
- j. Tube to tube-sheet joints
- k. Tube failure

Fig 3 - Test of channel
- c. Test of channel
- d. Test of gasket between channel and channel cover and tube-sheet

Fig 4- Test of shell
- f. Test of Gasket between shell and tube-sheet
- g. Test of shell

Case 2- bundle pressure > shell pressure

Test made: Figs. 2,3

Elements tested:

Fig. 2 - See Case 1

Fig. 3 - See Case 1

Notes:

(1) For tubes welded to the tube-sheet, a dye-penetrant examination or test with ammonia must be conducted before and after figures 1 or 2 tests to check and to locate any cracks.

(2) This test is made only when the tubes are welded to the tube-sheet.

Fig. 2-2: Standard for U-Tube Exchangers (Continued)

Figure 1

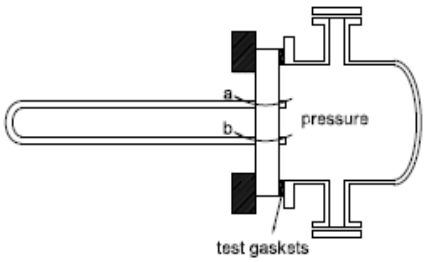
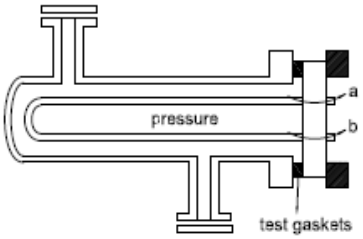
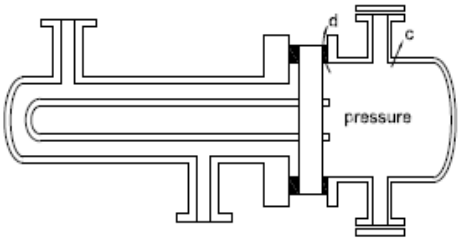


Figure 2



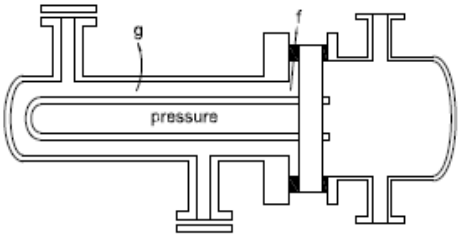
All gaskets are final gaskets

Figure 3



All gaskets are final gaskets

Figure 4



All gaskets are final gaskets

Case 1- Shell pressure ≥ bundle pressure

Tests made : Figs. 2,3,4

Elements tested:

Fig. 2 - Extra tubular space
a. Tube to tube-sheet joints
b. Tube failure

Fig 3 - Test of channel
c. Channel
d. Test of gasket between channel and tube-sheet

Fig 4 - Test of shell
e. Test of shell
f. Test of gasket between shell and tube-sheet

Case 2- Bundle pressure > shell pressure

Test made: Figs. 1,2 (Note 2),3,4

Elements tested:

Fig. 1 - Intratubular space
a. Tube to tube-sheet joints
b. Tube failure

Fig. 2 - See Case 1

Fig. 3 - See Case 1

Fig. 4 - See Case 1

Notes:

(1) For tubes welded to the tube-sheet, a dye-Penetrant examination or test with ammonia must be conducted before and after the hydraulic test to locate any cracking.

(2) This test is made only when the tubes are welded to the tube-sheet.

Fig. 2-3: Standard for U-Tube Exchangers (Continued)

Figure 1

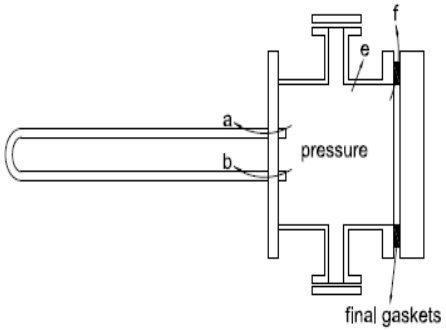


Figure 2

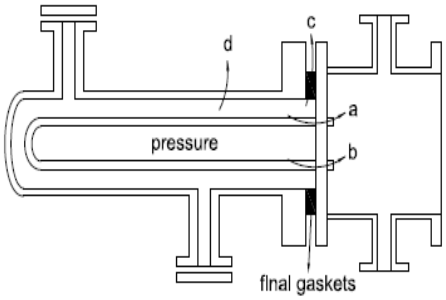
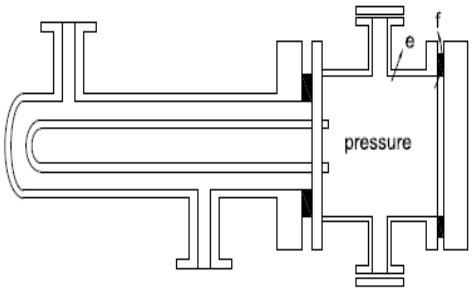


Figure 3



All gaskets are final gaskets

Case1-Shell pressure ≥ bundle pressure

Tests made : Figs. 2,3

Elements tested:

Fig. 2 - Extra tubular space
- a. Tube to tube-sheet joints
- b. Tube failure
- c. Gasket between shell and channel
- d. Shell

Fig 3 - Intratubular space
- e. Tube to tube-sheet joints
- f. Gasket between channel and channel cover

Case2-Bundle pressure > shell pressure

Tests made : Figs. 1,2

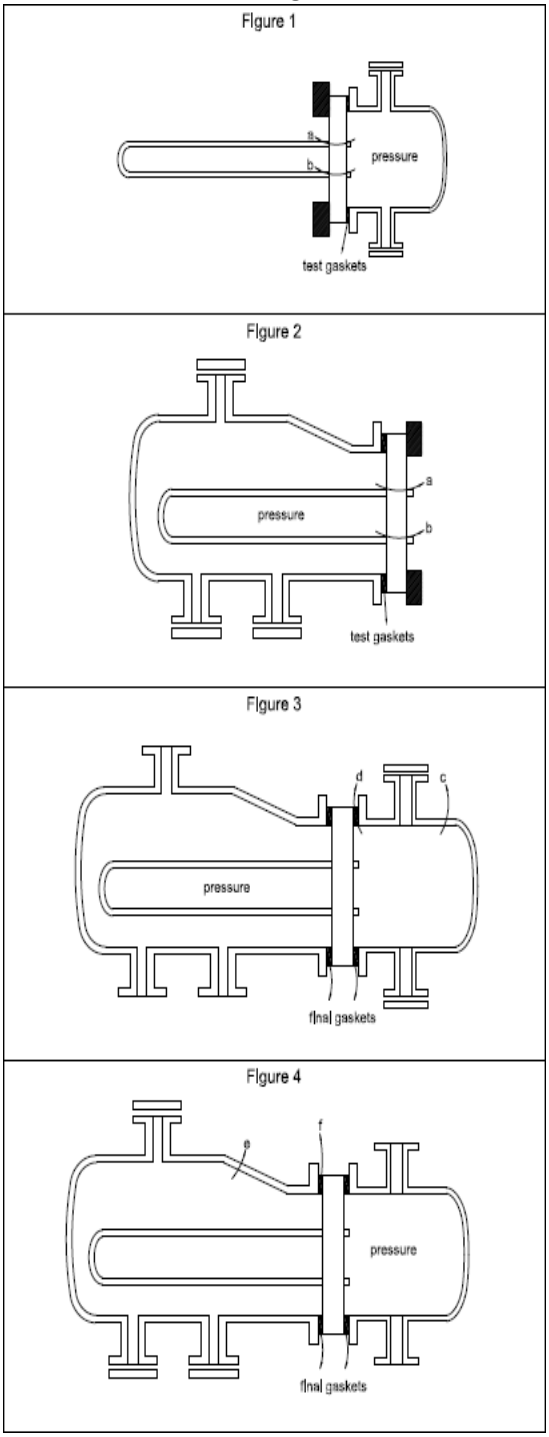
Fig. 1 - Intratubular space
- a. Tube to tube-sheet joints
- b. Tube failure
- c. Channel
- d. Gasket between channel and channel cover

Fig 2 - Extra tubular space
- c. Gasket between shell and channel
- d. Shell

Notes:

(1) For tubes welded to the tube-sheet, a dye-penetrant examination or test with ammonia must be conducted before figure 1 test and after figure 2 test to check the welds and locate any cracks.

Fig. 2-4: Standard for U-Tube Exchangers (Continued)



Case 1- Shell pressure

Tests made : Figs. 2,3,4

Elements tested:

Fig. 2 - Extra tubular spa
a. Tube to tube-shee
b. Tube failure

Fig 3 - Test of channel
c. Channel
d. Test of gasket betw

Fig 4 - Test of shell
e. Test of shell
f. Test of gasket betw

Case 2- Bundle pressu

Test made: Figs. 1,2 (No

Elements tested:

Fig. 1 - Intratubular spac
a. Tube to tube-shee
b. Tube failure

Fig. 2 - See Case 1

Fig. 3 - See Case 1

Fig. 4 - See Case 1

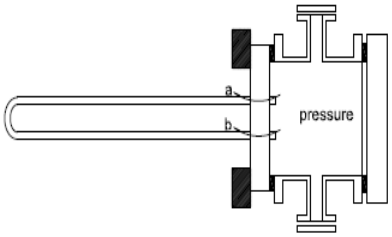
Notes:

(1) For tubes welded to t
examination or test w
conducted before and
the welds and locate

(2) This test is made onl
to the tube-sheet.

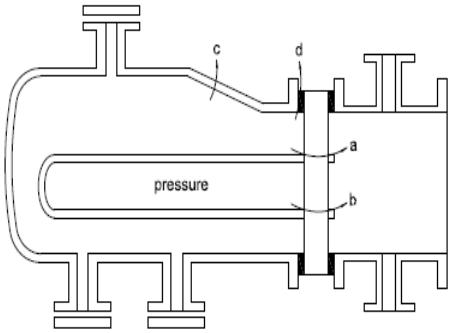
Fig. 2-5: Standard for U-Tube Exchangers (Continued)

Figure 1



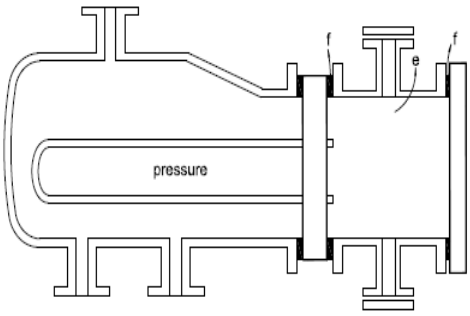
All gaskets are final gaskets

Figure 2



All gaskets are final gaskets

Figure 3



All gaskets are final gaskets

Case1-Shell pressure ≥ bundle pressure

Tests made : Figs. 1,2,3

Elements tested:

Fig. 1 - Intratubular space
a. Tube to tube-sheet joints
b. Tube failure

Fig 2 - Extra tubular space
a. Tube to tube-sheet joints
b. Tube failure
c. Test of shell
d. Test of gasket between shell and tube-sheet

Fig. 3 - Test of channel
e. Test of channel
f. Test of gasket between channel and stationary tube-sheet, and between channel and channel cover

Case2-Bundle pressure > shell pressure

Tests made : Figs. 2,3

Elements tested:

Fig. 2 - See Case 1

Fig. 3 - See Case 1

Notes:

(1) For tubes welded to the tube-sheet, a dye-penetrant examination or test with ammonia must be conducted before figure 1 test and after figure 2 test to check the welds and locate any cracks.

Fig. 3-1: Standard for Fixed Tube sheets Exchangers

Figure 1
B.E.M. Type

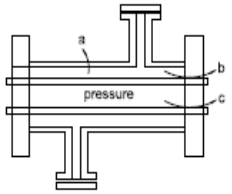
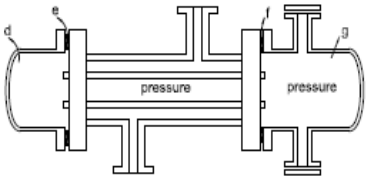


Figure 2
B.E.M. Type



All gaskets are final gaskets

Figure 1
B.E.L. Type

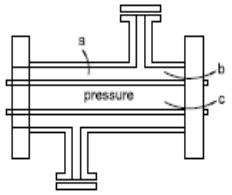


Figure 2
B.E.L. Type

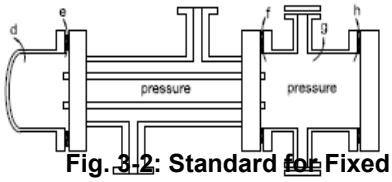


Fig. 3-2: Standard for Fixed Tube

Case1-Shell pressure ≥ bundle pressure

Tests made : Figs. 1,2

Elements tested:

Fig. 1 - Extra tubular space
- a. Shell
- b. Tube to tube-sheet joints
- c. Tube failure

Fig 2 -Intratubular space
- d. Stationary head-bonnet
- e. Gasket between bonnet and shell
- f. Gasket between shell and channel
- g. Channel
- h. Gasket between channel and channel cover

Case2-Bundle pressure > shell pressure

Same tests as Case 1, but for figure 2 tests:

- Do not drain after the test of the shell (figure 1 tests)

- Fit a glass tube onto an obturator in an upper nozzle of the shell.

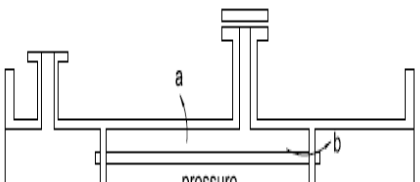
- Continue filling the shell until the water appears in the glass tube.
- Pressurize the channel and channel cover and note the water level in the glass tube.

Any leaks at the tube to tube-sheet joints will be indicated by the change of level in the glass tube.

Notes:

(1) For tubes welded to the tube-sheet, a dye-penetrant examination or test with ammonia must be conducted before and after the hydraulic test to

Figure 1



Case1-Shell pressure ≥ bundle pressure

Tests made : Figs. 1,2

Elements tested:

Fig. 1 - Extra tubular space
- a. Shell
- b. Tube to tube-sheet joints