



Exploration & Production

GENERAL SPECIFICATION

PIPING VALVES VESSELS

GS PVV 441

**Procedure for shop hydraulic tests of shell and tube
heat exchangers**

01	10/03	Change of Group name and logo
00	07/01	First issue
Rev.	Date	Notes



Contents

1. Scope	3
2. Reference documents.....	3
3. Preliminary arrangements for testing.....	4
3.1 Pneumatic test of reinforcements	4
3.2 Preparation of openings	4
4. Pressure gauges	4
5. Test devices.....	5
5.1 Test counter-flange	5
5.2 Test gland	5
6. Running of test.....	5
6.1 Pressurization	5
6.2 Duration of testing	6
6.3 Conduct of the test.....	6
6.4 List of test sequence standards with reference to TEMA Type	6
7. Arrangement to be made following testing.....	7
Appendix 1 – Standards Drawings.....	10



1. Scope

This specification defines the procedure to be followed for shop hydraulic tests of shell and tube heat exchangers. It applies to all exchangers designed and built in accordance with the provisions of general specification **GS PVV 441**.

The purpose of the tests described in this specification is to detect and locate any leaks or deformation there might be:

- In the shells
- At welds
- Where the tubes are rolled or welded to the tube plates
- At contact faces
- Under nozzle reinforcements.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
Not applicable	

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
TEMA	Standards of the Tubular Exchanger Manufacturers Association

**Other documents**

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS PVV 411	Shell and tube heat exchangers

3. Preliminary arrangements for testing**3.1 Pneumatic test of reinforcements**

Prior to the hydraulic test and before the vessel is filled with test water, the reinforcements shall undergo pneumatic testing. This shall be effected by the introduction of compressed air at 1 bar gauge between the shell and the reinforcing saddle.

The visible weld seams shall be coated with soapy water to detect any leaks that might exist.

3.2 Preparation of openings**3.2.1 Blanking of openings**

All openings shall be blanked except the following:

- Vents
- The opening for the test pressure gauge
- The telltale holes of the reinforcing saddles, in order to check the absence of moisture between the shell and the reinforcement (if moisture is present, any appropriate means shall be used to dry this zone, so as to eliminate any ambiguity at the time of test).

3.2.2 Orientation and arrangement of the openings used during the test

These openings shall be placed along the top generating line. This reminder applies to the case of vertical exchangers, which are always shop tested in a horizontal position.

A single opening may be used to advantage for these two functions, with the pressure gauge connected to the vent pipe; this pipe shall be fitted with a plug cock that is tight at the test pressure (see figure 1, attached to this specification).

4. Pressure gauges

Two pressure gauges must be installed on the circuit:

- A reference pressure gauge, which shall be placed on the highest point of the vessel.

For this pressure gauge, a calibration certificate issued within the past year must be presented by the Vendor at the request of the Engineering Company or of the Inspection Agency.



- Another pressure gauge (for verification) shall be placed on the pump discharge.

In addition, the fitting of the reference pressure gauge must comply with any local regulations, in particular as regards the connecting device and its dimensions (nozzle).

5. Test devices

The test devices are defined in the general specification **GS PVV 411**. Their principle of installation is shown in Figure 2 attached to this specification.

They consist basically of:

- A test counter-flange
- A test gland and any accessories.

5.1 Test counter-flange

The test counter-flange shall consist of a ring of which the diametrical dimensions shall be identical to those of the partition-head or shell flange having the larger inside diameter. The drilling shall be identical to those of these two flanges. The thickness of the counter-flange shall be equal to that of the partition-head or shell flange of the exchanger, whichever is thicker.

5.2 Test gland

The test gland shall consist of a flange/stuffing-box/packing assembly having outside and drilling diameters identical to those of the shell cover flange. The inside diameter shall be equal to the outside diameter of the floating tube-sheet + 3 mm. The packings must be such as to assure complete tightness along the perimeter of the floating tube-sheet at the test pressure. The Vendor may choose either graphite-coated non asbestos or O-ring packings.

5.2.1 Vessels with TEMA type S floating head

The test gland is as described above.

5.2.2 Vessels with TEMA type T floating head

In addition, a complete set of blind collar nuts must be provided so as to assure the tightness of the end-sheet attachment bolting hole. Tightness may be assured either by a ring-shaped flat gasket with holes matching the bolting holes, or by individual gaskets inserted under each blind nut.

6. Running of test

Test pressure T shall be established in accordance with the provisions of general specification **GS PVV 411**.

If there are disagreements between this procedure and local regulations, the Vendor must so inform the COMPANY who shall decide whether a test in accordance with this document must be run in addition to the test required by local regulations.

6.1 Pressurization

Pressurization must be gradual. For test pressures higher than 40 bars, pressurization shall be in stages, with a pause of a few minutes between stages.

The use of three stages is recommended:

- 0 to 1/3 P
- 1/3 to 2/3 P
- 2/3 to P

For test pressures higher than 120 bars, the first plateau shall be at 40 bars and the second at $\frac{P + 40}{2}$.

6.2 Duration of testing

The hold time of the hydrostatic test must never be less than 60 minutes for shells up to 25 mm thick; this minimum duration shall be increased to $\frac{60 \text{ minutes} \times \text{thickness in mm}}{25}$ in the case of thicknesses greater than 25 mm (but shall not exceed two hours).

6.3 Conduct of the test

The various test sequences required by the tables of this specification shall be carried-out according to the TEMA exchanger class and according to the highest test pressure.

In particular, the examinations prescribed for each sequence shall be made using the final bolting and gasket for each element that need not be moved thereafter for a subsequent sequence. In addition, it shall be checked by visual examination that there is no trace of moisture between the shell and reinforcing saddles.

6.4 List of test sequence standards with reference to TEMA Type

6.4.1 Floating-head exchangers

- SD PVV 441 A * S
- SD PVV 442 B * S
- SD PVV 443 A * T
- SD PVV 444 C * T (**)
- SD PVV 445 A K T
- SD PVV 446 B K T

6.4.2 U-tube exchangers

- SD PVV 451 A * U
- SD PVV 452 B * U
- SD PVV 453 C * U (**)
- SD PVV 454 B K U
- SD PVV 455 A K U



6.4.3 Exchangers with fixed tube-sheets

- **SD PVV 461** B * M, B * L, N * L
- **SD PVV 462** N * N

(*) For these exchangers, the middle letter of the TEMA reference may be E, F, G, H, J or X without affecting the order of the sequences.

(**) Also applies to C K T or C K U exchangers.

7. Arrangement to be made following testing

Immediately after testing, the heat exchangers shall be drained, then dried by a flow of warm dry air (heated to approximately 30°C above the ambient temperature, and not recirculated).

After drying, the provisions of the general specification **GS PVV 411**, completed by those of the particular specifications, if any, shall be applied.

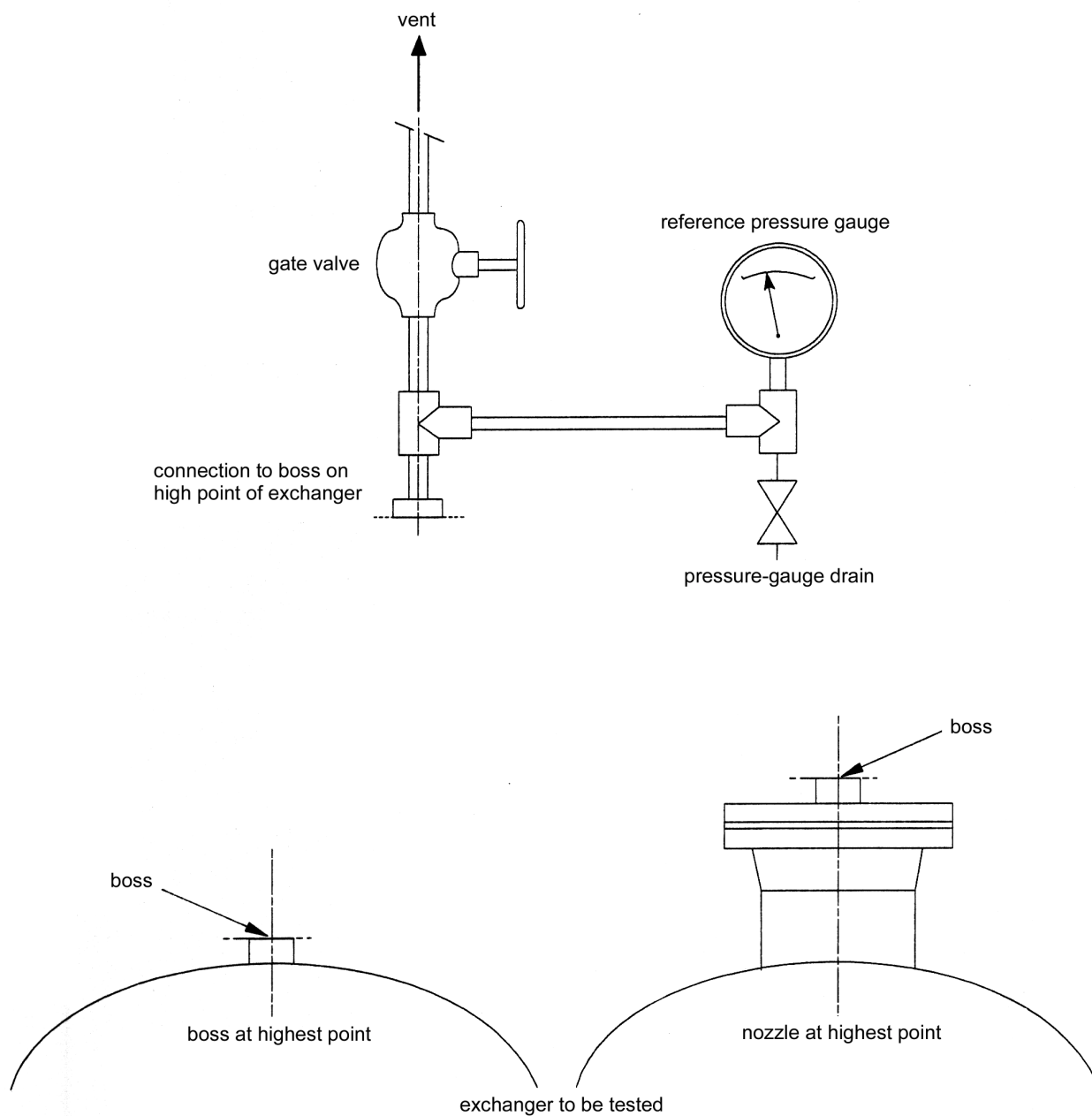


Figure 1 - Orientation and arrangement of the openings used during the tests

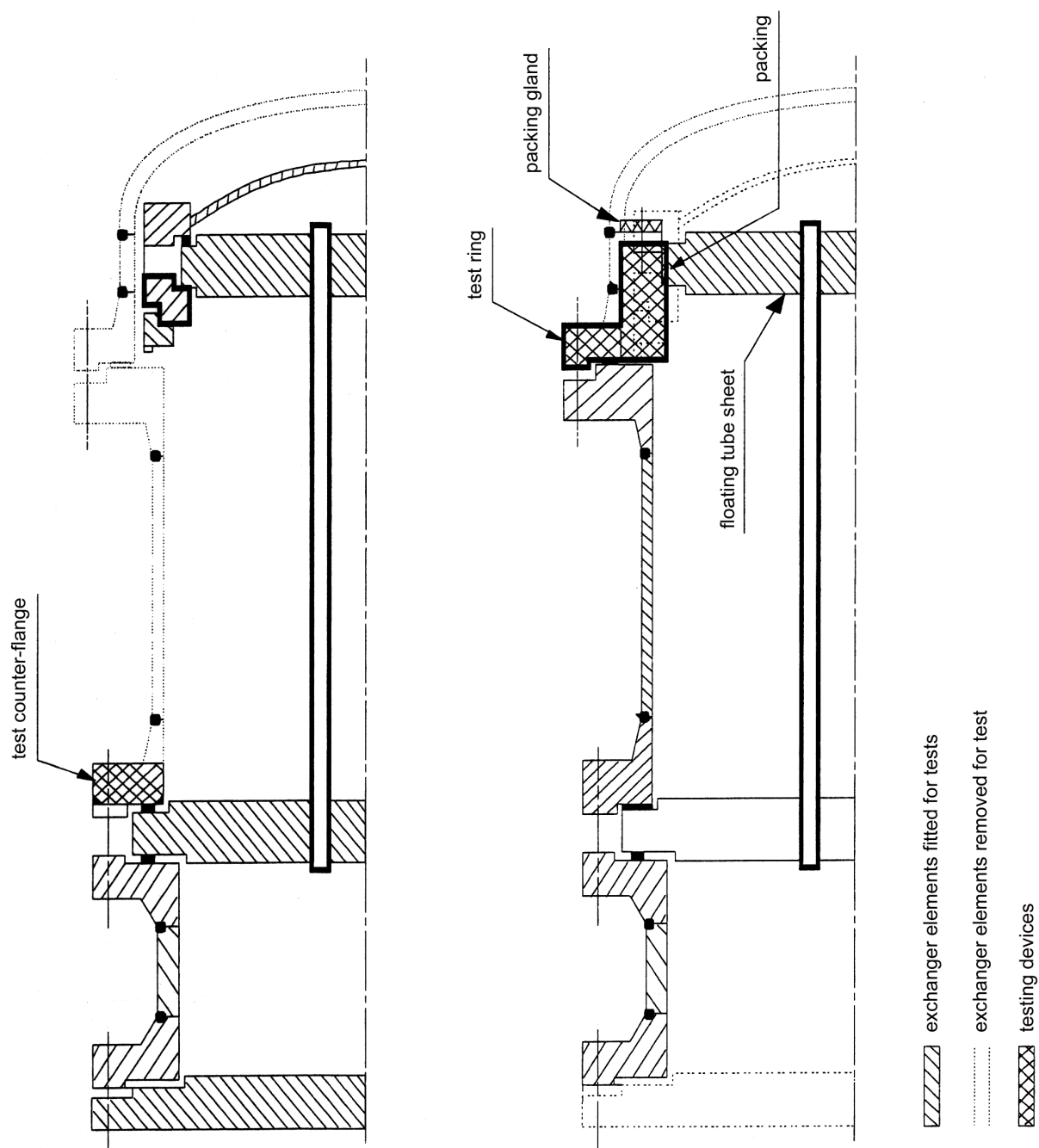


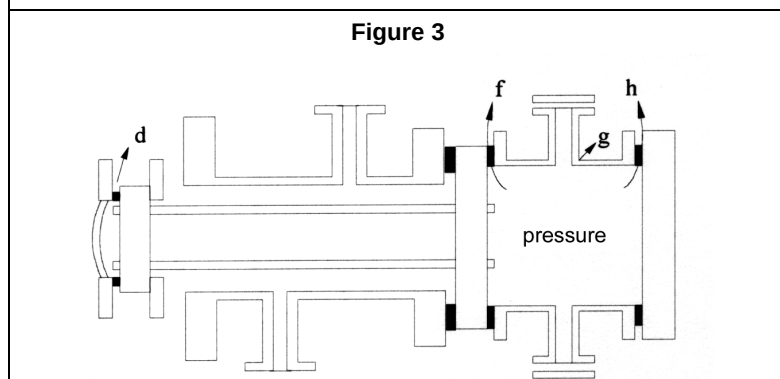
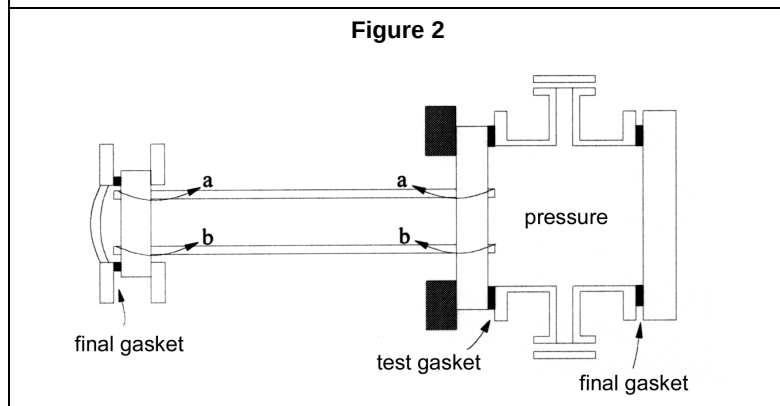
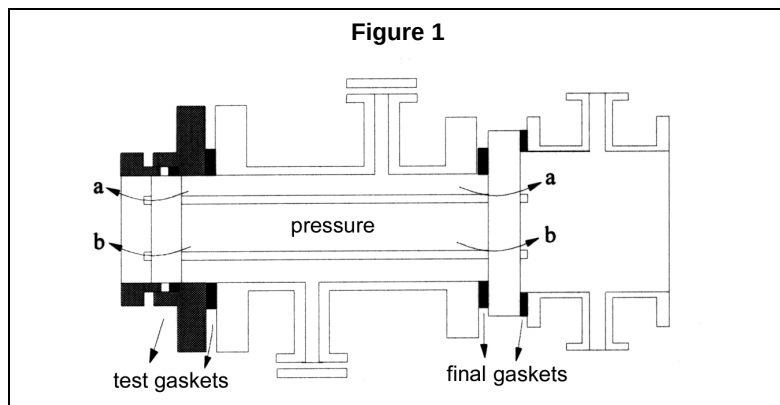
Figure 2 - Installation of test devices



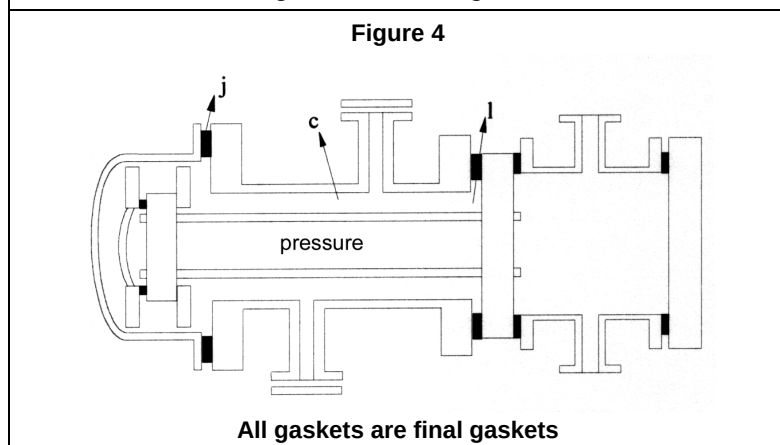
Appendix 1 – Standards Drawings

Reference	Title
SD PVV 441	Standard for floating-head exchangers
SD PVV 442	Standard for floating-head exchangers
SD PVV 443	Standard for floating-head exchangers
SD PVV 444	Standard for floating-head exchangers
SD PVV 445	Standard for floating-head exchangers
SD PVV 446	Standard for floating-head exchangers
SD PVV 451	Standard for U-tube exchangers
SD PVV 452	Standard for U-tube exchangers
SD PVV 453	Standard for U-tube exchangers
SD PVV 454	Standard for U-tube exchangers
SD PVV 455	Standard for U-tube exchangers
SD PVV 461	Standard for exchangers with fixed tube-sheets
SD PVV 462	Standard for exchangers with fixed tube-sheets

Standard Drawings	SD PVV 441
Standard for floating-head exchangers	Rev.: 01
	Date: 10/03



All gaskets are final gaskets



All gaskets are final gaskets

Case 1 - Shell pressure $\geq$ bundle pressure

Tests made: 1.3.4

Elements tested:

Fig. 1 - Extratubular 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 shell and tube-sheet

c. Shell + cover

Case 2 - Bundle pressure > shell pressure

Tests made: 1 (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

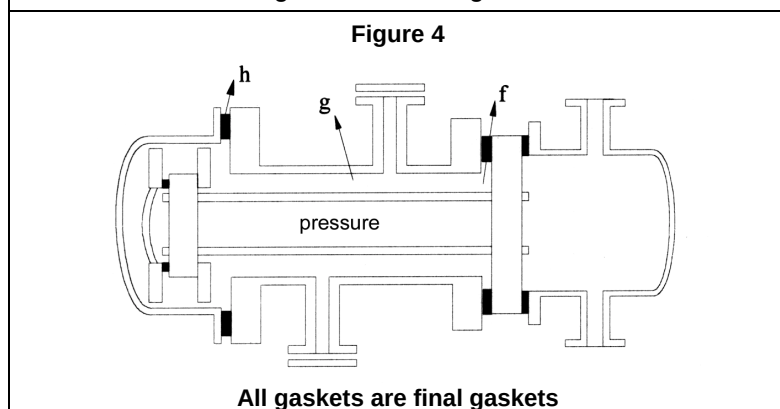
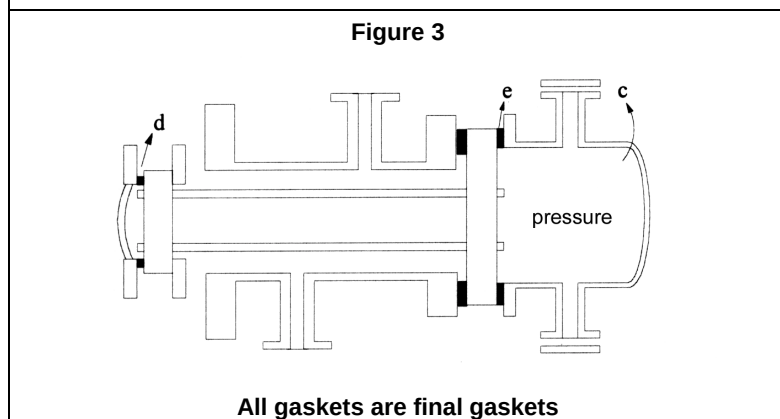
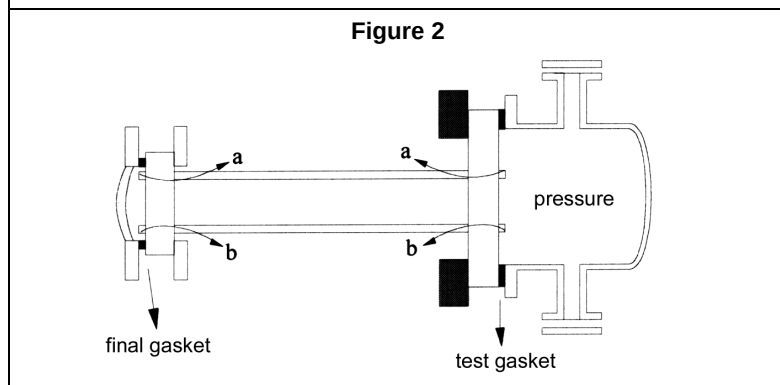
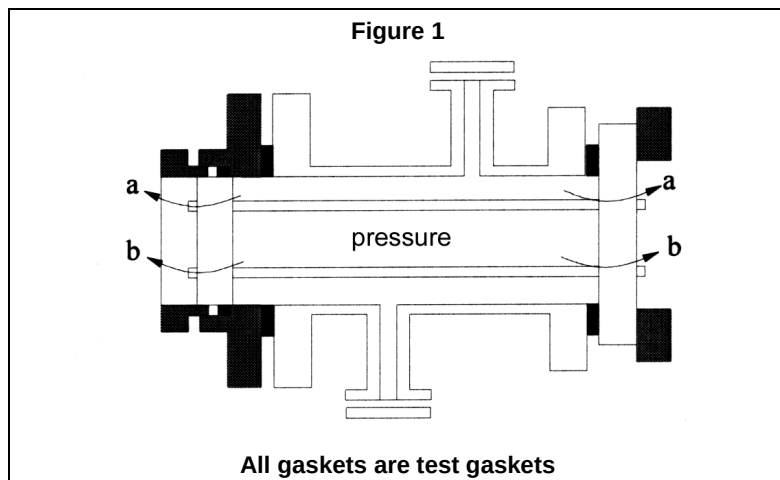
Fig. 4 - See Case 1

Notes:

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

(2) 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.

Standard Drawings	SD PVV 442
Standard for floating-head exchangers	Rev.: 01
	Date: 10/03



Case 1 - Shell pressure $\geq$ bundle pressure

Tests made: 1.3.4

Elements tested:

Fig. 1 - Extratubular space

a. Tube to tube-sheet joints

b. Tube failure

Fig. 3 - Test of channel and floating end

c. Channel

d. Gasket of floating end

e. Gasket between channel and tube-sheet

Fig. 4 - Test of shell cover

f. Gasket between shell and tube-sheet

g. Shell

h. Gasket between shell cover and shell

Case 2 - Bundle pressure > shell pressure

Tests made:

1 (as per SD PVV 441)

2.3.4

Elements tested:

Fig. 2 - Intratubular space

a. Tube to tube-sheet joints

b. Tube failure

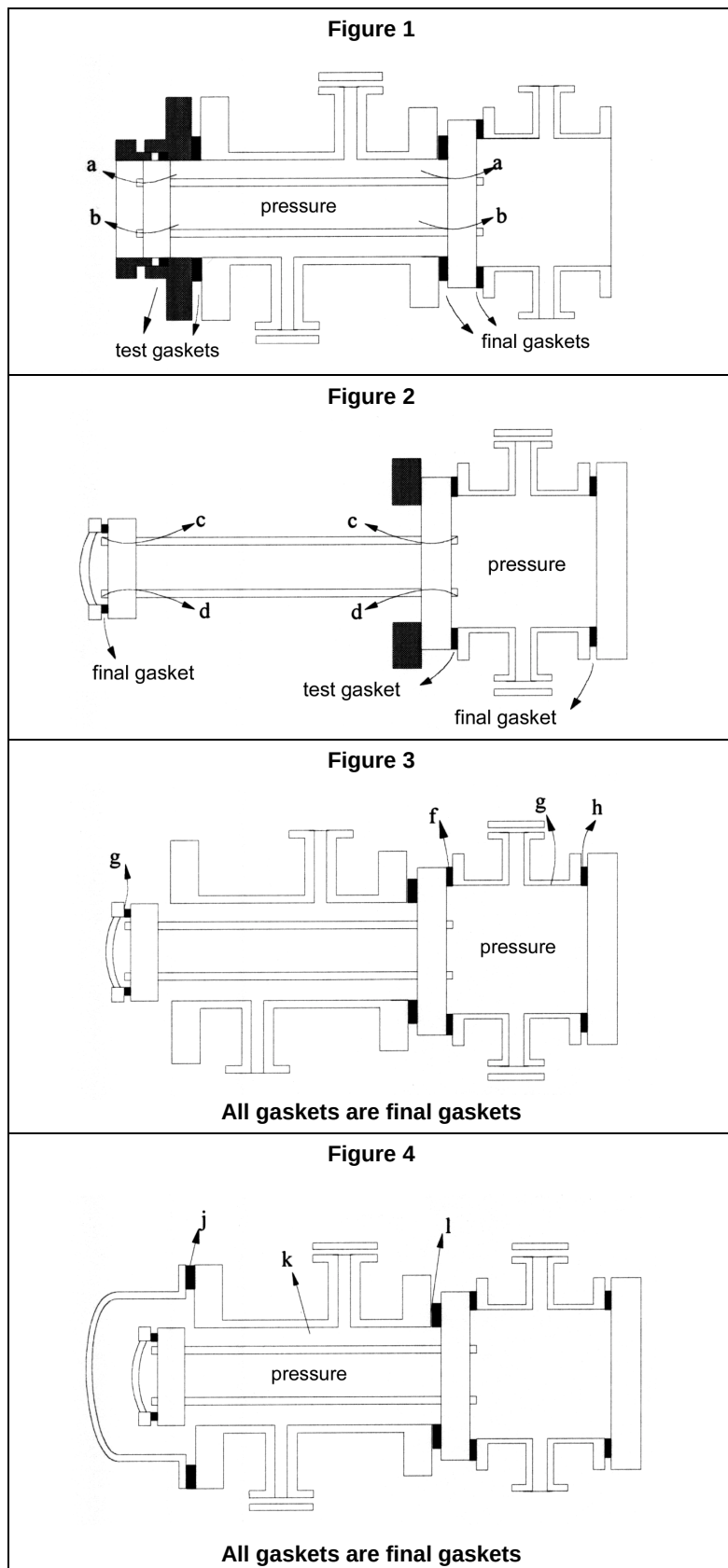
Fig. 3 - See Case 1

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 figures 1 or 2 tests to check the welds and locate any cracking.

Standard Drawings	SD PVV 443
Standard for floating-head exchangers	Rev.: 01
	Date: 10/03



Case 1 - Shell pressure $\geq$ bundle pressure

Tests made: 1.3.4

Elements tested:

Fig. 1 - Extratubular space

a. Tube to tube-sheet joints

b. Tube failure

Fig. 3 - Test of channel and floating head

g. Channel and floating head

h. Gasket between channel and channel cover

f. Gasket between channel and tube-sheet

Fig. 4 - Test of shell

j. Gasket between shell cover and shell

k. Shell

l. Gasket between shell and tube-sheet

Case 2 - Bundle pressure > shell pressure

Tests made: 1 (1) 2.3.4.

Elements tested:

Fig. 1 - See Case 1

Fig. 2 - Intratubular space

c. Tube to tube-sheet joints

d. Tube failure

Fig. 3 - See Case 1

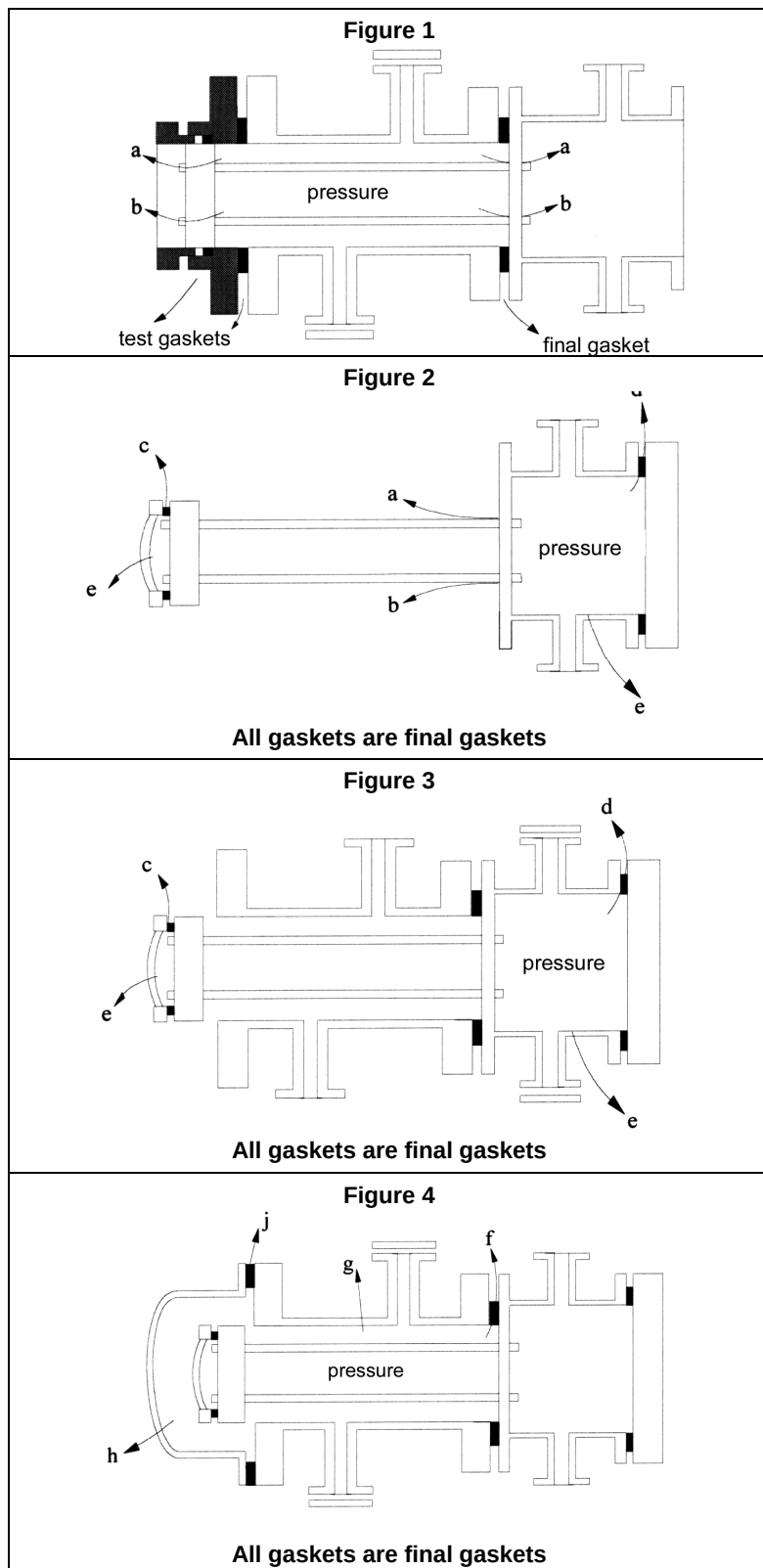
Fig. 4 - See Case 1

Notes:

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

(2) 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.

Standard Drawings	SD PVV 444
Standard for floating-head exchangers	Rev.: 01
	Date: 10/03



Case 1 - Bundle pressure > shell pressure

Tests made: 2.4 (1)

Elements tested:

- Fig. 2 - Intratubular space
- a. Tube to tube-sheet joints
 - b. Tube failure
 - c. Gasket of floating head
 - d. Gasket of channel
 - e. Test of channel and floating head

- Fig. 4 - Test of shell and shell cover
- f. Gasket between shell and channel
 - g. Shell
 - h. Shell cover
 - j. Gasket between shell and shell cover

Case 2 - Shell pressure ≥ bundle pressure

Tests made: 1.3.4.

Elements tested:

- Fig. 1 - Extratubular space *
- a. Tube to tube-sheet joints
 - b. Tube failure
- Fig. 3 - Intratubular space
- c. Gasket of floating head
 - d. Gasket between channel and channel cover
 - e. Channel and floating head

Fig. 4 - Test of shell and shell cover: See case 1.

Notes:

- (1) Test 1 must always be made when the tubes are welded to the tube-sheet.
- (2) Provide blind nuts and gaskets for floating tube-sheet.
- (3) 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 the welds and to locate any cracking.

Standard Drawings	SD PVV 445
Standard for floating-head exchangers	Rev.: 01
	Date: 10/03

Figure 1

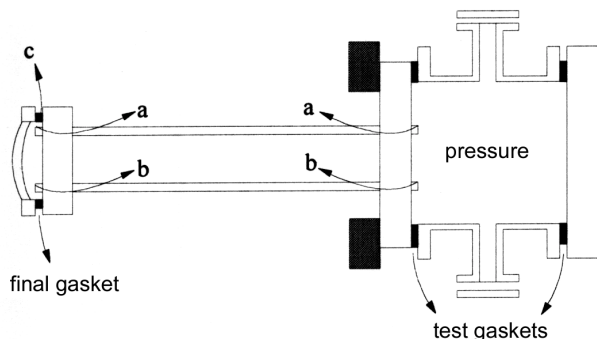
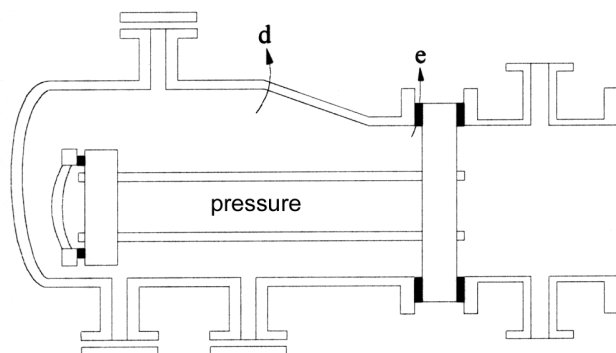
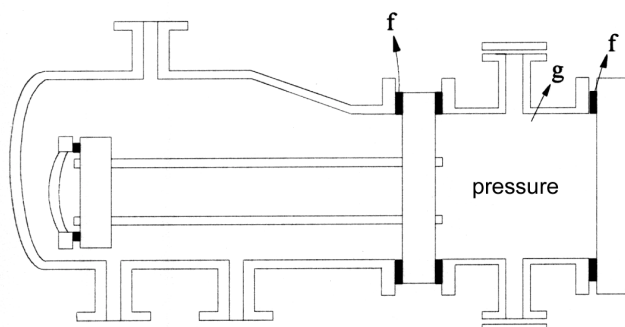


Figure 2



All gaskets are final gaskets

Figure 3



All gaskets are final gaskets

In all Cases:

Tests made: 1.2.3

Elements tested:

Fig. 1 - Extratubular space

a. Tube to tube-sheet joints

b. Tube failure

c. Floating head and gasket

Fig. 2 - Extratubular space

d. Shell

e. Gasket between shell and tube-sheet

Fig. 3 - Test of channel

f. Gaskets between channel and tube-sheet and between channel and channel cover

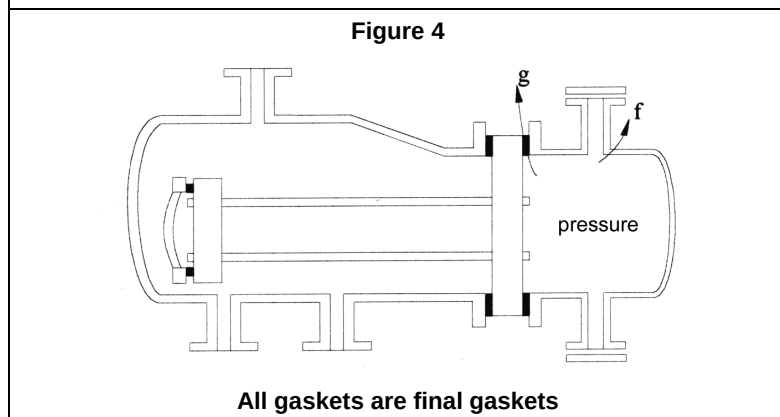
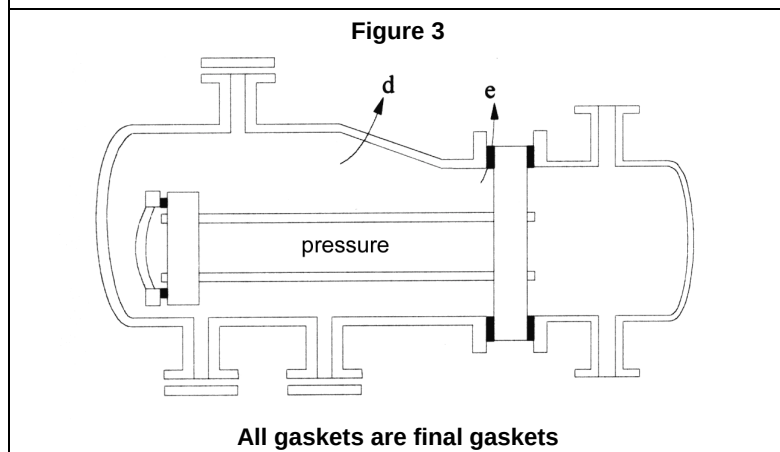
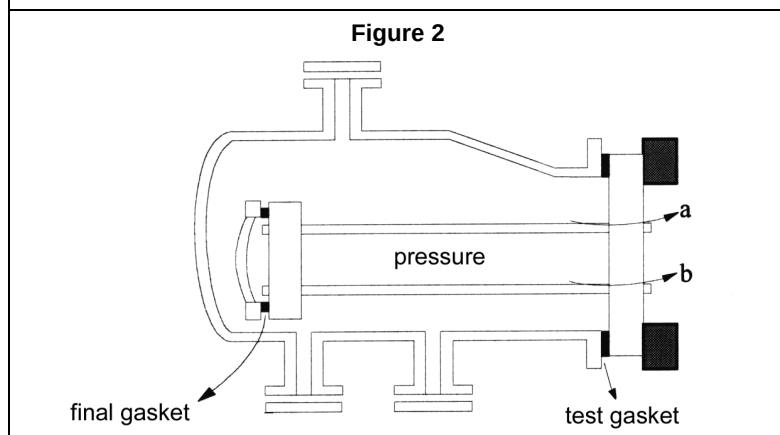
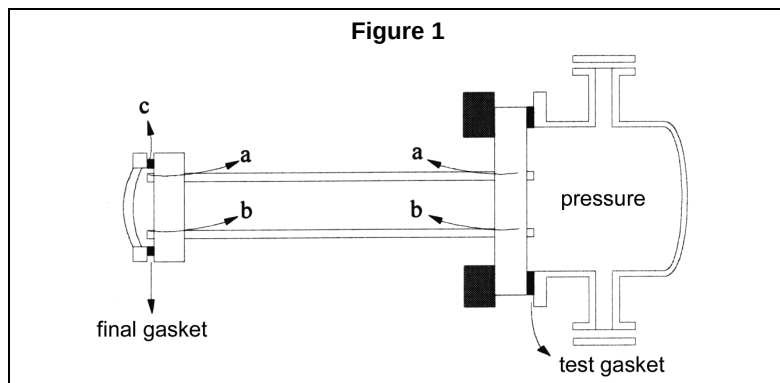
g. Test of channel

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 made before figure 1 test and after figure 2 test to check the welds and locate any cracks.

Standard Drawings	SD PVV 446
Standard for floating-head exchangers	Rev.: 01
	Date: 10/03



In all Cases:

Tests made: 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

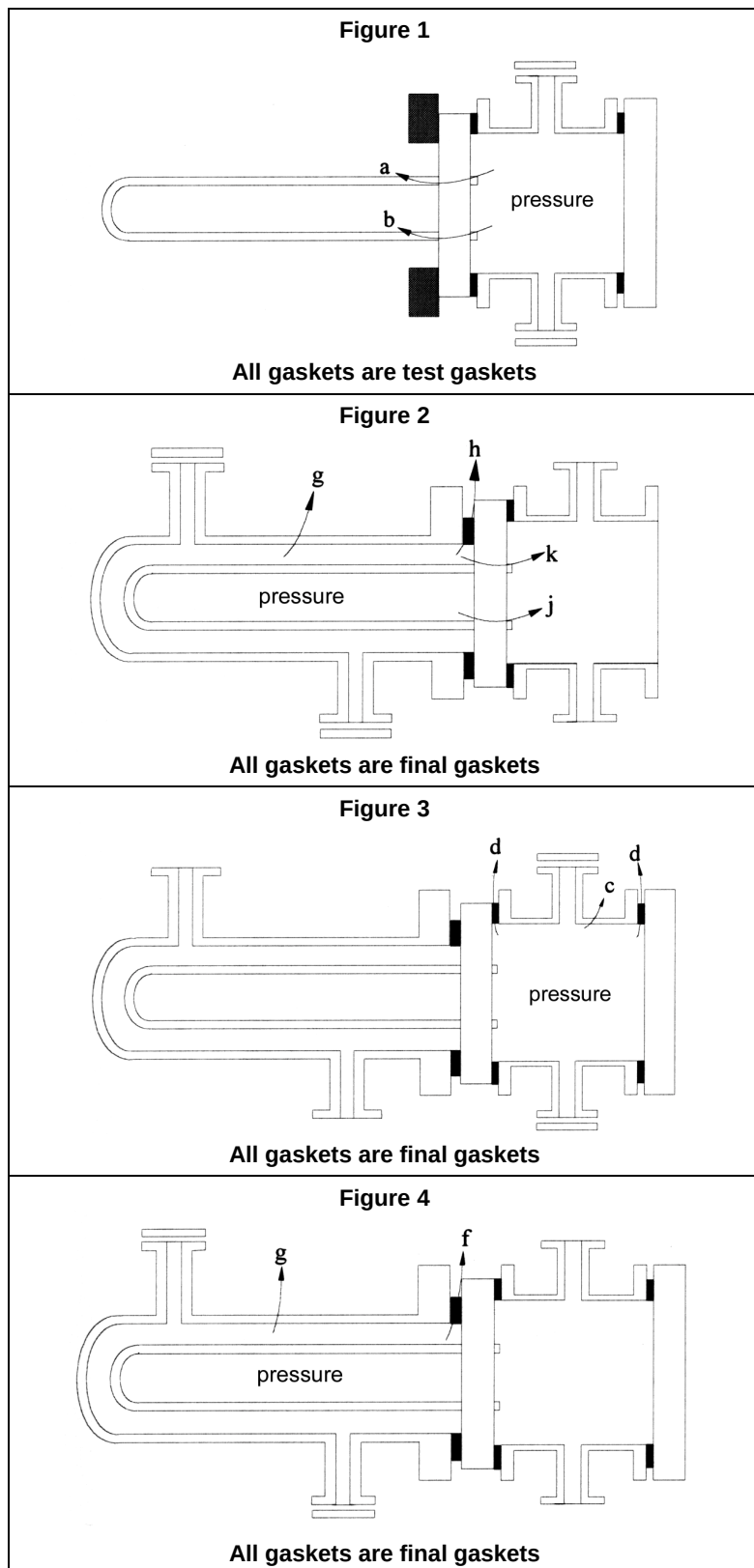
Fig. 2 - Extratubular space
a. Tube to tube-sheet joints
b. Tube failure

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

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

Standard Drawings	SD PVV 451
Standard for U-tube exchangers	Rev.: 01
	Date: 10/03



Case 1 - Bundle pressure $\geq$ shell pressure

Tests made: 1.2 (2). 3.4

Elements tested:

Fig. 1 - Intratubular space

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

Fig. 2 - Extratubular 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 gaskets 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 - Shell pressure $\geq$ bundle pressure

Tests made: 2.3

Elements tested:

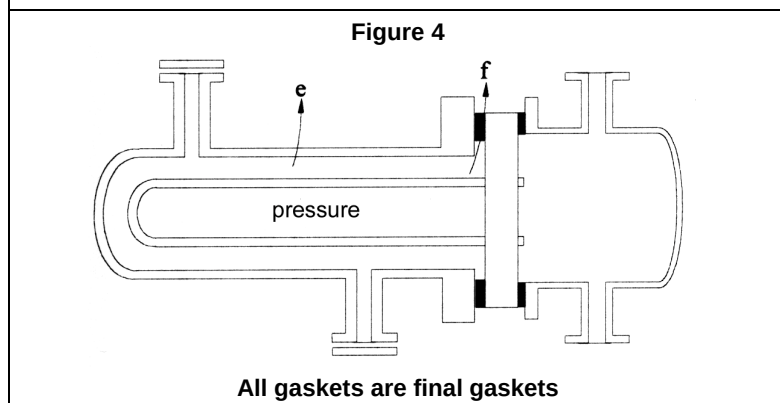
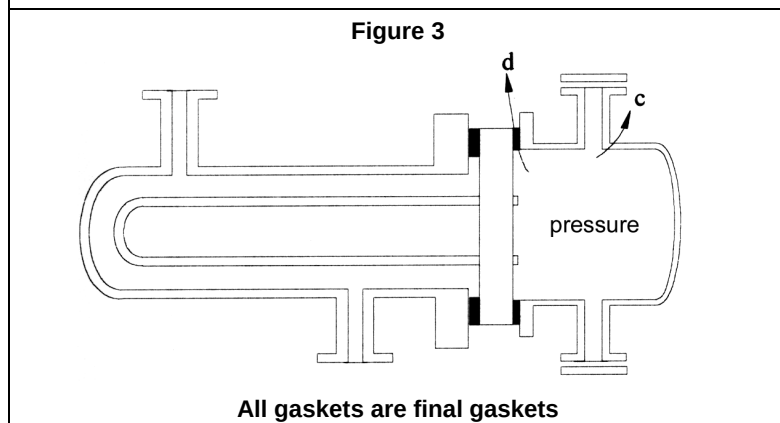
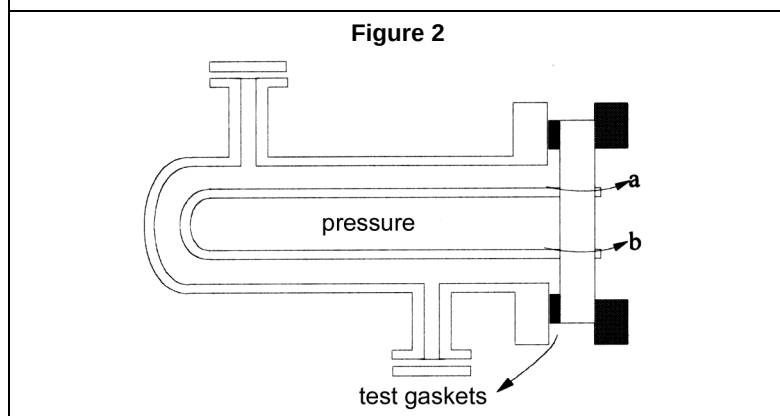
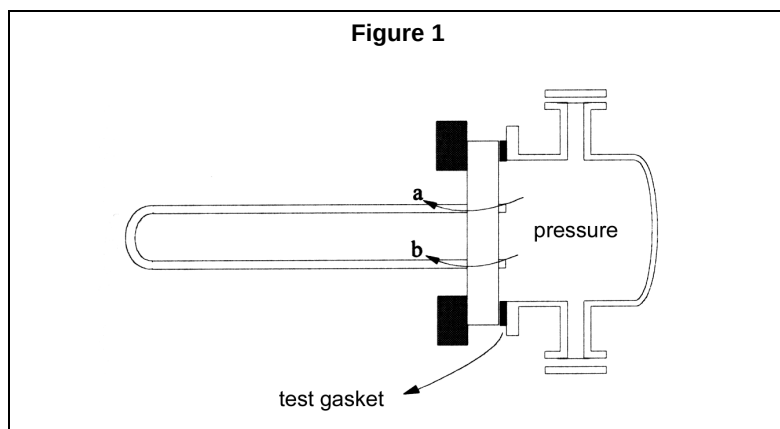
Fig. 2 - See Case 1

Fig. 3 - See Case 1

Notes:

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

Standard Drawings	SD PVV 452
Standard for U-tube exchangers	Rev.: 01
	Date: 10/03



Case 1 - Shell pressure > bundle pressure

Tests made: 2.3.4

Elements tested:

Fig. 2 - Extratubular space

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

Fig. 3 - Test of channel

- c. Test of 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

Tests made: 1.2 (2). 3.4.

Elements tested:

Fig. 1 - Intratubular space

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

Fig. 2 - See Case 1

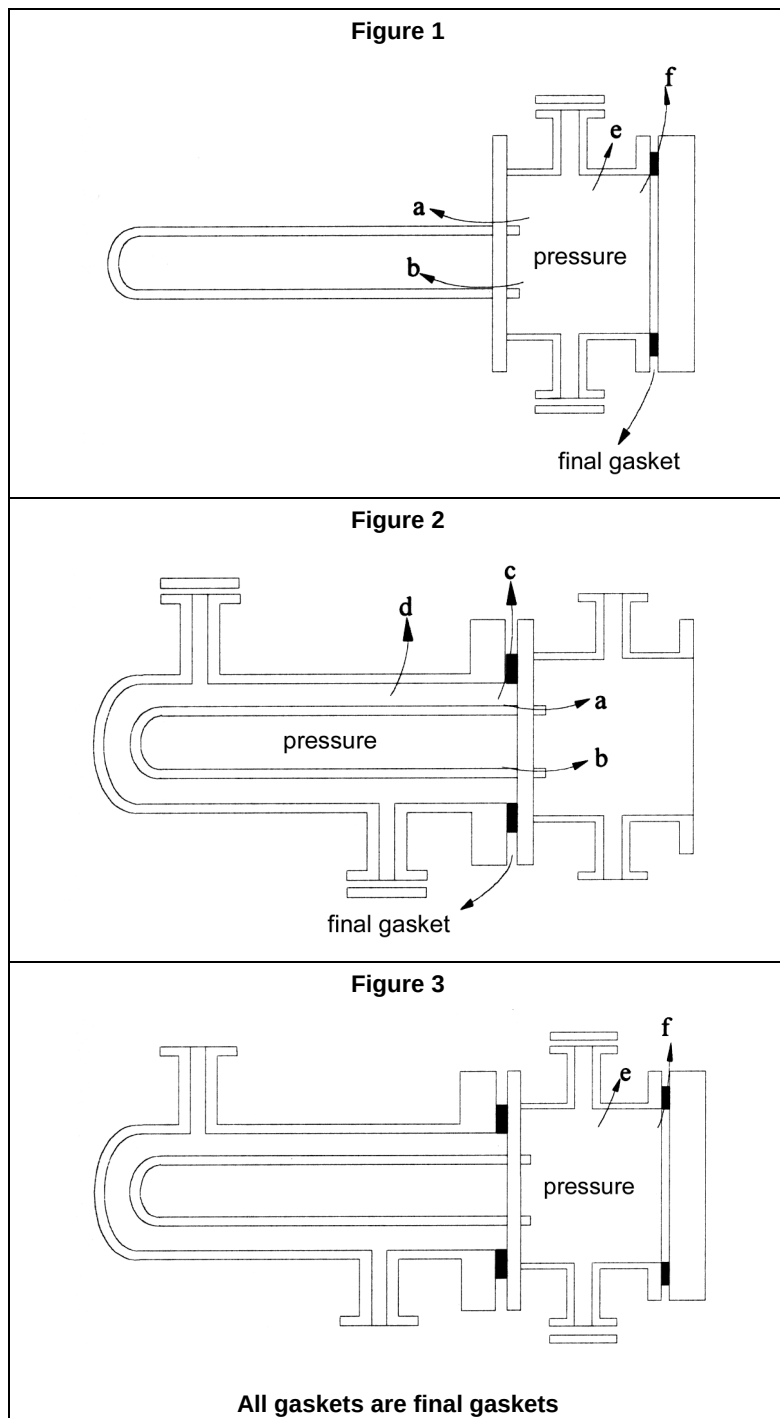
Fig. 3 - See Case 1

Fig. 4 - See Case 1

Notes:

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

Standard Drawings	SD PVV 453
Standard for U-tube exchangers	Rev.: 01
	Date: 10/03



Case 1 - Shell pressure > bundle pressure

Tests made: 2.3

Elements tested:

Fig. 2 - Extratubular space

- a. Tube to tube-sheet joints
- b. Tube failure
- c. Gasket between shell and channel
- d. Shell

Fig. 3 - Intratubular space

- e. Test of channel
- f. Gasket between channel and channel cover

Case 2 - Bundle pressure > shell pressure

Tests made: 1.2.

Fig. 1 - Intratubular space

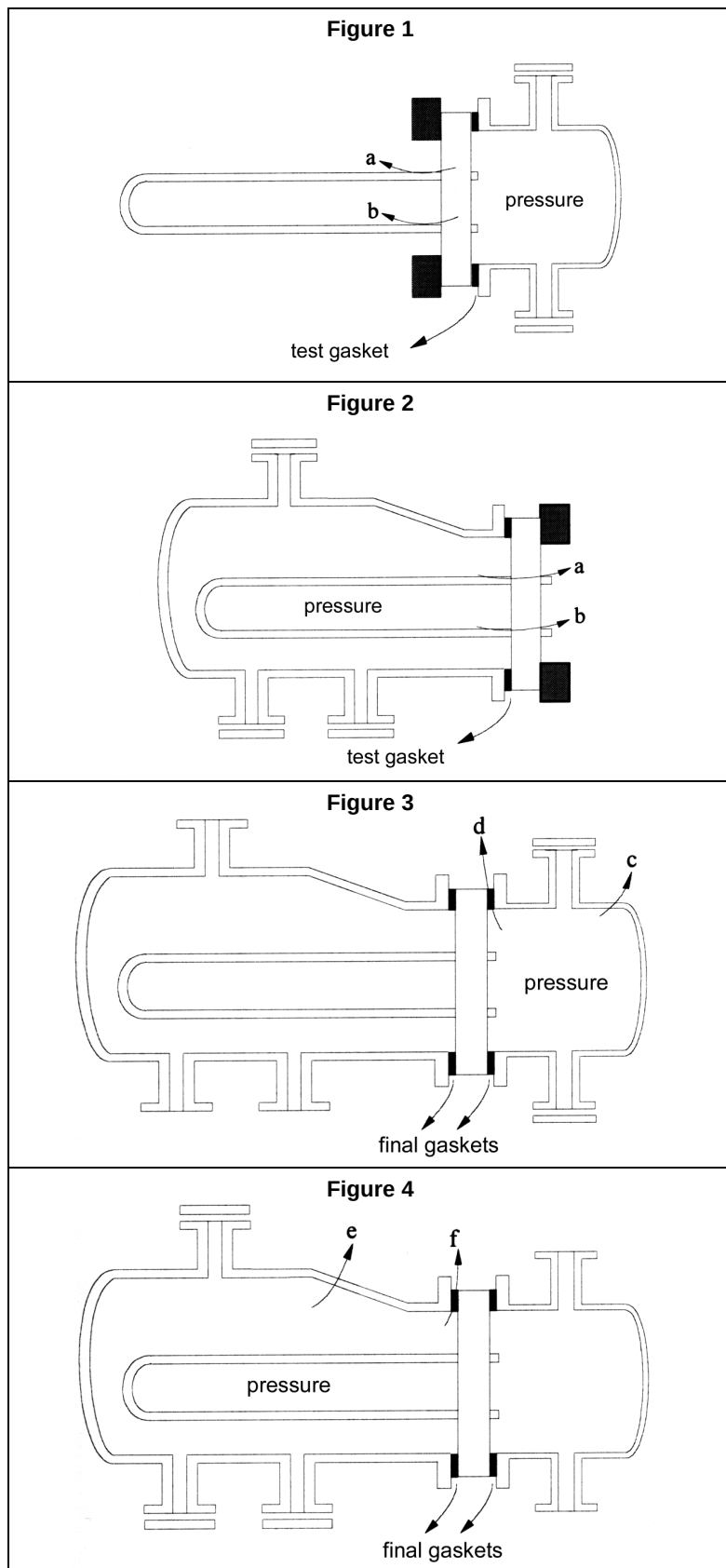
- a. Tube to tube-sheet joints
- b. Tube failure
- e. Channel
- f. Gasket between channel and channel cover

Fig. 2 - Extratubular space

- c. Gasket between shell and channel
- d. Shell

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

Standard Drawings	SD PVV 454
Standard for U-tube exchangers	Rev.: 01
	Date: 10/03



Case 1 - Shell pressure > bundle pressure

Tests made: 2.3.4

Elements tested:

Fig. 1 - Extratubular space

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

Fig. 3 - Test of channel

- c. Test of 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

Tests made: 1.2 (2). 3.4.

Elements tested:

Fig. 1 - Intratubular space

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

Fig. 2 - See Case 1

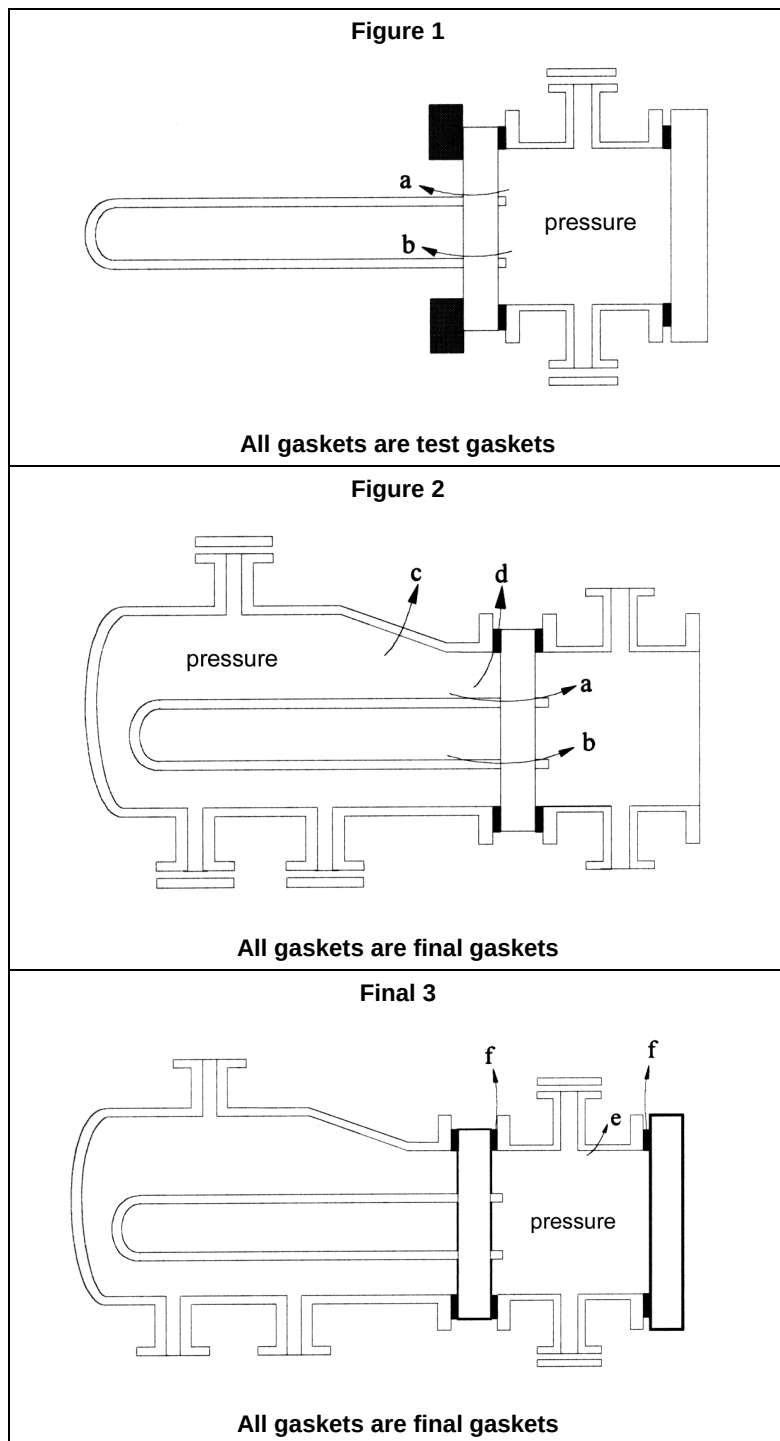
Fig. 3 - See Case 1

Fig. 4 - See Case 1

Notes:

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

Standard Drawings	SD PVV 455
Standard for U-tube exchangers	Rev.: 01
	Date: 10/03



Case 1 - Bundle pressure > shell pressure

Tests made: 1.2.3.

Elements tested:

Fig. 1 - Intratubular space

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

Fig. 2 - Extratubular 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 gaskets between channel and stationary tube-sheet, and between channel and channel cover

Case 2 - Shell pressure ≥ bundle pressure

Tests made: 2.3.

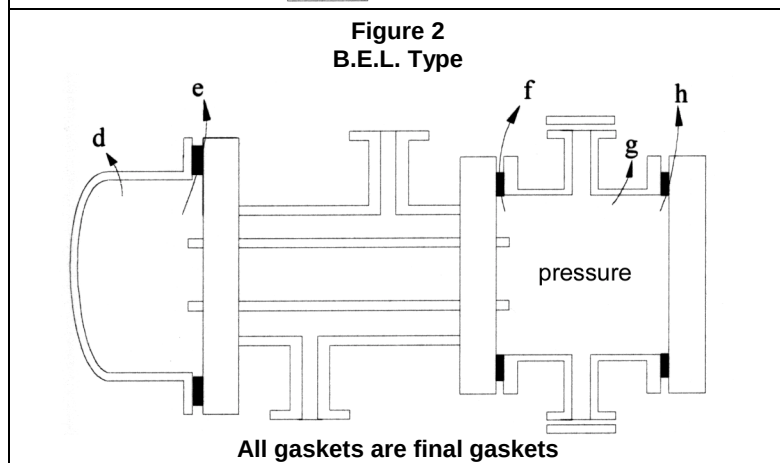
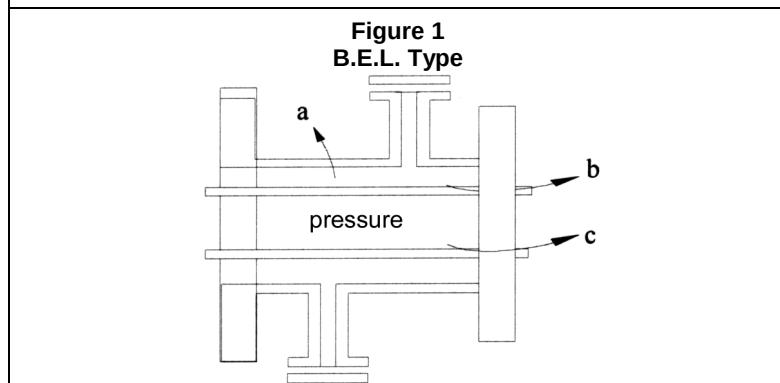
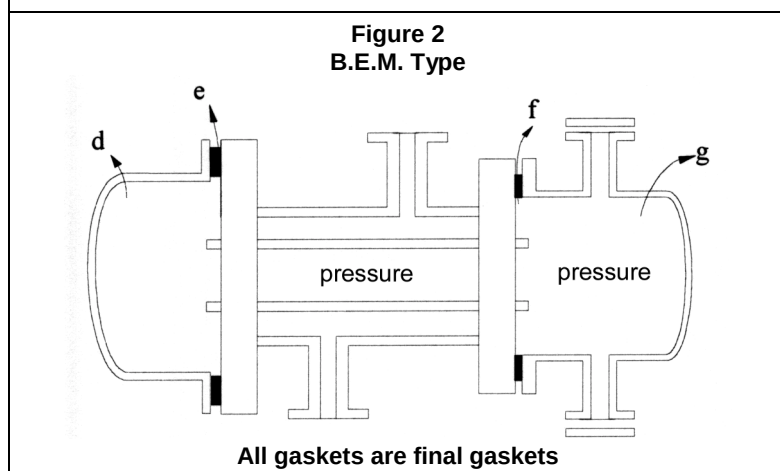
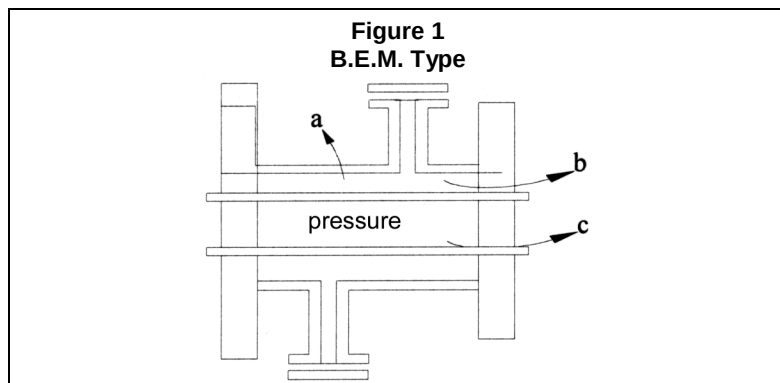
Elements tested:

Fig. 2 - See Case 1

Fig. 3 - See Case 1

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

Standard Drawings	SD PVV 461
Standard for exchangers with fixed tube-sheets	Rev.: 01
	Date: 10/03



Case 1 - Shell pressure > bundle pressure

Tests made: 1.2.

Elements tested:

Fig. 1 - Extratubular 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

Case 2 - Shell pressure < bundle pressure

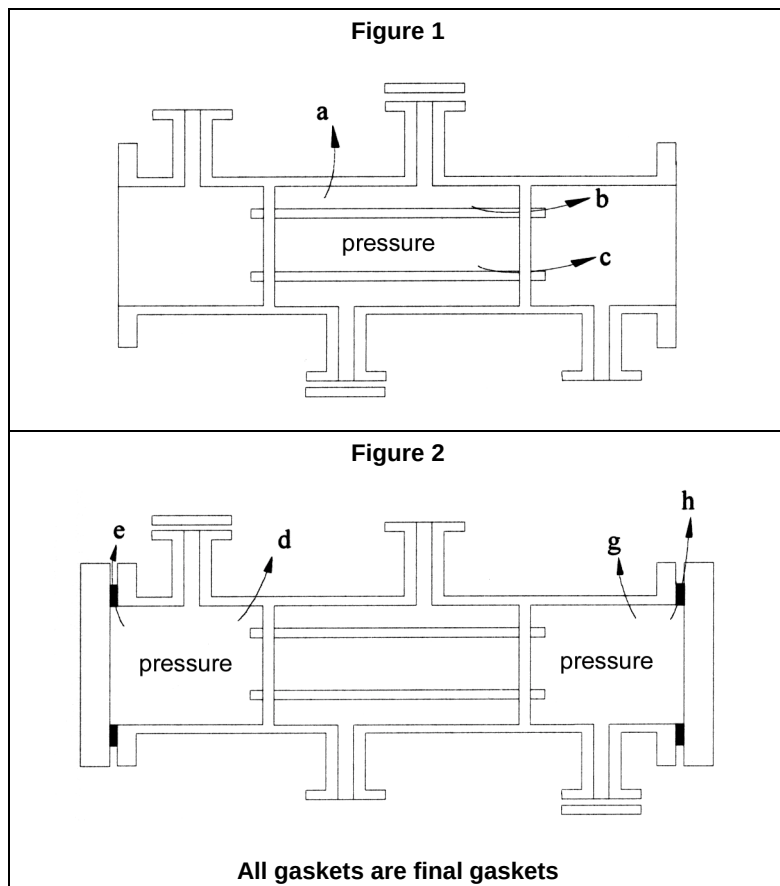
Same tests as Case 1, but for figure 2 tests:

- 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.

Note: For tubes welded to the tube-sheet, a dye-penetrant examination or a test with ammonia must be made before and after the hydraulic test to locate any cracks.

Standard Drawings	SD PVV 462
Standard for exchangers with fixed tube-sheets	Rev.: 01
	Date: 10/03



Case 1 - Shell pressure > bundle pressure

Tests made: 1.2.

Elements tested:

Fig. 1 - Extratubular space

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

Fig. 2 - Intratubular space

- d. Bonnet
- e. Gasket between bonnet and bonnet cover
- g. Channel
- h. Gasket between channel and channel cover

Case 2 - Shell pressure < bundle pressure

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

- Do not drain after the test of the shell (figure 1 test).
- 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 the cover, and note the water level in the glass tube.

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

Note: For tubes welded to the tube-sheet, a dye-penetrant examination or a test with ammonia must be made before and after the hydraulic test to locate any cracks.