

FOSTER
WHEELER
LIMITED



FIRE
HEATER
DIVISION

TECHNICAL NOTES FOR SHELL
AND TUBE HEAT EXCHANGERS

TS REQ. HEDD-67095

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REVISION 1

DATE May 1977

file in Hewlett Spec book

SHELL AND TUBE EXCHANGER DESIGNS

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ST0408240

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2- JUN 1977

FLUOR (GREAT BRITAIN) LTD.	
APPROVED	
EXCEPT AS NOTED	
NO RESPONSIBILITY IS ASSUMED FOR THE	
ACCURACY OF SHOP DIMENSIONS	
CH BY: <i>[Signature]</i>	DATE: <i>[Signature]</i>
ENG R: <i>[Signature]</i>	DATE: 2 JUNE 77

PLAINTIFF'S EXHIBIT

DOW-2432

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SHELL AND TUBE EXCHANGER DESIGNS

1.0 SCOPE

- 1.1 The design 'package' issued with this specification gives a full mechanical design in accordance with the relevant codes, specifications and standard drawings. This document is intended to specify general requirements applicable to all Foster Wheeler designs.
- 1.2 In cases of conflict between this TS Requisition, client specifications or the FW design 'package', the most stringent course of action should be followed.
- 1.3 Cases of inconsistency between design requirements shall be brought to the attention of Purchaser for clarification.

2.0 SPECIFICATIONS

- 2.1 The Vendor shall ensure that he complies with all the requirements of the codes, specifications and drawings listed on the Foster Wheeler design. Normally information contained in the client's standards will not be repeated on the Foster Wheeler design or specifications.
- 2.2 The Vendor's quotation should confirm that all standards, etc. have been reviewed and any exceptions/substitutions must be listed.

3.0 MATERIALS

- 3.1 The Vendor shall submit all proposed material substitutes for Foster Wheeler approval. A copy of sheet 2 of Foster Wheeler designs amended to show the proposed substitutes should be forwarded in all cases. Material A515 is not acceptance under any circumstances.
All material substitutes should be stated with quotations and must be equal to, or better than, the material required. This applies to pressure and non-pressure parts.
- 3.2 Reductions in thickness will not normally be allowed for materials with higher strengths.

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3.0 MATERIALS (Continued)

- 3.3 Where material specifications allow alternative heat treatments, Vendor shall specify appropriate heat treatment to achieve required mechanical properties.

4.0 THICKNESSES

- 4.1 All thicknesses specified are minimum as built; TEMA machining tolerances may be applied.
- 4.2 Dished heads to be spun or pressed from blanks of sufficient thickness to obtain at least the minimum thickness shown in the design.
- 4.3 All dimensions include cladding or corrosion allowances as specified.
- 4.4 Any increase in thickness shall be submitted for approval. Consideration must be given to impact requirements which may depend on thickness. If the barrel thickness is increased, a taper shall be provided at the flange junction to maintain the flange shape as specified on the design.

5.0 WELD DETAILS

- 5.1 Weld details shown on the design are schematic only. All welds are to comply with the code, specifications and local requirements as applicable.

6.0 GASKETS

- 6.1 Gaskets shall have the following maximum brinell hardness:-

Solid soft iron	90
Solid steel	120
Solid monel	110
Solid low alloy up to 5 Cr	135
Solid 13 Cr	135
Solid or jacketed 18/8	160

- 6.2 Metal clad gaskets must be double jacketed.

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6.0 GASKETS (Continued)

6.3 When spiral wound gaskets are specified the design will be based on Flexitallic Bulletin 171. Gasket manufacturers will demonstrate to Purchaser's satisfaction their ability to manufacture in accordance with the Flexitallic criteria. Details of the flange design will be required by gasket manufacturers. The Vendor shall submit a bolting-up procedure for approval including the measurement of at least eight studs to ensure correct pretension.

6.4 Flange gasket faces shall have the following surface finish:-

Asbestos gaskets	125 to 250 RMS
Spiral wound gaskets	125 RMS
Metal clad or solid metal gaskets	63 to 125 RMS

6.5 Stacked units shall be supplied with gaskets and bolting for interconnecting nozzles. Vendor will be advised in writing of type of gaskets required.

6.6 Vendor to supply two spare sets of gaskets for all joints, including girth flanges, interconnecting nozzle flanges and blind flanges for instrument connections etc.

7.0 NOZZLES

7.1 Nozzle flange dimensions to conform to ASA B16.5 for sizes 24" NB. and below. Larger sizes to be to MSS SP44 for large diameter carbon steel flanges.

7.2 Forged slip-on flanges may be used for fabricated nozzles, except above 300 pound standard rating or 400°C design temperature, unless shown otherwise.

7.3 Flanged supplementary nozzles to be provided with gaskets, bolting and blind flanges. Couplings to have bar stock plugs at least 75 mm long.

7.4 Pressure and temperature connections to be initially located transverse to exchanger longitudinal centre line. Vendor will be advised in writing, or on marked-up fabrication drawing, if different orientations are required. All temperature connections to be fitted at an angle of 15° up from the horizontal, unless specified otherwise on marked-up fabrication drawing.

7.5 Nozzle reinforcing pads to be provided with at least one 1/4 API threaded tell-tale hole which shall be plugged with a plastic plug.

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7.0 NOZZLES (Continued)

- 7.6 Where specified on the Foster Wheeler design all shell inlet nozzles to be fitted with impingement plates approximately 25 mm greater than nozzle opening all round.

8.0 TUBES AND TUBESHEETS

- 8.1 When expanded tube/tubesheet joints are specified, the Vendor is to ensure that they are satisfactory for the test pressure and design conditions. Consideration to be given to full thickness rolling if necessary. Tubesheet holes to be machined with at least two grooves, each approximately 3 mm wide and 0.4 mm deep. For clad tubesheets one groove shall be in the cladding and the cladding shall extend 3 mm beyond the groove.
- 8.2 Tubes shall extend 3 mm beyond the face of the tubesheet except on vertical exchangers when they will be flush with the face of the top tubesheet.
- 8.3 Strength welded tube to tubesheet joints shall be in accordance with Fluor specification SP 50780B/50790B-90.3.
- 8.4 Tapped holes for pulling eyes to be provided in stationary tube-sheet for all removable bundles per TEMA. Details to suit refinery bundle pulling gear where applicable. Plugs to be fitted for protection.

9.0 FLOATING HEADS AND CHANNELS

- 9.1 Floating head dish-to-flange weld shall be spot or full radiographed as specified. If radiography does not give satisfactory results, Vendor may offer ultrasonic examination as an alternative.
- 9.2 Pass partition plates to be provided with 6 mm diameter hole for drainage and edges may be tapered back to 10 mm where necessary to fit 13 mm wide grooves.

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10.0 TUBE BUNDLE

- 10.1 If the tube layout drawing is not supplied at the enquiry stage, the Vendor shall give a price per lb. or kg. for sealing strips. Sealing strips may vary between 13 mm and 250 mm in width and will normally be 6 mm thick. On 'U' tube exchangers Vendor to give price per lb. or kg. for dummy tubes to seal gap between innermost tube bends.
- 10.2 All "S" and "T" type exchangers to be provided with a support plate at the floating head end of the tube bundle as required by TEMA. The centre of the support plate to be cut out and/or segments cut off at the periphery to minimise the dead area of shell at the floating end.
- 10.3 Bundle runners are required where the shell diameter exceeds 610 mm. On smaller diameters the Vendor may use his direction.
- 10.4 Kettle type reboilers, etc. shall be provided with guide rails or tracks and a "hold" angle or bar above the floating head (or full diameter support plate on 'U' tube bundles) to keep bundle in place during shipment and handling.
- 10.6 'U' tube exchangers to have support plate close to tangent line of tubes if necessary to keep maximum unsupported tube length within TEMA limits. Support plates to be cut to allow flow over 'U' bends.
- 10.7 Baffles to be notched for drainage unless prohibited in client's specification.

11.0 PROVISIONS FOR MAINTENANCE

- 11.1 Lifting lugs to be provided at C of G for all channels, flat covers, shell covers and floating head covers. On lower exchangers of stacked units two lifting lugs at approximately 45° should be provided on each part. For vertical exchangers provision shall be made for handling in the vertical position.
- 11.2 On vertical "single pass" floating head exchangers, the Vendor is to recommend to Foster Wheeler the required attachments for assembly and dismantling in the vertical position.

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11.0 PROVISIONS FOR MAINTENANCE (Continued)

- 11.3 Vertical exchangers installed in "channel down" position shall have 4 collar bolts minimum for retaining the bundle in the shell when the channel is removed.
- 11.4 All "single pass" floating head exchangers, fitted with bellows shall be provided with restraining bars to protect the bellows assembly during handling. Normally these will also protect bellows during hydrotest. Details of bellows to be submitted for Foster Wheeler approval.
- 11.5 All bellows units to be protected by external shroud.
- 11.6 Jack screws to be provided at the shell cover, channel cover and pull-through floating head cover joints for dismantling.

12.0 BOLTING

- 12.1 All bolting shall, before assembly, have bolt threads and nut contact surfaces coated with lubricant FEL PRO C-5A. For temperatures above 427°C the lubricant shall be suitable for high temperature service.
- 12.2 If hydraulic bolt tensioners are specified, the Vendor is to submit bolt-up procedure for approval.

13.0 STACKED EXCHANGERS

- 13.1 Where two or more exchangers having interconnecting nozzles are to be stacked, they shall be checked in the shop for nozzle match. In no case shall the gasket faces of the flanges be out of parallel by more than 0.8 mm. Interconnecting nozzle flanges to be bolted together with gaskets before final welding.

14.0 NAMEPLATE AND WARNING PLATE

- 14.1 The nameplate shall include all details required by the code, TEMA, local regulations, and DOW specification E92-651. Included in the nameplate shall be the words - main contractor Fluor (Great Britain) Limited together with the Fluor Logo.

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14.0 NAMEPLATE AND WARNING PLATE (Continued)

- 14.2 The following wording "Designed by Foster Wheeler Limited of Reading, England" and the "FW" monogram shall be included on the nameplate.
- 14.3 Warning plates are required for differential pressure or temperature designs, low temperature operations, hydrogen service expansion bellows limitations or assembly procedures and any other special cases.

15.0 TESTING

- 15.1 All heat exchangers shall be hydrostatically tested and certified by the Vendor and witnessed by a Purchaser's inspector in accordance with the provisions of the ASME Unfired Pressure Vessel Code, Section VIII (latest revision). Sufficient number of tests shall be carried out to test fully:-

- (a) Shell side
- (b) Tube side
- (c) Both tubesheets for leakage

- 15.2 The fabricator shall satisfy himself and Foster Wheeler that the temperature of the water used during hydrostatic test is sufficiently high to avoid the risk of brittle fracture. A temperature of 21°C may generally be regarded as satisfactory without impact testing of the material.
- 15.3 It is preferred that the following procedures be observed when carrying out hydrostatic tests. Where Vendors wish to adopt alternative procedures they should submit their proposals to Foster Wheeler Limited for approval.

15.3.1 U-TUBE EXCHANGERS

15.3.1.1 Tubeside pressure greater than shellside.

- (a) Test channel and bundle outside shell to full tubeside test pressure.
- (b) Assemble complete exchanger with new contract gaskets. Test shellside and tubeside, not simultaneously.

15.3.1.2 Shellside pressure greater than tubeside, with Type 'A' Channel.

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15.0 TESTING (Continued)

15.3.1 (continued)

- (a) Assemble bundle in shell with channel fitted and contract gaskets either side of tubesheet. Channel cover removed. Test to shellside test pressure.
- (b) Test fully assembled exchanger as in 15.3.1.1(b) above.

15.3.1.3 Shellside pressure greater than tubeside, with Type 'B' Channel.

- (a) Fit bundle in shell with channel removed and test ring in place. Test shell to shellside test pressure.
- (b) Test fully assembled exchanger as in 15.3.1.1(b) above.

15.3.2 FLOATING HEAD EXCHANGERS

Although bundles are finally tested outside the shell where tubeside pressure is greater than shellside, it may be necessary during manufacture to insert the bundle and test with shellside pressure in order to locate any leaks at either fixed or floating tubesheet. This necessitates the use of a test ring at the floating end for this type of exchanger. The proposed testing procedure for exchangers with pull through type floating heads shall be subject to agreement with Foster Wheeler.

15.3.2.1 Tubeside pressure greater than shellside.

- (a) Test channel and bundle outside shell to full tubeside test pressure.
- (b) Test fully assembled exchanger as in 15.3.1.1(b) above.

15.3.2.2 Shellside pressure greater than tubeside but no removable cover at floating end of shell. Test as 15.3.2.1 (a) and (b).

15.3.2.3 Shellside pressure greater than tubeside with Type 'A' Channel.

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15.0 TESTING (Continued)

15.3.2 FLOATING HEAD EXCHANGERS (continued)

- (a) Fit bundle in shell with channel fitted and contract gaskets either side of tubesheet. Floating head cover, shell cover and channel cover removed. Test ring to be fitted on floating end. Test to shellside test pressure.
 - (b) Fit channel cover and floating end cover. Test tubeside to full tubeside test pressure.
 - (c) Fit shell cover and test fully assembled exchangers as in 15.3.1.1 (b).
- 15.3.2.4 Shellside pressure greater than tubeside with Type 'B' Channel.
- (a) Fit bundle in shell with floating head cover, shell cover and channel removed. Test rings to be fitted on floating end and at fixed tubesheet. Test to shellside pressure.
 - (b) Fit channel and floating head cover, shell cover and channel removed. Test rings to be fitted on floating end and at fixed tubesheet. Test to shellside pressure.
 - (b) Fit channel and floating end cover, test tubeside to full tubeside test pressure.
 - (c) Fit shell cover and test fully assembled exchanger as in 15.3.1.1 (b).

15.3.3 STACKED UNITS

- 15.3.3.1 On completion of initial shell and tubeside hydrostatic tests the units shall be fully assembled and stacked in the shop with contract type gaskets fitted in all joints, for the final hydrostatic test.
- 15.3.3.2 For mating joint and saddle faces a higher standard of alignment is necessary than that allowed by TEMA tolerances. During the stacking of units in the shop, it must be demonstrated to the inspecting authority that none of the bolting at these locations will be subject to undue stresses because of any such misalignment.

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15.0 TESTING (Continued)

15.3.3 STACKED UNITS (continued)

- 15.3.3.3 The shop-stacking requirements and testing procedure for multiple stacked or close-coupled units must be approved by Foster Wheeler.

16.0 PREPARATION FOR SHIPMENT

- 16.1 For stacked units, shims are to be supplied in consolidated thickness and are to be tack welded and match mark stamped in case they are displaced during transit. Thickness of shim is to be stamped on each support.
- 16.2 After completion of fabrication, the heat exchanger shall be thoroughly cleaned. Loose mill scale, spatter and debris shall be removed. Exposed machined surface shall be coated with an easily removable rust preventive. Flanged openings shall be protected.
- 16.3 Shop surface preparation and painting shall be carried out as required by DOW Standard as specified.

17.0 DRAWINGS

- 17.1 The Vendor shall provide fully detailed drawings of the actual construction of the heat exchanger.
- 17.2 The Vendor's drawings must be checked and signed before submission and must include:-
- Fluor (Great Britain) Ltd. contract number
Foster Wheeler Limited design number
Item number
Plant name and location
List of all applicable codes and DOW, Fluor (Great Britain) Ltd.,
F. W. Ltd. specifications.
The statement "Designed by Foster Wheeler Limited"
Details of, or reference to, welding procedures
- 17.3 A separate drawing must be supplied showing gasket details.



18.0 MANUFACTURER'S REPORTS (Retained by Fabricator for 10 years)

Heat exchanger manufacturer's reports shall include:-

- (1) Form U-1 of ASME Code Section VIII
- * (2)A Weld Procedure Specification - to be submitted on the FW form, see Appendix A.
- (3) Welder Performance Qualification - Form QW-484 of the ASME Code Section IX
- (4) Details of the chemical and mechanical properties of all pressure containing parts with a key to those parts.
- (5) Stress relieving charts where necessary.
- (6) Pressure test charts where available.
- (7) Outline drawing showing the location and reference numbers of radiographs.
- (8) Rubbing of heat exchanger stamping
- * (2)B Procedure qualification records on P.Q.R. forms similar to ASME QW 483 preferred,

NOTE All weld procedures need qualification.

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WELDING PROCEDURE DATA
(TO BE COMPLETED BY FABRICATOR ON F.W. DESIGNED EXCHANGERS)

APPENDIX A

CONTINUATION SHEET

1 JOINT DESIGN

Show here a sketch of joint used to qualify this procedure.
Shop drawing must show actual detailed design.

2 PROCEDURE DETAILS

Show here a sketch or sketches giving number and disposition of weld beads

3 Welding position:
(1G, 2G, 3G, 4G, 5G or 6G)

If necessary a separate sketch should be given for each weld position

4	BEAD NO.	ELECTRODE SIZE	AMPS	VOLTS	RATE OF TRAVEL mm PER SEC (NOTE 1)	GAS SHIELD FLOW RATE (NOTE 2)	GAS PURGE FLOW RATE (NOTE 3)
5							
6							
7							
8							
9							
10							

NOTES

- 11 (1) Rate of travel mandatory for automatic welds. Also for M.M.A. and M.I.G. ferritic welds subject to preheat.
12 (2) Gas shield flow rate required for all gas shielded processes.
13 (3) Gas purge rate required for all single-sided butt joints welded by T.I.G. or M.I.G. using inert gas.

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		WELDING PROCEDURE DATA (TO BE COMPLETED BY FABRICATOR ON F.W. DESIGNED EXCHANGERS)				APPENDIX A
1	Vendor:	Vendors Ref. No.				
2	Vendors Procedure No.	Welding Process				
3	Materials Welded (STATE: MATERIAL SPEC., P NUMBER, THICKNESS RANGE)					
4	WELDING PROCESS	CONSUMABLE				A.C./D.C. POLARITY
5		FILLER	TRADE NAME	MAKER	AWS/BSI CLASS	+ -
6	MANUAL METALLIC ARC	ELECTRODE				
7						
8	SUBMERGED ARC	WIRE				
9		FLUX				
10	T.I.G. OR M.I.G.	WIRE				
11		GAS SHIELD (COMPOSITION)				
GIVE FOLLOWING DATA						
12	Method of preparing welding edge:					
13	Method of fit-up (e.g. tacks, brackets, clamps etc):					
14	State welding procedure No.) and preheat for fit-up welds:)					
15	Preheat temperature:					
16	Interpass temperature and times:					
17	Method of applying preheat/) PWHT/interpass temperature:)					
18	Describe control of cooling) after welding:)					
19	Describe treatment between) cooling and any PWHT (Note 1))					
20	Postweld treatment temperature:					
21	Describe treatment of) reverse side of weld:) (Giving method)					
22	Describe treatment of) electrodes, i.e. storage and baking:)					
23	Describe type and size of) tungsten electrode when applicable:)					
24	Any other details:					
25	Note 1: Describe any temporary postweld heat treatment or prolongation of interpass temperature.					
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