

DEP SPECIFICATION

WATER-TUBE BOILERS

DEP 30.75.10.30-Gen.

February 2017

DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design, materials, fabrication, testing, preparation for shipment, and erection of fired industrial type water-tube boiler installations. It applies to continuously operated base load boilers with less than 100 cold start-ups and less than 200 hot start-ups in a 25-year lifespan, and in non-cyclic operation, as typically encountered in exploration and production facilities, oil refineries, chemical plants and gas plants.

This DEP specifies requirements for both heavy duty dual fuel, heavy oil fired units, and light duty gas fired units (possibly with diesel-type fuel back-up facilities).

CO boilers, in which the remaining carbon monoxide in the regenerator flue gas of a catalytic cracking unit is incinerated, may be an adaptation of a standard industrial type of radiant boiler design. In such a case, this DEP may be applied with a few amendments.

Combustor type CO boiler designs (with mainly convective heat transfer) are excluded from this DEP, for this type of CO boilers DEP 30.75.10.31-Gen. applies. Also excluded from the scope of this DEP are Heat Recovery Steam Generators (HRSGs) downstream of gas turbines, for which DEP 30.75.10.31-Gen. applies.

This DEP is not intended for once-through steam generators that are typically used for steam soaking and steam flooding in Upstream operations. Such steam generators are technically water-tube boilers, but they do not have steam/mud drums or superheaters. They produce a low quality steam for direct injection into wells. Parts of this DEP (including the relevant DEM1 requirement, may be applied for the design of these steam generators.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This DEP is a revision of the same number dated February 2016, see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in exploration and production facilities and, where applicable, in oil refineries, chemical plants, gas plants and supply/distribution installations. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

NOTE: The term **Vendor** is used in this DEP. The term **Vendor** shall be understood to mean the Manufacturer/Supplier.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant, authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
Alarm	Implies a notification or notification to the operator that requires the alarm team to determine whether the variable needs an alarm vs. an alert
Data/ Requisition Sheets	DEP 30.75.10.93-Gen. (6 sheets), which shall be used by the Principal and the Manufacturer to specify the detailed requirements and proposals for a particular installation.
Design Class	A categorization defining fit-for-purpose facilities developed through Value Improvement Processes (VIPs) during a project Front End Development (FED) phase.
Fuel	All fuels and combinations of fuels specified by the Principal for firing in the boiler.
Heavy duty service	Boilers fired with residual fuel oil or with waste (or other) gas streams of a fouling nature and boilers located in harsh desert environment exposed to high concentration of air born sand particles.
Light duty service	Boilers fired with clean gas (of a non-fouling nature)
Maximum Continuous Rating (MCR)	The steam production under design conditions, measured downstream of the steam main stop/check valve and any de-superheater. It shall be measured upstream of any take-off of auxiliary steam.
Peak Load	110 % of MCR, unless otherwise specified on the data/requisition sheets.

1.3.3 Abbreviations

Term	Definition
BMS	Burner Management System
BPS	Boiler Protection System
CEMS	Continuous Emission Monitoring System
CFD	Computational Fluid Dynamics
DCS	Distributed control system
EPRS	Effective Projected Radiant Surface
ERW	Electric-resistance-Welded
FLD	Functional Logic Diagrams
HHWL	High High Water Level (trip)
HRSG	Heat Recovery Steam Generator
HWL	High Water Level (alarm)
IPF	Instrumented Protective Function (safeguarding by instrumentation)
ITP	Inspection Test Plan
LLWL	Low Low Water Level (trip)
LWL	Low Water Level (alarm)
MCR	Maximum Continuous Rating
MMCF	Man Made Vitreous Fibre
MOS	Maintenance Override Switch
NDT	Non-Destructive Testing
NWL	Normal Water Level
PEFS	Process Engineering Flow Schemes (also known as Process and Instrumentation Diagrams, P&IDs)
PFS	Process Flow Schemes
PSFS	Process Safeguarding Flow Schemes
RATTS	Range, Alarm, Trip, Timer Settings List
RMS	Root Mean Square
SWG	Standard Wire Gauge

Term	Definition
UEFS	Utility Engineering Flow Schemes (also known as Process and Instrumentation Diagrams, P&IDs)
VDDR	Vendor Documents and Data Repository
WPS/PQR	Weld Procedure Specification / Procedure Qualification Record

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced in this DEP are listed in (6).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2016. The only changes are to DEP cross-references to reflect changes in the DEP library in 2017.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

1.9 DECISIONS

A bullet (●) is shown in the margin of this DEP where further decisions or information are to be provided by the Principal or Contractor. Refer to Standard Form DEP 30.75.10.81-Gen. for recording decisions on the bulleted items indicated in this DEP.

Decisions related to the Design Class performance categories for water tube boilers are beyond the scope of this DEP. Such decisions are intended to be made by the Principal in the project "Define" phase and detailed in project scope defining documentation, e.g., equipment BDEP (Basic Design Engineering Package) or project specifications. See DEP 00.00.07.71-Gen.

2. DESIGN AND ENGINEERING

2.1 GENERAL

- 1. The Principal shall specify in the requisition whether the boiler will be considered heavy duty service or light duty service. See (1.3.2).
- 2. The Principal shall specify whether ASME Section I or EN 12952 is to be applied as the boiler design code for the main equipment.
- 3. The Manufacturer/Supplier shall obtain all local code stamps and certificates needed.
- 4. The boiler shall be of the water-tube type, for liquid and/or gaseous fuels as specified, with forced-draught burner(s) and natural water circulation.
- 5. The boiler shall be suitable for outdoor operation.
- 6. The design shall be proven in practice, robust and capable of 2 years of continuous operation and with not less than 4 years between major overhauls.
- 7. The Manufacturer/Supplier shall give full details of the chemical and physical properties of the construction materials.
- 8. There shall be sufficient space and access for inspection, cleaning, removal and maintenance of such parts as drums, tube bundles, headers, retractable burner parts, fixed and retractable sootblowers, valves, pumps, fans, turbines and electric motors. Specific requirements apply to the accessibility of the flue gas path, superheaters and convective sections of heavy duty boilers.
- 9. If local conditions include risk of freezing, either in operation or out of operation on any part of the boiler (including drain and vent systems and silencers), Manufacturer/Supplier shall include proper freeze protection.
- 10. The Principal shall specify the required efficiency, which will set design targets for the required flue gas exit (stack) temperatures.
- 11. Proven technology shall be applied to comply with requirements for the emission of pollutants to the environment and to optimize energy efficiency.

In this context, 'proven' would be 20,000 operating hours in similar service.
- 12. Emissions during normal operation, startup, shutdown, peak load, minimum load, and soot blowing shall comply with the local/state rules/regulations and project specifications. See also (2.4.2).
- 13. The Manufacturer/Supplier shall provide a 3D model and follow DEP 30.10.05.11-Gen. for 3D model construction and review.
- 14. See (APPENDIX B) for requirements for mechanical erection/ cleaning, start-up and performance testing.

A typical overview of scope of services and supply and terminal points is provided in (Appendix A).

A typical overview of documentation and information exchange for boiler projects is provided in (Appendix C). Appendix C aligns with the Shell Vendor Documents and Data Repository (VDDR) for fired equipment.

2.2 PRESSURE PARTS

2.2.1 Heating surfaces general

2.2.1.1 General

1. In the event sulphur-containing fuels are fired, all metal surfaces in contact with flue gas shall be at a temperature at least 15 °C (27 °F) above the highest dew point (acid or water as the case may be) which may occur during any of the operating conditions (excluding start-up) in combination with any of the fuels specified in the requisition.
 - a. The dewpoint calculation shall be in accordance with the method in ISO 13705.
 - b. For fuels with very low sulphur content (below 20 ppm), the acid dewpoint margin as stated above may be neglected. In that case, the economiser inlet temperature shall still remain above the water dewpoint.
2. For heavy duty applications, convective heat transfer equipment shall have a square or rectangular pitch, and sootblowers installed.
 - a. For light duty applications, triangular pitch may be used.
3. Reduced drillings may be applied subject to approval by the Principal.
 - a. The reduced drillings shall be a minimum 90% of the related inner tube diameter.
 - b. Restriction orifices shall not be applied.
4. Individual tubes shall be supported and guided in order to prevent distortion (lateral movement >1.5 tube diameter) and vibration of the tubes.
 - b. For pendant type superheaters, this requirement may be relaxed to 100 mm (4 in) lateral movement.
5. The Supplier shall be responsible for including sufficient internal tube fouling factors to achieve the guaranteed performance.
 - a. The Supplier shall define and state the actual fouling factors considered for the design.
6. The following minimum internal tube fouling factors shall be applied to determine operating metal temperatures and resulting design temperatures. These fouling factors do not need to be included in the thermal rating for the boiler.
 - a. Economiser 4000 W/m² K (705 Btu/h·ft²·°F)
 - b. Evaporator 5880 W/m² K (1040 Btu/h·ft²·°F)
 - c. Superheater 11760 W/m² K (2075 Btu/h·ft²·°F)
7. A full calculation of the maximum tube temperatures shall be provided to the Principal.
 - a. These calculations shall be based on the peak heat flux derived from the circumferential heat flux distribution around individual tubes (125% of the average heat flux), and including a flue gas mass flow of +12.5% and temperature unbalance of 56 °C (100 °F).

2.2.1.2 Fin density and height

1. Extended surface tubing may be applied to fully convective heat transfer surfaces.
 - b. Where finned tubes are applied, the fins shall be fully welded to the tube and be sufficiently rigid to withstand mechanical cleaning.
2. The maximum fin density, fin type and tube alignment depend on the type of fuel to be fired as follows:
 - a. For light duty applications, the following shall apply:
 - i. minimum acceptable fin thickness ≥ 1.25 mm (0.05 in);
 - ii. maximum fin density ≤ 197 fins/m (5 fins/in);
 - iii. maximum height ≤ 19 mm (3/4 in);
 - iv. serrated (twisted) fins are acceptable;
 - v. staggered tube alignment is allowed.
 - b. For heavy duty application, the following shall apply:
 - i. minimum fin thickness ≥ 2.5 mm (0.1 in);
 - ii. maximum fin density ≤ 80 fins/m (2 fins/in);
 - iii. maximum fin height ≤ 12.5 mm (0.5 in);
 - iv. solid fins only;
 - v. inline tube alignment;
 - vi. installation of adequate tube bank cleaning facilities.
 - c. Alternative fin density may be applied subject to approval of the Principal's designated Technical Authority.

2.2.2 Boiler/combustion chamber

1. The firebox shall be entirely water-cooled.
2. Furnace walls shall be of gas tight membrane or welded wall construction.
 - a. Membrane-type walls constructed from tubes and strips shall be used, and welded over the whole length.
 - b. Attachments to membrane walls shall be made to the strips/fins between tubes and not to the tubes themselves, except for gas-tight boxes with small loadings at the walls.
3. The application of refractory shall be limited to the following:
 - a. burner throats;
 - b. flame observation windows;
 - c. the top and bottom header of the circulation system;
 - d. the sealing of (superheater) tube protrusions.
4. The Manufacturer/Supplier shall apply sloping firebox bottoms so that floor tubes do not need to be covered with floor tiles, wherever possible.
 - a. If the tubes are within 15° of horizontal, the furnace floor shall be partially or completely covered with refractory or bricks to avoid excessive vaporization.
5. Provision shall be made for draining the combustion chamber of the wash-down water that will be used at shutdowns or in case water has accumulated after a tube rupture.
6. For cleaning of boilers, chemical cleaning shall be in accordance with procedures as agreed with the Principal.

7. In sizing the firebox, the Manufacturer/Supplier shall take into account the following:
- the maximum local (peak) heat flux based on the projected tube surface exposed to the fireside to be limited to 250 kW/m^2 ($80,000 \text{ Btu/h.ft}^2$) if the boiler feedwater quality does not meet the specification in EN 12952-12:2003, Table 5.1 for demineralised feedwater for each individual component;
 - where the boiler feedwater quality meets the specification in EN 12952-12:2003, Table 5.1 for demineralised feedwater for each individual component, a maximum local (peak) heat flux of 400 kW/m^2 ($125,000 \text{ Btu/h.ft}^2$) is allowed (based on the projected tube surface exposed to the fireside), as long as the peak heat flux does not exceed the Manufacturer's own standards;
 - the need to limit the furnace exit gas temperature (in fouled condition) to avoid high temperature corrosion/overheating of the superheater tubes or other components. This temperature limitation depends on the type of fuel fired and is 1350°C (2500°F) for light duty applications or 1200°C (2200°F) for heavy duty applications;
 - the requirement to ensure completion of fuel burn-out in the combustion chamber and to comply with the emission of unburned hydrocarbons/particulates;
 - burner manufacturer's minimum requirements for distance between burners and for burner to side/rear wall distances, with an additional wall clearance of at least 20% to be applied relative to the flame dimensions indicated by the burner Manufacturer;
 - the fire box dimensions and design to be such that complete combustion occurs within the furnace volume without flame impingement on side walls, roof or target walls during any operating condition. Impingement is defined as contact of the flame contour with any of the tubes. Flame contour may also be based on a predefined concentration profile of CO;
 - compliance with the defined emission limits of nitrogen oxides and carbon monoxide in the flue gases;
 - compliance with circulation requirements as stated in (2.2.5).

This DEP imposes no fixed limiting values on volumetric or superficial heat release rates in the furnace, as these vary significantly with size and type of equipment.

8. The Manufacturer/Supplier shall optimise the furnace design and provide the total heat release rate based on furnace volume (kW/m^3 (Btu/h.ft^3)) and the heat absorption rate (kW/m^2 (Btu/h.ft^2)) based on the projected furnace heat transfer surface.
- This information shall be based on the lower heating value of the fuel and Maximum Continuous Rating (MCR) operating conditions and be provided on the data/requisition sheets.
 - For the calculation of the above quantities, the following definitions shall be used:
 - the furnace heat transfer surface is the projected surface of tube fraction and fins exposed to radiation of the planes which pass through the centres of all furnace tubes plus 10% of the surfaces which are covered by refractory or floor tiles and including the front half of the tubes perpendicular to the flue gas flow where the flue gases reach the first convective heat transfer surface;
 - the full circumferential surface of free hanging superheating panels in the firebox (e.g., platen superheaters) with a spacing between the panels of 300 mm (12 in) or more, may be added to the furnace heat transfer surface. If spacing is less, these superheater panels are considered the first convective heat transfer surface;

This definition slightly differs from the definition of Effective Projected Radiant Surface (EPRS).

- iii. the planes as described above enclose the furnace volume.
- 9. Furnace tubes shall be bent around observation ports, access doors, sootblowers, burner ports etc., in order to make room for them.
 - a. No (intermediate) distribution headers or bifurcated tubes shall be applied in the 2-phase flow regime.
- 10. For heavy duty boilers, the burner lay-out and the path of the flue gas through the boiler shall ensure symmetrical heat flux loading of the furnace walls and all convection coils.
 - a. To achieve this, front wall (or tangentially fired) boilers with vertical gas flow furnaces and convection passes shall be applied.
- 11. Other boilers may have horizontal furnaces with flue gas flow diversion in the horizontal plane (e.g., D-type and bi-drum boilers).

2.2.3 Superheater

- 1. The superheater shall have a substantially flat temperature-load characteristic, so that excessive desuperheating will not be necessary. See (2.2.4) for limits.
- 2. The steam flow shall be evenly distributed over parallel coils of the superheater(s) at MCR where the unbalance is a maximum of the following:
 - a. 3% for the secondary and final stage superheater;
 - b. 8% for the primary superheater.
- 3. Headers with a length more than 2.7 m (9 ft) shall be equipped with multiple inlet nozzles with a maximum spacing of 2.7 m (9 ft).
- 4. Uniform distribution of the flue gases shall be achieved over the superheater coils, avoiding flue gas bypassing.
- 5. All headers shall be outside the flue gas passage.
- 6. Superheaters with horizontal tube orientation shall be drainable.
 - a. Boiler designs including pendant superheaters with non-drainable loops are acceptable.
- 7. Arrangements shall be made and instructions given, as necessary, to ensure adequate cooling of the superheater during start-up.

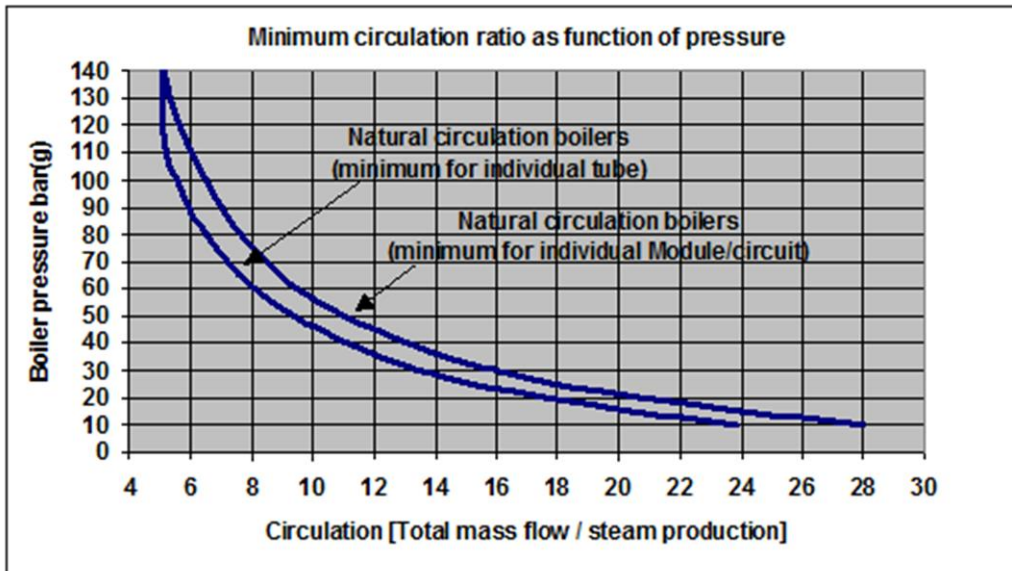
2.2.4 Steam temperature control

1. If the temperature variations of the superheated steam exceed the limits indicated by the Principal on the requisition, steam temperature control may be accomplished by desuperheating. For desuperheating using spray water injection, the following requirements shall apply:
 - a. the thermal design of the boiler to be balanced so that the total injection water flow will not exceed 15% of superheater steam supply to the steam header, provided the injection water quality complies with the water specification as described in EN 12952-12;
 - b. a steam pipe to be provided with internal sleeve and nozzle to allow for inspection.
2. De-superheating via a heat exchanger submerged in the boiler's lower drum (in a bi-drum arrangement) is not accepted, as steam formation in this drum readily disturbs circulation.
3. De-superheating in the steam drum may be allowed subject to approval of the Principal, if the Manufacturer/Supplier can prove that sufficient measures are taken to avoid effects on drum level (measurements) and steam quality.
 - a. The maximum steaming rate in the steam drum due to embedded de-superheaters shall not exceed 5% of MCR steaming production.
4. In order to ensure complete evaporation of the spray water, the steam temperature after desuperheating shall be maintained at a minimum of 25 °C (45 °F) above the steam saturation temperature in any design case.
5. The steam temperature directly upstream and downstream of the de-superheater station shall be provided to allow for monitoring and control (see Standard Drawing S 75.004).
 - a. The Manufacturer/Supplier shall strictly adhere to the instructions of the de-superheater Supplier with respect to minimum upstream and downstream (straight) distance.
6. For thermowells in steam lines, the immersion length shall be based on steam velocity and temperature.
7. The selection and specification of thermowells shall be according to DEP 31.38.01.11-Gen. which includes aspects regarding design, vibration and determination of possible fluid velocity limitations.
8. The Manufacturer/Supplier shall provide a thermowell vibration analysis calculation.

2.2.5 Evaporators

1. All evaporators shall be of the natural circulation type.
2. The circulation ratio (ratio of total circulating mass/steam production) and the applied velocities in both convective evaporators and firebox shall, as a minimum, comply with Figure 1 for each circulation circuit/tube.

Figure 1 Minimum circulation ratio as function of drum operating pressure



3. Depending on the level of detail of the Manufacturer/Supplier's circulation study, a minimum circulation ratio for tube modules shall be adhered to or a minimum circulation ratio in individual tubes.
4. For horizontal tubes (inclination less than 20°), the superficial water velocity at any location shall be at least 1.0 m/s (3.3 ft/s).
5. Sufficient water supply to each tube shall be ensured, also in case of more or less heat pickup, by means of both the following:
 - a. inlet and outlet manifold design with maldistribution of a maximum of 5% RMS at all operating conditions;
 - b. the Supplier providing flow/maldistribution and stability calculations for approval of the Principal.
6. The circulation ratio should be at least equal to the minimum requirements set by the Supplier for the proposed design and water quality.
7. The velocities of water and steam at the inlet and outlet of the various sections of the evaporator system shall be recorded on the data/requisition sheets.

2.2.6 Economiser

1. Economisers should not generate steam under any condition unless special precautions are taken, since two-phase flow may lead to a maldistribution of flow or flow/pressure instability in the economiser coils.
2. In heavy duty boilers with a vertical gas path, steaming may be accepted if all of the following are met:
 - a. the superficial water velocity is above 1.5 m/s (5 ft/s) at MCR at any location. Other velocity criteria may be used, but are subject to approval by the Principal;
 - b. the flow is entirely upwards without any low or high points;
 - c. no intermediate headers are applied in the sections where the approach temperature is predicted to be less than 10 °C (18 °F);
 - d. the Supplier proves to the Principal that a non-steaming economiser is not reasonably practicable within the thermal design of the boiler;
 - e. the steam drum connection for a steaming economiser is located below the centre line of the drum and upstream of the primary stage steam/water separators.
3. A non-steaming economiser outlet line shall be connected below the minimum water level of the drum, avoiding any interference with the drum level measurement and steam purity measurement.

2.2.7 Drums

1. The drum design and arrangement shall ensure the required steam and water separation, distribution and circulation in conjunction with the rest of the boiler.
2. The water level in the steam drum is controlled within a narrow band so as to ensure:
 - a. a constant supply of boiler water for cooling the radiant and convection sections;
 - b. no water carry-over into the superheater.
3. Heavy duty boilers shall be single drum type.
 - a. A bi-drum arrangement may be applied subject to approval of the Principal.
4. In a single-drum boiler the drum shall be outside the flue gas passage.
5. For drum internals, the following shall apply:
 - a. internals are fully accessible and cleanable with fully bolted construction;
 - b. internals are designed to fit through manholes without modifying internals or the drum;
 - c. all bolts/nuts to be secured with tagweld or other means to prevent unintended loosening of bolts/nuts.
6. For drum manholes, the following shall apply:
 - a. the drum(s) accessible from both sides via elliptical manholes (minimum size 490 mm × 390 mm (19in x 15 in)) that can be conveniently reached from platform;
 - b. drum manhole covers open to inside (to assist proper closure) and be supported by adjustable hitches/davits;
 - c. drum equipped with external and internal handgrip above the manhole to allow for safe entry.

7. Tube stubs, suitably prepared for welding, shall be provided at the drums if tubes are to be welded.
 - a. Nozzles, stub ends for valves, fittings, mountings, tubes and anything to which drum internals are to be secured shall be shop-welded into place.
 - b. The length of the stubs shall be such that welding the tubes to the stubs will have no adverse effects on the drum or stub-to-drum connections.
8. Rolled/expanded tube to drum connections are only permitted if approved by the Principal.
9. Nozzles on drums/vessels shall not be smaller than DN 40 (NPS 1-1/2), for strength reasons.
10. The steam drum volume shall be adequate to accommodate a 25% increase in steam generation per minute, relative to the rated load, without drum water carryover.
 - a. Drum water volume below the normal liquid level shall accommodate water shrinkage resulting from a 25% decrease in steam generation per minute, relative to the rated load, without actuating the low water alarm.
11. The size of the drum shall be determined by the following minimum requirements:
 - a. minimum level difference between NWL and LWL of 150 mm (6 in);
 - b. minimum level difference between NWL and HWL of 150 mm (6 in);
 - c. at MCR capacity, with continuous blowdown at its normal value, and no feedwater intake, a hold-up time of at least 60 s between low level alarm (LWL) and low-low level trip (LLWL);
 - d. at no steam flow, with feedwater intake at MCR capacity, a response time of at least 30 s between high level alarm (HWL) and flooded drum internals (high-high level trip (HHWL) if installed);
 - e. the HHWL trip, if installed, is at least 75 mm (3 in) above high level alarm (HWL) and at least 150 mm (6 in) below the secondary separators to ensure a good flow distribution to the separators.
12. The normal water level, the low-low trip level and the maximum trip level shall be indicated by engraved marks both on the drum(s) and on the level gauges with Engravings protruding outside the insulation.
13. The feedwater distribution manifold shall be provided to distribute water equally along the length of the drum.
 - a. Steam and water shall be separated evenly over the length of the drum.
14. In case phosphate chemicals are dosed to the boiler, the chemicals should be dosed in the boiler feedwater (BFW) piping section between economiser and drum, such that equal distribution of chemicals is achieved via the evenly distributed feedwater.
 - a. In case volatile chemicals are used, the dosing location should be upstream of the economiser.
15. The feedwater inlet connection(s) on the steam drum shall be designed with a thermal sleeve when the approach temperature is greater than 55 °C (100 °F) for any operating condition, or when required by the design code.
16. The steam drum shall have primary and secondary steam separators of sufficient capacity to achieve the required steam quality as Table 1.
17. The drum water pH/conductivity analyser sample connection shall have an independent nozzle on the drum (not connected to blow down lines), or alternatively on the downcomer.

Table 1 Steam drum efficiency

Pressure (Drum)		Required Efficiency	
[psi]	[bar]	[%]	Separation ratio
0-300	0-21	99.97	3500
301-450	21-31	99.97	3000
451-600	31-41	99.96	2500
601-750	41-52	99.95	2000
751-900	52-62	99.93	1500
901-1000	62-69	99.92	1250
1001-1800	69-124	99.90	1000
1801-2350	124-162	99.80	500
2351-2600	162-179	99.80	500
2601-2900	179-200	99.67	300

2.2.8 Downcomers

1. Downcomers shall be as near to the bottom of the drum as practicable to permit maximum use of drum water content.
2. Downcomers shall be equipped with sufficient means to avoid vortexes in drum level surface and vapour entrainment in the downcomer (not for small diameter downcomers in case of bi-drum arrangement).
Components installed to avoid vortexes and vapour entrainment could be vortex breakers or cover plates located at the inlet of the downcomer.
3. In light duty boilers, downcomers may be (partially) heated provided that the following conditions are met:
 - a. downcomers and riser are separated by drum internals so that only dedicated risers and downcomers are present;
 - b. for all tubes assigned as downcomers, the heat flux is so low that even if 3 times the expected heat flux is applied at the expected circulating mass flow, the water remains in single phase water flow;
 - c. the application of heated downcomers is restricted to the low temperature zones of the boiler where the flue gas temperature is below 600 °C (1100 °F) in any design case.
4. Water velocity in downcomers shall be limited to:
 - a. maximum 3 m/s (10 ft/s) in unheated downcomers;
 - b. minimum 1.5 m/s (5 ft/s) in heated downcomers.
5. Bottom distribution headers shall be equipped with nozzles of minimum DN 50 (NPS 2) and welded caps, to allow inspection of these headers and the water distribution piping to individual tube headers.

2.2.9 Air preheater

1. Air preheaters shall not be applied if the temperature of the feedwater entering the boiler is 20 °C (36 °F) or more below the flue gas stack temperature required to achieve the specified efficiency.
2. An air preheater is normally not applied for heavy duty boilers, however an air preheater may be accepted by Principal if the following requirements are met:
 - a. adequate means are in place to prevent S-dewpoint corrosion;
 - b. the air preheater is provided with adequate cleaning provisions.
3. If an air preheater is required, the size of the economiser shall be designed with an approach temperature between 10 °C (20 °F) and 30 °C (50 °F) at MCR.
4. The design of the air preheater shall take into account the minimum allowable metal temperature defined in (2.2.1) for minimum ambient temperature design.
5. The flue gas acid dew point shall be calculated and stated by the Manufacturer/Supplier, and any features for minimizing external coil corrosion identified.
6. A steam air pre-preheater may be installed in the airflow upstream of the air preheater to protect the air preheater from dew point corrosion. To avoid rapid fouling and ensure sufficient mechanical robustness, the following shall apply for this steam air preheater:
 - a. maximum fin density ≤ 236 fins/m (6 fins/in);
 - b. maximum fin height ≤ 19 mm (0.75 in);
 - c. tube diameter ≥ 19 mm (0.75 in);
 - d. fins to be aluminium material.
7. The air preheater should be provided with an air by-pass system to control the flue gas exit temperature.
 - a. Such a system should have mechanically interlocked isolating dampers, to direct air to the air preheater or air by-pass, as required.
8. Recuperative air preheater designs with cast iron tubes or open channels are acceptable.
9. Regenerative type air preheater designs (e.g., rotary type air preheater) may be considered upon approval by the Principal.
10. For heavy duty boilers, the flue gas side of recuperative air preheaters shall be equipped with automatically operated rake type sootblowers and water wash system.
11. The air/flue gas duct shall be designed so that the air is distributed evenly over the air preheater (across more than 95% of the cross sectional plane through the front of the heat exchanger the air velocity to be within 5% of the average).

2.2.10 Observation and access

1. Air-cooled observation windows shall be provided as follows:
 - a. provide an unrestricted view of all burners, tips, throats and the full flame envelope;
 - b. provide an unrestricted observation of all surfaces on the back and side walls, and the screen or superheater gas inlet on which flames can impinge; the line of sight being parallel to these surfaces;
 - c. be installed at each side of the boiler front to allow viewing along the side walls;
 - d. have windows with a diameter of at least 100 mm (4 in).
2. The Manufacturer/Supplier shall provide a general arrangement drawing of viewports and locations, together with view areas to show the visibility of screen, membrane walls and burners, for approval by the Principal.
3. Air purging shall be provided to keep observation windows sealed, clean and cool.
 - a. Air may come from the forced draught fan or from a separate cooling air fan.
4. The glasses shall be made from fused silica glass as a minimum, and provided with external covers to prevent cracking by rain ingress and with internal pivoting metal plate (protection flapper) to protect the flue gas side.
5. It shall be possible to renew the glasses during operation.
6. There shall be an access door and access space upstream and downstream of each tube bank and ducting separation (dampers or flow straightening devices).
 - a. For access doors in water tube walls, a minimum free opening of 450 mm (18 in) diameter (circular) or 450 mm x 450 mm (18 in x 18 in) (rectangular) is allowed,
 - b. For access doors in other duct walls, a rectangular opening of at least 600 mm x 600 mm (24 in x 24 in) mm is required.
 - c. The minimum distance for access between convective tube banks shall be a clear 700 mm (28 in).

2.3 AIR AND FLUE GAS SYSTEM

2.3.1 Fans

1. Unless otherwise specified on the data/requisition sheets, a single forced draught fan shall be provided.
2. The fan shall be sized for delivery of air under the most unfavourable local ambient condition. Where this results in excessive fan size, average ambient conditions may be used for the peak load case, subject to approval of the Principal
3. The fan capacity shall be sufficient to supply the total quantity of air required for auxiliary purposes plus the following, as applicable:
 - a. 20% excess air if the boiler is gas fired only;
 - b. 30% excess air if the boiler is dual fuel (gas/liquid), or liquid only fired at the specified fuels at maximum load (MCR);
 - i. Air requirement should be based on the most unfavourable local ambient conditions.
 - c. if there is a peak load specified, air requirement may be based on average ambient conditions.

4. For heavy duty boilers, the Manufacturer/Supplier shall include 5% allowance for the calculated pressure drop over the tube sections in the FD fan's or ID fan's differential head to overcome flue gas fouling (no allowance for burners, ducting, etc. shall be included).
5. Centrifugal fans shall comply with DEP 31.29.47.30-Gen.
- 6. The Principal shall specify on the fan data/requisition sheets what type of driver is required.
 - a. In the case of a dual drive (turbine and electric motor), override couplings of the synchronously self-shifting type shall be applied, which can transmit torque in only one direction.
- 7. The Principal shall specify whether inlet guide vanes or variable speed control will be used for the control of the combustion air flow and induced draft flue gas flow (if applicable).
8. Inlet guide vanes shall be equipped with a maximum and minimum mechanical stop.
 - a. The positioner shall be pneumatically controlled with a lock-up device.
9. Manual operation of the air control damper shall be possible.
 - a. A clear identification of the position of the vanes shall be given.
10. Lubrication facilities shall be provided on the vane adjusting mechanism to ensure that the mechanism cannot jam.
11. All bearings and pivot joints shall be located outside the duct to allow on-line lubrication.
12. Damper drive links shall be able to transmit 200% of theoretically required force and torque.
13. Damper linkages in duct diameters above 1.5 m (5 ft) shall be equipped with double linkages between the individual vanes.
14. The forced-draught fan shall be provided with a vertical suction pipe with its inlet at least 8 m (27 ft) above ground level.
 - a. The Principal may specify a vertical height of the vertical suction pipe exceeding 8 m (27 ft) based on local HSSE requirements.
15. The inlet shall be located in a non-hazardous area of the boiler plot, as indicated by the Principal (see Standard Drawing S 24.002).
16. The inlet shall be adequately protected against ingress of rain and solid matter and meet the following:
 - a. the rain hood/inlet shall be such that rain at an angle of 45° will not enter the air inlet;
 - b. the air velocity at the inlet grid shall not exceed 15 m/s (50 ft/s);
 - c. the inlet shall be protected with 25 mm (1 in) square mesh bird screen with galvanized wire netting (wire diameter 3.5 mm (1/8 in));
 - d. the bottom of the air inlet stack shall be equipped with a drain;
 - e. if required by local ambient conditions the inlet mesh shall be provided with winterization facilities to avoid accumulation of ice deposits.
17. For combustion air measurement a venturi section shall be installed in the air intake of the forced-draught fan (see Standard Drawing S 24.002).
 - a. In case the set up does not allow venturi measurement in the suction or in case individual air control is required by design, the venturi may be installed in the fan discharge (see Standard Drawing S 24.005).