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Guidance on Industry Standard for Shop Fabricated (Packaged) Boilers

GIS 56-101

BP GROUP
ENGINEERING TECHNICAL PRACTICES

Foreword

This is the first issue of Engineering Technical Practice (ETP) BP GIS 56-101. This Guidance on Industry Standard (GIS) is based on parts of heritage documents from the merged BP companies as follows:

British Petroleum

GS 156-3	Water Tube Boilers.
GS 156-4	Shell Type Fired Steam Generating Plant.

Amoco

PTA-FE-BLR-00-G	Boilers / Steam Generators Guide.
PTA FE-BLR-PKG-P	Boilers / Steam Generators: Packaged Procurement Specification.

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1. Scope

This GIS defines provides guidance for design, fabrication, inspection, testing, and documentation of shop fabricated (packaged) boilers within scope of ASME Boiler and Pressure Vessel Code, Section I.

This GIS defines general performance, guarantees, equipment, and information requirements for shop fabricated water tube boilers in any application.

The water tube boiler and general sections of this GIS are applicable to all conventional designs, whether fired or unfired.

Boiler scope of supply shall include all pressure parts and integral pipe work within battery limits. Additional equipment, such as feed water pumps or chimney that is outside direct boiler scope may be added to total scope of any project as required.

2. Normative references

The following normative documents contain requirements that, through reference in this text, constitute requirements of this technical practice. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this technical practice are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

American Boiler Manufacturers Association (ABMA)

Boiler Water Limits and Achievable Steam Purity for Water Tube Boilers.

American National Standards Institute (ANSI)

ANSI B 16.5 Steel Pipe Flanges and Flanged Fittings.

ANSI B 31.3 Chemical Plant and Petroleum Refining Piping.

American Petroleum Institute (API)

API 510 Pressure Vessel Inspection Code.

API 560 Fired Heaters for General Refinery Service.

API 598 Valve Inspections and Testing.

API 2218 Fire Proofing Practices in Petroleum and Petrochemical Processing Plants.

American Society of Civil Engineers (ASCE)

ASCE 7-93 Minimum Design Loads for Buildings and Other Structures.

American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code.

ASME B31.3 Chemical Plant and Petroleum Refinery Piping.

ASME B16.5 Pipe Flanges and Flanged Fittings.

American Society for Testing and Materials (ASTM)

ASTM D 1066 Standard Practice for Sampling Steam.



British Petroleum (BP)

GP 04-20	Civil Engineering
GP 06-60	Onshore and Offshore Paints and Coatings
GP 12-15	Wire & Cable
GP 12-20	Motors
GP 12-25	Earthing / Grounding
GP 12-60	Hazardous Area Electrical Installations
GP 18-01	General Requirements for Welded Fabrication
GP 30-70	Control and Instrumentation on Vendor Packaged Equipment
GP 32-10	I&T of New Equipment
GP 32-20	Site Inspection Testing & Pre-commissioning
GP 32-50	I&T of Electrical (ANSI)
GP 32-51	I&T of Electrical (IEC)
GIS 46-010	New Pressure Vessels
GP 56-10	Boilers & Auxiliaries
GP 60-50	General Issues – Equipment Packages
GP 62-01	Valve selection
GP 72-00	Design and Selection of Refractory Lining Systems

British Standards Institute (BS)

BS 470	Access and Inspection Openings for Pressure Vessels.
BS 759	Valves, Gages, and other Safety Fittings for Application to Boilers and to Piping Installations for and in connection with Boilers Part 1: Specification for Valves, Mountings, and Fittings.
BS 799	Oil Burning Equipment Parts 3 and 4.
BS 806	Ferrous Piping Systems for and in connection with Land Boilers.
BS 1113	Specification for Design and Manufacture of Water-Tube Steam Generating Plant (including Superheaters, Re heaters and Steel Tube Economisers).
BS 1560	Steel Pipe Flanges and Flanged Fittings for the Petroleum Industry.
BS 2790	Shell Boilers of Welded Construction (other than Water-Tube Boilers), Parts 1 and 2.
BS 2885	Code for Acceptance Tests on Stationary Steam Generators of the Power Station Type.
BS 3059	Specification for Steel Boiler and Superheater Tubes.
BS 3405	Measurement of Particulate Matter in Effluent Gasses (Isokinetic sampling)
BS 3601	Steel Pipes and Tubes for Pressure Purposes: Carbon Steel with Specified Room Temperature Properties.
BS 3602	Specification for Steel Pipes and Tubes for Pressure Purposes: Carbon and Carbon Manganese Steel with Specified Elevated Temperature Properties.
BS 3604	Specification for Steel Pipes and Tubes for Pressure Purposes: Ferrous Alloy Steels with Specified Elevated Temperature Properties.
BS 4504	Flanges and Bolts for Pipes, Valves and Fittings, Metric Series.
BS 5351	Ball Valves for the Petroleum, Petrochemical and Allied Industries.



International Standards

ISO R 831	Rules for the Construction of Water Tube Boilers
ISO 2204	Guide to International Standards on the Measurement of Airborne Acoustical Noise and Evaluation of Its Effects on Human Beings.

National Fire Protection Association (NFPA)

NFPA 8501	Single Burner Boiler Operation.
NFPA 8502	Prevention of Furnace Explosions / Implosions in Multiple Burner Boiler-Furnaces.
NFPA 85C	Standard for the Prevention of Furnace Explosions / Implosions in Multiple Burner Boiler-Furnaces.

Occupational Safety & Health Administration (OSHA)

1910 Subpart D	Working & Walking Surfaces
1910.95	Noise Standard

3. Symbols and abbreviations

For the purpose of this GIS, the following symbols and abbreviations apply:

BMS	Burner management system.
BWG	Birmingham wire gage.
DN	Nominal diameter (mm).
DNB	Departure from nucleate boiling.
EPRS	Effective projected radiant surface.
FD	Forced draft (fan).
FGR	Flue gas recirculation.
HP	High pressure.
ID	Induced draft (fan).
ID	Internal diameter (pipe).
LP	Low pressure.
MAWP	Maximum allowable working pressure.
MCR	Maximum continuous rating.
MOP	Maximum operating pressure.
MSDS	Material safety data sheet.
OD	Outside diameter.
PFD	Process flow diagram.
PMI	Positive material identification.
P&ID	Piping and instrumentation diagram.
TDS	Total dissolved solids.
UPS	Uninterruptible power supply.
Wg	Water gage.



4. General

- a. BP shall specify in accompanying document requirements necessary to enable Vendor to make offer.
- b. In general, boiler shall be designed and manufactured to have life span without limit if operated and maintained in accordance with Vendor instructions. Only possible exception shall be superheaters and re-heaters, which may be designed for minimum operational life of 100,000 hr without any tube or other pressure part replacement.
- c. Boilers shall generally be designed for continuous duty and capable of either fixed base load or load following control.
- d. Vendor shall advise on electrical power, steam, and other utility consumptions of boiler. Consumptions shall be subject to guarantee.
- e. Exception to this specification should be communicated to BP prior to submission of proposal.
- f. Conflicts in standards, codes, or regulations shall be brought to BP for resolution.

5. Scope of supply

- a. Scope of supply shall include all supporting steelwork, integral electrical and control equipment and cabling, and integral utility piping, e.g., compressed air, steam, nitrogen, from defined terminal points.
- b. Scope of supply may be modified as necessary and shall include the following:
 1. Stack.
 2. Boiler feed water pumps.
 3. Feed water heater.
 4. Fuel forwarding skid.
 5. Ducting.
 6. Silencers.
 7. Bypass stack.
 8. Isolating and control dampers.
 9. Chemical dosing skid.
 10. Sampling rack.

6. Materials

- a. Low ductility material shall not be used without prior BP approval.
- b. Proposal shall state whether backing rings are used. Sulphur or phosphorus content of any ferrous backing ring shall not exceed 0.04%.
- c. Cast iron shall not be used for any valve or fitting.
- d. Convection bank tubing with radial fins shall have carbon steel fin material with carbon content not exceeding 0.27%.
- e. Economiser pressure parts shall not be made from cast iron.
- f. Damper material shall be selected according to design operating temperature as follows:
 1. Carbon steel up to 426°C (800°F).



2. Alloy from 426°C to 538°C (800°F to 1000°F).
 3. 18/8 SS above 538°C (1000°F).
 4. Or otherwise specified on data sheets and drawings.
- g. Unless specified otherwise by BP, pressure parts shall be carbon steel of quality such that neither pre nor post weld heat treatment is required.
- h. Material specifications for plate, nozzles, flanges, bolts, and other materials shall be subject to BP approval.

7. Design

7.1. General

- a. Steam generation rate, pressure, purity, and temperature over all given operating ranges at discharge of scope of supply shall comply with shop fabricated (packaged) boiler data sheet.
- b. Boiler and auxiliary components shall be designed for specified:
 1. Operating conditions.
 2. Abnormal conditions, including:
 - a) Start of run and end of run.
 - b) Start-up and shutdown.
 - c) Special operating conditions that shall affect performance.
- c. Boiler furnace shall not exceed 880 kW-m³ (85,000 BTU/hr-ft³) combustion volume or 441 kW-m² (140,000 BTU/hr-ft²) effective projected radiant surface (EPRS) flux rating at BP specified design conditions.
- d. Definitions of furnace volume and EPRS shall be as defined by ABMA.
- e. Evaporator tubing sections having natural circulation shall be designed in accordance with the following:
 1. Down comer shall not generate steam.
 2. Down comers shall be either:
 - a) Unheated.
 - b) Heated (inlet water shall be sufficiently sub-cooled to prevent boiling at any point).
 3. Down comers shall absorb from 10% to 25% of available head.
 4. Down comer inlet nozzles shall avoid zones where proximity of riser discharge nozzles can induce carry under of steam.
 5. Division plates and / or boxes shall be used as required to create physical barrier to carry under.
 6. Maximum steam by volume in any riser shall not exceed 55%.
 7. For circulation design, evaporator circuits should be grouped according to similarity of heat absorption, diameter, length, and configuration.
 8. Riser heat absorption shall be characterised along length of tube if it varies by more than ±15%.
 9. Circulation calculations shall show net head developed by each group of risers at various water flow rates.



10. Summated curve for all riser groups and friction head of down comers shall also be presented to identify operating condition.
11. Maximum percent steam in each group of risers shall be identified, along with proportion of head used by down comers.
- f. Boilers that use control of fuel firing to maintain steam pressure shall limit rate of increase in firing rate to 25% of maximum firing rate per min.
- g. Evaporator tubing having forced circulation shall be designed according to the following criteria.
 1. Minimum water speed on entry to each riser tube should be 300 cm/s (1.0 ft/s).
 2. Overall pressure drop through tubes should be at least 3,5 bar (50 psi) minimum.
 3. Orifices installed on entry to each riser tube should provide minimum pressure drop of 350 mbar (5 psi).
 4. Layout of flue gas duct and tube orientation should be designed to ensure uniform heat input to each tube circuit.

7.2. Temperature

- a. Design temperature for components shall be equal to maximum fluid temperature by which they are affected.
- b. If maximum fluid temperature is not precisely known, margin of 28°C (50°F) shall be added to estimated maximum fluid temperature.
- c. Temperature of flue gases shall not be more than 56°C (100°F) below initial softening temperature of flue ash prior to entering superheater or re-heater.
- d. If component is internally lined with thermal insulating material, temperature reduction shall be determined based on lining system and range of ambient temperatures
- e. Steam temperature control for fired boilers shall be performed by spray de-superheating as described below:
 1. If superheat and / or reheat is required, Vendor shall provide all equipment (including control system) needed to maintain constant steam temperature.
 2. De-superheater system shall automatically maintain steam temperature within:
 - a) $\pm 5^{\circ}\text{C}$ ($\pm 9^{\circ}\text{F}$) of desired value under steady state conditions.
 - b) $\pm 10^{\circ}\text{C}$ ($\pm 18^{\circ}\text{F}$) of desired value under transient conditions (at maximum rate of change of firing).
 3. Auto / manual control station shall be provided in main control room.
 4. Control range should be designed to maintain steam temperature within limits from 70% MCR to 100% MCR.
 5. Steam temperature and control range shall be guaranteed.
 6. Spray water for de-superheating service should normally be supplied from boiler feed water pumps.
 7. Steam preheating to within 10°C (18°F) of boiler saturation temperature should be provided before injection into de-superheater.
- f. Requirement for steam temperature control for unfired boilers should be detailed by BP.
- g. If boiler heat source is hot fluid stream (which may be from process or engine), BP shall specify necessary fluid property data, including; fluid mass flow rate, composition, temperature, dew point, and dust burden.



7.3. Pressure

- a. Maximum allowable working pressure (MAWP) may be defined individually for each portion of boiler, but connected components that require simultaneous hydrotesting shall be designed to with stand highest test requirements of any connected component.
- b. Gas tightness design pressure for air and flue gas components shall be determined as:
 1. For balanced draft boiler casing, 150% maximum operating pressure (or vacuum).
 2. For pressurised boiler casing, test block pressure of forced draft fan or other gas side pressure as specified by BP.
- c. For fired boilers with natural circulation, minimum boiler operating pressure shall be 20 bar (290 psi).
- d. If application requires steam at less than 20 bar (290 psi), boiler shall be designed to supply steam through pressure reducing station.
- e. Boilers without firing control should have valve to sustain boiler pressure in event of significant drop in pressure of steam main.

7.4. Chemicals

- a. Necessary chemical mixing and injection equipment shall be included by boiler Vendor.
- b. Equipment necessary for safe handling and storage in closed system of hazardous chemicals shall be provided local to injection pumps.
- c. Required extent of duplication of equipment, such as injection pumps and chemical mixing tanks, shall be specified by BP.
- d. Type of container to be used for delivery of chemicals shall be specified by BP.

7.5. Steam quality

- a. Purity of steam leaving steam drum shall be 0,5 ppm total solids or better if dry steam is required and total solids in the boiler feed water do not exceed that recommended by ABMA or ASME for the specified operating pressure, whichever yields the highest purity.
- b. If less than 100% quality steam is required, steam purity requirements do not apply.
- c. For each steam pressure level, Vendor shall guarantee for all steady state conditions and steam load increases of up to 25% of MCR that:
 1. The steam silica content shall not exceed 0,02 ppm.
 2. The steam total solids content shall not exceed:
 - a) 1,0 ppm for steam pressures up to 60 bar (870 psi).
 - b) 0,5 ppm for steam pressures from 60 bar (870 psi) to 130 bar (1,885 psi).
 3. Above 130 bar (1,885 psi), requirements shall be subject to agreement among relevant parties, e.g., BP, Vendor, and turbine supplier.
- d. Limits on steam solids and silica content shall be attained with normal range of feed water and boiler water conditions. Limits shall be defined in project specification.
- e. Type and amount of steam purification equipment to be provided shall be indicated in proposal.
- f. If dry steam is required, steam drums shall have the following minimum purification equipment:
 1. One stage for boilers rated at less than 45 359 kg/hr (100,000 lb/hr).



2. Two stages for boilers rated at 45 359 kg/hr (100,000 lb/hr) or more. One stage shall be cyclones.

7.6. Water

- a. Boiler feed water treatment shall be specified by BP. Quality of boiler feed water available, including condensate if intended to be used, shall be specified by BP.
- b. Boiler designer shall notify BP of any objection or difficulties foreseen using specified water and shall recommend to BP any further treatment or conditioning of feed water considered necessary or advisable.
- c. Recommended maximum total dissolved solids (TDS) in boiler water shall be stated by boiler designer.
- d. For boilers intended to operate at low or zero solids in boiler water, quality of boiler water shall be continuously monitored and recorded, including pH, conductivity before and after an ion exchange vessel, residual ammonia level, and any other condition that might indicate change in water quality of any serious consequence. Appropriate alarms at control position shall be provided.

7.7. Blowdown

- a. Each boiler shall have its own blowdown drum.
- b. Continuous and intermittent blow down shall be provided and separately routed to blow down drum.
- c. Continuous blowdown line top shall be at least 76 mm (3 in) below lowest safe operating water level.
- d. Intermittent blowdown lines shall remove solids from mud drum.
- e. For each steam pressure level, blowdown water flow rate should be automatically controlled to maintain operation within normal range of boiler water conditions.
- f. Unless agreed otherwise by BP, all blowdowns shall be piped to blowdown drum with atmospheric venting and spray cooling as necessary.

7.8. Sampling

7.8.1. General

- a. System shall have:
 1. Means of drawing continuous sample.
 2. Sample cooler.
- b. Water sampling points for both boiler feed and boiler water, complete with coolers, shall be provided.
 1. Dedicated stainless steel sample lines shall be provided for:
 - a) Superheated steam.
 - b) Saturated steam.
 - c) Boiler water.
 - d) Feed water.
 2. Sample connections shall be taken from top of piping (to avoid ingress of debris into sample line) via adequately supported double isolation valves.
 3. Sample lines shall each have appropriate:



- a) Sample coolers.
- b) Conductivity monitors with local and remote indication.
- 4. If necessary, conductivity monitoring cells shall be protected from adverse effects of volatile substances, such as ammonia, amines, and CO₂.
- 5. Bottle samples to monitor satisfactory operation shall be supplied before and after protection device.
- c. Saturated steam line shall have ASTM D 1066 steam sampling nozzle.
- d. Steam sampling nozzle and condensate injection system, if specified, shall be located after superheater.
- e. Indicating thermometer shall be provided to measure temperature of effluent from sampling nozzle. Nozzle shall not be installed in vertical steam line with upward flow.
- f. Sample probe shall be located at least 5 diameters upstream and 10 diameters downstream from nearest fitting or valve.

7.8.2. Superheated steam sampling

- a. If sampling superheated steam:
 - 1. Multi port nozzle shall be used.
 - 2. Nozzle shall include condensate injection system.
 - 3. Water injected shall be purest available.
- b. If superheat temperature exceeds saturation temperature by 10°C (18°F) or more, sample nozzles shall be attached by thermal sleeve.
- c. If sample cooling system is specified, its tubing and valve trim shall be minimum of 18% chrome, 8% nickel stainless steel.
- d. Copper alloys shall not be used.
- e. In order of preference, orientation of steam sampling nozzle shall be one of the following:
 - 1. Vertical pipe, downward flow.
 - 2. Vertical pipe, upward flow.
 - 3. Horizontal pipe, vertical insertion.
 - 4. Horizontal pipe, horizontal insertion.

7.8.3. Effluent sampling

- a. Sampling location
 - 1. Sampling shall be performed in chimney / stack or as near to chimney / stack as possible.
 - 2. If plant has grit arrestor, sampling shall be before arrestor.
 - 3. If arrestor is located such that this cannot be done:
 - a) Sampling shall be taken after arrestor.
 - b) During period of test, weight of grit and dust collected shall be determined.
- b. Sampling method
 - 1. Samples shall be taken from at least four points uniformly distributed across section, and shall be isokinetic as per BS 3405.
 - 2. Three results shall be obtained.



3. Mean value shall represent measured value.
4. During periods of measurement, excess O₂ in flue gases shall be as specified for boiler.
- c. If there is possibility that solids emission shall exceed that allowed with proposed fuel and burners, cyclones shall be fitted in chimney base or other convenient position to reduce emission to acceptable level.

7.9. Winterisation

- a. In general, all plant and equipment, including auxiliaries, shall be protected against damage or inability to operate under winter conditions specified or agreed to by BP for location concerned.
- b. Detailed requirements for winterisation shall be as specified by BP in accompanying specifications.

8. Fabrication & construction

8.1. General

- a. Equipment shall be designed, fabricated, tested, and stamped in accordance with:
 1. Data sheets and drawings.
 2. This GIS.
 3. ASME Boiler and Pressure Vessel Code.
 4. State and local environmental rules and regulations.
 5. BS 2790.
 6. ISO R 831.
- b. Facilities shall be provided to enable inspection of internal surfaces without recourse to cutting and re-welding.
- c. Manways and covers shall:
 1. Be of internal type.
 2. Comply with BS 470 or equivalent national standard.

8.2. Welding

- a. Welding procedures and welders shall be qualified in accordance with ASME Code, Section IX. Welding procedures shall:
 1. Be subject to BP approval.
 2. Comply with GP 18-01.
- b. Welds and heat affected zones in chrome moly steels shall not exceed 225 Brinell hardness.

8.3. Pressure bearing parts

- a. Mechanical design of pressure parts and boiler mountings (valves, gages, and safety devices) shall comply with either or both of the following, as applicable:
 1. Local code for country where it shall be installed.
 2. ASME Code, Section I.
 3. BS 1113.



4. BS 759.
5. ISO standards.
- b. Minimum mechanical design pressure shall be 20 barg (290 psig).
- c. Boiler pressure parts, casings, and ducts should be carbon steel that does not require pre or post weld heat treatment for thicknesses up to 20 mm (4/5 in).
- d. Mechanical design of tubes shall have corrosion allowance as specified below:
 1. 1 mm (0.04 in) for 100 mm (4 in) OD or less.
 2. 1.5 mm (0.06 in) for OD larger than 100 mm (4 in).
- e. Superheaters:
 1. Drainable superheaters are preferred.
 2. Other pressure parts shall be drainable and appropriate provisions included.
- f. Pressure parts should be configured to minimise use of refractory

9. Valves

9.1.1. General

- a. Shall comply with:
 1. BS 759.
 2. ASME Code, Section I.
 3. ISO R 831.
 4. Equivalent state or national codes of on-site country.
- b. Boiler isolation shall be double isolation standard.
- c. Steam and feed water shutoff:
 1. Parallel slide valves shall be used for steam and feed water shutoff duty.
 2. Valves shall be steel construction suitable for pressure and temperature concerned.
 3. Main steam stop valve may be angle screw-down type mounted directly on boiler outlet nozzle.
- d. Valves shall:
 1. Be steel or as specified on data sheets & drawings.
 2. Have metal tag stating duty and identification number.
 3. Comply with GP 62-01.
 4. Comply with data sheet specifications.
- e. Steam and feed water isolation valves:
 1. If greater than DN 100 (NPS 4), shall be parallel slide type.
 2. If DN 100 (NPS 4) or smaller, shall be back seating with rising spindle.
- f. Vendor shall provide double isolation from steam main, with the following as minimum:
 1. Block valve.
 2. Screw-down non return valve.
 3. Drain valve.

