

DEP SPECIFICATION

STEAM, CONDENSATE AND BOILER FEED WATER SYSTEMS

DEP 30.75.10.10-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 and engineering of steam, condensate, demineralised water and boiler feed water systems for offshore and onshore oil and gas production installations, including refineries, chemical and LNG facilities. Functional requirements are provided for the various components included in such systems as boilers, feed pumps, water chemistry guidelines and distribution headers. The detailed technical specifications for the various components such as steam generation and consumer equipment are outside the scope of the DEP; however, some minimum requirements related to the system design have been included.

Sparing requirements are considered beyond the scope of this DEP and are addressed as part of the Design Class/Value Improvement work processes with requirements identified in the Basis for Design (BfD).

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

This is a revision of the DEP of the same number dated February 2015; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. 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.

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
Design Class	A categorization defining fit-for-purpose facilities developed through Value Improvement Processes (VIPs) during a project Front End Development (FED) phase.
Process Safety	Process Safety is the management of hazards that can give rise to major accidents involving the release of potentially dangerous materials, release of energy (such as fire or explosion) or both.

1.3.3 Abbreviations

Term	Definition
AC	Accidentally Contaminated
ASME	American Society of Mechanical Engineers
BFD	Basis for Design
BFW	Boiler Feed Water
CAPEX	Capital Expenditure
CBD	Continuous Blowdown
D.O.	Dissolved Oxygen
DWD	Deposit-Weight-Density
FAC	Flow Accelerated Corrosion
FED	Front End Development
GAC	Granular Activated Carbon

Term	Definition
HP	High Pressure Steam (<~68 barg (~1000 psig); >~22 barg (319 psig))
HAZOP	Hazards and Operability Analysis
IBD	Intermittent Blowdown
IPF	Instrumented Protective Function, now known as SIF (Safety Instrumented Function)
ISBL	In Side Battery Limit
LP	Low Pressure Steam (<~6 barg (85 psig))
LPG	Liquefied Petroleum Gas
MB	Mixed Bed
MCC	Motor Control Centre
MOC	Management of Change
MOV	Motor Operated Valve
MP	Medium Pressure Steam (<~22 barg (319 psig); >~6 barg (87 psig))
MSSV	Main Steam Stop Valve
NPS	Nominal Pipe Size
OEM	Original Equipment Manufacturer
OPEX	Operating Expenditure
PCV	Pressure Control Valve
PLC	Programmable Logic Controller
PRDS	Pressure Reduction and Desuperheating Station
QMI	Quality Measuring Instrument
SI	International System
TOC	Total Organic Carbon
VGB	Vereinigung Grosskraftwerks Betreiber
VHP	Very High Pressure Steam (>~68 barg (~1000 psig); up to~115 barg (1668 psig))
VIP	Value Improvement Processes

Term	Definition
WHB	Waste Heat Boiler

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 by this DEP are listed in (7).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a full revision of the DEP of the same number dated February 2015. The following are the main, non-editorial changes.

Section/Clause	Change
ALL	Restructured and clarified requirements, enforced shall/should.

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.
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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.

2. STEAM GENERATION

2.1 GENERAL DESIGN CONSIDERATIONS

1. Steam pressures shall be selected to meet the process users requirements.
 - a. Optimisation of steam pressures should be performed based on energy efficiency and investment, taking into account the limits to materials and piping class.
2. Steam temperature should be specified to provide the maximum degree of superheat for steam turbine consumers, but balanced against the impact on cost of equipment and piping due to higher ratings of flanges, seals, materials.
3. Superheated steam shall be supplied to the distribution headers to minimise condensation in the distribution network.
 - a. For processes which require saturated steam, the steam piping length should be minimized.
4. The degree of superheat for steam supplied to steam turbines shall be worked out on the following basis:
 - a. for condensing turbines, to include at least a 1% point margin on exhaust steam dryness over the original equipment manufacturer (OEM) exhaust condition corresponding to specified efficiency;

This is to reduce the risk of operation beyond steam turbine capability due to operational variations in steam pressure and temperature.
 - b. no additional superheater in the design for back pressure turbine exhaust steam or turbine extraction steam to be supplied to the downstream users.
5. For back pressure turbine exhaust desuperheating or tempering requirement of extraction steam should be verified for part load, start-up, shut down and full speed no load operation on a case-to-case basis.
6. The capacity and sparing of steam generators shall be selected according to the design class, project premise and range of operating conditions, including shutdown of the largest steam generator, turndown operation and ramp up rates.
 - a. Refer to DEP 00.00.07.97-Gen. for design class tables.
7. For very high pressure steam (VHP), high pressure steam (HP) and medium pressure steam (MP), Table 1 shall be applied in the absence of a more stringent OEM specification on steam purity.
 - a. Refer to (3.12) for steam sampling requirements.

Purity requirements are to avoid the formation of deposits on the super heaters, turbines and valves.

Table 1. Steam purity for turbines in continuous operation

Sr. No.	Parameter	Limit	Unit
1	Cation Conductivity* (at 25°C (77°F))	< 0.20	µS/cm
2	Silicic acid (SiO ₂)	<0.02	ppm
3	Total Iron (Fe)	<0.02	ppm
4	Total Copper (Cu)	<0.003	ppm
5	Sodium (Na)	<0.01	ppm

*Following cation exchange

8. Where steam turbines are not applied, the steam purity specification may be relaxed provided the resulting steam purity is within the design conditions of the boiler(s) and subject to the approval of the Principal.
9. For low pressure steam (LP), a total dissolved solid content of 1 ppm should be considered acceptable for heating or similar end use.

2.2 BOILERS/STEAM GENERATORS BLOWDOWN

2.2.1 General

1. In order to maintain the specified boiler water quality and to prevent corrosion and fouling in the boiler and downstream equipment, continuous blowdown and intermittent blowdown shall be used.

2.2.2 Continuous blowdown

The purpose of continuous blowdown is to control dissolved solids and facilitate adjustment of specified boiler water chemistry parameters.

1. For boilers serving process units where return condensate contamination is possible, at least a 5% continuous blowdown shall be applied to the design.
2. For combined cycle steam power plants or installations where all condensate is clean and sourced from turbine condensers only, a 3% continuous blowdown shall be applied to the design unless the Manufacturer's standard is a higher design rate.

Actual blowdown can be optimised during operation.

3. Continuous blowdown (CBD) from each steam generator should be routed for disposal and heat recovery to a flash vessel operating at LP applicable for the steam system where the recovered flash steam is used.
4. The hot water from a CBD vessel shall be routed to the atmospheric intermittent blowdown (IBD) vessel for disposal via the IBD vessel, or recycled (e.g., to the cooling tower), if applicable.
5. CBD shall be adjusted manually through a calibrated blowdown valve or through ratio control according to the feed water flow.
 - a. Blowdown ratio may be adjusted to handle changes in feed water quality on a site to meet the boiler water specifications.
6. Automatically controlled continuous blowdown based on conductivity shall not be used.
7. Automatically controlled phosphate dosing based on boiler drum water pH shall not be used.

2.2.3 Intermittent blowdown

1. Intermittent blowdown shall be designed to remove suspended solids and sludge formed in the boiler water.
2. In abnormal operating situations or during start up, intermittent blowdown should be used to restore the drum level from high to normal level.
3. The IBD system shall be designed to handle the flow rates during abnormal operating situations or during start up.
4. Intermittent blowdown shall be routed to the IBD vessel at atmospheric pressure.
5. Flash steam shall be vented to a safe location away from people access.
6. Hot condensate in the IBD vessel shall be cooled to less than 60°C (140°F) before being discharged to the accidentally contaminated (AC) drain system (to avoid flashing and hydrocarbon vapour cloud formation in the AC drain system).
 - a. Service water may be used for cooling.

2.3 CBD and IBD PIPING

1. The CBD/IBD piping shall be designed to handle two-phase flow (due to continuous flashing in the piping downstream of the blowdown valve) with minimal vibrations or hammering.
2. The calibrated continuous blowdown valve should be installed near the blowdown vessel to minimise the length of pipe sections downstream of the valve that are subject to the high velocities and hammering risks associated with a two-phase flow.
3. The piping downstream of the blowdown valves shall be sized such that the risk of water hammer and erosion (e.g., in elbows) is minimised.
4. The velocity of the fluid (steam and water mixture) in the blowdown lines downstream of blowdown valves shall not exceed 3.8 m/s (12.5 ft/s).
5. Blowdown valves shall be suitable for hot water flashing service.
 - a. Refer to DEP 31.38.01.11-Gen.
6. Blowdown valves shall be sourced from approved Manufacturers/Suppliers.
7. Angle valve shall be used for CBD.

Angle valves provide the least restriction to the flow path after flashing and minimise the impingement on the valve body.

 - a. Stellite 6, Colmonoy 6 or Principal approved equivalent hard facing type of material shall be applied for erosion resistance.
8. CBD/IBD vessels should be installed near the steam generator(s) to minimise the length of CBD/IBD piping.
9. Horizontal expansion loops shall be used in CBD/IBD piping downstream of CBD/IBD valves.
10. The CBD/IBD piping downstream of CBD/IBD valves shall be sloped for free draining to the blowdown vessel.
11. The pipe supports shall be designed to allow thermal expansions and limit piping movements and resulting failures due to water hammer induced by two-phase flow.
12. Vibration analysis shall be carried out for CBD/IBD lines as per DEP 31.38.01.11-Gen,
13. For CBD/IBD piping refer to DEP 31.38.01.11-Gen, section no 3. for pipe stress analysis and supports requirements.

2.4 CBD/IBD FLASH VESSELS

1. Dedicated IBD flash vessels should be provided for each boiler and process steam generator.
2. For multiple process heaters and waste heat boilers, the number of CBD flash vessels should be optimized by demonstrating that the risk of vibrations and water hammering in the piping has been mitigated. 3.
 - a. CBD from utility steam generators and process steam generators should not be combined.
3. The provision of diverting CBD to an IBD flash vessel shall be included in the design to ensure that common CBD flash vessel can be isolated for inspection and maintenance.
4. For flash steam recovery, the water carryover amount with flash steam from the CBD flash vessels shall be less than 1%.
5. The IBD flash vessel shall be designed for less than 1% water carryover with flash steam vented to the atmosphere to avoid unsafe conditions due to hot water in the proximity of IBD flash vessels.
 - a. The IBD Vessel should be supplied as part of the boiler manufacturer's scope.

2.5 SPARING PHILOSOPHY

1. Design capacity and sparing of boilers shall be decided according to the selected design class and project premise.
 - a. Refer to DEP 00.00.07.97-Gen. for design class.
2. As a minimum, an N+1 boiler should be installed unless another source of reliable steam is available.

This is to ensure that required steam generation capacity is available during the periodic statutory shutdowns of boilers for inspection and maintenance.
3. Reliability of boilers and availability of steam shall meet the overall plant availability requirement.
4. Where continuity of steam supply is required in the event of credible scenarios of power system unavailability or failures, utility boilers shall be provided with dual driveforced-draft fans driven with two independent utilities, preferably steam and electricity.

2.6 STEAM LOAD SHEDDING

1. Steam load shedding shall be included in the design such that process plants or steam drives shut off during steam shortage events have lower cost impact and higher steam curtailment.
2. Steam load shedding, if required by the Principal, shall include remotely operated valves.
 - a. Motor operated valves (MOVs)) should be considered to isolate the steam supply to the plants and steam drives to be curtailed.
 - b. The load shedding valve shall be activated manually by the Operator from the control room or automatically based on a set point.

2.7 PRE-START-UP AND OPERATIONAL CLEANING

1. Pre-start-up cleaning of steam generating equipment and distribution piping networks shall be carried out in accordance with VGB-R 513 e guidelines.

2.7.1 Chemical cleaning

1. Chemical cleaning shall be carried out according to VGB-R 513 e guidelines prior to the first start.
 - a. The design shall allow for cleaning during the operating life depending upon the extent of fouling of tubes or after major repairs.

2.7.2 Steam blowing

1. Steam blowing of steam generators and associated distribution pipework shall be done according to VGB-R 513 e to achieve the required cleanliness and prevent potential damage to steam turbines and other connected equipment.
2. A procedure describing all the activities involved in steam blowing shall be prepared by the Contractor for each system that requires steam blowing.
3. Steam blowing procedures shall include:
 - a. the disturbance factor to be achieved in the specific pipe segments;
 - b. type of target plates and locations;
 - c. Acceptance criteria in terms of the maximum diameter of indentation and the number of indentations on the target plates.
4. Silent steam blowing should be considered over conventional steam blowing due to benefits in terms of lower steam requirement, uninterrupted blowing and minimal environmental disturbance.

3. BOILER FEED WATER

3.1 BOILER FEED WATER QUALITY

1. Boiler feed water (BFW) quality shall conform to one of the following specifications, with the agreement of the Principal:
 - a. VGB-S-010-T-00;
 - b. EN 12952-12;
 - c. ASME guidelines, Consensus On Operating Practices For The Control Of Feedwater And Boiler Water Chemistry In Modern Industrial Boilers, CRTD-Vol 34.
2. Demineralised feed water shall be used for all the boilers with local heat flux densities in excess of 250 kW/m² (80,000 Btu/hr-ft²), irrespective of boiler pressure.
3. Supply of off-spec water from a demineralisation plant shall be prevented through online quality monitoring, alarms and shutdown on excursions.