NORSOK STANDARD P-100

Rev. 2, November 2001

Process systems

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ERRATA TO
NORSOK STANDARD
PROCESS SYSTEM
P-100
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Updated for misprints as noted per 2002-04-24

- Page 10, Section 5.2.3.1:

  Gas velocity
  Typical maximum gas velocity for a horizontal separator:

  $V_s = K \times [(\rho_l - \rho_g)/\rho_g]^{0.5} \times (L/6)^{0.58}$
  K = 0.137 (typical)
  LAH liquid level inside separator

- Page 14, Section 5.3.3.2:

  Last sentence
  "To avoid…………………" was erroneously included and has been removed.

Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for existing and future petroleum industry developments.

The NORSOK standards are prepared to complement available international standards ato fill the broad needs of the Norwegian petroleum industry. Where relevant NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

These standards are developed according to the consensus principle generally applicable for most standards work and according to established procedures defined in NORSOK A-001, which also applies for this NORSOK Directive.

The preparation and publication of the NORSOK standards is supported by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Manufacturing Industries). NORSOK standards are administered and issued by NTS (Norwegian Technology Centre).

Annex A is informative.

Introduction

The development of this standard is primarily based on proven technology, but it does not preclude the use of new technology.

Users of this standard are encouraged to give comments in order to improve the standard based on experience.

The following changes have been made to revision 2 of this standard:
- Included two new systems, Gas Conditioning (system 25) and Chemical injection (system 42).
- The document has been restructured with “normal” chapter numbers and the system number reflected in the heading text.
- A new chapter has been added, chapter 5, to cover general process equipment design of equipment being used in many of the systems, such as separators, scrubbers and heat exchangers.
- A lot of minor changes throughout the document based on incoming comments to the previous revision.

1 Scope

This NORSOK standard defines the minimum functional requirements for process systems on an offshore installation.

2 Normative references

The following standards include provisions which, through reference in this text, constitute provisions of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet or exceed the requirements of the standards referenced below.

API RP 520	Design and installation of pressure relieving systems in refineries.
API RP 521	Guide for pressure relieving and depressurising systems.
API 2000	Venting Atmospheric and low-pressure Storage Tanks
API RP 14C	Analysis, Design, Installation and Testing of Basic Surface Safety Systems on Offshore Production Platforms. (New revision of ISO 10418 to be used, when issued in 2002).
ISO 15663	Petroleum and natural gas industries - Life cycle costing - Part 1: Methodology
NAS 1638	Cleanliness requirements of parts used in hydraulic systems. National Aerospace Standard, 1964.
NORSOK P-001	Process design
NORSOK S-001	Technical safety
NORSOK S-002	Working environment
NORSOK S-003	Environmental Care
NORSOK Z-DP-002	Coding system (Z-002)
TEMA	Standards of Tubular Exchanger Manufacturers Association.

3 Definitions and abbreviations

3.1 Definitions

Normative references	Shall mean normative in the application of NORSOK standards.
Informative references	Shall mean informative in the application of NORSOK standards.
Shall	Shall is an absolute requirement which shall be followed strictly, in order to conform with the standard.
Should	Should is a recommendation. Alternative solutions having the same functionality and quality are acceptable.
May	May-indicates a course of action that is permissible within the limits of the standard (a permission).
Can	Can-requirements are conditional and indicates a possibility open to the user of the standard.
System sparing class:	A classification based on the consequence for oil and gas deliveries if the system fails: A Production shutdown, or reduced production for more than 2 hrs. B Short production shutdown, or reduced production (less than 2 hrs). C No effect on oil/gas production.

3.2 Abbreviations

BTX	Benzene Toluene Xylene
CCR	Central Control Room
CFD	Computational Fluid Dynamics
DAS	Data Acquisition System
ESD	Emergency Shutdown
HC	Hydro Carbon
HP	High Pressure
LAH	Level Alarm High (alarm level)
LAHH	Level Alarm High High (trip level)
LAL	Level Alarm Low (alarm level)
LALL	Level Alarm Low Low (trip level)
LAT	Lowest Astronomical Tide
LCC	Life Cycle Cost
LP	Low Pressure
LPG	Liquefied Natural Gas (butane-propane mixtures)
NGL	Natural Gas Liquids (mainly ethane, propane, butane)
NPSHA	Net Positive Suction Head Available
NPSHR	Net Positive Suction Head Required
OS	Operator Station
PAH	Pressure Alarm High
PAHH	Pressure Alarm High High (trip level)
PAL	Pressure Alarm Low
PALL	Pressure Alarm Low Low (trip level)
PSD	Process Shut Down
PSV	Pressure Safety Valve
SCF	Standard Cubic Feet
SIFF	Statens Institutt For Folkehelse (The National Institute of Public Health)
SFT	Statens forurensingstilsyn (State Pollution Agency)
UPS	Uninterruptable Power Supply
UV	Ultra violet
VDU	Visual Display Unit

4 General requirements

4.1 General

Chapter 4 and 5 covers requirements that applies for all systems. Process system design shall comply with the functional requirements and the design data stipulated for each system in separate data sheets.

General process design requirements are covered by Norsok standard P-001 Process design.

The supplier shall to the extent possible base delivery on standardised equipment/system packages within the constraints defined by the functional requirements in this document.

For each system, a design data sheet has been included in Annex A such that new projects can fill in data relevant to that particular project, thus making the design data sheet project specific. Note that part of the data can only be filled in after equipment design has been performed. Preliminary estimates can be given for some of these if it is considered necessary depending on the purchasing philosophy. Complete process data sheets (or other documents containing the same information) shall be prepared for final system selection.

4.2 General system design

4.2.1 LCC aspect of system design

System configuration shall be determined based on a combination of regularity and LCC principles as given in NORSOK standards Z-016 “Regularity management and reliability technology” and O-CR-001 (O-001) “Life cycle cost for systems and equipment”.

4.2.2 Design for minimum impact of platform movement

In the case of installations with large movements, design criteria should be drawn up for movement and acceleration conditions under which the process facility is required to operate. Any limitations should be stipulated in the operating procedures.

4.2.3 Dynamic simulations

Dynamic simulation of pressure, temperature and flow-characteristics in process and auxiliary facilities may be used to achieve facilities with improved availability and safety. Suitable simulation programmes may be valuable in order to identify transients imposing special requirements to facilities, control systems, procedures and operator intervention.

4.2.4 Design margins and turndown

Where this document specifies “some margin” it is the project owners responsibility to specify this margin. Turndown requirements shall also be specified by the project owner to ensure the design will work as intended within the operating range.

4.3 Commissioning and maintenance requirements

Commissioning / maintenance and operations personnel should participate in setting design targets and layout. This will minimise offshore hook up and commissioning and simplify maintenance in the operational phase.

4.4 Safety requirements

4.4.1 Safety analysis

Safety analysis shall be employed to ensure a systematic method of implementing principles for an operational safe platform (according to API RP 14C).

4.4.2 Hazard and operability (HAZOP)

Hazard and operability study shall be used as a tool in the system optimisation process to achieve system safety and operability.

4.4.3 General safety

Reference is given to Norsok standard S-001 Technical safety.

4.4.4 Working environment

Reference is given to Norsok standard S-002 Working environment.

4.5 Environmental requirements

Reference is given to Norsok standard S-003 Environmental Care.

5 General process equipment design

5.1 General

This chapter covers process equipment design which are valid for more than one system. The intention of this chapter is to avoid duplication of requirements within each system and to elaborate on special equipment such as separators, scrubbers and heat exchangers.

The requirements in this chapter are minimum requirements.

5.2 Separator design

5.2.1 General

This section gives guidelines for selection and design of horizontal separators.

5.2.1.1 Definitions

V_s = flowrate/available cross-sectional area (m/s), superficial gas velocity
ρ_g = gas density, (kg/m^3)
ρ_l = liquid density, (kg/m^3)
L = effective separation length, (m)

5.2.2 Functional requirements

Inlet separators shall be provided for 3-phase separation.

All separators shall be equipped with a steam out connection.

The outlet to instrument bridles shall be protected against blockage.

On separators initially intended for two phase (gas/oil) operation, water outlet nozzles and brackets for a weir plate shall be installed for future use.

5.2.3 Separator sizing

5.2.3.1 Gas velocity

Typical maximum gas velocity for a horizontal separator:

$V_s = K \times [(\rho_l - \rho_g)/ \rho_g]^{0.5} \times (L/6)^{0.58}$
K = 0.137 (typical)
LAH liquid level inside separator

5.2.3.2 Liquid residence time

Liquid residence time is dependent on fluid properties and should be verified by testing on actual fluid at operating conditions (pressure and temperature). The liquid residence time is normally supplied by the operating company.

The residence time to be calculated from normal levels in the separator.
The effective separation volume, from where the residence time shall be calculated, is from the flow straightening plate to the weir plate.

5.2.3.3 Liquid levels

In the sizing of the separators, the equivalent residence time between normal operating and alarm level and between alarm level and trip level shall not be less than 30 seconds or 100mm, whichever is greater, for both high and low ranges, however the major guiding factor will be a reasonable time for the operator to check reasons for operating outside the normal level. Motion effect shall also be considered.

The maximum slug volumes shall be designed for each project. The slug volume shall be accounted for between normal and alarm level.

5.2.4 Separator internals

For certain types of separator internals, e.g. inlet cyclones and gas demisters, the turndown of the equipment is important for its performance. In such cases, both minimum and maximum liquid, crude oil, water and gas rates must be considered.

Internals for motion damping shall be applied as necessary.

All internals shall be removable and installable through the manways without welding.

Increased internal pressure drop caused by fouling shall be considered for all relevant scenarios, including, but not necessarily limited to drain pipes (from gas outlet arrangement).

On floating installations motion/wave-dampening internals shall be installed.

The separator shall operate such that undesired channelling, non-plug flow or short circuit flows do not occur in both liquid and gas phase. For each project, a CFD analysis for the entire separator shall be carried out to visualise undesired flow patterns.

5.2.4.1 Inlet arrangement

The inlet arrangement shall have a documented design, and have a documented high efficiency towards prevention of foam and emulsion and minimise generation of small droplets.

The inlet arrangement shall be able to handle slug flow, if expected.

A flow straightening device should be located downstream the inlet device and shall cover the full sectional area. Care should be taken to avoid plugging due to fouling (scale, solids and asphaltenes).

5.2.4.2 Gas phase internals

Gas outlet nozzles shall be provided with demister arrangements. Pressure tappings should be installed upstream and downstream gas outlet device, for continuous measurement of differential pressure to detect clogging.

The liquid collected by the gas outlet device are collected and drained by a drain pipe to the bottom of the separator. The pipe must be submerged below the LALL. Sufficient drainage head must be assured, so that liquid carry-over through the drain pipe does not occur under any circumstances. The drainage is normally internal, into the vessel bottom, but should be routed externally in case of insufficient drainage height. The total differential pressure over the demisting section, measured in liquid height, shall not be more than 50% of the available drainage height related to LAHH.

5.2.4.3 Liquid phase internals

Internals in the liquid phase should be minimised due to potential clogging.

Internals for improved efficiency of liquid / liquid separation shall be applied based on knowledge about emulsifying and separability characteristics, and a thorough understanding of fouling tendencies (through all relevant mechanisms such as scaling, sand accumulation and deposits of heavy hydrocarbons).

Liquid outlet nozzles shall be provided with vortex breakers.

The bottom of the separator shall be possible to inspect with as little dismantling of internals as possible for access.

5.2.4.4 Solids removal

All separators shall, as a minimum, have nozzles for sand removal installed.

When solid production is likely the following requirements apply:
- All separators shall have sand pans.
- Internal jet water headers shall have nozzles for high volume / low driving pressure with a fan spray pattern which is overlapping between each nozzle
- The headers shall be spaced sufficiently for efficient sand removal by unidirectional jets towards the sand pan.
- Sand removal shall be based upon sand fluidisation rather than sand displacement.
- Consideration shall be given towards efficient sand removal along the entire length of the separator.
- Nozzles to be protected against damage or misalignment by human activity during normal vessel inspection/maintenance.

5.2.5 Nozzles

Manways shall be minimum 24" and installed to prevent trapped volumes when the separator is drained.

Instrument nozzles shall be located outside the sand accumulation area.

Gas nozzles to flare shall be located such that liquid carry-over is avoided.

Separator inlet and outlet process nozzles (gas, oil, water) shall be sized a minimum of one standard dimension larger than the connected pipe work.

5.3 Scrubber design

5.3.1 General

This section gives guidelines for selection and design of vertical scrubbers.

Operational experience has shown that sub optimisation of scrubber size in the design phase has resulted in serious detrimental effect with respect to actual production capacity and regularity. Therefore, care should be taken to avoid this sub optimisation in the design phase. It is also important to look at the scrubber design from a system point of view, instead of as isolated mechanical units. This may lead to different design criteria for the different scrubbers in the system.

Vertical scrubbers are used for separation of liquid from streams with high gas-to-liquid ratios. For elimination of very fine mist (droplet size < 3 microns) filter separators are required. Filter separators can only handle limited liquid loads. Several proprietary designs for filter separators exist, but this will not be covered here.

5.3.1.1 Definitions

K-value	$= V_s[(\rho_g/(\rho_l-\rho_g)]^{0.5}$ (m/s), design factor for demisting internals
V_s	= flowrate/available cross-sectional area (m/s), superficial gas velocity
ρ_g	= gas density, (kg/m^3)
ρ_l	= liquid density, (kg/m^3)

5.3.1.2 Functional requirements

The scrubber shall remove liquid in gas stream in order to:

- protect compressors from liquid carry-over.
- protect glycol/amine and other contactors from carry-over.
- conditioning and general protection of downstream equipment.

The specification for maximum allowable liquid entrainment from the scrubber, shall be set in agreement with the downstream equipment vendor and the operating company. A design margin (overlap) shall be included. A typical general specification of maximum liquid entrainment has historically been 13 litre/MSm^3 (0.1 US gallon/Million SCF).

It should be possible to monitor the scrubber performance, hence a 3" nozzle with full bore ball valve, for condition monitoring should be installed immediately upstream the gas inlet and downstream the gas outlet. It shall be possible to insert an iso-kinetic sampling probe through the nozzle.

Exposed level nozzles shall be shielded from gas and liquid impact inside the scrubber.

5.3.2 Scrubber design rates

The actual rate a scrubber will see will be different from the target average production capacity.

The design shall have a 20% margin for fluctuations due to process control. In addition scrubber blowdown and dynamic effects with respect to anti-surge operation shall be taken into consideration when defining the scrubber design rates. For these and other conditions, lasting for a short time, the specified separation efficiency cannot be expected, but the equipment shall be designed to avoid massive carry-over and secondary effects, that will lead to detrimental impact and shutdown of downstream equipment.

The flow variations should be reduced by careful design of the surrounding equipment, valves, compressors and process control implementation.

The scrubber shall also be able to handle turndown. The entire compressor (or system) operating envelope shall be checked when specifying scrubber design conditions.

5.3.3 Scrubber internals

Each of the following sections contribute to the overall scrubber performance and shall be designed based on valid assumptions.

5.3.3.1 General

Effect of upstream piping and equipment

The upstream equipment and flow regime determines the droplet size and fraction of bulk liquid entering the scrubber.

Mechanism	Droplet size, micron
Tray	6-800
Packing	6-800
Choking with high shear forces	0.1-10
Condensation on surface	20-800
Condensation saturated vapour /retrograde condensation	0.1-30

Flow regime correlations should be used when determining the fraction of mist versus bulk liquid in the inlet pipe. The upstream piping shall be designed without any pockets that can lead to slug flow into the scrubber.

Typically the following maximum inlet momentum for the inlet stream should be used:

No inlet device: $\rho V_s^2 <= 1000$ kg/ms^2
Half pipe: $\rho V_s^2 <= 1500$ kg/ms^2
Inlet vane: $\rho V_s^2 <= 6000$ kg/ms^2

The scrubber inlet piping should be designed with increased pipe diameter according to the inlet momentum above, for the last 20D (diameter according to the above criteria to be used as basis) upstream the scrubber. This to assure good inlet conditions.

Effects of inlet device

When designing the inlet device, conservative liquid carry-over from upstream equipment (e.g. separators) shall be assumed. A typical number for an upstream separator, with moderate carry over, is 0.15 m^3 liquid/MSm^3 gas. In addition, increased condensation +10% from upstream coolers should be used.

Different inlet devices exist. Operating outside their design point will have detrimental effect to the overall performance. A poor inlet separation will cause liquid overloading of the demisting section and result in carry-over. A good inlet device shall reduce the inlet momentum, separate bulk liquid with minimum creation or shattering of droplets, and create good vapour distribution.

Typical inlet device performance:

	TYPE OF INLET DEVICE				
Ability to	**None**	**Inlet Vane**	**Cyclone**	**Half pipe**	**Baffle**
Momentum reduction	Poor	Good	Good	Good	Good
Bulk separation	Good	Good	Good	Average	Poor
Prevent re-entrainment	Good	Good	Average	Average	Average
Prevent liquid shatter	Good	Good	Good	Average	Poor
Low differential pressure	Good	Good	Average	Good	Good
Not create foam	Poor	Average	Good	Poor	Poor
Ensure good gas distribution	Poor	Good	Average /poor	Poor	Poor

Based upon the table above, the inlet vane arrangement is usually used. Inlet cyclones may provide high inlet separation, but the design is critical and the operating envelope is more limited than for the inlet vane.

Effect of demisting elements
Typical applications for different outlet demisting elements are:

Axial Flow Cyclones:	High gas capacity, small droplet size removal and high pressure applications (typically 40 bar and higher).
Vanes:	High gas capacity, especially suited for low pressure applications.
Mesh:	Low capacity, small drop size removal, coalescing effects and clean service applications.

A combination of mesh and cyclones/vanes can increase the stable operating range, by overlapping performance. This is especially important for the mesh/cyclone combination.

Important design parameters are liquid capacity and gas velocity limits for reentrainment.

For visualisation of gas distribution in the demisting device, Computational Fluid Dynamics (CFD) should be used in the design phase.

It shall be possible to monitor the pressure difference across the demisting elements, without any flow disturbance. This can be done by careful consideration of nozzle location.

5.3.3.2 Mesh pad

Mesh as demister:
The mesh pad demister captures small droplets with high efficiency. The mesh can be of metal or plastic material, or a combination. Typical minimum droplet removal size is:

Metal mesh:	10 micron
Plastic/fibre:	3-5 micron

The mesh depth is typically from 100-300 mm with typical pressure drop of 0.1-3.0 millibar.
High liquid load/flooding will increase the pressure drop significantly. For efficient operation the demister K-value must generally be below 0.1 m/s. In potentially fouled service (hydrates, glycol freezing etc.) the mesh can become a problem, and hence a coalescing vane should be used instead.

At elevated pressures, and in critical service, the K-value must be multiplied by the following adjustment factors (source GPSA Engineering data book 1998 vol. 2, section 7, fig. 7-9):

Scrubber condition	Adjustment factor
1 barg pressure	1.00
20 barg pressure	0.90
40 barg pressure	0.80
80 barg pressure	0.75
Scrubbers upstream glycol and amine contactors	0.70
Scrubbers upstream compressors and expanders	0.75

Mesh as agglomerator:
At K-values above 0.1 the mesh will be flooded. This causes loss of separation efficiency, and the element will then act as an agglomerator, coalescing small droplets into larger. In this service the mesh can act as a conditioner for a secondary demisting element such as vanes or cyclones, as larger droplets will separate more easily in cyclones or vanes.

5.3.3.3 Demisting vanes

Double pocket vanes have higher efficiency and larger capacity as compared to single pocket vanes. Vanes are designed for both vertical and horizontal gas flow. Horizontal gas flow is recommended as this allows higher gas/liquid loads. Many different vane designs exist and a general performance factor can not be given, but the table below gives some conservative values:

Sizing factors for demisting vane elements:

	Vertical gas flow	Horizontal gas flow
ρV_s^2 (kg/ms^2)	20-30	30-45
K-value (m/s)	0.12 – 0.15	0.20 – 0.25

Note: Depending on pressure, liquid load and fluid properties, safety factors are usually employed by vendors.

Higher factors may be quoted, but these are often for air water/tests and shall not be applied for industrial applications unless relevant references with operating performance are provided.

Vanes give lower pressure drop than demisting cyclones and this may be an advantage at lower pressures such as in re-compressor scrubber applications (1-20 bar). At higher pressures, careful design is required to limit re-entrainment problems, but vanes have been used at pressures above 100 barg.

<u>Drainage:</u>
The liquid collected by the vanes are collected and drained by a drain pipe to the sump of the scrubber. The pipe must be submerged below the LALL. Sufficient drainage head must be assured (see section 5.3.3.4), so that liquid carry-over through the drain pipe does not occur under any circumstances. Some scrubbers may be without liquid at start-up due to level valve leakage or vapourisation. Liquid can be introduced before start-up, or special seal arrangements can be installed to maintain the liquid seal.

<u>Gas distribution:</u>
Uniform flow distribution into the face of the vane is important. Often, a perforated plate behind the vane is used to create an even flow. Computational Fluid Dynamics (CFD) should be used to confirm acceptable flow distribution. An agglomerating mesh may be used upstream the vane.

5.3.3.4 Demisting cyclones

Demisting cyclones in scrubbers are often axial type cyclones, but some other designs are also based on multi-cyclones with tangential entry. The following aspects relate to axial cyclones.

For axial cyclones, typical minimum droplet removal size is 5-10 microns depending on swirl velocity. The typical pressure drop is 20-100 mbar. The relatively high pressure drop requires a high drainage head, and is one of the critical parameters in cyclone design. The drainage is normally internal, into the vessel bottom, but should be routed externally in case of insufficient drainage height. The total differential pressure over the demisting section, measured in liquid height, shall not be more than 50% of the available drainage height related to LAHH.

A cyclone based scrubber should usually have a mesh upstream the cyclones. The mesh will act as a demistor at low gas rates, and as an agglomerator at high gas rates. The performance curves of the mesh and cyclones shall overlap to assure good demisting in the whole operating range.

The liquid handling capacity of the cyclones may limit the gas capacity and performance. Sufficient separation in the inlet/mesh section is required to stay below the liquid capacity limits of the cyclones.

The cyclone deck shall have a drain if liquid accumulation can occur.

Scrubbers with cyclones have been successfully implemented in both high and low pressure applications. A typical scrubber with inlet vane+mesh+cyclones should typically be sized for a maximum vessel K-factor of 0.15. This will assure successful operation in most applications. If higher K-factors are to be used, this shall be approved by the operating company and their experience.

5.3.4 Vessel height

The vessel height depends on the internals and requirements for liquid residence time or level control.

Level control:
Typically the time between normal and alarm level, and alarm and shutdown level is 45-60 seconds, or 200 mm, whichever is greater. The instrumentation shall be designed so that:

- offset due to variations in liquid and gas densities shall be negligible.
- joint use of a single nozzle for both liquid extraction and instruments is not allowed.
- the level glass shall, as a minimum, cover the total range from bottom to LAHH.

For floating installations vessel motion shall be considered and may increase the level distances.

Typical minimum distance between scrubber elements:
This will depend on scrubber type and the configuration of the internals. The objective is to assure an even gas distribution and avoid re-entrainment from the liquid surface. CFD analysis may be used to verify designs. Some typical minimum values, whichever is greater, are:

Inlet arrangement to LAHH	:	300 mm
Inlet arrangement to only mesh for demisting	:	900 mm or 1.0 x vessel diameter
Inlet arrangement to vane with horizontal gas flow	:	500 mm
Inlet arrangement to mesh as agglomerator	:	750 mm or 0.45 x vessel diameter
Mesh to outlet cyclones	:	750 mm or 0.35 x vessel diameter

5.3.5 Gas outlet

The gas outlet from scrubbers can be from the top or the side. Scrubbing with horizontal gas flow often employ side gas outlet. For vertical flow, demisting elements top outlet is recommended as this leaves more cross-sectional area available for the demisting internals. A top outlet also gives more space for capacity increase/later revamping.

5.4 Heat exchanger design

5.4.1 General

5.4.1.1 Definitions

Primary side	Main process fluid or main utility fluid (fluid to be treated)
Secondary side	Utility fluid

5.4.1.2 Design of heat exchanger area

The requirements for material design temperatures are given in NORSOK P-001.

In the rest of chapter 5.4, "design temperature", if not otherwise specified, is the temperature used to design the heat exchanger area.

Primary side design case:
Normally the maximum continuous duty will design the heat exchanger area, but for heat exchangers in a compressor train, the heat exchanger area shall be designed for all continuous operating cases including but not limited to:

- all possible flow rates and temperatures determined by the compressor map of the upstream compressor
- recycle flow rate and temperature along the whole anti-surge line of the downstream compressor. Temperature drop over anti-surge valve to be included.

For a heat exchanger in an oil train the heat exchanger shall be designed for all possible flow rates and temperatures determined by upstream or downstream pump map.

The heat exchanger shall be designed for turndown situations as specified in chapter 5.4.1.6.

Design margin:
Fouling or extra heat exchanger area shall be added as a design margin. Beware that such design margins easily can bring the wall temperature to fouling conditions (hydrate, wax, scale, decomposed glycol/degenerated glycol, coking) during turndown.

Fouling margin:
- Typical values for fouling (see TEMA).
- "Extra heat exchanger area" will depend on heat exchanger service, i.e. dirty or clean service and whether fouling has a strong influence on the total heat transfer coefficient. The extra area is typically an addition of 20% to 50% to the required clean area.

Temperature margin:
In the design of the heat exchanger area, the primary side temperatures shall have these design margins:
- Heat exchangers which have its feed from gas compressors shall have its inlet gas temperature increased by 10% in degree Celsius or 10°C, whichever is the larger, due to compressor wear and tear and due to the fact that the feed temperature to the compressor and the resulting outlet temperature of the compressor, can not be perfectly controlled.
- Heat exchangers which has its feed from production separators shall have its inlet fluid temperature increased (coolers) /decreased (heaters) by 5°C or more due to uncertainties in fluid inlet temperature into the production separator, or due to higher production from wells.
- Heat exchangers which has its feed from both gas compressors and production separators, shall have its inlet fluid temperature increased based on +10°C or 10% in degree Celsius, whichever is the larger, from the compressor and +5°C from the separator. The mixed temperature to be calculated.

An alternative to the above temperature margin requirements is to increase the secondary side flow rate to handle the same temperature margins without increasing the heat exchanger area, i.e. to increase the design flow rate of the secondary fluid.

Secondary side temperature to be used in design of heat exchanger area:
The heat exchanger area shall be designed with the following supply temperatures of the secondary fluid:
- Highest normal supply temperature of cooling fluid or
- Lowest normal supply temperature of heating fluid

5.4.1.3 Cleaning requirements

Nozzles for chemical flushing should be located on the heat exchanger or on the piping near to the heat exchanger to minimise chemical consumption (volume to be flushed). It shall be possible to isolate the exchanger by removing the removable spools, by inserting blinds or by the use of valves.

It shall be possible to drain out all chemicals after a "cleaning in place" operation.

Nozzles for chemical cleaning and vent/drain can be combined.

5.4.1.4 Drain/vent

It shall be possible to drain and vent all heat exchangers.

5.4.1.5 Bulk outlet temperature requirements

The bulk outlet temperature of the primary fluid shall under no circumstances, neither intermittent nor continuous, be below the wax or hydrate formation temperature – this to avoid plugging of the exchanger. Beware that multi-pass heat exchanger with its first pass as counter-current flow, may have internal temperatures which are below the bulk outlet temperature at turndown conditions.

The bulk outlet temperature of the secondary fluid has no requirements. There are only skin temperature requirements for the secondary fluid. See chapter 5.4.1.6 "Skin temperature".

5.4.1.6 Skin temperature

The skin temperature is the temperature outside the fouling layer or the metal surface temperature for a clean heat exchanger.

The maximum/minimum skin temperature is normally calculated from one of the operating cases listed in table 1 and 2. The heat exchanger skin temperature shall as a minimum be simulated for these operating cases (performance simulation with total heat exchanger area, i.e. for an exchanger designed with "extra heat exchanger area" as design margin, the extra area shall be included):

Table 1 – Off-design cases to be checked for skin temperatures for a heat exchanger where its primary side flow rate is determined by a compressor

Conditions to be used in the performance simulation (see explanation below)	1	2	3	4
Clean heat exchanger/minimum flow	X		X	X
Clean heat exchanger/maximum flow		X	X	X
Fouled heat exchanger (design fouling conditions)/min. flow	X		X	X
Fouled heat exchanger (design fouling conditions)/max. flow		X	X	X

Table 2 – Off-design cases to be checked for skin temperatures for a liquid heat exchanger where its primary side flow rate is determined by a separator control system (pump or valve)

Conditions to be used in the performance simulation (see explanation below)	4	5	6
Clean heat exchanger (no fouling)	X	X	X
Fouled heat exchanger (at design fouling conditions)	X	X	X

1. Gas flow rate defined by the compressor in the same recycle loop as the cooler operating at surge flow and minimum speed
2. Gas flow rate defined by the compressor in the same recycle loop as the cooler operating at surge flow and maximum speed
3. Gas temperature defined by the heat exchanger feed equipment(s) (see note 1 this chapter) with a margin on the gas temperature from compressor(s) of +10°C or 10% in degree Celsius, whichever is the larger, due to compressor wear and tear (and variation in compressor inlet temperature)
4. Minimum operating temperature of the cooling medium (cooler) or maximum operating temperature of the heating medium (heater)
5. Minimum normal operating flow of the primary fluid
6. Cooler: Maximum normal operating primary side temperature plus a margin of +5°C due to uncertainties in well fluid temperature. Heater: Minimum normal operating primary side temperature with a margin of minus 5°C due to uncertainties in well fluid temperature

Skin temperatures along the heat transfer area shall be reported for both the hot and cold side.

The skin temperature requirements are:
- Seawater side skin temperature shall be kept below 60°C to avoid scale deposition on the heat exchanger wall. See note 2) for exceptions to this requirement.
- The hydrocarbon side skin temperature shall be kept above the hydrate formation temperature or wax appearance point or below any temperature that will cause other fouling (e.g. coking,). See note 3) for exceptions any to this requirement.
- Skin temperature for coolant with anti-freeze (e.g. glycol mixtures) shall be kept below the decomposition temperature of the anti-freeze.

Note 1 is applicable for all heat exchangers
Note 2 and 3 is applicable for shell & tube and plate exchangers due to their large flow area, i.e. not printed circuit heat exchanger (PCHE) with narrow channels.

Note 1:
The equipment determining the feed temperature to a cooler in a gas compression train can, among other, be:

- the upstream compressor.
- the downstream compressor (typically the compressor in the same recycle loop as the cooler).
- both the upstream and downstream compressor (the downstream compressor is in the same recycle loop as the cooler and is operating at surge flow (up to 100% recycle flow).
- an upstream cooler in series with the cooler under evaluation.
- an upstream separator. The separator temperature shall have a margin of +5°C added due uncertainties in well fluid temperature.

When not otherwise specified, the highest (cooler) or lowest (heater) normal gas temperature from the feed equipment shall be used.

Joule-Thompson effect over the anti-surge valve shall be included in the calculation of temperature.

The compressor efficiency from the compressor chart at the actual operating point, shall be used.

Note 2:
Sea water side of sea water cooled heat exchangers

- Exception can be taken if parallel 100% equipment is installed so that regeneration or cleaning of the standby unit can be done during operation.
- For a clean heat exchanger, seawater skin temperature above 60°C can be accepted, but should be avoided. But when the exchanger has reached its design fouling condition, skin temperature on the seawater side above 60°C is not acceptable.
- For an exchanger which is designed with “extra heat exchanger area” as design margin:

Definitions:

1. “Main heat transfer area” is an area of the exchanger which is equal in size to the area before extra design margin was added.
2. “Margin area” is an area of the exchanger which is equal in size to the extra design margin added to the heat exchanger.

Skin temperatures above 60°C shall not occur in the “main heat transfer area”
Skin temperatures above 60°C can be accepted, but should be avoided, in the “margin area”.

Note 3:
For heat exchangers where the potential deposit will melt (such deposits are hydrate and wax) when the heat exchanger is brought back to normal operation, the exchanger is allowed to have wall temperature below the formation temperature of the deposit as long as the temporarily increase in fouling is acceptable. (It normally is due to low duty in turndown situations. This shall be confirmed by simulations.) Exception can be taken if parallel 100% equipment is installed so that regeneration or cleaning of the standby unit can be done during operation.

5.4.2 Shell and tube heat exchangers

Shell and tube exchanger shall be designed such that the maximum flow of primary and secondary fluid will not cause tube vibration which can damage the tube bundle. Special attention shall be given to high velocities near the impingement plate. The control system shall be designed so that the maximum flow is minimised at failure of the control system. Cases to be checked for vibration and high velocities are:

- Secondary fluid flow rate defined by a 100% open secondary fluid control valve at maximum delivery pressure from the secondary fluid circulation/feed pump when all other heat exchanger control valves, except for the unit under evaluation, are in closed position. The pressure downstream the control valve shall be at its minimum normal operating pressure. Calculation to be performed for no flow and normal flow of the primary fluid.
- Primary fluid gas flow rate defined by the compressor in the same recycle loop as the cooler, operating at maximum speed and minimum differential pressure.
- Primary fluid liquid flow rate defined by a 100% open primary fluid control valve at maximum differential pressure over the valve or maximum speed at minimum differential pressure over the primary fluid pump.

- If simultaneous failure of both primary and secondary side control system is possible, then the heat exchanger shall be checked for vibration for this case.

A travel stop to reduce the maximum flow rate through the control valve is not recommended as this may introduce a bottleneck in the process.

5.4.3 Plate heat exchanger (PHE)

Regular gasket plate heat exchanger is used for liquid to liquid duties at moderate temperatures and pressures. Fluids that are chemically aggressive towards standard gasket material must be handled by either semi-welded or fully welded plate heat exchangers.

5.4.4 Compact heat exchangers/printed circuit heat exchangers (PCHE)

Printed circuit heat exchangers can be used for gas and condensate cooling and heating. Special attention shall be given to:

- Particles: A permanent strainer of 300 micron shall be fitted on the inlet of both sides of a PCHE.
- Fatigue caused by thermo cycling. The temperature control shall be designed to limit thermo cycling. A travel stop for 20% minimum flow through the control valve is recommended to reduce the risk for thermal cycling.

Pressure drop over strainers and heat exchanger core shall be monitored.

Printed circuit heat exchangers are not recommended when sea water is used as coolant.

Wall temperatures along the heat transfer area shall be reported for both the hot and cold side for 3 channels: the two outer channels of the plate and the mid channel of the plate.

5.5 Pig launcher/receiver design

5.5.1 Pig launcher/receiver

Pig launcher and pig receiver shall be equipped with an interlock system to prevent opening of isolation valves around the launcher when the launcher door is open.

Flexible hose for purging with inert gas shall be available. Local pressure monitoring shall be provided for pig launchers and pig receivers.

When frequent pigging is necessary, pressure monitoring and pig detector alarm for launcher and receiver may be required.

5.5.2 Pig handling

Pig trolley and lifting arrangement shall be considered.

Space for transportation and handling of pigs to/from pig launcher and pig receiver shall be provided.

5.5.3 Drain/vents

Pig receivers/launchers shall be connected to flare, vent and drain system with hard piping. Pig receivers and launchers shall be provided with a small bore valve and vent (typical ½") to verify that the system is completely depressurised prior to opening the door.

6 Topside flowlines and manifolds (system 16)

6.1 Scope

This section defines the minimum functional requirements for the topside flowlines and manifolds system.

6.2 Functional requirements

6.2.1 General

The topside flowlines and manifolds system shall gather and transfer well stream from individual wells to downstream systems.

Typical manifolds are:

- Production manifold(s) (High pressure (HP)/Low pressure (LP)).
- Test manifold.
- Blowdown/equalisation manifold.
- Water source manifold

Further, the system includes a well service system providing access to individual wellbores for such operations as well clean-up and testing after completion and work-overs, kill operations, equalisation, blowdown, backflow, stimulation, valve testing, annulus bleed, methanol and chemical injection/squeeze treatment.

The system will be used to transport the following fluids in connection with such operations:

- Natural gas.
- Crude oil.
- Produced water.
- Water based mud.
- Brine (completion fluid).
- Diesel.
- Tracer chemicals.
- Methanol.
- Production chemicals.

6.2.2 Performance

In the design and sizing of the system, operating cases over the life time of the field should be taken into account.

6.2.2.1 Utility piping volume

Piping diameters shall be minimised in the well service piping and headers, because of frequent medium changeout.

6.2.2.2 Temporary hook-up

Connection points for temporary hook-up of chicksan pipe, flexible hoses or instrument tubing shall be available where relevant (to be specified by operating company).

6.2.2.3 Sand production/erosion

Heavy erosion, particularly in bends, from clean-up and backflow operations should be considered when determining wall thickness requirements. For the production and test manifolds, “Target T” bends should be used.

6.2.3 Sparing

System sparing class: A.

6.3 Operational requirements

6.3.1 Control and monitoring

Operations, control and monitoring should be from the CCR.

OS/VDU functions	P	T	F	Other	Remarks
Wellhead upstream choke	M	M			
Flowline downstream choke	M	M			
Choke				M	Valve opening 1)

Process variables: P=Pressure, T= Temperature, F= Flow.
Process functions: A= Alarm, C= Control, M= Monitoring.

Note The opening of each choke should be operated from the CCR with local manual override.

6.3.2 Safeguarding and shutdown

It should be noted that the maximum inflow is usually determined by the system design basis. However, production chokes may be able do deliver more flow into the system if they go fully open. The design shall address failure of choke fully open and the required system pressure protection. For details see section 16.2.1.

The piping in the production and test manifolds are normally rated to the maximum shut-in pressure to eliminate the need for overpressure protection.

6.4 Maintenance requirements

Only flanged valves shall be installed to facilitate frequent need for maintenance (due to erosion and high differential pressure).

There should be a possibility to remove one choke without having to dismantle other chokes on the same manifold.

Where heavy scale formation is expected, a provision for removal of scale shall be installed.

6.5 Isolation and sectioning

Individual well flowlines shall be accessible for maintenance and hook-up without shut-down of manifolds.

6.6 Layout requirements

Drainage of piping and manifolds to the closed drain system shall be ensured.

6.7 Interface requirements

Specific interface requirements shall be provided. Annex A contains data sheets with an Interface requirements list for provision of such information.

6.8 Commissioning requirements

No specific requirements are identified.

6.9 Safety requirements

No specific requirements are identified.

6.10 Environmental requirements

No specific requirements are identified.

7 Separation and stabilisation (system 20)

7.1 Scope

This section defines the minimum functional requirements for the separation and stabilisation system.

7.2 Functional requirements

7.2.1 General

The separation and stabilisation system shall stabilise and dewater the hydrocarbon liquid to export specification.

7.2.2 Performance

7.2.2.1 System capacity

In design and sizing of the system, a complete set of data on the predicted variations in the inlet/wellstream quantities and characteristics shall be considered. Simulation data shall be available to cover all known operating cases over the lifetime of the field. From the simulation results, sizing cases should be tabulated for each equipment item.

In selecting the design cases it is important to consider the:

- maximum total liquid rate with corresponding highest gas rate.
- maximum oil rate with corresponding highest gas rate.
- maximum water rate with corresponding highest gas rate.
- maximum gas rate with corresponding highest liquid rate.
- operating temperature (including variations in temperature) and pressure in all the above cases.

The crude oil export specifications are dictated by the downstream facilities/requirements.

7.2.2.2 System configuration

The system configuration shall be established based on optimisation of outlet specifications.

This must be considered:

- Number of separation stages.
- Operating pressure at each separation stage.
- Heating and cooling requirements (minimum energy consumption and CO_2 emission per produced unit).
- Fluid properties.
- Compression and pumping requirements (minimum energy consumption and CO_2 emission per produced unit).
- Special design requirements (e.g. floating production facilities).

Normally a single train shall be employed. However, two trains should be used in cases where:

- Vessel sizes exceed normal fabrication and/or transportation constraints.
- Increased oil production regularity justifies multiple trains.
- There is a substantial quality/price difference in the crude oils to be processed thus providing an economical justification for separate processing and offloading.
- HP and LP separation trains are required to process feeds from wells operating at very different pressures.

7.2.2.3 Sand control/removal

Jet water shall be supplied from one of the following sources, in the following priority:

1. Produced water.
2. Fresh water.
3. Seawater (requires injection of antiscale chemicals, and sulphate removal if necessary).

In addition, when sand production is expected, provision for dual level control valves should be considered.

7.2.2.4 Heat tracing

Bridles and field instrumentation shall be fitted with heat tracing and insulation, where malfunction can occur due to freezing or hydrate formation.

In case of heavy wax formation, a heating coil may be required to prevent problems at restart.

7.2.2.5 Pressure control

Pressure control (response times/control margins) shall be designed to avoid consequential shut-down of the oil separation train(s) as a result of unplanned gas compression shut-down (i.e. controlled process flaring).

7.2.2.6 Test separator

The test separator and its system shall be designed to operate both in parallel to the inlet separator and to lower pressure levels. The size shall as a minimum cater for the maximum production from any well, GOR and pressure level.

7.2.3 Sparing

System sparing class: A.

Normally one train, no spare. However, equipment as heat exchangers, pumps etc. must be evaluated based on the overall regularity requirements.

7.3 Operational requirements

7.3.1 Control and monitoring

Total control and monitoring from CCR

OS/VDU functions	P	T	L	F	Other	Remarks
Manifolds	M/A	M				
Test separator	C[1)]/A	M[1)]	C/A	M[1)]		[1)] = To be recorded
Production separators	C/A		C/A			Auto to flare
Production separators water outlets				(M)		Requirement for water flow to be evaluated
Heater/cooler		C/A				
Coalescer			C/A			

Process variables: P = Pressure, T = Temperature, L = Level, F = Flow.
Process functions: A = Alarm, M = Monitoring, C = Control.

Slug flow may require additional control.

7.3.2 Safeguarding and shutdown

No specific requirements are identified

7.3.3 Sampling

As a minimum sampling of oil and water from the separators shall be possible. The sampling stations shall be weather protected if environmentally exposed. The sampling stations shall be permanently piped to flare, closed and open drain.

7.4 Maintenance requirements

Maintenance requirements shall be:

- Full-flow bypass (with valve suitable for regulation) shall be installed across all level control valves (LCVs). Bypass piping should be considered installed across heaters, coolers and coalescer.
- To allow for inspection and clean out of the vessels, steam out and utility connections should be provided as appropriate.

7.5 Isolation and sectioning

7.5.1 Test separator

Flow measuring devices that will require frequent maintenance, shall be provided with isolation valves.

7.6 Layout requirements

The following lay-out considerations generally applies to the crude oil separation and stabilisation system:

- Level control valves should be located to avoid flashing upstream the valves, and to minimise slugging in the lines downstream such valves.
- The lay-out shall allow for gravity draining of the separators (without pockets in the drain lines) to the closed drain system.
- An electrostatic coalescer, if included in the separation train, shall operate liquid filled.
- Where a plate exchanger is used for oil cooling, the lay-out should be such that flashing will not occur in the cooler.
- Inlet piping to all separators shall be arranged to avoid high shear forces.

7.7 Interface requirements

Specific interface requirements are to be provided by the supplier. Annex A contains data sheets with an interface requirements list for provision of such information.

Individual injection points for anti foam chemicals shall be installed on test and separation manifolds and upstream all separator inlets. Injection points for emulsion breaker and potentially other chemicals shall be provided for on the production and test manifolds. Emulsion breaker chemicals may also be required upstream all separators. Consider injection of emulsion breaker and scale inhibitor upstream choke for improved efficiency. When two or more chemicals are injected into the same stream, it must be checked whether a minimum distance is required between the injection points to allow inmixing of one chemical before the next is added.

7.8 Commissioning requirements

Piping shall be fitted with high point vents and low point drains.

7.9 Safety requirements

In designing the separation and stabilisation system, the following safety aspects apply as a minimum:

- The separators hold large quantities of hydrocarbons in liquid and gaseous phase. Fire protection insulation on the vessels in order to ensure their integrity in the event of a fire shall be considered.
- Relief cases to be considered for sizing of relief valves shall include fire relief, blocked outlet, and gas blowby.
- During a process or emergency shutdown, the system should be segmented by use of actuated isolation valves. It is normal practice to treat each separator as an individual section and isolation valves shall be provided to automatically isolate each vessel in the event of a process or emergency shutdown.

7.10 Environmental requirements

No specific requirements are identified.

8 Crude handling (system 21)

8.1 Scope

This section defines the minimum functional requirements for the crude handling system.

8.2 Functional requirements

8.2.1 General

The crude handling and metering system shall meter and increase the oil export pressure as required for export to the defined destination.

The crude handling system typically includes crude cooling, pumping, metering and storage or pipeline export. Pigging facilities are also included for inspection and to enable removal of wax, free water etc. in the pipeline.

Alternatively, the pressure shall be increased to a level sufficient for shuttle tanker loading.

8.2.2 Performance

8.2.2.1 System configuration

The system configuration is dependant on whether the oil shall be exported by pipeline or by shuttle tanker.

8.2.2.2 General

Plate and frame heat exchangers are preferred as crude oil coolers. Coolers should be co-current heat exchanger to avoid/reduce waxing. If the wax appearance point is less than the cold medium inlet temperature, a counter-current heat exchanger is recommended. Cooler flow direction shall undergo critical evaluation as specified in section 5.4.

If flow-improving chemicals are used, location of the injection point should be considered with respect to type of chemical and effect of shear forces. The system must be evaluated for start-up mode.

8.2.2.3 Pipeline export

For pipeline export of stabilised oil, a booster pump may be required to provide enough pressure to transfer the oil through the coolers and for suction to the export pumps.

Booster pumps can be supplied with fixed speed while the export pumps should be supplied with variable speed drive. The selection of fixed speed vs. variable speed should be based on:

- energy and utility consumption
- power considerations during start up

The speed may be regulated by the level in the final stage separator. If pumps cannot tolerate free flow, they shall be started against back pressure towards the pipeline by use of a control valve or other means controlling pump motor load.

8.2.2.4 Shuttle tanker export

Shuttle tanker loading pumps should be of fixed speed type.

8.2.3 Sparing

8.2.3.1 Pipeline export

System sparing class:	A.
Sparing	Booster and crude export pumps shall be supplied with spare unit or spare capacity. Export cooler shall be supplied with spare unit when dewaxing operations are required.

8.2.3.2 Export shuttle tanker loading

System sparing class: B.
Sparing Pump configuration is preferred with a minimum 2 pump setup.
The need for pump sparing should be considered based on overall regularity requirements.

8.2.3.3 Continuous shuttle tanker export without storage

System sparing class: A.
Sparing Shuttle tanker export pump shall be supplied with spare capacity.

8.3 Operational requirements

8.3.1 Control and monitoring

Required monitoring in CCR as a minimum

OS/VDU functions	P	T	F	Other	Remarks
Booster pumps	M/A		C		
Coolers		C/M			Cooling medium control
Metering			M		
Pipeline pumps	A	A		C*	*Set by level in last stage separator if speed control by level
Loading pumps	A				

Process variables: P=Pressure, T= Temperature, F= Flow.
Process functions: A= Alarm, C= Control, M= Monitoring.

8.3.2 Safeguarding and shutdown

Platform isolation valve shall be installed downstream export pump and as close to riser as possible.

8.4 Maintenance requirements

Maintenance may be performed during operation since components are supplied with back up. Positive isolation is required for main equipment during maintenance. Plate heat exchanger may need to be repaired/overhauled onshore. Installation shall facilitate access for transportation.

8.5 Isolation and sectioning

Valves shall be located to enable maintenance on system main units.
Double block and bleed shall be installed on pig launcher inlet and outlet.

8.6 Layout requirements

- Space for transportation and handling of pigs to/from pig launchers shall be provided.
- Pumps should be located as low as possible to secure sufficient NPSHA.
- Crude coolers shall be located and designed so that no gas and particles are accumulated in coolers.

8.7 Interface requirements

Cooling
Cooling medium or seawater.

Chemicals (if required)
Hydrate inhibitor
Wax inhibitor
Corrosion inhibitor (pipeline export)
Flow-improver/drag reducer

8.8 Commissioning requirements

When commissioning of system 20 (separation and stabilisation) and 21 (crude handling) is planned to take place prior to well fluids being available (e.g. onshore), a tie-in tee should, if required, be installed downstream the pumps and upstream the separator, for connection of temporary recirculation lines through the systems.

8.9 Safety requirements
No specific requirements are identified.

8.10 Environmental requirements
No specific requirements are identified.

9 Gas compression (system 23, 26 & 27)

9.1 Scope
This chapter covers the minimum functional requirements for gas recompression, export and re-injection systems.

9.2 Functional requirements

9.2.1 General
The gas compression systems shall collect the gas from the different stages of separation, cool it, remove condensed liquids and compress the gas to a pressure suitable for export and or re-injection.

9.2.2 Performance

9.2.2.1 Capacity
The system shall be capable of handling the variations in capacity and gas compositions resulting from operations over the life of the field at the required delivery pressure. Rewheeling of compressors may be required to achieve this, and shall be evaluated. If installation of new equipment is required later in field life, tie-in points and space shall be provided, and utility and support system requirements shall be identified. Some margin with respect to flow, temperature and molweight shall be included.

9.2.2.2 Compressors
The compressor(s) should have variable speed drive(s) as a mean to optimise energy consumption and flexibility, however fixed speed drive can be used based on LCC.

To optimise compressor design to achieve the best overall efficiency, the intermediate operating pressure(s) shall be based on an energy optimisation study and compressor vendor recommendations.

To reduce the settle out pressure, the discharge side volume of centrifugal compressors shall be minimised, i.e. precooling is preferable to discharge cooling. The check valve should be located as close to the compressor as possible but downstream of the anti-surge recycle line and any discharge pressure safety valve (PSV).

Where a significant reduction in molecular weight can occur during start-up or recycling, a line to flare shall be provided to allow light gas to be discharged to enable the compressor to produce sufficient discharge pressure to establish forward flow.

When considering overpressure protection downstream the compressor, the following shall be taken into consideration:
- Maximum power available.
- Maximum speed.
- High suction pressure (PAHH suction pressure).
- Higher than normal molecular weight if applicable.
- Low suction temperature.
- The response time of PAHH and closed sectionalisation valve (sufficient margin between PAHH and PSV set pressure to allow for system response to avoid opening of PSV).

A compressor shall start with the suction valve open and the discharge valve closed. The discharge valve shall only open when the pressure is equal on both sides of the valve. Both suction and discharge valves shall close when a compressor is stopped.

If dry gas seals are used, the hydrocarbon seal gas shall be dehydrated, dewpoint controlled or superheated to prevent condensation or hydrate formation. For start-up purpose, use of nitrogen should be evaluated as a mean to avoid liquid drop out.

9.2.2.3 Scrubbers

The liquid removal efficiency of the scrubber shall match the requirements of the compressor to achieve the desired maintenance intervals.

The conditions downstream the liquid control valve shall be checked for hydrate formation, and suitable precautions taken, i.e.:

- control valve type to reduce potential for internal freezing
- injection point for methanol

When normally no flow of liquid out of scrubber is expected, level is to be controlled on an on/off basis.

Overpressure protection of the scrubber shall take into account leakage from the compressor discharge side if the discharge check valve fail to close on compressor shut down. If, in case of check valve failure, the common settle out pressure exceeds the design pressure (common settle out pressure based on volume upstream and downstream of compressor discharge check valve) of the scrubber, two check valves shall be installed in series. Check valves downstream compressors shall be of non-slam type.

When two check valves are used, monitoring of the intermediate pressure is required for leakage detection of check valves. Upstream safety valve to be designed for a predefined leakage through the check valve, typically 1% opening of the cross sectional area of the check valve. To reduce trapped in volumes between the check valves, it is recommended to locate the sectionalisation valve between the check valves. The pressure monitoring volume should be between the sectional valve and the downstream check valve.

Where two compression trains are running in parallel, the transient conditions when one compressor trips, shall be considered. The coolers and scrubbers should be able to withstand the maximum flow that the associated compressor can handle at minimum discharge pressure without incurring mechanical damage.

Where the gas at suction of one compressor stage have a normal operating temperature and pressure which is far away from the gas water or hydrocarbon dewpoint curve, and all possible variations in operating conditions does not create any liquid, the compressor suction scrubber may be avoided.

9.2.2.4 Condensate pumps

Special attention must be given to the design of condensate return pumps as the scrubber pressure can vary due to the dynamic in the compressor control.

9.2.2.5 Start-up

Special consideration should be given to restart after a complete depressurisation, especially if the injection wells are far from the compressor, i.e. subsea wells.

If blowdown valves are to be used in a start-up sequence, the blowdown valves shall be designed with sufficient actuator force to close against maximum operational differential pressure.

9.2.2.6 Design pressure

Pressure safety valves should, if at all possible, be avoided at very high pressures. This can be achieved by having no equipment except piping downstream the last stage of compression and analyse the compressor curves and possibly allow some degree of overpressure of the piping for limited periods (for details refer to NORSOK standard P-100 Process Design).

9.2.3 Sparing

The system is vital for production.
System sparing class: A.

9.3 Operational requirements

9.3.1 Control and monitoring

OS/VDU functions	P	T	L	F	Other	Remark
Compressor gas inlet				C		Input to antisurge
Compressor gas inlet	A,M	A,M				Input to antisurge, if required
Compressor gas outlet	A,M	A,M				Input to antisurge, if required
Scrubbers			C/A			
Coolers		C/A				

Process Variables: P = Pressure, T = Temperature, L = Level, F = Flow.
Process Functions: A = Alarm, M = Monitoring, C = Control.

Note: - Compressor vendor to be involved in control and monitoring of the total compressor system.

The following control requirements are valid for a minimum manning facility:

- The control system should allow all operations required to pressurise, start, run and stop the compressor system to be carried out from the control room.
- Variables required for condition monitoring and condition based maintenance planning shall be collected and stored automatically.
- Auxiliary systems to the compressor and driver shall be monitored to the extent required for obtaining prealarms prior to shutdown actions. The number of shutdown actions should be limited, and the use of critical alarms should be considered instead.

9.3.2 Safeguarding and shutdown

Automatic depressurisation due to seal oil/seal gas failure shall be included. Maximum depressurisation rate (dP/dt) to be specified by compressor vendor to ensure seal integrity.

9.4 Maintenance requirements

All major parts to be easily accessible and removable with a minimum disturbance to piping, i.e. break-out spools shall be provided on the major piping where equipment may have to be removed.

Water wash equipment to be provided for gas turbines.

Arrangement for direct filtering and filling of seal oil, plus drainage of seal and lube oil to closed drain, shall be installed.

9.5 Isolation and sectioning

Each compressor train shall be equipped with isolation valves and bleed for maintenance purposes.

9.6 Layout requirements

- Coolers and compressors should be elevated above scrubbers. Lines shall slope towards scrubber.
- Anti surge line should be sloped with the antisurge valve at the highest point.
- When methanol injection is required upstream the cooler, the main piping shall slope from injection point towards the cooler.

9.7 Interface requirements

The following utility and support systems may have to be provided to the compression system:

- Cooling medium or seawater for gas, lube and seal oil coolers.
- Nitrogen for isolation seal gas.
- Methanol if required for hydrate prevention and removal.
- Instrument air and hydraulic power.
- Electric power and UPS, as required.
- Service fresh water for turbine washing. Ion exchange filters to be part of the system.
- Fuel gas/diesel.
- Flare and drain.

Specific interface requirements shall be provided. Annex A contains data sheets with an interface requirements list for provision of such information.

9.8 Commissioning requirements

Commissioning requirements:

- Temporary strainers shall be installed upstream each compressor.
- If compact heat exchangers are used, temporary spools bypassing the exchangers may be provided to allow full flow flushing of the cold side piping. All inlets filters of 300 micron must be installed immediately upstream the exchanger, even if the service is clean during normal operation.
- If onshore commissioning is planned, type of fuel to the gas turbine should be considered.
- The gas coolers should be designed to allow for compressor testing with nitrogen or air, i.e. design temperature, increased water flow and vibrations.

9.9 Safety requirements

Compressors should, to the extent practical, be located away from large hydrocarbon inventories such as production separators.

9.10 Environmental requirements

The power consumption of compression systems should be minimised by utilisation of best available technology for antisurge-, and speed-control and load sharing where parallel units are operated.

When wet seals are used, and the pressures allow, the gas from the seal oil pots should be returned to the process. Gas from vacuum degassing units can normally not be recovered.

10 Gas treatment (system 24)

10.1 Scope

This chapter covers the requirements for water dewpoint control. The main emphasis is on absorption systems since most offshore systems for water dewpoint control are absorption systems. Systems combining water dewpoint control and hydrocarbon dewpoint control are covered in system 25.

10.2 Functional requirements

10.2.1 General

The dehydration system shall remove water vapour from the gas to a level suitable for transport, injection or further processing, whichever is the more stringent.

10.2.2 Performance

10.2.2.1 Capacity

The system shall be capable of handling the gas design capacity of the processing facility. No special design margin should be included. The dehydration system should however not be the limiting unit determining the gas capacity. It would be prudent to design the system for the maximum capacity of the compressors.

10.2.2.2 Glycol contactors

The movements on floating installations shall be taken into account when designing the glycol distributor, packing, chimney tray and glycol circulation rate.

The volume of the bottom section of the glycol contactor shall be designed to handle liquid draining from the packing/trays without initiating high level.

If a scrubber/coalescer is installed downstream the contactor, it shall be possible to drain the content to both the glycol regeneration system and crude handling system (typically the separator).

Packing/internals
Structured packing is preferred to trays. Packing selection should emphasise capacity and low pressure drop in preference to high efficiency and low glycol circulation rate.

The liquid must be evenly distributed across the packing. The type of distributor selected is critical in achieving this. Also, plugging of the distributor may be a problem, as some types are susceptible to blocking from sludge, scale, or corrosion products accumulating in the glycol. To prevent this, a filter may be installed upstream the contactor.

The contactor internals shall be able to withstand the maximum gas velocity that may occur under any operating condition, including backflow, without sustaining mechanical damage.

To minimise glycol losses, a demisting device shall be located at the gas outlet of the vessel. Sufficient height should be allowed above the demistor to assure that gas coning will not occur.

The chimney tray hats shall be designed to avoid liquid entrainment from hats.

Condensation
Hydrocarbon condensate will interfere with the efficient operation of the glycol contactor. Thus an efficient scrubber should be provided upstream the contactor, either as a separate vessel, or integrated in the same vessel as the contacting section.
Skimming of condensate from the glycol should be provided. Care should be taken to prevent condensation due to pressure or temperature drop in the line between the upstream scrubber and the glycol contactor. Alternatively superheating of gas might be required to avoid condensation in the contactor.

The skimming line shall be fitted with a valve to close on platform PSD and high level in the contactor to avoid loss of glycol during shutdowns.

The glycol inlet temperature shall be maintained 5°C above the feed gas temperature to prevent condensation where the glycol enters the contactor.

Insulation and heat tracing on the level bridles on both scrubber and contactor shall be provided according to Norsok standard P-001 Process design.
Condensation in the level glasses and level transmitters results in wrong readings. This shall be accounted for in design (draining of level glasses and transmitters and have separate connection for the condensate phase back to the contactor (level glasses and transmitters with three nozzles)).

10.2.2.3 Regeneration unit and storage

Atmospheric discharge of fuel gas stripping gas from glycol regeneration shall be minimised or preferably avoided.

A bypass line around the glycol contactor shall be provided to allow circulation and heating of the glycol in periods where the contactor is not operating. In this mode the glycol will not contain any gas, and fuel gas may be required to provide sufficient pressure in the regeneration system.

It shall be possible to measure the flow of glycol entering the contactor.

For gas stripping regeneration towers structured packing is recommended.

Where recirculation of a stripping gas or stripping agent is selected, the system shall be designed to avoid build up of CO_2, H_2S and methanol. Methanol lowers the boiling point of the glycol.

Glycol drainage
Drainage of all equipment shall be collected in a glycol sump. The sump and storage tank shall be blanketed by an inert gas to prevent oxidation of the glycol, and also, to route potential hydrocarbons to a safe location. The inert gas must have an oxygen level sufficiently low to prevent oxidisation at the relevant temperatures.

Chemicals
Provision shall be made to inject antifoam although this should only be used as a last resort as it can cause some fouling in the contactor tower. Corrosion inhibitor shall be injected to the system as needed.

The chemical injection package should be designed for continuos dosing at the suction side of the glycol circulation pump.

Reboiler
From an environmental point of view electric heating in the reboiler is undesirable. Heating by waste heat should therefore be evaluated. When electric heating elements are used for reboiling, it shall be possible to remove individual elements without draining the unit. The heater skin temperature shall not cause thermal decomposition of the glycol during normal operation and fluctuations.

The reboiler shall be designed for full vacuum.

Glycol flash tank
Efficient condensate removal facilities shall be installed.

Glycol filtration
Glycol filters shall be provided to remove particulate degradation and corrosion products from the lean glycol. If differential pressure is used as an indicator for filter replacement on a slip stream filter, this requires a flow measurement.

Still column
Dissolved hydrocarbons, mainly aromatics, may be present in the feed to the glycol reboiler. These will be vaporised in the reboiler and may cause flooding in the still column. This must be evaluated in the design of the still column, notably the increased vapour flowrate and the extra duty in the reboiler.
Structured packing is recommended in the still column. The upper section of the still column will have low liquid load, while the lower section will have a higher load. This shall be reflected in the selection of packing material.

To minimise glycol losses while maintaining sufficient glycol purity, the temperature in the top of the still column shall be controlled.

Be aware of CO_2 corrosion in the upper section of the still column.

10.2.2.4 Wet gas inlet coolers

It is advantageous to cool the inlet gas to the dehydration unit as much as possible to limit the water load. Note that low skin temperatures in such coolers may cause hydrate formation.

10.2.3 Sparing

The system is vital for production.
System sparing class: A.

10.3 Operational requirements

10.3.1 Control and monitoring

The dehydration unit shall be fully controlled from CCR. All operations required for starting and running the package as well as altering operating conditions shall be available from the operator station.

Required control and monitoring as a minimum

Component	P	T	L	F	Other	Remarks
Inlet cooler		C/A				
Scrubber			C/A			
Glycol contactor	M/A		C/A		M	Differential pressure and water content in produced gas
Reflux condenser		C/A				
Flash drum	C/A		C/A			
Reboiler		C/A				
Stripping column				M		Readout can be local only
Glycol cooler		C/A				
Glycol pumps	M			M	C/M/A	Start / stop / status
Glycol filters	M					Local readout of differential pressure

Process Variables: P = Pressure, T = Temperature, L = Level, F = Flow.
Process Functions: A = Alarm, M = Monitoring, C = Control.

10.3.2 Safeguarding and shutdown

The pipe from the glycol contactor to downstream the reflux coil shall as a minimum be designed to the same pressure as the contactor due to potential clogging of the reflux coil.

10.4 Maintenance requirements

All major parts to be easily accessible and removable with a minimum disturbance to piping, i.e. break-out spools shall be provided on the major piping where equipment may have to be removed.

Areas where frequent maintenance may be expected, like pumps and filters, shall have easy access.

Procedure for regular replacement of filters and charcoal elements shall be established.

10.5 Isolation and sectioning

Where multiple units are used, isolation shall be provided to allow work on one while the other is operating.

Isolation shall be provided to allow work on all parts of the regeneration system without having to depressurise the contactor column.

10.6 Layout requirements

It is recommended to locate the contactor in a location not exposed to weather and wind to avoid insulating the vessel due to condensation.
Minimise pipe routing from scrubber to contactor to avoid condensation.

The temperature transmitter controlling the glycol feed temperature to the contactor shall be located close to the contactor. This will ensure correct glycol temperature independent of ambient temperature and wind chilling.
Outlet piping from glycol reboiler should be designed to minimise backpressure on the reboiler.

10.7 Interface requirements

The following utility and support systems may have to be provided to the dehydration system:

- Cooling medium or seawater for gas and glycol coolers.
- Inert gas for blanketing storage and sump tanks.
- Methanol to injection points for hydrate prevention and removal where required.
- Instrument air.
- Electric power.
- UPS for instrumentation.
- Fuel gas for pressurising when in bypass mode, possibly for stripping
- Flare
- Open and closed drain system
- Atmospheric vent
- Filling line from tote tanks storage
- pH buffer to control the lean glycol pH level at around 6.5 to 8
- Antifoam to control foaming the contactor or glycol flash drum
- Corrosion inhibitor to control corrosion.

Specific interface requirements shall be provided. Annex A contains data sheets with an Interface requirements list for provision of such information.

10.8 Commissioning requirements

The regeneration unit should be fully prepared for test running before leaving the shop.

The glycol contactor and regeneration system shall be cleaned for debris and dirt (oil, grease etc.) prior to start up.

10.9 Safety requirements

Direct fired reboiler shall only be considered after a rigorous evaluation of safety aspects.

10.10 Environmental requirements

The atmospheric discharge of stripping gas should be avoided. If the stripping gas is rich in aromatics, some form of BTX recovery should be considered to reduce the emissions.

Electric heating of glycol reboilers has a low thermal efficiency. It should therefore be evaluated to use heating medium, preferably from waste heat recovery for this purpose. This will reduce CO_2 emissions.

It shall be possible to regulate the glycol circulation rate to the contactor to match the gas production rate. This will also reduce overall energy consumption.

11 Gas conditioning (system 25)

11.1 Scope

This chapter covers the minimum functional requirements for gas conditioning used for hydrocarbon dewpoint control and NGL stabilisation.

11.2 Functional requirements

11.2.1 General

The objective of the gas conditioning system is to process the feed gas stream to meet the downstream requirement and/or optimise the economic value of the products.

The gas conditioning system shall lower the hydrocarbon dewpoint to a level suitable for gas transport, sales gas requirements, gas injection or further processing, whichever is valid. The NGL product shall meet its export specification or be split in a stabiliser and mixed with oil and gas products while the product specifications still shall be met for the spiked products.

The gas conditioning process can typically be:

- Turbo expander
- Joule Thomson expansion
- External refrigeration

The use of a turbo expander is based on expansion through a turbine. Energy in the inlet gas is partly recovered and can be used to drive a gas recompressor or a generator. A turbo expander and a re-compressor on the same shaft is common. The turbo expander process is very efficient for the purpose, as the temperature drop is greater across an expander than it is over a valve with the same pressure drop.

Joule Thomson expansion is based on cooling of the gas as a result of adiabatic expansion through a valve (JT valve). Joule Thomson expansion is a simple system used in production systems where a pressure drop is possible and a very low temperature is not required..

External refrigeration may be required for partial condensation if the process conditions does not allow JT or turbine expansion.

The gas conditioning system can also be used to lower the water dewpoint, if separate gas dehydration system is not present, by injection of glycol. Glycol separation and regeneration will be required for such a system. If used, the system shall be designed to handle problems with high viscosity of glycol water mixtures at low temperature.

The main emphasis is on turbo expander systems since this is the most common type of gas conditioning facility used today, due to low cost and weight and its pressure recovery capability.

11.2.2 Performance

11.2.2.1 Capacity

The system shall be capable of handling the variations in capacity and gas compositions resulting from operations over the life of the field at the required delivery pressure. If installation of new equipment is required later in field life, tie-in points and space shall be provided, and utility and support system requirements shall be identified. If the amount of flash gas from oil stabilisation and the gas quality is uncertain, some margin with respect to flow and molweight should be considered.

11.2.2.2 Heat exchanger

Heat exchanger approach versus pressure drop optimisation can be important if available pressure drop is limited. The hydrate formation temperature is important and needs to be taken into account.

There shall be possibilities to bypass the cold stream(s) to allow melting of any freeze-outs and for temperature control.

Differential pressure protection of the heat exchanger shall be considered if a combined heat exchanger/scrubber-solution is chosen.

11.2.2.3 Scrubber

The liquid removal efficiency of the scrubber shall match the requirements of the expander to achieve the desired maintenance intervals.

Where two trains are running in parallel, the transient conditions when one train trips, shall be considered. The coolers and scrubbers shall be able to withstand the maximum flow that the associated expander can handle at minimum discharge pressure without incurring mechanical damage.

11.2.2.4 Turbo expander and recompressor unit

Hydrate inhibitor injection points shall be provided at the expander for start-up purposes. In general it is considered that liquids in the turbo expander outlet stream should be limited to 20 - 30% weight of outlet stream. This limitation may result in the use of two turbo expanders with interstage liquid separation.

A Joule Thomson (JT) valve system should be installed in parallel with the turbo expander. The JT valve is used during start-up to establish correct pressure and flowrate in the system to ensure a smooth start-up of the turbo expander. The JT valve can be used as a back up when the turbo expander is out of service, but the JT valve will not have the same efficiency with respect to temperature drop.

Gas recycle lines for start-up and turndown shall be considered as the turbo expander can operate only at a limited turndown. A recycle line to achieve sufficient flow shall be considered from downstream the compressor units. Production flaring shall be considered to maintain operation of the gas conditioning system during a downstream equipment shutdown (in order to preserve process chill).

If compressor dry gas seals are used, the buffer gas should be dehydrated, dewpoint controlled or superheated to prevent condensation and hydrate formation.

There is a possibility for CO_2 freezing at temperatures less than -57 °C, the triple point for CO_2.

The compressor part shall be equipped with antisurge control loop.

11.2.2.5 Condensate handling

The condensate recovered from the expander outlet must be handled based upon downstream requirements.

Typical parameters to optimise shall be:

- Number of flash stages – compressor intermediate pressures
- Stabiliser pressure considering heating duty and temperatures available

11.2.3 Sparing

The system is vital for production.
System sparing class: A.

Sparing:

Heat exchangers	No sparing
Scrubbers	No sparing
Expander/compressor	Sparing based on regularity requirements
Joule-Thompson valve	No sparing
Low temperature separator	No sparing

NGL separation	No sparing

11.3 Operational requirements

11.3.1 Control and monitoring

The gas conditioning system shall be fully controlled from CCR. All operations required for starting and running the package as well as altering operating conditions, shall be available from the operator station.

The control scheme for this system shall be adjusted to match the actual configuration, and the table below represents only one typical design.

Required control and monitoring as a minimum:

Component	P	T	L	F	Other	Remarks
Heat exchanger, cold side		M, A				Differential pressure for compact exchangers
Heat exchanger, hot side		M, A				
Scrubber			C, A			
Expander	C					Guide vane control
Recompressor	C			C		**Antisurge control**
Condensate separator	(C), A	(C), A	C, A			Dewpoint control. Control either on P or T
NGL stabiliser/reboiler	(C), A	(C), A	C, A			Control either on P or T

Process Variables: P = Pressure, T = Temperature, L = Level, F = Flow.
Process Functions: A = Alarm, M = Monitoring, C = Control.

11.3.2 Safeguarding and shutdown

The design pressure shall be equal through the whole system. Design temperature shall consider the very low temperatures that can be experienced through blowdown of cold systems. Pressure increase caused by liquid boil-off during shutdown of isolated system shall be considered.

During a process or emergency shutdown, the system should be segmented by use of actuated block valves. The segmenting shall consider the different temperature levels and liquid volumes that may boil off when a section is heated up to ambient temperatures during a shut-down.

11.4 Maintenance requirements

All major parts to be easily accessible and removable with a minimum disturbance to piping i.e. breakout spools shall be provided on the major piping where equipment may have to be removed.

Areas where frequent maintenance may be expected, like turbo expanders, shall have easy access.

LPG/NGL to be drained to the flare system (low temperature system). Closed drain system connections shall be designed for low temperatures and liquid boil-off/flashing.

Lubrication oil and seal oil drain and filling from tote tanks shall be hard-piped.

11.5 Isolation and sectioning

Where multiple units are used, isolation valves and bleed for maintenance purpose shall be provided (to allow work on one while the others are operating).

11.6 Layout requirements

The feed line to the expander and the compressor shall be sloped to ensure that liquids condensed in the piping is drained back to the inlet scrubber/separator.

Anti surge line going from the discharge side to the suction side of the recompressor should be sloped with the valve at the high point.

11.7 Interface requirements

The following utility and support systems may have to be provided to the gas conditioning system:

- Inert gas for blanketing storage and sump tanks.
- Glycol to injection points for hydrate prevention where required.
- Methanol to injection points for hydrate prevention and removal where required.
- Instrument air.
- Cooling medium or seawater.
- Electric power/UPS requirements.
- Hydraulic power.
- Flare HP/LP.
- Open and closed drain system.
- Atmospheric vent.
- Heating medium.

11.8 Commissioning requirements

Temporary strainers should be installed upstream the expander and the recompressor.

11.9 Safety requirements

Care must be taken to protect against low temperatures by shielding or personnel protection insulation.

11.10 Environmental requirements

No specific requirements are identified.

12 Water injection (system 29)

12.1 Scope

This chapter covers the minimum requirements for the water injection system.

12.2 Functional requirements

12.2.1 General

The water injection system shall deliver water at high pressure for injection to maintain the reservoir pressure. For seawater injection systems, treatment may include coarse filtration, fine filtration, disinfection, deoxygenation and chemical injection.

Note: Some of the requirements in this chapter may not be valid for a particular project due to reservoir conditions and/or material selection. Such requirements can be omitted. Typical examples are filtration, disinfection and deoxygenation.

12.2.2 Performance

12.2.2.1 Filtration

For permanent water injection systems, self cleaning filters shall be used.

Coarse/fine filtration is optional.

12.2.2.2 Disinfection

Disinfection facility is optional based on injection water requirements.

Disinfection shall be achieved with a minimum use of chemicals. Seawater supply shall be chlorinated. Continuos disinfection can be achieved by use of Ultra Violet (UV) sterilising units opposed to continuos injection of organic biocides. Typical design dosage is 40 mWs/cm^2 (milli-Watt-second pr. square centimetre) with a transmissivity of 95% in a 10 mm cell.

12.2.2.3 Deoxygenation

Optional based on reservoir requirements and material selection. If carbon steel piping and vessels are used, the water shall be deoxygenated. If high alloy seawater resistant steel is used, deoxygenation for corrosion purposes can be avoided.

Deoxygenation shall preferably be achieved without the use of chemicals.

For vacuum dearation tower(s) the following applies:

- Vacuum pumps to be oversized by 20% due to possible leakage in gaskets.
- Deoxygenated water should flow into a buffer tank (normally part of the deareator). Upstream of the buffer tank, provision shall be made for injection of chemicals for oxygen removal (oxygen scavenger) in case of operational problems with the deoxygenator unit. The buffer tank should be sized based on necessary time for chemical to react or to enable booster pump suction in case of fluctuations in seawater supply, whichever is largest.

Other processes for oxygen removal may also be used, such as stripping gas (e.g. nitrogen).

12.2.2.4 Booster pumps

Pumps should be of fixed speed type. Start up return/dump line to be installed downstream the booster pump.

The booster pump may be integrated into the injection pump.

12.2.2.5 High pressure pumps

The high pressure pumps should be of variable speed type. A fixed speed pump can be chosen based on LCC. Upstream the injection pump there must be adequate buffer volume to ensure safe water supply in case of system booster pump trip to safely run down the injection pump.

12.2.2.6 Chemical injection

A chemical injection package shall be available for injection of the chemicals as required. The interaction of different chemicals, type of chemical and location of injection point shall be considered as many of the chemicals may react with each other. A typical example is chlorine reaction with oxygen scavenger.

Disinfection:

Chlorine	Continuos injection in seawater supply to prevent marine growth, if not already present.
Organic biocides	Shock treatment at certain intervals for further reduction of living bacteria and control of biofilm build up.
UV sterilisation	Normally a more cost effective solution than continuos injection of large amounts of organic biocides.

Other chemicals:

Oxygen scavenger	Chemical removal of oxygen when the deoxygenator is out of service.
Antifoam	To prevent foaming in the deoxygenator.
Polyelectrolyte	Injected to enhance filtration efficiency in fine filters.
Scale inhibitor	May be required to prevent scaling in reservoir.

Note: The use of ferric chloride or equivalent coagulants to enhance filtration efficiency should be avoided due to experience with iron oxide precipitation in seawater injection systems.

12.2.3 Sparing

System sparing class: Class B.

Sparing:

Filtration	2 x 100%
Deoxygenation	No sparing required
Disinfection	No sparing required
Booster pumps	No sparing required
Injection pumps	No sparing required
Chemical injection	No sparing required

12.3 Operational requirements

12.3.1 Control and monitoring

Control and monitoring from the CCR

OS/VDU Functions	P	T	L	F	Other	Remarks
Coarse filter	M/A					Alarm on high differential pressure
Fine filter	M/A					Alarm on high differential pressure
Disinfection						Common alarm
Deoxygenation/ buffer tank	M/A		C	C	Oxygen content	
Booster pumps	M				Running status	
Injection pumps	M/A			M		Alarm on high and low pressure

Process variables: P=Pressure, T=Temperature, L=Level, F=Flow.
Process functions: A=Alarm, M=Monitoring, C=Control.

12.3.2 Safeguarding and shutdown

Water hammer effects during start up and shutdown shall be considered during design.

12.3.3 Sampling

Sampling points shall be provided for routine monitoring of water quality and process performance.

12.4 Maintenance requirements

Space shall be provided close to filters and pumps for laydown of dismantled components during major overhaul and repair.

12.5 Isolation and sectioning

Individual equipment items in parallel duty shall be equipped with valves for individual isolation.

12.6 Layout requirements

Booster pumps to be located at the lowest elevation of the system to achieve the NPSHR.

12.7 Interface requirements

Seawater	Seawater supply from the seawater system.
Water	Formation water.
Chemical injection	As required.
Power supply	Drivers for pumps, vacuum compressors and UV sterilising.
Instrument air	As required.
Utility air	For (dual) media filter, if applicable.
Inert gas	On booster pump buffer tank, if this is required.
Drain system	As required.

Specific interface requirements are to be provided by the supplier. Annex A contains data sheets with an Interface requirements list for provision of such information.

12.8 Commissioning requirements

No specific requirements are identified.

12.9 Safety requirements

The handling and spill of chemicals shall be limited to the extent possible.

12.10 Environmental

The chemicals selected shall comply with the Parcom regulation and be approved by the State Pollution Agency (SFT).

Dumping of chemically treated water should be avoided during start up, shutdown and minimum flow.

Environmental friendly chemicals shall be preferred.

13 Cooling medium (system 40)

13.1 Scope

This section defines the minimum functional requirements for the cooling medium system.

13.2 Functional requirements

13.2.1 General

The cooling medium system shall remove heat from process and utility systems where direct seawater cooling and air cooling is not applicable.

To avoid freezing in a liquid filled cooling medium system, the following two options are possible:

- The cooling medium shall have a freezing point equal to or below the minimum ambient temperature.
- Cooling medium with freezing point above minimum ambient conditions may only be selected when accepted by company. An evaluation of consequences (operating and maintenance of a large number of heat trace circuits, filling and drainage requirements, use of corrosion inhibitor and other chemicals in the cooling circuit) shall be performed.

If the piping in the cooling medium system is made of carbon steel, a slip stream filter shall be installed around the pumps to filtrate the flow with 80 micron filtration grade. 10% filtration rate is recommended. For cooling medium systems with printed circuit heat exchangers (PCHE), the heat exchanger vendor shall be consulted regarding filtration grade.

The system shall be designed in such a way that water hammer is avoided at pump start up and shut down in such a way that the system, including rupture discs, can withstand the maximum water hammer pressure.

13.2.2 Performance

13.2.2.1 System capacity

Pumps shall be sized for the sum of all normal continuous operating loads.

13.2.2.2 System operating pressure

Cooling medium shall be maintained at a higher pressure than the seawater in the cooling medium cooler to:

- prevent seawater (chloride) migration into the cooling medium.
- ensure that the cooling medium does not boil during low flow or turndown conditions, that is, keep the coolant pressure high enough so that it would not boil even if stagnant. The cooling medium vapour pressure at maximum normal hot side temperature in the exchanger, shall be used.

13.2.2.3 Expansion tank

The expansion tank shall have capacity to control volume expansion from temperature variation (between minimum ambient and maximum operating) within the 25% and 75% liquid level range. Hydrocarbon monitoring shall be installed enabling detection of leakage.

13.2.2.4 Fill-up/drainage

Fill-up line shall be permanently installed. System shall be gravity drained to tank or boat.

13.2.2.5 Mode of operation

Either pump may serve as standby pump. There shall be automatic start of stand-by pump on trip of operating pump.

13.2.3 Sparing

System sparing class: A.

Continuous load shall be handled by the normally operating pump(s). Additional pump(s) shall be available for periods with intermittent high loads and as spare.

13.3 Operational requirements

13.3.1 Control and monitoring

Control and monitoring from CCR

OS/VDU functions	P	T	L	F	Other	Remarks
Cooling medium pumps		M		C	A	Pump running status
Cooling medium coolers		C/A				
Cooling medium expansion tank	M/A		M/A		A	Hydro-carbon detection

Process variables: P = Pressure, T = Temperature, L = Level, F = Flow.
Process functions: A = Alarm, M = Monitoring, C = Control.

13.3.2 Safeguarding and shut-down

No specific requirements are identified.

13.4 Maintenance requirements

Cooling medium coolers should be designed for maintenance at location. Lifting devices shall be installed for dismantling and transportation.

13.5 Isolation and sectioning

Block valves and spool pieces as necessary, shall be installed around pumps, coolers and cooler users for individual isolation to allow removal of units for maintenance.

13.6 Layout requirements

Layout requirements:

- Cooling medium coolers shall be located at low elevation to reduce seawater pumping.
- Expansion tank shall be located at the highest point in the circulation loop.

13.7 Interface requirements

Inert gas	Expansion tank shall be continuously nitrogen blanketed.
Chemicals	Injection of corrosion inhibitor/PH stabiliser upstream of pumps shall be provided.
Power	Emergency or essential power shall be available for one pump. Pump selection may be done manually.
Seawater	Flow rate as required for energy balance.
Instrument air	As required.
Vent/flare facility	For venting of hydrocarbons if detected. Connection to rupture discs/relief valve on process cooler.

Specific interface requirements are to be provided by the supplier Annex A contains data sheets with an interface requirements list for provision of such information.

13.8 Commissioning requirements

Critical equipment such as compact heat exchangers have special requirements for cleaning.

13.9 Safety requirements

Process coolers with hydrocarbon on hot side shall be protected by rupture disc(s) or PSV if the maximum operating pressure of the hydrocarbon is higher than the cooling medium design pressure.

13.10 Environmental requirements

No specific requirements are identified.

14 Heating medium (system 41)

14.1 Scope

This chapter defines the minimum requirements for the heating medium system.

14.2 Functional requirements

14.2.1 General

The heating medium system shall provide required heat load to process and utility equipment. Heat energy is transferred by heating medium, circulating in a closed loop. The heat is usually supplied by means of waste heat recovery from turbines.

Where heat is required before start up of turbines, a start up heater is required.

The heating medium is normally water/glycol (TEG) or hot-oil depending on temperatures required. The danger connected with use of flammable heat medium should be considered.

The maximum operating pressure for the system shall cater for pressure surges and temperature variations in the system (start-up/shutdown and normal operation).

14.2.2 Performance

14.2.2.1 System Capacity

System capacity is calculated as design load of continuous consumers plus peak load from intermittent consumers (if relevant).

14.2.2.2 Pumps

Pumps and motor to be sized for maximum viscosity of heating medium, i.e. cold state. To ensure NPSH it shall be assumed that water based heating medium is at boiling point in the expansion tank.

14.2.2.3 Waste heat recovery units

It shall be possible to bypass the waste heat recovery tube bundle by bypassing the exhaust gas. This is important to avoid boiling or decomposition of heating medium within the heating coil. The exhaust bypass can be used as heating medium temperature control.

Minimum operating temperature for the exhaust gas is 120 °C, as stainless steels, subject to saline atmosphere, suffers from pitting corrosion at temperatures below this.

Minimum flow through heating coils in standby units should be included.

14.2.2.4 Filter

As a minimum a filter shall be provided and sized to take a slip stream to clean the heating medium. For heating medium system with printed circuit heat exchangers (PCHE), vendor to be consulted regarding filtration grade.

14.2.2.5 Stand by heater

Fired or electric heaters may be required as start up heater or for permanent heating, where enough waste heat is not available.

14.2.2.6 Expansion tank

The heating medium expansion tank should be blanketed with inert gas with spill off to flare. The back pressure during flaring shall be considered when selecting design pressure. The tank shall as a minimum be sized to cater for the volumetric expansion of the heating medium within the 25% and 75% liquid range (for temperatures between minimum ambient and maximum operating).

14.2.2.7 Insulation

The heating medium pipes and equipment shall be insulated for heat conservation.

Intermittent consumers and bypass lines shall be left uninsulated. In such case, personnel protection shall be considered.

14.2.3 Sparing

System sparing class: A.

Sparing:
Heating medium pumps: Sparing as required
Waste heat recovery unit(s): Sparing depending on criticality
Heating medium expansion tank: No sparing

The requirement for a heating medium essential pump shall be considered.

14.3 Operational requirements

14.3.1 Control and monitoring

Control and monitoring from the CCR

OS/VDU functions	P	T	L	F	Other	Remarks
Pumps				C/A	Running status	Alarm on low flow
Waste heat rec. unit		C/A				Alarm on high temperature
Expansion tank	M/A		M/A			Alarm on high pressure and high and low level
Consumers				C		Heating medium flow control
Hydrocarbon detector					A	Alarm on hydrocarbon leakage in expansion tank

Process variables: P=Pressure, T=Temperature, L=Level, F=Flow.
Process functions: A=Alarm, M=Monitoring, C=Control.

14.3.2 Safeguarding and shutdown

The heating medium circulation pumps shall stop on low level in heating medium expansion tank, provided the exhaust has been bypassed around the waste heat recovery unit.

Waste heat recovery/standby heater units shall be protected against overpressure in case the units are blocked in. Tube rupture in waste heat exchanger piping, resulting in heating medium leaking into exhaust/burner stack, shall be considered and accounted for in design.

Tube rupture in consumer heat exchangers shall be considered during design.

The use of flanges and connections shall be limited, as the high temperature tends to create leaks due to expansion/contraction.
Avoid insulation of flanges in systems using hot oil as heating medium.

The selected heating medium shall have a flame point above the highest operating temperature if parts of the system are located in non classified areas. Leakage combined with an ignition source can result in fire if the flame point of the heating medium is lower than the maximum operating temperature.

14.4 Maintenance requirements

Heating medium shall be drained to separate tanks for reuse after draining of equipment.
Filling and drain lines to be permanently installed.

14.5 Isolation and sectioning

It shall be possible to isolate major equipment of the system such as pumps, consumers and heat recovery/standby heater units.

Intermittent consumers of heating medium shall have block valves close to supply/return header.

14.6 Layout requirements

The heating medium expansion tank shall be located at the highest point in the heating medium system.

Heating medium pumps to be located below the expansion tank, and with sufficient height to ensure adequate net positive suction head.

14.7 Interface requirements

Turbine exhaust	Heat energy
Electric power	Circulation pumps
Heating medium	Fill lines
Instrument air	As required
Inert gas	Blanketing of expansion tank
Drain system	Drainage of system
Chemical	Corrosion inhibitor (depending heating medium type)
Flare	Spill off from expansion tank

Specific interface requirements are to be provided by the supplier. Annex A contains data sheets with an interface requirements list for provision of such information.

14.8 Commissioning requirements

The system shall be designed such that early commissioning of the turbines can be performed without damaging the waste heat recovery units or degrade the heating medium in the system. The normal solution is for the turbine exhaust to bypass the waste heat recovery unit.

14.9 Safety requirements

Personnel should be protected against the hot surfaces.

14.10 Environmental

Degraded heating medium shall be disposed without impact on the environment.

15 Chemical injection (system 42)

15.1 Scope

This chapter defines the minimum functional requirements for the chemical injection system.

15.2 Functional requirements

15.2.1 General

The chemical injection system shall store, distribute and inject chemicals into the process systems.
This system does not cover injection of hypoclorite or methanol as these are covered by system 46 (methanol injection) and 47 (chlorination). However the loading station for the chemical injection system may also be used for loading of methanol and hypoclorite (if applicable).

This system typically include facilities for:

- loading to the topside, either by boat transfer or transport pods (lifting of tote tanks).
- loading from tote tanks by gravity flow or boat loading to dedicated storage tanks for each chemical.
- dedicated pump systems with calibration devices to ensure constant flow to each consumer.
- disposal pod or storage tank for chemical spillage.
- drip tray with flushing facilities underneath loading area and pump skids.

Chemical injection is typically achieved by the following methods:

- Separate volumetric pump/head for each consumer (injection into pipelines, separators etc. where reasonable flow is required).
- Common fixed pressure injection pump with dedicated flow control valves to each consumer (typical arrangement for scale injection into many wells where each flow is very low).

15.2.2 Performance

15.2.2.1 General

Facilities for chemical injection and use of chemicals shall to the extent possible have fixed arrangements for storage tanks and piping.

Each chemical shall have separate piping from loading station to storage tank. If there are chemicals that can react violently with each other, these chemicals shall have unique quick connector couplings on the fill hoses to avoid mixing. Refer to company standard connections if available.

All chemical storage tanks, injection pumps and loading stations shall have drip trays to collect spillage. Dedicated facilities for flushing with fresh or seawater should be included to:

- remove chemical spillage.
- flush away chemical spill in case of reaction between chemical and pipework/drip tray.
- ensure proper work environment (refer to material data sheet).

Drag reducers may react with water or hydrocarbons to form a sticky slurry, hence drain from such systems should be routed to a separate drain transport tank.

15.2.2.2 System capacity

System capacity is calculated as design load of continuous consumers plus peak load from intermittent consumers per chemical to be injected (if relevant).

15.2.2.3 Loading station

Normal chemical loading is from tote tanks with gravity feed/or pumped to dedicated storage tanks. For large chemical consumers boat loading through hoses may be required.

15.2.2.4 Storage tanks

Storage capacity to be based on supply frequency and required safety factor in case of bad weather.

The storage tank should as a minimum have capacity to take the volume of one tote tank.

Vent pipes from storage tanks shall be located where the discharge does not represent any hazard or create a non-acceptable work environment. The combustibility or toxicity of the emissions shall be taken into account.

The liquid overflow system and drip tray drains from the various tanks may be routed to a common manifold provided that the total system has a continuous fall and no dead legs. Chemicals that cannot be mixed shall have dedicated lines. Return flow to tanks shall be avoided.

For certain high viscosity chemicals (e.g. drag reducers), it might be required to pressurise the storage tank (e.g. with nitrogen) to ensure sufficient pump NPSH.

15.2.2.5 Pumps/control valves

Where the pump can overpressure the downstream piping/process systems the system shall be protected by a PSV valve, and the valve shall be possible to maintain and calibrate. The PSV shall be tagged to ensure systematic calibration and functional testing (as required by any PSV).

Facilities shall be provided to maintain fluid pumpability.

Facility for calibration of flow to each consumer shall be provided. Chemical spillage during calibration shall be minimised.

Filtration of chemical upstream control valves may be necessary due to small flow passages. Consult control valve vendor for requirements. Strainer on fill line to storage tank or pump suction is recommended.

15.2.2.6 Injection points

Facilities to ensure proper inmixing of the chemicals shall be included. All injection points to be tubed/piped. When two or more chemicals are injected into the same stream, it must be checked whether a minimum distance is required between the injection points to allow inmixing of one chemical before the next is added.

15.2.2.7 Materials

Facilities for chemical injection shall be made of materials which from a safety point of view adequately resist the corrosive and caustic effect of chemicals.

15.2.3 Sparing

System sparing class: A, B or C, depending on the system receiving the chemical.

The design of the chemical injection skid, should include allowance for possible future injection needs.

15.3 Operational requirements

15.3.1 Control and monitoring

Control and monitoring shall as a minimum be in accordance with the table below.

OS / VDU functions	P	T	L	F	Remark
Storage tank			M,A		Low level, High level 1)
Injection pumps					Running status
Injection into systems where outfall **can not** be accepted 2)				M,C	Alarm as required
Injection into systems where outfall **can** be accepted					Alarm if pump is not running

Process variables: P=Pressure, T=Temperature, L=Level, F=Flow.
Process functions: A=Alarm, M=Monitoring, C=Control.

Notes:
1. High level detection is normally not required, however it should be included if the alternative is time consuming manual supervision.
2. Also valid for chemicals where the control and monitoring can be justified by chemical cost.

15.3.2 Safeguarding and shutdown

The chemical injection system shall be shut down simultaneously with the system it injects into unless injection is required in a shutdown situation. This may be omitted for system segments that are protected by PSV or rupture disc.

15.4 Maintenance requirements

The system shall be designed such that normal maintenance work can be performed on the injection system for one chemical without interfering with the operation of the injection system for other chemicals.

For continuous operating systems, provision shall be made to enable isolation and maintenance of a standby pump. Spool pieces shall be provided on all pumps to facilitate removal.

It shall be possible to flush pumps and tanks with sea/fresh water prior to maintenance to limit personnel exposure to chemicals.

15.5 Isolation and sectioning

A check valve and shut off valve shall be fitted as close to the injection point as possible.

15.6 Layout requirements

Chemical injection unit(s) and storage tanks is usually be installed in sheltered, unheated areas. Where loading is done by tote tanks, the fill area is recommended at a high elevation with gravity feed to storage tanks.

Piping/hoses from loading station shall be self draining to avoid pockets and liquid traps.

15.7 Interface requirements

Sea-/fresh water	Flushing of drip trays under pump skid and pod storage tank(s)
Compressed air	As required for valves and air driven pumps
Open drains / bilge	Drainage from drip trays
Electric power	Electric driven pumps
Diesel	Flushing/dilution of chemicals where required

15.8 Commissioning requirements

No specific requirements are identified.

15.9 Safety requirements

Always refer to the material safety data sheet for chemical to obtain instructions on how to handle the chemical and special safety precautions.

Be aware that some chemicals may react with each other, and if this is the case, take necessary actions to avoid this in the design.

Eye wash and safety shower shall be available close to the loading station, pump skids and chemical calibration skid.

When chemicals that can cause blockage of pipes etc. are used, this should be taken into consideration in designing the facility.

15.10 Environmental requirements

Chemical spillage directly to sea shall be avoided.
During the fill operation from tote tank to storage tank, the loading location shall be designed to handle the leakage of one tote tank without spillage to the open drain system or sea.

16 Flare (system 43)

16.1 Scope

This chapter defines the minimum functional requirements for the flare system.

16.2 Functional requirements

16.2.1 General

The flare system shall provide safe discharge and disposal of gases and liquids resulting from:

- full production relief;
- relief of excess pressure caused by process upset conditions and thermal expansion;
- system depressurisation either in response to an emergency, e.g. fire, or as part of a normal procedure , e.g. shutdown prior to maintenance;
- process flaring of gas, primarily to allow oil production to continue when downstream gas treatment or compression facilities are unavailable or during start-up;
- venting from equipment operating close to atmospheric pressure - vent gases may include blanket and purge gas along with various other minor discharges.

In addition the following shall be addressed:

- Opening of flowline isolation valves with 100% open choke valve (highest possible Gas Oil Ratio (GOR) in import flowline/riser shall be used in design).
- Failure of choke valve internals (highest possible GOR in import flowline/riser shall be used in design).

To accommodate releases to flare from systems operating at different pressures, practical and cost effective flare system design usually dictates a requirement for more than one collection and disposal system.

The three main categories are:

- The HP flare system - designed to operate at relatively high back pressure thereby minimising piping and equipment size. Systems which discharge to the HP flare must operate at sufficiently high pressure, typically 10 barg or above. The HP flare tip is usually specified to operate at sonic velocity and significant pressure drop, and with good emissivity characteristics to minimise radiation intensity.
- The LP flare system - designed to receive discharges from equipment and piping operating at pressures which are too low to utilise the HP flare system. System backpressure is minimised by the selection of appropriate piping sizes and by the use of a sub-sonic open pipeflare which incurs minimal pressure drop.
- The vent system - designed to receive discharges from equipment unable to withstand backpressures in excess of 0.07 barg. Vent system gases are either combusted or “cold” vented to atmosphere, and in many cases a production facility will have both a combusted and un-ignited vent system.

The HP and LP flare system may be combined into one system.

Depending on the design requirements, further segregation of the flare system into sub-systems such as “liquid” and “low temperature” flare systems may be required.

Recovery of flare gas, in order to reduce emission to the atmosphere, shall be evaluated.

16.2.2 Performance

16.2.2.1 Design data

The flare knock-out drum shall be sized to accommodate liquid accumulation and still have a gas volume to handle the separation requirements in table 3 for the following two cases:

- Full production relief in 90 seconds with initial level in knock-out drum equal to the LAHH level trip (PSD trip level).
- Production from the single production well/gathering line with highest flow in 15 minutes with initial level in knock-out drum equal to the LAHH level trip (PSD trip level).

Note: - A second LAHH at the same level or higher than the PSD level, shall initiate a shut down through the ESD system.

In addition there is a recommended time between LAH and LAHH (where the time available will affect platform regularity) which is:

- The knock out drum liquid containment capacity should be based on the largest foreseeable liquid condensation rate for a recommended period of at least 20 minutes from LAH to LAHH level trip. This period should provide realistic time to identify a problem and allow for operator intervention. Longer periods may be required, e.g. for subsea flowlines and in-field pipelines. This should be evaluated for each case.

The knock out drums shall be designed to prevent development of waves or entrainment of disengaged liquids during flaring at high gas and liquid rates.

Table 3 - Knock out drum design criteria's

	HP	LP	Vent
Source discharge pressure (barg)	>10		<0.07
Typical knock-out drum operating pressure (barg)	3-10	1-3	ATM
Knock-out droplet size (micron)	<400 [1)]	<300	<300

Note 1 - For subsonic flare, 300 micron shall be used.

16.2.2.2 System design

Once the segregation of the flare system into sub-systems such as HP, LP and Vent is determined, there are two fundamental elements in the design of each sub-system. These are:

- Establish rates and conditions for individual relief sources (pipe sizing between relief device and main flare header).
- Establish the overall platform flaring scenarios.

The overall platform flaring scenarios shall be identified to determine the design requirements for the main system components, i.e.:

- Flare headers.
- Knock-out drums.
- Flare structure, stack height and flare tips.

Flaring scenarios are normally classified as “continuous” or “intermittent” depending on the anticipated duration of the occurrence, and design criterias are different for the two types of scenarios. Radiation design criterias are given in NORSOK Standard Technical Safety, S-001.

Subsequent steps in flare system design are:

- Piping network calculations.
- Radiation calculation (ref. criterias in NORSOK S-001)
- Flare knock-out drum design.

These design activities are normally performed using commercially available software packages and computer models.

When calculating flow velocity downstream PSVs, the relief from single PSV shall be the only source to the flare system.

The liquid return system from knock out drums shall as a minimum have sufficient capacity to allow continuous production flaring without build up of liquids in the drums.

16.2.2.3 Flare gas recovery systems

Flare gas recovery systems shall be designed such that the integrity of the flare system is not jeopardised.

A flare gas recovery system may be provided for both the HP and LP flare system. These systems shall recover hydrocarbon gas from the flare system and return the gas to the main process. The gas shall be recovered downstream of the knock out drum. Recommended recovery systems are:

- to raise the operating pressure in the flare system sufficiently high to return the gas directly to the main process.
- installation of a re-compressor or an ejector.

The flare stack shall be isolated from the part of the flare system where gas is recovered by a fail open, quick opening shut off valve (hereby named the “flare valve”) which only open during abnormal or emergency flaring. Such valve shall be provided with a bypass loop containing a bursting disc, as the secondary protection, to avoid the flare system to be dependent upon instrumentation and valve operation.

A flare gas recovery system shall be purged with nitrogen, with possible fuel gas back-up, downstream the flare valve, in order to prevent the formation of an explosive mixture in the flare stack.

The low-point between the flare valve and the flare tip shall be continuously drained to avoid liquid downstream the flare valve.

The recovery line between the flare system and the main process shall be equipped with a valve which shall close when flaring gas.

Where a flare gas recovery system is provided, the recovery system shall be sized to accommodate the sum of the normal flow of gas into the flare or vent system (if any) plus the anticipated leakage from relief valves, blowdown valves and process pressure spill-off valves. The leakage rate shall be obtained from consultation with the instrument and valve suppliers, and operational experience.

Pressure Alarm High (PAH) in knock out or vent drum shall open the flare valve.

16.2.2.4 High integrity pressure protection systems (HIPPS)

HIPPS systems are normally employed to reduce instantaneous relief rates for overpressure protection, thus facilitating a reduction in the dimensioning design requirements for the flare systems, ref. NORSOK standard P-001 Process design.

16.2.2.5 Measurements

Flare systems shall be equipped with flow devices located downstream the knock-out drums with continuous measurements of fluids being flared. The rates shall be available on OS/VDU picture and as input to Data Acquisition System (DAS).

16.2.2.6 Pilots/flare ignition

Functionality shall be proven under all operating conditions.

16.2.3 Sparing

System sparing class: A.

16.3 Operational requirements

16.3.1 Control and monitoring

Control and monitoring from CCR

OS/VDU functions	P	T	L	F	Other	Remarks
Knock-out drum	M A 1)/C 1)	M/A	C/M/A			Alarm on low temperature and high/low liquid level
Flare				M		Input to DAS
Flare tip					A	Flare to be monitored by use of camera

Process variable: P = Pressure, T = Temperature, L = Level, F = Flow.
Process function: A = Alarm, M = Monitoring, C = Control.
1) Required for a flare gas recovery system

If a heater is installed in the flare knock-out drum, a low level trip shall ensure that the element is completely immersed during operation. The heater shall be protected against overheating.

16.3.2 Safeguarding and shutdown

In the event that the liquid level in the flare knock-out drum reaches high level, automatic production shutdown shall be initiated by 2 independent transmitters linked to the ESD and PSD systems respectively.

The flare system shall maintain its integrity (not rupture) until the process plant has been depressurised. The need for passive fire protection for the flare system shall be evaluated for a fire as defined in NORSOK standard S-001 Technical safety. Do note that flare lines with no flow during fire depressurisation will be heated more rapidly than flare lines with flow.

16.4 Maintenance requirements

All instrumentation shall be located available for testing, repair and replacement without production shutdown, except instrumentation at flare tip. Ladders and platform for access to flare tips shall be provided. Methods and temporary equipment for change out of flare tip shall be provided from the vendor.

16.5 Isolation and sectioning

Leaks into flare systems shall be minimised by proper selection of valves (tight shut-off)

16.6 Layout requirements

The design of the flare and vent systems shall take into account the following layout considerations:

- Flare and vent headers and relief valve tail pipes to be routed without pockets and sloped to allow free drainage to the respective knock-out drum.
- Relief valves and other overpressure protection devices to be located at high points in the process systems to minimise liquid carry-over.
- The flare stack to be located at the hazardous end of the platform, as far as possible from living quarters and the helideck and with due regard to the location of a drilling derrick and platform cranes.
- Atmospheric cold vent to discharge to safe location to minimise the risk of accidental ignition.
- The tip to be vertical in order to ensure maximum service lifetime for flare tips with a continuous burning flame.

16.7 Interface requirements

Specific interface requirements shall be provided. Annex A contains data sheets with an interface requirements list for provision of such information.

Power Knock out drums shall be fitted with heater(s) to prevent liquids from freezing due to low ambient temperature.

Purge gas Each system shall be continuously purged with nitrogen or fuel gas supplied upstream in headers and sub-headers.

Pilots Normally lit flare tips shall be equipped with pilot burners with alternative source provided as back-up.

Methanol Methanol injection points (temporary) shall be considered at locations where conditions are such that hydrates may form and the duration of the depressurisation operation is such that these can cause blockages.

16.8 Commissioning requirements

Spectacle blinds shall be provided as required to perform leak testing of system, excluding flare stack piping from the flare valve, if installed, or the knock-out drum outlets.

16.9 Safety requirements

The design of the flare and vent system shall take account of the following safety considerations:

- The flare system should be designed to operate within all specified criteria for backpressure, velocity, noise and erosion.
- The specification, location and orientation of flare and vent tips shall ensure that all requirements with respect to radiation levels, gas dispersion and potential liquid spill-over are met.
- Satisfactory operation of the flare ignition system shall be ensured at all times.
- Flame impingement from flare tips on nearby structures shall be prevented.
- The formation of ice or hydrates causing potential blockages shall be safeguarded against throughout the system. Preventive measures include:
- The use of flare knock-out drum heaters.
- Winterisation of liquid dead legs, e.g. knock-out drum outlet piping.
- Insulation and heat tracing of dead legs upstream blow down valves and PSVs.
- Provision of a separate low temperature flare header to avoid mixing of low temperature gas with hot, wet gas and/or liquid containing free water
- Flare and vent headers should be continuously purged with nitrogen or fuel gas to prevent the ingress of air which may create an explosive mixture.

- Pilot operated relief valves shall not be used in dirty service (typically wellstream and hydrate forming fluids) due to the risk of clogging impulse lines.
- Each isolation section, containing typically 1000 kg *) of hydrocarbons, shall be provided with a depressurisation line to allow for remote or automatic blowdown of the system in the event of an emergency.

*) Determined by S-001 or project specific requirements.

16.10 Environmental requirements

A flare gas recovery system shall be considered for all new installations. This evaluation is particularly relevant for the HP flare systems, and shall be based on LCC principles.

17 Oily water treatment (system 44)

17.1 Scope

This chapter defines the minimum functional requirements for the oily water treatment system.

17.2 Functional requirements

17.2.1 General

The system shall collect and treat produced water from the production separators and coalescer, such that the water can be discharged to sea or reinjected into the reservoir, and the oil can be recovered and returned to the production system.

Hydrocyclones are normally used for separation of oil and water, but centrifuges may also be evaluated for low capacity systems. Sand filters may be required where dissolved solids make the density difference between water and oil small (typically chalk suspended oil from chalk reservoirs).
However, the use of novel techniques and/or additional types of equipment, such as flocculation drums, to improve the separation of oil and water shall also be evaluated to achieve the most optimal system configuration.

Produced water that has been separated in the production separators should not be returned to the separation train, as this will impair oil/water separation.

Produced water should in general not be mixed with seawater before discharged to sea, as a mixture of seawater and produced water may cause scaling problems in piping and equipment, dependent on composition of the produced water.

When scaling problems are predicted, the following design precautions shall be taken:

- define scale inhibitor points as required
- flanged pipe connections or rod out points to be provided for easy cleaning of pipe sections
- line sizes to reflect some scaling to allow reduced cleaning frequency

17.2.2 Performance

17.2.2.1 System capacity

The system capacity shall be based on the produced water profile through the production lifetime, and also take into account build-up of water in the production separators. Spare nozzles for future hydrocyclones, or spare space for future liners in the hydrocyclones, shall be considered when the maximum water rates are future.

17.2.2.2 Hydrocyclones

The hydrocyclone configuration shall be based on the feed stream characteristics, turndown requirement and separation requirement. The number of hydrocyclones and number of liners in each hydrocyclone, shall be evaluated to give a flexible system with respect to separation efficiency, turndown requirements and maintenance requirements.

A mixing unit for flocculation chemicals upstream of the hydrocyclones, or other coalescing devices, should be considered.

The system shall be designed for sand erosion where applicable.

If booster pumps are required from upstream coalescer/LP separators, the pumps should be of low shear type to avoid shearing of oil droplets.

17.2.2.3 Flash drum

The flash drum shall be designed with a sufficient retention time for degassing of the water. The retention time shall as a minimum be 60 seconds.

Provisions shall be made for regular skimming or continuous of the oil collected on top of the water surface.

The drum shall be designed as a horizontal vessel. The inlet lines to the vessel shall be arranged to optimise oil droplet separation in the vessel. It shall be evaluated to have the inlet at the bottom of the vessel to get a flotation effect.
The flash drum shall be designed with a jet water system for on-line jetting and disposal of solid particles.

17.2.2.4 Reclaimed oil sump

The volume of the sump should as a minimum be sufficient to collect the liquid inventory of any one of the production separators from low liquid level.

The sump shall be designed as an atmospheric tank with continuous inert gas purging.

Heating in the sump should be avoided unless strictly necessary for prevention of wax formation. Freeze protection can be performed with circulation back to the tank.

17.2.2.5 Reclaimed oil sump pump

A pump type creating low shear forces shall be selected to prevent generation of small oil droplets.
The capacity of the pump shall as a minimum be equal to the average incoming flowrate to the sump.

The system design should take the following into consideration:

- The system should allow turndown to avoid transient and unstable conditions in the downstream system at reclaimed oil sump pump start. This can be achieved by using a positive displacement pump with a return line back to the reclaimed oil sump. A centrifugal pump with downstream throttling valve must be evaluated against the possible negative effect on shearing.
- The handling of the reclaimed oil shall aim to limit the degree of recirculation of the liquids back to the main separation train. If large water volumes are expected with the reject stream from the hydrocyclones, a secondary separation device should be evaluated.

17.2.2.6 Metering and sampling

Cleaned water from the flash drum shall be metered and sampled before discharged to sea. The samples shall be analysed for oil in water concentration. Location of sample connections shall be according to the requirements given by the relevant authorities (Norway SFT State pollution agency). Provisions shall be made for future installation of an on-line oil-in-water analyser.

17.2.3 Sparing

System sparing class: A.

Hydrocyclones shall be provided in parallel for the different separator pressure levels.

Sparing of reclaimed oil sump pump is required.

Normally no other sparing is required.

17.3 Operational requirements

17.3.1 Control and Monitoring

Control and monitoring from CCR

OS / VDU functions	P	T	L	F	Other	Remarks
Hydrocyclones	C/M					Diff. pressure control
Flash drum			C/M/A			High and low alarms
Water from flash drum				M		Flow indicator with totalizer
Reclaimed oil sump			C/M/A			
Reclaimed oil sump pump	A				Pump running status	High alarm. Start/stop of reclaimed oil sump pump by high/low level in the sump.

Process variables: P = Pressure, T = Temperature, L = Level, F = Flow.
Process functions: A = Alarm, M = Monitoring, C = Control.

17.3.2 Safeguarding and shutdown

No specific requirements are identified.

17.4 Maintenance requirements

Provision shall be made for safe withdrawal of a pump from the reclaimed oil sump pump during operation of the system.

17.5 Isolation and sectioning

The inlet and outlet lines to the hydrocyclones and the flash drum, and the inlet lines to the reclaimed oil sump shall be provided with spectacle blinds or spade and spacer for positive isolation during inspection or maintenance work.

17.6 Layout requirements

All equipment shall be located in hazardous areas.

The reclaimed oil sump shall be located at lowest possible elevation to ensure gravity draining from the sources.

Jet water disposal lines should have no pockets to avoid sand accumulation and blockage.

17.7 Interface requirements

Inert gas	Reclaimed oil sump shall be continuously purged to prevent ingress of oxygen in the tank. Flash drum may also need blanket gas.
Chemical injection	Biocide for batch dosing into the reclaimed oil sump. Emulsion breaker and flocculation chemicals may also be required.
Compressed air	As required.
Jet water	If required for the flash drum, produced water should be used.
Power	Reclaimed oil sump pump shall be powered from the main power distribution.

Specific interface requirements shall be provided. Annex A contains data sheets with an interface requirements list for provision of such information.

17.8 Commissioning requirements

No specific requirements are identified.

17.9 Safety requirements

No specific requirements are identified.

17.10 Environmental requirements

Water discharged to sea shall comply with authority requirements, and currently have an oil concentration of maximum 40 mg/l as a monthly average.

18 Fuel gas (system 45)

18.1 Scope

This chapter defines the minimum functional requirements for the fuel gas system.

18.2 Functional requirements

18.2.1 General

The fuel gas system shall provide superheated fuel gas at suitable pressures to the platform consumers. The fuel gas system shall provide both high and low pressure fuel gas.

Typical high pressure fuel gas users are power turbine drivers for:

- main power generators
- process gas compressors

Typical low pressure fuel gas users:

- pilot ignition
- back-up purge to HP/LP headers
- blanket gas
- stripping gas to glycol regeneration

Dry and dewpoint controlled hydrocarbon gas should be used, if available, to obtain high quality gas that will not form hydrates or condensate.

18.2.2 Performance

18.2.2.1 System capacity

The fuel gas shall meet the requirements from the different platform consumers.

The fuel gas scrubber and piping (headers) should be sized to have sufficient hold-up of fuel gas (above a specified minimum pressure for typically 20 seconds) to enable a smooth changeover of the power generator turbines from fuel gas to diesel or a high pressure gas reservoir back-up.

18.2.2.2 Operating pressure

The fuel gas pressure is depending on the pressure required to the gas turbines.

The fuel gas pressure should be set such that it is possible to:

- Choose between several types of gas turbines.
- Use low NO_x burner nozzles (require approx. 2.0 - 2.5 bar additional pressure).

18.2.2.3 Operating temperature

If waste heat is available on the platform, heating medium should be used to superheat the fuel gas, or electrical heating may be used.

For gas turbines and fired heaters, the fuel gas temperature should typically be kept:

- 20ºC above its water dewpoint.
- 25ºC above its hydrocarbon dewpoint.

Actual requirements will be determined by turbine vendor.

For purge, flare pilot gas e.g. 10°C above the water or hydrocarbon dewpoint is acceptable.

"Warm-up" lines routing the fuel gas at start-up to flare, should be provided upstream each of the gas turbines.

18.2.2.4 Fuel gas metering

The fuel gas shall be continuously metered as input to calculations for CO_2-taxes to the Norwegian Government. Allocation type meter with pressure and temperature corrections, should as a minimum be included.

18.2.2.5 Fuel gas filter

A dedicated filter separator is required on the fuel gas supply to each gas turbine at the turbine skid limit. Filtration requirements to be given by turbine vendor.

18.2.3 Sparing

System sparing class: A.

When continuous heating is covered by a heating medium, a smaller electric heater may be installed in parallel for start-up purpose.

18.3 Operational requirements

18.3.1 Control and monitoring

Control and monitoring from the CCR

OS/VDU functions	P	T	L	F	Other	Remarks
Fuel gas scrubber	C/A		C/A			Alarm on high / low level and pressure
Distribution temp.		C/A				Alarm on low temp.
Low distribution pressure	C/A					Alarm on high / low
Fuel gas flowrate				M		Include totaliser

Process variables : P = Pressure, T = Temperature, L = Level, F = Flow.
Process functions : A = Alarm, M = Monitoring, C = Control.

18.3.2 Safeguarding and shutdown

Process shutdown valves should be included at the following locations:

- In main supply line to the fuel gas system.
- In each back-up fuel supply line to the system.
- In main gas distribution header (high pressure).
- In low pressure distribution header.
- In all fuel gas supply lines to gas turbines.

The following shutdown signals shall close all PSD valves to/from the system and automatically switch over to back-up fuel on the main power generator turbines:

- High liquid level in the fuel gas scrubber.
- High and low pressure in the main gas distribution header.

The following shutdown signals shall only close the PSD valves as specified:

- Low level in the fuel gas scrubber shall close PSD valve in liquid outlet line.
- High pressure in LP distribution header shall close PSD valve in header supply line.
- If electric heater is included, then high distribution temperature shall shut down electric power to the heater.

Relief and blowdown of high-pressure fuel gas system shall be to HP flare system and low pressure fuel gas to the LP or atmospheric vent system.

18.3.3 Sampling

A sampling point downstream the fuel gas heater should be provided.

18.3.4 Heat tracing

Heat tracing of supply lines to critical consumers (e.g. gas turbines) should be included.

18.4 Maintenance requirements

All major parts shall be easily accessible.

Fuel gas heater(s) should be designed for maintenance offshore.

18.5 Isolation and sectioning

Block valves, spectacle blinds and spool pieces as required shall be installed around fuel gas scrubber, heater(s), metering unit and gas turbines filter/scrubbers for individual isolation to allow removal of equipment for maintenance.

Drainage of liquid volumes shall be to closed drain system.

18.6 Layout requirements

The system can be located in open air.

- Fuel gas line between the scrubber and heater to slope back to scrubber unit.
- Fuel gas lines between the heater and the gas turbines filter/scrubbers to have no pockets.
- Space for replacement of filter elements to be included.

18.7 Interface requirements

Hydrocarbon feed	From process section with suitable pressure, preferably dry gas.
Liquid return	To oil/condensate stabilisation.
Heating medium/electrical power	Required to superheat the gas to specified value.
Methanol	Injection of methanol in fuel gas supply if wet gas is used at start-up.
Instrument air	As required.
HP flare system	For relief and blowdown.
Atm. vent system	For maintenance.
Closed drain system	For maintenance.

Specific interface requirements are to be provided by the supplier. Annex A contains data sheets with an interface requirements list for provision of such information.

18.8 Commissioning requirements

Low point drains shall be installed.

18.9 Safety requirements

Fuel gas lines through non-hazardous area shall be welded.

In order to be able to depressurise the fuel gas line to the turbine when the generator is not running, one block valve inside the turbine hood and one block valve upstream the filter/scrubber should be provided.

18.10 Environmental requirements

Low NO_x-nozzles should preferably be used on all gas turbines to reduce NO_x to the atmosphere.

If diesel is used as back-up fuel for the main power generators gas turbines, standard dual-fuel nozzles must at present be used. Provisions for future installation of dual-fuel low NO_x-nozzles should be included.

19 Methanol injection (system 46)

19.1 Scope

This chapter defines the minimum functional requirements for the methanol system.

19.2 Functional requirements

19.2.1 General

The methanol system shall receive, store and inject methanol. Injection shall prevent and dissolve hydrates when required.

Methanol supply from injection pumps shall be adjustable either by means of variable speed/stroke and/or pressure control return to the storage tank. All injection points shall have a means of flow adjustment.

Subsea methanol injection systems should be designed to allow for multipurpose service such as depressurisation in connection with valve testing, hydrate plugs etc., in addition to methanol injection.

19.2.2 Performance

19.2.2.1 System capacity

The system capacity should be determined by methanol injection requirements for the hydrate prevention strategy of the production facility.

19.2.2.2 Operating pressure

The storage tank normally operate at atmospheric pressure.

19.2.2.3 Operating temperature

The system operate normally at ambient temperature.

For systems with recycle flow back to the storage tank, the methanol temperature in the storage tank may increase. The system design shall ensure that the temperature rise does not lead to excessive vapour losses or pump suction problems.

19.2.2.4 Storage tank

The storage tank sizing basis is dependent on whether the system operate intermittently or continuously.

For intermittent systems, as a minimum requirement, the storage tank should be sized with sufficient capacity to permit the operation with the largest volumetric requirement plus one shutdown where applicable.

For continuously operated systems, the storage tank shall be sized based on the maximum average daily demand and supply boat delivery frequency.

If the consumption is infrequent and in small volumes, tote tanks may be used as storage tanks.

19.2.2.5 Injection pumps

Injection pumps shall be sized based on the peak injection demand.

19.2.2.6 Material selection

When designing methanol systems, the following should be noted:

- Methanol may contain some water, which may require corrosion resistant material.
- Pumps, valves etc. should be thoroughly selected for methanol service.

19.2.3 Sparing

System sparing class: B.

Injection pumps should normally be spared to ensure start-up and safe shutdown.

19.3 Operational requirements

19.3.1 Control and monitoring

Control and monitoring shall be in accordance with the table below

OS / VDU functions	P	T	L	F	Remarks
Storage tank			M,A		High and low level alarms.
Injection pumps	C,A				High alarm
Injection points				C,M	For critical consumers

Process variables: P=Pressure, T=Temperature, L=Level, F=Flow.
Process functions: A=Alarm, M=Monitoring, C=Control.

19.3.2 Safeguarding and shutdown

The following signals will initiate a system shutdown:

- High injection pump discharge pressure.
- Low storage tank level (if injection pump can be damaged by running dry).

Following a system shutdown, the pumps shall stop and any actuated shutdown valve in an injection line shall close.

Emergency shutdown (ESD) valves should be included in the following locations:

- Injection lines to subsea locations.
- Injection lines to locations outside a riser isolation valve in continuous service.

19.4 Maintenance requirements

For continuously operating systems, provision shall be made to enable isolation and maintenance of a standby pump. Spool pieces shall be provided on all pumps to facilitate removal.

It shall be possible to remove the pumps and clean the suction strainer without draining the storage tank.

19.5 Isolation and sectioning

It shall be possible to isolate all consumers individually.

19.6 Layout requirements

The system is classified as hazardous.

The piping for the supply of methanol to the storage tank shall be self draining and without pockets.

The injection pumps should be located adjacent to the storage tank such that adequate suction head is provided directly from the tank.

19.7 Interface requirements

Cooling medium / seawater	Cooling requirement for large capacity injection pumps.
Inert gas	Storage tank purging / blanketing.
Power	Essential power may also be required.
Flare	Subsea depressurisation. Drainage of injection manifolds.
Atmospheric vent	Storage tank vent discharge.
Closed drain	Drainage of injection manifolds.

19.8 Commissioning requirements

The storage tank, pumps and return lines should be located in the same module to minimise offshore commissioning.

19.9 Safety requirements

Methanol is a hazardous fluid with a flashpoint which lies within the ambient temperature range.

Use of flanges shall be minimised. Loading hoses from supply boats shall be equipped with unique couplings and be electrically earthed.

19.10 Environmental requirements

Methanol is a toxic chemical, which poses a health risk. Facilities shall be provided to minimise handling requirements and exposure to personnel.

20 Chlorination (system 47)

20.1 Scope

This chapter defines the minimum functional requirements for the chlorination system.

20.2 Functional requirements

20.2.1 General

The chlorination system shall generate or receive, store and inject hypochlorite into systems containing seawater. The concentrations specified below shall prevent macro and micro biofouling of equipment and piping:

- Continuous design dosing concentration (equivalent free chlorine) 2.0 ppm (vol/vol).
- Continuous residual concentration (equivalent free chlorine) 0.2 - 0.5 ppm (vol/vol).
- Flexibility for batch treatment with higher dosage for shorter periods several times per day.

Feed to the hypochlorite generator shall be from downstream of the seawater filters. The system shall operate continuously and produce hypochlorite at a stable rate at the required concentration.

To reduce the concentration of hypochlorite discharge to sea, it is possible to install a combined hypochlorite-copper ion system. Copper ion in combination with hypochlorite is more efficient than hypochlorite alone. The overall pollution to sea will normally be reduced with such a system.

20.2.2 Performance

20.2.2.1 System capacity

The system capacity should be determined by the continuous seawater consumption of the facility. Facilities shall be provided to adjust the flow of concentrated hypochlorite to each consumer.

20.2.2.2 Operating pressure

The electrolysis cells shall operate at a pressure set by the supplier which will lie between the seawater lift pump discharge pressure and atmospheric pressure.

20.2.2.3 Operating temperature

The system shall essentially operate at seawater supply temperature. Actual operating temperatures may be higher due to heat generated in the electrolysis cells.

20.2.2.4 Electrolysis cells

The cell capacity, seawater flowrate, generated hypochlorite concentration and filtration requirements should be based on a standard supplier cell design.

The seawater flowrate to the electrolysis cells shall be at a sufficient rate to remove the generated heat at an adequate rate. Operation of the cells shall be such that solids deposition on the electrodes does not occur.

The electrolysis cells transformer / rectifier shall have the facility to adjust the current in order to adjust the hypochlorite concentration.

20.2.2.5 Hypochlorite head tank/air blower (if applicable)

The head tank shall be sized for a residence time of 20 minutes at maximum volumetric hypochlorite production.

The hypochlorite head tank shall operate at near atmospheric pressure.

The air blower shall have a minimum capacity of 100 times the volumetric rate of hydrogen production.

20.2.2.6 Sampling

Provision for sampling from the electrolysis cell inlet and outlet lines shall be installed.

20.2.3 Sparing

System sparing class: C.

System operation is not critical for production and a short outfall is acceptable.

No sparing is normally required except for the air blowers for hydrogen removal, which shall be spared.

20.3 Operational requirements

20.3.1 Control and monitoring

The system shall be controlled via a local panel with interface with the CCR restricted to shutdown input signals and supplier package common alarm output signals only.

Control and monitoring shall be in accordance with the table below

OS / VDU functions	P	T	L	F	Remark
Electrolysis cells	C			M,A	Self-actuated pressure controller. Low flow alarm
Head tank			C,A		High and low alarms.
Injection points				M	Local flowmeter.

Process variables: P=Pressure, T=Temperature, L=Level, F=Flow.
Process functions: A=Alarm, M=Monitoring, C=Control.

20.3.2 Safeguarding and shutdown

The system shall be equipped with internal shutdown trips for safeguarding and equipment protection.

The operation of the blower shall be interlocked to the cells such that loss of the blower will shut down the power supply to the cells. Upon a shutdown the blower shall continue to operate for a period to ensure a hydrogen free system.

20.4 Maintenance requirements

Facilities shall be provided to enable maintenance of part or all of the system while the seawater system is in operation. Facilities to drain the electrolysis cells shall be provided.

20.5 Isolation and sectioning

Isolation facilities shall be installed around each electrolysis cell. It shall be possible to isolate all consumers individually.

Isolation spool pieces shall be provided to prevent galvanic corrosion around the electrolysis cells.

20.6 Layout requirements

The hypochlorite generator should be sited in a sheltered, unheated location which may be freely ventilated. The hypochlorite generator should be close to the seawater lift pumps.

The hypochlorite storage tank should be located at a higher elevation than sea level to enable gravity flow to the lift pump suction.

20.7 Interface requirements

Seawater	Hypochlorite generation medium
Compressed air	Valve actuation as required
Electrical power	Essential power may be required for operation of the air blower
Open drains / bilge	Drainage from hypochlorite generator drip tray

Specific interface requirements relating to supplier packages are to be provided by the supplier. Annex A contains data sheets with an interface requirement list for provision of such information.

20.8 Commissioning requirements

No specific requirements are identified.

20.9 Safety requirements

The system generates hydrogen gas, which represents an explosion hazard. The hydrogen evolved from the cells shall be diluted by means of the air blower to a maximum of 25% of the lower explosive limit ,LEL, in air (LEL=1% vol/vol). The diluted hydrogen stream shall be vented to a safe location.

In addition the hypochlorite head tank overflow shall contain a liquid seal to prevent hydrogen leakage.

20.10 Environmental requirements

The system should be operated in such a way as to minimise chlorine discharges to sea. The design injection concentration given in section 20.2.1 should be reduced whenever possible, according to the breeding season of marine organisms, provided adequate equipment protection can still be achieved.

21 Sea water (system 50)

21.1 Scope

This chapter defines the minimum requirements for the seawater system.

21.2 Functional requirements

21.2.1 General

The system shall lift and filter seawater for distribution to the various platform users.

21.2.2 Performance

21.2.2.1 System capacity

System capacity is calculated as design load of continuous consumers plus peak load from intermittent consumer (if relevant). Design seawater supply temperature to be evaluated against running spare pump(s) during summer periods.

21.2.2.2 Pumps

Pumps to be selected to keep discharge pipe design pressure low and minimise variations in system pressure.

Fixed speed pumps shall have minimum flow protection. The minimum flow should be controlled on flow not pressure.

The discharge pipe from the pump minimum flow valve should be a "goose neck" arrangement in order to create a small backpressure which will limit cavitational problems.

If the pump has a high non-filled riser (at not running condition), the riser shall be equipped with vent valve to avoid vacuum when the pump is stopped.

Pump suction elevation shall be evaluated in order to limit particles and marine growth in the seawater.

21.2.2.3 Filters

A coarse filter shall be located downstream the pumps to avoid larger particles to enter the system (typical filtration requirement 2 mm or less). The filters should be equipped with an automatic backwash facility.

In the cases where seawater is routed direct from sea chest to the pump, a strainer may be located upstream of the pump to prevent large particles to enter and damage the pumps.

21.2.2.4 Prevention of marine growth

There shall be injection points for chlorine to prevent marine growth in the pipe work. The chlorine injection shall be stopped when the pump is stopped. The maximum residual chlorine content is 0.5 ppm.

21.2.3 Sparing

System sparing class: A.
Sparing: Seawater lift pumps minimum 2 x 100% or 3 x 50%.
Strainer on each pump suction
Filter 2 x 100% or online backwash

21.3 Operational requirements

21.3.1 Control and monitoring

The system shall have local control panel and field instrumentation.

Monitoring that shall be available on OS/VDU in CCR:

OS/VDU functions	P	T	L	F	Other	Remarks
Seawater lift pumps	A			C/A	Running status	Control on flow is preferred. Alarm on pressure on variable speed pumps.
Filter	A					Alarm on high differential pressure

Process variables: P=Pressure, T=Temperature, L=Level, F=Flow.
Process functions: A=Alarm, M=Monitoring, C=Control.

Standby pump shall start automatically upon trip of duty pump.

21.3.2 Safeguarding and shutdown

Pump and piping shall be designed in order to limit water hammer effects during start up and shutdown. The system shall be designed to handle transient conditions and pressures shall be within the requirements of the piping specification and design code. This can typically be achieved by soft start of pumps, liquid filled pump riser or pulsation damper at pump discharge check valve.

If direct seawater cooling of hydrocarbon systems is provided, coolers shall be equipped with shutdown valves on the seawater side to enable isolation in case of tube rupture or hydrocarbon leakage into the system.

21.4 Maintenance requirements

All major parts shall be easily accessible for maintenance. Pumps to have sufficient room for pulling.

21.5 Isolation and sectioning

Pumps shall have block valves to ensure maintenance on one pump while the other is in service.

21.6 Layout requirements

Pump discharge to be on the lowest part of the platform to limit water hammer during start up/shutdown.

Where direct seawater cooling is used as process cooling, it is recommended to dump seawater at a higher elevation than the high point in the seawater system, in an elevated caisson to:

- avoid the dump valve.
- reduce the possibility for vacuum.
- give more stable operating conditions for the sea water process control valves.
- have a high vent in case of gas leakage in coolers.

21.7 Interface requirements

Electric power supply	Seawater lift pumps.
Instrument air	As required.
Chlorine	Injection to prevent marine growth.

Specific interface requirements shall be provided. Annex A contains data sheets with an interface requirements list for provision of such information.

21.8 Commissioning requirements

System shall be designed for early commissioning.

21.9 Safety requirements

If glassfiber reinforced pipe is being used in the seawater pipework, special consideration shall be given to supporting and pipe routing due to the water hammer effects.

21.10 Environmental

Restrictions may apply to maximum seawater return temperature.

Termination of seawater outlet shall be in accordance with NORSOK standard S-003 Environmental care.

22 Fresh water (system 53)

22.1 Scope

This chapter defines the minimum functional requirements for the fresh water system.

22.2 Functional requirements

22.2.1 General

The system shall produce and/or receive, store and distribute fresh water to all users on the facility.

Potable water shall be provided by UV sterilisation of generated fresh water and by hypochlorite dosing and UV sterilisation of imported fresh water. Provision should also be made for hypochlorite dosing into generated fresh water upstream of the potable water tanks.

Separate storage tanks shall be provided for potable and service fresh water, and each shall be equipped with dedicated pumps and a dedicated distribution system.

The system shall be designed to eliminate the risk of contamination. Facilities shall be provided at each user to prevent backflow to the distribution system.

22.2.2 Performance

22.2.2.1 System capacity

The fresh water maker and/or fresh water import rate shall be selected to meet the total average daily demand.

Pump capacity shall be based on peak instantaneous demand.

22.2.2.2 Operating pressure

The storage tanks shall operate at atmospheric pressure.

The distribution pumps shall operate at a pressure according to distribution requirements.

22.2.2.3 Operating temperature

The system shall operate at ambient temperature conditions but shall not be allowed to fall to a level where freezing can occur.

Continuous circulation is preferable to heat tracing to prevent freezing, except for small lines at the extremities of the distribution system.

22.2.2.4 Fresh water maker

The fresh water maker shall be sized to meet the total average daily fresh water demand.

22.2.2.5 Fresh water treatment

The hypochlorite dosing unit and palatability unit shall be sized for the maximum fresh water production rate.

The palatability unit shall be specified for six months continuous operation.

Potable water quality shall meet the authority requirements (SIFF in Norway) for offshore potable water.

Service fresh water shall be colourless and odourless and meet the following requirements:

- Electrical conductivity (max) 75 mS/m at 25^{o}C
- pH 6.5 - 9.0

22.2.2.6 Fresh water storage

Fresh water storage capacity shall as a minimum be sufficient for four days total average daily demand.

22.2.3 Sparing

System sparing class: C.

Sparing of potable water equipment shall be in accordance with authority requirements.

22.3 Operational requirements

22.3.1 Control and monitoring

The fresh water maker shall be controlled via a local panel with interface with the CCR restricted to supplier package common alarm signals only.

Control and monitoring of the system via the CCR

OS / VDU functions	P	T	L	F	Remark
Storage tanks			M,A		Low level alarms
Distribution system	M,A				Auto start of standby pumps according to low pressure.
Running status					Pumps and UV steriliser out of spec. alarm

Process variables: P = Pressure, T = Temperature, L = Level, F = Flow.
Process functions: A = Alarm, M = Monitoring, C = Control

22.3.2 Safeguarding and shutdown

The fresh water maker shall be equipped with all necessary internal trips for protection of personnel and equipment.
In addition the following trips shall be provided in the system:

- UV steriliser low radiation intensity.
- Storage tank low level.

The above trips shall trip the corresponding supply pumps.

22.4 Maintenance requirements

Adequate facilities shall be provided to carry out on line maintenance of spared equipment and equipment, which can be by-passed. It shall be possible to carry out maintenance on fresh water production equipment without affecting storage and distribution.

Facilities shall be provided to enable all equipment and piping in the potable water system to be sterilised by flushing with hypochlorite solution.

22.5 Isolation and sectioning

For storage tanks, which are spared, adequate isolation shall be provided for maintenance of a tank while the other is on-line.

It shall be possible to isolate all consumers individually.

22.6 Layout requirements

The system is classified as non-hazardous.

All piping shall be designed such that there are no deadlegs or stagnant sections.

It shall be possible to completely drain all equipment and sections of piping.

Spool pieces shall be provided on all pumps to facilitate removal.

22.7 Interface requirements

Seawater	System water source
Heating medium	Fresh water maker
Power	Essential power required for potable water supply

22.8 Commissioning requirements

No specific requirements are identified.

22.9 Safety requirements

The system is essentially non-hazardous.

22.10 Environmental requirements

No specific requirements are identified.

23 Open drain (system 56)

23.1 Scope

This chapter defines the minimum functional requirements for the open drain system.

23.2 Functional requirements

23.2.1 General

The open drain system shall handle rainwater, firewater, wash down water including spillage of liquids and solids from deck areas, equipment drip trays and bounded areas.

The system shall be designed such that it can handle the impurities entering the system.

Hydrocarbon liquid spill shall be recovered, and only clean water shall be dumped to sea.

The hazardous and non-hazardous areas shall have dedicated collection systems kept apart from each other.

Drains from non-polluted areas should be routed directly to sea.

If drill cuttings is to be injected, drain water can be used as slurrification medium.

23.2.2 Performance

23.2.2.1 System capacity

For non-hazardous areas, the maximum washdown of one deck, or peak rainfall on weather decks, should be used as basis for the design flow.

For hazardous areas, the design flow to the collection tank should be based on the largest flow of peak rainfall or the maximum washdown of one deck.

The deluge water should be routed to sea either via overflow lines from the drain boxes or from fireseal overflow lines. The overflow lines shall be designed for the full deluge capacity for the actual area coverage. Provision shall be made to prevent flow of hydrocarbon liquid from one deluge area to another.

Open drain shall terminate at the open drain tank or caisson with a liquid seal.

The capacity of the collection tanks, pumps and treatment unit shall be thoroughly evaluated. Standard size treatment units should be used, and the capacity of the pumps shall match the treatment unit capacity. The size of the collection tanks shall be evaluated based on maximum incoming flowrate and pump capacity. The tanks shall have a buffer capacity to avoid overflow for short duration washdowns.

The use of high-pressure washers for washdown purposes may reduce the required capacity for the open drain system.

Vessels containing flammable liquid shall have drip tray, bounded areas or similar arrangements installed to collect small and unpredictable leakage, typically broken sight glass or leaks from gaskets.

23.2.2.2 Operating pressure

The collection systems shall operate at atmospheric pressure.

Pumps are required for transport of drain water from the collection tanks to the treatment unit. The pump pressure shall balance the static head, friction losses and required supply pressure to the unit.

23.2.2.3 Operating temperature

The system operates at ambient temperature.

23.2.2.4 Special considerations

The design of the system shall consider all potential types of spillage, chemicals etc. that can have impact on selection of material and surface protection.

23.2.2.5 Drilling drain

On a combined drilling and production facility there shall be no connection between the drilling and production open drain systems. The production open drain system is usually not designed for the quantities and type of solids from drilling activities, causing clogging of the production open drain system and damage of pumps and valves. The drilling system shall have a dedicated drain system designed to handle solids and deposition of such. Drilling drain water solid should be routed to the drilling slurrification unit.

23.2.3 Sparing

System sparing class: C.

Normally no requirement for sparing.

23.3 Operational requirements

23.3.1 Control and monitoring

Control and monitoring from CCR

OS / VDU Functions	P	T	L	F	Other	Remarks
Hazardous and non-hazardous open drain tanks			C /M			High level alarms
Drain water treatment pack age						Running status of centrifuges
Effluent water to sea				M		
Drain pump(s)					Pump running status	Auto start/stop of pump by high/low liquid in the drum.

Process variables: P = Pressure, T = Temperature, L = Level, F = Flow.
Process functions: A = Alarm, M = Monitoring, C = Control.

Sample connections shall be provided on the effluent line to sea. Provisions shall be made for future installation of an on-line oil-in-water analyser.

23.3.2 Safeguarding and shutdown

No specific requirements are identified.

23.4 Maintenance requirements

The fire seal pots should be available for maintenance without scaffolding.

Preferred location for pumps are outside the tanks. Where the location of the tanks makes this impractical, provision shall be made for safe withdrawal of a pump from the hazardous open drain tank during operation of the collection system.

The hazardous and non-hazardous open drain tanks shall be designed for easy disposal of solid particles. Corrosion resistant strainers should be considered upstream of the pumps to prevent excessive pump wear.

The drain headers shall be provided with rod out points.

The collection tanks should have sloped tank bottom to ease the tank cleaning. Strategy for handling solids build up in the drain tank shall be implemented in the design.

23.5 Isolation and sectioning

The inlet drain lines to the collection tanks shall be provided with spectacle blinds or spade and spacer for positive isolation during inspection or maintenance of the tanks.

Pumps, filters and treatment unit shall be provided with block valves for isolation of equipment to allow removal for maintenance.

23.6 Layout requirements

The hazardous open drain tank and pump, and the treatment unit shall be located in hazardous areas.

The non-hazardous open drain tank may be located either in non-hazardous or hazardous areas.

The collection tanks shall be located such that gravity draining is possible from all sources, except for bilge water.

Piping system shall be designed for solid particles. Adequate sloping (minimum 1:100) and rodout/flushing facilities shall be implemented. Minimum header size shall be 3".

Drain points shall be designed to represent low points in decks.

Drain points shall be located as to enable drainage of large drip trays during relevant operational movements on floating installations. The slope of drainage piping shall also reflect relevant operational movements on floating installations.

Drain headers shall be located above high levels in collection tanks.

Tundishes and gullies shall be designed for easy plugging to prevent HC gas migration during hot work.

23.7 Interface requirements

Inert gas	Hazardous open drain tank shall be continuously purged to prevent ingress of oxygen in the tank.
Fresh water	Service water for the centrifuges.
Seawater	For cooling of the centrifuges and as back-up water to the centrifuges.
Power	Pumps and centrifuges shall be powered from the main power distribution.
Vent	Vent of hazardous open drain tank.
Oily water treatment	Discharge of oil from treatment unit to reclaimed oil sump.
Biocide	Batch dosing when required.
Glycol	Freeze protection as required

Specific interface requirements shall be provided. Annex A contains data sheets with an interface requirements list for provision of such information.

23.8 Commissioning requirements

The open drain system is likely to be used before commissioning. Means for temporary drain to temporary collection tank(s) should be considered to avoid use of open drain tanks before commissioning.

23.9 Safety requirements

The non-hazardous and hazardous collection systems shall be completely segregated to prevent back flow of hydrocarbons from a hazardous to a non-hazardous area. The inlet lines to the collection tanks shall terminate below liquid low level in the tanks to prevent back flow of hydrocarbon gas from the treatment system.

Drains from hazardous areas shall be provided with a seal pot for every fire area. The seal pot shall prevent gas entrainment from one fire area to another.

23.10 Environmental requirements

Water discharged to sea shall comply with authority requirements, and currently have an oil concentration of maximum 40 mg/l as a monthly average.

24 Closed drain (system 57)

24.1 Scope

This chapter defines the minimum functional requirements for the closed drain system.

24.2 Functional requirements

24.2.1 General

The closed drain system shall collect hydrocarbon liquid drains from platform equipment and piping, and safely dispose and degas the liquid.

All drainage to the closed drain flash drum should be by gravity flow.

Liquid transfer from the drum to the reclaimed oil sump should be by gravity flow if possible. Pumps may be required for this service.

There shall be no hard piping connections between the open and closed drain system, except at the inlet of the reclaimed oil sump or similar.

Connection between closed drain system and drilling systems should be avoided.

24.2.2 Performance

24.2.2.1 System capacity

The design flow to the closed drain flash drum shall be based on credible coincident supplies to the flash drum. Both continuous and intermittent flows shall be evaluated.

The maximum flowrate from manual draining of vessels should cater for drainage of 50% of the largest vessel inventory in 1 hour.

24.2.2.2 Operating pressure

The system shall operate at the same pressure as the flare header connected to the closed drain flash drum. The pressure in the drum shall float on the flare system pressure.

24.2.2.3 Operating temperature

The system shall be able to receive liquid from all sources.

Due to depressurisation of the sources before draining, temperatures below minimum ambient can be expected for the system. However, the need for draining under such circumstances shall be evaluated.

24.2.2.4 Closed drain flash drum

The closed drain flash drum shall be designed for a liquid retention time of minimum 1 minute to achieve proper degassing.

The LP flare knock-out drum may substitute the closed drain flash drum, or collect some of the closed drain streams for degassing . The reclaimed oil sump may also be used for drainage of small oil volumes at levels below closed drain flash drum inlet level.

24.2.3 Sparing

System sparing class: B.

Normally there is no requirement for sparing of any equipment in the system.

24.3 Operational requirements

24.3.1 Control and monitoring

Control and monitoring from CCR

OS / VDU Functions	P	T	L	F	Other	Remarks
Closed drain flash drum			C,M,A			High / low alarms
Drain pump(s) (when applicable)					Pump running status.	Auto start/stop of pump by high/low liquid in the drum

Process variable: P = Pressure, T = Temperature, L = Level, F = Flow.
Process function A = Alarm, M = Monitoring, C = Control.

24.3.2 Safeguarding and shutdown

No specific requirements are identified.

24.4 Maintenance requirements

If drain pump(s) are provided, spool piece(s) at pump flanges shall be provided for easy removal of pump(s). Lifting arrangement shall also be provided for this purpose.

24.5 Isolation and sectioning

No specific requirements are identified.

24.6 Layout requirements

The equipment shall be located in hazardous area.

The closed drain flash drum should be located such that gravity draining is possible from all main sources, and it should be located above the reclaimed oil sump if pumps are to be avoided.

24.7 Interface requirements

Power	Normally not required, only applicable if pump is required for discharge of liquid from the closed drain flash drum.
Flare and vent	Discharge of degas products from the closed drain flash drum.
Oily water treatment	Routing of oil to reclaimed oil sump

24.8 Commissioning requirements

No specific requirements are identified.

24.9 Safety requirements

Before manual draining of equipment or piping inventory to the closed drain system, the actual sources shall be depressurised.

24.10 Environmental requirements

Hydrocarbon gas from the system shall be routed to the flare system for burning or recovery.
The liquid drain shall be routed back to the export/storage system or the production train for recovery of hydrocarbons.

25 Diesel oil (system 62)

25.1 Scope

This chapter defines the minimum requirements for the diesel oil system.

25.2 Functional requirements

25.2.1 General

The diesel system shall provide storage and treatment of raw diesel supplied by boat and supply treated and untreated diesel to users.

25.2.2 Performance

25.2.2.1 Pumps

Centrifugal pumps shall have minimum flow protection. Raw diesel pumps may be of low shear type.

25.2.2.2 Storage tanks

Total storage tank capacity should be for minimum 4 days normal consumption.
The storage tank shall include a low point for gathering and drainage of water.
To prevent vacuum during pumpout and drainage, reference is made to API 2000.

25.2.2.3 Hose loading stations

Hose loading stations shall be provided on two sides of platform. Sampling points shall be installed. Hook-up points for biocide treatment shall be installed.

Hose loading station shall as a minimum have a check and a block valve. A coarse strainer should be considered on the loading lines to the raw diesel tanks.

Hoses to be of anti-static type.

25.2.2.4 Day tanks

Automatic refilling shall be provided on large consumers. Overflow from day tanks shall be routed to raw diesel storage.

25.2.2.5 Filtration and water removal

Facilities to remove particles and water in treated diesel to be based on consumer requirements (diesel engines, turbines etc.).

25.2.3 Sparing

System sparing class: B.

Sparing:
Diesel transfer pumps to be 2 x 100% .
Hose loading stations, one on each platform side.
Raw diesel tanks, 2 x 50% or 3 x 33%.
Treated diesel tanks, 1 x 100%.

25.3 Operational requirements

25.3.1 Control and monitoring

Monitoring that shall be available on OS/VDU in CCR

OS/VDU functions	P	T	L	F	Other	Remarks
Diesel filter/treatment					A	Alarm on high differential pressure
Raw diesel storage			M/A			Alarm on low level
Treated diesel storage			M/A			Alarm on low level
Distribution system	A					Alarm if low pressure

Process variable: P=Pressure, T=Temperature, L=Level, F=Flow.
Process function: A=Alarm, M=Monitoring, C=Control.

Start up and shutdown of the diesel system should be local.

25.3.2 Safeguarding and shutdown

To prevent overfilling the day tank, it shall be fitted with a float to shut off the inflow (like a water closet).

Overflow lines shall be routed all the way back to the raw diesel tank to prevent diesel flowing out the vent line.

25.4 Maintenance requirements

All major parts shall be easily accessible for maintenance. Drip trays shall be installed under equipment where leaks may occur.

If the system is required to operate during a maintenance shutdown of the facility, it shall be possible to maintain all sections of the system during normal operation. Adequate provision of equipment bypass shall be made to enable such activities.

Storage tanks shall have low points with drain for easy cleaning and removal of dirt and drainage of water.

25.5 Isolation and sectioning

Isolation valves shall be installed in branches from main distribution header.

Pumps shall have block valves to ensure maintenance on one pump while the other is in service.

25.6 Layout requirements

Raw diesel can be stored in the platform deck structure.

Gravity feed piping to be sized to ensure positive pressure upstream consumers at maximum flow, i.e. standby unit in simultaneous operation.

Treated diesel can be stored in crane pedestals. For fixed installations treated diesel should be located at the highest elevation of the system, and consumers to be supplied by gravity feed.

25.7 Interface requirements

Electric power supply	Treated diesel pumps shall be on emergency power.
Instrument air	As required.
Drain system	For draining of smaller volumes of diesel.
Atmospheric vent	As required.
Chemical Injection	Biocide as required
Fresh water	Centrifuge

Specific interface requirements shall be provided. Annex A contains data sheets with an interface requirements list for provision of such information.

25.8 Commissioning requirements

A combination of day tank storage capacity and availability of the treatment system shall enable early commissioning and start up of system.

The system shall be operable before the main power is available.

25.9 Safety requirements

No specific requirements are identified.

25.10 Environmental

Overflow lines to sea are not acceptable.

26 Compressed air (system 63)

26.1 Scope

This chapter defines the minimum functional requirements for the compressed air system.

26.2 Functional requirements

26.2.1 General

The compressed air system shall provide compressed air at a defined quality and pressure to instrument air consumers and to plant air consumers.

A compressed air system may include facilities to provide:

- instrument air.
- plant air.
- topping air.
- black start air.

Instrument air is the motive force for all pneumatic controllers and valve actuators and is used for purging of electrical motors and panels.

Plant air is used for air hoists/winches, air motors, sand blasting, spray painting, air tools, motor purging and transport of dry substance (e.g. cement, barite).

Blackstart air compressor typically charge the start air vessel/bottles for the emergency generators and fire water pumps.

Topping up compressor typically maintains the pressure in the start air vessels/bottles during normal operation.

26.2.2 Performance

26.2.2.1 Dehydration

The air to be cooled as much as possible before water knock out to minimise requirement for dehydration. In design it shall be assumed air with 100% humidity at maximum ambient temperature. Air should at least be treated to a dewpoint corresponding to -25^{o}C at max operating pressure.

26.2.2.2 Filtration

Filters should be considered installed between dryer and receiver dependent on requirements from end users.

26.2.2.3 Air receiver

Air receivers must be sufficiently sized to provide instrument air at specified pressure for five minutes after compressor shutdown.

26.2.2.4 Topping air / blackstart air compressors

If topping air / blackstart air compressors are considered required, the following design criteria should be followed:

- The topping air compressor should be sized to maintain the pressure in the air start vessels under normal operation.
- The blackstart air compressor should be sized to charge the air start vessels to a typical pressure of 35 barg in reasonable time.

26.2.2.5 Operating pressure

Typical range of instrument setpoints:

Normal operating pressure	8.8 barg
Stand-by compressor start	8.6 barg
Plant air totally restricted	7.7 barg
Plant air to inert gas isolated	7.4 barg
Alarm is activated	7.1 barg

Note: - The max allowable operating pressure for instrument air shall be maximised to10 barg.

26.2.2.6 Oil content

If oil lubricated compressors are used, facilities to remove oil impurities should be installed upstream dryers.

26.2.3 Sparing

System sparing class: A.

A shut down valve shall be installed to close the feed to all the plant air consumers if the air pressure falls below required pressure.

Two compressors are sufficient on the condition that each compressor covers the total instrument air capacity requirement and both covers the total air requirement.

The instrument air shall be supplied with 100% sparing with regard to air drying. For plant air 1 x 100% shall be installed as a minimum.

Minimum two instrument air compressors should be connected to emergency power. However, only one should run at the same time.

Bleed air from gas turbines should be considered as additional supply source if needed.

26.3 Operational requirements

26.3.1 Control and monitoring

Monitoring that shall be available in CCR as a minimum

OS/VDU functions	P	T	F	Other	Remarks
Compressor package	M			A	Running status alarm
Cooler					
Receiver	M				
Dryer				A	Humidity high

Process variables: P=Pressure, T= Temperature, F= Flow.
Process functions: A= Alarm, C= Control, M= Monitoring.

26.3.2 Safeguarding and shutdown

Low priority users (e.g. plant air) shall, in case of low system pressure, automatically be shut off favouring high priority users (e.g. instrument air, inert gas feed).

Gas detection shall be provided on air intake unless air is supplied from an area that already has gas detection.

26.4 Maintenance requirements

During maintenance of the air receiver, a by-pass line must be installed to route the instrument and plant air directly to the instrument ring main and the plant air main header.

Spectable blinds are required for positive isolation of the air receiver during maintenance.

Space shall be provided for maintenance of all equipment on the unit.

Compressor/drivers shall be possible to remove/replace.

26.5 Isolation and sectioning

Valves shall be located to enable maintenance on system main units, and on distribution system to enable modifications/extensions to the system during operation.

26.6 Layout requirements

The discharge dump line from compressor control valve should be routed away from areas where personnel will require frequent access.

Low point drains should be provided to remove any moisture accumulating in the distribution headers.

Inlet air should be taken from safe location.

Connection for temporary connection for extra plant air shall be supplied.

26.7 Interface requirements

Open drain	For maintenance.
Seawater/cooling medium	For cooling.
Electric power	Normal and emergency power as required.
Diesel	Blackstart air compressor

Specific interface requirements shall be provided. Annex A contains data sheets with an interface requirement list for provision of such information.

26.8 Commissioning requirements

Connections and isolation facilities on ring main should be provided to supply instrument air to all users during commissioning.

26.9 Safety requirements

No specific requirements are identified.

26.10 Environmental requirements
No specific requirements are identified.

27 Inert gas (system 64)

27.1 Scope
This chapter defines the minimum functional requirements for the inert gas system

27.2 Functional requirements

27.2.1 General
The inert gas generator shall deliver inflammable, filtered inert gas mixture with low oxygen content at a specified pressure and temperature.

Inert gas is used for blanketing and purging of tanks, and for purging of equipment and systems before maintenance.

The inert gas system may be divided into three sub-systems:

- Nitrogen generator/source.
- Storage system.
- Distribution system.

There are several different processes available for nitrogen generation. The most commonly used techniques for extraction of nitrogen from air is membrane separation.

27.2.2 Performance

27.2.2.1 System capacity

Typical inert gas users:

Consumer description	Remarks
Compressor gas seals.	Per compression stage. Actual rate depending on gas seal design /type.
Produced water flash drum.	Back-up gas for pressure maintenance
Produced water disposal caisson.	Purge gas.
Heating medium expansion vessel.	Back-up gas for pressure maintenance.
Methanol storage tank.	Purge/blanketing gas. The flow rate to be 5% higher than maximum pumping capacity.
High pressure flare header.	Continuous purging of flare stack/tips to avoid ingress of air (note 1).
Low pressure flare header.	Continuous purging of flare stack/tips to avoid ingress of air (note 1).
Atmospheric vent header.	No direct purging. Purged through vents from disposal caisson, tanks and sumps.
Hazardous open drain sump.	Purge gas. The flow rate to be 5% higher than maximum pumping capacity.
Closed drain flash drum.	Purge gas. The flow rate to be 5% higher than maximum pumping capacity.
Reclaimed oil sump.	Purge gas. The flow rate should equal pumping capacity.
Utility stations.	Used during initial start-up and maintenance.
Deareators.	In connection with the Minox process.

Note 1: - Evaluation should be done with respect to the consequence of purging hot flares with non combustible gases.

Peak loads during maintenance periods may be supplied by liquid nitrogen. The distribution system must allow connection from vaporiser package.

27.2.2.2 Operating/design conditions

Typical supply pressure is 6-9 barg when using plant air feed.

Typical design and operating criteria for the main equipment:

Feed air pressure	8-10 bara
Feed air temperature	30-50 °C
Feed air particle size	3 μm
Feed air dew point (at 10 bar)	-25 °C
Oil free feed air	yes
Design pressure	13.5 barg
Design temperature, min/max	-10/60 °C
Product pressure, min/norm	6.0/8.0 barg

Design and operating conditions for the Inert gas generator:

Product quality	Inert content: 97% vol at normal operation and 95 % at peak load
	Water dewpoint: Better than -20°C

27.2.2.3 Inlet temperature

Requirement for feed air heater is pending feed air temperature and is a trade-off between cost for heater and cost for additional membrane modules to meet purity and productivity requirements.

27.2.3 Sparing

System sparing class: C.

No sparing, except inlet filter. Critical consumers e.g. compressor gas seals to have separate back up.
A nitrogen receiver vessel may be installed downstream the nitrogen generator as a buffer in order to dampen nitrogen pressure and purity variations. A receiver vessel may also be used as a storage device in case of limited supply of nitrogen after nitrogen generator shut-down.

27.3 Operational requirements

27.3.1 Control and monitoring

Monitoring that shall be available in CCR as a minimum

OS/VDU functions	P	T	F	Other	Remarks
Feed air		C			If heater is installed
Inlet filter				M, A	Alarm on high differential pressure
Nitrogen distribution	M			M	Alarm on high oxygen content
Membrane back pressure	C				

Process variables: P = Pressure, T = Temperature, L = Level, F = Flow.
Process functions: A = Alarm, M = Monitoring, C = Control.

27.3.2 Safeguarding and shutdown

Low priority users shall, in case of low system pressure, automatically be shut off favouring high priority users.

Oxygen monitor shall initiate opening of a product dump valve at high level.

27.4 Maintenance requirements

27.4.1 Generator

The regular maintenance work on the generator package must be facilitated by maximum access for:

- Calibration of oxygen analyser.
- Replacement of feed air filter element.

27.4.2 Oxygen analyser

The oxygen analyser needs frequent calibration. Hence, the signals from the analyser must be possible to override during maintenance.

27.4.3 Feed air filter

The feed air filter elements are replaced upon high differential pressure. Installation of 2 x 100% filters is required, hence the replacement work will not disturb operation of the plant.

27.4.4 Feed air heater

A by-pass line around the feed air heater should be installed to allow maintenance without plant shut down.

27.5 Isolation and sectioning

Valves shall be located upstream and downstream each membrane to enable turndown and modification/extension to the system during operation.

27.6 Layout requirements

Nitrogen storage/back-up shall be located in the utility area. Major users, like flare system purge, shall have dedicated line, while smaller users can be served by branch lines from ring distribution.

27.7 Interface requirements

The inert gas system has interface against compressed air system for feed air supply.

Normal recipients for purge gas is listed in clause 27.2.2.1.

27.8 Commissioning requirements

No specific requirements are identified.

27.9 Safety requirements

The inert gas plant should, because of the risk of a non-breathable atmosphere, be located in a naturally ventilated area. Oxygen rich gas shall be ventilated to safe area.

27.10 Environmental requirements

No specific requirements are identified.

28 Hydraulic power (system 65)

28.1 Scope

This chapter defines the minimum requirements for the topsides hydraulic power system.

28.2 Functional requirements

28.2.1 General

The hydraulic power package shall provide the hydraulically operated topside valves with hydraulic power, and also supply hydraulic power to all other topside users at specified pressures and cleanliness levels.

It may be necessary with several hydraulic power packages to supply all users.

28.2.2 Performance

28.2.2.1 System capacity

The system shall have a back up facility in case the main power source fails.

28.2.2.2 Reservoir

The hydraulic reservoir shall be sized such that when all actuators are driven, the tank shall not be less than 25% full, and when total actuator capacity is returned, the level shall not be greater than 75%.

The system shall be designed to avoid the accumulation of water/solids and shall be provided with adequate means for their removal.

- A filter shall be installed on the fill line to the hydraulic reservoir.
- If the system is static (i.e. no valve movements during normal operation) it will influence on cleanliness level. This should be compensated for (circulation of oil in the reservoir through a filter is one possible method).
- Return from "dirty service" shall be returned to closed drain or to a separate drain pot with vent to safe area. Drain pot to be manually drained to open drain system. Typical dirty service is the down hole safety valve.

The hydraulic oil shall have a cleanliness level according to the hydraulic components requirements.

The hydraulic reservoir shall be equipped with an atmospheric vent nozzle with a breath filter. The reservoir shall be designed for easy draining of particles collecting at tank bottom.

28.2.2.3 Pumps

Sized, allowing for simultaneous use of standby pumps, to have sufficient capacity to move all valves and equipment away form their shutdown positions within a 10 minute period with all accumulators empty.

28.2.2.4 Filters

Particles larger than typically 5 microns should be removed by filters in the pump discharge line.

28.2.2.5 Accumulator capacity

The hydraulic system shall be equipped with central accumulator capacity to activate connected valves minimum once without use of any hydraulic source. Valves with local accumulator should not be included in this calculation. This requirement is included to give the system operational flexibility when operating many valves without tripping the hydraulic system on low pressure.

Provision for expansion of central accumulator capacity should be included.

28.2.3 Sparing

System sparing class: A.

Sparing:
Pumps to be 2 x 100%.
Filters to be 2 x 100%.

28.3 Operational requirements

28.3.1 Control and monitoring

Required control and monitoring from the CCR

OS/VDU functions	P	L	F	Other	Remarks
Pump	C/A				Alarm for high and low pressure
Filter	A				Alarm on high differential pressure
Hydraulic reservoir		M/A			Alarm on low level
Heater in reservoir				A	Alarm on heater off

Process variables: P=Pressure, T=Temperature, L=Level, F=Flow.
Process functions: A=Alarm, M=Monitoring, C=Control.

28.3.2 Safeguarding and shutdown

Start up and shutdown of the hydraulic power package shall be local. For normal operation, the pumps shall have an auto start and stop function initiated by the system header pressure transmitters and should include a routine operation of standby pumps to meet periods of high demand. In addition it shall be possible to override the pressure transmitter to enable manual operation for maintenance or emergency situations.

Downstream of the various valves, the hydraulic oil shall be collected in a common return header and sent to the hydraulic reservoir. The return header shall not impose any restriction on safety-related valves and equipment returning to their fail positions within their specified minimum stroke times.

28.4 Maintenance requirements

Preventive maintenance shall be based on inspection and monitoring of performance. Services and repairs shall be carried out as required by technical condition and performance of components.

Oil sample points shall be included on the reservoir, supply and return lines**.**

Maintenance of any part of the system, with the exception of the reservoir, shall be possible during operation.

The consequences of isolation and maintenance of a standby pump shall be evaluated since full capacity may not be available during high demand.

The hydraulic unit shall have a drip tray for collection of hydraulic oil spills during maintenance.

28.5 Isolation and sectioning

During normal operation of the platform, it shall be possible to do maintenance work on the hydraulic power system without affecting the processing of hydrocarbons.

Where parallel units are installed it shall be possible to work on one unit with the other in operation. In such cases the high pressure side shall be isolated by double block valves.

28.6 Layout requirements

The system should be located in a sheltered area. The system should be located in the area with most consumers, and hook up between modules/areas should be minimised to reduce offshore commissioning. Layout of skid to allow for easy maintenance (filter change etc.).

28.7 Interface requirements

Electric power supply	Essential power may be required.
Instrument air	As required.
Drain system	Drain from hydraulic reservoir and drip tray.
Atmospheric vent stack	For hydraulic reservoir.
Inert gas	Reservoir blanketing.
Nitrogen	Accumulator operation.

Specific interface requirements shall be provided. Annex A contains an interface requirements list for provision of such information.

28.8 Commissioning requirements

System installation shall be planned such that early commissioning, hook up and operation of the system can take place.

Typical critical aspects are hook-up of modules versus loop testing of hydraulic valves.

28.9 Safety requirements

The system is classified as non-hazardous, however, if there is a possibility of hydrocarbons being returned to the reservoir with the hydraulic fluid, the system shall be classified as hazardous.
The vent from the reservoir shall be routed to a safe location.

28.10 Environmental

The hydraulic oil shall be of biodegradable type. Used hydraulic oil shall be safely disposed into oily drain systems or transportation pod.

Annex A
(informative)
System design data sheets

PDS-016	Well related production topside	Rev. 2, November 2001
PDS-020	Separation and stabilisation	Rev. 2, November 2001
PDS-021	Crude handling and metering	Rev. 2, November 2001
PDS-023	Gas recompression, cooling and scrubbing	Rev. 2, November 2001
PDS-024	Gas treatment (drying)	Rev. 2, November 2001
PDS-025	Gas conditioning	Rev. 2, November 2001
PDS-026	Gas injection to reservoir	Rev. 2, November 2001
PDS-027	Gas export and metering	Rev. 2, November 2001
PDS-029	Water injection	Rev. 2, November 2001
PDS-040	Cooling medium	Rev. 2, November 2001
PDS-041	Heating medium	Rev. 2, November 2001
PDS-042	Chemical injection	Rev. 2, November 2001
PDS-043	Flare	Rev. 2, November 2001
PDS-044	Oily water	Rev. 2, November 2001
PDS-045	Fuel gas	Rev. 2, November 2001
PDS-046	Methanol injection	Rev. 2, November 2001
PDS-047	Chlorination	Rev. 2, November 2001
PDS-050	Sea water (low to medium pressure)	Rev. 2, November 2001
PDS-053	Fresh water	Rev. 2, November 2001
PDS-056	Open drain	Rev. 2, November 2001
PDS-057	Closed drain	Rev. 2, November 2001
PDS-062	Diesel oil	Rev. 2, November 2001
PDS-063	Compressed air	Rev. 2, November 2001
PDS-064	Inert gas	Rev. 2, November 2001
PDS-065	Hydraulic power	Rev. 2, November 2001

Design data

	Unit	
Required regularity	%	
Design operating life	years	

Design data for the production and test manifold

Condition	Unit		
Number of production wells			
Production rate per well gas/liquid :	Sm^3/d	Max. gas case	Max. liquid case
Wellhead shut-in pressure	bara	* max. * min.	
Flowing wellhead pressure	bara	* max. * min.	
Flowing wellhead temperature	^oC	* max. * min.	
Sand production	g/hr		

Specified conditions for transport of the following fluids at the well service manifold(s)

Fluid	Unit	Quantity	Condition
Well production (backflow from wells)	Sm^3/d		
Water-based mud	m^3/d		
Brine	m^3/d		
Diesel	m^3/d		
Methanol	m^3/d		
Chemicals	m^3/d		
Other	m^3/d		

Interface requirements list

Utility	Unit	Quantity	Condition
Instrument air	Sm^3/hr		
Electric power	kW		
Brine	m^3/hr		
Diesel	m^3/hr		
Methanol	m^3/hr		
Hydraulic power	kW		
Mud	m^3/hr		

Design data

Process variable	Unit	Value
Required regularity	%	
Design operating life	years	

Inlet/wellstream conditions

Condition	Unit		
Wellhead/inlet pressure	bara	* max. * min.	
Wellhead/inlet temperature	°C	* max. * min.	
Sand production	g/hr		

Separators and coaleshers

Process variable	Unit	Value
Design pressure/temperature	max. / min. barg / °C	
Operating pressure/temperature	barg / °C	
Inlet conditions:		
Design flowrate	kg/h	
Composition		
Density	kg/m^3	
Dynamic viscosity	Ns/m^2	
Vapour outlet conditions:		
Design flowrate	kg/h	
Composition		
Density	kg/m^3	
Dynamic viscosity	Ns/m^2	
Molweight	MW	
Compressibility		
Liquid outlet conditions:		
Design flowrate	kg/h	
Composition		
Density	kg/m^3	
Dynamic viscosity	Ns/m^2	
Water outlet conditions:		
Design flowrate	kg/h	
Composition		
Density	kg/m^3	
Dynamic viscosity	Ns/m^2	

Heat Exchangers

Process variable	Unit	Value
Hot side:		
Fluid description		
Temperature inlet/outlet	°C	
Flow	kg/h	As for separator inlet
Minimum skin temperature	°C	
Pressure drop	mbar	
Fouling resistance		
Cold side:		
Fluid description		
Temperature inlet/outlet	°C	
Flow	kg/h	
Maximum skin temperature	°C	
Pressure drop	mbar	
Fouling resistance		

Interface requirement list

Utility	Unit	Quantity	Condition
Instrument air			
Hydraulic power			
Chemicals			
Electric power			
Heating medium	kW		
Cooling medium	kW		
Jet water			
Open drain			
Closed drain			
Flare			
Vent			

Design data

Process parameter	Unit	Value
Required regularity	%	
Design operating life	years	
Flow rate	kg/h	
Density	kg/m^3	
Viscosity	Ns/m^2	
Operating pressure/temperature	barg / °C	
Design pressure/temperature	barg / °C	
Pumps:		
Differential pressure required	bar	
NPSH available	m	
Driver	kW	
Heat exchanger:		
Hot side temperature inlet/outlet	°C	
Minimum skin temperature	°C	
Pressure drop	mbar	
Fouling resistance		
Cold side temperature inlet/outlet	°C	
Flow	kg/h	
Maximum skin temperature	°C	
Fluid description		
Pressure drop	mbar	
Fouling resistance		
Metering package:		
Operating pressure	barg	
Operating temperature	°C	
Allowable pressure drop	mbar	
Turn down ratio		

Interface requirement list

Utility	Unit	Quantity	Condition
Power	kW		
Cooling	m3/h		
Instrument air			
Hydraulic power			
Chemical injection			

Design Data	Unit	Case no	Case no	Case no
Regularity	%			
Design Operational Life	Years			
Feed flowrate	kg/hr			
Pressure	bar a			
Temperature	^{o}C			
Composition				
Contaminants				
Cooler				
Hot side temperatures inlet/outlet	^{o}C			
Hydrate formation temperature	^{o}C			
Minimum skin temperature at turndown	^{o}C			
Pressure drop	mbar			
Cooling fluid				
Cold side temperatures inlet/outlet	^{o}C			
Maximum skin temperature at turndown	^{o}C			
Pressure drop	mbar			
Scrubber				
Vapour flowrate	kg/hr			
Pressure	bar a			
Temperature	^{o}C			
Demistor pressure drop	mbar			
Composition				
Droplet cut-off size	µ			
Liquid content in vapour	mg/m^3			
Liquid flowrate	kg/hr			
Composition condition				
Pressure downstream Level Valve (LV)	bar a			
Temperature downstream LV	^{o}C			
Hydrate formation temperature ds. LV	^{o}C			
Compressor				
Flowrate	kg/hr			
Temperature inlet/outlet	^{o}C			
Pressure inlet/outlet	bar a			
Molweight	MW			
Seal / lube oil in gas	mg/m^3			
Allowed head rise to surge	%			
Power consumption	kW			
Installed driver power	kW			

Interface requirements list

Utility	Unit	Consumption	Condition
Cooling medium	m^3/hr		
Seawater	m^3/hr		
Inert gas N_2	Sm^3/hr		
Methanol	m^3/hr		
Instrument air	Sm^3/hr		
Hydraulic power	m^3/hr		
Electric power	kW		
UPS for instrumentation	kW		
Fresh water	m^3/hr		
Fuel	Sm^3/hr		
HP flare system	Sm^3/hr		
LP flare system	Sm^3/hr		
Atmospheric vent	Sm^3/hr		
Closed drain system	m^3/hr		
Open drain	m^3/hr		

Design Data

Required data for absorber and regeneration system

Design Data	Unit	Case no	Case no	Case no
Required regularity	%			
Design Operational life	Year			
Absorber section				
Flowrate gas	kg/hr			
Composition				
Contaminants				
Aromatics content	mol %			
Water content inlet / outlet	ppm V			
Temperature inlet/outlet	^oC			
Pressure inlet/outlet	bar a			
Pressure drop in inlet and packing/trays	mbar			
Amount of condensate formed in packing	m^3/hr			
Glycol circulation rate	m^3/hr			
Glycol water content inlet/outlet	wt %			
Glycol temperature inlet/outlet	^oC			
Condensate entrained with glycol	wt %			
Flash drum				
Pressure	bar a			
Temperature	^oC			
Gas flow	kg/hr			
Glycol residence time	s			
Reboiler and still				
Pressure top/bottom	bar a			
Temperature top/bottom	^oC			
Vapour flow to still (included HC)	m^3/hr			
Reboiler duty	kW			

NB: Data for coolers and scrubbers must also be given.

Interface requirements list

Utility	Unit	Consumption	Condition
Cooling medium	m^3/hr		
Seawater	m^3/hr		
Inert gas	Sm^3/hr		
Methanol	m^3/hr		
Instrument air	Sm^3/hr		
Hydraulic power	m^3/hr		
Electric power	kW		
UPS for instrumentation	kW		
Fuel gas	Sm^3/hr		
HP flare	Sm^3/hr		
LP flare	Sm^3/hr		
Atmospheric vent	Sm^3/hr		
Closed drain system	m^3/hr		
Open drain	m^3/hr		
Filling of glycol (transport tanks, supply boats, other)	m^3/hr		

Design data

Design Data	Unit	Case no	Case no	Case no
Required regularity	%			
Design Operational life	Year			
Vapour flowrate	kg/hr			
Temperature inlet	^oC			
Pressure inlet	bar a			
Viscosity	cP			
Molecular weight	MW			
Composition				
Contaminants				
Aromatics content	mol %			
Water content	ppm V			
Pressure inlet	bar a			
Glycol entrained	ppm V			
Treated gas product				
Dewpoint temperature	^oC			
Dewpoint pressure	bar a			
Outlet pressure	bar a			
NGL product				
Boiling point temperature	^oC			
Boiling point pressure	bar a			
Outlet pressure	bar a			
Vapor waste-product				
Dewpoint	^oC			
Dewpoint pressure	bar a			
Entrained liquid	ppm V			
Outlet pressure	bar a			

Interface requirements list

Utility	Unit	Consumption	Condition
Cooling medium	m^3/hr		
Heating medium	m^3/hr		
Seawater	m^3/hr		
Methanol for hydrate prevention	m^3/hr		
Glycol for hydrate prevention	m^3/hr		
Instrument air	Sm^3/hr		
Inert gas	Sm^3/hr		
Hydraulic power	m^3/hr		
Electric power	kW		
UPS for instrumentation	kW		
Fuel gas	Sm^3/hr		
HP flare	Sm^3/hr		
LP flare	Sm^3/hr		
Atmospheric vent	Sm^3/hr		
Closed drain system	m^3/hr		
Open drain	m^3/hr		

Design Data	Unit	Case no	Case no	Case no
Regularity	%			
Design Operational Life	Years			
Feed flowrate	kg/hr			
Pressure	bar a			
Temperature	^oC			
Composition				
Contaminants				
Cooler				
Hot side temperatures inlet/outlet	^oC			
Hydrate formation temperature	^oC			
Minimum skin temperature at turndown	^oC			
Pressure drop	mbar			
Cooling fluid				
Cold side temperatures inlet/outlet	^oC			
Maximum skin temperature at turndown	^oC			
Pressure drop	mbar			
Scrubber				
Vapour flowrate	kg/hr			
Pressure	bar a			
Temperature	^oC			
Demistor pressure drop	mbar			
Composition				
Droplet cut-off size	µ			
Liquid content in vapour	mg/m^3			
Liquid flowrate	kg/hr			
Composition condition				
Pressure downstream Level Valve (LV)	bar a			
Temperature downstream LV	^oC			
Hydrate formation temperature ds. LV	^oC			
Compressor				
Flowrate	kg/hr			
Temperature inlet/outlet	^oC			
Pressure inlet/outlet	bar a			
Molweight	MW			
Seal / lube oil in gas	mg/m^3			
Allowed head rise to surge	%			
Power consumption	kW			
Installed driver power	kW			

Interface requirements list

Utility	Unit	Consumption	Condition
Cooling medium	m^3/hr		
Seawater	m^3/hr		
Inert gas N_2	Sm^3/hr		
Methanol	m^3/hr		
Instrument air	Sm^3/hr		
Hydraulic power	m^3/hr		
Electric power	kW		
UPS for instrumentation	kW		
Fresh water	m^3/hr		
Fuel	Sm^3/hr		
HP flare system	Sm^3/hr		
LP flare system	Sm^3/hr		
Atmospheric vent	Sm^3/hr		
Closed drain system	m^3/hr		
Open drain	m^3/hr		

Design Data

Design Data	Unit	Case no	Case no	Case no
Regularity	%			
Design Operational Life	Years			
Feed flowrate	kg/hr			
Pressure	bar a			
Temperature	^oC			
Composition				
Contaminants				
Cooler				
Hot side temperatures inlet/outlet	^oC			
Hydrate formation temperature	^oC			
Minimum skin temperature at turndown	^oC			
Pressure drop	mbar			
Cooling fluid				
Cold side temperatures inlet/outlet	^oC			
Maximum skin temperature at turndown	^oC			
Pressure drop	mbar			
Scrubber				
Vapour flowrate	kg/hr			
Pressure	bar a			
Temperature	^oC			
Demistor pressure drop	mbar			
Composition				
Droplet cut-off size	μ			
Liquid content in vapour	mg/m^3			
Liquid flowrate	kg/hr			
Composition condition				
Pressure downstream Level Valve (LV)	bar a			
Temperature downstream LV	^oC			
Hydrate formation temperature ds. LV	^oC			
Compressor				
Flowrate	kg/hr			
Temperature inlet/outlet	^oC			
Pressure inlet/outlet	bar a			
Molweight	MW			
Seal / lube oil in gas	mg/m^3			
Allowed head rise to surge	%			
Power consumption	kW			
Installed driver power	kW			

Interface requirements list

Utility	Unit	Consumption	Condition
Cooling medium	m^3/hr		
Seawater	m^3/hr		
Inert gas N_2	Sm^3/hr		
Methanol	m^3/hr		
Instrument air	Sm^3/hr		
Hydraulic power	m^3/hr		
Electric power	kW		
UPS for instrumentation	kW		
Fresh water	m^3/hr		
Fuel	Sm^3/hr		
HP flare system	Sm^3/hr		
LP flare system	Sm^3/hr		
Atmospheric vent	Sm^3/hr		
Closed drain system	m^3/hr		
Open drain	m^3/hr		

Design Data	Unit	Value
Required Regularity	%	
Design Operational Life	Years	
System Location (haz./non-haz.)		
Injection water requirements:		
System Design Flowrate	m^3/hr	
System Normal Flowrate	m^3/hr	
System injection pressure - normal / max	Barg	
Oxygen Content	ppb	(20-80)[2)]
Free chlorine (on wellhead)	ppm vol	(0.5)[2)]
Coarse filtration	micron	
Fine filtration	micron	
Water supply:		
Standard Density	kg/Sm^3	
Dynamic Viscosity	Ns/m^2 [1)]	
Water supply pressure	Barg	
Water supply temperature	°C	
Oxygen content of seawater supply	ppm	8 ppm
Free chlorine	ppm vol	(0.5)[2)]
Chemical requirements:		
Organic Biocide (shock treatment)	ppm	(1000)[2)]
Organic Biocide (continuous injection)	ppm	(200)[2)]
Oxygen scavenger continuous/intermittant	ppm	
Polyelectrolyte	ppm	
Scale inhibitor	ppm	

1) 1 Ns/m^2 = 1000 centipoise
2) Values in brackets ( ) are typical values
ppm = parts per million
ppb = parts per billion

Interface requirements list

Utility	Unit	Quantity	Condition
Power	kW		
Instrument air	m^3/h		
Electric Power	kW		
Inert gas	m^3/h		
Drain system	m^3/h		
Organic Biocide (shock treatment)	m^3/h		
Organic Biocide (continuous injection)	m^3/h		
Oxygen scavenger continuous/intermittant	m^3/h		
Polyelectrolyte	m^3/h		
Scale inhibitor	m^3/h		

Design data

	Unit	
Required regularity	%	
Design operating life	years	
System location (haz./non-haz.)		
Cooling medium (C.M.)		35 wt.% TEG in water (typical)
Total system duty	kW	
Total C.M. flowrate	m^3/h	
Total seawater demand	m^3/h	
C.M. supply temperature	^oC	
C.M. return temperature (average)	^oC	
Seawater inlet temperature	^oC	
Seawater outlet temperature	^oC	
C.M. supply pressure	barg	
Seawater inlet pressure	barg	

User List

Continuous users

User	System design flowrate kg/h	Unit design flowrate kg/h	Unit duty kW	Return temperature ^{o}C
TOTAL				

Intermittent users

User	System design flowrate kg/h	Unit design flowrate kg/h	UnitDesign duty kW	Return temperature ^{o}C
TOTAL				

Interface Requirements List

Utility	Unit	Quantity	Condition
Instrument air			
Electric power			
Nitrogen			
Corrosion inhibitor/ pH stabiliser			
Required drain volume			
Cooling medium make up			

Design data

Design Data	Unit	Value
Required Regularity	%	
Design Operational Life	Years	
System Location (haz./non-haz.)		Hazardous
System capacity:		
System Heat duty	kW	
System Design Flowrate	kg/h	
System Normal Flowrate	kg/h	
System operating pressure in expansion tank	Barg	
System operating pressure at pump discharge	Barg	
System design pressure	Barg	
System Operating/Design Temperature	°C	
Heating Medium:		
Density at operating temp.	kg/m^3	
Density at Standard condition	kg/m^3	
Dynamic Viscosity - Operating temperature	Ns/m^2 1)	
Dynamic Viscosity - Standard condition	Ns/m^2 1)	
Specific heat - Operating temperature	J/kg K	
Specific heat - Standard condition	J/kg K	

1) 1 Ns/m^2 = 1000 centipoise

User list

Continuous users

User	System design flowrate kg/h	Unit design flowrate kg/h	Unit duty kW	Return temperature °C
TOTAL				

Intermittent users

User	System design flowrate kg/h	Unit design flowrate kg/h	Unit duty kW	Return temperature °C
TOTAL				

Interface requirements list

Utility	Unit	Quantity	Condition
Turbine exhaust			
Electric power			
Heating medium			
Instrument air			
Inert gas tank			
Drain system			
Chemical			
Flare			

Design Data

Process parameter	Unit	Value
Design operating life	years	

Chemical	MSD * number	Freeze point [°C]	Viscosity (at temperature)	Storage tank capacity (days consumption)

*) MSD = Material Safety Data Sheet

User list

Chemical	User	Required regularity %	Required pressure (barg) **	Flowrate litre/h

**) Pressure at injection point

Interface requirements list

Utility	Unit	Quantity	Condition
Seawater/fresh water			
Compressed air			
Electrical power			
Open drains			
Diesel			

Design data

	Unit	
Required regularity	%	
Design operating life	years	
System design temperature	°C	
System design pressure	barg	
Flare Knock-Out Drum		
Vessel volume	m^3	
Operating temperature	°C	
Operating pressure	bara	
Vapour mass flowrate	kg/h	
Vapour density	kg/m^3	
Vapour viscosity	cp	
Vapour molweight	kg/kgmol	
Liquid mass flowrate	kg/h	
Liquid density	kg/m^3	
Liquid viscosity	cp	
Liquid specific heat - Note 1	KJ/Kg°C	
Liquid conductivity - Note 1	W/M°C	
Design droplet size	µm	
Flare K.O. Drum Pumps		
Number of units		
Design capacity	m^3/h	
Liquid density at oper.T&P	kg/m^3	
Liquid viscosity at oper. T&P	cp	
Suction temperature	°C	
Suction pressure	bara	
Discharge pressure	bara	
Pump head	m	
NPSH available - Note 2	m	
Automatic start required	Yes/No	
Start with closed disch. valve	Yes/No	

	Unit	
Flare Tip Package		
Design case		Blocked outlet of 1st Stage Separator- Note 3
Design vapour mass flowrate	kg/h	
Vapour density	kg/m^3	
Vapour viscosity	cp	
Vapour molweight	kg/kgmol	
Vapour k-value (Cp/Cv)		
Vapour net heating value	KJ/Sm^3	
Entrained liquid droplet size	µm	
Vapour composition	Mol %	Note 4
Tip allowable pressure drop	bar	
Tip max./min. design temp.	°C	
Tip orientation	45 or 90°	
Design wind speed at tip	m/s	
Wind direction		
Purge gas type		
Required purge gas flowrate	Sm^3/h	
Flare Ignition Package		
Type of ignition		
Dimensions LxWxH	mm	

Notes:
1. If heater is included within the Flare Knock-Out Drum
2. NPSH = Net Positive Suction Head
3. Only given as an example
4. Composition to be defined on separate sheet.

Scale drawings showing the plan view and side elevation (with respect to the flare structure) should be attached to the data sheet.

The following information should be requested from the vendor:
- Radiation isopleths for the specified design cases.
- Flare tip turndown capabilities.
- Noise emission levels and indication of any expected acoustic vibration.
- Smoke production levels.
- Flare tip life.
- Curve giving flare tip pressure drop as a function of flowrate

Interface requirements list

Utility	Unit	Quantity	Condition
Instrument air			
Electric power			
Nitrogen			
Fuel gas			
Propane/LPG (bottles)			
Methanol			

Design Data

Process parameter	Unit	Value
Required regularity	%	
Design operating life	years	
System location (haz./non-haz.)		Hazardous
Design pressure HP hydrocyclone	barg	
Design temperature HP hydrocyclone	^oC	
Design flowrate HP hydrocyclones	m^3/h	
Oil content in feed	ppm	
Design pressure LP hydrocyclone	barg	
Design temperature LP hydrocyclone	^oC	
Design flowrate LP hydrocyclones	m^3/h	
Oil content in feed	ppm	
Design pressure flash drum	barg	
Design temperature flash drum	^oC	
Design flowrate flash drum	m^3/h	
Design pressure reclaimed oil sump	barg	
Design temperature reclaimed oil sump	^oC	
Design flowrate reclaimed oil sump	m^3/h	
Design pressure reclaimed oil sump pump	barg	
Design flowrate reclaimed oil sump pump	m^3/h	
Design duty reclaimed oil sump pump	kW	

User list

User	Flowrate m^3/h Continuous	Flowrate m^3/h Intermittent	Flowrate m^3/h Design
TOTAL			

Interface requirements list

Utility	Unit	Quantity	Condition
Inert gas			
Chemical injection			
Compressed air			
Jet water			
Power			
Flare and vent system			
Oil separation			
Water injection (optional)			

Design data

Design data	Unit	Value
Required regularity	%	
Design operational life	Years	
System location (haz./non-haz.)		Hazardous area
Fuel gas (F.G.)		Hydrocarbons, preferably dry
Net heating value	MJ/Sm³	
Standard density	kg / Sm³	
System design duty	kW	
System design flowrate	Sm³/h	
System normal flowrate	Sm³/h	
High press. F.G.distribution pressure	barg	
Low press. F.G. distribution pressure	barg	
F.G. distribution temperature	ºC	
High press. F.G. design press./temp.	barg /ºC	
Low press. F.G. design press./temp.	barg /ºC	
Filtration requirement	micron	Note 1

1) For gas turbines, fuel gas according to manufacturers specifications

User list

Continuous users

User	System design flowrate kg/h	Unit design flowrate kg/h	Unit duty kW
TOTAL			

Intermittent users

User	System design flowrate kg/h	Unit design flowrate kg/h	Unit duty kW
TOTAL			

Note: The design flowrate should include start-up of the stand-by main generator with gas turbine driver at idle speed (equal 40% of ISO-rating)

Interface requirements list

Utility	Unit	Quantity	Conditions
Heating medium			
Electric power			
Methanol / glycol			
Instrument air			
HP flare			
LP flare			
Closed drain			

Design data

Process parameter	Unit	Value
Required regularity	%	
Design operating life	years	
Design pressure HP	barg	
Design pressure LP	barg	
Design temperature	^oC	
Storage volume	m^3	

User list

User	Flowrate m^3/h Continuous	Flowrate m^3/h Intermittent	Flowrate m^3/h Design
TOTAL			

Interface requirements list

Utility	Unit	Quantity	Condition
Cooling medium / seawater			
Inert gas			
Electrical power			
Flare			
Atmospheric vent			
Open drains			
Closed drains			
Compressed air			

Design Data

Process parameter	Unit	Value
Required regularity	%	
Design operating life	years	
Design pressure	barg	
Design temperature	°C	

User list

User	Flowrate m^3/h Continuous	Flowrate m^3/h Intermittent	Flowrate m^3/h Design
TOTAL			

Interface requirements list

Utility	Unit	Quantity	Condition
Seawater			
Compressed air			
Electrical power			
Open drains			

Design data

Design data	Unit	Value
Required Regularity	%	
Design Operational Life	Years	
System Location (haz./non-haz.)		
Seawater:		
Design Flow	kg/hr	
Normal Flow	kg/hr	
Discharge pressure max / normal /min	barg	
Seawater supply temperature max / normal / min	°C	
Design pressure	barg	
Design temperature	°C	
Discharge elevation (reletive LAT)	m	
Suction elevation (relative LAT)	m	
Seawater filtration	micron	2000 (2 mm)
Free Chlorine, residual	ppm vol	0.3 - 0.5
Standard Density	kg/m^3	
Dynamic Viscosity	Ns/m^2 [1)]	

1) 1 Ns/m^2 = 1000 centipoise

User list

Continuous seawater users:

User	System design flowrate kg/h	Unit design flowrate kg/h	Unit duty kW	Return temperature °C
TOTAL				

Intermittant seawater users:

User	System design flowrate kg/h	Unit design flowrate kg/h	Unit duty kW	Return temperature °C
TOTAL				

Interface requirements list

Utility	Unit	Quantity	Condition
Electric Power			
Instrument air			
Clorine			

Design data

Process parameter	Unit	Value
Required regularity	%	
Design operating life	years	
Design pressure	barg	
Design temperature	^oC	
Supply boat frequency	days	
Generation capacity	m^3/h	
Storage tanks (number of/volume)	m^3	
Number of persons on facility		Note 1

Notes:
1. Typical potable water consumption value is 200 liter/person pr. day

User list

User	Flowrate m^3/h Continuous	Flowrate m^3/h Intermittent	Flowrate m^3/h Design
TOTAL			

Interface requirements list

Utility	Unit	Quantity	Condition
Seawater			
Heating medium			
Electrical power			
Open drains			
Compressed air			

Design data

Process parameter	Unit	Value
Required regularity	%	
Design operating life	years	
System location (haz./non-haz.)		
Tank design pressure	barg	0.07 + liquid head
Tank design temperature	^oC	
Tank volume	m^3	
Treatment capacity	m^3/h	

Source list

Sources	Flowrate m^3/h Continuous	Flowrate m^3/h Intermittent	Flowrate m^3/h Design
TOTAL			

Interface requirements list

Utility	Unit	Quantity	Condition
Inert gasNitrogen			
Fresh water			
Seawater			
Power			
LP flare			
Vent			
Oily water tratment (reclaimed oil)			
Biocide			
Glycol			

Design data

Process parameter	Unit	Value
Required regularity	%	
Design operating Life	years	
Tank design pressure	barg	
Tank design temperature	^oC	
Tank volume	m^3	
Pump capacity	m^3/h	

Source list

Sources	Flowrate m^3/h Continuous	Flowrate m^3/h Intermittent	Flowrate m^3/h Design
TOTAL			

Interface requirements list

Utility	Unit	Quantity	Condition
Power			
HP flare			
Vent			
Oily water treatment			

Design data

Design data	Unit	Value
Required Regularity	%	
Design Operational Life	Years	
System Location (haz./non-haz.)		
Diesel:		
Standard Density	kg/m^3	850
Dynamic Viscosity	Ns/m^2 1)	
Raw diesel:		
Raw diesel storage	m^3	
Raw diesel consumption	m^3/h	
Diesel transfer pressure (nozzle of pumps)	Barg	9
Treated diesel:		
Treated diesel storage	m^3	
Trated diesel consumption	m^3/h	
Filtration requirement	micron	Note 1
Free water	ppm by vol.	< 100 2)

1) 1 Ns/m^2 = 1000 centipoise
2) For gas turbines, treated diesel according to manufacturers specifications.

User List

Raw diesel users

User	System design flowrate m^3/h	Unit design flowrate m^3/h
TOTAL		

Treated diesel users

User	System design flowrate m^3/h	Unit design flowrate m^3/h
TOTAL		

Interface requirements list

Utility	Unit	Quantity	Condition
Electric Power			
Instrument air			
Open drain			
Vent			
Chemical injection			
Fresh water			

Design data

Instrument and plant air

Process parameter	Unit	Value
Required regularity	%	
Design operating life	years	
Design pressure	barg	
Design temperature	^{o}C /	
Dew point air	^{o}C at 10 barg	
Particle size	Max. micrometer	Typical 2-3 µm

Topping (start) air

Process parameter	Unit	Value
Inlet pressure	barg	
Design pressure	barg	
Design temperature	^{o}C /	
Dew point air	°C at 10 barg	
Charging time	1)	

Blackstart air

Process parameter	Unit	Value
Inlet pressure	barg	
Outlet pressure	barg	
Design pressure	barg	
Design temperature	^{o}C	
Diesel daytank storage	m^3	
Charging time	1)	

Note 1: Charging time to be evaluated based on reasonable time for repressurization of start air bottles.

User list

Sources	Flowrate Continuous Sm^3/h	Flowrate Intermittent Sm^3/h	Flowrate Design Sm^3/h
Instrument air Total instr.air required			
Plant air Total plant air required			
Total compressed air requirement			
Topping air			
Black start air			

Interface requirement list

Utility	Unit	Quantity	Condition
Atmospheric air			
Open drain			
Seawater			
Power			

Design data

Process parameter	Unit	Value
Required regularity	%	
Design operating life/ performance	% drop per years	
Inlet pressure		
Design pressure	barg	
Design temperature	^{o}C	

User list

Sources	Flowrate Continuous Sm^3/h	Flowrate Intermittent Sm^3/h	Flowrate Design Sm^3/h
TOTAL			

Interface requirement list

Utility	Unit	Quantity	Condition
Compressed air			
Heating			

Design data

Process variable	Unit	Value
Required Regularity	%	
Design Operational Life	Years	
System Location (haz./non-haz.)		
Hydraulic Oil		Bio Degradable
Standard Density	kg/m^3	
Dynamic Viscosity	Ns/m^2 1)	
Bulk Modulus of Elasticity	N/m^2	
System Design Flowrate	m^3/h	
System Normal Flowrate	m^3/h	
Cleanliness level	NAS 1638	Class 6 (typical)
Discharge pressure	Barg	
Supply filter	micron	5
Return filter	micron	25
Circulation filter (if added)	micron	5
1) 1 Ns/m^2 = 1000 centipoise		

User list

Continuous users

User	Flow Rate m^3/h	Pressure Barg
TOTAL		

Intermittent users

User	Flow Rate m^3/h	Pressure Barg
TOTAL		

Interface requirements list

Utility	Unit	Quantity	Condition
Electric Power			
Instrument air			
Drain			
Vent			
Inert gas			
Nitrogen			

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