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1. INTRODUCTION & INTENDED PURPOSE OF REGULATION

The purpose of the General Process Design Criteria is to establish the sizing criteria to be considered during the design of a hydrocarbon production and processing facilities as part of OMV engineering activities.

This standard, which must be followed to perform the Process Engineering Design, specify the basic requirements, define the appropriate codes and standards and assists in the standardization of facilities' design across all operations.

The standard is intended to be applied to the design of new projects or where major changes on existing plants are performed. The design process needs to consider project specific factors such as the location, production composition, production rates and pressures, the process selected and the size of the plant. This standard aims to address a wide range of the above variables, however it is recognized that not all circumstances can be covered. In situations where project specific considerations may justify deviation from this standard, a document supporting the request for deviation shall follow the OMV procedures for deviations (GT-M Standard 009 Management of Change in Capital Projects).

This document is not relieving any CONTRACTOR or third party carrying out any design activity as part of OMV engineering activities from their design responsibilities.

2. GENERAL

2.1. Definitions

Can: verbal form used for statements of possibility and capability, whether material, physical or casual.

Company: The entities mentioned in the *Scope of Effectiveness* of this document.

Contractor: The name of company (entity) delivering goods or services to the company

May: verbal form used to indicate a course of action permissible within the limits of this standard.

Shall: verbal form used to indicate requirements strictly (mandatory) to be followed in order to conform to this standard and from which no deviation is permitted, unless accepted by all involved parties.

Should: verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required.

Design pressure (DP): pressure, together with the design temperature, used to determine the minimum permissible thickness required to assure pressure containment integrity of mechanical equipment and piping/instrument components (or to determine physical characteristic of each component as determined by the design rules of the pressure design code).

Maximum allowable operating pressure (MAOP): the maximum internal gauge pressure predicted including plant operation during critical or unstable conditions (shutdown, start-up, ramp-up, control requirements, process upset, abnormal conditions etc.). The MAOP should be equal or less than the DP. From process point of view MAOP is considered Minimum DP. In this case DP = MAOP + extra margin.

Maximum operating pressure (MOP): the MOP is typically 105% of the OP in order to provide sufficient flexibility for the control of the intended operations. If this margin is not sufficient for control, starting up, shutting down or other specific operations, a higher MOP shall be specified (MAOP).

Operating pressure (OP): pressure which the process system experiences during normal operation, including normal variations.

Settle out pressure: pressure equilibrium after a compressor shutdown (pressure trapped between the upstream and downstream sectionalisation valve).

Shut-in pressure: shut-in pressure for pumps and compressors determined by the curves for a "no flow" situation i.e. blocked outlet.

Maximum design temperature: The material temperature representing the most severe condition of coincident pressure and temperature. The maximum design temperature shall cover the maximum operating temperature.

Maximum operating temperature: maximum temperature in the equipment including plant operation at unstable conditions (start-up/shutdown, control requirements and process upsets).

Minimum design temperature: The minimum temperature which serves as a base for specifying the low temperature characteristics of the material. The design temperature shall cover the minimum operating temperature.

Minimum design metal temperature: The temperature arbitrarily selected by the user of the vessel according to the type of fluid and the temperature range the vessel is going to handle. (MDMT) is one of the design conditions for pressure vessels engineering calculations, design and manufacturing.

Minimum operating temperature: minimum temperature in the equipment including plant operation at unstable conditions (start-up/shutdown, control requirements and process upsets).

Operating temperature: the temperature in the equipment when the plant operates at steady state condition, subject to normal variation in operating parameters.

2.2. Units of Measurement

The units of measurements shall be basically the SI System, with the exception for pressure units where bar or mm H_2O are accepted.

Deviation for SI System can be accepted only in the OMV branches where the Imperial System is normally used. CONTRACTORs shall align the units to the local amendment and provide a conversion table in the pertaining documents. CONTRACTOR shall also warranty the consistency of the calculations in respect of the limits and criteria establish in this standard.

2.3. Codes, Standards & Regulation

Codes, standards and regulations referred to this standard shall be of the latest edition and shall be applied in the following order of precedence:

- Local regulations (e.g. respective national law considering PED)
- Contractual documents (e.g. Scope of work)
- OMV Corporate regulations
- OMV divisional regulations
- OMV branch office amendments

- International standards (e.g. ISO, IEC)
- National standards (e.g. SR, ON, NFPA, NORSOK)

Design of the system shall comply with the standards listed within this COMPANY standard, however, for instances where local standards are more stringent local standards shall apply.

2.4. Process Design Approach

2.4.1. Fluids Specification

During the design of process facilities the required local export specification for process fluids shall be taken into consideration. The CONTRACTOR, along with COMPANY approval, shall establish the required margin to be considered for design.

Well fluid characterization is also a critical aspect for process design. Values for WAT, pour point, asphaltene deposition, suspended solids, emulsion tendency and stability, water separation efficiencies (variations with temperatures and chemicals), rheology and viscosity variations with presence of emulsion and real measured viscosity curves have a fundamental and critical impact on design (e.g. emulsion test gives more useful data for residence time and separation efficiency than any theoretical calculation).

For the case where emulsion presence may alter the viscosity of the mixture, special attention shall be given in order to estimate actual viscosity (should not be parameterized from direct single phase viscosity values). Annex 1 offers a typical approach to deal with this issue.

2.4.2. Process Evaluation

During the development of a project the process deliverables shall be performed according to GT-M Standard 003 - Discipline Authority Framework (DAF) in order to meet the project requirement in accordance with lifecycle business needs and performance delivered within this specification.

During process design the following evaluation shall be performed:

<u>Evaluate potential processes taking into account future conditions (for E&P)</u>

Additional future equipment requirements should be estimated, such as:

- Pipeline steady state and transient analysis (static/dynamic models, flow assurance)
- Extreme ambient conditions (process to remain on line or to be shutdown)
- Corrosive products appearing in the well fluids (H_2S, CO_2) originally in reservoir or from the result of enhanced oil recovery methods (corrosion study, material selection).
- Official production forecast P50% shall be used if no other indication from reservoir engineering department. The forecast shall be provided in a signed off format by the representative of Reservoir Engineering department.
- Chemical injection in the well, in the facilities, effects downstream (chemical injection program/philosophy)
- Extra air cooling/mechanical refrigeration
- Wellstream compression (upstream of plant)
- Pipeline compression (downstream of plant)

- Addition of facilities/extension of capacity Central control room/controls at site (check Hazardous Area Classification)

Establish the product specification:

- Fluid production behaviour in time (equipment operability, process control philosophies, turn down limits)
- Variability of the fluid with seasons, e.g. with soil temperature, influence of gas on pipeline specification, volatility of oils in storage tanks, winterization.

Establish the plant specification:

- Effects on facilities of (short term) process disturbance, e.g. plant to shut down, plant to go on standby, measures to detect or prevent process disruptions such as material selection for untreated gas accidentally entering facilities.
- Flexibility required (short term and long term) to allow for variations in flow, pressure, fluid composition.
- Minimum fluid specification required.

Review alternative processes

Select a process and facility type/size with regard to existing equipment standards, operating and maintenance philosophy, etc. Spares policy should be reviewed for incorporation in the project guidelines/specification.

2.4.3. Software

The following list of process software is preferred by COMPANY for design calculations. Any other process-software intended to be used by CONTRACTOR or party accountable for Process design shall be approved by COMPANY. This list shall be approved by COMPANY related Process DA 2, according DAF.

Plant thermodynamic simulations:

- Aspen HYSYS
- PROMAX - Bryan Research and Engineering.

Multiphase pipelines calculations:

Steady state:

- Aspen HYSYS (option Pipeline)
- PIPENET – Sunrise Systems Ltd.
- PIPESIM – Schlumberger
- IPM-GAP – Petroleum Expert Suite

Transient conditions:

- OLGA – SPT Group
- PIPENET – Sunrise Systems Ltd.

Heat exchangers thermal calculations:

Shell and tube:

- HTRI - Heat Transfer Research, Inc.
- Aspen HYSYS

Air coolers:

- HTRI - Heat Transfer Research, Inc.
- HTFS - Aspen Air Cooled Exchanger

De-pressurisation calculations:

- Aspen HYSYS (option Depressurizing)

Flare/Vent & Blowdown calculations:

Heat radiation:

- FLARESIM - Softbits Consultants

Vent dispersion:

- PHAST - Det Norske Veritas (DNV)

Blowdown network:

- FLARENET - Aspen Flare System Analyser

Surge protection on liquid systems and water hammer calculations:

- PIPENET – Sunrise Systems Ltd.

Fluid characterization:

- IPM-PVTP – Petroleum Expert Suite

Surface/Subsurface integration model:

- IPM-RESOLVE – Petroleum Expert Suite

3. GENERAL DESIGN

3.1. Criteria for Selection Project Drivers

Project drivers are describing the key performance criteria of a project, having an impact to the design of new or revamped facilities. These criteria shall be selected in accordance with GT-M 001 – Capital Project Management Directive.

3.2. Design Pressure

3.2.1. Equipment

The design pressure (DP) is related to the Maximum Allowable Operating Pressure (MAOP). **DP shall be equal or bigger than MAOP.**

Generally the Minimum design pressure or MAOP of a piece of equipment (excluding storage tanks/vessels, atmospheric tanks or close to the atmospheric pressure and pipelines) shall be determined / calculated from process simulation or shall be taken as the following:

Maximum Operating Pressure (MOP) (barg)	Minimum Design Pressure /MAOP (barg)
0 ÷ 10	MOP + 1 bar but not less than 3.5 barg
> 10	MOP + 10%

Table 1: Equipment Design Pressure

When required, OMV branch offices shall develop an additional amendment to the above table without overcoming or contradicting the specified limits.

Equipment that is part of a pressure system protected by a relief valve discharging into a flare system or combined vent system shall have a minimum design pressure of least 3.5 barg.

Lower design pressures may be considered if the relief valves blows directly to atmosphere. Care should be taken when using sonic flare tips as design pressures may be required to be considerably higher than 3.5 barg.

If a minimum DP (MAOP) of 110% MOP is substantially more costly than a DP of 105% (e.g. because of a step up in flange rating), then 105% MOP may be acceptable provided suitable relief valves are used which can have their set pressure adjusted accurately.

This should be the subject of approval of the DA 2.

For batch reactions it is sometimes possible (at acceptable cost) to select a design pressure so that in the event of runaway all reaction products are contained without exceeding the allowable pressure limits. In such a case, the requirements specified in ASME VIII UG-140 shall be followed when the runaway relief case is not included as a basis for the sizing of the relief system.

For the minimum-design pressure it shall be considered that:

- Unless otherwise noted, the design pressure specified by Process applies to the vapour phase at the top of the vessel.
- Minimum design pressure is not applicable for thin wall equipment such as storage tanks. In that case the governing parameter is the static pressure in the equipment full of liquid.
- The design pressure shall also account for upset or transient conditions such as start-up, pressure surge, settle-out pressure at compressor suction, etc. The increase of the design pressure due to incidental pressure versus the mitigation measures shall be evaluated from technical – safety and economical point of view.
- Vapour pressure at design temperature should be considered as minimum design pressure except when safety relief valves are provided.
- Hydraulic pressure due to the relative elevation between equipment and the PSV's location shall be also considered.
- The liquid density and the maximum liquid height shall be specified on the Process data sheet to allow the vessel designer to calculate the bottom thickness.

3.2.2. PSV Setting

A margin of 10% on operating pressure is generally adequate in order to ensure protection of the equipment and/or the process with one conventional pressure relief safety valve

(PSV), one high pressure alarm (PAH) and one high high pressure switch (PSHH). In any case, to safeguard the integrity of the system, PSV's set shall be equal or less than the system design pressure.

OMV Branch Offices DA 2 can adjust the set point of PSV's according the specific process/requirements but this set point (at the maximum tolerance) should not exceed MAOP.

In case of absolute necessity (for example in case of high pressure), the use of piloted PSV (tolerance of ±1% on set point) may be used to reduce the design pressure.

If two or more PSV are in service, the set pressure will be staggered to avoid chattering. The set points of the subsequent PSV's shall not exceed 5% of the design pressure.

The following tolerances are generally admitted for conventional instrumentation.

- PSV opening: ± 3%
- PSV closing: ± 5%
- PSV recommended leak test: 10% below set point
- Pressure transmitter (or pressure switch derived from a transmitter): ± 1%

3.2.3. Piping

Process design pressure for piping should be the maximum pressure that any associated piece of equipment can reach e.g. centrifugal pump shut off head or the reciprocating compressor stall pressure. In cases this is not possible relief protection shall be provided. Particular attention shall be paid to transient conditions such as equilibrium pressure plus hydrostatic pressure, water hammer, or possible surge effects for liquid filled systems containing large quantities of fluid, which may induce higher operating pressures.

3.2.4. Vacuum conditions

The design pressure of a piece of equipment (excluding storage tanks, atmospheric tanks and pipelines) subject to operate at pressure below atmospheric pressure shall also be taken as the following:

Operating Pressure (bara)	Design Pressure (bara)
< 0.35	Full vacuum
0.35 ÷ 0.6	OP - 0.1 bar
> 0.6	0.5

Table 2: Design Pressure for Vacuum Conditions

These considerations apply to equipment that could face vacuum under abnormal conditions such as:

- Vacuum conditions during start-up, shutdown and/or regeneration purges
- Normally operated full of liquid but that could be blocked in and cooled down
- Containing condensable vapour but that could be blocked in and cooled down
- Could undergo a vacuum condition through the loss of heat input or external cooling (e.g. deluge) will be treated case by case. They will not be designed for full vacuum

if protective devices are provided (vacuum breaker, pressurisation gas, low pressure switch, etc.).

3.2.5. Compressors & Pumps

Selection of design pressure for compressors and pumps shall be in accordance with specific OMV Standard.

3.2.6. Heat Exchangers

Heat exchanger design pressure consideration shall be in accordance with TEMA, API 660 and ASME Code VIII. For heat exchanger overpressure protection API 520 and API 521 / ISO 23251 shall be considered.

The recommended practice consists in oversetting, if necessary, the design pressure of the low pressure side of heat exchanger:

- in all cases up to the limit of 150# ANSI rating
- after analysis, case by case, for higher pressure

This practice applies both to the heat exchanger itself and to the relevant piping and valves.

Alternatively to the use of a PSV, the capacity of the shell side to bear a pipe rupture shall be considered.

According to API 521, double pipe type of heat exchangers are not concerned.

For heat exchangers using steam full vacuum conditions shall be added to design conditions since vacuum can occur during the cooling of such equipment (if it is not connected to atmosphere) unless fully reliable protective devices are provided (vacuum breaker, pressurization gas, low pressure switch, etc.).

3.2.7. Columns

For columns, the same design pressure shall be selected for the top of a fractionation tower and associated condenser, reflux drum and inter connecting piping.

The design pressure at the bottom of a fractionation column (vapour phase) shall be determined by adding the column pressure drop at the column overhead design pressure. Design pressure at column bottom must also reflect hydrotest conditions (height of water fill).

Liquid density and maximum liquid height in the bottom shall be specified on the process data sheet to allow the vessel designer to calculate the bottom thickness.

3.2.8. Tanks

Storage tanks that normally operate at atmospheric pressure will be designed for the head of liquid in the tank i.e. full of water (or full of product if the product specific gravity > 1) as a minimum. Depending on the type of tank, higher design pressures could be specified. These are treated case-by-case depending on tank type.

The minimum requirements to set the design pressure for atmospheric tanks shall be in accordance to API 650, EN 14015 and EN 12285.

3.2.9. General Considerations

Downstream of wellheads, the design pressure should be at least the wellhead Shut in Pressure or Static Tubing Head Pressure (STHP). Anyhow rating change on downstream equipment can be accepted after pressure protection devices (PSV's, HIPPS, etc.).

Relief valves will be provided to protect equipment and pipework from overpressure where necessary. The sizing basis for relief valves and establishing relief load should be according to API 520 and API 521.

Bursting discs can be used instead of relief valves where very rapid response is required e.g. protection of heat exchange equipment from the effects of tube rupture. If bursting disks are applied the margin between the design pressure and the operating pressure must be considered in the selection of rupture disk type, as the maximum permitted ratio of system operating pressure to burst pressure will vary. For this consideration API RP 520 shall be applied.

3.3. Design Temperature

The design temperature is the temperature used for the mechanical design of equipment. The minimum or maximum design temperature of equipment may not be coincident with the selected design pressure. Coincident temperature and pressure conditions must be specified on the process data sheets.

3.3.1. Maximum Design Temperature

The Maximum Design Temperature (MDT) shall be specified at least of the highest of the following:

- Maximum operating temperature + 15°C
- Maximum ambient temperature
- Boiling water service: saturation temperature at design pressure
- Sun bare metal temperature for above ground piping not buried or insulated, and consequently exposed to solar radiation.
- Proper consideration shall be made for cycled operation such as end of run bed regeneration.
- For Greenfield applications additional allowance of 15°C above MDT shall be add for flowlines and gathering systems up to 1st stage separation in order to cover eventual increase of reservoir temperature. For Brownfield application it will depend on the specific case (not a mandatory requirement).

3.3.2. Minimum Design Metal Temperature

The Minimum Design Metal Temperature (MDMT) shall be specified at least of the lowest of the following:

- Minimum operating temperature – 5°C
- Minimum ambient temperature
- Minimum metal temperature calculated as a result of blowdown
- Fluid temperature for cryogenic and very low temperature systems.

The Minimum Design Temperature shall be indicated together with the coincidental pressure.

For the calculation of MDMT the cold depressurization procedure shall be taken into account.

When required, OMV branch offices shall develop an additional amendment to what indicated in paragraph 3.3.1 & 3.3.2 without overcoming or contradicting the specified limits.

3.3.3. Emergency Depressurization

The minimum design temperature must take into account any depressurisation and re-pressurization (depending on material selection) of the equipment/piping that may occur either during emergency or shutdown situation or gas blow-by from one equipment to another equipment and to the possible consequence of change of material.

Minimum temperature cases should be treated individually, taking account of the heat capacity of the system and heat input from the environment. Depressurisation should be considered to start from a realistic temperature such as the operating temperature or ambient if the plant is blocked in and allowed to cool down before depressurisation.

The emergency depressurization shall impact the material selection as follows:

Piping Material

Piping material will be selected taking into account the temperature occurred during depressurisation. Piping depressurization shall be considered as to be performed with the minimum ambient temperature (cold depressurization).

Vessel Material

The minimum temperature due to the blowdown conditions shall be also associated with the design pressure. Although, in general, depressurization of any section of the plant cannot be performed unless the section is isolated and permissive is obtained, re-pressurization may take place due to operator’s intervention or a valve failure, therefore the minimum temperature shall be associated with the design pressure. In general, no special devices are provided to ensure that relevant section of the plant shall remain isolated and depressurised after an emergency depressurization scenario.

In addition the above criteria will ensure safe operation also in case residual piping stress is present (in particular for low diameter nozzle/piping).

3.3.4. Heat Exchangers and Air Coolers

Consideration for design temperature definition should be given to cooling medium failure when coolers are used. Downstream of an air cooler, the design temperature is determined considering that 20% of the duty is provided by natural draft.

For bypassed air cooler, the design temperature of the downstream equipment, if any, will be the maximum upstream operating temperature of the bypassed exchanger.

Downstream other coolers, the design temperature will be the upstream maximum operating temperature. These considerations generally apply to the immediate downstream process equipment only.

3.3.5. Steam-out conditions

Steam-out will be applied to equipment and piping based on OMV standards and operating procedures. Steam-out conditions apply to:

- Vessels subject to steam-out as a part of routine operation. The lowest available steam level shall be used for steam-out. Steam-out condition shall be indicated on data sheet as dual design conditions:
  - 1 barg @ 120°C and 0 barg @ site LP steam design temperature

- Vessels subject to steam out for normal maintenance shall be designed for partial vacuum and the operating manual shall indicate that vessel is not to be blocked-in when full of steam:
  - 0.5 barg @ 120°C and 0 barg @ site LP steam design temperature

3.3.6. Discontinuous/Cycled Processes

Mixing of extreme conditions of pressure and temperature shall not be considered.

For discontinuous/cycled processes, such as regeneration, various pressure and temperature conditions sets shall be specified for each phase of equipment operation. One typical example is molecular sieve vessel design conditions specification. The set of design conditions of each phase of the operating cycle shall be specified, i.e. design conditions during the adsorption phase, during the regeneration phase, etc.

3.3.7. Exceptional Cases

Considerations for upset and transient conditions such as start-up, shut-down, etc.: in this case, both pressure and temperature conditions have to be provided.

The exceptional temperature generated by fire will not be considered for design temperature selection.

The accidental temperature which may occur in emergency situations such as loss of utilities, valve closure, air cooler failure or any abnormal operation corresponding to a short duration are not to be taken into account as long as the temperature increase does not exceed the codes limits (investigation has to be followed with specialists on a case by case basis).

For compressors (settle out temperatures), recycle and hot gas bypass must be taken into account.

Depending upon the depressurisation philosophy of the plant, thermodynamic simulations of equipment have to be performed so as to determine the relevant pressure and temperature depressurising conditions.

Temperature associated to a gas blow-by should be accepted by COMPANY as minimum design temperature only after transient calculation provided by CONTRACTOR.

3.4. Material Selection

During projects development Material Selection & Corrosion Study has to be followed with specialists on a case by case basis in order to identify the most suitable material selection for equipment and vessels. Specific OMV standard shall be applied and in case of deviation OMV mechanical specialists shall be consulted.

3.4.1. Corrosion due to CO_2/H_2S Service

Corrosion evaluation shall be based on the maximum partial pressure of CO_2/H_2S, either at equipment design pressure when no protection under the form of PSHH is implemented on the concerned system, or at PSHH pressure when existing.

For sour service the material selection shall be followed in accordance with NACE MR 0175 / ISO 15156 and NACE MR 0103 / ISO 17945.

3.4.2. Corrosion Allowance

The corrosion allowances recommended in this chapter are to be considered indicative or "minimum requirement". Final corrosion allowance selection shall be defined according to dedicated corrosion assessment and material selection report:

	C.A. on Carbon Steel and low alloy steel (mm) (1)	**Corrosion Resistant Alloy CRA (mm)** (5)
Corrosive process service (2)	3	0
Non corrosive process service	1	0
Corrosive utility service (2)	3	0
Non corrosive utility service	1	0

Table 3: Corrosion Allowances for Process Services (3, 4, 5)

Notes:

1. Minimum corrosion allowance depending on corrosion control philosophy.
2. Including corrosion inhibitor systems.
3. The corrosion allowance applies for pressure vessels, shell and tube exchangers and hairpin exchangers.
4. For piping, refer to piping classes.
5. When C.A. for carbon steel exceeds 6 mm the use of corrosion resistant alloys is recommended.
6. For storage tanks, the following minimum corrosion allowance shall apply:

	Not Painted (mm)	**Painted (mm)**
Bottom and First plate	3.0	1.5
Other plates and Roof	1.5	1.0

Table 4: Corrosion Allowances for Tanks

Protective painting is applied on roof and bottom part of shell when water or any conductive/corrosive fluid may be accumulated in the tank.

Licensors recommendations to be followed for concerned tanks.

3.5. Overdesign Factors

The following table summarizes the over-design factors to be included in the process design capacity:

Equipment	Over Design Factor
Production Separators	10% on gas flowrate & 10% on liquid inlet flow rate (attention shall be paid also to the liquid surge)
Storage tanks	10% on volume
Surge vessels/drums(1)	10% on liquid hold-up
Columns	10% on flowrate
Shell & tube, frame & plate, hairpin heat exchangers and air-coolers (2)	10% on surface area 10% on duty & flowrate
Reflux pump and boiler feed water pump (3)	20% on flowrate
Other process pump & utility pump (3)	10% on flowrate
Loading pump (to a tanker) (3)	0% on flowrate
Export pump from storage to pipeline (continuous operation) (3)	15% on flowrate
Compressors (4)	10% on flowrate 10% on dynamic head
Compressors KOD	10% on compressor design flowrate
Compressors Intercoolers	10% on duty based on compressor design flowrate
Gas Turbine	10% on power output
Filters	10% on flowrate
Fire heaters & furnaces	10% on duty & flowrate
Boilers	10% on steam flowrate
Flare/Vent & Blowdown Lines	Sized for highest coincident relieving contingency without margin
Piping	10% on flowrate

Table 5: Equipment Overdesign Factors (2,5,6)

Notes:

1. Exception of this case shall be considered for Slug Catchers. In this case sizing shall be performed considering the results of the slugging transient calculation.
2. When two overdesign factors are indicated, each overdesign factor shall not be considered at the same time. The worst conditions in each of the two overdesign cases have to be assumed.
3. For pumps when a non-automatic minimum flow protection has been installed, the permanent re-circulation flow if required must be added to the net process flow rate. Normal and rated flows will be identical in such instance as: intermittent service pumps, when the pump has been overrated to allow for a centrifugal type and if overrating is ≥ 10% & re-circulation flow such as for product loading lines or through amine filtration system.
4. For compressors if the flow is constant, no flow margin is required, but if the flow is coming from a production separator a flow margin of 10% is recommended in order to take into account the possible transient variations at the inlet of these production separators. The variations of gas compositions, molecular weight, Cp/Cv, etc., and the operating conditions (mainly suction pressure and temperature) shall be written on Process data sheets and shall be taken into account for the sizing of the said compressors.
5. No over design is to be applied on other equipment unless specified on case by case and agreed by COMPANY.
6. For sizing factor to be applied for selection of equipment such as electrical motors, diesel engines, gas turbines, etc., refer to the relevant specifications issued by other disciplines.

3.6. Sparing Philosophy

Both process and utilities equipment sparing philosophy shall depend on the main project critical elements (plant capacity, location, type and duty of compressors, pump, power plant etc.) and project requirements in terms of availability required or its failure impact on the process/cost/ safety point of view. If the relative impact is very high then 100% sparing may be required.

Project sparing philosophy shall be defined in accordance with the COMPANY's existing philosophies, in order to ensure required plant availability.

A dedicated RAM analysis is recommended to be carried out in order to properly set sparing requirements.

When project drivers lead to installation of train's, the number of trains shall be defined considering the aspects such as: production profile, the possibility of phasing the installation, the availability and the size of the equipment and the absorbed power.

The following guidelines are to be considered as reference while defining the general sparing philosophy for the main critical process and utility equipment.

The general sparing philosophy for the main critical equipment should be as follows:

- Vessels: no spare
- Columns: no spare
- Heat exchangers: no spare (1)
- Reboilers: n+1

- Heaters: n+1
- Furnaces: n+1
- Pumps: n+1
- Compressors & Blowers: n+1
- Fans (for air coolers): the performance of the bundle shall be guaranteed at least 60% with one fan off
- Filters: n+1 (2)
- PSV: n+1 (3)

Notes:

1. The heat exchangers shall be normally without spare. The heat exchanger sparing "n+1" shall be however strongly recommended when the fluid composition and profile could be affected by important change during project cycle and/or during asset life. In the case of electrical heater, the sparing of the electrical element is strongly recommended.
2. No spare can be considered in case the filter can be put off-line and bypassed for the time necessary for any maintenance operation (i.e. replacement of the filtering elements), without any appreciable problem during regular plant operation.
3. PSV spare can be avoided in case of thermal relief valves or when spare equipment or train is present.

The sparing philosophy for the utilities should be as follows (for critical equipment):

- Air compression unit: n+1 on air compressors & dryers
- Fuel gas: n+1 on fuel gas heaters
- Heating medium system: n+1
- Main power generation: n+1
- Emergency power generation: no spare
- Drain system: no spare
- Firefighting system: n+1 on pumps (main pump electrical driven, stand by pumps to be diesel engine driven type)

4. EQUIPMENT DESIGN

4.1. Vessels

4.1.1. Design Criteria

Vessels design pressure, temperature and flowrate shall be in accordance with chapter 3: "General Design".

Design of the vessel shall be in accordance of the following international standard and directives:

- Pressure Equipment Directive 97/23/EC (applicable only for projects in EU)
- Simple Pressure Vessels Directive 87/404/EEC

- EN13445
- EN 764
- ASME Code VIII
- API 12J (specific for oil & gas separators)

4.1.2. Selection Criteria

The main types of vessel and a general guideline for the relative selection criteria and application are listed hereafter in Table 6:

Service	Application	Selection Criteria
Storage/Buffer vessels	Feed Drums	Typically horizontal type. Vertical drums preferred when plot plan area is limited.
Liquid/Vapour Separators	Flash Drums Reflux Drums Accumulators	Vertical drums are preferred over horizontal when: – a small plot plan area is available – periodic solids removal is required (fouling service). Horizontal drums are preferred over vertical when: – where limited headroom is available – splashing and dispersion of liquid droplets must be limited – for foaming liquids – for high liquid and vapour flow-rates. For very large vapour flows, horizontal split-flow drums (with flow split and directed to opposite ends of vessel) usually result in the most economical vessel design because the diameter is reduced (even though the vessel length is somewhat increased).
	Knock-out Drums Slug Catchers	Vertical drums preferred for the separation of small amounts of liquids from a gas. Exception shall be made for Slug Catchers where horizontal drums or finger type equipment are preferred since are designed to handle large gas capacities and liquid slugs on a regular basis.
Liquid-Liquid Separators	Settlers	Horizontal drums are preferred over vertical, since: – available separation length is longer (more residence time) – larger liquid surface area provides optimum conditions for releasing entrapped gas – travel time of dispersed droplets to the separated phase is shorter – with use of correct inlet pipe, horizontal drums provide a close to laminar flow pattern, enhancing separation.
Vapour-Liquid-Liquid Separators	Gas/oil/water Separator	Horizontal drums with boot are preferred over vertical, since: – separation length is longer, providing more residence time – more accurate heavy phase (water) level control is possible, due to smaller diameter of boot.

Service	Application	Selection Criteria
Columns	Fractionators, Absorbers, Strippers	Used for component separation. Type selection based on physical separation process required.
Reactors	Fixed Bed Vessels (Mol-sieve Dryers)	Type selection by Licensor or Vendor. Multiple reactors if transportation to construction site is limiting or if multiple stages are required from a process point of view.

Table 6: Vessel Types & Selection Criteria

4.1.3. Surge Volume for Liquids

The minimum liquid surge times between LAL and LAH shall be specified as follows:

Services	Time (Minutes)
Unit Feed Surge Drum - to heater - to others	 5 3 without pump (5 with pump)
Reflux Drum	5
Fractionation tower bottom	3 without pump 5 with pump
Steam flash drum(process units)	5
Steam drum (utility generation)	10
Steam deaerator	15
Atmospheric degassing drum "gas boot"	15 for storage tank with floating roof 10 for storage tank with fixed roof
Others Drums	2 without pump 3 with pump

Table 7: Minimum Liquid Surge Time in Vessel

The above values are to be considered minimum requirements. They may need to be increased depending on specific process requirements (e.g. additional hold-up time for adequate gas disengagement, specific requirements for operational flexibility, criticality of the application, regulatory requirements, etc.).

If the vessel is sized to receive a liquid slug, that liquid slug volume shall be taken between NLL and LAH. The LALL connection nozzles should generally be located at least 300 mm above the tangent line for vertical vessel and at least 150 mm above the bottom for horizontal vessel, but in any case above any potential source of plugging (e.g. due to solids accumulation). Alternative arrangements are acceptable for clean services (no risk of plugging of instrument nozzle) where the lower instrument nozzle may be located on the bottom.

When applicable, the surge time below the LALL has to be compatible with the time required to close a SDV or to stop a pump.

4.1.4. Level Positions

The upper and lower LG connections shall be located so that it is possible to read all alarms and shutdown levels.

For vertical vessels, if the operating levels are located in the bottom head, the non-linear evolution of level with draw-off shall be considered.

The level positions on a vessel shall be placed as follows:

- NLL shall be based on process requirements and separation function.
- LAL minimum at 10% of the controllable range.
- LAH maximum at 90% of the controllable range.
- LALL allowing typically 1 to 2 minutes minimum between LAL and LALL.
- LAHH allowing typically 1 to 2 minutes minimum between LAH and LAHH.

The above values are to be considered minimum requirements. They may need to be increased if the required time for operator intervention (before reaching the trip value) demands it and also depending on the criticality of the application (e.g. manual intervention required from operator, etc.).

In general level switches are not allowed. For very specific cases exceptions may be granted (requiring approval from relevant COMPANY Discipline Authority).

Connections for level instruments for safety related functions (ESD) will be independent from the other instrument connections and from non-safety related level instruments (process and control). In case the level instrument is required to be installed on a standpipe, the valve connections shall be LO (locked open).

The above levels positions are also applied for interfaces levels.

<u>Stand Pipes</u>:

- Level controllers and level gauges can be normally grouped on standpipes if 3 or more instruments are required.
- Minimum size of connection to vessels is 2". In general, standpipes shall be minimum 3" diameter (exceptions may be granted given the vessel size and weight limitations).
- Standpipes are installed with isolating valves. CSO valves are recommended to allow for maintenance of level instruments without shutting down the unit.

4.1.5. Diameter of Vessels

As a general rule, inside diameter will be specified on process data sheets (in mm). If the required internal diameter for a vessel is lower than 800 mm, a note shall be added specifying that a piping element is acceptable and shall be approved by COMPANY related Process DA 2.

For vessels with internal diameter less than 1000 mm I.D., flanged heads may be accepted.

4.1.6. Nozzles and Manways

The number of manholes depends on internals. Internals shall be removable through the manhole. In any case for vessels with a length greater than 9 m, two manholes are required.

In the following table manhole diameter recommended values are listed depending on the vessels diameter:

Vessel Diameter (mm)	Manhole Diameter (mm)
900 ≤ d < 1500	450
1500 ≤ d < 2500	500
≥ 2500	600

Table 8: Recommended Manhole Diameters

4.1.7. Vent, Drain and Overflow Connections

The drain nozzles of the vessel should be connected:

- To the outlet line at low point for vertical vessel.
- Directly on vessel bottom for horizontal vessel.

For horizontal vessels having a length greater than 6 m, additional drain connections are required with a maximum distance of 3 m between each drain connection.

For vessels equipped with internals (baffle), a drain connection is required on each compartment.

Overflow connections: For vessels equipped with overflow connections, the overflow nozzle and line size will be one size greater than the inlet/outlet nozzle (whichever is greater).

Vent and drain connections for vessels shall be sized as follows:

Volume or diameter of vessel (m^3 or mm)	Minimum Diameter (inches)	
	Vent	Drain
V ≤ 15 or D ≤ 2500	2"	2"
15 < V ≤ 75 or 2500< D ≤ 4500	2"	3"
75 < V ≤ 220 or 4500 < D ≤ 6000	3"	4"
220 < V ≤ 420 or D > 6000	4″	4″
V > 420	6″	4″

Table 9: Vent & Drain Connections Sizes for Vessels

Vents and drains for packaged equipment shall be discussed with Vendors for size, back pressures, temperatures, products, etc. (in general the prescriptions in this standard should prevail with exceptions granted based on specific requirements properly justified).

4.1.8. Utility Connections

Utility connections shall be sized as follows:

- Drums and heat exchangers: 2"
- For large vertical drums, two 2″ connections will be provided for diameter ≥ 4.5 m
- For horizontal vessel with a length > 6 m and operating in toxic service, two 2″ connections will be provided
- If vessel is equipped with internals (baffle), one 2″ connection will be provided on each compartment
- Columns: as follows with regard to the column diameter, D (m)

- D ≤ 4: 2"

- 4 < D ≤ 5.5: 3"

- D > 5.5: 4"

Note: Utility connections, when specifically required, are not necessarily located on vessels (advantage will be taken of available connections such as drains for steam out service) but should remain operational when the vessel is isolated.

4.1.9. Separator Sizing

Separators design general characteristics shall be equal to those indicated for vessels design criteria (chapter 4.1.1).

In order to improve separators performance the use of internals is highly recommended. The most commonly internals are listed hereafter:

- Inlet diverters
- Wave breakers
- Defoaming plates
- Vortex breakers
- Stilling well
- Sand jets & drains
- Mist extractors (wire-mesh, vane pack, etc.)
- Coalescing plates

<u>Length / Diameter Ratio</u>

For the separators particular case, the relation length / diameter usually is between 3 and 5. This relation will be such that the equipment must be optimized in order to comply with the process requirements (residence time and G/L separation).

In the following table L/D recommended values are listed depending on the vessels design pressure:

Pressure Range (barg)	**L/D Ratio**
< 17	1,5 – 3
17 – 35	3 – 4
> 35	4 – 6

Table 10: Recommended L/D Ratio

<u>Selection of Separation Stages</u>

The optimum number of stages is very difficult to determine as it may be different from well to well and it may change as the wells' flowing pressure declines with time. The following table is an approximate guide to the number of stages in separation, excluding stock tank, and should not replace flash calculations, engineering studies and engineering judgement:

Initial Separator Pressure (barg)	Number of Stages
< 10	1
10 – 20	1-2
20 – 35	2
>35-50	2-3

Table 11: Stage Separation Guidelines

Residence Time

For the design of separators one of the most important parameters to achieve the required performance of separation is the residence time. The required residence time can be acquired through laboratory tests (emulsion test or bottle test) which are used to predict and evaluate the emulsion behaviour at various conditions for oil/water separation (refer to chapter 2.4.1 for fluid characterization). Emulsion tests provide more useful data for residence time and separation efficiency than any theoretical calculation.

When case field or pilot data are not available, recommendations from API 12J for the residence time may be used.

4.1.10. Column Sizing

In the early stages of a project, tray or packing columns sizing can be performed base on the procedure of the best available engineering literature (i.e.: GPSA, Campbell, etc.). During later stages of the project (definition/execution) the Column sizing criteria shall be verified by the Vendor taking into account the following sizing considerations:

Tray Sizing Considerations

- ∞ Column sizing shall be based on a maximum 85 % of flooding. Small side (1800 mm) diameter or less shall be based on a maximum 75 % of flooding.
- ∞ System factor to be used should be:

Service	System Factor
Hydrocarbons fractionators	1
Lean oil absorbers	0.8
Amine systems	0.8
Inorganic systems	0.75
Glycol systems	0.7

- ∞ Column inside diameters and tangent-to-tangent lengths shall be specified by increments of 150 mm.
- ∞ Minimum trayed column size shall be 750 mm inside diameter. For exceptional cases where trayed columns which require diameters less than 750 mm columns with flanged heads and cartridge type trays may be considered.
- ∞ Maximum and normal liquid levels and shutdown levels shall be specified from bottom tangent line for columns.
- ∞ Required tray flexibility shall be 60-110% of the nominal capacity unless otherwise specified.

- The minimum number of manholes to be installed shall be placed at the head, bottom, feed and side streams. Depending on the service, the following table applies:

Service	Additional Manhole location
Clean	1 manhole every 15 trays
Fouling	1 manhole every 10 trays
Severe Fouling	1 manhole every 4 trays

- Minimum distance from top tray to top tangent shall be 750 mm or as required to accommodate manway, internals or nozzles.
- Column trays shall be numbered from bottom to top commencing with number 1 for the bottom tray.
- The column down-comer should fulfil the following dimensions and conditions:
    - Width is a minimum of 150 mm. Exceptions may be considered for small columns (750 mm) diameter or for very low liquid rates.
    - Bottom area is a minimum of 60% of the top area (in case of tapered instead of straight downcomers).
    - The flow path is a minimum of 400 mm, which is required for internal manways.
    - Clearance (space between down-comer and tray) is 13 mm minimum and a maximum equal to the weir height. Normally it is the weir height less 13 mm.
    - Number of downcomers depends on column diameter.

Packing Sizing & Considerations

- Reflux ratio, flow quantities and number of theoretical plates are determined in the same manner as for other columns.
- Column diameter to column packing size ratio should be greater than 30 for raschig rings, 15 for ceramic saddles, and 10 for rings or plastic saddles.
- Packed columns should operate near 70% flooding.
- Internal liquid distributors are usually required to obtain good liquid distribution over the packing. A redistribution tray may be required between beds of small diameter towers.
- The crushing strength of the packing itself needs to be considered in determining the maximum allowable height of the packing bed. If the bed is too deep, the packing at the bottom of the bed will be crushed by the weight of the packing above it.
- Packing support grates should be chosen so that the free space is at least equivalent to the free space per cross sectional area of the packing itself. The holes should not be so large that the packing can fall through them.
- Design shall ensure that the packing is thoroughly wetted with liquid at all times.
- Regarding manholes for packed columns, the previously above given guidelines can be used, but taking into consideration additional space requirements for draw out and replacement of internals.
- For system factor & flexibility data, previously above indicated guidelines shall be considered.

- Structured Packed Column will be preferred by COMPANY based on economic calculation.

4.2. Heat Exchangers

4.2.1. Design Criteria

Heat exchanger design pressure, design temperature and design flow rate shall be in accordance with chapter 3: “General Design”.

Design of the heat exchanger and air coolers shall be in accordance of the following international standards:

- TEMA
- API 660 / ISO 16812
- API 661 / ISO 13706
- EN 307

4.2.2. Selection Criteria

Shell and Tube Exchanger: this type of exchanger is the most widely used and can be designed for virtually any application. There are well established design procedures, can be constructed from a wide range of materials and are capable of withstanding high pressure and temperatures. The different types and relative merits of each are described in detail by TEMA standards. Equations for heat transfer, LMTD, heat transfer coefficients and correction factors are also available in TEMA standards and most process literature.

Double type Pipe Exchanger: this type is used for small heat duties such as fuel gas preheat, gas condensate cooling at pump suctions or where space is limited. Units can be connected in series to extend their capacity. They are simplest types, they can be constructed from standard pipe and fittings.

Plate Exchanger: these exchangers are easy to maintain, can achieve very low approach temperatures, are very flexible – it is easy to add extra plates, suitable for highly viscous materials and fouling tends to be less than for shell and tube exchangers. However the maximum operating temperature is limited to about 250°C, mainly due to the performance of the gasket materials. Plates cannot resist high pressures.

For instance these are used for liquid duties up to an operating pressure of 14 barg e.g. crude oil and cooling medium cooling. These can show significant weight and space savings over shell and tube exchangers.

Plate-Fin Exchanger (Brazed Aluminium): these are essentially plates separated by corrugated sheets, which form the fins. They are made up in a block and are sometimes referred to as matrix exchangers. These are restricted to clean services such as condensers or refrigerant exchangers where cleaning is not necessary. These exchangers can achieve very low temperature approaches and can give significant weight and space savings over shell and tube heat exchangers but generally limited to a maximum design pressure of approximately 80 bar g and 150°C.

Spiral Heat Exchanger: a spiral heat exchanger can be considered as a plate heat exchanger in which the plates are formed into a spiral.

They can be fabricated in any material that can be cold-worked and welded but this does limit their maximum operating pressure to 20 bar and maximum operating temperature to 400°C. However they are compact units: 250m^2 heat transfer area can be reduced to approximately 10m^3 and they give true counter-current flow. Spiral heat exchangers can be used for very dirty process fluids and slurries because they can be easily cleaned and the turbulence in the channels is high.

Air Cooled Exchanger: generally used where it is preferable for the user to be independent of the main cooling system e.g. emergency and life support equipment or where cooling water is in short supply / expensive. Also they can be used when the product temperature is so high that the use of cooling water would lead to limescale.

4.2.3. Fouling Factors for Shell & Tube Heat Exchangers and Air Coolers

The selection of fouling factor has a significant effect on exchanger design. For process and utility units TEMA standards shall be applied to select the typical fouling factor.

General Considerations:

- Fouling is not usually severe below 120°C.
- Fouling is more severe for heating hydrocarbons than cooling. To reduce salt fouling in crude exchangers', where feasible, process design should favour water removal through dehydrators/desalters before the crude reaches "salt deposition" temperature through heat exchangers.
- Vaporisation in an exchanger can cause severe fouling by concentrating the fouling components.
- High velocities reduce fouling, particularly cooling water, but too high velocity may cause erosion. Design the cooling water velocity for 1.1 to 2.5 m/s.
- Minimum salt water velocity is 0.9m/s. Velocity shall be maximised for the listed tube materials:

Tube Material	Velocity (m/s)
Carbon Steel	3.0
Al Brass, Al Bronze	2.1
Cu-Ni (90-10)	2.4
Cu-Ni (70-30)	3.0
Inhibited Admiralty	1.8
Stainless Steel	3.0

Refer to TEMA for more information on heat exchanger velocities (shell & tubes) vs. fouling.

4.2.4. Fouling Factors for Plate Type Heat Exchangers

For Plate Frame Heat Exchangers, an overall fouling factor of 0.00005 m^2°C/W shall be taken for all fluids.

For Plate Fin Heat Exchangers, no fouling factor shall be applied but an extra surface of 15% shall be added on calculated area.

4.2.5. Pressure Drop Considerations

Pressure drop, particularly shell side pressure drop, is often critical to the design of heat exchangers. High velocities through the exchanger lead to high pressure drops but also create a high degree of turbulence which will promote good heat transfer because of rapid renewal of the film on the inside and the outside of the tube wall. One of the main aspects of the design of heat exchangers is the compromise between the heat transfer and the maximum pressure drop.

A maximum of 10 psi pressure drop per exchanger shell is normally used. If a high degree of accuracy is required proprietary programs are normally used.

The typical exchanger shell and tube and air cooling shell side pressure drops are the followings:

Service	bar
High Pressure Vapours	0.35-0.70
Low Pressure Vapours	0.1-0.35
Near atmospheric	0.035-0.1
VDU condensers	<0.016
Liquids	0.5 - 2.1

The specified allowable pressure drop includes nozzle losses, which should be less than 15% of the total.

Generally, higher liquid pressure drops are allowed for heavier, more viscous streams to avoid exotic designs.

The fouling reaching unacceptable levels sets typical cooling water outlet temperature. The following are recommended:

Cooling Water Type	Typical Outlet Temperature
Salt Water	49 °C
Brackish Water	52 °C
Fresh Water	54 °C

4.2.6. Temperature Approach

The temperature approach shall be optimised for heat exchangers but it shall not be smaller than:

- 3°C for kettles
- 5°C for others shell and tubes exchangers
- 10°C for air coolers
- Case by case for plate type heat exchangers.

4.2.7. Specific Requirements

The construction standard will generally be to "TEMA R" for all shell and tube and hair pin type heat exchangers.

Fixed Tube Sheet Exchangers: these exchangers are acceptable for non-fouling service on the shell side. In this case, the designer shall define all exceptional operating conditions (start-up, shutdown, etc.) to assess the necessity to provide an expansion bellow on the shell.

Reboilers: for boiling liquids the design is limited by the heat flux, for hydrocarbon reboilers a limiting flux of 5000 W/m^2 is usually acceptable. For reboilers operating near the critical pressure, a lower limit of 20000 W/m^2 is advisable. If the heat flux is high, square tube pitch is required.

Hydraulic rules are as important as heat transfer in thermosyphon installations with the system hydraulics interlinked to vaporisation and ultimately duty. Use 25% vaporisation for preliminary hydraulic design. Allowable pressure drops are between 0.017 to 0.035 bar with normal liquid inlet velocities of 0.6 to 2 m/s.

Condensers: this type of exchanger removes latent and sensible heat. For many applications the condensing curve is non-linear and a weighted mean temperature difference must be used.

Generally the exchanger can be split into three zones, vapour subcooling, condensation and liquid subcooling. The surface area should be calculated separately for each zone and summed together to give the total exchanger surface area. For total condensers pressure drops are generally low. Care must be taken to ensure symmetrical piping if two or more shells are required in parallel.

Condensers Air Coolers: for air coolers, 50% of the fans can be equipped with variable/dual speed motors (instead of auto-variable blade pitch control) when process control is required.

4.3. Pumps

4.3.1. Design Criteria

Pump design pressure, temperature and flowrate shall be in accordance with chapter 3: "General Design".

Design of pumps shall be in accordance with specific OMV Standard. The following international standards shall be also taken into consideration:

- API 610 / ISO 13709
- API 674 / ISO 13710
- API 675
- API 676

4.3.2. Selection & Sizing Criteria

Pump types can be divided into kinetic and positive displacement pumps. The most commonly used kinetic pumps are centrifugal pumps. Positive displacement pumps can be subdivided into reciprocating and rotary pumps.

Pump selection & sizing criteria shall be in accordance with specific OMV Standard.

4.4. Compressors

4.4.1. Design Criteria

Compressor design pressure, temperature and flowrates shall be in accordance with chapter 3: "General Design".

Design of compressors shall be in accordance with specific OMV Standard. The following international standards shall be also taken into consideration:

- API 617 / ISO 10439
- API 618 / ISO 13707
- API 619 / ISO 10440-1

- ISO 13631 / API 11P

Design of compressor stations shall comply with EN 12583 / ASME B31.8.

4.4.2. Selection & Sizing Criteria

The type of the compressors will be selected according to the flowrates, the head and in order to guarantee operation flexibility.

Compressor selection & sizing criteria shall be in accordance with specific OMV Standard.

4.5. Storage Tanks

4.5.1. Design Criteria

Tanks design pressure, temperature and flowrates shall be in accordance with chapter 3: "General Design".

Design of tanks shall be in accordance with the following international standards:

- API 620
- API 650
- API 12 D
- API 12 F
- EN 14015
- EN 12285
- API 2000 / ISO 28300

4.5.2. Selection Criteria

The main driver for storage type selection is minimizing Volatile Organic Components (VOC) emissions. VOC emissions from storage tanks vary directly with the volatility of the stored material, frequency of filling, and filling rate. Breathing losses result from variations in ambient temperature and pressure, and depend on the vapour pressure of the stored material as well as the volume of the vapour space.

The followings are the typical type of tanks:

Fixed roof tank: fixed roof tanks are used for the storage of liquids with low pressure, low volatility and a relatively high flash point. Products stored in this type of tank must have low potential for loss by evaporation and tank breathing and must represent only a limited fire hazard.

Fixed roof tank are generally used for gas oil, distillates and fuel oil.

When a fixed roof tank is used for the storage of volatile products it is recommended and in some cases required to equip them with an internal floating roof.

Floating roof tank: this type of tank is used in the following cases:

- Volatile fluids: crude oil, gasoline
- Fluids with a low flash point: kerosene, naphtha, light slops.
- All fluid for which contact with air should be avoided: chemical solvents, lubricating oil, reformer feed.
- Corrosive products

Pressurised Tanks: these tanks are cylindrical or spherical type. They are widely used for the storage at ambient temperature of LPG's such as propane, butane and butane. Spheres are also commonly used for the semi-refrigerated storage of ethylene or ethane. For the design of pressurised tanks, API 2510 shall be taken into consideration.

4.5.3. Tank Capacity

Storage net operating capacity (normally set in the operating range of 20% to 80% of the total volume) and required number of tanks is determined by the tank function and required hold-up time based on loading/unloading rates, frequency and typical tender size.

The net storage volume shall be designed depending on project/facility requirements on a case-by-case basis. Final tank dimensions shall be fixed based on the layout constraints and/or contractual specifications.

Tanks are typically manufactured according predetermined dimensions, due to the standard dimensions of plate building blocks. For final selection of tank dimensions API 650 lists the available standard tank heights/widths and corresponding nominal capacities, based on a fixed plate heights.

4.5.4. Breathing Requirements

Breather valves are mandatory (except for tanks open to atmosphere) and protect the tank from collapsing or exploding. The total normal venting capacity (inbreathing and outbreathing) shall be at least the sum of the venting requirements for liquid movement and thermal effects.

The following guidelines may be used for a quick estimate of breathing requirements for liquid movement based on ISO 28300/API 2000:

- Out-breathing: Provide a minimum 2.02 Nm^3/h of venting capacity for every 1.0 m^3/h of maximum filling rate for liquids with flash point of less than 38°C or 1.02 Nm^3/h for every 1.0 m^3/h of maximum filling rate for liquids with flash points of 38°C or higher.
- In-breathing: Provide a minimum of 0.94 Nm^3/h of inbreathing gas for each 1.0 m^3/h of maximum emptying rate.

The thermal breathing capacity shall be added to above mentioned breathing requirements for liquid movement. For thermal venting requirements, refer to ISO 28300/API 2000.

4.5.5. Blanketing System

For stored product sensitive to oxygen, for avoiding corrosion and from safety point of view a blanketing system shall be applied. The blanketing media commonly used are nitrogen or fuel gas. Blanketing may be applied to:

- Fixed roof tanks
- Fixed roof tanks with internal floating covers.

Blanketing with fuel gas may also be applied for recovery of volatile hydrocarbons. In this case the vented hydrocarbons are collected in a gas-holder and compressed, after which they are re-injected into the fuel gas system.

Blanket pressure is controlled by adding gas at a low pressure threshold, and venting gas at a high pressure threshold. The set-points for this 'split range' control should be within the range for set pressures of breathing valves.

5. PIPING DESIGN

5.1. General Design & Hydraulics

5.1.1. Isolation & DBB

For Isolation & DBB procedures CONTRACTOR shall follow OMV Standard TO-HQ-02-034-00 – Isolation of Process System Onshore.

5.1.2. Control valves

Non-continuous control valves do not require bypasses. Control valves in continuous service and less than or equal to 6″ should have block and by-pass valves manifold if operation can be achieved in manual operation.

Above 6", the control valve can be provided with a hand wheel and no by-pass, subject to OMV approval by Instrumentation department.

For main utility control valves (fuel gas and air), the by-pass should be replaced by a spare control valve.

In case of mal-operation, the gas blow-by situation shall consider the flow rate through the control valve full open and its by-pass also fully open when it is installed. If that flow rate becomes the sizing case for the flare, the manual by-pass could be deleted to avoid an increase of the flare size or alternatively a mechanical interlock between the upstream control valve manual block valve and upstream by-pass valve manual block valve should be installed.

Sizing of bleed devices of control valve manifolds:

<u>Upstream control valve line size ≥ 6":</u>

- For control valve open by fluid failure (FO), one maintenance bleed valve (1″ block valve with blind flange) will be installed downstream the control valve.
- For control valve closed by fluid failure (FC), two maintenance bleed valves will be installed, one upstream and one downstream the control valve.

<u>Upstream control valve line size < 6":</u>

- One maintenance bleed valve will be installed downstream the control valve whatever the control valve position (FO or FC) by fluid failure.

5.2. Insulation and Heat Tracing

5.2.1. Insulation

Insulation for hot or cold services is required when applicable for:

- Heat or cold conservation of equipment and piping
- Personnel protection of equipment for operating temperatures above 70°C. A physical barrier with warning signs attached to hot surface is preferred to insulation
- To avoid external water condensation or ice
- Steam, hot water or heat tracing.
- Reduce noise levels to meet environmental and health and safety requirements.

In all cases, insulation shall be designed in order to limit CUI (Corrosion Under Insulation) and to allow access to instruments and pipe fittings without destroying the shield. Fire resistant insulation may be specified in order to reduce the relief load to the flare system in case of fire. However the normal engineering practice is to take no credit for heat insulation.

Control and relief valves and driven machinery (compressors, pumps and turbines) are sources of significant noise levels. This noise can get transmitted along the connected pipework. Providing acoustic insulation on the affected pipework can reduce this noise. Increased pipe size to reduce the flow does not reduce the transmitted noise level.

5.2.2. Heat Tracing

Rate of heat loss determines the heat tracing requirements. Thermal conductivity of typical insulation materials are shown below. The heat tracing requirement is the energy required to replace the heat that is lost

Material	Temperature Range (°C)	Thermal Conductivity kcal/hr.m.°C
Calcium Silicate	6 - 540	0.042 – 0.097
Glass Fibre	20 -150	0.027 – 0.038
Mineral Wool	95 - 540	0.042 – 0.093
Rock Fibre (resin bonded)	60 - 540	0.032 – 0.078
Cellular Glass	-20 - 150	0.043 – 0.068

5.3. Line sizing criteria

5.3.1. Minimum Permissible Pipe Sizes

A minimum size of DN50 (2") should in general be used for all process, process support and utility piping to ensure adequate mechanical integrity. Smaller piping can be used, where protection and/or support is provided to withstand human activity. Selection of a smaller piping shall be approved by COMPANY related Process DA 2.

Minimum size for the sewage and open drain header shall be DN100 (4") and sub-headers DN80 (3"). Overflow from atmospheric tanks shall as a minimum be equal to the largest inlet pipe.

Tubing may be used for air, hydraulic oil and other non-combustible/non- hazardous fluids.

5.3.2. Pipe Roughness

For all calculations of pressure drop, the following pipe roughness values should be used:

Carbon Steel (CS) non-corroded:	0.05 mm
Carbon Steel (CS) corroded:	0.5 mm
Stainless Steel (SS):	0.05 mm
Titanium and Cu-Ni:	0.05 mm
Glass-fibre Reinforced Pipe (GRP):	0.02 mm
Polyethylene, PVC:	0.005 mm

Flexible hose: Vendor to be consulted. As a rough estimation for steel carcass hoses, ID/20 mm can be used (where ID is in inches); for plastic coating use 0.005mm.

5.3.3. Gas Lines

The following line sizing criteria shall be followed for gas and steam piping lines within the process plant (gas pipelines are not covered by these criteria):

Service Type	$\rho \bullet v^2$ max. $[kg/(m \bullet s^2)]$ (1)	Max. Velocity (m/s) (2)	DP (bar/km)	
			Normal	Max.
Continuous Operation:				
P ≤ 20 barg	6000	20	Pressure drop must be considered compatible with corresponding service.	
20 < P ≤ 50 barg	7500			
50 < P ≤ 80 barg	10000			
80 < P ≤ 120 barg	15000			
P > 120 barg	20000			
Compressor Suction	compatible with above		0.2	0.7
Compressor Discharge	compatible with above		0.45	1.15
Discontinuous Operation:				
P ≤ 50 barg	10000		Pressure drop must be considered compatible with corresponding service.	
50 < P ≤ 80 barg	15000			
P > 80 barg	25000			
Column Overhead	15000 (high pressure columns)			
Stripper Vapour Return			0.2	0.45
Kettle Vapour Return			0.2	0.4
Steam Lines:				
P ≤ 10 barg				
short line (L ≤ 200 m)	15000		0.5	0.15
long line (L > 200 m)	15000		1.0	0.25
10 < P ≤ 30 barg				
short line (L ≤ 200 m)	15000	42	1.2	0.25
long line (L > 200 m)	15000	42	2.3	1.0
P > 30 barg				
short line (L ≤ 200 m)	15000	30	1.2	0.35
long line (L > 200 m)	15000	30	2.3	1.0

Table 12: Gas Line Sizing Criteria

Notes

1. Units: ρ = Gas density in kg/m3; V= velocity in m/s
2. When gas velocity and momentum are both indicated the worst conditions in each of the two criteria have to be assumed.

5.3.4. Liquid Lines

The following line sizing criteria shall be followed for liquid piping lines within the process plant (oil export pipelines are not covered by these criteria):

Service Type	DP (bar/km)		Max. Velocity (m/s) (2,4)			
	Norm.	Max.	To 2″	3″ to 6″	8″ to 18″	from 20″
Pump Suction:						
liquid at bubble point with dissolved gas	0.6	0.9	0.6	0.9	1.2	1.5
non boiling liquid	2.3	3.5	0.9	1.2	1.5	1.8
Unit Lines:						

Service Type	DP (bar/km)		Max. Velocity (m/s) [2,4]			
	Norm.	Max.	To 2″	3″ to 6″	8″ to 18″	from 20″
liquid at bubble point with dissolved gas	0.6	1.0	0.6	1.0	1.4	1.8
non boiling liquid	2.3	3.5	0.9	1.2	1.8	2.4
Pump Discharge: [1]						
disch. pres. ≤ 50 barg	3.5	4.5	1.5 to 4.5 m/s			6.0
disch. pres. > 50 barg	7.0	9.0	1.5 to 4.5 m/s			6.0
Column Outlet	0.6	0.9	0.6	0.9	0.9	0.9
Gravity Flow		0.5	1.4	1.4	1.4	1.4
Water Lines (CS): [3]						
Cooling water & service water						
large feeders between pumps and units	1.5		1.5 to 3.0 m/s			
unit lines (long)		1.5	1.5	2.5	3.0	3.0
unit lines (short)		3.5	1.5	2.5	3.0	3.0
Boiler feed						
P ≤ 50 barg	3.5	4.5	1.5 to 4.5 m/s			6.0
P > 50 barg	7.0	9.0	1.5 to 4.5 m/s			6.0
Sea water lines			2.5 to 3.5 m/s (2 m/s min.)			
Steam condensate return			1 to 1.5 m/s			
Reboiler feed (for indication)	0.2	0.4				

Table 13: Liquid Line Sizing Criteria

Notes

1. 3.0 m/s max. (2 m/s average) at storage tank inlet or in loading.
2. Vendor and/or Licenser requirements could supersede maximum velocity values upon COMPANY approval.
3. Special considerations can be applied for copper-nickel or glass reinforced plastic piping upon COMPANY approval.
4. Maximum velocity can exceed 1 m/s, if it reduces carbon steel corrosion.

5.3.5. Multiphase Lines

The following criteria shall be considered for the line sizing for two phase flows:

- $Vm_{MIN} \geq 10$ ft/s (≈3m/s) to minimize slugging of separation equipment.
- Vm ≤ 80% of the Erosional Velocity (see paragraph 5.3.6 "Corrosion/Erosion Criteria"). However the CONTRACTOR shall inquire case by case the necessity to adopt a different value.
- ΔP: must be compatible with the corresponding service. For multiphase fluid line sizing calculations the average fluid density ρm (kg/m^3) shall be used in order to estimate the apparent fluid velocity Vm (m/s).

As a general rule, continuous flow patterns should be ensured such as:

- Stratified, annular, bubble, wavy flow patterns, etc. for horizontal lines or slightly sloped.
- Annular or bubble flow, etc. for vertical lines.

- For horizontal lines in slug and plug flow regimes and for vertical line in slug flow regimes reinforced anchoring shall be specified.

5.3.6. Corrosion/ Erosion Criteria

Corrosion

For corrosion resistant material (SS, special alloys, etc.), no limitation of flowing velocity up to 100 m/s is required and no requirement for corrosion allowance apply.

For non-corrosion resistant material, in corrosive fluid service, corrosion allowance for a design service life and corrosion inhibitor injection is required. The flowing velocity is limited by the inhibitor film integrity.

Erosion

For Duplex, SS or alloy material, the flowing velocity must be limited to the following:

- 100 m/s in single phase vapour lines and multiphase lines in stratified flow regime (65 m/s for 13% Cr material).
- 20 m/s in single phase liquid lines and multiphase lines in annular, bubble or hydrodynamic slug flow regime.
- 70 m/s in multiphase lines in mist flow regime.

For Carbon Steel material, the following criteria shall apply:

- In case of continuous injection of corrosion inhibitor, the inhibitor film shall ensure a lubricating effect which drifts the erosion velocity limit. The corrosion inhibitor erosion velocity limit will be calculated taking into account the inhibitor film wall shear stress.
- In case of uninhibited fluid, the API RP 14E / ISO 13703 recommendation should apply: the flowing velocity must be maintained below the erosional limit.

The erosional limit is defined as:

$$v_e = \frac{C}{\sqrt{\rho_m}}$$

Where:

ve = erosional velocity in ft/s

ρm = gas/liquid mixture density at flowing conditions in lb/ft^3

C = empirical constant equals 150 to 170; values up to 200 can be considered on peak flow rate only in case of absence of abrasive (solid) particles such as sand. When solid and/or corrosive contaminants are present C value shall not be higher than 100.

When erosional service cannot be avoided reference shall be made to DNV RP 0501.

5.3.7. Flare/Vent, Relief & Blowdown Lines

The lines sizing criteria for flare/vent, relief & blowdown lines shall be calculated according to API 521 / ISO 23251 and API 520.

PSV Inlet Lines

The following design rules shall be applied for PSV inlet lines:

- The inlet line pressure drop shall be less than 3% of the set pressure (gauge) calculated at rated flow based on the installed PSV orifice area.

- When isometrics are not available to perform previous calculation the following criteria shall be followed:
  - Lines ≤ 2”: $\rho v^2 \leq 25000$ [kg/m.s^2]
  - Lines > 2”: $\rho v^2 \leq 30000$ [kg/m.s^2] when relieving P is ≤ 50 barg
  - Lines > 2”: $\rho v^2 \leq 50000$ [kg/m.s^2] when relieving P is > 50 barg
- The inlet line shall not be smaller than the inlet flange of the relieving device
- Manual block valve (for isolation) must be full bore and locked open
- In case of PSV sparing (n+1) the isolation shall be mechanically interconnected (key interlock system) and locked in position as follows:
  - Duty PSV: locked open
  - Spare PSV: locked closed
- The inlet system should be self-draining towards the protected equipment

<u>BDV Inlet Lines</u>

The following design rules shall be applied for BDV inlet lines:

- The same criteria as per PSV Inlet Lines shall be followed

<u>PSV Outlet Lines</u>

The following design rules shall be applied for PSV outlet lines:

- The discharge piping system should be designed so that the built-up back pressure caused by the flow through the valve does not reduce the capacity of the relieving device. Limits are given as per API 520 (Part 1) as follows:
  - Conventional Valves: back-pressure at relief valve outlet < 10% of the set pressure (gauge)
  - Bellows Valves: back-pressure at relief valve outlet < 30% of the set pressure (gauge)
  - Pilot Operated Valves: back-pressure at relief valve outlet < 50% of the set pressure (gauge)
- Mach number (Ma) shall be limited to 0.7 calculated at rated flow (in case of no isometrics available this criteria shall be follow.
- Minimum size 2” and however the outlet line shall not be smaller than the outlet flange of the relieving device.
- Outlet lines shall slope downwards to the relief header, without any low point (minimum slope 1:200).
- The connections to headers/sub-headers shall be done with no low point and preferably top entry. Connection will be preferably done at 45°C in the flow direction.
- Manual block valve (for isolation) must be full bore and locked open.

<u>BDV Outlet Lines</u>

The following design rules shall be applied for BDV outlet lines:

- The discharge piping system should be designed so that the built-up back pressure caused by depressurization does not reduce the capacity of the relieving device (i.e. critical pressure ratio).

- The same criteria as per PSV Outlet Lines shall be followed.

Flare/Vent Headers & Sub-Headers

The following design rules shall be applied for Flare/Vent Headers & Sub-Headers

- The discharge piping system should be designed so that the built-up back pressure does not reduce the capacity of the relieving devices. Since this calculation might imply that different scenarios have to be taken in account, the use of specific software might be necessary.
- Mach number shall be limited to 0.5.
- Headers shall slope downwards to the flare KOD, without any low point (minimum 1:200).
- Minimum size 2".
- The connections to headers shall be done with no low point and preferably top entry. Connection will be preferably done at 45°C, in the flow direction.
- If required two networks shall be foreseen:
  - Low Pressure: to collect the reliving devices at low pressure
  - High Pressure: to collect the reliving devices at high pressure

Flare/Vent Stacks

Flare stacks shall be sized in order to limit Mach number to 0.7. In case of sonic flares this criteria is not applicable and flare Vendor shall recommend the suitable value.

5.3.8. Fire-water System

Line sizing of fire-water systems shall comply with the applicable local regulations and with the standards referenced thereof. NFPA and EN recommend using a special and more conservative formula called the Hazen-William's equation for calculating head losses in fire-water distribution systems.

- For further details, refer to: EN 12845, EN 12259, ISO 6182, CEN/TS 14816, NFPA , API 2030 NFPA 15 for Fire Water systems
- EN 13565, ISO 7076, NFPA 11 for Foam systems.

5.3.9. Nozzle Sizing Criteria

Feed Inlet Nozzle

The internal nozzle diameter may be taken equal to that of the feed pipe:

Inlet Device	**$\rho m \bullet v^2$ max. [kg/(m•s²)]** (1)
Vessel with no Inlet Device	≤ 1000
Vessel with Half-Open Pipe	≤ 1500
Vessel with Cyclone Device	≤ 8000
Heat Exchanger - Tube Side	≤ 6000
Heat Exchanger - Shell Side (non-corrosive, non-abrasive, single phase fluids) (2)	≤ 2200

Inlet Device	$\rho m \bullet v^2$ max. [kg/(m•s²)] (1)
Heat Exchanger - Shell Side (corrosive and abrasive liquids) (2)	≤ 750

Table 14: Equipment Inlet Nozzle Criteria

Notes

1. ρm is the average density of the mixture in the feed pipe
2. If the maximum value of $\rho m.v^2$ exceeds the ones shown in the table 21, impingement plates on shell side inlet nozzles shall be foreseen to protect the bundle against impingement by the incoming fluid. However, the inlet nozzle area should not have a $\rho m.v^2$ greater than 6000 kg/m.s².

Gas Outlet Nozzle

The diameter of the gas outlet nozzle should normally be considered equal to that of the outlet pipe, but the following criteria shall be satisfied:

- $\rho m.v^2 \leq 6000$ kg/m.s²

In High Vacuum Units this criteria may result in a high outlet velocity, leading to a pressure drop which is too high. In that case the gas outlet nozzle shall be sized such that the pressure drop requirements between column and downstream system are met.

Liquid Outlet Nozzle

The diameter of the liquid outlet nozzle shall be chosen such that the liquid velocity does not exceed 1 m/s and the minimum diameter is 2". In case of unpractical sizes special considerations can be given and shall be discussed and accepted by COMPANY.

The liquid discharging nozzles shall be provided with vortex breaker at least in the following cases:

- if connected to pump suction
- if connected to termosiphon or kettle inlet
- if connected to let-downs to a low pressure or if connected to control devices (control valves, calibrated orifices, magnetic/ultrasound flow meters, etc.)
- No vortex breaker shall be normally provided on maintenance drain nozzles.

Flare KOD nozzle

The momentum criteria (mix density multiplied by two-phase flow velocity squared) for nozzles provided with a half open pipe shall not exceed 5000 kg/m.s² while for nozzles provided with a cyclone inlet device this value can be increased to 10000 kg/m.s². The momentum criteria for the outlet nozzle shall be 6000 kg/m.s².

6. PROCESS VALVES DESIGN

6.1. Control Valves

6.1.1. Pressure Drops

For process circuits where the pressures upstream and downstream of the control valve are not interdependent, control valve minimum required pressure drop values shall be normally taking into account at least all the following minimum criteria:

- 20% of circuit pressure drop, excluding the valve.
- 10% of the static pressure of the system which the circuit discharges into, for pressures up to 15 bar; 1.5 bar for pressures from 15 bar to 30 bar; 5% for pressures over 30 bar.
- 0.7 bar (for liquids), 0.2 bar (for gasses/vapours with non-butterfly valve), 0.05 bar (for gasses/vapours with butterfly valve).

For process circuits where the pressures upstream and downstream of the control valve are interdependent (i.e. around a column reflux control valve), the control valve's minimum required pressure drop values shall at least take into account all the following minimum criteria:

- 10% of circuit pressure drop, excluding the valve.
- 0.5 bar (for liquids), 0.2 bar (for gasses/vapours with non-butterfly valve), 0.05 bar (for gasses/vapours with butterfly valve).

Control valves on reflux and recycle lines where static pressure variations influence the whole circuit shall be sized according to the same minimum values.

The DP for the closed valve shall be preliminary assumed as being equal to upstream design pressure, except for recycle lines such as reflux and recycle Hydrogen.

If a lowest minimum pressure drop is required, a design deviation would be required for specific types of control valve; OMV instrument specialists shall be consulted.

6.1.2. Flowrate

In order to guarantee correct functioning at the extremes of the operating range, control valves shall be usually specified for the following operating conditions:

- Maximum flowrate: 100% of max. operating flowrate.
- Minimum flowrate: Minimum operating flowrate related to the process turndown requirements.

At maximum flowrate the calculated valve Cv should not be normally higher than the 80% of the valve installed Cv. At minimum flowrate the calculated valve Cv should not be normally lower than the 20% of the valve installed Cv.

Additional operating conditions could be specified on valve datasheet if necessary (i.e. in case of wide pressure or fluid characteristics variation in the different operating scenarios).

If the required operating range of the control loop does not allow to select a single valve (i.e. very low turndown on flowrate, or very high pressure or delta pressure variation in the different operating cases), selection of two or more valves operating in parallel with split range configuration shall be considered.

Control valves shall also be checked in order that allowable noise levels are not exceeded.

6.2. Safety Valves

6.2.1. Pressure Relief Devices

Pressure Relief Devices shall be design according to API 520 and API 521 / ISO 23251, ISO 4126 series and ASME Codes.

CONTRACTOR shall preliminary size the Pressure Relief Devices base on the relief scenarios, relief load calculation and pressure relief valve sizing criteria indicated in the above mentioned standard. During later stages of the project (define/execute) the Pressure Relief Devices sizing criteria shall be verified by the Vendor.

6.2.2. Blowdown Valves & Depressurizing

Emergency depressurization system, consisting in automatic blowdown valves (BDV) working in conjunction with the shutdown valves system (SDV), isolates and depressurizes process equipment in the event of a fire or incident where the process inventory is required to be removed, e.g. fire or major gas leak.

Blowdown will be initiated automatically via the Emergency Shut Down system (ESD), which allow blow down to commence after isolation via the shutdown valves.

BDV valve are installed on the depressurizing line of the process section followed by a flow orifice (FO) sized to depressurize the gas volume entrapped in the required time. Each valve is normally closed so that no flow to the vent occurs during the normal plant operation. In emergency case valves open and the system depressurization is possible.

The blowdown system shall be design according to the OMV Standard TO-HQ-02-036 Philosophy for Flare Relief & Blowdown. Depressurizing calculations shall be carried out in HYSYS using the dynamic depressurization utility (see chapter 2.3.5 “Software”). The calculation shall take into account the following:

- Vaporisation of any associated liquid due to the reduction in pressure.
- The change in density of the vapour in the equipment due to the pressure reduction and temperature increase.
- The blowdown start pressure of the equipment under consideration shall be the maximum operating pressure.
- Vaporisation due to the heat input from the external fire (in accordance with the guidance provided by API 521).
- Cold blowdown from minimum ambient temperature.

6.2.3. General Considerations

PSV and BDV shall be sized as per API 520/521. API 2000 shall be followed in case of atmospheric tank.

Inlet lines shall have a slope towards the upstream equipment. No pockets are accepted.

Outlet lines shall have a slope towards the flare/vent KOD system/unit. No pockets are accepted.

All the process plants shall be designed according to the following stages of protection:

- Normal operation (DCS)
- Emergency situation (ESD)
- Mechanical protection (full rating or PSV).

The three stages of protection shall be completely independent in all elements.

HIPPS is acceptable as third element of protection instead of PSV to limit discharge to atmosphere. The HIPPS system shall be independent, certified and subjected to dedicated and programmed maintenance.

In case of spare PSV the inlet/outlet isolation manual valve shall be preferably mechanically interconnected (key interlock system).

Inlet/outlet isolation manual valve on PSV shall be full bore and locked open or car seal open.

Outlet isolation manual valve on PSV shall be locked open also when PSV is used as spare.

Inlet/outlet isolation manual valve on BDV shall be locked open or car seal open.

Inlet isolation manual valve on BDV shall be full bore.

BDV shall be normally failed open. SDV shall be normally failed closed.

PSV's shall be set at the design pressure of the equipment to be protected.

In case of PSV installed on equipment on equipment full of liquid (e.g. desalter) the hydrostatic head shall be taken into account.

7. PROCESS SAFETY REQUIREMENTS

This chapter provides general considerations to highlight the area of concern and the type of approach to minimize loss (loss prevention) thus identifying major hazards in a process plant.

For more details, the CONTRACTOR shall follow also, OMV Document HSSE-R-028 Facility Documentation.

7.1. Process Safety Design

In particular the following criteria have to be considered during the design:

- Provide two levels of protection. As far as possible, the two levels of protection will operate on functionally different basis. Duplication of identical safety devices with different set points does not satisfy the requirement of two levels of protection.
- The block valves cannot be used as regulation valves.
- PSVs, a blow down system and a vent system shall be foreseen to discharge the calculated flowrates and to guarantee the maximum accepted radiation level, where personnel can be present, in case of accidental ignition; relieving systems shall meet the requirements of API RP 521.
- Fire detection devices have to be installed on equipment handling hydrocarbons or flammable fluids for automatic ESD.
- Maintenance activities on process equipment will be protected by ensuring positive isolation from the process. Facilities for ensuring adequate purging shall be provided.
- Provision of an emergency generator to supply the essential utilities of the plant.

7.2. Emergency Shut Down

The normal process control system allows the plant to operate safely and efficiently within the plant design constraints. As far as possible, hazardous incidents shall be avoided by means of the process control system.

The emergency shutdown system shall be performed according to the OMV Standard TO-HQ-02-024 – Philosophy for Emergency and Process Shutdown Systems.

7.3. Hazardous Area Classification

The classification of the areas has the scope to establish the presence of areas with danger of explosion in which must be adopted technical and organizational provisions in order to minimize the risks deriving from the explosive, or potentially such, atmosphere presence.

The hazardous area classification shall be performed according to ATEX directive.

8. MAINTENANCE CONSIDERATIONS

The process design shall take cognisance of equipment maintenance requirements specified in the plant's maintenance philosophy to ensure that plant life cycle costs are minimised.

The design shall aim to reduce costs associated with maintenance (i.e. materials, manpower and production losses) by providing sufficient redundancy in line with the overall plant availability criteria.

The plant isolation philosophy shall be consistent with the maintenance philosophy to ensure that sufficient isolation valves are available to isolate spare equipment without disruption to operations.

The design shall include sufficient vents, drains and purge/ flushing connections to allow the equipment and piping to be made safe prior to any intrusive maintenance.

Consideration shall be given to providing duty/ standby arrangements for critical process equipment with low availability (i.e. rotating machinery) whereby a single unit failure would have a large impact on plant uptime.

9. DOCUMENTATION REQUIREMENTS

The minimum project documentation to be produced to cover the process design of the system shall be performed according to GT-M Standard 003 - Discipline Authority Framework (DAF).

10. CERTIFYING AUTHORITY REVIEW REQUIREMENTS

Some plants may require a design that is to be certified, validated and authorized by an independent certification authority or local national authority base on local regulations or as instructed by OMV.

Under these circumstances the certifying authority will require as a minimum the following documents for review:

- Basis of Design document
- Process Calculations for Safety Critical Items (e.g. PSVs)
- P&IDs
- Cause and Effect Charts
- Emergency Shutdown Philosophy
- Operating and Control Philosophy

These should be issued to the Certifying Authority in a timely manner to obtain approval before commencing construction.

11. INTERNAL REFERENCE LINKS

O_RefStd_5550	General Process Design Criteria
EF FA HA 01 ST	Company Standard for Areas Classification

PE-D-HA-PRO-001-01-E_ ATEX Procedure for ProjectsTO-HQ-02-021 Philosophy for Process Control Systems

K 1001	Instrumentation and Process Automation Design
TO-HQ-02-024	Philosophy for Emergency and Process Shutdown Systems
TO-HQ-02-032	Philosophy for Utility Systems - General Design Guideline
H 2402	Stations of Utilities
TO-HQ-02-034	Philosophy for Isolation of Process Systems
O_RefStd_3410	Emergency Isolation Valves
TO-HQ-02-035	Philosophy for Overpressure Protection and Safeguarding
O_Norm_H1002	Safety valves
TO-HQ-02-036	Philosophy for Flare, Relief and Blow-down
TO-HQ-02-037	Philosophy for Piping Design
O_RefStd_1111_H	Piping Design and Planning
TO-HQ-02-039	Philosophy for Rotating and Reciprocating Equipment
EP ME 01 PH	Philosophy for Centrifugal Pumps
O_RefStd_1711	Centrifugal Pumps
O_Norm_G2002	Reciprocating Compressors
O_Norm_G2003	Turbocompressors
O_Norm_G2004	Reciprocating Compressors
TO-HQ-02-040	Philosophy for Pressure Vessels and Storage Tanks
O_Norm_DEF2001	Pressure Vessels
O_Norm_T2001	Flat Bottom Tanks
Engineering 0002	Pipeline Material Selection
Engineering 0006	Pipeline Design Onshore
HSSE-R-028	Facility Documentation

12. EXTERNAL REFERENCE LINKS

API 5L / ISO 3183	Petroleum and natural gas industries – Steel pipe for pipeline transportation systems.
API 12 D	Field Welded Tanks for Storage of Production Liquids

API 12 F	Specification for Shop Welded Tanks for Storage of Production Liquids
API 12J	Specification for Oil and Gas Separators.
API 14E /ISO 13703	Recommended Practice for Design & Install of Offshore Production Platform Piping System
API 520 series	Sizing, selection and installation of pressure – relieving devices in refineries.
ISO 4126 series	Safety devices for protection against excessive pressure .
API RP 521/ ISO 23251	Guide for pressure-relieving and depressurizing systems.
API 610 / ISO 13709	Centrifugal pumps for petroleum, heavy duty chemical and gas industry service
API 617 /ISO 10439	Centrifugal compressors for petroleum, chemical and gas service industries
API 618 / ISO 13707	Reciprocating compressors for petroleum, chemical and gas service industries
API 620	Design and Construction of Large, Welded, Low Pressure Storage Tanks
API 650	Welded Steel Tanks for Oil Storage
API 660 / ISO 16812	Shell and Tube Heat Exchangers
API 661 / ISO 13706	Air Cooled Heat Exchangers
API 674 / ISO 13710	Positive displacement pumps - Reciprocating
API 675	Positive displacement pumps – Controlled volume
API 676	Positive displacement pumps – Rotary
API 2000 / ISO 28300	Venting atmospheric and low-pressure storage tanks (Non- Refrigerated and Refrigerated).
API 2510	Design and Construction of LPG Installations
EN 14620 series	Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0 °C and 165 °C
ASME VIII DIV 1, 2 & 3	Boiler & Pressure Vessel Code Rules for Construction of Pressure vessels
EN 13445 series	Unfired Pressure Vessels
ASME B31.3	Process Piping
ASME B31.4	Pipeline Transportation Systems for Liquid Hydrocarbons & Other Liquids
ASME B31.8	Gas Transmission & Distribution Piping Systems
EN 12583	Compressor stations. Functional requirements
EN 307	Heat exchangers. Guidelines to prepare installation, operating and maintenance instructions required to maintain the performance of each type of heat exchanger

EN 764 series	Pressure equipment series standard
EN 13480 series	Metallic industrial piping series standard
EN 14015	Specification for the design and manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded, steel tanks for the storage of liquids at ambient temperature and above
EN 12285 series	Workshop fabricated steel tanks
EN 1127-1	Explosive atmospheres - Explosion prevention and Protection - Part 1: Basic concepts and methodology
IEC 60079 series	Explosive Atmospheres
DNV RP 0501	Erosive Wear in Piping Systems
NACE MR 0175/ISO 15156	Materials for use in H_2S – containing environments in oil and gas production.
NACE MR0103 / ISO 17945	Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments
ISO 6182	Automatic Sprinkler System
ISO 7076	Foam fire extinguishing systems
EN 12845	Automatic sprinkler systems
EN 12259 series	Components for sprinklers and water spray systems
EN 13565 series	Fixed firefighting systems. Foam systems
CEN/TS 14816	Water Spray Systems
API RP 2030	Application of Fixed Water Spray. Systems for Fire Protection in the Petroleum and Petrochemical. Industries
NFPA 11	Standard for Low-, Medium-, and High-Expansion Foam
NFPA 13	Installation of Sprinkler Systems
NPFA 15	Water Spray Fixed System for Fire Protection
TEMA	Tubular Exchangers Manufacturer's Association Standards
ALPEMA	Standard for Brazed Aluminium Plate-Fin Heat Exchanger

The latest edition of the Standards or codes (including any updates) shall apply.

13. OBSOLETE REGULATIONS

TO-HQ-02-031	Philosophy for Process Systems- General Design Guidelines
EP FA PS 03 PH	Philosophy for Process Systems - General Design Guidelines Onshore

14. TERMS & ABBREVIATIONS

ANSI	American National Standards Institute
API	American Petroleum Institute
BDV	Blowdown valve
BFW	Boiler feedwater

CS	Carbon steel
CUI	Corrosion under insulation
CSO	Car sealed open
DBB	Double block & bleed
DCS	Distributed control system
ESD	Emergency shut down
FO / FC	Failure open / Failure close
FSLL	Low low flow switch
GRP	Glass-fiber reinforced pipe
HIPPS	High integrity pressure protection system
ISO	International organization of standardization
KOD	Knock out drum
LAH / LSH	High level alarm / High level switch
LAHH / LSHH	High high level alarm / High high level switch
LAL	Low level alarm
LALL / LSLL	Low low level alarm / Low low level switch
LG	Level Gauge
LMTD	Log mean temperature difference
LPG	Liquefied petroleum gas
MAOP	Maximum allowable operating pressure
MDMT	Minimum design metal temperature
MDT	Maximum design temperature
MOP	Maximum operating pressure
NFPA	National Fire Protection Association
NLL	Normal liquid level
NPSHA	Net positive suction head available
NPSHR	Net positive suction head required
P&ID	Piping & instrumentation diagram
PAH	High pressure alarm
PSHH	High high pressure switch
PSV	Pressure safety valve
PVC	Polyethylene
RAM	Reliability availability & maintainability
SDV	Shut down valve
SS	Stainless steel
STHP	Static tubing head pressure
TEMA	Tubular Exchanger Manufacturers Association
TL	Tangent line
VOC	Volatile organic components

15. KEYWORDS / SEARCH CRITERIA

Engineering, Design, Process Design, Process Safety, Project, Design Levels, Equipment, Equipment sizing & design, Equipment selection, Overdesign Factor, Sparing, Design Temperature, Design Pressure, Flow, Pump, Compressor, Heat Exchanger, Air Cooler, Desalter, TEMA, API, Approach temperature, Fouling, Pressure Vessels, Column, Separator, Surge time, Hold-up time, Nozzle, Storage Tank, Blanketing, Piping, Line sizing, Erosion, Erosional velocity, Corrosion, Material Selection, Hydraulics, Insulation, Safety valve, Blowdown, Vent, Flare, Control valve, Heat tracing, NPSH, Steam out, Level.

16. PRINCIPLES ANNEXES

- Annex 1: Viscosity Estimation for Liquids Mixture.

17. AMENDMENTS FROM PREVIOUS VERSIONS

N/A

18. TRANSITORY PROVISIONS

N/A

Annex 1: Viscosity Estimation for Liquids Mixture

The average oil viscosity is obtained on a volume average basis as follows:

$$\propto_{mix} = \left(Q_{oil} \times \propto_{oil} + Q_w \times \propto_w\right) \cdot 4 \cdot \left(Q_{oil} + Q_w\right)$$

Where:

μ_{oil} = viscosity of dry oil, determined from a viscosity-temperature chart as shown in figure 1 (to be defined case by case by laboratory)

μ_w = viscosity of water

Q_{oil} = volumetric flowrate of dry oil

Q_w = volumetric flowrate of water

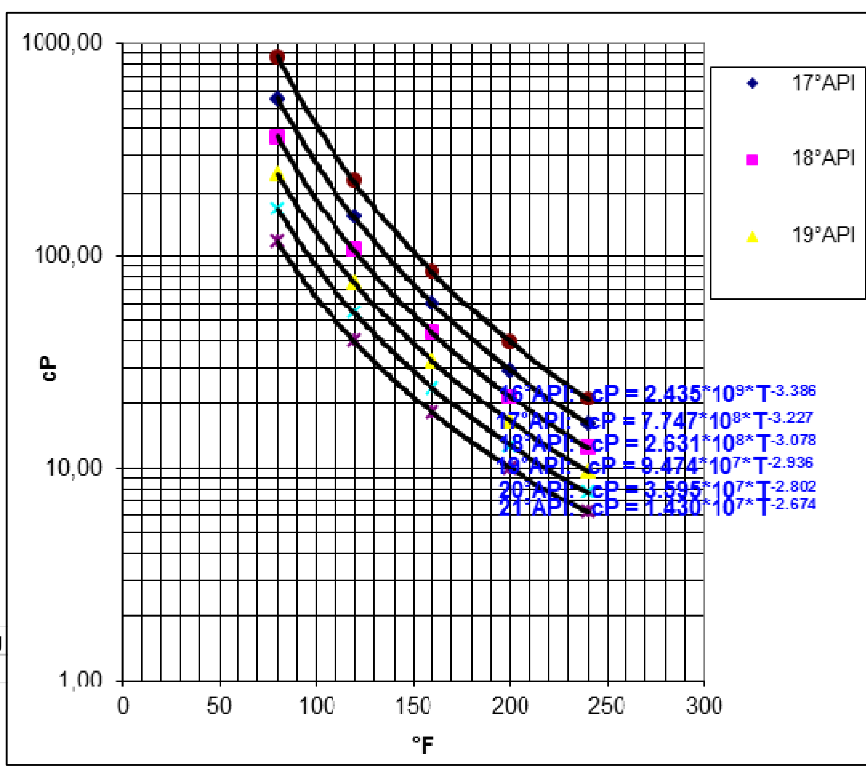

Figure 1: Typical Dry Oil Viscosity-Temperature Chart

Viscosity of emulsion is ascertained by application of the factor chart as shown in figure 2 (to be defined case by case by laboratory):

$$Emulsion\ Viscocity = Factor \times \mu_{mix}$$

Where:

μ_{mix} = viscosity of the emulsion mixture assuming the base oil and water viscosities alone prorated for the percent water cut.

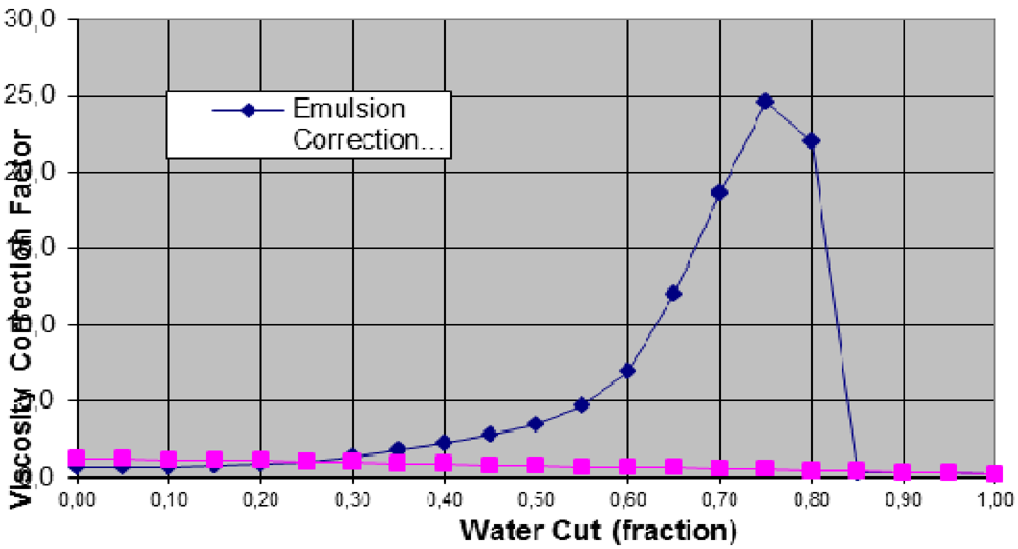

Figure 2: Typical Viscosity Correction Factors Plot for Oil Water Mixture & Emulsion

For cases where a liquid is a mixture of emulsion and free water the viscosity is calculated as follows:

$$\mu_{mix} = \left(Q_e \times \mu_e + Q_w \times \mu_w\right) \cdot 4 \cdot \left(Q_e + Q_w\right)$$

Where

μ_e = viscosity of emulsion

μ_w = viscosity of water

Q_e = volumetric flowrate of emulsion

Q_w = volumetric flowrate of water.