

GENERAL SPECIFICATION

PROCESS

GS EP ECP 103

Process sizing criteria

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General Specification		GS EP ECP 103
Process sizing criteria		
Rev.: 07	Effective date: 11/2012	Page: 2 of 49

Contents

1. Scope	4
1.1 Purpose of the specification	4
1.2 Applicability	4
2. Reference documents	4
3. General	6
3.1 Terminology and definitions	6
3.2 Abbreviations	8
4. Mechanical design	9
4.1 Process equipment	10
4.2 Pipelines and risers	15
5. Design methods	16
5.1 Pumps	16
5.2 Compressors	17
5.3 Gas Dehydration Unit (TEG)	17
5.4 Other process equipment	17
5.5 Storage / RVP	18
6. Vessel sizing criteria	18
6.1 Vapour area	18
6.2 Surge volume for liquids	20
6.3 Level measurement	21
7. Diameter of vessels	22
8. Heat exchangers	22
8.1 Fouling factors	22
8.2 Plate type heat exchangers	24
8.3 Temperature approach for heat exchangers	24
8.4 Specific requirement for heat exchangers	24
9. Equipment nozzles	24
9.1 Nozzles and manholes	24

General Specification		GS EP ECP 103
Process sizing criteria		
Rev.: 07	Effective date: 11/2012	Page: 3 of 49

9.2	Vent, drain and overflow connections.....	25
9.3	Utility connections	25
10.	Elevation of equipment.....	26
11.	Piping	26
11.1	General design and hydraulics	26
11.2	Material selection	29
11.3	Insulation and heat tracing	29
11.4	Line sizing criteria	30
12.	Flare and cold vent systems	36
12.1	Determination of flare load	36
12.2	EDP calculations.....	36
12.3	Flare tip selection.....	37
12.4	Radiation and noise levels criteria.....	38
12.5	Emissivity coefficient.....	38
12.6	Flare and cold vent line sizing criteria	39
12.7	Flare knock-out drum sizing	40
12.8	Purge gas	41
12.9	Installation.....	43
13.	Software	44
13.1	Plant thermodynamic simulations.....	44
13.2	Fluid property table generation.....	44
13.3	Multiphase pipelines calculations	45
13.4	Surge protection on liquid systems and water hammer calculations.....	45
13.5	Heat exchangers thermal calculations.....	45
13.6	Depressurization calculations (excluding pipelines)	46
13.7	Flare system	46
Appendix 1	PSV's installation with one upstream isolating valve.....	47
Appendix 2	PSV's installation with two upstream isolating valves	48
Appendix 3	Depressurization valve arrangement	49

General Specification		GS EP ECP 103
Process sizing criteria		
Rev.: 07	Effective date: 11/2012	Page: 4 of 49

1. Scope

1.1 Purpose of the specification

This general specification gives minimum requirements for process sizing criteria to be used during pre-project and basic or detailed engineering studies.

1.2 Applicability

This general specification is intended for use for facilities such as oil and gas production plants, gas plants, LNG plants and LNG import terminals.

This specification is not retroactive. However it shall apply to new installations and to major modifications or extensions of existing installations, both onshore and offshore. It is also applicable to Vendor's packages and to pipelines and subsea pipeline systems (refer to specific notes).

For oil sand froth production or subsea process equipment (separator, pump etc.), a specific design basis document shall be developed and submitted to Company for approval.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
API STD 520 PT I	Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries Part I - Sizing and Selection -
API RP 520 PT II	Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries Part II—Installation -
EI	Guidelines for the avoidance of vibration induced fatigue failure in process pipework (2008)
ISO 23251 / API STD 521	Petroleum, petrochemical and natural gas industries Pressure relieving and depressuring systems
TEMA R	Tubular exchanger manufacturers association

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP COR 004	Limiting flow velocities calculations for erosion corrosion purpose
GS EP ECP 101	Glycol package unit
GS EP ECP 105	Process documents to be prepared during engineering phase
GS EP INS 101	Instrumentation engineering, supply and construction general requirements
GS EP INS 120	Control Valves
GS EP MEC 028	Rotating Machine Package Specification - Positive Displacement Motopump according to API Standard 674
GS EP MEC 251	Supply of Axial and Centrifugal Compressors and Expander-compressors for Petroleum, Chemical and Gas Industry Services according to API Standard 617
GS EP MEC 271	Centrifugal Pumps for the Petroleum, Chemical and Gas Industry Services According to API Standard 610
GS EP PLR 100	Submarine pipeline systems
GS EP PVV 107	Piping Stress Analysis
GS EP PVV 112	Piping material classes
GS EP PVV 119	Design and fabrication of metallic piping supports - Standard for piping supports
GS EP PVV 211	Design and fabrication of pressure vessels according to ASME VIII
GS EP PVV 212	Design and fabrication of pressure vessels according to BSI PD 5500
GS EP SAF 228	Liquid drainage
GS EP SAF 253	Impacted area, restricted area and fire zones
GS EP SAF 260	Design of High Integrity Protection Systems (HIPS)
GS EP SAF 261	Emergency Shutdown and Emergency De-Pressurisation (ESD & EDP)
GS EP SAF 262	Pressure protection relief and hydrocarbon disposal systems
GS EP SAF 321	Fire pump stations and fire water mains
GS EP SAF 361	SIL assignment
GS EP TEC 260	HIPS Design, Implementation and Life cycle

General Specification		GS EP ECP 103
Process sizing criteria		
Rev.: 07	Effective date: 11/2012	Page: 6 of 49

3. General

3.1 Terminology and definitions

There are five types of statement in this specification, the “shall”, “should”, “may”, “can” and “must” statements. They are to be understood as follows:

Shall	Is to be understood as mandatory. Deviating from a “shall” statement requires derogation approved by Company.
Should	Is to be understood as strongly recommended to comply with the requirements of the specification. Alternatives shall provide the same level of protection or performance and this shall be documented.
May	Is to be understood as permission.
Can	Is to be understood as a physical possibility.
Must	Expresses a regulatory obligation

For the purpose of this specification, the following definitions shall apply:

Heat and material balance: this is the document giving the normal operating conditions, compositions, thermodynamic and physical properties of all streams for each steady state process case.

Normal operating conditions: these are the range of possible internal pressure, temperature, flow rate and fluid composition in stable steady state conditions considering seasonal changes, production changes during facility lifetime etc. Normal operating conditions are required to maintain product specifications and system performance.

Normal Operating Pressure/Temperature (normOP, normOT): It is the highest (positive) or the lowest (negative) normal operating pressure/temperature amongst all steady state process cases.

Maximum/Minimum Operating Pressure/Temperature (MOP, MinOP, MOT, MinOT): these are the maximum/minimum acceptable internal pressure/temperature beyond which product specifications or system performance are not maintained. Maximum/minimum operating pressure/temperature are the upper/lower boundaries of the normal operating range and correspond to high/low alarm set points.

Note for pipelines, subsea pipeline systems and reception facilities: maximum/minimum operating pressure/temperature take into account transient modes such as start-up, shutdown, turndown conditions, slugging regime, pigging, packing, and normal preservation sequence (if applicable).

Minimum wall temperature: this is the lowest temperature the equipment wall can reach. It takes into account emergency depressurization final temperature, LPG or refrigerant fluid atmospheric boiling point etc.

Minimum design temperature: this is the internal lower temperature used for the system mechanical design and material selection (i.e. coincident with maximum design pressure).

Maximum design pressure: this is the internal upper pressure used along with the design temperature for the system mechanical design. This is also the reference pressure used to

General Specification		GS EP ECP 103
Process sizing criteria		
Rev.: 07	Effective date: 11/2012	Page: 7 of 49

determine at which pressure the system will be tested prior to being put on line. In case the system is protected against the risk of overpressure by a PSV, the PSV set-point is the maximum design pressure. Design codes stipulate the allowable overpressure limits (i.e. transient excursions beyond the system design pressure).

Minimum design pressure: this is the internal lower pressure used along with the design temperature for the system mechanical design. In case the system is protected against the risk of collapse with a vacuum breaker, the vacuum breaker set point is the minimum design pressure.

Maximum design temperature: this is the internal upper temperature used for the system mechanical design (i.e. coincident with design pressure). No system shall be operated beyond its maximum design temperature. Fire conditions are not taken into account.

Process Flow Diagram (PFD): it presents the succession of operations in the fluid(s) processing to reach the required products specifications including associated off sites. Refer to [GS EP ECP 105](#).

Utility Flow Diagram (UFD): equivalent of PFD for utilities generation and distribution systems. Refer to [GS EP ECP 105](#).

Piping and Instrumentation Diagram (P&ID): it is the detailed drawing used for assistance to construction and operation of the processing plant including associated off sites and utility fluids.

P&ID's symbols are used for a good understanding and also in order to simplify the representations on P&ID's. Refer to [GS EP ECP 105](#).

Process data sheet: it is the data sheet for all process components (packages, control valves, PSV's, rupture disks, instruments, etc.) containing the information required for sizing. A sketch with main dimensions such as internal diameter, length, liquid levels for vessels and columns. It is issued by Process discipline. Refer to [GS EP ECP 105](#).

The information given in the process data sheets are also used in the "mechanical data" sheet, issued for the purchasing of the said equipment. Refer to API, ASME, TEMA codes for Mechanical Data Sheet templates.

Process rated flow: This terminology is mainly used for rotating equipment. It is the normal Process flow rate multiplied by the design factor and it shall be specified on the Process data sheet. It is generally the flow rate at the guaranteed point (100% rotating speed). The Process rated flow rate is the net Process flow because it does not take into consideration losses (i.e. internal recycle, external consumption such as the air needed for air-dryers regeneration for an air compressor package etc.).

Standpipe: is an external extension of the pressure vessel, to which multiple level instruments can be connected, but no instrument is installed inside the standpipe itself. No isolation valves are installed between the vessel and the standpipe. Each instrument is provided with individual isolation valves. Not to be confused with level instrument sensor cage.

Sensor cage: is an individual chamber in which the level sensor is installed, part of a single level instrument (normally supplied by the instrument manufacturer). The sensor cage is installed either on the pressure vessel or on a standpipe, and has dedicated process isolation valves and vent/drain facilities, allowing the level sensor to be safely removed whilst the system it is connected to is on stream. Not to be confused with standpipe.

General Specification		GS EP ECP 103
Process sizing criteria		
Rev.: 07	Effective date: 11/2012	Page: 8 of 49

Toxic fluid: refer to **GS EP SAF 253**.

3.2 Abbreviations

BDV	Blow Down Valve
BS&W	Basic Sediment and Water
CFU	Compact Flotation Unit
CI	Corrosion Inhibitor
EDP	Emergency Depressurization
EOR	Enhanced Oil Recovery
FC/FO	Fail Closed / Fail Open
FVF	Fluid Viscosity Factor
HIPS	High Integrity Protection System
ID	Internal Diameter
ILAH	Interface Level Alarm High
ILAL	Interface Level Alarm Low
ILSHH	Interface Level Safety High High
ILSLL	Interface Level Safety Low Low
INLL	Interface Normal Liquid Level
LAH	Level Alarm High
LAL	Level Alarm Low
LCV	Level Control Valve
LG	Level Gauge
LSHH	Level Safety High High
LSLL	Level Safety Low Low
LT	Level Transmitters
MinOP	Minimum Operating Pressure
MinOT	Minimum Operating Temperature
MOP	Maximum Operating Pressure
MOT	Maximum Operating Temperature
MSL	Mean Sea Level
NLL	Normal Liquid Level
normOP	normal Operating Pressure
normOT	normal Operating Temperature

General Specification		GS EP ECP 103
Process sizing criteria		
Rev.: 07	Effective date: 11/2012	Page: 9 of 49

NPSH	Net Positive Suction Head
OD	Outside Diameter
P&ID	Piping & Instrumentation Diagram
PAH	Pressure Alarm High
PFD	Process Flow Diagram
PFP	Passive Fire Protection
PSHH	Pressure Safety High High
PSLL	Pressure Safety Low Low
PSV	Pressure Safety Valve
PWL	Power Level
RO	Restriction Orifice
RVP	Reid Vapour Pressure
SDV	Shut-Down Valve
SIL	Safety Integrity Level
SIS	Safety Instrumented System
TEG	Tri Ethylene Glycol
TSHH	Temperature Safety High High
TSL	Temperature Safety Low Low
UFD	Utility Flow Diagram
WHSIP	Wellhead Shut-In Pressure

4. Mechanical design

The mechanical integrity of all process, pipeline and piping systems and their operability must be maintained under all possible coincident pressure and temperature conditions. As a general statement, all assumptions made during the early phase of the study shall be firmed up as and when the design develops.

All modes of operation with associated pressure and temperature conditions shall be described in an auditable document as well as the interface conditions at the system battery limits.

Several sets of design pressure and temperature (one per operating mode) shall be defined where necessary.

The thermal specifications for pipeline systems shall be issued during basic engineering study and revised in detailed engineering study if required.

For specific applications such as deepwater field developments, temperature and pressure profiles along the pipeline system may be required.

The risk of overpressure due to reverse flow conditions shall be duly accounted for.

Process sizing criteria

Rev.: 07

Effective date: 11/2012

Page: 10 of 49

Additionally, the potential impacts of a connection on an existing system (the design conditions of which may be different from the new ones) shall be thoroughly reviewed.

As stipulated in **GS EP SAF 361**, a SIL assignment analysis shall be conducted for all instrumented safety functions (PSHH, TSLL, LSHH etc.).

Reference is made to **GS EP SAF 260** for protection by a SIS or HIPS.

For a system protected by a PSV, the system pressure will increase above the PSV set point to open the valve to its full lift and full capacity position. For a system protected by a SIS, the system pressure will increase above the SIS set point until the trip signal shuts down the source of pressure. The SIS set point and response time shall be selected so that it offers a protection equivalent to the one offered by a conventional overpressure protection system. The pressure excursions beyond the system design pressure due to PSV accumulation and SIS response time shall be within the overpressure limits established by the applicable design code. The same applies to all process parameters (temperature, flowrate, level etc.).

All pressures shall be given at the selected pressure reading (gauge or absolute).

4.1 Process equipment

The following requirements apply to process components and piping designed to **GS EP PVV 112**.

4.1.1 Design pressure

4.1.1.1 Maximum design pressure

The maximum design pressure shall be selected by adding a safety margin on normOP.

As a minimum, the safety margin between normOP and the maximum (upper) design pressure of a process equipment (excluding storage tanks, atmospheric tanks, pipelines and subsea systems, receiving facilities) shall be taken as follows:

Table 1 Design pressure of equipment with positive operating pressure

normOP (bar g)	Upper design pressure (bar g)
< 1	2 or 3.5 ^(*) minimum
1 – 10	normOP + 1 bar, 2 or 3.5 ^(*) minimum
> 10	normOP + 10%
> 150	normOP + 15 bar

The Process engineer shall define MOP which is the upper boundary of the normal operating range. The high pressure alarm set point PAH shall correspond to MOP.

It shall be checked that the maximum design pressure takes into account all possible excursions beyond MOP due to upset, blocked outlet, instrument failure etc. Refer to section 4.1.1.3.

PSV set point (if any) shall correspond to the maximum design pressure.

^(*) 2.0 bar g for PSV discharging to atmosphere, 3.5 bar g for PSV discharging to flare

General Specification		GS EP ECP 103
Process sizing criteria		
Rev.: 07	Effective date: 11/2012	Page: 11 of 49

The safety margin between normOP and the maximum design pressure may need to be increased above Table 1 minimum values in order to stagger successive layers of overpressure protection (PAH, PSHH, PSV and/or SIS). The interval between these set points shall be at minimum 0.5 bar.

Reference is made to [API STD 520 PT I](#) for typical pressure relief systems characteristics (tolerances etc.).

The maximum design pressure of all process equipment and piping shall take into account transient conditions such as surge pressures due to water hammer phenomena. The water hammer surge pressure shall be calculated as per the method described in section 11: the sum of this surge pressure and normOP shall be checked against the system maximum design pressure and appropriate surge protection shall be implemented if required.

All pressures shall be given for the vapour phase. The equipment elevation relative to grade (reference level) shall be indicated.

The liquid density and the maximum liquid height shall be specified on the Process data sheet.

4.1.1.2 Minimum design pressure

The Process engineer shall define MinOP which is the lower boundary of the normal operating range. The low pressure alarm set point PAL shall correspond to MinOP.

For equipment operating under vacuum, the minimum design pressure shall be selected by adding a safety margin on normOP.

The minimum design pressure of a process equipment (excluding storage tanks, atmospheric tanks, pipelines and subsea systems) operating at pressure below atmospheric pressure shall also be taken as follows:

Table 2 Design pressure of equipment operating under vacuum conditions

normOP (bar a.)	Lower design Pressure (bar a.)
≤ 0.35	Full vacuum
0.35 – 0.6	normOP – 0.1 bar
> 0.6	0.5

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 on a case by case basis. They may not be designed for full vacuum if protective devices are provided (vacuum breaker, pressurization gas, low pressure switch, etc.).

General Specification		GS EP ECP 103
Process sizing criteria		
Rev.: 07	Effective date: 11/2012	Page: 12 of 49

4.1.1.3 Particular cases

4.1.1.3.1 For receiving facilities, all possible operating modes such as packing, pigging, shut-down and restart, slugging regime etc (and associated dynamic effects) shall be taken into account to determine the required safety margin between normOP and the maximum design pressure.

4.1.1.3.2 Where no PSV are provided, the maximum design pressure shall take into account the fluid vapour pressure at maximum design temperature.

4.1.1.3.3 The design pressure of a process equipment connected to flare shall be equal to or greater than the flare system design pressure.

4.1.1.3.4 At the discharge of reciprocating compressor (piping and equipment):

- Design Pressure = normOP + 2 bar minimum for normOP $\leq$ 20 bar g
- Design Pressure = normOP + 10% minimum for normOP > 20 bar g

PSV's shall be provided at compressor discharge.

4.1.1.3.5 At the discharge of centrifugal compressor:

- Design Pressure = normOP + 1 bar minimum for normOP $\leq$ 10 bar g
- Design Pressure = normOP + 10% minimum for normOP > 10 bar g

For centrifugal compressor driven by a variable speed driver, the design pressure should be reviewed when the compressor operating curves are issued so that the compressor can operate in its entire operating range.

PSV's are required at compressor discharge if not fully rated. For the sizing of PSV's, the following upset case shall be considered:

- Compressor discharge blocked outlet.
- PSHH condition in inlet scrubber.
- Driver at maximum capacity (e.g. turbine at maximum speed).

4.1.1.3.6 Consideration shall be given to centrifugal compressor arrangement to determine the "settle out pressure" of the isolated system.

The settle out pressure is the equilibrium pressure reached between the suction and discharge isolating valves of the compression train when the compressor is stopped. The design pressure of the equipment and piping at compressor suction shall be equal to or greater than the maximum settle out pressure in order to prevent unnecessary PSV's lifting. As specified in **GS EP MEC 251**, it shall be possible to restart the compression train from the settle out pressure without depressurization.

4.1.1.3.7 Generally no PSV's are provided at the discharge of centrifugal pumps and the design pressure shall be the discharge pressure of the pumps at no flow with the maximum suction pressure and the maximum specific gravity (maximum shut-off pressure).

General Specification		GS EP ECP 103
Process sizing criteria		
Rev.: 07	Effective date: 11/2012	Page: 13 of 49

If the pump characteristic curve is not yet available, the maximum shut-off pressure shall be estimated with the following formula:

$$P_d = P_{smax} + \frac{1.2 * head * d_{max}}{10.2}$$

with:

- P_d = design pressure at pump discharge, in bar g
- P_{smax} = design pressure of suction drum + static head at d_{max} and at LAH, in barg
- head = head of the pump at design point, in m
- d_{max} = maximum specific gravity of liquid pumped under normal operating conditions (obtained for maximum BS&W),

Note: when the pump characteristic curve becomes available, the system design pressure shall be checked against the actual maximum shut-off pressure.

4.1.1.3.8 At discharge of volumetric pumps:

- Design Pressure = normOP + 2 bar minimum where normOP ≤ 10 bar g
- Design Pressure = normOP + 20% minimum where normOP > 10 bar g

PSV's shall be provided at pump discharge.

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

4.1.1.3.10 Atmospheric tanks shall be designed 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 (treated on a case by case basis depending upon tank type).

4.1.1.3.11 Hydraulic pressure due to the relative elevation between equipment and also the PSV's location shall be considered.

4.1.2 Design temperature

The design temperature is the temperature used along with the design pressure for the mechanical design of equipment.

4.1.2.1 Maximum design temperature

The maximum design temperature shall be specified as follows, with due consideration for the special cases discussed in section 4.1.2.3.

Maximum (upper) design temperature = normOT + 15°C or maximum surface temperature due to solar radiation, whichever is greater.

The 15°C margin between normOT and the upper design temperature covers the following uncertainties:

- Process model accuracy.
- Reservoir fluid temperature.

- Reservoir fluid thermal properties.
- Reservoir model accuracy.
- Well model accuracy etc.

The Process engineer shall define MOT which is the upper boundary of the normal operating range. The high temperature alarm set point TAH shall correspond to MOT.

The margin between normOT and the upper design temperature may be reduced where the system MOT can be determined accurately and/or when better quality information becomes available. In any case, it shall not be lower than 5°C.

The margin between normOT and the upper design temperature shall not be reduced where a SIS (TSHH) is implemented. The interval between the successive layers of protection shall be at minimum 5°C.

4.1.2.2 Minimum design temperature

The Process engineer shall define MinOT which is the lower boundary of the normal operating range. The low temperature alarm set point TAL shall correspond to MinOT.

For process equipment and associated piping (designed to **GS EP PVV 112**), MinOT excludes exceptional cases such as emergency depressurisation (EDP).

Minimum design temperature = MinOT - 5°C or minimum wall temperature or minimum ambient temperature, whichever is lower.

The minimum design temperature takes into account the minimum wall temperature (resulting for instance from EDP) unless it is demonstrated that there is no possibility to immediately re-pressurize the system after an emergency depressurisation event (i.e. a protection system is implemented to prevent coincident minimum wall temperature and maximum design pressure).

Refer to section 14 for depressurization calculation methodology and determination of minimum wall temperature.

Where a SIS (TSLL) is implemented, TSLL set point shall be at least 5°C lower than MinOT and 5°C above the minimum design temperature.

4.1.2.3 Particular cases

4.1.2.3.1 Equipment handling LPG or refrigerant fluid shall be designed for the fluid atmospheric boiling point.

4.1.2.3.2 The minimum design temperature shall take into account potential gas blow-by from a high pressure system into a low pressure system.

4.1.2.3.3 Consideration shall be given to cooling medium failure when coolers are used.

Downstream of an air cooler, the maximum design temperature should be determined considering that 20% of the duty is provided by natural draft.

Downstream of other coolers, the maximum design temperature shall be the upstream MOT.

These considerations generally apply up to the following equipment only.

4.1.2.3.4 Steam out conditions (pressure and temperature) shall be specified where steaming is considered.

4.1.2.3.5 Due consideration shall be given to upset and transient conditions such as start-up, shut-down, etc. In this case, both pressure and temperature conditions shall be specified.

4.1.2.3.6 The exceptional temperature generated by fire shall not be considered to specify the maximum design temperature.

4.1.2.3.7 For cryogenic equipment, the lower design temperature case may not be the governing case for mechanical design; the upper design temperature case (along with the associated design pressure) may prevail.

4.1.2.3.8 Where a minimum design pressure is specified, the coincident design temperature shall be defined.

4.1.2.3.9 For discontinuous/cycled processes, a set of pressure and temperature conditions shall be specified for each mode of operation.

One typical example is molecular sieve vessel for which different design conditions shall be specified for the adsorption phase and the regeneration phase.

4.2 Pipelines and risers

Reference is made to **GS EP PLR 100**.

For pipelines and subsea pipeline systems, MOP, MinOP, MOT and MinOT shall take into account transient modes of operation including packing, pigging, shut-down and restart and normal preservation sequence (if applicable). Commissioning and installation activities are excluded (for example, onshore testing of a subsea pipeline system).

4.2.1 Design pressure

All pressures shall be given at the reference level (MSL). The fluid type and its properties (minimum and maximum densities) shall be specified.

4.2.1.1 Maximum design pressure

As some standards allow transient excursions beyond the system design pressure during surge incidents, the Process engineer in charge shall provide the following information:

- MOP.
- The list of all potential pressurization sources including, but not limited to WHSIP, compressors, dead oil pumps, water injection pumps, production pumps, chemical injection pumps.
- The maximum design pressures associated to these pressure sources (with no consideration of potential surge pressure).
- The potential pressure increase due to surge.
- PSV accumulated pressure or the overpressure reached before completion of the shutdown sequence. In case of a full pressure rated system, there is no relieving device and the ultimate pressure corresponds to the maximum design pressure with surge.

Exceptional scenarios such as the pressurization of a production pipeline or jumper by chemical injection (methanol, inhibitors etc.) are not expected to occur during normal operation cycles,