# BAND-E-KARKHEH

# PRODUCTION FACILITIES BASIC DESIGN

# PHASE I

# PROCESS DESIGN CRITERIA

| | | | | | |
|---|---|---|---|---|---|
| B4 | | | | | |
| B3 | | | | | |
| B2 | | | | | |
| B1 | | | | | |
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# Revision Sheet

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# 1. GENERAL

## 1.1 Scope

The petroleum engineering and development department of national Iranian oil company (PEDEC) has planned to develop the green Band-e-Karkheh oil field. The Band-e-Karkheh Field (BKH) is part of the Mehr Block which lies in the main producing area of the Central Zagros fold belt. The BKH field is located north-west of Ahwaz in Khuzestan province, onshore western Iran. The reservoir is an elongate anticline structure, immediately adjacent to the giant Ahwaz Field, which is less than 15km to the southeast.

Because of lack of data, and production ambiguities, the field development is defined in 2 phase:

**Phase A** (Early production phase) including:

1. Drilling & repair of 3 oil producing wells (BKH_2, 5 and 7).
2. EPC of one Gathering center and first stage separation with crude transportation pipeline to Ahwaz- 3 production unit for more treatmen
3. Preparation of MDP for phase B

**Phase B named as phase 1** (Fully development phase) including:

1. Drilling of more new wells (14 oil producing and 1 water disposal)
2. EPC of oil production, desalination, stabilization, sweetening and gas re-pressurizing & transportation facilities

The phase A basic design and EPC contractor tendering were finished and is under EPC activities execution.

This document is prepared by Pars Consulting Engineers (PCE) according to basic design of Phase (Phase B) facilities which is awarded to this company by PEDEC.

## 1.2 Project data

Project name: Band-E-Karkheh Production Facilities

Client: National Iranian Oil Company (NIOC)

Site location: north-west of Ahwaz in Khuzestan province

Contract number: ------------------

## 1.3 Language and Measurement System

All engineering and design data including technical information of all quotation should be in SI unit otherwise specific unit which is specified in section 11. For more information about applicable uni that will be used in this project see section 11. All drawings, instruction for installation, operati manuals, maintenance manuals, and vendor and sub-vendors documents shall be in English language.

## 2. APPLICABLE DOCUMENTS

**Table 1: IPS Standards**

| Spec No. | Description |
|---|---|
| IPS-E-PR-170 | Process flow diagram |
| IPS-E-PR-190 | Layout and Spacing |
| IPS-E-PR-200 | Basic engineering design data |
| IPS-E-PR-230 | Piping & instrumentation diagrams (P&IDs) |
| IPS-E-PR-250 | Performance guarantee |
| IPS-E-PR-308 | Numbering System |
| IPS-E-PR-310 | Process design of water system |
| IPS-E-PR-330 | Process design of compressed air system |
| IPS-E-PR-410 | Process design of hot oil & tempered water circuit |
| IPS-E-PR-700 | Process design of crude oil electro static Desalter |
| IPS-E-PR-730 | Process design of waste water treatment and recovery system |
| IPS-E-PR-735 | Process design of waste water treatment and disposal system |
| IPS-E-PR-750 | Process design of compressor |
| IPS-E-PR-771 | Process Requirements of Heat Exchanging Equipment |
| IPS-E-PR-785 | Process Requirements of air cooled heat exchanger |
| IPS-E-PR-810 | Process Requirements of furnace |
| IPS-E-PR-830 | Process Design of valves and control valves |
| IPS-E-PR-850 & 880 | Process Design of gas-liquid separators |
| IPS-E-PR-420 | Process design of heat tracing and winterizing |
| IPS-E-PR-440 | Process Design of Piping Systems (Process Piping and Pipelines) |
| IPS-E-ME-100 | Atmospheric Above Ground Welded Steel Storage Tanks |
| IPS-G-ME-220 | Shell & Tube Heat Exchangers |
| IPS-E-PR-460 | Process Design of Flare & Blow down Systems |
| IPS-E-PR-730 | Process Design of Plant Produced water Treatment & Recovery Systems |
| IPS-E-SF-140 | Foam Generating and Proportioning Systems |
| IPS-E-SF-220 | Fire Water Distribution and Storage Facilities |
| IPS-E-SF-220 | Fire Fighting Sprinkler Systems |
| IPS-E-GN-100 | Units |
| IPS-C-PI-100 | Plant Piping Systems |
| IPS-E-ME-100 | Atmospheric Above Ground Welded Steel Storage Tanks |
| IPS-M-PM-200 | Reciprocating Compressors for Process Services |
| IPS-M-PM-220 | Positive Displacement Compressors, Rotary Other International Standards |
| IPS-G-ME-220 | Shell & Tube Heat Exchangers |
| IPS-E-RP 521 | Guide for Pressure-Relieving and Depressuring Systems |

Except where otherwise stated, for the design, construction, assembly and test, reference shall be made to the following international codes and standards.

**Table 2: International Codes and Standards**

| Spec No. | Description |
|---|---|
| API 610 | Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries |
| API RP 521 | Guide for Pressure-Relieving and Depressurizing Systems |
| API RP 520 Pt.1 | Sizing, Selection, And Installation of Pressure-Relieving Devices In Refineries-sizing and selection |
| API RP 520 Pt.2 | Sizing, Selection, And Installation of Pressure-Relieving Devices In Refineries-Installation |
| ANSI B16.5 | Steel Pipe Flanges and Fittings |
| API STD 661 | Air Cooled Exchangers For General Refinery Service |
| API STD 674 | Positive Displacement Pumps-Reciprocating |
| TEMA | Standards Of The Tubular Exchanger Manufacturers Association |
| ASME/ANSI B31.3 & B31.4 & B36.10 | Process Piping |

| Spec No. | Description |
|---|---|
| NFPA & IPS & API | Safety and Fire Protection |
| ASME SEC.VIII Div.1, 2 | Pressure Vessels |
| API 650,AWWA M 42 | Water Storage Tanks |

20B**Note:** Iranian petroleum standard (IPS) shall be considered as the basis for designing all process facilities. Any deviation from IPS shall be approved by N.I.O.C.

## 2.1 20BApplicable Documents

| Doc. No. | Description |
|---|---|
| 88603-BKH-BDP-00-PR-BD-01 | Process Basis of Design |
| 88603-BKH-BDP-00-PR-RP-03 | Process Plant Identification and Numbering System |
| 88603-BKH-BDP-00-PR-RP-01 | Heat & Material Balance /Process Flow Diagram |
| 88603-BKH-BDP-00-PR-PI-01~10 | Piping & Instrument Diagram (P&IDs) |

## 2.2 Conflicting requirements

If any difference and/or conflict between the documents listed in this specification should occur, the most stringent requirement prevails.

Any ambiguity or conflict shall be referred to the purchaser and approved solution shall be applied.

## 2.3 Purpose of documents

This document defines all the design Criteria data for the surface facilities for the Band-E-Karkheh (BKH) field development phase-1. All data and specification will be finalized during detail phase engineering phase by client

The purpose of this document is to:

- Provide standards for pipe line and equipment sizing.
- Establish and correlate a source of basic information of typically multidiscipline interests for easy access and common reference.
- Agree and record minimum basic sizing criteria

## 2.4 EQUIPMENT INFORMATION ON PFD and P & ID

Minimum information requirement for equipment in PFD and P & ID shall be mentioned in related documents based on IPS-E-PR-230. Information & specification of pressure vessel, tank other equipment will be written on top of PFD & P & ID.

Information & specification of machinery equipment like pump & compressor will be written on bottom of PFD & P & ID.

# 3. DESIGN GUIDES

## 3.1 Engineering Units

SI or METRIC Units may be used for calculation; however, all final results shall be presented in SI units.
All equipment specification, sizes, etc. which are issued for client's approval shall be in SI units.
Process flow Diagrams and materials balances may be presented in SI Units.
All piping sizes will be in English units.

| | |
|---|---|
| Temperature | °C (°K) |
| Pressure | Barg, kpa (psig) |

| | |
|---|---|
| Weight (mass) | Kg (Ib) |
| Volume (liquids) | $m^3$ ($ft^3$) |
| Volume(gases) | $Nm^3$ or $Sm^3$ ($ft^3$) |
| Density | kg/$m^3$ |
| Flow (liquids) | kg/h (Ib/hr) |
| Water | $m^3$/h ($ft^3$/h) |
| Hydrocarbon Condensate or Liquid | STBD |
| Chemical | LPM |
| Flow (gases) | kg/h (Ib/hr) |
| Natural gas | MMSCMD (MMSCFD) |
| Air/Nitrogen | $m^3$/h, $Nm^3$/h or $Sm^3$/hr ($ft^3$/h) |
| Power | kW |
| Heat transfer coefficient | W/m2.°C |
| Heat capacity (Specific Heat) | kJ/kg.°C |
| Thermal Conductivity | W/m.°C |
| Viscosity | CP |
| Length, Diameter | m or mm(In) |
| Pipe Sizes , | In |
| Nozzle Sizes | In |
| Velocity | m/s |
| Heat Duty | kW |
| Enthalpy | kJ/kg |
| Flange Rating | lb |
| Voltage | V |
| Current | A |
| Impedance | Ohm |
| Capacitance | Farad |
| Other electrical units | See IEC |

### 3.1.1 Design Pressure

#### 3.1.1.1 General

The design pressure is the value used for the mechanical sizing of equipment.

The design pressure of a piece of equipment (excluding storage tanks, atmospheric tanks and pipelines) shall be taken as the following (REF.IPS-E-PR-850):

| Maximum Normal operating Pressure (bar g) "MOP" | Minimum Design Pressure (bar g) |
|---|---|
| Under vacuum | Full vacuum, Max 3.5 barg<br>External Pressure 0.5 barg using ASME Code |
| < 1.5 | 2 or 3.5 (*) minimum |
| 1.5 – 20 | Maximum Normal operating Pressure + 2.0 ba |
| 20 – 80 | 110% Maximum Normal operating Pressur |
| 80 – 140 | Maximum Normal operating Pressure + |
| Above 140 | 1.05 Maximum Normal operating Pressure |

- 2.0 barg for PSV discharging to atmosphere, 3.5 barg for PSV discharging to flare networks.

- Unless otherwise noted, the design pressure specified by process applies to the vapor phase at the top of the vessel.
- Minimum design pressure not applicable for thin wall equipment such as silos and storage tanks. In that case the governing parameter is full of liquid.
- The design pressure shall also account for upset or transient conditions such as start-up, pressure surge, water hammer, settle-out pressure at compressor suction, etc.
- Vapor pressure at design temperature should be considered as design pressure except when safety relief valves are provided.
- Equipment that could face vacuum under abnormal conditions such as:
    1. Vacuum conditions during start-up, shut down and/or regeneration purges.
    2. Normally operated full of liquid but can be blocked in and cooled down.
    3. Containing condensable vapor but can be blocked in and cooled down.
    4. Could undergo vacuum condition through the loss of heat input.
    5. Will be treated case by case. They will be designed for full vacuum unless fully reliable protective devices are provided (vacuum breaker, pressurization gas, low pressure switch…). Note that these devices should only be considered as an alternative if it would not be practical to design the equipment for full vacuum conditions i.e. low pressure storage tanks etc.
    6. For equipment in equilibrium with flare, the design pressure of the equipment is the flare system design pressure.
    7. Hydraulic pressure due to the relative elevation between equipment and also the PSV's location shall be considered.
    8. Pressure vessels should normally have a design pressure of not less than 3.5 barg, especially when fitted with relief valves relieving to flare systems. Lower design pressure can result in increased sizing of the flare system to limit acceptable back pressures. However, consideration may be given to increasing the design pressure if this can significantly reduce, or eliminate, relief loads.
    9. In exceptional circumstances the margins between maximum operating pressure and design pressure for any system protected by relief valves can sometimes be reduced by use of pilot operated relief valves.
    10. Conversely, the margins between the maximum operating pressure and the design pressure may be increased, e.g. so that the equipment can tolerate pressure caused by tube rupture or other potential sources of pressure.
    11. The design pressure of storage tanks is not usually specified by any general arbitrary rules, i.e. each is individually examined. The vapor pressure, tank venting, purging, and relieving systems described in API 2000 must all be considered before determining the maximum operating pressure of the tank. Tank design pressures may be selected from the recommendations in the appropriate design codes, e.g. those given in API 620 and 650, or BS 2654, and IPS-E-PR-360.
    12. When the design pressure for an item which is remote from the source of pressure is being determined, it may be necessary to consider the influence of the pressure drop through the system, on the design pressures of all items in the system.
    13. Full vacuum should be considered for process vessel mechanical design.

#### 3.1.1.2 PSV Setting

- The PSV set pressure should comply with the applicable codes of practice. In general for single relief valves this will be the design pressure of the system. Normally the maximum operating pressure will be 90% of the set pressure. This margin be operating pressure and set pressure may be reduced by the use of pilot operated relief valves.
- It is reminded that the following tolerances are generally admitted for conventional instrumentation.
- Set Pressure tolerance: +/- 3%.
- PSV recommended leak test: 10% below set point.
- In case of absolute necessity (for example in case of high pressure), the use of pilot operated PSV could help to reduce the design pressure.
- If two or more PSV are in service, the set pressure will be staggered to avoid chattering. The difference between set points shall be less than 5% of the design pressure see API 520 / IPS-E-PR-450 for specific details.
- Refer to ASME Section VIII Appendix M for guidance on set pressures above 69 bar

#### 3.1.1.3 Pipelines

For pipelines, the design pressure is function of the Maximum Allowable Operating Pressure (MAOP) and the design factor, which depends on the class location.
Process determines only the MAOP.
MAOP is normally the design pressure of the last equipment upstream the pipeline plus the hydrostatic pressure due to the pipeline profile.
Particular attention shall be paid to the transient conditions such as equilibrium pressure plus hydrostatic pressure, water hammer, etc.
Design of pipeline thickness & design pressure is in accordance to relative ANSI standard formulation.

#### 3.1.1.4 Compressors

At reciprocating compressor discharge:

- MOP+ 2 bar for MOP < 20 bar g,
- MOP + 10% for MOP > 20 bar g.
- PSV’s are required.

MOP= (Maximum Operating Pressure)

At the discharge of centrifugal compressor:

- MOP + 1 bar for MOP < 10 bar g.
- MOP + 10% for MOP > 10 bar g.

MOP= (Maximum Operating Pressure)

Generally surge pressure is above design pressure and PSV’s are required.
Consideration to be given to compressor arrangement to determine the settling pressure of the isolated system. The settling pressure is the equilibrium pressure reached between the suction and discharge isolating valves of the compressor system when the compressor is stopped or shut downed. Generally the design pressure of the equipment and piping at compressor suction should be above this settling pressure in order to avoid the use of unnecessary PSV’s.

3.1.1.5 Pumps

3.1.1.5.1 Centrifugal pumps

- 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.

- When the discharge pressure of the pumps at no flow is not available, this pressure can be estimated:

$$P_d = P_S \max. + \frac{1.25.head.d_{\max}}{10.2}$$

| | | |
|---|---|---|
| Pd | = | Design pressure at pump discharge (bar g.) (shut off pressure) |
| PS max. | = | design pressure of suction drum + static head at d max and at HLA |
| Head | = | head of the pump at design point (m) |
| d max | = | maximum specific gravity of liquid pumped under normal operating conditions |

- **Note:**

1-When pump curves are known, this design pressure has to be checked with actual head of the pump at no flow condition with the maximum suction pressure and the maximum specific gravity.
2-Equipment elevation (from tangent line to grade shown on P&lD and data sheet) shall be considered as estimated and shall be minimized when NPSH available I required are known.

3.1.1.6 Heat Exchangers

If a control or block valve is installed downstream the heat exchanger, the design pressure shall be the same of the upstream equipment or the actual shut-off pressure of the upstream pump.
If a control or block valve is installed upstream the heat exchanger, the design pressure shall be calculated as the design pressure of the downstream equipment at the inlet point plus 1.20 times the pressure drop of the circuit between the heat exchanger inlet and the inlet point of the downstream equipment plus static head (if any).
According to API 521 (3.18.2) a safety valve maybe required if design pressure of low pressure side<2/3 of design pressure of high pressure side.
Exchanger Design Pressures and Temperatures should be selected based on IPS standard (IPS-E-PR-771).

3.1.1.7 Tanks

Tanks shall be design according API 650 & all requirements shall be followed.
Atmospheric tanks shall be designed full of water or full of product if product specific gravity >1 as a minimum. Depending on the type of tank, higher design pressures could be specified. To be treated case by case depending on tank type.

### 3.1.2 Design Temperature

Equipment design temperature shall be determined to the following Table:

**Equipment design temperature**

| OPERATING TEMP (°C) | DESIGN TEMP(°C) |
|---|---|
| -29 ~ 60 | - Min. Ope.Temp / Sun Temp |
| 60 ~ 343 | OT + 25°C or sun temp whichever is greater |
| Above 343 | To be specified according to the selected material and process requirement |

- Minimum upper design temperature should be 85°C due to solar radiation. This should be examined case by case for equipment on which differential expansion can occur (such as double-wall tank, fixed tube sheet, plate heat exchanger) and for insulated high pressure vessels (not to increase wall thickness). For those equipment not influenced by solar radiation the maximum design temperature for all equipment shall be at least 55°C. This is the maximum estimated temperature that can be achieved in insulated equipment after prolonged shutdown.

#### 3.1.2.1 Emergency Depressurizing

- The minimum design temperature must take into account for material selection in any depressurization and depressurization of the equipment I piping that may occur either during emergency or normal shutdown or gas blow-down cases.

- Piping material
  Piping material will be selected based on the minimum operating temperature which occurred during depressurization.

- Vessel material
  Vessel material will be selected based on the minimum/maximum temperature due to the blow down conditions associated with the design pressure.

#### 3.1.2.2 Exceptional Cases

Consideration for upset and transient conditions such as start-up, shutdown , 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.
A specific design temperature will be given with the specified vacuum design pressure.

### 3.2 Line Sizing Criteria

### 3.2.1 Line Size

The nominal pipe size (NPS) shall be designated DN (Diameter Nominal), although in calculations the diameter is normally expressed in millimeters (mm). Following table shows DN and NPS equivalents.

**DN and NPS Equivalents**

| DN (mm) | NPS (inches) | DN (mm) | NPS (inches) |
|---|---|---|---|
| 15 | 1/2 | 350 | 14 |
| 20 | 3/4 | 400 | 16 |
| 25 | 1 | 450 | 18 |
| 40 | 1 1/2 | 500 | 20 |
| 50 | 2 | 600 | 24 |
| 80 | 3 | 650 | 26 |
| 100 | 4 | 700 | 28 |
| 150 | 6 | 750 | 30 |
| 200 | 8 | 800 | 32 |
| 250 | 10 | 900 | 36 |
| 300 | 12 | 1000 | 40 |

The following general guidelines shall be used to size of in plant or unit lines.

### 3.2.2 Limitations

- For single phase lines pressure drop and velocity limitation in different fluid media (gas or liquid) should be met according to Appendix 1.
- For two phase lines erosional and minimum velocity criteria should be met.
- Appendix I present pressure drop and velocity to be used for selecting pipe sizes.

### 3.2.3 Corrosion/Erosion criteria

3.2.3.1 Corrosion

- For corrosion resistant material (Stainless Steel (SS), specials alloys, etc.), there is no limitation of flowing velocity up to 100 m/s
- For non corrosion resistant material such as carbon steel (CS), low temperature carbon steel (LTCS), etc., in corrosive fluid service, a corrosion allowance for the design service life and corrosion inhibitor injection is required. The flowing velocity is limited film integrity.

3.2.3.2 Erosion

- For Duplex, SS or alloy material, the flowing velocity shall be limited to:
  - 100 m/s for single phase vapor lines and multiphase line in stratified flow regimes (65 m for 13% Cr material).
  - 20 m/s in single phase liquid lines and multiphase lines in annular, bubble o hydrodynamic slug flow regime.
  - 70 m/s in multiphase lines in mist flow regimes.

- For carbon steel material:
  - In case of continuous injection of corrosion inhibitor, the inhibitor film ensure a lubricating effect which allows for higher fluid velocity limit will be calculated taking into account the inhibitor film wall shear stress.
  - In case of uninhibited fluid, the API-RP-14-E recommendation should apply: the flowing velocity must be maintained below the erosional limit:

$$Ve = \frac{C}{\sqrt{\rho m}}$$

Whit : Ve =erosional velocity in ft/s (m/s in SI units)

$\rho_m$= gas/liquid mixture density at flowing condition in lb/ft3 (kg/m3 in SI units)

C=empirical constant equal to 150 to 170(183 to 207.4 in SI units).C value up to 200 (244 in SI units) can be considered on peak flow rate only in case of absence of abrasive (solid) particle such as sand. When solid and/or corrosive contaminants are present C value shall not be higher than 100(122 in SI unit).

### 3.2.4 Line Sizing Considerations

Considering the economics of the project, the following factors may be used in selecting a line size:

-Available pressure drop

-Velocity limitation

Line sizing shall be based on the total available pressure drop & Velocity which will ensure a minimum line diameter. Care shall be exercised to limit the velocity in the pipes. The pressure drop limitations are shown on Appendix1

The above values are somewhat arbitrary, which may be applied for continuous services. These limitations may be exceeded for intermittent services, while problems of noise, erosion, and water hammer shall be considered.

## 3.3 Control Valve Sizing Criteria

Control valves shall be sized based on ISA-S-75.1.

The following control valve pressure drop will be considered for hydraulics check inside process units:

- At normal rate, 50 percent of the variable system pressure drop exclusive of the control valve; or in other words, one-third of the total variable system drop including control valve.
- For control valves at the discharge of reflux, charge and recycle pumps valve pressure drops at normal and maximum design rate are calculated as follows:

  At maximum design rate (i.e. the rated flow on the pumps data sheets is up to 125% of the normal flow rate), 15% of the total variable system pressure drop including pressure drop of the control valve.

  At maximum design rate (i.e. the rated flow on the pump data sheet is higher than 125% of the normal flow rate), 10% of the total variable system pressure drop including pressure drop of the control valve.

  Minimum 0.7 bar pressure drop should be considered for control valve.

  Variable system pressure drop is the pressure drop across the system which varies with the flow rate. It is the sum of pressure drop associated with the heat exchangers, vessels, heaters, piping & etc., which are located in the system.

  If the viscosity of the liquid at operating temperature is above 10 C.S. the ( viscosity on the CV should be applied.

  Fouled condition pressure drop such as filter should be added into the variable system pressure drop.

## 3.4 Equipment Design Criteria

### 3.4.1 Pumps

The minimum margin between the normal and rated flow for a pump will be as below: (IPS-E-PR-491)

| | | |
|---|---|---|
| reflux pump | = | +20% of normal flow |
| chemical injection | = | +20% of normal flow |
| other process pump | = | +10% of normal flow |

export pump from storage (continuous operation) = +15%~20% of normal flow

To be noted that:

1) When a non-automatically controlled minimum flow protection has been installed, the permanent recirculation flow (if required) must be added to the net process flow.

2) Normal and rated flows will be identical in such instance as:
   - Intermittent service pumps: sump pump
   - When the pump has been overrated to allow for a centrifugal type and if overrating is >10%
   - Recirculation flow such as for product loading lines or through amine filtration system.

3) Automatic start
   - Automatic start is determined considering the following rules.
   - Personnel safety: for example flare KO drum pump will be started in order to avoid liquid in flare tips.
   - Equipment safety: for example BFW pump will be started in order to protect the steam drum and the steam coil.
   - Severe process upset: pump generating by its shutdown one process unit trip or generating an off spec product shall be spared automatically.

3.4.1.1 Physical Properties

Physical properties of the fluid being pumped are based on the heat and material balance, handbooks, information supplied by the customer, or other standard and reliable sources of data.

3.4.1.2 Suction Calculation

This calculation yields the system pressure available at the pump centerline of horizontal pumps or at the centerline of the suction inlet nozzle for vertical shaft pumps. It involves the summation of the feed vessels normal operating pressure and the static head loss the pressure drop in the suction piping resulting from friction, inlet-exit, and other losses.
The static head for vertical vessels is calculated from the bottom tangent line while for horizontal vessels, the bottom invert line is used. Usually, no credit is taken for the head contributed by liquid operating levels in a vessel. This should be reviewed on a case by case basis.

a) Suction line calculation (Le)

Pressure drop of suction line will be calculated by Simulator package based on user inputs of line length and fittings or below:

**EQUIVALENT LENGTHS OF VALVES AND FITTINGS**

Representative Equivalent Length in Pipe Diameters (L/D) Of Various Valves and Fittings:

| DESCRIPTION OF PRODUCT | | EQUIVALENT LENGTH IN PIPE DIAMETERS (L/D) | |
|---|---|---|---|
| Globe valves | Conventional | o With no obstruction in flat, bevel, or plug type seat | Fully open : 340 |
| | | o With wing or pin guided disc | Fully open : 450 |
| Angle valves | Conventional | o With no obstruction in flat, bevel or plug type seat | Fully open : 145 |
| | | o With wing or pin guided disc | Fully open : 200 |

| | | | |
|---|---|---|---|
| Gate valves | Conventional wedge disc, double disc<br><br>or plug disc | | Fully open : 13<br>Three-Quarters open : 35<br>One-Half open : 160<br>One-Quarter open:900 |
| Check valves* | onventional swing<br>Clear way swing<br>Globe lift or stop<br>Angle lift or stop<br>in-Line ball | | Fully open :135<br>Fully open :50<br>Fully open same as globe<br>Fully open same as angle<br>Vertical & horizontal.... Fully open: 15 |
| Butterfly valves (DN 150 and larger) | | | Fully open :20 |
| Fittings | | 90 Degree Standard Elbow | 30 |
| | | 45 Degree Standard Elbow | 16 |
| | | 90 Degree Long Radius Elbow | 20 |
| | | 90 Degree Street Elbow | 50 |
| | | 45 Degree Street Elbow | 26 |
| | | Square Corner Elbow | 57 |
| | | Standard Tee | With Flow Through Run : 20<br>With Flow Through Branch : 60 |
| Close pattern / Return bend | | | 50 |
| Enlargement** | | Sudden d/D = ¼ | 37 |
| | | d/D = ½ | 24 |
| | | d/D = ¾ | 8 |
| | | reducer d/D = ½ | 30 |
| | | d/D = ¾ | 8 |
| Contraction** | | Sudden d/D = ¼ | 74 |
| | | d/D = ½ | 30 |
| | | d/D = ¾ | 11 |
| | | reducer d/D = ½ | 16 |
| | | d/D = ¾ | 3 |

Note:
* Minimum calculated pressure drop (kPa) across valve to provide sufficient flow to lift disc fully.
** Equivalent lengths are in terms of small diameter.
***Values applicable up to DN 600.
**** Exact equivalent length is equal to the length between flange faces or welding ends.

**Net Positive Suction Head Available (NPSHA)**

NPSHA is calculated by deducting the vapor pressure of the fluid at max.operating Temp.pumping conditions from the suction pressure and converting it to pressure head in terms of liquid column. Vapor Pressure Shall Be Specified @T, P At Data Sheet.
The static head used in calculating the NPSH shall be taken from either the tangent line in the suction vessel to one of the following:
The design of suction lines from storage tanks shall be based on the NPSH taken from the lowest specified level in the tank at which rated pump capacity is required.
Suction line sizing for reciprocating pumps shall take into account acceleration head.

3.4.1.3 Discharge Calculations

For pump discharge lines when fittings and valve count are not available, a reasonable estimate of the total equivalent length shall be made, by applying a multiplying factor to the approximate run of the actual pipe length.

**Fitting Factor**

| Approximate line length (m)-ft | 3" pipe or less | 4" pipe | 6" pipe | 8" pipe or over |
|---|---|---|---|---|
| 30.5 (100) | 1.9 | 2.2 | 2.7 | 3.4 |
| 61(200) | 1.6 | 1.8 | 2.1 | 2.4 |
| 152(500) | 1.2 | 1.3 | 1.4 | 1.6 |

3.4.1.4 Shutoff Pressure

The maximum shutoff pressure of a typical centrifugal pump is approximately equal to the sum of the maximum suction pressure and 120% of the net differential pressure generated by the pun based on the maximum anticipated fluid density. Other pumps with steep HQ curves such as turbine, multistage and mixed flow pumps, however, will have higher shutoff pressures. The process engineer specifying these types of pumps shall consult with the Rotating Equipment Group to determine this value since it may influence the design pressure of downstream equipment.
Maximum pressure at suction of pumps is calculated as follows:
Taking suction from tankage open to the atmosphere:
MSP (max. suction pressure) = static head measured from high-high liquid level in the tank and zero frictional losses across piping.
Taking suction from a pressure vessel:
MSP = setting of relief valve at top and static head measured from highest liquid level (zero frictional line loss)
For a system unprotected by a relief valve that has a pump upstream:
MSP = shutoff pressure of an upstream pump.
The maximum discharge pressure sets the design pressure of a pump casing. This is the sum of the maximum suction pressure and maximum differential pressure, which usually occurs at zero flow. In cases where the feed vessel is protected by a safety relief valve, the maximum suction

pressure will be equal to the sum of the safety valve set pressure and the maximum static head.

### 3.4.2 Miscellaneous Equipment Pressure Drops

The following typical pressure drops may be used in line size calculation when the actual pressure drop data are not available:

| MAX. EQUIPMENT PRESSURE DROPS | |
|---|---|
| Equipment | ΔP (Bar) |
| Heat Exchangers (S&T, Air Cooler) | 0.7/0.7 |
| Drum ,separator ,pressure vessel with internal | 0.5~1 (at dirty conditior |
| Flow Orifice | (0.15 for gas/0.25 for liquid) |
| Pump Suction Strainer | 0.07 |
| Rotary & Turbine Flow Meters | 0.4 |

### 3.4.3 Compressors

10% margin should be taken on capacity.
The variations of gas compositions, molecular weight, Cp/Cv, etc., and the operating conditions (mainly suction and discharge temperature, pressure and volume flow rate) shall be taken into account to determine the sizing case.

3.4.3.1 Compressor Process Specifications
2.1.1.1.1 Operating Case

If more than one case exists, all these alternative cases shall be included in the specification so that the compressor vendor is able to evaluate the most stringent case for design.

3.4.3.1.1 Capacity

The volume flow rate, mass flow rate, composition submitted to the compressor manufacturer from the data sheet provided.

3.4.3.1.2 Suction Temperature

Suction temperature is to be accurately specified since it is directly related to the volume of gas at suction conditions, the discharge temperature, and the horsepower requirements. It is important for the vendor to know the minimum and maximum temperatures for proper compressor design and selection of correct driver rating.

3.4.3.1.3 Suction Pressure

Suction pressure is the pressure at the suction flange of the compressor and not before filters, pulsation dampers, etc. The suction pressure must be accurately specified.

3.4.3.1.4 Molecular Weight

Molecular weight is an important consideration in the design of a centrifugal compressor. When this or any type of compressor is to be used in multiple services, the vendor is to be supplied with data on the molecular weight of all the gases.

3.4.3.1.5 Specific Heat Ratio

The specific heat ratio is also an important consideration in the design of centrifugal and reciprocating compressor as it affects both power and efficiency of the machines. It should be clearly documented what the basis for the stated Cp/Cv ratio e.g. ideal or polytrophic etc.

3.4.3.1.6 Compressor Power Estimation

Compressor power estimates shall include gear losses. When a compressor is to be used in vacuum or refrigeration service, peak driver load may be required during start-up and a footnote to this effect is to be added to the specification form. The final determination of compressor power requirements and discharge gas temperatures is part of the vendor’s responsibility.

3.4.3.1.7 Gas Composition

This is to be supplied by the process engineer and is to be expressed on a wet basis if the gas contains moisture.

3.4.3.1.8 Discharge Temperature (Maximum Allowable)

This is to be supplied by the process engineer when a known process limitation exists. Discharge temperatures are limited by gas reactions, e.g. polymerization or in the case of air compressors with the lube oil, safe lubrication temperatures. Some compressors are limited by mechanical considerations and these will be defined by the compressor vendor.

3.4.3.1.9 Corrosive Compounds

Corrosive compounds in the gas (such as sulphur oxides, hydrogen sulphides. acidic compounds, chlorides, etc.), are to be specified by the process engineer as these may determine the selection of materials by compressor manufacturer.

3.4.3.1.10 Start-Up Considerations

Start-up methods are to be considered by the process engineer since items such as anti-surge control systems, bypass lines, valve lifters and pockets on reciprocators, etc., are involved. In addition, compressors generally require a running-in period during which time an alternative feed gas may be used. If air is to be used for running-in, then suitable vents, etc. may be an additional requirement.

3.4.3.1.11 Compressor Selection and Comparison

Centrifugal compressors are the preferred type for the majority of applications.
Reciprocating compressors are to be considered for conditions of low flow, high differential pressures, intermittent loads, varying gas densities, and varying discharge pressures, combined with moderate temperatures.

Screw compressors may be employed for applications involving relatively low flows and differential pressures. Their selection should be referred to the rotating equipment specialists.

3.4.3.1.12 Safety Considerations

The following potential hazards are to be considered for compressor installations.

- At high pressures, many reactions proceed at higher rates, e.g. the reaction between a hydrocarbon lube oil and oxygen or air. The discharge temperature of air from reciprocating compressors is generally limited to about 150°-190°C. Compressor circuits frequently have automatic shutdown instrumentation, which operates on high gas discharge temperature.
- Excessive discharge pressures from positive displacement machines can be attained if a discharge valve is inadvertently closed. Therefore, safety valves are mandatory for this class of compressors.
- Adequate ventilation of the compressor house should be provided when compressing toxic or flammable gases.
- Adequate inlet K.O drum should be provided where necessary to prevent liquid slugs from damaging compressor. Providing demister in the K.O drum can reduce entrainment.
- Rotating compressors and their drivers have speed limitations Trip outs are indicated and these are usually supplied by the vendor and specified by the Mechanical Equipment Section.

### 3.4.4 Heater & Fired Heater

The design margins to be applied are as follows:

Heater ,Fired heaters and furnaces : 10% on maximum duty and flow rate.

### 3.4.5 Vessels & Separators

3.4.5.1 Over Design Factor

| | | |
|---|---|---|
| 1st stage separation equipment (plant inlet) | : | Min. 10% on inlet flow rate. |
| Other drums | : | Min. 10% unless specific requirements. |

3.4.5.2 Vapor Area Sizing

If internals are installed, the common vapor internal shall be a wire mesh but for some services a vane pack can be used after discussion with the Client.

A high efficiency inlet distributor can be considered to improve gas / liquid separation provided that EPC contractor verify pressure drop through distributor and (dimensions between inlet distributor/mesh and inlet distributor/HLA

The volume of a vapor liquid separator above the liquid level as vapor spacing shall be considered.

The height provided between bottom of the wire-mesh pad and liquid level of a vapor-liquid separator called Disengaging Height

Demister pad thickness will be considered 100-150 mm according to vendor data and vapor area is 0.15 $D_v$

Type of internal in compliance to process requirement shall be checked during detail engineering and based on client’s request.

The following excludes the flare/vent drums, desalters and electrostatic dehydrators.

- If internals are installed, the common vapor internal shall be a wire mesh but for some Services vane pack can be used after discussion with Company
- The use of others vapor internals such as cyclones, etc... Requires a Company approval.
- The basis of sizing is the critical velocity $V_c$

$$V_c = k ((\rho l - \rho g) / \rho g)^{0.5}$$

With $\rho_l$ = liquid density in kg/m3

$\rho_g$ = vapor density in kg/m3

The maximum gas velocity is K*Vc.

K is a coefficient depending of the service, and the use or the absence of wire mesh.

Typical data of K-value will be defined in GPSA handbook and process standard.

3.4.5.3 Hold up Residence Times of Liquids

If the vessel is sized to receive a slug, that slug volume shall be taken between NLL and HLA.

The residence time corresponds to half of the hold-up time, the Normal Liquid Level (NLL) being set at 50% of the HLL-LLL range. Exceptions will be specified on data sheet.

The minimum liquid residence time between LLA and HLA are as follows:

Automatic control

5 minutes for product to storage

5 minutes for feed to a furnace

4 minutes for other applicatior

Manual control

20 minutes. Two phase vessels

The following criteria should be followed to specify levels which could be controlled by instrumentation.

| ISA SYMBOL | DATA SHEET SYMBOL | VERTICAL DRUM | HORIZONTAL DRUM |
|---|---|---|---|
| LAHH/LSHH | HHLA/HHLS (HLL) | | |
| | | At least 1 to 2 mit*. with 150 mm min.<br>to verify: min. 10% of control range<br>IF only HLL : HLA-HLL : 10% of control range | At least 1 to 2 mit. with 150 mm min.<br>to verify: min. 10% of control range<br>IF only HLL : HLA-HLL : 10% of control range |
| LAH | HLA | | |
| | | liquid hold up time to be considered with 300 mm min. | liquid hold up time to be considered with 300 mm min. |
| LAL | LLA | | |
| | | At least 1 to 2 mit. With 200 mm min.<br>to verify: min. 10% of control range<br>IF only LLL : LLA-LLL : 10% of control range | At least 1 to 2 mit. With 100 mm min.<br>to verify: min. 10% of control range<br>IF only LLL : LLA-LLL : 10% of control range |
| LALL/LSLL | LALL/LSLL (LLL) | | |
| | | 300 mm min., but to be compatible with time required to close a SDV | 150 mm min., but to be compatible with time required to close a SDV |

* Minute=mit & Minimum=Min

**Three Phase separator**

| ISA SYMBOL | DATA SHEET SYMBOL | VERTICAL DRUM | HORIZONTAL DRUM |
|---|---|---|---|
| LAHH/LSHH | HHLA/HHLS (HLL) | | |
| | | At least 1 to 2 mit*. with 150 mm min.<br>to verify: min. 10% of control range<br>IF only HLL : HLA-HLL : 10% of control range | At least 1 to 2 mit. with 150 mm min.<br>to verify: min. 10% of control range<br>IF only HLL : HLA-HLL : 10% of control range |

| | | | |
|---|---|---|---|
| LAH | HLA | | |
| | | Lightest density liquid hold up time to be considered with 200 mm min. | Lightest density liquid hold up time to be considered with 200 mm min. |
| LAL | LLA | | |
| | | At least 1 to 2 mit. With 200 mm min. to verify: min. 10% of control range IF only LLL : LLA-LLL : 10% of control range | At least 1 to 2 mit. With 100 mm min. to verify: min. 10% of control range IF only LLL : LLA-LLL : 10% of control range |
| LALL/LSLL | LLLA/LLLS (LLL) | 450 mm min. | 450 mm min. |
| LDAHH | HHIA (HIL) | | |
| | | At least 1 to 2 mit. With 150 mm min. To verify: mit. 10% of control range IF only HIL : HIA-HIL : 10% of control range | At least 1 to 2 mit. With 100 mm min. To verify: mit. 10% of control range IF only HIL : HIA-HIL : 10% of control range |
| LDAH | HIA | | |
| | | highest density liquid hold up time to be considered with 200 mm min. | highest density liquid hold up time to be considered with 200 mm min. |
| LDAL | LIA | | |
| | | At least 1 to 2 mit. With 200 mm min. to verify: min. 10% of control range IF only LIL : LIA-LIL : 10% of control range | At least 1 to 2 mit. With 100 mm min. to verify: min. 10% of control range IF only LIL : LIA-LIL : 10% of control range |
| LDALL | LLIA (LLIS) | | |
| | | 300 mm mit., but to be compatible with time required to close a SDV | 150 mm mit., but to be compatible with time required to close a SDV |

* Minute=mit & Minimum=Min

To be noted that:

Exception is made for vertical vessels with negligible liquid on clean service with manual or on/off liquid outlet valve; in that case volume of the hemi-spherical head can be used:
LLL (or LLLA/LLLS) location has to be still compatible with SDV or control valve closing time.

1) The distance between HLL and LLL will be in the typical range of 1 to 3.5 meters.
2) When applicable, the holdup time below the very low liquid level (LLLA or ILLLA) has to be compatible with the time required to close a SDV.
3) For three-phase separators, the retention time for the two liquid phases shall be considered.
4) The effective retention volume in a vessel is that portion of the vessel in which the two liquid phases remain in contact with one another. As far as the two liquid phase separation is concerned, once either substance leaves the primary liquid section, although it may remain in the vessel in a separate compartment, it cannot be considered as a part of the retention volume.
5) The highest density liquid retention volume is taken between the bottom and the normal interface level (INLL).
   The lightest density liquid retention volume is taken between the INLL and the normal liquid level (NLL) & for LSHH to Top of vessel Minimum 3 mit. Based on the total inflow to the vessel or 4 mit . Based on liquid stream flow from the vessel which ever greater.
6) Stand pipe shall be installed on clean service when at least 3 level instruments have to installed (independently from level instrument required for safety actions) e.g. one level transmitter with two level gauge.

7) Gauge glasses and level controller will cover the full range of level transmitters and alarms witches.
8) Connections for level instruments generating a trip function shall be independent from control function.
9) The volume of a vapor liquid separator above the liquid level as vapor spacing shall be considered. The height provided between bottom of the wire-mesh pad and liquid level of a vapor-liquid separator called Disengaging Height.
10) Demister pad thickness will be considered 100-150 mm according to vendor data and vapor area is 0.15 D

3.4.5.4 Diameter

- As a general rule, inside diameter will be specified on process data sheets (in mm).
- If the required diameter for a vessel is lower than 800 mm, a note will be added specifying that a piping element is acceptable.
- For vessels less than 1000 mm ID, flanged heads may be specified.
- Suggested values of L/D ratio for horizontal vessel are 2.5 to 6.
- Higher value is recommended for high-pressure application.

3.4.5.5 Man ways

Size of man ways

- Horizontal vessels

| | |
|---|---|
| 900 to 1300 mm ID | Man way, on the head, 460 mm (18") ID. |
| Larger than 1300 mm ID | Man way, on the side or on the top 610 mm (24") ID.* |

- Vertical vessels

| | |
|---|---|
| Under 900 mm ID | Top head flanged. |
| 900 to 1300 mm ID | Man way, in shell, 460 mm (18") ID. |
| Larger than 1300 mm ID | Man way, in shell, 610 mm (24") ID.* |

- Packed vessels

  Each packed bed shall have a man way at top and a man way at bottom
- Tray columns
  - Man ways shall be provided above the top tray, bellow the bottom tray, at any feed and side cut
  - Draw off tray and at intermediate points. The maximum number of trays between man ways in the
  - Trays section shall not exceed 10 trays.

* Note:

Higher size man way shall be provided if required to accommodate internals.

Location of manholes

At the opposite side of the utility connection for horizontal vessel

Number of manholes

- Vessel:

For vessels with length or height less than 6 m a single manhole will be provided. For other vessels (length or height > 6m), two manholes have to be provided at least one manhole each 6 m for

longer or higher vessel. If vessel is equipped with internals (baffle, etc.), one manhole has to be provided on each compartment.
Except when provided with full bolted full diameter end closure all vessels 900 mm O.D. and larger shall have at least one man way for inspection maintenance requirements.

3.4.5.6 Hand hole

Hand hole size = 8". Hand hole to be installed on vessel with diameter lower than 800 mm or on vessel where severe fouling of internals is expected.

3.4.5.7 Vortex Breaker

Vortex breaker to be installed for the following services:

- pump suction
- Thermo siphon or kettle inlet.
- letdown to a low pressure capacity

Vortex breaker on fouling service has to be at 150mm from vessel wall.

3.4.5.8 Vent, Drain and Steam Out

- Location

The drain of the vessel shall be connected:
To the outlet line at low point for vertical vessel.
Directly on the capacity for horizontal vessel or for vertical vessel with outlet line entering inside vessel.
Vent connections must be located on the top of the vessels.
Vent and drain location as per IPS-E-PR-230 will be considered.

**The Size of vent and drain diameter shall be defined as follows, (IPS-E-PR-200):**

| Vessel diameter (mm) | Vent size | Drain size | Steam Out Size |
|---|---|---|---|
| D < 1200 | 1.5 " | 1.5" | 1" |
| 1200 to 2500 | 4" | 2" | 1 1/2" |
| 2500 to 3500 | 4" | 3" | 1 1/2" |
| 3500 to 6000 | 4" | 3" | 2" |
| 6000 and larger | 4" | 3" | 3" |

- Drain number:

For horizontal drums having a length greater than 6 m TL to TL, additional drain connection required. Additional drain is also required on each compartment of the vessel.
On toxic service, an open drain connection (washing out) to be provided with blind flange (not connected to outside).Size of open drain will be in the same diameter as drain connection.
If vessel is equipped with internals (baffle), one steam out connection will be provided on each compartment.

- Steam out or nitrogen purging will be applied during start-up and shut down.

3.4.5.9 Boot

Design considerations are as follows:
There shall be a minimum 5 minutes of residence time
The height/diameter shall range from 2:1 to 5:1.

Maximum boot diameter shall be 1/3 of the vessel inside diameter.
Minimum diameter shall be 300mm.

3.4.5.10 Three-Phase Vessel Weir Plates

Generally, the weir plate should be 150 mm (minimum) above the oil-water interface. It can vary in height, bottom inside shell wail to top of plate, from 300 mm to th midpoint of the vessel.

3.4.5.11 Feed and outlet nozzles sizing

Nozzle sizing shall be based on actual flow rates (excluding the appropriate design margins).
Sizes of inlet and outlet nozzles are normally the same as those of the connecting process. However, there are cases where the liquid outlet nozzle size might have to be larger than the line size to avoid vortex formation. In these cases, the transition piece connecting the oversized outlet nozzle with the smaller size process line should be thirty nozzle diameters long (30 d) but not more than 3 m.

3.4.5.11.1 Inlet Nozzle

- Knock-out Drum without Mist Extractors:

The diameter of the nozzle, Dn, shall satisfy the following criteria:
$\rho_{mix} * V^2_{mix} < 1000$ kg/(m*s$^2$) if no inlet device is used.
$\rho_{mix} * V^2_{mix} < 1500$ kg/(m*s$^2$) if a half-open pipe is used as inlet device.

Where:
$\rho_{mix}$: liquid-vapor mixture density, kg/m3
$V_{mix}$: liquid-vapor mixture velocity, m/s

- Demister Separators:

The diameter of the nozzle, dn, shall satisfy the following criteria:
$\rho_{mix} * V^2_{mix} < 6000$ kg/(m*s$^2$)
The length of the vane type inlet nozzle should be about five times the feed nozzle diameter.

3.4.5.11.2 Vapor Outlet Nozzle

$\rho_V * V^2g$, out < 3750

Where:
$\rho_V$: vapor density, kg/m3
$V_{g,out}$: vapor outlet velocity, m/s

3.4.5.11.3 Liquid Nozzle

The liquid outlet nozzle velocity, VL, should be less than 1 m/s. The minimum recommended nozzle diameter is 50 mm (2 in.).

3.4.5.11.4 Two Phase Flow:

For preliminary mixed phase fluid line size calculations, the average density method will be used while considering the following criteria:

$V_m$: 10 to 23 m/s
$\rho_m V^2$: 5000 to 10000 Pa

Where:

$\rho_m = W / ((W_L/\rho_L) + (Wv/\rho v))$ in kg/m$^3$
W = WL+ Wv = total flow rate in kg/h
$\rho_L$ = liquid density in kg/m3
$W_L$= liquid flow rate in kg/h
$\rho_v$ = vapor density in kg/m3
$W_v$ = vapor flow rate in kg/h

And the apparent fluid velocity Vm expressed as:

$Vm = W / (3600\ \rho_m\ D^2/4)$ in m/s
D = internal diameter of the line in m.

As a general, 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 the vertical lines
- For horizontal lines in slug and plug flow regimes and for vertical line in slug flow regimes reinforced anchoring shall be specified.

#### 3.4.5.12 Inlet Diverter

An inlet diverter should always be included, because it will break up the bulk of the inlet stream into smaller particles. There are various types available, all of which are used by manufacturers. These types are as follows:
The dished end type inlet diverter directs the inlet fluid back into the vessel head. It is used in cases where the inlet nozzle is in the head of the vessel.
A 90 degree elbowed pipe is used for gases and directs the fluid back against the vessel head.
Currently, the most common types are vane, angle or pipe inlet diverters in a box type arrangement.

#### 3.4.5.13 Elevation of Equipment

As a conventional rule for a vessel containing a product at its boiling temperature, a minimum elevation of 5000 mm will be specified when a recovery bottom centrifugal pump is provided. The elevation will be updated when NPSH requirements are defined with rotating equipment specialist. If there is no process requirement regarding the elevation, a note on P&ID will be indicated "minimum for piping".

### 3.4.6 Air Coolers

The heat exchanger department usually does a definitive design of an air cooler. However, a process engineer is usually required to prepare a duty specification based on some main design criteria that are covered in this section.

3.4.6.1 Allowable pressure drop

Suggested pressure drop for various services are given below. However, care should be taken to ensure that the selected pressure drop results in the most economic overall installation.
The allowable pressure drop for product cooling and non-critical services should not control the size of the exchanger, as this may result in an uneconomic design which could be avoided by considering the hydraulics of the process circuit.
Special considerations are required for wide temperature range cooling of viscous liquids, low pressure gases or consideration of vapors at very low pressures. In these services, pressure drop is a critical requirement, which greatly influences the size of the heat transfer surface.

**Allowable Pressure Drop**

| Service | Allowable Pressure Drop (bar) | |
|---|---|---|
| Liquid Cooling | | Note 1 |
| Gas Cooling:<br>Operating Pressure 1.0 to 3.5 bar | | |
| Condensing: (atmospheric pressure and above) | | Note 2 |
| Total Condensation | 0.035 min | Note 3 |
| Partial Condensation | 0.14 to 0.35 | Note 3 |

Notes:
1) Valid for Viscous Fluids.
2) For vacuum service selection of an allowable pressure drop should be from the results of an economic study. Pressure drops are usually in the range of 3-5 mmHg
3) For multi pass air coolers high pressure drops assure proper flow distribution. The higher pressure drop will also assure proper distribution at lower than design throughput.

3.4.6.2 Over Design Factor

Air coolers : Min. 10% on maximum duty and flow rate.

**3.4.7 Other Process Design Considerations and Specifications Tube side**

a) Heat exchanged
Alternative specification sheets will be prepared when the maximum heat duty does not correspond to the maximum viscosity, pour point of flow rate.
b) Fouling factors
Only the fouling resistance of the fluid on the inside of tubes is specifies. The standards of Tubular Exchanger Manufacturers Association (TEMA) give fouling resistances for various process fluids.
c) Fluid flow rates
Flow rates corresponding to the design heat duty are specified. If this is not the maximum flow rate, specify this also, as it will probably control the pressure drop through the exchanger. Additionally, where a fluid has a high pour point or high viscosity it is mandatory to specify the minimum flow rate.
d) Fluid viscosity

The viscosity of the fluid will be specified at two temperatures within the cooling range of the process fluid. If the exchanger has a range of duties, specify also the maximum viscosity case. For fluids with very high viscosity, it may be necessary to increase the allowable design pressure drop to ensure turbulent flow.

e) Tube side Velocity
   Specify any limitation on tube side velocity. To minimize fouling minimum velocities are specified where the process fluid contains solids such as catalyst or where the process fluid is water (for these services the velocity is generally not less than 0.9 m/s) In addition, maxim velocities are sometimes specified to prevent erosion.
f) On stream cleaning
   If special arrangements (e.g. extra nozzles) are required to permit on-stream cleaning, they must be specified.
g) Header vents
   In condensers used for total condensation but which may contain non-condensable, a vent should be located in the outlet header.
h) Air Side
   For site and meteorological data required for air cooler design, refer to section 1.5 of curre document.

### 3.4.8 Preliminary Sizing

The size and surface of the air cooler will depend on the correct selection of tubes, fins, number of rows, motor size, air velocity and other factors.
The process engineer will estimate the preliminary size and utility requirement of the air coolers. This program requires that $U_d$ (overall heat transfer coefficient) be defined as an Input. Typical $U_d$ values for gas applications are listed below:

**Typical Overall Heat Transfer Coefficient Bare Outside Surface**

| | |
|---|---|
| Gas Cooling | |
| Air or Flue Gas at 3.5 kg/cm2 g (DELTA P= 0.07) | 10 |
| Air or Flue Gas at 7 kg/cm2 g (DELTA P= 0.14) | 20 |
| Air or Flue Gas at 7 kg/cm2 g (DELTA P= 0.35) | 30 |
| H/C Gases at 1 to 3.5 kg/cm2 g (DELTA P= 0.07) | 30-40 |
| H/C Gases at 3.5 to 18 kg/cm2 g (DELTA P= 0.21) | 50-60 |
| H/C Gases at 18 to 105 kg/cm2 g | 70-90 |
| Ammonia reactor stream | 80-90 |

### 3.4.9 Fouling Resistances

The following tabulated values of fouling resistances allow for over sizing heat exchangers so they will meet performance requirements with recode able intervals between shut down and cleaning. These numbers are extracted from TEMA standard for Tubular Heat Exchangers.

| DESIGN FOULING RESISTANCES | |
|---|---|
| Application Industrial Fluids | R.m$^2$.°C/W |
| Steam | 0.000088 |
| Refrigerant Vapors | 0.000176 |
| Refrigerant Liquids | 0.000176 |
| Acid gases | 0.000352 |
| Glycol solutions | 0.000352 |
| Caustic solutions | 0.000352 |
| Cooling water (closed loop) | 0.000176 |
| Natural gas | 0.000176 |
| Overhead products | 0.000176 |
| Natural gasoline and LPG | 0.000176 |

(Extracted from TEMA standard for tubular heat exchangers recommended good practice)

#### 3.4.10 Stabilizers Column

Maximum normal load of the trays shall be considered for the design purpose.

- Generally valve type trays shall be used(finalized by supplier)
- Flooding factor for stripping column 75 [%] maximum
- Down comer back-up 50 [%] maximum of the tray spacing type of internals
- Structured packing may be applied, upon OWNER approval, if technically feasible.
- Column over sizing will correspond to 10 [%] of normal flow rate.
- Minimum distance from the top tray to top tangent line shall be 750 [mm] or as required to accommodate man way, internal or nozzles.
- Minimum trayed column size shall be 800 [mm] internal diameter.

#### 3.4.11 Process Package & Chemical Packages

Process package and other chemical package shall be considered in compliance to process requirement .vendor supplier shall be finalized package detail and considered process specification & target .type of chemical and dosing rate shall be finalized during detail stage by EPC contractor. Over design factor in package sizing should be considered 10 %.for more information see package utility flow diagrams & definitions

### 3.5 Relief System Design Criteria

#### 3.5.1 General

Safety relief valves shall be provided to protect all equipment subject to overpressure, and under certain other conditions specified here. Safety devices shall be provided when the overpressure exceeds the design pressure of the equipment.

Pressure relieving systems design shall conform to the requirements of IPS-E-PR-450, API RP-520 and RP-521.

In addition, IPS-G-ME-250, on “UNFIRED PRESSURE VESSELS” and ASME code section VIII should be consulted. Some of the special considerations are discussed in this section.

The pressure/vacuum relief requirement and relief load capacity for atmospheric and low-pressure storage tanks shall be evaluated according to API Standard 2000, unless otherwise specified in IPS-E-PR-450.

### 3.5.2 Provisions of Pressure Safety Relief Valves

Pressure safety relief valves shall be provided for all cases specified below.

#### 3.5.2.1 Vessels

Safety relief valves shall be provided in the following cases:
When designed according to ASME, Section VIII, Unfired Pressure Vessel Code, and the overpressure exceeds the design pressure
When designed according to ASME, Section I, Power Boiler Code, and the overpressure exceeds the maximum allowable working pressure as defined in that code.

#### 3.5.2.2 Pumps

Safety relief valves shall be provided in the following cases:
On discharge of positive displacement pumps
On discharge of centrifugal pumps to protect downstream equipment from overpressure based on pump shutoff pressure
On discharge of all pumps where under blocked discharge, the horsepower rating (kilowatts) of the electric motor drive may be exceeded.
On pump suction lines from a ‘bottled in” system, where overpressure can be imposed on suction piping by backflow through the pump or through a control valve bypassing from pump discharge to suction.

#### 3.5.2.3 Compressors

Safety relief valves shall be provided in the following cases:

- At each stage of reciprocating compressors to protect inter stage, intercooler, compressor frame or cylinder.
- On suction lines where overpressure occurs on suction lines or frame, or overloads the electric motor driver before inter stage or discharge safety valve opens.

#### 3.5.2.4 Fired Process Heaters

Safety relief valves shall be provided to prevent overpressure due to heat input resulting from blocking the lines downstream of the heater, where check valves or other valves upstream of the heater are closed by the same action blocking the upstream line(s), except for the condition covered in the next paragraph. The safety valve may be located anywhere between the upstream and downstream blocking valves.

#### 3.5.2.5 Piping and Connected Equipment

Safety relief valves shall be provided in the following cases:
To protect piping, heat exchangers and other equipment served by the piping against overpressure in the following locations:

- At the fuel inlet to gas engine drivers

- Downstream or upstream of all control valves when the piping or equipment could be subjected to overpressure, assuming that the control valve will fail in the open or closed position
- On pedestal or gland water systems to pumps and turbines where overpressure is caused by water pump shut-off pressure. One safety valve may be provided on the supply line to a group of pumps, turbine glands or pedestals in lieu of a safety valve on the line to each piece of equipment.

3.5.2.6 Pressure Safety Relief Valves Not Required

Pressure safety relief valves shall not be provided on the following systems:
Interconnected vessels (excluding those falling under the requirements of ASME, Section I, Power Boiler Code,), if they meet the following conditions:
The vessel that is the source of pressure is equipped with a safety valve sized to protect all of the interconnected equipment and the interconnected piping (including heat exchanger equipment).
At least one interconnecting piping system between the protected vessel and any other vessel must be free of the following:

- Any equipment that may fail or stop in a closed position
- Any block valves control or check valves
- Any orifices or similar restrictions to flow.

A lower pressure piping system such as a pump-out is routed to an offsite slop or emergency tank with overshot connections (connections entering the top of the tank without block valves).
Depressuring systems are routed to a flare, if all valves at the unit limit, cooling boxes, or downstream Depressuring valves are locked open.

### 3.5.3 Selection of Type

3.5.3.1 Conventional (Unbalanced) Safety Relief Valves

The conventional safety relief valve shall be used where the service is as follows:

- Clean and non-corrosive
- Corrosive, with provision of corrosion resistant materials.
- Conventional valve shall not be used in the following cases:
- Corrosive materials may damage the guide and disk, or guide and spindle, or spring and bonnet.
- The variable back pressure is greater than 10% where 10% accumulation is allowed or gre than 20% where 20% accumulation is allowed under fire conditio
- The differential pressure is less than 10% when the valve is relieving, compared to the mal differential pressure across the protected equipment. Also, where the service is corrosive, with provision for corrosion resistant materials.
- When the relieved material may contain coke in suspension or slurries containing particles which may clog the guiding surfaces.

3.5.3.2 Balanced Bellows Safety Relief Valves

Use the balanced bellows safety relief valve where the service is as follows:

- The relieving pressure is to be independent of the back pressure.
- The bellows is used to prevent corrosive products from damaging the guiding surfaces, spring or associated pieces.
- Back pressure as specified in 2.6.7.1 above exists and either liquid or vapor relief is to be handled.

- Saving in discharge piping and size of flare header may be realized through use of higher back pressure in the flare header.
- Bellows balanced valves shall not be used for services involving materials with a pour point at or above the lowest ambient temperature (e.g. materials containing wax) or where coking can be expected. Balanced valves with a piston only shall be used in such cases.

### 3.5.4 Set Pressure

3.5.4.1 General

Unless otherwise specified in this section, safety relief valves shall be set to relieve initially at the design pressure of the equipment, within the limitations of the allowable blow down and accumulation specified in this section.
Unless otherwise specified in this section, the initial relieving pressure, is specified as the value of set pressure plus the over pressure.
In general, set pressures (SP) and maximum relief pressures (MRP) of safety relief valves, expressed in relation to the design pressure of the protected equipment, and in gauge pressure, shall not exceed the values provided in Table below.

**Note:** For the pressure setting of the safety relief valve instead of the design pressure (DP), the maximum allowable working pressure (MAWP) is used.

**Set pressure and Maximum Relieving Pressure**

| | Set pressure | | Maximum relieving pressure | |
|---|---|---|---|---|
| | Non-fire conditions | Fire conditions | Non- fire conditions | Fire conditions |
| Single valve | 100% of DP | 110% of DP | 110% of DP | 121% of DP |
| Multiple valves | One valve 100% of DP the others at 105% of DP** | 110% of DP* | 110% of DP | 121% of DP |

* Relief valves for fire protection may be set only at 110% of DP if they are installed in additi adequate relief protection of process equipment against non-fire situations.

**For set pressures below 1000 kPa (145 psig), staggering set pressure becomes im because of the difference between the set pressure tolerance of 3% (according to ASME VIII UG 134) and the value of 5% of the DP becomes too small.

The above shall also apply to safety relief valves discharging liquid and flashing liquid.

### 3.5.5 Sizing

3.5.5.1 Pressure Safety Relief Valves

3.5.5.1.1 General

Safety relief valve capacity formulas used for calculation of orifice area shall be according to API RP 520, Part I, Section 4, and Procedures for Sizing

Standard effective orifice areas and corresponding letter designations shall be according to API Standard 526.

Thermal expansion valves shall be DN 25 x DN 25 (1 inch x 1 inch) with the orifice area of 38.7 x 10-6or 71.0 x 10-6 m2, as required.

All safety relief valves shall have flanged inlet and outlet connections of 300 # RF and 150 respectively, unless the service requires a higher rating or a different type of facing.

When estimating the normal fluid mass inflow to the system at blocked outlet conditions, credit shall be given that, the vessel under emergency is at relieving conditions (i.e., at PSV set pressure plus accumulation). When evaluating relieving requirements, it is assumed that any automatic control valve that is not the cause of upset will remain in the normal position. Credit may, therefore, be taken for the normal capacity of these valves, corrected for relieving conditions and limited to the flow rates that downstream equipment can safely handle.

A load summary table showing the following information shall be provided for each safety relief valve (a typical arrangement of a pressure safety relief valve load summary table is shown in IPS-E-PR-450, Appendix A):

- Item number
- P&ID number
- Protected equipment
- Size and type
- Set pressure bar(g)
- Discharge to …………
- Emergency failure. All applicable emergency causes shall be recorded. For each applicable emergency cause, the following information shall be provided:
- MW for vapor and kg/m3 at flowing conditions for liqui
- kg/h for vapor and m3/h at flowing conditions for liqui
- °C
- V or L
- Area (only for fire case).

Remarks.

### 3.5.6 Arrangement of Safety Relief Valves

3.5.6.1 General

Safety devices shall be arranged such that their proper functioning is not hampered by the nature of the vessel contents. If necessary, the use of protecting devices such as rupture discs, swan-neck seals or purge arrangements is permissible, but these shall not interfere with the proper functioning of the safety device.

If a rupture disc is used in combination with a safety relief valve, a pressure gauge preceded by a block valve shall be provided between rupture disc and safety relief valve.

Pressure drop in the connection between equipment and safety relief valve should not exceed 3% of the valve set pressure.

Safety relief valves discharging to atmosphere shall in general be located at maximum practical elevation to economize on discharge piping, considering ease of maintenance.

Safety relief valves connected to a closed relief system shall be located slightly above the relief header, if possible.

If valves must be below the header, the outlet lines leading to the header shall be steam traced from the safety relief valve to their highest point. However, Owner's approval shall be obtained for lowering the valve in such a way. Branches should be connected to the headers so that the latter cannot drain back into them, even with the header full of liquid.

3.5.6.2 Location on Vessels

Where a safety valve is provided for a vessel, the connection for the safety valve shall be provided on the vessel and not on the vapor line or discharge line from the vessel, except as follows:
When access to the safety valve or discharge piping arrangement can be improved by locating the safety valve on vessel piping, such a location is permissible, provided the maximum pressure drop permitted between the vessel and safety valve inlet does not exceed the allowable value according to the previous paragraph, and provided the safety valve can be properly supported with full consideration to the reaction forces.
Safety valve nozzles shall be vertical when placed in the top head of vessels, except as follows:
In cases where vessel diameter is small enough to prohibit vertical nozzles, the safety valve nozzle should be attached at a 45 degree angle from the top head, with a 45° elbow so that the fl face is horizontal and above the nozzle.
If the safety valve inlet nozzle cannot be installed on the top head due to constructions or limited working space, then the safety valve nozzle should be attached to the vessel shell at a 45° an with a 45° elbow, so that the flange, face will be horizontal and above the nozzle.

3.5.6.3 Location of Safety Valve Nozzles to Minimize Turbulence

Where safety valves are installed to protect piping and are located downstream of control valves, pressure reducing stations, orifice plates, flow nozzles or pipe fittings such as elbows, which may cause turbulence, the safety valve shall be a sufficient distance downstream of these devices to avoid improper operation of the safety valves due to turbulence.
The minimum number of straight-pipe diameters that must be provided between the source of turbulence and the safety valve shall be according to API RP 520, Part II.

3.5.6.4 Location of Safety Valve Nozzles to Minimize Pulsation

Where there are pressure fluctuations at the pressure source (discharge of reciprocating pumps or compressors) with peak close to the set pressure of the safety valve, it is beneficial to Locate the safety valves farther from the pressure source, in a more stable pressure region.

3.5.6.5 Inlet Piping of Safety Relief Valves

Piping from the vessel to the safety valve inlet shall be, at minimum, the same size as the safety valve inlet connection. The pressure drop, including that in any block valve or fittings shall be of 3% of the set pressure or less.
Where this requirement cannot be met, ways must be found to reduce the pressure drop by rounding the entrance connection, using block valves (when required) with full area ports, or by enlarging the inlet piping.
The inlet piping or nozzles to safety valves on vessels shall be kept as short and direct as possible, preferably a single nozzle for each valve. Where more than one safety valve is involved, avoid mounting them on a common header tee type nozzle to prevent turbulence and excessive, pressure drop.

3.5.6.6 Discharge Piping of Safety Relief Valves

3.5.6.6.1 General

In the design of outlet piping, the effect of superimposed or build-up back pressure on the particular type of valve and its service shall be considered.
In addition to any specific requirements set forth in this document, determination of discharging to atmosphere or to a closed system shall be governed by API RP 520, Part I and IPS-E-PR-460.

3.5.6.6.2 Permissible Pressure Drop in Closed Flare System

The permissible pressure drop from the outlet of a safety valve to a flare system shall be as given for the standard safety valve or balanced bellows safety valve, as stated above.
The pressure drop permitted shall be limited to a great extent by the lowest set safety valve in the system, because this determines the pressure permitted at the point where this safety valve ties in to the flare header.
The pressure drop in any emergency cooler and the pressure required at the unit flare knockout drum must be subtracted from the permitted pressure drop.
A minimum of 35 kPa (g) shall be used for the pressure in the unit flare knockout drum. The type of safety valve used on the lowest set safety valve shall permit this back pressure to exist.

3.5.6.6.3 Closed header design considerations

A single maximum discharge occurrence for one safety valve or manual depressurizing valve shall be used to determine header size.
The header shall be sized according to maximum relief load.
Consideration shall be given to using balanced bellows safety valves where pressures available are limiting.
Unless further restricted by job specifications, hot streams that flow into the closed above-ground headers shall be limited to 232°C maximum downstream of the safety valve. An emergency cooler shall be provided to cool to 232°C all relief streams that exceed this maximum, except for the following:
A relief stream where a temperature higher than 232°C will be reached under fire conditions, ar
where the safety valve size is not set by fire conditions, need not have an emergency cooler unless it is required for other reasons. A cooler is required for such streams when the safety valve size is set by fire conditions.
Under the conditions permitted in the above point, the piping and flare appurtenances shall be designed for the temperatures involved.

3.5.6.6.4 Vapor Safety Valve Piping

Sizing:
Sizing of discharge piping for vapor safety valves depends on whether the valve is relieving to atmosphere, or to a closed relieving system, and whether a standard or bellows type safety valve is used.
Permissible Pressure Drop:

- Conventional (Standard) Safety Valve:
  The permissible pressure drop in discharge piping from the safety valve in vapor service is 10% of the set pressure under normal relief where 10% accumulation is used, and 20% of th
  pressure under emergency fire condition where 20% accumulation is us

- Balanced Bellows Safety Valve:
  The permissible pressure drop in discharge piping for balanced bellows safety valves in vapor service is 25% to 45% of valve set pressure. For these particular valves, the manufacturers cur shall be used.

3.5.6.6.5 Liquid Relief Valve Piping

Because the pressure drop in the outlet piping affects the set pressure of a conventional safety relief valve and the capacity of both conventional and balanced bellows relief valve, these impacts shall be evaluated when determining the size of outlet piping.
Most liquid relief valves have short discharge lines, for example, relieving into suction of a pump, where the discharge line relieves back to tankage. A considerable pressure drop may be developed, and its effect must be considered.
Discharge piping from safety valves in liquid service shall be no smaller than the outlet connection on the safety valve and shall be increased where pressure drop significantly affects set pressure or capacity of the relief valve.

3.5.6.7 Block Valves

3.5.6.7.1 General

When spare safety valves are required, block valves shall be provided as follows, to permit removal of all of the valves being spared and the spare safety valve

- Block valves shall be provided only on the inlet of the safety valve where the safety valve discharges independently to the atmosphere.
- Block valves shall be provided on the inlet and outlet of a safety valve that discharges into a system operating under pressure or into a common discharge header.
- Block valves, according to the applicable piping material service specification, shall be provided in the pressure sensing piping to the pilot operated valves and in the inlet piping to the controlled relief valves, when spare safety valves are required.

Although it is not permitted, except as noted above, provision for block valves and bypass lines may be requested in the job specification for all safety relief valves providing protection of vessel(s), in order to make possible removal of safety relief valves for maintenance purposes while the unit or system is under normal operation. In such cases, safety features concerning the equipment or system shall be taken into account. The inlet and outlet block valves shall be locked open in any case.

3.5.6.7.2 Block Valves on Inlet of Safety Valves

Block valves conforming to applicable inlet piping material service specifications shall be used.
Block valves for the inlets of safety valves shall be, at minimum, the same size as the safety valve inlet. They shall be larger where necessary to reduce the pressure drop in the inlet piping to that essential for proper operation of the safety valve.

3.5.6.7.3 Block Valves on Outlet of Safety Valves

Block valves conforming to the piping material service specification for the service involved at the discharge shall be used.
Block valves for the outlet of safety valves shall be, at minimum, the same size as the outlet of the safety valve. They shall be larger where required to reduce the pressure drop in the outlet piping to ensure proper operation at the capacity required.

3.5.6.7.4 Locking Methods

Suitable devices shall be provided on all block valves at the inlet or the outlet of safety valves, which will allow locking of the valves by authorized persons in an open or closed position. The job specification will specify whether the valves are suitable for a padlock and chain or a car seal, depending on plant preference.

3.5.6.8 Discharge Piping of Temperature Safety Valves

3.5.6.8.1 Water service

Temperature safety valves in water service may discharge to grade or to the sewer system.

3.5.6.8.2 Hydrocarbon Service

Temperature safety valves in hydrocarbon service on process units shall be piped to the nearest safe location, such as drain or sewer hub, with the end of the discharge pipe visible.
Temperature safety valves located in National Electrical Code, Division 2 el cal classification areas shall have discharge piped to an open drain or sewer hub, with the end visible outside the Division 2 area.
Temperature safety valves in storage or product loading areas shall not discharge to atmosphere but shall have discharge pipe, using a spring loaded popped type check valve around block valves, check valves, pumps, etc. back to storage.

3.5.6.8.3 Chemical Service

The procedure for handling discharge from temperature safety valves in chemical service shall be specified in the job specification.

# 4. PIPING

## 4.1 Design Pressure and Temperature

### 4.1.1 Design Pressure

Design pressure for piping system shall be determined in accordance with ANSI/ASME B 31.3 with the following additions:

- Where the pressure is limited by a relieving device, the design pressure shall not be less than the pressure which will exist in the piping systems when the pressure relieving device starts to relieve or the set pressure of the pressure relieving device, whichever is the greater.
- The maximum differences in pressure between the inside and outside of any piping component or between chambers of a combination unit, e.g. a jacketed pipe, shall be considered, including the loss of external or internal pressure.
- Piping subject to vacuum shall be designed for a negative pressure of 1 bar unless a vacuum breaker or similar device is provided, in which case a higher design pressure may be approved.
- The value of the design pressure which be used, shall include the static head, where applicable, unless this is taken into account separately.

- Design pressure of a piping system subject to internal pressure shall be defined as one of the following:
  - Design pressure of the equipment to which the piping is connected.
  - Set pressure of relief valve of the piping equipment system (if lower than the design pressure of the equipment to which the piping is connected).
  - A pressure no lower than the shut off pressure or that resulting from the sum of the maximum suction pressure plus 1.2 times the design differential pressure, for discharg es of pumps not protected by a relief valve.

### 4.1.2 Design Temperature

Design temperature shall be determined in accordance with ANSI/ASME Code B31.3 with following additions:

- Design temperature shall include an adequate margin to cover uncertainty in temperature prediction.
- Design maximum temperature shall not be less than the actual metal temperature expected in service and shall be used to determine the appropriate design stress "S" for the selected material.
- In case exterior of components are thermally insulated, the lowest metal temperature shall be taken to be the minimum temperature of the contents of the pipe.

## 4.2 Control Valve Manifold

The operation, severity, and maintenance frequency shall dictate the manifold configuration. The design of manifolds shall be in accordance with IPS-C-IN-160, ISA-RP-75.6.

The following shall be noted:

- The block valves on either side of control valve shall be gate valves with the same size as the manifold size.
- Bypass valves shall be full manifold size globe valves up to 4”, and full manifold gate valves in larger sizes.
- Two 3/4” bleed valve shall be installed control valves and both sides block valves.
- Where the line size is more than two sizes larger than the size of the control valve, line size may be considered to sewage ahead of the manifold and then the manifold shall be size as described before.
- 1/16” Clearance shall be provided at each flange for the gaskets.
- Control valves above 2” size shall have minimum ANSI rating of 30
- A straight run of 8 diameters shall be provided downstream of valves, in flashing services, and it shall be noted on the P&ID.
- For recommended minimum block and bypass valve sizing refer to the Appendix II.

## 4.3 Pump Manifolds

If the difference between nozzle and pipe size is less than or equal to one size, then:

- Pump suction block valve shall be the same size as the suction line size.
- If the pump discharge nozzle is smaller than the discharge line, block valve shall be one size smaller than the line size.

- If the difference between the suction or discharge nozzles and the line size are more than one size then:
- Block valve should be one size smaller than the pipe size. (IPS-E-PR-230)
- The pump discharge block and check valves shall be the same size.
- If the selected size of check valve is such that under minimum and normal conditions the full lift of the disc is not obtained, then the check valve shall be selected as the pump discharge nozzle size.
- A block valve is not required at the vessel on pump suction lines which have a block valve located within 10 m (30 ft) in a horizontal direction from vessel
- Temporary strainers shall be installed in all pump suction manifolds.

### 4.4 Sample Connections

- All sample connections shall be in accordance with IPS-E-PR-230.
- All sample connections shall have minimum size of 3/4”.

### 4.5 Insulation

In order to protect personnel, all insulations shall be done in accordance with IPS-E-TP-700 “Thermal Insulation “

Consideration shall be given to the following:

- All surfaces, above 55 °C which could be touched, or where the radiant heat could be dangerous in the course of normal operating duties, shall be guarded or insulated to reduce the surface temperature to a maximum of 55°C. These requirements may not be applied to the surfaces where the high surface temperature is caused solely by local climatic conditions.
- Pumps shall not normally be insulated unless it is desired from process or safety aspects.
- If credit is taken for thermal insulation in determination of heat input to a vessel during fire condition, and the pressure relief valve is sized on this basis, then the clad insulation shall be secured such that to resist the force of fire hose streams.
- Where condensation on the outside of insulation is undesirable, i.e. in salty atmosphere or inside building, and insulation requirements are in excess of that required for heat infiltration, Client shall be advised of such requirements.
- A physical barrier with warning signs attached to hot surface is preferred to thermal insulation if it is not required for process reasons.

### 4.6 Heat Tracing

- Heat tracing, where required shall be in accordance with IPS-E-PR-420, related project specifications and standard drawings.

### 4.7 Battery Limit Block Valves

Based on IPS-E-PR-230 all lines crossing the battery limit shall have the followings, inside the plar battery limit.

A block valve.

A spectacle blind located upstream of block valve

A 3/4” plugged bleed valve located upstream of block valve.

### 4.8 Selection of Valves

The IPS-E-PR-830 shall be used to select the type of valves for specific applicatior

## 5. PIPELINE

The transmission line as related to the requirements of this criteria is a pipeline transporting gas or liquid and also two-phase flow from oil fields to the loading points or production Units such as refineries and natural gas plants. IPS-E-PR-440 will be follow for considering pipeline sizing and specification.

### 5.1 Sizing Criteria

Although pressure loss is primary criterion in determining line size, the following points should be taken into consideration when designing a pipeline.

- Design consideration should be given to flow velocity within a range which will minimize corrosion. The lower limit of the flow velocity range should be that velocity which will keep impurities suspended in the commodity, thereby minimizing accumulation of corrosion matter within the pipeline.
- The upper limit of the velocity range should be such that erosion-corrosion cavitations or impingement attack will be minimal.
- Slug flow conditions should be avoided where possible. If operating criteria dictate the need for intermittent flow, design consideration should be given to obtaining an operating velocity which will pick up and sweep away water or sediment that accumulates in lower places in the line during periods of no flow.
- If water, sediment or other corrosive contaminates are expected to accumulate in the pipeline, design should include loading and receiving pig trap. Operating procedures should be developed and implemented for adequate cleaning (see also NACE MR 0175).
- Rout and elevation profile shall be considered for pressure-temperature study.MAX. EVR (erosion velocity ratio) shall be considered 1.

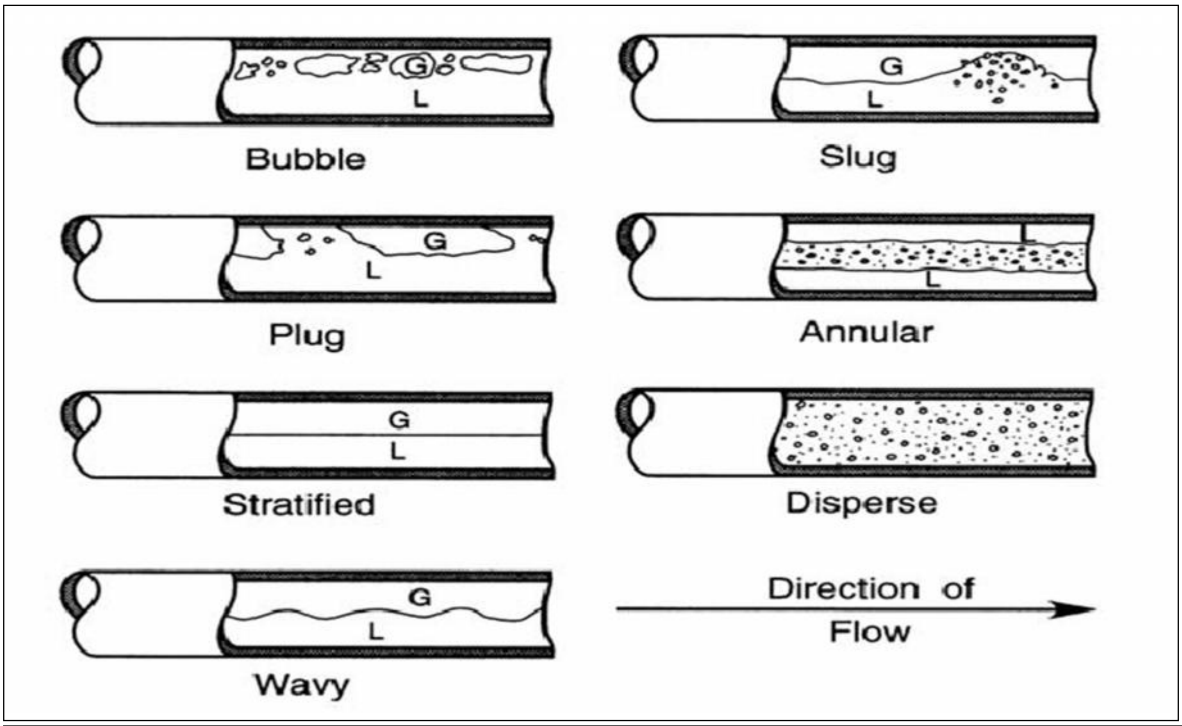
### 5.2 Two Phase Flow Sizing Process pipeline

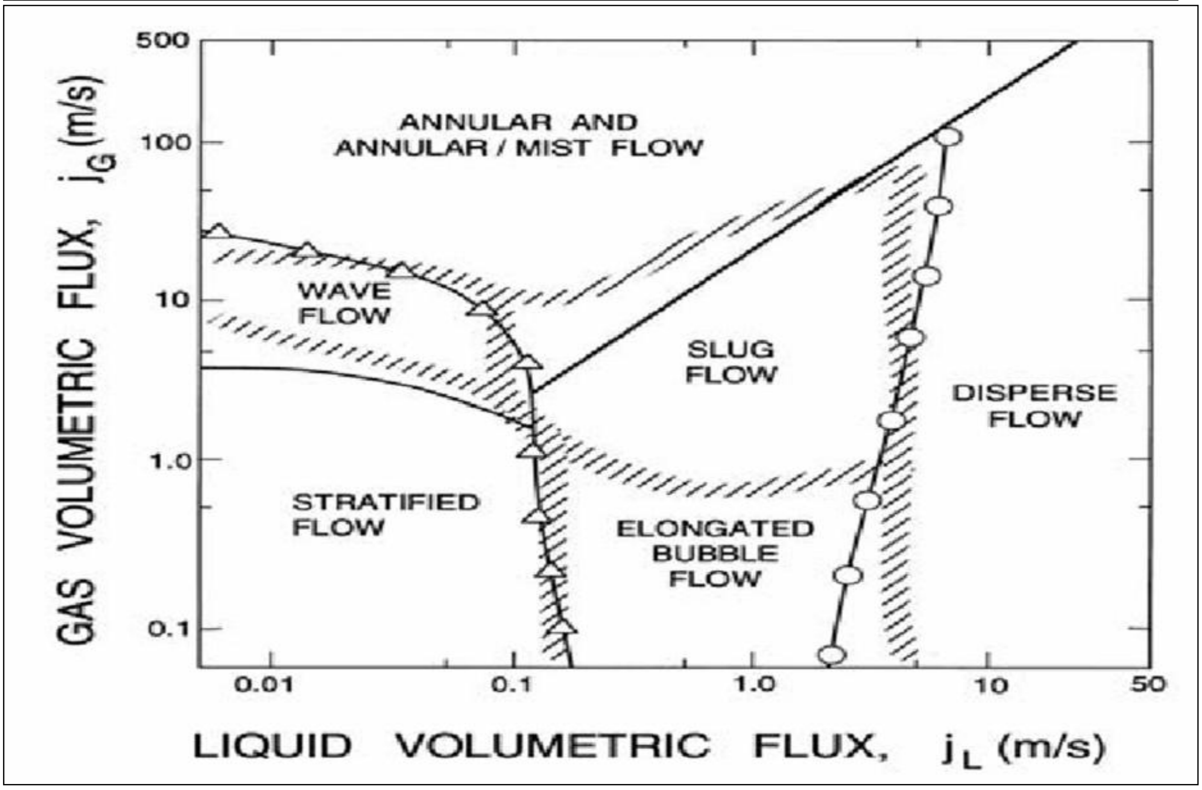
Two-phase flow resistance is calculated in two main steps:

A. A possible flow pattern is selected by calculating coordinates of flow region chart.
B. Unit pressure losses are determined by calculating vapor-phase unit loss only, corrected by applicable two-phase flow correlation.
C. Where $\Delta P_{100}$ (liquid) is calculated assuming only liquid is flowing in the pipe and $\Delta P_{100}$ (vapor) is calculated assuming only vapor is flowing in the same size pipe. X remains constant for one set of flow conditions.

### 5.3 Two-phase flow regions

The two-phase flow patterns are shown in below Table. The borders of the various flow pattern regions in graph are shown as lines. In reality these boarders are rather broad transition zone.
Below graph shown the most popular region of two phase flow and selections:




## 6. SOFT WARE

The following software will be used for process related calculation.

### 6.1 Plant Simulations

ASPEN HYSYS ver. 7.1

### 6.2 Pipeline Calculation

PIPSYS1.6 - Pipe Phase 8.1-pipesim ver. 2008.1

### 6.3 Heat Exchanger Calculation

ASPEN B-Jac7.1

### 6.4 Flare Radiation Levels

In-house package

### 6.5 Flare Network

Flare net (In-house Package)

**Appendix I**

**VELOCITY AND PRESSURE DROP LIMITATIONS**

1) GAS and TWO PHASE SERVICE

| Line type | Maximum ρV² (kg*m/s²) | Maximum Velocity (m/s) | ΔP bar/km Normal | ΔP bar/km Max. |
|---|---|---|---|---|
| SINGLE PHASE: | | | | |
| - Normal Pressure | | 20/25 | 0.4/1 | |
| - Very low Pressure (equal or below 3 bara except flares) | | 30 | 0.2/0.7 | |
| TWO PHASE: | | | | |
| Continuous operation: | | | ΔP must be considered compatible with the corresponding service | |
| - P ≤ 20 barg | 6000 | | | |
| - 20 < P ≤ 20 barg | 7500 | | | |
| - 50 < P ≤ 80 barg | 10000 | | | |
| - 80 < P ≤ 120 barg | 15000 | | | |
| - P > 120 barg | 20000 | | | |
| Discontinuous operation e.g.: | | | | |
| - Compressor anti-surge: | | | | |
| - P ≤ 50 barg | 10000 | | | |
| - 50 < P ≤ 80 barg | 15000 | | | |
| - P > 80 barg | 25000 | | | |
| COMPRESSOR: | | | | |
| - Compressor Suction: | To be compatible with above | | 0.2 | 0.7 |
| - Compressor discharge: | | | 0.45 | 1.15 |

2) LIQUID SERVICE

| Liquid line type | ΔP (bar/km) | | Max. Velocity. (m/s) (2) | | | |
|---|---|---|---|---|---|---|
| | **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 | | | | | | |
| - 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 bar g | 3.5 | 4.5 | | 1.5 to 4.5 m/s | | 6.0 |
| - Disch. Pres. > 50 bar g | 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 | 0.25 | 0.45 | 0.6 | 0.6 | 0.6 | 0.6 |
| Water lines (CS) (3) | | | | | | |
| - Cooling water & service water (4) | | | | | | |
| 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 | | | | | | |
| - Pres. <= 50 bar g | 3.5 | 4.5 | | 1.5 to 4.5 m/s | | 6.0 |
| - Pres. > 50 bar g | 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 mini) | | |
| - Steam cond. return | | | | 1 to 1.5 m/s | | |
| - Reboiler feed (for indication) | 0.2 | 0.4 | | | | |

Notes:

- 3.0 m/s maximum (2 m/s average) at storage tank inlet or in loading.
- Vendor and/or Licenser requirements could supersede maximum velocity values upon Company approval.
- Special considerations can be applied for copper-nickel or glass reinforced plastic piping upon Company approval.
- Velocities below 0.91 m/s should not be used for cooling water service to a s deposition.
- For amine service velocity should not exceed 1 m/s to avoid corrosion/erosion.
- For lines containing mixtures of hydrocarbon and water, velocity should be limited to 1 m/s to avoid generation of static charge.

**Appendix II**

**CONTROL VALVE MANIFOLD DESIGN**

| CONTROL VALVE SIZE (IN.) | BLOCK BYPASS VALVE SIZE (1) | PIPE LINE SIZE (IN.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **3/4** | **1** | **1-1/2** | **2** | **3** | **4** | **6** | **8** | **10** | **12** | **14** | **16** | **18** | **20** |
| 3/4 | BLOCK | 3/4 | 1 | 1-1/2 | 2 | | | | | | | | | | |
| | BYPASS | 3/4 | 1 | 1-1/2 | 2 | | | | | | | | | | |
| 1 | BLOCK | | 1 | 1-1/2 | 2 | 2 | | | | | | | | | |
| | BYPASS | | 1 | 1-1/2 | 2 | 2 | | | | | | | | | |
| 1-1/2 | BLOCK | | | 1-1/2 | 2 | 3 | 3 | | | | | | | | |
| | BYPASS | | | 1-1/2 | 2 | 3 | 3 | | | | | | | | |
| 2 | BLOCK | | | | 2 | 3 | 3 | 4 | | | | | | | |
| | BYPASS | | | | 2 | 3 | 3 | 4 | | | | | | | |
| 3 | BLOCK | | | | | 3 | 4 | 4 | 6 | | | | | | |
| | BYPASS | | | | | 3 | 3 | 4 | 6 | | | | | | |
| 4 | BLOCK | | | | | | 4 | 6 | 6 | 8 | | | | | |
| | BYPASS | | | | | | 4 | 4 | 6 | 8 | | | | | |
| 6 | BLOCK | | | | | | | 6 | 8 | 8 | 10 | | | | |
| | BYPASS | | | | | | | 6 | 6 | 8 | 10 | | | | |
| 8 | BLOCK | | | | | | | | 8 | 10 | 10 | 10 | | | |
| | BYPASS | | | | | | | | 8 | 8 | 10 | 6 | | | |
| 10 | BLOCK | | | | | | | | | 10 | 12 | 10 | 12 | | |
| | BYPASS | | | | | | | | | 10 | 10 | 8 | 8 | | |
| 12 | BLOCK | | | | | | | | | | 12 | 12 | 12 | 14 | |
| | BYPASS | | | | | | | | | | 12 | 10 | 10 | 10 | |
| 14 | BLOCK | | | | | | | | | | | 14 | 14 | 14 | 16 |
| | BYPASS | | | | | | | | | | | 14 | 12 | 12 | 12 |
| 16 | BLOCK | | | | | | | | | | | | 16 | 16 | 16 |
| | BYPASS | | | | | | | | | | | | 14 | 14 | 14 |

**NOTES:**

(1) USE GLOBE BYPASS VALVES FOR SIZES 4 INCHES AND SMALLER.
USE GATE BYPASS VALVES FOR SIZES 6 INCHES AND LARGER.

(2) CLEAR BLOCK BAYPASS VALVE SIZES TO RIGHT OF HEAVY LINE WITH INSTRUMENT ENGINEER BEFORE USE.