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NATIONAL IRANIAN OIL REFINING & DISTRIBUTION COMPANY

NATIONAL IRANIAN OIL ENGINEERING

& CONSTRUCTION COMPANY

NIOEC SP

NIOEC SPECIFICATION

FOR

DESIGN CRITERIA FOR PROCESS AND MECHANICS

SECOND EDITION

DECEMBER, 2009

IN THE NAME OF GOD

FOREWORD

By their very nature, technical standard specifications are continuously subject to modifications and revisions. To strengthen their merit and usefulness, continuous improvements, addendum, deletion of disparate information and consequently provision of updated revisions are to be made in order to ascertain that such standard specifications meet the current requirements, inclusive of Iranian Petroleum Standards (IPS) and the recognized and acceptable national and international standards, as well as the optimal codes and practices based on the accumulated in-house know-how and plant knowledge and experiences.

However, in reality, due to several reasons, not to mention the complexity of the matter, the ultimate goal of continuous direct embedment of the required changes on the relevant standard specifications may be far reaching. Therefore, in the interim periods between the officially issued revisions, the required changes will appear in other documents related to the engineering and design work of the ongoing projects.

In response to the initiative of the Design Division of the Engineering and Construction Directorate, and considering that the task of the execution of several important and mega projects for the realization of the new oil refineries, pipelines and oil terminals as well as improvements of the existing facilities, has been assigned to NIOEC, it was decided to update the NIOEC Specifications and to issue new official revisions.

The Design Division of the Engineering and Construction Directorate was itself entrusted to carry out this important task, and as such by forming several special technical committees, working in close co-operation and cohesion and sharing their expertise and knowledge, the updated and revised NIOEC Specifications were successfully prepared and complied.

These Specifications are intended to be used for Oil Refineries, Distribution Depots, Oil Terminals, Pipelines and Pump Stations within NIOEC's projects, and have been proven to be of high value for such purposes. It must however be appreciated that these Specifications represent the minimum requirements and should in no way be interpreted as a restriction on the use of better procedures, engineering and design practices or materials.

We encourage and highly appreciate the users and other clear sighted and experts to send their comments on the Specifications to the Design Deputy of the Engineering Department of NIOEC for evaluation and consideration.

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NOTES:

1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.
2) REMARKS RELATED TO EACH REVISION SHOW A BRIEF DESCRIPTION. THESE REMARKS SHALL BE INTERPRETED IN CONJUNCTION WITH THE REVISED TEXT MARKED BY REVISION NUMBERS.
3) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.
4) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

REV.	DATE	PREPARED	CHECKED	APPROVED	AUTHORIZED
A5					
A4					
A3	DEC., 2009	M.A.A.SAJEDI		M.R.FARZAM	M.A.A.SAJEDI
A2	JAN., 2009	M.A.A.SAJEDI		M.R.FARZAM	M.A.A.SAJEDI
A1	JULY, 2006	M.A.A.SAJEDI		M.R.FARZAM	M.A.A.SAJEDI
A0	JULY, 2005	M.A.A.SAJEDI		M.R.FARZAM	M.A.A.SAJEDI

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0. INTRODUCTION

To satisfy the requirements of basic philosophies to be applied during design and engineering of all projects in the field of refinery/oil plant, distribution depots, pump stations and pipelines, this NIOEC Specification shall be used.

1. SCOPE

NIOEC specifications cover the general requirements for detailed engineering, procurements, testing, inspection & construction of refinery/ oil plant, distribution depots, pump stations and pipelines.

This Specification covers the minimum requirements for Process and Mechanics design criteria including essential instructions and points of noteworthy to be applied during implementation of process and/or utility units design and engineering activities.
The purpose of this Specification is to standardize the basis of design for all process and/or utility units.
In case of conflict between this Specification and other NIOEC's Specifications/engineering dossiers, the requirements as stipulated in this Specification are in first priority.

2. REFERENCES

Throughout this Specification, the following dated and undated standards/ codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard.
For undated references, the latest edition of the referenced document (including any supplements and amendments) applies. For dated references, the edition cited applies.
The applicability of changes in dated references that occur after the cited date shall mutually be agreed upon by NIOEC and the vendor/contractor.

API (AMERICAN PETROLEUM INSTITUTE)

Standard 610, 10th. Ed., "Centrifugal Pumps for General Refinery Services"

Standard 620, 10th. Ed., "Design and Construction of Large, Welded, Low-pressure Storage Tanks"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

ASME Boiler and Pressure Vessel Code:

Section I: "Power Boilers"

Section VIII: "Pressure Vessels"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

ASTM Specification D- 396- 61 T

NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)

NFPA 170, "Standard for Fire Safety Symbols"

NIOEC-SP (NIOEC SPECIFICATIONS)

NIOEC-SP-00-10 "NIOEC Specification for Units"

NIOEC-SP-00-11 "NIOEC Specification for Site Conditions"

NIOEC-SP-00-52 "NIOEC Specification for Process Flow Diagram"

NIOEC-SP-00-55 "NIOEC Specification for Piping & Instrumentation Diagram"

NIOEC-SP-00-62 "NIOEC Specification for Numbering System"

NIOEC-SP-00-75 "NIOEC Specification for Pressure and Vacuum Relief Devices"

NIOEC-SP-00-76 "NIOEC Specification for Process Design of Flare & Blow down Systems"

NIOEC-SP-00-89 "NIOEC Specification for process design of compressors"

NIOEC-SP-46-01 "NIOEC Specification for Centrifugal Pumps for General Refinery Services"

NIOEC-SP-46-12 "NIOEC Specification for Centrifugal Pumps for General Services"

NIOEC-SP-47-04 "NIOEC Specification for Flare and Flare Stack"

NIOEC-SP-50-08 "NIOEC Specification for Winterizing & Heat Conservation"

NIOEC-SP-70-01 "NIOEC Specification for Instrumentation"

3. UNITS

International system of units (SI) shall be used in accordance with NIOEC-SP-00-10, unless otherwise specified.

4. PROCESS UNITS DESIGN BASIS

4.1 GENERAL

4.1.1 General legends and symbols for PFD, P&ID, electrical, instrumentation, HVAC, civil and structure drawings and abbreviations shall be in accordance with NIOEC standard drawings as specified herein below:

- PFD- Symbols and legends; "SD-00-0001-1/1"
- P&IDs –Symbols and legends (Piping) ; "SD-00-0100-1/4"
- P&IDs –Symbols and legends (Instrument) ; "SD-00-0100-2/4"
- P&IDs –Symbols and legends (Equipment) ; "SD-00-0100-3/4"
- P&IDs –Symbols and legends (Miscellaneous Equipment) ; "SD-00-0100-4/4"
- P&IDs –Abbreviation ; "SD-00-0101-1/1"

- Fire Safety Symbols : Refer to NFPA 170

4.1.2 The numbering of the equipment, drawing and all engineering documents shall be as per NIOEC-SP-00-62.

4.1.3 The drafting procedure for process flow diagrams (PFDs) and piping & instrumentation diagrams (P & IDs) shall be as per "NIOEC-SP-00-52" and "NIOEC-SP-00-55 respectively.

4.1.4 Separate Process Flow Diagram(s) (PFDs) and respective Heat and Material Balance tables shall be prepared for each operation mode as well as regeneration in each unit.

4.1.5 The enthalpy reference conditions (temperature & pressure) shall be noted on all Heat & Material Balance Tables.

4.1.6 Integration of the process units shall be avoided unless otherwise specified. The design shall facilitate normal operation, start-up, shutdown, regeneration and turndown of the process units separately and individually.

4.1.7 The Licensor shall specify the composition as well as Cyanide content of the effluent sour water for licensed units.

4.1.8 Facilities shall be provided for the neutralization of the austenitic stainless steel piping and equipment during shutdown of the unit.

4.2 MACHINERY / DRIVERS SELECTION PHILOSOPHIES

4.2.1 Isolation facilities shall be provided for each machinery equipment.

4.2.2 The stand- by steam turbine drivers shall automatically be started up for low discharge pressure of the respective machinery.

4.2.3 No spare is required for centrifugal compressors.

4.2.4 Where, condensing steam turbine driver is specified, the drivers of the condensate pumps shall be back pressure steam turbine (MP to LP) type for main pump and electrical type for spare pump.

4.2.5 All pumps in continuous operation shall have individual spares. Spare pumps shall be provided as follows:

No. of Operating Pumps	No. of Spare Pumps
1	1
2	1
3	2

4.3 WINTERIZING AND HEAT CONSERVATION

4.3.1 Protection of the process and all associated equipment, lines and instruments against atmospheric temperatures which would cause congealing or freezing of contents,

interfere with operation or cause damage to equipment shall be shown on the Piping & Instrumentation Diagrams (P&IDs).

However, steam or electrical tracing details shown on the diagrams are indicative and denote only the necessity of tracing in basic design stage.

Type of tracing and insulation, use of thermal cement or otherwise numbers and size of steam traps will be determined at detail design stage. Protection described by standard nomenclature on the P & I Diagrams should be reviewed in detail engineering to insure that proper standards or requirements in this regard have been met.

4.3.2 The winterizing should be based on a winterizing temperature as specified in the site conditions of each project as per NIOEC-SP-00-11.

4.3.3 Protection of lines, instruments and equipment not shown on the P&I diagrams should be provided by the detail engineering to the extent and in accordance with NIOEC-SP-50-08.

4.3.4 Lines in Asphalt and liquid Sulfur services should be steam jacketed. Valves in these lines are generally steam jacketed wedge plugs.

4.3.5 The objective temperature for heat traced pipelines and equipment shall generally be the fluid pour point plus 22 ºC . The objective temperature for sour gases and reciprocating compressor suction lines and drum shall be minimum 22 ^{o}C above the fluid dew point.

Fuel gas system containing C3 & heavier materials and/or sour gas shall be traced for an objective temperature of 49 ºC.

Fuel oil supply and return lines shall be traced for an objective temperature of 120 ºC.

The minimum maintaining temperature for the specified commodities shall be according to the following Table A. The objective temperature shall be shown on P&IDs.

TABLE A

MINIMUM MAINTAINING TEMPERATURE

COMMODITY	TEMPERATURE, (ºC)
- Water Aqueous Solution	24
- Light Diesel	*
- Heavy Diesel	*
- Waxy Distillate	*
- Heavy vacuum slop	*
- Dewaxing Unit Feed	*
- Vacuum Residue	*
- Deasphaled Oil	*
- Fuel Gas	49
- Hot Slops	66
- Base Oil	60
- Fuel Oil (Supply & Return)	120

- Caustic Solution:
  - * 50 Degree Baume 28
  - * 25 Degree Baume 11
  - * 4.5 Degree Baume 20
- Slack wax 90
- Asphalt (*) (Steam Jacketed)
- Liquid Sulfur (*) (Steam Jacketed)

(*) Temperature will be determined in basic design phase.

5. DESIGN BASIS

5.1 DESIGN PRESSURE AND TEMPERATURE

5.1.1 Design Pressure for Individual Equipment Items

The design pressure is the maximum and / or minimum pressure for which the mechanical calculation shall be performed. The operating pressure is defined as the maximum/minimum (for vacuum services) anticipated normal operating pressure.

The design pressure shall be established according to the following criteria except in special cases approved by the Company. In addition, where, process fluid static head or other appropriate loads significantly increase the internal pressure, the design pressure shall be increased accordingly for the vessel section concerned.

A) For maximum normal operating pressure less than 1.5 barg (except item "G" below): Whichever is greater:

- 3.5 bar gage, or
- Flare design pressure if the vessel is connected to flare.

B) For maximum normal operating pressures between 1.5 and 20 barg, use the maximum normal operating gage pressure +2 bar.

C) For maximum normal operating pressures between 20 and 80 barg, use 110% of the maximum normal operating gage pressure.

D) For maximum normal operating pressures between 80 and 140 barg, use the maximum normal operating gage pressure +8 bar (see Note 2).

E) For maximum normal operating pressures above 140 barg, use the maximum normal operating gage pressure + 5% (see Note 2).

F) Equipment normally operated under vacuum shall be designed for full vacuum and for the highest pressure which the equipment can experience in case of vacuum system failure, (see Note 3).
Full vacuum shall be specified for isolable equipment containing fluid having a vapor pressure lower than atmospheric pressure at ambient temperature.
For equipment operated under vacuum, minimum internal pressure shall be 3.5 barg.
For vacuum rating designation, pressure shall be noted as external.

G) For equipment operating under Atmospheric pressure, use hydrostatic (water) pressure + 50 mm Water column (see Note 4).
For Atmospheric storage tanks operated under blanketed gas:

- For seal pressure lower than 100 mm of H2O tank design pressure shall be hydrostatic Pressure considering the tank full of liquid plus 150 mm of H2O,

- For seal pressure not higher than 400 mm of H2O, tank design pressure shall be according to API 620.

NOTES: The following design notes shall be taken into consideration for establishing design pressure :

1) In case of equipment connected in series, without block valves in between, the design pressure for the upstream equipment shall be the same as the design pressure for the downstream equipment (equipped with safety valve) increased by 120% of the pressure drop foreseen between the two equipment under safety valve discharge accordingly.

2) When design pressure lower than 110% max. operating pressure is specified, safety valves blow down shall be selected accordingly .

3) Design for vacuum :

a) Steam drums shall be designed for full vacuum conditions.

b) Vacuum design conditions shall not be required as consequence of equipment block-in after steam out operation. However, vacuum conditions shall be studied during start-up, shut-down and regeneration and shall be considered for equipment design where applicable.

c) Due consideration shall be taken to establish external design pressure for vessels subject to internal pressure but connected to the suction of compressor or other evacuating equipment .

d) Exchangers operating under a vacuum shall be designed for full vacuum.

e) Low pressure vessels that may be affected by decreasing in ambient temperature which cause vacuum condition in the vessel shall be designed for such vacuum conditions. As an example, main column overhead receiver which is operating at low pressure and receive feed from air cooled exchanger.

f) Vacuum design shall be specified for vessels which normally operate liquid full and can be blocked in and cooled down.

g) Vacuum design shall be specified for fractionators and associated equipment that can undergo a vacuum condition through the loss of heat input.

4) Same criteria are applied for the design of atmospheric storage tanks (without gas blanketing).

5) The set pressure of the relief valve must be lower than or equal to the equipment design pressure.

6) In case of fractionators and towers:

- Design pressure of the main column and connected side strippers shall be calculated based on the column bottom maximum normal operating pressure. Bottom maximum normal operating pressure shall include allowance for hydrostatic head (HHL Level) and pressure drop across trays and / or internals.
- Design pressure of the overhead condenser and reflux drum shall be calculated based on the column top maximum normal operating pressure.
- Design pressure of the bottom reboiler shall be calculated based on the column bottom maximum normal operating pressure plus static head.

7) Design pressure of the fired heater coils shall be calculated considering the design pressure of the downstream vessel plus fouling allowance (if any) plus 120% of the allowable pressure drop in clean conditions.

5.1.2. Design Pressure for Complete Systems

When several pieces of equipment are protected by the same relief valve, each piece of equipment shall be designed, at least, for the pressure imposed by the discharge conditions of the relief valve in case of emergency (see Note-1 under 5.1.1 above).

5.1.2.1. Exchangers, vessels and other equipment on the discharge of a pump

Equipment which could have to bear the shut-off pressure of a pump in case of a valve closing (either control valve or block valve) shall have a design pressure equal to or higher than the shut-off pressure of the pump. Pump shut-off pressure shall be estimated according to the following criteria, whichever is greater:

a) Design pressure of the suction vessel plus liquid height at vessel HLL at pump suction + pump differential pressure at rated flow of the pump.
b) Normal suction pressure plus liquid height at vessel HLL at pump suction + 120% of pump differential pressure at rated flow of the pump.

Shut off pressure of the centrifugal pumps shall be rechecked when Vendor's characteristic curves of selected pumps are available. If it exceeds the estimated pump shut-off pressure, the design pressure of downstream equipment shall be revised accordingly.

5.1.2.2. Exchangers which are not subject to pump shut-off

If no control or block valve is installed downstream the heat exchanger, the design pressure shall be calculated as the design pressure of the downstream equipment at the inlet point plus 1.2 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).

5.1.2.3. Process system similar to that of a reactor - recycle gas-loop

In this case, Licensor's design philosophy and/or the recommendations given in the API Recommended Practice 520 and API recommended Practice 521, last editions shall be followed "settle out pressure".

5.1.3. Design Temperature

a) Unless otherwise specified , equipment design temperature shall be established according to the following criteria :

Operating Temperature(OT)	**Design Temperature (DT), Min./ Max.**
- Less than – 100 ºC	- Min. oper. temp./ 85 ºC min.
- Between – 40 ºC and –100 ºC	- 100 ºC/85 ºC min.
- Between – 30 ºC and – 39 ºC	- 45 ºC/85 ºC min.
- Between – 29 ºC and +60 ºC	- Min. oper. temp. / 85 ºC
- Between + 60 ºC and 343 ºC	- Max . oper. temp. +25 ºC.
- Above 343 ºC	- To be specified according to the selected material and process requirement .

b) The design temperature is determined for the maximum temperature coincident with the design pressure as determined above. Indicate any higher temperatures as alternate design conditions.

c) When, due to the possible loss of flow of the cooling medium in coolers, the tubes, tubes sheets and floating heads may be subject to the full inlet temperature, it shall be indicated on the individual process data sheet and these components shall be designed for the maximum anticipated operating temperature of the hotter medium.

d) The design temperatures for multiple exchangers in series shall be selected in accordance with the maximum temperatures likely to occur on each exchanger in both clean and fouled condition. The design temperature indicated in the process data sheet is the temperature of the hottest exchanger.
Intermediate design temperatures shall be calculated assuming the highest heat transfer coefficient with fouled surface and the lowest heat transfer coefficient with fouled surface for the colder and hotter sections respectively.
The irregular heat profiles shall be indicated on the process data sheet.
All calculations shall be based on the information noted on the process data sheet for worse conditions.

e) For fixed tube sheet exchangers without expansion joints, the differential between the average shell metal temperature and the average metal temperature of any one tube pass shall not exceed 28 ºC. When temperature differentials exceed 28 ºC an expansion joint shall be furnished.
For two pass shell exchangers the differential between the inlet and the outlet temperature of the shell side fluid shall not exceed 194 ºC.

f) The overhead receivers and relevant pumps casing shall be designed for operating temperature plus 25 ºC or the overhead maximum operating temperature of upstream columns, whichever is greater.

g) Columns with fired feed heater with / without side cut strippers in the zone between the drawoff trays of two adjacent side cuts, the design temperature shall be the drawoff temperature of the heavier side cut plus 25 ºC. In the zone between the heaviest side cut drawoff tray and the bottom of the column, the design temperature shall be the flash zone temperature plus 25 ºC.

h) For the fractionators with reboiler, the design temperature shall be the reboiler return temperature plus 25 ºC.

5.1.4. Purging Equipment with Steam

For equipment subject to steam purging at start – up or shutdown indication shall be given on the specification sheet.

5.1.5. Cyclic Operating Conditions

For equipment subject to pressure and temperature swings, the magnitude and frequency of these swing will be given on the specification sheet.

5.2 CORROSION ALLOWANCE (for equipment and lines)

5.2.1. Carbon steel (including low Alloy <5% Cr. Steels)

Whichever is greater:

- Corrosion allowance calculated for 20 years of service for equipment and 10 years of service for piping.
- Corrosion allowance of 1.0 mm. for piping and 3.0 mm for equipment (except for storage tanks' roof which shall be 1.5 mm).

Note (1): For removable carbon steel parts of internals, a minimum of 1.5 mm of **c**orrosion allowance on each side in contact with the operating fluid shall be given.

Note (2): The corrosion allowance to be considered for any equipment and line should not be greater than 6 mm. Should in specific cases, a corrosion allowance greater than 6 mm is required, alternate solutions such as application of coating or lining or change of material to be considered.

5.2.2. High Alloy / Stainless Steels

Corrosion allowance calculated for 20 years of service for equipment and 10 years of service for piping.

Note: In general, no corrosion allowance will be given for removable alloyed parts of internals. However, corrosion allowance shall be specified for internals submitted to sever condition such as reactor internals.

5.3 VESSELS, REACTORS AND TOWERS

5.3.1 Minimum flange rating shall be 150 pounds except for the following cases which shall be 300 pounds:

i) Level instrumentation pipe columns.
ii) Pressure relief valve connections.
iii) Nozzle sizes lower than 1-1/2”.

All nozzles except process nozzles over DN 40 (1 1/2") shall be flanged. Process nozzles' size shall be minimum DN 25 (1") and all connections shall be flanged.

Connections 1-1/2” and smaller may be with forged steel couplings. Such connections shall be limited to vessels for which the design pressure and temperature is less than 41.4 barg and 232 ºC respectively. Couplings shall be 6000 PSI rating for 1-1/ 2” and smaller connections. Couplings shall not be used in lined portions of alloy lined vessels, on bottom heads of vertical vessels. Threaded fittings or tapped holes are not permitted. The minimum size of nozzles shall be 1” except that for alloy lined nozzles the minimum size is 1-1/ 2”. For vessels in hydrogen service minimum size connection shall be 1” and all connections shall be flanged.

Separate steam-out connections shall be provided for each vessel .The configuration shall include check valve , ¾” bleeder , pressure blind and gate valve adjacent to the vessel on the low pressure steam supply line towards the vessel .

5.3.3 On unlined horizontal vessels, a manway shall be provided on the top or side of the vessel at or below the horizontal centerline. If the bottom half of the horizontal vessel is lined, the manway shall be located on the upper side or the top of the vessel.
Additionally, on horizontal vessels over 3 meters in tangent length, a blanked off ventilation nozzle shall be provided on the top of the vessel near the end, opposite the manway . The ventilation nozzle shall be sized as follows:

Vessel Tangent Length	blanked off Nozzle size
- 3.0 meters through 4.4 meters	4”
- Over 4.4 meters through 7.5 meters	6”
- Over 7.5 meters	8”

5.3.4 Size of manways shall be 24” (NPS). Minimum inside diameter shall be 18”. Larger size to be specified when required accommodating internals.

Manways shall be provided as follows:

- **Horizontal vessels :**

* 900 to 1300 mm ID: Manway on the head, 18” ID
* Larger than 1300 mm ID: Manway on the side or Top shell, 20” ID

- **Vertical vessels :**
* Under 900 mm ID : Top head flanged
* 900 to 1300 mm ID : Manway , In shell , 18” ID
* Larger than 1300 mm ID : Manway , In shell , 20” ID

- **Packed vessels:**
Each packed bed shall have a manway at above of bed and a manway at bottom for withdrawal.

- **Trayed columns:**
Manways shall be provided above the top tray, below the bottom tray, at any feed and side- cut drawoff tray and at intermediate points so that the maximum number of trays between manways does not exceed 10 unless otherwise required by the process and / or mechanical designer.

- **Special services:**
In special services in which frequent cleaning is anticipated (Vacuum columns, etc.) the number of manways shall be increased in accordance with the severity of the service and/or tower internal vendor requirements.

- **Reactors:**
Reactors design shall be according to the relevant Licensor’s criteria.
Multi-thermocouples thermowells shall be provided to reduce number of instrumentation nozzles in the reactor shells.

5.3.5 When required, liquid drop legs (drawoff boots) shall be provided on horizontal Vessels as follows :

i) If the vessel is lined and the drop leg diameter is less than 30 inches, the drop leg shall be unlined and flanged to the vessel.
ii) If the vessel is lined and the drop leg diameter is 30 inches or greater, the drop leg shall be internally lined and welded to the vessel.
iii) If the vessel is unlined, the drop leg shall be unlined and shall be welded to the vessel regardless of drop leg diameter.

5.3.6 Water drawoff boots, if any, shall be welded to the vessels regardless of the boot diameter. If the vessel is lined, the boot shall be lined and welded to the vessel.

5.3.7 All vessels shall be sized according to inside diameter and 2:1 elliptical heads or hemispherical heads.

5.3.8 Liquid Residence Time
The following criteria shall be used unless otherwise specified by the Licensor.

5.3.8.1 Residence time is defined between low liquid level (LLL) and high liquid level (HLL).

SERVICE	RESIDENCE TIME (minutes)
- Feed surge drum	: 20
- Feed to the columns	: 10
- Columns feeding other units	: 15 (on net liquid product)
- Columns discharging to storage only	: 5
- Columns feeding heat exchangers trains	: 5 (on net liquid product)
- Columns feeding fired heaters	: 10 (with respect to equivalent flowrates of the vapor generated in the fired heater plus 5 minutes on net bottom product full)
- Vacuum column bottom	: 4 (with quench)
- Columns feeding multistage charge pumps (5 or more stages)	: 20
- Drums feeding other equipment for further processing	: 10
- OVHD receivers	: 5 (on reflux plus net product)
- Drums feeding fired heaters	: 10 (on total liquid)
- Reboiling by thermosiphon	: 15 to 30 seconds
- Gas and water separators	: 5 (on water flowrate)
- Water boots	: 5 (below normal interface level or 10 minutes on water (HLL-LLL), whichever is greater)
- Compressor suction K.O . Drums	: 240 (on maximum entrained liquid in the inlet line) or 14 inch level range (HLL-LLL), whichever is greater.
- Other types of K.O. Drums	: A volume corresponding to 15 meters of liquid slug in the inlet line or a 14 inch level range, whichever is greater.
- Tower with kettle reboiler,	: Minimum liquid level shall be held in the tower and hold-up volume allocated in the kettle shall allow 3 minutes residence time of liquid product below HLL. For deethanizer kettle reboiler, residence time shall be 2 minutes.

5.3.8.2 In case LSLL and/or LSHH is provided, the following additional hold-up times shall be taken into consideration (where, LSHH and LSLL are located above HLL and below LLL respectively):

- Liquid hold-up time between LLL and LSLL shall be minimum 2 minutes based on the total inflow to the vessel (or section of the tower) or 3 minutes based on the liquid stream flow from the vessel, whichever is greater.
- Liquid hold-up time between HLL and LSHH shall be minimum 3 minutes based on the total inflow to the vessel (or section of the tower) or 4 minutes based on the liquid stream flow from the vessel, whichever is greater.
- For vertical vessels, the elevation between feed nozzle and LSHH shall be equal to drum diameter multiplied by 0.3 or 750 mm, whichever is greater (including flash drums and excluding trayed towers) and the elevation between LSLL and bottom tangent line (TL) shall be minimum 300 mm.

5.3.8.3 In case LSLL and/or LSHH is not provided, the following criteria shall be considered:

- For vertical vessels, the elevation between feed nozzle and HLL shall be equal to drum diameter multiplied by 0.3 or 900 mm, whichever is greater (including flash drums and excluding trayed towers) and the elevation between LLL and bottom tangent line (TL) shall be minimum 550 mm (200 mm for compressor K. O. Drums).

5.3.9 Minimum internal diameter of horizontal vessels shall be 900 mm. Minimum water boot diameter shall be 300 mm.

5.3.10 In trayed columns, minimum distance from the top tray to top tangent line shall be 750 mm or higher as required to accommodate manway, internals or nozzles.

5.3.11 Minimum trayed column size shall be 750 mm internal diameter.

5.3.12 The minimum vapor space above the high liquid level in horizontal vessels should not be less than 25 percent of the vessel inside diameter or 12 inches, whichever is greater.

5.3.13 Sizing criteria of nozzles on vessels and towers:

A) Minimum size of vent, drain and steam out nozzles:

Vessel Volume (m3) and ID (mm), (Note-1)	**VENT SIZE**	**DRAIN SIZE**	**STEAM OUT NOZZLE**
V<45, D<1200	DN 40 (1½")	DN 40 (1½")	DN 25 (1")
45<V<75, 1200<D<2500	DN 50 (2")	DN 50 (2")	DN 40 (1½")
45<V<75, 2500<D<3500	DN 80 (3")	DN 80 (3")	DN 40 (1½")
45<V<75, 3500<D<4500	DN 100 (4")	DN 80 (3")	DN 50 (2")
75<V<220, 4500<D<6000	DN 100 (4")	DN 80 (3")	DN 80 (3")
220<V<420, D>6000	DN 100 (4")	DN 100 (4")	DN 80 (3")
V>420, D>6000	DN 150 (6")	DN 100 (4")	DN 100 (4")

Notes:

(1) Size of nozzles shall be selected based on vessel volume and vessel inside diameter, whichever to be greater.

(2) Drain on vertical vessel may be located on bottom line.

(3) Select drain size to be same as process line, when process connection is to be smaller than the above table.

B) Size of process and utility nozzles:
See article **5.6-E.1** of this Specification.

5.3.14 Trays and Tower Internals

5.3.14.1 Column trays shall be numbered from bottom to top commencing with No. 1 for the bottom tray.

5.3.14.2 The material of trays shall be stainless steel (type 410) or better alloy when process conditions require.

5.3.14.3 Valve trays shall be used unless otherwise other types required by the process conditions.

5.3.14.4 Columns shall be designed with the following maximum flooding factors:

- 75 for vacuum towers,
- 78 for all fractionators,
- 70 for column diameters under 900 mm ,
- 75 for steam stripping and side cuts strippers ,
- 80 for pumparound trays and other services.

5.3.14.5 The trayed columns shall be designed to operate properly at the specified operating conditions for the tower loadings at 120% and 50% of the unit normal flowrate.

5.3.14.6 Utilization of packing in vacuum services shall be taken into consideration when economically and / or technically is justified.

5.3.14.7 Leak tight trays (tight seating valve trays or bubble cap trays) are required for the following services :

- Once through reboiler draw off boxes
- Side draw off tray draw pan
- Chimney trays
- Vacuum service

5.3.14.8 For new towers, recommended minimum tray spacing to be as follows. For revamped towers, where, the tray spacing is limited due to tower height and economical reasons, tray spacing less than the following figures to be approved by NIOEC.

1300 mm ID or less	:	450 mm
1300 mm to 3000 mm	:	550 mm
3000 mm ID and larger	:	600 mm

Tray spacing shall be greater than the above mentioned minimum values where required for access to column internals, manway location, vapor disengaging, nozzle interference or other reasons.

5.3.14.9 Downcomer back-up shall be 50 percent of maximum of tray spacing.

5.3.15. For vessels with design temperature over 343 ºC, the material welded to the vessel for skirt shall have similar welding properties to that of the vessel.

5.3.16. All vessels operating valves or equipment which are needed manipulation or services during operation shall be easily accessible from ladders or platforms. For ease of operation, vessels close together should have common platforms.

5.3.17. Manholes in vessels will not require platforms when the centerline elevation is 4.6 meter or less from grade, unless a platform is required at manhole elevation for access

to level instruments or other connections, in which case, the platform should be extended to reach the manhole where this extension is 1.53 meters or less.

5.4 NOZZLES IDENTIFICATION

The following symbols shall be used for identification of the nozzles on pressure vessels, tanks, exchangers, pumps, compressors, etc.

Nozzle	Identification Symbol
A,A1,A2	Inlets
B	Outlet
C	Condensate
D	Drain
E*	
F	Feed
G	Level Gauge or Gauge Glass
H	Hand hole
J	Pumpout
K*	
L	Level Instrument (Also LT, LI)
M	Manhole
N	Reboiler Connection
P	Pressure Connection (Also PT, PI)
R	Reflux
S	Steam or Sample Connection
T	Temperature Connection (Also TI, TE, TW)
V	Vapor Vent
W	Relief Valve Connection (Oversize unless actual size known)
(*)	Use E or K when none of the other symbols apply. Do not use I, O, Q, U, X, Y or Z.

5.5 CONTROL VALVE SIZING

5.5.1 The following control valve pressure drop should be considered for system Hydraulics calculations.

i) The sizing pressure drop (DP sizing) shall be sufficient as per this article **(5.5)** and to obtain good regulation at the normal minimum quantity within the rangeability of the selected valve. If in primary design stage maximum flow is not available, then valves shall be selected to have twice the Cv required for normal design flow at specified conditions.

ii) The pressure drop across the control valve at the maximum flow shall be at least 20% of the pressure drop across the control valve at normal flow.

iii) 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 normal rate , one-third 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

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.
- Except for low pressure services , in any other cases minimum pressure drop shall be 0.7 bar .

iv) For control valves in the steam line to reboilers, allow a pressure drop of 5% to 10% of the initial absolute steam pressure or, when operating with low pressure steam of 2 bar or less, use a minimum drop of 0.35 bar unless otherwise system operating pressure requires a lower drop.
The same criteria to be applied to vapors and gases other than steam.

5.5.2 The calculated Cv shall be determined based on the following conditions:

- Minimum flow: Quantity at minimum flow while valve DP calculated for minimum flow conditions.
- Normal flow: Quantity at normal flow while valve DP calculated for normal flow conditions.
- Maximum flow: Quantity at maximum flow (whatever determined by process requirements but not less than 10% higher above normal flow) while valve DP calculated for maximum flow conditions.

5.5.3 The selected Cv shall be such that the valve opening is approximately at 75% of full opening at the maximum value of calculated Cv as per item 5.5.2 above. The valve should never have less than 25% opening at minimum flow.

5.5.4 If the viscosity of the liquid at operating temperature is above 10 C. St. the effect of viscosity on the control valve should be applied.

5.5.5 Fouled condition pressure drop such as vacuum heater / Visbreaker heater / filter should be added into the variable system pressure drop.

5.6 LINE and NOZZLE SIZING CRITERIA

A. GENERAL

A.1 The fluid quantities to be used in determining line sizes shall be those called for by the maximum process design flowrates and in any case shall not be less than 110% of the unit design throughput.
However, line sizes shall be in compliance with the equipment (pumps, exchangers, etc.) design capacity.

A.2. The friction loss shall be calculated in accordance with the standards of Hydraulic Institute on the basis of the following figures for absolute roughness of pipe:

PIPE MATERIAL	ABSOLUTE ROUGHNESS (mm)
- Commercial steel	0.05

- Cast Iron	0.26
- Drawn Tubing	0.0015
- Concrete/Cement Lining	0.30

B. LIQUID LINE SIZING CRITERIA (1), (9)

Service	Friction Loss Ranges *(Bar/100 m)*	Velocity range *(m/s)*
Pump Suction	0.05 ~ 0.10	(note 2)
Pump discharge	0.20 ~ 0.45	(note 2)
Cooling water (header)	0.06 ~ 0.24	(note 2)
Cooling water (branches)	0.30 ~ 0.45	(note 2)
Gravity Flow	0.035 (MAX.)	

Notes:

1. The limiting factor in line sizing is either the upper limit of the friction loss range or maximum velocity (upper limit of the velocity range).
When available pressure drop in the system calls for a lower friction loss/velocity as compared to the above ranges, then such lower friction loss/ velocity shall apply.

2. Velocity limits depend on line diameter:

		SUBCOOLED m/s	BOILING m/s
Pump suction: (4) & (5)	up to 2”	0.3 ~ 0.6	max. 0.5
	from 3” to 6”	0.6 ~ 1.0	max. 0.9
	from 8” to 10”	0.8 ~ 1.5	max. 1.2
	over 12”	0.9 ~ 3.0	max. 2.0
Pump discharge (8) & (11)	up to 2”	0.6 ~ 1.2	max. 1
	from 3” to 6”	1.0 ~ 2.4	max. 2
	from 8” to 10”	1.5 ~ 2.8	max. 2.4
	over 12”	2.4 ~ 3.6	max. 3.2

3. Reciprocating pumps line sizing criteria shall be based on the maximum flow rate of pulse flow. Suction and discharge line for simplex and proportioning pumps should be sized for 1.6 and 3.14 of the maximum pumping rate respectively.

4. Saturated liquid pump suction lines call for larger suction nozzles to prevent vortexing, when no enough liquid depth on vessel is provided.
The line must run 6 ~ 8 times nozzle diameter vertically before reducing the size of the line.

5. Pump suction lines to be primarily sized by NPSH requirement.

6. In general for corrosive or erosive fluids velocity limits should be halved. Lines in corrosive and erosive services shall be investigated individually and in case of requirement of lower velocity then such lower velocity shall be based upon for the design of such line.

7. Above friction loss/velocity ranges can be slightly exceeded for short branch lines, when pressure-drop is not limiting or in intermittent services.

8. Cooling water header and branches sizing shall be based on velocity range within a max. limit of 3 m/s. for branches and 2.44 m/s for main header.

9. Above criteria shall apply unless more stringent requirement is mandatory by the process Licensor.

10. Snuffing steam piping shall be sized according to the maximum pressure available at injection point at steam flow rate corresponding to firebox fill up in 2 minutes. Snuffing steam for fire box, header boxes and convection section shall be three separate laterals.

11. For cement lined pipe, maximum velocity limit is 3 m/s.

C. GAS AND STEAM LINES SIZING CRITERIA (1) , (7)

Service	Friction loss Ranges (Bar/100 m)	Velocity range (m/s (2))
Gas and vapors		
Less than 1 bar (a) (vac.)	0.01 ~ 0.02	20 ~ 30
Up to 7 bar (g)	0.02 ~ 0.1	20 ~ 30
From 7 to 69 bar (g)	0.1 ~ 0.4	20 ~ 35
Over 69 bar (g)	0.7 % of the op. press.	20 ~ 40
Steam (saturated)		
Less than 3.5 bar (g)	3.3 % of the op. press.	15.2 $(d)^{0.5}$ (3)
From 3.5 to 17 .2 bar (g)	0.1 ~ 0.3	12.0 $(d)^{0.5}$ (3)
From 17.2 to 69 bar(g)	0.3 ~ 0.7	9.0 $(d)^{0.5}$ (3)
steam (super heated)		
Less than 17.2.bar (g)	same as gas and vapor	
Above 17.2.bar (g)	2.3 % of the op. Press.	15.2 $(d)^{0.5}$ (3)

Notes:

1. The limiting factor in line sizing is either the upper limit of the friction loss range or maximum velocity (upper limit of the velocity range).
   When available pressure drop in the system calls for a lower friction loss / velocity as compared to the above ranges, then such lower friction loss / velocity shall be applied.

2. Absolute maximum velocities limits, where technically applicable, are as follows:

   - gas and vapors and superheated steam
     less than 17.2 bar (g) : 50% sonic (*)
   - saturated steam and superheated steam
     above 17.2 bar (g) : 30.5 $(d)^{0.5}$
     subject to the following absolute limitations
   - saturated steam : 50 m/s ;
   - superheated steam : 75 m/s

   (*) sonic or acoustic velocity:
   - sonic velocity : 91.2 $\{ (T / M . W) \}^{0.5}$.

   Where:
   T = fluid temperature, deg. K
   M.W. = fluid molecular weight
   d = Nominal pipe Diameter (inches)

3. For corrosive or erosive fluids velocity limits should be halved.

4. Above friction loss / velocity limits can be slightly exceeded for short branch lines, when pressure drop is not limiting or in intermittent services.

5. Operating pressure refers to in absolute pressure.

6. Above criteria shall apply unless more stringent requirement is indicated by the process licensor.

D. MISCELLANEOUS

1. Two phase flow :

   i. In addition to the above friction loss / velocity criteria, special consideration shall be given to the type of flow, to ensure flow stability.
   ii. The maximum limit shall be 4.5 Bar / Km for pressure drop and "122 / $(Dm)^{0.5}$" maximum average velocity . Where Dm = mixed phase density in Kg / m 3.
   iii. The maximum average fluid velocity for transfer lines between furnace and tower shall not be higher than "V = 73 / $(Dm)^{0.5}$" at operating conditions.

2. Drainage and Sewer Lines :
   - Funnels diameter is 4 inches minimum.
   -Sewer header size will be determined during Detailed Engineering according to final layout.

3.Rundown Lines to Storage:
   Friction loss considered shall be 2.3 bar / km max.

4.Water hammer effect shall be checked with maximum limits of velocity for sizing.

5.Start-up and shut-down lines should be sized for ½ unit design flow throughput.

E. SIZE OF PROCESS AND UTILITY NOZZLES

E.1 Size of process and utility nozzles on vessels and towers is to be same as the line sizing criteria, (Re Para. A,B,C and D above) unless otherwise specified in this Specification . However for shell and tube exchangers the criteria specified in TEMA shall be applied.

E.2 COLUMN DRAW OFF NOZZLES

The nozzle and line used to withdraw a stream from the side of a fractionating Column should be sized for a maximum velocity according to the following table:

Suction Box Max . Velocity	Liquid Falling from above 0.3 m/s	From quiet Zone 0.6 m/s
Draw off nozzle Min. Velocity	Min . Liquid L.	Height Above Nozzle
1.2 m / sec	914 mm	610 mm
0.9	762	457
0.6	610	305
0.3	305	152
0.15	152	0

From a point 3048 mm below the draw off nozzle, the line can be reduced to its regular size.

5.7 SHELL AND TUBE HEAT EXCHANGERS

5.7.1 Heat Exchangers shall be designed according to TEMA class "R".

5.7.2 When alternate operating is specified, the exchanger unit shall be designed to handle either condition without exceeding the allowable pressure drop.

5.7.3 For shell side fouling factor of 0.0004 hr. ^{o}C m^2 / kcal or greater, square pitch shall be specified.
For services with a fouling factor less than 0.0004 hr .^{o}C m^2 / kcal, a triangular pitch may be used . Tube size and Pitch shall be as per following table:

Shell side Fouling (hr . m2 .^{o}c/kcal)	Tube Side Fouling (hr. m2 .^{o}c/kcal)	Tube O.D. (inch)	Pitch (inch)
Up to 0.0004	Up to 0.0006	¾	1 Triangular
Up to 0.0004	Over 0.0006	1	1 ¼ Triangular
Over 0.0004	Up to 0.0006	¾	1 Square
Over 0.0004	Over 0.0006	1	1 ¼ Square

Exceptions:
- Use square pitch if shell side allowable pressure drop is low
- Use square pitch if vapor / liquid separation is required.
- Use triangular pitch if turbulence required.

5.7.4 Unless otherwise technically justified:
i. Dirty fluids should be passed through the tubes.
ii. High pressure fluids, corrosive stock and water are sent through the tubes.
iii. Large volume fluids (vapors) are passed through the shell.
iv. Vapors that contain non-condensable gases are sent through the tubes.
v. If the pressure drop must be low, the fluids are sent through the shell.
vi. In fin tube equipment, high pressure, dirty or corrosive stock is sent through the fin tube.
vii. Condensing steam is normally passed through the tubes.
viii. If the temperature change of one fluid is very large (greater than approximately 145 ^{o}C to 175 ^{o}C), that fluid is usually passed through the shell rather than the tubes.

5.7.5 U tubes could be specified, when the fouling factor on the tube side is equal to or less than 0.0004 hr. ^{o}C m^2 / kcal or when required by the process fluid on the shell side.
Floating head exchangers shall be specified for fouling services and cooling water services, except for surface condenser of steam turbines.

5.7.6 Shell and tube type exchangers to be preferred to double pipe or multitube type exchangers.

5.7.7 The fouling factors for the various services shall be selected according to the figures listed in the "Standards of Tubular Exchanger Manufacturers Association (TEMA)".
The tube side fouling resistance shall be increased by the outside / inside surface ratio as per TEMA.
For fresh water cooling system the fouling factor shall be 0.0004 hr.^{o}C m^2/ kcal.

5.7.8 Four way back-flushing valves shall be provided for all water cooled exchangers except for following sizes:

- Higher than 12",
- Equal or lower than 2".

5.7.9 The inlet and outlet of all shell and tube process / process exchangers shall have a board TI at the inlet and outlet of each stream. For water coolers, the water side outlet to be equipped with a local TI only. The shell side in and out shall be provided with board TIs . Thermowells to be provided between each shell side and tube side of the same service for stacked exchangers.

5.7.10 A globe valve shall be provided on the water return line from each water cooler for line sizes 6" and lower.

5.7.11 The following overdesign factors to be considered for the heat exchangers:

a) Overhead condensers: to take into account the greatest of either 10% of the estimated maximum operating duty or the duty increase of the corresponding reboiler.

b) To take into account the risk of undersizing of heat recovery systems (i.e. feed-effluent, feed bottom), the following oversizing to be specified:

- Effluent cooler (or feed preheater): 10% of cooler duty (or Preheater duty) or 5% of feed / effluent exchange duty, whichever is greater.
- Reboiler: 5% of feed bottom exchange or 10% of reboiler duty whichever is greater.
- Bottom cooler: 10% of cooler duty or 5% of feed / bottom exchange duty, whichever is greater.
- Pumparound exchangers: 10% on flow rate.
- Steam turbines condensers: greater of 10% on duty or 10% on flow rate.

c) For all other cases 10% overdesign on the flow rate shall be considered.

5.7.12 The nominal straight tube lengths in order of preference are as follows. Using of any other type is not allowed.

- 6.10 m (20 f t)
- 4.88 m (16 f t)
- 3.66 m (12 f t)

5.7.13 Unless otherwise specified on the Process Data Sheet (e.g. presence of ammonia), all water cooled exchangers shall have inhibited Admiralty Brass or superior material tubes with Naval Brass tube sheets. Carbon steel material for tubes and tube sheets of water coolers is not acceptable. Exchangers operating with water on the shell side should have baffle and tube supports of Naval Brass.

5.7.14 The heat transfer area and heat transfer coefficients shall be based on the outside effective tube surface.

5.7.15 For all exchangers a maximum nominal diameter of the tube bundle of 1140 mm is allowed. For special cases, higher diameters may be permitted only by the Owner's approval. For steam generation exchangers and kettle type reboilers the maximum tube bundle diameter of 1540 mm is accepted.

5.7.16 Design average velocities in tubes for cooling water shall be kept within the under mentioned operating range. Velocities for fluids other than water in the tubes shall

be such to create a turbulent flow but in no case shall exceed 3 meters per second. Average velocities for shell side should be kept between 0.3 to 1 m/s.

	Average Speed m/sec.	
Tube Materials	Min.	Max.
Carbon steel	0. 9	1. 8
Admiralty	0. 9	1. 8
Aluminium brass	0. 9	2. 4
Aluminium bronze	1. 5	3. 1
Cupronickel	1. 5	3. 1
Aluminium	0. 9	3. 1
Monel	1. 8	3. 1
Stainless steel	2. 4	3. 1

5.7.17 When the design pressure of the low pressure side is less than 10/13 of the design pressure of the high pressure side, the design pressure of the low pressure side shall be increased to at least 10/13 of the design pressure of the high pressure side to reduce possibility of tube failure risk.

5.7.18 Water cooling shall be specified for turbine exhaust steam surface condenser.

5.7.19 Water cooler outlet temperature for process side shall be maximum 46 ºC.

5.7.20 The carbon steel partition plates of water cooled exchangers should be protected by installation of Magnesium sacrificial anodes.

5.7.21 Exchangers shall be provided with jackscrew to move bundles into position for handling by mobile crane. Tube bundle jack and lifting devices shall be provided as required.

5.8. AIR COOLERS

5.8.1. Air cooling shall be maximized.

5.8.2 Tube length of 9.15 m (30 ft) shall be used . When appropriate, shorter tube lengths is allowed upon the Owner's approval .

5.8.3 The preferred process temperature breakpoint between air and water cooling for services when air cooled exchanger to be followed by water cooled exchanger is 58 ºC. Air cooler outlet temperature with no downstream water cooler is preferred to be 50 ºC (if economically feasible based on air design conditions).

5.8.4 Forced draft fans to be used in all air cooled exchangers.

5.8.5 When winterizing is required, the following criteria shall be followed:

- provision of louvers plus steam coil ,
- internal or external air recirculation plus steam coil (for more sever cases).
- For winter design conditions , the minimum tube wall temperature shall be at least 8 ^{o}C higher than pour point for both normal and minimum design throughputs.

5.8.6 Limit nozzles into header to 6" size.

5.8.7 The tube side fouling factor is net value and must be adjusted by total effective outside to inside surface ratio. All heat transfer surfaces and coefficients shall be based on total effective outside tube and fin surface.

5.8.8 When it is required to control the process fluid outlet temperature or justified to conserve electrical power, 50% of the fans in the air bay shall be specified with auto-variable (AV) type blade pitch control.

5.8.9 An overdesign factor to be considered for the air coolers as following criteria:

- Overhead air condensers: to take into account the greatest of either 10% of the estimated maximum normal operating duty or the duty increase of the corresponding reboiler.
- To take into account the risk of undersizing of heat recovery systems (i.e. feed – effluent , feed – bottom), the following oversizing to be specified :
    - Reactor effluent air cooler: 10% of air cooler duty or 5% of feed / effluent exchange duty, whichever is greater.
    - Bottom air cooler: 10% of air cooler duty or 5% of feed / bottom exchange duty, whichever is greater.
    - Pumparound or overhead product air cooler: greater of 10% on air cooler duty or 10% on flow rate.
- For all other cases 10% overdesign on the flow rate shall be considered.

5.8.10 CONTROL OF AIR FLOW

Control of air flow is required for one and / or more of the following reasons:

a. Where a close control on heat removal rate is required.

b. Where the possibility exists that a portion of the fluid being cooled or condensed freezes as "frost" on the inside tube surface.

c. Where fluid being cooled may, if overcooled, become so viscous that flow will decrease in coldest tubes and possibly fluid will be congealed on tube walls. This results in increasing of pressure drop, insufficient cooling of fluid through open tubes, and in some cases loosening of tube rolls and subsequent leaking.

d. When an air cooled heat exchanger is being designed for alternate operation, which are somewhat different in regard to throughput and / or temperatures of normal operation, such a situation could exist in conjunction with any one of the above mentioned conditions.

5.8.11 FAN EQUIPMENT RECOMMENDATION (*)

a. For the reasons mentioned in **5.8.10** above and conservation of electric power the following is recommended : One- half (1/2) of fans in the air bay shall be the auto-variable (AV) type where blade pitch is automatically adjusted to desired angle by manual adjustment of a remote control knob into a pneumatically actuated relay system . Remaining fan (s) shall be the standard type where blade pitch can be adjusted manually when fan is stopped.
They are designated hereafter as (SP) type.
The manual loading control equipment ** (and transducer if required) will be furnished by others to operate the (AV) fan (s).
It will have a 0.2 to 1.034 bar (g) output range. The control station will be located:

* on main control board .

☐ near exchanger site .

Dry, oil free, instrument air at 6.2 bar (g) is available for actuation of power cylinder that positions (AV) fan blades .
When there are multiple bays, there will be multiple (AV) fans. All parallel (AV) fans for a common service, including grouping of several or more items into a single bay , shall be controlled in unison through one control station . Outlet temperature observation stations for each item will be located near (AV) fan control station to guide operator. Air exchanger vendor shall furnish the (AV) fan complete with hub mechanism and include air operated actuators plus other devices that are required . Provide volume booster when multiple (AV) fans are involved for a common service. (AV) fan hubs shall be designed to go into high pitch position in event of failure of the control system . If the fan does not respond in this manner, means shall be included by vendor to physically lock the blades in high pitch position . This permits continued operation even if the air system fails .

NOTES : (*) All fans of fractionator's overhead condensers shall be the auto-variable (AV) type .

(**) When exact process outlet temperature is required a temperature indicator controller (TIC) shall be provided for equipment and shown on the respective Mechanical Flow Diagrams.

b. Manufacturer shall verify and guarantee that the above recommendation as specified in item "**a**" above , will satisfactorily fulfill the operating and design conditions, limitation and variation as specified in the individual air cooled heat exchanger project specification and data sheets. Otherwise, the manufacturer shall design and include in his quotation , special features for control of air flow. Such special features shall be approved by the Owner.

c. Manufacturer shall also include facilities for thawing in case of an inadvertent freeze-up and for heating in case of an inadvertent congealing of fluid in the tubes , or for use after a shut down .
Such facilities shall be included in manufacturer quotation and shall be guaranteed that these facilities will eliminate possibilities of occurrence of inadvertent freeze- up or congealing of fluid in the tubes of the relevant air cooled heat exchanger during operation and shut down.

5.8.12 All welded steel plate headers shall be stress relieved after completion of header but prior to tubing installation.

5.8.13 For determination of fan H.P. rating, the calculated static pressure drop over the tube bundle at maximum design temperature shall be increased by 20%.

5.8.14 Necessary flanged should be considered on air cooler headers and manifolds in order to avoid lifting big sections of headers to remove air cooler sections.

5.8.15 All tubes shall be in fully annealed conditions as received from the mill.

5.8.16 Omit vent and drain connections for “Reactor Condensers” (or coolers) on Hydrogen services.

5.8.17 Manifold piping requirements for single phase and two phase inlet fluids of air coolers shall be according to the good distribution of the flow and approved by the Company.

5.9.HEATERS

5.9.1 Gas burners only, without provision for the future installation of oil burners may be provided for the following heaters when required by the Licensor:

- Reactor charge heaters.

All other heaters shall be equipped with combination of oil and gas burners (dual purpose elements) unless otherwise specified by the Company/Licensor.

5.9.2 Vertical firing is preferred for all heaters unless otherwise specified.

5.9.3 A pilot burner shall be provided for each burner.

5.9.4 Solid finned tubes according to API Standard 560 can be used in the convection section of gas fired heaters only. For oil fired heaters bare tubes shall be used. However, in gas fired heaters, minimum two rows in bottom of convection section shall be bare tubes.

5.9.5 Fully retractable soot blowers shall be provided for convection section in the following cases:

- Fuel oil fired heaters,
- Fuel gas fired heaters with finned tubes in the convection section.

5.9.6 For all heaters, maximum reasonably attainable heater efficiency shall be approached. However, heaters with total duty of 29000 kw or higher shall be equipped with static type air preheater and forced draft and induced draft fans and heaters with total duty between 15000 kw and 29000 kw shall have forced draft fans.

5.9.7 Minimum stack height above grade shall be calculated such that to minimize pollution in accordance with the latest European standards. Moreover, furnace stacks shall reach at least 7 meters above the highest platforms located within 30 m, which may require attendance during operation. Individual stack supported from each heater shall be provided unless otherwise indicated on the heater data sheet.

5.9.8 Low NOx emission burners shall be used.

5.9.9 All heaters shall be provided with knife edge skin thermocouples for each pass.

5.9.10 The following instrument connections as minimum requirement shall be provided for each heater:

a. Draft gauge connections: at burners, below convection section and above and below stack damper.
b. Flue gas sampling connections :
   Below convection section and below stack damper, and at suitable locations for analyzing of flue gas .
c. Oxygen analyzer connection: below convection section.
d. Temperature measurement connections: below convection section and below stack damper.

5.9.11 For multipass heaters following shall be specified:

- Mixed phase: symmetrical arrangement of the passes and board temperature indicator on each pass outlet.
- Liquid phase: flow control valve with a minimum flow stopper on each pass inlet and board temperature indicator on each pass outlet .
- Vapor phase: symmetrical arrangement of the passes and board temperature indicator on each pass outlet .

5.9.12 Flow alarm low and flow switch low low (for heater shutdown purpose) shall be provided at inlet streams to the heater. In multipass heaters flow switch low low may be provided only on the selected passes upon recommendations of the manufacturer.

5.9.13 For convection type heaters, board mounted temperature indicator for each pass shall be provided at transition zone between the convection and radiation.

5.9.14 Oversizing shall be considered as following:

- Feed heater : 10% of heater duty or 5% of feed /effluent exchange duty (if any), whichever is greater.
- Reboiler heater : 10% of reboiler duty or 5% of feed / bottom exchange duty (if any) , whichever is greater.
- Other heaters: As per process requirements or 10% of heater duty, whichever is greater.

5.9.15 Snuffing steam connections and lines shall be provided for all heaters.

5.9.16 Burners and Fuel System

For heater firing arrangement, reference shall be made to the following standard drawings in addition to the requirements stipulated herein below:

- SD-00-0102-1/2 "Typical Furnace FO/FG Firing Arrangement"
- SD-00-0102-2/2 "Typical Furnace Fuel Gas Firing Arrangement"

a. Arrangement of the burners shall be in accordance with heater supplier's standard design so as to give the most uniform tube-wall skin temperature. Heat release per burner and arrangement of burners shall be such that the flame will not impinge on the tubes of the heater at a release of 50 percent above design with maximum draft.
b. Provision shall be included so that fuel atomizing steam and combustion air to each burner can be manually adjusted from normal operating platforms 25% to 150% of design rates.
c. All special burners hoses, fitting and special valves shall be supplied by the vendor.
d. All burners are to be equipped with pilots and suitable strainers in each pilot line. Mesh shall be 18/8 S.S.
e. A minimum of three burners shall be used for liquid fuel fired heaters.
f. Burner isolation valves from the main fuels and steam shall not be located under the heater, and shall be arranged to be within arms length of the peep-holes enabling burner flames to be seen.
g. Burner isolation valves, including pilot valves shall be ball appropriate class. Clear indication of "open" and "closed" positions is required.
h. In addition to burner steam purging, oil and gas fuel lines between burner valves and burners shall have purging facilities with purging valve adjacent to burner isolation valves.
i. Heater boxes are not mandatory where coils are of all welded construction. Plug return heaters (clean - out heaters) shall be completely enclosed in air-tight insulated steel boxes with hinged doors or removable panels. Heater boxes shall be provided with a 2 inch forged steel coupling for snuffing steam connections. Heater compartment doors shall have positive locking devices and asbestos gasket seal. Heater boxes shall be insulated to keep the outside insulation surface temperature below 60 ^{o}C.
Heater boxes shall be provided with a drainage connection.
j. Snuffing steam shall be made available at furnace heater boxes and fire boxes.

k. When combination of oil and gas burners shall be provided, it must be capable of firing any combination of fuel gas, and liquid fuels.
Fuel properties are shown on the Fired Heater Data sheets.
l. Multiple burners are preferred on all heaters.
m. Burners shall be designed if possible to permit automatic operation form 25 to 125% of design heat release. If practical greater turn-down ratios are desirable.
n. Pilot gas isolation valves shall be positioned out of line with the burners.
o. A solenoid operated bubble tight shut - off valve shall be installed in each main furnace fuel line adjacent to the control valve. Operation shall be remote manual or automatic on closing, and manual only on opening. Loss of fuel or atomizing steam pressure shall also automatically close these valves. Pressure switch low and pressure switch low low shall be provided downstream of main control valve on fuel and atomizing steam lines.
p. Main fuel and pilot headers to the furnace shall be equipped with manually operated isolation valves and grouped together with firebox steam purge valves and process blowdown valves between 15m and 20m from the furnace in an easily accessible location at grade.
q. The regulated pilot gas, where possible should be from an independent sweet gas supply or from a separate off- take on the fuel gas main (upstream of main fuel gas control valve) with its own spaded block valve. If continuous pilots are specified, additionally a solenoid operated shut - off valve shall be installed in the pilot gas line operated by emergency shut - down switch only. Low pressure alarm and pressure switch low low to shutdown the heater (when actuates) on pilot gas line downstream of PCV shall also be fitted.
r. Atomizing steam should be supplied via a steam /oil differential pressure controller operable over the specified firing range of the burner.
s. All fuel (including fuel gas) lines shall be independently traced, except gasoline.
t. The fuel oil system shall be designed such that 2 parts be supplied to the heater, one part burned and one part returned. The size of the return header shall be the same as the size of supply header.

5.9.17 Welded U bends for heaters are not acceptable.

5.9.18 Calculated and guaranteed heater efficiencies shall be based on the design duty, fuel lower heating value, ambient temperature of 25 ºC and 15 percent excess air for fuel gas or 25 percent excess air for fuel oil.

5.9.19 Furnaces shall be equipped with steam air decoking connections. These facilities shall include one 4” blinded connection on inside of inlets and outlets of furnace terminal connections.

5.9.20 Stack and ducts shall be based on the operation at 125 percent of furnace design capacity with 50 percent excess air.

5.9.21 Steam superheater coils shall be designed for no flow conditions when steam generation facilities are not included in the heater design.
For heaters equipped with both steam generation and superheater coils, the design of the steam system shall consider the protection of the steam coils under all operating conditions .

5.9.22 Oxygen analyzer shall be specified for all heaters.

5.9.23 Use of studded tubes in gas firing shall be subject to Employer's approval.

5.9.24 Castible refractory shall be used. Ceramic fiber refractory is not acceptable.

5.10 PUMPS

5.10.1 Oversizing factors (based on the maximum operating flowrate) shall be as follows:

- 20% for reflux , pumparound and reboiler pumps ,
- 10% for product pumps ,
- 100% for injection pumps ,
- 10% for other transfer pumps (excluding feed pumps) ,
- No overdesign for feed pumps.

5.10.2 Electrical motor drivers shall be used except for critical services such as following which steam turbines shall be used .

- Pumps specified by the Licensor (if any) ,
- Surface condenser condensate main pump,
- Main Reflux Pumps

5.10.3 Continuous service process pumps shall be provided with full (100%) spares unless otherwise approved by the company.

5.10.4 All pumps shall be equipped with permanent strainer. The strainers shall be shown on P & IDs . “Y” type strainer can be used for all pumps with suction line size of 2” and less . Basket or "T" type strainer shall be used for all other pumps. Strainers DN150 (6 inch) and larger shall have DN 25 (one inch) drain valve.

5.10.5 Pumps in the process area shall be specified to conform to API - 610 standards. For light duty, non hydrocarbon services outside the process area, non API pumps in conformity with NIOEC Specifications NIOEC-SP- 46-01 & NIOEC-SP -46-12 may be used upon Employer’s approval.

5.10.6 Vertical pumps application shall be limited to the services where NPSH or head limitations make use of horizontal pumps impractical.

5.10.7 Dual seals (double or tandem depending upon process requirements) shall be used for specific services such as:

- Hydrocarbons above their auto ignition temperature or at a temperature > 250°C,
- Dirty service ,
- Vapor pressure of pump fluid greater than 5 bar (abs) on each operation temperature in seal chamber,
- LPG and C4 or more light hydrocarbon pump fluid,
- High pressure pumps (> 38 barg),
- Toxic or carcinogenic fluid.
- For services that the H_2S composition of the fluid leakage rate shall probably exceed 1g/s when the seals fail.

5.10.8 Horizontal pumps shall be centerline mounted.

5.10.9 Shaft sleeves are required for all pumps.

5.10.10 All horizontal pumps with 2 or more stage and all horizontal double suction pumps shall have the impellers mounted between bearings.

5.10.11 Mechanical seal end plate should be stainless steel material.

5.10.12 Pumps with mechanical seals operating above 121 ºC shall be provided with water jacketed stuffing boxes.

5.10.13 Bellows type mechanical seals with all metallic parts shall be used for hot services where liquid is clean and fluid temperature is 232 ºC and higher up to 426 ºC.

5.10.14 Centerline discharge nozzle pumps (AVS type) are not acceptable.

5.10.15 NPSH calculation considerations:

a. The suction line losses shall be based on rated flow capacity of the pump. Pressure drop through any permanent strainer should be 0.61m of liquid head for NPSHA calculations.
b. For subcooled liquids, the source pressure shall be at the maximum operating pumping temperature.
c. Static head shall be measured from the vessel bottom tangent line to the centerline of a horizontal pump, or to the suction nozzle of a vertical pump.
d. If vortex breaker is installed at vessel outlet, the pressure drop through it shall be considered.
e. For horizontal centrifugal pumps, the elevation of the pump centerline shall normally be 0.9m. above grade unless the actual elevation is known.
f. For viscous fluids, the correction factors in the Hydraulic Institute Standards, paragraph B.70 through B.74 shall be used.

5.10.16 Drains shall be installed above the seat in flanged check valves if check valve is located in vertical lines for 2" and smaller check valves. The connection may be in the line immediately above the valve. Valves 3" and 4" shall be drilled and tapped ½" and valves 6" and larger shall be drilled and tapped for a ¾" drain.

5.10.17 The following criteria shall be applied to sizing of pump valves:

a. Suction block valve to be same size as suction line if the pump nozzle is one size smaller than line. Suction block valve may be one size smaller than suction line if the pump nozzle is two sizes smaller than line.
b. Discharge block and check valve could be one size smaller than the discharge line, but not smaller than pump discharge nozzle. For lines 2" and smaller, all valves (block and check) shall be line size.

5.10.18 Valved vents and drains shall be installed on the low and high points of the pump case. Casing vents shall be provided so the pump casing can be filled with liquid before the pump is started. Casing vents and drains shall be piped as follows.

COMMODITY	VENT	DRAIN
- C4 and lighter	(*) Pipe to flare or suction source	(*) Pipe to flare or suction source
- Liquids above flash point	(*) Pipe to flare or suction source	(*) Pipe to flare or suction source and sewer with drain cooler
- Liquids with RVP > 0.35 BARA	Pipe to flare or suction source	Pipe to flare or suction source and sewer
- Liquids below flash point	Pipe to sewer	(**) Pipe to sewer
- Heavy subcooled liquids (Asphalt, etc.)	plug vent valve	(**) Pipe to drain
- Hazardous service	(*) Pipe to flare or suction source	(*) Pipe to flare or suction source

(*) Vents and drains in this service shall be double valved with a ¾" drain, valved and plugged bleeder between the valve.
(**) The drain valve shall be pipe to the oily sewer or appropriate sewer relative to the material handled, blowdown, pit (for asphalt) or pumpout system.

Note:

(1) In addition to the requirements setforthed above, double valve and bleeder shall be provided for all vent and drain of the pump casing when the pump discharge line pressure rating is equal to or greater than 300#.

5.10.19 For vent in vacuum pump service, the following precautions shall be considered:

a. Vent line should be 1- ½" to 2" in size to maintain circulation at high rates to sweep out gas pockets in the suction line.
b. The vent line should be returned to the suction source.
c. Vents shall be adequately steam traced and insulated if the pumped liquid will congeal at ambient temperatures.

5.10.20 Suction valves for vacuum pumps and where gas entrainment in the suction line may be a problem should be in vertical piping (3 m. minimum). Maximum velocities in the vertical piping shall be 0.6 m/sec for 4" and smaller lines and a maximum of 0.75 m/sec for larger sizes so that gases must work upwards readily.

5.10.21 Suction piping layout shall conform to the following :

a. Suction piping should not contain pockets where vapor or liquid may accumulate.
b. All vacuum suction lines shall be minimum length.

5.10.22 A warm-up bypass shall be provided for pumps which may be idle or on standby during plant operation and which will operate at or above 170 ^{o}C, or if the process fluid will solidify at ambient temperature. The bypass shall be sized for 3% of normal flow or shall be a ¾" line (whichever is greater). The bypass shall have a globe valve and shall be installed around the pump discharge check valve.

5.10.23 Reciprocating pumps shall have pulsation dampeners on the discharge side where liquid pulsation should be minimized from process and operation viewpoints. The size shall be as follows:

PUMP TYPE	DAMPENER VOLUME
- Simplex	6 X Displacement per stroke
- Duplex	3 X Displacement per stroke
- Triplex	3 X Displacement per stroke

5.10.24 Pumps charging fractionation system or columns should be checked for adequate differential head to maintain a substantial flow rate to the column when possible maximum normal pressure may occur. The system control valve should be able to "give up" enough pressure drop to maintain a substantial flow rate to the column.

5.10.25 Spares in critical services shall be equipped with automatic start facilities when the spare pumps actuated by loss of discharge pressure of the regular pump unless otherwise specified by the Licensor. Typical critical services are:

- Fired reboiler circulating pumps,
- Steam generation circulating pumps,
- Refrigeration pumps,
- Surface condenser condensate pumps,
- Compressor lube oil and seal oil pumps.

5.10.26 Reciprocating and Rotary Positive Displacement Pump Max. Pressure:

a. Pump stalling pressure shall be checked to determine it does not exceed the maximum pressure of the piping and equipment which could be subject to this pressure.
If the stalling pressure is higher than the system pressure rating, either the system pressure rating must be increased accordingly or a pressure relief

valve must be installed on the pump discharge.

b. Maximum allowable pressure is defined as the highest pressure which can occur in the pump when bypassing the full of the pump through its relief valve with an accumulation of not more than 10% above the maximum set pressure.

5.11 COMPRESSORS

5.11.1 The compressor's oversizing shall be as follows:
- Make-up: 10% plus spill back rates (if any).
- Recycle: depends upon the process but not less than 20% on flowrate.
- Gas quench: 20% (minimum)
- Product gas and other services: 10%

5.11.2 When compressing wet gases, the type of compressor shall be horizontal.

5.11.3 Centrifugal and axial compressors will not be spared, but a spare rotor shall be provided. In addition, an appropriate shop test shall be specified for centrifugal and axial compressors.

5.11.4 Bearing temperature and vibration monitoring equipment shall be specified. Vibration and axial position probe shall be none contacting type.

5.11.5 The impellers shall be designed to limit maximum stress at maximum continuous speed to a value of 70% of the material yield strength.

5.11.6 Maximum yield strength for the recycle gas compressor impellers shall be 5517.2 bar (80000 PSI). Unless otherwise specified on the data sheet, the impeller material should be AISI 4130 or approved equal and double tempered to ensure 100% tempered martensite structure.

5.11.7 Lube oil console for recycle compressors shall be shop tested with their respective compressor.

5.11.8 For compressor cylinder cooling water temperature, alarm should be provided for each cylinder. High level alarm in moist separators should also be provided.

5.11.9 Alarm and shutdown for high vibration shall be provided for all reciprocating compressors.

5.11.10 Unless otherwise specified herein above, for process design of compressors, reference shall be made to NIOEC-SP-00-89.

5.12 CONTROL SYSTEM AND INSTRUMENTATION

For control system and instrumentation reference shall be made to the design criteria for process control and instrumentation as outlined in NIOEC-SP-70-01.

5.13 PRESSURE SAFETY RELIEF VALVES

Pressure safety relief valves shall be according to NIOEC-SP-00-75 unless otherwise specified herein below in this Specification.

5.13.1 General

a) Pressure relief valves shall be provided as indicated on the P&IDS, required by local authorities, applicable pressure vessel code and as recommended by the referenced codes.

b) It is the obligation of the detailed engineering contractor to implement the requirements of local authorities/regulations; this may include more stringent requirements for over-pressure, blow down, etc.

c) Pressure relief valves shall have flanged or welded process connections.

d) Pressure relief valves with welded process connections, if any, shall be provided with a lifting lever and tested for proper operation immediately after the valves are welded in the pipeline.

5.13.2 Specification

Safety valves (excluding thermal relief valves) shall be specified in accordance with the following table:

TYPE	**SPRING FULL LIFT**	**PILOT, SNAP ACTING**	**PILOT, MODULATING**
NOZZLE	FULL	SEMI, FOR THERMAL RELIEF VALVES	
BELLOWS	Where back pressure is superimposed Where built-up back pressure exceeds 10 % of set pressure Where there is a rupture disc downstream of the valve Where valve vents in a closed header system (e.g. flare header)		
LIFTING LEVER	In steam, air and water services above 60 C For valves with welded ends As required by local authorities		
GAG	Required for all valves installed on equipment to be hydro-tested		

Notes:

1. Lifting levers shall not be used in flammable service.

2. Test rods shall be supplied as loose items. Test rods may be used during hydrostatic testing of pipe lines however shall always be removed before start-up of the plant.
Pressure relief valves shall be installed in full compliance with the valve Manufacturers instructions, taking notice of weep hole requirements etc. Special attention shall be paid to the valve supports in view reaction forces induced by a relieving valve.

5.13.3 Accumulation

The accumulation used in calculating sizes of relieving devices shall be as follows:

SERVICE	**ACCUMULATION**
Steam service where ASME Power Boiler Code applies	3 %
Gas and vapour service and liquids except as notes 1 and 2 below.	10 %
Note 1: Fire exposure on unfired pressure vessels.	21%
Note 2: Liquids-for thermal relief of pipelines and pump discharges.	25 %

5.13.4 Application

a) Single pressure relief valve shall be specified for each service unless:

- Multiple valves are necessary because the required capacity can not be provided in a single valve or are preferred for a particular services
- Dual valves are required in accordance with the American Society of Mechanical Engineers (ASME) for Boiler and Pressure Vessel Code, Section I.

b) Spare pressure relief valves are normally not required unless otherwise specified by the Licensor/Basic Designer.

c) For steam service governed by ASME Boiler and Pressure Vessel code, section I, the use of inlet or outlet block valves is not permitted.

d) All pressure vessel pressure relief valves (except as noted in this item) should be equipped with L/O blocked valves at inlet & outlet and by-pass line (when discharging to closed relief header).

e) Criteria for Discharging PR valves to closed systems shall be as follows:

- Pressure Relief (PR) valves handling hydrocarbon liquid materials or partially liquid at the valves inlet.
- PR valves normally in vapour service, but which under any single contingency may discharge flammable, corrosive or hazardous liquids.
- PR valves located in the vapour space of partially liquid filled vessels, which could rapidly fill with liquid during a plant upset.
- PR valves in toxic or polluting vapour services where discharge to the atmosphere would result in the calculated concentration at the property line or at any working area (either at grade or an elevated platform) exceeding the Threshold Limit Value (TLV).
- Release of flammable vapours which, if discharged to atmosphere, would in the event of inadvertent ignition result in radiant heat intensities in excess of the permissible exposure level for personnel.

f) Criteria for discharging PR valves to the Atmosphere shall be as follows:

- The fluid handled must be all vapour at the valve inlet.
- The valve must not fall into any of the criteria noted in item 5) above.
- The density of the released gas is lower than the air density.
- Such disposal is not in conflict with the current regulations concerning pollution and noise.
- Gas released is non-flammable, non-hazardous and non-condensable.
- The gas velocity at the emission is higher than 150 m/sec.
- The gas does not condense at the ambient temperature.

g) Blow down System for Liquid Relief Stream Disposal for voluntary and involuntary liquid discharges shall be:

- To onsite dedicated liquid blow down drum (separately for each case) if the material discharged contains solvent to be recovered may congeal at low temperatures in closed relief system (flare).

- To oily water sewers only if the material will not cause hazardous conditions and/or will not be congealed at the ambient conditions.
  The liquid discharged to an oily water sewer shall be non-volatile and non-toxic. The required liquid relief rate shall be within the oil removal capability of the oily water treating system.

- To pump suction if pump will not overheat or can withstand the expected temperature rise.
  Required liquid relief shall discharge to an upstream liquid reservoir from which the pump takes suction.
  The liquid relief may discharge directly to the pump suction line if sufficient cooling is provided to prevent a temperature rise of the liquid recycled through the pump when the safety/relief valve opens or when a constant displacement pump is used.

5.14 PILOT OPERATED PRESSURE RELIEF VALVES

Pilot operated pressure relief valves shall be specified where:

a) Process operating pressures are close to set pressure of the pressure relief valve;
Or

b) The relieved service fluid is corrosive.

In general, valves of pop-action type are used. Where minimum loss of fluid or stable operation is required during relief, valves of modulating action type are to be considered.
The pilot operated pressure relief valve design should be such that, in the event of failure of an essential part of the pilot, the main valve opens automatically at the set pressure and discharge its full rated capacity.

5.15 RUPTURE DISCS

Rupture discs shall generally not be used when a safety valve could fulfill the demands.
However, for the following cases, a rupture disc may be considered:

a) For secondary relief

b) If 100% tight shut off is required, rupture disc may be located upstream of the safety valve

c) If fluid is corrosive and standard materials for safety valve trim are not sufficient, a rupture disc of special material or with a coating may be located upstream of a safety valve

d) If over-pressure in liquid systems may rise to fast too open safety valve in time

e) If total de-pressurization is required after relief

A rupture disc shall be provided with a "rupture indicator", suitable for remote alarm in the control room when used as primary or secondary relief. In flammable fluid service, the rupture sensor shall be intrinsically safe (Eex "i").

5.16 UNIT BATTERY LIMIT ISOLATION REQUIREMENTS

5.16.1 Block valve, ¾" bleeder and spectacle pressure blind shall be provided for cooling water supply and return, plant water, process water, sour water, condensate, fuel oil, fuel gas, plant air, instrument air, chemicals, Nitrogen, flare header, fire water and all hydrocarbon lines except as noted in this Specification item **5.16.2** below.

5.16.2 Double block valves, ¾" bleeder (1" for hydrogen) and spectacle pressure blind shall be provided for the following services:
-Boiler feed water (Note-1)
-High pressure and medium pressure steam (Note-3)
-Low pressure steam (Note-1)
-Slops lines (Note-2)
-Hydrogen (Note-2)
-All hydrocarbon lines in piping class of 300"and higher.
-Toxic Gas
-Acid Gas

NOTES:

(1) Double block valves and bleeder shall be located at upstream of the pressure blind at unit battery limit.

(2) One block valve at upstream and another one at downstream of the unit pressure blind shall be provided.

(3) Double block valves and bleeders shall be provided at upstream of the pressure blind at unit battery limit. One ¾" warm-up by-pass line with ¾" globe valve shall be provided for each individual block valve for all sizes of 4" and larger.

5.16.3 One ¾" bleeder shall be provided at upstream of the battery limit pressure blind (in unit's side) on all lines in addition to the requirements setforthed in item 2.14.2 above.

5.16.4 For all other cases not mentioned in item 2.14 (e.g. instrumentation, etc.), reference shall be made to NIOEC-SP-00-55.

5.17 EQUIPMENT DESIGN LIFE

Equipment design life shall be in accordance with the following table:

DESCRIPTION	DESIGN LIFE (YEARS)
Reactors / Heavy wall vessels or exchangers	50
Reactor removable internals	15
Columns, other vessels	20
Other heat exchangers	20
Stainless steel, high alloy and non ferrous material heat exchanger tube bundles	15
Carbon steel / low alloyed steel heat exchanger tube bundle	10
Furnace tubes	15
Piping	10

5.18 FLARE SYSTEM DESIGN

5.18.1 Flare system design (applicable to all lines, headers, stack, K. O. Drums, etc.) shall be complied with the requirements of following NIOEC's Specifications unless otherwise specified in this Specification:

-NIOEC-SP-00-76,
-NIOEC-SP-47-04.

5.18.2 The basis of flare system design shall be as follows:

-Constant superimposed back pressure: 0.3 barg
-Built up back pressure (excluding superimposed back pressure): 1.2 barg
-Total Superimposed plus built up back pressure: 1.5 barg
-Mechanical design pressure: 3.5 barg
-Maximum velocity in the flare headers and subheaders: 0.5*Sonic Velocity

6. SAFETY AND ENVIRONMENTAL REQUIREMENTS

6.1SIS (Safety Instrumentated Systems) related to chemistry

In case of risk to the chemistry of the reaction, the S1L (Safety Integrity Level) shall be specified by Licensor/basic designer in order to fit the corresponding SIS. The S1L number

shall be indicated on the Piping and Instrumentation Diagrams (P&1D) and instrument Data Sheet "SHUT-DOWN LOGIC IS" (IS = Interlock Safety).

If Licensor or basic designer specifies a S1L, a typical SIS configuration to be represented for concerned loop(s) and close to the safety interlock (IS) or instrument(s) corresponding to the loop, the following note to be indicated:
"This Safety Instrumented System (SIS) has to be in accordance with safety Integrity Level (S1L ×) for this instrumented loop.

The Engineering Contractor shall make sure that the type and quality of the instrumentation supplied for the SIS, the redundancies which are possibly necessary for sensors and final elements, the logic system, and the on site test frequency will be compatible with the S1L level which is specified."

These S1L numbers shall be indicated on final Piping and Instrumentation Diagrams (P&ID) issued by EPC Contractor.

6.2 SIS not related to chemistry

The S1L and the corresponding SIS connected to equipment protection will be the responsibility of the Engineering Contractor. Licensor/Basic designer shall show on the P&IDs a simple configuration of the SIS.

6.3Fast depressurization

- Fire case : Normally considered for the reaction sections operating at a pressure higher than or equal 17 barg, the depressurization to normaly 50 per cent of the vessel design pressure shall be done manually from a push button, duration: 15 minutes.
  For vessel with thickness lower than 25 mm or for vessel with light hydrocarbons (C_3 to C_5) the depressurization shall be done to 7 barg (or 50 percent of the vessel design pressure if lower), duration: 15 minutes.
- Runaway case: Considered for the possibility of runaway in the reactor, Licensor/basic designer shall specify depressurization device and the activation in accordance with the SIL level-1
  The SIS corresponding to this depressurization shall be in accordance with the SIL, level already specified for the risk of runaway.

6.4 Shutdown of pumps by low level in upstream vessel

Licensor/basic designer shall specify automatic shutdown of the process pumps (or more appropriate actions) by level switch low low (LSLL) via a level transmitter (LT) connected to ESD in upstream vessel.

The Detail Engineering shall indicate during the kick-off meeting if a different philosophy shall be applied by the Licensor/basic designer.

6.5 Shutdown of pumps by low level in upstream vessel

Licensor/basic designer shall indicate a minimum flow bypass with flow control for centrifugal pumps for the following cases:

- Differential pressure multistage pumps higher than or equal 35 bar;

- Large pumps with driver power higher than 160 kW;
- For process reason (turndown), flowrate lower than or equal 30 per cent of max flowrate; The pump data sheet will specify the process flow without provision for the minimum flow which will be specified by the pump's vendor.

6.6 Automatic isolation valves between process vessel and pumps

Licensor/basic designer shall consider automatic isolation valves for:

- an inventory of the process vessel over 8 m^3 of light ends (LPG) :
- an inventory of the process vessel over 8 m^3 and with a product above its auto-ignition temperature or at a temperature above 250 degree C ;
- an inventory of the process vessel above 16 m^3 and a flammable product.

The closure of these valves shall result in the automatic shutdown of the corresponding pumps.

6.7 Spare pump driver for critical service

In case of steam turbine driver selection for pump with critical service the steam turbine will be specified for the normal operation, the electric motor for the spare pump.

6.8 High High levels in feed drum or reaction section separator drum (if necessary)

To avoid overfilling, an independent High High Level alarm (LSHH) via a Level Transmitter (LT) will be specified and connected to ESD.
The level transmitter will be connected to the drum with independent nozzles.

6.9 Isolation of compressor

To reduce the consequences of a fire in compressor area, remote activated isolation valves will be installed in the suction and discharge of any compressor with a power higher than or equal 150 kW and handling flammable or toxic gases.

6.10 Prevention of back flow overpressure

Following devices will be considered at the pump discharge:

- Pressure lower than or equal 40 barg: one check valve
- Pressure higher than 40 barg and smaller than 80 barg: two check valves of different type (stem or shaft blow out resistant, preferably of the non slamming type).
- Pressure higher than or equal 80 barg: two check valves of different type (stem or shaft blow out resistant, preferably of the non slamming type) plus an automatic shut-off valve in case of low flow.

6.11 Isolation of a fired heater

In case of tube rupture in a fired heater and to minimize the consequences of a fire:

- a motor operated isolation valve will be installed at the inlet of the fired heater, if no possibility to shut down the feed flow,
- a check valve or motor operated isolation valve will be installed at the outlet of a fired heater in the following cases:

- heater operation at high pressure higher than or equal 70 barg
- reboiling heater of a column with high gas inventory.

6.12 Seals on pumps

Dual mechanical seals (pressurized or unpressurized according to process considerations) or sealless pumps shall be considered in the following cases:

- LPG
- Hydrocarbons above their auto ignition temperature or at a temperature higher than 250 degree C
- Toxic or carcinogenic fluid
- Pump operating at high pressure higher than or equal 50 barg

6.13 Constraints due to handling of benzene

Due to the known carcinogenety of benzene, the following provisions shall be taken when applicable:

- For all streams containing 0.5 per cent weight or more of benzene and 25 per cent weight or more of C_7 through C_9 aromatics, the following shall apply:

• closed sampling
• closed aromatics collection system with an below grade drum in an open pit receiving all drains of the corresponding process part,
• pumps will be equipped with dual mechanical seals or pumps will be sealless if operating conditions allow it,
• detailed engineering of valves, flanges and joints shall be such as to satisfy the requirements of TWA (Time-Weighted Average) exposure limit of 1 ppm for an 8 hour workday (OSHA's requirement),

- All water streams saturated with aromatics shall be sent to a suitable processing or treating facility in order to minimize aromatic emissions to the environment.

6.14 Constraint due to streams containing H_2S

When a process unit contains streams with H_2S content higher than or equal 10 ppm wt, the following precautions shall be taken into account to avoid release of H_2S to atmosphere:

- Sample connections will be with a closed loop.
- Draining of pressurized liquids which could release H_2S after expansion shall be sent to a dedicated system to be defined by Engineering Contractor:

  • Below grade drum in an open pit for hydrocarbons,
  • Sour water treatment system for acid waters.

Engineering Contractor shall provide adequate H_2S detection system in the process unit.