BASIS OF DESIGN

REV.	DESCRIPTION	PREPARED	CHECKED	APPROVED	DATE
B1	Approved by OWNER	JSM	DPG	JHA	01/2007
A1	ISSUED FOR OWNER REVIEW / APPROVAL	JSM	DPG/CFS	JHA	11/2006

OWNER:

NATIONAL PETROCHEMICAL COMPANY
PETROCHEMICAL INDUSTRIES DEVELOPMENT
MANAGEMENT COMPANY (PIDMCO)

N.P.C.
PIDMCO

PROJECT:

NF3 PLANT OF BIPC

namvaran

TECNICAS REUNIDAS

ASFALT TOUS

NCE DOCUMENT NO.					OWNER DOCUMENT NO.	
NCE JOB NO	Type	Size	Group	Doc. No.	BOD-4-PR-405 / 1	
1211-GN	PR	4	EPP	1405		
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TABULATION OF REVISED PAGES

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2	X	X							52	X	X						
3	X	X							53	X	X						
4	X	X							54	X	X						
5	X	X							55	X	X						
6	X	X							56	X	X						
7	X	X							57								
8	X	X							58								
9	X	X							59								
10	X	X							60								
11	X	X							61								
12	X	X							62								
13	X	X							63								
14	X	X							64								
15	X	X							65								
16	X	X							66								
17	X	X							67								
18	X	X							68								
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28	X	X							78								
29	X	X							79								
30	X	X							80								
31	X	X							81								
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38	X	X							88								
39	X	X							89								
40	X	X							90								
41	X	X							91								
42	X	X							92								
43	X	X							93								
44	X	X							94								
45	X	X							95								
46	X	X							96								
47	X	X							97								
48	X	X							98								
49	X	X							99								
50	X	X							100								

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1. INTRODUCTION

A future increment of the NGL production (Natural Gas Liquid) in the Bandar Imam Petrochemical Complex (BIPC) will require the installation of a new NGL fractionation train (third plant of NGL fractionation). The new plant (train) will process 662.5 m^3/h NGL feed at standard conditions equal to 100,000 standard barrel per stream day, and produce the following products: ethane, propane, butane, pentane, pentane + (naphtha) and hexane plus. B1

The plant shall be located within the battery limit of Bandar Imam Petrochemical Complex (BIPC) in the South of Iran.

This document presents the process design basis and criteria to develop the basic engineering of project: "Third NF Plant of BIPC".

2. DESCRIPTION AND SCOPE OF PROCESS SECTIONS

The new NF Plant consists of the following process sections: NGL feed surge drums to stabilize and remove any dissolved gases in the feed, a depropanizer, deethanizer, demethanizer, debutanizer and dependentanizer to separate the different products and two refrigeration sections to supply external refrigeration for the columns (one with ethane and the other with propane). Additionally, the third NF Plant will have two sweetening and drying sections (one for methane/ethane/propane and the other for butane), an ethane sweetening section, and piping interconnections. For more detail, see documents 1211-PA-PR4EPP-1400/1401/1402 "Process Description – Process and Storage Area/Surge Drums"

The new plant (train) will have the same process scheme as the other two existent trains (NF1 and NF2), being the depropanizer column (De-C3 column) the first column. The 662.5 m^3/h of NGL feed at standard conditions will be delivered according to two different conditions (summer and winter cases). Therefore, the operating conditions of the equipment will be adjusted in each case in order to obtain the following purities and recoveries:

PRODUCT	PURITY (% mol)	RECOVERY (% mol)
Ethane	97.78	98.00
Propane	98.24	98.00
Butane	98.345	97.50 B1
Pentane	98.997	97.90
Hexane Plus	-	99.00

3. LOCATION AND SITE DATA

3.1 LOCATION

The Bandar Imam Petrochemical Complex (BIPC) is situated in Mahshahr City, named Bandar too (Khuzestan Province), bordered by the Persian Gulf. This city is 965 kilometers (600 miles) from southwest of Teheran (capital of Islamic Republic of Iran). B1

The new plant will be under an area limited by the following UTM coordinates:

	North	East	
Process Area			
	4,393.30 m	4,516.30 m	
	4,393.30 m	4,680.00 m	
	4,206.90 m	4,680.00 m	
	4,187.66 m	4,594.72 m	
	4,264.38 m	4,594.72 m	
	4,264.38 m	4,516.30 m	
Storage Area	5,200.00 m	4827.71 m	B1
	4,942.80 m	4827.72 m	B1
	5,200.00 m	5083.37 m	B1
	4,943.35 m	5020.97m	B1

References:

1. Drawing No. 1421-DI0E7- , Rev.: A3 (Sept. 2005). "Plot Plan for Process Area NF3 in BIPC". (Project: Third NF Plant of BIPC).
2. Drawing No. 1421-DI1EPP-2000, Rev.: A3 (Sept. 2005). "Main Storage Plot Plan". (Project: Third NF Plant of BIPC).

The average elevations above sea medium level are shown in attachments 3 and 4, annex 2A-1 of Petrochemical Industries Development Co. (Nov. 2005 / Bandar IMAM, Iran). "Grant of License: Basic and Detail Engineering, Procurement and Supply of Equipment, Construction & Erection, Pre-Commissioning, Commissioning and Start Up Contract (Vol. 1/2)".

3.2 SITE DATA

Ambient Temperature:

Maximum / Minimum recorded temperature	55 °C / -3.5 °C
Design maximum ambient temperature (for mechanical, civil, structure, etc.)	55 °C
Maximum temperature for equipment exposed to sunlight	85 °C
Design temperature for electrical equipment	Max. outdoor: 48 °C (in the shadow)
	Indoor (Max. / Min.): 45 °C / 5 °C
Winterizing temperature	Not applicable
Design minimum temperature	5 °C B1
Dry / Wet bulb temperature (for design of air cooler, fans, compressors)	48 °C / 31 °C B1

Relative Moisture:

Maximum	90% at 31 °C
Average (in January)	Morning: 70% / Noon: 45%
Minimum	45%
Design	30% at 48 °C

Barometric Pressure:

Maximum	1.020 bara
Average	Not available
Minimum	0.995 bara

Rainfall and Snow Precipitation:

Rainfall and Snow Precipitation:	
3 minutes	17 mm
10 minutes	24 mm
Maximum rain in one hour	40 mm/h
Rainfall for sewer design	40 mm/h
Design snow load	25 kg/m^2

Wind Velocity and Direction:

Value	162 km/h at 15 meters above ground level (design criteria to be based on UBC)
Prevailing direction	From NW ± 30° (for mechanical and civil purpose, shall be considered from all directions)

Earthquake (Seismic Factor):

Earthquake shall be considered for zone 2B as per UBC (Uniform Building Code).

4. CAPACITY NEW PLANT

The new NGL fractionation plant (train) will have a capacity to process 662.5 std. m^3/h equal to 100,000 barrel standard per stream day of NGL. The turndown ratio shall be equal to 40%. B1

B1

For the storage area, the capacities and characteristics of the pumps (propane, butane and C_5^+) are the following ones: B1

Specification of C_3 Transfers Pumps (P-9001 A/B/C):

Configuration	In parallel
Operation	Two in operation and one is spare
Design Capacity	800 t/h each
Working Capacity	200 – 800 Ton/h each
Design Temperature	-47 °C B1
Operating Temperature	-46 °C B1
Discharge Pressure	10.5 barg B1

Specification of C_4 Transfers Pumps (P-9010 A/B/C):

Configuration	In parallel	
Operation	Two in operation and one is spare	
Design Capacity	800 t/h each	
Working Capacity	200 – 800 t/h each	
Design Temperature	-5 ºC	B1
Operating Temperature	- 5 ºC	B1
Discharge Pressure	10.5 barg	B1

Specification of C_5^+ Transfers Pumps (P-9020 A/B):

Configuration	In parallel	
Operation	One in operation and one is spare	
Design Capacity	-	
Working Capacity	750 m^3/h each	
Design Temperature	-	
Operating Temperature	Ambient	B1
Discharge Pressure	8.5 barg	

5. FEED CHARACTERISTICS

COMPONENT	SUMMER (% MOLAR)			WINTER (% MOLAR)		
	DESIGN	REAL	DESIGN SUMMER	DESIGN	REAL	DESIGN WINTER
CO_2	0.278	0.171	0.2245	0.298	0.183	0.2405
Methane	2.724	2.897	2.8105	2.304	2.450	2.3770
Ethane	25.813	25.140	25.4765	27.672	26.992	27.3320
Propane	34.131	34.744	34.4375	35.705	35.880	35.7925
i-Butane	6.683	6.772	6.7275	6.551	6.638	6.5945
n-Butane	15.132	14.472	14.8020	14.489	14.323	14.4060
i-Pentane	4.586	4.820	4.7030	4.108	4.318	4.2130
n-Pentane	4.834	5.050	4.9420	4.272	4.466	4.3690
Hexane	3.239	3.270	3.2545	2.683	2.700	2.6915
Heptane	1.122	1.721	1.4215	0.886	1.359	1.1225
Octane	0.719	0.685	0.7020	0.531	0.516	0.5235
Nonane	0.485	0.183	0.3340	0.338	0.128	0.2330
Decane	0.254	0.075	0.1645	0.163	0.048	0.1055
	SUMMER (WT. PPM)			WINTER (WT. PPM)		
H_2S	-	20	-	-	20	-
COS	-	22	-	-	22	-
Me-SH	-	16	-	-	16	-
Et-SH	-	26	-	-	26	-
Pr-SH	-	53	-	-	53	-
Water content	Saturated			Saturated		

6. BATTERY LIMIT CONDITIONS

Plant Inlet

	SUMMER	WINTER
Pressure, barg	26.5	11.2
Temperature, °C	46	3

The battery limit conditions for each product are the following ones:

PRODUCT	PRESSURE (barg)	TEMPERATURE (°C)	REMARKS	
C_2	20.1	39 Max	C_2 product to olefin plant	B1
C3	10.5	-46	C3 product will be discharged by their transfer pumps (total: 1,600 t/h) to C3 existing pump discharge line	B1
C4	10.5	-4	C4 product will be discharged by their transfer pumps (total: 1,600 t/h) to C4 existing pump discharge line	B1
C5	4.9	37	C5 product to olefin plant	
C6+	4.9	15 / 45	Outside Battery Limits	

7. PRODUCT SPECIFICATIONS

The product quality shall be as follows:

Ethane (C_2):

TYPICAL TEST	UNIT	SPECIFICATION	TEST METHOD
Methane	Mol %	0.972 Max.	GC
CO_2	Mol %	0.2 Max.	GC
Ethane	Mol %	97.78 Min.	GC
Propane	Mol %	1.048 Max.	GC
Total Sulfur	WT. ppm	10 Max.	-

Propane (C_3):

TYPICAL TEST	UNIT	SPECIFICATION	TEST METHOD
Ethane	Mol %	0.4 Max.	GC
Propane	Mol %	98.24 Min.	GC
Butane	Mol %	1.35 Max.	GC
Total Sulfur	WT. ppm	1 Max.	Based on ASTM D-3246
Hydrogen Sulfide	Vol. ppm	1 Max.	ASTM D-2420 / Drager
Vapor Pressure at 100 °F	psia	200 Max.	ASTM D-2598
Water Content	Vol. ppm	Pass	ASTM D-2713
Copper Corrosion	-	No. 1a Max.	ASTM D-1838

B1

Butane (C_4):

TYPICAL TEST	UNIT	SPECIFICATION	TEST METHOD
Propane	Mol %	0.902 Max.	GC
Total – C_4	Mol %	98.345 Min.	GC
Total – C_5	Mol %	0.753 Max.	GC
Total Sulfur	WT. ppm	1 Max.	Based on ASTM D-3246
Hydrogen Sulfide	Vol. ppm	NIL	ASTM D-2420 / Drager
Vapor Pressure @ 100 °F	psia	70 Max	ASTM D-2598
Water Content	Vol. ppm	10 Max.	Shaw Dew Point
Copper Corrosion	-	No. 1a Max.	ASTM D-1838
Residue on Evaporation	Vol %	0.05 Max.	-

Pentane (C_5):

TYPICAL TEST	UNIT	SPECIFICATION	TEST METHOD
C_3 & Lighter	Mol %	Traces	GC
Total – C_4	Mol %	0.505 Max.	GC
Total – C_5	Mol %	98.997 Min.	GC
C_6 & Heavier	Mol %	0.498 Max.	GC
Density @ 15.6 °C	g/cm^3	0.604 Max.	ASTM D-4052

Naphtha (C_5 +):

TYPICAL TEST	UNIT	SPECIFICATION	TEST METHOD
Density at 15.6 °C	g/cm^3	0.735 Max.	ASTM D-4052
Reid Vapor Pressure	psi	12 Max.	ASTM D-323
Color Saybolt	-	16 Min.	ASTM D-156
Lead Content	WT. ppm	20 Max.	ASTM D-3559
Total Sulfur	WT. ppm	300 Max.	ASTM D-3120
Initial Boiling Point	°C	30 Min.	ASTM D-86
Final Boiling Point	°C	180 Max.	ASTM D-86
Paraffins	WT. %	70 Min.	GC
Olefins	WT. %	1 Max.	GC
Naphtenes + Aromatic	WT. %	Balance	GC
Total Chlorides	WT. ppm	10 Max.	IP-AK/81

B1

8. STORAGE CAPACITIES FOR THE PRODUCTS

The following Storage tanks shall be considered:

PRODUCT STORAGED	NUMBER OF TANKS	WORK CAPACITY	ID REQUIERED
Propane	2	31,500 t	52,302 mm
Butane	2	31,500 t	52,302 mm
C_5^+	2	15,000 t	39,000 mm B1

9. UTILITIES AVAILABILITY AND CHARACTERISTICS

9.1 AVAILABILITY

Utilities required for the plant shall be supplied from outside the BATTERY LIMIT of the plant. The existing facilities have a capacity to supply the following services: diesel, instrument and plant air, fuel gas, high pressure steam, nitrogen, drinking and industrial water at two pressures, demineralized water, electricity and lean gas. While, the cooling water and chemical injection systems are part of the new facilities. B1 B1

9.2 CHARACTERISTICS

The following specifications shall be considered for the utilities coming from outside of the plant (except cooling water) for the purpose of process and mechanical design of the plant (See document "Minutes of Meeting Between PIDMCO – NCE – ATC – TR For NF3 Plant of BIPC, 31 Jan. 2006 to 2nd Feb. 2006"). B1

High Pressure Superheated Steam

Process Design:		
Pressure barg	Max.	53.9
	rNo.	47.0
	Min.	46.1
Temperature °C	Max.	440
	Nor.	430
	Min.	420

Mechanical Design:		
Pressure barg		58.8
Temperature °C		492

Medium Pressure Steam

Process Design:		
Pressure barg	Max.	15.7
	Nor.	13.7
	Min.	--
Temperature °C	Max.	207
	Nor.	202
	Min.	--
Mechanical Design:		
Pressure barg		17.6
Temperature °C		258

B1

Low Pressure Steam

Process Design:		
Pressure barg	Max.	4.9
	Nor.	2.5
	Min.	2.0
Temperature °C	Max.	230
	Nor.	185
	Min.	--

Mechanical Design:		
Pressure barg		6.4
Temperature °C		276

Steam Condensate Recovery (at NF Pump Discharge)

Process Design:		
Pressure barg	Max.	--
	Nor.	3.9
	Min.	--
Temperature °C	Nor.	80
Mechanical Design:		
Pressure barg		5.9
Temperature °C		96

Note: Fouling factor for all steam levels and condensates shall be 0.0002 M^2 °C / W

Instrument Air and Plant Air

Process Design:	Plant Air	Instrument Air
Pressure barg	Max. 8.8	Max. 9.3
	Nor. 7.8	Nor. 8.3
	Min. 6.9	Min. 7.4
Temperature °C	Ambient	Ambient
Mechanical Design:		
Pressure barg	10.3	10.8
Temperature °C	75	75
Dew Point °C at 1 atm.	--	< - 40

Note: Free from dust, water droplets and oil.

Nitrogen

Process Design:		
Pressure barg	Max.	9.3
	Nor.	8.3
	Min.	7.4
Temperature °C		Ambient
Mechanical Design:		
Pressure barg		12.3
Temperature °C		-20 / 100 °C
Purity, mol %		
N_2 Content, vol %		More than 99.9
O_2 Content, vol %	Max.	< 10 PPM

Note: Dry, Free from dust and oil.

Water

Demineralized Water (DM Water)

	Pressure	Temperature
Operating	4.9 barg	Ambient
Mech. Design	6.4 barg	65 °C

Water Quality

Silica (as SiO_2):	< 0.3 PPM
Conductivity:	< 10 µS / cm
pH:	6.5 – 9.5
MALK:	< 3 PPM

Note: Conductivity at 25 ° C behind highly acidic sampling cation exchanger, continuous measurement at the sampling position. B1

Drinking Water

Quality		WHO European Standard
Chloride	As Cl	< 200 PPM
Total hardness	As Ca CO_3	< 300 PPM
pH		5.8 – 8.6
Turbidity	(Jackson Unit)	< 2 PPM
Total dissolved solids		< 500 PPM
Chlorine		0.1 – 0.8 PPM
Supply condition	Pressure	Temperature
Normal	3.9 barg	Ambient
Mech. Design	6.4 barg	65 °C

B1

Note: Guidelines from the WHO European drinking water standards are indicated for comparison with the maximum and minimum levels where applicable.

Fire Water (*)

The firewater quality to be supplied to BL of the PLANT from the firewater pump house, is the same as Industrial Water.

Process Design:		
Pressure barg	Max.	11.1
	Nor.	10.8
	Min.	8.3
Temperature °C		Ambient
Mechanical Design:		
Pressure barg		16.7
Temperature °C		65

Note 1: * at most remote hydrant.

Industrial Water

Min. Pressure barg	0.5
Nor. Pressure barg	1.5
Max. Pressure barg	2.9
Temp. °C	39
pH	7.75 – 8.6
Conductivity (µs / cm)	585 – 2,173
Calcium (ppm)	134 – 469
Chloride (ppm)	79 – 622
Total Hardness (ppm)	200 - 524

Note: Fouling factor for cooling media for high duty heat exchanger is 0.00035 m^2 °C / W.

Mech. Design.

Pressure barg	4.9
Temp. °C	65

Pressurized Industrial Water (at OL Pump Discharge)

Press.	Max. 6.1 barg
	Nor. 5 barg
Temp.	Max. 48 ° C
	Nor. 40 ° C

Quality at the same industrial water

Mechanical design

Press.	10.3 barg
Temp.	65 ° C

Analysis of Industrial Water (*)

Parameter	Normal	Design	Units
pH	8.3	7.75 – 8.60	
P Alkalinity	3	-	meg/lt
M Alkalinity	160	-	meg/lt
Chloride	300	79 – 622	mg/lt Cl^-
Total Hardness	440	200 – 524	mg/lt $CaCO_3$
Ca	260	134 – 469	mg/lt Ca
Mg	180	-	mg/lt Mg
Sulphate	-	-	mg/lt SO_4^{-2}
Potassium Permanganate Cons.	2.8	-	mg/lt $KMnO_4$ as O_2
Conductivity	585 – 2,173	585 – 2,173	µS/cm
Fe	0.4	-	mg/lt Fe
Mn	-	-	mg/lt Mn
SiO_2	1.7	-	mg/lt SiO_2
Turbidity (JTU)	8	-	JTU
TDS	1,144	372 – 1,327	mg/lt TDS
Sodium and Potassium Cons	212.8	-	mg/lt as Na
CO2	-	-	mg/lt as free CO2
Nitrate	-	-	mg/lt as NO3
Phosphate	Trace	-	mg/lt PO4
Hydrogen Carbonate	-	-	mg/lt HCO3
Carbonate	-	-	mg/lt CO3
Hydroxide	-	-	mg/lt OH
TSS	-	-	mg/lt TSS
TOC	Trace	-	mg/lt TOC
T max.	Amb.	39	ºC

B1

B1

(*): Based in letter Nº NF3-NT-TM-L-073 (September 18, 2006) by NAMVARAN. Subjects: Make-up Water Quality. NF3 Plant of BIPC.

Fuel Gas

Heat Value: kcal / nm^3	10,300 ~ 15,000
Pressure barg	Min. 6.9
	Nor. 7.8
	Max. 11.8
Temperature °C	Fuel gas saturated temp. plus 20 °C
Mech Design:	
Pressure barg	13.2
Temperature °C	Fuel gas saturated temp. plus 50 °C

Electricity

Electricity shall be generally supplied at 66 kv, 3 phases, 3 wires, 50 Hz, unless otherwise specified.

The standard voltage ratings for various utilization loads shall be as follows:

No.	Item	AC/DC	Rated Voltage	Phase / Wire
01	Motors			
	150 kw up to 2500 kw	AC	3300 V	3 / 3
	0.2 kw to below 150 kw	AC	380 V	3 / 3
	Below 0.2 kw	AC	220 V	1 / 2
02	Construction and Maintenance	AC	220 / 380 V	3 / 4
03	Lighting Fixture	AC	220 / 380 V	1 / 3
04	Emergency Fixture	AC	220 V	-
05	Instruments	AC	110 V	1 / 2
06	Controls for HT Boards	DC	110 V	-
07	Control for LT Boards	AC	220 V	1 /2

All electrical equipment shall comply with the area classification requirements and agree with the gas group and temperature class.

The electrical equipment used in the hazardous area shall be certified or approved by a recognized authority on certification.

Lean Gas

Pressure barg	Max. 29.4
	Nor. 27.4
	Min. 24.0
Temperature °C	Ambient
Mech Design:	
Pressure barg	32.4
Temperature °C	65

B1

Analysis of Lean Gas

B1

COMPONENT	TEST REFERENCE	UNITS	RESULT
C_1	GC	% Mol	85.292
C_2	GC	% Mol	10.601
C_3	GC	% Mol	3.203
i-C_4	GC	% Mol	0.314
n-C_4	GC	% Mol	0.559
CO_2	GC	% Mol	0.031
O_2	GC	Mol ppm	< 1
Total Sulphur	Micro Coulometry	WT. ppm	< 0.5
Water Content	Dew Point	Vol. ppm	< 1

B1

Methanol (at OL Pump Discharge)

Pressure Nor. barg	39.2
Temp. °C	Amb

10. INSTRUMENTATION AND CONTROL

10.1 GENERAL

The instrumentation and control system shall be kept as simple as possible with a minimum number of components and shall incorporate the latest field proven technological advances to ensure measurements with high accuracy, and an efficient final control element with the required characteristics and rangeability. B1

The operational philosophy is to control the entire plant from one DCS in the central control room (outside the battery limits) with a minimum operator intervention. Hence all necessary and sufficient process measurements, control loops and protection system facilities shall be provided to operate the plant safely and efficiently with the optimum design capacities and product specifications.

The necessary process measurement information shall be available to the operator in the central control room, in order to enable him to monitor remotely and take appropriate actions in the event of any equipment malfunction and/or process deviation.

Local control panels shall be provided as necessary. However these systems shall be designed so that all necessary process measurement information is also available in the central control room to enable the operator to take the appropriate actions, as previously mentioned.

The area classification shall be in accordance with national electrical codes. The temperature classification shall be in accordance with whichever is higher between the maximum operation temperature and the maximum ambient temperature. See ISA Standards S12.1, S12.10 and S12.12 for additional details.

10.2 INSTRUMENT SIGNAL TRANSMISSION SYSTEM

All signal transmissions to and from local panels or the control room shall be electrical with electrical to pneumatic converters to operate only pneumatic final
control elements. Pneumatic local transmitter will not be used as spare.

The signal system shall be as follows:

Signal Type	Specifications
Electronic Analogical	4 to 20 mA DC
Electronic Discreet	At 24 VDC. Digital communications standard in accordance with ISA SP50 committee. Pulses = 0 – 10 kHz as minimum
Pneumatic	0.21 barg (3 psig) to 1.03 barg (15 psig)
	Dual redundant MODBUS plus RTU

B1

The design shall ensure that instruments are capable of communicating with all other interconnected components. Other signals require a prior OWNER's approval, i.e: PLC internal communication buses, etc.

10.3 INSTRUMENT PROCESS CONNECTIONS

All instrument connections on piping, vessel and equipment shall conform to the corresponding vessel and/or piping specification. Special attention shall be given to the size and location of instrument connections of each item during detailed engineering, taking into account the fluid phase or phases, and the physical chemical / corrosion properties of fluids.

In the following table, a guide of application recommended to instrument connections to process is shown:

Type of Measurement	Connection Sizes on Vessels/Piping		
	Threaded	Flanged	RTJ
Analysis	¾"	1 ½"	1 ½"
Flow	½"	-	-
Level			
Screwed d/p cell		1"	1"
Flanged d/p cell	-	3" min	3" min
Displacer	-	2"	2"
Gauge glass	-	1"	1"
Bridle system	-	2"	2"

Type of Measurement	Connection Sizes on Vessels/Piping		
	Threaded	Flanged	RTJ
Pressure	¾"	1"	1"
Temperature	1"	1 ½"	1 ½"

Connections shall be made on the side or top of process equipment, but not at the bottom. This requirement applies to both pipe and vessel taps. Low lateral connections shall be sufficiently high to prevent plugging due to dirt or suspended solids. The connection shall be short and without pockets.

Temperature sensors and analyzer sampling probes shall be located where there is flow and a rapid response, for example in an elbow against flow direction, rather than where fluid is stagnant. Analyser sampling probes shall ensure a true representation of the fluid to be analyzed.

The insertion lengths and construction details of thermowell and analyzer sampling probes shall be designed to resist high fluid velocities and a physical / corrosion impact.

Pressure sensing points (for pressure, differential pressure or level measurement) shall be situated very far from locations where measurements can be affected by local impact and velocity variations.

Lead lines between the first block valve and the instrument shall be kept as short as possible. All instruments shall be mounted close–coupled and on vibration free supports.

10.4 INSTRUMENT ENCLOSURES

All items shall be appropriate for the service conditions (pressure, temperature, corrosion, erosion, etc.) and housed in enclosures adequate to withstand the most severe ambient conditions to be expected at the installation site (rain, marine atmosphere, dust, wind, electrical or magnetic noise, etc.). The enclosure required shall be IP-65 as a minimum.

If an instrument is not available, either intrinsically safe or as an explosion – proof item, a purged system with inert gas or air shall be considered in accordance with NFPA 496. All such applications are subject to OWNER approval.

10.5 MEASUREMENT ACCURACY

For flow measurement, an accuracy less than ±2.0% is required in all applications.

For level measurement, an accuracy less than ±2.0% too is required in all applications.

For pressure and temperature measurement, an accuracy less or equal to ±½% is required in all applications.

For analysis measurement, the system shall be designed to ensure the least possible error consistent with the application required.

11. ENGINEERING GENERAL CRITERIA

11.1 TIME OF USEFUL LIFE AND SERVICE FACTOR

On-stream time shall be 7,920 hours per annum. B1

The useful lifetime to the new installation must be equal to 20 years. Construction materials and corrosion allowances shall be considered to a minimum of 20 years of depreciation of the plant.

11.2 SAFETY AND ENVIRONMENT IMPACT

11.2.1 Labeling of Valves B1

The OWNER shall accept responsibility about labeling of valves as CSO (Car Seal Open), CSC (Car Seal Close), LO (Locked Open) and LC (Locked Close).

11.2.2 Effluents B1

The design proposed shall consider a minimum generation of effluent solids, liquids and/or gases and proper mediums to handle/discharge the wastes.

Vapors discharges to atmosphere shall be based in a proper dispersion calculation.

11.2.3 Separation between Equipments B1

The separation between equipments, piping and installations shall be in accordance with the criteria applicable (see design practices of PIP). In any case, these separations shall take the result of risk quantitative analysis (RQA) and proper operations and maintenance.

11.2.4 Noise Level B1

The maximum noise level shall be limited to 85 dB at 1 meter from any piping or equipment.

11.2.5 Grounding B1

All equipments shall be properly connected to an earth network.

11.2.6 Drains and Vents B1

All valves connected to atmosphere (vent to atmosphere or open drain) in process service shall be plugged or blind flanged. B1

Drain & vent / relief lines, sub-headers and headers shall have a proper slope and no pockets (free draining).

Close drains of high pressure shall have a double valve (with first valve of globe) or a valve with plug or blind flange. B1

All closed pressure relief valve discharge leads shall be free draining from the pressure relief valve to the top of the discharge header.

Weep holes of ¼" shall be provided at low points of a pressure relief valve and rupture disk discharge lines to atmosphere.

12. DESIGN CRITERIA

12.1 GENERAL

The objective of applying these guidelines is to optimize costs of new installations operations, obtain a safety, easy maintenance and operation and a minimum environment impact.

For the design, the latest edition of the project applicable norms, codes, recommended practices and/or regulations shall be followed (see sect. 13, where is shown a list of these norms). In case of a conflict of interest between two or more guidelines, the most strict and conservative criteria shall be applied. The last editions of international, national and/or local laws in safety / environment matter shall be followed too. When there is no guideline concerning some particular point, the good engineering practices shall be followed.

The measurement system applied will be the metric, including "ºC" for temperature and "barg" for pressure, except for pipe and fitting sizes, flange ratings and nozzle dimensions, which in British System shall be applied. B1 Other measurement systems could be used if approved by client or if they are normally used in the petroleum industry. The language used in drawings, documents, letters, fax, e-mails, etc., shall be the English. NF3 Project P&ID legends and symbols shall be used. B1

Licensor design margins, if more stringent and required by the licensor, will take precedence over project design allowances.

12.2 GENERAL OF PROCESS DESIGN

In general, the factor of over design to mass flow rates shall be 1.10. For specific cases, the following design factors shall be used:

- Air cooler shall be designed for 110% of the operating duty based on the dry bulb design temperature.
- In general heat exchangers shall be designed to 110% of their operating duty.
- Columns overhead coolers shall be designed to 120% of their operating duty.
- Normally, pumps shall be designed to 110% of their maximum required flow rate in worse case of operation.

The turndown ratio shall be equal to 40%. B1

For pumping equipments, a 100% of stand-by shall be considered unless specified in other way. For propane and butane transfer pumps the stand-by applied shall be 50%. Stand-by to static equipments shall not be considered.

To choose process alternatives, the following factors shall be taken into account: VPN at 20 years, flexible operation, easy maintenance, easy design, safety and environment impact.

To choose materials of construction the following criteria shall be taken into account: operation conditions and service, corrosion properties, initial investment, safety and environment impact.

12.3 DESIGN CONDITION

12.3.1 Design Temperature

Design temperature for process equipment shall be whichever is higher:

- Maximum operation temperature plus 15 ºC (+ 25 ºC for feed/effluent exchanger). B1
- Boiling temperature at design pressure of process medium inside, if applicable.

For not-refrigerated atmospheric storage tanks, the design temperature shall be calculated by whichever is higher: the maximum ambient temperature or the maximum fluid temperature. B1

For piping, design temperature shall be determined according to ASME B31.3.

Design temperature shall be rounded up to full 5 °C steps.

12.3.2 Minimum Design Metal Temperature (MDMT) or Exposure Critical Temperature (ECT)

Only to piping or equipment operating below 0 °C, MDT (or ECT) shall be specified the. This value shall be the process minimum temperature (consider blow down events too) minus 5 °C. Special attention shall be given to low boiling liquids, such as LPG, etc. LPG low pressure atmospheric tanks (refrigerated) shall be designed according to API-620. B1

12.3.3 Hydrostatic Test Minimum Temperature

The hydrostatic test minimum temperature shall never be less than a minimum design metal temperature (MDT). It shall be equal to MDT + 6 °C for wall thickness equal or less than 50 mm or up to or equal to MDT + 17 °C for wall thickness up to 50 mm.

12.3.4 Design Pressure

General rule
Design pressure of process static equipment shall be based on the maximum operating pressure. The maximum operating pressure (MOP), shall never be less than a 5% above of normal operating pressure. B1

Design pressure shall be selected from the list below:

- For a maximum operation pressure below 2 bar g use 3.5 bar g.
- For a maximum operation pressure between 2 bar g and 15 bar g, use the maximum operation pressure plus 1.5 bar. B1
- For a maximum operation pressure between 15 bar g and 100 bar g, use the maximum operation pressure plus 10% of maximum operation pressure. B1
- For a maximum operation pressure equal and above 100 bar g use the maximum operation pressure plus 10 bar. B1

Equipment under Vacuum:
Equipment normally operating under vacuum shall be designed for a full vacuum and for the highest pressure it can experience, in case of a vacuum failure.

Equipment containing a fluid with a vapor pressure at ambient temperature lower than atmospheric pressure, which can be isolated,

shall be equipped with vacuum breaking devices or be designed for full vacuum.

Equipment subject to vacuum due to mal-operation or failure shall be equipped with vacuum breaking devices or designed for full vacuum.

Thinwalled Tanks and Vessels:
Atmospheric thinwalled tanks and vessels shall have a design pressure equal to the highest pressure imposed upon discharge of the pressure relief device.

The design pressure for vacuum shall be equal to the lowest pressure imposed upon suction of the vacuum relief device.

Equipment on the discharge of a pump:
Equipment which may have to bear the shut-off pressure of a centrifugal pump shall have a design pressure equal to or higher than the shut-off pressure.

If the real shut-off pressure (by the vendor) is higher than the calculated shut-off pressure (by process discipline), it shall be evaluated if short time steps' rule applicable, a pressure relief device shall be installed. B1

Equipment / piping to discharge of positive displacement pumps (rotatory or reciprocating) shall be a design pressure equal to or higher than the set pressure of relief device to discharge pump plus the corresponding static head.

Tube and Shell Heat Exchanger:
Design pressure for shell and tubes shall be calculated separately, but shall follow the 10/13 rule. B1

Piping:
Piping to pressure, protected by pressure relief devices, shall have a design pressure equal to or higher than the set pressure of relief device to pumps discharge plus the corresponding static head.

Piping to pressure unprotected by pressure relief devices, shall have a design pressure equal to a maximum pressure developed in any unexpected (not fire), as blocked discharged, control valve failure, utilities failure, unadvisable close valve, etc. B1

Design pressure to piping, operating at 1.03 bar g or less, shall be at least, equal to the normal operating pressure + 0.14 bar, but shall never be less than 1.10 bar g. B1

The double block valves and pipe, between those valves, shall be designed to a more severe piping classification in both sides of pipe.

12.3.5 Corrosion Allowance

Materials of construction and corrosion allowance for all equipment and machinery shall have a design life of 20 years (except for heat exchanger tubes). However, carbon steel shall have a minimum corrosion allowance, including 0.5 Mo alloy steels:

Pressure vessels and other applicable equipment	3 mm
Storage tanks	1.5 mm
Piping	1.5 mm
Removable parts or internals (on each side in contact with operating fluid)	0.75 mm
Stainless Steel / Titanium agree	0 mm
Carbon steel with epoxy resin coating	3 mm

12.3.6 Wall Thickness

To calculate wall thickness, a corrosion allowance according with manufacturing tolerance shall be added. This last, is 87.5% of wall thickness, without corrosion allowance. B1

12.4 PIPING & HYDRAULICS

12.4.1 General

All piping systems shall be designed by ANSI B31.3 and API Spec. 6D. ANSI B31.1 shall be used to steam & condensate.

The use of plug valves is not recommended but the use of ball valves with reduced or full bore is recommended. The use of ball valves with full bore (reduce bore will be more common) is not necessary. Gate valve is recommended to utility less than 2" or water lines larger than 2". In case of gate valves, regular port is recommended and a full port is necessary.

All piping arrangements shall be easy and shall have proper distances of separation.

Branches of pumps suction shall be connected to a principal header through a bottom. In case of use of reducers for suction branches, it shall be eccentric and shall have a flat side in top of the pipe.

Drain and vent & relieve lines shall have a proper slope to avoid pockets.

For process piping, the minimum size accepted is 2". Carbon steel pipe sizes 1 ¼", 2 ½", 3 ½", 5", 22" and 26", shall not be used, except for connection to the equipments. Pipe size of 2 ½" may be used by hydrants B1

and/or control valves connections.

Pipe sizes smaller than ½" shall not be used except for instrumentation and analysis.

In general, where a specification break between two connecting lines occurs, the highest specification shall include the first block, check or relief valve on the lowest class line. B1

Cooling water piping for exchangers shall be arranged so that the cooling equipment stays full of water in the event of failure of cooling water supply.

Piping of relief and vent system shall have a positive slope to permit free drainage (no pocket). B1

Piping of open drain and close drain system shall be underground.

Open drains (sewers) shall be adequately sloped and properly sized. Size shall not be less than 4".

All sewer branches shall be connected to the main one with an angle of 60° or less (with 45° elbows or manholes).

All sewer connections to main headers or manholes shall be with water sealed.

Atmospheric condensate from steam traps shall be led to drains to avoid wet floors.

All piping leaving the plant shall be designed with a block valve at the battery limits.

The velocity in liquid and multiphase lines shall be forever lower than the erosion velocity. This value is calculated as follows:

$$ver. = k / \sqrt{\rho}$$

Where:

ver:	Erosional velocity, in m/s
k:	Constant (122 to continuous flow and 153 to intermittent flow)
ρ:	Fluid density, in Kg/m^3

The velocity in gas lines shall be forever lower than the sonic velocity. This value is calculated as follows:

$$vs = \sqrt{k \times g \times (R / MW) \times T}$$

Where:

vs: Sonic velocity, in m/s

k: Specific heat relation, un-dimensional

g: Gravity acceleration, 9.81 m/s^2

R: Gases universal constant, 8.314 Joule/Kg-mol °K

MW: Molecular Weight, kg / kg-mol

T: Absolute temperature, K

12.4.2 Liquid

Table 1. Criteria for the Design of Liquid Flowing Lines

Case	ΔPmax (bar/km)	V max (m /s)	Comments
Water and liquids general (carbon steel lines) - General recommendation - Laminar flow - Turbulent flow • ρ =1600 kg/m^3 • ρ =800 kg/m^3 • ρ =320 kg/m^3	9.0	1.5-4.6 1.2-1.5 1.5-2.4 1.8-3.0 3-4.6	As a general rule, the flow velocity shall not be less than 1 m/s to minimize deposition of solids and accumulation of water at the bottom of the pipe.
Gravity run liquid	0.7		It may be admissible a ΔP of 2,3 bar/km, if the height difference is adequate for this. See *Note 1.*
Pump suction - Boiling liquids - Subcooled by 30 °C - At boiling point for C1, C2, C3 at low temperature	0.7 1.1 0.2-0.7	1.8 1.8 0.5	2,3 bar/km is permitted if the available NPSH allows it.
Pump discharge - Carbon steel lines. • Q< 60 m^3/h • 60 <Q<230 m^3/h • Q>230 m^3/h - Alloy steel lines. • Q< 60 m^3/h • 60 <Q<230 m^3/h • Q>230 m^3/h	13.6 9.0 4.5 18.0 13.6 6.8	6.0 6.0 6.0 6.0 6.0 6.0	The ΔP value might be higher than these limits in the branches that do have any effect on the discharge pressure required by the pump or if the available ΔP allows it. The ΔP value might be higher than these limits in the branches that do have any effect on the discharge pressure required by the pump or if the available ΔP allows it.

Case	ΔPmax (bar/km)	V max (m /s)	Comments
Line between the discharge nozzle of the pump and the main discharge line (section with a check valve).			The diameter immediately lower than the main discharge line must be selected provided that it is not lower than the pump´s discharge nozzle.
Cooling water - Main headers - Lines to individual users	 3.4 9.0	 3.6 3.6	
Fuel oil - Pump suction - Pump discharge (long lines) - Pump discharge (branches)	 0.7 4.5 9.0	 1.8 3.6 3.6	The Reynolds number shall be calculated to determine the type of regimen (laminar or turbulent) in order to calculate the pressure drop.
Hot oil		1.0 min.	
Nearly boiling liquids to a control valve	0.2		It may be necessary to decrease the ΔP up to 0,2-0,4 bar/km, in order to avoid vaporization before the valve. A higher value may be admissible, provided this major pressure drop does not cause vaporization.
Plastic pipe or rubber-lined pipe carrying - Liquids in general - Liquids with suspended solids		 3.0 0.9 min.	
Bottoms outlet	1.3	1.2-1.8	
Liquid from condenser	1.1	0.9-1.8	
Liquid to chillers		1.2-1.8	
Liquid feed to towers		1.2-1.8	
Utilities/Boiler water (P<50 bar)	3.4-4.5	1.5-3.0	
Boiler feed water (P≥50 bar)	6.8-9	2.4-4.6	
Steam condensate	0.2-0.4	0.9	Liquid lines, no two phase condensate

Case	ΔPmax (bar/km)	V max (m /s)	Comments
Tower side stream draw-off - Diameter ≤2" - Diameter ≥3"	 0.6 0.6	 0.6 0.9	Nozzle shall be sized according to these criteria. Provide a minimum vertical run of the highest of 3 meters or 5 diameters, from nozzle, at nozzle size, before reducing the size of the line. A maximum ΔP of 0,9 bar/km should never be exceeded.
Drains		1.8	
High viscosity fluids - Pump suction and gravity run liquid - Pump discharge • Long sections • Branches Slurry lines	 9.0 4.5 9.0	0.6-1.2 4.2	 The minimum velocity should be calculated to prevent settling of solids. If erosion is of particular concern, limit maximum velocity to 3 m/s. See section *Design criteria for two-phase (solid-liquid) flow.*
Refinery water lines	5.6	0.6-1.5	
Corrosive liquids - Carbon steel lines. • General • Caustic solutions (general) 0-30% w.t. 30-50% w.t. +50% w.t. • Phenolic waters • Sulfuric acid • Sea water • Lean amine • Rich amine • Sour water • Stripped sour water		 0.9 1.5 1.8 1.5 1.2 0.9 0.3 1.8 2.0 0.9 2.0 1.5	

Case	ΔPmax (bar/km)	V max (m /s)
• Wastewater collection		
- Stainless steel lines.		3.0
• CO_2-Rich amines		3.0
• Rich amine (series 300 and higher alloys)		
-Cement pipe or coal tar enamel-lined pipe		4.0
• Sea water		4.6

Note 1. Self-Venting. For the Vertical gravity lines to be self-venting, they shall be designed so that the Froude number is less than 0.3 to avoid air entrainment and ensure undisturbed flow with pulsations. Rearranging the equation for Froude Number, gives the following criterion:

$$D > 0.9465\ (Q)^{0.4}$$

D, pipe diameter in inches
Q, flow rate in US gpm

12.4.3 Vapors

The diameter must be selected according to the controlling criterion. The pressure and velocity should not exceed significantly the below indicated values. These recommendations should be considered as general guidelines and admit certain flexibility.

Maximum frictional pressure drop, bar/km

General recommendations:

- Long sections (>250 m). The maximum frictional pressure drop will be 0.2% of the absolute pressure, with a high limit of 1.8 bar/km.
- Medium sections (90-250 m). The maximum frictional pressure drop will be 0.4% of the absolute pressure, with a high limit of 2.7 bar/km.
- Short leads. The maximum frictional pressure drop will be 0.6% of the absolute pressure, with a high limit of 5.6 bar/km.
- Compressor suction. The maximum frictional pressure drop will be 0.5% of the absolute pressure, with a high limit of 0.7 bar/km.

The previous criteria are applicable for all types of gases and vapors, including steam, fuel gas and compressed gases. In the following table the values corresponding to several pressure levels have been included.

Table 2. Previous Pressure Drop Criteria for Gases and Vapors

Pressure	ΔP max, bar/km				ρV^2 (Pa)
	Long sections	Medium sections	Short leads	Compressor suction	
≥ 27.6 barg	1.8	2.7	5.6	0.7	10000
20.7 barg	1.4	2.7	4.3	0.7	7500
13.8 barg	1	1.9	2.9	0.7	6000
6.9 barg	0.5	1.0	1.6	0.7	6000
3.4 barg	0.3	0.6	0.9	0.7	6000
1.7 barg	0.2	0.4	0.5	0.4	
0.3 barg	0.09	0.2	0.3	0.2	
0 barg	0.07	0.1	0.2	0.2	
0.7 bar	0.04	0.09	0.13	0.11	
0.4 bar	0.02	0.04	0.09	0.07	
0.3 bar	0.02	0.04	0.04	0.04	
0.1 bar	0.02	0.02	0.02	0.02	

Maximum velocity

As a general rule, the velocity for gases and vapors shall not be higher than the values of the next figure (Figure 1). The two lowest straight lines are applied for a reciprocating compressor. The thick line is valid for general cases, including the suction and discharge of centrifugal compressor. Velocities corresponding to “high noise level” must not be exceeded, except for the gas relief lines.

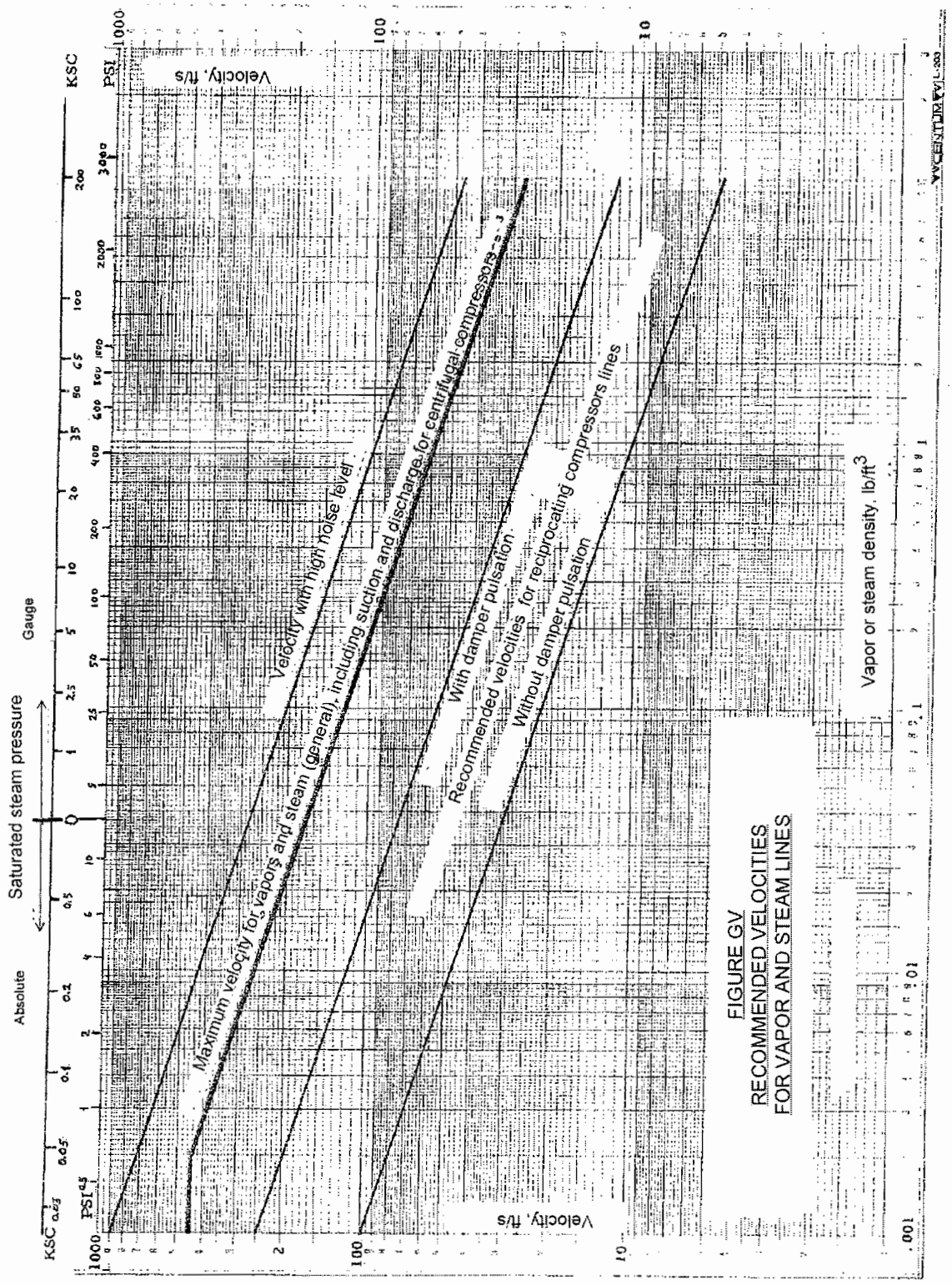

Figure 1. Velocity for Gases and Vapors

Table 3. Vapor Lines in Process and Equipment Service

Type of service	Recommended velocity m/s	ΔP_{max} bar/km
Gas lines within battery limits		1.1
Compressor piping suction	See Figure 1	
- Reciprocating		0.7
- Centrifugal		1.1
Compressor piping discharge	See Figure 1	
- Centrifugal		3.4
- Reciprocating		2.5
Refrigerant suction lines	4.6 – 10.7	
Refrigerant discharge lines	10.7 – 18.3	
Tower overhead		
- Pressure (P > 3,44 bar)	12.2 – 15.2	0.7 – 1.3
- Atmospheric	18.3 – 30.5	0.4 – 1.1
Kettle reboiler return line		0.4

B1

Table 4. Recommended Velocity and Maximum ΔP for Carbon Steel Vapor Lines.

Steam lines

Type of service	Recommended velocity m/s	ΔP_{max} bar/km
General recommendation. Maximum		
- Saturated	61.0	
- Superheated	76.0	
Steam pressure = 0- 3 barg	61.0 (max)	0.6
Pipe diameter (inches)		
¾ - 2	12.0-24.0	
3 – 4	14.0-27.0	
6	15.0-37.0	
8 – 10	24.0-46.0	
12 – 14	30.0-52.0	
16 – 18	34.0-58.0	
20	37.0-61.0	
Steam pressure = 3-10 barg	61.0 (max)	1.1
Pipe diameter (inches)		
¾ - 2	12.0-24.0	
3 – 4	14.0-27.0	
6	15.0-37.0	
8 – 10	24.0-46.0	
12 – 14	30.0-52.0	
16 – 18	34.0-58.0	
20	37.0-61.0	

Table 5. Recommended Velocity and Maximum ΔP for Steam Lines.

Type of service	Recommended velocity,m/s	ΔP_{max}, bar/km
Steam pressure =10-34 barg	46.0 (max)	2.3
Pipe diameter (inches)		
¾ - 2	9.0-18.0	
3 – 4	11.0-21.0	
6	14.0-24.0	
8 – 10	20.0-27.0	
12 – 14	24.0-30.0	
16 – 18	27.0-43.0	
20	30.0-46.0	
High pressure steam lines	30.0-46.0 (max)	
- Short (L < 180 m)		2.3
- Long (L > 180 m)		1.1
- Short leads		5.6
Exhaust steam lines (P>1,013 bar)		1.1
Leads to exhaust header		3.4
Feed lines to pumps and reciprocating engines	3.8 – 4.6	2.3
Power House equipment and process piping (saturated at P ≥ 1,7 barg)	30.5 – 51.8	
Boiler and turbine leads (superheated to P≥13,8 barg)	35 – 100.6	
Vent steam	61.2 (max)	

12.4.4 Multiphase Flow

The regime of flow recommended is stratified or wavy, the bubble, plug or slug flow's regime (intermittent) shall be avoided. B1

The pressure drop shall be less than or equal to 0.90 bar/100 m.

12.5 EQUIPMENTS

In the sizing of equipments, the proper criteria of VENDOR shall be followed, but in any case the following items shall be applied:

- All group or pieces of equipments shall have proper facilities to maintenance and transportation. They shall be portable units in skids.
- The height between low-low liquid level (LLLL) and tangent line of bottom vessel shall not be less than 150 mm. B1
- All process pumps shall be centrifugal. B1
- The minimum height between the centerline of vessel liquid outlet nozzle and the suction nozzle of pumps shall be to provide enough available NPSH as necessary.
- The maximum height between the floor and the centerline of suction nozzle in pumps shall not be higher 600 mm.
- The liquid time of residence of vessels shall be enough to supply liquid in any conditions (start, etc.).
- The time of response of operator (between HHLL and HLL or LLLL and LLL) shall guarantee a good control and a minimum impact of operations.
- The vapor stream from the plant exit shall have a liquid drag of less than 1 kg per each 100 kg of gas. B1
- In separators, mist eliminators shall be used (width equal to 6" as a minimum). Vane or centrifugal-revolutions or filters cartridge type are not necessary. B1
- Cooling water or steam streams recommended shall go through tubes side in heat exchangers. B1
- Fluid with higher pressure shall go through tubes side in heat exchanger. In case of amine rich/lean exchanger E-7052, amine rich shall go through tubes side.
- Fluid with fouling or more corrosive shall go through tubes side in heat exchangers.

12.5.1 Vessels

For vessels, the following criteria shall be applied:

- The diameter of vessels shall be of 600 mm (24") as a minimum. For small vessels, diameters of 300 mm (12") or 450 mm (18") are possible. In any case, this diameter shall be a multiple of 50 mm (2") and shall be in steps of 150 mm (6"). B1

- The height of vertical vessels or the length of horizontal vessels shall be multiple and in steps of 750 mm (2'-6").

12.5.2 Heat Exchanger

For shell and tube heat exchangers, the following criteria shall be applied.

- The shell diameter for shell and tube's heat exchanger, shall be from 200 mm (8") as a minimum. B1
- The length of tubes shall be from 3,600 mm (12') as a minimum to 12,000 mm as a maximum in steps of 1,200 mm (4').

B1

12.6 PUMPS

Pumps shall be designed to 110% of their maximum required flow rate in the worst case of operation.

For pumps associated to fractionation columns (reflux): flow rates shall be equal to 120% of the maximum required flow rates. B1

The margin between the NPSH available and required shall not be less than 600 mm.

To preliminary calculations of suction pressure:

- The reference level for suction pressure shall be equal to 600 mm up to floor level.
- The minimum suction pressure shall not be less than 0.83 bara.
- Pressure drop across permanent / temporary filters to suction shall be equal to 0.07 bar.
- The suction pressure shall be calculated to low – low liquid level (LLLL). B1
- In case of atmospheric tanks (non-refrigerated and refrigerated), the height of outlet nozzle shall correspond to standard (API 620, 650, 12F) or rational guidelines.

The design factor of the flow rate to calculate the NPSH available shall be in accordance with the pump over design factor. B1

For preliminary calculations of discharge pressure, the following guidelines shall be taken into account:

- 600 mm as reference level from center line of discharge nozzle.
- High – High liquid level.

The minimum pressure drop across control valves in discharge lines or recirculation lines shall not be less than 0.70 bar.

The shut-off pressure calculated (design pressure) shall be whichever is higher:

- Maximum initial pressure at suction side + HLL (high liquid level) suction static head + 120% of differential head at rated flow.
- 120 % of design pressure suction side + HHLL (high – high liquid level) suction static head + differential head at rated flow.

If the real pump acquired has a shut-off pressure higher than the shut-off pressure calculated, then the short time steps rule shall be applied and if this is not applied, a pressure relief device in the discharge line shall be installed.

All centrifugal pumps shall normally operate in the range of 70% to 120% of its best efficiency point (BEP). B1

For suction systems, the following guidelines will be applied:

- The minimum continuous right pipe shall be 10 times the pipe diameter.
- The suction branches shall be connected to the principal head by the bottom.
- Reducing elbows shall not be used to avoid pocket.
- Excentric reducers with flat face in the top of pipe shall be used.
- A permanent strainer in each suction branch is required (basket, conic, "Te" or "Y" type). B1

For discharge systems, the following guidelines will be applied:

- In case of positive displacement pumps, a pressure relief device shall be used in each discharge branch.
- The size of discharge flanges shall not be higher than the size of suction flanges.

- In case of reciprocating pumps, a pulsation dampener shall be used in each discharge branch.

12.7 COMPRESSORS

In general, compressors shall be designed to a minimum of 110% of their maximum required flow. However, they are subject to special considerations according to the process.

For centrifugal compressors, the process scheme to anti – surge control, shall be done by the vendor.

The maximum ratio per stage shall normally be in the range of 3.6 to 4.0. B1

The interstage temperatures shall be maintained under 140 °C.

The inlet gas to compression unit shall be free of liquid.

For suction systems, the following guidelines shall be applied:

- All reciprocating compressors shall be provided with a KO drum in the suction lines located as close as possible to the compressor.
- Centrifugal compressor generally requires KO drums, however, under some circumstances; they may take suction from a process vessel. In this case, this vessel shall be provided as close as possible and shall have the same type of sizing basis and operating safeguards as a KO drum.
- Compressors with a permanent cone – type strainer shall be provided.
- The suction line shall be drainage free (slope) forward the suction vessel (KO Drum or process vessel). B1
- Reciprocating compressor suction lines downstream of KO drum, shall be traced and insulated if the process gas is within 14 °C of its dew point at suction conditions.

For discharge systems, the following guidelines shall be applied:

- In case of positive displacement compressors, in each discharge branch a pressure relief device shall be used.

- The size of discharge flanges shall not be higher than the size of suction flanges.

- In case of reciprocating compressors, a pulsation dampener shall be used in each discharge branch.

12.8 HEAT EXCHANGERS

In general, heat exchangers shall be designed to 110% of their operating duty. Columns overhead cooler shall be designed to 120% of their operating duty.

For columns overhead cooler, heat exchangers type plate are preferred, however, heat exchangers or fin – fan cooler could be used too.

For reboilers, in columns bottom, a kettle type or horizontal/vertical thermosiphon shall be used, but kettle type is preferred. B1

Heat exchangers type plates prior shell and tube heat type shall be used. The last shall be used prior to hair pin type.

Large heat exchangers shall be divided into two or more shells (or plates' bundles) for easy operations and maintenance.

An approach (difference between hot fluid's exit temperature and cold fluid's inlet temperature) equal to 6 °C shall be used. B1

For hair pin heat exchangers the following guidelines shall be taken into account:

- The length of tubes shall be equal to 3.66, 4.88, 6.00 or up to 12 meters.

- The outlet diameter of shell (only exchangers) shall be 8" as a minimum. B1

- The outlet diameter of tubes could be equal to ¾", 1", 1 ¼", 1 ½" and 2". The outlet preferred is 1".

- The bundle tube arrangement preferred is triangular. B1

When steam out nozzles are applicable in heat exchangers, these shall be 2".

12.9 COLUMNS AND SEPARATION VESSELS

12.9.1 General

The minimum height between the bottom of vessels and the low – low liquid level (LLLL) shall be 150 mm.

The minimum height between the low – low liquid level (LLLL) and the low liquid level (LLL) and that between the high liquid level (HLL) and the high – high liquid level (HHLL) shall be based in a operator response time of 3 ~ 5 minutes (not control action from control room) or 1 minute (control action from control room). B1

The residence time shall be in accordance with the table shown in section 12.9.2 of this document.

The outlet diameter of a column / vessel shall be a multiple of 50 mm (2") and shall be increased in steps of 150 mm (6"). The height of vertical vessels / columns or length of horizontal vessels shall be a multiple of 750 mm (2'-6") and shall be increased in steps of 750 mm (2'-6").

Normally, the wall thickness shall not be higher than 50 mm (2").

The minimum outlet diameter to vessels shall be as follow:

- In general, it shall be 600 mm (24"), but in case of non-process small vessels, it could be accepted until 300 mm (12") and/or 450 mm (18") too.
- In case of a frequent entry into vessel to maintenance (internals cleaning), 900 mm (36") it shall be the minimum outlet diameter.

Normally, the size of manholes in vessels shall be 24". If there are any restrictions (short diameter), this shall not be smaller than 20".

For tray towers, manholes at top, bottom, feed point, draw-off point of tower and for each 20 trays or 15 meters of elevation distance shall be provided, whichever shorter distance, as a minimum. B1

The minimum size for nozzles shall be of ¾" (or 1" to stainless steel). The minimum size to flanged connection shall be of 1 ½".

Vent, drain and water fill nozzles for columns or vessels (re-boilers type Kettle and chillers type shell and tube, are included), will normally be provided at the minimum length on overhead or bottom line in accordance with the following table:

Volume (V) or outlet diameter (D) (m^3 or mm)	Vent Diameter	Drain Diameter	Water fill Diameter
V ≤ 75 or D ≤ 4,500	2"	2"	3"
75 < V ≤ 220 4,500 < D ≤ 6,000	3"	3"	4"
220 < V ≤ 420 D > 6,000	4"	4"	6"
V > 420	6"	4"	6"

Notes:

1. Vent ant drain connections are not necessarily located in vessels.
2. Drain nozzles shall be able to drain the vessel (process fluid from HLL) in eight (08) hours.

The steam out nozzles shall be sized as follows:

Diameter (mm)	Nozzle
Drums (all diameters)	2"
Columns	
D ≤ 4,000	2"
4,000 < D ≤ 5,500	3"
D > 5,500	4"

Hand hole or inspection hole shall have a minimum of 6" (is preferred 8").

Instrumentation nozzle shall be a section of instrumentation.

The nozzle rating shall be in accordance with the connected piping. The minimum acceptable is 150# RF.

For sizing of process nozzles the following guidelines shall be applied:

	Velocity (m/s)
Liquid feed	≤ 3,0
Biphasic feed in drums/vessels without demister	$\leq 54.9/(\rho_L)^{1/2}$
Biphasic feed in drum drums/vessels with demister	$\leq 73.2/(\rho_m)^{1/2}$
Gas/Vapor Outlet	$\leq 73.2/(\rho_G)^{1/2}$
Liquid Outlet	0.91 – 1.83

12.9.2 Hydraulic Retention Times

Type of Service	Retention Time	Remarks
Feed surge drum	5.3 hours(1) (summer case)	Based on 4,000 m^3
Reflux drum	5 min	
Column feed on flow control On flow control On cascade level/flow control	 5 min 5 min	
Rebilling by thermosiphone	30 seconds on circulation	
Products to storage Without pumps With pumps	 5 min 5 min	
Feeds and products feeding another units On flow control On cascade level/flow control	 5 min 5 min	

Note 1: Based in calculations for 8 vessels (D = 3,000 mm, L = 35,000mm).

Other Services:

Type of Service	Retention Time	Remarks
Steam condensate pot	1 min	
Surge drums / Receivers	10 min	
Compressors suction drums	10 min	
Steam condensate tanks	2 hours	
IA receivers	30 min	Not applicable in NF3 Project

B1

In case of pumps ensuring several services, such as reflux and liquid distillate to storage, the retention time of the corresponding vessels will be whichever is greater from the above list.

12.9.3 Columns

The spacing between plates shall be 450 mm (18"), 600 mm (24") or 750 mm (30").

Columns with trays are preferred.

12.10 ATMOSPHERIC AND LOW PRESSURE STORAGE TANKS

Tanks shall be designed according with API-620 – Recommended Rules for Design and Construction of Large, Welded, Low Pressure Storage Tanks. Design pressure up to 1,0342 barg. B1

For operational purposes, the minimum unusable heights will be:

- Bottom: 12 " (300 mm).
- Top: 12" (300 mm).

13. DESIGN NORMS AND CODES APPLICABLES

13.1 HEAT EXCHANGER

Process exchangers and double pipe heat exchangers (Hayrpin type)	ASME Sect. II, V, VIII div. 1 or 2, IX and TEMA class R
Auxiliary exchangers for rotating and package equipment	Vendor's standard
Surface condensers	ASME Sect. VIII div. 1 / HEI (Heat Exchanger Institute)
Air cooled exchangers tube bundles	API 661
Plate and Frame exchangers	API-662 and Vendor's standards
Welded type heat exchangers	Vendor's standards

B1 B1

13.2 PRESSURE VESSELS

Pressure vessels	ASME Sect. VIII Div. 1 or 2, Sect. II, V and IX
Steam drums / Power boiler	ASME Sect. VIII Div. 1 or 2, Sect. II, V and IX
Auxiliary vessels for rotating and vessels packaged equipment	Vendor's standards

13.3 BOILER

ABMA, Press. Part. ASME Sec. I and others vendor's standard.

13.4 FIRED HEATER

ASME Sec. I, API 650, ASTM, API 630, API RP 530.

13.5 QUENCH SYSTEM (INCLUDED STEAM DRUM)

ASME Sect. VIII, div. 1.

13.6 STORAGE TANKS

Atmospherics	API 620, 650 and 2000
Pressurized	ASME Sect. VIII Div. 1

13.7 INSULATION

Wall thickness shall be in compliance with the typical guides of the international petroleum industry (API, PIP). Materials shall comply with ASTM, DIN or BS.

13.8 FIRE FIGHTING AND PROTECTION SAFETY

Design	API RP 500, RP 520, RP 521, 2000 and NFPA 11, 12 13, 15, 2001, 70 and 72. DIN and NPC regulations and standards
Materials	Vendor's standards

B1

13.9 PACKAGE EQUIPMENT

Main pressure vessels	ASME Sect. VIII, div. 1
Main exchangers	ASME Sect. VIII, div. 1 and TEMA
Auxiliary vessels, tanks and exchangers	Vendor's standards
Compressors, pumps and fans/blowers	Vendor's standards
Internal piping	Vendor's standards
Connection flanges w/outside	ASME B16.5
Instruments / Electrical	IEC - ISA

13.10 ROTATING MACHINERY FOR PROCESS B1

Centrifugal compressors	API 617
Blower / Centrifugal fans	API 617 and 673
Process compressors	API 617, 618 and 619
Reciprocating compressors	API 618
Rotary compressors	API 619
Air compressors	API 672 and Vendor's standards
Centrifugal pumps	API 610, except for slurry pumps or any other particular pumps, which cannot be covered by API, well known by international standards to be specified. For water pumps up to 60 m^3/h, ISO or ANSI may be used
Reciprocating pumps	API 674
Rotary pumps	API 675 and 676
Steam turbines	API 611, 612
Gas turbines	API 616 and Vendor's specifications
Lubrication, shaft sealing and control oil	API 614
Mechanical seal	API 682 for API Pumps
Vibration, axial position bearing, temperature monitoring	API 670
Gear Units	API 677, 613, AGMA 420
Chemical Injection Units	Vendor's standards
Auxiliary systems	Vendor's standards

13.11 PIPING

Process / Utility piping under battery limits	API RP 14 E, ANSI B31.3
Boiler piping	ANSI B31.1
Relief devices	API RP 520, RP 521, 576 and ASME Sect. VIII or I
Pressure / Vacuum relief devices for atmospheric tanks	API 2000
Flare piping	ANSI B31.3, API RP 521 and 537
Fitting / Bolts, Nuts, Gaskets	API, ASME / ANSI
Flanges	ASME B16.5, B16.47 Serie B
Valves	ANSI / ASME, API or BS (if ANSI / ASME and/or API not available)
Cement lined piping	AWWA C 602-83 or equivalent vendor's standards
Rubber lined piping	ASTM D 3491-85 or equivalent vendor's standards
Rubber seated butterfly valves	AWWA C 504 or equivalent vendor's standards

13.12 INSTRUMENT

General	ISO, ISA, API, IEC, NEMA
Orifice plates	ISO 5167
Thermocouples	IEC-60548

In addition, the rules, norms, guides and standards of the following organisms, shall be applied:

- International Standarization Organization (ISO).
- Institute of Engineering Electrical and Electronics (IEEE).
- National Electrical Code (NEC).
- American Institute of Steel Construction (AISC).
- American Concrete Institute (ACI).

- Uniform Building Code (UBC).
- American Water Work Association (AWWA).
- American Association of State Highway & Transportation Officials (AASHTO).
- American Iron and Steel Institute (AISI).
- American Society of Civil Engineer (ASCE).
- American Welding Society (AWS).
- Crae Manufacturers Association of America (CMAA).
- Occupational Safety and Health Standards (OSHA).
- Department of Transportation (DOT).
- National Association of Corrosion Engineers (NACE).

In case of lack of symbols in any particular case, the good judgment shall be followed always and the new symbols shall be represented in the drawing as a legend.

14. INSULATION

For insulation, the proper specifications of this PROJECT and of OWNER shall be followed.

Insulation for limit noise levels, personnel protection and heat conservation could be used.

Personnel protection shall be provided for metal surfaces having temperature above 65 ºC. In case of requirement:

- Insulation for heat conservation shall be provided with a temperature equal to or upper 21 ºC or at an ambient temperature (with electric or steam tracing or steam jacket). B1
- Insulation for reduction of condensation control shall be provided to a temperature equal to or under 21 ºC. B1

The thickness of insulation shall be following the typical guidelines of API or PIP.

15. MISCELLANEOUS CRITERIA

15.1 SIMBOLOGY

The simbology used in this PROJECT shall be the approved NF3 project P&ID legends and symbols. B1

15.2 LANGUAGE

The language in this PROJECT (technical documents, calculations, data sheets, drawings, nameplates, advices, letters, faxes, e-mails, etc.) shall be English with modes and typical uses in the international petroleum & gas industry.

15.3 UNITS OF MEASUREMENT

The units of measurement used shall be SI with "bar" for pressure (absolute with "a" and gauge with "g") and "degrees Celsius" (ºC) for temperature except for pipe and pipe fitting sizes, flange ratings and nozzle dimensions. B1