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3-10) Flare System

3-10-1) Flare Stack Sizing

The flare boom or stack length is determined by the maximum allowable thermal radiation tolerable on the platform or surrounding area.
Recommended radiation levels and exposure time necessary to reach the pain threshold are given below:

Recommended Design Total Radiation		
Permissible Design Level (K)		Conditions
British Thermal Units Per Hour per Square Foot	Kilowatts per Square Meter	
5000	15.77	Heat intensity on structures and in areas where operators are not likely to be performing duties and where shelter from radiant heat is available (for example, behind equipment)
3000	9.46	Value of K at design flare release at any location to which people have access(for example. At grade below the flare or a service platform of a nearby tower), exposure should be limited to a few seconds, sufficient for escape only
2000	6.31	Heat intensity in areas where emergency actions lasting up to 1 minute may be required by personnel without shielding but with appropriate clothing
1500	4.73	Heat intensity in areas where emergency actions lasting several minutes may be required by personnel without shielding but with appropriate clothing
500	1.58	Value of K at any location where personnel with appropriate clothing may be continuously exposed

Notes:

i) On towers or other elevated structures where rapid escape is not possible, ladders must be provided on the side away from the flare, so the structure can provide some shielding when K is greater than 2000 British thermal units per hour per square foot (6.31 kilowatts per square meter).

ii) Solar radiation contribution varies by geographical location and is generally in the range of 250 to 330 BTU/hr/ft2 (0.79 to 1.04 KW/m3).

6-4-7) Earthquake Load
6-4-8) Truck Loads
6-4-9) Railway Loads
6-4-10) Impact Load
6-4-11) Vibration Load
6-4-12) Thermal Load
6-4-13) Erection Load
6-4-14) Maintenance Load

6-5) Loading Combinations

6-6) Allowable Stresses

6-7) Methods of Design
6-7-1) Reinforced Concrete
6-7-2) Structural Steelwork
6-7-3) Masonry Structures
6-7-4) Storage Tank Foundations
6-7-5) Vibrating Machine Foundations

6-8) Civil Work
6-8-1) Plant Roads and Paved Area
6-8-2) Surface Drainage System

Section 7- Fire Fighting & Safety

Section 8- Corrosion Protection

Section 9- References & Attachments

Introduction

According to Lavan oil refinery company (LORC) requirement it is planned to execute the subject project. Based on EMPLOYER declarations within issued scope of work, the main objectives of LORC are:

- Reviewing the Pre- Basic Design Report and finalizing refining configuration to cover the following main requirements:
  - Total through put of 50,000 BPSD mixed crude oil and condensate
  - The mixed feed stock shall include of 30,000 BPSD Lavan Export Crude Oil and 20,000 BPSD South Pars Condensate.
- Preparing the basic design package for Open Art units, Licensed units as well as Utilities and Offsite facilities for the case of through put of 50,000 BPSD.
- Preparing EPC tender documents for EPC phase of the package

Section 1- General & Site Conditions

Lavan refinery located in the Lavan Island in the Persian Gulf, south of Gavbandi port.

1-1) Climatic Conditions

The climatic conditions of site are shown on table (1-1).

TABLE (1-1) - Climatic Conditions

Wind Design Velocity	100 MILES/HR
Maximum Ambient Temp	50ºC
Minimum Ambient Temp	0ºC
Relative Humidity (Average)	95-100%
Maximum Rainfall Per Hour	1" OR 3"/12 HR
Earthquake	Zone 3 (Acc. To UBC Categories – See section 6.4.8)
Snow Loading	None
Maximum Sea Water Temp	33.3ºC (Maximum sea water return temp. from heat exchangers is 46.1ºC)
Solar Radiation	250 Btu/hr. ft^2

1-2) Utility Characteristics

Existing utility characteristics are shown on table (1-2).

Low pressure steam at 5 kg/cm2 (g) & 160ºC conditions is assumed to be produced in refinery at future and is used as LPS in this project.

TABLE (1-2) – Utilities Characteristics

DESCRIPTION	OPER/DES PRESS. (KG/CM^2G)		OPER/DES TEM. (°C)	
1- COOLING WATER	4.5	7.0	33~35	50 MAX.
2- TREATED WATER	3.0	5.0	35	50 MAX.
3- FIRE WATER (NORMAL)	4.6	7.0	35	50 MAX.
4- MEDIUM PRESSURE STEAM	10.54	12.5*	186	189
5- HIGH PRESSURE STEAM	42.0	44 *	380	385
6- PLANT AIR	8.5	10.5	--	49 Max.
7- INSTRUMENT AIR	5.0	7.0	--	49 Max.
8- ELECTRICAL SUPPLY: AC 6000 VOLT X 3 PHASE X 50 HZ AC 380 VOLT X 3 PHASE X 50 HZ AC 220 VOLT X 1 PHASE X 50 HZ DC 110 VOLT				

* Safety valve set pressure

9- Fuel Gas

Fuel gas to fuel gas drum (D 2202) is supplied from existing CRU unit (before installation of LPG unit and other new units at future), with 4 different sources of gases. The design compositions & conditions of each of these different sources and their mixture are shown in table (1-3).

TABLE (1-3) – Design Conditions of Fuel Gas

Name Phase / Compositions	SEPERATOR GAS DRY VAPOR	DEBUTANIZER OVHD MIXED	SPLITTER OVHD GAS MIXED	STABILIZER OVHD GAS MIXED	CRU OFF GAS WET VAPOR (MIXTURE)
H20	0.0000	0.0000	0.1406	0.2812	0.4218
H2	170.0497	2.5083	8.1419	0.7303	181.4301
H2S	0.0000	0.0000	0.2359	0.7983	1.0342
C1	32.3288	2.4947	3.2159	1.5967	39.6361
C2	20.3893	4.6040	0.9026	2.1274	28.0233
C3	11.6580	4.2501	0.1225	0.9072	16.9378
IC4	3.3689	1.6873	0.0907	1.5059	7.1528
NC4	4.0695	1.7826	0.2359	5.1710	11.2590
IC5	0.4894	0.0000	0.4763	0.1452	1.1108
NC5	0.3866	0.0000	0.6486	0.0272	1.0625
NC6	1.4707	0.0000	0.4672	9.0703e-03	1.9470
N2	0.0000	0.0000	0.0000	0.0000	0.0000
CO2	0.0000	0.0000	0.0000	0.0000	0.0000
Total Rate, KG-MOL/HR	244.7110	17.3270	14.6780	13.2995	290.0155
Temperature. °C	42.2000	42.2000	41.7000	42.2000	36.8346
Pressure, KG/CM2	22.1300	18.9600	9.1900	8.2000	8.2000
Enthalpy, MKCAL/HR	0.0259	0.0499	0.0121	0.0555	0.1435
Molecular weight	10.7883	33.0481	17.1362	42.4561	13.8917
Mole frac. Vapor	1.000	0.9893	0.9848	0.9573	1.000
Mole frac total liquid	0.000	0.0107	0.0152	0.0427	0.0000
Mole frac H/C liquid	0.000	0.0107	0.0144	0.0314	0.0000
Mole frac free water	0.0000	0.0000	7.9459E-04	0.0113	0.0000

Also, the design pressures upstream & downstream of letdown valves for each of these sources are as follows:

		Upstream Press.(Psig)	Down stream press.(Psig)
1-	Sweet Gases		
	a- SEP. OVHD GAS	300	50
	b- DEB. OVHD GAS	255	50
2-	Sour Gases		
	a- SPLOVHD GAS	116	86
	b- STABOVHD GAS	102	72

10- Nitrogen

Nitrogen design conditions & purity are as follows:

Gaseous Nitrogen flow max	100	Nm3/h
Oxygen content max*	0.100	% Vol. O2
Nitrogen supply pressure at B.L.	7.0	bar abs
Dew point at 1 bar(a) approx.	-40	ºC

* Actual O2 content is 0.2% vol.

1-3) Process Design Basis

Refer to attachment (9-1)

Section 2- Design Codes, Standards & References

According to booklet of "Scope of work & technical specification of project", International standards like ASTM, ASME, API, IEC and also IPS standards are to be considered as main standards in this project.

Based on this requirement the following standards have been considered in different discipline:

2-1) Process & Mechanical

2-1-1) Heat Exchangers

TEMA	Standards of the Tubular Exchanger Manufacturers Association
API STD 660	Shell and Tube Heat Exchangers for General Refinery Services
API STD 661	Air Cooled Heat Exchangers for General Refinery Services
API STD 662	Plate Heat Exchangers for General Refinery Services
IPS E PR 771	Engineering Standard for Process Requirements of Heat Exchanging Equipment
IPS E PR 775	Engineering Standard for Process Design of Double Pipe Heat Exchangers
IPS E PR 785	Engineering Standards for Process Design of Air Cooled Heat Exchangers (Air- Coolers)

2-1-2) Separators

API Spec 12J	Specification for Oil and Gas Separator
IPS E PR 880	Engineering Standard for Process of Gas (Vapor) – Liquid Separators
IPS E PR 850	Engineering Standard for Process Requirements of Vessels, Reactors and Separators

2-1-3) Piping and Pipelines

ANSI	B	31.3	Chemical plant & petroleum refinery piping
ANSI	B	1.1	Unified screw threads
ANSI	B	1.20.1	Pipe threads
ANSI	B	16.5	Steel pipe flanges, flanged fittings
ANSI	B	16.9	Factory-made wrought steel, butt welding fittings

ANSI	B	16.10 Face to face & end to end dimensions of ferrous valves
ANSI	B	16.11 Forged steel fittings, socket welding & threaded
ANSI	B	16.21 Nonmetallic flat gaskets for flanges
ANSI	B	16.25 Butt welding ends
ANSI	B	36.10 Welded & seamless wrought steel pipe
ANSI	B	16.34 Steel valves
API	STD	607 Fire test for soft seated valves
API	SPEC	6FA Spec for fire test of valves
API	STD	598 Valve inspection & test
API	SPEC	5L Specification for line pipe
API	STD	600 Steel gate valves flanged & butt welding ends
API	STD	602 Compact carbon steel gate valve
BS	6755	(PART 1) Specification for production pressure testing requirements
BS	1868	Steel check valve
BS	1873	Steel globe & globe stop & check valves
BS	5351	Steel ball valve
BS	5352	Specification for steel wedge gate, globe and check valves
MSS	SP6	Standard finishes for contact faces of pipes, flanges & connecting end flanges of valves and fittings
MSS	SP25	Standard marking system for valves, fittings, flanges & unions
MSS	SP44	Steel pipeline flanges
MSS	SP45	Bypass & drain connection standard
MSS	SP97	Forged carbon steel branch outlet fitting, socket welding, threaded & butt welding end.
ASTM		American society for testing & materials
NACE	MR	01.75 Material requirements, sulfide stress cracking resistant metallic materials for oil field equipment.
IPS-E-PI-200		Engineering Standard for Flexibility Analysis
IPS-E-PI-221		Engineering Standard for Piping Material Selection (on Plot Piping)
IPS-E-PI-240		Engineering Standard for Plant Piping Systems
IPS G-PI-280		General Standard for Supports

2-1-4) Heaters

API STD 530 Calc. of Heater-Tube Thickness in Petroleum Refineries

API STD 560 Fired Heaters for General Refinery Services

API RP 556 Instrumentation and Control Systems for Fired Heaters and Steam Generators

API Publ 534 Heat Recovery Steam Generators

API Spec 12K Specification for Indirect Type Oil Field Heaters

2-1-5) Pressure Relieving

API RP 520 Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries

API RP 521 Guide for Pressure-Relieving and Depressuring Systems

API STD2000 Venting Atmosphere and Low-Pressure Storage Tanks Non-Refrigerated and Refrigerated

IPS E PR 460 Engineering Standard for Process Design of Flare and Blow-down Systems

IPS E SF 860 Engineering Standard for Air Pollution Control

2-1-6) Pumps

API STD 610 Centrifugal Pumps for General Refinery Services

API STD 674 Positive Displacement Pumps-Reciprocating

API STD 675 Positive Displacement Pumps-Controlled Volume

API STD 676 Positive Displacement Pumps-Rotary

API STD 681 Liquid Ring Vacuum Pumps and Compressors for Petroleum, Chemical and Gas Industry Services

2-1-7) Compressors

API STD 617 Centrifugal Compressors for General Refinery Services

API STD 618 Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services

API STD 619 Rotary Positive Displacement Compressors for Petroleum, Chemical and Gas Industry Services

API STD 680 Packaged Reciprocating Plant and Instrument Air Compressors for General Refinery Services

API Spec 11P Specification for Packed Reciprocating Compressors for Oil and Gas Production Services

2-1-8) Storage Tanks

API STD 620	Designs and Construction of Large, Welded, Low Pressure Storage Tanks
API STD 650	Welded Steel Tanks for Oil Storage
API RP 1525	Bulk Oil Testing, Handling and Storage Guidelines
API Spec 12B	Specification for Bolted Tanks for Storage of Production Liquids
API Spec 12D	Specification for Field Welded for Storage of Production Liquids
API Spec 12F	Specification for Shop Welded for Storage of Production Liquids
API Spec 12P	Specification for Fiberglass Reinforced Plastic Tanks

2-1-9) Safety & Miscellaneous

API RP 50	Natural Gas Processing Plant Practices for Petroleum of the Environment
API RP 51	Onshore Oil and Gas Production Practices for Petroleum of the Environment
API RP 551	Process Measurement Instrumentation

2-1-10) Other Equipment / Packages / Process

API STD 2610	Design, Construction, Operation, Maintenance and Inspection of Terminal and Tank Facilities
API RP 1124	Ship, Barg and Terminal Hydrocarbon Vapor Collection Manifolds
B.S. 2594	Carbon Steel Welded Horizontal Cylindrical Storage Tanks

2-1-11) Environmental Protection

Environmental Protection Organization of Iran	Environmental Regulations & Standards

2-2) Electrical

- NIOC Engineering Standards for electrical
- IEC Standards
- CENELEC Standards
- BS Standards
- NFPA Bulletin 70
- API
- IPS (Iranian Petroleum Standard)

2-3) Civil & Structural

2-3-1) Design

a) Reinforced Concrete Structures:

- ACI (American Concrete Institute) 318 “Building Code Requirements for Reinforced Concrete”.
- British Standard Code of practice, CP 110, and CP 114, “The Structural use of Reinforced Concrete in Buildings”.

b) Steel Structures:

- AISC (American Institute of Steel Construction) Specification for the Design, Fabrication and Erection of Structural Steel in Buildings.
- Iranian Standards ISIRI No. 519 Min. design loads in Buildings and other structures.
- AWS: American Welding Society.
- ASTM: American Society for Testing and Materials.

c) Masonry Structures (Brick work and concrete Masonry)

- British Standard Code of Practice CP-111, “Structural Recommendations for Load bearing Walls”.
- Uniform Building Code (UBC)
- ACI 318, “Building Code Requirements for reinforced Concrete.
- ASTM:
  - ASTM C26.83 for masonry bricks
  - ASTM C652.81A for hollow brick

- ASTM C216.81 for facing brick
- EMPLOYER'S STANDARDS

d) General Loading, Load Combinations and Allowable Stresses for Buildings and other Structures:

- ISIRI No. 519, “Minimum Design Loads in Buildings and other structures”, Institute of Standards and Industrial Research of Iran.
- Uniform Building Code (UBC); International Building Code (IBC)
- Iranian Code for seismic resistant design of buildings, standard No.2800.
- ANSI / ASCE-7

e) Roads, Railway, Bridges and other Similar and Related Structures:

- American Association of State Highway and Transportation Officials (AASHTO).
- ASTM: American Society for Testing and Material D977, D995, D1073 and MS2.
- Asphalt Institute Handbook.
- American Railway Engineering Association (AREA), Manual of Railway Engineering.

2-3-2) Materials

a) Structural Steel: Mild Steel Grade St.37 in accordance with DIN 1025, 1050 and 17100 Specifications with a minimum yield stress of 2400 Kg/cm2 or approved equivalent.

b) Reinforcement:

- Plain Mild Steel Bars, Grade I, in accordance with DIN 1045 Specifications with a minimum yield stress of 2200 Kg/cm2 or approved equivalent.
- Deformed steel bar Grade II in accordance with DIN 1045 specification with a minimum yield stress of 3000 Kg/cm2 or approved equivalent.
- Deformed High Tensile Strength Steel Bars grade III, in accordance with DIN 1045 Specification with a minimum yield stress of 4000 kg/cm2 or approved equivalent.

- Reinforcing Fabric Mesh in accordance with BS 4483 or other standards approved by EMPLOYER. Sizes shall be as follows:
  - 200 x 100 x 7 x 7 mm
  - 200 x 100 x 8 x 8 mm
  - 200 x 200 x 7 x 7 mm
  - 200 x 200 x 8 x 8 mm
  - 150 x 150 x 8 x 8 mm
  - Other sizes, shall be approved by EMPLOYER.

c) Bolts, Nuts and Washers:

- Hexagonal bolts and nuts shall be in accordance with DIN 7990 specifications or approved equivalent for structural steel connections.

- Hexagonal nuts shall be in accordance with DIN 555 specifications or approved equivalent.

- Circular washers shall be in accordance with DIN 7989 specifications or approved equivalent.

- Square Washers shall be in accordance with DIN 434 for connections of steel channels and DIN 435 for connections of steels I-Sections, or approved equivalent.

d) Welding Electrodes:

- Welding Electrodes for manual shielded metal-arc welding shall conform to the “Specification for mild Steel covered, Arc. Welding Electrodes”, American Welding Society, AWS A5.1, or approved equivalent.

- Bare Electrodes and Granular Flux used in the submerged-arc process shall conform to F6 and/or F7 AWS flux classification of the “Specification for Bare Mild Steel Electrodes and Fluxes for Submerged Arc-welding “American Welding Society, AWS A5.17 or approved equivalent.

e) Cement:

Shall be an approved brand of Portland cement in accordance with ASTM C-150 specification or approved equivalent. Type of cement shall be in accordance with soil investigation report, subject to EMPLOYER’S approval.

f) Aggregates – Sand:

Fine and coarse aggregates for concrete and sand for mortar and grout shall conform to ASTM C33 or BS 882 or AASHTO M6 and M80 Standards.

g) Concrete:

Concrete shall generally conform to the requirements of ACI 211, 301, 305 & 306.

h) Bricks:

Brick specification shall conform to ASTM standard for brick.

i) Quality Control of Materials and Workmanship

The quality of the materials and workmanship shall be controlled by tests and other methods recommended by relevant standards and Codes such as ASTM, AASHTO, ACI and relevant EMPLOYER'S standards.

2-4) Instrumentation

In general, IPS shall be followed for instrumentation. Any conflict between IPS and above standards shall be brought to the EMPLOYER and approved by EMPLOYER case-by-case.

Instrumentation will be designed and fabricated in accordance with engineering codes and standards:

- **ANSI**

B 16-34	Valves: Flanged, threaded and welding end
FCI 70-2	Control valve seat leakage
MC 96-1	Temperature measurement thermocouples

- **API** **Manual of petroleum measurement standards**

API RP 500	Recommended practice for classification of locations for electrical installations at petroleum facilities classified as class I
API RP520	Sizing selection and installation of pressure relieving devices
API RP 521	Guide for pressure relief and depressurizing systems
API STD 526	Flanged steel safety valves for use in petroleum industry (Including marking)
API STD 527	Commercial seat tightness of safety relief valves with metal to metal seat

API RP 550 Manual on installation of refinery instruments and control systems

API RP 551 Process measurement instrumentation

API RP 552 Transmission system

API RP 554 Process instrumentation

API RP 555 Process analyzers

API STD 598 Valve inspection and testing

API STD 670 Vibration,axial position & bearing temperature monitoring systems

- **ASME**

ASME, Div. 1Flange rating when temperature exceeds the limits of sect. VIII, ap. 2 ANSI B 16.5

ASME, Div. 1Hydraulic test for safety relief valve sect. VIII

- **IEC**

IEC 60-068.2 Basic environmental testing procedures for electronic components and electronic equipment

IEC 60-079 Electrical apparatus for explosive gas atmosphere

IEC 60-331 Fire resisting characteristics of electrical cables

IEC 60-332 Tests on electric cables under fire conditions (with part 1 and part 3c)

IEC 60-529 Classification of degree of protection provided by enclosures

IEC 60-584 Thermocouples

IEC 60-751 Industrial platinum resistance thermometer sensors

IEC 60-801 Electromagnetic compatibility for industrial process measurement and control equipment

- **IEEE**

IEEE 472 Surge protection criteria

- **ISA**

ISA S5.1 Instrumentation symbols and identification

ISA S75.01 Flow equations for sizing control valves

ISA S75.03 Uniform face to face dimensions for flanged globe style control valve bodies

ISA S18.1 Annunciator sequences and specifications

- **Others**

EIA RS232/422/485 Interface between data terminal equipment and data Communication equipment employing serial binary data

NACE MR 01 75 Standard Material Requirement: Sulfide stress cracking resistant metallic materials for oilfield equipment

2-5) Safety & Fire Fighting

- NFPA
  NFPA-58: Liquefied Petroleum gas Code
  NFPA-15: Water Spray System
  NFPA-10: Portable Extinguishers
  NFPA-24: Private Fire Service Mains
  NFPA-2001: Standard on Clean Agent Fire Extinguishing System

- APIA

- API 2030: Application of Fixed Water Spray Systems for Fire Protection

- Design calculations are based on relevant procedures and work instructions of quality assurance system of NCE.

- Document numbering procedure is based on 1166-PR4PM-7011 document.

Section 3- Process

3-1) Codes & Standards

Refer to section (2-1).

3-2) P&ID Engineering Units

International system of units (SI) is basically used in this project except for normal diameter and rating of piping materials for which the English Units will be used.
The following units, although some are "non-SI unit" are allowable in this project.
The accuracies shown in Table (3-1) shall be used.

TABLE (3-1) – Engineering Units

Quantity	Unit	Accuracy (Decimal Places)
Pressure	Kg/cm^2 (Note-1)	1
Temperature	°C	-
Mass flow rate	Kg/Hr	-
Volume flow rate:		
Gases	Nm3/Hr (Note-2)	-
Liquids	m^3/Hr	1
Petroleum Liquid	BPSD	1 (Note-4)
Mole flow rate	Kgmol/Hr	2
Viscosity	CP	2
Density	Kg/m3	2
Length	M,mm,in(Note-3)	
Power	KW	-
Duty	MKCal/Hr	-

NOTES:

(1) Kg/Cm2 is defined as absolute pressure. Use the term Kg/Cm2 (G) to indicate gage pressure.

(2) Normal condition is defined as:
T=0 °C and P= Atmospheric Pressure (1.03 kg/Cm2(a))
A standard condition is defined as:
T=15.6 °C (60 °F) P= Atmospheric Pressure (1.03 kg/cm2(a))

(3) Inches shall be used only for piping and nozzle sizes.

(4) BPSD (Barrel per Std. Day) shall be used only for petroleum liquids.

3-3) Design Condition

3-3-1) Design Pressure Criteria

The design pressure is the maximum and/or minimum pressure for which the mechanical calculation shall be performed. The set pressure of the relief valve must be lower than or equal to the design pressure of equipment. For vacuum rating designation, pressure shall be shown as external.
The maximum operating pressure is defined as the maximum pressure which occurs during normal modes of operation, including start-up and shutdown, and should take full account of any hydrostatic head, and other pressure drop across the item.

Maximum Operating Pressure	Design Pressure
Under Vacuum	Full vacuum and 3.5 Barg internal while external Pressure is atmospheric
0-18 Barg	3.5 Barg or maximum operating pressure plus 1.8 bar, whichever is greater. For PSV discharging to Atm, 2.0 Barg
18-69 Barg	110% of maximum operating pressure
69 Barg and higher	110% of maximum operating pressure if conventional safety valve is used and 105% of maximum operating pressure if pilot operated safety valve is used.

- For lines and equipment located on discharge side of rotating machineries (pumps, compressors, …) and are not protected by pressure relief valve, design pressure shall be:

  1- Maximum shut-off
  2- Blocked-in pressure plus static head (if any)
  3- Above mentioned pressure whichever is greater.

- OVHD condenser and reflux drum: design pressure will be calculated based on the column top operating pressure.
  Bottom reboiler: design pressure will be calculated based on the maximum column bottom operating pressure plus static head.

- For the CDU main column the following conservative criteria will be applied:
  Design pressure is calculated based on the bottom section and is applied to all the sections of tower and also a group of related towers such as main column and side stripper.

Operating pressure is defined as the maximum anticipated operating pressure at the top of the vessel as per ASME. Mechanical design of

bottom of vessel shall include allowance for hydrostatic head and pressure drop across trays and or other internals.

Notes

a) Vacuum design conditions must be adopted for all equipment that normally operate under vacuum conditions or subject to evacuation during start-up, shut-down/or regeneration.

b) Special consideration shall be given to the design for external pressure of vessels normally subject to internal pressure, but connected to the suction of a compressor or other evacuating equipment. Low-pressure vessels that may be affected by decreasing in ambient temperature shall also be considered, such as overhead receiver operating at low pressure and receiving feed from an air-cooled exchanger.

External pressure in these cases shall be half of vacuum. As an example, main column overhead receivers, which are operating at low pressure and receive feed from an air-cooled exchanger.

c) Vapor pressure at design temperature should be considered except when PSV is provided.

d) For S&T heat exchangers, design pressure of one side shall not be less than operating pressure of the other side.

e) It is not normal practice to design a vessel for full vacuum because of the possibility of mal-operation during hydro-testing, as this is covered by procedures.

f) As with jacketed vessels, some tanks such as double wall tanks will be subject to an external design pressure, because the external pressure in the annulus between the walls may exceed the internal pressure, even when the internal pressure is at or above gauge pressure. Open vents or other means of relieving the annulus pressure is often employed to limit this external pressure.

g) The design pressure of the fired heaters coils shall be calculated considering the design pressure of the downstream vessel plus fouling allowance pressure drop plus 120% of the allowable pressure drop in clean conditions.

h) If a control or block valve is installed downstream the heat exchanger, the design pressure shall be the same of the upstream equipment or the actual shut-off pressure of the upstream purchased pump.
If a control or block valve is installed upstream the heat exchanger, the design pressure shall be calculated as the design pressure of the downstream equipment at the inlet point plus 1.20 times the pressure

drop of the circuit between the heat exchanger inlet and the inlet point of the downstream equipment plus static head (if any).

j) In Atmospheric storage tanks:

- Without gas blanketing, the design pressure shall be the hydrostatic pressure considering the tank full of liquid.
- gas blanketed and with a seal pressure lower than 100 mm of H2O, the design pressure shall be the hydrostatic pressure considering the tank full of liquid plus 150 mm H2O.
- gas blanketed and with a seal pressure not higher than 400 mm of H2O, design pressure shall be the hydrostatic pressure considering the tank full of liquid plus 500 mm of H2O.

k) For Welded Steel Tanks for Oil Storage, unless otherwise specified by the purchaser, the internal design pressure shall not exceed the weight of the roof. In no case shall the maximum design pressure exceed 9 inches water column. When the design pressure for a tank with an aluminum dome roof is being calculated, the weight of the roof, including structure, shall be added to the weight of the shell. Vents shall be sized so that the venting requirements can be handled without exceeding the internal design pressure.

l) For Large, Welded, Low-Pressure Storage Tanks, design pressure, in pounds per square inch gauge, shall be at least equal to the total pressure on the wall of the tank at the level where the cover plate is located or shall be 15 pounds per square inch gauge, whichever is greater. The design pressure for the gas vapor space of the tank shall not exceed 2 pounds per square inch gauge.

3-3-2) Design Temperature

The design temperature is the maximum and/or minimum value for which the mechanical calculation of the equipment shall be performed. The maximum or minimum temperature shall be specified if the mechanical design can be affected. The following is a guideline for the design temperature calculation:

Operating temperature	Design temperature
Up to –30°C	Minimum operating temperature minus 5°C
-30°C up to 343°C	Operating temperature plus 25°C
Higher than 343°C	The design temperature shall be defined according to the selected material

- When minimum blow-down temperature is calculated less than –30°C, or maximum blow-down temperature can be calculated more than 343°C, the same temperatures shall be defined as minimum / maximum design temperatures. Otherwise, flare Blow-down vessels shall be designed for -30°C minimum design temperature and +343°C maximum design temperature.

- The overhead receivers and relevant pumps casing shall be designed for the operating OVHD temperature of the relevant upstream columns plus 25°C.

- For vessels having a design pressure not higher than 3.5 Barg, the minimum design temperature shall be 120°C.

- Vessels subject to steam-out operation shall be designed to meet temperature during such operation.

- Lines subjected to steam tracing shall be designed to minimum saturation temperature of steam.

- Columns with fired feed heater with/without side cut strippers:

  - In the zone between the draw off trays of two adjacent side cuts, the design temperature shall be the draw off temperature of the heavier side cut plus 25°C,
  - In the zone between the heaviest sides cut draw off tray and the bottom of the column the design temperature shall be the flash zone temperature plus 25°C.

- Side cut strippers with stripping steam: The design temperature shall be the operating inlet temperature of the process stream plus 25°C.

- Fractionators with reboiler: The design temperature of bottom section shall be the reboiler return temperature plus 25°C
- Steam out conditions should be quoted as 140 °C and 1.5 Barg. Full vacuum, at 140 °C, should also be quoted if steam-out connections are permanent. To avoid designing for full vacuum, it is acceptable if it is possible to rely on operating practice or vacuum break systems.

- For seawater supply systems where the maximum operating temperature is defined by the seawater yearly variations, the maximum operating temperature shall be used as the maximum design.

- For seawater systems, the maximum operating temperature shall be calculated at the minimum seawater flow. Minimum seawater flow is calculated at lowest seawater supply temperature and heat exchanger without fouling.

- The design temperature relevant to special equipment included in LICENSED UNITS shall be defined by the relevant LICENSORS.

3-4) Line Sizing Criteria

The following general guidelines should be used for sizing in-plant pipes. For single phase fluids (gas or liquid), pressure drop and velocity limitations in pipe should be according to the following criteria. For two phase fluids, erosional and minimum velocity criteria should be met as described here-in below.

However, minimum recommended size for process and utility pipe is 1.5 inches to ensure adequate mechanical intensity. For overflow from tanks, the pipe size shall be as a minimum equal to the largest inlet pipe. For sewage and open drain headers and subheaders the 4 inches and 3 inches is minimum recommended size, respectively.

If in any case, the following criteria for velocity & DP is not applicable, specific line sizing criteria must be approved by Dep. Head/Deputy.

3-4-1 Single Phase Lines

Liquids

Service	DP (bar/100m)			Velocity (m/s)		
	Norm.	Min.	Max.	Norm.	Min.	Max.
General					0.9	4.6
Pump Suction						
Boiling Liquids	0.06					
ID <= 8"						0.9
ID > 8"						1.4
Subcooled liquids	0.23					
ID <= 8"						1.5
ID > 8"						2.4
Viscous Liquids						1
Reciprocating Pumps						
Speeds up to 250RPM				0.61		
Speeds 251-330RPM				0.46		
Speeds above 330RPM				0.30		
Pump Discharge						
P < 50barG		0.2	0.5			
P > 50barG		0.3	0.9(1)			
Reciprocating Pumps						
Speeds up to 250RPM				1.83		
Speeds 251-330RPM				1.37		
Speeds above 330RPM				0.90		
Centrifugal Pumps						
ID <= 2"						1.2
2" < ID <= 6"						2.4
6" < ID <= 10"						3.0
ID >= 10"						4.6
Gravity Flow	0.025		0.035			0.6
Liquid at its boiling point to control valve						<1
Boiler Feed					1.5	4.5
Steam condensate return						1
Lean Amine Line					0.9	1.53
Rich Amine Line					0.3	0.9
Column Bottom Liquid to Reboiler			0.045	0.04		0.06
Liquid at Bubble point or with dissolved gas			0.1			

(1): If the piping is alloy steel, the pressure drop up to 1.6Bar/100m is allowable.

Gases & Vapors

Pipe sizing for gas, vapor & steam shall be performed based on the following criteria and the given algorithm at NCE-EP-WI-201.

Service	DP (bar/100m)			Velocity (m/s)	ρv2 ($kg.m.s^{-2}$)
	Norm.	Min.	Max.	Max.	Max.
Steam Line					
Saturated Steam					
P <= 3.5 barG				$15.2\ d^{0.5}$	15000
Header/Subheader			0.1		
Short Lines			0.2		
3 < P <= 17.2 barG				$12\ d^{0.5}$	15000
Header/Subheader			0.2		
Short Lines			0.4		
P > 17.2 barG				$10\ d^{0.5}$	15000
Header/Subheader			0.3		
Short Lines			0.5		
Superheated Steam					
P <= 3.5 barG			0.35	60	15000
3.5 < P <= 17.2 barG			0.35	42	15000
P > 17.2 barG			0.5	30	15000
Process Gas or Vapor Line					
Less than 1 BarA		0.01	0.06		15000
0 BarG to 1 BarG					15000
Short Lines			0.02		
Long Lines			0.01		
1 BarG to 10 BarG					15000
Short Lines			0.1		
Long Lines			0.05		
10 BarG to 30 BarG					15000
Short Lines			0.2		
Long Lines			0.1		
30 BarG to 70 BarG					15000
Short Lines			0.3		
Long Lines			0.15		
Over 70 BarG	0.5% Abs. Op. Press.				15000
Column OVHD Line					
ATM - 13.4 Bar			0.05		
More than 13.4 Bar			0.1		
Relief header				0.5 Mach	
Suction Lines to vaccum pump				0.6	
Compressor anti-surge *					
Up to 50 BarG					10000
From 50 to 80 BarG					15000
Over 80 BarG					25000
Compressor Suction			0.07		3000
Compressor Discharge					
0 BarG	0.06				
1 BarG	0.09				
3.5 BarG	0.1				
7 BarG	0.18				
14 BarG	0.34				
35 BarG	0.4				
Higher	0.5%Outlet Pressure				
Reciprocating				$83.18\ (MW)^{-0.5}$	
Centrifugal					15000

Short Line <200 m
Long Line >=200 m
Line Length is based on equivalent line length
d: Nominal pipe diameter
MW: Gas or vapor molecular weight
***** These lines are not normal process routes; therefore it's enough to consider just mentioned velocity criteria and is not necessary to follow the given algorithm.

Service Water & Produced Water (Up to 150 Psig)

Glass-Fiber reinforced plastic:	
ID <6″	1.6 m/s (5ft/s)
ID >8″	2.5 m/s (7ft/s)

Note:

1- From Erosion – corrosion standpoint, the above maximum velocity limit for different services shall be considered.

3-4-2 Two phase (liquid / gas) Lines

Each mixed phase flow line shall be handled as special cases, taking the following considerations into account:

a) Erosional velocity

Two phase flow should be sized primarily on the basis of flow velocity. Flow velocity should be kept at least below fluid erosional velocity. The velocity above which erosion may occur can be determined by the following empirical equation:

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

V_e = fluid erosional velocity, ft/s

C = empirical constant
= 125 for non-continuous services
= 100 for continuous services

ρ_m = gas / liquid mixture density at operating pressure and temperature, lb/ft^3

$$\rho_m = \frac{12409 S_l P + 2.7 R S_g P}{198.7P + RTZ}$$

P = Operating pressure, psia
S_l = Liquid specific gravity (water=1, use average gravity for hydrocarbon water mixture) at standard condition
R = Gas/liquid ratio, ft3/barrel at standard condition
T = Operating temperature, R

S_g = gas specific gravity (air=1) at standard conditions

Z = gas compressibility factor

The minimum cross sectional area required to avoid fluid erosion may be determined from the following equation:

$$A = \frac{9.35 + \frac{ZRT}{21.25P}}{V_e}$$

A = Minimum pipe cross sectional flow area required, in^2/1000 barrels liquid per day

b) Minimum Velocity

Stable flow Pattern shall be established for two phase flow lines. This method is to be used to determine the maximum line size permissible, before unstable flow occurs. If possible, the minimum velocity at minimum flow (turn-down) should be about 10 ft/s to minimize slugging of separation equipment.

3-5) Pipeline Hydraulics

Pipeline hydraulics is to be calculated based on the relevant NCE work instructions with the following general guidelines:

- The Mukherjee & Brill pressure drop correlation is to be used, unless the client asks for another correlation.
- The Mukherjee & Brill Hold-up correlation is to be used, unless the client asks for another correlation.
- Minimum temperature of 60°F(15.6°C) and maximum temperature of 90°F(32.2°C) should be considered for soil temperature at one meter depth in the Iranian southern area.
- Soil conductivity is to be calculated from detail soil reports. If such data is not available, Soil conductivity of 0.5 Btu/hr.ft^2 in maximum soil temperature case and soil conductivity of 0.4 Btu/hr.ft^2 in minimum soil temperature case should be taken for Iranian south oil fields area.
- A 10°C (18°F) margin shall generally been considered between operating temperature and hydrate formation temperature.

3-6) Pump Hydraulics Calculation Criteria

3-6-1) Some Points in Pump Hydraulics Calculation

- It should be considered that maximum normal flow rate should be used as the basis of hydraulic calculation.

- Minimum suction static head used in NPSHA calculation shall be based on perpendicular distance between min. liquid level in suction vessel and pump shaft level.

- Min. Liquid levels in the suction vessel, column and tank for NPSH calculation are as follows:

Vertical vessel	:	Bottom tangential
Horizontal vessel	:	Bottom of vessel
Column	:	Bottom of tangential line
Tank	:	Bottom of tank nozzle
Boot of vessel	:	Bottom tangential line of boot

Refer to Annex 3-1.

- For a strainer in suction line, friction loss of 0.05 bar at maximum normal flow shall be estimated if not specified otherwise.

- For an orifice, friction loss of 0.2 bar at maximum normal flow shall be estimated if not specified otherwise.

- For heat exchangers and fired heaters, allowable pressure drop specified in data sheets shall be used.
- For control valves, allowable pressure drop specified in data sheets shall be used. If not specified, the following procedure is used as a general guideline. Whichever greater of the below ΔP c.v [a,b] is selected as the design pressure drop of the control valve.

a) $\Delta P_{c.v.}$ = ΔP (friction losses) + ΔP (static head difference) where, ΔP (friction losses) is assumed 20-25% of circuit friction losses (excluding the control valve) at maximum normal flow rate.
ΔP (static head difference) is assumed as 5-10% of circuit static pressure difference.

b) $\Delta P_{c.v}$ = Static head of 5m liquid height.

- In Calculation of Max.Suction pressure, Max. liquid level in suction vessel and tank (HLL) shall be used. Refer to Annex 3-2.

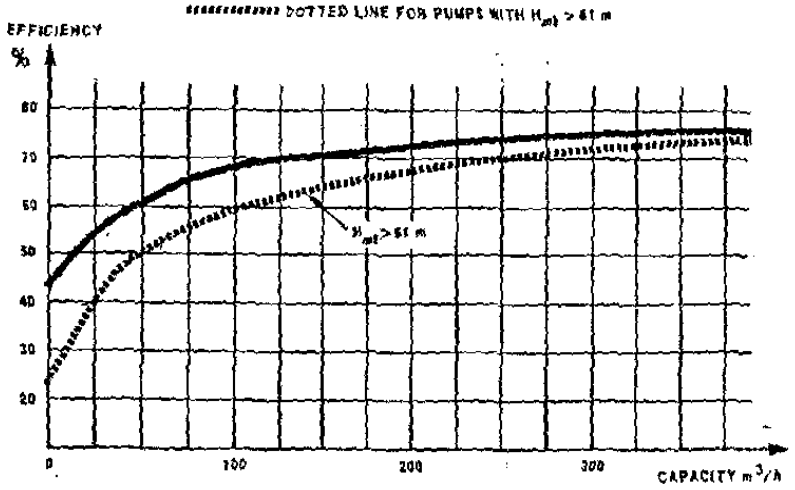
  The following formula is used in max. Shut-off pressure calculation:
  Max. shut-off pressure for centrifugal pump (barg) = Max. suction pressure (barg) +1.2 x Diff. Pressure (bar). For existing pump must be obtained from actual performance curve.

- For Pump design capacity and head the following equations shall be used.
  Pump design capacity=max. Normal flow rate x design Oversizing factor
  Pump design head = Pump head at maximum normal flow rate

- General Pump Design Oversizing Factor for different services:

a. Unit feed : 10% on maximum normal flow rate
b. Feed booster : 10% on maximum normal flow rate
c. Unit product : 10% on maximum normal flow rate
d. OVHD reflux : 20% on maximum normal flow rate
e. Pump around : 20% on maximum normal flow rate
f. Reboiler feed : 15% on maximum normal flow rate
g. Boiler feed water : 10% on maximum normal flow rate
h. Surface condensers cond. : 10% on maximum normal flow rate
i. Chemical injection : 20% on maximum normal flow rate
j. Metering pumps : 30% on maximum normal flow rate
k. Recip. and rotary pumps : 15% on maximum normal flow rate
l. All other pumps : 10% on maximum normal flow rate

- Efficiency is estimated from the following graph for new pumps.



- Motor drivers shall have horsepower ratings, including service factor, if any, at least equal to the following percentage of pump rated brake horsepower:

Motor Nameplate Rating	Percentage of Rated Brake Horsepower
25 horsepower and less	125
30-75 horsepower	115
100 horsepower and more	110

- Fluid characteristics always quote at pumping temperature i.e.: normal suction temperature.
- For an estimate, 30% of normal flow is used for pump minimum flow. For existing pumps, minimum flow shall be obtained from vendor data sheet.

3-6-2) Equivalent length

Equivalent length of lines is estimated as follows:
Equivalent Length = Correction Factor × Actual Length of Pipe
Table shown below gives good estimate of correction factor when piping layout information is not available

Line Size	Correction Factor	
	L* <300	L * ≥300
8″ and larger	3.6-0.008L	1.2
6″	3-0.006L	1.2
4″	2.4-0.004L	1.2
3″ and smaller	2.1-0.003L	1.2

* Actual Length of line (m)

When more accurate size check is required, equivalent length of each section element must be calculated, using the procedure illustrated in “Flow of Fluids”, CRANE, after piping layout information becomes available.

3-7) Vessel Design Criteria

3-7-1) Liquid Levels in Vessels

In the sizing of the separators, the equivalent residence time between normal operating and alarm level and between alarm level and trip level shall not be less than 30 seconds or 100mm, whichever is greater, for both high and low ranges. However, the major guiding factor will be a reasonable time for the operator to check reasons for operating outside the normal level motion effect shall also be considered. The following criteria can be used as a guideline:

- Drums feeding other equipment for further processing: 10 minutes (HLL- LLL).
- OVHD receivers: 5 minutes on reflux plus net product (HLL-LLL).
- Drums feeding fired heaters: 10 minutes (HLL-LLL) on total liquid.
- Gas and water separators: 5 minutes (HLL-LLL) on water flow rate.
- Water boots: 5 minutes below normal interface level or 10 minutes on water (HLL-LLL), whichever is greater.
- Compressor suction K.O. drums: 240 minutes on maximum entrained liquid in the inlet line (HLL-LLL if level control is provided otherwise HLA-BTM tangent line).
- Compressor suction drums will consider this time or the use of a 14 inch level range, whichever greater.
- Other types of K.O. drums: A volume corresponding to 15m of liquid slug in the inlet line (HLL-LLL if level control is provided otherwise HLA-BTM tangent line) or a 14 inch level range, whichever is greater.
- Vessel or tower from which liquid is fed to other equipment for further processing: 5-10 minutes (LLL-HLL).

- Vessel or tower from which liquid is fed to other process unit, where a surge drum is provided at the other process unit :2 min (HLL-LLL), 2 min (LLL-LLA)
- Surge Drum : 5 minutes (HLL-LLL)
- Liquid-Liquid separator: Based on separate ability of phases
- Vertical Separators:

  300mm (Bottom of inlet baffle-HLL) or ½ vessel Dia (Inlet nozzle – HLL) whichever is greater.

  300mm (HLL-LLL) or residence time required by process considerations, whichever is greater.

  300 mm (LLL-LLA),300 mm (HLL-HLA)

- Horizontal separators:

  380mm (HLL – Top of vessel) or as required for separation, whichever is greater.

* HLL means: High Liquid Level LLL means: Low Liquid Level
HLA means: High Liquid Alarm LLA means: Low Liquid Alarm
Water settling requirements take priority over these times where are applicable.

3-7-2) Sizing Criteria of Nozzle on Vessels

a) General

300 Pounds flange rating minimum shall be used for nozzle sizes equal and less than 1 ½'.

Thermo well nozzles will be flanged and the minimum size will be 1" I.D.

Alloy lined thermo well nozzles shall be of larger nominal diameter in order to ensure 1" minimum inside diameter of lining,

b) Size of Vent, Drain and Steam out Nozzles

Vessel Diameter (mm)	Vent[3] (inch)	Drain [1,2] (inch)	Steam-out (inch)
Up to 1200	1 1/ 2″	1 1/ 2″	1″
1200 – 2500	2″	2″	1 1/ 2″
2500 – 3500	3″	3″	1 1/ 2″
3500 – 6000	4″	3″	2″
> 6000	4″	4″	3″

(1) Drain on vertical vessel may be located on bottom line.
(2) Select drain size to be as same as process line, in case process connection is to be smaller than the above table.

(3) Vent size for atmospheric vessels shall not be less than inlet and outlet line size to allow tank breathing during fill-up or drain.

c) Size of Inlet, Gas Outlet and Liquid Outlet Nozzles

- **Inlet**

a) Size based on normal volumetric flow + 10% (liquid + vapor flow)
b) Limit inlet velocity to 7-13 m/s
c) Round nozzle diameter up or down to nearest standard size

- **Gas outlet**

a) Size on normal flow
b) Velocity limit 15-30 m/s

- **Liquid outlet**

a) Normal flow + 10%
b) Velocity limit 1-3 m/s HC
2-4 m/s water
c) Min. diameter = 2″ (avoid plugging)

Note-1

The momentum (ρv^2) shall also be checked not to exceed the; maximum allowable momentums listed here-below:

$\rho v^2 < 1000$ kg/ms^2 *where no inlet device is available.*

$\rho v^2 < 1500$ kg/ms^2 *where half pipe inlet device is available.*
$\rho v^2 < 6000$ kg/ms^2 *where vane type inlet device is available.*

ρ is mixture density (gas/liquid) and v is mixture velocity (gas/liquid).

3-8) Towers Recommended Minimum Tray Spacing and Oversizing Factor in Tray Towers

3-8-1) Minimum Tray Spacing

TRAY DIAMETER	TRAY SPACING
1300 mm ID or less	450 mm
1300 to 3000 mm ID	550 mm
3000 mm ID and larger	600 mm

* ABOVE FIGURES SHALL BE USED JUST AS A FIRST ESTIMATION. FOR PRECISE FIGURES CONFIRMATION OF VENDOR IS NEEDED.

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

Minimum distance from top tray to top tangent line shall be 750mm or as required to accommodate man way, internals or nozzles. Minimum hole

diameter for perforated trays shall be 1/2 inch. Minimum trayed column size shall be 750mm internal diameter.

3-8-2) Design Oversizing Factor:

- Flooding factor for fractionating trays : 78% maximum
- Flooding factor for pumparound trays : 83% maximum
- Flooding factor for steam stripping trays and side cuts strippers regardless of Stripping medium : 75% maximum

- Down comer back-up : 50% maximum of the tray spacing.
- Type of internals: structured packing may be applied, provided that they are compatible with coke formation tendency of the service. Random packing can be used in columns less than 750 mm in diameter.

3-9) General Design Criteria for Control Valve Sizing

- Generally, the range of control valve opening should be between 10% for minimum flow rate and 80% for maximum (design) flow rate. At the normal flow rate valve opening percent should be 60%-70%.
- Control valve pressure Drop (ΔPcv) which is utilized to size the control valve should be calculated / specified for routes without and/or with compressor/pump separately as follows:

i) For the routes without comp. /pump, ΔP_{cv} should be calculated according to the following relation:

$$\Delta P_{cv} = (P_s - P_e) - \Delta P_{sh} - F$$

Where P_s and P_e are operating pressure of equipment in the start and end of the route, ΔP_{sh} is the static head difference between start and end of the route and F is the total frictional press. Drop of the route excluding the control valve which to be calculated at design flow rate through control valve.

ii) For the routes with compressor/pump, ΔP_{cv} should be considered 16 psi or 10-15% of the total pressure drop of the route including pressure drop of control valve, whichever is greater, at the maximum design flow rate.

In both cases ΔP_{cv} should be calculated using the mentioned equation at the normal and minimum flow rates through control valve and control valve opening to be checked to make sure that it is not below the lower opening limit.

- Pressure drop at maximum design flow rate (minimum pressure drop of control valve) shall be calculated at the condition of the minimum suction liquid level and maximum discharge liquid level. Minimum liquid level shall be based on low liquid level (LLL).

- Pressure drop at minimum flow rate (maximum pressure drop of control valve) shall be calculated at the maximum suction liquid level.

Exposure Times Necessary to Reach the Pain Threshold		
Radiation Intensity		Time to Pain Threshold
British Thermal Units per Hour per Square Foot	Kilowatts per Square Meter	seconds
550	1.74	60
740	2.33	40
920	2.90	30
1500	4.73	16
2200	6.94	9
3000	9.46	6
3700	11.67	4
6300	19.87	2

Since the allowable radiation level is a function of the length of exposure, factors involving reaction time and human mobility should be considered. In emergency releases, a reaction time of 3 - 5 seconds may be assumed. Perhaps 5 seconds more would elapse before the average individual could seek cover or depart from the area, which would result in a total exposure period ranging from 8 to 10 seconds.
The above table is maximum allowable radiation intensities inclusive of solar radiation. The solar radiation in southern parts of Iran shall be taken as 300 $Btu/hr.ft^2$. Flare stack diameter is generally sized on a velocity basis, although pressure drop should be checked. One may want to permit a velocity of up to 0.5 Mach for a peak, short-term, infrequent flow, with 0.2 Mach maintained for the more normal and possibly more frequent conditions for low-pressure flares. However, sonic velocity operation may be appropriate for high-pressure flares. The tip pressure drop is taken from vendor's information. For sonic type tip the backpressure will be assumed 2 to 5 Barg depending on load, when there is not any information.

3-10-2) Header Sizing

The major criteria governing the sizing of the header are the backpressure and gas velocity. Flare headers must be large enough to prevent excessive back pressure on the plant safety valves and to limit gas velocity and noise to acceptable levels.
The sonic velocity of the relief gas is calculated as below.

$$V_{sonic} = 91.9 \sqrt{\frac{KT}{MW}} \ (\frac{m}{s})$$

$$K = \frac{Cp}{Cv}$$

T: Temperature (K)

MW: Molecular Weight

Maximum velocity in a line is 0.7 Mach for short duration relieves only.
Maximum flowing velocity in the lines between of the PSV's to the first sub header shall in general be less than 0.7 Mach. For the PSV's where the outlet velocity is higher, a reducer shall be installed as close as possible to the PSV to increase line size and hence limit the velocity to max 0.7 Mach downstream at the reducer.

3-10-3) Flare Knock - Out Drum

Sizing a knockout drum is generally a trail and error process. The first step is to determine the drum size required for liquid entrainment separation.
The recommended particle sizes in onshore and offshore are given below.

- Onshore
  The allowable velocity in the drum may be based on that necessary to separate droplets from 300 micrometers to 600 micrometers in diameter.

- Offshore

Vertical Flare	150 μm
Inclined Flare >45°	150 μm
Inclined Flare <45°	400 μm
Remote Flare	600 μm

The second step in sizing a knockout drum is to consider the effect any liquid contained in the drum may have on reducing the volume variable for vapor/liquid disengagement. This liquid may result from Condensate that separates during a vapor release (liquid droplets),

(b) Liquid streams that accompany a vapor release (liquid carryover). The volume occupied by the liquid should be based on a release that lasts 20 to 30 minutes.

Economics of vessel design in selecting a drum size, which may influence the choice between a horizontal and a vertical drum. When large liquid storage is desired and the vapor flow is high, a horizontal drum is often more economical although horizontal and vertical knock-out drums are available in may designs, the differences are mainly in how the pat of the vapor is directed, (for more information refer to API-RP-521 standard)

3-10-4) Pressure Safety valves

The upstream and downstream line shall be sized on the rated capacity of the PSV. The upstream line shall be sized so that the pressure loss is below 3% of valve set pressure to avoid valve chattering.
The Maximum Backpressure on PSV's should be determined by consulting API 520/521. Normally the maximum backpressure on a spring loaded PSV is 10% of set point. If the backpressure on a PSV goes above 30-50% of set

pressure the flow in the PSV may become subsonic. This is normally not advisable, as the flow through the PSV becomes unstable. For balanced relief valves 30-50% can be allowed for without a reduction in the valve capacity. For vent lines maximum backpressure shall be 0.09 Barg .

3-10-5) Environmental Pollution

a) Allowable Limits of Pollutants for Discharge into Environment from Flare Stacks

Pollutants	Emission
SO_2	800 ppm
H_2S	10 mg/m^3
CO	350 mg/m^3
Particulate Matters	100 mg/m^3
Opacity (Percent)	20

3-11) Heat Exchanger

In removable bundle units, when mechanical cleaning of the tube is specified, tube lanes should be continuous.

Triangular or rotated triangular pattern should not be used when the shell side is to be cleaned mechanically.

Although thermal efficiency and economic considerations require as small a diameter as possible, ¾" (19.05mm) tubes are the minimum size specified as these are the smallest practical size considering the mechanical cleaning of tubes.

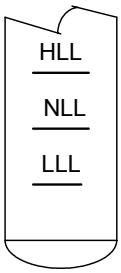
Expanded tube to tube sheet joints are specified except for high temperature or high pressure services, or where extra precautions must be taken against inter-leakage of tube side and shell side fluids, where a welded joint is required.

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

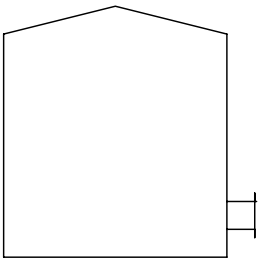
ANNEX 3-1: MINIMUM LIQUID LEVEL IN SUCTION VESSEL FOR NPSH CALCULATION

HORIZONTAL VESSEL

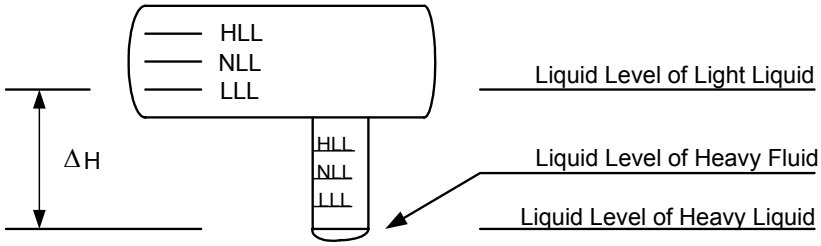
Vertical Vessel & Column



TANK



HORIZONTAL VESSEL

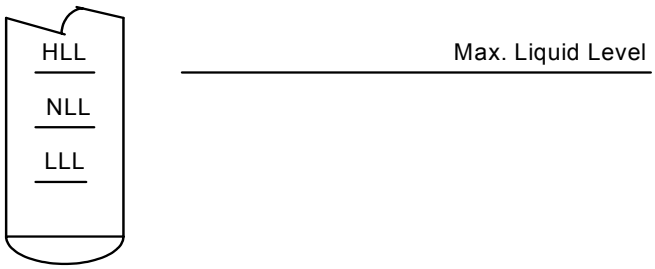


ΔH (Static Head of Light Fluid) Shall be Included in the Min. Static Head of Heavy Fluid

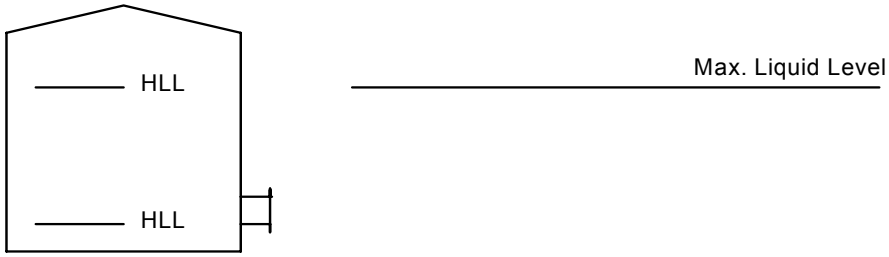
ANNEX 3-2: MAXIMUM LIQUID LEVEL

HORIZONTAL VESSEL

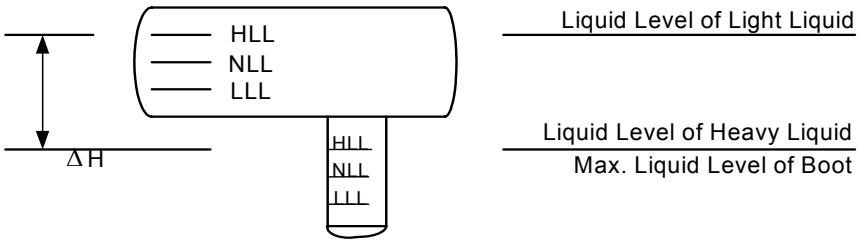
Vertical Vessel & Column



TANK



HORIZONTAL VESSEL



ΔH Shall be Included in the Max. Static Head of Heavy Fluid

3-12) Area Code / Numbering

According to the Revamping and Upgrading plan, New Units, Utilities and Offsite have the following sections, which their Area numbers will be as bellow:

- o New Process Units
  - CDU (New) Area 1100
  - VDU (New) Area 1200
  - NHT + CRU (New) Area 1300
  - Isomerization Area 1500
  - Gasoil/Kero HDS Area 1600
  - SRU Area 1700
  - SWS Area 1800
  - Amine (New) Area 1900

- o New/Expanded Utilities
  - Waste Water Systems (Non Industrial) Area 3500
  - Water System (Sea Water Intake) Area 3600
  - Fire Water Area 3700
  - Power Generation & Distribution Area 1400*
  - Condensate Recovery & Steam Systems Area 2000
  - Air Systems Area 4000

- o New/Expanded Offsites
  - Flare System Area 5300*
  - Waste Water Systems (Industrial) Area 5400
  - Storage Area 9000

* New Equipment/Instrument should be numbered follow by existing Equipment/Instrument.

3-13) Equipment & Instrument numbering

The method of numbering is as follow:

X X X X X – AABB

Where:

X X X X X : Type of equipment / Instrument
(For instrument max. 5 characters) (For equipment max 2 characters)

AA : Unit number where equipment / Instrument is located
BB : Serial number

Unit number of Process units / Utility units / Offsite units which should be considers for equipment & instrument numbering will be as bellow:

- New Process Units
  - CDU (New) 11
  - VDU (New) 12
  - NHT + CRU (New) 13
  - Isomerization 15
  - Gasoil/Kero HDS 16
  - SRU 17
  - SWS 18
  - Amine (New) 19

- New/Expanded Utilities
  - Waste Water Systems (Non Industrial) 35
  - Power Generation & Distribution 14
  - Condensate Recovery & Steam Systems 20
  - Air Systems 40
  - Water System (Sea Water Intake) 36
  - Fire Water 37

- New/Expanded Offsites
  - Waste Water Systems (Industrial) 54
  - Flare System 53
  - Storage 90

3-14) Line Designation

The piping within a unit will have a number as bellow:

AA – BB CC– DDD – EEEE – F – GG

AA : Unit where the pipe located
BB : Fluid Code
CC : Unit number where from the piping started
DDD : Serial number
EEEE: Piping classification
F : Pipe Nominal Diameter (inch)
GG : Insulation/Coating e.g. IH: hot insulation

NOTE:

Each piping, from an apparatus connection or connection with another piping to another apparatus connection or connection with another piping bears its own number. This does not include:

- By-pass line of the control valves, which bear the same number of piping on high the said control valve, is located,

- Drains and vents discharging into atmosphere bear the number of the piping they are on,

- Collector branches, connected to an apparatus or a piping without a check valve, bear the number of the piping from which they branch off.
  Piping branches bear numbers of units in which they branch off from the main line.

3-15) Piping Material Specification

Piping material specification is based on IPS-E-PI-221/1&2 and shown on attachment (9-2).

Section 4- Instrumentation & Control

This section covers the minimum requirements used for measurement and control of process variables and provides guidance for the selection and specification of instruments used for the project. All instrumentation systems and components, as far as mechanical characteristics and electrical characteristics and performances are concerned, shall conform to the present general specification and to the specifications issued for each system and/or components. Any deviation from the present specification at any stage of the project shall be subject to the LORC approval.

4.1 Basic Conditions And Utilities

4.1.1 Environmental Conditions

Ambient conditions outside building:

- Maximum temperature 50^{o}C
- Minimum temperature 0 ^{o}C
- Maximum steel surface exposed to sun 80^{o}C
- Relative humidity (average) 95-100 %

Ambient conditions inside CCRs and ITRs:

- Maximum temperature 25 ^{o}C
- Minimum temperature 23 ^{o}C

The instruments installed in the cabinet inside of closed area shall be able to withstand the minimum and maximum conditions in case of HVAC failure.

4.1.2 Abbreviations

The following abbreviations are used throughout this specification:

- Central Control Room CCR
- Fieldbus Control System FCS
- Emergency Shutdown ESD
- Fire and Gas System FGS
- Input/Output I/O
- Intrinsically Safe IS

- Instrument Technical Room ITR
- Motor Control Center MCC
- Personal Computer PC
- Programmable Logic Controller PLC
- Uninterruptible Power Supply UPS

4.1.3 Selection of Instrument Housing

Field mounted instrument shall be suitable for operation in industrial, humid, sulfurous and corrosive surrounding atmosphere and be adequately designed to prevent generation of an explosion.

Instrument enclosure's "degree of protection"shall be in accordance with IEC 529. The minimum degree of protection for junction boxes (containing terminals only) shall be IP 54. For enclosures containing electronic components or coils (solenoid valves) the minimum degree of protection shall be IP 65.

Instruments/JB's located in areas subject to deluge shall be IP 66.

For instruments below grand level/underground, it shall be IP 68.

The minimum degree of protection for indoor instrument shall be IP 42.

The use of aluminum parts shall be minimized and requires the LORC approval.

Instruments, boxes and panels located in a hazardous area shall be certified to meet the electrical area classification; any certified equipment shall be stamped according to the protection and the relating code and shall be delivered with a conformity certificate issued by a recognized laboratory.

Gas Group classification is done according to CENELEC/IEC standards. The correspondence chart hereafter is used for CENELEC/IEC classification (only to use for conversion from API to CENELEC/IEC):

CENELEC/IEC	API	REMARKS
Group IIC	Class I, Group A	Acetylene
Group IIC	Class I, Group B	Hydrogen
Group IIB	Class I, Group C	Ethylene, ethyl-ether, …
Group IIA	Class I, Group D	Methane, butane, propane, naphtha, …

Zone 0	Division 1	Explosive mixture is continuously present
Zone 1	Division 1	Explosive mixture is likely to occur in normal operation
Zone 2	Division 2	Explosive mixture is not likely to occur in normal operation

The temperature class is indicted by the following symbols:

- T1 Maximum external temperature 450 ^{o}C (842 ^{o}F)
- T2 Maximum external temperature 300 ^{o}C (572 ^{o}F)
- T3 Maximum external temperature 200 ^{o}C (392 ^{o}F)
- T4 Maximum external temperature 135 ^{o}C (275 ^{o}F)
- T5 Maximum external temperature 100 ^{o}C (212 ^{o}F)
- T6 Maximum external temperature 85 ^{o}C (185 ^{o}F)

The method of protection is defined by the CENELEC/IEC rules and identified by a small letter as follow:

-	d	Flameproof enclosure (explosion-proof)	CENELEC EN 50-018/IEC 79-1, 79-1A
-	e	Increased safety	CENELEC EN 50-019/IEC 79-7
-	ia	Intrinsic safety for Zone 0	CENELEC EN 50-020/IEC 79-3, 79-11
-	ib	Intrinsic safety for Zone 1 or 2	CENELEC EN 50-020/IEC 79-3, 79-11
-	p	Pressurized enclosures	CENELEC EN 50-016/IEC 79-2
-	n	Electrical apparatus for potentially explosive atmospheres	CEI EN 50-021

Within Zone 0, electrical instrument installation is subject to the LORC approval.

Type p (Pressurized enclosure) is subject to the LORC approval.

For standardization purpose, installation of certified type instrument in non-hazardous area is acceptable.

As far as possible, explosion proof protection type shall be used instead of intrinsically safe.

The minimum requirement of protection method shall be done according to the following chart:

Equipment	Zone 1	Zone 2
Instrument	EEx-d/EEx-ia/ib	EEx-d/n
Solenoid valve	EEx-d	EEx-d
Junction box	EEx-e	EEx-e
Local enclosure (with relays, electronic, …)	EEx-d/EExp	EEx-n
Lamp indicator (LED)	EEx-ia/ib	EEx-d/n
Thermocouple	EEx-ia/ib	EEx-d/n
Push button	EEx-ia/ib	EEx-d/n
Lighting	EEx-e	EEx-e
Level gauge illuminator	EEx-d	EEx-d
Horn	EEx-d/e	EEx-d/e

All equipment concerned by above protection shall be delivered with conformity certificate(s) issued from one of the following laboratories:

For CENELEC rules:

- BELGIUM INIEX
- DENMARK DEMKO
- FRANCE LICE or INERIS
- GERMANY PTB or BVS
- GREAT BRITAIN BASEEFA or HSE
- ITALY CESI

For NEC rules:

- U.S. Factory mutual (FM) or Underwriter Laboratory (UL)
- CANADA CSA

Electrical equipment suitable for zone 1 and 2 shall be designed and certified for gas group IIB class T3 according to CENELEC/IEC normalization.

If no standard equipment is exiting with IEC protection method while it exists with NEC (US) protection, the supplier may propose NEC protected equipment only after the LORC agreement. In this case, a certificate issued from the relevant laboratory shall be delivered.

All equipment shall be marked according to the method of protection by an indelible stamp or a permanent plate. The marking shall include (but not limited to):

- the level of protection (EEx-…),
- the rule relating to this protection,

- the temperature class,
- the laboratory,
- the certificate number.

4.1.4 Protection Of Instrument Against Environment

All printed circuit cards shall be protected against corrosion and humidity by means of appropriate varnish coating and gold plated contacts on connectors (even for those located within control and technical rooms).

All Instruments and microprocessor-based system shall meet the following Radio Frequency Immunity (RFI) requirements that shall be tested at the acceptance test stage. Basic reference standard is IEC 801 (part 3) for design and manufacturing considerations.

Hazard due to the lightning shall be considered in the installation of instruments and cables.

Electronic component of instrumentation shall be tropicalized. Appropriate measures will be taken in housings and enclosures to deal with condensation from daily temperature fluctuations.

4.1.5 Units Of Measurement

For the whole project, engineering calculation results, instrument ranges and control setting shall be present in SI units.

The following metric units shall be used for process data and instrument scales:

- Flow rate:
  - Steam kg/h (kilograms per hour) or t/h (ton per hour)
  - Vapour, gas kg/h (kilograms per hour) or t/h (ton per hour)
  - Liquids std m^3/h (cubic meter per hour) at 15 ^oC
- Pressure:
  - Pressure gauge Barg
  - Pressure absolute Bara
  - Differential pressure mBar or mm of water for flow measurement
  - Draught gauge mm of water
- Temperature: ^oC (degrees centigrade)
- Density: kg/m^3 (kilograms per cubic meter) at 15 ^oC

- Level: %, and for tank gauging: m, cm, mm
- Viscosity:
  - Liquid cP (mPa.s)
  - Gas cP (mPa.s)
- Other units:
  - Rotation rpm (rotation per minute)
  - Linear velocity m/s (meter per second)
  - Power kW or kVA
  - Voltage V (volt)
  - Electrical intensity A (ampere)
  - Length mm, cm, m
  - Time s, min, h
  - Volume m^3

4.1.6 Electrical Power Supply

All control and safety systems located in CCR's and ITR's shall be powered from 110V AC UPS system located in electrical substation. Necessary autonomy requires battery back up for 30 min. This UPS is limited to feed the FCS, F&G, ESD systems, PLC's, equipment, analyzers, and other instruments. This power supply shall not be used for lighting or tracing. No voltage other than 24V DC, 110V DC or 110V AC will be used except if clearly specified by LORC. Other voltages may be used internal to the systems so long as these voltages do not exceed 110V AC or 110V DC and they are generated by system Supplier/ Vendor. Equipment such as FCS, ESD, F&G system cabinets shall be powered by a set of redundant UPS feeders (i.e. 2 feeders) for each equipment. Equipment such as printers, stations, solenoid valves, etc. shall be powered by a single UPS feeder from related systems. FCS, ESD and F&G systems shall be equipped with reliable DC generation systems provided by Supplier. These internal power supplies and distribution systems shall be redundant.

Package control cabinets will receive 110V AC 50 Hz supplied by a single or dual feeder system (to be defined for each package).

4.1.7 Instrument Connections

Connections of instrument shall be as follows:

Instrument Type	Process Side Size/Type/Rating	Instrument Side Size/Type/Rating
Pressure gauge	On pipe: 3/4"/SW, Thread/800# On vessel: 1"/Flange/300#	1/2"/NPT
Differential pressure or pressure instruments (general purpose)	On pipe: 3/4"/SW, Thread/800# On vessel: 1"/Flange/300#	1/2"/NPT
Differential pressure or pressure instruments (diaphragm seal type)	3"/Flange/300#	3"/Flange/300#
Level gauge	2"/Flange/300#	2"/Flange/300#
Displacer type level instruments (external chamber)	2"/Flange/300#	2"/Flange/300#
Float type level switches (external)	2"/Flange/300#	2"/Flange/300#
Differential pressure type level transmitters	1"/Flange/300#	1/2"/NPT
Temperature instrument	On pipe: 1 1/2"/Flange/300# On vessel: 2"/Flange/300#	On pipe: 1 1/2"/Flange/300# On vessel: 2"/Flange/300#
Pneumatic type instrument	Instrument air header	1/2" or 1/4"/NPT

4.1.8 Pneumatic Supply

The operating range for pneumatic signal transmission shall be 0.2 to 1 barg.

All pneumatic components of instrument system shall be designed for the following supply conditions:

- Pressure:

- 5 Barg Minimum operation

- 7 Barg Maximum operation

- Temperature:

- Ambient Temperature (normal)

- 49 ^{o}C Temperature (maximum)

- -10 ^{o}C at 7 barg Dew point

- Oil content: Oil free

An air set with filter, output gauge and regulator shall be provided with each instrument consuming instrument air.

4.2 Instrument General Requirements

This specification is to be taken as minimum requirements:

4.2.1 Selection Of Ranges

Unless otherwise specified, the instrument ranges shall be selected such that the normal value is between 50 and 75 percent of span for linear scale and 60 to 80 percent of span for square root inputs scale.

When threshold is derived from an analogue signal, set point shall be 10 and 90 % of adjustable range.

Special attention shall be paid to cases requiring:

- A “narrow span” range,

- A range elevation (zero suppression),

- Range suppression (zero elevation).

4.2.2 Field Sensors General Requirements

4.2.2.1 Field Sensor

The same type of instruments shall be used for control of utilities and for process control. Safety components shall be completely independent from process control component. Trip contact shall not be derived from the same instrument. Single component failure shall have a minimum effect on overall availability.

The following requirements with respect to the field instrumentation shall be implemented:

- Materials exposed to the process fluid shall be in accordance with the fluid conditions (pressure, temperature, corrosion) and with the relevant piping class.
- Carbon steel body construction (except transmitters, see here after) shall be a minimum specification for parts exposed to process fluid when not specified otherwise.
- For pressure and differential pressure transmitter, both body and element material shall be AISI 316 as a minimum standard, or the manufacturer's standard material, whichever provides the best corrosion resistance. Where the nature of fluid requires a higher alloy or other material, the material shall be consistent with the piping or equipment specification.
- Movements for instruments shall be stainless steel or better when specified.
- All inserted instruments (e.g. thermo-wells, sampling probes, etc.) shall be specified as per the process data sheet including all service conditions (pressure, velocity, temperature, density, fluid composition) which shall be provided by Contractor.
- NACE requirement shall be applied in case of sour service.
- The design of pressure parts shall be based on the allowable stresses of the ANSI.
- All components, particularly if containing electric contacts, shall be vibration resistant.
- On line instrument shall have flanged connections.
- All instruments shall have an over-range protection up to the maximum design static pressure indicated on the instrument data sheet.

- Instrument exposed to vacuum shall have under-range protection to full vacuum.

- All electronic field instruments shall have cable gland entries of ISO M20x1.5.

4.2.2.2 Local Switch

Process variables used for initiating the shutdown systems shall be derived, as a general rule, from the electronic switches.

When switches are used as sensing devices they shall have normally closed contact to open on trip condition.

When they are provided for safety purpose in non fail-safe configuration they shall include a resistor for line monitoring.

Switch devices shall have a minimum rating of 120V AC, 2A, inductive, unless specified otherwise on the relevant data sheets.

4.2.2.3 Transmitters

Electronic transmitters, strain gauge or capacity type shall be used as general rule. Transmitters generally will be digital from FF certified bus-powered.

Those connected to the ESD system will be preferably of smart transmitter type and compatible with HART. If smart type transmitters are selected for ESD application they shall be configured as “read only”.

Smart transmitters (2 wires) with digital calibration superimposed on 4-20 mA signals shall be the rule to allow remote calibration from a “pocket” interface at marshalling level.

Electronic transmitters will be provided with an integral digital indictor for maintenance purpose. A digital display indicator can be provided, using digital mode communication when associated to “smart” transmitter.

4.2.2.4 Diaphragm Seal and Capillary

For measurement of viscous fluids, solids containing fluids, highly corrosive fluids or where temperature changes may influence the fluid conditions, the use of diaphragm seal and capillary may be considered as an alternative to instrumentation with flushing on the measuring impulse line. Diaphragm seal shall normally be integral with the instrument.

Special coating materials may be considered where these will improve the corrosion resistance of the diaphragm.
For remote seal applications, capillaries shall be kept as possible (at least 1meter) and shall not exceed 6m. For differential pressure application the capillary shall be of

the same length. The capillary tubing material shall be of AISI type 316 type stainless steel and be shielded by flexible stainless steel tubing with PVC cover, according manufacturer's standard.

4.2.3 Signal Requirements

4.2.3.1 Inputs

- IS digital from FF certified bus-powered transmitters,
- Non-IS digital from FF certified bus-powered transmitters,
- IS analogue 4-20 mA, 24 VDC from smart type two-wire transmitters with HART protocol,
- Non-IS analogue 4-20 mA, 24 VDC from smart type two-wire transmitters with HART protocol,
- IS analogue 4-20 mA DC from smart type four-wire transmitters with HART protocol,
- Non-IS analogue 4-20 mA DC from smart type four-wire transmitters with HART protocol,
- On-Off hardwired signals for non-safety related interlock performance from volt-free contacts,
- IS inductive high frequency pulses from proximity sensors, pulse or BCD,
- Communication with ESD and other systems,
- On-Off signals from ESD, substation, other systems, via volt-free contacts.

4.2.3.2 Outputs

- IS digital to FF certified positioners via bus segment,
- Non-IS digital to FF certified positioners, via bus segment,
- IS analogue 4-20 mA, 24 VDC to smart type positioners with HART protocol,
- Non-IS analogue 4-20 mA, 24 VDC to smart type positioners with HART protocol,
- On-off signals to external hardwired annunciator, substation, etc. volt-free SPDT contact rated minimum 2 Amps at 24 VDC,
- Communication signals (Modbus, TCP/IP, etc).

4.2.4 Instrument Nameplate

4.2.4.1 General

All instruments, junction boxes, cabinets and ancillary equipment shall be provided with nameplates indicating the tag number. Full and properly engineered tag and service labeling is and essential part of the facilities.

4.2.4.2 Field Instruments Nameplate

All plant mounted instruments shall be provided with an engraved tag number plate bearing their loop identification number.

All label fixing shall not affect the "IP" rating or certification of the equipment.

Labels shall be "white/black/white" i.e. black lettering on a white background for all non-IS and general service. For IS circuits, labels shall be blue/white/blue and for F&G service, labels shall be red/white/red. Manual shutdown/alarm switches shall have red/white/red traffolyte labels.

4.2.4.3 Nameplate For Indoor Use

All panel mounted instruments shall be provided with nameplates in accordance with the manufacturer’s standard bearing the loop identification number.

All panel mounted ancillary equipment such as switches, indicating lights, etc., shall be labeled by the Contractor to suit the particular application.

4.2.5 Instrument Accuracy Classes

In general the accuracy of instruments shall be equal or better than 0.5% of the calibrated span. For transmitters except displacer type level transmitter the accuracy shall be 0.1% of span.

4.3 Flow Instruments

As a general rule flow shall be measured from orifice plate differential pressure, unless special considerations make necessary to use other types of instruments such as:

- Variable-area flow meters for local indication,
- Electromagnetic flow meters,
- Ultrasonic flow meters,
- Vortex flow meters,
- Coriolis flow meter,
- Turbine flow meters or positive displacement meter,
- Thermal flow meter.

4.4 Level Instruments

As a general rule level for remote transmission or local control shall be from differential pressure transmitter or from displacement type level instrument.

Displacement-type transmitter shall be selected for interface measurements.

For special applications, other principles of measurement may be considered, such as ultrasonic instrument or instruments based on capacity, conductivity, radar/laser or bubble type.

4.5 Pressure Instruments

Generally the range upper limit will be 1.5 times the normal operating pressure.

Over-range pressure protection shall be provided, up to design pressure indicted on data sheets. For differential pressure transmitters over-range pressure protection shall be able to protect the sensing element from the maximum design pressure applied to each side with the opposite side vented to atmosphere.

Pressure gauges shall normally be bourdon tube-type with external part filled with glycerin or silicone oil. Process connection shall be 1/2" NPT male, bottom position suitable for direct mounting.

4.6 Temperature Instruments

For process temperature up to 500 ^{o}C, as a general rule, temperature transmission shall be achieved by resistance element associated with a transmitter.

Use of RTD separate amplifier and use of thermocouples shall be restricted to machines and heaters.

RTDs and thermocouples shall be ground insulated type.

Head mounted ohm/I (RTD) or mV/I (T/C) converters shall generally be applied.

The temperature detectors shall be installed in thermowells. Standard length thermowells shall be used. Process connection for thermowells shall be 1 1/2" on pipe work up to 2500# and 2" on lines over 2500# and on vessels.

For the measurement of fluid temperature below 0 ^{o}C, the length of the head extension shall suit the insulating thickness but the head shall extend at least 200 mm outside the insulation.

Thermowells shall be solid machined and drilled in a tapered configuration. They shall be stainless steel as a minimum, flanged type. Where the nature of fluid requires a higher alloy or other material, the thermowell material shall be consistent with the piping or equipment specification.

Thermowells for test points shall be provided with plug.

Where high velocity gases are present, it will be necessary to check thermowells for the “vortex shedding effect”.

Where the application of thermowells would be impractical, thermocouples and resistance thermometers may be located on the surface of pipes or vessel, etc.

Spring-loaded sensor shall be used.

The minimum length for 4" pipe and larger shall be approximately midway between the center of the pipe and the opposite wall, unless otherwise specified by calculated fluid velocity.

Wake frequency calculation to ASME PTC 19.3 shall be produced in high velocity lines; the wake frequency shall not exceed 80% of the natural frequency of the thermowell. Calculations shall be provided for all non-standard lengths.

4.7 Control Valves

The preferred style of control valves is flanged single seat globe with the body being of cast construction.

Where low pressure drop or high recovery can not be achieved by globe valves, butterfly or characterized ball valves may be considered.

The valve body rating should be equal to or better than the flange rating specified in the data sheets.

The flange finish shall be in accordance with ANSI B46.1.

Control valve bodies shall not be fitted with bottom drain plugs. A bottom flange shall be provided for valves that require bottom access for trim removal.

Control valves shall not be used for any shutdown or blow down application.

The material selection of the body (including bonnet and/or bottom flange) shall be as specified in individual data sheets.

Cast iron bodies shall not be used.

Vendor shall quote the trim material in accordance with control valves data sheets. The vendor shall take in due consideration the overall material selection philosophy and the specified data of corrosion, suspended solids, cavitations flashing and fluid velocity. The trim material on control valves data sheets shall be considered as a minimum requirement. Suitable material shall be furnished as trim where sever service

require greater hardness, special alloys or coatings to prevent excessive erosion or corrosion.

Components exposed to process fluid shall be guaranteed as fully suitable for the specified application. Anyhow hardened metal facing shall be provided for flashing liquids and cavitations flow conditions.

The trim and particularly the seat ring(s) shall be of the easy/quick replaceable type.

For globe valves, soft seats can deteriorate quickly and should be avoided as far as possible for following applications:

- Erosive services,
- Wet gas or steam service with a pressure drop greater than 5 bar,
- Other services in which the pressure drop is greater than 10 bar at design conditions.

Valve bonnets shall be of bolted construction with fully retained gaskets.

Flow direction shall be permanently and clearly marked on the valve body.

Guide bushings shall be of corrosion resistant material.

Packing glands shall be equipped with flange style gland followers with bolted construction.

A lubricator with steel isolating valve shall be provided where packing lubrication is required.

Packing materials shall be:

- PTFE-based for packing temperatures below 200 ^{o}C,
- Graphite-based, metal-reinforced, for packing temperatures between 200^{o}C and over.

Packing shall not contain asbestos.

External lubricators or grease nipples shall not be applied.

Depending upon the design of the valve, an extended bonnet may be required to keep the temperature at the stuffing box at an acceptable value for the applied packing.

Control valve seat leakage shall be designed and constructed in accordance with the requirements specified on the individual data sheet and classified according to ANSI B16-104.

Control valve shut off class, as a minimum shall be class IV on venting applications, where the valve is closed most of time. Control valves shall have class V or class VI leakage as per ANSI shut off classes.

Actuator stems shall have adequate strength to withstand maximum developed thrust of actuator.

All valves shall be equipped with a valve stem travel indicator.

Painting shall be done by the vendor, in accordance with project painting specification.

4.8 Safety Relief Valves

Safety and relief valves shall generally be full nozzle high lift, spring loaded type with integral flanges and shall be of the enclosed spring type except for steam and air services.

Balanced bellows type shall be considered for relief into closed flare and blowdown systems where the variable back pressure is more than 10% of set pressure and where the process fluid contains lethal or toxic substances.

Pilot operated valves shall be considered where low set pressure is required and/or where operating pressure is greater than 95% of set pressure.

Flanged connections shall be used except for thermal relief valves, which will be threaded.

Valves shall comply with the pressure/temperature ratings as per requirements of ANSI B16.5.

Unless otherwise specified or higher rating is imposed by the construction requirements, the outlet connection rating shall be 150# ANSI, as minimum.

The finish for flange facing of raised face flanges shall be 125 to 250 AARH as per ANSI B46.1.

Body drain with a plug shall be provided as a standard feature on every pressure relief valves.

All calibration screws shall be protected by a cap and sealing to prevent tampering.

Thermal relief valves shall be installed either on the exchanger or in the water piping between the inlet and outlet block valves.

Thermal relief valves shall normally be ¾”x¾” brass for water and ¾”x1” carbon steel or better for all other liquids, in accordance with piping specification.

Connections shall be NPT, female, as per ANSI B1.20.1.

Plain lifting lever shall be provided whenever the fluid to be relieved, is steam, air or hot water (60 ^{o}C and above).

Bonnet shall be of the closed type in general. Open type of bonnet may be used for nontoxic fluids and for safety valves designed as per ASME code.

Valve spring design shall permit an adjustment of 10% above or 10% below the set pressure for pressure up to and including 17 (kg/cm^2)g; for pressure above this, it shall permit an adjustment of 5% above or 5% below the set pressure.

Safety relief valves shall be set no higher than the design pressures except as permitted by the vessel codes.

Unless otherwise specified, the maximum overpressure in percentage of the set pressure shall be as follows:

- 3% for steam services where ASME power boiler code applies,
- 10% for gas and vapor services and liquids except as noted below,
- 20% for fire exposure on unfired pressure vessels,
- 25% for liquid on thermal relief of pipelines and pump discharges.

The allowable tolerances in set pressures are as below:

- ±0.10 kg/cm^2 for set pressures up to and including 5 (kg/cm^2)g,
- ±0.3 % for set pressures above 5 (kg/cm^2)g.

Rupture discs may be used in lieu of or in combination with safety and relief valves for corrosive process fluids and where process material may render a safety valve inoperative or where a loss of valuable material by leakage should be avoided. All rupture discs shall be furnished with protecting ring assemblies designed for installation between piping flanges. The protecting rings shall meet the ANSI pressure and temperature requirements of the combination flanges. If a purge connection is required it shall be in the protecting ring on the pressure side of the disc.

Rupture discs shall preferably be reverse buckling type with accuracy of ±2% or better.

Vacuum break valves shall be of pilot operated type utilizing the principle of back loading the top, or large area of a differential area membrane with line pressure to hold this member closed up to set pressure.

The vacuum pilot shall be mounted on the main vacuum valve with the sense line properly connected and secured.

Vacuum break valves shall be provided with external blow down adjustment facility with a range of 5 to 20% of set pressure.

Vacuum break valves shall be provided with an arrangement of check valves to admit an outside pressure source connection to enable field testing of set pressure without blocking the break valve.

4.9 Self Actuating Regulators

The self actuated regulator as a variation of the diaphragm actuator and normally uses the process fluid as the operating medium. For pressure applications, some self actuated regulators use bellows instead of diaphragms for the actuator. For temperature applications, bellows with a filled system and bulb shall be used instead of diaphragms.

All regulators, whether they are being used for pressure, level or flow control fit into one of the following two basic categories:

- Direct operated
- Pilot operated

Characteristically, direct operated regulators are adequate for narrow range control, and where the allowable change in outlet pressure can be 10 to 20 percent of the outlet pressure setting. Direct operated regulators are used to provide constant reduced pressure to pneumatic instrumentation and other control equipment.

Pilot operated regulators are preferred for broad range control, or where the allowable change in outlet pressure is required to be less than 10% of the outlet pressure setting. Pilot operated service regulators are ideal for applications involving pressure factor measurement.

Construction material shall be selected according to the process requirement and indicated as per data sheet.

Body material and spring case and major metal internal parts shall be stainless steel. Valve plug seating surfaces and diaphragm shall be neoprene or SS.

Special consideration shall be given to the rating of downstream section of regulators with respect to the maximum upstream shut in pressure, based on the assumption that the regulators may leak.

Self contained regulators shall be considered for services such as starting gas or air, blanket gas, individual engine fuel gas, and other applications with the following characteristics:

- The set point is changed frequently,
- Proportional only control is not an impediment to effective process control,
- Remote control of the valve is not necessary.

- The application is at a remote location where air is not available for control valve operation.

4.10 Analytical Instruments

Analyzers will be used for monitoring process streams composition.

Where possible the analyzers shall be of direct on line type. Process analysers requiring sampling shall be supplied already pre-assembled with own sampling and conditioning systems.

The measuring systems (analyzers) shall be installed in suitable houses located in the process areas.

Analyzers shall be as close to the process connection as practical. It may be installed in the main control room as well.

Normally the control circuits of the analyzer should be powered from the control panel. Each analyzer shall have an over-current protective device. Local disconnect switches shall also be provided so that the instruments can be safely serviced.

Probe connection for gas service shall be from the top of the main line. For liquid, connection shall be done from the side.

Generally, wetted metal part in contact with the process fluid shall be 316 SS as a minimum.

Section 5- Electrical

5.1 SCOPE

This design criteria covers the minimum requirements for basic and detail design, Engineering, supply of EQUIPMENT and materials and construction/erection, pre commissioning and commissioning of electrical systems of UNITS.

5.2 CODES AND STANDARDS

The latest issue of the following codes and standards shall be used for the design, construction and materials selection. In the absence of a specified standard or code, IEC shall serve as basis. IEC equivalent standard may also be accepted subject to EMPLOYER prior APPROVAL.

5.2.1 Power Transformers

IEC-60076 (International Electrotechnical Commission) and EMPLOYER standard (*) shall be applied for definition, design, manufacturing, testing, power and cooling method.

(*) General Note:

EMPLOYER's standards are generally as per IEC codes and standards. In case of conflict between EMPLOYER's standards and IEC, the more stringent specification/requirement shall be applicable and EMPLOYER's decision shall be considered as final. In the case that EMPLOYER's standard exists, but there is no IEC recommendation, EMPLOYER's standard shall be followed.

5.2.2 Squirrel Cage Electric Motors

1. IEC 60034, 60072, 60079

2. ISO (International Standard Organization), ISO R 281, 1940, 2372, 10816 and ISO 1680.

3. EMPLOYER's standard (*)

5.2.3 Medium Voltage Switchgear

The switchgear shall be designed, manufactured, wired and tested in compliance with all applicable sections of the following Standard and Code:

IEC (International Electrotechnical Commission).

EMPLOYER'S standard (*)

5.2.4 Low Voltage Motor Control Centre

The low voltage motor control centre assemblies shall be designed,manufactured, wired and tested in compliance with all applicable sections of the following Standard and Code:

IEC (International Electrotechnical Commission).

EMPLOYER's standard (*)

5.2.5 Cables and Wires

The cables and wires shall be designed, manufactured and tested in compliance with all applicable sections of the following Standard and Code: IEC (International Electrotechnical Commission).

EMPLOYER'S standard (*)

5.2.6 Electrical System Installation

Installation of electrical EQUIPMENT shall be in accordance with all applicable sections of the following Standards and Codes except as modified by EMPLOYER'S Standard: (*)

1. IEC

2. API

5.2.7 Area Classification

API-RP 505 (classification of location for electrical installations in petroleum refineries). Selection of electrical equipment for classified area shall be as per IEC 79.

5.2.8 Cathodic Protection

Unless otherwise specified by EMPLOYER, all design, engineering and EQUIPMENT shall be in accordance with NACE standards and relevant American Fire Code. The British Standard Institution (BSI) codes of practice for Cathodic Protection will also be applied if not in conflict with NACE standard.

5.2.9 Low Voltage Switchgear

The assemblies shall be manufactured, wired and tested in accordance with all applicable sections of the following standards, codes and as per EMPLOYER's standard: (*)IEC (International Electrotechnical Commission).

5.2.10 Deleted

5.2.11 Control Bench Boards

The control bench boards shall be manufactured, wired and tested in accordance with following Standards, Codes and as per EMPLOYER'S Standard: (*)

IEC

5.2.12 Battery and Battery Chargers

The Batteries and chargers shall be manufactured and tested in accordance with the following Standards, Codes and as per EMPLOYER'S Standard: (*)

1. IEC

2. ANSI, NFPA-70

In case of conflict between IEC standard and ANSI code, IEC will prevail.

5.2.13 Uninterruptable Power Supply System (UPS)

The UPS (Uninterruptable Power supply) shall be constructed and tested in accordance with the following Standards, codes and or as per EMPLOYER'S Standard (*)

1. IEC

2. ANSI, NFPA - 70

3. VDE 0875

5.2.14 Symbols, Diagrams and Abbreviations

The electric symbols, diagrams and abbreviations shall be as per IEO 61182, 61346, 617 and EMPLOYER'S standards (*) •

5.3. CERTIFICATION

EQUIPMENT operating in hazardous area shall be certified by an officially recognized authority (ies), such as PTB for Germany, BASSEFA for UK, UL FOR USA or any

other approved by EMPLOYER in compliance with one of the following standards/code IEC/EN/CENELEC/BS/NFPA/ANS/, for full compliance with safety requirements in classified areas, as a minimum to SITE conditions.

5.4. MINIMUM REQUIREMENT

1. Electrical system and EQUIPMENT shall be so designed to have the highest reliability and minimum failure in order to achieve safe, efficient, accurate and easy operation under various operational requirements with minimum possible maintenance and operating cost.

2. The electrical system shall be designed based on safety to personnel during operation and maintenance, reliability of services, ease of maintenance, convenience of operation, maximum interchangeability of EQUIPMENT and parts and shall be capable for future expansion of loads. All major electrical EQUIPMENT shall be centralized as far as possible and located in safe areas to make maximum use of industrial type switchgear, motor control EQUIPMENT, concealed panel boards etc.

3. Documents involved in calculations, drawings, catalogues shall have sufficient and necessary information for satisfactory operation, maintenance, trouble shooting, calibration, spare parts list etc.

4. According to process requirements, some of the electrical information shall be indicated and/or reported by monitoring and logging system in the PROCESS UNITS/UNITS with FCS.

5. All guarantee figures shall be measured by sufficient and accurate metering system.

6. As far as possible designer and supplier shall consider EQUIPMENT with low variety and high interchangeability.

7. Generally spare parts shall be in the form of individual parts except for capital spares that are in complete set or main part of vital EQUIPMENT. Supply of spare part shall be guaranteed by manufacturer/VENDOR for a minimum of 10 years.

8. Necessary spare EQUIPMENT and space for future expansion to the best knowledge and experience of CONTRACTOR shall be considered. EMPLOYER'S APPROVAL shall be necessary for the case where there is no figure appearing for spare parts in the CONTRACT.

In general 20% shall be considered as a basis for spare/space requirement.

9. Enough bulk materials for contingencies shall be added to the related material take-off lists.

10. As a whole, design of the electrical system shall be based on the safety of personnel and EQUIPMENT during all expected modes of operation and maintenance, having minimum power losses, mechanical protection of EQUIPMENT, interchangeability of EQUIPMENT and parts, and being capable and ready to be expanded.

11. EQUIPMENT shall be designed and de-rated for SITE ambient condition.

12. Specifications of electrical EQUIPMENTS shall be prepared by CONTRACTOR and submitted to EMPLOYER for APPROVAL.

13. As far as possible, power supply of those PROCESS UNITS/UNITS of each PROCESS UNITS/UNITS which can work separately shall be fed from separate buses.

14. Throughout these specifications the initial load means the foreseen load of PROCESS UNITS/UNITS at full operation of the related state.

15. Electrical drawings, EQUIPMENT specification etc. of package units shall be included in the related overall PROCESS UNITS/UNITS drawings and equipment specifications.

16. Degree of protection of enclosure shall be as follow:

All indoor equipment IP4l

All outdoor equipment IP55

All MV and LV motors IP 55

All terminal box of LV and MV motors IP55

17. All softwares shall meet at minimum the requirements on items 7.1.13 to 7.1.19 of Annex 2C-3

18. In general clustered LED lamps shall be provided for indication.

5.4.1 Electric power distribution system

5.4.1.1 Distribution philosophy

Basic philosophy of normal electrical power distribution in the REFINERY shall be shown in relevant drawings.

Electric power for each unit and all MV/LV switchboards shall at least be supplied by two main incoming lines. Each incoming line shall be capable for the total PROCESS UNITS/UNITS electric demand required in normal condition at full load operation plus 20 %.

Normally appropriate number of CBs shall be located in transmission line or cable feeder. The incoming lines CBs and bus ties CB shall be properly interlocked.

All switchboard/MCC/PMCC and critical panels shall be provided with two bus section and bus tie. Automatic and manual transfer system shall be provided between two incoming CB's and bus tie.

5.4.1.2 Power failure and emergency power supply

1. In case of power failure on one of the incoming lines with the other in service, automatic and manual option transfer and load reacceleration for critical load if necessary, by CONTRACTOR in ENGINEERING DESIGN SPECIFICATION shall be provided. Back ward is done automatically or manually. The same arrangement for medium and low tension power distribution shall be provided. Each bus bars as well as emergency bus bar shall be fed through two normal incoming feeders.

2. For the loads that can not accept momentary supply interruption, autonomy batteries (back up batteries of chargers and UPS systems) shall be established.

5.4.1.3 Voltage levels

1. Incoming

Two 6 kV feeders in 14B substation will be supplied by EMPLOYER, 3 ph, 3 wires, 50 Hz + 5 %, neutral ungrounded. Minimum and maximum short circuit level of incoming feeder will be specified by EMPLOYER. Preparation the measurement trans and protection relays for this feeders and provision the cable and installation from 14B substation to new substation is in scope of EPC contractor.

2. Motors from 150 KW Up to 2500 KW	6 KV ± 5 %, 50 HZ, 3 ph, neutral of power transformer ungrounded .
3. Motors up to 150 KW	400 V ± 5 %, 50 HZ, 3 ph neutral directly and heaters above 3KW grounded
4. Non process	400/230 V as above 3/1 phase with neutral accessible and directly grounded.

5. Control voltage switchgear and motor	110 DC (from Batteries) starter of 6KV, incoming LV main circuit breakers and LV bus tie circuit breaker
6. 400 V motor control	230 V, 50 HZ, single phase + neutral from isolating transformer

7. Instrumentation

a) noncritical 110 V, 50 HZ, single phase (from transformer).

b) Critical 110 V, 50HZ, single phase from UPS and 24 V DC.

8. Intercommunication 230 V, 50 HZ, back up 110 DC voltages

9. Lighting

a)	Normal	230V, 50 HZ
b)	Emergency	Process area: 230V, 50HZ with internal battery back up Building: 230V, 50 HZ from UPS
c) Safety lighting		230V, 50 HZ with internal battery back up

10. Socket outlet

50 HZ, 230 V(lph, N, E), 400 V (3 ph, E), and
24 V AC socket and portable 11OVAC and
24VAC

5.4.1.4 Power factor improvement

UNIT power factor on main incoming lines, at full load operation shall not be less than 0.85 minimum.

Suitable capacitor banks with auto and manual control shall be provided on 400 V, 6 KV buses if necessary.

5.4.1.5 Fault Current Calculation

The possibility of a short circuit to earth or between the phases due to mechanical and! or electrical breakdown shall be considered. A short circuit analysis shall be

made for each PROCESS UNITS/UNITS included in the UNIT. All switchgears, motor control centres, conductors and circuit protective devices shall be selected to meet the calculated short circuit requirements. Short circuit levels shall be determined in accordance with the UNIT power supply and distribution requirement for EQUIPMENT selection and protection relay setting, but in any case EMPLOYERS prior APPROVAL is required.

5.4.1.6

Load flow study, restarting I re- acceleration and load shedding study shall be made for the UNIT.

5.4.2 Hazardous Area Classification

The UNIT shall be divided into classified areas considering the possibility and frequency of presence of flammable gases and liquids, according to the standard already stated. Electrical EQUIPMENT in each area shall be certified for suitable application. The enclosure of Ex type electrical equipment shall be metal (cast aluminium or stainless steel), THERMOPLASTIC MATERIAL IS NOT ACCEPTED.

5.4.3 Substation

1. Unless otherwise specified the substation shall be located in a safe area and consisting of transformers yard and switch room in its neighbourhood. Generally the switch room shall be designed to be dry, cold, clean etc.

2. The area shall be a non-hazardous location as a rule.

3. The transformer yard shall be enclosed with side walls of suitable height, with necessary gates. Fire separation wall shall be provided between two transformers.

4. Gates and doors shall be provided with key operated locks and high voltage warning signs. Gates, doors or removable sections shall be properly and adequately sized for easy entrance of personnel and related EQUIPMENT.

5. Concrete foundations extending at least 200 mm and sufficiently above ground surface shall be provided for transformers and other EQUIPMENT in transformers yard. Sun shades shall be provided above transformer bays to protect them from direct sun rays. The remaining enclosed area shall have proper slop to drain out the waterlliquids and covered with sand, gravel or other suitable materials.

6. Adequate facilities shall be provided in switch room for installation of initial EQUIPMENT and 25 (twenty five) percent space for future installation. Additionally, ample space shall be provided for construction and maintenance activities including the removal and transportation of all initial and future installed electrical EQUIPMENT.

7. The switch room shall be provided with two doors to outside preferably at opposite sides, two doors to control room (if required), one door to battery room, at least one of the doors to outside shall be adequately sized to pass the EQUIPMENT. For emergency doors refer to Annex 2C-4 Paragraph 9.10 item 9.

8. For necessary clearance around equipment in the switch room, refer Annex 2C-1, clause 2.4.

9. The switch room shall be equipped with air conditioning system to maintain appropriate temperature below 25 0C (max. design temperature for substation EQUIPMENT shall be 45 0C).

10. Provision shall be made for dust proofing of doors, windows and others.

11. The portion of high tension electric cable pit connecting the switch room to the transformer yard outside shall be sealed by suitable material after cabling.

12. Generally, switch room shall include one room for medium voltage switchgear and the other for low voltage switchgear. These two rooms and yard shall be directly connected to each other by at least one door. Battery room shall be considered in switch room with at least one door in between.

13. Substation shall be designed with provision of a cable room.

The cable room shall be above ground if underground water level is high. The clear height of cable room below the beams shall be mm. 2000 mm.

5.4.4 Earthing and Bonding

Grounding system shall be provided for safety of personnel and EQUIPMENT in case of electrical failure, lightning and static electricity. IEC and NFPA 78 recommendations shall be employed and taken into account in design and construction.

1. Lighting and electronic EQUIPMENT shall have individually their own earthing system which may be connected to main earthing ring as per IEC-1000-5.2.

2. General earthing resistance shall be less than 5 Ohms at any point even at worst condition and for lightning less than 5 Ohms.

3. Grounding conductor shall have green/yellow colored PVC insulated stranded copper conductor, having mm. 95 mm2 for main conductor and 16 mm2 for taps except for tanks, towers, control board etc. shall have 35 mm2 earthing conductor. The exact size of cable for main earth grid shall be finalized based on calculations to be furnished by CONTRACTOR for EMPLOYER’s approval.

4. Power transformers, switchgear, high voltage motors, lighting panels etc., shall be directly connected to main grounding system.

5. The metallic enclosures, housing, structures of all electrical EQUIPMENT shall be connected to the common continuous grounding system and also all metallic structures, process EQUIPMENT and any other metallic mass shall be bounded as protection against static charges and lightning.

6. Grounding conductor shall be laid in cable trenches as far as possible, when intending above ground they shall be protected by RGS (Rigid galvanized steel) conduit stub-up extending up to 50 cm above ground.

7. Underground splices shall be made by exothermic welding (cad weld or thermo weld) and above ground shall be made compression type connectors.

8. The armoured cables shall be grounded mainly via cable gland at motor and/or user side.

9. In general, the third pole of each 3-pole socket outlet shall be solidly and permanently connected to the UNIT grounding system through the third core and for 3-wire, 4-pole shall be used via separate ground wire. For tubes and light gauge conduit separate ground wire shall be used.

10. For discharging of static electricity, all pipelines carrying inflammable fluids shall be grounded as follows:

a) Flanges fastened by insulated bolts shall be provided with bonds.

b) In case fastening bolts are not insulated, bonds shall be provided for every 30 metres and pipeline shall be grounded at the same portions.

c) Bonding wires shall be connected to lug plates welded near flanges and shall not be connected to flange fastening bolts.

d) The pipelines shorter than 30 meters which are connected to EQUIPMENT shall be regarded as a portion of the EQUIPMENT and not required to be bonded and/or grounded.

5.4.5 Power system control centralization

5.4.5.1 General

Electrical distribution monitoring and control shall be achieved by means of the electrical control system Power Distribution Control System — PDCS.

The PDCS, in conjunction with the relevant Process Control System — FCS, shall be used for power system monitoring and annunciator system, handling the MV and LV

power supply, the automatic change-over as well as emergency power generator start-up.

Furthermore, failure of the PDCS must not stop operation of any part of the distribution system. Only facilities provided by PDCS should be lost in this case.

The PDCS shall be based upon one Programmable Logic Controller (PLC) installed in a dedicated PDCS room of the Electrical Substation building.

The PDCS hardware shall include the redundant CPU, redundant power supply, program memory, software timers, input and output units, etc. as required for system operation.

The software packages will permit to have the monitoring of the system circuit breakers, measuring, graphic pages, event listing, alarm pages, event indication with graphic curves and harmonic indication for each switchboard, etc.

The system will be completed with operating station realized with 2 VDU, 2 keyboards and 2 printer installed in centralized control room.

A communication channel through serial link shall be foreseen for the connection to an engineering workstation for loading or modifying the application programs and the configuration data for the resident processor's memory system.

5.4.5.2 System Description

The PLC consists of two separate processors (redundant CPU), separate memories, separate power supply (not parallelable) and separate communication cards, one set of which operating as a back up of the other one.

The two subsystems shall run in synchronized mode. Both processors run the application programs and an external switchover unit shall swap the output control to the slave processor if a failure on master PLC shall occur. Output swaps function shall be performed within 5ms.

5.4.5.3 Fault-tolerant Architecture

The processing data subsystem shall be fault-tolerant; in other words, it shall have the capacity to diagnose any fault or error conditions, whether temporary or stable, and to take appropriate corrective actions on-line, in real time, while the process is under control.

5.4.5.4 Hardware Requirements

1. Central Processor (CPU)

Each CPU shall contain the program memory at static RAM level, and it shall guarantee program storage with EPROM memories.

It shall be possible to substitute each CPU (one by one), completely or partly, with the system in operation.

2. Input/Output Modules

The I/O system shall be capable of receiving and transmitting both digital and analog signals.

It shall be possible to plug-in or plug-out the I/O modules while the chassis is energized, without disconnecting the field connections.

All the I/O terminations shall be wired to screw terminals on separate terminal blocks mounted inside the system cabinet.

Each I/O module shall continuously monitor its status and it shall be signalized by means of status LED's installed on the front panel of the module itself.

Each card will be checked and in case of fault or malfunction, action will be taken to put the system in fault-tolerant conditions.

3. I/O Serial Link

The system shall be complete with interface, via serial link, for digital and analog I/O signals.

Serial link shall be able to communicate with:

- remote PLC's,
- operating stations,
- MV and LV switchboard control unit (If any),
- process control system (FCS),
- etc.

System protocol for serial link interfaces shall be developed and installed inside the PDCS system and shall be standard.

5.4.5.5 Other Requirements

1. Electrical Power Supply

Two feeders at 11OV, 50Hz, ± 5%; shall be made available from redundant UPS, installed in Main Control Room. The two power supplies are not parallelable.

One feeder at 230V, 50Hz, ± 5%; shall be made available for PLC services power supply (fans, light, heaters).

System power supplies shall be redundant type.

2. Cabinets

All the system components shall be housed in cabinets with minimum mechanical protection P41 .Painting shall be suitable for the site conditions.

5.4.5.6 Software Requirements

1. General

The supply shall include all the software required for developing the application programs, their modification and debugging.

The software shall have the possibility to be modified in ‘run” without change the output signals status.

The programs and logic diagrams implemented in the system shall be documentable in print by means of the printer.

The system will be supplied with the operating software necessary for system and application program management.

The system application programs will mainly consist of:

- Program for data acquisition and operator interface management
- Support programs for maintenance, diagnostic and eventual system enlargement
- Configuration programs to permit variables and interlock configuration

- Diagnostic program for automatic and operator requested diagnostic tests

- Management of workstation and printer interface
- Sequence and interlock operations

2. Autodiagnostic

The system will be supplied with an autodiagnostic procedure able to detect any possible malfunction of each part of the system.

Said procedure shall be performed during power-on phase and it will particularly control the efficiency of:

- input-output
- memories
- CPU
- output congruence
- power supply systems

The summarizing data about system status shall be displayed on the front board, such as the conditions of:

- input cards
- output cards
- power supply system
- diagnostic system
- CPU

A summary alarm status shall be provided and wired to the terminal blocks for remote purpose.

5.4.5.7 PDCS system functional requirements

1. Supervision of Distribution System

The PDCS shall facilitate the supervision of the distribution system and shall show in clear graphic form on the VDU displays the status of:

- MV Switchboard : Incoming A circuit breaker

Incoming B circuit breaker

Bus tie circuit breaker

All types of outgoing circuit breaker or fuse contactor

- 400V Power Centers: Incoming A circuit breaker

Incoming B circuit breaker

Bus tie circuit breaker

- All type of outgoing circuit breakers except motor feeders which shall be shown in FCS of process, the VDU shall also show the following information (value as well as the graphic curve for different phases).

- Voltage on MV and LV bus bars.
- Frequency on MV bus bars.
- Harmonic of voltage on MV and LV bus bars
- Current on MV and LV bus bars.
- Consumption rate on MV and LV bus bars.
- Power factor on MV and LV bus bars.
- Consumption rate on UPS (AC and DC) and lighting transformers (If any).

2. Event Recording and Alarming

The PDCS shall record all significant events and actions which occur in the power distribution systems. All faults shall be discriminated and correctly recorded with date and time.

Only alarms and faults should be acknowledged. No acknowledgement is required for status.

Alarms shall be displayed on a VDU alarm page, and shall remain until acknowledged. The printer is normally dedicated to event recording as soon as an event appears, but it shall be possible to retrieve, display and print the event history file.

PDCS may also provide facilities for displaying and printing events based on criteria to be defined.

3. Remote Control of Circuit Breakers

The remote control (closing and opening) of MV switchgear and main 400V distribution system circuit breakers shall be possible from the PDCS Operating Station located in Centralized Control Room.

The remote controls shall be hardwired between PDCS and the relevant circuit breakers.

The protection devices shall trip circuit breakers/contactors independent of the PDCS, because they actuate directly the trip coil of each circuit breaker/contactor.

4. Automatic Transfer

The automatic transfer load shall manually be initiated either in the Central Control Room via an operator acting the operating station or locally at the switchboard via the dedicated selector switches. The operation shall be achieved with momentary parallel, without supply interruption.

Check synchronizing relays (out of PDCS scope of supply) shall prevent closure (for any reason) of both incoming or bus section breakers unless supplies are synchronized or at least one bus is dead.

For Emergency Generator load test purpose, it shall also be possible to manually initiate its starting from the PDCS in this case interlocks shall be provided to ensure the diesel generator shall not go in parallel with the normal supply.

5. Information to be exchanged

Summary of information exchanged between PDCS and other equipment as a minimum are as follows:

- Signalling between PDCS and MV and LV switchgear shall be via serial links.
- Control sent from the PDCS to the MV and LV switchgear shall be hardwired.

a) Information which sent from PDCS to FCS shall be via serial link and as minimum will be as follows:

- Loss of input to the UPS (DC and AC).
- Failure of the ups (AC and DC).
- Low DC voltage batteries

b) Between Main Distribution Circuit-Breakers and PDCS as a minimum are as follows:

- Status (circuit-breaker opened/closed, withdrawn, etc.) sent to the PDCS via serial links.
- Measurements sent to the PDCS via serial link.
- Discriminated alarms/faults via serial link.
- Controls (opening/closing) hardwired from the PDCS

c) Between Emergency Generator Control Panels and PDCS

- Status (ready to start)
- Measurements (Minimum as per Item 1 above)
- Discriminated alarms/faults
- Control (start/stop) shall be hardwired.

d) Between PDCS and FCS

Power distribution system monitoring (overall single diagram) which shall show status of main circuit breakers.

Alarms/status shall be through serial link.

5.4.6 Lighting

1. The minimum illumination levels shall be equal to the average recommended in API-540.

2. Lighting fixtures shall be provided with power factor correction capacitor (0.9 min-PF). Weather explosion proof fixtures with shock resistant globe guard shall be

provided for outside installation and suitable for local area classification. The following type of fixtures shall be provided:

A. Indoor installation

- Fluorescent tube (lx 40 W, 2x40 W or 2x20 W)
- Mercury vapour lamp if required (1x250 W or 1x125
- Incandescent (lx 150 W)

B. Outdoor installation

- High pressure Mercury vapor lamp
- Floodlights (1000 W or 400 W) for large area
- Fluorescent fixtures
- Incandescent
- All fluorescent tube shall be bipin type

3. Emergency lighting system will consist of fluorescent, flood lights and incandescent lights backed up by the emergency electrical supply and shall be by external emergency power generation set during power failure, for mm 20 % of total lighting in building and process area except for control room, cabinet room, substation and laboratory to be mm. 50 %. In addition, safety lighting fixtures shall be provided for critical escape points to assure safe personnel exit from substation, control room and strategic points of process area. Safety Lights shall be fluorescent type with built in battery charger/inverter and with automatic switching system. Safety lights shall be fed from emergency.

4. Aircraft warning lights shall be provided on highest column according to ICAO, IEG 529 and EMPLOYERs standard

5.4.7 Communication System

5.4.7.1 Telephone system

1. Telephone system shall be provided for process area as well as buildings of the UNIT such as control room, substation, laboratory, workshop, etc. The telephone system comprise a PABX (Public Automatic Branch Exchange) with sufficient no. extension line, operator console, battery & charger, telephone sets etc, all for interconnection to form an integrated telephone system. Telephone system of UNIT shall be equipped with facilities compatible with the whole REFINERY telephone system. The referred PABX will be provided by others for the whole REFINERY

2. A wall buried box with minimum 20 couples of terminals as main distribution board of telephone shall be installed at proper location in central building of each PROCESS UNIT/UNIT. Other sub boxes shall be provided for large and/or separated buildings with minimum 10 couples of terminals.

3. Telephone outlets shall be buried type and installed in proper location of each room. Minimum number of telephones required, shall be in accordance with PROCESS UNITS/UNITS OF THE UNIT Requirements and shall be APPROVED by EMPLOYER.

4. In buildings, telephone cables shall be laid in properly sized conduits. Unburied conduits shall be suitable and acceptable for industrial building (taking into account any special requirements of PROCESS UNITS/UNITS) such as substation, analyzer room etc.

5. 20 nos. of Ex- telephone sets for the field area shall be provided as a minimum subject to EMPLOYER's approval.

5.4.7.2 Radio system

1. Complete design and specification of radio system with mm. 6 frequency channels shall be considered based on Iranian network. PROCESS UNITS/UNITS radio system shall be equipped with facilities compatible with whole REFINERY radio system. EMPLOYER will supply frequency band and frequency details during detailed engineering.

2. Sufficient number of channels with mm. 6 frequency channels for walkie-talkie shall be considered throughout the PROCESS UNITS/UNITS communication system by taking into account future expansion.

3. Mm. 25 nos. intrinsically safe, IP-65 walkie-talkie devices shall be provided. (subject to EMPLOYER approval).

4. One radio base station shall be provided for control room along with suitable antenna installed on the roof.

5.4.7.3 Intercommunication System (Public Address)

1. The intercommunication system shall consist of:

a) Central call station placed in control room

b) Loud speakers installed in various points of UNIT area so that calling is audible anywhere in the PROCESS UNIT/UNITS

c) Local set stations installed in various point of PROCESS UNIT/UNITS area

2. The system shall permit the following operation:

a) Central station; call through all or selected group of loud speakers, bidirectional talk with other local set station

b) Local set station; call through speakers even central station, bidirectional talking between all stations (local and central)

3. General specifications of the system is as follows:

a) No acoustic feedback, with ambient noise rejection

b) Power supply 400/230 V, 50 HZ from emergency bus and internal chargeable Nickel-Cadmium battery back-up for 24 hours.

4. Speakers and local station shall be suitable for the hazardous locations.

5.4.8 Fire Alarm System

This system shall be provided in accordance with the requirements, NFPA code, IEC 439, 529 and ISA 18.1.

1. Fire alarm system shall be computer aided, microprocessor based, and analogue addressable type.

2. Power supply 400/110 V AC, 50HZ from UPS (normally) and equipped with internal chargeable battery backup, capable of maintaining the system in normal operating condition for a period of not less than 48 hours after failure of AC power supply and with sufficient battery capacity shall remain to provide at least 30 minutes.

3. The system including sensors and local central station in the PROCESS UNIT/UNITS control room (s) with interconnection to overall PROCESS UNIT/UNITS fire alarm system, which is installed in overall REFINERY control room (s) or related department.

4. Sensors including push buttons and heat/smoke detectors shall be properly installed throughout the PROCESS UNIT/UNITS including buildings and wired up to main local station via main junction-box.

When fire alarm system is actuated. An alarm signal from the system shall be sent to REFINERY fire fighting station.

5.4.9 Cathodic Protection

All underground metallic pipelines (such as cooling water, raw water, fire water, potable water etc.), tanks and structures including structures affected by stray current shall be protected by cathodic protection according to following Codes and Standards:

1. All the design and installation shall be in accordance with the latest editions of NACE and BS standards.

2. For materials and EQUIPMENT IEC and NEC codes shall be followed.

3. Coating procedure and its materials shall be in accordance with the latest edition of ASTM standard.

Structures affected by stray current shall be protected either by bonding of installation of sacrificial anodes, but generally impressed current shall be used for the REFINERY. Silicon diode transformer rectifier unit with input supply 400 V, 3 ph, 50 HZ, shall be located in the PROCESS UNIT/UNITS substation. Input and output circuits shall be protected by moulded case breaker. Input voltage and output current at least shall have indicator. Min. life of anode shall be 25 years. The cathodic protection system shall be designed so that the potential at any point of the protected pipeline shall be between -0.85 V to -1 .3 V with reference to copper / copper sulphate reference electrode. All interface flanges of protected and unprotected pipes and EQUIPMENT or protected by other source(s) shall be isolated by insulation flanges and grounding cell shall be provided for these flanges.

CONTRACTOR shall provide facilities for cathodic protection testing the anodes, protected masses and grounding cells, for example:

1. Junction box for group of anodes in case of impress current.

2. Junction box for measuring the potential of pipe to soil potential. Application of sacrificial anode is limited and each shall be APPROVED by EMPLOYER.

5.4.10 Additional requirement for electrical EQUIPMENT

5.4.10.1 Wires and cables

1. Cable installation shall be in accordance with EMPLOYER'S standard (*). In general, cable shall be laid in concrete trenches (concrete trenches will apply only to paved areas) which shall be completely filled by clean sand and covered by removable covers and crossing shall be by means of Rigid Galvanized Steel (RGS) conduits embedded in concrete casting. Direct buried cable shall not be used unless otherwise APPROVED by EMPLOYER.

2. Minimum 20 % (percent) spare space shall be considered for future cable laying.

3. Generally power and control cable in PROCESS area shall be installed in concrete cable trench. These shall be done according to area classification requirements.

4. Where necessary, above ground closed conduits shall be rigid, hot dipped galvanized steel, however generally above ground cables shall be run on cable trays. Above ground cables shall be selected and installed according to area classification requirements as mentioned in IEC 79-14. Cable trays shall generally be hot dip galvanized. In corrosive areas they shall be corrosion resistant material.

5. Above ground conduit and trays shall be securely and adequately supported and grouped in selected portion of the pipe racks.

6. Route of underground cables shall be indicated by above ground marks (direction and voltage).

7. Flexible conduits shall be used to connect vibrating EQUIPMENT and instruments. Flexible conduits shall be liquid tight and suitable for the area classification in which it is installed.

Since motor feeder cables shall be armoured, they will be connected to the motors by means of suitable cable glands instead of flexible conduits.

8. The use of electrical metallic tubing (EMT) shall be restricted to indoor installations in ancillary building. Light gauge metal conduits shall be used for lighting, wiring and others in local office, workshop, store and so on.

9. Underground cable route shall be accessible and as far as possible shall not cross the underground pipes and other buried EQUIPMENT and accessories.

10. All cables specification shall be steel wire or tape armoured type with overall PVC jacket, XLPE or PVC insulated, with stranded and annealed copper conductor. XLPE insulated cables shall be used for power cables. PVC insulated cables shall be used for control cables.

11. All electrical cables shall be flame retardant type. For critical loads, fire resistant cables shall be used.

12. Cable sizing shall be in accordance with the followings:

a) Cable capacity shall be determined according to IEC, taking into account installation, environmental, characteristics of cable.

b) Cable minimum size shall be sufficient to withstand, without injury, the bolted short circuits.

c) Allowable cable voltage drop at normal operation shall be maximum 5 % of source voltage. At motor starting operation, the voltage drop will not exceed 15 % of source voltage at terminals of motor.

Minimum conductor size shall be as follows:

- Control cable to Local Control Station 2.5 mm^2
- Wire 2.5 mm^2
- Cable of 6 KV and above 50 mm^2
- Low voltage power cable 4 mm^2

13. Wires and cables shall be applied according to their application and in case they are liable to chemical attack or operation and maintenance mishaps, more resistible material such as lead cover shall be used.

14. Under ground cables for use in the process area except flexible cables shall be armored by corrosion protection. For the UNIT FCS control system, the suitable cable shall be selected by CONTRACTOR in compliance with applicable and related international codes and standard.

15. Generally metal enclosed bus duct shall be provided on secondary of power transformer. Bus bars shall be insulated with current capacity compatible with power transformer rating.

Bus duct shall be provided as follows:

- LV transformers> 1250KVA
- MV transformers with current higher than 1500 A

16. Branch circuit to lighting fixtures shall be installed by unarmored PVC/PVC cable routed in close conduits or tray (no elbow). For installation near hot surfaces, suitable branch circuit with 200 0C (or above) insulation shall be used.

17. Communication and signal circuit shall not be installed in the same raceway with power or lighting circuits.

18. Initial loading of branch circuits shall not exceed 75 % of their capacity.

19. Demand factor of welding outlet shall be maximum 0.4.

20. Cables for indoor EQUIPMENT shall be laid in cable room on cable ladders/trays in switch room and for transformer yard sand filled trench with concrete cover is preferred.

21. Floor level in each trench shall be fixed as follows:

a) Dimensions of cable trench shall be enough for cable laying, bending radius, future expansion and/or modification.

b) In the switch room, bottom level of the cable room shall be sufficiently high to protect it from rain water slippage.

c) In the transformer yard, bottom level of the cable trench shall be adequately inclined and be sufficiently high to facilitate draining.

5.4.10.2 Welding and convenience outlets

1. Socket outlets generally shall be provided with the facilities required by operation, inspection, maintenance and so on and shall also conform to EMPLOYER's standard (*)•

2. The following points shall be considered for welding sockets:

a) Rating AC, 400 V, 5 poles (3 phase and grounded) 60 A, weatherproof industrial type (minimum IP-55) and in accordance with the area classification welding socket complete with probe plug and facilities to avoid under voltage plug draw in/out operation.

b) Unless otherwise specified the sockets shall be provided within 30 m from any point of the PROCESS area. The sockets shall be max. of 4 welding outlets connected to each 4x25 mm2 feeder cable.

3. Convenience outlets of AC, 230 V and 24 V shall be provided at suitable location inside the UNIT so that to be available within max. 15m from any inspection

point (manholes, reactors, towers, etc.). Sockets generally shall be explosion proof, 3 poles (single phase and grounded), 16 A, complete with plug, max. 8 outlets on each feeder which is connected to a moulded case circuit breaker with earth leakage protection from lighting panel.

4. 10 nos. of ex-protected transportable plug and socket outlet units 230/24 V shall be supplied for the case of 24 V EQUIPMENT in Reactors, vessels, columns. In addition 10 nos. of ex-protected transportable plug and socket outlet units 230/110 VAC shall also be provided.

5. at least 10 nos., 24 V hand lamps, explosion proof type with shock resistant globe guard shall also be provided for maintenance purpose.

5.4.10.3 Power transformer

1. Generally power transformer shall be in accordance with IEC standard, oil immersed, inert gas seal type or with conservator, outdoor type, oil/air natural cooling type, off load tap changer on HV side and in compliance with the requirements of EMPLOYER'S standard (*). The transformers up to and including 2500 KVA shall be sealed type.

2. Transformer capacity and spare space of transformer yard shall be respectively 120 % and 20 % of max. initial requirement. Maximum initial requirement covers the needs of CONTRACTOR plus 3 nos. 100 Amps. 400 V feeder for EMPLOYER use, for the UNIT.

3. Transformer shall have sufficient protection EQUIPMENT for internal and external abnormal fault. Protection of transformers above 1250 KVA and also application of non-inert gas sealed type transformer shall be subject to EMPLOYER'S APPROVAL.

4. Transformers terminals shall be brought out in suitable air filled disconnecting chambers, to accommodate cable/bus termination. Cable shall enter disconnecting chamber through suitable glands.

5. Instrument transformers shall be dry and impregnated type class "F' minimum or cast resin class "F" for process installations and be oil immersion or dry for other areas.

6. Valves (with plug) for oil filling, discharging and sampling shall be considered.

7. Dial indicator/switches shall be 100 mm and thermowell is necessary for temperature indicator.

8. Provide abnormal pressure relieving device, oil level gauge and temperature indicator switches (alarm and SD) as minimum for oil immersed transformer. Other protection as Buchholz relay (alarm and SD), oil level indicator with switch (for alarm), bursting relay, pressure, indicator, differential relay, etc, shall be in accordance with

EMPLOYER'S standard (*). In case of differential relay the primary CT's on HV bushing of transformers shall be provided by switchgear manufacturer.

9. Rating capacity of each transformers shall be subject to EMPLOYER'S approval.

10. Degree of protection of terminal box and auxiliary box shall be min. IP55.

5.4.10.4 Medium and high voltage switchgear

1. Generally, switchgear shall be indoor, free standing vertical, metal cladded, dead front steel structure and suitable for future expansion. Switchgear includes dry type, vacuum and draw-out (three positions) circuit-breaker and all parts related to control, interlock, protection relays, motors buses and so on. Control voltage is 110 V DC.

Minimum mechanical protection shall be as per the requirements of IP 41.

2. For motors up to 1000 kW, combined fused contactor type starters, draw-out type, metal cladded, single stage with all accessories and protection shall be used.

3. For each bus section the following shall be considered as spare capacity for future expansion:

a) For incoming circuit breaker one main switching devices.

b) Fully equipped spare transformer feeders with their switching devices, circuit breaker & grounding switches and protection relays, 20% of total feeders and min. one for each type feeders.

c) Fully equipped spare motor feeders (20% of total MV motor feeders and minimum one), which includes main switching device and components mentioned above.

For above outgoing feeders the current transformers is included

d) Mm. 20% of spare space for extension of panels shall be considered.

4. Each group of motors controller shall be fed from a common bus, equipped with a voltmeter and polyphase switch. The front of each motor controller shall be included in an ammeter with a polyphase switch. Large motors shall have time delay in the control circuit to be protected against overheating from successive start. A ground bus shall be provided in each starter.

5. States of breakers (open/close/trip/test) shall be indicated by LED lamps.

6. Generally, secondary voltage and amp. of PT and CT are respectively 100 V AC and 1 ampere.

7. Facilities shall be provided for earthing the incoming side of each supply, the circuit side of each outgoing feeder and each section of busbar through at least one unit. MV switchgear earthing operations could be executed through earthing isolator switches, circuit breakers or earthing trucks according to type of panel and/or manufacturer's standards.

8. Signal lamp shall be provided for "on" state of heater(s) related to each medium voltage motor.

9. Power bus shall be copper and shall be completely isolated and insulated with flame retardant, non-hygroscopic insulation.

10. Motor supply panel for motors over 1000 kW shall be consisting of circuit breaker, grounding switch, current transformer, ammeter with selector switch, instantaneous overcurrent relay, current balance relay, ground fault relay (instantaneous), thermal relay, differential protection, Jock-out relay, automatic device for space heater supply and winding temperature, undervoltage and locked rotor relay.

11. Design maximum substation temperature is 45 0C.

5.4.10.5 Low voltage Motor Control Centre

1. Generally each motor control centre (MCC) or switch board shall consist of metal enclosed, free-standing, dead front, dust-proof, vertical steel structure, containing buses, starters, feeder switches, metering and control EQUIPMENT etc, shall be in accordance with IEC 439 (Min. IP41).

2. Provisions for sufficient spares shall be made for each bus section at design stage according to following criteria:

a) For each size of MCC or switch board modules an average spare of about 20 % (min. one for each type feeders) shall be provided and will be shared over these MCCs.

b) Spare space shall be provided in each MCC or switch board for about 20 % of occupied space.

3. Power buses shall be made of copper and shall be insulated except vertical with flame retardant non-hydroscopic insulation.

4. Draw - out multistage combination starter, normally consists of:

a) Automatic air circuit breaker which mechanically interlocks to compartment door and switch as operating handles.

b) Electrically operated air contactor.

c) Thermal overload, ambient compensated sensitive to single phasing with hand reset.

d) All the motors rated 4 kW and above shall have ammeter showing amperes on local control stations and switchgear. For this purpose, each low voltage motor starter unit in MCC will have a 1 ampere secondary current transformer (CT).

e) MCC will have the ammeter for all power feeders.

f) Earth leakage relay shall be provided for all motors >22kW or according to personnel safety whichever prevails.

g) Requirement for current indication in FCS will be dictated by PROCESS when necessary for correct unit operation disregarding the power rating consideration.

h) All signaling and interlocks between substation and control room shall be done through an electrical and instrumentation cabinet (EII). This cabinet shall be equipped with I/O terminals and auxiliary flag relays (24 V DC) and relevant accessories.

i) For each type of motors and power feeders protection EQUIPMENT are required in accordance with international standards and recommended practice.

j) Auxiliary relays, timers, switches, signal lamps (stop! running! tripping), fuse (for control system) and so on.

k) Reacceleration and automatic restart device for emergency loads as per PROCESS requirements.

l) Power supply for control 230 V, 50 HZ

5. Electronic motor control card with power supply 230 V AC and 24 V DC is acceptable for FCS control system, after EMPLOYER'S prior APPROVAL (if applicable).

5.4.10.6 Low Voltage Distribution Board

1. Following shall be installed in each switch room:

a) Main lighting panel

b) Instrument power supply board

c) DC distribution board, UPS distribution board (the main AC UPS distribution board shall be located in control building)

d) Emergency and/or critical loads panels (if necessary)

2. Signal lamps indicating high-voltage motors “on” shall be provided for every circuit breaker for space heater use.

3. Branch feeder for important instrument use shall be provided for every two instrument panels and a selective ground relay shall be provided for each.

5.4.10.7 Motors

I. Unless otherwise specified by EMPLOYER, all motors shall be direct on line (D-O-L) squirrel-cage induction motors. Other types may be accepted after EMPLOYER’S APPROVAL.

2. Motors shall be sized taking into consideration of the followings:

a) Motors shall be capable to operate continuously at rated horsepower for the specified altitude and ambient temperature and other conditions of SITE.

b) Service factor shall be considered as 1.

c) Motor driving compressors and reciprocating pumps shall be sized so that the product of the motor name plate rating and the motor service factor shall be at least 110% of the greatest horsepower required (including gear and etc) for any of the compressor and reciprocating pump operating conditions.

d) Motors driving centrifugal pumps shall have horsepower rating at least equal to the following percentage of pump design point brake horsepower:

Motor Rating (kW)	Percent of pump BHP
18.5 and less	125
22 to 55	115
75 and above	110

3. Bearing of motors shall be in compliance with the requirements of the ISO R 281. Application of ball bearing for motors above 150 kW shall be APPROVED by EMPLOYER on case to case basis. In addition the following factors shall be taken into consideration:

e) Vertical motors shall have thrust bearings suitable for the load imposed by the driven machinery.

f) Housing of sleeve bearing shall be equipped with sight-feed oiler or sight gauge marked with proper oil level.

4. Insulation & enclosures for motors will be insulation class F, temperature rise class B, IP55 and terminal box IP55.

5. Lead of space heaters, control or detection signal shall be terminated in terminal boxes separate from that have been used for the main power load terminal box (es). Space heaters shall be provided for motors above 3 KW. (Medium voltage motors)

6. For totally enclosed, water-air fan cooled and etc, shall be considered with additional facilities, like temperature indicator, alarm for cooling air, means for detecting and draining water in the motor housing, temperature indicator on oil of sleeve bearing and so on.

7. Rated torque shall be adequate for frequency variation between -5 % and +5 %, and also by voltage variation in the range of ± 5 %.

8. Full voltage starting of induction motor is preferred for simplicity and economy, provided motor load in various conditions will permit and the power system will function without acceleration of motor after power failure because of undue voltage disturbance during starting.

9. Motor controllers shall include devices to protect the motor at least under overload, locked rotor and fault conditions.

10. In case of critical PROCESS service, motors shall have time delay relay adjustable from zero (0) up to 10 sec. for under voltage, preferably it shall be in the motor control enclosure.

11. Motor shall be controlled at least by start-stop push button stations in safe and convenient locations within sight of the motor operator and from other location according to PROCESS UNITS/UNITS requirements and in compliance with the requirements of EMPLOYER's standard (*)•

12. For single phase motor both thermal and overload protection shall be used as minimum.

13. Thermo-resistance (RTD) shall be considered for protection of motors as specified in instrument section.(only for motors above 150 kW)

14. Preferred speed for motors is 1500 RPM. Maximum speed for pump motors as package could be higher depending on the speed requirement of selected pump.

15. Min. number starts of motors shall be as follow:

a) Three successive starts for cold case.

b) Two successive starts for hot case.

5.4.10.8 Direct Current and Uninterruptable Power Supply (UPS)

For control circuitry and whereever specified DC or UPS shall be furnished to provide a reliable means for continuity of system operation.

1. Direct current supply

a) The system shall consist of a battery bank, dual charger and panel. During normal operation the battery shall be on floating charge and the battery charger shall feed the connected loads, but in case of troubles in power supply or charger itself, the storage batteries shall be capable to supply the connected loads continuously without any break and trouble for loads according to the requirements of the system taking into account minimum possible interruption time and process requirements. Equalizing facilities shall be considered on charger.

b) The system shall consist of fixed units, assembled to have an integral type panel and shall include the followings:

i. Fully automatic static battery charger with all associated parts.

ii. Distribution panel, with outgoing feeders equipped with moulded case circuit breakers.

iii. Floating batteries shall be vented Ni-Cd type (mounted in separate battery room). The autonomy period of the battery shall be as per process requirements but not less than 2 hours. The above mentioned batteries shall be exclusively used for its charger.

c) Unless otherwise specified by EMPLOYER power supply of charger shall be considered as 400 V, 3 ph. 50 HZ from the normal bus. Each charger shall be used for unique DC voltage 24 V or 110 V.

d) Unless otherwise specified by EMPLOYER spare capacity of charger shall be 20 % of maximum initial loads.

2. Uninterruptible Power Supply (UPS)

a) UPS shall consist of two chargers, both supplied from normal busbar, two inverters, one battery bank, panel and etc., as required.

b) During normal operation, the chargers and inverters are in service but the batteries are on floating charge. During the abnormal condition the system shall be as follows:

i. Inverters continuously feed the loads without any break in case of power supply failure and charger trouble.

ii. In case of trouble in inverters, power supply shall be transferred automatically (or manually) without any break to automatic voltage regulator circuit and without any trouble to load via static switches. After repairing troubles, power supply shall be transferred to inverter circuit, without any trouble for connected loads.

c) Unless otherwise specified by EMPLOYER, power supply shall be 400 V, 3 ph, 50 HZ from the emergency bus and normal busbar. Inverter bypass shall be fed from separate busbar with minimum probable failure.

d) The UPS shall also consists of the followings:

i. Battery charger, with automatic control feature.

ii. Floating type Ni-Cd alkaline battery (mounted in the separate battery room). These batteries are exclusively used in this system.

ii. Normally power for important instruments shall be supplied by inverter.

iv. Back-up transformer shall be dry type, with automatic voltage regulator.

v. Automatic transfer switch.

vi. Distribution panel, with outgoing feeders equipped with moulded case circuit breakers.

vii. Control electronic parts of UPS shall be redundant.

(including battery charger and inverter)

viii. A manual switch of make before break type shall be provided to isolate the static transfer switch from the system.

e) Spare capacity shall be minimum 20 % of initial peak loads.

f) Storage batteries shall be capable to supply 120 % of maximum initial load for required period and at least 30 minutes for maximum initial loads.

g) The inverter shall be synchronized to the power system frequency.

h) Impact drop of output voltage for start-up of a maximum load shall be maximum 5 % of rated voltage, without any trouble to loads.

5.4.10.9 Deleted

5.4.10.10 CCTV

Closed circuit television system (CCTV) shall be used for multipurpose, security and observation of Process area.

Colour television system shall be as per IRAN'S TELEVISION SYSTEM.

Arrangement of cameras (minimum eight cameras) shall be provided and suitably located so that, the area to be observed is well covered.

To obtain the correct field of view with the given distance between the camera and the object to be observed, the lens must be of the appropriate focal length. Camera tube shall be selected ~Ytype. Coaxial cable shall be used for the connections between cameras and monitor. These cables must have a characteristic impedance of 75Q. The control signals, which are produced by a keyboard in the vicinity of the monitor, must be conveyed to the camera through a multi-core cable.

CCTV shall be so designed to install television (LCD, TFT monitoring system) in control room system, therefore suitable facilities shall be considered.

Functionally CCTV system is required for the surveillance of the UNIT and equipment. All the cameras shall have Pan and Tilt control. The camera-viewing angle can be varied between 70 to 400 and shall have zooming facility.

The CCTV central unit shall be located in the control room as required. Separate monitors shall be suitably located either in console area or wall/ceiling supported and keyboard, joystick etc shall be located on the hardwired console.

The minimum enclosure protection degree of the system components shall be in accordance with IEC 60529 as follows:

a) Outdoor IP 55

b) Indoor IP42

c) Panels with open doors IP 20 (live parts shielded)

Control unit and all peripherals shall be installed in air-conditioned control room. Cameras shall be installed outdoor in the field. Cameras with its accessories shall be housed in explosion proof certified Ex'd' housing suitable for gas grouping of the UNIT.

The system shall include all hardware, wiring, cabinets, materials and application software for a fully function system. Components shall be for industrial grade.

Cameras shall be as a minimum, comply with the following specification:

a) Pick up element : 1/2/1/3” interlined CCD colour

b) Picture point : 512 x 582

c) Sampling system : PAL standard CCIR 625/50 lines per frame

d) Video band width : 5 MHz -3 dB

e) Horizontal resolution : Minimum 450 lines

f) Sensitivity : 0.1 lux for a good picture (@F= 0.95 and 3200 K)

g) Zoom lens : 11-66mm

h) Controls : Zoom, Focus, iris and external synchronization

i) Signal noise ratio : Approx. 50 dB

j) Gamma : 0.5

k) Automatic light level Control : 1:10

l) Temp. range : 0 - 800C

m) Video output 1 V peak To peak : 75 Ω0 unbalanced

n) Camera identification : Yes

o) Automatic gain control facility : Yes

The zoom objective shall be equipped with an automatic diaphragm control, auto focus and spot filter.

The time lapse Video recorder shall be as below:

a) Digital tape : Standard 2 hour 1/2 S-VHS E-120 or E-180

b) Record/play back speed : 2, 12, 24 and at least up to 72 hours.

c) Video input/output : 1 V peak to peak 75 0 unbalanced.

(Digital cameras may be used instead).

Movable cameras shall have an electric control mechanism (pan and tilt) which shall be controllable through a joy stick and the same shall be located on the hardwired console. The pan and tilt shall comply with the following:

a) Angular travel : Pan 0-335 degrees Tilt + 90 degrees

b) Stops : Externally adjustable

c) Speed (no load) : Pan 6 degrees/second, Tilt 3 degrees/second

d) Loading : Suitable for camera and camera housing

For Hazardous area locations cameras and accessories shall be housed in an 'Exd' and ingress protected (IP 65) housing. Sand protector, wash and spray installation on the lens cover shall be provided. A sun cap shall prevent direct sun radiation into the lens and camera housing. The enclosure shall be epoxy painted.

Cameras with its accessories shall be installed on steel structure (mounting poles). Mounting pole/structure shall be 10 meter high (minimum and shall be designed for maximum wind velocity of the UNIT location. The allowable deflection at the top shall be + 5 mm. The mounting pole/structure shall be supported on a concrete foundation. A ladder shall be provided to access the camera at top for the purpose of installation and maintenance of camera and its accessories. The design, supply, fabrication and erection of poles including its support arrangement shall be in contractor's scope. The structural steel shall be epoxy painted to meet the environment.

a) From a master control panel (keyboard) it shall be possible to select any camera and display the picture at the monitor.

b) Remote control panels/keyboard shall be programmed for the control of selected cameras with the possibility to call up any camera connected to the system.

c) Commands from the control unit are sent via a data transceiver to the control receiver at the camera side. The control receiver will control the camera lens and pan/till functions.

d) Operator shall be able to control all cameras and pan, tilt and zoom functions manually.

e) The Video recorder shall record the activities at all entrances and at locations where alarms have been alerted. The time lapse video recorder(s) shall be able to record up to 72 hours without reloading.

f) It shall be possible to view pictures of four cameras or three cameras and VCR simultaneously on the screen. Suitable quad unit shall be provided.

Wiring and connection shall be as below unless specified otherwise:

a) All the cables (indoor/outdoor), connectors and plugs shall be supplied. The connectors shall be BNC type.

b) Flexible cables shall only be used for flexible connections.

c) Video signals from cameras to the control unit shall be transmitted via coaxial cables.

d) Camera control signals may be transmitted either via twisted pair or via multicore cables.

e) All interconnection cabling between field mounted cameras to control equipment shall be shielded and armored. Outdoor cabling between control equipment monitor / keyboard and optical fiber cable shall also be shielded and armored.

f) Materials shall be of proven design for similar application.

All the outdoor items shall be tropicalized and epoxy painted. All carbon steel bolting shall be hot dip galvanized or Cadmium plated and bi-chromate. Screws, rivets, brackets and stiffeners shall be stainless steel. Colour of the topcoat of panels shall be of manufacturer standard.

15% installed spares and 10% spare space shall be provided in system for future expansion.

All of control units for CCTV shall be connected together.

Control units and CCTV shall be digital-type and monitors shall be minimum quad-type.

The body of CCTV shall be stainless steel.

CCTV system shall be connected to Fire-Alarm

5.4.10.11 Electrical Heat Tracing

Electrical Heat Tracing system shall be provided for temperature maintenance or to prevent freezing for the services specified in the P&IDs and shall also conform to EMPLOYER’s standard.

Section 6- Civil & Structural

6-1) General

This Criteria is prepared for and shall be used in all civil and structural design works of the PLANT.

6-2) Reference Codes and Standards

Refer to section (2-3).

6-3) Geotechnical and Soil Investigation Data

LORC will supply Geotechnical and soil investigation report at his costs and expenses. Design will be carried out according to soil parameters and information in the soil report. An authoritative soil consultant engineer will provide the soil report.

Records of borings and soil investigations will be made available to EPC Contractor but it will be the responsibility of the EPC Contractor to make additional investigations as required to determine all soil conditions.

6-4) Design Loads

The following loads shall be considered, as applicable in the detailed design of structures, including bridges and culverts, foundations, roads and buildings.

a) Dead Load
b) Operating Load
c) Test Load
d) Live Load
e) Snow Load
f) Wind Load
g) Earthquake Load
h) Truck Loads
i) Railway Loads
j) Impact Load
k) Vibration Load
l) Thermal Load
m) Erection Load
n) Maintenance Load
o) Explosion Load

6-4-1) Dead Load

a) Dead Load shall be considered as the weight of the materials forming a permanent part of the structure Plant. It shall be defined as the total weight of all empty vessels and equipment, structures, fireproofing, insulation, piping and electrical conduit and etc.

b) The specific weights of the materials shall be based on ISIRI 519 Code where applicable.

c) Other weight shall be in accordance with the specifications and/or drawings of vendors and manufacturers.

6-4-2) Operating Load

Operating Load shall be the dead load plus the weight of any liquids or solids present within the vessels, equipment and/or piping during normal operation including the weight of all permanently stored materials for operation on vessels/structure.

6-4-3) Test Load

Test Load shall be defined as the dead load plus the weight of any liquid necessary to pressure-test vessels, equipment or piping.

6-4-4) Live Load

a) Live Load shall be defined as the weight of all movable loads, including personnel, tools, miscellaneous equipment, cranes, hoists, parts of dismantled equipment, and temporarily stored materials.

b) Generally where applicable, the live loads shall be in accordance with ISIRI 519 Code, except otherwise stated in this Design Criteria.

c) The Live Loads shall be considered as uniformly distributed over the horizontal projection of the loaded areas, except for the loads with a concentrated nature.

d) The following minimum live loads shall be considered for the Detail Engineering of the Project:

i) Pitched Roofs

Uniformly distributed load of 100 Kg/m^2 or a concentrated load of 100 Kg at any point over the roof, whichever is critical.

ii) Flat Roofs

Uniformly distributed load of 175 Kg/m^2 or a concentrated load of 100 Kg at any point over the roof, whichever is critical.

iii) Floors

- Control Rooms:

  Uniformly distributed load of 1000 Kg/m^2 (or recommended by Vendor).

- Switch Gear Rooms:

  Uniformly distributed load of 1000 Kg/m^2 (or recommended by Vendor).

- Battery Rooms:

  Uniformly distributed load of 1000 Kg/m^2

- Laboratories:

  Uniformly distributed load of 500 Kg/m^2

- Compressor Buildings:

  Uniformly distributed load of 1000 Kg/m^2

- Pump Houses:

  Uniformly distributed load of 1000 Kg/m^2

- Workshops:

  Uniformly distributed load of 1000 Kg/m^2

- Warehouses and Storage Areas:

  Loads to be determined from the proposed usage or otherwise are in accordance with the ISIRI 519 Code.

- Other Buildings:

  Loads to be determined in accordance with the ISIRI 519 Code

iv) Platforms

- Storage Areas:

Uniformly distributed load of 600 Kg/m^2 for light and 1200 Kg/m^2 for heavy storage areas or a concentrated load of 900 Kg at any point over the platform, whichever is critical.

- Operating Platforms:

  Uniformly distributed load of 500 Kg/m^2 or a concentrated load of 900 Kg at any point over the platform, whichever is critical.

- Access Platform:

  Uniformly distributed load of 250 Kg/m^2 or a concentrated load of 450 Kg at any point over the platform, whichever is critical.

- Stairs, Ramps and Landings:

  Uniformly distributed or concentrated loads equal to those of platform.

- Pipe Supports and Pipe-Racks:

  One concentrated load of 100 Kg at mid-span or two concentrated loads of each 100 Kg at quarter points along with the span (as a minimum load).

- Cover Plates and Slabs:

  Uniformly distributed load of 500 Kg/m^2 or a concentrated load of 1000 Kg at any point, whichever is critical. (For heavy traffic area, these loads shall be defined in accordance with “AASHTO” code.)

- Pedestrians

  Uniformly distributed load of 500 Kg/m^2

- Garages and Parking

  Loads to be determined in accordance with ISIRI 519 Code

6-4-5) Snow Load

Snow loads shall be taken as 25 Kg/m^2 uniformly distributed over the horizontal projection of the loaded areas.

6-4-6) Wind Load

Wind load shall be considered according to UBC.

6-4-7) Earthquake Load

a) The PLANT structures shall be designed to resist earthquake forces in accordance with the Uniform Building Code ("UBC") and based on soil report for Seismic Risk Zone. All other codes referred to in clause 2.1 of this Design Criteria shall be considered as supplementary, and the Uniform Building Code (UBC) shall govern in case of any conflict.

b) Seismic Risk Zone 3 for Lavan in accordance with the Uniform Building Code (UBC) or according to Iranian Seismic Code 2800 for region 2 with seismic relative hazard for design base acceleration of 0.30g.

c) The coefficient "W" shall be defined as the "load Coefficient". For different facilities, "W" shall be equal to the loads or load combinations as follows:

- Buildings:

  As per Uniform Building Code

- Storage and Warehouse Occupancies:

  The total dead load, including partitions, plus 25% of the floor live load plus 75% of the snow load, as per Uniform Building Code.

- Petrochemical Process Facilities:

  Operating load

- Storage Tanks:

  Operating load plus 75% of the snow load

- Vibrating Equipment:

  150% of the total static weight

- Pipe Racks:

  Operating load

d) When computing the lateral earthquake force on industrial buildings and structures, the total weight of the cranes, if any, but excluding the lifted loads, shall be considered as dead load.

e) The distribution of the total lateral earthquake force over the height of building and other structures shall be based on the following procedures:

- Buildings:

As per Uniform Building Code

- Vertical Vessels, Stacks and Storage Tanks:

  Apply a concentrated force "Ft" at top and the remaining force (V-Ft) at 2/3 of the height (triangular distribution). The magnitude of the concentrated force Ft shall be computed in accordance with the Uniform Building Code.

- Horizontal Vessels:

  Apply the total lateral earthquake force "V" along the center line of the vessel in the direction under consideration.

- Heat Exchangers (Single Level):

  Same as Horizontal vessels

- Heat Exchangers (Multi-Level):

  Apply a concentrated force Ft along the centerline of the top most vessels and the remaining force (V-Ft) along the line passing through the C.G. of the vessels in the direction under consideration.

f) In industrial buildings and structures the portion of the total lateral earthquake load, which has been computed, based on the total weight of the cranes shall be applied to only one main frame, when the lateral direction of the building is under consideration.

g) Alternatively a dynamic analysis shall be used, by prior approval of the EMPLOYER, in order to establish the site-specific earthquake forces.

h) The overturning moment due to statically applied earthquake forces shall not exceed 2/3 of the resisting moment of the structure during the empty or operating condition i.e. the stability ratio shall not be less that 1.5.

i) The overturning moment under the action of site-specific ground motion, using a dynamic analysis, shall not exceed the resisting moment of the structure during the empty or operating condition (stability ratio of 1.00).

j) The weight of the earth superimposed over the foundations shall be included in the loads causing the resisting moment of the structure.

k) The factor of safety against sliding due to earthquake shall be at least 1.5 during the empty or operating condition.

l) The resisting force against sliding shall be taken as the full frictional force between foundation and the sub-soil strata plus 50% of the earth's passive resistance or 50% of the frictional force plus 100% of the earth's passive resistance, whichever is greater. The weight of the earth

superimposed over the foundations may be included in the loads causing the resisting frictional force.

m) All the members in braced frames shall be designed for 1.25 times the seismic force computed by either static or dynamic analysis. Connections shall be designed to develop the full capacity of the member, or alternatively designed for the above forces without regard to the one-third-stress increase normally allowed for earthquake forces.

n) Earthquake and wind forces shall not be considered simultaneously.

6-4-8) Truck Loads

All pavements, slabs, bridges, trenches, trench covers and underground installations accessible to truck loading shall be designed to withstand the worst of the following loading cases.

a) HS 15-44 wheel loading or its equivalent lane loading as defined by the American Association of State Highway and Transportation Officials (AASHTO) under Standard Specifications for highway bridges.

b) 9 Tons Truck loading based on ISIR 519 Code.

6-4-9) Railway Loads

Cooper E72 railway loading as defined by the American Railway Engineering Association under Manual of Railway Engineering shall be used for the design of any installation subjected to railway loading.

6-4-10) Impact Load

Impact load shall be defined as an equivalent static force caused by a moving object.

a) Truck Loads as specified in clause 4.9 of this design criteria shall be subjected to an appropriate increase, as explained hereinafter, to provide for the impact.

b) HS 15-44 Wheel Loading or its equivalent Lane loading shall be increased by an Impact Factor of “I” percent as follows:

$$I = \frac{15}{L + 38} < 30\%$$

Where L = Span (meters)

c) The wheel loads of the 9 Tons Trucks Loading shall be multiplied by an Impact Factor of 1.5.

d) For structures supporting live loads which induce impact, the assumed live load shall be increased sufficiently to provide for the impact. If not specified, the increase shall be as follows:

- Elevator Supports 100%
- Traveling Crane Supports 25%
- Monorail Supports 25%
- Machinery Supports 50%
- Davits 50%
- Hangers supporting floors and Balconies 33%

e) The lateral impact loads and crane runway horizontal forces shall be as follows:

- Crane Runway:

  The transverse or lateral force shall be 20% of the sum of the weights of the lifted load plus crane trolley and hoist (but exclusive of the other parts of the crane). The force shall be assumed to be applied at the top of the rail, one-half on each side of the runway and shall be considered as acting in either direction normal to the runway rail.

  The longitudinal force shall be taken as 10% of the maximum wheel loads of the crane applied at the top of the rail and acting in either direction.

- Monorails:

  The transverse or lateral force shall be 20% of the weight of the lifted load. The longitudinal force shall be 10% of the sum of the weights of the lifted load, the crane trolley and hoist. The transverse and longitudinal forces shall be considered as acting in either direction.

- Handrails:

  Handrails for stairs, platforms or other uses shall be designed to withstand a uniformly distributed load of 75 Kg/m applied at the top of the rail.

- Davits:

  Davits shall be designed to withstand a lateral force of 20% of the weight of the lifted load.

f) Transverse and longitudinal impact forces shall not be assumed to act simultaneously.

6-4-11) Vibration Load

a) Vibration loads are those dynamic forces, which are caused by vibrating machineries such as pumps, compressors, blowers, turbo-generators, fans and other similar machineries. Surge forces similar to those acting in fluid cockers, hydro formers and crackers shall also be included.

b) All supports and foundations for vibrating equipment shall be designed to limit vibrations to an acceptable level based on recognized amplitude/ frequency curves.

6-4-12) Thermal Load

a) Thermal load are those forces caused by a change in temperature. Such forces shall include those caused by vessel or piping expansion or contraction, and expansion or contraction of structures.

b) Forces caused by vessel or piping expansion or contraction shall be defined as those required to overcome the static friction between two surfaces in contact and one liable to sliding over the other, and shall be termed as friction forces.

c) The following coefficients of static friction shall be used to determine the friction forces at sliding surfaces of vessels:

- Steel on steel 0.30
- Steel on concrete 0.50
- Teflon on Teflon 0.10
- Lubrite on Lubrite 0.10

d) On pipe racks and pipe supports with 4 or more lines the friction force shall be taken as 10% of the total pipe weight tributary to that pipe rack or pipe support, under operating condition.

e) On Pipe Racks and Pipe supports with 3 or less lines the friction force shall be taken as 20% of the total pipe weight tributary to that pipe rack or pipe support, under operating conditions.

f) The thermal load caused by the expansion or contraction of structures shall be computed based on the coefficients of expansion as specified in AISC manual of steel construction.

6-4-13) Erection Load

Erection load are temporary forces caused by erection of structures and/or equipment.

6-4-14) Maintenance Load

a) Maintenance load are temporary forces caused by dismantling, repair or painting of equipment. Such forces shall include the bundle-pull force of heat exchangers.

b) Supports for heat exchangers shall be designed to withstand a longitudinal bundle-pull force equal to half of the tube – bundle weight or 1000 Kg, whichever is greater.

6-4-15) Explosion Load

1. Explosion load are horizontal or vertical, uniformly distributed, static overpressures equivalent in their design effect to dynamic overpressures created by explosions.
2. Elements of building specified as “Blast Proof Building” shall be designed to withstand the following equivalent static overpressures:

a) Each external wall for an external overpressure of 10000 kg/rn2 acting from outside of the building and separately, for an internal overpressure of 3350 kg/rn2 acting from inside of the building.
b) Roof slabs and beams for external and internal overpressures, from outside and inside of the building respectively, as follows:

Span (in)	Overpressure (kg/rn2)	
	External	Internal
Upto3.00	5000	2500
4.00	4500	2250
5.00	4000	2000
6.00	3500	1750
7.00	3000	1500
8.00 and over	2500	1250

c) Main structural frames for the worst combination of the above overpressures as applied to external walls and also of the roof tributary to that frame.

3. Explosion overpressures need not be assumed to act simultaneously with wind or earthquake forces.

6-5) Loading Combinations

Combinations of loads defined before shall be considered to determine the maximum stress conditions for design, as follows:

6.5.1 Allowable Stress Design for steel design:

- All of the below mentioned conditions should be considered in load combinations:

Empty condition

a) Dead load plus wind or earthquake load.
b) Dead load plus maintenance load.
c) Erection load plus wind load.

Operating condition

a) Operating load, plus live or snow load plus impact load, plus vibration load, plus thermal load.
b) Operating load, plus snow load, plus vibration load, plus wind or earthquake load.

Test condition

a) Test load plus live load.
b) Test load, plus 50% live load, plus 20% wind or earthquake load.
c) When there is more than one vessel to be tested in a structure, they shall normally be tested concurrently unless written instruction is given to the piping group requesting them to show non-concurrent testing on the pressure test flow diagram for the specific structure.

- Design load combinations according to UBC- 97 are as follows:

Empty condition:

a) Dead + Live + Live (R)
b) Dead + Live + 0.5 Snow + Wind
c) Dead + Live + Snow + 0.5 Wind
d) Dead + Live + Snow + 1/1.4 Empty EQ.
e) Dead + Live + (Wind or 1/1.4 Empty EQ.)
f) 0.9 Dead + 1/1.4 Empty EQ.

Operating condition:

a) Dead + Oper. + Live + Live (R)
b) Dead + Oper. + Live + 0.5 Snow + Wind
c) Dead + Oper. + Live + Snow + 0.5 Wind

d) Dead + Oper. + Live + Snow + 1/1.4 Oper. EQ.
e) Dead + Oper. + Live + (Wind or 1/1.4 Oper. EQ.)
f) 0.9 (Dead + Oper.) + 1/1.4 Oper. EQ.

Test condition:

a) Dead + Test + Live + Live (R)
b) Dead + Test + 0.5 Live + 0.2 (Wind or 1/1.4 Test EQ.)

6.5.2 Strength Design for Concrete design:

- All of the below mentioned conditions should be considered in load combinations:

Empty condition

a) Dead load plus wind or earthquake load.
b) Dead load plus maintenance load.
c) Erection load plus wind load.

Operating condition

a) Operating load, plus live or snow load plus impact load, plus vibration load, plus thermal load.
b) Operating load, plus snow load, plus vibration load, plus wind or earthquake load.

Test condition

a) Test load plus live load.
b) Test load, plus 50% live load, plus 20% wind or earthquake load.
c) When there is more than one vessel to be tested in a structure, they shall normally be tested concurrently unless written instruction is given to the piping group requesting them to show non-concurrent testing on the pressure test flow diagram for the specific structure.

- Ultimate load combinations according to ACI 318-05 are as follows:

Empty condition:

a) 1.4 Dead
b) 1.2 Dead + 1.6 Live + 0.5 Live (R)
c) 1.2 Dead + 1.6 Live (R) + (0.8 Wind or n^* Live)
d) 1.2 Dead + n^* Live + 0.5 Live (R) + 1.3 Wind
e) A^* Dead + n^* Live + m^* Snow + 1.0 Empty EQ.

f) B* Dead + 1.0 Empty EQ.
g) 0.9 Dead + 1.3 Wind

Operating condition:

a) 1.4 Dead + 1.4 Oper.
b) 1.2 (Dead + Oper.) + 1.6 Live + 0.5 Live (R)
c) 1.2 (Dead + Oper.) + 1.6 Live (R) + (0.8 Wind or n* Live)
d) 1.2 (Dead + Oper.) + n* Live + 0.5 Live (R) + 1.3 Wind
e) A* (Dead + Oper.) + n* Live + m* Snow + 1.0 Oper. EQ.
f) B* (Dead + Oper.) + 1.0 Oper EQ.
g) 0.9 (Dead + Oper.) + 1.3 Wind

Test condition:

a) 1.4 (Dead + Test)
b) 1.2 (Dead + Test) + 1.6 Live + 0.5 Live (R)
c) 1.2 (Dead + Test) + 1.6 [0.5 Live (R)] + [n* (0.5 Live) or 0.8 (0.2 Wind)]
d) 1.2 (Dead + Test) + n* (0.5 Live) + 0.5 [0.5 Live (R)] + 1.3 (0.2 Wind)
e) 1.25 (Dead +Test) + n* (0.5Live) + 0.2 Test EQ.
   - m = 0.7 for roof configurations that do not shed snow off the structure (saw tooth roofs and roofs with tall parapets)
   - m = 0.2 for other roof configurations
   - n = 1.0 for live loads greater than 500 kg/m^2
   - A = 1.34 when I = 1 , 1.375 when I = 1.25
   - B = .76 when I = 1 , 0.725 when I = 1.25
   - I = Importance factor

6.5.3 Definition of loads

Definitions of loads applied in load combinations of clauses 6.5.1 and 6.5.2 are as follows:

- Dead: dead loads
- Live: loads
- Snow: snow load
- Live (R): roof live load
- Wind: wind loads
- Oper.: Operating loads
- Test: testing loads
- Empty EQ.: Horizontal effect of earthquake load acting on structure in empty condition
- Oper. EQ.: Horizontal effect of earthquake load acting on structure in normal operating condition
- Test EQ.: Horizontal effect of earthquake load acting on structure in test condition
- T: Thermal loads
- F: Loads due to fluids
- H: Loads due to lateral pressure of soil or water in soil

6-6) Allowable Stresses

6-6-1) The allowable stresses for structural steel, concrete, masonry and structural connections shall be in accordance with relevant code in clause 2.1.

6-6-2) The allowable stresses for wood shall be in accordance with the uniform Building Code.

6-6-3) The allowable stresses for loading combinations involving wind or earthquake load shall be increased by 33 (1/3) percent except for anchor bolts supporting spheres and vertical vessels.

6-6-4) The allowable stresses for all steel elements and their connections subject to test loading without Wind or earthquake shall be increased by 20 percent.

6-7) Methods of Design

6-7-1) Reinforced Concrete

a) Reinforced concrete buildings, foundation and other structures, except tanks for the storage of water shall be designed in accordance with ACI 318, building code requirements for reinforced concrete.

b) Reinforced concrete tanks for the storage of water shall be designed in accordance with ACI 350 and or the British Standard Code of Practice BS 5337. The structural use of concrete for in aqueous liquids.

The following grades of concrete according to Min. compressive characteristic strength at 28 days (f'c) on cylinder specimen (ASTM C39) shall be used.

- Cast in place concrete f'c = 250 Kg/cm^2
- Precast concrete f'c = 250 Kg/cm^2
- Tank & reservoirs f'c = 250 Kg/cm^2
- Prestressed concrete f'c = 300 Kg/cm^2
- Foundation for vibrating Machine f'c = 250 Kg/cm^2
- Lean concrete f'c = 150 Kg/cm^2
- Fire proofing concrete f'c = 210 Kg/cm^2

For vibrating equipment it is required to have concrete with f'c 250 Kg/cm^2.

6-7-2) Structural Steelwork

a) Structural steelwork shall be designed on elastic limit basis (Allowable Stress Design) and in accordance with AISC specifications.

b) Where practicable welded connections shall be used. No riveted connections are permitted.

c) The minimum thickness of all structural steel except rolled I– sections and channels shall be 6mm.

d) Not less than two bolts are to be used in end connections.

e) Anchor bolts for foundations shall be of plain mild steel bars with a minimum diameter of 20 mm.

f) The thickness of gusset plate shall not be less than 8 mm.

g) The thickness of all cap plates shall not be less than 10 mm.

6-7-3) Masonry Structures

Masonry structures shall be designed in accordance with the Codes as specified in Clause 2.1 (c) of this Design Criteria.

6-7-4) Storage Tank Foundations

a) Reinforced concrete ring walls shall be used in congested Process and Interconnection and tankage areas.

b) The structural analysis and the design of the ring wall shall be based on a recognized and logical method and in accordance with the recommendations of API 650 Code.

c) The thickness of the ring wall shall not be less than 300 mm.

d) The base of the ring wall shall be one meter below the lowest adjacent final natural grade.

e) The area of the reinforcement in the ring wall shall not be less than 0.002 x h x t where h and t are the height and the thickness of the ring wall, respectively.

f) Min. height of bottom of tank above surrounding ground surface shall be 300mm.

g) If the diameter of the storage tank is less than 4.50 meters a solid octagonal reinforced concrete foundation may be used instead of a ring wall.

h) Material under tanks bottom plate shall be according to EMPLOYER's standards.

6-7-5) Vibrating Machine Foundations

a) Vibrating machines shall be defined as equipment having reciprocating or rotary masses. Engines, pumps, compressor, turbines, generators and other similar equipment are included in this definition.

b) A vibrating machine having a gross plan area of more than 30 sq. ft. (2.8 sq. m.) or a total weight greater than 5000 lbs (2270 Kg) shall be qualified as a heavy vibrating machine.

c) Foundations for heavy vibrating machines, reciprocating or centrifugal, shall be designed using a dynamic analysis based on the "Theory of Elastic Half – Space" in addition to static analysis, but the weight ratios and other requirements, as explained hereinafter shall also be satisfied.

d) Foundations for Vibrating Machines having a gross area less than 30 sq.ft. (2.8 sq.m.) and a total weight less than 5000 lbs. (2270 Kg) and an operating speed greater than 1200 r.p.m. May be designed by weight ratios and static analysis, but the other requirements, as explained hereinafter shall also be satisfied.

e) Weight Ratios

- Reciprocating machines:
  The minimum weight of the foundation for reciprocating machines shall be at least 5 times the total weight of the machine, the base plate, and the driver or as recommended by the vendor whichever is greater.

- Centrifugal machines:
  The minimum weight of the foundation for centrifugal machines shall be at least 3 times the total weights of the machine, the base plate, the driver, and the reducing gear or as recommended by the vendor, whichever is greater.

f) General Requirements for Vibrating Machine Foundations

Vibrating machine foundations, reciprocating or centrifugal, designed by static and/or dynamic analysis and proportioned by weight ratios shall also satisfy the following general requirements.

- The minimum thickness of the foundation mat or the substructure for all foundations shall be 500 mm or 1/10 of its maximum dimension, whichever is greater.

- The depth of all foundations shall be at least one meter below the lowest adjacent final natural grade.

- All parts of the machine foundation shall be independent of adjacent foundations.

- Joints with a minimum thickness of 15 mm and filled with an approved elastic filler shall be provided between all floor slabs and machinery foundations.

- The area of reinforcement for foundation mat and piers (if any) of machinery foundations shall be computed in accordance with ACI 318 Code with a load factor of 1.4 applied to all the loads. The requirements of this Code regarding the minimum amount of reinforcement shall also be considered, but in any case the provided reinforcement shall not be less than 16mm diameter deformed bars extending horizontally and vertically near all faces of the foundation block at 300 mm centers.

- The minimum clear concrete cover to all reinforcing bars shall be 50 mm.

- The minimum distance between the edges of the foundation and the edge of the machine's base plate or skid shall be 50 mm.

- The minimum distance between the edges of the foundation and the centerline of the anchor bolts shall be 100 mm.

- The maximum soil bearing pressure under the foundations of reciprocating and centrifugal machines shall not exceed one-quarter and one-half of the safe allowable soil bearing value, respectively.

g) Reciprocating Machines

The static analysis shall take into account the following loads and forces:

- The total weight of the machine, the base plate and the driver.

- The total weight of the foundation.

- Earthquake forces and possible live loads.

- Unbalanced forces and couples shall be applied as specified by vendor.

h) The dynamic analysis shall take into account the following loads and forces:

- The lumped mass, which shall take, into account the following loads and the soil above the foundation mat.

- All the primary unbalanced forces, couples and moments at specified operating speeds for calculation of the primary amplitudes.

- All the secondary unbalanced forces, couples and moments at twice the specified operating speed(s) for calculation of the secondary amplitudes.

i) Foundations for all reciprocating machines shall be so proportioned that the following conditions are satisfied:

- The width of the foundation mat or the dimension perpendicular to the crankshaft to be at least 1.5 times greater than the distance from the centerline of the shaft to the bottom of the foundation.

- The length of the foundation mat or the dimension parallel to the crankshaft to be approximately 600 mm (2.0 ft.) greater than the length of the pier, if any.

j) Foundations for reciprocating machines, if the machine is qualified as a heavy vibrating machine, shall be so proportioned that the following conditions are also satisfied:

- The horizontal eccentricity, in any direction, between the centroid of the machine–foundation system and the base centroid of the base contact area shall not to exceed 5% of the respective base dimension.

- The center of gravity of the machine – foundation system and the lines of action of the unbalanced forces to be as close as possible.

- The total peak-to-peak amplitude not to exceed 0.002 inches (0.05 mm).

k) Centrifugal Machines

The static analysis shall take into account the following loads and forces:

- The total weight of the machine, the base plate, the driver, and the reducing gear.

- The total weight of the foundation.

- Earthquake forces and possible live loads.

- Lateral forces representing 25% of the weight of each machine, including its base plate, applied normal to its shaft at a point midway between its bearings.

- Longitudinal forces representing 25% of the weight of each machine, including its base plate, applied along the axis of the shaft.

- The total lateral and longitudinal forces shall not be considered to act concurrently.

- Short circuit load, as specified by the vendor. This load shall be assumed not to act concurrently with lateral and longitudinal forces as mentioned above, and may be neglected as an overturning couple.

- The dynamic analysis shall take into account the following loads and forces:

  - The lumped mass which shall include only the machines, the foundation and the soil above the foundation mat.

  - Dynamic forces from each rotor, calculated by the following equation, to determine maximum amplitudes:

    Dynamic force = Wr* Sr/6000
    Where
    Wr = Weight of the rotor
    Sr = Speed of the rotor (r.p.m.)

  - Dynamic forces shall be transversely applied to the shaft midway between the bearings.

  - When dynamic forces furnished by the Vendor are greater than those calculated by the above equation, the Vendor's forces shall be used.

  l) The width of the foundation mat or the dimension perpendicular to the crankshaft shall be at least 3/4 of the distance from the centerline of the shaft to the bottom of the foundation.

  m) Frequency Ratios

  - For heavy vibrating machines, reciprocating or centrifugal, the ratio of natural frequencies to disturbing frequencies shall be kept below 0.7 or greater than 1.4, but if is not possible, the effects of damping shall be considered.

  - For vibrating machines, reciprocating or centrifugal, which do not qualify as a heavy vibrating machine, the ratio of natural frequencies to disturbing frequencies shall be greater than 1.4. natural frequencies may be estimated using empirical methods such as the following equations.

    Fn = K/Pg

or
fn = fnr/Pg
Where:

fn = Natural frequency (r.p.m.)
fnr=Reduced natural frequency as presented by Tschebotarioff (c.p.m.)
k = coefficient of sub grade reaction (pci)
Pg= Gross soil bearing pressure (psf)

6-7-6) A FEW COMMENTS ON FOUNDATION DESIGN

a) For single footing tie will be considered in two perpendicular directions if possible.

b) In footing shrinkage/temperature reinforcement will be distributed in top& bottom of footing so that this reinforcement not less than 1/3 of total requirement reinforcement in each face.

6-8) Civil Works

6-8-1) Plant Roads and Paved Area

All Plant roads and paved areas shall be designed for the loads as specified in Clause 5.4.9 of this Design Criteria and the required thickness calculated. The designed thickness or the following minimum values shall be used for all Plant roads and paved areas, whichever is greater.

a) 70mm asphalted concrete (Binder) and 30mm wearing course on 250 mm thick base course for main roads and access ways between sections and area inside Plant on which mobile equipment may move.

b) 50mm asphalted concrete (Binder) and 20 mm wearing course on 150mm thick base course for pedestrians, pathways and unused areas within the Plant boundaries.

c) 250mm thick concrete, reinforced by two layers of 200 x 200 x 8 x 8 mm reinforcing fabric mesh in exchanger bundle pulling areas and other areas where large cranes must be positioned for equipment maintenance operations.

d) 150mm thick concrete, reinforced with one layer of 200 x 200 x 8 x 8 mm reinforcing fabric mesh in areas of process liquid spills, under piping and subject to truck traffic.

e) 100mm thick concrete, reinforced with one layer of 200 x 200 x 7 x 7 mm reinforcing fabric mesh in areas of process liquid spills and inaccessible to vehicular traffic.

f) Unused areas outside Plant and areas surrounded by dykes will not be paved nor receive any surface treatment.

g) Areas not subject to oil spillage shall be paved with 10 Cm gravel layer.

h) Ground areas around and under the pipe sleeper ways shall not be paved nor receive any surface treatment.

i) Paved areas shall have slopes ranging from a minimum of 1% to a maximum of 4% inclusive.

6-8-2) Surface Drainage System

a) The surface drainage system of the Plant shall be based mainly on open drainage ditches and nullah drains. The use of catch basins, storm drains and culverts shall be minimized. The system shall be designed for rainfall intensity as per specific Site conditions. In special process areas sewer system with catch basin and manholes shall be used, as required.

b) The surface storm water runoff shall be determined by rational method from the following equation.

$$Q = 2.778\ C.I.A.$$

Where
Q = Rate of runoff (liters/sec)
C = Runoff coefficient
I = Design rainfall intensity (mm/hr)
A = Area of the drained surface (hectares)

The design rainfall intensity " I " shall be taken as per specific site conditions.

The runoff coefficient C shall be taken as follows:

- Paved areas and roof surfaces, C=1.00
- Graveled areas, C = 0.50
- Landscaped areas, C = 0.40
- Unpaved areas, C = 0.50

c) The open drainage ditches shall be designed using the Manning's formula. The Manning's formula when employed in metric system is as follows:

$$Q = 1/n \cdot A \cdot R^{2/3} \cdot S^{1/2} \text{ or}$$

$$V = 1/n \cdot R^{2/3} \cdot S^{1/2}$$

Where:

Q = Rate of flow (m^3/sec)

A = Cross-sectional area of the water in the drainage ditch (m^2)
R = Hydraulic radius (m)
S = Hydraulic gradient (meters per meter)
V = Velocity of the flow (m/sec)
n = Roughness coefficient
The roughness coefficient n shall be taken as follows:

- Lined drainage ditches:

  i) Concrete lined surface 0.014 ~ 0.015
  ii) Gunite lined surface 0.016
  iii) Asphalt lined surface 0.014
  iv) Dressed ashlar surface 0.016

- Unlined drainage ditches

  i) Very fine sand, silt or loam 0.020
  ii) Sand and gravel 0.025.
  iii) Coarse gravel 0.030

- Free board or additional wall heights, shall be added above the calculated water surface level of the drainage ditches as followes:

  i) 0.30m (minimum) for drainage ditches with capacities up to 1.4 m^3/sec.

  ii) 0.45m for drainage ditches with capacities from 1.4 m3/sec to 5.6m3/sec.

  iii) For drainage ditches with capacities larger than 5.6m3/sec the free board shall be determined by the following equation but it shall not be less than 600 mm:

  F= 0.873 Y
  Where:
  F= Free Board (m)
  Y= Depth of Water (m)

  iv) The minimum velocity of flow in drainage ditches shall be 0.60 to 0.90 m/sec.

  v) The maximum velocity of the flow in unlined drainage ditches shall not exceed 0.75 m/sec.

6.9) Architectural work

6.9.1 Masonry

- All masonry units and materials used in the works shall conform to the relevant standards. Masonry units shall comply with requirements for compressive strength in accordance with the uniform building code. Contractor shall submit for approval by the EMPLOYER a detailed specification of the product proposed for these works.

- Mortar and grout proportions and specification of cementitious and aggregate material shall comply with all relevant codes and standards.

Brick/ block walling

Walls shall be constructed with facing bricks, and/ or common bricks to achieve facade features shown on the architectural drawings.

The brick/ block work shall include concealed steel profile lintels, pre-formed concrete windowsills and bed reinforcement. All external walls shall be tied into the surrounding concrete frame work and the external walls which have been shown in the architectural drawings, shall be internally insulated and lined with gypsum board as specified in this specification and architectural drawings.

- Internal walls shall be constructed with approved masonry units or stud partitioning systems designed to achieve the required sound insulation and fire rating.

Accessories

All necessary steel ties and anchoring systems shall conform to all relevant codes and standards. Restraints to soffit and joint filler to tops of internal non-load bearing walls shall be of an approved type to ensure compliance with design requirements.

6.9.2 Finishing:

Flooring

- Furnishing all floors with travertine stone with dimension of 40x40x2cm.
- In second order spaces like warehouses and/ or mechanical rooms Iranian terrazzo tile can be used.
- Using 2 cm of sand cement mortar under the paving.
- Using travertine stone 4 and 2 cm thick on the tread and rise of the stairs respectively.
- Using 20x20x1cm ceramics in sanitary facilities like toilets, locker rooms, shower rooms and etc. with appropriate grading and insulation details.
- Providing anti-acid tiles in the spaces where the use of acid is probable, such as battery rooms and laboratories.
- Suspended ceiling will be used for electrical and mechanical facilities and all area of control room with Acoustic tile.
- False floor with steel pedestals and steel tile deck with vinyl cover as vendor data shall be used.

Internal walls finishing

- In office rooms one layer of gypsum plaster together with one layer of finishing gypsum shall be used.
- Using 20x20 colored glazed tile in sanitary facilities and tearooms up to height of 2.40m. The rest of the height shall be covered with white cement plaster.
- Using anti-acid glazed tile in a for emanation height in laboratories and battery rooms
- Walls in aisles and lobbies shall be finished by stone, with the same color and material of the floors, up to 2.4m.

In second order spaces like mechanical rooms, locker rooms and warehouses
white cement plaster shall be used.

Linings /dry partitioning

Plaster board dry linings.
External walls shall be internally insulated and lined with gypsum board drywall system on a proprietary steel frame. The internal lining shall be of the types indicated below:

- Thermal lining to external walls which have been shown in architectural drawings.
- Water resistant lining to all wet areas (toilets/ showers/ tea rooms). The water resistant lining board shall be of a suitable type and thickness and shall be installed in strict accordance with the manufacturers, recommendations.
- All board linings shall be installed in maximum usable lengths in order to minimize end joints.
- All edges shall be tapered and the system shall include all edge trim, corner beads and control joints.

6.9.3) Doors & windows

Supply and installation of the door and window types, shall be based on the foreseen locations and generally as follows:

- All toilet and shower areas shall be fitted with aluminum doors.
- All external doors from aluminum with 2 layer glass.
- All windows have to be fabricated from colored aluminum with plane two-layer glass.
- The frame of internal doors shall be fabricated from plane profile with out any glass fan light.

6.9.4) Roof finishing

- The roofs shall be covered with Iranian 30x30x3cm terrazzo tile.
- For roof skirting terrazzo tiles shall be used.
  The skirting shall be inclined regarding the roof level.
- Internal finishing of the parapets will be white cement plaster.

Section 7- Fire Fighting & Safety

Refer to “Safety Concept”, document No. SP-4-EMS-2501

Section 8-Material Selection

Refer to “Material Reports”, document No.:

- RP-4-EMM-2405 for CDU/VDU
- RP-4-EMM-2415 for AMIN Unit
- RP-4-EMM-2420 for Sour Water Unit
- For Licensed units, please refer to Licensor Data Books

Section 9- References & Attachments

ATTACHMENT (9-1)

PROCESS DESIGN DATA

Document Title	Document No.
CDU/VDU Design Basis	1214-PR-4-EPP-1012
Amine unit Design Basis	1214-PR-4-EPP-1201
SWS unit Design Basis	1214-PR-4-EPP-1301
Storage Design Basis	1214-PR-4-EPP-1901

ATTACHMENT (9-2)
PIPING MATERIAL SPEC

FOR THIS DOCUMENT SEE SP-A-EMG-2001