طرح نگهداشت و افزایش تولید 27 مخزن

HVAC & PLUMBING DESIGN CRITERIA

نگهداشت و افزایش تولید میدان نفتی بینک

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AFD: Approved For Design
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REVISION RECORD SHEET

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1.0 INTRODUCTION

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 20 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO).Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

GENERAL DEFINITION

The following terms shall be used in this document.

CLIENT:	National Iranian South Oilfields Company (NISOC)
PROJECT:	Binak Oilfield Development – General Facilities
GENERAL CONTRACTOR (GC):	Petro Iran Development Company (PEDCO)
EPC CONTRACTOR:	Joint Venture of :Hirgan Energy – Design & Inspection(D&I) Companies
VENDOR:	The firm or person who will fabricate the equipment or material.
EXECUTOR:	Executor is the party which carries out all or part of construction and/or commissioning for the project.
THIRD PARTY INSPECTOR (TPI):	The firm appointed by EPD/EPC CONTRACTOR(GC) and approved by CLIENT (in writing) for the inspection of goods.
SHALL:	Is used where a provision is mandatory.
SHOULD:	Is used where a provision is advisory only.
WILL:	Is normally used in connection with the action by CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR
MAY:	Is used where a provision is completely discretionary.

2.0 SCOPE

This document covers minimum necessary requirements for basis of design and main equipment's to be used for the Heating, Ventilating, Air-Conditioning and pressurizing and plumbing system for buildings for project

3.0 NORMATIVE REFERENCES

3.1 LOCAL CODES AND STANDARDS

- IPS — Iranian petroleum standards
- INBC — Iranian National Building Code

3.2 INTERNATIONAL CODES AND STANDARDS

- ASTM — American Society for Testing Materials Relevant Parts
- API 610 — Centrifugal Pumps for General Refinery Service, 10th Edition
- ISO 15156 — Petroleum and Natural Gas Industries. Materials for use in H2S Containing Environments in Oil and Gas Production
- AMCA — Air Movement and Control Association
- ANSI — American National Standards Institute.
- ASHRAE — American Society of Heating, Refrigeration and Air-conditioning Engineer
- ASTM — American Society for Testing and Material
- BOCA — Building Officials and Code Administrators international
- BS — British Standards
- CIBSE — Chartered Institute of Building Services Engineers.
- NFPA — National fire protection association
- SBCCI — Southern Building Code Congress International
- SMACNA — Sheet Metal and Air Conditioning Contractors' National Association
- AWWA — American Water Works Association
- ASME — The American Society of Mechanical Engineers

Note: The latest issued or revised edition of all above mentioned codes and standards shall be considered as reference.

4.0 ABBREVIATIONS

Item	Description
HVAC	Heating Ventilation and Air Conditioning
DX	Direct Expansion
NFPA	National Fire Protection Association
F & G	Fire and Gas Detection system
DCS	Distributed Control system
AHU	Air Handling Unit
ACC	Air Cooled Condenser
PF	Panel Filter
BF	Bag Filter
CF	Centrifugal Fan
AF	Axial Flow Fan
CC	Cooling Coil
HC	Heating Coil
SD	Supply Air Diffuser
SG	Supply Air Grille
EG	Exhaust Grill

5.0 REQUIREMENT AND PRIORITY CONFLICT

In case of conflict between this document and its referenced documents and the above listed codes and standards, the CONTRACTOR shall bring the matter to the Company's attention for resolution and approval in writing. In all cases the most stringent requirement shall apply.

Any conflict should occur as a result of applying this Specification; the order of precedence shall be as follows:

- Data Sheet and Drawing
- This Specification and this Criteria
- IPS Standard
- Codes and Standards referred to within this Specification and its attachments.
- Applicable Standard

Compliance by the CONTRACTOR with the provisions of this Specification does not relieve him of his responsibility to furnish equipment and accessories of a proper mechanical design, suited to

meet the specified service conditions and/or local codes governing health, safety and the environment.

6.0 DESIGN CRITERIA

6.1 GENERAL

The HVAC system(s) shall be designed in accordance with the above codes and standards, together with criteria outlined in this specification.

HVAC systems are provided in all closed buildings in order to:

- Maintain the required comfort conditions (i.e. temperature, humidity, air quality) for personnel.
- Create a satisfactory controlled environment for essential and non-essential electrical, instrumentation equipment installed in the buildings,
- Provide the minimum fresh air quantity for persons in mechanically ventilated areas,
- To extract when necessary, fumes and products produced by equipment (battery rooms, kitchen, etc.)

In no case this document to be used to supersede, delete and/or cancel lower applicable laws, codes and/or local regulations or requirements.

Any deviation from this specification, at any stage of the project shall be clearly stated by the Contractor in order to be approved by the Company in written form otherwise the equipment will be rejected.

Building layout and arrangement shall be finalized during detail engineering phase, based on site condition, prevailing wind, direction of sun radiation, in order to optimizing energy consumption in summer and winter.

During detail engineering phase, in order to determination of main & auxiliary equipment layout, location and dimension of openings were located in buildings, point of view of other disciplines shall be considered. HVAC equipment selection and related control system shall be coordinated by safety and instrument disciplines during detail engineering phase.

7.0 SITE CONDITIONS

The following information is related to Bandar Deylam and Genaveh.

7.1 SITE LOCATION

- Latitude 30° 32’ N

- Longitude 50° 17' E
- Elevation 10 m

7.2 EXTERNAL DESIGN CONDITIONS (FOR HVAC DESIGN CALCULATION)

- Summer dry bulb temperature : 41° C
- Summer wet bulb temperature : 30.5° C
- Summer daily range temperature : 15.0° C
- Winter dry bulb temperature : 6.0° C
- Winter relative humidity : 100%

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Note1: Outdoor refrigeration equipment shall be designed to maintain design conditions with an 50 °C temperature.

8.0 INTERNAL DESIGN CONDITIONS

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The HVAC system shall be designed to comply with the following indoor conditions:

Room	Min. Fresh Air (Note 3)	Min. Exhaust	Room Temp Winter/Summer (Deg C)	Relative Humidity Winter/Summer (Min/Max)%	Over Pressure Value (Pa)	Equipment Heat Gain (Watts)
Extension of Existing Elec. Building						
Co2 Room	-	6 ACH	NC	NC	Negative	-
Capacitor Room	1 ACH	-	10/30	30/60	Positive	See 13.3
HV Room	1 ACH	-	10/30	30/60	Positive	See 13.3
LV Room	1 ACH	-	10/30	30/60	Positive	See 13.3
Control Room Building						
Control Room	10% supply air	-	22/24	30/60	Positive	See 13.3
Engineering Room	10 l/s. person	-	22/24	30/60	Positive	
UPS & Charger Room	1 ACH	-	22/24	30/60	Positive	See 13.3
Toilet	-	15 ACH	20/26	NC	Negative	-
Battery Room	1 ACH	10 ACH	NC	NC	Negative	-
Corridor	10 l/s. person	-	22/24	30/60	Positive	-
Air Lock	10 l/s. person	-	22/24	30/60	Positive	-
Office	10 l/s. person	-	22/24	30/60	Positive	-
Archive	10 l/s. person	-	22/24	30/60	Positive	-
HVAC Room	1 ACH	-	10/30	NC	Positive	-

Room	Min. Fresh Air (Note 3)	Min. Exhaust	Room Temp Winter/Summer (Deg C)	Relative Humidity Winter/Summer (Min/Max)%	Over Pressure Value (Pa)	Equipment Heat Gain (Watts)
Switchgear Building of Well pad						
LV Switchgear Room	1 ACH	-	10/30	30/60	Note 3	See 13.3
Capacitor Room	1 ACH	-	10/30	30/60	Note 3	-
Battery Room	-	10 ACH	NC	NC	Negative	-
Security Building						
Rest Room	10 l/s. person	-	22/24	30/60	-	-
Guard Room	10 l/s. person	-	22/24	30/60	-	-
Pantry	10 l/s. person	6 ACH	22/24	30/60	Negative	-
Toilet	-	15 ACH	NC	NC	Negative	-

NOTES

1 Values shall be checked by the CONTRACTOR in accordance with the architectural, electrical and instrumentation design during the detail design phase.

2 Design point for Temperature / Humidity level shall be the midpoint of the range shown in table

3 Fresh air quantity for Split air conditioning system shall be provided by sand trap louver or fresh air self-contained packaged unit.

9.0 HVAC SYSTEM DESIGN BASIS

9.1 HVAC CONDITIONS

Air conditioning system & air flow ventilation rate should be sufficient to satisfy not only air removal specification, but also to maintain overpressure and temperature specifications. It should be also capable to avoid wind penetration in order to meet the requirements of a conditioned space, simultaneous control of temperature, humidity, cleanliness, contamination and air distribution should be considered in design & selection of HVAC equipment.

9.2 SAND TRAP LOUVER:

% 90 efficiency for particles from 350 to 700 µ at 1 m/s.

% 80 efficiency for particles from 75.7 µ at 1 m/s.

D04

9.3 DUST

Pre filters: % 80-85 efficient according to the ASHRAE weight arrestance test (gravimetric method)

Bag Filter: %90-95 efficient according to the ASHRAE dust spot test (opacimetric method).

10.0 NOISE LEVEL

All equipment, ductwork and pipe work shall be designed taking into account noise criteria levels specified by ASHRAE standards.

Typically sources of noise in HVAC and plumbing systems shall be as follow:

- Rotating and reciprocating equipment such as fans, compressors and pumps, etc. A minor unbalance in such equipment can vibrate machine surfaces to produce noise.
- Air and fluid noises such as those associated with ductwork, pipe work, grilles, diffusers, etc.
- Excitation of surfaces (such as friction), movement of duct & pipes.

Anti-vibration mounting shall be provided to isolate all rotating equipment.

The duty of main circuits shall have capacity to maintain the maximum allowable temperature within space served.

The permissible noise level in each room is mentioned in the below table:

HVAC Room	85 db(A)
Electrical substations, electrical rooms, switchgear rooms, etc …	60 db(A)
Battery rooms	60 db(A)
Instrument technical rooms and other technical rooms without occupancy	60 db(A)
Control room	50 db(A)
Offices / Engineering rooms	45 db(A)
Workshop & maintenance buildings	60 db(A)
Warehouses	60 db(A)
Toilet & lockers	55 db(A)
Pantry	60 db(A)

The noise level shall be measured at 1m above the floor and at 1m horizontal distance from any equipment or air intake and outlet when all equipment is operating.

For outdoor requirement acceptable sound pressure level is up to 85db at 1m distance from equipment when all equipment is operating.

If the generated noise by the equipment is more than specified noise level, suitable sound insulation or attenuator shall be provided to achieve the noise level required.

11.0 AIR VELOCITY IN OCCUPIED AREAS

Unless otherwise indicated, air speed in areas occupied by persons shall not exceed 0.25 m/sec for conditioned area and 0.38 m/sec for ventilated area.

12.0 HEAT TRANSMISSION COEFFICIENTS (U VALUES)

The heat transmission coefficients shall be calculated according to ASHRAE calculation method and architectural specification. Heat transmission coefficients at walls, roofs with adequate thermal insulation will be considered as a basis for cooling and heating loads calculations. Heat transfer coefficient shall be extracted from public material property which has been issued by public reference such as NIBR, topic 19.

13.0 HEAT GAINS

13.1 HEAT GAINS FROM LIGHTING

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Area	Heat Loss
Control Room	20 **(w/m2)**
ITR	20 **(w/m2)**
Capacitor Room	20 **(w/m2)**
HV Room(existing area)	1000 w
LV Room(existing area)	1000 w

13.2

HEAT GAINS FROM PEOPLE

Sensible Heat: 72 w/person (office work)

Latent Heat: 60 w/person (office work)

13.3 HEAT GAINS FROM EQUIPMENT

Heat gains from each equipment shall be distinguished by its manufacturer and taken into account in the HVAC calculations. In the absence of complete information, the heat gain shall be determined by the HVAC designer and according to HVAC codes and standards. Heat dissipation

rates from equipment are generally proportional to their loads. In a cooling load estimate, heat gain from all the following appliances located in each building shall be taken into account. Electrical equipment includes electrical & instrument panels, motors, computers, office equipment, laboratory equipment, etc. Gas or steam equipment includes laboratory equipment, cooking equipment, etc.

SPACE	KW
Control Room	4
Instrument Technical Room	20
UPS Room	5
Battery Room (in Control Building)	2
HVAC Room	2
LV Room (in Elec. Building)	19
HV Room (in Elec. Building)	11
Capacitor Bank (in Elec. Building)	10
Cable Gallery (in Elec. Building)	12
Well Pad Substation	8

The above heat dissipation shall be checked according to the final heat dissipation from vendor in detail design.

14.0 CALCULATION

14.1 COOLING & HEATING LOADS CALCULATION

Calculation method shall be developed by using the latest revision of a computer program based on Carrier (HAP) recommended method or similar.

14.2 MAKE UP AIR FLOW CALCULATION

Air flow quantity shall take into account:

- The minimum fresh air quantity in respect with rooms occupancy and equipment requirements,
- The exhaust air requirements,
- The total sensible heat gains.

Duct sizing shall be carried out in accordance with equal friction method.

For air distributing at the conditioned or ventilated area the following items shall be considered:

- If the concentrated heat source is located at the occupancy level of the room, the heating effect can be counteracted by directing cool air toward the heat source, or by locating an exhaust or return grill adjacent to the heat source.
- Exhaust air outlets shall be located such that exhaust air does not create a noise.
- Supply air diffuser shall have adjustable horizontal and vertical louvers for deflecting air stream in any direction.

14.3 FRESH AIR MAKE-UP CALCULATION

Make-up air quantity shall take into account:

- The minimum fresh air quantity in respect with rooms occupancy and equipment requirements
- The exhaust air requirement
- The indoor overpressure with respect to outdoor, where applicable
- For others rooms the minimum fresh air quantity shall conform to requirements indicated in table for spaces which two or three parameters are listed, fresh air shall be calculated regarding to which is greater.

14.4 PRESSURIZATION

- The volume of fresh air shall be sufficient to ensure, when doors are closed, the room over pressure shall meet.
- The room over pressure indicated in table of clause 8, shall be maintained at positive pressure to ensure that dirt, dust and gas are not ingresses in to the internal environment.
- Battery room's pressure shall be relatively lower than adjacent rooms. Pressure control of spaces requires controlling the direction of airflow between adjacent spaces with various levels of cleanliness. This is equivalent to controlling the relative pressures between the spaces.

14.5 SAFETY FACTOR

For all cooling and heating calculation, the following safety factor shall be considered:

- Sensible cooling: 10%
- Latent cooling: 10%

- Heating: 10%

14.6 INFILTRATION

For the buildings which provided by central HVAC it may be assumed that no infiltration shall occur due to the fact that the buildings shall be positively pressurized inside.

For the buildings which provided by split room air conditioner for the purposes of heating and cooling calculations, Infiltration rate will be determined by the following method:

14.6.1 AIR CHANGE METHOD (VOLUME METHOD):

In this method, the following formula is used to calculate the amount of air infiltration

V= v×n / 60

Where:

V = Air Infiltration (CFM)

v = Space Volume (Ft3)

n = Air Change per Hour (ACH) According to the following table:

Air Change per Hour (ACH)

Space	Air Change Per Hour (ACH)
One Exterior Wall	1
Two Exterior Walls	2
Three or four Exterior Walls	3

For the spaces that they shall be pressurized, infiltration doesn't consider.

15.0 STANDBY EQUIPMENT AND DESIGN MARGINS

15.1 STAND BY EQUIPMENT

In order to ensure continuous operation , HVAC cooling equipment for all sensitive areas such as Substation, Control Building shall be duplicated (duty/stand by, with an automatic change-over).

15.1.1. CONTROL BUILDING:

Air conditioning units (duty/stand-by)

Battery room centrifugal exhaust fans (duty / stand by)

15.1.2. SWITCHGEAR BUILDING OF WELL PADS

D04

Battery room exhaust fan

15.2 EQUIPMENT OVER CAPACITY

The following equipment shall include over capacity margins as follows:

- DX cooling coils +10%
- Electric heaters +10%
- Air Cooled Condensing Units +10%

16.0 HAZARDOUS AREAS

All ventilation (HVAC) systems serving enclosed areas shall intake air at least 3000mm from any hazardous area as defined in the hazardous area classification drawings.

The separation between non-hazardous intake and exhaust outlets shall be a minimum of 4500mm but more where practicable.

17.0 GENERAL CONSIDERATION

Electrical and instrumentation equipment associated with the HVAC installations shall be selected in accordance with the area classifications and environmental conditions and shall be suitable for operation in the conditions in which it shall be expected to operate.

Electrical equipment used in hazardous area shall be certified and approved by recognized national certifying authority for continuous operation in the specified hazardous atmosphere. Externally mounted equipment shall be suitably weatherproofed and protected against the prevailing environment. Electrical equipment used in hazardous shall be equipped with Explosion proof motor. (Such as air-cooled condensers)

Ease of maintenance, physical size, lower pressure drop, weight and ability of component parts to resist corrosion shall be of paramount importance. The need for reliability and safety shall be the factors influencing the design of the equipment and control. Noise generated by the equipment shall not exceed the design parameters. When the noise generated by the equipment exceeds the specified noise level, the vendor shall provide suitable sound insulation to achieve the level required in each HAVC room which units are located; units shall operate quietly at acceptable sound levels.

Painting and coating of all equipment of the HVAC system shall be in accordance with the relevant reference painting documents. Each equipment shall be completed by marking tags corresponding to marking number defined on diagrams and drawing. By vendor these markings shall be engraved on 0.5 mm stainless steel sheets and fixed by screw.

Construction of trenches, equipment foundations, drain pits shall be per HVAC vendor drawings. The foundation pads shall be laid to the full width of supporting channels where required. They shall be dead level in both directions.

17.1 AIR FILTRATION

17.1.1. FRESH AIR FILTRATION REQUIREMENTS

Sand trap louver shall be required for outdoor air intakes. Sand trap louvers with drop boxes shall be provided upstream of filters and outdoor air intakes to remove the bulk of the large particles.

Sand trap louvers shall have minimum %95 efficiency for particles from 150 to 700 µm at 1 m/s.

All Fresh inlets shall be fitted with sand trap louvers.

17.1.2. RE-CIRCULATED AIR FILTRATION REQUIREMENTS

Minimum filtration efficiency shall be as follows:

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Filtration Efficiency

Filter Stage	Filter Type	Efficiency
Pre-Filters	Pre filters shall be heavy duty, double stage configuration and washable type. Aluminum washable type filter are installed inside mixing-box in V or W type	Pre Filter Section **80-85% arrestance.** (According to ASHRAE weight arrestance test (gravimetric method).
Final Filters	Bag filter	Final Filter Section **90-95% dust spot.** (according to ASHRAE dust spot test (opacimetric method).

18.0 DESIGN PHILOSOPHY

The HVAC system shall be designed to satisfy the following principles:

- For buildings in all areas, the type of HVAC system will vary from natural ventilation to ventilating or air conditioning depending on the area usage and building finishing schedule.
- As a minimum the proposed HVAC system for each building must:
    1) Maintain the desired interior environment through all conditions and occupant activities.
    2) Physically fit into the building without detriment to the aesthetics of the structure.
- In addition to the environmental aims, associated with temperature control, humidity control, air movement, air purity (filtration and outside air make-up) and pressurization, full consideration shall be given to other criteria such as:
    1) Possibility of operation of equipment such as computer or maintenance of electronic or other equipment.
    2) Suitability of the environment for personnel to reduce fatigue and errors (e.g. office).
- Air change rates for mechanical ventilation shall be based upon full space volume without reduction being made for contained equipment.
- Sufficient cooling shall be provided to remove heat gains from air infiltration, equipment, lights, building fabric including solar, personnel and to maintain each space within the internal design conditions.
- Critical places that require cleaner atmospheres such as Control room shall be provided with a positive pressure relative to surrounding places to ensure that gas dirt, dust and sand are not ingresses into internal environment. The effects of pressurization on building air leakage shall be taken into account when calculating fresh air loads.
- Extract rates for battery rooms shall facilitate the safe exhaust of gases attributed to the by-product of battery charging, as a minimum, 10 air changes per hour shall be provided by forced ventilation.
- The electrical motor of exhaust fan for battery room shall be totally enclosed, flameproof, anti-sparking, anti-static and suitable for hazardous areas. Fans motors shall be explosion proof type Eexd-IIC-T3 and too exhaust fan and all accessories should be certify for zone 2 class hazardous areas.

- HVAC systems shall be designed to prevent the widespread distribution of smoke from a fire from one area to other areas by installation of fire & smoke damper for supply and return ducts.
- Position of inlet and outlet openings shall be selected to minimize the effect of wind driven sand on air conditioning and ventilation systems. Where possible, the HVAC inlets and outlets shall be located in sheltered area.
- The separation between air intakes and extract outlets should be a minimum of 4.5m but greater where practicable.
- In order to reduce the concentration of sand particles in the air to an acceptable level sand trap louver shall be provided at each fresh air inlet.

18.1 HVAC SYSTEM SELECTION

The HVAC system will be considered in according to the treatments required for the various building.

18.1.1. CONTROL BUILDING

The building shall be conditioned and heated with an all-air system with recirculation basically; the HVAC system shall be composed by:

- Air handling unit (100% standby) and air-cooled condensing unit (100% standby) for control room, Instrument Technical Room, Engineering Room, UPS room, corridor, offices and other spaces.
- Ducting system properly insulated for air distribution complete with diffusers, supply and return grilles, and necessary controls and fire dampers.
- Exhaust fans for ventilation from spaces such as, toilet & janitor's closet.
- Air exhausting system from battery room by EX. Type exhaust fans (100% standby)
- Electrical Water heaters for Service. Electrical water heater shall be wall or floor mounted type.
- Power and control electric panel.
- Emergency Power: During an emergency, all HVAC system and exhaust system of battery room shall operate on emergency power supply. Change over from normal power to emergency power shall be done automatically.

18.1.2. EXTENSION OF EXISTING ELEC. BUILDING

The building shall be conditioned and heated with (split room air Condition unit (heat pump)); basically, the HVAC system shall be composed by:

- Air Conditioning Split type room air conditioner (heat pump type) for switch gear(LV, HV) rooms and capacitor bank.
- Air exhausting system from CO2 room by exhaust fan.

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18.1.3. SWITCHGEAR BUILDING OF WELL PADS

The building shall be conditioned and heated with split room air Condition unit (heat pump basically), the HVAC system shall be composed by:

- Air Conditioning Split type room air conditioner for LV Switchgear room, capacitor room.
- One EX type exhaust fans shall be installed to extract the air of the battery room. Air shall be discharged to outdoor through a ducting fitted with a gas tight shut-off damper. Fan motor shall be EEx 'd' -IIC-T3.
- Power / Control panel.
- Emergency Power: During an emergency, all HVAC system and exhaust system of battery room shall operate on emergency power supply. Change over from normal power to emergency power shall be done automatically.

18.1.4. SECURITY BUILDING OF WELL PADS

The building shall be conditioned and heated with split room air Condition unit (heat pump basically), the HVAC system shall be composed by:

- Air Conditioning Split type room air conditioner for Guard room and Pantry/bed room.
- Air extracting system from spaces pantry and toilets by exhaust fans.
- Electrical water heaters for pantry and toilets. Electrical water heater shall be wall mounted type.
- Emergency Power: During an emergency, all HVAC system and exhaust system shall operate on emergency power supply.

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HVAC CONTROL SYSTEMS

- For Instrumentation and control refer to specification for instrumentation Doc. No: BK-GNRAL-PEDCO-000-IN-SP-0001 and specification for instrument and control of package Unit system (PU) Doc.No: BK-GNRAL-PEDCO-000-IN-SP-0004. The requirement shall be according to " type C".
- UPS power for HVAC Panel shall be supplied by vendor. Only 400VAC , 3 phase will be supplied by EPC contractor.
- Air conditioning, ventilation and pressurization systems shall be monitored by HVAC local control panels in each building. Particular attention should be paid to energy efficiency measures.
- Panels shall contain electrical power distribution modules (e.g., motor, starters), as well as separate control modules and conform to Project electrical and instrumentation specifications.
- HVAC control systems must operate at maximum ambient temperature (up to max. recorded temperature) without damage.
- HVAC control systems shall meet the following functions:
  - Control and monitor pressurization and ventilation
  - Control and monitor room temperature and humidity conditions.
  - Maintenance of internal temperature conditions.
  - Maintenance of internal humidity.
  - Monitor status conditions (e.g., on, off) and faults for each component of HVAC systems.
  - All alarms.
  - All the running conditions: on, off, fault, for each part of equipment.
  - Normal starting sequence of each system.
  - Emergency operation including the shutdown of the HVAC equipment.
- The HVAC control shall have the facilities for receiving signals from F&G panel in order to activate the required emergency actions.
- Alarm’s output shall be provided such as: Individual alarm for pressurization fault in critical rooms. Common alarm for fault of HVAC system.
- Automatic change over to standby-to-standby equipment
- Fire damper control (open/close)
    - Each air-conditioning, ventilation system shall be controlled by an independent stand-alone programmable logic controller (PLC) system. Control system shall be mounted on the units together with electrical system. The HVAC control unit shall be able to

work at the maximum ambient temperature without failure.

- Interface between HVAC control system and DCS and F&G shall be as below:

  -One serial link shall be considered between DCS and HVAC control panel for monitoring.

  - Hardwire signals between DCS and HVAC control panel are as below:

  Time synchronization

  General fault

  General alarm

  Also, hard wire signal between F&G panel and HVAC control panel are as below:

  -HVAC shut down command

19.0 ELECTRICAL UTILITIES

- Electrical equipment shall be designed for operation under the following conditions:
  - 400 VAC / 3 phase / 50 Hz / 4 wire / TNS system
  - 230 VAC / 1 phase / 50 Hz / 3 wire / TNS system
  - 24 VAC for control systems

20.0 DUCT WORK

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20.1 DUCTING REQUIREMENTS

The noise level of HVAC system shall meet the requirements and recommendations of "ASHRAE standards and handbooks".

Low velocity ductwork is hereby defined to include work with velocities not exceeding 2000 fpm and static pressures not exceeding 2" w.g. Duct work is Low Pressure class.

The sheet metal gauge used in the ducts and the reinforcing required depend on the pressure conditions of the system. Rectangular duct work shall be constructed as here in after specified and shall meet ASHRAE codes and standards.

All sheet metal work shall be constructed of prime quality galvanized sheet metal according to SMACNA, ASTM A653M, COATING DESIGNATION Z275 and 924M, IPS-E-AR-160, IPS-E-AR-120

The following gauges for rectangular ducts dimensions shall be used:

Gauge	Tickness (mm)	Max. Side(mm)
24	0.6 mm	up to 762

Gauge	Tickness (mm)	Max. Side(mm)
22	0.8 mm	787 to 1524
20	1.0 mm	1549 to 2286
18	1.2 mm	2311 up

All slip joints shall be made in the direction of flow, all elbows shall have a center line radius equal to 1-1.2 times the width of the duct.

Duct work inside mechanical rooms and in shafts shall not be less than 20 gauge (1.0 mm thick).

All transitions or changes in duct size shall increase as gradually as space permits with a slope of not more than 1:4 where possible.

Turns in ducts shall be made with the radius not less than three-fourths the width of the duct.

Factory fabricated turning vanes shall be installed in all radius and rectangular elbows as per the following schedule:

Width of Duct (cm)	No. of Vanes
Up to 45	1
46 to 90	2
91 and over	3

20.2 DUCT INSULATION

Supply and return air duct shall be insulated with rock wool blanket 25 mm thickness or polyurethane or polystyrene or equal, non- flammable and vapor barrier covered with aluminum jacketing base on below table:

Insulation Heat Resistance for External Duct

Heating system			Cooling System		
ADDH	Min. Heat Resistance		ADDC	Min. Heat Resistance	
	$h.ft^2.F/BTU$	$M^2.k/W$		$h.ft^2.F/BTU$	$M^2.k/W$
≤ 1500	3.3	0.581	≤ 500	3.3	0.581
1501 to 4500	5	0.881	501 to1150	5	0.881
4501 to 7500	6.5	1.145	1151 to 2000	6.5	1.145
≥ 7501	8	1.409	≥ 2001	8	1.409

Insulation Heat Resistance for Internal Duct

(T in – T out) of Duct		Min. Heat Resistance			
		Heating system		Cooling system	
° F	° C	$h.ft^2.F/BTU$	$M^2.k/W$	$h.ft^2.F/BTU$	$M^2.k/W$

≤ 15	≤ 8.3	**No Need**			
≤ 40 ≥ 15	≤ 22.2 ≥ 8.3	3.3	0.581	3.3	0.581
≥ 40	≥ 22.2	5	0.881	5	0.881

20.3 DUCTWORK AND FANS CALCULATION

Ductwork design shall be in accordance with recommended velocities given in SMACNA or other approved recommendations as below Table:

Application	Air Velocity(FRM)			
	Main Duct		Branches	
	Supply	Return	Supply	Return
Manned area	1500 ~ 2000	1500 ~ 1800	1500 ~ 1800	1200 ~ 1500
Unmanned Area	2200 ~ 2500	1800 ~ 2200	1800 ~ 2200	1200 ~ 1800

The Air velocities in "HVAC" shall not exceed the followings:

Duct Element	Face Velocity (FPM)
Louvers	
Intake:	
7000 CFM and Greater	400
2000 to7000 CFM	250to 400
Exhaust:	
5000 CFM and Greater	400
Less than 5000 CFM	300 to400
Filter	
Panel filter:	
Viscous impingement	200 to800
Dry– type‹extended– Surface	
Flat (low efficiency) Duct velocity	
Pleated media	Up to 750
HEPA	250
Renewable media filters:	
Moving– curtain viscous Impingement	500
Moving– curtain dry media	200

Coils	
Heating coils	500 to1000 (Min:200 to Max:1500)
Cooling coils	500 to550 (Min:200 to Max:1000)
ElectricalcoilsRefertoMFG. data	
Grilles&Diffuser	500 to750

- Ducting design shall be based on low velocity ducting with equal percent friction method.
- Ductwork inside mechanical rooms and in shafts shall not be less than gauge20(1.0mm thickness).
- All slip joints shall be made in the direction of flow, all elbows shall have center line radius equal to 1-1/2 times the width of the duct.
- All transitions or changes in duct size shall increase as gradually as space permits with a slope of not more than 1:4 where possible.
- Turns in ducts shall be made with the radius not less than three-fourth the width of the duct.

21.0 PLUMBING DESIGN PHILOSOPHY

21.1 DESIGN PRINCIPLES

The aim of plumbing system design for each building shall be to safely and reliably provide domestic hot and cold waters and to remove sanitary wastes.

Plumbing systems shall be designed using materials that are durable and maintenance-free to the extent possible.

All plumbing fixtures must be made of smooth, non-absorbent and corrosion resistant material and shall be installed so that maintenance and cleaning are readily accomplished.

Each fixture directly connected to the drainage system must be equipped with a trap.

The drainage system shall be designed with proper venting to prospect all fixture water seals from siphon age and blow out under ordinary conditions of use.

The plumbing facilities required for each building shall be distinguished by the architect. In the absence of complete or adequate architectural plans, the requirements for various facilities shall be done by plumbing designer and according to plumbing codes and standards.

21.2 PLUMBING SYSTEM CONSIDERATION OF PROJECT

The fixture units of plumbing and sewage piping, hot water demand and minimum fixture pressure for various units shall be as follows:

21.3 PLUMBING WATER SYSTEM

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Following load values assigned for fixtures shall be considered for water distribution system design:

HOT &COLD-WATER PIPING

Fixture	Occupancy	Load Values				
		Fixture unit			Min. Fixture Pressure (PSI)	Min. Fixture Branch Pipe Size (inch)
		Total	Cold	Hot		
Lavatory	Private	0.75	0.5	0.5	8	½
	Public	2	1.5	1.5	8	½
Kitchen Sink	Private	1.5	1	1	8	½
	Public	3	2.25	2.25	8	½
	Restaurant	4	3	3	8	3
Shower Head	Private	1.5	1	1	8	½
	Public	4	3	3	8	½
Water closet, Flush Tank	Private	2.5	2.5	-	8	½
	Public	5	5	-	8	½
Drinking Fountain, Office		0.25	0.25	-	8	½
Janitor		2	1.5	1.5	8	½

The minimum acceptable operation pressure for various plumbing fixtures shall meet the quantity of above table

HOT WATER DEMAND (GPH)

Fixture	Occupancy	Load Values		
		Office	Industrial	Restaurant
Service	Private	2	2	2
	Public	6	12	8
Pantry Sink	Private	10	-	-
Kitchen Sink	Public	20	20	3
	Restaurant	-	-	5
Shower Head		30	50	3
Demand Factor (DF)		**0.3**	**0.4**	**0**
Storage Factor (SF)		**2**	**1**	**0**

Following quantities shall be considers as the minimum fixtures supply sizes:

Minimum Pipe Size

Fixture	Size(in)
Drinking Fountain	1/2
Kitchen Sink	1/2
Lavatory	1/2
Shower	1/2
Flash Tank	1/2

21.4 SANITARY SEWER SYSTEM

Following load values assigned for fixture units are the same for sewage system sizing.

SWAGE TRAP SIZE & FIXTURE UNIT

Fixture	Occupancy	Fixture Unit	Trap Size (inch)	Branch Pipe Size (inch)
Lavatory	-	1	1 1/4	2
Sink	-	2	1 ½	2
Shower Head	-	2	1 ½	2
Water Closet	Private	4	4	4
	Public	6	4	4
Drinking Fountain		1 ½	1 1/4	2
Janitor	-	2	3	3
Floor Drain	Private	2	2	2
	Public	2	3	3

Note: Size of floor drain shall be determined by area of floor to be and/or the drain of indirect discharge received from plumbing fixtures.

21.5 PLUMBING CALCULATION

Plumbing calculation shall be based on plumbing codes recommendation.

21.6 PIPE WORK CALCULATION

Calculation shall be developed using established design methods as given in ASHRAE Handbook Fundamentals or similar approved methods.

22.0 PLUMBING SYSTEM

This specification covers the criteria to be followed in calculating and designing sanitary facilities of buildings.

22.1 WATER DISTRIBUTION SYSTEM

Water distribution system is a system of pipes which convey water from a water valve pit located adjacent the building to each utilization point inside the building.

Domestic hot water shall be provided for building by Electrical water heater tank with suitable capacity and temperature control equipment adjustable between 40°C &60°C.

The water closet shall be eastern type for buildings, also western type shall be considered for guest house and control building if required. All water closets shall be located in east-west direction. Flush tank shall be used for all water closets.

Velocities at peak flow in all branches shall not exceed 1 m/s and also velocity in main pipes shall not exceed 2 m/s.

23.1.1 MATERIAL

The water piping material of internal building shall be 5 layers Pex-Al-Pex accordance with ASTM F1281-00, F 1335 and DIN/DVGW 542, for multi-layer

Fittings for Pex-Al-Pex pipes shall be Screw type.

Galvanized steel pipe shall be used for cold & hot water in larger size. Galvanized steel pipe shall be medium weight (STD) according to ASTM-A53, threaded and coupled ends with threaded ends malleable iron fittings according to ASME-B16.3, (pipes 1 ¼", 2 ½" will not be used and will be substituted one size larger)

23.1.2 INSULATION

Pipe work shall be insulated where necessary to prevent condensation and unnecessary heat exchange.

Insulated piping shall be provided with saddles at hanger points and hardwood plugs or blocks at hanged points to prevent compression of insulation.

All insulating materials used shall:

- be non-combustible
- not emit toxic fumes or smoke when heated
- be inorganic and non-hygroscopic
- be chloride free
- be asbestos free

Vapor barriers shall form a complete seal to prevent condensation occurring on the exterior surface of the pipe.

All penetrations through the vapor barrier shall be sealed by wrapping with aluminum tape.

Pipe work shall be insulated with mineral wool in thickness according to pipe sizes listed below:

- Domestic Cold Water:

All sizes 15 mm (1/2”) (Only when piping is exposed, located in attic space, in pipe chases, at exterior walls and/or passing through electrical equipment rooms.)

For Domestic Hot Water the below table should follow:

Nominal Pipe Diameter (mm)				**Thermal conductivity (W/m.k)**	**Environment Temp. (°C)**	**Water Temp. (°C)**
≥ 50	32 to 50	To 25	To 50	0.034	24	To 60
Insulation Thickness (mm)						
40	25	15	15			

All exposed insulated pipe work shall be covered with aluminum jacket as a vapor barrier.

23.1.3 VALVES

2 inches and smaller gate, globe and check valves shall be screwed end type, 125# and bronze body.

2-1/2 inches and larger gate globe and check valves shall be flanged end type, 150# and cast iron body.

22.2 SANITARY SEWER

Joints of pipes shall be solvent cement. All site work shall be carried out strictly in accordance with the pipe manufacturer's instructions.

Pipe work and fittings shall be easily accessible for maintenance, repair and replacement. Access points shall be suitably located to facilitate maintenance work and to minimize nuisance to users.

Horizontal drainage piping of 3 inches diameter and less shall be installed with a fall of not less than ¼ inch per foot. Larger than 3 inches diameter drainage pipes shall be installed with a fall not less than 1/8 inch per foot.

Discharge stacks and branches shall conform to the design requirements and local building regulations. Pipe routes shall be the shortest practical with as few bends as possible and no bends in the wet portion of the soil stack.

Minimum Slope of Horizontal Sewage Pipe

Nominal PipeSize		Min Slope	
(mm)	(inch)	Percent (%)	In/ Ft. Length
Up to 65	Up to 1 ½	2	1/4
80 to 150	3 to 6	1	1/8
200 &over	8 &over	0.5	1/16

23.1.4 MATERIALS

Sanitary sewage and its vent pipes, fittings and accessories shall be of plastic (PVC-U) material, according to ANSI / ASTM D2665.

22.3 RAINWATER SYSTEM

Rainwater disposal pipes and fittings shall be Galvanized steel pipe or plastic (U-PVC) material, according to ASTM D2665 that it should be resistant to sunlight.

System shall be designed to ensure gutters and down pipes discharge freely and shall have access for cleaning at locations prone to blockage including offsets in vertical pipe work and at the end of pipe branches.

All fittings shall be of a proprietary type and be compatible with roof materials. Gutter outlets of more than 150mm diameter shall include gratings.

Size of leaders and storm drains and gutters shall be based on the maximum projected roof area, according to following tables:

Table 1 - Vertical Leaders

Diameter of Leader (in)	Normal Rate of Rainfall (in)					
	2	3	4	5	6	8
	Square Feet of Roof Area					
2	1.440	960	720	576	480	360
2 1/2	2.600	1.733	1.300	1.040	865	650
3	4.400	2.933	2.200	1.760	1.470	1.100
4	9.200	6.133	4.600	3.680	3.070	2.300
5	…	…	8.650	6.920	5.765	4.325
6	…	…	…	…	9.000	6.750

Table 2 - Size of Gutters

Diameter of Gutter[1] (in)	Maximum Projected Roof Area for Gutters of Various Slopes (sq.ft)			
	1/16 in.	1/8 in.	1/4 in.	1/2 in.
3	170	240	340	480
4	360	510	720	1.020
5	625	880	1.250	1.770
6	960	1.360	1.920	2.770
7	1.380	1.950	2.760	3.900
8	1.990	2.800	3.980	5.600
10	3.600	5.100	7.200	10.000

Table 3 - Horizontal Storm Drains

Drain Size (in.)	1/8in Slope, Inches Rainfall					1/4in Slope, Inches Rainfall				
	2	3	4	5	6	2	3	4	5	6
	Square Feet of Roof Area									
3	1.644	1.096	822	657	548	2.320	1.546	1.160	928	773
4	3.760	2.506	1.880	1.504	1.253	5.3000	3.533	2.650	2.120	1.766
5	6.680	4.453	3.340	2.672	2.227	9.440	6.293	4.720	3.776	3.146
6	10.700	7.133	5.350	4.280	3.566	15.100	10.066	7.550	6.040	5.033
8	23.000	15.333	11.500	9.200	7.600	32.600	21.733	16.300	13.040	10.866

23.0 INSTALLATION SCOPE

23.1 PIPING & HANGER

Give careful consideration to clearances under beams, over windows, etc. to provide maximum head-room in all cases, and to location of lines and type of fittings used to obtain these clearances. Coordinate the piping ductwork and lighting trades with each other, and with all other equipment.

Cut pipes accurately to measurements established at the building work into plate without springing or forcing, and properly clear windows, doors and other openings. Ream all piping to remove burrs and install so as to permit free expansion and contraction without causing damage.

Make all changes in direction with fittings and changes in main sizes through eccentric reducing fittings.

Piping at all tanks, packaged unit coils, condenser, pumps, etc. shall be supported independently so that no weight will be supported by the equipment.

Provide adjustable hangers, inserts, brackets, rolls, clamps, supplementary steel, etc. as required for proper support of all pipe lines. Hangers shall be designed to allow for expansion and contraction of pipe lines and shall be of adequate size to permit covering to run continuously through hangers.

Pipe support spacing and sizes of pipe hanging suspension rods shall conform to the following table:

MAX. SPACING (APPROXIMATE)		PIPE SIZE		Pipe Material
Horizontal (m)	Vertical (m)	(inch)	(mm)	
1.8	3	All Size		Cast Iron
2.1 2.1 2.7 3.4 4.3	3 3 3.7 4.6 4.6	≤ 1 1 ¼ 1 ½ to 2 2 ½ to 3 4	≤ 25 32 40 to 50 65 to 75 100	Galvanized Steel
1.8 2.4 2.7 3	2.4 3 3 3.7	1 1 ¼ to 1 ½ 2 2 ½ to 4	≤ 25 32 to 40 50 65 to100	Copper

0.5	1.2	¼ to 2	7 to 51	Polyethylene - Reticular Pex
0.8	1.2	3.8 to 2 ½	9 to 61	Pex-Al-Pex
0.8	1.2	3.8 to 2 ½	9 to 61	Combined polyethylene + Al
0.5 0.6 0.9 1.2	1.2 1.2 1.8 1.8	1 ¼ to 1 ½ 2 3 to 4 6	32 to 40 50 75 to 100 150	PVC

23.2 DUCT SUPPORTS

Use strap hangers for ducts up to 750 mm wide and angle hangers for ducts over 750 mm wide. Make strap hangers 25mm×3mm minimum extend down both sides of the duct and under bottom, fastening to sides and bottom with sheet metal screws. Angle hangers may be formed by extending the vertical bracing angles or by rods passing through the bottom bracing angles. The contractor shall submit the proposed hanging methods for approval by the employer before proceeding.
Hangers shall be spaced on centers not exceeding 3000 mm. supporting angles shall be placed completely around ducts wherever possible.

24.0 HVAC EQUIPMENT INSTALLATION

Vendor shall consider installation clearance and required equipment spacing in his design. For installation & commissioning of have equipment of major items, see generally vendor installation and operation manuals. Format of operation manual and required documentation shall be finalized during detail engineering phase, before purchase order.

25.0 HVAC ELECTRICAL INSTALLATION

Electrical equipment associated with the HVAC installations shall be selected in accordance with the area classifications and environmental conditions and shall be suitable for operation in the conditions in which it will be expected to operate. All equipment and steelworks connected directly to the structure shall be bonded so as to eliminate fire explosion initiated by static electricity.

26.0 FINAL TEST

The following measurements shall be performed precisely:

- Temperature measurement
- Relative humidity measurement
- Air speed measurement
- Air flow measurement
- Measurement of the equipment performance
- Noise level measurement
- Control test
- Supplementary measurements

In case of prevailing seasonal operations in the conditioning plant, winter and summer testing shall be carried out.

Proven theoretical extrapolation method based on measurement results will be used whenever final tests have been carried out in outdoor conditions other than the design ones.

Temperature and relative humidity measurements shall be done.

Final acceptance is subject to the rectification of all defects, re-testing of equipment, delivery of final test report and all documents.