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मध्य भोटेकोशी जलविद्युत कम्पनी लिमिटेड

MADHYA BHOTEKOSHI JALAVIDYUT COMPANY LIMITED

Middle Bhotekoshi Hydroelectric Project (102 MW)

Addendum No. 4

APPENDIX 1

VOLUME 3 - CIVIL WORKS SPECIFICATIONS

SECTION 17 AIR CONDITIONING AND VENTILATION SYSTEM

Lot 1: Civil and Hydro-Mechanical Works (EPC Contract)

Contract Identification No. MBJCL/MBKHEP/068/69/EPC-1

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AIR CONDITIONING AND VENTILATION (HVAC)

17.1 INTRODUCTION

This Section contains the Specifications for ventilation and air conditioning systems installations in the Powerhouse Complex and the Headworks Service Building located at the weir site. All these Works shall be designed and furnished by the Contractor who shall also provide the automatic and control system arrangement (ACSA) interface.

The Contractor shall deliver and install the complete HVAC system; checking through water analysis the suitability of the water quality and measures to achieve suitable water quality is part of this obligation.

Design of the HVAC systems shall meet the requirements of the Lot 2 Contractor with respect to the safe and durable operation of his equipment.

The Contractor shall prepare and deliver all information, circuit diagrams and arrangement drawings in order to provide detail for interface for power supply and for measuring/control signals to the station control system.

The general specification herein describes the general arrangement and scope of works of HVAC that shall be supplied and installed by the Contractor.

17.2 VENTILATION AND AIR CONDITIONING PRINCIPLE IN POWERHOUSE

17.2.1 GENERAL

The main principle for the ventilation system under normal operation is that all supply of ventilating air to the powerhouse complex shall be taken from the free surface flow. This will provide fresh air supply cooled down to the temperature of the water flow all year round. The exhaust air is evacuated through the Powerhouse. Generators and transformers are cooled directly with water. Excess heat dissipated through walls and floors from the generators will be absorbed in the general ventilation system.

17.2.2 POWERHOUSE VENTILATION

Inlet air is taken from the outside of the building; an intake ventilation room, denoted as HVAC Room, is located at the turbine basement level. The HVAC Room has double inlet fans and dehumidifying units. From there air supply to the different rooms will be distributed through ventilation ducts installed between the concrete structures of the Powerhouse. Every room to be ventilated shall have separate inlet air. Outlet air is led to the machine hall and shall be evacuated by means of exhaust fans located at higher levels.

17.3 SCOPE OF WORKS

The Contractor shall design, supply and install the systems below:

Powerhouse Building

- Ventilation systems
- Chilled water system
- Control systems

Service Building at Headworks

- Wall/roof mounted ventilation and air-conditioning split units

17.4 STANDARDS

Unless otherwise prescribed in this Specification, the services shall comply with following standards and regulations:

- Building standards and regulations in force in Nepal
- ISO Standards
- British Standards and Codes of Practice
- ASHRAE Standards
- ARI Standards
- ASTM specifications
- Local byelaws and regulations.

Before the start of design and installation, the Contractor shall clarify which standards he intends to follow. In case of deviation from the standards, this shall be reported to and approved by the Engineer.

One copy of each relevant standard and code of practice shall be handed over to the Employer's Representative at no extra cost.

17.5 VENTILATION AND AIR CONDITIONING

17.5.1 DESIGN PHILOSOPHY FOR THE AC AND VENTILATION SYSTEMS

a) GENERAL

The Powerhouse shall have central air conditioning and ventilation systems. For the Service Building individual Air-Conditioning and Ventilation Systems will be sufficient.

The ventilation systems shall provide a good indoor air quality. No return air shall be transferred to the air supply systems.

To maintain the design indoor temperature without increasing the air flow in the system beyond what is necessary for health reasons, fan coil units shall be installed in rooms with heat emission and temperature requirements.

b) HVAC ROOMS

HVAC Room servicing the powerhouse is situated on turbine basement level. Alternative location can be proposed within the Contractors obligation of the EPC Contract. The room will contain double air inlet fans including dehumidifying units, air handling units for general ventilation and the water chiller unit. The water chiller will get the cooling water supply from the conveyance system or from borehole.

c) NOISE

Noise generated from any part of the air conditioning system shall not exceed NC 35 in rooms for normal occupancy.

d) DRAUGHT

Air velocity in air conditioned areas for permanent occupancy shall not exceed 0.2 m/s in occupied spaces.

e) DESIGN PARAMETERS

Prior to final design, the Contractor shall collect permissible temperature and humidity data with respect to equipment from the Lot 2 Contractor and shall collect temperature and humidity data for the site, and base his calculations upon these.

17.5.2 ELECTRICAL WORKS

The Contractor is responsible for all electrical cabling from the ventilation and air conditioning equipment to the local sub distribution board.

The Contractor is responsible for all the control signal cables from the ventilation and air conditioning equipment to the control boards.

17.5.3 LABELLING

The air handling unit components shall have labels describing their main function, showing inspection and maintenance procedure with simple symbols. All main ducts shall have labels showing whether they are for supply or exhaust air, in addition to air flow direction. All dampers shall have simple symbols showing adjustment positions.

Likewise shall all pipes have symbols for content and arrows for flow directions.

Pumps and valves shall have operation modes visualised by symbols.

17.5.4 MATERIALS AND EQUIPMENT

a) DUCTS

In general the ducts shall be prefabricated rectangular ducts or spirally wound ducts.

b) MANUFACTURING

In general the SMACNA Low Pressure Duct Construction Standards shall be followed.

The ductwork shall be made from galvanized steel.

No sharp edges or corners will be accepted on the outside of the duct work, flanges, supports, etc. Any part of the ductwork where the galvanized protection is damaged during manufacture or erection shall be painted with two coats of corrosion resistant paint.

The ducts shall be designed for the following air velocities:

Powerhouse Complex:

- Maximum 13 m/s in the main distribution ducts

Elsewhere:

- 9 m/s.

Permissible air leakage shall be 4 m3/m2h for rectangular ducting and 2 m3/m2h for spirally wound ducting. The test pressure shall be 200 Pa.

c) MATERIAL

Galvanised ductwork shall be constructed from cold reduced, continuously hot dip galvanised, flat steel sheets to BS 2989 Class F.

Table 1: Material Thickness of Galvanised Ducts

Material Thickness of Circular, Galvanized Ducts (all dimensions in mm)						
Type/Diam	60	75-150	175-300	325-800	800	1000
Spirally wound ducts	0.4	0.5	0.63	0.80	0.90	0.90
Longitudinal seams	0.70	0.70	1.00	1.25	1.25	1.25
Welded ductwork of sheet steel	1.50	1.50	1.50	1.50	1.50	1.50

Material Thickness of Rectangular, Galvanized Ducts (all dimensions in mm)				
Circumference of duct	660	660-2000	2000-2400	4000
Seamed ductwork	0.80	1.00	1.26	1.59
Welded ductwork of sheet steel	2.0	2.0	2.0	2.0

d) INSTALLATION METHOD

Longitudinal seams may be either grooved seams or Pittsburgh lock seams. Alternatively, longitudinal joints may be welded, but where this method is used, ducts must be hot dip galvanized after manufacture.

Bends, off-sets and branch connections on the ductwork shall be of swept pattern as far as space between the building structure and the ductwork permits. A minimum throat radius equal to the width of the duct shall be used. Where square or mitre bends are required, turning vanes must be fitted. In a transformation or change-section piece, the included angle in both the vertical and horizontal planes shall not exceed 60°.

Items of plant shall not be supported by or from the ductwork. Similarly, ductwork shall not be supported by or from items of plant. All ductwork must be supported so that it does not distort or twist, and supports shall be spaced in such a manner to ensure that the ductwork does not sag under its own weight and the weight of any insulation. All ducting shall be so arranged to ensure that it does not slip. Special attention must be paid to the supporting of ductwork on either side of bends. Wherever possible, the ductwork shall be supported at the angle joints. The supports may be of such type as band strap, cantilever bracket or trapeze type hanger appropriate to the ductwork layout and building structure.

Test holes (Ø 15 mm) with cover plates shall be provided wherever necessary for testing the air conditioning and ventilating systems. These shall be properly positioned in straight ducts for measurements of static pressure, velocity pressure and temperature.

The measurements shall be used in connection with fan performance tests, calibration of filter controls determination of air flow, branch balance and regulation of the ventilation and air conditioning system.

Access and inspection doors shall be provided for all items of inline plant, at control dampers, duct attenuators, and at all fire dampers. Access and inspection doors must be fitted with an effective air seal. Ductwork must not be weakened by the provision of access and inspection doors. Additional stiffening shall be fitted if so required. Doors which will be opened frequently, such as access to filters, shall be hinged and provided with quick, release latches.

To avoid accumulation of dirt or dust in the ducts, no duct or equipment is allowed to stand open during construction. All ducts shall be delivered sealed and clean and shall be installed with sealed ends. Only when connecting ducts or equipment the seal is allowed to be removed for connection. Dirt or dust accumulated in the ductwork or equipment is to be removed by the Contractor before handing over the work.

e) STEEL DUCTS EMBEDDED IN CONCRETE

Embedded ducts shall be steel pipes with wall thickness of minimum 4 mm shall be used. Joints shall be welded continuously. Changing of direction shall be made with curved bends. Necessary measures shall be taken to prevent deformation of the pipe during concreting.

f) DUCT INSULATION

All ducts for conditioned and return air running through unconditioned areas shall be insulated with at least 25 mm high density mineral wool insulation complete with factory applied vapour barrier jacket consisting of white kraft bonded to aluminium foil and fibre glass yarn reinforced. Access doors and panels shall be insulated separately for easy operation. All insulation joints shall be sealed with mastic.

All insulated ductwork, plenums and housings in plant room shall be finished with a layer of glass cloth applied over a full brush coat of vapour barrier adhesive. All joints shall be lapped minimum 50 mm and all outside corners of insulation shall be provided with metal edges under the final glass cloth.

g) FIRE DAMPERS

Fire dampers shall be made of mild galvanized steel sheets. All dampers to be at least 150 mm long.

Fire dampers shall be located in ducts and fixed to the concrete structure at the following locations:

- where ductwork passes through floors and is not concealed in fireproof cases;
- where ductwork passes through fire-rated walls;
- where wall-mounted filters are installed.

The fire dampers shall be capable of providing the same class of fire resistance as the wall or floor through which the ductwork passes and make shall be approved by the Engineer.

h) SOUND ATTENUATORS

Where necessary, in order to satisfy the noise level requirements, sound attenuators shall be installed in the ducts. The attenuators shall be made with a casing of galvanised sheet steel. The sound absorbent material shall be nontoxic, unburnable and give no dust or fibres to the air.

Acoustical treatment with sound absorbent material glued or fastened in any other way inside the ducts will not be accepted.

i) FAN COIL UNITS

The cooling coil shall be operated with chilled water.

The fans may have forward curved blades, double inlet directly mounted or motor shafts. Fan section shall be removable for maintenance and service. The fans shall be well balanced and shall be operated with three speeds.

The unit shall have an insulated, corrosion protected drain pan which shall be connected to a waste water system leading to a floor drain or a bucket sink. The drain pan outlet and the drain pipe shall be designed properly to prevent clogging from dust and fibres. All interior surfaces

subject to condensation shall be galvanized for corrosion protection. Panels exposed to cold air shall be insulated to prevent sweating.

Filter, discharge grille and return air grille shall be supplied. Three models shall be considered:

- Vertical units for floor mounting equivalent to Carrier 42 X;
- Horizontal units for mounting under the ceiling equivalent to Carrier 42 PH;
- Horizontal units for offices equivalent to Carrier 42 WK.

The units shall be selected to comply with the noise requirements and with normal water temperature difference (7-12°C).

Each unit shall have a thermostatic valve with the bulb fitted in the air stream to the unit.

The Carrier type 42 WK shall be delivered with the factory installed valve assembly comprising isolating valve and three-way control valve, drain pan kit, condensate discharge pump and a remote control kit with thermostat.

j) AIR HANDLING UNITS

The air handling units shall comprise:

- Motorised inlet air damper system
- Low velocity throw-away filters, with capacity according to the general requirements and efficiency equal to ISO standard EU7
- Cooling coil with copper tubes and protected aluminium fins.
- Rust proof condensate pan. The drain pan outlet and the drain pipe shall be designed properly to prevent clogging from dust and fibres.
- Centrifugal fan with backward curved blades. The fan wheel shall be dynamically and statically balanced.
- The casing shall be made of sandwich panels of galvanised steel with insulation between the panels.
- The inspection doors shall be hinged and have easy-to-open latches.
- The air handling unit shall be mounted on a set of vibration damping springs or suitable rubber pads with vibration damping properties. The connections to the ducts shall be with flexible sleeves.

k) EXHAUST FANS

The exhaust fans shall be of the centrifugal type with dynamically and statically balanced wheel.

The installation shall be as specified above for air handling units with vibration dampers and sleeve-connections to the ducts.

l) LOUVERS

Louvres/grilles in outer walls for intake air or exhaust air shall be made of galvanized steel. Louvres for outdoor installation shall be rain proof and fixed to it on the inside shall be a galvanised insect screen.

m) ROOF MOUNTED EXHAUST FANS

The fan shall be made of galvanised steel and given a painted surface which stands the weather conditions in the area. The motor/fan assembly shall be mounted on vibration dampers. The motor, shall have two speeds and the speed shall be selected from the switch.

The housing shall be made with rain water drainage.

n) WALL MOUNTED AIR CONDITIONERS

All air conditioners shall be wall mounted. Window mounted units shall not be accepted. Each unit shall have a control panel for individual control of air temperature and velocity. Where two or more units are mounted in the same room, a central control panel shall serve all the units.

Every unit shall have a fan with at least three speeds, easy access filters, built-in sound reducers, corrosion-resistant base pan, and slide-out chassis for easy maintenance. The unit must provide the possibility to direct the conditioned air in every inward direction.

Where necessary the units shall have a drain pan outlet leading outdoors or to drain.

o) WALL MOUNTED VENTILATION FANS

In some locations there shall be installed wall mounted local ventilation fans operating single rooms. Included in the scope of this work are also the louvres in front of the fan and for separate air intake. The local fans shall secure a ventilation of 15 m3/m2h. The fans shall have continuous speed control (stepless) controlled from a separate electric panel located at the entrance of each room.

p) BALANCING DAMPERS

Balancing dampers shall be made especially for balancing purposes with a handle, which can be locked in any position and with a marker and scale 0-90°, which makes it possible to read the exact throttling position of the damper.

q) SUPPLY AIR GRILLES

The grilles may be made of steel or aluminium with a baked enamel surface. The grilles shall have adjustable front vanes for directing the air stream in horizontal and vertical direction, as well as adjustment damper for balancing purpose.

The grilles shall be selected for correct throw and air velocity in the occupancy zones.

r) EXHAUST AIR GRILLES

The grilles may be made similar to the supply air grilles with adjustment damper, but with one set fixed front vanes only.

s) CEILING DIFFUSORS

Ceiling diffusers may be made in the same material as the wall grilles and be delivered with air adjustment damper. The diffuser shall be selected for correct throw and air velocity in the occupancy zone.

t) AIR TRANSFER GRILLES

Air transfer grilles are to be similar to the exhaust air grilles, but without the adjustment damper and with louvres of the "no see through" type. The grilles shall be wall mounted, or installed in the door panel.

u) BALANCING PROCEDURE

When the ventilation and air conditioning systems have been installed, a complete balancing procedure shall be carried through in such a way that the airflow to and from the various rooms and cubicles shall be in accordance with the design values.

A protocol listing the ventilated and air conditioned rooms with designed values and obtained values of the air flow through the room, shall be set up prior to the PSA.

There shall also be a protocol listing all the balancing dampers, their designations and in which throttling position they are locked.

17.5.5 CHILLED WATER SYSTEM

a) WATER CHILLERS/CONDENSING UNITS

The units shall be factory assembled and water cooled. All factory wiring and piping shall be contained within the unit enclosure. The unit shall be encased in a weather proof cabinet where all steel parts as basic treatment are galvanized after any machining or welding. All electrical components shall be installed in waterproof enclosures.

Construction and ratings shall be in accordance with latest ARI Standard 590 and shall comply with ANS B9.1. Safety Code, National Electrical Code and applicable ASME Code.

Each compressor shall be reciprocating, serviceable hermetic type and shall have an automatic reversible oil pump and an operating oil charge. Compressors shall be equipped with suction and discharge shutoff valves and be mounted on spring vibration isolators. Motors shall be cooled by suction gas passing around the windings and shall have thermal protectors embedded in the windings. Manual restart of unit shall be required after motor stoppage due to thermal overload or insufficient oil pressure. Each compressor shall be equipped with an insert-type crankcase heater to control oil dilution during shut-down.

There shall be a factory-installed contactor and a calibrated manual reset, ambient, insensitive magnetic circuit breaker for each compressor. The circuit breaker shall open all three phases if an overload should occur on any phase. Each compressor shall be provided with electrically operated equipment for cylinder unloading.

The evaporator shall be of well insulated shell-and-tube type.

The condensator shall be mechanically cleanable shell-and-tube type with finned tubes. Each condenser shall be constructed to provide positive sub-cooling of the liquid refridgerant. A pressure relief valve, purge cock and liquid shut-off valve shall also be provided for each condenser.

Each refridgerant circuit shall include a hot gas muffler, combination moisture indicator and sight glass, replacable refridgerant filter drier, liquid line solenoid valve, maximum operating pressure thermal expansion valve, a feed valve and a refridgerant circuit drain valve.

Controls shall be factory wired, in a weather proof box, and shall include an acting timer to prevent short-cycling of compressor and to delay restart of compressor after shut-down. The unit control box shall also include high and low pressure-stats, multiple-step water temperature controller, chilled water safety thermostat, field power and control circuit terminal blocks, fuses and circuit breakers, motor contactors, control relays, disconnecting switch, and oil safety switch.

In the main chilled water pipe, flow switches shall be installed in such a way that the compressors cannot start until a water flow is established. The flow switches shall be condensation proof, function properly under all conditions and shall have non-corroding contact surfaces. An auxiliary power box shall contain a terminal block for a complete independent power source to supply the control circuit.

b) COOLING WATER PUMPS

The pump shall be directly driven by an electric motor, the housing shall be made of cast iron, with a wheel of bronze and a shaft of stainless steel.

c) CHILLED WATER PUMPS

The pump shall be directly driven by an electric motor, the housing shall be made of cast iron, with a wheel of bronze and a shaft of stainless steel. The chilled water pumps shall be installed on the water inlet side.

d) BALANCING VALVES

The balancing valves shall be made of brass and have control cocks for connection to a differential manometer for determination of the water flow through the valve. The valve shall be of a type which combines the function of a balancing valve and an isolating valve.

The balancing scale shall be easy to read. Together with the valves shall be delivered rating charts which show the relation between the setting, the pressure drop and the water flow.

The valve shall be equivalent to the STAD and STAF from Tour Andersson, Sweden.

e) ISOLATING VALVES

The isolating valves shall be high quality ball valves or butterfly valves.

The valve material shall be special brass made for this purpose, the ball shall have lining of PTFE (polytetrafluoroethylene = Teflon) and the packing rings shall be PTFE. The valves shall be selected equivalent to Tour Andersson.

f) CONTROL VALVES

The control valves with motor shall be three-way seat valves made of brass. The valves shall be selected in such a way that the water resistance in the loop rests on the valve and not the coil.

In the third port of the valve there shall be fitted an orifice or a throttle valve/balancing valve which will maintain the resistance in the loop regardless of whether the water flows through the valve only or through the coil.

g) EXPANSION SYSTEM

The expansion system shall comprise a diaphragm type expansion tank and a set of spring-loaded safety valves.

The expansion volume shall correspond to a temperature rise in the system from 7°C to 40°C.

The preloading of the tank and the set values of the safety valves shall be in accordance with the pressure conditions in the system.

h) CHILLED WATER PIPES

Chilled water piping shall be made to ISO 65-1981 medium series hot galvanized steel with screwed joints for dimensions below 2" and screwed or flanged joints for dimensions above. When flanged, the pipe shall be hot galvanised after finishing the welding work.

For each water chilling unit, each air handling unit and each fan coil unit there shall be shut off valves in each pipe, and throttle valve for attainment of correct water flow. Those valves shall have control cocks for connection to differential manometers and rating chart for the relation between pressure drop and water flow.

The cooling coils in the air handling units shall be connected to the pipe system in such a manner that the water flow in the main system and through the water chiller is approximately constant.

i) PIPEWORK SUPPORTS

All piping and piping connected equipment, including valves, strainers, traps and other specialities and accessories shall be supported in a manner that will not result in or produce objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or in the building structure either during erection, cleaning, testing or normal operation of the systems. Piping shall not introduce any strains or distortion to the connected equipment.

Hangers for insulated piping shall be sized for the outside diameter of the pipe insulation or the insulation protection saddle.

j) INSULATION OF CHILLED WATER PIPES

All insulation work shall be executed by skilled workers. Insulation applied to chilled water piping and equipment, shall be completely vapour sealed and free of pinholes or other openings. Insulation shall be Closed cell, flexible foamed plastic conforming to ASTM C534, "Performed Flexible Elastomeric Cellular Thermal Insulation in Sheet & Tubular Form".

Application:

a) Pipe: slip insulation over pipe or slit insulation sections and apply around pipe, then seal longitudinal and circumferential joints with adhesive recommended by insulation manufacturer;

b) Valves, fittings and flanges: shape tubing insulation into covers by butting and mitring joints as required, then seal all joints with adhesive;

c) Equipment: shape sheet insulation as required to conform to the contour of the equipment, then seal all joints with adhesive.

Insulation thickness:

- ½" through 1" 20 mm
- 1¼" through 2" 25 mm
- 2½" and over 30 mm

Finish paint with special elastomeric paint.

k) PAINTING

All exposed insulated pipework shall be given two coats of gloss paint. The colour of the paint shall be as approved by the Engineer. After insulation has been completed, all un-insulated pipework shall be given two coats of the appropriate colour of gloss paint. This shall be in addition to the coat of metal primer, which shall be given immediately after erection of the pipework.

The colours shall be chosen in accordance with the Contractors colour code which shall state different colours for the different liquid systems, one colour for chilled water, one for cold water, one for hot water, etc. All pipework supports shall also be given two coats of the appropriate colour of gloss paint. This in addition to the coats of metal primer applied before and after erection.

Coloured arrows are to be supplied showing the direction of flow.

l) CLEANING

All piping systems shall be cleaned by air blowing or water, and flushed free of dirt, loose scale, debris and other loose foreign materials prior to and after testing.

m) TESTING

Test Criteria

All pressure pipework shall be hydrostatically tested with a test pressure of 1.5 times the normal working pressure. The test pressure shall be applied for a period of four hours. The test shall be witnessed by the Engineer. Notice shall be given one week in beforehand.

The drainage pipes from fan coil drip pans shall be hydrostatically tested for leaks. The test pressure of 1 m water pressure shall be applied for a period of 24 hours.

The hydrostatic test pressure shall be limited to the maximum test pressure of the weakest component in the piping and equipment system.

Lines which are normally open to atmosphere such as vents and safety valve discharges shall not be tested but all joints shall be visually inspected for proper installation.

Seats of iron valves shall not be subject to a pressure in excess of the maximum working pressure of the valve. Pressure tests against other closed valves shall not exceed twice the normal rating.

Test Medium

Fresh water shall be used as the testing medium for the hydrostatic testing of piping and equipment systems.

Testing Equipment

The Contractor shall supply all weld caps, flanges and gaskets required for testing.

Test pressure shall be applied by means of a suitable test pressure source which shall be isolated from the system until ready to test. A pressure gauge shall be provided at the source discharge for guidance in bringing the system up to pressure. The source shall be attended constantly during the test by authorised persons.

Retesting of lines after repair shall be done at pressure originally specified for the test.

Test Records

Test records shall be prepared and maintained for all piping during testing. Test records shall include date of test, identification of piping tested, operating and test pressure, test fluid and approval signatures of the person in charge of testing and the Engineer.

n) BALANCING PROCEDURE

The chilled water system shall be balanced in such a way that with fully open valves to the cooling coils, the design value of water flow shall be obtained through all the valves simultaneously.

A protocol showing the balancing valves, their designation, pressure drop and water flow shall be set up prior to the PSA.

17.5.6 MEASURING INSTRUMENTS AND CONTROLS

a) AIR HANDLING UNITS

Each handling unit and fan coil unit shall have:

- Air flow measuring station for air delivery
- Thermometers for entering and leaving air, accuracy 0.3°C
- Thermometers for entering and leaving chilled water, accuracy 0.3°C
- Pressure drop gauge for the filters.

b) ELECTRIC PANELS

Electric panels containing service switches, starters, fuses, light bulbs, motor overload protection, etc. shall be provided in each plant room. Each electric motor shall have a service switch next to the motor.

The panels shall be built in two different sections; one for the fuses and starting equipment, and one for the control equipment (low voltage). Distributed Control Processors (DCP) to be placed close to, or built in the "low voltage" section.

Switches and signal lamps for indicating running and alarm shall be mounted in front of the panels. The switches shall be operated by special keys to avoid unauthorised use.

Switches for testing of lamps shall be included.

The panels shall be provided with cylinder locks operated with a special key.

Before delivery onto site, the panels with all functions shall be tested at the factory.

Panels are to be built in accordance to the IEE regulations and British Standards applicable for this type of equipment.

All panels and DCP's shall have 25% excess space for future expansion.

c) CONTROLS-GENERAL

The controls shall be of electronic, computerised DDC (Direct Digital Control) type. All temperatures, which are to be controlled and/or indicated, shall be indicated and transferred to be displayed as well on the computer screen in the main control room. All settings and switching shall be possible from the same computer.

In this specification only functions and requirements are specified. The Contractor shall provide and install all the necessary components to achieve these requirements.

Temperature sensors shall be Pt 100 with transmitter 4-20 mA. The controls shall be operated with 110 V DC battery power.

d) CABLING

The control cables shall be separated from the power cabling and laid in separate conduits in such a way that signal transfer will not be interfered with by the power cables.

e) CONTROL PROCEDURE

Air Handling Units

When starting, the inlet damper will open. A temperature sensor in the leaving air will operate the three-way chilled water valve for maintaining the set temperature, which will be in the range of 12 - 20°C. Normal set temperature would be 14°C. When the unit stops, the damper will close. The operating program shall be governed through a time channel.

Fan Coil Units

The units will run continuously, and the chilled water three-way valve is controlled by a temperature sensor in the inlet air stream of the unit for maintaining a pre-set temperature of 22 - 26°C. Normal set temperature would be 24°C. The operating program shall be governed through a time channel.

Water Chiller

The water chiller shall be operated on the factory-installed controls.

Air Condition Units

Wall mounted air conditioning units are operated by manual controls.

f) SIGNAL TRANSFER

As a minimum, the following signals shall be transferred to the computer screen in the Control Room:

- Exhaust temperature in the rooms where fan coils are installed
- Set temperature: 24°C, adjustable
- Alarm temperature: 27°C, adjustable
- Leaving and entering chilled water temperatures for the water chiller
- Set temperature for leaving chilled water: 7°C

- Alarm temperature for entering chilled water: 14°C
- Leaving air temperatures from the air handling units
- Entering air temperatures for the exhaust fans
- Status for water chiller controls
- Failure signals for all motors.

17.5.7 SYSTEM SPECIFICATION

a) POWER STATION

The air shall be ducted to all parts of the Powerhouse at a ventilation rate of minimum 5 m^3/hm^2. The air from the outside is dehumidified and supplied to the Powerhouse by centrifugal fans in the HVAC Room at the turbine basement level. The air is distributed to the different rooms and areas through a duct system The inlet grilles shall be equipped with balancing dampers.

The ventilation rate for the battery room shall be in accordance with the German VDE 0510 and DIN 57510 Standards.

For ventilation of the drainage sumps, exhaust fans shall be installed. The fans shall be sized to give one complete air change per hour.

Where temperature control is required, chilled water operated fan coil units shall be mounted horizontally under the ceiling. The drain water outlet from the fan coil units shall be connected to a waste water system. The installed number of fan coil units in each room shall have a total capacity of 100% of the total demand for the room.

Control Room and electrical rooms

The rooms shall have a balanced air-conditioned system. Inlet air shall be air-conditioned in HVAC Room and ducted to the rooms at a general ventilation rate of 15 m^3/hm^2.

The exhaust air is let out through exhaust grilles into the machine hall.

b) HEADWORKS SERVICE BUILDING

The air-conditioning and ventilation systems shall have the following characteristics:

a) The control room and the low voltage distribution room shall have air conditioning units in the wall, capable of maintaining a room temperature of 23°C ± 3°C.

b) The drainage from the drip pan shall be led out of the building.

c) The transformer room shall have louvres in the full height of the room. Width x height of each opening shall be approximately 1.25 m x 3.0 m.

d) The battery room shall have louvres at the ceiling and the floor. Width × height of each opening shall be approximately 0.5 × 0.5 m.

e) Toilets shall have air inlet from the corridors through slits below doors and exhaust fans in ducts to outlets over the roof.

c) CHILLED WATER SYSTEMS

Two chillers shall be installed in HVAC Room in the Powerhouse each with a capacity of 50% of the total demand. Two circulation pumps shall be installed, each with a capacity of 100% of the total demand. In order to avoid too frequent starts and stops of the chillers, an accumulation tank shall be fitted into the system.