SECTION 12

Controls

DIVISION 15

MECHANICAL WORKS

SECTION 12.00

CONTROLS

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DIVISION 15

MECHANICAL WORKS

SECTION 12.00

CONTROLS

12. 1 PART (1): CONTROL EQUIPMENT & SEQUENCE OF OPERATION

12.1.1 Control Equipment

1. General

Automatic control systems may be of the electromechanical or electronic type as described in the attached documents. Unless otherwise specified control systems shall be energized as follows :

Electric Control Systems 230 volts Electronic Control Systems - Standard 24 volts Electronic Control Systems - D.D.C. 0.10 volts

The installation may be a single system or a combination of systems.

All control equipment including all control valves, dampers and actuators shall be selected sized and rated to suit the application and operating conditions of the systems in which they are installed to provide stable and repeatable performance of the systems being controlled.

All items of control equipment shall be compatible within any system, between systems and with controlled equipment. All items of control equipment shall be sited such that access for adjustment and maintenance purposes is not impeded. However, where items of control equipment are mounted in accessible positions within normally occupied areas, the control items shall be provided with secure tamper proof enclosures to prevent unauthorized interference.

Control systems shall be arranged such that, in the event of electrical power failure or other abnormal operating conditions, inherent fail-safe features are provided to equipment and systems to prevent potentially hazardous conditions arising.

The sensitivity of sensors and the speed of response of actuators shall be selected for complete compatibility with the system application requirements.

Basic adjustments for original setting of controls such as: control characteristics, sensitivity, set points, anti-hunting adjustments, timers, set back and boost, shall be contained and concealed in tamper-proof. lockable panels.

All controllers shall be provided with built-in adjustable neutral zone.

All control components shall be of high quality, low risk rate and of long term reliability for both continuous and intermittent use and shall maintain accuracy and high repeatability of commissioned performance.

12.1.1 Control Equipment (cont'd)

Where equipment requires less than 220 volts supply, all necessary voltage transformers shall be provided either separately or integrated with the various packaged equipment. Equipment requiring D.C. supply shall be provided with all necessary current rectifiers and shall be suitable for the connected loads.

Control shall be suitable for connection to a building management installation if required at a future date.

2. Sensing Elements:

Sensing elements for temperature controls may be of the thermistor type providing they have been subjected to an aging stabilizing process.

Temperature transmitter sensor elements shall be of the platinum wire or semi-conductor type.

Elements sensing liquid temperature in pipework shall be:

- provided with means for withdrawal for calibration, servicing etc., without the need for draining the system;
- positioned so that the active part of the element is wholly within the liquid ;
- positioned so that the element is not less than 12 pipe diameters downstream from a point of mixing.

Elements sensing the temperature of air in a duct shall be positioned so that:-

- the element is not subject to radiation;
- account is taken of temperature stratification, (i.e. positioning for high temperature limit sensing, positioning for average temperature sensing);
- if of the capillary averaging type, it is installed on a suitable framework and is suitably arranged for servicing;
- if used for determining the dew point and the air adjacent to the element is known to be saturated within acceptable limits, the construction and material of the element shall be compatible for use in moist air.

Elements sensing the temperature of a solid surface shall be positioned and fixed so as to give good thermal contact.

The precise location of site elements sensing the temperature of a room or other such space in a representative position shall be approved by the Engineer.

- where indicated it shall be at a height of approximately 1.7 m above floor level (when fitted in a room);
- in the return air path where indicated.

12.1.1 Control Equipment (cont'd)

Elements sensing the temperature of air external to a building shall be positioned as indicted and away from the influence of direct solar radiation and local heat gains.

Humidity sensing element positions shall be :

- representative of the space in which the humidity is being measured;
- such that the air flow is within the range required by the sensing element;
- arranged to ensure that the air reaching the elements is free from airborne contaminants;

Basically all sensing elements shall be correctly located strictly in accordance with the manufacturer's recommendations.

Temperature sensing elements located adjacent to large coils in air handling plant and large duct mounted coils, particularly for dew point control, shall be of the averaging type with the sensing element continuously supported across the face of the coil, or, alternatively, multiple sensors shall be supplied to give an average reading.

3. Control Valves:

All control valves shall be selected and sized by the controls equipment manufacturer and shall be suitable for the systems application and operating conditions.

Unless otherwise stated valves shall be of the modulating type with adequate rangeability, having equal percentage or power linear characteristics. Where butterfly valves are specified they shall have "near quadratic" characteristics.

Valves shall be provided with the following minimum valve lifts:

Size- up to 25 mm. 32 to 50 mm. 65 and above
Lift- 8 mm. 12 mm. 20 mm.

Valve authorities shall generally not be less than 0.3 for mixing applications and 0.5 for diverting but compatible with economic valve pressure drops sufficient to provide adequate control without promoting cavitations.

Actuators on all valves, particularly two-port valves, shall be capable of opening and closing the valves against the maximum system operating pressures. Double seated balanced type valves shall be used where two-port valves operate against high system pressures.

All valves, other than on terminal units such as fan coil units shall be provided with external position indicators. They shall be complete with actuators, mounting brackets and all necessary auxiliary switches.

12.1.1 Control Equipment (cont'd)

Three-way valves, unless otherwise specified shall be accompanied with an isolating valve on each port. The valve on the by-pass port shall be of the double regulating type.

Unless otherwise specified, and in all circumstances where valve seat leakage is likely to cause nuisance, unnecessary by-passing or mixing losses, energy consumption, control instability, temperature conditions above or below the required control band or where circuit isolation is required, all control valves shall be of the tight shut-off type, which may entail special seatings, particularly for double-seated valves, and shall not be of the rotating shoe or sliding disc type.

- Seats and stems shall be removable and of stainless steel, except where alternative seating material is necessary to provide tight shut-off.

- Valves up to 50 mm. shall be of bronze bodies construction with stainless steel trim.

- Valves of 65 mm. size and above shall be of cast/modular iron or steel bodies construction as suitable for the pressure and temperature conditions having stainless steel trim.

- The copper content of alloy valves shall be as high as possible to avoid dezincification.

All valves shall be embossed with the manufacturer's logo, valve size and direction of flow.

Valves shall be provided with clutch or lifting mechanism to enable valves to be controlled manually in the event of power source failure.

All butterfly valves shall include resilient seatings.

Shoe type valves shall not be accepted.

Unless otherwise specified, control valve actuators for chilled water coils shall be fitted with spring returns to the safe position on failure of electrical supply, to provide necessary plant protection shut-off or relief conditions to systems or equipment.

4. Control Dampers

Control dampers and actuators shall be selected and sized to provide the desired power and performance characteristic in accordance with the control equipment manufacturer's recommendations.

All damper actuators shall be provided with a heavy duty and rigid mounting bracket and all necessary auxiliary devices.

Mixing and volume control dampers shall be of the modulating type.

- All actuators shall be provided with position and direction indicators.

12.1.1 Control Equipment (cont'd)

Mixing and throttling dampers shall be sized to provide adequate control over the full movement of the dampers, giving near linear characteristics without incurring high pressure drops which should not exceed 10% of the controlled circuit pressure drop when fully open.

Rotation angle of the damper spindle shall where possible correspond with the required operating angle of the damper to which it is connected.

5. Step Controllers

Step controllers shall have adjustable differential and time delay between operations of each step and speed of loading and unloading. Each stage shall operate in sequence. The controllers shall be capable of interlocking with each other for series operation from the same sensor output.

The controllers shall recycle to ensure that on normal shut-down, power failure or manual interruption of the power supply, the controllers recycle to the "off" position before re-energizing the controlled circuits.

All contacts shall be suitably rated for the imposed load(s).

Switching condition shall be indicated by lamps on the front face of the controller.

6. Standard Control Interlocks

Unless otherwise specified the following equipment inter-locks shall be provided:-

- Provide timers in the control circuits of all pumps to enable the pumps to continue to run for a pre-set period after shut-down of cooling plant.

- On plant start up and shut down operation, control circuits shall be arranged for staggered switching of motors to avoid simultaneous large electrical loads being imposed on the power cabling and power plant.

- Under normal operating conditions, the extract fan starters shall be interlocked with their respective supply fan starters and stop locks.

- Where duty and standby pumps are provided, the selected duty pump shall start and operate as required. Should the duty pump fail to start, a fault alarm shall be given and the standby pump, after a pre-set period, shall operate. The same automatic change-over sequence shall apply should a pump fail during normal running.

- When heating and cooling coils are to be operated in sequence a dead zone shall be provided between each sequence.

- All chilled water valves shall close on all plant shut down conditions unless otherwise stated.

12.1.1 Control Equipment (cont'd)

- On systems where refrigeration plant is not required to provide cooling in the winter season, an outdoor temperature detector shall be provided to shut down chiller plant and pumps when ambient conditions fall below a set point.

7. Installation

All control cabling shall be neatly run, adequately supported and securely clipped in position.

All field mounted sensors, actuators and other ancillary equipment shall be located to allow easy access and maintenance.

Adequate precautions shall be taken to protect all control panels equipment and wiring from mechanical and water damage.

Tapings shall be provided for measuring instruments adjacent to all temperature, humidity, pressure, velocity and sampling sensors. Where possible, sensors and measuring devices shall be mounted on the same probe.

The fitting of actuators, sensors and other field mounted control equipment shall be left as late as it is conducive to the programme of work, in order to avoid damage by other trades.

12.1.2 Air Handling System

A. Component and Arrangement

The components, arrangements and control devices and control points are shown on drawings No. M518:-

B. Sequence of Operation

1- AUH – FA

Full Fresh Air Supply Side Only (CAV)

a. When supply fan is off, fresh air damper is closed, control valve is closed.

b. The supply fan shall not operate until fresh air damper is fully open and the associated extract fans are operating.

c. The temperature control loop is only initiated when the supply fan is operating.

d. The differential pressure switch across the supply fan and extract fans shall initiate an alarm in case of air flow failure.

e. The differential pressure switch across primary and bag filters shall give signals to indicate filter status (dirty/clear filter).

12.1.2 Air Handling System (cont'd)

f. The room temperature sensors shall modulate the control valve from 0% to 100% to maintain the required setpoints. In case of more than one room temperature sensor, the sensors shall modulate the control valve on average valve basis.

g. The ambient temperature sensor shall close the control valve when the ambient temperature is below a certain value (15°C).

h. Smoke detectors installed in AHU zone shall initiate an audible and visible alarm at the main fire alarm panel and at BMS, and the supply fan and extract fans shall stop.

i. The twin extract fan (for toilets) unit shall operate on the standby basis and alternatively for equal use.

2- AUH – ST & AHU - SST

Full fresh air double deck, with energy recovery system (CAV)
Items (a), (b), (c), (d), (e) same as (1)

f. The temperature / humidity sensor mounted at the main extract duct shall modulate the control valve from 0% to 100% sequancly with the electric humidifier to maintain the required setpoint.

g. Same As (1)

h. Smoke detectors installed at the main extract duct shall initiate an audible and visible alarm at the main fire alarm panel at BMS, and shall stop supply and extract fans, fresh air damper shall close, and energy recovery system shall stop.

3- AUH – EXH1, EXH2, TG & MEH

Re-circulating, Double Deck (VAV)

Same as (2) but without energy recovery system and with return air damper and mixing box. The following items to be incorporated:-

1. The ambient air temp. sensor shall modulate the FA and RA dampers to maintain the supply air temp.

2. In the event of fire the smoke detector installed at the return duct shall close FA and RA dampers, supply fan shall stop, extract fan shall stop after time delay, and shall initiate and audible ad visible alarm at main fire alarm panel and at BMS.

12.1.3 CHILLED WATER PLANT

SYSTEM ARRANGEMENT

The central chilled water plant shall include three air cooled packaged water chillers located on the roof of the hospital building.

The primary circulating chilled water pumps shall be of a constant flow direct driven type and shall be housed in the Roof Mechanical Plant Room of the hospital building. Each pump shall be interlocked with it respective chiller. The primary chilled water pumps shall be operated at supply temperature = 7°C and return temperature = 13°C and controlled to maintain a supply flow that exceed the total secondary chilled water flow.

The secondary chilled water system are splitted and categorized to two independent circuits :

1- Circuit I Air Handling Units Secondary Circuit

This circuit is to serve all air handling units of the hospital

Three variable speed secondary chilled water pumps (two on duty and one standby) shall be installed to serve all units.

The secondary circuit may need to be fitted by a bypass connection, which shall be actuated at the minimum permissible flow of the pump. The by pass flow shall be confirmed with the selected pump manufacturer.

Two port valves will be installed for all air handling units and fan coil units.

The chilled water supply temperature of this circuit shall be maintained at = 7°C and the return temperature = 14°C.

2- Circuit II Hospital Fan Coil Units Secondary Circuit

This circuit is to serve all hospitals fan coil units.

Three variable speed secondary chilled water pumps (two duty and one standby) shall be installed to provide variable flow and constant temperature of the chilled water.

An injection circuit shall be used to enable the chilled water supply temperature to be increased so that the desired condensation does not normally occur at the fan coil units which will, in turn, reduce mould growth on FCUs condensate trays.

The secondary circuit may need to be fitted by a bypass connection, which shall be actuated at the minimum permissible flow of the pump. The by pass flow shall be confirmed with the selected pump manufacturer.

The chilled water of this circuit shall be maintained at supply temperature = 9°C and return temperature = 14°C.

12.1.3 CHILLED WATER PLANT (cont'd)

BASIC LOGIC CONTROL

Chillers

1- Each chiller shall be supplied with its own integrated control panel.

2- The Chillers control panel shall be completely interfaced with the building management system.

3- Each chiller shall be remotely enabled (started) by building management system.

4- Each chiller shall be provided by flow switch to enable start of the compressor after the complete flow of the primary flow pump.

5- Each chiller shall be provided with supply temperature sensor

6- System pressure shall be within the operating limits (signals to be provided by pressurization system).

Primary Chilled Water Circuit

1- The common supply temperature shall be provided with flow sensors (meters)

2- The common primary return line shall be provided with return temperature sensor

3- Each primary pump shall be remotely started and stopped.

Secondary Chilled Water Chilled Water Circuit

1- A differential pressure switch shall be provided across each secondary pump.

2- A temperature sensor shall be provided on the supply and return lines of each secondary circuit.

3- A flow sensor shall be provided on the supply line of each secondary circuit (before injection.)

4- A temperature sensor shall be provided on the supply of the secondary circuit (after injection).

5- Differential pressure sensors shall be provided on the on 70 % distances and at locations as shown on drawings.

6- A mixing three way injection valve shall be installed to all injection secondary circuits.

7- Remote bypass valves shall be installed at the end of risers to allow for minimal pump flow as recommenced by the pump manufacturer.

12.1.3 CHILLED WATER PLANT (cont'd)

Pressurization set

1- A low level switch shall be provided for the pressurization set.

2- A status indicator shall be provided for the pressurization.

3- System pressure sensor shall be provided.

SEQUENCE OF OPERATION :

Primary Chilled Water Circuit

1- System shall be scheduled to run 24 hours a day all year round.

2- System operation shall be under the complete manual and automatic control of the building management system.

3- Chillers operations shall be scheduled to operate in lead lag sequence of operations.

4- Chilled water supply shall be maintained at 7 C.

5- Compressors operations is to maintain max $\Delta T = 6°C$ between main supply and return temperatures.

6- An alarm signal shall be indicated on the BMS should ΔT between supply and return to exceed 7°C.

7- The BMS shall measure and compute the flow of each secondary circuit and of the main primary circuit.

8- The BMS shall sum up all secondary chilled water flows and compare to the primary chilled water flow.

9- The primary pumps shall be under the control of the computed differential sums between the primary and secondary flows. Pumps sequence of operation shall be to the following:-

   a- At least one primary pump shall remain on operation for the minimal or zero load. The lead pump shall alternate operation on monthly basis.

   b- When the differential water flow rate between the primary and secondary circuits drops below 5.0 L/s for more than five minutes, then the second pump shall be set on operation.

      Accordingly, its respective chiller shall be enabled and energized for operation based on the flow switch signal..

      Should the flow switch fail to send a flow signal. then the pump shall shut down and the third pump shall set on operation. An alarm signal shall be sent to BMS.

12.1.3 CHILLED WATER PLANT (cont'd)

Refrigeration compressors operations shall remain under the control of the return temperatures of each chiller. which shall be incorporated within the chiller's control panel.

The sequence of operation shall also be repeated for chillers three.

c- When the differential water flow rate between the primary and secondary circuits exceeds 30 L/s for more than five minutes, then the second pump shall be turned off.
Accordingly, its respective chiller shall be denergized based on the flow switch signal.

Should the flow switch fail to send a non flow signal. then an alarm signal shall be sent to BMS.

The sequence of operation shall also be repeated for chillers three.

d- Should the flow sensors fail to operate or BMS fail to meet the set points, then all primary pumps shall be set on operation and an alarm signal shall be sent to BMS.

e- Each chiller control panel shall send a signal to the BMS for run trip indication.

Secondary Chilled Water Circuit

1- System is scheduled to run 24 hours a day all year round.

2- System operation shall be under the complete manual and automatic control of the building management system.

3- Secondary chilled water pumps shall alternate operations periodically, based on predetermined schedule of operation

4- Should the on duty pump fail to operate. the stand by pumps shall set on operation, and an alarm signal shall be sent to BMS.

5- Chilled water supply shall be maintained at 7 C for AHUs circuits.

Chilled water supply shall be maintained at 9 C for the hospital FCUs circuits. This shall be maintained via the 3-port injection valve.

Injection Valve position shall be under the control of the secondary circuit supply temperature sensor.

6- The return temperature along the supply temperature and flow rate sensors shall determine the energy consumption of each subcircuit.

7- Variable speed pumps shall be under the control of the differential pressure sensors DPS. The pump controller shall determine the demand based on the following procedure:-

12.1.3 CHILLED WATER PLANT (cont'd)

- The controller shall compare each signal of differential pressures sensor DPS to the predetermined set point

- When all of the measured DPS are satisfied at their set points, the pump speed shall remain constant at the optimum energy consumption level.

- The BMS shall continuously scan and compare each zone variable to its individual set point and control to the least satisfied zone.

- As the worst case zone deviates from set point, the BMS shall send the appropriate analog signal to speed up or slow down the pump/motor.

- In the event of the failure of a zone differential sensor DPS, its process variable signal shall be removed from the scan/compare program. Other zone sensor/transmitters, shall remain in the scan/compare program for control.

- The zone number corresponding to the failed differential sensor/transmitter shall send an alarm signal to BMS

- In the event of failure to receive all zone process variable signals, the pump shall maintain 100% speed, reset shall be automatically reset upon correction of the zone failure.

12.1.4 Water Storage Tanks

Water storage tanks shall be provided with high and low level probes which shall provide alarm indication.

12.1.5 Cold Water Booster Pumps

Each cold water booster pump set (mains and softened) shall be controlled and monitored by the MCC or control panel as mentioned.

Run and trip together with high and low pressure indication shall be given at the panel.

High and low water pressure shall also raise visual and audible alarm at the panel.

Each booster set shall be complete with integral pressure controls, duty sharing and automatic pump changeover etc.

12.1.6 Fire Fighting Pumps

As described in section (10.00) of this specifications.

12.1.7 Submersible Pumps

Submersible pump shall be complete with integral float switches. However, the control panel shall provide the following monitoring facilities. Power on, run and trip together with alarm signaling for continuous operation over a preset maximum time period.

12.1.8 Motor Control Centers

A) Enclosures:

Motor control centres shall be free standing standard extendible cubicle, multi-tier, low voltage, flush fronted, in line assemblies designed for front access only.

Motor control centres shall be fabricated in either:-

i) 2 mm hot dipped galvanized MS sheet to BS 2989 as Z2 G275.S.

ii) 2 mm MS sheet hot zinc sprayed after fabrication.

All doors shall be fitted with concealed hinges together with gaskets to provide dust and weather protecting enclosures to the degree of protection specified within IP.54. The panels shall be fully vermin proof, meet the requirements of BS 4941 and be fitted with anticondensation heaters.

Unless specified otherwise the boards shall be rated for a fault level of 31 MVA at 380 volts for 0.5 seconds.

The boards shall be fitted with air insulated busbars run in separate enclosures. Busbars shall run the full length of the boards. Busbars and connections shall conform to BS 159.

Moulded case circuit breakers and miniature circuit breakers shall be used throughout for excess current protection and isolation of the individual circuits. These shall be adequately rated for their duty and the prospective fault rating at their point of installation.

Control circuits shall be 230v A.C. 50HZ. They shall be divided in small logical groups or sections, each being supplied through a miniature circuit breaker so that only one small group or section is affected if a circuit fault occurs.

The boards shall be made up in standard width sections with an incoming section housing the incoming main supply cable terminations, isolating switch, incoming voltmeter, ammeters, current transformers, and selector switches.

A suitable control and instrument section shall be provided to accommodate relays, instruments, pressure gauges, temperature indicators, recorders and free issue equipment as specified.

External fixing screws, door and switch handles, handle lock barrels, push-button and indicating lamp bezels shall be chromium plated steel.

12.1.8 Motor Control Centers (cont'd)

Access doors shall be efficiently earthed to the fixed enclosure by braided copper straps and have an additional restraint to prevent damage to the hinged and painted surfaces.

Moulded case circuit breakers, isolators and overload relay resets shall be arranged for through the door operation.

Suitable kicking space shall be provided at the base of every control board.

Switchgear and control boards shall not be bolted direct to concrete floors but to steel channels inset into the floor screed. The channels shall be supplied and fixed by the Contractor.

Provision shall be made for conduits, cables, instrument piping, etc., to enter at the top or bottom of the respective panels as specified. Suitable approved cable cleats shall be provided to ensure that the weight of incoming cables is not carried by the cable glands.

Removable eye bolts or lifting lugs to facilitate unloading and erection shall be provided together with blanking set screws.

B) Component:

Relays, ammeters, voltmeters, kilowatt hour meters, clocks, hours run meters, push buttons and indicating lamps shall be flush mounting and shall not be mounted at a height greater than 1800 mm or less than 450 mm from finished floor level. Where push buttons, lamps, meters and switches are mounted on access doors, their terminals shall be screened to prevent accidental contact.

Excess current protection and isolation of each motor circuit shall be made using a moulded case circuit breaker.

Excess current protection of control circuits or sections of control circuits shall be made using miniature circuit breakers.

Cubicle isolators or moulded case circuit breakers shall be capable of breaking the stalled motor current and shall be mechanically interlocked with the cubicle door. The contacts and live terminals shall be shielded. The isolator or moulded case circuit breaker shall be rated for the full load motor current, taking into account any de-rating factors which may apply.

The supply to control circuits shall be isolated through auxiliary contacts of the motor moulded case circuit breaker or isolator.

Where a control panel is interconnected with another control panel or item of electrical equipment, interposing relays shall be provided in each control panel or item of equipment to provide complete isolation between the two sources of electrical supply. These relays shall be mounted in an enclosure which must be removed to gain access to them.

The control panel or item of equipment's main supply isolator shall also be equipped with a sufficient number of auxiliary contacts to isolate all interconnecting wiring.

12.1.8 Motor Control Centers (cont'd)

When this is not possible a multi-pole isolating switch shall be provided adjacent to the relays.

A warning notice shall be installed on the relay unit engraved "DANGER. SEVERAL ELECTRICAL SUPPLIES PRESENT DO NOT INTERCONNECT".

Test facilities shall be provided at the starter cubicle such that the control voltage is maintained but the mains supply to the motor is isolated. There shall be a mechanical interlock to prevent the mains voltage being applied whilst the starter cubicle is in the "Test' position.

Starters and contactors shall be compatible with the motors and motor duties as supplied by the manufacturers of the Mechanical Equipment

Individual drive reference labels are to be provided on the front door of each starter/ feeder. All controls shall be clearly labeled. Labels shall be engraved on white/black/white Traffolyte.

Starters shall be direct-on-line up to 4 kw, above which assisted starting shall be used.

All cabling, circuit breakers, moulded case circuit breakers, miniature circuit breakers and all marking and labeling shall be as described in the General Requirements unless otherwise described elsewhere in this Specification.

Unless otherwise described, metering solid state equipment and precautions concerning access to dangerous voltage shall be as described in the General Requirements. Timers shall be as described in the Particular Requirements and shall be variable solid state. All equipment shall be suitable for the required application and supply voltage.

Contactors shall comply with BS 5424: Part 1 and be mounted in an enclosure complying with BS 5490 classification IP 32 for use indoors and IP 54 with corrosion - resistant finish for use outdoors. Contactors shall be utilization category AC3 of Table 2, BS 5424, unless otherwise described elsewhere in this Specification.

Contactors shall be duty rated as specified or where not so described then the appropriate rating shall be determined from the duty or function of the equipment and to the approval of the Consultant.

Where contactors are used in conjunction with earth fault relays, the contactor shall be rated to break the full earth fault current or other measures shall be taken to ensure that the fault current is safely interrupted.

Earth leakage protection shall comply with local Electricity Authorities codes.

Hours run meters shall have flush mounting non-resettable cyclometer type dials with 6 digits. The first digit shall register in 0.1 hour increments. The plastic surround shall be black of the same pattern as ammeters and voltmeters.

Ammeters shall be industrial pattern accuracy with 100 mm dials and the scale shall be marked with a red line to indicate the FLC of the motor to which it is connected.

12.1.8 Motor Control Centers (cont'd)

C) Push buttons and Switches.

Push buttons and indicating lamps shall be of matching design arranged for single hole fixing and of small body size to allow close grouping.

Terminals shall be of the screw clamp type having minimum screw size of 4 mm.

Start and stop push buttons shall be of the shrouded type. Emergency stop push buttons shall be of the mushroom push type with stop/ lock action. All push buttons for use outdoors shall be protected to IP 65.

Indicating lamps shall be of the step down transformer push to test type having 10 volt secondary and 12 volt bulbs to give long bulb life. They shall be arranged so that the bulb may be replaced from the front and shall have shallow bezels which incorporate plastic lenses of the specified colour.

When key switches are specified to match the push buttons and indicating lamps, duplicate keys shall be provided.

Engraved legend plates shall be fitted with all push buttons, indicating lamps and switches. The minimum character height shall be 3 mm. They shall be made from anodized aluminum with black enameled lettering or white/ black/white Traffolyte.

Selector switches shall be positive action rotary cam switches which shall incorporate double break contacts. They shall be of modular construction and suitable for extension to twelve cells. It shall be possible to arrange the switches for four, six or eight positions and operation shall be in either direction.

Selector switch contacts shall be double break and of hard silver alloy. They shall have a minimum continuous current rating of 10 amps and be of high breaking capacity.

Connections shall be by large terminals with clamp screws of minimum size 5 mm.

Operating knobs shall be of the type which positively indicates the position of the switch. The switch positions shall be clearly marked.

Where required for remote automatic operation the 'Local/Off/Remote' control switch shall be arranged such that in the 'local position the respective drive shall be controlled from the cubicle.

A suitable selector switch or flush mounting board shall be provided to enable the motor drive duties to be interchanged where specified for Duty/Standby operation.

Drive shafts and operating knobs shall not be of round section.

D) Terminals:

Terminals for incoming and outgoing control wiring shall be of 'Klippon' manufacture with screw type pressure connectors and of minimum size SAK 4. When more than one connector is required for each termination jumper bars shall be used.

12.1.8 Motor Control Centers (cont'd)

Terminals for incoming and outgoing power connections shall be of the bolted type using brass nuts with additional locknuts and shall be provided with cable lugs or clamp washers as required.

Partitions shall be provided between phase terminals and protection covers shall be fitted over incoming connections.

Each terminal shall be clearly and indelibly marked with the terminal designation and shall conform to the 'As Fitted' drawings.

All incoming and outgoing terminals shall be horizontal rows at least 200 mm from the cubicle base/top dependent on the cable entry.

Provision shall be made for the support of cables between the gland plate and control panel terminals.

E) Wiring

Switchgear and panel wiring shall be carried out in 600 volt grade PVC insulated cables having multistrand copper conductors of not less than 1.0 mm2 cross section terminated by crimp type lugs, tags or pins.

Swichgear and panel wiring shall be run in neat looms and shall be installed vertically and horizontally and not diagonally across any framing.

Where practicable cable looms shall be installed in PVC trunking.

Wiring shall be provided with colour coded Critchley Z type marking ferrules at every connection and termination point. The markings shall conform to the 'As Fitted' drawings.

F) Transformers:

The primary input shall be 230/400V 50Hz controlled from a way of the distribution fuse board.

The secondary outputs shall be 110 volt and 24 volt protected by two fuses in each circuit and shall be centre point earthed. Terminals for both input and output cabling shall be provided.

The transformer shall be located within its own compartment of the control board.

The control circuit of the motor starters, remote and local control circuits etc. shall be supplied at 230 voilts from a continuously rated, wound transformer with metallic earthed screen between the primary and secondary windings.

A separate control circuit cubicle shall be provided within the control board housing the transformer and associated control gear.

12.1.8 Motor Control Centers (cont'd)

The transformer shall comply with BS 3535 and be capable of controlling the whole of the board, and rated to 125% of the initial load as a minimum requirement.

The primary input voltage shall be 230/400V 50Hz controlled from a suitable fuse switch.

The secondary output of the transformer shall be 110V with one pole connected through a miniature circuit breaker and the other pole connected solidly to earth.

A removable earth link shall connect the earth side of the transformer to the earth side of the control circuit.

The earth side of the control circuit shall be wired with PVC insulated cable with all earth connections brought back to the control circuit earth terminal.

G) Starter Equipment:

Each starter shall comply with BS 4941 having Type C co-ordination and be complete with the following:

1 set of busbars and/or dropper bars of similar ratings to the incoming protection.

1 moulded case circuit breaker of suitable rating interlocked with the door for isolation and excess current protection.

1 set of contactors with auxiliary contacts, timing devices, interlocks etc. suitable for a minimum of 15 starts per hour.

1 overload and single phase protection device as specified.

Earth leakage protection devices as required by Jordan Electricity Authorities codes.

1 test switch to allow operation of contactors, relays etc. without energizing the main circuits.

1 thermal overload device to protect the rotor /stator resistance, where applicable.

1 indicator light to show motor has stopped for any reason.

1 indicator light to show motor running.

1 indicator light to show test facility has been selected.

1 set of 'START'/ 'STOP' - push buttons.

1 HAND/OFF + AUTO/OFF selector switch.

1 LOCAL/REMOTE selector switch where specified

1 230V anti-condensation heater with thermostat, hand control switch, and also auxiliary contacts to isolate the panel heater and corresponding motor heater when running.

1 set of terminals.

1 set of starting equipment as specified.

12.1.8 Motor Control Centers (cont'd)

1 suitable engraved duty label.

1 KWH meter where specified.

1 thermistor relay where specified

H) Miniature and Moulded Case Circuit Breakers

Miniature and moulded case circuit breakers shall comply with BS 3871 and BS 4752 respectively and shall be installed with due regard to the environmental conditions prevalent on site. All breakers shall be selected in accordance with the British Standards with due regard to operating characteristics, current rating, calibration and discrimination. Miniature circuit breakers shall be unconditionally rated at a category of duty M6 or higher. The effect of ambient temperatures, operating duty, and application shall be fully considered in applying de-rating factors for application at site.

Miniature and moulded case circuit breakers shall have means for preventing any one pole of a multi pole circuit breaker being operated or tripping independently of the other poles.

Miniature and moulded case circuit breakers shall have locking facilities and be supplied with all keys, or shall be enclosed in cases with locking facilities which shall be provided with keys.

Miniature and moulded case circuit breakers shall be of the same type throughout the Contract.

I) Low Voltage Fuse Switchgear and Isolator Switches

All low voltage fuse switchgear for indoor locations shall comply with:-

BS 159
BS 162
BS 4752
BS 4794
BS 5372
BS 5419
BS 5420
BS 5424
BS 5486
BS 5490

and shall be metal clad, fully dust proofed, painted to an approved finish and protected against ingress of solid foreign bodies and liquid according to IEC recommendations 144 Degree of protection IP54. Where switchgear is exposed to weather, it must be completely watertight to IP65. All units are to be suitable for cable or conduit entry as required.

12.1.8 Motor Control Centers (cont'd)

All isolators and fuse switch units shall be complete with "ON/OFF" padlocking facilities, including padlocks and keys, where complete safety can be assured only by making dead a system inside a cubicle or cabinet. The doors of the cabinet or cubicle shall have interlocking facilities so that the act of opening a door removes power from the contents of the cabinet or cubicles.

All live metal parts shall be fully surrounded between phases and from each phase to earth by moulded shrouds.

All low voltage fuses switches and isolators shall be load breaking' fault making' and each shall have a proved rupturing capacity of not less than 31 MVA at 400 Volts. All switch boards shall be of the heavy duty industrial type metal clad floor standing or wall mounting as required and as approved by the Consultant fully rust-proofed and waterproofed where exposed to weather with isolators and fuse switchgear units mounted thereon and complete with all necessary interconnections. All fuse switchgear shall carry short-circuit rating test certification.

The contractor shall submit with his design layout drawings and dimensions of all items of switchgear offered for comment and approval by the Engineer

All fuse switches shall be supplied complete with H.R.C. cartridges together with a complete set of spares.

12.2 PART 2: BUILDING MANAGEMENT & AUTOMATION SYSTEM

12.2.1 GENERAL :

1. An engineer's building automation system shall be as required by THE OPERATOR. The central console and associated equipment shall be located in the Control Room or as directed.

2. Building automation and temperature control system shall control and / or monitor the following systems:

   a. Air handling systems, including, but not limited to, single and multiple zone 100% outdoor air ventilation systems, and constant and variable volume air conditioning systems.

   b. Central utility plant, including chillers, boilers, chilled water pumps,.... etc.

      (Note: Chillers and boilers shall be provided with their own operating controls. Interface points shall be provided for remote monitoring and setpoint adjustment via building automation and temperature control system).

   c. Plumbing: Miscellaneous monitoring and alarm points as described herewithin and in the Plumbing Specifications.

12.2.1 GENERAL (CONT'D)

d. Electrical: Miscellaneous monitoring and alarm points as described herewithin and in Electrical Specifications.

e. Elevators: Alarm point monitoring as described in the elevator section of the specifications.

f. Refrigeration / Cold Rooms / Deep Freezers: Remote temperature indication.

g. Submetering:

1. Each electrical metering point as defined in Electrical Specifications.

2. Each water, chilled water, heating, steam and gas flow rate metering point as defined, in the Plumbing Specification Section 18, Article 27, " Submetering ".

3. Automatic controls must be provided for all public and hotel space systems. A totally direct digital control (DDC) system with electric actuation of control valves and dampers is the preferred type. A DDC system utilizing pneumatic control of valves and dampers is not acceptable. Sensors shall, generally, be located in the spaces they control. Return air sensors are only to be used where specified hereinafter, or as approved by the hotel operator.

4. All building automation equipment and automatic temperature controls shall be the responsibility of one manufacturer and shall be installed complete in all respects by competent mechanics, regularly employed by him.

5. Complete shop drawings are required to be submitted for approval by the designing engineer prior to starting field installation. Such drawings shall give a complete description of all equipment, controls, operating sequences, control wiring diagrams, etc..

6. After completion of the automation and control installation, the manufacturer shall regulate and adjust all sensors, control valves, damper motors, etc., and place the entire system into complete operating condition subject to the approval of the Owner's representative(s). Complete instruction shall be given to the operating personnel for a period of six days. Installation shall be guaranteed for a period of one year.

12.2.2 BUILDING AUTOMATION EQUIPMENT:

1. A central console, located in the Engineer's Control Room or as directed, shall function as the primary means of overall system control and monitoring. The following components shall be mounted on the console :

PC based network computer.

Colorgraphic CRT.

12.2.2 BUILDING AUTOMATION EQUIPMENT (CONT'D)

Logging and alarm, receive only printer.

Desk mounted direct line telephone for communications with the life safety system personnel.

a. The network computer shall include the following:

1) 128.0 MB RAM.

2) One 1.44 MB diskette drive.

3) Serial port. parallel port.

4) 8 GB internal hard disk drive.

5) Processor shall be minimum 500 MHZ Pentium 3 (or latest industry standard).

6) Mouse port.

7) Mouse.

8) 20 " SVGA video output 0.28 resolution low radiation non interlaced (1024 x 1024 pixels true colors).

9) Audio tone generator to activate on reception of an alarm. Audio tone shall be capable of being enabled or disabled on operator command.

b. Provide two printers, one printer shall be dedicated for alarms and the other for normal prints. ding reporting.

1) The printers shall be wide carriage color ink jet heavy duty type with 132 characters per line. Printers shall be provided with alarm tone sound.

2) The output typed copy shall be paper and shall be suitable for easy insertion into ring binder with calendar date and time of day automatically typed at beginning of each log.

3) The alarm printer supplied with the system shall operate when messages and alarms fall due irrespective of the network computer if off-line. The printer shall be used for the recording of information associated with system logs requested by the operator, binary off-normals of analog indication, and operator changes introduced through the keyboard. A descriptive format shall be used, for ready interpretation by the operator without use of an index or other reference.

4) The alarm printer shall utilize two-color printing or an alternative approved means to distinguish between alarm conditions and return to normal.

12.2.2 BUILDING AUTOMATION EQUIPMENT (CONT'D)

c. The colorgraphic display terminal (CRT) shall be of large capacity, 48 lines with 80 characters per line. The CRT capacity, shall be capable of displaying colorgraphics and text. The display area shall have a resolution of 1024 horizontal by 1024 vertical resolvable pixels. The CRT shall be capable of displaying 16 colors selected from a palette of 25 colors. The minimum screen diagonal measure shall be 20 inches.

d. A digital display clock shall display on the monitor at all times. Provision for manually resetting it shall be provided. It shall be a 24 hour real time clock and seven day calendar to provide data for logging.

e. Software passwords shall allow automatic functions of the system to continue, but prevent unauthorized tampering with any keyboard push buttons while the network computer is unattended. This shall not disable the scanning or alarming functions. When the network computer is in operation, it shall continuously store in memory alarm functions transmitted from local direct digital control (DDC) units regardless of what software programs are currently operating. On a loss of power to the network computer or communication with the DDC units, the DDC units shall store their respective alarm function in memory. On return of power and communication, the DDC units shall transmit their alarms to the network computer.

f. The network computer shall be capable of remote communication through a dedicated auto dial-out/auto answer dial-in modem.

g. The modem shall be capable of interface with the network computer through a standard EIA R5232-C connection. Speed/data communication rate shall be 9600 baud minimum. An operator accessing the system via a modem shall be capable of executing all commands permissible by his access level. Modem communication shall at no time interfere with the operation and performance of the network computer or the direct digital field control units.

h. The network computer keyboard and colorgraphic CRT shall be the primary means of operator access to the system, providing the operator interface for the entire system.

i. Network computer software shall be user friendly and run under the latest revisions of Disk Operating System (DOS) and Windows Software, with pull-down menus, pop-up windows, on-line help, etc.

j. Network computer software shall include a fully implemented and operational color graphic software package which shall minimize the use of a typewriter style key board through the use of a mouse. The software package shall contain g library of standard symbols and templates of typical configurations which shall be used for Owner operator generated graphics. A graphic shall be provided for each system, indicating all field devices with dynamic data displayed. In addition, a Graphic shall be provided for each floor plan indicating zone temperatures. Alarm conditions shall be indicated by a change in color of the equipment in alarm. Each graphic shall indicate if a system is in manual or automatic mode.

12.2.2 BUILDING AUTOMATION EQUIPMENT (CONT'D)

k. Network computer software shall include operator definable report generation. Reports shall include, but not be limited to, energy usage, alarm status, trend logs and point status.

l Network computer software shall include user pages, which allow an operator to define technical equipment data sheets, create messages, define maintenance instructions, etc.

m. Network computer software shall contain a trend logging feature consisting of:

1. Operator selected variables (e.g., temperatures) displayed simultaneously or individually with operator adjustable parameters.

2. Operator adjustable time intervals (15 seconds, one minute, one hour, daily, monthly).

3. Continuous storage of totalized points or groups for archive on hard disk.

4. The direct digital control system shall consist of a network of microprocessor based direct digital control units (DDC). Each direct digital control unit shall perform all specified control and monitoring functions independently. Failure of one control unit shall have no effect upon any other unit in the network. The direct digital control units shall communicate with each other and a network computer located at the central control console, located in the Engineer's Office.

a. Communications between the direct digital control units and the network computer shall be by way of a network communications cable.

b. The operator, through the network computer, shall have the ability to monitor DDC application and sensor data, override set points and schedules, set and reset control points and download programs to the local direct digital control units. The network computer is to be furnished programmed and debugged.

c. Field monitoring and control for the DDC system shall be by stand - alone field programmable, microprocessor based DDC units, which shall provide the following :

1) Monitoring and control of the facility automation and control systems.
2) Specified software functions.
3) Specified energy management functions.

d. Each direct digital control unit shall control, at a maximum three (3) central air conditioning systems provided they shall be located in the plant room. In addition, a direct digital control unit shall be dedicated to the chilled and condenser water systems, and one (1) direct digital control unit shall be dedicated to the hot water systems.

12.2.2 BUILDING AUTOMATION EQUIPMENT (CONT'D)

In addition, the system shall be configured so that the loss of a control unit will not result in loss of an entire system for those systems associated with the chilled water and hot water systems. Where this arrangement cannot be implemented, additional direct digital control units shall be provided as required. The DDC control units shall be located in the Mechanical Equipment Room.

e. DDC unit shall be housed in a key locked metal cabinet and shall have battery backup for memory and real time clock for 72 hours minimum, with automatic restart and battery recharge

f. A field programming unit, either as an integral part of the DDC control unit or as a portable hand-held terminal, and required software shall be provided to allow programming and operator interface of field DDC units. The operator shall be capable of performing any of the following functions :

1) Display the status of any point.

2) Change set points.

3) Command points on or off, with feedback verification.

4) Enable or disable existing points.

5) Report status of all points in the system.

6) Report all failed points.

7) Report all points being trended (90 minimum trend intervals).

8) Report all points being totalized.

9) Report command priority of all points.

10) Report all points in alarm status.

11) Add a new point.

12) Modify an existing point.

13) Remove an existing point.

14) Copy an existing point.

15) Adjust control settings (proportional band reset rate, etc.).

16) Initiate energy management programs.

12.2.2 BUILDING AUTOMATION EQUIPMENT (CONT'D)

17) Define control algorithms via standard function blocks and without the knowledge of computer language.

18) Acknowledge alarms.

19) View equipment operating time in hours.

g. The DDC shall be provided by 25% spare points of the total number of points as stand by, but not to be less than 4 points.

2. Each direct digital control unit shall communicate with each other and the network computer through a software " token passing" protocol. If a control unit or the network computer fails, all other devices on the communications network shall be notified of the failure and the communications network shall automatically adjust to reflect the failure. When the failed control unit(s) or network computer reestablishes communications, all other devices on the Network shall be notified and normal communications shall resume.

3. The direct digital control units shall store system alarms in memory on loss of communication with the network computer, or a loss of power to the network computer. When power or communication is restored, the direct digital control units shall transmit the stored alarms to the network computer.

4. The building automation and temperature control system shall interface with the fire protection alarm panel described in the Electrical Section.

5. The DDC unit shall be capable of performing the following minimum energy management functions:

Supply air reset from specific load demands.

Economizer control.

Optimal start using an adaptive algorithm to prevent the need for manual adjustment of parameters.

100% return air startup phase prior to physical occupancy.
Warm-up mode.
Cool-down mode.
Intermediate season (dead zone) control.
VAV fan matching and supply fan control.
Trending of system variables at DDC or network computer.
Short term data storage.
Totalization of system variables.
Time of day, week and holiday programming.
Supply water reset.
Duty cycling.
Adjustable staggered restart.
Client tailored programs.

12.2.2 BUILDING AUTOMATION EQUIPMENT (CONT'D)

Peak Demand Control for electricity and district heating where high demand charges are applied.

Night setback for selected heating or cooling circuits and air handlers.

Dynamic control strategies.

Indoor air quality control for areas with large change in occupancy in order to reduce outside air requirements, e.g., lobby, Function Rooms serving more than 100 people, etc.

Display of real time efficiency of chillers and boilers.

Multiple chiller automatic start/stop.

Automatic control (open/close) of steam supply to laundries and Kitchens.

Automatic recording of degree-days.

7. Pocket Paging System

A pocket pager interface shall be provided to accept alarm signals originating from the Building Automatic System (BAS), either directly or via the building telephone system, to achieve the desired indications on pocket pagers. The BAS provider must coordinate with the designers of the paging and/or telephone systems to ensure the proper signals are originated and received. Each alarm signal shall be given two codes: Priority and type of trouble/equipment code.

12.2.3 SYSTEM POINTS

The minimum requirement for remote points which shall be transmitted to the central control console for display alarm and/or specified operation are listed herewithin for guidance only. Other points may be required depending upon the intended operation of the Hotel for its location or the "System Control Types" listed herewithin. Operator defined "Special Instructions" shall be simultaneously displayed with the alarm. Number of alarms shall be recorded at the network computer by alarm type and system for further analysis. The network computer software shall be configured so that nuisance alarms shall be suppressed when failures occur (i.e., power loss, communication loss, DDC unit malfunctions, etc.).

Refer to control diagrams drawings for minimum requirement of remote points.

12.2.4 TEMPERATURE CONTROL MATERIALS :

1. Automatic Control Valves:

   a. All automatic control valves shall be fully proportioning with modulating plug or V-port inner guides, unless specified otherwise: The valves shall be quiet in operation and fail-safe in either normally open or normally closed position in the event of control failure. All valves shall be capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load requirements. The valves shall be capable of operating in sequence when required by the sequence of operation. All control valves shall be sized by the Control Engineer or the Contractor and shall be guaranteed to meet the heating and cooling loads as specified. All control valves shall be suitable for the pressure conditions and shall close against the differential pressures involved. All control valves shall have throttling guides and renewable seats and discs. Valve operators shall be electric spring return type, capable of a 30 second travel from full open to full close and full close to full open. Body pressure rating and connection type (screwed or flanged) shall conform to pipe schedule. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent. Where pressure and flow combinations exceed ratings for commercial valves and operators, industrial class valves and operators shall be provided.

   b. Steam control valves shall be single seated type with equal percentage flow characteristic Reheater and water heater valves shall be normally discus shall be composition type with bronze trim for steam pressure up to 105 kPa (15 psig) and shall be of stainless steel for steam pressures above 105 kPa (15 psig). Whenever the steam flow rate is such as to require a single valve larger than 65 mm. (2-1/2 inches), there shall then be installed two valves in parallel which shall operate sequentially. Low pressure (15 psig) steam valve shall provide tight closure at a pressure at least 10 psig higher than the normal. maximum operating pressure.

   c. Hot water control valves shall be single seated type with equal percentage flow characteristics. When used on reheaters, they shall be as specified under system control types. The valve discs shall be composition type with bronze trim.

   d. Chilled water valves shall be of three or two port as specified and shall be of throttling type. Three-way type and bypass valves shall have equal percentage flow characteristics. Valves shall be single seated type, except where pressure and flow combination exceed rating for commercial valve operators, industrial class valves and operators shall be used.

   e. Fan coil unit water control valves shall be of two way flare fitting motorized valves. Control valves for dual temperature operation shall include a built-in a quastat. Valves shall be furnished complete with flare nuts. Manufacturer shall furnish ten spare valves.

12.2.4 TEMPERATURE CONTROL MATERIALS (CONT'D)

f. All motorized valves shall be of the butterfly type with lug ends and shall be furnished with electric spring return motor operators. Valve body shall be carbon steel with 316 stainless disc, 17-4 pH stainless shaft. Seat and seal materials shall be teflon. The valve shall be provided with a speed control device (adjustable) to prevent the valve from too rapid a closure rate. Valves shall be rated in all sizes for bubble tight closure at 150 psi differential across the disc and a maximum operating temperature of 2.12'F. The motor operator shall be provided with an external position indicator. Valves shall be full-bodied, full lug type only (wafer type or semilugged valves will not be permitted). Valves shall be bolted from both ends of the flanges.

g. All motorized valves shall be provided with manually operated hand wheels for overriding the operator.

2. Duct Smoke Detectors:

These detectors shall have output of two signals, one signal relayed to the BMS and the other to be relayed to the fire detection system, through input modules specified under electrical section.

3. Damper Operators :

a. All damper operators shall be electric spring-return type such that damper will fail-safe upon interruption of electric power. The failure position shall be as specified or as required to suit job conditions. Dampers shall be capable of a 30 second travel from full open to full closed and full closed to full open.

The operators shall be capable of operating in sequence when required by the sequence of operation. The operators shall have external adjustable stops to limit the stroke in either direction. The operator linkage arrangement shall be such as to permit normally open or normally closed positions of the dampers as required.

b. A sufficient number of damper operators shall be installed to operate single and multiple damper sections smoothly and in unison at the maximum rated static pressure and air velocity, and to provide the close-off torque required to meet damper leakage criteria. Provide auxiliary drive shafts with pillow block bearings and bearing support brackets rigidly attached to the damper frame assembly on damper banks more than one damper section wide.

4. Dampers :

a. Dampers Which Require opposed Blade Action:

1) Dampers in modulating service such as outdoor air, return air and spill air dampers in air conditioning systems.
2) Outdoor air intake, exhaust air, and recirculation air dampers in ventilation systems which are under modulating control.

12.2.4 TEMPERATURE CONTROL MATERIALS (CONT'D)

b. Dampers Which Require Parallel Blade Action :

1) Dampers in two position service such as outdoor air intake and exhaust air dampers in ventilation systems which are under two-position control.
2) Fan discharge dampers.
3) Floor isolation dampers in supply and return air ducts.

c. The bearings shall be nonferrous sleeve type. The frames shall be of 89mm.x13 mm. (3-1/2 in.x1/2 in.) channel iron with welded corners and stiffening members to form a rigid assembly. Dampers shall have both blades and frames galvanized. All dampers shall have stainless steel blade end seals, and the edges of the blades shall be crimped with neoprene seals to interlock in order to prevent leakage when dampers are closed.

5. Watt-Hour Transducers :

1) Watt-hour transducers shall included a 2 wire, 4-20 mA transmitter and transducer. Potential and current transformers will be provided under the Electrical Section of the Specifications. Mount transmitter and transducer in a single nema enclosure, suitable for 1, 2, 3 element, single-phase and/or three phase service at the a.c. line voltage level. Nominal potential input shall be as indicated on electrical drawings.

2) Each transmitter shall be factory adjusted to a calibrated accuracy of.1% over the operating span. Provide certified calibration sheet from manufacturer with 2 year warranty. Manufacturer shall be Rochester Instrument Systems, Series WWH, Scientific Columbus Exceltronic watt-hour transducer. Wiring between current transformers, potential transformers and the kwh transducer, and between the kwh transducer and the DDC system, shall be provided by this Contractor.

6. Differential Pressure Transmitters

a. Differential pressure transmitters shall be variable capacitance type arranged for 2 wire, 4-20 mA control signal output. Transmitter shall be enclosed in a gasketed, dust and watertight housing. A11 body cavities open to the process fluid shall be provided with drain ports at the top of the cavity. Both drain and vent ports shall be minimum 1/4 inch-18 NPT. The transmitter shall have continuously adjustable (externally) zero and span.

b. The differential pressure range span shall be adjustable to permit maximum zero elevation of 600% of calibrated span and a maximum zero suppression of 500% of calibrated Span. These adjustments shall be made within the transmitter housing without a change of parts. The transmitter housing of sustaining differential pressures in either direction, up to the body rating without damage to the instrument or a loss of accuracy or zero shift.

c. The transmitter shall be fully compensated for both process and ambient temperature variations and a calibrated accuracy of +0.25% of calibrated Span.

12.2.4 TEMPERATURE CONTROL MATERIALS (CONT'D)

7. Annubars:

   a. Annubars shall be industrial type, Dietrich Standard Corporation annubars.

   b. Assembly shall consist of an averaging pilot tube (annubar) flow element and a differential pressure transmitter. Assembly shall be provided with insertion/retraction mechanism complete with 1 inch cast steel ball Value, compression fitting nipples, contoured weld coupling required for installation.

   c. Annubar flow element shall be installed so that the total head pressure ports are set in line with the pipe axis facing upstream and the static pressure port is facing downstream.

   d. Annubars shall be installed in plane with upstream elbow, with a minimum of 10 upstream and 5 down stream pipe diameters of straight run. If a modulating valve is installed upstream of the annubar, 25 pipe diameters of straight run are required.

   e. Accuracy shall be $\pm$0.1% of actual value. Repeatability shall be $\pm$0.1% of actual value. Annubars shall be suitable for the design pressures and temperatures involved.

   f. Annubars shall be provided with all necessary mounting hardware to allow for the removal of the flow sensor under pressure without shutting down the pipeline. The annubar shall be provided with a 1/8 inch female NPT by 1/2 inch male NPT adaptor for the future connection of 1/2 inch impulse tubing and 1/2 inch pipe-to-tube connector.

   g. Frequency Inverter
   Frequency Inverter drives shall be suitable for use on standard squirrel cage motors as specified and be of the pulse width modulation type. The control range shall be 0.5 to 120Hz. The motor nameplate current shall not be exceeded on start up.

   Frequency Inverter drives shall be capable of connection to a motor already rotating in the correct direction at any speed up to the specified maximum without braking the motor to a standstill, and connection to a motor driven fan wind milling in reverse direction without causing tripping, and returning the fan correctly to the set conditions of speed and direction.

   Drives shall withstand 500 milliseconds mains interruption without causing tripping and be fully protected against any electrically induced disorders without operating fuses.
   Drives shall be suitable for local and remote control and provide means of running at a fixed (selectable) speed on closure of a remote volt-free contact, overriding the speed control reference.

   Frequency inverters shall have digital display of all operating conditions and recall of design limits. These shall be keyboard adjustable where applicable.

12.2.4 TEMPERATURE CONTROL MATERIALS (CONT'D)

Volt-free contacts shall be provided to monitor all alarm functions.

A4-20mA analog output signal shall be provided, programmable for, but not limited to, the following:

(i) output frequency
(ii) reference signal
(iii) output current
(iv) motor torque
(v) motor power.

The manufacturer of the frequency Inverter drive shall ensure that the Inverter and motor are entirely compatible and shall provide details regarding the production of harmonics, mains borne and airborne (radiated, magnetic or electro-static) interference. Written guarantees shall be given that disturbance levels will not exceed the limits of the EEC Electromagnetic Compatibility (EMC) Standards.

Frequency inverters shall comply in all respects with the UL or relevant British and European Standards.

12.2.5 ELECTRICAL WIRING AND MATERIALS :

1. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. All wiring, except plenum cable, shall be installed in conduit.

   a. Provide wiring and conduits between all field control and alarm devices and unit controllers and DDC's and Building Management System.

   b. Provide primary voltage power supply to every direct digital control unit, CRT, network computer, transmission power supply, annunciator module, modem, intercom module, printer, and to other devices as required in this Section. It is the intent that the entire building automation system and all peripheral devices, alarms etc., shall be in the building. The power supplies are to be extended in conduit and wire from available spare circuit in emergency panel boards.

   c. Provide status function conduit and wiring for equipment covered under this Section.

   d. Provide conduit and wiring between the direct digital control system panels and the temperature, humidity, or pressure sensing elements, including low voltage (under 100 volt) control wiring and coaxial cable in conduit.

   e. Provide conduit and control wiring for devices specified in this Section.

   f. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in direct digital control units located in the vicinity of motor control centers.

12.2.5 ELECTRICAL WIRING AND MATERIALS (CONT'D)

g. Provide conduit and wiring between the network computer, electrical panels metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contractors, and direct digital control unit, as shown on the drawings or as specified.

h. Provide control and signal conduit and wiring between the DDC system and the chiller control panels, and all control and signal interwiring between the chillers and their local control panels.

2. All conduit shall be in accordance with the Electrical Section and all local Codes.

3. Wires and cables shall be as follows:

a. Single Conductor (primary voltage/a.c.):

1.5 mm.^{2} (No.12 AWG) stranded copper with 600 volt insulation color coded red for hot leg, white for neutral, black for all others, for use in conduit. Larger gauge cables shall be provided where necessary to limit the voltage drop to 3% or 3.6 volts. 1.5 mm.^{2} (No. 12 AWG) shall be used for instrument heat tracing feeders.

b. Signal Cables (4-20 mA Analog) :

1) For Use in Areas Other Than Air Plenums :

2/C 1.0 mm.^{2} (No.16 AWG) shielded and multi-pair 0.75 mm.^{2} (No. 20 AWG) individually shielded.

2) For Use in Air Plenums:

Plenum type teflon insulated, 2/C 1.0 mm.^{2} (No. 16 AWG) shielded and multipair 1.0 mm.^{2} (No. 20 AWG) individually shielded.

NOTE:
The cables listed above have conductors with 300 volt insulation ratings. Similar cables with 600 volt insulation ratings must be provided for any cable terminating within or occupying an enclosure containing conductors operating at a voltage greater than 240 volts (i.e., 415 volt motor starter enclosure).

c. Alarm, Digital input/output and Control Cables (C24 volt a.c.) :

1) For Use in Areas Other Than Air Plenums:2/C 1.0 mm.^{2} (No.16 AWG), and multi-pair 0.75 mm.^{2} (No. 20 AWG).

2) For Use in Air Plenums: Plenum type teflon insulated, 2/C 1.0 mm.^{2} (No. 16 AWG) and multi - pair 0.75 mm.^{2} (No. 20 AWG).

3) Larger gauge cables shall be provided where necessary to limit the voltage drop to 1.2 volts.

12.2.5 ELECTRICAL WIRING AND MATERIALS (CONT'D)

NOTE:

The cables listed above have conductors with 300 volt insulation ratings. Similar cables with 600 volt insulation ratings must be provided for any cable terminating within or occupying an enclosure containing conductors operating at a voltage greater than 240 volts (i.e., 415 volt motor starter enclosure).

d. RTD Wiring :

1) For Use in Areas Other Than Air Plenums: 3/C 1.0 $mm.^2$(No. 16 AWG).

2) For Use in Air Plenums: Plenum type teflon insulated 3/C 1.0 $mm.^2$ (No. 16 AWG).

e. DDC Communications Cables:

DDC communications wiring between the local control unit and the network computer shall be 1.0 $mm.^2$ (No. 16 AWG) shielded cable, and shall be run in trays where available, otherwise in approved raceways.

4. Tags for wires and cables shall be clip-sleeve type nonmetallic wire markers or equivalent.

5. For conduit fittings, conduit hangers and supports, terminal junction boxes, expansion joints, sleeves and wiring devices, see applicable paragraph of the Electrical Section.

12.2.6 ELECTRICAL WIRING INSTALLATION :

1. All wiring in Mechanical Equipment Rooms, communications or electrical closets shall be in approved raceways (cable tray, conduit, etc.). Open wiring strung above ceilings shall be plenum rated cable, bundled together and protected from mechanical damage. Wiring shall be independently supported from the building structure with bridal rings and clips. The supporting of wiring from mechanical ductwork or piping is not acceptable.

2. Cables for primary voltage a.c. wiring and low level signal wiring (i.e., 4-20 mA analog) shall always be run in separate raceways.

3. Use liquid tight flexible metal conduit, 1/2 inch minimum size, for making connections at instruments and devices mounted on piping or vessels or on equipment subject to vibration.

4. Low level signal wiring homeruns to local control stations may be by means of multi-pair cables. The number of pairs in such cables shall be uniform throughout the installation, and, in general, there shall be at least 20% spare pairs in each such cable.

12.2.6 ELECTRICAL WIRING INSTALLATION (CONT'D)

5. Primary voltage a.c. circuits used for control and instrumentation shall be taken from panel boards connected to the emergency power distribution system, with the exception of circuits powered from motor starters. Panel board and circuit breakers shall be provided under the Electrical Section, but the wiring and raceway materials and installation for ATC system power requirements shall be furnished under this Section.

6. Primary voltage a.c. circuits used for control and instrumentation shall be dedicated to the ATC system and shall not be used for any other purposes.

7. Conveniently located terminal junction boxes shall be used for the transition from the single pair local signal cables to the multi-pair home run cable. These boxes shall have "terminal schedules" attached to the inside of their covers displaying the terminals and the service tags of the cables terminated there.

8. Conduits shall be run exposed in mechanical spaces, concealed in occupied space, and parallel or perpendicular to structural members or architectural features.

9. Bends in conduit shall not have a radius less than six (6) times the diameter of the conduit, nor bend more than 90 degrees, and shall be in accordance with local Codes.

10. Provide junction boxes or pull boxes as required and necessary to avoid excessively long runs or too many bends between outlets.

11. Fittings in conduit containing multi-conductor cables shall be oversized to accommodate 3 times cable bending radius for 90 degree bends and 4 times bending radius for straight runs.

12. Expansion fittings shall be provided with bonding jumpers. Expansion joint fittings shall be provided at each point where conduits cross expansion joints and conduit is rigidly attached to structure on both sides of joint. Where there is a 45 degree or greater bend and five feet of unconfined conduit on one side of the joint, the fittings may be omitted.

13. For conduit supports and installation of wires and cables, see applicable paragraphs of the Electrical Section.

14. Conduit entering a cabinet, box, trough, etc., shall be secured with a locknut on the outside and on the inside, such that the conduit system is electrically continuous throughout. A bushing shall also be provided on the inside. Bushings shall be mortal with insulated throats. Locknuts shall be the type designed to bite into the metal, or on the inside of the enclosure shall have a grounding wedge lug under the locknut. Top or side of any enclosure in a nonfinished area such as Garages, Substation Rooms, etc., shall be terminated with screw tape waterproof hubs.

15. Conduit box type connectors for conduit entering enclosures shall be the insulated throat type.

16. Conduits shall be offset where they enter surface mounted equipment. Wiring installed in panels and other enclosures shall be neatly looped and laced.

12.2.6 ELECTRICAL WIRING INSTALLATION (CONT'D)

17. Conduit runs which extend from the interior to the exterior of a building shall be sealed to prevent the circulation of air. This shall be accomplished by the installation of sealing fittings.

18. All signal wires shall be tagged with their wire designations and all signal cable pairs shall be tagged with their service designations where terminated at devices and in terminal boxes.

19. Wires shall be terminated with insulated spade type lugs on screw terminals. Soldered connections shall only be made at instruments where no other means of termination is practical.

20. Perform continuity testing for all wiring installed.

21. Control raceways shall not be hung from electrical raceways or attached to ceiling grid hanger wires.

22. Percent fill of conduit shall not exceed Code maximum, regardless of service.

23. No 300 volt insulated wiring shall terminate within or occupy any enclosure containing conductors operating at a voltage greater than 300 volts. This particularly applies to any analog or digital I/O wiring entering 208 volt motor starter enclosures or motor control centers.

24. Provide, install and wire receptacles for control room devices.

25. Exhaust Fans Sequence :

    1) Fan Off : Discharge damper closed.

    2) Fan On : Discharge damper open.

    3) High temperature sensor or smoke detector on suction side of fan stops when air temperature rises above 51 C.(125 F.).

12.2.7 INSTRUMENTATION

1) Adequate instrumentation shall be provided for system operation evaluation, system adjustment and system malfunction indication.

2) Pressure gauges shall be fitted with shutoff cock rend in the pressure range of the system, minimum 114 mm. (4-1/2 inch) diameter case, white face with black numbers and pointer.

3) Thermometers shall be installed in water systems with separable sockets. Bronze sockets shall be used in nonferrous systems and stainless steel in ferrous systems. Thermometers shall be mercury actuated, 230 millimeter (9 inch) scale, for field adjustment.

12.2.7 INSTRUMENTATION (CONT'D)

4) Thermometers shall be installed in duct systems with separable sockets. Thermometer shall have uniform scale, 90 millimeter (3-1/2 inch) dial, and suitable range for application.

SCHEDULE OF INSTRUMENTATION

Item	Location
Pressure Gauges,	inlet and outlet of each pump inlet and outlet of each chiller evaporator inlet and outlet of each heat exchanger inlet and outlet of each preheat coil inlet and outlet of each cooling coil inlet and outlet of each reheat coil upstream and downstream of each pressure reducing valve station

Note: Gauge cocks only are to be installed at reheat coils in hung ceilings.

Thermometers	each pump header inlet and outlet of each chiller evaporator inlet and outlet of each chiller condenser inlet and outlet of each heat exchanger inlet and outlet of each preheat coil inlet and outlet of each cooling coil inlet and outlet of each reheat coil supply fan discharge duct return fan intake duct

END OF SECTION