



BMS Specification

Version: 01

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1 Introduction

This specification is to be read in conjunction with the latest revision of the following:

- 1) Bid specification BOQ which includes the points list
- 2) The information within this specification relates to the BMS design, procurement, installation and setting to work. Any discrepancies or contradictions shall be referred to the Engineer for review prior to purchasing or proceeding. The BMS contractor shall design, supply, install, test and commission a complete and fully integrated and operational automatic monitoring and controls system as indicated within this package including interfacing with the ICT network. The BMS shall be a DDC based control system comprising Supervisory Controllers (inclusive of downstream stand-alone DDC Controllers) communicating directly with field sensors and actuators which communicate with the central monitoring and control stations.
- 3) This documentation shall be read as part of the combined project package. Make all due allowances for interfaces between Work Packages and trades against items detailed within each separate Works Package technical documentation. All requirements outlined in the various project documentation packages shall equally apply to this scope of works whether directly stated or referenced. In the event of any conflict between packages, the more stringent requirement shall be considered the project requirements, and any the conflict shall be raised to the Engineer before proceeding with procurement.

1.1 Objectives

1. The intent of this specification is to:
 - a) Define the priorities and objectives that shall guide the design & documentation decisions
 - b) Define the technical requirements for the equipment, installation, testing, commissioning & documentation
 - c) Equipment requirements
 - d) Preparation of documentation for submission to the engineer
 - e) Installation of equipment
 - f) Commissioning of equipment

1.2 Scope delineation

1. The following table confirms the scope of the supplier's supply:

Table 1-1 Scope delineation

Delineation of scope					
Item	Description	Responsible Contractor			
		BMS	Electrical	HVAC	Supplier
1	Manufacture, supply, deliver to site BMS equipment as put out in the points list and BOQ	X	-	-	-
2	Manufacture, supply and deliver to site Plant controllers	X	-	-	-
3	Install and commission Plant controllers	X	-	-	-
4	Install communication between flow meter and chiller	X	-	-	-
5	Installation of flow meters and pressure sensors (supply by BMS)	X	-	-	-
6	Communication connections between BMS, plant & field sensors to CPC	X	-	-	-
7	FAU connection to BMS	X	-	-	-
8	Data hall temperature and humidity sensors supply, installation and link to BMS	X	-	-	-
9	Leak detection supply, installation and link to BMS	X	-	-	-
10	CRAC units link to BMS	X	-	Install temp sensors supplied with CRAC units	-
11	All graphics and set-up of standard trending as per existing trend reporting	X	-	-	-
12	Commissioning (as per RACI matrix)	X	-	-	X

1.3 Information to be provided with Tender

- As a minimum, the following information shall be provided with Tender and table to be signed as confirmation:

Table 1-2 Confirmation of information to be provided

Information		Confirmed submitted
a)	Tender Equipment Schedule and Scope Delineation	
b)	Tender Summary	
c)	Schedule of rates	
d)	Delivery schedules	

1.4 Programme

- Provide a programme of works.

1.5 Warranty

- The warranty shall incorporate the following:
 - Warranty commences the day the plant has been commissioned and continues for a period of 12 months after commissioning (L3-SAT, not PC). Allowance is to be made for an extension of 12-24months after this period lapses at additional cost.
 - Warranty means that all patent and latent defects will be rectified by the Vendor arising from defective materials, workmanship or design at his expense during the warranty period.
 - Warranty excludes defects that may arise from the misuse or abuse by the Employer.
 - Servicing of the equipment is to be conducted during continuous operation, when the unit is in cold standby mode.

2 Design Requirements

2.1 Industry Standards & Guidelines

- All work shall meet all the requirements of national and local Statutory Authorities and shall be in accordance with the following:

Table 2-1 Industry standards

Standard Number	Description
ASHRAE 90.4	Thermal energy standard for data centres
ASHRAE TC9.9	Data centre powered equipment thermal guidelines best practices
SANS 10400	South African national standards
OSH Act 1993	The Occupational Health and Safety Act of 1993, as amended
SANS 10142	Wiring of premises
	Government, Provincial and Local authorities ordinances, regulations, by-laws, rules and other statutory requirements
SANS	Specifications and codes of practice issued by the South African Bureau of Standards and British Standards Institute. The former shall have precedence over the latter where both bodies have issued conflicting specifications or codes of practise.

3 Specification – BMS

3.1 Definitions

BMS Contractor	shall provide a common head-end graphical user interface in accordance with the requirements of the specification.
Building Engineering System Installers	The Building Engineering System are the installers of the various Works Package systems and sub-systems
IDF	Intermediate Distribution Frame – The equipment racks or cabinets containing the edge switches and associated patch panels.
NOC	Network operations centre – The room(s) containing the central network hub equipment, servers and data storage etc. associated with the Security systems.
UPS	Uninterruptible power supply
LAN	Local Area Network
UTP	Unshielded twisted pair (cabling)
VLAN	Virtual Local Area Network
PoE	Power over Ethernet
VPN	Virtual Private Network
SNMP	Simple Network Management Protocol

3.2 Strategy Establishment

- 1) The BMS Contractor shall lead the controls integration of all Works Packages and coordinate the BMS interfaces and integration. The BMS Contractor shall lead coordination between the BMS and all associated interfacing systems to ensure full and complete data connection and interfaces across the platforms, information relaying and representation at the Graphical User Interface. This includes:
 - a) Provision and location of hard wired (low level) contacts in control panels and field equipment
 - b) High level interfacing direct to the BMS Supervisory Controllers or head end
 - c) High level interfaces to use BACnet protocol unless otherwise agreed with the Engineer
- 2) The BMS Contractor shall at all times undertake to ensure that all targeted goals are achieved. As and when any risks arise that could compromise the achievement of one or more of the targeted goals, the Contractor shall bring these to the attention of the Engineer immediately.

- 3) The BMS Contractor shall carry out such design activities as required to complete the installation. These activities include:
 - a) Design and development of the BMS including software, controls function, network architecture
 - b) Coordination with all other Contractors and interfacing Work Packages and identify all network interfacing physical connections and software communication protocols before any Works Package procurements.
 - c) Selection of control items in coordination with all other trade Contractors.
 - d) Control strategies for incorporation into the description of the operation document. This is to be based on the sequence of operations provided
 - e) The Graphical User Interface (GUI) including coordination and management of all Work Package system interfaces with the BMS for full connection and interoperability across the ICT systems. Via the BMS GUI, the Operator shall be capable of monitoring, representing and trending all interfacing systems
 - f) The BMS Contractor shall allow all points as indicated within any of the various project works specifications, drawings and schematics to ensure full operation of all detailed equipment and systems

3.3 Supply and Install

- 1) Supply and install a complete integrated Building Management System including but not limited to the following elements:
 - a) Building Management System providing supervisory management, monitoring over a range of building systems as further described
 - b) Mechanical services Direct Digital Control (DDC) system
 - c) Installation and integration to vendor specific supervisory controllers and plant management systems
 - d) System interfaces and graphical representation of all associated systems interfacing with the BMS
- 2) The BMS shall monitor building energy consumption and system performance and operation of the air conditioning system through predictive analysis and data tracking based on a whole of system performance. It shall include monitoring the out-of-hours operation of any portion of the BMS building and tenant areas as well as calculation of instantaneous and annual PUE.
- 3) The BMS shall also monitor and dynamically represent operating conditions for all systems interfacing with the BMS either via High Level Interface (HLI) or Hard Wired (HW). This shall be done graphically via visual screen system representation and shall include dynamic operational status and alarms identification.
- 4) The Building Management System shall as a minimum:

- a) Be capable of operating at a system level even if the ICT Network is lost, with the information automatically reinstated upon Network reconnection. The network installed under this part of the works shall be fully redundant ring network such that the loss of any switch will not affect the network on either end of the switch nor will a break in the network ring effect anymore that a single switch at most.
- b) Dedicated web based server with UDP/IP protocol in accordance with BACnet for communications and graphical user interfaces
- c) Provide the Graphical User Interface for the various Works Package building integrated systems connected into the BMS. This includes all building engineering system interfacing modules, software, testing and commissioning and the like across Work Packages to ensure a fully functional, and tested integrated building engineering system
- d) Monitor the mechanical services
- 5) Wiring of control valves and damper actuators shall be coordinated with the associated MEP works.
- 6) Submit functional specification at start of project covering initial commissioning plan. These are to be continually updated and maintained live throughout the installation and commissioning process
- 7) Water leak detection system interfacing with BMS
- 8) Network time synchronization of all events and alarms and for of all devises connected to the BMS
- 9) Inclusive of all necessary hardware, software and licenses to perform the specified functionality. All Licenses shall be for the lifetime of the system software / hardware
- 10) The BMS includes, but is not limited to:
 - a) Field devices, actuators, sensors, microprocessor BMS controllers, relays, switches and associated control wiring.
 - b) Software including control algorithms, real time graphics, alarm handling and trend logs.
 - c) Operator workstation, with personal computer, printer, and backup storage device.
 - d) BMS Panels
 - e) Supervisory and plant controllers
 - f) Local start/stop switches and run on timer controls
 - g) Field and network cabling
 - h) Integration with Head End systems via high-level interface.
 - i) All High Level Interfaces (HLI) communication and software to allow for correct interface between various building services systems.

- j) UPS backup and STS for single supply network switches and Supervisory Controllers to allow continuity of operation through a loss of power and generator start-up event.
 - k) Interconnecting cables and patch leads.
 - l) Underground cabling shall run in conduits provided by the Main Contractor.
 - m) Cabling, containment and high level interface from BMS to the associated building operational systems.
 - n) Cabling, containment and interface connection from the BMS to the terminal strip within Mechanical Control Panels.
- 11) Install patch leads to provide required connectivity.
- 12) If additional cabling is required for connectivity external to the works areas, design, provide, terminate and test all additional cabling required.

3.4 Technical Proposals

- 1) The following is considered detail final design by the BMS Contractor:
 - a) Final design shall be prepared in accordance with the Specification. The Technical proposals shall include the following data/ information as a minimum. The order of listing here is not intended to indicate, nor should it be construed to indicate the relative importance of the data/ Information.
- 2) Information on organizational capability to handle this project (management, personnel, manufacturing, single source responsibility, etc.).
- 3) Information on training program to demonstrate Specification compliance.
- 4) System Configuration as proposed
 - a) Describe system architecture including a schematic layout with location and type of all control panels.
 - b) Describe system operation, functions and control techniques.
 - c) Modularity.
 - d) Provisions against obsolescence due to technological advancement.
- 5) Technical data to support the information on the hardware configuration.
- 6) Detailed description of all operating, command, application and energy management software provided for this project.
- 7) A signed certificate stating that the Contractor 'has read the performance and functional requirements, understanding them and his Technical Proposal shall comply with all parts of the Specification'.

3.5 Construction Stage

The BMS Contractor shall submit the following:

- 1) Shop Drawings and schematics.
 - a) Shop Drawings shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages.
- 2) Equipment and systems requiring acceptance of the Statutory Authorities shall comply with such regulations and be accepted.
- 3) The BMS Contractor shall correct any errors or omissions noted in the first review.
- 4) BMS network architecture diagrams including all nodes and interconnections, system schematics, sequences and flow diagrams, interfaces with other services, location and identifier of equipment and controls and sensors, tray and conduit layouts, switchboard and control panel layouts with terminal numbering, cable type and size and marking, control logic diagrams, label schedule and metering tree's.
- 5) BMS Functional Descriptions describing:
 - a) Operational intent of each system and equipment
 - b) Normal mode operation
 - c) Event mode operation (multiple scenarios for key areas)
 - d) Fire mode operation
 - e) Loss of power operation
 - f) Start up, shut down and changeover
 - g) I/O points list
 - h) Alarm actions and priorities
- 6) Points schedule in the BMS shall identify each hardwired (I/O), VSD connection, software with data points, communication protocol, baud rate, device ID. All points shall individually present:
 - a) Object Name.
 - b) Expanded ID.
 - c) Display Units.
 - d) Controller Type.
 - e) Address
 - f) Samples of Graphic Display screen types and associated menus.
- 7) Detailed Bill of Materials list for each system or application, identifying quantities, part numbers, description and optional features.

- 8) Room Schedule including a separate line for each unit indicating location and address. Details of all BMS interfaces and connections to the work of other trades.
- 9) Product data sheets or marked catalogue pages, including part number, photo and description for all products, including software
- 10) Submit manufacturer's specifications for all components of the system, including installation instructions and system generation instructions.
- 11) All product data should be provided for consultant acceptance, including list of materials used with complete part number, data points summary (schedule of Input/ Output points), drawings that show control over mechanical/ electrical section, sequence of operation (performance narratives), complete technical catalogues of submitted devices that comply with the consultant's technical specifications.
- 12) All instrument installation plans, detailed panel diagrams, point to point wiring diagrams, control loops and control diagram including detailed sequence of operation using the accepted part numbers.
- 13) Provide completed description for each cable (type, size, function, tag, etc.).
- 14) Provide identification tags for all control equipment on the appropriate mechanical/ electrical sections.
- 15) Supplementary Product Literature: Include a statement from the manufacturer for the design life of the system.
- 16) Certified test data.
- 17) Outline technical specifications reflecting proposed materials and systems.
- 18) A list of proposed suppliers and Subcontractors intended to be used.
- 19) Submit within 2 weeks of award of Contract a schedule of manufactures of equipment, materials and components. This shall include the following:
 - a) BMS Panel and controllers
 - b) Room temperature & humidity sensors
 - c) Pipe temperature sensors
 - d) Water pressure sensors
 - e) Duct velocity grids and sensors
 - f) Duct humidity sensors
 - g) Fresh Air sensors
 - h) Electromagnetic Flow meters
 - i) Actuators for modulating dampers
 - j) Air filter sensors

- k) LAN switches
- 20) Sample of each of the above shall also be provided
- 21) Range of submissions: Submit manufactures data for all equipment, materials, components and systems to be provided including the following **as applicable**:
- a) Functional specifications
 - b) Control valve selections and sizing calculation
 - c) Evidence of compliance with specified product certification schemes
 - d) Evidence of coordination with other trade Contractors
 - e) Drawings, showing size, arrangement, operating and maintenance clearances
 - f) Schematic wiring and control drawings
 - g) Type test reports
- 22) Performance and rating curves or tables marked with each selection showing for duty point and part load conditions:
- a) Capacity
 - b) Energy consumption and power factor
 - c) Recommendations for installation and maintenance.
 - d) Preliminary Method Statement.
 - e) Preliminary Quality Plan.
 - f) Summary of deviations from the Specification.
 - g) Comply with the local Municipality Submittals requirements

3.6 Execution

3.6.1 Examination

- 1) Verification of Conditions: Examine areas for compliance with requirements for installation and conditions affecting performance of the Work. Identify conditions detrimental to a proper and timely completion and notify the Engineer of the unsatisfactory conditions. Proceed with installation only after unsatisfactory conditions have been corrected.

3.6.2 Delivery

The contractor shall allow for the following:

- 1) Storage of equipment off-site
- 2) Delivery to the site
- 3) Protection of equipment on site

- 4) Fixing equipment and materials
- 5) Installation and wiring of all BMS items

3.6.3 Co-Ordination

- 1) Liaise with the other Works Contractors to co-ordinate the physical location of all services to avoid clashes and to facilitate installation and maintenance. BMS Contractor shall follow and number all signals in accordance with the approved standard.

3.6.4 Painting, Finishes and Identification

- 1) All equipment, sensors and devices shall come to the site with factory finishes to the colour nominated by the Engineer
- 2) All services exposed or visible through the ceiling are to be painted black or to a colour to be confirmed by the Engineer
- 3) All services exposed or visible from Public Areas are to be painted to a colour to be confirmed by the Engineer
- 4) All equipment is to be professionally painted
- 5) Traffolyte labelling and individual identification and scheduling of all field equipment and devices including modulating dampers, motorised valves, Supervisory Controllers, stand alone DDC Controllers etc
- 6) Labelling and individual identification of all services at locations of access and within back of house areas including plantrooms and risers
- 7) Only pre-galvanized cable trays shall be allowed in the data hall

3.6.5 Installation

- 1) During the Progress of the Site Work the contractor shall:
 - a) Advise on the correct siting and installation of controls and the correct wiring of the controls.
 - b) Particular attention shall be paid to the mounting of actuators on valves, dampers, the correct linkages from actuators to valves and dampers and that all controls and instruments are installed with adequate clearance for removal. Clearances shall be such that all wiring connections may be visibly inspected without removing the equipment.

3.6.6 Spare Parts

- 1) Manufacturers to provide full replacement during the warranty period and provide a list of recommend spares with material submittals during approvals process.

3.7 Operation and Maintenance (O+M) Manuals

- 1) Include component list with manufacturer's reference numbers, descriptions of materials and procedures for repairing and cleaning of finishes and cleaning frequency.

- 2) Backup procedures for the BMS including all controllers and panels
- 3) Project specific systems, communication and software configurations including protocols, gateway, trouble shooting and remedial. A manufacturers catalogue alone will not be accepted
- 4) 3 x copies of the Operation and Maintenance (O+M) Manuals shall be provided to the Engineer upon completion of the project. The entire Operation and Maintenance (O+M) Manual shall be furnished in soft copy and include the following for the BMS provided:
 - a) As-built system record drawings. Computer Aided Design (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
 - b) Manufacturer's product data sheets or catalogue pages for all products, including software.
 - c) System operator's manuals.
 - d) Archive copy of all Site-specific datasets and sequences.
 - e) BMS network diagrams.
 - f) Interfaces to all third-party products and work by other trades.
- 5) The Operation and Maintenance (O+M) Manual CD shall be self-contained and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display zoom and search all documents.
- 6) On-line documentation: After completion of all tests and adjustments the Contractor shall provide a copy of all as-built information and product data to be installed on a customer designated computer workstation or server.

4 Design criteria

4.1 General

- 1) The equipment shall be of proven design and manufacture and shall be manufactured and supplied by a well-established organization specializing in such systems.
- 2) The system shall be installed, calibrated and commissioned by personnel fully trained and experienced in this field. Such personnel shall be approved employees or representatives of the equipment manufacturer or his agent.
- 3) The supplier shall agree to carry out the entire design and programming of the system in their local office.
- 4) The control equipment is to function normally under the following ambient conditions:
 - a) Temperature 5°C to 55°C.
 - b) Humidity 10% RH to 95% RH non-condensing

c) Sensors and devices to be suitable for the local environment, including fine dust carried in suspension in the atmosphere.

5) System Response Times

a) Times below are maximum overall elapsed times after initial event (non-cumulative). Critical system response times shall be minimised.

Table 4-1 System response times

Function	Response	Timeframe
Alarm category 1 or 2	Supervisory Controllers detection	5s
	Workstation alarm	10s
	Event initiated action	10s
Alarm category 3, 4 or 5	Supervisory Controllers detection	10s
	Workstation alarm	30s
	Event-initiated action	30s
Priority global command (fire, safety)	Supervisory Controllers action	15s
Normal global command	Supervisory Controllers action	60s

6) Graphic Display Delays:

- a) Refresh of values displayed on graphics at the operator’s workstations: To be minimised and not more than 5s
- b) Generation of a graphic following transfer from another graphic: To be minimised and not more than 5s
- c) Boot up time from switching on PC to viewing graphics: <60s

5 Scope of works

5.1 General

- 1) In addition to the details as put out above, the BMS Contractor shall also allow for the following:
 - a) Licence upgrade as per BOQ.
 - b) Relocation of the existing NOC room

6 Systems, products and devices

6.1 Quality Assurance

The BMS and its associated elements shall comply with the following:

1) Acceptable Manufacturer:

- a) Bids by wholesalers, Franchised Dealers, Channel Partners or any firm whose principal business is not that of manufacturing and installing direct digital control systems for Building Management shall not be acceptable.
- b) The system shall be installed by vendor-accredited competent technicians under the supervision of the manufacturer.
- c) Single source responsibility of the supplier shall be the complete installation and proper operation of the BMS and control system. It shall include debugging and proper calibrations of each component in the entire system.
- d) Supplier shall have an in-place support facility within a 50 kilometre radius of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment, complete maintenance and support services on a 24-hour-a-day, 7-day-a-week basis. Evidence of this requirement being met shall be submitted with the tender. As evidence and assurance of the Contractor's ability to support the Employer's system with service and parts, the Contractor shall have been in the BMS business for at least 15 years and have completed projects of at least the value of this Contract in each of the preceding 5 years.
- e) Submit for the Engineer's review and acceptance qualifications and experience details of the proposed installer's project manager, project engineer, engineering staff, and electronic technicians to be involved with the supervision, engineering and installation of the automatic controls and BMS. All submitted materials shall be in English. The Contractor shall submit 3 complete sets of documentation (Product Data, Shop Drawings and Technical Proposals).
- f) Comply with ASHRAE 135 for DDC system components.

2) All electronic equipment shall conform to all requirements and regulations which govern radio frequency electromagnetic interference.

3) BMS shall comply with UL Listed / CE Mark and be listed at the time of bid.

4) All system components shall be designed and built to be fault-tolerant.

5) Satisfactory operation without damage at 10% above and 15% below rated voltage and at +3 Hertz variation in line frequency.

6) Static, transient and short circuit protection on all inputs and outputs.

7) Communication lines protected against incorrect wiring, static transients and induced magnetic interference.

- 8) Bus connected devices shall be AC coupled or equivalent so that any single device failure shall not disrupt or halt bus communication.
- 9) All field real time clocks and data file RAM shall be battery backed for a minimum of 15 minutes.
- 10) It shall be possible to receive and print out alarms at the central location, even when the host computer is non-operational or taken out of service for periodic maintenance.

6.2 BMS Functionality

- 1) Fully integrated building management system (BMS) incorporating Direct Digital Controls (DDCs) for energy trending and monitoring including colour graphic workstations (GUI).
- 2) The BMS shall be IP based and consist of the following:
 - a) Supervisory Controllers
 - b) Stand-alone DDC Controllers.
 - c) BMS Control Station
 - d) Portable operator's terminals.
 - e) Personal computer operator workstations.
 - f) Modular BMS in nature permitting expansion of both capacity and functionality through the addition of sensors, actuators, Controllers and operator devices.
- 3) BMS with system architectural design to eliminate dependence upon any single device for alarm reporting and control execution. Each Supervisory and DDC Controller shall operate independently by performing its own specified control, alarm management, operator Input/Output and data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices. Controllers shall be able to access any data from, or send control commands and alarm directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central processing device. In the event of failure of any critical equipment which is controlled and supervised by the BMS, the DDC Controllers shall also be able to send alarm reports to multiple operator workstations and contact via a wireless connection selected mobiles of FM staff (auto-dial DDC Controllers) without dependence upon a central processing device.
- 4) The BMS system is an expansion of the existing Tridium and PME platforms.
- 5) Access to system data shall not be restricted by the hardware configuration of the building integrated system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.

6.3 BMS Network Architecture

6.3.1 Open Systems

Managed switch & static switch for power

- 1) The BMS system shall be an extension of the existing system, platform and communication protocols shall mainly consist of BACnet IP as well as Modbus IP. The network backbone extension shall consist of 24 pair multi-mode fibre (laser optimized 50/125 OM3 minimum) connecting to at least layer 3 switches. The network topology will be a ring feed extending from the existing A & B servers.
- 2) Connections between Supervisory Controllers and the Network utilizing the Network Ethernet TCP/IP (fiber optic backbone). Each Supervisory Controller shall have IP connection to the Network. Connections between Supervisory Controllers, Stand Alone DDC Controllers and major field controllers to be BACnet MS/TP
- 3) The Field Controller LAN shall comply with BACnet ISO 16484-5
- 4) Provision for communication between operators workstations and other systems or buildings. System to system interface shall be fully interoperable and open, proprietary data communications protocol, TCP/IP on ISO 8802.3 (Ethernet).
- 5) Interoperability is defined that controllers from proprietary system "A" can be connected to the system architecture where there may be controllers from proprietary system "B".
- 6) Values from either system can be equally logged, alarmed, displayed on schematics, audit trailed for changes and interact to provide the most economical building control strategy.
- 7) All sub-systems integrating into the BMS shall be open protocol and directly compatible to the BMS. Any gateways shall be provided fully lifetime licensed
- 8) The system shall be able to utilize different protocols and architectures to maximize the media infrastructure.

6.3.2 Automation / Monitoring Network

- 1) The automation network shall be based on a PC industry standard over IP. Where used, LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.
- 2) The BMS shall network multiple user interface clients, supervisory controllers, system controllers and application-specific controllers.
- 3) All BMS devices on the automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
- 4) Supervisory Controllers shall reside on the automation network.
- 5) The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

6.3.3 Control Network

- 1) Controller hierarchy:

- a) Supervisory Controllers. Network system interface
 - b) DDC Controllers (ULC's's). Network system interface. Major equipment
 - c) Terminal Equipment Controllers. Minor equipment and field devices
- 2) Supervisory Controllers shall provide supervisory control over the BMS control network and shall support the following communication protocol:
 - a) BACnet / IP ISO 16 484-5
 - b) BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9
 - 3) The Controller shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
 - 4) The Controller shall be tested and certified as a BACnet Building Controller (B-BC).
 - 5) Control networks shall provide either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.
 - 6) DDC Controllers shall reside on the control network
 - 7) Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.
 - 8) A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.
 - 9) Two-wire UTP communication is only permitted between field controllers and minor peripheral devices.

6.4 Software and Systems

6.4.1 Licenses

- 1) Provide all necessary software licenses and agreements extended for lifetime.

6.5 Supervisory/Plant Controllers

- 1) Supervisory Controllers shall be capable of performing all following operations.
 - a) Logical Operations
 - i) AND, IF_THEN_ELSE, OR, NAND, NOR, NOT, XOR
 - b) Mathematical Operations
 - i) ADD, SUBTRACT, DIVIDE, MULTIPLY, SQUARE, SQUARE ROOT, AVERAGE,
 - ii) HIGH OR LOW SELECT
- 2) Calibration. Provide facility for individual sensor calibration and span adjustment.

6.5.1 High level interface software

- 1) Control Loops

a)Types: Two position, step, floating, proportional, proportional plus, integral, proportional plus integral plus derivative and adaptive.

b)Adjustments: Setpoints, differentials, proportional bands, reset and derivative functions.

6.5.2 Communications

- 1) Each Supervisory Controllers shall be capable of communication peer to peer and to the operators workstations.
- 2) If network communication is lost, Supervisory Controllers shall continue to operate as stand-alone controllers.
- 3) Where values derived from the network (eg cooling call, Fresh Air temperature) are utilised, the commissioned value shall continue to be used on loss of communication, until communication is restored.

6.5.3 Start and Stop Schedules.

- 1) Provide equipment start and stop schedules resident on the Supervisory Controllers serving each item of equipment, and a facility to download amendments to the schedule from the operations workstation.

6.5.4 Power Failure Alarm Suppression and Plant Restart.

- 1) If loss of power occurs at a Supervisory Controllers, suppress consequential alarms and upon restoration of power, restart the plant in an orderly sequence and reactivate alarms.

6.5.5 Backup Facility.

- 1) It shall be possible to down-load and up-load all application software between operators workstation and Supervisory Controllers for storage on hard disk and back-up to tape.

6.5.6 Local Access to Supervisory Controllers Software

- 1) Modifications to application software or set-points shall be possible from the operators workstation, Supervisory Controllers keypad (if fitted) or Supervisory Controllers lap top connection. Such changes shall be password-protected.

6.5.7 Report generation.

- 1) Report generation to be customizable for parameter selections without reprogramming to meet the users' requirements

6.5.8 User Interface

- 1) Each Supervisory Controller shall have a touch screen User Interface (UI) as previously described. All computers connected to the automation network shall have access to the UI.
- 2) The UI software shall be embedded in the Supervisory Controllers. Systems that require a local copy of the system database on the user's personal computer are not acceptable.

- 3) The user shall have the capability to access all system data through one Supervisory Controller.
- 4) Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.
- 5) The Supervisory controller shall support the following functions using a standard latest version of Microsoft Internet Explorer:
 - a) Configuration
 - b) Commissioning
 - c) Data Archiving
 - d) Monitoring
 - e) Commanding
 - f) System Diagnostics
- 6) The Supervisory Controllers shall allow temporary use of portable devices without interrupting the normal operation.
- 7) The Supervisory Controllers shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
- 8) The Supervisory Controllers shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
- 9) The Supervisory Controllers shall be tested and certified as a BACnet Building Controller (B-BC).
- 10) A BACnet Protocol Implementation Conformance Statement shall be provided for the Supervisory Controllers.
- 11) The Supervisory Controllers shall support a minimum of 50 control devices.
- 12) Each Supervisory Controller shall have sufficient memory, a minimum of one day of trended storage, to support its own operating system and databases, including:
 - a) Control Processes.
 - b) Energy management applications.
 - c) Alarm management applications, including custom alarm messages for each level alarm for each point in the system.
 - d) Historical/ trend data for points specified.
 - e) Maintenance support applications.
 - f) Custom processes.
 - g) Operator Input/ Output.
 - h) Manual override monitoring.
 - i) Built-in port for (POT) portable.

6.5.9 Control Software Description.

- 1) As well as the described logical functions, the Supervisory controllers shall have the ability to perform the following pre-tested control algorithms:
 - a) Two-position control.
 - b) Proportional control
 - c) Proportional plus integral control.
 - d) Proportional, integral, plus derivative control

6.5.10 Control functionality.

- 1) Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any 1 hour.
- 2) Upon the resumption of normal power, each Supervisory Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.
- 3) Supervisory Controllers shall have the ability to perform any or all the following energy management routines:
 - a) Time-of-day scheduling.
 - b) Calendar-Based scheduling.
 - c) Temporary schedule overrides.
 - d) Start-stop time optimization.
 - e) Enthalpy demand limiting.
 - f) Temperature-compensated duty cycling.
 - g) Fan speed control.
- 4) All programs shall be executed automatically without the need for operator intervention and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Sequence of Operation.
- 5) Supervisory Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines. It shall be possible to use any of the following in a custom process:
 - a) Any system measured point data or status.
 - b) Any calculated data.
 - c) Any results from other processes.
 - d) User-defined constants.
 - e) Arithmetic functions (+, -, *, square root, exp, etc.).

- f) Boolean logic operators (and/ or, exclusive or, etc.).
- g) On-delay/ off-delay/ one-shot timers.
- h) Custom processes may be triggered Based on any combination of the following:
 - i) Time interval.
 - j) Time-of-day.
 - k) Date.
 - l) Other processes.
 - m) Time programming.
 - n) Events (e.g. point alarms).
- 6) A single process shall be able to incorporate measured or calculated data from any and all other Supervisory Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other Supervisory Controllers in the network.
- 7) Processes shall be able to generate operator messages and advisories to operator Input/ Output devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
- 8) The custom control programming feature shall be documented via English.
- 9) Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Supervisory Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the Supervisory Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local Input/ Output device or communications with other panels on the network.
- 10) All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
- 11) The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of 6 No. priority levels shall be provided for each point. Point priority levels shall be combined with user-definable destination categories (PC, printer, Supervisory Controllers, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controllers shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
- 12) Alarm reports and messages shall be directed to a user-defined list of operator devices or PCs.
- 13) In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.

- 14) Each Supervisory Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.
- 15) Supervisory Controllers shall be RJ45 or similar network connection to enable a laptop computer to interrogate the network from the Supervisory Controllers
- 16) Supervisory Controllers shall store programs so that they are retained during power failure of up to two weeks, with batteries that automatically recharge upon mains power availability.
- 17) Operator-selected alarms shall initiate a call to a remote operator device. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the Input/ Output summary.
- 18) Supervisory Controllers shall store historical data for selected analogue and digital inputs and outputs. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Supervisory Controllers point group. 2 No. methods of collection shall be allowed: either by a predefined time interval or upon a predefined change of value. Sample intervals of 1 minute to 7 days shall be provided. Each Supervisory Controllers shall have a dedicated RAM- Based buffer for trend data and shall be capable of storing a minimum of 25,000 data samples.
- 19) Trend data shall be stored at the Supervisory Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in third party personal computer applications.
- 20) Supervisory Controllers shall also provide high-resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point Input/ Output summary. Provide capability to view or print trend and tuning reports.
- 21) In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into selected LOOP statement.
- 22) For troubleshooting in manual mode, the operator shall be able to select variables to override default values. Calculated PID gains shall then be reviewed before they are inserted into the selected LOOP statement.
- 23) Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation or remotely. For all loop-tuning functions, access shall be limited to authorized personnel through password protection.
- 24) Supervisory Controllers shall automatically accumulate and store run-time hours for digital input and output points as indicated in the point Input/ Output summary.

- 25) Supervisory Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly Basis for user-selected analogue and digital pulse input type points as indicated in the point Input/ Output summary.
- 26) Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, litres, watt, tons, etc.).
- 27) The Totalization routine shall have a sampling resolution of 1 minute or less.
- 28) The user shall have the ability to define a warning limit. Unique, use specified messages shall be generated when the limit is reached.
- 29) Supervisory Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event Totalization shall be performed on a daily basis for points as indicated in the point Input/ Output summary.
- 30) The event Totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.
- 31) The user shall have the ability to define a warning limit. Unique, use specified messages shall be generated when the limit is reached.
- 32) Monitoring of the following type of inputs, without the addition of equipment outside the Supervisory Controllers:
 - a) Analog inputs: 4-20mA, 0-10Volts DC, thermistors, 1000 ohm RTDs, PT1000, LG-Ni 1000, PT100, 0-20mA.
 - b) Digital inputs: Dry contact closure, Pulse accumulator, Voltage sensing.
 - c) Direct control of electronic actuators and control devices. Each Supervisory Controllers shall be capable of providing the following control outputs without the addition of equipment outside the Supervisory Controllers:
 - d) Digital outputs (contact closure): Contact closure maintained, Contact closure pulsed, Contact closure staged.
 - e) Analog outputs: 0-20psi, 4-20mA, 0-10Volts DC.
- 33) Each Supervisory Controllers shall have a minimum of 25% spare capacity after Testing and Commissioning for future point connection. The type of spares shall be in the same proportion as the implemented Input/ Output functions of the panel, but in no case shall there be less than 2 No. spares of each implemented Input/ Output type. Provide all processors, power supplies and communication controllers complete ensuring that the implementation of a point only requires the addition of the appropriate point input/ output termination module and wiring.
- 34) Provide sufficient internal memory for the specified control sequences, for 1 day trended storage, and have at least 25% of the memory available for future use at the completion of Testing and Commissioning.

- 35) Supervisory Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals.
- 36) For critical systems where there are multiple devices or equipment serving the same function under duty share or duty standby (eg chilled water pumps, plantroom AHU, smoke extract fans etc), the equipment / devices shall be separately configured so that they are grouped and served from at least separate Supervisory Controllers
- 37) As indicated in the point Input/ Output schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the Supervisory Controllers via local, point discrete, on-board hand/ off/ auto operator override switches for digital control type points and gradual switches for analogue control type points. These override switches shall be operable whether the panel processor is operational or not.
- 38) Switches shall be mounted either within the Supervisory Controllers key-accessed enclosure, or externally mounted control has been inhibited. Supervisory Controllers shall also collect override activity information for reports.
- 39) Supervisory Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. Supervisory Controllers shall also collect override activity information for reports.
- 40) Supervisory Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator Input/ Output device. Graduated intensity LEDs or analogue indication of value shall also be provided for each analogue output. Status indication shall be visible without opening the panel door.
- 41) Each Supervisory Controllers shall continuously perform self - diagnostics and communication diagnosis of all panel components. The Supervisory Controllers shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
- 42) Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEE Standard 587-1980.
- 43) In the event of the loss of normal power, there shall be an orderly shutdown of all Supervisory Controllers to prevent the loss of database or operating system software.
- 44) Non-volatile memory shall be incorporated for all critical controller configuration data and individual battery backup shall be provided to support the real- time clock and all volatile memory for a minimum of 72 hours.
- 45) Upon restoration of normal power, the Supervisory Controllers shall automatically resume full operation without manual intervention.

46) Should Supervisory controller memory be lost for any reason, the user shall have the capability of reloading the Supervisory Controllers via the local RS-232C port, ~~via telephone line dial in~~ or from a network workstation PC.

6.6 DDC Controllers (ULC's)

- 1) DDC Controllers will be responsible for monitoring major mechanical equipment including Air Handling Units (AHU), Outdoor Air Handling Unit (OAHU), Computer Room Air Conditioning (CRAC) Units, Pumps and Fans (and their associated equipment valves, dampers and sensors)
- 2) The DDC Controllers (or Unit level controllers / ULC's) shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol
- 3) The ULC shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
- 4) The ULC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
- 5) The ULC shall be tested and certified as a BACnet DDC Controllers (B-ASC).
- 6) A BACnet Protocol Implementation Conformance Statement shall be provided for the ULC.
- 7) Shall be capable of performing all the following operations:
 - a) Logical Operations
 - i) AND, IF_THEN_ELSE, OR, NAND, NOR, NOT, XOR
 - b) Mathematical Operations
 - i) ADD, SUBTRACT, DIVIDE, MULTIPLY, SQUARE, SQUARE ROOT, AVERAGE,
 - ii) HIGH OR LOW SELECT
 - c) Calibration. Provide facility for individual sensor calibration and span adjustment.

6.6.1 Control Loops

- 1) Types: Two position, step, floating, proportional, proportional plus, integral, proportional plus integral plus derivative and adaptive.

6.6.2 Adjustments:

- 1) Setpoints, differentials, proportional bands, reset and derivative functions.

6.6.3 Control Functions.

- 1) Enthalpy control, optimum start/stop, night set back, thermostat/pressure stat, duty cycling, reset, load shed, scheduling, pulse counting.

6.6.4 Communications

- 1) Each Controller shall be capable of communication peer to peer and to the operators workstations.

- 2) If network communication is lost the DDC Controllers shall continue to operate as stand-alone controllers.
- 3) Where values derived from the network (eg cooling call, Fresh Air temperature) are utilised, the last recorded value shall continue to be used on loss of communication, until communication is restored.

6.6.5 Start and Stop Schedules

- 1) Provide equipment start and stop schedules resident on the DDC Controllers serving each item of equipment, and a facility to download amendments to the schedule from the operations workstation.

6.6.6 Local Access to Controllers Software

- 1) Modifications to application software or set-points shall be possible from the operators workstation, Supervisory Controllers keypad (if fitted) or Supervisory Controllers lap top connection. Such changes shall be subject to password protection.

6.6.7 User interface

- 1) The Controllers shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
- 2) The Controllers shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
- 3) The Controllers shall be tested and certified as a BACnet Building Controller (B-BC).
- 4) A BACnet Protocol Implementation Conformance Statement shall be provided for the Controllers.
- 5) The Controllers shall support a minimum of 50 control devices.
- 6) Each Controller shall have sufficient memory, a minimum of 4.5 Megabytes, and one day trended storage, to support its own operating system and databases, including:
 - a) Control Processes.
 - b) Energy management applications.
 - c) Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - d) Historical/ trend data for points specified.
 - e) Maintenance support applications.
 - f) Custom processes.
 - g) Operator Input/ Output.
 - h) Manual override monitoring.
 - i) Built in port for (POT) portable.

j) Software Description. As well as the described logical functions, the Controllers shall have the ability to perform the following pre-tested control algorithms:

- k) Two-position control.
- l) Proportional control
- m) Proportional plus integral control.
- n) Proportional, integral, plus derivative control
- o) Control functionality.

6.6.8 Control software

- 1) Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any 1-hour period.

6.6.9 Control functionality

- 1) The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
- 2) Upon the resumption of normal power, each Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.
- 3) Controllers shall have the ability to perform any or all the following energy management routines:
 - a) Time-of-day scheduling.
 - b) Calendar-Based scheduling.
 - c) Temporary schedule overrides.
 - d) Start-stop time optimization.
 - e) Temperature-compensated duty cycling.
 - f) Fan speed control.
- 4) All programs shall be executed automatically without the need for operator intervention and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Sequence of Operation.
- 5) DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines. It shall be possible to use any of the following in a custom process:
 - a) Any system measured point data or status.
 - b) Any calculated data.

- c) Any results from other processes.
- d) User-defined constants.
- e) Arithmetic functions (+, -, *, square root, exp, etc.).
- f) Boolean logic operators (and/ or, exclusive or, etc.).
- g) On-delay/ off-delay/ one-shot timers.
- h) Custom processes may be triggered Based on any combination of the following:
 - i) Time interval.
 - j) Time-of-day.
 - k) Date.
 - l) Other processes.
 - m) Time programming.
 - n) Events (e.g. point alarms).
- 6) A single process shall be able to incorporate measured or calculated data from any and all other Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other Controllers in the network.
- 7) Processes shall be able to generate operator messages and advisories to operator Input/ Output devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
- 8) The custom control programming feature shall be documented via English.
- 9) DDC Controllers shall also provide high-resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point Input/ Output summary. Provide capability to view or print trend and tuning reports.
- 10) In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
- 11) For troubleshooting in manual mode, the operator shall be able to select variables to override default values. Calculated PID gains shall then be reviewed before they are inserted into the selected LOOP statement.
- 12) Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation or remotely. For all loop-tuning functions, access shall be limited to authorised personnel through password protection.
- 13) Controllers shall automatically accumulate and store run-time hours for digital input and output points as indicated in the point Input/ Output summary.

- 14) Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly Basis for user-selected analogue and digital pulse input type points as indicated in the point Input/ Output summary.
- 15) Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, litres, watt, tons, etc.).
- 16) The Totalization routine shall have a sampling resolution of 1 minute or less.
- 17) The user shall have the ability to define a warning limit. Unique, use specified messages shall be generated when the limit is reached.
- 18) DDC Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event Totalization shall be performed on a daily basis for points as indicated in the point Input/ Output summary.
- 19) The event Totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.
- 20) The user shall have the ability to define a warning limit. Unique, use specified messages shall be generated when the limit is reached.
- 21) Monitoring of the following type of inputs, without the addition of equipment outside the Controllers:
 - a) Analog inputs: 4-20mA, 0-10Volts DC, thermistors, 1000 ohm RTDs, PT1000, LG-Ni 1000, PT100, 0-20mA.
 - b) Digital inputs: Dry contact closure, Pulse accumulator, Voltage sensing.
 - c) Direct control of electronic actuators and control devices. Each Controllers shall be capable of providing the following control outputs without the addition of equipment outside the Controllers:
 - d) Digital outputs (contact closure): Contact closure maintained, Contact closure pulsed, Contact closure staged.
 - e) Analog outputs: 0-20psi, 4-20mA, 0-10Volts DC.
- 22) Each DDC Controller shall have a minimum of 20% spare capacity at the completion of Testing and Commissioning for future point connection. The type of spares shall be in the same proportion as the implemented Input/ Output functions of the panel, but in no case shall there be less than 2 No. spares of each implemented Input/ Output type. Provide all processors, power supplies and communication controllers complete ensuring that the implementation of a point only requires the addition of the appropriate point input/ output termination module and wiring.
- 23) Provide sufficient internal memory for the specified control sequences, for 1 day trended storage, and have at least 25% of the memory available for future use at the completion of Testing and Commissioning.

- 24) Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals.
- 25) For critical systems where there are multiple devices or equipment serving the same function under duty share or duty standby (eg chilled water pumps, plantroom AHU, smoke extract fans etc), the equipment / devices shall be separately configured so that they are grouped and served from at least separate DDC Controllers
- 26) As indicated in the point Input/ Output schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the Controllers via local, point discrete, on-board hand/ off/ auto operator override switches for digital control type points and gradual switches for analogue control type points. These override switches shall be operable whether the panel processor is operational or not.
- 27) Switches shall be mounted either within the Controllers key-accessed enclosure, or externally mounted control has been inhibited. Controllers shall also collect override activity information for reports.
- 28) Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. Controllers shall also collect override activity information for reports.
- 29) Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator Input/ Output device. Graduated intensity LEDs or analogue indication of value shall also be provided for each analogue output. Status indication shall be visible without opening the panel door.
- 30) Each Controllers shall continuously perform self - diagnostics and communication diagnosis of all panel components. The Controllers shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
- 31) Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEE Standard 587-1980.
- 32) In the event of the loss of normal power, there shall be an orderly shutdown of all Controllers to prevent the loss of database or operating system software.
- 33) Non-volatile memory shall be incorporated for all critical controller configuration data and individual battery backup shall be provided to support the real- time clock and all volatile memory for a minimum of 72 hours
- 34) Upon restoration of normal power, the Controllers shall automatically resume full operation without manual intervention.
- 35) Should controller memory be lost for any reason, the user shall have the capability of reloading the Controllers via the local RS-232C port, via telephone line dial-in or from a network workstation PC.

- 36) Provide a separate Controllers for each AHU, pumps, fans and other main HVAC system equipment. It is intended that each unique system shall be provided with its own point resident Controllers.
- 37) The ASC shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
- 38) Controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable. The ASC shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
- 39) Each DDC Controller shall be able to extend its performance and capacity through the use of remote DDC Controllers (ULCs).
- 40) Each ASC shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network.
- 41) Each ASC shall be microprocessor-based, multi-tasking, real-time digital control processor.
- 42) Modulating control equipment (AHU, Pumps, Fans etc)
- 43) Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide hand/ off/ automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised to inform the system that automatic control has been overridden. As a minimum, 50% of the point inputs and outputs shall be of the Universal type, allowing for additional system flexibility. In lieu of Universal inputs and outputs, provide a minimum of 50% spare parts of each type via additional point termination boards or controllers.
- 44) Each controller shall support its own real-time operating system. Provide a real time clock with battery backup to allow for standalone operation in the event communication with its DDC Controller is lost and to ensure protection during power outages. Clock accuracy : <5 seconds per anum, with resolution to 100 milliseconds
- 45) Point database, operating programs, local alarming and local trending. All database and programs shall be stored in non-volatile EEPROM or a minimum of 15 minute battery backup shall be provided (batteries automatically charged upon power rest). All programs shall be field-customized to be in accordance with the user's exact control strategy requirements. Central system controllers utilizing pre-packaged or canned programs shall not be accepted. As an alternative, provide DDC Controllers for all central equipment to be in accordance with custom control strategy requirements.

6.6.10 PC Hardware.

- 1) Existing system to be integrated to.

6.6.11 Operating System Software

- 1) Existing system to be integrated to.

6.7 Equipment Enclosures

- 1) Equipment enclosures in the following areas shall be provided with protection in accordance with BS EN 60529:1992 Specification for degrees of protection provided by enclosures (IP code).
 - a) Dry plant rooms and internal locations: IP42
 - b) Wet plantrooms: IP 55
 - c) Wet plantrooms and outdoor locations: IP 65

6.8 BMS Hardware

6.8.1 Field Level Devices - Input Devices

- 1) General Requirements
 - a) Installation, testing and calibration of all sensors, transmitters and other input devices shall be provided to meet the system requirements.
 - b) Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
 - c) The temperature sensor shall be of the resistance type and shall be with 4 wire RTD to have accuracy of reading.
 - d) All sensors and devices shall be industrial type
- 2) Space Temperature Sensor.
 - a) Room temperatures sensors: Thermistor type with resistance approximately 10,000 Ohms at 00C. Mount 1500mm above finished floor level behind a tamper resistant cover.
 - b) Accuracy: <0.2°C over 55°C span
 - c) Annual drift: <0.2°C
- 3) Fresh Air Sensors
 - a) Fresh Air sensors shall be designed to withstand the environmental conditions to which they shall be exposed. They shall also be provided with a solar shield.
 - b) A perforated plate that surrounds the sensor element shall shield sensors exposed to wind velocity pressures.
 - c) Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

d) Type: Thermistor similar to the room temperature sensors noted above. Mount in a fresh air intake duct or in a shaded ventilated weatherproof enclosure.

4) Duct Mount Sensors

a) Duct mount sensors shall be mounted in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.

b) Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.

c) For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

d) Duct cross-section <1.0 m²: Thermistor type with sensing element located on 100mm long probe.

e) Duct cross-section >1.0 m²: Averaging sensor >2m long. Accuracy: <0.2°C over 55°C span

f) Annual drift: <0.2°C.

g) Duct Pressure Sensor

h) Type: Capacitive with range 0 to 300 Pa and accuracy of +10 Pa.

i) Duct Velocity Sensor

j) Type: Fixed, duct mounted, pressure sensing grid transmitting pressure differential signal for determination of airflows for continuous BMS monitoring of supply, return, outside and exhaust air.

k) Accuracy: 5%

l) Velocity range: 1m/s to 10m/s.

5) Thermo wells

a) When Thermo wells are required, the sensor and well shall be supplied as a complete assembly, including well head and fitting.

b) Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.

c) Thermo wells and sensors shall be mounted in a thread outlet or ½" NPT saddle and allow easy access to the sensor for repair or replacement.

d) Thermo wells shall be SS barstock with insertion length ¾th of the pipe size. It shall be based on the service of the sensor.

6) Pipe Temperature Sensor

a) Type: Thermistor or thin film platinum resistance type. Install in pipe mounted sensor pockets filled with conducting paste.

b) Accuracy: <0.2°C over 55°C span

- c) Annual drift: <0.2oC.
- d) Provide grade 316L stainless steel sensor wells to allow sensors to be withdrawn without draining the pipe.
- e) Provide lagging extensions for insulated piping.

7) Averaging Sensors

- a) For ductwork greater in any dimension than 1200mm and/ or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.
- b) For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/ or air turbulence. The averaging string shall have a minimum of 4 sensing points per 3650mm long segment.
- c) Capillary supports at the sides of the duct shall be provided to support the sensing string.

8) Humidity Sensors

- a) The sensor shall be a solid state type, relative humidity sensor of the bulk polymer design. The sensor element shall resist service contamination.
- b) The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20mA, 0-100% linear proportional output.
- c) The humidity transmitter shall be in accordance with the following overall accuracy of +4%RH for the range of 10% to 90% RH and +6%RH from 0 to 10 %RH and 90 to 100%RH, including lead loss and analogue to digital conversion.
- d) Fresh Air relative humidity sensors shall be installed with a rainproof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with saltine fittings and stainless steel bushings.
- e) A single-point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
- f) Duct type sensing probes shall be constructed of polycarbonate lexan 950 and anodized aluminum 6061-F.
- g) Room humidity sensor:
 - h) Type: Polymer thin film capacitor. Mounted behind a tamper-resistant cover matching the adjacent room temperature sensor
 - i) Accuracy +/-2% RH at 24oC
 - j) Annual drift <2% RH at 24oC.
 - k) Outside air humidity sensors: Polymer thin film capacitor type similar to the room temperature sensors. Mount similarly.

9) Differential Pressure Transmitters for General Air and Water Pressure Transmitter

- a) Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
- b) Pressure transmitters shall transmit a 0-5Volts DC, 0-10Volts DC, or 4-20mA output signal.
- c) Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the Balancing Subcontractor and Employer permanent, easy-to-use connection.
- d) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover.
- e) A minimum of NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.
- f) 2 way and 3 way manifolds shall be installed for pressure transmitter and differential pressure transmitter for water service
- g) Water pressure sensor
- h) Type: Diaphragm operated strain gauge or capacitive type
- i) Range 0 to 400kPa or 0 to 150kPa as appropriate
- j) Accuracy <5% of range.

10) Differential Pressure Switches for Air

- a) Pressure switches shall be diaphragm operated. They shall be supplied with air connections permitting their use as static or differential pressure switches.
- b) The switch shall be of differential pressure type complete with connecting tube and metal bends for connections to the duct. The housing shall be IP54 rated.
- c) The pressure switches shall be available in a minimum of 3 ranges suitable for applications like airflow proving, dirty filter, etc. The set point shall be concealed type. The contact shall be of the automatic reset type with SPDT contacts rated for 2Amps at 250Volts AC.
- d) A complete installation kit shall be provided, including static pressure taps, tubing, fittings and air filters.

11) Differential Pressure Switches for Water

- a) Pressure switches shall be selected for the correct velocity and pipe size and mounting conditions.

12) Flow Switches for Water

- a) Flow switches shall be selected for the correct velocity and pipe size and mounting conditions.

13) Water Line Pressure Sensor

- a) Low Pressure range: -1 to 8 bar
- b) High pressure range: 0 to 30 bar
- c) Material: Stainless steel 1.4435, IP Class-65. It shall comply with IEC 68 standard for vibration/ shock resistance.
- d) It shall use the principle of Piezo-resistive principle pressure sensitive chip for great longtime stability and highly reliable.
- e) The detector shall have sensitivity such that a change of 0.2% from the stabilized condition shall cause modulation of the corrective element.
- f) 2 way and 3 way manifolds shall be installed for pressure transmitter and differential pressure transmitter for water service

14) Duct Air Flow Measuring Stations

- a) Each device shall be designed and built in accordance with and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of Fundamentals, as well as in the Industrial Ventilation Handbook.
- b) Airflow measuring stations shall be fabricated of 14-gauge galvanized steel welded casing with 90° connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air directionalizer and parallel cell profile suppresser (3/ 4" maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 30 m/s. This air directionalizer and parallel cell honeycomb suppresser shall provide 98% free area, equalize the velocity profile and eliminate turbulent and rotational flow from the air stream prior to the measuring point.
- c) The total pressure measurement side (high side) shall be designed and spaced to the Industrial Ventilation Manual, 16th Edition, Page 9-5. The self- averaging manifolding shall be manufactured from brass and copper components.
- d) The static pressure sensing probes (low side) shall be bullet-nosed shaped, per detailed radius, as illustrated in Industrial Ventilation Manual 16th Edition, Page 9-5.
- e) The main take-off point from both the total pressure and the static pressure manifolds shall be symmetrical.
- f) Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area and specified airflow capacity.

15) Water Leak Detection

- a) Type: Sensor tape (3m lengths to suit the tank / equipment)
- b) 3 mil copper fibre, ¼ " gap

6.8.2 Field Level Devices - Output Devices

- 1) General Requirements
 - a) Damper and valve actuators shall be electronic.
 - b) Thermal valve/ damper actuators are not acceptable.
 - c) In case of modulating actuators, floating valve/ damper actuators are not acceptable.
- 2) Electronic Damper Actuators
 - a) Electronic damper actuators shall be direct shaft mount.
 - b) Type: Modulating electric, operating from an analogue control signal.
 - c) Include visual indication of position
 - d) Actuator torque 150% of the torque required to operate the associated damper.
 - e) Closing time at this damper torque: 60 – 180 seconds.
 - f) Return time for spring return dampers: 10s maximum
 - g) Position accuracy: <5% relative to input signal.
 - h) Modulating and 2-position actuators shall be provided as required by the sequence of operations noting that all dampers to be full modulating unless otherwise specified. Damper sections shall be sized based on the actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators shall have exterior adjustable stops to limit the travel in either direction, a gear release to allow manual positioning and shall have mechanical spring return facility.
 - i) Modulating actuators shall accept 24Volts AC power supply, consume no more than 15VA and be UL listed. The control signal shall be 2-10Volts DC or 4-20mA and the actuator shall provide a clamp position feedback signal of 2- 10Volts DC or 4-20mA. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of 1 No. damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
 - j) Two-position or open / closed actuators shall accept 24Volts AC power supply and be UL listed. Isolation, smoke, exhaust fan and other dampers, as indicated in the sequence of operations, shall be furnished with adjustable end switches to indicate open/ closed position or be hard wired to start/ stop associated fan. Two-position actuators, as indicated in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.
- 3) Valve Actuators

- a) Type: Modulating electric, operating from an analogue control signal.
 - b) Alternative for valves <0.1L/s: Two position electric with slow closure (solenoids not acceptable).
 - c) Capacity: 200% of the torque required to operate the associated control valve. Closing time at this torque: 100 – 240 seconds.
 - d) Position accuracy: <5%.
 - e) Indication: Include visual indication of valve position.
 - f) Configure actuators to close valves when the associated plant stops, excepting for heating, chilled or condenser water system bypass valves, which shall open when the associated plant stops.
- 4) Electronic Valve Actuators
- a) Electronic valve actuators shall be manufactured by the valve manufacturer.
 - b) Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
 - c) Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized Based on the valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. All direct shaft mount rotational actuators shall have exterior adjustable stops to limit travel in either direction.
 - d) Modulating Actuators shall accept 24Volts AC power supply and be UL listed. The control signal shall be 2-10Volts DC or 4-20mA and the actuator shall provide a clamp position feedback signal of 2-10Volts DC or 4-20mA. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble- shooting purposes.
 - e) Two-position or open/ closed actuators shall accept 24 or 240Volts AC power supply and be UL listed. Butterfly isolation and other valves, as indicated in the sequence of operations, shall be furnished with adjustable end switches to indicate open/ closed position or be hard wired to start/ stop the associated pump or chiller.
- 5) Control Valves
- a) All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer (within the authority of 0.4 to 0.65) and shall be guaranteed to meet the heating and cooling loads,

as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (screwed, or flanged) shall conform to the pipe schedule elsewhere in this Specification.

b) Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves and for all two-position, open/ close applications. In-line and/ or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50° of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.

6) Coil control valves

a) Provide 2-way or 3-way mixing control valves as shown.

7) Bypass Control Valves

a) Provide double seated pressure balanced bypass control valves.

- i) Valve Type and Characteristic
- ii) Modulating linear ports
- iii) chilled water coil valves (3 way only)
- iv) chilled water bypass valves
- v) Modulating equal percentage ports
- vi) chilled water valves
- vii) Two position valves where specified
 - (1) ball valves < 50 DN
 - (2) butterfly valves > 50 DN

b) Valve Selection

c) Rangeability: 30 to 1 minimum

d) Close-off pressure drop: > scheduled pump head.

e) Pressure rating: > piping design pressure. Refer to Piping section.

f) Materials: Comply with Piping section.

8) Pressure Independent Control Valves (PICVs)

a) The two-way pressure independent control valve (PICV) shall be installed for each cooling coil for Fan Coil Unit / Air Handling Unit / Close Control Unit on the Tertiary chilled water system. This valve shall function as a pressure independent control valve with integral differential pressure control, adjustable flow limiting and temperature control via a fully modulating actuator (0 – 10V signal).

- b) The valve is a combination of balancing valve and control valve and differential pressure control valve and shall be able to control the flow independent of the system pressure fluctuation.
- c) They shall be full stroke, equal percentage temperature control valve. Adjustment of flow should not limit the stroke length.
- d) For the Terminal Unit valves (15 mm to 32 mm) it shall be possible to adjust the flow setting knob without removing the actuator.
- e) The valve should have in-built 2 nos. pressure ports/taps as test points.
- f) Valve Specification:
 - i) Body material:
 - (1) 15 to 50 mm - Brass (DZR) , Bronze or Ductile Iron
 - (2) 65 to 150 mm - Ductile Iron
 - ii) End Connections:
 - (1) 15 to 50 mm - Threaded Connection.
 - (2) 65 to 150 mm - Flanged Connection.
 - iii) Diaphragm & Seals: EPDM or HNBR
 - iv) Leakage Rates:
 - (1) Class IV IEC 60534-4 up to 20 mm
 - (2) Class III IEC 60534-4 for 25-32 mm
 - (3) Class VI IEC 60534-4 for 40-50 mm
 - (4) The valve must ensure a leakage rate shall not exceed of 0.01% of max flow rate up to 50 mm and shall be 0.05% of max flow rate from 65 mm till 150 mm.
 - v) Valve Plug: Polyphenylsulphide (PPS), dezincification-resistant copper alloy or Stainless Steel.
 - vi) Spring: Stainless Steel.
 - vii) Temperature Operating Range: -10 to 120 deg C.
 - viii) Maximum working pressure shall be 24 bar (secondary CHW), 16 bar (tertiary CHW)
 - ix) Maximum close-off pressure is 6 bar (600 kPa) for all terminal unit applications up to 50 mm and 4 bar (400 kPa) for sizes 65 mm to 150 mm.
- g) Actuator Specifications:
 - i) A fully modulating electric motorised actuator to be supplied by the valve manufacturer to ensure compatibility with PICV. Thermal actuators are not acceptable.

- ii) Actuator shall accept 0-10VDC, 2-10VDC or 0-20 mA, 4-20 mA (with reversed option) control signal for accurate modulating control.
 - iii) Actuator stroke shall be compatible with the stroke of the control valve for reliable and versatile operations.
 - iv) Actuator for PICV's shall have end of stroke confirmation/auto-calibration.
 - v) Actuator shall have status indication either through LED, position indicator or display.
 - vi) Actuator shall be rated IP43 for terminal unit applications up to 32 mm and IP54 for AHU/FAHU applications from 40 mm – 150 mm.
 - vii) Actuator shall be suitable for ambient temperature ranging from 0 to 50 deg C (10-90% RH)
 - viii) Actuator noise rating shall be less than 30 dB(A) for Terminal Unit applications.
- h) Power Supply: 24VAC/230VAC, 50Hz.
- i) All the actuators shall provide the status (feedback) to the BMS system.
 - j) Identification:
 - i) Direction of flow shall be permanently marked on the valve body.

7 HVAC operating functional requirements

7.1 General

- 1) This section should be read in conjunction with the drawings, schematics and technical specifications and sequence of operations document. All controls functionality required to enable full and complete operation to these systems across each document (drawings, schematics, specification) shall be provided.
- 2) The sequence of operation document is to be referenced to indicate the design functionality intent, all equipment types and system Control Strategies shall be further developed and detailed by the Contractor as part of the Construction submittal process to confirm clarity of understanding. This is in addition and to support the Contractors Functional Brief comprising the typical and equipment/device detailed BMS points list, set point strategies and controls diagrams.
- 3) The project BMS infrastructure and supervisory functionality shall be fully integrated with the Operators Workstation GUI.
- 4) An indicative control description of mechanical services plant is given in the sequence of operations. Allow for all BMS functionality including DDC systems software and hardware as required enable the detailed controls functionality, system monitoring and trending to be provided.
- 5) Identified I/O points are category based for identification of functional intent and not intended to represent the required quantities. Determination of required quantities shall be as detailed

across the controls description, drawings, schematics, equipment schedules and as detailed within the other Works packages. The controls description is around equipment operation, allow for the associated field devices as detailed elsewhere within the full technical package, or required to ensure the operational intent is met.

- 6) All identified I/O points and HLI connections are for each individual item of equipment or device. Where a system comprises multiple elements that operate in parallel or series, the points list shall be individually applied to each individual item of equipment or device, and all points shall be individually represented on the BMS graphics
- 7) Supervisory Controllers to be provided as shown, interfaced into the BMS network
- 8) All fans, pumps, valves and dampers to be provided with feedback confirmation upon actuation or speed control adjustments
- 9) All FAU, AHU, pump, heat exchanger filter and strainers assemblies to be provided with dP sensors with dirty condition identified
- 10) Where there is multiple mechanical equipment serving critical operational systems (chilled water and condenser water pumps, LMR FCU, Electrical Room FCU/AHU, CRAC units etc), these shall be separately served from a minimum 2 off Supervisory Controllers (ie split N+1 equipment and separately group and connect to separate DDC). All Supervisory Controllers to be UPS supported.
- 11) In the sequence of operations document a Central Plant Controller (CPC) is used to refer to the supervisory controller for the central chilled water generation plant where as the data hall controllers are referred to as Supervisory controllers.
- 12) All set points are to be fully adjustable and nominal only, and shall be field proven and set during the testing and commissioning period
- 13) Allow 5 minute settle time upon starting of equipment to allow the system to settle prior to operating floating set point control and operations
- 14) All automatic equipment and device operation shall be able to be manually overridden at the Operators Workstations and at the Control Panel but shall be visually identified as Overridden on the BMS and alarm logged
- 15) All sensors and control devices to be provided in a directly viewable and maintainable position
- 16) Provide automatic test functionality for all dampers and valves. The Facility Manager shall be capable of running individual automatic test scenario on each equipment system from the head end where the dampers and valves are driven from their current normal position (open/closed) to the opposite condition (closed / open) and any feedback error is raised as an alarm for the system.
- 17) Refer to the Cause and Effect matrix for fire mode operation of the HVAC system.
- 18) Alarm priorities and associated actions shall be agreed with the Engineer and Facilities Management during the Construction Stage.

Appendix A

Tender Equipment Schedule

Schedules below shall be completed and returned with the tender for each product Option listed in the Specification document. Schedules to be resubmitted for reconfirmation for all subsequent purchase order confirmations

1.	<u>BMS system</u>	
1.1.	Platform	
1.1.1.	Software package name	
1.1.2.	Graphics package	
1.2.	Field controller supplier	
1.2.1.	Managed switch supplier	
1.3.	Automation server PSU make and model	
1.4.	Communication cable make and model	
1.5.	Lead time	

List of Abbreviations

AC	Alternating Current
ANSI	American National Standards Institute
BS	British Standard
CB	Circuit Breaker
CD	Compact disk
DC	Direct Current
EMC	Electromagnetic compatibility
EOJ	End of Job
FAT	Factory Acceptance Test
Gb	Gigabyte
GPS	Global Positioning System
HMI	Human Machine Interface
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IP	Ingress Protection
ISO	International Organisation Standardisation
I/O	Input / Output
kV	kilovolt
LAN	Local Area Network
LED	Light-Emitting Diode
LV	Low Voltage
m	Meter
Max	Maximum
Mb	Megabyte
MCB	Miniature Circuit Breaker
mm	millimetre
ms	milliseconds
MV	Medium Voltage
OEM	Original Equipment Manufacturer
PC	Personal Computer
PFC	Power Factor Correction
PLC	Programmable Logic Controller
QOS	Quality of Supply
SAT	Site Acceptance Test
SABS	South African Bureau of Standards
SANS	South African National Standards
SCADA	Supervisory Control and Data Acquisition
UPS	Uninterruptible Power Supply
V	Volt

°C Degrees Celsius