SECTION 23 09 23 - DIRECT DIGITAL CONTROL SYSTEM FOR HVAC
BUILDING MANAGEMENT SYSTEM (BMS)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

1.02 SCOPE OF WORK

A. The BMS contractor shall provide the Building Management System (BMS), shall implement all features called for in this specification and shall implement the necessary sequences for satisfactory operation of the system. The BMS contractor shall be a BMS specialist. The BMS contractor shall coordinate with other trades as necessary to provide a fully functional system that meets the requirements of these specifications.

1.03 RELATED WORK

A. The following Sections contain requirements that relate to this Section:
1. Division 21 "Fire Suppression"
2. Division 22 "Plumbing"
3. Division 23 "Heating Ventilating and Air Conditioning"
4. Division 25 “Integrated Automation”
5. Division 26 "Electrical"
6. Division 27 "Communications"
7. Division 28 "Electronic Safety and Security"
8. Division 34 "Transportation"
9. Division 40 "Process Integration"
10. Division 41 "Material Processing and Handling Equipment"

B. The MEP Contractor, the Main Contractor and the I2BS contractor shall be responsible for all necessary coordination and liaison between the BMS contractor and the third party system contractors to ensure that the intent and requirements of these specifications are attained.

C. The BMS Contractor shall become familiar with the Integrated Intelligent Building Solution (I2BS) specification and shall comply with all of the requirements of the I2BS specification that are relevant to the BMS. Coordinate with the I2BS Contractor to ensure that there is full interoperability between the BMS and the I2BS.

1.04 ABBREVIATIONS

AGP - Advanced Graphics Processor
ANSI - American National Standards Institute
ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AOCC</td>
<td>Airport Operational Control Center</td>
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<tr>
<td>BTL</td>
<td>BACnet Testing Laboratory</td>
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<td>BIBBB</td>
<td>BACnet Interoperability Building Block</td>
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<tr>
<td>BMS</td>
<td>Building Management System</td>
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<tr>
<td>CCP</td>
<td>Communications Control Panel</td>
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<tr>
<td>CD-RW</td>
<td>Compact Disk with Read and Write capability</td>
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<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
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<tr>
<td>DAT</td>
<td>Digital Audio Tape</td>
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<tr>
<td>DCP</td>
<td>Distributed Control Panel</td>
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<tr>
<td>DDC</td>
<td>Direct Digital Control</td>
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<tr>
<td>DDR</td>
<td>Double Data Rate</td>
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<td>EP</td>
<td>Electric-to-Pneumatic</td>
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<td>FAS</td>
<td>Fire Alarm System</td>
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<tr>
<td>FCU</td>
<td>Fan Coil Unit</td>
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<tr>
<td>FMS</td>
<td>Facility Management System</td>
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<tr>
<td>GACA</td>
<td>The General Authority for Civil Aviation</td>
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<tr>
<td>HHWT</td>
<td>Hand Held Wireless Terminal</td>
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<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
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<tr>
<td>HVAC</td>
<td>Heating, Ventilating and Air Conditioning</td>
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<td>I2BS</td>
<td>Integrated Intelligent Building Solution</td>
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<tr>
<td>ICT</td>
<td>Information and Communications Technology</td>
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<tr>
<td>IDE</td>
<td>Integrated Drive Electronics (hard disk)</td>
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<td>ISO</td>
<td>International Standards Organisation</td>
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<tr>
<td>ID</td>
<td>IDentification</td>
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<td>I/O</td>
<td>Input/Output</td>
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<tr>
<td>ISA</td>
<td>Instrument Society of America (now International Society for Measurement and Control)</td>
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<tr>
<td>KAIA</td>
<td>King Abdul-Aziz International Airport</td>
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<tr>
<td>LAN</td>
<td>Local Area Network</td>
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<tr>
<td>LCD</td>
<td>Liquid Crystal Display</td>
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<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
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<tr>
<td>LIT</td>
<td>Level Indicating Transmitters</td>
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<tr>
<td>LON</td>
<td>Local Operating Network</td>
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<tr>
<td>LSF</td>
<td>Low Smoke and Fire</td>
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<tr>
<td>MATV</td>
<td>Master Antenna Television</td>
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<tr>
<td>MSTP</td>
<td>Master Slave / Token Passing</td>
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<tr>
<td>N2</td>
<td>Johnson Controls terminology for a proprietary communications network</td>
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<td>NEC</td>
<td>National Electric Code</td>
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<td>NEMA</td>
<td>National Electrical Manufacturers Association</td>
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<td>NIU</td>
<td>Network Interface Unit</td>
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<td>NPT</td>
<td>National Pipe Taper (pipe thread specification)</td>
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<tr>
<td>ODBC</td>
<td>Open Data Base Connectivity</td>
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<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>OIW</td>
<td>Operator Interface Workstation</td>
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<tr>
<td>OLE</td>
<td>Object Linking and Embedding</td>
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<tr>
<td>OPC</td>
<td>OLE for Process Control</td>
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<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Act</td>
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<tr>
<td>PABX</td>
<td>Private Automatic Branch eXchange</td>
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<tr>
<td>PC</td>
<td>Personal Computer</td>
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<tr>
<td>PCI</td>
<td>Peripheral Component Interconnect</td>
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<td>PE</td>
<td>Pneumatic-to-Electric</td>
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<tr>
<td>PICS</td>
<td>Protocol Implementation Conformance Statement</td>
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<tr>
<td>PDA</td>
<td>Personal Digital Assistant</td>
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</table>
PIM - Process Interface Module  
PIT - Pressure Indicating Transmitter  
POT - Portable Operator Terminal  
PTFE - Polytetrafluoroethylene (Teflon)  
PT - Pressure Transmitter  
RAID - Redundant Array of Inexpensive Disks  
RAM - Random Access Memory  
RFI - Radio Frequency Interference  
RH - Relative Humidity  
RTD - Resistance Temperature Device  
SAMA - Scientific Apparatus Manufacturer’s Association  
SCADA - Supervisory Control And Data Acquisition  
SCBA - Self Contained Breathing Apparatus  
SCPT - Standard Configuration Property Type  
SCSI - Small Computer System Interface  
SMS - Short Message Service (cellular phones text messaging)  
SNMP - Simple Network Management Protocol  
SNVT - Standard Network Variable Type  
SOAP - Simple Object Access Protocol  
SQL - Structured Query Language  
SSPC - Standing Standard Project Committee  
SVG A - Super Video Graphics Adapter  
TDS - Technical Data Sheets  
TIT - Temperature Indicating Transmitter  
UART - Universal Asynchronous Receiver-Transmitter  
UC - Unitary Controller  
UCPT - User-defined Configuration Property Type  
UNVT - User-defined Network Variable Type  
UPS - Uninterruptible Power Supply  
VAV - Variable Air Volume  
VDU - Video Display Unit  
VFC - Volt Free Contacts  
VPN - Virtual Private Network  
VSD - Variable Speed Drive  
WAN - Wide Area Network  
XIF - eXternal Interface File  
XML - eXtensible Mark-up Language  

1.05 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem.

B. Analogue: A continuously varying signal value (temperature current, velocity, etc.).

C. BACnet: The Building Automation and Control Network open protocol communication standard developed by ASHRAE (ASHRAE SSPC/135) and which is now an ISO and ANSI standard. BACnet can operate over media including Ethernet, ArcNet and MSTP.  

D. BACnet Object: A physical or virtual point with a set of associated properties such as a temperature sensor that has properties including, name, current value, maximum and minimum values, high and low alarm levels, etc.
E. BACnet Conformance: A description of the capabilities of a device for communicating information to other BACnet devices. It is usually a set of requirements to be met in order for a device to conform to BACnet standards. There are 6 levels of conformance for standard BACnet objects and services. The higher the conformance class the more features that are covered. The BACnet devices furnished under this contract shall, at minimum, be conformance class 4.

F. BACnet Interoperability Building Blocks (BIBBs): A BIBB defines a small portion of BACnet functionality needed to perform a particular task. BIBBs come in pairs, A and B, which reflect the client/server nature. The A BIBB represents the client, i.e. the device requesting information or commanding an action. The B BIBB represents the server, i.e. the device furnishing the information or executing the command. For 2 devices to be interoperable the A BIBB and the B BIBB must be the same.

G. BACnet/IP: The building automation and control network open protocol communication standard which complies with Annex J to the ASHRAE SSPC/135 standard.

H. Binary: A two-state system where a high signal level represents an “ON” condition and an "OFF" condition is represented by a low signal level.

I. BMS: This shall mean the complete Building Management System including the components at the Field, Automation and Management Levels.

J. Component: Any individual element of the BMS furnished under this contract including hardware, software and materials.

K. Contractor: The BMS Contractor who shall provide the Building Management System and shall be responsible for the integration of the BMS with the other low voltage building systems as detailed in the specifications. The BMS contractor shall be a BMS specialist.

L. Control Wiring: This includes conduit, wire, and wiring devices to install complete HVAC control systems, including motor control circuits, interlocks, sensors, PE and EP switches, and like devices. This also includes all wiring from node to node, and nodes to all sensors and points defined in the I/O summary shown on drawings or specified herein, and required to execute the sequence of operation. Does not include line voltage power wiring.

M. Diagnostic Program: Machine-executable instructions used to detect and isolate system and component malfunctions.

N. Direct Digital Control (DDC) involves the connection of microprocessor-based controllers to field level sensors and actuators. The signals received from field level instrumentation are converted from analogue to digital format so that the data can be used in software logic. Control signals are determined by software logic and they are converted from digital to analogue format so that the final control elements can be adjusted.

O. Distributed Control: A system whereby all control processing is decentralized and independent of a central computer.
P. Engineer: This refers to the Construction Manager. In this case, Dar Al Handasah – Shair & Partners

Q. Furnish: Purchase and deliver to the appropriate installing Contractor, complete with every appurtenance, document, commission and warranty.

R. Gateway: A device that contains an input/output (I/O) software driver to translate input data from one communications protocol to output data in a second communications protocol.

S. Human-Machine Interface (HMI): Human-machine interfacing allows the operator to manage, command, monitor, and program the system.

T. Integration: Establishing communication and meaningful data transfer between two devices based on a standard protocol or through the use of a standards based gateway.

U. Interoperability: The ability of systems from different manufacturers and of different types to share information with each other without losing any of their independent functional capabilities and without the need for complex programming.

V. LonMark Interoperability Association: Standards committee consisting of numerous independent product developers and systems integrators dedicated to determining and maintaining the interoperability guidelines for the LONWORKS® industry.

W. LonMarked™: Device has been certified for compliance with LonMark standards by the LonMark association.

X. LonTalk™: Open/standard communication protocol developed by the Echelon Corporation.

Y. LonWorks: The overall communications technology for control systems developed by Echelon Corporation. The technology employs routers, gateways, bridges, and multimedia transceivers to permit topology and media-independent control solutions. Refer to standard ANSI/EIA - 709.1

Z. Native BACnet: This term is used to imply that BACnet devices (i.e. the BMS controllers and workstation) only communicate in BACnet protocol and do not require a gateway for protocol conversion. The BACnet devices shall be connected on a peer-to-peer network using one of the approved LAN technologies such as Ethernet, ARCNET, MS/TP, LonTalk or BACnet/IP.

AA. Network: A system of distributed control units that are linked together on a communication bus. A network allows sharing of point information between all control units. Additionally, a network provides central monitoring and control of the entire system from any distributed control unit location.

BB. Operating System (OS): Software that controls the execution of computer programs and which provides scheduling, debugging, input/output controls, accounting, compilation, storage assignment, data management, and related services.

CC. Operator Interface Workstation (OIW): The OIW consists of a high-level processing personal computer and peripheral I/O devices that enable access to the PC and to the entire Management Level Network.
DD. Operator: The operator shall refer to the operator at an I2BS workstation, an operator at the POT and an operator at the HHWT.

EE. Owner: The General Authority for Civil Aviation (GACA).

FF. Peer-to-Peer Communication: Communication directly between devices that operate on the same communications level of a network, without intervention from any intermediary devices such as a host or server.

GG. Peripheral I/O: Input/Output (I/O) equipment used to communicate to and from the computer and make hard copies of system outputs and magnetic files. Peripherals include VDU, printers, hard drives, disk drives, and modems, etc.

HH. Portable Operator Terminal (POT): Permits remote operator interface to facilitate network management, node commissioning, diagnostics, and general operator interface with the BMS. This is a Thin Client PC that shall be able to perform any function that can be undertaken from any other Thin Client PC on the system.

II. Provide: Furnish, install, commission, test and warrant. Refer to the definition of “furnish”.

JJ. Router: A device that routes messages destined for a node on another segment subnet or domain of the control network. The device controls message traffic based on node address and priority. Media converters which serve as communication links between power line, twisted pair, fibre, coax, and RF media are sometimes referred to as Routers.

KK. Standard Network Variable Type (SNVT): LonWorks controllers use SNVTs to define data objects. Each SNVT is identified by a code number that the receiving controller can use to determine how to interpret the information presented.

LL. Standing Standard Project Committee (SSPC): ASHRAE terminology for a technical committee that oversees the maintenance of a standard.

MM. Software: Generic term used for those components of the computer systems that are intangible rather than physical. The term "software" is used to refer to the programs executed by the computer systems as distinct from the physical hardware of the computer systems and encompasses any programs such as operating systems, applications programs, operating sequences and databases. The term "software" shall be interpreted to include firmware if, in the context in which it is used, the term "software" does not exclude the use of read-only memory and the use of firmware meets all of the applicable criteria detailed in these specifications.

NN. Thin Client: Thin client technology involves delivering windows applications to client workstations from a centrally based server. The thin client workstation has the ability to process information but data storage, applications and administrative functions reside on the terminal server. The applications run on the server and screen updates are sent from the server to the client. The thin client workstation displays the screen updates and sends operator entered requests/commands via the keyboard and mouse back to the server for execution.
Unitary Controller: A controller generally designed for a specific application and for a single piece of equipment. They are generally of two types: application specific and “freely” programmable. The “freely” programmable unitary controllers shall be provided for this project.

Virtual Private Network (VPN): This is a network that uses encryption and other technologies to provide secure communications over the Internet or an Intranet.

“External Interface File” contains the contents of the manufacturer’s product documentation.

XML/SOAP: Simple Object Access Protocol (SOAP) is a simple eXtensible Markup Language (XML) based protocol that enables applications to exchange information over HTTP. Or more simply: SOAP is a protocol for accessing a Web Service.

The above definitions shall apply to the words:

1. When they are in upper case, when they are in lower case and when they are capitalized.
2. In the singular and in the plural.
3. In all grammatical tenses.

OVERALL BMS PHILOSOPHY

A. The following is a description of the overall BMS philosophy that shall be applicable to all BMS installations in KAIA buildings and facilities included in Contract 421. It is provided for the purpose of placing the work of this contract in context with the total work involved in the KAIA Building Systems.

B. The Integrated Intelligent Building Solution (I2BS), provided under a separate contract, shall provide the management level functions for the BMS. The BMS provided under this contract, therefore, shall not have a workstation or head end PC. The BMS controllers shall communicate with the Integrated Intelligent Building Solution (I2BS) directly or via a Network Interface Unit (NIU), which shall be provided by the I2BS contractor. The provision of the I2BS is not in the scope of work of this contract. The I2BS shall be capable of accessing all the information available at the BMS controllers.

C. A Wide Area Network (WAN) shall be provided by others. This WAN shall serve as the medium of communication between the building ELV building services systems and the I2BS.

D. The building BMS system that is to be provided as a part of this work shall be integrated to the I2BS system via a Network Integration Unit (NIU) panel provided by the I2BS contractor. The BMS installation shall be closely coordinated with the I2BS Contractor. The interface with the NIU is a part of this work and the BMS contractor is responsible for coordinating with the I2BS Contractor.

E. The NIU Panel, provided by others, shall provide the interface between the BMS Automation Level controllers and the Airport Data Network and shall provide global supervisory control functions over the Automation Level controllers connected to the NIU Panel. The NIU shall reside on the Airport’s WAN. The NIU Panel shall be capable of executing application control programs to provide:
1. Calendar functions.
2. Scheduling.
3. Trending.
5. Time synchronization.
6. Integration of LonWorks and BACnet BMS Automation Level controller data.
7. Graphics. (These shall reside at both the NIU panel and the I2BS Application Servers)

F. The BMS shall communicate with the NIU in one of the following native protocols:
1. BACnet
2. LonWorks

G. The use of BMS proprietary protocols and gateways shall not be permitted.

H. Provide comprehensive documentation to the I2BS Contractor regarding the protocol and the format/address of the data communicated to the NIU. In particular a BMS Contractor who provides Automation Level controllers that communicate using BACnet shall provide complete details of all BACnet object IDs and a BMS Contractor who provides Automation Level controllers that communicate using LonTalk shall provide details of all LON SNVT IDs.

1.07 WORK OF THIS CONTRACT

A. These contract documents cover the following scope of work:
1. The provision of a fully functioning BMS that will undertake the monitoring and control of the HVAC systems for the facility. This shall include but shall not be limited to the following monitoring and control functions:
   a. The monitoring and control of the air handling units, fan coil units, VAV terminal units, extract fans and other miscellaneous fans used for the distribution of airflow.
   b. The monitoring and control of the chilled water systems. The monitoring of the chillers in the Load Centres via the Chillers Management System (CMS) is not in the scope of work of this contract however, the BMS shall monitor all heat exchanger temperatures, control valves, etc associated with the chilled water system within the facility.
   c. The monitoring and control of the various plumbing systems.
   d. The monitoring and control of water leak detection systems, if applicable.
   e. The monitoring and control of the variable speed motors. The variable speed drive (VSD) controllers shall interface directly to the BMS Automation Level through a BACnet or LonWorks to third party gateway, depending on whether the associated DDC controllers are BACnet or Lon. The gateway shall reside on the same network as the BACnet or Lon DDC controllers that provide monitoring and control of the VSD motors. The intent is that the exchange of information between the VSD controllers and the DDC controllers associated with the variable speed drives shall not be lost in the event of a Management Level component failure. The gateway shall be provided and connected into the data port of the VSD controller by the VSD supplier. The BMS contractor shall connect the gateway
into the BMS network. The BMS contractor shall obtain a list of the BACnet objects or Lon SNVT IDs/names, as applicable, from the VSD supplier and shall map the BACnet objects or Lon SNVT into the DDC controllers. The BMS contractor shall provide the VSD supplier with the BACnet object or Lon SNVT IDs, as applicable, for points that are to be mapped from the BMS DDC controllers into the VSD controllers and the VSD supplier shall map these points into the VSD controller. The BMS contractor shall be able to incorporate points from the VSD controllers into the various BMS sequences of operation in exactly the same manner as any points monitored directly by DDC controllers. These points shall be treated in exactly the same manner as any points monitored/controlled by the BMS DDC controllers directly.

f. The monitoring of the switchboard electronic meters.
g. Monitor ambient conditions and air quality.
h. Monitor and control other points as determined during the detailed system design.
i. The BMS contractor shall be responsible for mapping any points that are sent via the I2BS into the BMS. The BMS contractor shall request details of the points to be mapped from the I2BS contractor.

B. The BMS shall be a turnkey installation and shall include the interface to the NIU and testing of the BMS as detailed in these specifications. Each BMS shall comprise, at minimum, the following components:

1. Distributed Control Panels (DCP).
2. Unitary Controllers (UC).
3. Hand Held Wireless Terminals (HHWT).
4. Portable Operator Terminals (POT)
5. Automation level Local Area Networks (LAN).
6. Field instrumentation including intelligent sensors.
7. Automatic Valves.
8. Actuators for automatic valves and motorised dampers.
9. Software as detailed herein.
10. Cable and containment.

All power supplies and conditioners, interlocking and control relays, equipment enclosures and other components, materials and services required for a completed and fully operational turnkey BMS installation meeting these specifications.

C. The BMS shall meet the following general criteria:

1. Fully networked.
2. Real time.
3. Distributed processing.
4. No single point of failure.
5. Native BACnet or LonWorks

D. The BMS shall be configured to ensure reliability of systems operation and control of critical functions/systems. In general, all monitoring and control of separate systems shall be achieved via single control panels. Critical inputs of a system shall be wired directly to the controlling panel. Where required, dedicated control panels shall be provided and shall not share any point monitoring or control with other systems.
E. All components of the BMS at the automation level, except for the unitary controllers, shall operate on UPS. The BMS contractor shall not provide the UPS. The BMS contractor shall advise the Electrical contractor within 8 weeks of award of contract what the BMS load will be for UPS power.

F. The components furnished under this contract shall be the most recent products offered by the BMS manufacturer that meet the specifications. If there are improved models of any components furnished under this contract that become available before the on-site commencement of installation then these shall be offered by the BMS contractor to the Owner at no additional cost. The Owner shall have the option to accept or decline the offer. The components offered shall have been in successful operation in at least 2 similar applications for a minimum of 12 months.

G. The BMS contractor shall provide a Portable Operator Terminal complete with BMS management level software installed for testing of the BMS functions as detailed in these specifications. The POT shall be provided with all configuration tools necessary to configure all components furnished under this contract. The BMS contractor shall provide all software licenses necessary for the legal operation of the components furnished under this contract. The licensing requirement shall not be based on the points in the system. The Owner shall be able to expand the system without being required to buy any additional licenses.

H. The BMS contractor shall provide all necessary configuration tools for all equipment furnished to Owner. The configuration tools shall be installed onto the I2BS system server and onto the POT to allow for remote configuration of the equipment. Provide all necessary software licenses.

I. All electrical equipment, devices and components and their installation shall comply with the latest edition of the NEC wiring regulations and all other applicable codes, regulations and statutes.

J. All components shall be IP 2X finger protected such that live components cannot be accidentally touched. Interior enclosures shall be, at minimum, IP 45 and exterior enclosures shall be weather proof IP 65 unless specifically noted otherwise within these contract documents.

K. All electrical installation work shall conform to the requirements specified in the electrical trade contract documents. Where there is any conflict between the requirements of the different project trade contract documents, statutes, codes, regulations, local ordinances and any requirement of an agency having jurisdiction over the project, the most stringent requirement shall apply unless determined otherwise by the Engineer. Advise the Engineer of any discrepancy between the various requirements for the project.

L. Each component shall meet, at minimum, the following requirements:

1. Manufactured by experienced manufacturers of the specific component and facilities.
2. Designed to minimize the requirement for field repair or maintenance.
3. Modular design.
4. Electronic components shall have internal failure diagnostics.
5. Each component shall be maintainable without significantly affecting the ongoing operation of the other components.
6. Components, test ports and cable terminations shall be readily accessible.
7. Damage caused by the failure of one component will be limited to the component that has failed without affecting the ongoing operation of the other components.

M. Equipment, devices and materials shall conform to all performance requirements of the specifications when exposed to the following interferences:

1. Project lighting, telephone and elevator equipment.
2. VHF and UHF signals as generated by external or internal portable or fixed transmitters.
3. AM signals as generated from transmitters.
4. Electrical noise on the building power system, both spurious and harmonics.
5. The installations shall not radiate signals that cause interference to the correct operation of the Owner's on-site equipment.
6. The BMS and all individual electrical equipment, devices and components shall comply with the requirements of the applicable UL/NEMA/IEEE standards regarding general emissions and all other applicable codes and statutes with respect to the radiation and conduction of radio frequency interference.

N. Provide adequate earthing on all equipment to prevent the build-up of electromagnetic voltage potentials. Provide screening of panels, enclosures, devices, or components that emit interferences. All monitoring and control and communications cables shall be screened with one end earthed.

O. Provide the following support for all components furnished under this contract:

1. Warranty and service during the defects liability period.
2. Submittals, samples and record documentation.
3. Comprehensive commissioning and testing, including pre-acceptance integrated testing with the I2BS and other ELV systems as necessary.
4. Detailed theoretical and practical training services for the Supervisors and Operators.
5. Coordination with other site contractors.
6. Reporting to the owner and Engineer for the coordinated and timely execution of the Work
7. Comprehensive and complete interoperability documentation and method statement for third party systems. The BMS contractor shall provide separate interoperability documentation at the end of execution of the project, which shall detail integrating BACnet objects or LON SNVT's, details of the interfacing of controllers with the NIU

P. The BMS contractor shall be responsible for coordinating with the I2BS contractor for all information that is to be sent from the BMS controllers to the NIU or received from the NIU by the BMS controllers.

Q. The BMS contractor shall be responsible for ensuring that any changes made to the BMS system via the POT or HHWT shall be broadcast to the relevant controllers as well as to the NIU. Similarly, any changes sent via the NIU should be broadcast to the applicable controllers and updated on the POT and HHWT the next time they are connected to the BMS network.
1.08 BMS EXPANSION

A. The BMS, as installed, shall incorporate a minimum of 20 percent additional hardware (field) points without adding controllers or I/O Point Interface Modules (PIM). The number and type of the installed spare points shall be uniformly distributed between the installed controllers.

B. The Automation level network and network components shall not be more than 30% loaded.

C. Network architecture shall allow unlimited expandability by the addition of new sub networks and associated routers, gateways, etc.

D. Subsequent to the potential expansion detailed in 1.08.B and .C above:
   1. The BMS performance shall not be degraded in any manner and shall meet all performance criteria detailed in these specifications.
   2. Equipment installed under this Contract shall not become redundant as a result of implementing these BMS expansion requirements.

1.09 MAKING GOOD DEFECTS DURING THE DEFECTS LIABILITY PERIOD

A. Repair work shall only be undertaken at times approved by the Owner.

B. Repair work shall not include routine maintenance during the Defects Liability Period. The cost of providing routine maintenance during the Defects Liability Period shall be provided separately as an Optional Price as detailed below.

C. Replace or repair all supplied defective installations. Respond and be on site within 2 hours of the Engineer and/or the Owner placing a system trouble call for items of an immediate nature (e.g.: failed component, non-functioning controller, etc.). Response to warranty calls by the Engineer and/or the Owner shall be within 24 hours for items not requiring immediate attention. Work to troubleshoot and identify the cause of the BMS system or component failure shall begin immediately and shall continue until repaired to the satisfaction of the Engineer and the Owner.

1.10 WARRANTY AND SERVICES DURING THE DEFECTS LIABILITY PERIOD (OPTIONAL PRICE)

A. Submit an Optional Price for routine maintenance services during the Defects Liability Period. The provision of such services shall be at the sole discretion of the Owner who may instruct accordingly.

B. Provide routine maintenance services during the Defects Liability Period. The maintenance services shall cover routine preventative maintenance but shall not include emergency maintenance or the cost of replacing defective materials during the Defects Liability Period.

C. Under routine maintenance components of the BMS shall be selectively inspected and serviced during the Defects Liability Period. Provide, at minimum, four (4)
preventative service inspections during the Defects Liability Period. Perform, at minimum, the following during each preventative service inspection:

1. Verify the proper operation of Portable Operator Terminal (POT) and Hand Held Wireless Terminal (HHWT)
2. Verify proper operation of each digital controller and network, including any hubs, network interface cards, routers, etc. Clean enclosures.
3. Verify the satisfactory operation of at least 25 percent of each type of field device including valves and dampers. All field devices shall be checked at least once during the initial Defects Liability Period and shall be calibrated and adjusted as necessary.
4. Provide a comprehensive written report to the Owner indicating the results of each inspection and all repairs and adjustments made.
5. Perform complete backup of all software.

D. The routine maintenance services during the Defects Liability Period shall include 20 hours per year of programming changes to the BMS as requested by the Owner.

E. Any software upgrades and new software programmes that become standard product offerings from the BMS contractor and/or BMS equipment vendors during the Defects Liability Period shall be brought to the attention of Owner together with the cost and, if Owner wishes, he shall purchase the software. If at any time during the Defects Liability Period, software patches that correct software errors become available Owner shall be notified immediately and they shall be made available to Owner at no additional cost.

F. Update as-built documentation, submitted at the time of taking-over of the Works as necessary to reflect any changes that may have been introduced during the Defects Liability Period.

G. Detail the minimum number of hours to be spent on routine maintenance during the Defects Liability Period in the tender submittal.

H. The BMS contractor shall maintain an inventory of common components in the local office for the replacement of failed components as detailed under “Spare Parts”.

I. Provide replacement components within the specified time periods for the following components. The contractor shall guarantee to Owner that the delivery of replacement components will be provided within the specified time periods.

<table>
<thead>
<tr>
<th>BMS Component</th>
<th>Delivery Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Portable Operator Terminal</td>
<td>Five (5) days</td>
</tr>
<tr>
<td>2. Primary and secondary BMS communication LAN components including any hubs, network interface cards, bridges, routers, concentrators, protocol converters, termination plugs, etc.</td>
<td>One (1) days</td>
</tr>
<tr>
<td>2. DCP including any required input/output point interface modules.</td>
<td>Two (2) days</td>
</tr>
<tr>
<td>3. Unitary controllers including any input/output point interface modules.</td>
<td>Two (2) days</td>
</tr>
<tr>
<td>4. Temperature sensors</td>
<td>One (1) days</td>
</tr>
</tbody>
</table>
5. Any other items of instrumentation Two (2) days

J. The BMS contractor shall replace all used consumable items during the Defects Liability Period. Consumable items shall include but not be limited to the following:

1. Batteries for equipment furnished under this Contract.
2. Other consumable items furnished under this contract that have a life expectancy that would render them less than 100% effective before the end of the Defects Liability Period.

K. During the Defects Liability Period the BMS contractor shall maintain a minimum of 10% spare DCP and UC of each type installed on site under this contract. At the end of the Defects Liability Period the BMS contractor shall hand over DCP and UC of each type to Owner which shall, at minimum, be equal to 10% of the number of installed DCP and UC of each type installed on site under this contract.

L. During the Defects Liability Period the BMS contractor shall maintain a minimum of 10% spare sensors of each type installed on site under this contract. At the end of the Defects Liability Period the BMS contractor shall hand over sensors of each type to the Owner, which shall, at minimum, be equal to 10% of the number of installed sensors of each type installed on Site under this contract.

1.11 MAINTENANCE SERVICE CONTRACT AFTER THE DEFECTS LIABILITY PERIOD (OPTIONAL PRICE)

A. Submit an Optional price to extend the Defects Liability Period and the maintenance during that period for ten (10) one (1) year periods. The maintenance service contract shall be an all-inclusive labour and parts contract but the Owner reserves the right to obtain parts from alternative sources. The requirements during each additional year shall be exactly the same as those detailed in Part 1.10 of this Section.

B. The BMS contractor shall enter into a direct contract with the Owner to provide the maintenance services for a minimum period of ten (10) years. The signing of a maintenance services contract, if the Owner so chooses, shall be a pre-requisite to obtaining substantial completion. The Owner shall have the option to renew each year if the Owner so wishes. The BMS contractor shall submit the cost for the maintenance service agreement in one of the following ways:

1. A fixed price for a ten (10) year Agreement with a break-out between labour and parts, or
2. A fixed price for the first year of the ten (10) year Agreement with a break-out between labour and parts for the first year and a percent value or a table of percent values that the labour portion of the cost would be escalated at during the succeeding nine (9) years and a percent value or a table of percent values that the parts portion of the cost would be escalated at during the succeeding nine (9) years, or
3. A fixed price for the first year of the ten (10) year Agreement with a break-out between labour and parts for the first year with the annual increase for labour and parts over the succeeding nine (9) years based on the annual percent increase in a cost of living index from one year to the next, the cost of living index to be used is to be specified by the BMS contractor in the tender submittal.
C. If at any time during the maintenance service contract, software patches that correct software errors become available Owner shall be notified immediately and they shall be made available to Owner at no additional cost.

D. During the period of the maintenance contract the BMS contractor shall maintain a minimum of 10% spare DCP and UC of each type installed on site under this contract. At the end of the maintenance contract the BMS contractor shall hand over DCP and UC of each type to Owner, which shall, at minimum, be equal to 10% of the number of installed DCP, and UC of each type installed on site under this contract.

E. During the period of the maintenance contract the BMS contractor shall maintain a minimum of 10% spare sensors of each type installed on site under this contract. At the end of the Defects Liability Period the BMS contractor shall hand over sensors of each type to Owner, which shall, at minimum, be equal to 10% of the number of installed sensors of each type installed on site under this contract.

1.12 CODES, PERMITS AND APPROVALS

A. Obtain all required permits and inspection certificates. All permits and certificates shall be made available to Owner.

B. The latest requirements of all national, county, municipal and other authorities having jurisdiction shall be met.

C. Work shall be performed in compliance with the Owner’s insurance underwriters’ requirements.

D. All electrical work shall comply with NEC regulation.

1.13 SCHEDULE

A. Complete all requirements of the BMS contract in accordance with the project programme and prior to the scheduled Substantial Completion date for each phase.

B. Attend project meetings as requested by the Engineer.

C. Provide to the Engineer a schedule indicating the sequence of work, durations of individual tasks, delivery dates for all material, devices and equipment and detail any interface that must be coordinated with any other Contractors.

D. Provide written status reports at required intervals and in a format acceptable to the Engineer. An updated schedule of work shall be included in each status report.

E. Comply with the Project Construction Schedule. Provide additional staffing or work overtime as required to comply with the Project Schedule so as not to interfere with other on-site Contractors in their effort to comply with the Project Schedule. Confirm, prior to tender submittal, that all equipment, devices, material and services proposed are available and will be delivered accordingly to comply with the Project Schedule.
F. Provide written Request For Information notices to the Engineer when specific information or clarification of the specifications is required. Request For Information notices shall be provided at least two (2) weeks prior to the need for the information.

1.14 BMS INSTALLER QUALIFICATIONS

A. The BMS contractor shall:

1. Have a local staff, within 100 kilometres of the project site, of trained personnel capable of giving instructions and providing routine and emergency maintenance on the BMS, all components and software/firmware and all other elements of the BMS.
2. Have a proven record of experience in the supply and installation of equivalent systems over a minimum period of 10 years in the Middle East area.
3. Have comprehensive local service and support facilities for the total BMS that shall be capable of responding to Owner call-out within 2 hours, 7 days a week.
4. Maintain local, or have approved local contracted access to, supplies of essential expendable parts.
5. Undertake to maintain necessary project staff and maintenance personnel as per the Owner’s requirements.
6. Have staff experienced with integration projects with similar past project experience. Staff must have solid understanding of the requirements to integrate with the NIU. Staff must be experience in the use of BACnet and/or LonWorks based systems depending on the BMS system provided.

B. The BMS shall be listed and manufactured to ISO 9001 and ISO 9002.

C. The BMS contractor shall only offer equipment that meets UL 916 requirements and all electrical components shall be UL listed and shall carry the UL label.

D. The BMS contractor shall only offer controllers that are fully BACnet and/or LonWorks compliant. BMS contractor shall submit interoperability certificates for LonMark and BTL as applicable.

1.15 HEALTH AND SAFETY

A. Work shall comply with all the requirements of the Health and Safety Commission and with all of the instructions of the Engineer.

1.16 EQUIPMENT AND MATERIALS - GENERAL

A. All equipment and materials shall be new and without any defect. All components of one type shall be products of one manufacturer (temperature sensors, dampers, etc.).

B. Hazardous Materials Notification: In the event no product or material is available that does not contain asbestos, PCB, or other hazardous materials as determined by the Engineer, a written application shall be made by the BMS contractor to the
Engineer providing all relevant details concerning a proposed product or material that contains hazardous material prior to installation.

C. Asbestos and PCB Certification: After completion of installation, but prior to Substantial Completion, the BMS contractor shall certify in writing that products and materials installed, and processes used, do not contain asbestos or polychlorinated biphenyls (PCB).

### 1.17 PERFORMANCE CERTIFICATION

A. The BMS contractor shall certify in writing with the tender submittal that all components proposed for this project comply with all of the following requirements:

1. Complete and thorough testing has proven that performance shall not be affected when the building electrical distribution system experiences disturbances of the type and magnitude normally encountered in buildings of this nature.

2. An independent testing laboratory has verified that the VAV terminal unit unitary controller meets the performance requirements detailed in these specifications. If so required by the Owner, the testing laboratory shall test a project VAV terminal unit complete with the BMS unitary controller and the BMS contractor shall demonstrate that the VAV terminal unit UC can meet all of the requirements for monitoring and control accuracy and can undertake all of the sequences of operation associated with the VAV as detailed in these specifications. The independent testing laboratory test report is to be submitted with the shop drawings.

3. Power line disturbance tests involving the cycling of mains voltage showed that all components operated satisfactorily when the voltage dropped to 75% or less of the nominal mains voltage and normal operation resumed when the voltage returned to less than 85% of the nominal mains voltage. Following these brownout conditions the components were free of any stress and/or damage, operated as normal and no data at the DCP and/or UC was lost or corrupted.

B. The BMS contractor shall certify in writing with the tender submittal that all components are free of date related problems.

### 1.18 AMBIENT CONDITIONS

A. Provide equipment, devices and materials for interior and exterior applications that shall be capable of withstanding and operating satisfactorily in, at minimum, the following ambient conditions:

1. 0 Deg. C. (41 Deg. F.) to 60 Deg. C. (140 Deg. F.) temperature.
2. 10-95 percent relative humidity (non-condensing).
3. Electrical power to suit the project’s requirements.
1.19 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products to site under provisions of the Contract Documents

B. Accept products on site and verify damage.

C. Protect products from construction operations, dust, and debris by storing in conditioned space.

1.20 SPARE PARTS

A. As soon as practicable after approval of materials and equipment and, if possible, not later than 4 months prior to the date of practical completion, submit spare parts data for each different item of equipment furnished. Data to include a complete list of the sources of supply, a list of parts and supplies that are either normally furnished at no extra cost with the purchase of the equipment, or specified hereinafter as EXTRA MATERIALS to be furnished as part of the Contract; and a list of additional items recommended by the manufacturer to assure efficient operation for a period of 360 days at the particular installation. The foregoing shall not relieve the Contractor of any responsibilities under the guarantee condition.

1.21 EXTRA MATERIALS

A. Provide special hardware and software tools required for maintenance.

B. Provide two of each plug-in circuit board.

1.22 COMPUTER ANTI VIRUS

A. Provide antivirus software for all components that are vulnerable to viruses. At minimum, antivirus software shall be installed on the Portable Operator Terminal (POT). Antivirus software shall be provided with free virus definition updates for the duration of the warranty. Antivirus software should automatically scan the computer bios and all files opened, created, copied, and/or received for viruses. Include directions for updating virus definition files upon expiration of warranty within the record documentation.

1.23 INTERACTIVE PROCEDURE

A. The term "interactive" is used to mean that the system shall operate in a conversational mode whereby the operator shall receive English language prompts in the form of:

1. Tables into which the operator enters data.
2. Questions that are responded to by the operator.
3. Selections that are made by the operator based on a list of suggested alternatives that is generated by the BMS.
B. Interactive procedures shall be such that the operator can readily execute a task without reference to instruction manuals and without knowledge of the BMS control language.

C. All setpoints, alarms limits, deadbands, software time delays, report configuration and requests, operating time limits, etc. shall be operator definable through an interactive procedure via the associated NIU and POT. Coordinate this work with the I2BS contractor, who is responsible for providing the NIU.

1.24 QUALITY ASSURANCE

A. General: maintain a complete test, inspection and documentation program covering all phases of construction and implementation of the instrumentation and control systems. Also maintain an engineering assurance program throughout final design and equipment selection phases of the project. Quality control and engineering assurance programs to be fully documented in a project procedures manual which is to be submitted for approval.

B. Project procedure manual is to detail, but is not necessarily limited to, the following:

1. Equipment selection criteria.
2. Design standards.
3. Installation standards.
4. Field personnel qualification procedures such as for welders and non-destructive testing personnel.
5. Equipment calibration procedures.
6. Calibrated loop check procedures.
7. System test and start-up procedures.
8. Interoperability assurance procedures.

C. Start up procedures: portions of the manual may be equipment dependent such as start up procedures. In such cases submit these portions in accordance with the requirements of sub-section SUBMITTALS. However, selection criteria, design standard, and installation standards to be established and approved before detailed design starts.

D. Inspection: the Engineer has the right, at all times, to inspect the work, equipment, or quality assurance procedures as applicable to confirm that requirements as set forth are being complied with. Provide all tools, instruments and equipment necessary to facilitate these inspections.

E. Inspection: cooperate with the Engineer in establishing when the various inspections or tests will be performed during progress of the work.

F. Obligations: the presence or activities of the Engineer are in no way to relieve the Contractor of his obligations.

G. Inspection duties assigned to the Contractor's personnel are to include, but are not limited to, the following:

1. Verify that all non-destructive testing personnel are qualified for the work being done.
2. Verify that all components received comply with the Specification and receipt, inspection and storage of materials comply with requirements of the Specification.
3. Verify that the Contractor's storage facilities are maintained.
4. Verify that rack wiring check and electrical continuity tests are conducted in accordance with the Specification.
5. Witness that all hydrostatic tests performed on instrument sensing lines are in accordance with the Specification and that all tests are properly filled in signed and submittal for approval.
6. Witness all pneumatic leak tests performed on instrument sensing lines and pneumatic tubing required by the Specification.
7. Verify that all wiring insulation tests are performed in accordance with the Specification and that all test reports are properly filled in, signed and submitted for approval.
8. Verify that assembly and nameplates of the transmitter racks are in accordance with the Specification.
9. Verify that all racks, panels and local instruments have been located in accordance with the Specification.
10. Verify that all tubing supports are in accordance with the Specification.
11. Verify that all tubing has been installed in accordance with the Specification.
12. Verify that all repairs and revisions to instrument components and assemblies are in accordance with the Specification.
13. Verify that all repairs and revisions to instrumentation, tubing and their components are in accordance with the Specification.
14. Inspect in detail the tubing system or portions of the system as completed to verify that system or portion of system is correct and complete as specified prior to the initiation of any flushing, hydrostatic test, or leak test operation.
15. Witness the construction loop inspection performed by the Contractor. All items control components to conform to the specification requirements and drawings. Equipment and components to be undamaged as determined by visual examination. All documentation as required to be complete and on file. Construction loop inspection, as performed, to comprehensively and conclusively prove completeness and conformity of the installation to the Drawings and Specification.
16. Verify that calibration of instrumentation and control loops is in accordance with the approved procedures as submitted in the project procedures manual.
17. Witness the calibrated loop check and verify that all calibration reports are properly filled in, signed and submitted for approval.
18. Witness the system operational tests on a sub-system basis to assure operational integrity and conformance to operational requirements as specified.
19. Verify all plant documentation required for plant acceptance is in accordance with sub-section SUBMITTALS for completeness and conformance.

1.25 TECHNICAL PROPOSALS

A. Technical proposals shall be prepared in accordance with these specifications. Three copies of the proposal shall be submitted. The technical proposal 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:
1. Information on organizational capability to handle this project (management, personnel, manufacturing, single source responsibility, etc.)
2. Information on training program to demonstrate specification compliance.
3. System Configuration as proposed with specific reference to interoperability:
   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.
4. Technical data to support the information on the hardware configuration in No. 3 above.
5. Detailed description of all operating, command, application and energy management software provided for this project.
6. A signed certificate stating the Contractor "has read the performance and functional requirements, understands them and his technical proposal will comply with all parts of the specification."
7. The BMS contractor shall provide necessary documentation in the technical submittal to convince the engineer and the Owner about the BACnet or LonWorks interoperability capability of the system proposed. This shall include capability to integrate 3rd party systems data as providing all the data of the proposed BMS to another system. The information provided shall include interoperability schematics, method statements and certifications.
8. Other requirements for inclusion in the technical proposal are located throughout this specification.

B. Submit Unit Price schedule with the proposal.

C. Submit technical proposals with pricing in accordance with Instructions to Bidders.

PART 2 - PRODUCTS

2.01 PANELS AND ENCLOSURES

A. Provide panels and enclosures for all components of the BMS except where it is specifically identified within these contract documents that the enclosure shall be furnished by another trade. Panels and enclosures shall meet, at minimum, the following requirements:

1. Painted steel panels with locking door. All panels shall be lockable with the same key.
2. Ventilated to prevent excessive heat build-up, where required.
3. Field cabling shall be terminated on a terminal strip. Provide strain relief.
4. Internal components shall be installed to allow easy access for diagnostics, maintenance, removal or replacement.
5. Panel or enclosure shall be suitable rated for the environment for which it is to be installed. Interior enclosures shall be, at minimum, IP 45 and exterior enclosures shall be weather proof IP 65 unless specifically noted otherwise within these contract documents.

B. Panels and enclosures shall only be located as indicated on the drawings and at Engineer approved locations.

C. The BMS contractor shall not furnish MCC panels, motor starters, variable speed controllers and local disconnect switches. The trade furnishing the motor starters and
variable speed drives shall provide an interface terminal strip in a dedicated enclosure which may be a separate external enclosure or may be a compartment within the motor starter enclosure or VSD enclosure. Refer to the contract documents for the trade furnishing the motor starter and the variable speed controllers for the details of the enclosures. The DDC controllers shall not be located in the MCC panels.

2.02 LABELLING

A. Provide labelling for all DDC controllers, gateways, routers, hubs, field level components, etc, panels and enclosures. Labelling shall meet, at minimum, the following requirements:

1. Plastic laminated label that shall be affixed to the panel or enclosure with rivets or permanent adhesive.
2. Lettering 6mm (0.25 inch) high that sharply contrasts the background colour.
3. Consistent throughout the project.
4. Indicated on the record documentation.

B. Provide labelling of all cabling and containment. Labelling shall meet, at minimum, the following requirements:

1. Identified with permanent tag or self-adhesive label within the panel.
2. Cross referenced on the associated record documentation and laminated record drawing within the panel enclosure.
3. The BMS contractor shall provide labelling for all cable furnished and installed by the ICT contractor for the use of the BMS contractor.

2.03 WARNING NOTICES

A. Provide warning notices at all equipment controlled by the BMS and at all associated motor starters and MCC panels where notices of a similar manner have not been provided by other trades. Warning labels shall be installed, at minimum, at the following locations (if applicable):

1. AHU access doors.
2. AHU motor starter and VSD controllers.
3. Pump motors.
4. Pump motor starter and VSD controllers.
5. Fan enclosure or access panel.
6. Fan motor starter and VSD controllers.
7. Chiller control panel.
8. Chiller disconnect/power panel.
9. Cooling tower access ladders.
10. Cooling tower MCC.
11. All other equipment and installations that are monitored and/or controlled by the BMS.

B. The warning notices shall be 75 mm by 125 mm (3in. by 5in.) minimum, with yellow background and with black lettering. The notices shall state the following:

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THIS EQUIPMENT IS UNDER AUTOMATIC CONTROL AND MAY START OR STOP AT ANY TIME WITHOUT WARNING.
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2.04 CONDUIT, TRUNKING AND FITTINGS

A. The BMS contractor shall provide containment and cables as necessary for a fully functioning system as detailed in these specifications.

B. Flexible metallic rustproof conduit shall be provided for the final one (1) metre before connection from a non-vibrating location to equipment subject to vibration or movement. Flexible metallic conduit shall be provided for between the last 300mm and the last 1000mm of connection to field instrumentation, relays and final control elements as necessary to facilitate the removal of devices without the disconnection or the bending of the non-flexible conduit. Watertight conduit to be provided where appropriate.

C. Conduit and trunking shall be securely mounted in accordance with NEC regulations and shall be concealed in all areas to which the public have access.

D. Conduit and trunking shall run parallel or perpendicular to the building lines and shall be installed in a workmanlike manner. Avoid obstructions and crossovers where possible.

E. Conduit/trunking shall be installed such that any condensation in the conduit cannot run into BMS equipment. Where necessary conduit shall enter enclosures from the bottom or shall be sloped up to the enclosure.

F. Junction and pull boxes shall be securely fastened to the conduit, shall be accessible, and shall be provided where required by code and where necessary to facilitate the pulling of cables.

G. Coordinate installation of conduit/trunking with building structure and other trades. Conduit/trunking installation above accessible ceilings shall be such that there will be no interference with the installation of lighting fixtures, fire protection devices, air distribution devices or any other devices.

H. The BMS contractor shall colour code all conduit/trunking at least every 3,000 mm (10 feet) along the conduit with a blue and green band at least 50mm wide and colour code every junction box in a bright yellow.

I. Containment shall be provided for all BMS cable except where specifically noted otherwise.

J. BMS monitoring and control cable shall not share conduit with cable carrying voltages in excess of 48 volts and shall be partitioned from higher voltage cable in trunking.

K. LAN cable shall not share conduit with any other cable or shall be in a dedicated partitioned compartment in trunking.
L. When cable for digital outputs is installed in conduit it shall be in dedicated conduit and when installed in trunking shall be partitioned from other cable.

M. All trunking, conduit and accessories shall comply with all applicable codes and standards.

N. Containment shall meet all of the requirements detailed in the Division 26 electrical contract documents.

2.05 CABLE - COPPER

A. Provide all cables for the BMS Automation and Field Levels and cable to interconnect the Management Level devices and the Management Level Network as detailed in these specifications. Cable shall meet, at minimum, the following requirements:

1. Minimum 98% conductivity copper.
2. Stranded conductors.
3. Proper impedance for the application as recommended by the BMS component manufacturer.
4. Monitoring and control cable shall be screened #18 AWG (0.82sq.mm) or larger dependent on the application.
5. LAN cable shall be screened #24 AWG (0.82sq.mm.) CAT 5, CAT 6, CAT 7 or twisted pair as identified elsewhere in these documents.
6. All monitoring and control cable shall be screened with the screen earthed at the DCP, UC or control panel end only so as to avoid earth loops.
7. Continuous runs without splices.
8. Identification of each end at the termination point. Identification should be indicated on and correspond to the record drawings.
9. All cabling installed without conduit shall be suitably rated for the application and the cable jacket shall be clearly marked. Use unique colour schemes for easy identification and prevention of inadvertent splicing of cabling.

B. Power wiring shall be sized in accordance with the applicable codes and shall be a minimum of 1.5 sq. mm stranded copper. The BMS contractor shall provide all power cable and containment and shall terminate the power cable at a power outlet close to the component to be powered and shall provide the power outlet. The MEP contractor shall terminate the power cable at the MCC/distribution board as applicable.

C. Cable for all applications shall be LSF.

D. Terminations shall be mechanically and electrically secure. Twist type wire nuts shall not be acceptable. Insulated tinned copper lugs shall be provided.

E. Cable within panels or enclosures shall be installed in wiring guides.

F. LSF cable not required to be in conduit (refer to requirements for conduit above) shall be routed parallel and perpendicular with the building column lines. Provide cable rings and supports to support the cabling.
G. All wiring terminations within field panels shall be terminated at terminal stripes and shall be identification tagged on both sides of the terminal strip.

H. Cable run in vertical trunking shall have means of cable support, at minimum, every 3m.

I. Cables shall comply with all applicable codes including, but not limited to, the NEC wiring regulations latest edition and the electrical contract documents. Where there is a conflict between any codes, standards, ordinances, regulations or the requirements of the jurisdiction having authority, the most stringent requirements shall apply.

2.06 CABLE - FIBRE OPTIC

A. Fibre optic cable may be used for data communication.

B. Fibre optic cable (data transmission) shall meet, at minimum, the following requirements:
   1. 50 micron core (multi-mode/single mode fibre as necessary to match the fibre provided by the ICT contractor).
   2. 850 nm or 1300 nm LED compatible operation, as required.
   3. Minimum 125 micron cladding.
   4. Maximum attenuation of 4.5 db/km (850 nm).
   5. Outdoors and below grade fibres shall be run in gel filled tube to protect against moisture and micro bending. Tube and fibre shall have a kevlar braid surrounding, with suitable outside protective jacketing.
   6. Cable shall contain 100% more fibres than required for a single point-to-point communications connection.
   7. Outdoor fibre shall be equipped with a central non-conducting member for long pull applications.

C. Fibre optic cable shall comply with TIA/EIA-568-B.3 (Optical fibre cables. Generic specification - Basic optical cable test procedures) and all other applicable codes.

2.07 PORTABLE OPERATOR'S TERMINAL (POT)

A. BMS contractor shall provide 3 No. POT with all necessary tools/software required. The POT shall be provided with all configuration tools necessary to configure all components furnished under this contract. The POT shall be provided complete with BMS management level software for standalone testing of the BMS. The BMS management level software shall be used for testing and configuration purposes only. During normal operation all management programming shall reside in the NIU and at the individual BMS controllers as detailed in these specifications.

B. Provide a jack at each DDC controller and at each mechanical and electrical room for the plug connection of the POT. Provide two spare cables for plug connection for each POT. The operator shall be able to communicate with the BMS via the POT.

C. The POT shall meet, at minimum, the following requirements:
   1. Intel Duo Core Processor with minimum speed of 2.33 GHz.
   2. 80 Gigabyte hard disk.
   3. 4 Gigabytes SDRAM memory.
4. Internal 100/1000 Ethernet adapter.
5. Internal dual band wireless card (a/g).
6. 512MB Video Card.
7. Minimum 350mm inch active matrix display with minimum 1280x800 resolution.
8. Internal 8X Speed DVD +/-RW drive.
9. Integral power supplies which shall be suitably rated for the service.
10. Integral QWERTY keyboard with full ASCII character set.
11. Integral touchpad.
12. Fingerprint reader and cable lock slot for security.

2.08 HAND HELD WIRELESS TERMINAL (HHWT)

A. Provide 2No. HHWT. These devices shall not be used by the BMS contractor for commissioning the BMS or for any other purpose and shall be delivered new to the Owner immediately prior to acceptance testing.

B. Provide HHWT with all necessary configuration tools

C. The operator shall be able to communicate with the BMS via the HHWT from any place in the facility. The hand held wireless terminal shall have a web browser and shall be able to communicate with the BMS either via the browser or through the configuration tool. The operator shall, subject to password access control, be able to undertake the same functions from the hand held terminal as from the POT. Detail any limitations of this device in the tender submittal.

D. The HHWT shall meet, at minimum, the following requirements:

1. Weight, including carrying case, not to exceed 0.2kg.
2. Provide a carrying case designed specifically for the HHWT that ensures adequate protection.
3. HHWT shall be powered by a rechargeable battery and shall also be powered by a 120 Vac, nominal 60 Hz source. Provide batteries adequate for a minimum of 4 hours of operation.
4. The HHWT shall have a colour LCD screen with a minimum display of 12 lines of up to a minimum of 20 characters minimum per line.
5. Minimum communications speed shall be 10Mbps.
6. This device shall be a PDA.

2.10 WEB ACCESS

A. Unless determined otherwise at a future date by the Owner, the system shall remain a private intranet that is not accessible from the Internet. The Intranet shall enable access to the systems via a standard web browser interface such as Microsoft Internet Explorer or Netscape Navigator.

2.11 BMS CONTROLLERS

A. There shall be 2 types of BMS control panels:

1. Distributed Control panels (DCP).
2. Unitary Controllers (UC).

B. All BACnet controllers shall be based on native BACnet and shall support all applicable BIBBs from the data sharing, alarm event, schedule, trend and device manager groups. Standard BACnet object types supported by the controllers shall include:

1. Binary input and output and value.
2. Analogue input, output and value.
3. Multi-state input and output.
4. Loop, calendar, notification class, command, file, program, schedule, group, event enrolment and device.
5. Proprietary object types shall not be used unless specifically approved by the Owner/Engineer.

C. All LonWorks controllers shall use SNVTs which are approved by the LonMark Association and which are published by the LonMark Association. Configuration properties shall be standard property types (SCPTs) as defined by the LonMark Association.

D. DCP shall be located at the Automation level and shall meet the following requirements:

1. DCP controllers shall be freely programmable and shall have an I/O capability to handle major items of equipment such as air handling units.
2. DCP shall be software programmable controllers at the Automation Level and shall interface via Point Interface Modules (PIM) to the field instrumentation and final control elements.
3. DCP may be used for any equipment monitored and controlled by the BMS. A dedicated DCP shall be provided, at minimum, to monitor and control:
   a. A single air-handling unit. Each AHU shall have a dedicated DCP.
   b. Other major items of equipment.
4. The DCP shall control its own communications so that the failure of any one node, shall not inhibit communications on the network between the remaining nodes. Provide integral network communication connections.
5. DCP shall be totally independent of any other primary and secondary LAN nodes for their monitoring and control functions. DCP shall monitor and control entire systems, multiple DCP for a single system shall not be allowed.
Where a DCP receives data from other nodes, such as an outdoor air temperature, which is used for a global system program strategy executed at that DCP, then alternative control strategies shall be automatically initiated, based on operator definable default values, if there is a loss of communication of the required data.

6. DCP failure shall not place any BMS component or any BMS controlled component in a situation that may cause damage to equipment or harm or discomfort to building occupants and operations staff. The failure of a DCP shall not affect the operation of any other network node.

7. The failure of any DCP shall be annunciated as a critical alarm at the NIU.

8. Cabling shall be terminated on rugged and easily accessible terminal strips. Each termination shall be clearly marked and shall be as detailed in the shop and record drawings.

9. Each DCP shall have its own power supplies that shall be rated such that they will adequately accommodate all foreseeable uses of the DCP.

10. Each DCP shall have, at minimum, a 16-bit microprocessor.

11. All operating sequences, schedules and trend data for equipment controlled by the DCP shall reside at the DCP.

12. Provide each DCP with a battery back up for the protection of volatile memory for a minimum of 72 hours. Provide a 10-hour minimum full function battery support capability.

13. Provide a real-time clock at each DCP. The real-time clock at the DCP shall be synchronized from the NTP clock as detailed in these specifications. Time synchronization shall occur at least once every 24 hours.

14. The DCP shall have a port for the connection of the POT.

15. DCP shall be housed in enclosures that shall meet the requirements detailed in Section titled “Panels and Enclosures” of these specifications. The DCP shall be placed at the same location as the equipment they control. The BMS contractor shall provide a suitably rated enclosure for all associated BMS components, including the controllers, relays, wiring guides, terminal strips, etc. The installation of the control enclosure and the installation of all cable and containment between the field instrumentation, including any current sensing relays in the MCC panels, and the DCP shall be by the BMS contractor.

16. Interfaces to field instrumentation and final control elements shall have Point Interface Modules (PIM) that shall:
   a. Enable the DCP to receive signals from the digital and analogue instrumentation.
   b. Enable the DCP to output control signals to the final control elements.

17. PIM shall be incorporated into the DCP by one or the following methods:
   a. Plug in type modules with specific or universal input/output capabilities.
   b. Integral to the DCP controller board.

18. PIM shall accommodate the following point types:
   1. Analogue and digital inputs.
   2. Analogue and digital outputs.
   3. Pulse inputs.

19. Analogue input PIM shall have a minimum 10-bit analogue-to-digital conversion and shall interface to all of the signal types listed in the Schedules of BMS Control Points. Provide LED indication of the status.

20. Analogue output PIM shall have a minimum 10-bit digital-to-analogue conversion and shall meet all of the output signal requirements detailed in the Schedules of BMS Control Points. Provide LED indication of the status.
21. Digital input and output PIM shall have electrical isolation and all relay contacts shall be suitably rated for the application. Provide LED indication of the status.

22. All PIM shall be easily exchanged and the failure of one PIM shall not affect any other PIM. Field terminations shall be such that the removal of a failed PIM shall not require the removal and reconnecting of field device cable terminations.

23. Provide LED on the PIM to indicate the status of each PIM.

24. All PIM shall be such that all output points can be manually positioned via an on board on-off-auto or potentiometer dial as applicable to the individual point.

25. Control shall be based on either three term algorithms, i.e. proportional plus integral plus derivative, or two term algorithms, i.e. proportional plus integral, unless specified otherwise.

26. DCP mounted on vibrating equipment, such as on air handling units, shall have vibration isolation protection that ensures their satisfactory operation.

27. DCP shall have opto-isolation or equivalent.

28. DCP shall be native BACnet or LonWorks controllers and shall comply with all of the requirements of ASHRAE SSPC/135 and ANSI/EIA-709.1 respectively.

29. The BMS contractor shall provide interoperability documentation for the BACnet DCP. All the data related to the DCP shall be presented along with their respective BACnet object ID created in the system, along with their PICS, BIBBS, addresses and method statements to read and write data via integration of the DCP with another system in future. This may be part of the overall interoperability documentation.

30. The BMS contractor shall provide full documentation for the LonWorks controllers (if provided) including details of all SNVTs, SCPTs, UNVTs, UCPTs and External Interface Files (XIF). The LonWorks interoperability data shall also include their respective BACnet object ID generated in the system against their LonWorks SNVT/SCPT data and method statements to read and write data via integration of the DCP with another system in future. This may be part of the overall interoperability documentation.

H. Unitary Controllers - General:

1. Unitary Controllers (UC) shall be "freely programmable" controllers with pre-packaged operating sequences maintained in EEPROM or flash EPROM. If LonWorks UC are provided they shall have a 3120 or 3150 Neuron microprocessor controller. Unitary controllers shall reside at the Automation level. Customisation of "freely programmable" controllers shall be possible to the extent that variable operating parameters, such as sequences of operation, setpoints, control loop parameters, control constants, and schedules shall be changeable on-line by the operator at the I2BS via the NIU and from the HHWT and POT. Provide all necessary configuration software and licenses to achieve this. UC shall be on a BACnet or LonWorks BMS LAN and shall provide an interface via PIM to the field instrumentation and final control elements of the following types of equipment:
   a. 1No. VAV terminal unit.
   b. 1No. fan coil unit
   c. Up to 6No. miscellaneous fans.
   d. Up to 4No. miscellaneous pumps.
   e. Up to 2No. self-contained AC units.
   f. Lighting control relays.
g. Miscellaneous input monitoring.
Panels meeting the requirements of DCP shall control all other types of equipment and systems.

2. The UC shall be a node on the primary BMS LAN if it is a native BACnet controller and shall be a node on the secondary BMS LANs if it is a LonWorks controller. The UC shall control its own communications so that the failure of any one node shall not inhibit communications on the network between the remaining nodes and the Management Level Network.

3. UC shall be totally independent of other secondary LAN nodes for their monitoring and control functions.

4. UC failure shall not place any BMS component or any BMS controlled component in a situation that may cause damage to equipment or harm or discomfort to building occupants and operations staff. The failure of a UC shall not affect the operation of any other secondary network node.

5. The failure of any UC shall be annunciated as a critical alarm at the I2BS via the NIU.

6. Cabling shall be terminated on rugged and easily accessible terminal strips. Each termination shall be clearly marked and shall be as detailed in the shop and record drawings.

7. UC shall be powered from the electrical service that serves the equipment monitored and controlled by the UC. The BMS contractor shall furnish transformers suitably rated for the application. The UC shall be housed in an enclosure that provides adequate physical and electrical protection.

8. Each UC shall have, at minimum, an 8-bit microprocessor.

9. Provide each UC with a battery back up for the protection of volatile memory for a minimum of 72 hours. Batteries shall be rated for a 7-year life. The UC serving VAV terminal units and FCU shall not be placed on UPS power.

10. Provide a real time clock at each UC. The real-time clock at the UC shall be synchronized from the real-time clock at the terminal server at least once every 24 hours. The clock shall have a battery back up of at least 72 hours.

11. UC shall be housed in enclosures that shall meet the requirements detailed in Section titled “Panels ” of Part 2 of these specifications. The UC shall be placed at the same location as the equipment they control. The BMS contractor shall provide a suitably rated enclosure for all associated BMS components, including the controllers, relays, wiring guides, terminal strips, etc. The installation of the control enclosure shall be by the BMS contractor and all cable between the field instrumentation and the BMS contractor shall furnish the UC.

12. Interfaces to field instrumentation and final control elements shall have integral PIM that will:
   a. Enable the UC to receive signals from the digital and analogue instrumentation.
   b. Enable the UC to output control signals to the final control elements.

13. PIM shall accommodate the following point types:
   a. Analogue and digital inputs.
   b. Analogue and digital outputs.
   c. Pulse inputs.

14. Analogue input PIM shall have a minimum 8-bit analogue-to-digital conversion and shall interface to all of the signal types listed in the Schedules of BMS Control Points.

15. Analogue output PIM shall have a minimum 8-bit digital-to-analogue conversion and shall meet all of the output signal requirements detailed in the Schedules of BMS Control Points.
16. Digital input and output PIM shall have electrical isolation and all relay contacts shall be suitably rated for the application.

17. UC shall control and monitor all points associated with a system. Multiple UC shall not be used to control and monitor a single system.

18. All applications programs shall reside at the UC.

19. Operating sequences for UC shall be resident at the UC. Database changes shall be undertaken from the I2BS via the NIU and from the POT. Schedules and trend data shall reside at the UC. They shall be accessible from the I2BS via the NIU and from the POT.

20. Control shall be based on either three term algorithms, i.e. proportional plus integral plus derivative, or two term algorithms, i.e. proportional plus integral, unless specified otherwise.

21. UC mounted on vibrating equipment, such as on FCU, shall have vibration isolation protection that ensures their satisfactory operation.

22. UC shall be native BACnet or LonWorks controllers and shall comply with all of the requirements of ASHRAE SSPC/135 and ANSI/EIA-709.1 respectively.

23. The BMS contractor shall provide interoperability documentation for the UC. All the data related to the UC shall be presented along with their respective BACnet object ID created in the system, along with their PICS, BIBBS, addresses and method statements to read and write data via integration of the UC with another system in future. This may be part of the overall interoperability documentation.

24. The BMS contractor shall provide full documentation for the LonWorks controllers (if provided) including details of all SNVTs, SCPTs, UNVTs, UCPTs and External Interface Files (XIF) together with all addresses. The LonWorks interoperability data shall also include the respective BACnet object ID generated in the system against their LonWorks SNVT/SCPT data and method statements to read and write data via integration of the UC with another system in future. This may be part of the overall interoperability documentation.

I. Unitary Controller - Fan Coil Units:

1. Each fan coil unit shall have a UC that shall meet all of the requirements detailed in Part H. above. The number, type and location of FCU shall be as indicated on the Mechanical Drawings.

2. The FCU manufacturer shall provide the following components for each fan coil unit for interface and mounting of the UC:
a. 24 Vac fan control relay interface.
b. Suitable mounting device for the temperature sensors for those FCU that have the temperature sensor located in the recirculation port. The FCU manufacturer shall provide a suitably constructed enclosure with electrical barriers as required by the applicable codes and standards.

3. The BMS contractor shall furnish the following components for each FCU to the MEP contractor for installation by the MEP contractor:
a. Unitary controller.
b. 24 Vac control transformer.
c. Temperature sensors for those FCU that have the temperature sensor located in the recirculation port.
d. Chilled water valve and actuator. The MEP contractor shall install the valve.

e. Provide the FCU manufacturer with the following documentation to coordinate the mounting of the UC and related components:

   i. Multi-colour point to point wiring diagram detailing the wiring and tubing of the UC and other control equipment installed on the terminal devices.

   ii. Written instructions and drawings containing sufficient information to enable the terminal unit manufacturer to undertake the installation satisfactorily.

4. Provide a wall mounted space temperature sensor for the monitoring of the space temperature associated with the FCU. The sensor shall be provided with LCD display and shall meet the following minimum requirements:

   a. RTD or thermistor sensors meeting the specifications detailed in Section titled “BMS Field Instrumentation” together with their associated signal conditioning facilities.

   b. Temperature reported shall have an accuracy of + or – 0.5 Deg. C.

   c. Enclosure shall be rugged plastic and shall be white. There shall be no logos, trademarks or names on the enclosure and there shall be no evidence of their removal. Refer to the Schedules of BMS Control Points and to the sequences of operation of the project documents to determine which functions shall be displayed on the LCD display. Temperature reported at the LCD shall have an accuracy of + or – 0.5 Deg. C. and the difference between the LCD and the I2BS/POT reported temperatures shall not differ by more than 0.2 Deg. C. Cover shall be removable to allow access to the plug for the POT. The enclosures shall be submitted to the Engineer for approval and shall be amended as instructed by the Engineer at no cost to the Owner. Temperature sensor housings with LCD display shall be intelligent and shall communicate with their associated UC via a digital communications network over screened twisted pair cable or equivalent. This communications network may use a proprietary protocol. Enclosures associated with FCU that have speed control shall also incorporate speed selection buttons.

   d. The temperature sensor enclosure shall be temporarily mounted alongside the FCU and shall be subsequently relocated as required by the fit-out design. Those temperature sensor enclosures that are wall mounted shall be located 1500 mm above finished floor level. Coordinate exact locations with Architectural Plans.

   e. Space temperature sensors for UC serving public areas shall use button type sensors as specified in Section titled “BMS Field Instrumentation”.

5. Temperature sensors located in the recirculation port shall have appropriate protection from physical damage and shall be mounted by the FCU manufacturer.

6. Provide the MEP contractor with the following documentation within 4 weeks of receiving the request from the MEP contractor:

   a. Multi-colour point to point wiring diagram detailing the wiring of the FCU controller and other control equipment installed on the terminal devices.

   b. Wiring instructions for those units controlled by the intelligent thermostats. The BMS contractor shall provide a list of all FCU that shall have programmable thermostats.
c. Written instructions and drawings containing sufficient information to enable the MEP contractor to undertake the installation satisfactorily.

d. The BMS contractor shall provide a list of all FCU that shall have the temperature sensor located in the recirculation port.

7. The BMS contractor shall meet with the MEP contractor before commencement of the UC installation and cabling to ensure that the proposed installation procedures are satisfactory. The MEP contractor shall prepare a drawing of the wiring for the UC and all associated instrumentation and final control elements based on the information provided by the BMS contractor. The MEP contractor and the BMS contractor shall both certify on the drawing that the drawing is correct and the drawing shall be submitted as a shop drawing for review by the Engineer.

8. UC for each production run shall be handed over to the MEP contractor at least two weeks prior to the scheduled shipment dates to the job-site. Obtain the FCU shipping dates from the MEP contractor.

9. The BMS contractor shall periodically meet with the MEP contractor to inspect the installation of the UC and to verify proper operation via a POT.

10. The BMS contractor shall enter all data into the UC at the site after the FCU has been installed.

11. The UC shall monitor and control the following parameters for FCU:
   a. Space temperature.
   b. Fan on/off control.
   c. Cooling coil valve.
   d. Setpoint reset (applicable only to those units with wall mounted enclosures having a setpoint reset capability).
   e. Fan speed control selection (applicable only to those units with wall mounted enclosures having a setpoint reset capability).

12. PID algorithms shall maintain the system operation within + or - 0.5 Deg. C. of the space temperature setpoints.

13. The operator shall be able to access the UC by connecting the POT to the LAN at the space temperature sensor enclosure. It shall not be necessary for the operator to obtain access to the ceiling plenum in order to obtain an operator interface to the UC. At minimum, the operator shall be able to undertake the following functions via the POT when connected at the temperature sensor enclosure, DCP and UC, via the HHWT and via the I2BS:
   a. Change space temperature setpoints for a single FCU.
   b. Change an alarm limit/value.
   c. Change the operating mode for a single FCU.
   d. Change the schedules for a single FCU.
   e. Turn the fan on/off for a single VAV FCU.
   f. Set the cooling coil valve to fully open and fully closed and any intermediate position.

14. The BMS contractor shall install data into the UC on site as necessary for the correct operation of the FCU including:
   a. FCU-UC LAN address.
   b. Occupied space temperature setpoints.
   c. Unoccupied space temperature setpoints.
   d. Control constants.
   e. Engineering units conversion factors.
   f. Default operating schedules.
   g. Definition of FCU type.
h. Other parameters as necessary to define the operation of the FCU in accordance with these specifications.

15. The BMS contractor shall calibrate the space temperature sensor at the project site.

16. Following the installation of the FCU the BMS contractor shall undertake the following tasks:
   a. Physically connect the UC into the BMS LAN.
   b. Enter all parameters that may not have been entered before shipment of the FCU to the site.
   c. Verify that the UC modulates the cooling coil valve from fully open to fully closed and vice versa.
   d. Verify that the FCU-UC is satisfactorily integrated into the LAN.
   e. Verify that the operating sequences are correct and that there is stable modulation of the cooling coil valve.
   f. Calibrate the temperature sensor.

17. UC shall have opto-isolation or equivalent protection.

18. UC shall be native BACnet or LonWorks controllers and shall comply with all of the requirements of ASHRAE SSPC/135 and ANSI/EIA-709.1 respectively.

19. The BMS contractor shall provide interoperability documentation for the UC. All the data related to the UC shall be presented along with their respective BACnet object ID created in the system, along with their PICS, BIBBS, addresses and method statements to read and write data via integration of the UC with another system in future. This may be part of the overall interoperability documentation.

20. The BMS contractor shall provide full documentation for the LonWorks controllers (if provided) including details of all SNVTs, SCPTs, UNVTs, UCPTs and External Interface Files (XIF) together with all addresses. The LonWorks interoperability data shall also include their respective BACnet object ID generated in the system against their LonWorks SNVT/SCPT data and method statements to read and write data via integration of the UC with another system in future. This may be part of the overall interoperability documentation.

J. Following a loss of power the DCP and UC shall reboot in an orderly fashion and attain a normal operating status within 2 minutes of the return of power. This shall be accomplished without operator intervention.

2.16 NETWORK TIME PROTOCOL (NTP) CLOCK

A. The times at all nodes on the Airport Network, including the BMS controllers, shall have their real time clocks updated by the Airport’s NTP clock. The Airport’s ELV Building Services Systems clocks shall be synchronised with the I2BS Application Server clock. The ELV contractor shall coordinate this work with the I2BS contractor such that the BMS controllers’ clocks are updated every 24 hours, at minimum.

2.17 SOFTWARE OPERATING SYSTEMS
A. All programming, scheduling, alarm limits, integration requirements, etc. shall reside in the DCP’s however a backup copy shall be maintained at the I2BS. Provide backup copy to the I2BS contractor after final acceptance testing. Coordinate this work with the I2BS contractor.

B. The BMS contractor shall provide a site-wide software license that shall permit the Owner to add an unlimited number of controllers if required in the future without the requirement to obtain an additional software license.

2.18 CONTROLLER MONITORING AND CONTROL SOFTWARE

A. Scan rates at the DCP and/or UC shall meet the following requirements:

1. Each analogue and digital input point shall be scanned at least once every 5 seconds.
2. If a point is in alarm, then the alarm shall be annunciated at the NIU within 2 seconds of the termination of the time delay period following detection of the alarm condition.

B. DDC outputs shall be updated at a frequency defined by the operator. The operator shall be able to select a frequency, at minimum, in the range of 2 seconds to 256 seconds.

C. The operator shall be able to define a minimum time delay between successive starts of equipment so that disturbances created on the building electrical system are minimised in frequency and amplitude. It shall be possible for the operator to assign at least 6No. start times and 6No. stop times in any 24-hour period.

D. BMS controller analogue and digital outputs shall change as the result of either an operator entered command or a BMS generated software command. These two modes of BMS controller output are referred to as the BMS MANUAL CONTROL mode and the BMS SOFTWARE CONTROL mode and differ as follows:

1. In the BMS manual control mode, the signal to a final control element such as a valve or a damper actuator and to a relay such as a motor control relay shall change as the result of a command manually entered at one of the operator terminals. When an output is in the BMS manual control mode, there shall be no means by which it can switch to the BMS software control mode or by which the value or state of the BMS output can change without operator intervention.
2. In the BMS software control mode, the signal to the final control element or relay shall be changed automatically as the result of software such as a schedule, operating sequence or Applications Package such as the Optimised Scheduling feature.

E. The operator shall be able to select the mode of output control for each analogue and digital output.

F. The operator shall be able to define the minimum time delay between the stopping of a piece of equipment and its subsequent restart. This time delay shall be in effect for motors in the BMS software control mode and for motors in the BMS manual control mode.
G. If there is a discrepancy between the actual and BMS commanded state of a motor then the motor control relay shall be set automatically to the OFF state, an alarm shall be generated and the motor shall be placed in the BMS manual control mode. In all cases a motor shall only restart following an operator manually entered command.

H. The BMS controllers shall not override any hardwired interlocks such as those provided at motor starters for overload protection, damper interlock, pressure interlock, etc. and those provided to facilitate control by the Fire Alarm System regardless of the BMS output control mode.

I. Unless stated otherwise elsewhere in these Specifications, the modulation of final control elements by the BMS controllers in the BMS software control mode shall be based on a Proportional-Integral-Derivative (PID) control algorithm. The control constants for the PID algorithm shall be definable by the operator. If self-tuning algorithms are provided, it shall still be possible for the operator to manually tune the control loops. The software shall incorporate facilities to enable the bumpless transfer of a modulating output from BMS manual control to BMS software control and vice versa and the prevention of integral wind-up. PID algorithms shall maintain the system operation within the desired tolerance around the setpoint. Setpoint tolerances shall be as follows:

1. Supply air temperature control, + or - 0.5 Deg. C.
2. Space temperature control, + or - 0.5 Deg. C.
3. Duct static pressure control, + or - 50 Pa
5. Space static pressure control, + or - 10 Pa
6. Relative humidity, + or - 3%

J. Software shall automatically inhibit the generating of an alarm on an analogue input when the status of an associated digital input indicates that an alarm condition is to be expected. Such would be the case, for example, when an air handling unit is off as it would be expected that the supply air temperature would be outside the alarm limits established for the operating state. An interactive procedure shall enable the operator to link any analogue value to a digital input so as to inhibit unnecessary alarms. Points with their alarms locked out shall continue to be displayed on reports and VDU displays. The alarms shall remain locked out for an operator defined time delay following the start-up of the associated equipment.

K. If for any reason the operator wishes to terminate the monitoring of a particular digital or analogue input, then it shall be possible to take the point out of service via an interactive procedure. If the point is the monitored variable in a control loop, then the control loop shall be disabled, any sequence dependent on the point shall also be disabled and all associated BMS outputs shall go to the BMS manual control mode.

L. An interactive procedure shall enable the operator to add, delete and modify points monitored and controlled by the BMS controllers.

M. An interactive procedure shall enable the operator to configure control loops. The operator shall define Setpoints for control loops or they shall be derived from software logic as detailed these specifications.

N. All configuration tools shall be provided to the Owner.
2.19 OPERATING SEQUENCES

A. The sequences of operation shall be resident at the controllers and shall be as detailed on the drawings.

B. Where terms are used, such as “operator determined”, “operator changeable”, etc., which indicate an operator originated decision, it shall mean that an operator shall be able to amend a value, such as a setpoint, alarm limit, time delay, etc. through an interactive approach. The term "interactive" is used to mean that the system shall operate in a conversational mode whereby the operator shall receive English language prompts in the form of:

1. Tables into which the operator enters data.
2. Questions that are responded to by the operator.
3. Selections that are made by the operator based on a list of suggested alternatives that is generated by the BMS.

C. The procedure by which an operator amends a value or implements a selection shall be such that the operator can readily execute the task without reference to instruction manuals and without knowledge of the BMS control language.

D. All setpoints, alarms limits, deadbands, software time delays, report configuration and requests, operating time limits, schedules, etc. shall be operator definable through an interactive procedure at the POT, HHWT and I2BS via the NIU as detailed in the Sequence of Operation shown on the Drawings. The BMS contractor shall be responsible for ensuring that all interoperability data (BACnet IDs or Lon SNVTs) is provided to the I2BS contractor in sufficient detail such that the I2BS contractor is able to achieve this function. The BMS contractor shall ensure that all necessary configuration tools are installed on the POT and provided to the Owner.

E. The equipment that is fed from emergency power and which is controlled by the BMS controllers shall operate normally under emergency power conditions and shall be monitored and controlled by the BMS controllers under emergency power conditions. Ensure that all equipment furnished under this contract that is associated with the control of equipment on emergency power is fed from the emergency power service and can maintain normal equipment operations when the equipment is on emergency power. Following a loss of normal power, the BMS CONTROLLERS shall resume normal equipment control and monitoring functions for that equipment on emergency power within 20 seconds of the availability of emergency power and similarly when there is a return to normal power. If necessary provide an uninterruptible power source in order to meet this 20 seconds resumption of operation requirement.

F. The BMS contractor shall identify on the cable and containment shop drawings which components are to be fed from emergency power and which components are to be fed from a UPS source.

G. The BMS contractor shall provide an easy to use means of defining the operating sequences such as a high-level control language or a graphical/flowcharting facility.

H. The means provided for the creation of the operating sequences shall be suitable for the implementation of the sequences detailed on the control diagrams that form a part of these contract documents.
I. If the BMS contractor requires additional instrumentation to that indicated in the BMS Point Schedules and Diagrams of the project documents in order to implement the operating sequences as detailed on the control drawings then the BMS contractor shall include such additional instrumentation within the tender price. Such instrumentation shall meet the requirements detailed in the Section titled "BMS Field Instrumentation" or, where specifications are not provided, details of such instrumentation shall be submitted to the Engineer for approval.

J. The operating sequences shall be written in a readily understandable high level control language such as Pascal, Basic, C or equivalent or they shall be constructed using an easily understood graphics interface package. Provide adequate English language notation in the software to assist the operator understand the intent of the programmed sequences.

K. The control language shall be capable of implementing 32-bit floating-point calculations using. At minimum, the following arithmetic operators:
   1. Addition.
   2. Subtraction.
   3. Multiplication.
   4. Division.
   5. Roots.
   7. Natural logarithms.

L. The control language shall, at minimum, be able to implement the following logic operations and relational operations:
   1. and
   2. or
   3. not
   4. nand
   5. nor
   6. If then else statement
   7. less than
   8. less than or equal to
   9. equal to
   10. greater than or equal to
   11. greater than
   12. not equal to

M. The BMS contractor shall be responsible for the stable operation of all control loops. The BMS contractor shall provide self-tuning PID control algorithms. Verify that the control loops are stable.

N. If any BMS controllers or system component should fail during the operation of a system, then the BMS controllers shall execute the procedure detailed in the sequences of operation. Where a failure mode is not provided for a BMS controlled item of equipment the BMS contractor shall obtain details of the required failure mode from the Owner/Engineer.

O. Where there are multiple filter banks the BMS contractor shall furnish a differential pressure switch across each filter bank. The BMS contractor may elect to monitor each filter alarm individually or may elect to wire the differential pressure switches
such that if any filter is in alarm a general filter alarm shall be monitored by the BMS controllers.

P. Any information required by the BMS contractor for the implementation of the software shall be requested in writing from the Engineer at least four (4) weeks prior to the time it is required. Submit the request for information in the form of tables or forms for the Owner’s personnel to complete and return.

Q. The operating sequences detailed in this section shall only apply when the BMS controllers is controlling and monitoring the system in the BMS software control mode.

R. In cases where outside air duct cross-sectional area exceeds a certain amount, multiple damper sections rather than a single section shall be furnished and shall be controlled in groups. Refer to the mechanical trade documents to determine the number of damper sections and the number of actuators.

S. Where indicated on the control diagrams, the BMS contractor shall interlock motorised dampers with fans such that when the dampers are closed the associated fans stop.

T. The BMS contractor shall provide any modifications to the operating sequences as requested by the Engineer without additional costs until the substantial completion of the entire BMS.

U. The sequences of operation are detailed on the Drawings of the contract documents. Where sequences have not been specifically identified for a mechanical, electrical or public health system/component, the BMS contractor shall obtain instruction from the Engineer and shall implement the required sequences at no additional cost to the Owner.

2.23 CONTROLLER APPLICATIONS SOFTWARE

A. Applications software functions associated with the control and monitoring of the mechanical and electrical systems by the BMS controllers shall be resident at the DDC controllers, POT and shall be provided to I2BS Contractor for installation at the I2BS. The application of these features shall be in accordance with the details provided in the Schedule of BMS Control Points and the Drawings “Sequences of Operation”. The BMS contractor is to implement all applications programmes. Where additional information is required the BMS contractor shall request the information in writing to the Engineer at least 4 weeks before it is required by the BMS contractor.

B. These application software packages shall include but not be limited to the following:

1. Provide the following programs for the optimization of energy usage:
   a. Electrical Load Control
   b. HVAC control
2. Provide the following programs for the calculation of data:
   a. Energy usage and demand
   b. Psychometric properties
   c. Equipment operating time
3. Provide the following programs for the restart of building mechanical systems:
   a. Equipment restart following a fire alarm
   b. Equipment restart following a power failure

C. Energy Management Features: BMS controllers shall perform all energy management functions specified herein to reduce energy consumption. The system shall provide energy supervisory management routines that improve the energy efficiency of the building HVAC systems and the lighting. These routines shall coordinate the execution of all energy management application features, acting as an executive software system for them, and as an interface for their control strategy with other application features in the system. These energy management functions to be categorized under load control and HVAC control. These features shall reside at the DDC controllers and are to operate independently of the POT and I2BS.

D. Load Control:

1. BMS contractor to provide predefined control algorithms to accomplish peak demand control and power consumption reduction through Demand Limiting and Duty Cycle control application. Although the primary focus of these applications is towards electrical energy usage, the system to be capable of applying these predefined algorithms to other energy sources, such as steam, without software revisions. The load control functions shall be applied as identified in the Schedule of BMS Control Points and the Drawings “Sequences of Operation”.

2. Demand Limiting and Duty Cycle control applications to be coordinated through energy supervisory management routines. These routines to coordinate the control action required by Demand Limiting and Duty Cycle between themselves, all other energy features, and all application features within the system.

3. Load Shed systems/meters to support a minimum of 32 load control systems/meters, each capable of being defined with a unique set of parameters/characteristics. Each system/meter to support English or metric units of measurement and be assigned a unique identifier used to request operator-relevant load control status data. Each meter shall support Demand Limiting and Duty Cycle. Load Shed systems/meters and their associated points and parameters to be online definable. Any additions, modifications or deletions to be made online. Each system/meter to be individually identified with a unique English language descriptor.

4. Controllable loads to be able to be defined for Demand Limiting and/or Duty Cycle. A load is to be considered eligible to be shed if its minimum on-time has expired, and considered eligible for restoration if its minimum off-time has expired, provided the energy operating conditions are met (e.g., online unlocked, normal mode, eligible for control, etc.)

5. Each load shed system to provide a saving profile summary. The following information, at minimum, is to be communicated to the I2BS and shall be available in report form at the I2BS workstation and the POT:
   a. Period start date as defined by operator.
   b. Daily profile time (on, off, mid-peak or all).
   c. Daily peak measured demand and its time of occurrence.
   d. Daily peak projected demand and its time of occurrence.
   e. Daily measured energy usage.
   f. Daily projected energy usage.
   g. Period profile time.
h. Period measured energy usage.
i. Period projected energy usage.
j. Period peak measured demand.
k. Period ratchet clause percentage and number.
l. Period billed demand.

These documented savings values to be automatically historically stored for the current defined period and a minimum of twelve past periods.

6. Operator Output Information to be available from Load Shed program in a minimum of two types of summaries. It is to be output upon operator request or preselected time, as detailed under the Weekly Scheduling of this specification.

7. All summaries to include the Load Control system English language descriptor.

8. At minimum the following information is to be communicated to the I2BS and a system summary shall be output on a scheduled basis or on a request basis at the I2BS workstation or at the POT:
   a. Demand interval.
b. Current KW power.
c. Current measured demand.
d. Projected demand usage.
e. Energy units defined for the energy system.
f. Maximum expendable load.
g. Average expandable load.
h. Current expandable load.
i. Maximum deferrable load.
j. Average deferrable load.
k. Current deferrable load.
l. Demand limit status.
m. Demand limit target value.
n. Demand limit control action in the last minute.
o. Duty Cycle status.
p. Duty Cycle target value.
q. Duty Cycle control action in the last minute.
r. Convergence time.
s. Restore bandwidth.

9. A System Load Summary shall be available on a scheduled or request basis at the I2BS workstation or at the POT. The following minimum information is to be communicated to the I2BS and shall be included in the System Load Summary:
   a. Expendable/deferrable load type.
b. Point type.
c. Point ID.
d. Point status.
e. Load rating.
f. Minimum off, maximum off and minimum on times.
g. Today’s shed time for each load.
h. Today’s shed frequency for each load.

10. Demand Limiting control algorithms/programs to monitor total power consumption per meter and shed associated loads automatically to reduce power consumption to an operator presentable maximum demand target value. Program to use a floating window type demand determination to monitor average rate of energy usage/demand and by comparing this usage to target value and request control action to be taken to satisfy its requirements.
11. Duty Cycle control algorithms/program to briefly turn selected loads off periodically to evenly reduce power consumption to an operator presettable target value. Duty Cycle program to be properly integrated and interactive with the Demand Limiting program specified above.

12. Loads to be shed automatically throughout Duty Cycle interval by selection of groups on a priority factor and loads within a group to satisfy calculated control action. If control action cannot be satisfied, the system is to notify the operator through an advisory message.

E. HVAC Control:

1. BMS controllers to provide predefined control algorithms to accomplish Optimal Run (start/stop) Time, Supply Air Reset and Enthalpy Switchover Optimization applications.

2. Optimization applications to be coordinated through energy supervisory management routines. These routines to coordinate control action required by optimization applications between themselves, all other energy features, and all application features within the system.

3. Each control system to support English or metric units of measurement and be assigned a unique identifier which is to be used to request operator-relevant HVAC control status data. Each control system to be capable of supporting Optimal Run Time, Supply Air Reset, and Enthalpy Switchover Optimization.

4. Control systems and their associated points and parameters to be online definable. Any additions, modifications or deletions to be made online. Each system to be individually identified with a unique English language descriptor.

5. A savings profile summary shall be available at the I2BS and the POT which shall document, at minimum, the following:
   a. Period start date as defined by operator.
   b. Calculated optimal start time daily saving values.
   c. Calculated optimal stop time daily saving values.
   d. Calculated optimal start time daily saving values during current period.
   e. Calculated optimal stop time daily saving values during current period.
   f. Calculated SAR (Supply Air Reset) daily saving values.
   g. Calculated SAR saving values during current period.
   h. Calculated ESQ (Enthalpy Switch-over) daily saving values.
   i. Calculated ESQ saving values during current period.
   
   These documented savings values to be automatically historically stored for the current defined period and a minimum of twelve past periods.

6. Optimal Run Time (ORT) Programme is to:
   a. Control start up and shutdown of HVAC control equipment.
   b. Provide the most efficient operation during potentially energy wasteful periods of the day based on occupancy schedules, outside air temperature, seasonal requirements and interior room mass temperatures.
   c. Start up systems by using outside air temperature and room temperatures to "learn" the building's thermal characteristics through a dynamic adaptive modelling technique.
d. Predict and self-adjust the HVAC control system for how long building takes to cool down under different conditions, using the adaptive model.

e. Determine how early it can shut down the system without adversely affecting ventilation, by using the outside air temperature.

f. Automatically determine the seasonal mode and worse case condition for each day, by analyzing multiple building mass sensors.

g. Analysis to require only easily obtained occupancy schedule data and desired mass temperatures for implementation.

7. Supply Air Reset (SAR) Programme is to:
   a. Monitor cooling loads in building spaces.
   b. Monitor single zone unit discharge temperatures.
   c. Adjust HVAC control discharge temperature to the most energy efficient levels that still satisfy the measured load.
   d. Raise cooling temperatures to highest possible value, and still cool and dehumidify the warmest monitored room served by fan.

F. Electrical energy usage and demand:

1. Provide software to monitor electrical energy usage and instantaneous energy demand. This feature shall also store data for recall via the historical data trend package.

2. The BMS controllers shall monitor the demand kW, kVA and kWh at the switchboards. The BMS controllers shall also monitor and provide reporting on kWh usage of controlled equipment within the building based on equipment operating time and monitored kW for each piece of equipment. If an item of equipment is not monitored then it shall be possible for the BMS contractor to input the kW of the equipment as a constant to be used in the calculation. The kW value shall be obtained from the manufacturer’s literature and shall be verified by the manufacturer.

3. The BMS controllers shall provide a 15-minute interval counter for the metered inputs.

4. The BMS shall communicate the necessary data to the I2BS in order to enable the I2BS to output a report on a scheduled and request basis detailing the following:
   a. Demand (at each meter) at time of report.
   b. Usage for present day to time of report.
   c. Usage on previous day.
   d. Usage for present week to time of report.
   e. Usage for previous week.
   f. Usage for present month to time of report.
   g. Usage for previous month.
   h. Usage for year to time of report.
   i. Usage for previous year.
   j. Peak demand for the present day, week, month and year to time of report.
   k. Peak demand for the previous day, week, month and year.

5. In addition to the above reporting of data the operator shall be able to assign any monitored or calculated value to the real-time plotting and historical data trend features.

6. As part of the work of this contract the BMS contractor shall implement all energy management calculations as requested by Owner. Submit in writing to the Owner, at least 4 weeks prior to the acceptance testing, a request for points to be placed on the energy management calculation feature.
written request will clearly indicate the information required from Owner and the format in which it is to be provided.

G. Psychometric properties:

1. Provide a software package to determine the following properties of ambient air:
   a. Wet bulb temperature.
   b. Dew point temperature.
2. The above parameters shall be calculated using the monitored values of ambient air-dry bulb temperature and relative humidity.
3. This software package shall also calculate the enthalpy of ambient air and ducted return air on the basis of the dry bulb temperature and relative humidity monitored in ambient air and the ducted return air.
4. These psychometric calculations shall be based on sea level data and shall cover the dry bulb temperature range of +10 Deg. C. to +60 Deg. C.
5. The psychometric data shall be sent to the I2BS via the NIU. It shall also be possible to view the data dynamically on the POT, when connected. With the input of any two variables all other psychometric data shall be automatically displayed on the psychometric chart.

H. Equipment operating time:

1. Provide a software package that will accumulate the operating times for motors as selected by the operator using an interactive procedure. Any piece of equipment that has its status monitored by the BMS controllers shall be selectable for inclusion in this feature. It shall be possible to concurrently monitor the accumulated operating time for every item of equipment monitored and/or controlled by the BMS controllers. Data shall be stored at the local controllers and shall be uploaded to the NIU at regular intervals. In the event of loss of communications between the NIU and the local controller the local controller shall continue to monitor and store data such that the data can be downloaded when the communication is restored. The number of starts and stops of motors shall also be accumulated.
2. The operator shall be able to establish on-line, using an interactive procedure, a value for the accumulated operating time at which a suitably worded message shall be output to the operator advising that the reporting limit has been reached for a specific motor. The message shall be sent to the I2BS via the NIU.
3. The operator shall be able to change the accumulated total for any motor to any value.
4. The accumulated operating times shall be updated at least every 15 minutes.
5. The operator shall be able to obtain a report on demand and on a scheduled basis detailing the accumulated operating times.
6. Operating times and the number of equipment starts/stops shall be input by the BMS equipment-scheduling programme to the Owner’s Facility Management System and shall be the basis of maintenance programming.

2.24 DATA ANALYSIS, STORAGE AND PRESENTATION SOFTWARE

A. Data analysis, storage and presentation software shall reside at the I2BS and shall not be in the scope of work of this project.
B. Data required for dynamic trending and dynamic graphical displays shall be communicated to the I2BS at the required frequency by the BMS controllers. Data for historical data trending functions shall be stored at the BMS controllers/NIU and uploaded to the I2BS application and data servers on a scheduled or as requested basis.

2.25 THIRD PARTY INTERFACES

A. General:

1. The BMS controllers shall communicate with other Extra Low Voltage Building Services Systems via the I2BS except in the case of the variable speed drives which shall communicate with the BMS controllers at the automation (controller) level.

2. The VSD contractor shall provide the gateway and complete documentation to the BMS contractor. The BMS contractor shall connect the gateway to the Automation Level Network and shall map the BACnet object or Lon SNVT IDs, as applicable, to the associated DDC controllers and shall advise the VSD contractor of the BACnet objects or Lon SNVT IDs, as applicable, that are to be mapped to the VSD from the BMS. Information that is provided by third party systems at the Automation Level shall be available at the Management Level Network. Coordinate this work with the third party VSD contractor and the I2BS contractor.

3. The intent of this section is to identify the minimum information that shall be sent from the VSD to the BMS and made available at the I2BS by the BMS. If the VSD is able to supply additional information to the BMS then the VSD contractor shall advise Owner/Engineer who shall determine which additional information is to be transferred.

4. The BMS contractor shall liaise with the manufacturer and/or contractor responsible for the VSD and shall provide all details regarding the BACnet/LonWorks protocol as necessary for the VSD contractor to implement the interface between the VSD and the BMS.

5. The interface between the Automation Level Network and the VSD shall be demonstrated at an offsite location. The tests shall be fully coordinated by the BMS contractor who shall liaise with all concerned parties including the VSD contractor and the I2BS contractor. The BMS contractor shall provide all additional hardware and software as necessary for the tests to indicate conclusively that the BMS can communicate with the VSD. If the test is successful the VSD contractor shall advise the Engineer and Owner and a time shall be established that is acceptable to the Engineer and Owner when the interface can be demonstrated to the Engineer at the VSD contractor’s facility or some other location acceptable to the Engineer.

6. A watchdog procedure must be implemented by the BMS contractor that enables the identification of the point of failure, i.e. where in the communications chain between the two systems did the failure occur. The watchdog function must operate at a frequency that detects a communications failure within a maximum of 30 seconds.

B. Interface between the Automation Level Network and variable speed drives (VSD):

1. The variable speed drive suppliers shall provide a BACnet or LonWorks interface to the Automation Level Network.
2. The digital communications interface shall be set up so as to provide the BMS, at minimum, with the following monitoring and control points:
   a. Start and stop control (this may also be accomplished via a hardwired relay).
   b. Speed control (this may also be accomplished via a hardwired analogue output).
   c. Speed reference feedback.
   d. Motor operating status.
   e. VSD alarm.
   f. Motor power in kW.
   g. Motor kWh.
   h. Motor current.
   i. Motor voltage.
   j. Hours run.
   k. DC link voltage.
   l. Thermal load on motor.
   m. Thermal load on VSD.
   n. Heat sink temperature.

3. The BMS contractor shall obtain all BACnet object or Lon SNVT IDs, as applicable, together with all other relevant information from the VSD contractor and shall map the information to the associated DDC controllers. The BMS contractor shall provide an AutoCAD drawing of the schematic display of the points to the I2BS contractor. The information shall be mapped to the I2BS servers as BACnet objects in exactly the same manner as information monitored by the BMS controllers directly is communicated to the I2BS.

4. The VSD interfaces shall be at the automation level such that the failure of the Management Level Network shall not affect the interchange of information between the associated BMS controllers and the VSD controllers.

2.26 SUBMITTALS

A. Submit documentation and samples in accordance with the requirements of Division 1.

B. Shop Drawings: Indicate system configuration; interconnection wiring diagrams; location, data characteristics, range and units for each input and output point; logic diagram for each type of control routine; programming and operating reference for central processing unit operating system; programming and operating reference for each application and programming language provided.

C. Product Data: Provide for each component, including sensors, control drives and elements, plug-in circuit boards, and enclosed equipment units. Include cabinet dimensions, weights, and support point locations for each item of enclosed equipment.

D. Design Data: Indicate basis of optimization algorithms.

E. Manufacturer's Installation Instructions: Indicate installation instructions.

F. Manufacturer's Certificate: Certify system meets or exceeds listing requirements of Underwriter's Laboratories, Inc. for fire alarm and security equipment.
G. Submit software provider's license agreement stating limits on use, copying, and transferring software.

H. Manufacturer's Field Reports: Indicate acceptance of component and equipment installation, interconnecting wiring, and weekly progress on installation and start-up of system software.

I. Where installation procedures, or any part thereof, are required to be in accord with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.

J. System Schematics: The BMS contractor shall supply system schematics to the I2BS contractor in an AutoCAD format. These drawings will illustrate the HVAC, Electrical and other systems monitored and/or controlled by the BMS. The location of monitored and controlled points and the associated BACnet/Lon object ID shall be shown on the drawings at the appropriate location.

K. Technical Data Sheets: control and instrumentation technical data sheets (TDS) to be prepared for each device. TDS to be similar to and meet the intent of ISA-S20, 1975.

L. Loop Diagrams: control and instrument loop diagrams prepared and furnished for all instrument systems. Typical diagrams are not permitted. Loop diagrams are to be unique for each loop.

M. Equipment Installation Plans: to indicate location of instrument junction boxes, individual field instruments, transmitter racks, and routing of cable duct from junction boxes to respective remote processing units and back to Central Control Room. This is to be accompanied by a list of control points connected by each FPU, with indication of related control functions. Interfacing provided is to be listed; these are to be grouped as per standard sub- module size of digital and analogue input/output boards, comprising similar requirements; such as interposing relays amplifiers, level translators, etc.

N. Instrument Installation: detail drawings for each field installation are to be furnished. Details are to include but are not limited to instrument piping details, transmitter rack details and pipe mounted equipment installation details.

O. Logic Diagrams detailing the operational logic are to be completed for the digital binary operations. In addition to these drawings, operational logic descriptions are to be prepared detailing the sequence of operation and operational constraints and limitations. These drawings are to be in conformance with ISA-S5.2, 1976. Submit details for each primary and secondary processing units separately, in addition to logic diagrams relating Central Control Room processing functions and resulting operations.

P. Instrument Schedule listing all devices to be keyed to instrument loop number and device numbers. Schedule to be submitted in two (2) formats; first, in an alphanumeric listing by device type and second, a listing with equipment grouped by loop number. Schedule to contain as a minimum the following information:

1. Instrument identification number.
2. Service.
3. Flow diagram number.
4. Logic diagram number.
5. Piping drawing number.
6. Installation plan number.
7. Manufacturer’s name.
8. Processing units termination, interfacing and communication.
9. Wiring drawing number.

Q. Instrument Schedule to provide a comprehensive data source indicating where all specific information may be found for each service. Schedule to include not only balance of plant equipment but also that equipment furnished as part of packaged systems and is to be noted as such.

R. All Input/Output schedules for each controller identifying the type of signal, device and equipment location.

S. Prior to procurement of equipment submit for approval the following drawings and documents:

1. Process and instrumentation flow diagrams.
2. Equipment specifications and completed technical data sheets.
3. Control logic diagrams and logic descriptions.
4. Input/output points charts for every processing unit.
5. Statement of specification compliance.
6. Interoperability documentation as detailed in these specifications.
7. All other certifications as detailed in these specifications.

T. Prior to start of system installation and construction submit for approval the following drawings and documents:

1. Shop drawings for valves, dampers, transducers, transmitters, signal conditioners, indicators, recorders, miscellaneous instruments, central operator processing unit, consoles and ancillary.
2. Control loop diagrams.
3. Electrical elementary diagrams.
4. Instrument installation plans.
5. Detailed panel diagrams.
6. Point to point wiring diagrams.
7. Instrument schedule, including processing unit panel termination/interface.

U. Prior to commencing start-up activities the documents to be submitted for approval:

1. System construction inspection procedures.
2. Points calibration procedures.
3. Calibration technical procedures.
4. Plant operational system test procedures.
5. Operator and maintenance personnel training curriculum.

V. Prior to system acceptance and turnover and as a condition of system acceptance, the following documents are to be submitted in four copies in accordance with requirements of Division 1:

2. Systems maintenance manual including specifications on each piece of equipment, trouble-shooting charts, and preventive maintenance instructions, technical data sheet for each instrument referenced for each application.
3. As-built drawings including equipment outlined dimension drawings, equipment wiring and or piping connection drawing.
4. Complete supplementary information about software and hardware of system supplied. This to include:
   a. System block diagram (hardware).
   b. Software "functional" flow diagram.
   c. Memory map of all units.
   d. Specific tasks performed by each processor, especially where a distributed processing architecture is provided. These are to be clearly indicated in functional form.
   e. Source and object lists of software program.
5. Internal equipment wiring, complete with circuit diagrams for each processing unit, board layout (single and double sided), plus edge connection schedule and lists of all components (integrated circuits, transistors, regulators, resistors, capacitors, etc.) plus edge-connection schedules.
6. Tests and calibration data pertinent to each item installed in the systems.
7. Password at all levels.
8. Meets LonMark™ Interoperability Association Standards.
   9. Interoperability documentation as detailed in Part 1.07.N.7 of these specifications.
   10. All documentation as detailed in paragraph V. above.
   11. Documentation as detailed in Part 2.22.Q of these specifications.
   12. All other documentation as detailed in these specifications.

W. The BMS contractor shall provide interoperability documentation for the BACnet and components. All the data related to the components shall be presented along with their respective BACnet object ID created in the system, along with their PICS, BIBBS, addresses and method statements to read and write data via integration of the components with another system in future.

X. The documentation shall include comprehensive and complete details of the LonWorks components (if provided) including details of all XIF, SNVTs, SCPTs, UNVTs, UCPTs and External Interface Files (XIF). The LonWorks interoperability data shall also include their respective BACnet object ID generated in the system against their LonWorks SNVT/SCPT data and method statements to read and write data via integration of the LonWorks components with another system in future.

The BMS contractor shall handover all programmes, database, configuration and network data to the Owner.
PART 3 - EXECUTION

3.01 TRAINING

A. Submit an outline of the training courses to be given. This outline shall include a schedule of the training sessions in at least one-half day increments, indication of the topics to be covered in each session and any prerequisite requirements that should be met prior to attendance. The training outline shall be submitted with the initial shop drawing and submittals packages. Training shall not commence unless the Engineer has approved a training outline. Training shall be coordinated with the Owner’s designated training coordinator.

B. Training sessions shall include classroom type instruction and "hands on" instruction and shall be given by the contractor at the BMS contractors facilities and on-site as detailed below. The trainers shall be factory trained, shall be experienced with the hardware and software and shall be experienced trainers. The resumes of the trainers shall be submitted to Owner and Engineer for approval. The resumes shall indicate clearly the experience and expertise of the proposed training staff.

C. Training shall consist of, 8 No. 4-hour sessions at the BMS contractor’s facilities. These training sessions shall be tailored to the construction schedule and they shall be presented in accordance with a flexible schedule that shall be acceptable to the Owner. Follow up training shall consist of 4 No. 4-hour sessions on-site using the installed components that shall be given during the period immediately prior to the acceptance testing. Further follow up training shall consist of 4 No. 4-hour sessions on-site during the warranty period. These training sessions during the warranty period shall be scheduled with the Owner.

D. Provide all training materials (hand-outs, textbooks, workbooks etc.) and any audiovisual equipment required to execute the training.

E. Training sessions shall be formatted to maximize the usage of time of the attendees and prevent redundant coverage of materials for advanced students. Training sessions shall be designed on the basis of experience and knowledge of the attendees scheduled to participate and shall differentiate between the requirements of supervisory, operations and maintenance personnel. The training shall be specific to this project and shall cover, at minimum, the following:

1. Data base features.
2. Operating sequence programming.
3. Interface to the NIU.
4. An overview of the BMS topology.
5. Information access.
7. Operator definable values.
10. Maintenance and calibration of instrumentation (Maintenance personnel only)
11. Use of the Portable Operator Terminals (POT) and the Hand Held Wireless Terminals (HHWT)
12. Interfaces between the low voltage building systems.
13. Other subjects necessary to ensure that the operators, maintenance and supervisory staffs will be able to operate the BMS without any on-going assistance from any outside party.

F. Provide sufficient training to Owner’s staff such that they shall be able to add new points to BMS controllers and send this information to the NIU.

3.02 BORING AND PATCHING

A. Boring and patching for work undertaken by the MEP contractor to install BMS components shall be undertaken by the MEP contractor but the BMS contractor shall provide boring and patching of work in those instances where the BMS contractor has caused damage requiring boring and patching. The BMS contractor shall provide boring and patching for all installation work undertaken by the BMS contractor. Boring and patching shall meet, at minimum, the following requirements:

1. Before boring any structural components, obtain the Engineer's approval.
2. Make boring with clean, square and smooth edges. Patches shall be inconspicuous in covered areas and visually undetectable in areas normally accessible to the tenants.
3. Restore fire ratings if boring has violated the fire rated assemblies.

3.03 FIRE STOPPING

A. The MEP contractor shall provide fire stopping for components installed by the MEP contractor on behalf of the BMS contractor but if the BMS contractor damages fire stopping installed by another trade or the work undertaken by the BMS contractor requires that fire stopping be replaced or added, the BMS contractor shall seal all conduit, cable, or cable tray penetrations of fire rated assemblies. Seal or fire-stop shall meet, at minimum, the following requirements:

1. Comply with all applicable codes, regulations and statutory requirements.
2. Approved by the authority having jurisdiction.
3. Firesafing system or device used shall not derate the ampacity of electrical cables passing through it.

3.04 HANGING AND SUPPORTING

A. Install all equipment, devices, materials and components in compliance with the manufacturers recommendations. Supports shall be suitable for the environment within which the component is to be installed. Coordinate all hanging and supporting of components with all trades.

B. Boring and cutting shall be kept to a minimum and conducted in a neat and workmanlike manner. Provide reinforcing and fastening materials as necessary.
3.05 TESTING AND INSPECTIONS

A. General Requirements:

1. The BMS contractor shall not receive a Contract until it has been determined that the interface between the I2BS Network Interface Panel and the BMS meets all of the requirements of these specifications. Once the Pre-Approval testing has determined that the I2BS and BMS controllers can meet the requirements of their respective specifications and award of contract has been confirmed, the following tests shall be undertaken:
   a. Factory Tests – Software and hardware shall be thoroughly tested before it is shipped to the site.
   b. Inspection/testing during installation.
   c. Components shall be tested on site and shall be individually accepted by the Engineer prior to the commencement of the acceptance testing of the integrated I2BS and ELV Building Services Systems.
   d. Acceptance Testing of the installed integrated components.

2. All components shall be tested by the BMS contractor to ensure compliance with the specifications before they leave the BMS contractor's premises and shall be tested again on-site by the BMS contractor before the commencement of acceptance testing. The BMS contractor shall not ship components to the project site until they have been found to be fully compliant with the specifications and the BMS contractor shall not request the commencement of acceptance testing until such time as the BMS contractor has made a complete and thorough checkout of all equipment on site.

2. Any component furnished under this contract shall be made available for inspections or tests, as deemed necessary by the Engineer. Use of any component by Owner and Engineer shall not imply acceptance of the system or acceptability of any component. Availability and demonstration of the systems shall not be withheld and the use of components shall not imply the start of the Defects Liability Period.

3. Costs associated with the required inspections and testing shall be included in this scope of work. Additional charges will not be accepted.

4. The BMS contractor shall make available all equipment, calibrated instruments and ladders, as necessary to satisfactorily demonstrate the acceptability of the components and systems. Instrumentation to be used for the verification of monitored parameters shall be calibrated or supplied by an approved laboratory or manufacturer. Provide copies of the calibration data with the component test sheets.

5. Installation, engineering, software and system personnel shall be available on-site during the commissioning tests. These personnel shall be familiar with the installation and shall undertake all tests as requested by the Engineer in order to verify that the BMS components individually and in total meet the specifications.

6. The BMS contractor shall confirm that the person(s) who will be conducting the commissioning tests on behalf of the BMS contractor has been actively involved (on site) throughout the commissioning of the control system. Software shall be developed, tested and demonstrated over a time span short enough to guarantee continuity of personnel.

B. Pre-Approval Testing of the BMS Controllers:

1. The data transfer between the various Extra Low Voltage Building Services Systems controllers and the I2BS shall be demonstrated at a test facility established by the I2BS Contractor prior to the award of contract to the ELV
Building Services System Contractors. The tests shall be fully coordinated by the I2BS Contractor. The BMS contractor is required to cooperate with the I2BS contractor to ensure that the testing is fully coordinated. The I2BS Contractor shall liaise with each party concerned and shall ensure that the necessary test facilities, including a data port to a 10-gigabit per second Ethernet network, are available and operational. The ICT Contractor shall provide the Data Network. The I2BS Contractor shall provide an I2BS Applications Server, Operator Workstation and a NIU. The BMS contractor shall provide all necessary BMS controllers. It shall be conclusively demonstrated that the BMS can communicate via the NIU with the Applications Server and vice versa. If the test is successful a time shall be established that is acceptable to Owner/Engineer when the interface can be demonstrated. This test must be completed within 90 days of the issue of the letter of intent to award a contract for the BMS. Each party involved in the test shall provide the applicable components necessary to perform the demonstration. Ensure the presence of suitably skilled personnel at the tests. The components provided for and the functions performed at the tests by each party shall be those that they are required to provide for the actual installation. The testing of the interface between the BMS controllers and the I2BS Management Level shall verify, at minimum, that:

a. All points mapped from the BMS controllers to the I2BS Management Level are reported correctly at the I2BS workstation.
b. All mapped points are identical with regard to value, the engineering units and significant digits at both the BMS controllers and the I2BS Management Level.
c. The communications watchdog is functioning correctly.
d. Communications speed between the systems is satisfactory.
e. Systems restart and communications between the systems resume following a power failure without operator intervention.
f. All response times with respect to the annunciation of changes of state and equipment alarms shall be shown to comply with the requirements detailed in these specifications and in the I2BS System specifications.

2. Subsequent to the Pre-Approval testing detailed above at the I2BS Test Facility, the BMS contractor shall submit a report to Engineer detailing the results of the tests. If the BMS contractor cannot successfully demonstrate compliance with the requirements of I2BS specification and the BMS specifications with respect to the interoperability the contractor shall not be awarded a contract.

3. The I2BS Test Facility shall be a major tool for the training of Owner’s personnel. The Owner’s staff shall be involved in all aspects of the I2BS Test Facility operation during interoperability compliance testing and during the set up and testing of the Test Facility.

C. Factory Tests/Software Tests:

1. All components shall be tested by the BMS contractor to ensure compliance with the specifications before they leave the contractor's premises and shall be tested again on-site by the BMS contractor before the commencement of acceptance testing. The BMS contractor shall not ship components to the project site until they have been found to be fully compliant with the specifications.

2. Subsequent to the factory testing detailed above at the BMS contractors Facility, the BMS contractor shall submit a report to Owner/Engineer detailing the results of the tests.
3. If Owner decides to witness the tests, the Owner/Engineer, the I2BS Contractor and BMS contractor shall establish a mutually agreed time for the testing to take place.

4. The BMS contractor shall not commence installation on site until the approval of the Engineer has been received and such approval shall not be given until such time as all interfaces/data exchanges have been successfully demonstrated off site.

5. The interfaces between the NIU and the BMS controllers shall be fully demonstrated to the Engineer prior to the installation of any microprocessor based components at the project site. The demonstration shall include all hardware and software components associated with the interfaces.

C. Inspection During Installation:

1. Prior to commissioning tests, the BMS shall be available for use by the Owner and the Engineer. Use by the Owner and Engineer shall not imply acceptance of any component of the BMS or the commencement of the Defects Liability Period.

2. Provide staff to assist the Engineer in the inspections made during the installation period to review the progress and quality of the ongoing work. The Engineer will generate Field Observation Reports on the findings of the inspection. The Engineer shall advise the BMS contractor during the inspection of any concerns noted with respect to the installation and shall repeat the concerns in writing as soon as possible after the inspection is completed. The BMS contractor shall take corrective action to meet the requirement of the specifications.

3. Failure of the Engineer to identify any error or omission during inspections shall not relieve the BMS contractor of any of the specification requirements and shall not imply that a deviation from the specification has been accepted.

D. Component Testing/Point To Point Testing:

1. Prior to the scheduling of the commissioning tests with the Engineer, perform a complete and detailed operational check of each BMS component. Tests shall be documented as detailed below and shall cover all of the testing requirements detailed in this Section for the commissioning tests. The Engineer shall undertake such random testing as the Engineer considers necessary to verify the acceptability of the components.

2. All component testing involving the verification of air and water flow rate monitoring shall be scheduled in conjunction with the air and water-balancing contractors. In particular, this shall apply to the verification of all control and monitoring parameters for terminal units.

3. Point to point checks shall be proven from the field device/interface operation to the controller/oustation and from the controller to the presentation of the point on the graphics. The results from the point-to-point tests shall be submitted for approval on pre-defined schedules.

4. Point to point checks shall verify:

a. Correct location of the field device for the application.
b. Correct installation of the control device/interface with reference to the manufacturers literature and check that sufficient access has been provided for maintenance.

c. That the control device has the correct range for the application, that the range is correctly entered in the controller and the display of values is correctly engineered on the operator's terminal.

d. Correct operation of the controls device/interface, including any associated alarm and alarm text.

e. Correct installation of each valve and damper actuator, and ensure that each valve and damper actuator is stroked correctly when checked against the BMS output.

f. Calibration of the control device.

g. Labels provided on the control devices and mechanical equipment are correct.

E. Final Acceptance Testing:

1. Final Acceptance testing shall not commence until all components have been satisfactorily tested by the BMS contractor and the test results approved by the Engineer.

2. The BMS contractor shall schedule a repeat of the system testing at a time convenient to Owner. These tests for the verification by Owner/Engineer shall not be scheduled until the BMS contractor has verified that all systems are operating in accordance with the specifications.

3. Final acceptance testing of the BMS shall comprise a demonstration to Owner/Engineer that all components meet specification. The demonstration shall be performed by the BMS contractor and the I2BS Contractor and shall be witnessed by the Owner/Engineer. The BMS contractor shall remedy any BMS deficiencies that are observed during the final acceptance testing and retesting shall be scheduled at a time suitable to Owner/Engineer. If there are deficiencies remaining after the follow-up final acceptance testing that require further testing by Owner/Engineer, then the expenses of the Owner/Engineer incurred in providing the additional follow-up tests to verify compliance with the specifications, including travel, subsistence, accommodation and normal consulting fees, shall be paid by the BMS contractor at no additional cost to Owner.

4. The following shall be demonstrated as a minimum:

   a. Each and every software and hardware component of the BMS meets specification.

   b. All data transfer between systems is undertaken as specified.

   c. All system alarms comply with the specification.

5. Testing of the BMS during the systems and integrated testing shall be coordinated with all other trades associated with the system being tested. The system shall be tested as a complete entity during these tests. The BMS portion of the systems shall not be tested in isolation.

F. Testing Of VSD Interface:

1. The BMS contractor shall develop and fully test all software required for the interface between the BMS and VSD prior to the delivery of the associated hardware and software components to the project site. There shall be no software development on site except that associated with the entry of database items such as setpoints, alarm limits, control constants and schedules.
2. The VSD interface shall be fully demonstrated to the Engineer and Owner at the BMS contractor’s facilities prior to the installation of any BMS microprocessor based components at the project site. The demonstration shall include all hardware and software components associated with the interfaces.

3. The VSD interface shall be re-tested on site following the testing and acceptance by the Engineer of the individual low voltage systems.

4. The BMS contractor shall fully demonstrate that the BACnet objects are provided at the Management level network in accordance with the requirements of these specifications.

G. Test Documentation:

1. Test results shall be documented using test sheets. The test sheets shall be prepared in an appropriate format for the various categories of component and systems to be tested. Format of the proposed test forms shall be submitted by the BMS contractor for approval at the shop drawing stage. The BMS contractor shall make any changes requested by Owner at no cost. It is the responsibility of the BMS contractor to provide test verification sheets for each component and system that accurately reflect the sequences of operation and appropriate data for the components and systems as furnished under this contract.

2. Completed component test sheets indicating the test results for each BMS component within the system shall be submitted to the Engineer, together with a proposed schedule for system commissioning tests, at least two (2) weeks prior to the proposed system commissioning tests. The Engineer shall determine on the basis of the BMS contractor’s component testing, whether or not it is appropriate to commence system-commissioning tests. It shall be the Engineer’s decision as to whether the system commissioning tests can proceed as proposed by the BMS contractor or whether deficiencies have to be remedied and additional testing undertaken before the system commissioning tests can proceed.

3. At minimum, component test sheets will be prepared to cover each of the following items:
   a. Digital input point.
   b. Digital output point.
   c. Analogue input point.
   d. Analogue output point (one for each type of final control element, e.g. valve, damper, etc.).
   e. Information exchange between the BMS and I2BS.

4. All test documentation shall be maintained in electronic format and in hard copy.

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