

National Manual of Assets and Facilities Management

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Building Management System (BMS) Operations - Offices Procedure



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Building Management System (BMS) Operations - Offices Procedure

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Building Management System (BMS) Operations - Offices Procedure

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1.0 PURPOSE

The purpose of this document is to provide guidelines and practices to the Entity to manage the operations of the Building Management System (BMS) in office Facilities Management (FM) sectors. It is essential to operate and manage BMS systems according to the installation and design methodology to achieve efficient and effective building operations.

These guidelines contain operations expectations consistent with the Expro approach, using best practices developed through industry experience. Furthermore, they provide adequate references and best practices to follow as a minimum in order to ensure optimal performance of the engineering systems through BMS to meet operational needs.

2.0 SCOPE

The scope of this document is to provide guidelines to the office Entity or service providers to improve and enable site-specific Operation Management processes in relation to BMS operational activities such as, but not limited to:

- Performance monitoring of the BMS system and integrated building systems
- Controls and monitoring to achieve operational efficiency
- Comfortable and productive indoor working environment
- Control climate of building/safety of assets
- Customized control strategies
- Operational flexibility and ease of change
- Auto changeovers over failed equipment
- Improved operational environment and comfort
- Support energy utilization and operational cost
- Integration with other building services to improve effectiveness
- Optimize quality service delivery

For the purpose of this document, an “office facility” has been defined as a building, portion of a building or space where businesses operate, such as but not limited to:

- High rise buildings
- Low rise buildings
- Commercial blocks
- Business centers/hub
- Others

3.0 DEFINITIONS

Term	Definition
Adaptive Control System	A system in which automatic means are used to adjust system parameters to achieve optimum performance
Building Automation and Control Network (BAC net)	The Building Automation and Control networking communication protocol (American National Standards Institute (ANSI)/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 135). It provides a mean by which building automation devices from various manufacturers can share data and work together
Building Management System	A building-wide network that controls and monitors building engineering systems. It may also include any third party systems.
Direct Digital Control (DDC)	Implies that the control algorithms are in the form of software. Analogue inputs or outputs may coexist with digital control
Energy Management and Control System (EMCS)	A computer system designed to automate the building operations of energy consuming assets such as heating, ventilation and air conditioning (HVAC), power, lighting, security systems and water



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	systems. Also capable of monitoring environmental conditions and load demand, and adjusting operations to optimize energy usage accordingly.
Extra Low Voltage	Not exceeding 50 V between conductors and not exceeding 30 V AC or 50 V DC between and conductor and earth
Facilities Operations Management	Client/Building owner representative
Modbus	A serial communication protocol that has become a standard communication protocol in industry and is now the most commonly available means of connecting industrial and buildings electronic devices
Open Communication	A term used for the exchange of data between various pieces of equipment on the basis of open or standardized protocols
Outstation	A device connected to sensors and actuators which can perform local control and other functions
Transmission Control Protocol/Internet Protocol (TCP/IP)	Encompasses media access, data packet transport, session communications, etc. TCP/IP is supported by a large number of hardware and software vendors
Abbreviations	
ACOPS	Approved Code of Practice
ACS	Access Control System
AHJ	Authority Having Jurisdiction
AI	Analogue Input
ANSI	American National Standards Institute
AO	Analogue Output
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ATS	Automatic Transfer Switch
BAS	Building Automation System
BCS	Building Control Specialist
BIM	Building Information Modelling
BMCS	Building Management and Control System
BMS	Building Management System
BOD	Basis of Design
CB	Capacitor Banks
CIBSE	Chartered Institution of Building Service Engineers
CMMS	Computerized Maintenance Management System
CMT	Crisis Management Team
CT	Computerized Tomography
DDC	Direct Digital Controller
DI	Digital Inputs
DMC	Digital Master Controller
DO	Digital Outputs
ELV	Extra Low Voltage



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EMCS	Energy Management and Control System
EMP	Emergency Management Plan
EMS	Elevator Management System
EPDS	Emergency Power Distribution System
ES	Electrical Systems
ELV	Extra Low Voltage
FAS	Fire Alarm System
FM	Facilities Management
FMC	Facilities Management Company (Facilities Operations)
FOC	Facilities Operating Clients
FOM	Facilities Operations Management
HF	Harmonics Filter
HLI	High Level Interface
HMI	Human-Machine Interface
HSSE	Health Safety Security Environment
HTM	Health Technical Memorandum
HVAC	Heating, Ventilation, and Air Conditioning
IPS	Isolated Power Supply Unit
ISO	International Organization for Standardization
IT	Information Technology
LAN	Local Area Network
LCS	Lighting Control System
LAN	Local Area Network
LON	Local Operating Network using Lon Works protocol
LON	Local Operating Network
M&T	Monitoring and Targeting
MDB	Main Distribution Unit
MEP	Mechanical, Electrical, and Plumbing
MRI	Magnetic Resonance Imaging
MS	Method Statement
NFPA	National Fire Protection Association
O&M	Operation and Maintenance
OE	Operations Engineer
OEM	Original Equipment Manufacturer
PC	Personal Computer
PDS	Product Data Sheet
PMCS	Power Monitoring and Control System



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PMS	Parking Management System
PPE	Personal Protective Equipment
PTS	Pneumatic Tube System
PTW	Permit to Work
RA	Risk Assessment
RAMS	Risk Assessment and Method Statement
RMU	Ring Main Unit
SCADA	Supervisory Control and Data Acquisition
SMDB	Sub Main Distribution Unit
SOO	Sequence of Operation
SOP	Standard Operating Procedure
UPS	Uninterruptible Power Supply
VFD	Variable Frequency Drive
WLDS	Water Leak Detection System

4.0 REFERENCES

- Chartered Institute of Building Services and Engineers (CIBSE guide H) – 'Building Control Systems'
- American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE 13) – Specifying Building Automation Systems
- National Fire Protection Association (NFPA 101) – Life safety code
- National Fire Protection Association (NFPA 72) – National Fire Alarm and Signaling Code
- EPM-KEO-GL-000009 Building Management System and Mechanical System Integration Guideline
- EPM-KEO-GL-000007 ELV Systems Integration Guideline
- International Organization of Standardization (ISO 50001) – Energy Management
- HSE Approved Code of Practice (ACOPS) L8 & HSG274
- SBC 201 Building Code – General
- SBC 401 Electrical Code
- SBC 501 Mechanical Code
- SBC 601 Energy Conservation

These shall be selectively applied based on the evaluation of individual requirements. Where the standards stipulated conditions conflict, the most stringent shall govern, unless otherwise noted herein. When there is any conflict with the Saudi Building Code (SBC), only the Saudi Building Code will be applied.

5.0 RESPONSIBILITIES

The Entity is the final Authority Having Jurisdiction (AHJ) unless specifically stated otherwise in other sections of the National Manual of Assets and Facilities Management. If a conflict is discovered between these guidelines and other operations management documents, the conflict shall be brought to the attention of the Entity, who will provide a resolution or direction to evaluate if all BMS goals and requirements have been met.

5.1 Management Responsibilities



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It is primarily the responsibility of management to ensure that inspections, services, and maintenance activities are carried out safely without any hazard to the Operations Team or any stakeholder. Clear lines of managerial responsibility should be in place to avoid any ambiguity for the safe operations of the building engineering systems through BMS/EMS. Management should conduct a periodic review of the systems in order to ensure that the operational standards are being met. BMS/EMS systems require periodic inspections and verification. Hence, management should ensure that a competent team is appointed to perform all these assessments. The Operations Management Team shall ensure that staff is adequately trained and competent to carry out the operational tasks which should include, but are not limited to:

- Staff briefing
- Safe systems of works
- Personal Protective Equipment (PPE)
- Quality control and assurance
- Health and Safety Executive (HSE)
- Risk Assessments Method Statement (RAMS)
- Permit to work (PTW)
- Stakeholder communication
- Training

5.2 Designated Staff Functions

Only trained and competent persons should be appointed by management to operate and maintain BMS/EMCS.

Role	Description
Designated Person (Electrical)	An individual who has overall authority and responsibility for the premises containing the electrical supply and distribution system within office and has a duty to prepare and issue a general policy statement on health and safety at work.
Duty Holder	A person on whom the 'electricity at work' regulations impose a duty in connection with safety.
Authorizing Engineer (Low Voltage (LV))	A Chartered Engineer or Incorporated Electrical Engineer with appropriate experience and the necessary degree of independence from local management who is appointed in writing by office building management to implement, administer and monitor the safety arrangements for low voltage electrical supply and distribution systems to ensure compliance and to assess the suitability and appointment of candidates in writing to be authorized persons.
Authorized Person (LV/ELV)	An individual possessing adequate technical knowledge and appropriate training, to be responsible for the practical implementation and operation of management's safety policies and procedures.
Competent Person (LV/ELV)	An individual who on the opinion of an authorized person has sufficient technical knowledge and experience to prevent danger when carrying out operations on defined low voltage systems.
Operations and Maintenance Person (BMS)	A member of engineering staff, BMS manufacturer or operations maintenance organization employed by management to carry out duties BMS/EMCS.
BMS Operator	An authorized individual who operates BMS/EMCS.

Table 1: Designated Staff Functions

5.3 BMS/EMS Levels of Operations

BMS/EMS is designed for monitoring and control of MEP systems and also includes maintainability and future system expansion. System architecture shall incorporate functional overview for monitoring the status, health and operational aspects of MEP systems and shall comprise the following logical layers:



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- Management user level processor (System access)
- Operations user level processor (System access)
- System user level controllers (System access)

Interaction with the BMS may take place at all levels of the system and, at each level; there may be different requirements for different operator classes.

BMS Network Integration Structure		
Levels	Operator	Function
BMS managers level	Facilities Manager System Administrator	Reporting Energy Monitoring and Targeting (M&T) Offline Data Analysis
Operations Level Central Supervisor	Non-Technical Personnel (Security, Caretaker)	Response to alarm notifications and messages
	Specialist Engineer	Reprogramming Fault Finding expansion
Service Tools	Specialist Engineer	Monitoring Reconfiguration Fault Finding
System Level Outstations	Non-Technical Personnel	Some local control of operations
Zone level local control	Specialist Engineer	Parameter Adjustment Reprogramming Fault Finding
	Occupants	Set Point adjustments

Table 2: BMS Network Integration Structure

5.3.1 Operations Levels: Plug In Additional Keypad

A keypad may be plugged into a BMS outstation to review events, receive alarms, and provide some parameter adjustments for all the controls mounted within the panel (e.g., pressure, temperature, and overrides according to building requirements).

5.3.2 Systems Levels: Touchscreen and Network PCs

A PC can sit on the network providing either full control or reduced input and output capacity compared with main supervisor. However, it can have access to the entire network. This may consist of graphs, pictures, knobs, dials, and text. This display screen may function differently based on building specific BMS/EMS.

5.3.3 Operators Level: Supervisor

The supervisor computer also known as 'head end PC' is commonly connected with a printer. The head end PC is the prime interface between the system operator and BMS/EMS. This is where the operational team can perform limited BMS/EMS functions such as local overrides, set point change and alarms identifications.

5.3.4 Users Level

The enormous power and flexibility of the PC based supervisor means that the software must be carefully chosen to allow appropriate operation by different user levels. Generally, there are three levels of operation:

- Operation and adjustments by technicians
- Operation by senior technicians and supervisors
- Operations by controlled engineer



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5.3.5 Training

The successful operation of a BMS/EMS depends on the skills and knowledge of the operators. A proper training schedule is essential to understand the requirements for operating a BMS system. Building owners must decide who will operate the BMS. These individuals could be internal building trained staff. However, contracting out of FM services is becoming more common. It is recommended that:

- At least two BMS operators attend courses administered by the BMS Specialist to train operators to manage offices building operations
- All new operators who may subsequently be appointed should also receive proper training
- An internally trained individual can develop an in-house training module to train other operators and technicians
- It is recommended that refresher training is administered periodically to all staff members

6.0 PROCESS

6.1 BMS and EMCS System Overview

BMS is also known as Building Management and Control System (BMCS) or Building Automation System (BAS) according to OEM terminology. The fundamental requirement of the system remains the same, irrespective of the label used, which is that building Mechanical, Electrical and Plumbing (MEP) services shall be automated and monitored to control engineering systems such as heat pumps, lighting systems, security systems, Heating, Ventilation, and Air Conditioning (HVAC) etc. This simplifies the work requirements of engineers and building operators. These building systems should be operating with optimal energy efficiency while maintaining safe, healthy and comfortable conditions for the occupants of the spaces being served.

Furthermore, BMS/BAS cannot effectively optimize building operations management, since its primary purpose is to automate and control MEP systems. However, this is supported by an EMCS which provides office building's operations managers with advance analytics tool to act as the brains of engineering operations. EMCS captures data from BMS/BAS system and processes the information as it is logged in terms of energy consumption for power, water, gas and steam. Additionally, it can perform advance analytics and highlight areas where energy can be potentially saved. This results in energy saving opportunities and will reduce overall operating costs for office buildings. Below are some key features of BMS/EMCS for operation managers to focus and base their forecasts on:

- Building performance monitor
- Generate reports, graphs and, annunciate alarms during system malfunction
- Operation management in an energy efficient and economical manner
- Environment friendly
- Sustainability
- Advance reports
- Energy management, demand and consumption dashboards
- Air quality management
- Sequence selections based on building demand
- Equipment's lifecycle

The operation managers shall endorse specific building requirements, policies and procedures to optimize BMS/BAS and EMCS.

6.1.1 BMS Key Components

- Hardware
 - o Direct Digital Controller (DDC)
 - o Sensors
 - o Actuators
 - o Human Machine Interface (HMI) display – Human Machine Interface



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- o PC workstation
- o Server to store extensive database
- Software
 - o Programming or configuration tools
 - o Graphics or User Interface
- Networking protocols including, but not limited to the following:
 - o Transfer Control Protocols/Internet Protocol (TCP/IP)
 - o Building Automation Controller Network (BACnet)
 - o Modbus
 - o LonWorks
 - o CAN bus

The fundamental for all above mentioned protocols remains the same, using high-level security to transfer data from one device to another device.

6.2 BMS and MEP Systems

All engineering plant, system, and equipment associated with the internal office building's environment should, where possible, be monitored and controlled by a BMS.

Effective systems should be in place for both off-site and on-site response to alarms.

BMS to be found within office facilities shall cover the control and/or monitoring of HVAC, Mechanical, Electrical, ELV, and any other third-party integration.

The diagram below provides the Operational Team a high-level view of the configuration for all associated systems.



Figure 1: High-Level View of the Configuration of BMS and MEP Systems

The systems listed below are expected to run through BMS in order to meet building operational requirements. These systems must be monitored and controlled to ensure HVAC, mechanical, and electrical services are operating effectively. If the below systems partially or fully fail to operate, this can lead to a significant impact on the operation of office buildings. Hence, operational control measures such



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as emergency response Standard Operating Procedures (SOP) or emergency action plan shall be in place for operation managers to refer to in case such a critical event or emergency should arise.

6.2.1 HVAC

HVAC systems for monitoring and control through BMS should include, but are not limited to:

- Equipment monitoring and control
 - o Air handling unit
 - o Fan coil unit
 - o Variable air volume boxes
 - o Exhaust fans
 - o Chilled water pumps
 - o Cooling tower
 - o Condenser water pumps
 - o Hydronic hot water pumps
 - o Chillers
 - o Boilers
 - o Condensate recovery unit
 - o Steam generators
 - o Others
- System monitoring and control for building systems
 - o Chilled water distribution – primary or primary/secondary system
 - o Condenser water distribution
 - o Air distribution system
 - o Other

6.2.2 Mechanical System

Mechanical systems for monitoring and control through BMS include, but are not limited to:

- Control of Mechanical Fire and Life Safety System such as:
 - o Zoned smoke control system
 - o Staircase pressurization utilizing Variable Frequency Drive (VFD) scheme
- Monitoring of Mechanical Fire and Life Safety System such as:
 - o Lift lobby or lift shaft pressurization system
 - o Atrium smoke extraction system
 - o Car parking smoke extraction system
- Plumbing booster and sewage pumps
- Fire pumps (as applicable)
- Water tank level status
- Fuel tank level status
- Fuel transfer and distribution systems
- Others

6.2.3 Electrical

Electrical and equipment integration systems for monitoring and control through BMS include, but are not limited to:

- Switchgear
- Automatic Transfer Switch (ATS)
- Transformer
- Ring Main Unit (RMU)
- Main Distribution Unit (MDB)



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- Sub Main Distribution Unit (SMDU)
- Generators
- Digital Master Controller (DMC)
- Isolated Power Supply Unit (IPS)
- Capacitor Banks (CB)
- Harmonics Filter (HF)
- Uninterrupted Power Supply (UPS)
- VFD
- Power Monitoring and Control System (PMCS)
- Elevator Management System (EMS)
- Others

6.2.4 Extra Low Voltage (ELV)

ELV system integration for monitoring and control through BMS should include the following, as applicable to the building:

- Fire Alarm System (FAS)
- Security Systems
- Access Control System (ACS)
- Lighting Control System (LCS)
- Parking Management System (PMS)
- Pneumatic Tube System (PTS)
- Water Leak Detection System (WLDS)
- CO monitoring
- Voice and data infrastructure
- Master clock system
- Others

6.3 BMS/EMCS Function

The figure illustrated below depicts the three functions of basic BMS/Building Control Systems:

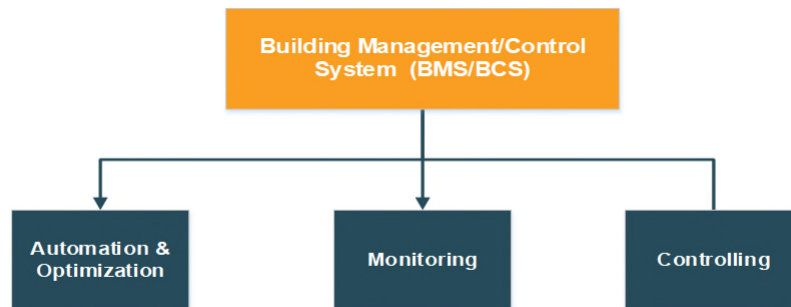


Figure 2: Function of basic BMS/Building Control System

6.3.1 Control Strategies for BMS/EMCS and Sub Systems

A control system must ensure safe operations of the system it controls. It shall give adequate warning of any malfunction and if necessary, to take appropriate action in the event of equipment failure. BMS/EMCS employs a variety of alarms, interlocks and control strategies to automate office building operations. These strategies are found over a wide range of different engineering systems and are treated together below to avoid repetition.



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- **Alarms:** Installed to indicate the operator that a system variable has exceeded a pre-determined limit
- **Interlocks:** Interlocks ensure that particular system or equipment may only operate together or are prohibited from operating together
- **Safety Strategies:** Safety switches override normal engineering systems' operation to prevent harm to plant or personnel and should be monitored and controlled through BMS/EMCS. The use of safety switches through complex computer systems may serve to conceal potential problems or unexpected control actions in alarm situations. A process must be in place to ensure correct Sequence of Operations (SOO) during start-up and shutdown of office building engineering systems
- **Fire and Smoke Control:** The operations of fire control system are separate from other office building engineering systems. The BMS receives fire alarm signals must act accordingly. A stringent process shall be put in place by the operations team in the event of receiving such alarms to manage operations. Where there is a central HVAC system integrated with BMS, the BMS/EMCS response to a fire alarm may be either:
 - o Plant shutdown including supply and extract fans with inlet and exhaust dampers closed
 - o Plant shutdown with the extract fan continuing to run with exhaust damper open

6.3.2 Fine Tuning

Office buildings operate under the control of an appropriate staff which includes, but is not limited to, in-house staff, a contracted FM company, OEM specialist or internal or external contractor who manages the BMS systems operations. Fine tuning/adjustments are essential because the manner of building use by occupants cannot always be predicted. Therefore, it is expected that BMS/EMCS will require attention and tuning/overrides by BMS operators on a day-to-day basis. A stringent process/provision should be developed to ensure that these adjustments are managed in a controlled manner without having an impact on operational performance.

6.3.3 Monitoring

In some situations, it is possible to monitor the condition of a system or a plant. This provides valuable information on the performance and reliability of office building engineering systems and can detect early signs of trouble in systems or equipment. The central head end computer (BMS/EMCS) receives and processes the metered data (systems information). The computer may be a separate machine dedicated to monitor and display the BMS/EMCS engineering data or information. Within some buildings, this may be situated offsite and communicates via modem or internet. Negligence in active monitoring can cause following results:

- Pressure drop which can lead to MEP systems failure
- Efficiencies can be significantly impacted
- Operating variables can be compromised

A facilities manager is responsible for monitoring the following items:

- KPIs, which are agreed upon between the Facilities Management Company (FMC) and the Entity
- The power consumption within buildings or by different systems, to analyze high consumption areas and identify potential power saving opportunities. A custom-made report should be set to determine the power consumption.
- Energy usage is monitored and recorded in relation to site volume, floor area, employee count, and/or official equipment utilization. Seasonal variations in energy usage should also be monitored to assist in highlighting anomalies in energy usage across the site and to benchmark energy utilization against other similar entities.
- Work orders under the Computerized (or paper) Maintenance Management System (CMMS) should be actioned in accordance with the agreed contract requirements and standards
- Assets in the Computerized (or paper) Maintenance Management System (CMMS) should be audited and kept up to date as per the agreed contract requirements and standards. This should be undertaken to prevent an accumulation of unregistered assets on the CMMS.



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- A staff training matrix should be used and updated regularly. Staff training should be relevant and include any new applicable statutory and mandatory legislation. A percentage of operational staff should be trained on first aid as per site requirements.
- Regular checks are carried out to ensure that operational and maintenance remedial actions are in place to prevent minor faults from developing into operational issues. Once these issues have been addressed, the associated work orders must be closed within specified SLAs.

6.3.4 Metering

Energy metering hardware in a BMS/EMCS system consists of, but is not limited to, the below components:

- **Meter Module:** Measures the desired quantity and converts it to an electrical output; could function with Modbus or LonWorks
- **Display Module:** Displays the present values of the rate of energy consumption in addition other derived quantities
- **Data Logger:** Accepts pulses from the meter, processes and stores data on energy consumption, and transmits data on demand to the central computer containing BMS/EMCS software
- **Data Transmission System:** Connects one or more data loggers to the central computer
- **Computer:** Contains the analysis software

6.3.5 Records/Drawings/System Architecture

The Entity should have accurate and up-to-date records and/or drawings. Where possible, these should be backed up electronically and should be readily available on site, in an appropriate format, for use by BMS/EMCS Engineering Services Team. The FM should also be aware of the increasing use of Building Information Modeling (BIM) and have the provisions to access BIM information where possible.

Refer to **Attachment 5** for a sample of BMS Integration Block Diagram.

6.3.6 Energy Monitoring and Targeting (M&T)

A major feature of BMS/EMCS is energy conservation and management. Although the proper and efficient control of office building engineering systems contributes to efficient energy consumption, but it is also imperative that the Office Facility Operations Manager receive accurate and up-to-date information on energy utilization in the office building. M&T requires that data on energy consumption be regularly collected, summarized and compared with target consumption figures. Computerized (BMS/EMCS) collection and analysis of data makes M&T a power tool for the control of reduction of energy consumption.

Office Facilities Engineering Managers should utilize this tool to determine:

- The control of energy (power, heat, steam, fuel and water) use by monitoring consumption through BMS and comparing it against historical data and benchmark for similar buildings
- Improvements in the efficiency of energy utilization by the setting of future targets. The monitoring portion of M&T shall have four stages as a minimum:
 - o Data collection
 - o Data analysis
 - o Reporting
 - o Action

6.3.7 Supervisor/Graphics

A supervisor is a computer which allows an operator access to data stored within controllers and allows modification to the software held inside the controller. Large BMS/EMCS are appointed a head end supervisor who has access to and can monitor and control the entire BMS network to:



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- Clearly present data required to check the status of a system or subsystem without clutter and in a logical visual format
- Facilitate navigation from a graphic page, either up to a system overview or down to a sub-unit or point history in an intuitive, point-and-click manner
- Ensure that graphics are available on all systems and sub systems
- Ensure that temporary trend graphics can be set up by all users and do not require high level skills or access
- Configure a full building system report to enable effective systems management
- Enable different levels of equivalent user authorization level control (e.g. programmer, system controller, maintenance staff, managers etc.)
- Enable intuitive, point-and-click access to data, graphics, and agreed control functions for each user

6.4 BMS Operations Management

Within an office facility, there are critical pieces of equipment (assets) and engineering systems which have a greater impact on overall performance of the services. Therefore, there is a need to identify what equipment or system is critical in ensuring the safety, comfort, and amenity of a facility, particularly in areas including, but not limited to, security control rooms, office telecom rooms, hub rooms, data centers, and utility areas.

The loss of service of these areas would seriously degrade the ability of the premises to deliver optimal services. In order to ensure reliable service provisions, it is essential to inspect, verify and maintain these office facility utility systems at appropriate intervals. For many of these systems, a permit-to-work will need to be completed to ensure that taking these systems out of service does not compromise the activities of the user department. In any event, it will be necessary to liaise with the user department when taking the system offline to carry out routine inspections and maintenance.

6.4.1 Alarms Management

A process should be in place to handle active alarms that appear on head end PC's. Some BMS systems forward these alarms on to the other networked PCs (or display, CMMS) as per designed configuration. The alarm handling system (BMS) is vulnerable to failure due to maintenance, programming or any breakdown (hardware or software) and no alarms will be forwarded during this time. Hence, a manual process/locations to access field routers shall be in place to manage BMS operations. A process shall be developed to determine the response to alarm messages. These responses can be as follows:

- **Acknowledged:** This may be used where confirmation is required that an alarm has been received (or, in non-alarm terms, that a message was received by another controller)
- **Request/Response:** A message is sent to a controller when the message has been processed; the response confirms that the alarm was received and understood
- **Repeated:** A message is sent and re-sent a number of times, but no acknowledgement is required (e.g., low priority alarms)

At the receiving end (BMS/EMCS – head end PC), where the alarm is displayed and acted upon, the following points should be considered dependent on the desired reliability and the importance of the alarms being handled:

- Resilient power supplies
- Dual redundant servers
- A resilient Information Technology (IT) Network
- Software for alarms acknowledgement

6.4.2 Alarm Requirements

Alarm priorities will vary based on the severity of the fault and the nature of the building and associated plant. Alarm points for specialist equipment or particular complex systems that are part of utility services in



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offices. It should be monitored on regular intervals and escalated to the relevant engineering discipline to action these in the field.

6.4.2.1 High Priority

Fire alarm status, power failure, control circuit failure, alarm inhibit switch operation, gas sensor alarm, emergency are sent directly to Office Building Maintenance Team and Operations Manager.

6.4.2.2 Medium Priority

High temperatures to a group of areas and critical areas in an office building facility should be sent directly to the Maintenance Team and if these conditions persist, they should be routed to Office Building Operations Manager.

6.4.2.3 Low Priority

Change of state reports, hardware alarms, and dirty filter alarms should be sent directly to the Office Building Maintenance Team.

6.4.3 Operation Schedule

Operational schedules are essential to managing office building facility operations efficiently. These can be changed based on required and load demand in the facility. However, it shall not compromise the basic sequence and design schedules. Threshold limits must be taken into consideration while conducting any changes in the controlled part of the systems. Few specific schedules may include the following areas:

- Zoning
- Environmental parameters
- Alarm limits, priority, and routing
- Initial time programs
- Plant operating sequences
- Load shedding sequences
- Actions on start-up
- Actions on shutdowns/warnings/alerts
- Actions on seasonal shutdown
- Actions on communication failure
- Actions on BMS failure
- Actions of total power failure

6.4.4 Risk Management

In developing office operations management processes for office buildings, it is vital to consider the risks associated with inappropriate operation of the BMS and associated engineering systems which include, but are not limited to:

- Asset loss or system failure, including consequential financial loss
- Reduced asset life
- Breach of statutory obligations
- Creating an unhealthy or unsafe environment and consequential liabilities
- Risk of harm to the environment
- Inefficient operational performance resulting in higher operating costs;
- Adverse perception among stakeholders

6.4.4.1 Shutdown & Outage Management

In office building operations management, planned utility plant or system shutdowns or outages are significant events that must be managed with due diligence. A clearly agreed upon and approved strategy



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shall be in place including implementation by Operations and Maintenance (O&M) Team. A shutdown and outage strategy shall identify the shutdown/outage duration, along with the required material, manpower, specialist contractors, and other critical resources to deliver the required work.

6.4.4.2 Faults & Incident Response

Faults and incident response encompasses responding to failures and incidents in office building operations in a systematic manner. There shall be a process in place which includes incident detection and identification, fault analysis, use of standard responses, temporary and permanent repair procedures, and reporting and updating equipment or systems information.

6.4.5 Documentation

Sound operations management documentation is necessary for effectively managing the day-to-day operations of the engineering services of the office building. The documentation should include:

- Written description of plant operations
- Control strategies or logic diagrams
 - o Network architecture drawings
 - o Diagrams detailing physical wiring connections to controllers
- Details of system application software configuration
- Point list including hard and soft points
 - o DI – Digital Inputs
 - o DO – Digital Outputs
 - o AI – Analogue Input
 - o AO – Analogue Output
 - o HLI – High Level Interface
- Copies of certificate of compliance with relevant standards
- Data sheets for all control components and equipment
- Instructions for switching on, operation and switching off, isolation, fault finding, and for dealing with emergency conditions
- Instructions for any precautionary measures
- Instructions for servicing
- Instructions in the use of software routines for creating procedures, graphic reports etc., wherever applicable
- Description of user adjustable points

6.4.6 Operational Considerations

- Tuning and optimization
- Importance of system documentation
- System maintenance: what, how often, and by whom
- Life cycle expectations and considerations

6.5 Procedures

6.5.1 Start-up Procedures

A start-up procedure is a reference document to be used when preparing a process to operate a system from an offline position. The actions within the procedure are intended to ensure that a methodological approach is taken when bringing an engineering system or piece of equipment back online. The Start-up Procedure for HVAC and integrated MEP systems shall include the following:

- Health and Safety
- Pre-approvals
- System readiness
- Pre-start checks



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- Start checks
- Notifications

Refer to **Attachment 1** for full generic BMS start-up procedure.

6.5.2 Shutdown Procedures

A shutdown procedure is a reference document for a planned activity to take a system or a piece of equipment offline. The shutdown procedure should be clear, prescriptive and well understood. The specific steps often mirror those taken with a start-up procedure, but include additional consideration for the effect on utilities and other building services connected to the process. HVAC and integrated MEP systems' shutdown procedures shall include the following:

- Health and Safety
- Pre-approvals
- Standby system condition
- Pre-shutdown checks
- Routine stop
- Post-stop checks
- Notifications

Refer to **Attachment 2** for full generic BMS shutdown procedure.

6.5.3 Daily Reporting/Monitoring

A well designed and managed BMS provides great opportunities for improvements in energy efficiency and monitor early alarms/faults to prevent equipment failures or any catastrophic failures of engineering systems. Therefore, a clearly understood process is required to manage alarms and equipment's events to avoid any incidents related to the operation of office buildings. This process shall define timelines required to raise any reactive, corrective, or emergency issues occurring in monitoring, control, or running of the BMS as well as integrated sub systems with acceptable time period to address any faults in effective time. Daily reports/monitoring provide great opportunities for improvements in energy efficiency by:

- Enabling Office Building Operations Managers to provide an optimal working environment consistent with maintaining a building's energy efficiency rating
- Early identification of equipment failure
- Identification of unusual patterns, trends of energy usage such as equipment and/or system being left on, out of required hours in common areas, office building facility areas etc.
- Monitoring effectiveness of Emergency Management Plans (EMPs)

Refer to **Attachment 3** for a full generic BMS system monitoring/daily rounds checklist.

6.5.4 Emergency Response/Actions

Emergency procedures are intended to highlight the key issues that may arise at the departmental level in the event of monitoring or controls failures. Good practice in emergency management should include development of an EMP and actions that outlines responsibilities, identification of high risk areas, and appropriate responses. Clear identification of safe areas during an emergency, an evacuation plan for disabled persons, and an emergency plan with response actions will be further detailed in **Attachment 4 – Emergency Response Actions**.

Within the “office building operating procedures,” there will be many elements of the overall Facilities Operating Clients (FOC) EMP that the Facilities Management Companies (FMC) plan will need to feed into and take direction from. The response actions required will then depend on these plans and integrations.

Below is an example of the possible FMC emergency plan integration elements, reporting entities, and designated person organization that are required to build a basic plan.



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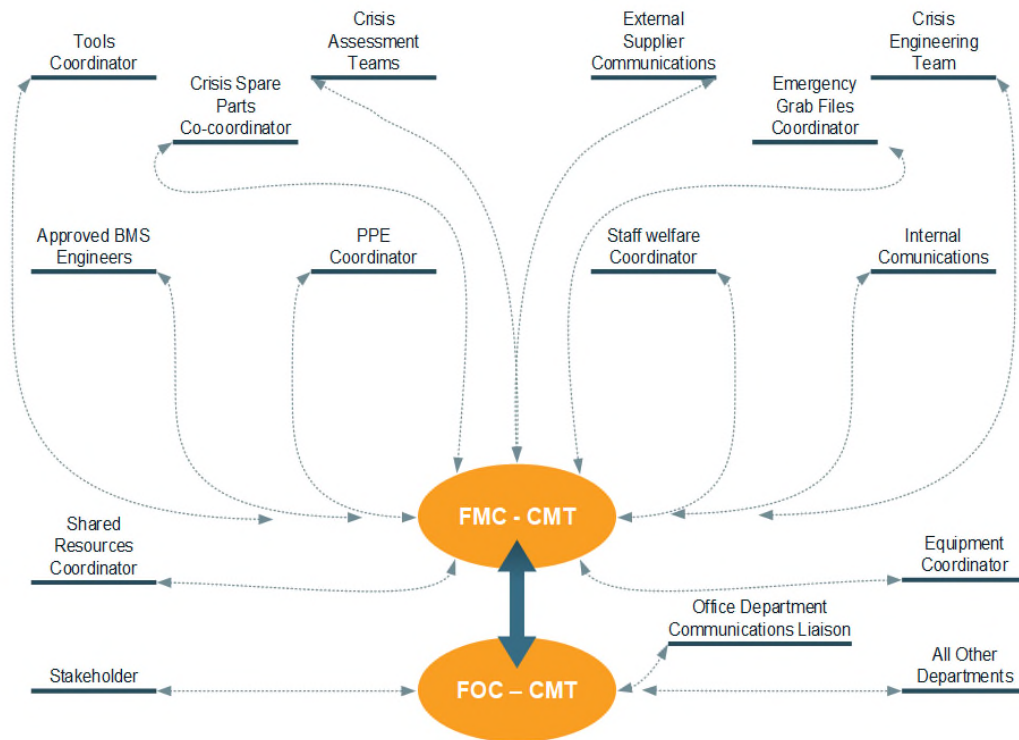


Figure 3: FMC Emergency Plan Integration Elements

For FMC (Operations), this will be focused around management for the continuation of service to and from the facility as outlined below:

To:

- Power
- Water
- Gas
- Fuel
- HVAC
- Medical gas
- Oxygen
- Spares Supplies
- Other

From:

- Sewage
- Grey water
- Waste
- Other

Plan development should take into consideration how different emergency scenarios and situations will impact the operation of facilities and in which areas the emergency has originated. It is a good practice to prioritize these emergency origins and impact areas into specific categories and document the influence on site operations that may occur due to these emergencies. Emergency origins may be categorized as:

- **External Disaster** (earthquake, flooding, weather, multi discipline disruptions etc.)
- **External Specific** (major distribution service provider outage, localized area outage, specific transformer outage, local cabling, BMS communication, IT connectivity etc.)
- **Internal Disaster** (major fire, major flooding, critical site wide systems failure, etc.)



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- **Internal Specific** (power failure to the BMS controllers, communication failure, data loss, programming issues, or any specific malfunction in system monitoring or control from these categorized headings the plan can be expanded and action direction formulated.

From the high level headings, the impact to other systems and/or facilities can be identified and therefore, the action plans formulated.

Below is an example of how the emergency action planning development may flow for one scenario. Other plans applicable to other scenarios should also be put into emergency grab packs giving the FMC emergency response staff clear initial direction to an emergency while the FMC Crisis Management Team (CMT) and FOC – CMT are convened and become fully operational.

External Disaster (earthquake, flooding, weather, multi discipline disruptions etc.)

Scenario 1: Major Earthquake

1. Scenario Parameters

- External electrical supply has been lost
- External supply chain is not responding
- Office building facility is not required to assist external casualties

2. Initial Actions

- Relevant grab packs to be given out to and/or taken by the emergency response engineering staff
- Implement the FMC emergency action plan/plans
- Establish/Convene at the FMC crisis management command center/designated area
- Establish communication with the FOC (client) – CMT
- Establish the communication process with external governmental departments through FOC – CMT process

3. Assessments

- Assess the impacted BMS and other integrated systems
- Formulate action requirements from the emergency grab packs
- Prioritize in conjunction with FOC – CMT direction and/or consultation
- Calculate load shedding requirements to conserve resources (stored diesel etc.) in line with FOC – CMT direction and/or consultation
- Access the monitoring and control through other redundant BMS measuring points in building network

4. Implementation

- Deploy to FMC – CMT designated command area
- Initiate initial action process
- Establish communications processes
- Initiate initial assessment process
- Select relevant emergency grab packs
- Report initial assessment findings to FOC – CMT
- Take informed direction from FOC – CMT
- Initiate emergency grab pack/s process
- Initiate staff deployment
- Report, update, and direct FMC CMT ↔ FOC – CMT
- Continue intensive situation assessments until emergency is stabilized
- Initiate forward operation requirements
- Assess staffing requirements
- Assess staffing welfare requirements



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- Operate on emergency operations requirements until emergency stand-down is agreed
- Initiate emergency stand-down processes in conjunction with FOC – CMT

The following procedures and checklists have been prepared for FM personnel to meet the needs of their own organizations during failure of a system.

They are not intended to be appropriate or definitive for all facilities, but they provide an idea of the general format that may be used and the different levels of technical content that may be applied to contrasting sites.

Further procedures will be required within an office building Entity and a regular review is important to ensure that the directives of staff and equipment remain current.

Refer to **Attachment 4** for full emergency response actions.

7.0 ATTACHMENTS

- Attachment 1: EOM-ZO0-TP-000076 - Start-up Procedure BMS and Associated Systems Checklist
- Attachment 2: EOM-ZO0-TP-000077 - Shutdown Procedure BMS and Associated systems Checklist
- Attachment 3: EOM-ZO0-TP-000078 - System Monitoring Procedure Checklist
- Attachment 4: EOM-ZO0-TP-000079 - Emergency Response Actions Checklist
- Attachment 5: BMS and Other Systems Integration Block Diagram



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Attachment 1: EOM-ZO0-TP-000076 - Start-up Procedure BMS and Associated Systems Checklist

1. Building NAME:	2. Reference No.	3. REV- 00A		
No.	Start Up Procedure	CHECKED SATISFACTORY		
		N/A	YES	NO
	BMS and Associated System – Office Facilities			
Health and Safety				
1	Required Personal Protective Equipment (PPE) available	☐	☐	☐
2	Risk Assessments Method Statement (RAMS) available	☐	☐	☐
3	Location of first-aid instructions and supplies available	☐	☐	☐
4	Emergency eyewash and showers available	☐	☐	☐
5	Emergency evacuation plan reviewed	☐	☐	☐
6	Emergency contact details of the authorized person and the contractors	☐	☐	☐
7	Life safety systems (fire extinguishers, sprinklers, gas suppression & fire alarm)	☐	☐	☐
8	Ventilation	☐	☐	☐
Pre-approvals				
9	System owner/Manager/Engineering Team's approvals available	☐	☐	☐
10	End-user department head's approvals available	☐	☐	☐
11	Quality, Health, Safety and Environment Management (QHSE) approvals available	☐	☐	☐
12	Specialist contractor's schedule of work	☐	☐	☐
13	Approved Permit to Work (PTW)	☐	☐	☐
BMS System Checks				
14	Building Management System (BMS) server communication	☐	☐	☐
15	BMS workstations and communication systems are powered	☐	☐	☐
16	Field DDC and switches communication	☐	☐	☐
17	BACnet routers communication	☐	☐	☐
18	BMS system firewalls active	☐	☐	☐
19	Base LAN/WAN communication	☐	☐	☐
20	Building network communication	☐	☐	☐
21	Areas are cleaned and egressed check	☐	☐	☐
BMS and integrated system functional checks				
22	System fault free/alarm free check	☐	☐	☐
23	Original Equipment Manufacturers (OEM) startup procedure available	☐	☐	☐
24	Automatic controller check (communication checks)	☐	☐	☐
25	Parameters set point check (pressure, temperature, flow)	☐	☐	☐
26	Previous service reports check (3 rd party specialist)	☐	☐	☐
27	Primary supplies system/plants check	☐	☐	☐
28	System architecture/control logic function/modes of operation	☐	☐	☐
BMS Post Start checks				
29	Mechanical, Electrical and Plumbing (MEP) system operating/parameters checks	☐	☐	☐
30	MEP system alarms/warnings checks	☐	☐	☐
31	MEP systems duty/stand by communication of equipment	☐	☐	☐
32	System/programming BMS operation running checks	☐	☐	☐



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Attachment 2: EOM-ZO0-TP-000077 - Shutdown Procedure BMS and Associated Systems Checklist

1. Building Name:		2. Reference No.		3. MEV- BDA	
No.	Shutdown Procedure	CHECKED SATISFACTION			
		N/A	YES	NO	
BMS and Associated System – Office Facilities					
Health and Safety					
1	Required Personal Protective Equipment (PPE) available	☐	☐	☐	
2	Risk Assessments Method Statement (RAMS) available	☐	☐	☐	
3	Location of first-aid instructions and supplies available	☐	☐	☐	
4	Emergency eyewash and showers available	☐	☐	☐	
5	Emergency evacuation plan reviewed	☐	☐	☐	
6	Emergency contact details of the responsible person and the contractors	☐	☐	☐	
7	Life safety systems (fire extinguishers, sprinklers, gas suppression & fire alarm)	☐	☐	☐	
8	Ventilation	☐	☐	☐	
Pre-approvals					
9	System owner/ Manager/Engineering Team's approvals available	☐	☐	☐	
10	End-user department head's approvals available	☐	☐	☐	
11	Quality, Health, Safety and Environment Management (QHSE) approvals available	☐	☐	☐	
12	Specialist contractor's schedule of work	☐	☐	☐	
13	Approved Permit to Work (PTW)	☐	☐	☐	
BMS System Checks					
14	Redundant Building Management System (BMS) system working	☐	☐	☐	
15	Server connection	☐	☐	☐	
15	Data saved	☐	☐	☐	
17	Soft shutdown SOP/procedure to follow	☐	☐	☐	
18	Auto mode/overrides	☐	☐	☐	
19	Events/logs saved	☐	☐	☐	
20	Redundant BMS system working	☐	☐	☐	
21	Mechanical, Electrical and Plumbing (MEP) systems mode of operation/system architecture/control logics	☐	☐	☐	
Pre-shutdown Checks (Integrated system functional checks)					
22	System is alarm free	☐	☐	☐	
23	Automatic control panel parameters check	☐	☐	☐	
24	Stand by systems working	☐	☐	☐	
25	Overrides/auto functions active	☐	☐	☐	
Routine Stop					
26	Lock Off Tag Out (LOTO) checks	☐	☐	☐	
27	Server working	☐	☐	☐	
28	No events/alarms on standby systems	☐	☐	☐	
Post-stop Checks					
29	MEP system functioning	☐	☐	☐	
30	Other monitoring PC's active	☐	☐	☐	
31	Control active	☐	☐	☐	
32	Alarms/warnings	☐	☐	☐	



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Attachment 3: EOM-ZO0-TP-000078 - System Monitoring Procedure Checklist

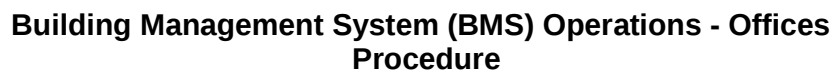
1. Building NAME:		2. Reference No.		3. HEV - BSA		
No.	Systems Monitoring / Daily Rounds	CHECKED SATISFACTORY				
		N/A	YES	NO		
	BMS and associated systems – Office Facilities					
	This monitoring checklist is intended to highlight the key issues that may arise day-to-day at local level. The procedure and any supporting information should be reviewed and amended as necessary to ensure the document remains up-to-date and definitive for the facility					
1	System inspection and checking (Is the Building Management System (BMS) running)	☐	☐	☐		
2	System assessment (Is the unit and its associated plant secure from unauthorized access)	☐	☐	☐		
3	Remote monitoring of ventilation, air conditioning, and other Mechanical, Electrical and Plumbing (MEP) systems and equipment through BMS	☐	☐	☐		
4	System functions/mode of operation	☐	☐	☐		
5	Identifying maintenance risks on equipment and raising work orders in case of any discrepancy into MEP systems	☐	☐	☐		
6	Investigating fault /alarms for MEP systems	☐	☐	☐		
7	Ensure BMS program, back end applications and software is running	☐	☐	☐		
8	Duty/standby system are healthy and communicating	☐	☐	☐		
9	Field controllers, routers and switches are online and communicating	☐	☐	☐		
10	System architecture functioning	☐	☐	☐		
11	Performing emergency repairs promptly and efficiently	☐	☐	☐		
12	Providing technical direction to ensure system maintains online	☐	☐	☐		
13	Keeping daily logs and records of all operation functions	☐	☐	☐		
14	Ensuring compliance with appliance standards and with occupational health and safety	☐	☐	☐		
15	Complying with service standards, work instructions and user requirements	☐	☐	☐		
No.	Reviewer's Comments	Resolution				
Originator's Name/Signature and Date:		Checker's Name/Signature and Date:				



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Attachment 4: EOM-ZO0-TP-000079 - Emergency Response Actions Checklist

1. Building NAME:		2. Reference No.		3. H&V - B&A	
No.	Emergency Response Action	CHECKED SATISFACTORY			
		N/A	YES	NO	
	BMS and associated systems – Office Facilities				
	Emergency Response Action Plan (ERAP)				
	This Emergency Action Plan (EAP) is a guide intended for areas of a facility with complex services, for example, a major boiler house or specialist plant room. The actions to be taken by designated and authorized persons may be expressed in a checklist. The steps below are simple indication of some issues that may arise although a more detailed list may be appropriate for each specific area. The designated staff functions of office functions need to be made clear in order that the correct measures are taken to minimize the impact of any crisis.				
1	Define ownership of the problem	☐	☐	☐	
2	Will tenants/public/staff safety/care be affected	☐	☐	☐	
3	Will evacuation be required	☐	☐	☐	
4	Risk of fire outbreak or reduced re-fighting ability	☐	☐	☐	
5	Consider impact on electricity supply and Building Management System (BMS) controls	☐	☐	☐	
6	Consider impact on gas supply and BMS controls	☐	☐	☐	
7	Consider impact on water supply and BMS controls	☐	☐	☐	
8	Consider impact on drainage and BMS controls	☐	☐	☐	
9	Consider impact on any third party system and BMS controls	☐	☐	☐	
10	Consider impact on site security	☐	☐	☐	
11	Consider impact on data loss and data security	☐	☐	☐	
12	Impact on re-alarms	☐	☐	☐	
13	Will critical system be affected and time period of outage	☐	☐	☐	
14	Is there an impact on clinical waste	☐	☐	☐	
15	Agree responsibility boundaries	☐	☐	☐	
16	Clinical department procedures	☐	☐	☐	
17	Control of infection team involvement if BMS data not available	☐	☐	☐	
18	Do public relations need to be addressed	☐	☐	☐	
19	Consider service level agreements with suppliers	☐	☐	☐	
20	Involve commercial services	☐	☐	☐	
21	Record entities personnel contact details	☐	☐	☐	
22	Locate supply of specialist/redundant BMS equipment	☐	☐	☐	
No.	Reviewer's Comments	Resolution			
Originator's Name/Signature and Date:		Checker's Name/Signature and Date:			



The diagram illustrates a BACnet/IP system architecture. At the top, an 'IT LAN - TCP/IP' block is connected to five 'Ethernet Switch/Router' units. These routers are connected to various components:

- The first router connects to a 'BMS Workstation/Server Management Level'.
- The second router connects to a 'BACnet Building Network Controller'.
- The third router connects to a 'BMS Workstation Operation Level (Limited Functionality)'.
- The fourth router connects to another 'BACnet Building Network Controller'.
- The fifth router connects to a 'BACnet XXXX or Modbus Gateway'.

 The BACnet Building Network Controllers are connected to 'BACnet Advanced Application Controllers'. These controllers manage various building equipment, including 'Lighting', 'AHU', 'FOU', and 'VAV'. The diagram also shows 'Option 2 Digital Input to DDC' and 'Option 1 Electromechanical Interior' connections. A 'Starter VFD' is connected to a 'Negative Isolation Room' and a 'Negative Isolation Room AHU'. The BACnet XXXX or Modbus Gateway is connected to a 'LON or Modbus Building Network Controller', which in turn manages 'LON or Modbus Advanced Application Controllers' for 'Lighting', 'AHU', 'FOU', and 'VAV'.