

National Manual of Assets and Facilities Management

Volume 6, Chapter 6

BMS Maintenance Plan for Healthcare

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BMS Maintenance Plan for Healthcare

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1.0 PURPOSE

Successful Building Management System (BMS) maintenance planning for healthcare Entities relies upon conducting maintenance at the right time to the right level such that system performance may be optimized and equipment life may be maximized.

The purpose of this document is to provide an Entity or Facilities Management Company (FMC) guidelines for the improvement and further enhancement of their maintenance management plan for a Building Management System (BMS) within the healthcare sector. The guidelines incorporated into this document will further support the Entity and/or FMC to improve and enhance the overall understanding of a BMS. In addition, it will convey best practice that is intended to enable a structured approach to develop BMS maintenance plans.

2.0 SCOPE

The scope of this document is to provide guidelines to the Entity, FMC, or their specialist service providers to improve and enhance current practice and develop new maintenance plans for managing effective maintenance regimes and improving the facilities maintenance team's quality assurance and quality control.

This document provides information developed from international standards, Saudi Arabia Codes, and best industry practices to develop, improve, or enhance the maintenance plans within healthcare facilities.

Furthermore, it will support the Entity for a better understanding of:

- Elements involved in maintenance planning of the BMS
- Maintenance tasks management and execution to optimize BMS system efficiency
- Quality assurance and Quality control (QA/QC) of the maintenance tasks
- An improved BMS, and associated equipment's efficiencies
- Consideration to health and safety of stakeholders and environment

A 'Conduct of Maintenance' shall be established to effectively maintain assets and equipment for an engineering system to be efficient and optimally utilized.

For the purpose of this document "a healthcare facility" has been defined as any location where healthcare is provided, such as but not limited to:

- Hospitals
- Clinics
- Nursing homes
- Dental care facilities
- Psychiatric facilities/Institutes

This document provides information developed from international standards, and best industry practices to either develop, or improve and enhance the BMS maintenance plans within a "Healthcare" Entity.

3.0 DEFINITIONS

Term	Definition
BACnet	Building Automation and Control networks
Basis of Design (BOD)	A mandatory generated pre-construction document based on American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), Leadership in Energy and Environmental Design (LEED), and National Fire Protection Association (NFPA) to prepare Mechanical, Electrical, and Plumbing (MEP) system's manual, and commissioning documents
Best Practice	A method or technique that has been generally accepted as superior to any alternatives because it produces results that are superior to those achieved by other means or because it has become a standard



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Term	Definition
	way of doing things (e.g., a standard way of complying with legal or ethical requirements)
Calibrated Tools	Measurement tools that have a calibration requirement, either as a statutory or risk assessed requirement.
CEng	Chartered Engineer
Consumable	Physical part of an engineered system, Personal Protective Equipment (PPE), or a cleaning, treatment, or preservative liquid or compound whose consumption or use as part of a maintenance task is necessary and predictable
Criticality	Typically, a 4-5 level ranking system that categorizes the importance of the component, asset, or maintenance task. Refer to Volume 2 Asset Management
Data Point Schedule	A table format which shall show the monitoring and control points for the equipment and system. Points such as control and monitoring as I/O points (Input and Output point to and from the controller)
Facility	The term for the group of fixed civil engineering assets that are not a building. For example, a bridge, a mast, a harbor
Frequency (FQ)	Refers to a cyclic time period
IEng	Incorporated Engineer
Maintenance Levels	The complexity of maintenance activity. For example, level 1: reset, level 2: Predicative Maintenance, level 3: monthly related to the skillset/competence level and experience of the operative. Sometimes referred to as Task Level
Maintenance Program/Schedule	Refers to the time basis of the delivery activity.
Monitor/Head end PC	See engineering equipment's, systems' status for monitoring and control the operations
Parameter	The name of a unit or metric. For example, 'pressure', 'hertz', 'temperature'
POWRA	Point of Work Risk Assessment – A short checklist that operatives refer to at the 'location of' and immediately before carrying out a task.
Process and Instrumentation Diagram (PID)	A schematic presentation which shows the equipment field devices and input/output modules and Direct Digital Controller (DDC) to comprehend the functional logic of the equipment and system
Permit to Work (PTW)	A safety management documented system adopted by most organizations for management of work activities
Quality Assurance (QA)	Method by which to assess that quality standards are being met
Quality Control (QC)	Quality standards to be attained
Regime	The collective noun for Maintenance Plan applied to an asset, system, facility, or building
Run to Failure (RTF)	A maintenance strategy where the asset is deliberately not maintained but allowed to run until it fails
Sequence of Operation (SOO)	A written explanation and description on the MEP systems how the systems are intended to work
Test	Verifying by means of observation or measurement that the system meets the expected and/or acceptable requirements
Threshold	Numerical value of a parameter at which a decision is made.
Abbreviations	
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BMS	Building Management System
BOM	Bill of Materials
CIBSE	Chartered Institution of Building Services Engineers
CMMS	Computerized Maintenance Management System
CPU	Central Processing Unit
ECV	Exhaust Control Volume



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Term	Definition
ELV	Extra Low Voltage
FDD	Fault Detection and Diagnostics
FM	Facilities Management
GUI	Graphical User Interface
HSSE	Health, Safety, Security, and Environment
I/O	Input/output
IT	Information Technology
JHA	Job Hazard Analysis (see POWRA)
LEED	Leadership in Energy and Environmental Design
LV	Low Voltage
MEP	Mechanical, Electrical, and Plumbing
NAE	Network Automation Engine
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NMA&FM	National Manual for Assets and Facilities Management
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
PAR	Periodic Automatic Replenishment
PAT	Portable Appliance Test
PC	Personal Computer
PM	Planned Maintenance
PPE	Personal Protective Equipment
RAMS	Risk Assessment and Method Statement
SC	Statutory Compliance
UPS	Uninterruptible Power Supply
VAV	Variable Air Volume
VCV	Volume Controlled Ventilation
VDU	Visual Display Unit

Table 1: Definitions

4.0 REFERENCES

- American Society of Refrigeration and Air Conditioning (ASHRAE 13) – Specifying Building Automation Systems
- Chartered Institution of Building Services Engineers (CIBSE) – Building Automation System
- EPM-KEO-GL-000009 – BMS and Mechanical system integration guideline
- EPM-KEO-GL-000007 – Extra Low Voltage (ELV) systems integration guideline
- EOM-ZW0-GL-000002 – Maintenance Procedure Writers Guide
- EPM-KT0-TP-000051 – Graphics Testing Template
- Health Technical Memorandum (HTM 05) – Building management system
- Health Technical Memorandum (HTM 2020) – Electrical safety code of Low Voltage (LV) system
- National Fire Protection Association (NFPA 101) – Life safety code
- National Fire Protection Association (NFPA 72) – National Fire Alarm and Signaling code
- National Manual of Assets and Facilities Management, Volume 10 – Health, Safety, Security, and Environment (HSSE)
- National Manual of Assets and Facilities Management, Volume 12 – Risk Management
- National Manual of Assets and Facilities Management, Volume 11 – Quality
- National Manual of Assets and Facilities Management, Volume 2 – Asset Management
- National Manual of Assets and Facilities Management, Volume 4 – Financial Planning
- Standard Maintenance Specification for Building Services (SFG 20)
- National Manual of Assets and Facilities Management, Volume 7 – Work Control



5.0 RESPONSIBILITIES

Only trained and competent persons should be appointed by management to perform maintenance tasks on BMS systems.

Designation	Responsibilities
Designated Person (Electrical)	An individual who has overall authority and responsibility for the premises containing the electrical supply and distribution system within healthcare 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)}	<p>A chartered engineer or incorporated electrical engineer with appropriate experience and possessing the necessary degree of independence from local management, who is appointed in writing by management of healthcare 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</p> <p>Refer to HTM 2020 – Electrical safety code of low voltage systems, for further details</p>
Authorized Person (LV/ELV – electrical)	An individual possessing adequate technical knowledge and received appropriate training to be responsible for the practical implementation and operation of management's safety policies and procedures
Competent Person (LV/ELV – electrical)	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 LV systems
Operations and Maintenance Person (BMS)	A person of the engineering staff, BMS manufacturer, or Operations and Maintenance (O&M) organization, employed by management to carry out duties on BMS
BMS Operator	<p>An authorized individual who operates BMS/EMCS</p> <p>Refer to HTM 05 – BMS, for further details</p>

Table 2: Responsibilities

5.1 BMS Levels of Operations

BMS 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:

- 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 Measuring 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



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BMS Network Integration Structure		
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 3: BMS Network Integration Structure

5.2 Roles and Responsibilities – Planned Maintenance (PM)

Below is the demonstration of roles and responsibilities for PM Implementation:

Roles & Responsibilities for PM Scheduling and Implementation

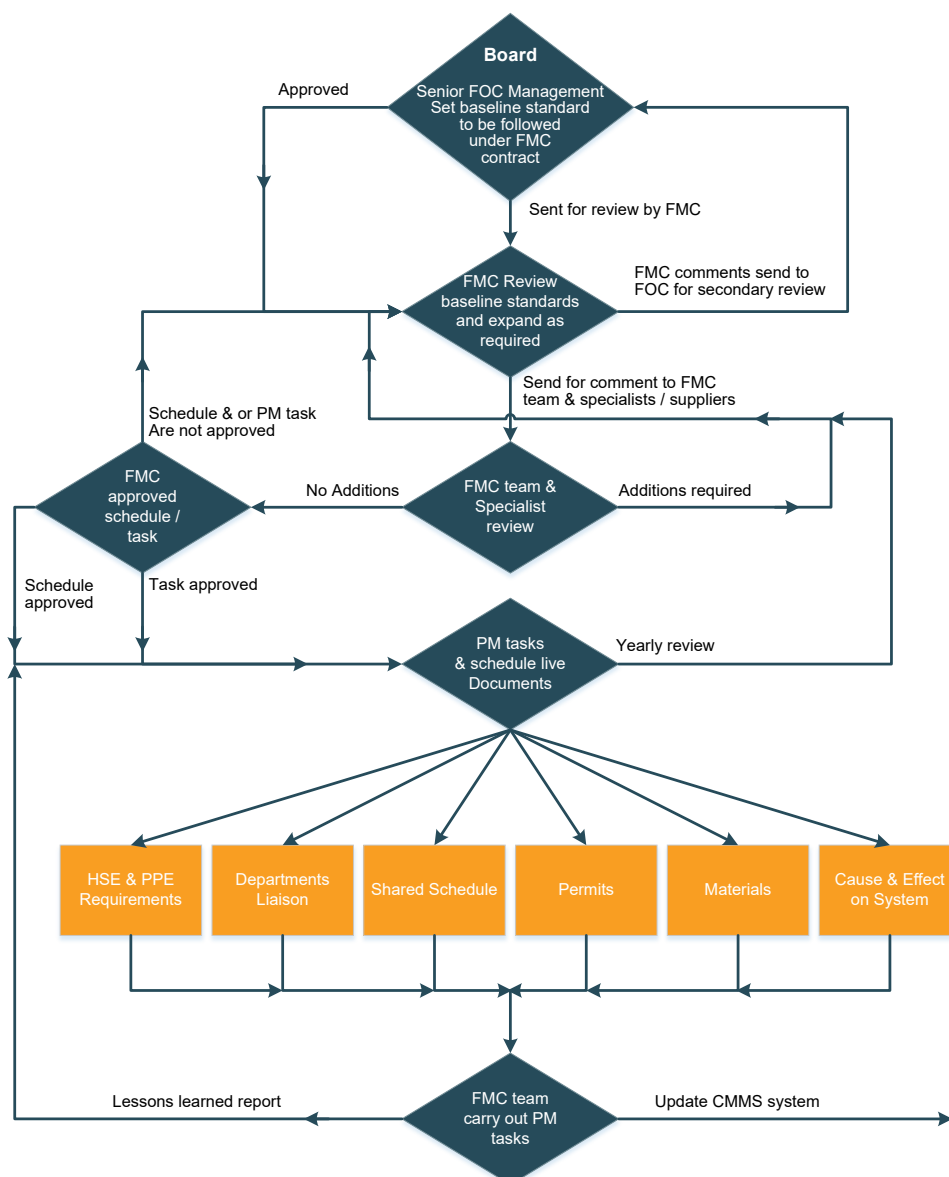


Figure 1: Roles & Responsibilities for PM scheduling and implementation

6.0 PROCESS

6.1 BMS Introduction



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A BMS is a computer based approach to measure, monitor, and manage the performance of building services such as heating, ventilation, air-conditioning, lighting, and security services. A BMS coordinates the operation of various systems in the building such as boilers, air handling units, fans, and others. It gathers data from sensors such as light detectors or sensors that track occupancy, temperature, pressure, humidity or occupation within occupied areas of the building to create and retain a comfortable indoor environment.

Due to system wide approach to control all these building engineering equipment and systems, they can also make an important contribution to increased energy efficiency and reduced operating costs for buildings. This is particularly true if information from meters for electricity, gas, water, and other utilities is fed into the BMS. A BMS can monitor how much energy is being used and can contribute in reducing energy consumption by adjusting or turning off equipment according to usage.

Facility Managers can access the BMS through user interfaces which includes Personal Computers (PCs), laptops, and handheld devices that provide information on building performance in user friendly formats such as graphs, charts, and reports.

The key point in BMS is that it will only function according to the system configuration.

Figure 2 illustrates the advantages of a BMS system.

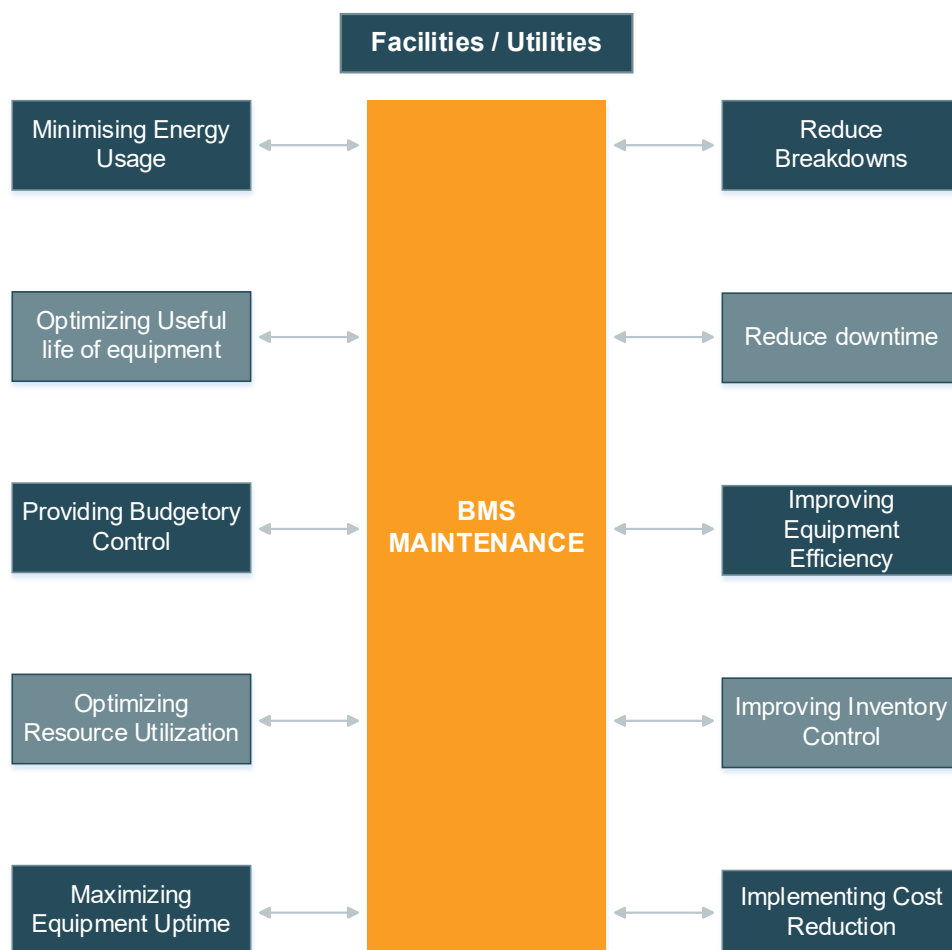


Figure 2: Advantages of a BMS system

6.2 BMS Maintenance Strategy

Maintenance is a combination of all technical, administrative, and managerial actions during the life cycle of a device. A maintenance strategy is intended to retain or restore a device or piece of equipment to a new or as new condition in which it can perform the required function. BMS maintenance shall cover tests, measurements, replacements, adjustments, and repairs intended to retain or restore a unit or equipment



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to a state where equipment or asset can perform a function. It is essential to keep and preserve equipment and a facility in a functional state.

The figure below depicts the various types of maintenance activities involved in operating and maintaining a reliable BMS system:

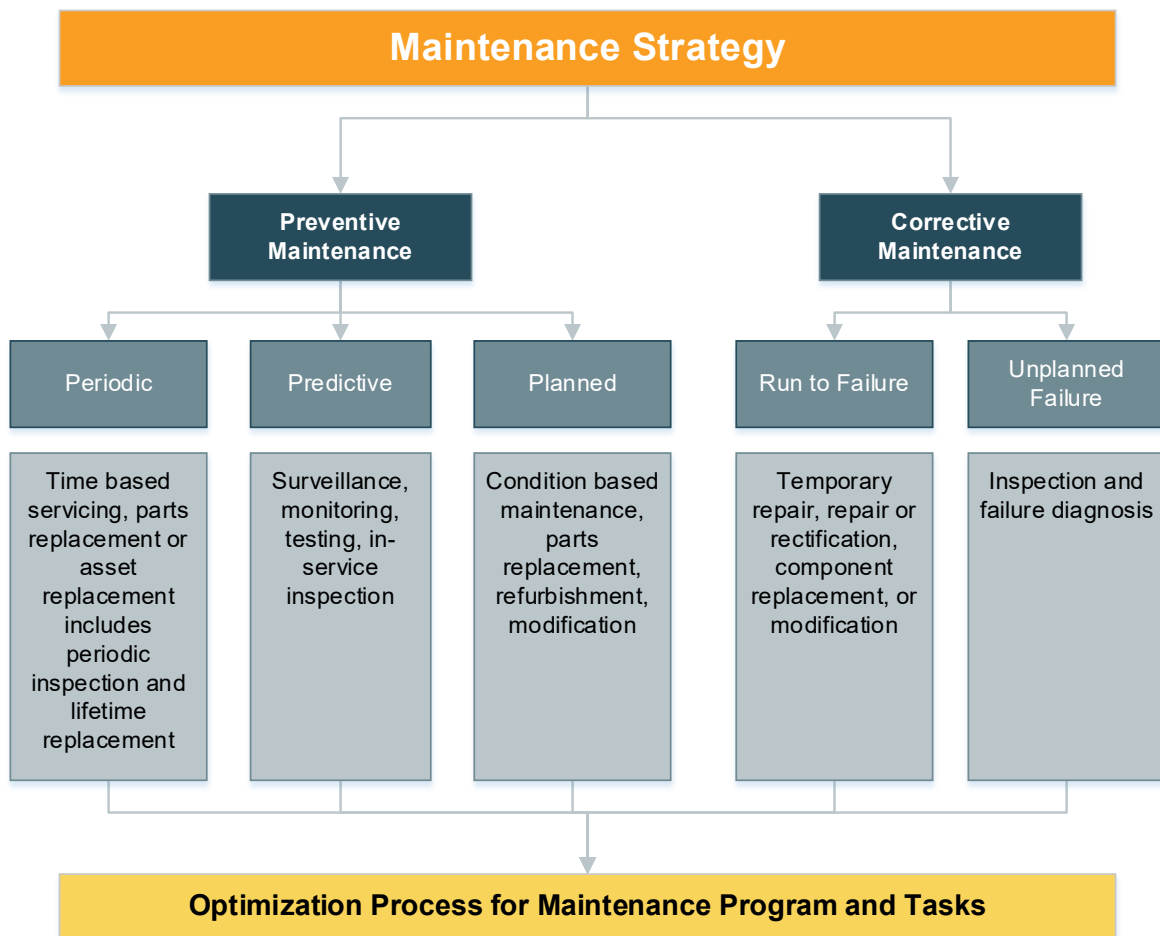


Figure 3: Relationship of maintenance concepts and activities

6.3 Types of Maintenance

Depending on the Entity's asset management strategy, organizational maturity, and funding, the following types of maintenance may be applied to HVAC systems within each facility:

- Planned Maintenance: Preventive and Predictive (PM, PdM)
- Unplanned Maintenance: Corrective and Emergency (CM, EM)

This document focuses primarily on Planned Maintenance, other maintenance types are described within NMA & FM, Volume 6 Chapter 3 – Descriptions and Definitions (EOM-ZM0-PR-000002).

6.3.1 Planned Maintenance

Planned maintenance is a regime that is carried out at predetermined intervals or frequencies on an asset to lessen the likelihood of it failing and to maintain the equipment's safe running conditions and efficiencies. PM is performed before equipment failure takes place and eliminates unexpected breakdowns.

Key elements and advantages while scheduling and executing PM are:



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- The care and servicing by personnel for the purpose of maintaining equipment and facilities in satisfactory operating condition by providing for the systematic inspection, detection, and correction of incipient failures, either before they occur or before they develop into major defects
- Maintenance including tests, measurements, adjustments, and parts replacement, performed specifically to prevent faults from occurring
- Elimination or mitigation of the consequences of equipment failure
- Preventative maintenance and condition-based maintenance help to prevent failure
- Preservation and restoration of equipment reliability by replacing worn components before they fail
- Planned maintenance tasks including partial or complete changes, upgrades or partial major components replacement, and minor or major adjustments

6.3.1.1 Statutory Requirements

It is incumbent that BMS system maintenance shall be performed on system/assets that require regular maintenance/inspections at set intervals as specified by Original Equipment Manufacturers (OEM) recommendations, and Statutory Compliance (SC) requirements. BMS monitors and controls a wide range of healthcare utilities systems such as:

- Heating, Ventilation, and Air Conditioning (HVAC) systems
- Fire Alarm System (FAS)
- Fire suppression system
- Customized alarms and surveillance systems
- Lift management systems
- Energy Conservations (EC)

It is advised that these integrated systems are inspected and maintained according to the National Fire Protection Association (NFPA), Health Technical Memorandum (HTM) and Chartered Institute of Building Services and Engineers (CIBSE) requirements at specified intervals.

A Planned Maintenance Program Procedure is provided within NMA & FM, Volume 6 Chapter 3 (EOM-ZM0-PR-000003).

6.4 Maintenance Planning & Scheduling

Planning decides what maintenance tasks are to be conducted, how they are to be performed, and the time estimates associated with the completion of these tasks. The individual responsible for performing a particular maintenance tasks, their frequency or at what time intervals these tasks are to be performed are accounted for in a maintenance schedule.

Proper planning is a vital part in successfully managing the maintenance of equipment. Planners must collaborate with internal or external stakeholders to achieve optimal results. A comprehensive maintenance schedule shall be developed, and equipment or assets should be listed in the maintenance schedule.

When putting BMS maintenance schedules together, all maintenance activities, along with other department recommendations, personal experiences, equipment history, and Original Equipment Manufacturer (OEM) recommendations shall be considered. Moreover, a maintenance schedule shall define clearly the types of maintenance activities, like corrective maintenance, planned maintenance, predictive maintenance, RTF maintenance, and planned shutdowns. BMS integrates other engineering critical or non-critical assets. Hence, a proper briefed cause and effect matrix shall be considered to illustrate the full impact of maintenance on educational services.

The following elements shall be taken into consideration when planning and scheduling the BMS maintenance tasks:



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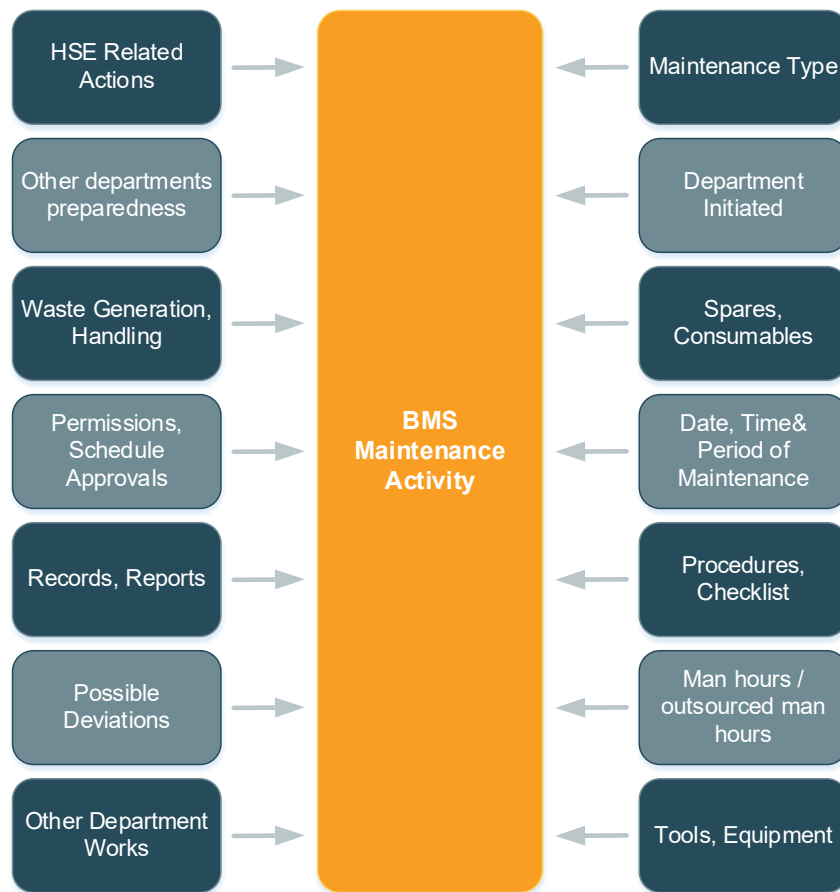


Figure 4: Pictorial Representation of Links of Maintenance Activity

The Entity should consider the specific requirements detailed in NMA & FM Volume 2 – Asset Management & Volume 7 – Work Control, while requesting, prioritizing, scheduling and planning maintenance tasks.

6.5 CMMS Requirements

Each Entity shall employ a Computerized Maintenance Management System (CMMS) or other Entity-approved centralized system to capture maintenance plans and outcomes. BMS maintenance plans captured within CMMS shall:

- Feature a list of tasks numbered by priority, and associated frequencies.
- Enable decision making which supports optimized system performance, maximizes equipment life, and offers energy and cost-saving opportunities.
- Highlight equipment criticality and procedures for deferring maintenance activities

BMS maintenance plans captured within CMMS shall also:

- Refer to an industry resource and feature site specific guidelines to support maintenance activities
- Recommend the storage method for BMS and integrated data points and control points
- Feature check points for additional parameters (record sheets shall be attached to work orders to validate the results during testing and maintenance)

The Entity shall consider the specific requirements detailed in NMA & FM Volume 2 – Asset Management

6.6 Health and Safety

BMS is a hazardous activity which involves working alongside equipment, a running system, or being in close contact with energized BMS devices. Maintenance activities which pose significant risk to people and



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to the BMS system are non-routine maintenance tasks, and those which involve exceptional working conditions such as confined spaces or task involved live work due to healthcare operations.

Regardless of the maintenance activity being undertaken, human error is a factor of maintenance activities that can lead to near misses, accidents, and system malfunction. Given that the BMS governs HVAC systems, lighting system, and other high number of critical engineering systems within healthcare facility, scheduled BMS maintenance during summer months, for example, requires activities to be executed such that downtime is minimized. Corrective BMS maintenance executed during the same period shall be assigned the highest priority level to prevent discomfort to healthcare facility users, reduce impact to patient safety to a minimum, or damage to building fabric.

Maintenance personnel are, therefore, required to plan maintenance appropriately based on analysis of system data and performance history, then work towards reducing risk to people, system, and the environment.

The Entity should consider the specific requirements detailed in NMA & FM Volume 10 – Health, Safety, Security & Environment (HSSE), to enable safe practices during maintenance activities.

6.7 Risk Management

The Maintenance team shall complete a comprehensive set of Risk Assessments and Method Statements (RAMS) covering all systems within healthcare facility. For task specific activities, a Job Hazard Analysis (JHA) shall be conducted, using the content of RAMS as a basis. Visitors, contractors, and others working under site specific health and safety plans shall all be considered within all RAMS and shall sign onto JHA as required.

Below elements shall be considered when carrying out risk assessments for BMS maintenance:

- Identify hazards associated with each maintenance activity, for example:
 - Loss of BMS-controlled systems
 - Impact on operation of facilities
 - Data loss
 - Corruption of BMS software
 - Configurations, applications, and equipment failure.
- Establish maintenance personnel, service providers, and building users who are at risk as a result of the maintenance activity
- Quantitatively evaluate risks using a risk matrix. Involve maintenance team, subject matter experts, and HSSE team in risk assessment process and hold a Risk Workshop as necessary
- Take action – decide on mitigation or fall back measures needed, required investment, responsibilities and timeline
- Review the risk evaluation following implementation of mitigation measure
- Record findings

The Entity should consider the specific requirements detailed in NMA & FM Volume 10 – Risk Management, for carrying risk assessment.

6.8 Quality Control and Quality Assurance

Quality Control (QC) represents the quality standards that shall be met by each Entity. However, Quality Assurance (QA) is the method that indicates whether the quality standards are being met, and capturing opportunities for continuous improvement.

QC shall be determined by the content of BMS maintenance plans, for example:

- Actions to be undertaken through maintenance are based on system-specific and site-specific performance data
- Frequency of maintenance is based upon OEM recommendations
- Data point thresholds which are set up in CMMS and used for refining maintenance plans

QA should be determined using a number of techniques and data analysis, for example:



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- Findings deduced from CMMS data trending
- Checklists designed for each maintenance activity
- Permit to Work (PTW), which ensures a safe system of work to protect people from the system, but also limits human error by removing single point of failure through involvement of Authorized Persons (AP).

The Entity shall consider the specific requirements detailed in NMA & FM Volume 11 – Quality, for carrying risk assessment.

6.9 Spares Parts

Each Entity shall ensure that a Bill of Materials (BOM) is established for the BMS and associated equipment. An asset hierarchy shall be established with equipment criticality identified in order to develop:

- Maintenance strategy
- Spare parts list
- Critical spare parts list
- Running arrangements
- Risk assessments

The BOM shall include the following as a minimum:

- Part number
- Make and model
- Quantity
- Replacement cost
- Asset ID and location indicator

Parts/consumables with high failure rate shall be highlighted during maintenance activity and further analysis shall be performed to identify root cause analysis of the components failure. Wherever possible, parts shall be made available in good time for maintenance activities to be undertaken. Facility managers shall also review critical spares stock holdings and review maintenance checks on these spares and components.

The Entity shall consider the specific requirements detailed in NMA & FM Volume 4 – Financial Planning, to develop its life cycle model and to manage obsolescence management for BMS and its components.

6.10 BMS Maintenance Methodology

6.10.1 BMS Maintenance

The maintenance team shall establish a periodic maintenance schedule for the BMS system. This schedule shall cover routine tests, visual inspections, and other planned maintenance activities against time.

BMS maintenance consists primarily of inspection, cleaning, lubrication, adjustments, calibrations, and replacing minor components parts (e.g., field devices, Direct Digital Controllers (DDCs), fan coil units, Variable Air Volumes (VAVs), BMS server and PC) to minimize malfunction, breakdown, and premature deterioration. BMS maintenance schedules shall also include integrity testing and functionality checks of field devices and outstations, application software, and associated controllers.

The timely completion of planned maintenance tasks without compromising quality of the work will increase equipment reliability and service life. Depending upon several factors, including failure history, impact of failure (asset criticality), and cost of equipment replacement; planned maintenance tasks shall be scheduled at a prescribed frequency by the O&M person assigned to manage BMS maintenance.

In the absence of OEM recommendations, the periodic maintenance schedule shall cover weekly, monthly, quarterly, biannual, and annual maintenance as a minimum. Maintenance activities shall be applied against



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system boundaries, which are based on asset tagging, asset hierarchy, and direction from the Maintenance Supervisor.

In a healthcare facility, as a minimum, the following BMS inspections shall be made to maintain system integrity against the Basis of Design (BOD) and Sequence of Operations (SOO):

- Checking of controllers and supply power voltage
- Checking and verifying each Input/output (I/O) points for proper terminations from end to end, during planned maintenance activity
- Termination tags
- Panels to be free from dust and debris
- Controllers network communication
- Checking and maintaining the integrity of data connections and cabling within risers and vulnerable areas, to prevent communication failure
- Measuring sensors and transmitters data using handheld measuring devices and comparing it with BMS data. Any deviation shall be recorded and actioned via work orders to eliminate the faults
- Simulation of switches and contacts e.g. pressure switches and relays, and verification at BMS head end PC. All mismatch findings shall be recorded and correct
- Start/Stop/Operate all equipment connected to BMS including fan motors, cooling valve, electric duct heater, dampers, and humidifiers for their functionality. These shall get close/off when fan motor gets off (Refer to site specific BOD and SOO for inspection).
- Checking of process control logics by adjusting set points e.g. setting temperature set point below or above actual temperature. These shall modulate the cooling valve to meet the desired temperature set point (Refer to site specific BOD and SOO for inspection).
- Checking and verification of the reliability and functionality of all BMS workstations graphics and applications
- During maintenance, checking and verification shall be carried out to ensure BMS PC is free from unwanted programs and temporary files
- All gathered results and data shall be filled in PM sheets for references and use

6.10.2 Pre-Requisites of the Maintenance

- Tools/Specialized Tool Kits/PPE
 - All software, databases, configuration tools, and analysis tools shall be used as needed during inspection and performance test
 - Measurement and calibration tools shall be Portable Appliance Test (PAT) tested and National Institute of Standards and Technology (NIST) certified
 - Where necessary calibration procedures shall be programmed within the CMMS for periodic testing
- Risk Assessment Method Statement (RAMS)
 - Risk assessment and a comprehensive method statement shall be in use as a safe practice of work. All results identified from risk assessments shall be documented and shall include and referred to method statement for the completion of maintenance tasks
 - A person performing maintenance activity shall be deemed competent to carry out maintenance tasks on BMS and integrated equipment and systems
 - Shall have recognized qualification relevant to BMS and engineering
 - Shall have sufficient training and experience in BMS or electrical engineering field
 - JHA shall be carried by personnel carrying out maintenance
- Permit to Work (PTW)
 - Switching off any switch fuse, power circuits, distribution boards, or mains circuit board that may affect any of the equipment associated to BMS controllers and server shall be subject to PTW authorized by an engineer or manager of the facility
 - All PTW shall include an approved RAMS to perform maintenance tasks
 - Where required a LOTO shall be applied to prevent inadvertent energizing of equipment during maintenance activities
- Drawings/Schematics



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- The drawings/schematics shall be included along with PTW to identify the point of maintenance activities and consequences shall be marked up at planning stage
- Sequence of Operation (SOO)
 - Maintenance task shall include SOO so that process and system cause and effect shall be cleared and understood to all parties involved in the maintenance task
- Redundancy Planning
 - Healthcare facilities mostly cover critical equipment and systems, henceforth, it is essential to keep backup or stand by equipment ready whenever needed. While planning maintenance plans, a substantial level of planning shall be performed and redundant equipment or system to be used during emergencies shall be considered
 - BMS equipment such as, but not limited to supervisory control PC, Network Automation Engine (NAE), DDC units, stand by units, main server, temporary server, and other essential equipment shall be available to manage BMS functions during any emergency into operations, any component failure, or during any planned maintenance activity. Cause and effect shall be comprehending during all scenarios and contingency plan shall be in place
- Documentation
 - Documentation is an essential element of maintenance tasks. Facilities operations team shall ensure that relevant documentation of the pre-maintenance tasks and post-maintenance tasks to be available with facilities technicians, supervisors, and engineers to track maintenance logs/records. These shall be kept within the CMMS as digital copies for historical purpose and monitoring of system. Below documents shall be available within facilities team, but not limited to:
 - Written maintenance procedure and RAMS
 - SOO
 - PTW
 - Drawings/Schematics
 - Task sheets
 - Work orders to record non conformities
 - Completed job orders and maintenance reports
 - Others site specific

6.10.3 BMS and Integrated System Testing

Below BMS maintenance fundamentals shall be covered while developing task sheets and maintenance schedule for BMS, but not limited to the following:

- Control strategy or application software functionality shall be checked
- BMS functionality check and integrated MEP systems for parameters monitoring and control in accordance to the Basis of Design (BOD)
- Set Points – All set points shall be checked to ensure realistic values, thresholds, and operating ranges
- Time control – All time routines shall be checked (removal of temporary schedules)
- Interlocks – All interlocks shall be checked
- Digital input (DI)/Digital output (DO) ranges shall be checked for voltage and current according to OEM standard and on the basis of design parameters:
 - 0 to 10 VDC
 - 4 to 20 mA
 - Contact closure
 - Pulse inputs
- Digital/Analog inputs on field devices such as flow switches, pressure sensors or differential pressure sensors, and DDC
- MEP systems ramp up/ramp down shall be checked according to the basis of design
- Startup/Shut down routines shall be checked for correct sequence
- Different Sequence of Operation (SOO) strategies during power failures, load demands, and when power is reinstated
- Cause and effect shall be checked according to the basis of design
- Monitoring status of e.g., valves, dampers shall be checked
- Field wiring connections, interlock connections, and hardwired connection shall be checked



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- Software points shall be checked
- Auto changeovers of integrated plant due to plant failures and auto changeover on running hours
- Sequence of events following the failure of the duty/stand by systems shall be checked
- Alarm Functions:
 - The operation of each alarm function shall be checked
 - Time delay on each alarm function shall be checked
 - Level of category of alarm, its destination, and reporting method shall be checked
 - Operation of alarm masking shall be checked
 - Correct notifications to key personnel (email/SMS)
- GUI/Supervisory/Field Inspection and Check Points
 - Hard copies of BMS graphics shall be checked
 - Cyber security
 - Application/Software check/Firmware updates
 - User level modes and restrictions
 - Information Technology (IT) connections, speed, drive capacity, Graphics User Interface (GUI), bandwidth, time sync, server, redundancy, and security
 - Fault Detection and Diagnostics (FDD)
 - BMS Status (ON/OFF) and Commands status
 - BMS value (Running hours, voltage, current, pressure, running command status, frequency)
 - Alarms, trends, and communication
 - Building Automation and Control networks (BACnet) Master Slave Token Passing (MS/TP) Bus Address
 - Thermostats functionality and calibration
 - Temperature set points
 - Humidity
 - Supply air temperature
 - Room pressures
 - High Efficiency Particulate Air (HEPA) filters (if applicable)
 - Design flow rates (L/sec)
 - Hot water temperature
 - Actuator commands
 - Exhaust control valves
 - ECV/VCV differential pressures
 - Damper positions/Actual flow rate
 - CO2 level
 - CO2 set point
 - Damper positions at high CO2 levels
 - Local controller operation
- Connected power supplies and devices according to system architect
- Backup power supplies and UPS devices that may be fitted
- NAEs/Controllers
 - NAE battery status
 - Fault status
 - Device counts/Overload
 - Online/Offline status
 - NAE object counts
 - Central Processing Units (CPU) temperatures
 - Board temperature
 - Panel temperature
 - Back up

Contained within **Attachment 1** is a BMS Planned Maintenance Schedule (PM) presented in the form of a checklist and the Entity shall use the format presented within it to prepare its own site specific BMS PM Schedule. While preparing its own PM schedule, the entity shall ensure that aforementioned requirements are reflected as applicable, and that site specific considerations are included.

7.0 ATTACHMENTS

Attachment 1: EOM-ZM0-TP-000049 – BMS Planned Maintenance Schedule



BMS Maintenance Plan for Healthcare

Attachment 1 – EOM-ZM0-TP-000049 – BMS Planned Maintenance Schedule

Healthcare Facility Name:			Reference No:		REV- 00A:		
Functional Critical PM – BMS							
No.	Item	FQ	Action	Notes	CHECKED		
					SATISFACTORY	N/A	YES
1	Supervisory PC/Micro based system						
1.1	Diagnostic routine on computer (where appropriate)	Biannual	Perform diagnostic tasks and check computer operation	This routine will check all aspects of computer hardware and software	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.2	Clock and Calendar	Biannual	Check real-time clock and date settings		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.3	Cooling Fans	Biannual	Check condition, clean and lubricate if necessary	Do not lubricate if sealed for life bearings. Wipe off any excess lubricant as it will attract dust which will stick to it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.4	Filters	Biannual	Check condition, clean and lubricate if necessary		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.5	Software Archives	Biannual	<ul style="list-style-type: none"> Take backup copy of site-specific data files Verify operating programs and functionality 	Ensure that security is retained and that any updating of files is incorporated. It is recommended that a copy of backup data is stored in a fireproof safe or off-site	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.6	Cables and Connectors	Biannual	Check security, integrity and for physical damage		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.7	Discs and Drives	Annual	Clean according to the manufacturer's instructions		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.8	Clock Battery	Annual	Check and replace, if necessary	Battery disposal should be in accordance with regulation and environmental requirements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.9	Mouse	Annual	Check for smooth operation and clean ball as necessary	More frequent cleaning can be implemented, if needed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.10	Visual Display Unit (VDU)/Monitors	Annual	Check: <ul style="list-style-type: none"> Focus Contrast Brightness For correct operation		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.11	Keyboard	Annual	Check for correct operation and clean		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.12	Cleaning	Annual	Clean with approved cleanser	Treat with anti-static compound. Depending on use and location, more frequent cleaning may be necessary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.13	Cables and Connectors	Annual	Check security, integrity, and for physical damage		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.14	Cleaning	Annual	Use recommended cleaning agent	Remove paper or tape debris	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.15	Test Sequence	Annual	Check, adjust and replace if necessary: <ul style="list-style-type: none"> Paper feed Transport system Printer cartridge 		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.16	Consumables (Wherever applicable)	Annual	Clean stocks		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2							



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Healthcare Facility Name:			Reference No:			REV- 00A:		
Functional Critical PM – BMS								
2.1	Data Communications	Annual	Check integrity of data flow in both directions	If more than one path exists, all must be verified	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2.2	Central Station units	Annual	Check operation and visually inspect. Check if environmental conditions of all equipment are within prescribed limits	To include modems, line drivers, telemetry cables, and interface units	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2.3	Central Station/ Outstations	Annual	Check integrity of data flow in both directions	If more than one data path exists, all must be verified. Caution – there may be interaction with specialist applications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2.4	Connectors	Annual	Check security, integrity, and for damage		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2.5	Alarms Receiving	Annual	Confirm that all critical alarms are received by the central supervisor. Check spurious alarms and report faults (as incurred)		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2.6	Alarms Generating	Annual	Check generation of alarms from all input and output devices		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2.7	Network	Annual	Check communications between central supervisory computer and outstations and other networked devices		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3								
3.1	Outstation Hardware	Annual	Check mechanical and environmental condition	Environmental conditions, such as temperature and humidity should be within manufacturer's recommended limits	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.2	Connectors	Annual	Check security, integrity, and for damage	Includes security of incoming cables, prevention of ingress of moisture, door seals.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.3	Power Supplies	Annual	Carry out voltage check on all power supplies	Check automatic restart/rebooting of software program	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.4	Stand-by batteries/Uninterruptible Power Supplies (UPS)	Annual	Check against manufacturer's specification. Replace as necessary		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.5	Digital Inputs	Annual	Check by activating sensing/control devices in field	Care shall be taken to isolate local operation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.6	Digital Outputs	Annual	Check operation of output stopping by operating routine (where appropriate). Check switching by software interlocks.		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.7	Analogue Inputs	Annual	Read and check calibration of analogue inputs		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.8	Analogue Outputs	Annual	Check for accuracy of output signal		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.9	Manual Override (Physical)	Annual	Check status	Review, Record, and Report	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3.10	Installed Program	Annual	Check integrity, alarms, interlocks, optimization		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	



BMS Maintenance Plan for Healthcare

Healthcare Facility Name:			Reference No:			REV- 00A:		
Functional Critical PM – BMS								
4								
4.1	Control Loops	Biannual	Check integrity of the installed program. Check sequence, operation of control, outputs and check stability of plant. Undertake as necessary fine tuning of control loops. Adjust settings in conjunction with the building manager to achieve the required internal environmental conditions	Frequency should be agreed with client. This action should be related to the critical nature of the operation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.2	Optimized Start/Stop	Annual	Verify operation by interrogating software/hardware copy	Building layouts and occupational requirements are seldom of a static nature. Therefore, control strategies and their suitability need to be reassessed on a regular basis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.3	Time Clock	Annual	Check real time clock and date for accuracy throughout system		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.4	Time Switching	Annual	Review current operating parameters according to site needs	Time settings and schedules	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.5	Data Logging	Annual	Review need for existing data logs. Delete/archive logs as required	Report to Management on the need to review existing arrangements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.6	Alarm - faults, out of limit alarms	Annual	Check that plant alarms and software interlocks with safety implications are operating correctly. Check alarm priorities, routings, and reactions. Check alarm priorities are appropriate	The checking of possible reactions to certain critical alarms and programs must be carefully coordinated with other trades and building tenants. Where there are safety implications, verify alarm integrity. Review system of reporting outstanding alarm conditions and report discrepancies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.7	Alarm Management and Report	Annual	Review frequencies of generated alarms. Review alarm log records for indication of untoward conditions	Report and record if any non-conformance, as appropriate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.8	Power Failure and Restoration	Annual	Check plant startup/shutdown sequence and integration with other assets according to the logic	Report and record if any non-conformance, as appropriate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.9	Generator loading program	Annual	Check plant startup/shutdown sequence and integration with other assets according to the logic	Report and record if any non-conformance, as appropriate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4.10	Maximum demand/load shedding	Annual	Check plant startup/shutdown sequence and integration with other	Report and record if any non-conformance, as appropriate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	



BMS Maintenance Plan for Healthcare

Healthcare Facility Name:			Reference No:			REV- 00A:		
Functional Critical PM – BMS								
			assets according to the logic					
4.11	Load Cycling	Annual	Check operation	Report and record if any non-conformance, as appropriate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.12	Software Interlocks	Annual	Check and verify operation	Report and record if any non-conformance, as appropriate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.13	Manual status review/function	Annual	Check manual overrides and effect on system and effect on system operation	At site level, review parameters, lockouts, changes, all points in manual override, and forced analogue values. Review findings with client	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.14	Outstations	Biannual	Back up all outstation files. Make two copies. Store one onsite and one offsite		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.15	O&Ms	Annual	Advise where control strategy descriptions in operating and maintenance manuals are incorrect. Ensure, where appropriate, additional documentation meets all quality assurance procedures		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.16	Schematics	Annual	Check schematics indicate correctly		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.17	Logbooks	Daily	Maintain a logbook of all changes made to the system	As necessary to the site-specific requirements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Specific Planned Maintenance (PM) Notes								
No.	Reviewer's Comments			Resolution				
Originator's Name / Signature and Date:				Checker's Name / Signature and Date:				