EXPRO
هيئة كفاءة الإنفاق والمشروعات الحكومية
Expenditure Efficiency & Projects Authority

# National Manual of Assets and Facilities Management
# Volume 6, Chapter 6

# BMS Maintenance Plan for Municipal

Document No. EOM-ZM0-PL-000010 Rev 001

**Document Submittal History:**

| Revision: | Date: | Reason For Issue |
|---|---|---|
| 000 | 28/03/2020 | For Use |
| 001 | 18/08/2021 | For Use |

## THIS NOTICE MUST ACCOMPANY EVERY COPY OF THIS DOCUMENT

## IMPORTANT NOTICE

This document, ("Document") is the exclusive property of Government Expenditure & Projects Efficiency Authority.

This Document should be read in its entirety including the terms of this Important Notice. The government entities may disclose this Document or extracts of this Document to their respective consultants and/or contractors, provided that such disclosure includes this Important Notice.

Any use or reliance on this Document, or extracts thereof, by any party, including government entities and their respective consultants and/or contractors, is at that third party's sole risk and responsibility. Government Expenditure and Projects Efficiency Authority, to the maximum extent permitted by law, disclaim all liability (including for losses or damages of whatsoever nature claimed on whatsoever basis including negligence or otherwise) to any third party howsoever arising with respect to or in connection with the use of this Document including any liability caused by negligent acts or omissions.

This Document and its contents are valid only for the conditions reported in it and as of the date of this Document.

## Table of Contents

## 1.0 PURPOSE

Successful Building Management System (BMS) maintenance planning for municipal buildings relies on 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 each Entity operating municipal facilities with guidance in developing and improving maintenance management plans for its BMS. Furthermore, the document seeks to improve and enhance the Entity's overall understanding of BMS and convey best practice.

## 2.0 SCOPE

Guidance contained herein covers key elements of maintenance planning for BMS within municipal facilities, including, but not limited to: maintenance task management; optimizing BMS system efficiency; quality assurance; equipment efficiency; and health and safety of stakeholders, and the environment.

For the purpose of this document, a "municipal facility" has been defined as a building, portion of a building or space where business activities for organization's are done such as but not limited to:

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

The types of facilities considered within the documents are as follows:

- Buildings that are multi use in local community facilities that may also be open to public use
- Smaller regional government offices (libraries, town hall, community centers)
- Regional facility buildings under the control of local government (excluding Civil Defense & Saudi Arabian National Guard (SANG) buildings))
- Larger Office Buildings
- Mosque Prayer facilities

## 3.0 DEFINITIONS

| Term | Definition |
|---|---|
| BACnet | Building Automation and Control networks |
| Basis of Design | A mandatory generated pre-construction document based on ASHRAE, LEED, and NFPA to prepare MEP systems 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 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 |

| Term | Definition |
|---|---|
| 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' |
| Permit to Work | A safety management documented system adopted by most organizations for management of work activities |
| 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 | 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 |
| Quality Assurance | Method by which to assess that quality standards are being met |
| Regime | The collective noun for Maintenance Plan applied to an asset, system, facility, or building |
| Run to Failure | A maintenance strategy where the asset is deliberately not maintained but allowed to run until it fails |
| 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. |
| Sequence of Operation | A written explanation and description on the MEP systems how the systems are intended to work |
| **Abbreviations** | |
| ASHRAE | American Society of Heating, Refrigerating, and Air-Conditioning Engineers |
| BMS | Building Management System |
| BOD | Basis of Design |
| BOM | Bill of Materials |
| CIBSE | Chartered Institution of Building Services Engineers |
| CMMS | Computerized Maintenance Management System |
| CPU | Central Processing Unit |
| ECV | Exhaust Control Volume |
| 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 |

| Term | Definition |
|---|---|
| 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 |
| P&ID | Process and Instrumentation Diagram |
| PM | Planned Maintenance |
| POWRA | Point of Work Risk Assessment |
| PPE | Personal Protective Equipment |
| PTW | Permit to Work |
| QA | Quality Assurance |
| QC | Quality Control |
| RAMS | Risk Assessment and Method Statement |
| RTF | Run to Failure |
| SC | Statutory Compliance |
| SOO | Sequence of Operation |
| UPS | Uninterruptible Power Supply |
| VAV | Variable Air Volume |
| VCV | Volume Controlled Ventilation |
| VDU | Visual Display Unit |

**Table 1**

## 4.0 REFERENCES

- SFG 20 – Standard Maintenance Specification for Building Services
- Chartered Institution of Building Services Engineers (CIBSE Guide H) - Building Automation System
- American Society of Refrigeration and Air Conditioning (ASHRAE 13) – Specifying Building Automation Systems
- EPM-KEO-GL-000009 - BMS and Mechanical system integration guideline
- EPM-KE0-GL-000007 - Extra Low Voltage (ELV) systems integration guideline
- EOM-ZW0-GL-000002 - Maintenance Procedure Writers Guide
- EPM-KT0-TP-000051 - Graphics Testing Template
- 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
- 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. Key personnel are described in the below table. Figure 1 describes the process which maps these responsibilities to the action of planning and implementing Planned Maintenance.

| Designation | Responsibilities |
|---|---|
| Authorized Person – LV/ELV | 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 |
| Authorizing Engineer – Low Voltage | A Chartered Engineer (CEng) or Incorporated Electrical Engineer (IEng) with appropriate experience and possessing the necessary authority to implement, administer, and monitor safety arrangements for LV electrical supply and distribution systems. This individual ensures safety compliance, assesses, and appoints candidates in writing, to be Authorized Persons. |
| BMS Operator | An authorized individual who operates BMS/EMCS. |
| 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 LV systems |
| Designated Person – Electrical | An individual who has overall authority and responsibility for the premises containing the electrical supply and distribution system 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 |
| BMS Maintenance Supervisor | A person of the engineering staff, BMS manufacturer, or Operations and Maintenance (O&M) organization, employed by management to carry out duties on BMS and can assign duties to BMS and instrumentation technician's |

**Table 2**

| BMS Network Integration Structure | | |
|---|---|---|
| **Levels** | **Operator** | **Function** |
| 'BMS managers' level | Facilities manager system administrator | Reporting energy 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 |
| | Specialist engineer | Parameter adjustment reprogramming Fault-finding |
| Zone level local control | Occupants | Set point adjustments |

**Table 3 - BMS Network Integration Structure**

## Example of process flow to plan and implement PM

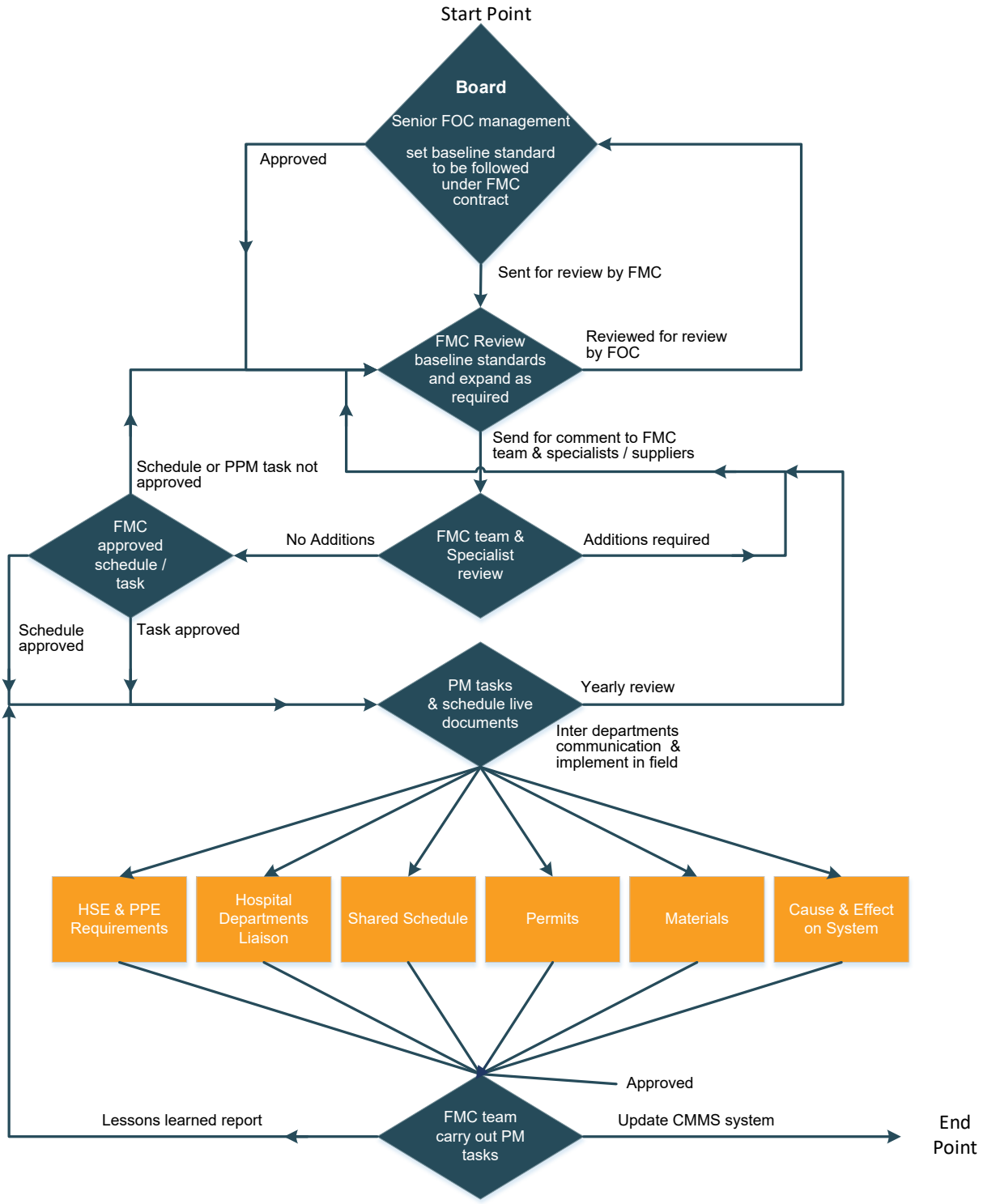


**Figure 1: Roles & Responsibilities for PM Scheduling and Implementation**

# 6.0 PROCESS

## 6.1 BMS Introduction

A BMS is a computer based approach to measuring, monitoring, and managing 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 buildings 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. BMS monitors how much energy is being used and can also contribute in reducing energy consumption by turning down or turning off equipment according to usage.

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

In summary, BMS provides tangible savings in both energy conservation and maintenance. More importantly, the technology gives the building owner better control over the building and can save labor and energy costs through remote diagnostic and troubleshooting.
**The key point in BMS is that it will only function according to the system configuration.**

Figure 2 shows advantages of a BMS system.

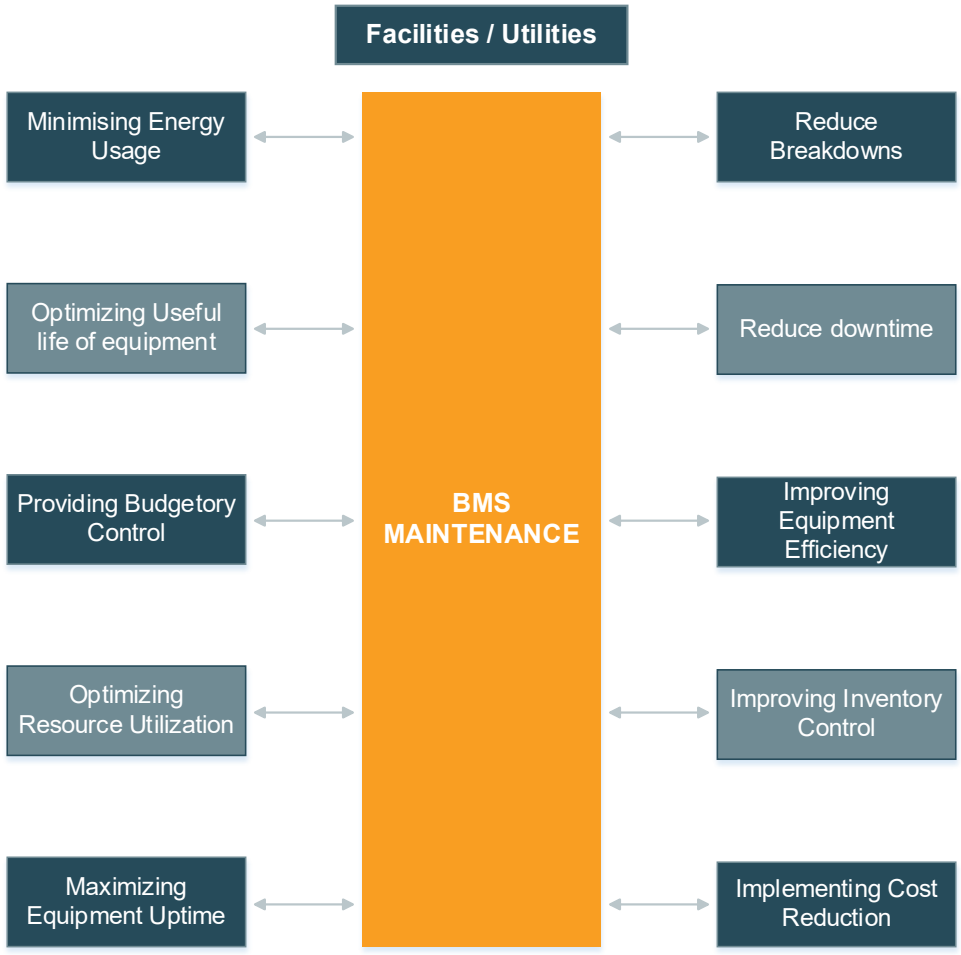


**Figure 2: Advantages of a BMS System**

## 6.2 BMS Maintenance Strategy

Maintenance is a combination of all technical, administrative, and managerial actions during the life cycle of an item, intended to retain it in or restore it into a state 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 to a state where equipment or asset can perform a function. It is essential to keep and preserve equipment and facility in a functional state.

Below figure shows the various type of maintenance activities involved to operate and maintain a reliable BMS system.

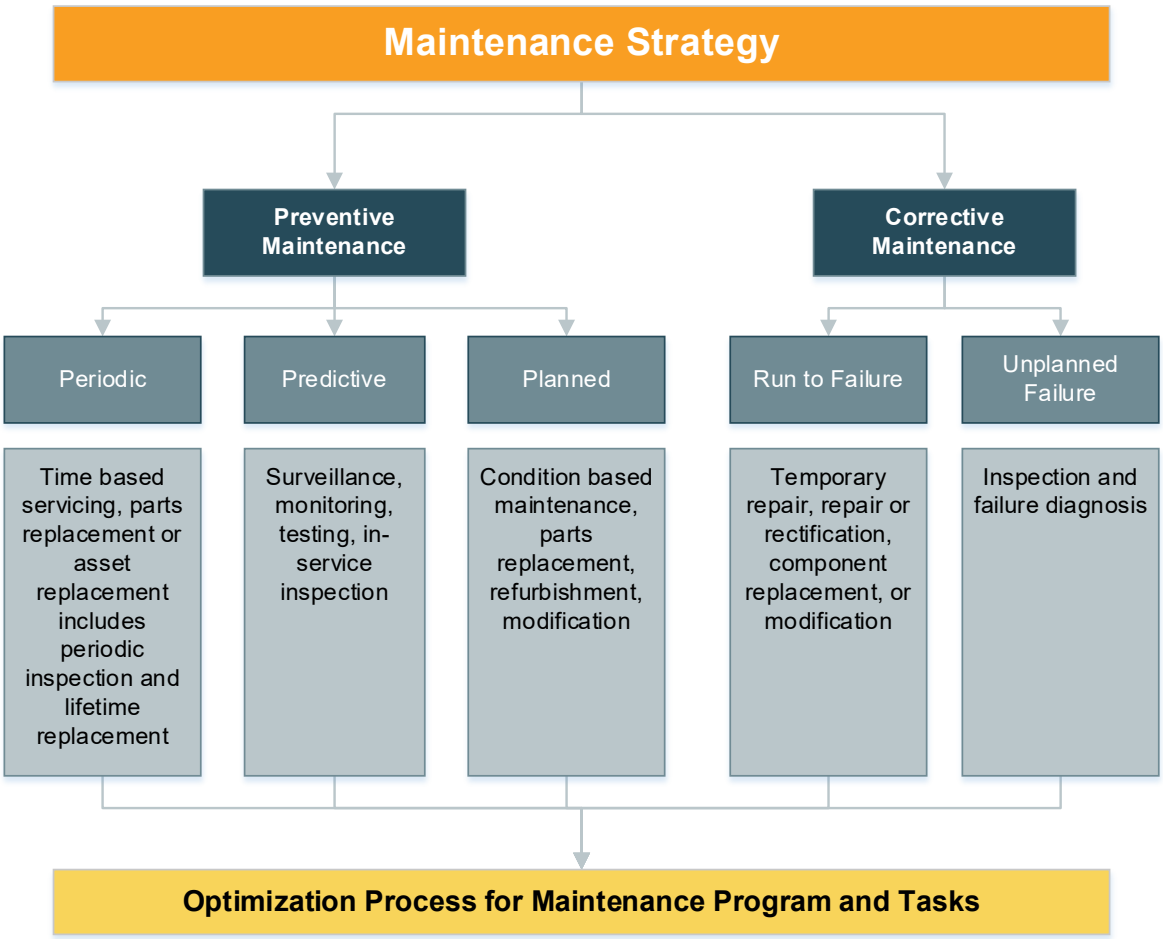


**Figure 3: Relationship of Maintenance Concepts and Activities**

## 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).

This document focuses primarily on Planned Maintenance.

### 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 its failing and to maintain equipment's safe running conditions and efficiencies. Planned Maintenance is performed before equipment failure takes place, and to eliminate unexpected breakdowns.

Key elements and advantages while scheduling and executing Planned Maintenance are:

- The care and servicing by personnel for the purpose of maintaining equipment and facilities in satisfactory operating condition by providing for 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
- To eliminate or mitigate the consequences of failure of equipment
- Planned maintenance and condition-based maintenance help to prevents failure
- Preserve and restore equipment reliability by replacing worn components before they actually fail
- Planned maintenance tasks include partial or complete changes, upgrades or partial major components replacement, minor or major adjustments, and so on

#### 6.3.1.1 Statutory Requirements

BMS system maintenance shall be performed on assets which require regular maintenance/inspections at set intervals as specified by Original Equipment Manufacturer's (OEM's) recommendations, and Statutory Compliance (SC) requirements. The BMS monitors and controls a wide range of systems such as: Heating Ventilation Air Conditioning (HVAC), Fire Alarm System (FAS), Fire Suppression System, customized alarms and surveillance systems, and lift management systems. It is advised that these integrated systems are inspected and maintained according to the National Fire Protection Association (NFPA), and Chartered Institute of Building Services and Engineers (CIBSE) standards.

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

## 6.4 Maintenance Planning & Scheduling

Planning decides what, how, and time estimate for maintenance tasks. Schedules decides when and who will perform the maintenance tasks. Proper planning is vital part in successfully managing the maintenance of equipment. Planners must collaborate with internal or external stakeholders to achieve optimum results. A comprehensive maintenance schedule shall be developed and equipment or assets should be listed in the maintenance schedule. When putting BMS maintenance schedule together, all maintenance activities, along with other department's recommendations, personal experiences, equipment history, and OEM recommendations shall be considered. Moreover, schedule shall define clearly the types of maintenance activities, like corrective maintenance, planned maintenance 'run to fail' 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 comprehend the full impact of maintenance on municipal facility services.

Below elements shall be taken into consideration when planning and scheduling the BMS maintenance tasks.

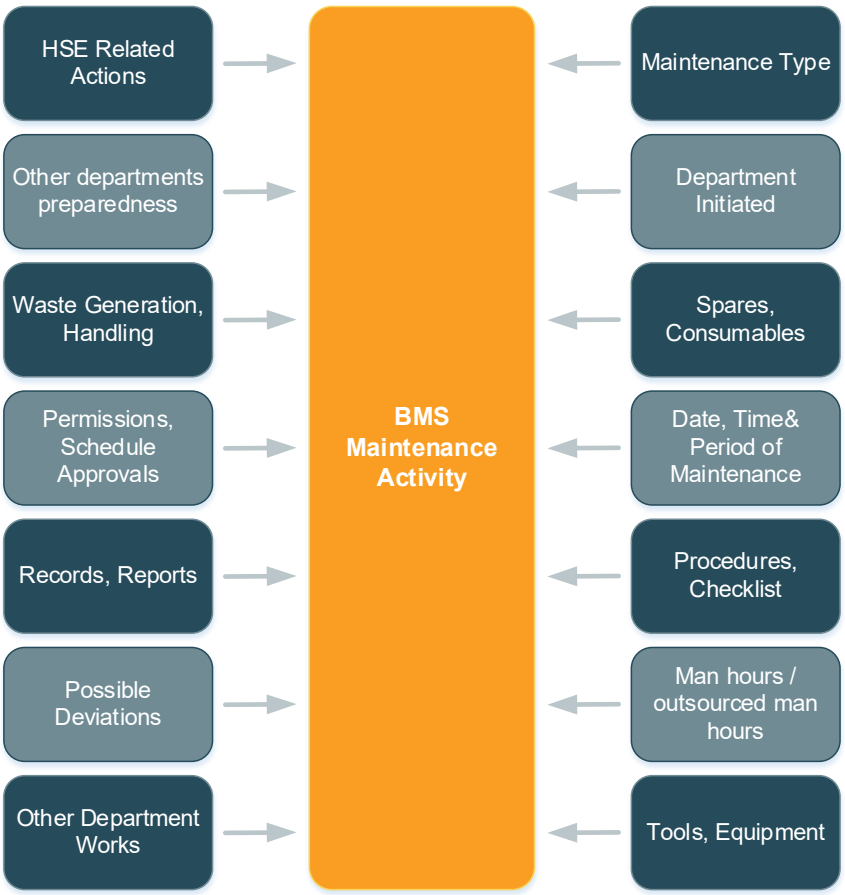


**Figure 4: Pictorial Representation of Links of Maintenance Activity**

*The Entity should consider the specific requirements detailed in volume 7 Work Control, chapter 2 of Asset Management of National Manual of Assets and Facilities Management while requesting, prioritizing, scheduling and planning maintenance tasks.*

## 6.5 CMMS Requirements

Each entity shall employ a Computerized Maintenance Management System (CMMS) or other Expro-approved centralized system to capture maintenance plans and outcomes. The CMMS shall feature ability to set threshold values against system parameters and execute trend analysis. 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.

BMS maintenance plans captured within CMMS should also:

- Refer to an industry resource and feature site-specific guidelines to support maintenance activities
- Recommend the storage method for recorded values (‘data 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 should consider the specific requirements detailed in volume 2 Asset Management of National Manual of Assets and Facilities 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 to the BMS system are non-routine maintenance tasks, and those which involve exceptional working conditions such as confined spaces.

Regardless of the maintenance activity being undertaken, human error is a factor of maintenance activities which is most likely to lead to near misses, accidents, and system malfunction. Given that the BMS governs HVAC and lighting systems within a high number of municipal facilities within KSA, 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 should be assigned the highest priority level to prevent discomfort to building users, 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 to reduce risk to people, the system, and the environment.

*The Entity should consider the specific requirements detailed in volume 10 Health, Safety, Security & Environment (HSSE) of National Manual of Assets and Facilities Management 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 every system within the municipal facility. For task-specific activities, a Job Hazard Analysis (JHA) shall be conducted, using the content of RAMS as a basis for the JHA. Visitors, contractors, and others working under site specific Health and Safety plans shall all be included within all RAMS and shall sign onto JHA as required.

The 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, and 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 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 volume 12, Risk Management of National Manual of Assets and Facilities Management for carrying risk assessment.*

## 6.8 Quality Control and Quality Assurance

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

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

- 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.

*The Entity should consider the specific requirements detailed in volume 11, Quality, of National Manual of Assets and Facilities Management for carrying risk assessment.*

## 6.9 Spare 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 inform:

- Maintenance strategy
- 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 (RCA) of the components failure. Wherever possible parts shall be performed in good time for maintenance activities to be undertaken. Facilities managers should also review Critical Spares stock holdings and review maintenance checks on these spares and components.

*The Entity should consider the specific requirements detailed in Volume 4 (Financial Planning) of National Manual of Assets and Facilities Management 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 (i.e. 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 on 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 Maintenance Supervisor.

In the absence of OEM recommendations, the periodic maintenance schedule shall cover: weekly, monthly, quarterly, biannual, or annual maintenance as a minimum. Maintenance activities shall be applied against system boundaries, which are based on: asset tagging, asset hierarchy, and direction from the Maintenance Supervisor.

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) within each municipal facility:

- 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 shall be free from dust and debris
- Controllers network communication
- Measuring sensors and transmitters data using handheld measuring devices and compare 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. *Please 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. *Please 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 Planned Maintenance sheets for references and use

### 6.10.2 Pre-requisites of BMS 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

- Risk Assessment and 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 back to method statement for the completion of maintenance tasks
  - A person performing maintenance activity shall be deemed competent to carry put 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

- Drawings/Schematics
  - 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

- Municipal 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. 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
    - Others site-specific

### 6.10.3 BMS and Integrated System Testing

As a minimum, the following BMS maintenance fundamentals shall be included when developing task sheets and maintenance schedules for each BMS:

- Control strategy or application software functionality shall be checked
- BMS functionality check and integrated Mechanical, Electrical, and Plumbing (MEP) systems for parameters monitoring and control in accordance to the 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
- 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 $V_{DC}$
  - 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
- Start-up/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 valves, dampers etc. shall be checked
- Field wiring connections, interlock connections, and hard wore connection shall be checked
- 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

- 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, Graphical 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
    - Exhaust Control Volume (ECV)/Volume Controlled Ventilation (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 presented in the form of a checklist. The Entity shall use the format presented within Attachment 1 to prepare its own site-specific BMS Planned Maintenance Schedule. While preparing its own BMS Planned Maintenance Schedule, the Entity shall ensure that aforementioned requirements are reflected as applicable, and that site-specific considerations are included.

## 7.0 ATTACHMENTS

1. Attachment 1 – EOM-ZM0-TP-000059 – BMS Planned Maintenance Schedule

## Attachment 1 – EOM-ZM0-TP-000059 – BMS Planned Maintenance Schedule

| Building name: | | Reference No. | | Rev-00A | | |
|---|---|---|---|---|---|---|
| **Functional Critical Planned Maintenance BMS System** | | | | | | |
| **Sr. No.** | **Item** | **FQ** | **Action** | **Notes** | **CHECKED SATISFACTORY** | |
| | | | | | **N/A** | **Yes** | **No** |
| **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 | ☐ | ☐ | ☐ |
| 1.2 | Clock and Calendar | Biannual | Check real-time clock and date settings | | ☐ | ☐ | ☐ |
| 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 | ☐ | ☐ | ☐ |
| 1.4 | Filters | Biannual | Check condition, clean and lubricate if necessary | | ☐ | ☐ | ☐ |
| 1.5 | Software Archives | Biannual | • take back up copy of site-specific data files<br>• 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 the back-up data is stored in a fireproof safe or off-site | ☐ | ☐ | ☐ |
| 1.6 | Cables and Connectors | Annual | Check security, integrity and for physical damage | | ☐ | ☐ | ☐ |
| 1.7 | Discs and Drives | Annual | Clean according to the manufacturer's instructions | | ☐ | ☐ | ☐ |
| 1.8 | Clock Battery | Annual | Check and replace, if necessary | Battery disposal should be in accordance with regulation and environmental requirements | ☐ | ☐ | ☐ |
| 1.9 | Mouse | Annual | Check for smooth operation and clean ball as necessary | More frequent cleaning can be implemented, if needed | ☐ | ☐ | ☐ |
| 1.10 | Visual Display Unit (VDU)/Monitors | Annual | Check:<br>• Focus<br>• Contrast<br>• Brightness<br>• For correct operation | | ☐ | ☐ | ☐ |
| 1.11 | Keyboard | Annual | Check for correct operation and clean | | ☐ | ☐ | ☐ |
| 1.12 | Cleaning | Annual | Clean with approved cleanser | Treat with anti-static compound. Depending on use and location, more frequent cleaning may be necessary | ☐ | ☐ | ☐ |
| 1.13 | Cables and Connectors | Annual | Check security, integrity, and for physical damage | | ☐ | ☐ | ☐ |

| Building name: | Reference No. | Rev-00A |
|---|---|---|

**Functional Critical Planned Maintenance BMS System**

| Sr. No. | Item | FQ | Action | Notes | CHECKED SATISFACTORY | | |
|---|---|---|---|---|---|---|---|
| | | | | | N/A | Yes | No |
| 1.14 | Cleaning | Annual | Use recommended cleaning agent | Remove paper or tape debris | ☐ | ☐ | ☐ |
| 1.15 | Test Sequence | Annual | Check, adjust and replace if necessary:<br>• Paper feed<br>• Transport system<br>• Printer cartridge | | ☐ | ☐ | ☐ |
| 1.16 | Consumables (Wherever applicable) | Annual | Clean stocks | | ☐ | ☐ | ☐ |
| **2.** | | | | | | | |
| 2.1 | Data Communications | Annual | Check integrity of data flow in both directions | If more than one path exists, all must be verified | ☐ | ☐ | ☐ |
| 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 | ☐ | ☐ | ☐ |
| 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 | ☐ | ☐ | ☐ |
| 2.4 | Connectors | Annual | Check security, integrity, and for damage | | ☐ | ☐ | ☐ |
| 2.5 | Alarms Receiving | Annual | Confirm that all critical alarms are received by the central supervisor. Check spurious alarms and report faults (as incurred) | | ☐ | ☐ | ☐ |
| 2.6 | Alarms Generating | Annual | Check generation of alarms from all input and output devices | | ☐ | ☐ | ☐ |
| 2.7 | Network | Annual | Check communications between central supervisory computer and outstations and other networked devices | | ☐ | ☐ | ☐ |
| **3.** | | | | | | | |
| 3.1 | Outstation Hardware | Annual | Check mechanical and environmental condition | Environmental conditions, e.g. temperature and humidity should be within manufacturer's recommended limits | ☐ | ☐ | ☐ |
| 3.2 | Connectors | Annual | Check security, integrity, and for damage | Includes security of incoming cables, prevention of ingress of moisture, door seals etc. | ☐ | ☐ | ☐ |
| 3.3 | Power Supplies | Annual | Carry out voltage check on all power supplies | Check automatic restart/rebooting of software program | ☐ | ☐ | ☐ |

| Building name: | Reference No. | Rev-00A |
|---|---|---|

**Functional Critical Planned Maintenance BMS System**

| Sr. No. | Item | FQ | Action | Notes | CHECKED SATISFACTORY | | |
|---|---|---|---|---|---|---|---|
| | | | | | N/A | Yes | No |
| 3.4 | Stand-by batteries/Uninterruptible Power Supplies (UPS) | Annual | Check against manufacturer's specification. Replace as necessary | | ☐ | ☐ | ☐ |
| 3.5 | Digital Inputs | Annual | Check by activating sensing/control devices in field | Care shall be taken to isolate local operation | ☐ | ☐ | ☐ |
| 3.6 | Digital Outputs | Annual | Check operation of output stopping by operating routine (where appropriate). Check switching by software interlocks. | | ☐ | ☐ | ☐ |
| 3.7 | Analogue Inputs | Annual | Read and check calibration of analogue inputs | | ☐ | ☐ | ☐ |
| 3.8 | Analogue Outputs | Annual | Check for accuracy of output signal | | ☐ | ☐ | ☐ |
| 3.9 | Manual Override (Physical) | Annual | Check status | Review, Record, and Report | ☐ | ☐ | ☐ |
| 3.10 | Installed Program | Annual | Check integrity, alarms, interlocks, optimization | | ☐ | ☐ | ☐ |
| **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 | ☐ | ☐ | ☐ |
| 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 | ☐ | ☐ | ☐ |
| 4.3 | Time Clock | Annual | Check real time clock and date for accuracy throughout system | | ☐ | ☐ | ☐ |
| 4.4 | Time Switching | Annual | Review current operating parameters according to site needs | e.g. Time settings and schedules | ☐ | ☐ | ☐ |

| Building name: | Reference No. | Rev-00A |
|---|---|---|

**Functional Critical Planned Maintenance BMS System**

| Sr. No. | Item | FQ | Action | Notes | CHECKED SATISFACTORY | | |
|---|---|---|---|---|---|---|---|
| | | | | | N/A | Yes | No |
| 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 | ☐ | ☐ | ☐ |
| 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 | ☐ | ☐ | ☐ |
| 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 | ☐ | ☐ | ☐ |
| 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 | ☐ | ☐ | ☐ |
| 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 | ☐ | ☐ | ☐ |
| 4.10 | Maximum demand/load shedding | Annual | Check plant startup/shutdown sequence and integration with other assets according to the logic | Report and record if any non-conformance, as appropriate | ☐ | ☐ | ☐ |
| 4.11 | Load Cycling | Annual | Check operation | Report and record if any non-conformance, as appropriate | ☐ | ☐ | ☐ |
| 4.12 | Software Interlocks | Annual | Check and verify operation | Report and record if any non-conformance, as appropriate | ☐ | ☐ | ☐ |
| 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 | ☐ | ☐ | ☐ |
| 4.14 | Outstations | Biannual | Back up all outstation files. Make two copies. Store one onsite and one offsite | | ☐ | ☐ | ☐ |
| 4.15 | O&M | Annual | Advise where control strategy descriptions in operating and maintenance manuals | | ☐ | ☐ | ☐ |

| Building name: | Reference No. | Rev-00A |
|---|---|---|

**Functional Critical Planned Maintenance BMS System**

| Sr. No. | Item | FQ | Action | Notes | CHECKED SATISFACTORY | | |
|---|---|---|---|---|---|---|---|
| | | | | | N/A | Yes | No |
| | | | are incorrect. Ensure, where appropriate, additional documentation meets all quality assurance procedures | | | | |
| 4.16 | Schematics | Annual | Check schematics indicate correctly | | ☐ | ☐ | ☐ |
| 4.17 | Logbooks | Daily | Maintain a logbook of all changes made to the system | As necessary to the site-specific requirements | ☐ | ☐ | ☐ |
| **13.0** | **Specific Planned Maintenance Notes** | | | | ☐ | ☐ | ☐ |
| | | | | | | | |



| No. | Reviewer's Comments | Resolution |
|---|---|---|
| | | |
| | | |
| | Originator's Name/Signature and Date: | Checker's Name/Signature and Date: |