EXPRO
هيئة كفاءة الإنفاق والمشروعات الحكومية
Expenditure Efficiency & Projects Authority

National Manual of Assets and Facilities Management
Volume 6, Chapter 7

Instrumentation Systems Maintenance Plan for Offices

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1.0 PURPOSE

The purpose of this document is to provide guidelines and practices to the Entity or Facilities Management Company (FMC) for developing and improving instrumentation and control systems maintenance management plans in the offices sector. It is essential to operate and manage the instrumentation and associated equipment for buildings within the Entity as per the guidance conveyed herein to achieve efficient and effective facility operations.

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

The standards and guidelines incorporated into this document will support the Entity and those responsible for the maintenance of the instrumentation field devices and interface controllers. They shall be applicable to all maintenance strategies following best industry standards, compliant with the Nation codes, and legislation of Kingdom of Saudi Arabia (KSA). For the purpose of this document, Section 4 can be referenced for legislation and current best practice, which is relevant to:

- Designers
- Manufacturers
- Installers
- Maintainers
- Building owners
- Stakeholders
- Operators
- Professional advisors
- Specialist providers

2.0 SCOPE

The scope of this document is to guide those responsible for ensuring that maintenance is carried out in a consistent and reliable manner by focusing on planned activities and the reduction of costly and disruptive reactive maintenance. The Entity, FMC, and/or the specialist service providers shall take steps to enhance the current practice of developing a maintenance plan for efficient building operations. A Planned Maintenance (PM) strategy is an ultimate goal to improve and optimize an engineering system and further reduce the risk of component failures.

A well-written maintenance plan shall provide the Entity with a high level of confidence to safely and execute maintenance and repairs in the applicable environments effectively. The objective of this document is to direct maintenance from a standard minimum acceptable quality to a required consistent improved high-level quality, through professional technical advice and instruction.

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

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

3.0 DEFINITIONS

Term	Definition
Basis of Design (BOD)	An Architect/Engineer generated mandatory pre-construction document by American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), Leadership in Energy and Environmental Design (LEED), and National Fire Protection Association (NFPA) which is the basis of preparation for the Systems Manual, Commissioning Plan, and Construction Documents. The BOD covers the operation in more detailed, specific, and technical terms
Best Practice	A method or technique that has consistently given reliable and repeatable results, which are superior to the standard way of achieving those same results
Calibrated Tools	Measurement tools that have a calibration requirement, either as a statutory or risk assessed requirement
Consumable	The 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; for further information refer to Volume 2: Asset Management
Frequency (FQ)	Refers to a cyclic time period
Permit to Work (PTW)	A safety management documented system adopted by most organizations for management of work activities
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
Schedule	Refers to a time based delivery of action
Sequence of Operation (SOO)	A written explanation and description on the Mechanical, Electrical, and Plumbing (MEP) systems, and the manner in which the systems are intended to work
Test	The process of verification by means of observation or measurement that the system meets the expected and/or acceptable requirements
Threshold	The numerical value of a parameter at which a decision is made
Tool	A manual or powered device used to repair a system or part. It can include electrical testing meters
Abbreviations	
AE	Authorizing Engineer
AP	Authorized Person
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BMS	Building Management System
BOM	Bill of Material
CAFM	Computer Aided Facility Management
CIBSE	Chartered Institution of Building Services Engineers
CM	Corrective Maintenance
CMMS	Computerized Maintenance Management System
CP	Competent Person
DDC	Direct Digital Controller
EC	Energy Conservations
FAS	Fire Alarm System

Term	Definition
FM	Facilities Manager
FMC	Facilities Management Company
FOC	Facility Operating Company
HSE	Health and Safety Executive
HSSE	Health, Safety, Security, and Environment
HTM	Health Technical Memorandum
HVAC	Heating, Ventilation, and Air Conditioning
JHA	Job Hazard Analysis
KSA	Kingdom of Saudi Arabia
MEP	Mechanical, Electrical, and Plumbing
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NMA & FM	National Manual of Assets and Facilities Management
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
PC	Personal Computer
PDM	Predictive Maintenance
PMT	Post Maintenance Test
PPE	Personal Protective Equipment
PM	Planned Maintenance
QA	Quality Assurance
QC	Quality Control
QMS	Quality Management System
RAMS	Risk Assessment and Method Statement
SAP	Systems Applications and Products
SC	Statutory Compliance
SCE	Saudi Council of Engineers
SOP	Standard Operating Procedure
SWP	Safe Work Procedures
UM	Unplanned Maintenance
WO	Work Order

Table 1: Definitions

4.0 REFERENCES

- American National Standards Institute/American Society of Heating, Refrigeration and Air Conditioning (ASHRAE 135) – Building Automation and Control Systems
- Chartered Institute of Building Services and Engineers (CIBSE) Guide M – Maintenance Engineering and Management Standards
- International Organization of Standardization (ISO 9001) – Quality Management System
- Kingdom of Saudi Arabia's (KSA) National Codes and Legislation
- National Manual of Assets and Facilities Management, Volume 2 – Asset Management
- National Manual of Assets and Facilities Management, Volume 4 – Obsolescence Management
- National Manual of Assets and Facilities Management, Volume 5 – Seasonal Planning
- National Manual of Assets and Facilities Management, Volume 6 – Post Maintenance Test Procedure
- National Manual of Assets and Facilities Management, Volume 6 – Planned Maintenance Program Procedure
- National Manual of Assets and Facilities Management, Volume 6 – Maintenance Plan Writers Guide

- National Manual of Assets and Facilities Management, Volume 7 – Maintenance Procedure Writers Guide
- National Manual of Assets and Facilities Management, Volume 7 – Requesting, Prioritizing, Scheduling and Planning Work
- National Manual of Assets and Facilities Management, Volume 8 – Supply Chain Management
- National Manual of Assets and Facilities Management, Volume 10 – Health, Safety, Security and Environment (HSSE)
- National Manual of Assets and Facilities Management, Volume 11 – Quality Control
- National Manual of Assets and Facilities Management, Volume 12 – Risk Management
- National Fire Protection Association (NFPA 90A) – Standard for Installation of Air Conditioning and Ventilation Systems
- Occupational Safety and Health Administration (OSHA) – Occupational Safety and Health
- Standard Maintenance Specification for Building Services (SFG 20)

5.0 RESPONSIBILITIES

Only trained and competent personnel should be appointed by management to perform maintenance tasks on the instrumentation and controller systems.

Role	Description
Authorized Person (AP)	An individual appointed by the Authorizing Engineer (AE) (or by an authorizing body within the Entity); who is trained, competent, skilled, experienced, responsible, and has gained necessary site knowledge to operate and maintain the system in a controlled and safe manner. The AP is responsible for work or testing carried out on the system
Competent Person (CP)	An individual with the necessary training, and who has been appointed by an Authorized Person (AP) (or by an authorizing body within The Entity) after conformation of competence, knowledge, skill, and experience. CP can execute the required actions within a Permit to Work (PTW) and/or other directional documents as may be assigned to him
Facilities Management Company (FMC)	An appointed client representative, who in collaboration with the client, controls the maintenance engineering departments. FMC is responsible and accountable for the APs and CPs, as well as the site engineering systems, their maintenance, and ensuring that control of these systems is in line with the client Standard Operating Procedure (SOP) for the maintenance activities
Facilities Operating Client (FOC)	A governing body representing the Entity who sets the baseline standards to be followed by the FMC. The client to the Facilities Management Company who agrees on the scope of work under the maintenance strategies
The Authorizing Engineer (AE) – (MEP) all disciplines	An engineer such as approved by the Saudi Council of Engineers (SCE) with appropriate experience and possessing the necessary authority to implement, administer, and monitor safety arrangements for Mechanical, Electrical, and Plumbing (MEP) systems. This individual ensures safety compliance, assesses, and appoints candidates in writing, to be Authorized Persons
The Responsible Person (Director of Facilities)	An individual who is employed directly by the Entity and is the “Duty Holder” of engineering systems and the staff who operate those systems. The Responsible Person is overall responsible and accountable for system design, installation, operation, and maintenance; and has a legal responsibility to ensure that the Entity has complied with relevant legal regulations pertaining to engineering systems

Table 2: Roles and Responsibilities

Proper training and certifications of the Competent Persons (CP) responsible for the maintenance should be verified, and routine audits be completed to ensure that the training is current and identify refresher or continuation training requirements.

5.1 Levels of Operations

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

Instrumentation Network Integration Structure		
Levels	**Operator**	**Function**
Instrumentation 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
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: Network Integration Structure

5.2 Roles and Responsibilities: Planned Maintenance (PM)

Following diagram is an example of the process flow chart, which maps the responsibilities for planning and implementing a PM regime within an Entity:

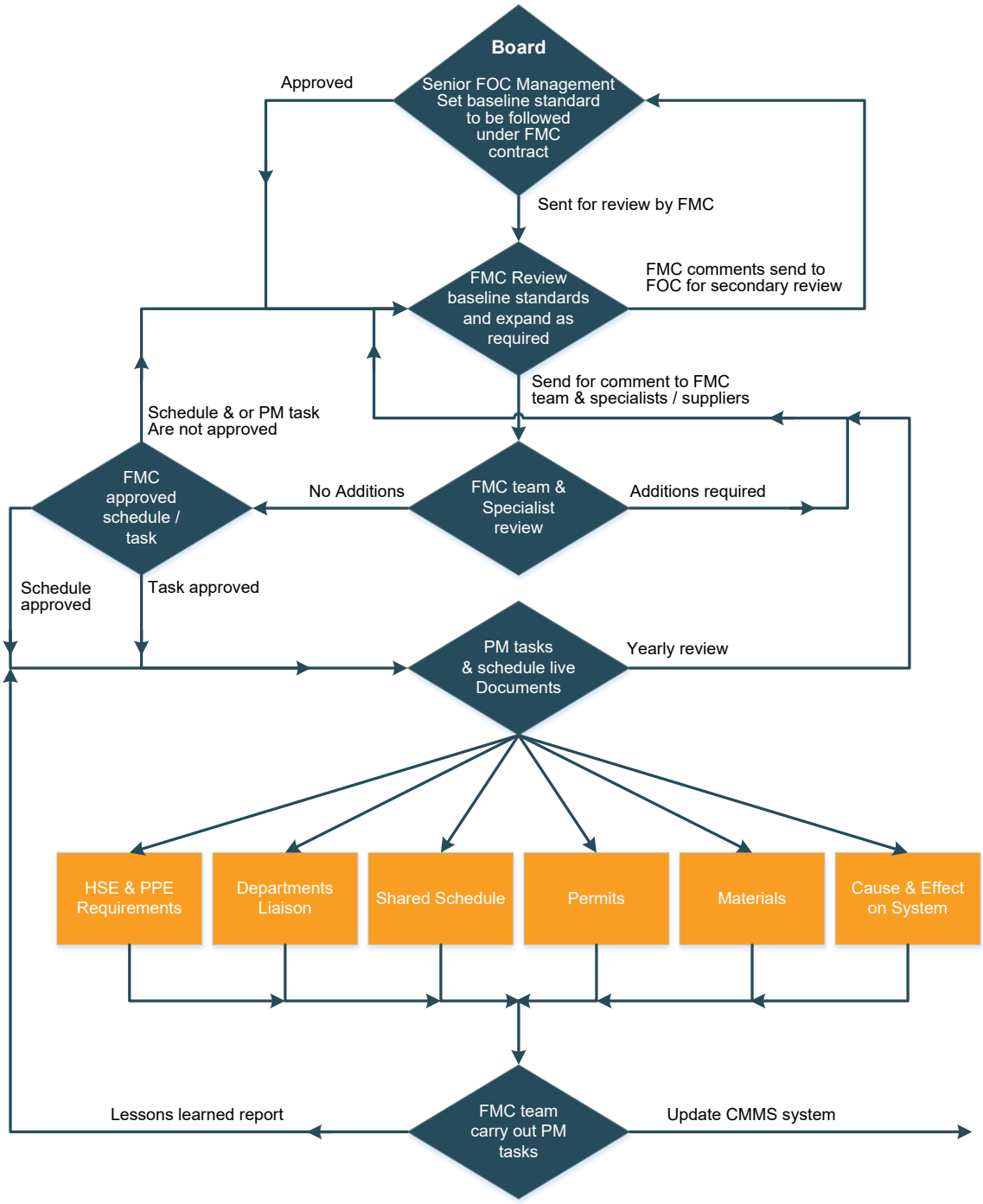

Figure 1: Roles and Responsibilities for PM Scheduling and Implementation

6.0 PROCESS

6.1 Introduction to Instrumentation Maintenance

Instrumentation field devices form an engineering system, which controls parameters such as flow, pressure, and temperature of a building; and are critical to its effective and efficient operation. Field devices also play a crucial role in the safety and security of the building. Instrumentation field devices measure, monitor, and control MEP systems within the facility including, but not limited to Heating, Ventilation and Air Conditioning (HVAC), lighting, security, elevators and escalators, water pumping, water treatment, and water quality.

A thorough review of assets within each facility is required to understand which equipment comprises MEP services. Once this information is attained and an assessment of buildings and infrastructure is complete, a better understanding of what will be needed in terms of maintenance of the asset is possible. Maintenance plans for MEP systems should be developed mindful of:

- The reality that each building is unique; and manufacturers and suppliers may vary from building to building
- Existing guidelines and practices
- Original Equipment Manufacturers (OEM) recommendations for maintenance, testing and adjustments
- A one-size-fits-all approach for maintenance across all Entity-owned facilities will achieve the desired level of performance due to several factors such as:
    - Varying system specifications
    - Historical maintenance regimes
    - Variance in facility operations

Instrument service management is a critical component when maintaining an engineering system. Proper management starts with the correct installation of the equipment and user training, which is followed by routine planned maintenance. Routine instrument maintenance will increase the longevity of the instrumentation; reduce downtime and waste, and lower costs in an operation. Contracting a reputable service provider is as important as the quality of equipment. Quality maintenance support of equipment throughout the product lifecycle is a key component to the success and longevity of an instrumentation system, as they control the degrees of an entire engineering system, irrespective of the MEP systems.

Following are the examples of instrumentation systems typically found within offices facilities:

- HVAC systems controls
- Lighting and electrical controls including security and Closed Caption Television (CCTV)
- Plumbing systems control
- Fire protection systems and life safety systems control
- Generators/Fuel/Secondary back-up systems controls
- Specialized equipment used in kitchens, labs, cafeterias, and specialized workshops (e.g., automotive, welding, carpentry, instrumentation, robotics, machine shops)
- Water treatment systems monitoring, testing and control including swimming pools

The instrumentation tools are linked through controllers, which are interfaced through a Building Management System (BMS). Facility Managers (FM) can access information and data through user interfaces, which include Personal Computers (PCs), laptops, and/or handheld devices. This important information on building performance helps the maintenance teams determine critical maintenance and focus on PPM in a building. A maintenance management plan is only effective if it is strictly followed and tracked by all personnel involved.

Additional systems may also be installed within a facility and should be captured as part of the Asset Management System (AMS). Maintenance of these systems should be included within the PPM

schedule and activities following instructions within the Original Equipment Manufacturer (OEM) documentation.

For further information on the types of equipment, sensors, and controls, refer to National Manual of Assets and Facilities Management, Volume 5: Operations Procedures – Offices

6.2 Instrumentation Maintenance Strategy

Maintenance is a combination of managerial, technical, and administrative actions during the life cycle of an asset, intended to retain or restore it to a state where it can perform the required function. Instrumentation and controller maintenance shall cover tests, measurements, replacements, adjustments, and repairs. A maintenance plan shall include the following stakeholders to ensure that all responsibilities are being fulfilled:

- Asset management team
- Facilities management team
- Store/Procurement personnel
- Computerized Maintenance Management System (CMMS) program
- Qualified and competent maintenance teams

As stated, a maintenance plan may not always be necessary, however, to ensure consistent Quality Assurance (QA)/Quality Control (QC), proper records and documentation certify that the Entity operates on practices that can be tracked through a documented process. A maintenance plan is a document which will address what systems or assets need to be maintained based on the work required. The plan will include, but not be limited to:

- Work with clear descriptions
- Job plans, including a sequence of events, and checks and balances
- Maintenance procedures, including Safe Work Procedures (SWP) and Job Hazard Analysis (JHA)
- Procured parts and consumables for the task
- Required tools and any specialty tools to complete the work required

The maintenance plan should:

- Identify the work to be undertaken
- Identify stakeholders that need to be informed, and obtain permissions from
- Plan the work efficiently to minimize operations
- Schedule the work to be done involving all necessary tools, manpower resources for a successful execution
- Execute the work activity to be undertaken in a safe environment
- Record the work that was done; tracking maintenance ensures history and consistency
- Conduct failure analysis to prevent problems from reoccurring

Figure 2 describes how key personnel work with an engineering system within the Entity that can be suitably organized in order to enable safe O&M of that Entity.

Figure 2: Maintenance Team Example

6.3 Types of Maintenance

Instrumentation devices are found in all the engineering disciplines of a building. The field instruments would need applicable maintenance based on the OEM specifications, recommendations and guidelines. The maintenance types are described in more detail within the following sections, but the focus of this program is to work towards developing a proven maintenance strategy that is based on collecting data and planning ahead. A PM program is a proven strategy to reduce costs and be effective and efficient at ensuring longevity of any asset. Although Corrective Maintenance (CM) is discussed below, the goal is to work towards a planned strategy.

Depending on the Entity's asset management strategy, organizational maturity, and funding; the following types of maintenance may be applied to an instrumentation system within a 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 (PM)

PM is a regime that is regularly performed on a piece of system's equipment to lessen the likelihood of failure, maintain safe operating/running conditions, and efficiencies. PM is performed while the equipment or asset is still operating to eliminate unexpected breakdowns. Condition monitoring is often used as part of the PM, which allows for real-time trend analysis of instrumentation devices.

Key elements and advantages while scheduling and executing a PM are as follows:

- Ensures consistent practices designed to improve the performance and safety of the equipment

- Reduces major repairs and failures; and ensures equipment availability
- Allows for better management and increased life expectancy of assets
- Allows for efficient manpower resources use of the required specialization, to ensure that activities are carried out in a correct manner
- Reduces costs and ensures efficient utilization of maintenance staff due to working on a scheduled basis instead of a reactive basis
- Improves safety and quality conditions for stakeholders and those coming in contact with maintenance activities

Planned Maintenance Program (PMP) and Post Maintenance Testing (PMT) procedures are provided within National Manual of Assets and Facilities Management (NMA & FM). Whilst all equipment may not be subject to PMT, it is the Entities responsibility to identify equipment or a plant that may need to undergo PMT, for statutory compliance.

For the maintenance of an office building or infrastructure, personnel can refer to the many maintenance checklists and documents for each of the elements of an engineering system. These would be listed in detail in the NMA & FM, Volume 6, and Chapter 6. Instrumentation devices are found in all the MEP disciplines, furthermore a buildings HVAC system also has its own chapters in the NMA & FM.

Refer to the following for specific requirements:

- National Manual of Assets and Facilities Management, Volume 6 – Planned Maintenance Program Procedure
- National Manual of Assets and Facilities Management, Volume 6 – Post Maintenance Testing procedure (PMT)
- National Manual of Assets and Facilities Management, Volume 6 – Maintenance Plan Writers Guide

Utilization of a PM strategy in combination with a CMMS system will assist the Entity in following a proven strategy that can be demonstrated to internal and external stakeholders. The use of QA/QC will further assist in continuous improvement and review processes.

Refer to International Organization of Standardization (ISO 9001) – Quality Management System for more details.
An example of a Quality Management System (QMS) is provided in the figure below:

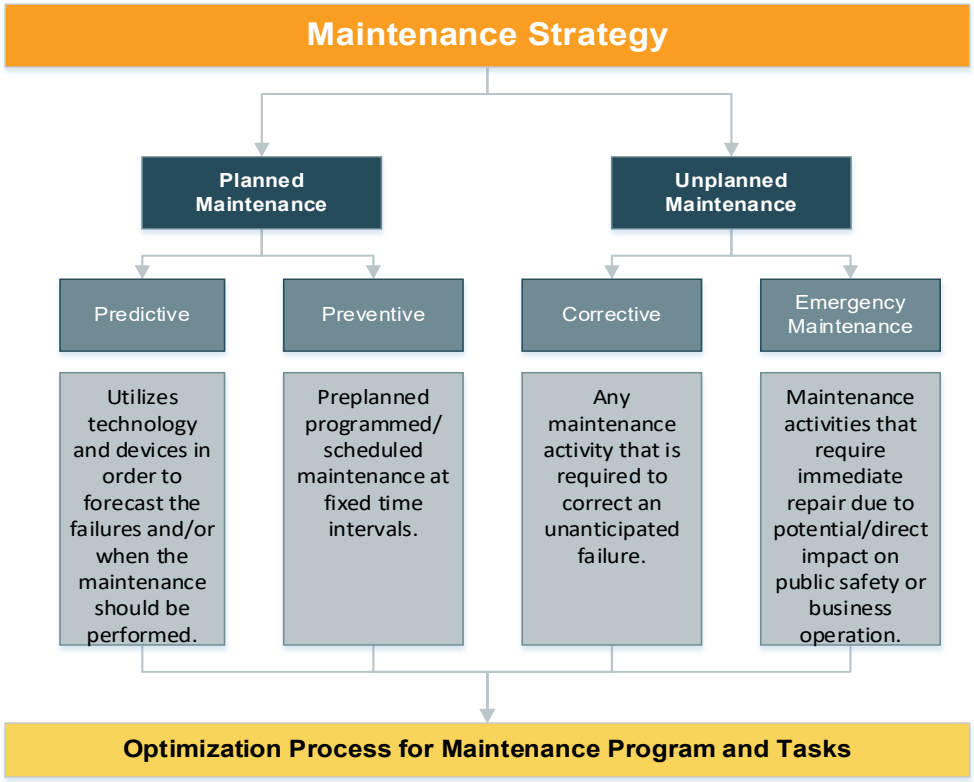

Figure 3: Relationship of Maintenance Concepts and Activities

6.3.1.1 Predictive Maintenance (PdM)

Condition Based Monitoring (CBM) of system's equipment/assets is an effective way of using data to study and predict when a component failure is going to happen. For example, some forms of PdM use oil/fluid sampling to study elements in the fluids used to lubricate certain parts. If there are elevated levels of an element, it could indicate wear on the asset. PdM can also use sensors to determine when certain conditions occur that indicate maintenance is needed to ensure optimal running of the equipment/assets. Vibration monitoring can be used on circulation fans to monitor the health of bearings, identifying any abnormalities. Numerous methodologies for CBM and Reliability Centered Maintenance (RCM) exist and can be used either as an alternative or addition to PdM activities. The following applications or instruments/technologies of predictive maintenance can be exercised to predict the potential failure of components or systems:

- Vibration monitoring and analysis
- Infrared (IR) imaging/thermography
- Oil analysis
- Airborne ultrasonic
- Motor circuit analysis
- Leaser shaft alignment
- Tong tests

6.3.1.2 Preventive Maintenance

Preventive maintenance by definition is a regime of scheduled maintenance performed at fixed time intervals. Some activities typically included in preventive maintenance include but are not limited to:

- Periodic or occasional inspection
- Adjustment
- Lubrication

- Cleaning
- Painting
- Replacement
- Major and minor repairs
-

6.3.2 Unplanned Maintenance (UM)

Unplanned maintenance is any maintenance operation for which a predetermined work cycle is not recorded, or for which all manpower, resources, supplies, and equipment required to perform the task are not estimated, and their availability is guaranteed before the task begins. Corrective and emergency maintenance fall under unplanned maintenance and are described below.

6.3.2.1 Corrective Maintenance (CM)

CM may be due to failed component of plant or equipment that leads to unforeseen downtime causing disruption to the Entity. Additionally, CM may be performed during a planned maintenance schedule, where a failed part or piece of equipment is found to be defective while undertaking a maintenance activity and is also repaired/replaced to restore a system to normal operating condition. It is often a part of unplanned maintenance, however, if found during a PM schedule can be helpful to avoid further downtime during normal operating conditions.

6.3.2.2 Emergency Maintenance

By definition, an emergency maintenance is any maintenance activity that requires immediate repair due to potential/direct impact on public safety or business operation. It is therefore important for the Entity to have an emergency maintenance management system in place to prevent minor emergencies from transforming into major emergencies.

6.3.3 Statutory Compliance (SC) Requirements

It is recommended that instrumentation system maintenance shall be performed on systems/equipment/assets that require regular maintenance/inspections at set intervals as specified by OEM recommendations and SC requirements. Instrumentation systems monitor and control a wide range of office facilities utilities systems. These integrated systems shall be inspected and maintained for monitoring and control of the smooth operations of systems/assets, according to the NFPA, and CIBSE requirements at specified intervals.

For further information regarding statutory requirements, refer to the following:

- Chartered Institute of Building Services and Engineers (CIBSE) Guide M – Maintenance Engineering and Management Standards
- National Fire Protection Association (NFPA)
- National Manual of Assets and Facilities Management, Volume 6 – Planned Maintenance Program Procedure

6.4 Maintenance Planning & Scheduling

Maintenance planners are often utilized for their experience to monitor, plan, and schedule the maintenance of a facility. Skilled maintenance planners use industry best practices to successfully develop comprehensive maintenance schedules. The prescribed schedules will dictate when maintenance tasks are due and the competency level of personnel undertaking the activity. The maintenance plans could include, but not limited to work orders (WO), Permit to work (PTW), Safe Work Procedures (SWP), and check sheets for QA/QC.

Further guidance is provided below:

- Planners must communicate and work with the affected stakeholders to complete the type of maintenance required to keep the facility operating efficiently

- Records need to be kept of the maintenance undertaken to ensure the following:
  - Accountability
  - Cost controls
- Monitor spare parts (including pre order to ensure availability)
- Ensure inventory
- Ensure safety of the employees doing the repairs

Attachment 1 demonstrates an example of the Instrumentation Planned Schedule for a building within the offices sector. This should be further developed by the Entity in line with the facilities instrumentation system, assets, and equipment located at a site-specific level. It should not be used as a comprehensive list, but as guidance for further development.

For further information on specific requirements, refer to National Manual of Assets and Facilities Management, Volume 7 – Prioritizing, Scheduling and Planning Work.

Below elements shall be taken into consideration when planning and scheduling the MEP maintenance tasks:

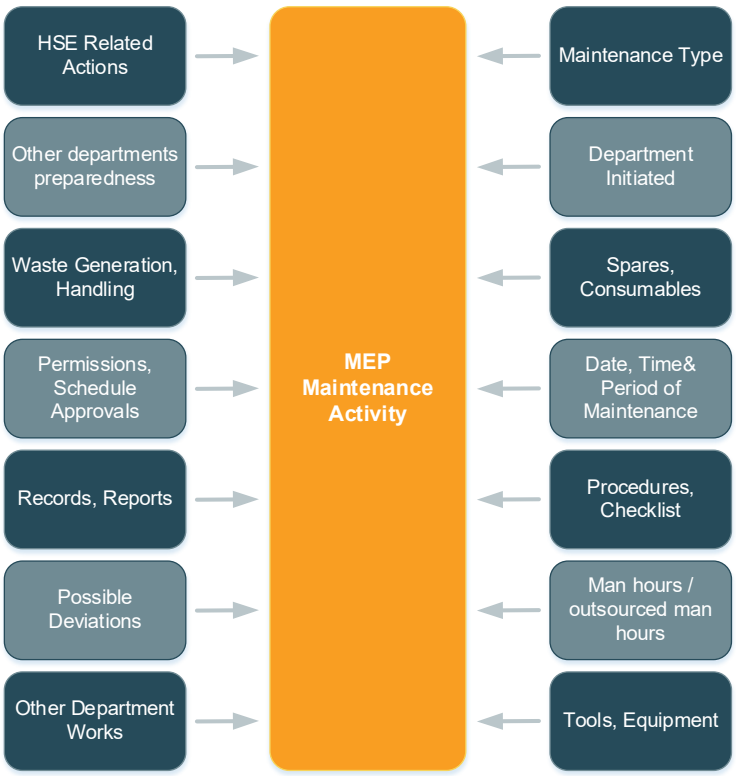

Figure 4: Pictorial Representation of Links of MEP Maintenance Activities

6.4.1 CMMS Requirements

Each Entity shall require a CMMS to effectively monitor and track the daily maintenance operations of the facility including associated factors mentioned above. The CMMS can deliver end-to-end communication from trend analysis to closing a WO. The CMMS will differ for each Entity as seen by the systems already in place; therefore, an assessment will need to be conducted to understand the path forward.

A good CMMS shall:

- Streamline maintenance plans, thus improving efficiency
- Communicate with stakeholders and streamline permissions for maintenance activities
- Reduce risks, ensuring a safer work environment
- Enhance tracking and historical monitoring of components/equipment
- Streamline parts and inventory, hence reducing costs
- Track metrics and report on Key Performance Indicators (KPIs)
- Improve reliability of the engineering systems
- Balance resources and costs in order to properly manage backlog maintenance
- Maintain a record of staff competencies allowing effective allocation of resource to activities
- Maintain support equipment for maintenance such as calibration and insurance inspections so they do not go overdue, impacting tasks or reductions of service

6.4.2 Health and Safety

The management of occupational health, safety, and wellbeing is crucial for the effective operation of any facility. The health and wellbeing of the workforce on site is a legal obligation of Health and Safety Executive (HSE).

Organizations have a legal liability to put in place suitable arrangements for managing health and safety. It should be a part of the everyday processes for supporting the Entity and an integral part of workplace behaviors and attitudes. The key to effectively manage health and safety is dependent on:

- Leadership and management using proven business processes
- Trained/skilled workforce following the rules and set standards
- Continuation and refresher training to all staff
- Upholding a culture within the Entity that promotes and exercises safe practices
- Ensure that activities take into consideration those affected by the actions (e.g. employees, visitors, administrations)

Health and Safety of the workplace must follow guidelines set in accordance and compliance with the Expro approach. These rules and regulations will be further defined in additional documents to ensure that the workforce responsible for the maintenance of a facility is following all policies and procedures to work in a safe and incident-free environment.

For further information on specific requirements, refer to the following:

- National Manual of Assets and Facilities Management, Volume 10 – HSSE
- Occupational Safety and Health Administration (OSHA) – Occupational Safety and Health

6.4.3 Risk Management

While developing office facilities operations management processes, it is vital to consider the risks associated with a lack of scheduled maintenance and monitoring. Troubleshooting, repairs, and maintenance must be made as soon as possible when a fault is detected to prevent damage or a loss of a system in a facility. It is critical to strictly adhere to the maintenance plans for a facility and associated engineering systems, otherwise the following issues could result:

- System failures, and contingent damage to facilities, causing increased O&M costs and reduced asset life
- Violation of codes and standards
- Decreased operational efficiencies with negative monetary effects
- HSE risks and infractions

For further information on specific requirements, refer to the following:

- National Manual of Assets and Facilities Management, Volume 10 – HSSE
- National Manual of Assets and Facilities Management, Volume 12 – Risk Management

6.4.4 Quality Control and Quality Assurance

The Entity shall ensure in the maintenance of a building or facility that quality standards are built into the maintenance processes and workmanship. For QA, the Facilities Manager would set expectations that all maintenance is performed as per the standards and guidelines set out by the NMA & FM. Knowing that the work has a form of QC means that consistent maintenance is being completed. The following points should be followed to assure QA/QC:

- Develop a PTW, which shall be followed for maintenance tasks
- Perform all maintenance activities as per manufacturer manual and recommendations
- Follow PM strategies as per manufacturer guidelines, which will differ based on the equipment used
- Record all maintenance records manually or through CMMS (if available), both hard copies and soft copies shall be maintained for references

For further information on specific requirements, refer to National Manual of Assets and Facilities Management, Volume 11 – Quality Control.

6.4.5 Spares/Consumables/Inventory

Having a spares/consumables inventory allows for quick decision making, if a failure occurs onsite. A list of spare equipment that can be accessed and used wherever standard practice applies shall be in place. Clear description of part numbers, makes, models and quantities shall be captured. Ideally, this shall be part of CMMS information to retrieve material details whenever required. CMMS systems will generally contain scheduling and procurement modules linked to the asset. This will also include functions for creating a WO, ordering parts, tracking and adjusting the parts and consumables on the system, and further make it efficient and interfaced to the entire maintenance program. This will assist in the monitoring of maintenance actives performed on an asset and provide information to stakeholders on current conditions and future investment required for spares, consumables and equipment life cycles. These types of lists can be programmed to have minimum stock levels allowing reordering in place with procurement, as inventory levels of regularly used parts may be replenished. Additionally, using Just-in-Time processes may allow parts to be contained within central warehousing facilities or vendor premises until needed, thereby, reducing associated costs of storage facilities to the Entity.

Inventory control process shall define critical/non-critical items and below elements shall be considered while developing the inventory details:

- High cost spares/consumables
- Long lead items
- Items obsolete in market
- High/Low use items
- Alternate material selection options
- Technical specifications
- Others

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. These components shall run up to their designed life in order to optimize efficiency and cost.

For further information on specific requirements, refer to the following:

- National Manual of Assets and Facilities Management, Volume 8 – Supply Chain Management
- National Manual of Assets and Facilities Management, Volume 4 – Obsolescence Management

6.4.6 Pre-requisites of the Maintenance

- Tools/Specialized Tool Kits/PPE
    - Inspection of all hand tools is required to complete the job safely without risk
    - Measurement and calibration tools shall be certified and documented in accordance with the standards set out by the NMA & FM, or statutory requirement
    - Provision of PPE, which is used by the maintenance staff to complete repairs of the facility

- Pre job meeting and maintenance testing

    - Pre job meetings to understand what scope of the work is
    - Testing required before a failure occurs as part of a periodic system maintenance
    - Troubleshooting required as part of failure repair or during live testing while an engineering system is being monitored

- Risk Assessment Method Statement (RAMS)

    - RAMS shall be in use as a safe practice of work. All results identified from risk assessments shall be documented, and shall include and refer to the method statement for the completion of maintenance tasks
    - Generic or standard method statements shall be avoided and site specific be used

- The individual performing maintenance activity shall be deemed competent to carry out maintenance tasks of the required equipment and systems
- The individual shall have recognized qualification relevant to Instrumentation engineering
- The individual shall have sufficient training/experience in Instrumentation and control engineering
- Job hazard analysis (JHA) shall be carried by personnel carrying out maintenance
- As part of the RAMS, housekeeping of the work area should be undertaken throughout the activity and upon completion

- Permit to Work (PTW)

  - Putting off any switch – fuse, power circuits, distribution boards, or mains circuit board that may affect any of the equipment associated to the instrumentation controllers and server shall be subject to PTW authorized by an engineer or manager of the facility to protect the system
  - All PTW shall include an approved RAMS to perform maintenance tasks
  - Sign off is required before a task is started, closed out and filed after work is completed

For further information on specific requirements, refer to National Manual of Assets and Facilities Management, Volume 10 – HSSE.

- Drawings/Schematics

  - The Entity should have accurate and up-to-date records and/or drawings. These should be readily available on site and in an appropriate format, to be used by the engineering services and facilities management teams. Records, drawings, and system architecture libraries should be readily available to the trained staff to improve understanding systems maintenance. OEM manuals shall be provided with the equipment used in a facility so that trained staff has access to the proper documentation to complete their maintenance tasks safely and properly. Ideally a web based system should be utilized so that copies are maintained in the event of an incident (e.g. fire, flood)

- Sequence of Operation (SOO)

  - Maintenance task shall include Service Order of Operations (SOO) so that process and system cause and effect shall be cleared and understood to all parties involved

- Redundancy Planning

  - Office facilities will contain critical equipment and systems, (e.g., backup generators), henceforth, it is essential to keep this equipment ready whenever needed. While developing maintenance plans, a substantial level of planning shall be performed and redundant equipment or systems to be used during emergencies shall be considered

- Documentation

  - Documentation is an essential element of maintenance tasks. Facilities maintenance teams shall ensure that relevant documentation of the pre and post maintenance tasks are available to facilities technicians, supervisors, and engineers to track maintenance logs/records. Daily, weekly, and monthly checklists are forms of documentation, which are helpful in the success of O&M. Ideally documents should be retained at site for a minimum of three (3) years before being archived. Below documents shall be available within facilities team, but not limited to:

    - Written maintenance procedure and RAMS
    - SOO needs to be understood by a technician to know what is being repaired/replaced and how it effects the engineering system.
    - PTW to ensure safety of the critical services and maintenance staff

- JHA to ensure safety of the employees
- Drawings/Schematics of the system
- Task sheets
- Work orders to record work done
- Other site-specific documentation

These prerequisites are just a guideline to a quality PM. Each Entity may have a different approach, based on the maintenance requirements of the building.

7.0 ATTACHMENTS

Attachment 1: EOM-ZM0-TP-000068 – Instrumentation Planned Maintenance Schedule Template – Offices

Attachment 1 - EOM-ZM0-TP-000068 - Instrumentation Planned Maintenance Schedule Template – Offices

Building name:				Reference #:	REV: 00A		
Instrumentation PM Schedule – Offices							
Date:							
Item	Part	FQ	Action	Notes	Checked		
					N/A	Y	N
1	Transmitter	Monthly	Check connection, clean, check battery voltage				
2	Switch	Monthly	Check connection, clean, check power				
3	Level Switch	Monthly	Proper operation, clean connection				
4	Float Valve	Monthly	Function, seals on body, movement, clean strainer				
5	Isolation Valve	Monthly	Check operation, Lubricant				
6	Motion sensor	Monthly	Clean				
7	Infrared sensor	Monthly	Clean				
8	Beam Sensor	Monthly	Clean, local beam test				
9	VESDA	Monthly	Check air flow, clean sample ports, conduct piping integrity smoke test, check power supply				
10	CO Sensor	Monthly	Remove dust and test alarm				
11	Window sensor	Monthly	Clean, check power				
12	Occupancy sensor	Monthly	Clean, check power				
13	Smoke & Fire sensor	Monthly	Proper operation, check alarm				
14	Temperature sensor	Monthly	Check accuracy with temperature gauge				
15	Solenoid valve	Monthly	Inspect for leakage, check wiring on coil, connection				
16	Flow meter	Annually	Calibration, check connections, clean monitor				
17	Photo electric sensor	Monthly	Clean eye, check power				
18	Vibration sensor	Annually	Clean, check accuracy, check connections				
19	Thermocouples	Annually	Clean, check position, check coupler				
20	Humidity sensor	Monthly	Check sensor filter for dirt and dust				
21	DDC controller	Monthly	Check calibration, check set points, check data base entries, check damper actuators				
22	Current switch	Monthly	Check connectors, clean, inspect for damage, check for corrosion				
23	Relay	Monthly	Check connectors, clean, inspect for damage, check for corrosion				
24	Current Transformer	Monthly	Check primary current, check operation, rated load				
25	Voltage transformer	Monthly	Check primary voltage, check operation, rated load				
26	Smart meter	Annually	Check current, clean, any damage, check function, calibration				
27	I/O modules	Annually	Check margins, clean, connections, calibrate				
28	Damper	Monthly	Check linkage, freedom of movement, clean				
29	Air Pressure sensor	Monthly	Visual checks, seals, connections				
30	Alarms	Monthly	Alarm test, power supply				
31	Controller screen	Monthly	Clean				
32	O&Ms	Annually	Ensure documentation current, QA/QC				

33	Power supplies	Monthly	Check all output voltages in specification				
Additional Notes:							
Work complete: Y/N Name:			Signature:				