هيئة كفاءة الإنفاق والمشروعات الحكومية
Expenditure Efficiency & Projects Authority

National Manual of Assets and Facilities Management
Volume 6, Chapter 8

Mechanical Systems Maintenance Plan for Schools & Universities

Document No. EOM-ZM0-PL-000020 Rev 001

Document Submittal History:

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

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1.0 PURPOSE

The purpose of this document is to provide the Entity and/or Facilities Management Company (FMC) with guidelines for the development of their Maintenance Management Plans for Mechanical Systems (MS) within Schools and Universities Facilities.

This Plan provides examples of maintenance planning, scheduling frequencies, and advises best practice for Planned Maintenance (PM), Corrective Maintenance (CM) and Predictive Maintenance (PdM) tasks. This document is intended to:

- Impart knowledge that enables the Entities and/or FMCs a base structure from which they can develop a set of documents and procedures.
- Enable the Management, Senior Management, and Engineers to have a clear understanding of the minimum maintenance requirements, along with Entity, Client, FMC, staff roles, and responsibilities.
- Identify the base analytical information that should be recorded by engineers and technicians to ensure discrepancies are pre-emptively identified and rectified through the maintenance management processes applied.
- Ensure that the use of mechanical systems for Schools and University comply with the mandatory Royal Decree passed by the Saudi Council of Ministers. This stipulates that systems in the facilities are fully maintained, operated safely and are protected throughout their design life.
- Guide the Entity and FMC service providers on how to develop the Mechanical Maintenance Management Plans/Manual.
- Provide a structured flow and reliable reference points within the document that can be related back to the relevant sections.

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 effectively execute maintenance and repairs in the applicable environments. 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.

This document will address the following criteria of a maintenance management plan:

- **What** needs to be included - formulated tasks against adopted standard
- **Why** it should be incorporated - standards, regulations, law, good practice, and efficiencies
- **How** to build the document - structure, process, guidance, and flow
- **Who:** Roles and Responsibilities - responsibilities for what elements, competence level requirements, and management inputs
- **When:** Scheduled frequency - required scheduled periods, PM intervals, and incorporated content. This is dependent on adopted standards, or best practice where these standards do not exist.

Incorporated diagrams and/or flow charts are for guidance and should not be classed as all-inclusive but as elements that should be further developed as required. These should be in-line with the finalized document ensuring structured flow and reliable reference points that can be related back to relevant sections of documentation.

Entities and FMCs should be aware that the variants of facilities that the document covers may not include the equipment highlighted in this document, as a standard. Therefore, care around developing the bespoke maintenance plan is paramount.

Schools and Universities facilities feature a wide range of operations including recreation areas, training halls, kitchen facilities, swimming pools, reception areas, conference rooms, chemical laboratories, and washrooms. The Entity has an obligation to support all of these spaces, as they all feature some form of mechanical systems.

For Facilities that have such departments and/or plant/equipment, the development of the maintenance plan shall include cross-referencing to other specialist equipment/plant that may be found in other Facilities types and by referencing the specialist manufacturer Operations & Maintenance (O&M) requirements.

This document also covers maintenance techniques to improve equipment and system-operating efficiencies and reliability in relation to improving utilities in existing and new buildings. Overall responsibility for the efficient maintenance management of the mechanical systems shall be under the overall control of the Entity and the Mechanical Safety Group.

For the purposes of this document, Mechanical Systems are assets with moving parts and are classified as plant, machinery, or equipment. A ‘school’ or ‘university’ has been defined as a form of building or facility which contains spaces designed to be used for teaching, training, or instructing students. Schools and Universities may include lecture theaters, classrooms, kitchen facilities, physical education equipment, swimming pools, staff rooms, shared common areas and atriums, receptions areas, conference rooms, and washrooms.

The types of Schools and Universities facilities considered within this document include, but are not limited to:

- Physical activity buildings such as those designated for sports, games, fitness centers, indoor and outdoor sports complex, and swimming pools
- Social activity buildings including, but not limited to, parties’ halls, banquets, libraries and picnics areas, laboratories.
- Facilities for outdoor activities including, but not limited to camping, walking/hiking and backpacking.

Maintenance procedures covered within this document, relate to activities detailed through internal best practice, Original Equipment Manufacturer (OEM) guidelines, and industry best practice. Other strategies exist that may be of assistance to the Entity in completing maintenance activities such as thermographic surveys, vibration analysis, and spectrographic oil analysis. Adoption of alternative techniques must undergo a cost benefit analysis to ensure that it meets with the Entity’s aims and follows statutory/mandatory requirements imposed, added or amended from time to time.

3.0 DEFINITION

Term	Definition
Competence	The measure of ability to perform a specific task based on knowledge, judgment, experience, and skill
Corrective Maintenance (CM)	It is type of maintenance to perform on the systems, identification, isolation, and rectification of faults of systems equipment's can be restored at working condition.
Emergency Maintenance	Any (unplanned) maintenance activity that requires immediate repair due to potential/direct impact on public safety or business operation.
Entity	Means Government Entity, authority, or ministry responsible for the Operations and Maintenance (O&M) works
Facilities Management (FM)	The organizational function which integrates people, place, and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business
Mechanical Systems	Assets with moving parts which are classified as plant, machinery, or equipment
Planned Maintenance (PM)	Scheduled maintenance routines, set out to ensure machinery, services and equipment are all maintained at regular intervals
Predictive Maintenance (PdM)	PdM is method, used for systems maintenance to measurement of various parameters that show a predictable connection with the component life cycle and its associated subsystems.
Acronyms	
AE	Authorizing Engineer
ANSI	American National Standards Institute
AP	Authorized Person
ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ASSE	American Society of Sanitary Engineers
ASTM	American Society for Testing and Materials
BESA	Building Engineering Services Association
BMS	Building Management System
BOM	Bill of Materials
CE	Civil Engineer
CEng	Chartered Engineer
CAFM	Computer Aided Facilities Management
CIBSE	Chartered Institution of Building Service Engineers
CM	Corrective Maintenance
CMMS	Computerized Maintenance Management System
CP	Competent Person
DCP	District Cooling Plant
EE	Electrical Engineer
FIST	Facilities Instructions, Standards and Techniques
FM	Facilities Management
FMC	Facilities Management Company
FOC	Facilities Operating Client
FOM	Facilities Operations Management
HSSE	Health, Safety, Security and Environment
HTM	Health Technical Memorandum
HVAC	Heating, Ventilation, and Air Conditioning
IC	Instrumentation and Control Engineer
IEng	Incorporated Electrical Engineer
JHA	Job Hazard Analysis
ME	Mechanical Engineer
MEWP	Mobile Equipment Work Platform
MS	Mechanical Systems
NFPA	National Fire Protection Association
NMA&FM	National Manual of Assets and Facilities Management
O&M	Operations and Maintenance

OE	Operations Engineer
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
PAR	Periodic Automatic Replenishment
PF	Power Factor
P&ID	Process and Instrument Design
PdM	Predictive Maintenance
PMT	Post Maintenance Testing
PME	Plant, Machinery and Equipment
PM	Planned Maintenance
PTW	Permit to Work
QA	Quality Assurance
QC	Quality Control
RA	Risk Assessment
RAMS	Risk Assessments and Method Statements
RO	Reverse Osmosis
SBC	Saudi Building Code
SME	Subject Matter Expert
SOP	Standard Operating Procedure
SPL	Spare Parts List
STP	Sewage Treatment Plant
UV	Ultraviolet
WTS	Water Treatment Systems.

Table 1: Definitions and Acronyms

4.0 REFERENCES

- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- American Society of Sanitary Engineers (ASSE)
- American Society for Testing and Materials (ASTM)
- Building Management System and Mechanical System Integration Guide
- Chartered Institute of Building Service Engineers (CIBSE) – Guide Mechanical Systems
- Facilities Instructions, Standards and Techniques (FIST)
- Health Technical Memorandum (HTM) – HTM 01-01
- Health Technical Memorandum (HTM) – HTM 02-01
- Health Technical Memorandum (HTM) – HTM 04-01
- National Manual of Assets & Facilities Management (NMA&FM) – Volume 10, HSSE
- National Fire Protection Agency (NFPA) – NFPA 70 National Electrical Code
- National Fire Protection Association (NFPA) – NFPA 72: National Fire Alarm and Signaling code
- National Fire Protection Association (NFPA) – NFPA 101: Life Safety Code
- National Fire Protection Association (NFPA) – NFPA 90A: Standard for Installation of Air Conditioning and Ventilation Systems
- National Manual of Assets & Facilities Management (NMA&FM) – Volume 5, Chapter 2: Seasonal Planning (5.2.6)
- Saudi Building Code (SBC) – Fire Protection Requirements 801
- Saudi Building Code (SBC) – Mechanical Systems 501
- Saudi Building Code (SBC) – Sanitary Requirements 701
- The Building Engineering Services Association (BESA) - SFG 20 Task Schedules
- The Occupational Safety and Health Administration (OSHA)
- White book (HSSE)
- National Manual of Assets & Facilities Management (NMA&FM) – Volume 10 (HSSE), Vol 3: Asset Management (EPM-KEO-GL-000009)
- National Manual of Assets & Facilities Management (NMA&FM) – Volume 6, Chapter 3: A Preventative Maintenance Program Procedure (EOM-ZM0-PR-000003)
- National Manual of Assets & Facilities Management (NMA&FM) – Volume 6, Chapter 7: Requesting, Prioritizing, Scheduling and Planning Work (EOM-ZW0-PR-000001)

- National Manual of Assets & Facilities Management (NMA&FM) – Volume 6, Chapter 27: PMT Procedure (EOM-ZM0-PR-000008)
- ISO 9001: Quality Management Systems

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

5.0 RESPONSIBILITIES

Only trained and competent persons should be appointed by management to perform maintenance tasks on mechanical systems. Table 2 (below) describes key mechanical systems maintenance personnel.

Role	Description
Facilities Operating Client (FMC)	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 agree on the scope of work under the maintenance activities
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, Maintenance, and ensuring control of those systems is in line with the Client Standard Operating Procedure (SOP) for the maintenance activities
Authorized Person (AP)	An individual who has been appointed by the Authorizing Engineer (AE) (or by an authorizing body within the Entity); who is trained, competent, skilled, experienced, and 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
The Authorizing Engineer (AE) (MEP) all disciplines	A Chartered Engineer (CEng) or Incorporated Engineer (IEng) with appropriate experience and possessing the necessary authority to implement, administer, and monitor safety arrangements for (MEP) systems. This individual ensures safety compliance, assesses, and appoints candidates in writing, to be Authorized Persons
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. The CP can execute the required actions within a Permit to Work (PTW) and or other directional document as may be assigned to them
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.

Sub-contractor	A subcontractor assists in the maintenance of a facility. The subcontractor is managed by a Building or Facility manager which are given specific duties to ensure that building is properly functioning. Sub-contractors normally supply their own tooling and supplies to operate and maintain a building, which is detailed in a contractual agreement

Table 2: Responsibilities

All personnel involved with maintenance of mechanical systems shall be mapped against a skills matrix as contained within Attachment 1. The skills matrix shall be used to establish competency levels and ensure appropriate governance.

Figure 1 (below) describes the process which maps above roles and responsibilities with planning and implementing Planned Maintenance (PM).

5.1 Mechanical Safety Group

The aim of the Mechanical Safety Group (MSG) is to introduce a structured approach for the management of Mechanical Services/Plant, Machinery and Equipment in compliance with current Health Technical Memorandum (HTM) Standards and guidelines. Whilst not a direct requirement of the Schools and University sector it is deemed as best practice to adapt the example below to suit the Entity's goals and objectives.

The purpose of highlighting the organizational structure is to encompass those facilities which may have a healthcare training or research element to their prospectus.

The primary purpose of the MSG is to provide guidance to stakeholders within the organization to create a robust and measurable process for the safety and protection of those engaged in activities, and those personnel (e.g. staff, visitors and students) that may come into contact with mechanical systems. This will include, but is not limited to:

- The Health and Safety of employees in the conduct of their work
- The Health and Safety of those coming into contact or may be affected by activities
- The Legal and Statutory requirements of the organization
- Meeting with local and organizational requirements / standards
- Safe and effective maintenance using best practice and approved spare parts
- Communication to stakeholders and users
- The training and development of service staff.

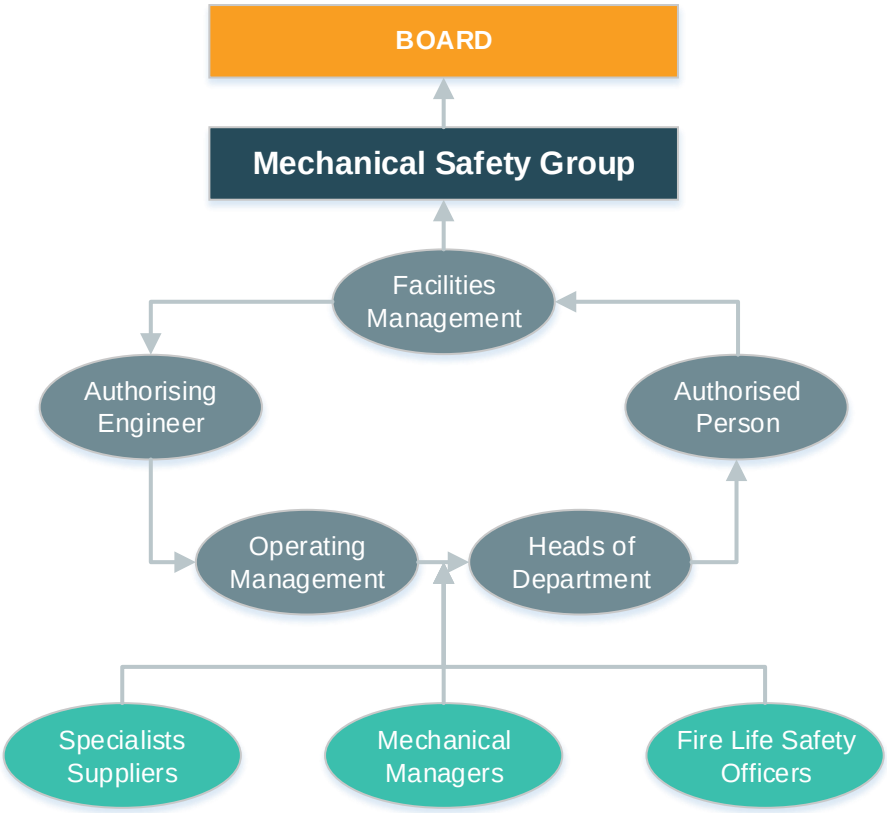

Figure 1: Mechanical Safety Group

Roles & Responsibilities for PM Scheduling and Implementation

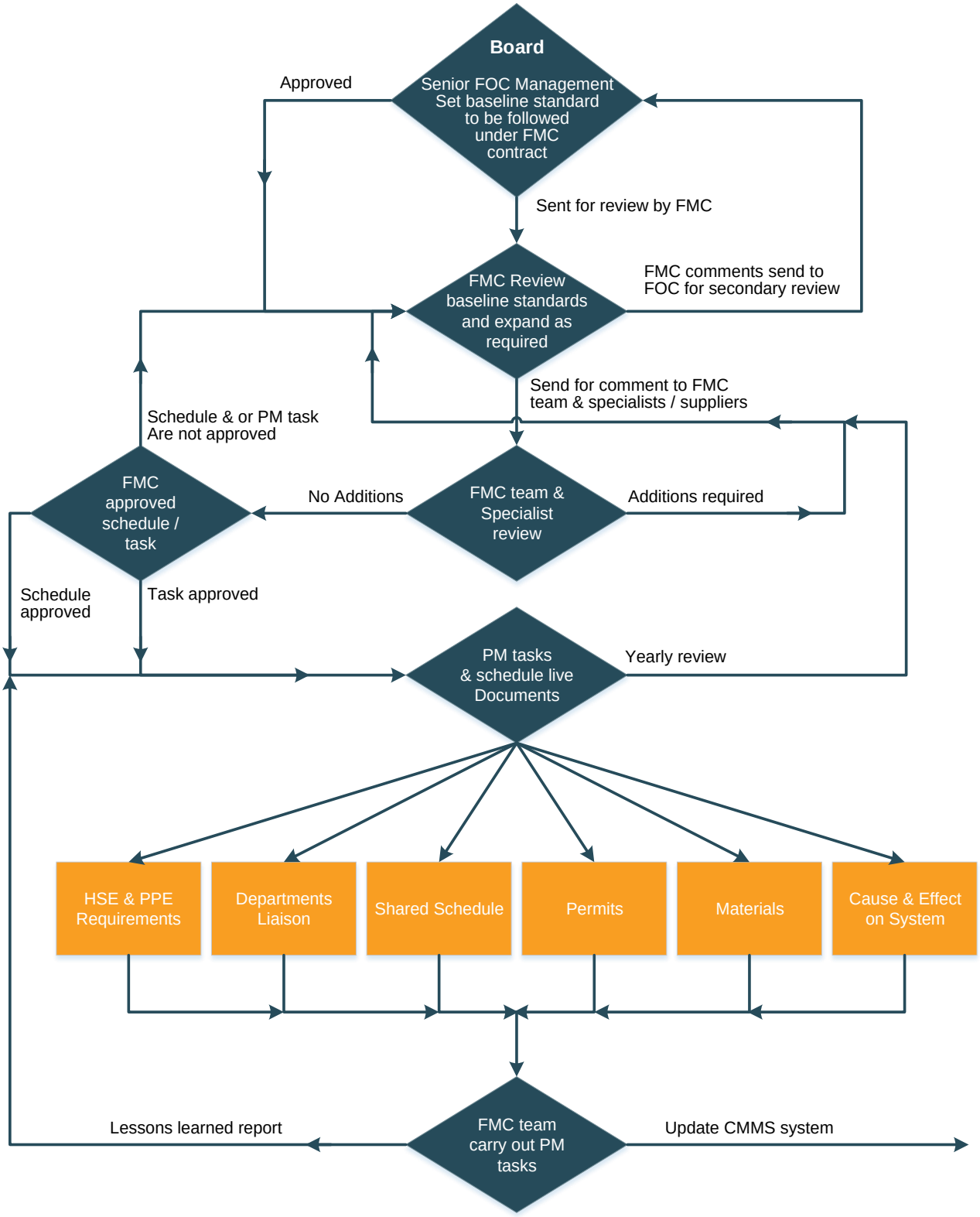

Figure 2: Roles and Responsibility for Schedule and Task Sheet Implementation

6.0 PROCESS

Figure 3 (below) describes the components which should form part of a maintenance plan for mechanical systems. This section shall focus on key components, such as maintenance frequency, competency requirements, maintenance testing, Quality Assurance (QA), and Quality Control (QC).

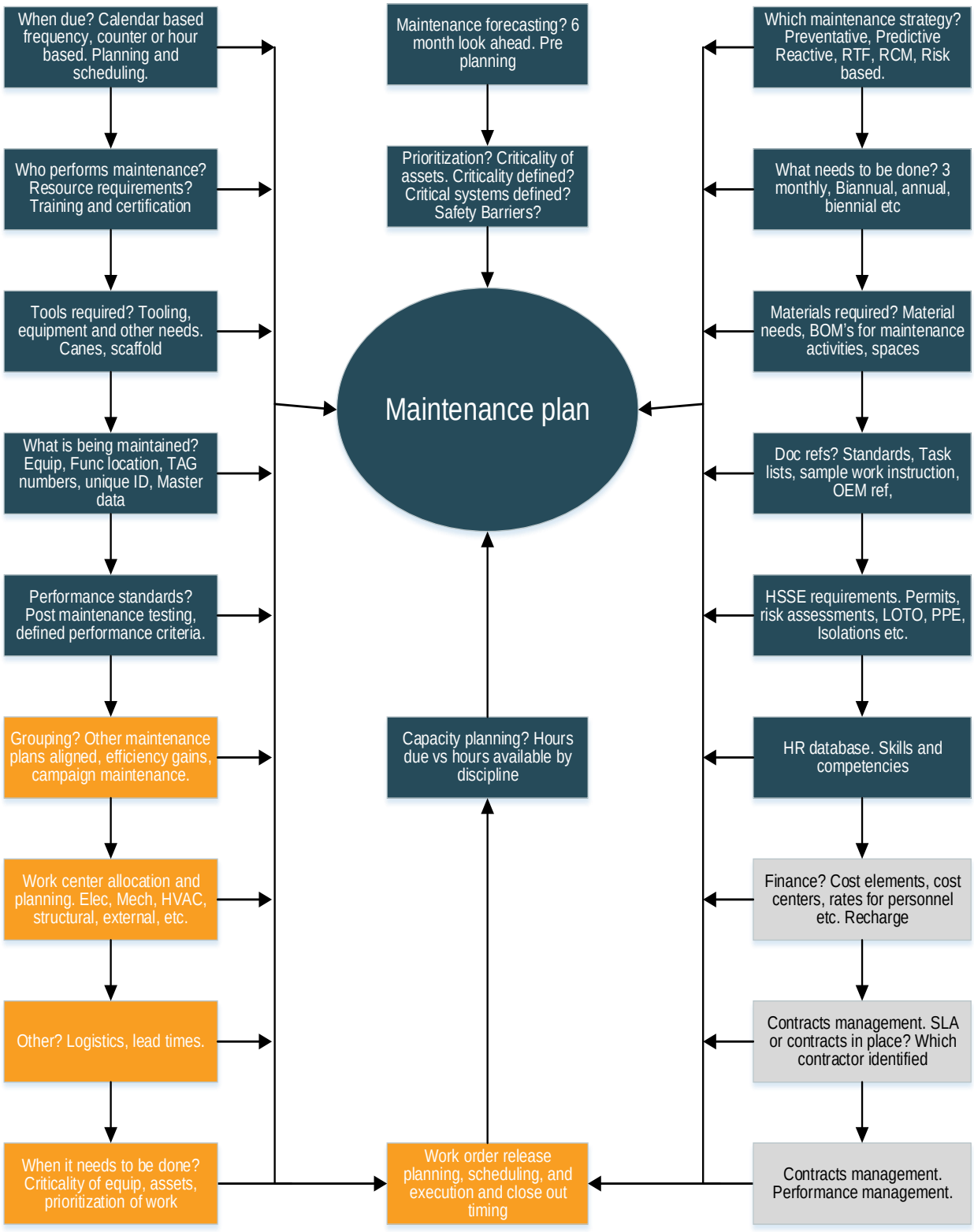

Figure 3: Maintenance Planning Element

6.1 Introduction to Mechanical Systems

Mechanical systems are assets with moving parts and are classified as plant, machinery, or equipment. Such systems therefore operate primarily on the principals of thermodynamics, fluid mechanics, and dynamic structures.

Due to their dynamic nature, which require intensive energy use, mechanical systems can significantly impact energy efficiency and operating costs for a school or university. While Facility Managers (FM) may not be directly involved in the operation and maintenance of mechanical systems, their performance will directly affect the facility's performance and efficiency. For example, increased inductance within the electrical distribution system caused by inefficient motor loads (e.g. primary and secondary water pumps) can significantly reduce Power Factor (PF) which in turn reduces power quality and increases facility operating costs.

Schools and Universities are comprised of main mechanical systems and associated sub-systems. Examples of mechanical systems typically found within a school or university include:

- Water Treatment Systems (WTS)
- Plumbing Systems
- Fire Protection Systems
- Heating, Ventilation, and Air Conditioning (HVAC) Systems
- Generators/Fuel Systems
- Medical Gas Labs Systems
- Chiller Plants/Systems.

Examples of mechanical sub-systems include:

- Chilled Water Systems (Closed Loop Secondary Systems)
- Cooling Tower or Condenser Water (Open Loop Systems for Buildings)
- District Cooling Plant (DCP) or Cooling Tower
- Steam Boiler Systems
- Domestic/Potable Water Systems
- Swimming Pool Treatment Systems
- Water Feature/Fountain Treatment Systems
- Filtration/Ultraviolet (UV) System
- Grey Water Treatment
- Sewage Treatment Plant (STP).

Mechanical systems and associated sub-systems shall be inspected and maintained according to world-leading professional bodies such as:

- American Society of Mechanical Engineers (ASME)
- American Society of Plumbing Engineers (ASPE)
- American Society of Sanitary Engineers (ASSE)
- American Society for Testing and Materials (ASTM).

6.2 Types of Maintenance

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

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

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.

6.2.1 Planned Maintenance

Planned Maintenance is a regime that is carried out at predetermined intervals or frequencies on an asset to: reduce the likelihood of its failing, maintain safe running conditions and ensure equipment efficiencies. PM is performed before equipment failure takes place, and to eliminate unexpected breakdowns.

Task Instruction sheets shall be prepared by each Entity as part of the Planned Maintenance regime to enable maintenance of mechanical systems – a sample is contained within Attachment 3: EOM-ZM0-TP-000026 – Task Instruction Frequency Sheet for Mechanical Systems in Schools and Universities

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

6.3 Computerized Maintenance Management System (CMMS) Requirements

Each Entity shall employ a 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. Mechanical systems maintenance plans captured within the 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.

Mechanical systems maintenance plans captured within the CMMS should also:

- Refer to industry resources and feature site-specific guidelines to support maintenance activities
- Feature check points to enable Quality Assurance (QA); record sheets shall be attached to work orders to validate the results during testing and maintenance.

The Entity should employ trained and competent staff who are familiar with the CMMS system in use to undertake the dynamic reporting of maintenance activities and amend schedules/tasks as required. Where necessary the software vendor should be consulted for training and advice as required.

6.3.1 Record Keeping

Mechanical system design and performance information is important for effective maintenance planning, regardless of the maintenance activity being performed. Therefore, the Entity shall gather, upload and uphold all internal and third party reports (e.g. from engineering studies, modelling or testing) associated with each system.

During normal operations and emergency scenarios, the availability of as-built drawings is also critical for understanding system design, maintenance approach, testing, and troubleshooting. Drawings shall also be stored in a centralized location with document numbering and control in line with ISO 90001: 2015 – Document Management System. It is advisable that a web-based system is considered for ease of access and also for security of documentation in the event of an incident (e.g. fire, flood damage).

6.4 Maintenance Planning and Scheduling

The aim of maintenance planning for mechanical systems is to set out:

- What activities shall be undertaken
- How the activities shall be undertaken
- How long each task shall take to be completed?

A comprehensive Maintenance Schedule shall be developed by Maintenance Planners within each Entity, featuring the following as a minimum:

- Start date and time
- End date and time
- Planned duration
- Required parts
- Responsible personnel
- Assets to be maintained
- Maintenance activities to be executed and their associated type code (e.g. CM, PdM, PM).

Maintenance Schedules shall be based upon several inputs, including cross-department recommendations, Operations and Maintenance (O&M) team individual experience, equipment history and Original Equipment Manufacturer (OEM) recommendations. Maintenance Planners shall collaborate with internal and external stakeholders (as applicable) to achieve an optimized Maintenance Schedule.

The Frequency of maintenance is a critical aspect of maintenance planning for mechanical systems. The Frequency of maintenance should range, for example from daily checks, up to major overhauls on a 5-yearly basis.

During maintenance planning tasks, a cause and effect matrix shall be prepared to comprehend the full impact of maintenance on operations within the Municipal Facility. This exercise may be captured within the Risk Workshop described within Section 6.9.

6.5 Quality Control (QC) and Quality Assurance (QA)

QC represents the quality standards which shall be met by each Entity. However, QA is the method that shall be used to ensure quality standards are being met and to capture opportunities for continuous improvement.

QC shall be determined by the content of mechanical systems 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 the Computerized Maintenance Management System (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) ensures a safe system of work to protect people and limits human error by removing single point of failure through involvement of Authorized Persons (APs).

Further information can be obtained within ISO9001: Quality Management Systems.

6.6 Spare Parts

Spare parts are components featuring an asset tag which are used to replace damaged, expired, or failed parts of mechanical systems. However, consumables are those which are not assigned an asset tag, but are required to enable mechanical systems to operate (i.e. fuel oil for diesel generators, and chemicals for the chemical dosing system).

Each Entity shall ensure that a Bill of Materials (BOM) is established for all mechanical systems. An asset hierarchy shall be established with equipment criticality identified in order to inform:

- Maintenance strategy
- Spare Parts List (SPL)
- Running arrangements
- Risk Assessments (RAs).

A sample Equipment Criticality Matrix is provided in Attachment 2 to support the process of assigning criticality.

The BOM shall include the following as a minimum:

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

The BOM should become part of the Computerized Maintenance Management System (CMMS) to enable centralized storage and retrieval of asset data for mechanical systems. However, in case of unavailability of the CMMS, a soft copy of the BOM shall be available with the Facilities Management (FM) team which shall determine the Periodic Automatic Replenishment (PAR) levels.

An inventory control process shall govern the procurement and installation of critical and non-critical equipment. The following elements shall be considered while developing BOM:

- High cost spares / consumables
- Long lead items
- Items obsolete in market
- Replacement of components which are no longer in production by the Original Equipment Manufacturer (OEM) according to the original specification shall be assessed carefully without compromising quality, efficiency and Process and Instrument Design (P&ID) functions
- Equipment duty
- Main and back-up arrangements
- Alternate material selection options
- Technical specifications.

Parts with high failure rate shall be highlighted through maintenance activities and further analysis shall be performed to identify root cause analysis of component failure. Maintenance schedules may require to be altered to prevent unwanted breakdown and further design analysis should be considered.

6.7 Maintenance Testing

The Entity's asset management strategy, performance requirements, organizational maturity, and funding are factors which dictate the Entity's approach to maintenance testing. Certain critical equipment may require additional testing to be undertaken following maintenance activities, or certification to stakeholders.

Post Maintenance Testing (PMT) should be identified and performed as required following execution of maintenance activities. Refer to NMA&FM Volume 6, Chapter 27: PMT Procedure (EOM-ZM0-PR-000008).

6.8 Health and Safety

Maintenance of mechanical systems holds inherent hazards due to proximity of energized equipment and moving parts. Maintenance activities which pose significant risk to people and to mechanical systems 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 malfunctions. Given that the mechanical systems will drive Heating, Ventilation, and Air Conditioning (HVAC) equipment within Schools and Universities, scheduled maintenance during summer vacation months, for example, requires activities to be executed such that downtime is minimized whilst student and staff numbers will be at a minimum. Corrective Maintenance (CM) 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 personnel, systems, members of the public and visitors coming into contact with maintenance activities, whilst also protecting the environment. In particular, the safe disposal of waste materials, oils and contaminated filters.

Further information with respect to Health and Safety can be found in NMA&FM Volume 10 (HSSE).

Further information with respect to Waste Management Procedures are contained within NMA&FM Volume 6, Chapter 22.

6.9 Risk Management

The facilities maintenance team shall complete a comprehensive set of Risk Assessments and Method Statements (RAMS) covering each mechanical system for Schools and Universities. 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 (RAs) for mechanical systems maintenance:

- Identify hazards associated with each maintenance activity, for example: loss of critical systems (e.g. HVAC and water); impact on operation of facilities; and equipment failure
- Establish maintenance personnel, service providers, and building users who are at risk as a result of the maintenance activity.
- Identify competency requirements for personnel undertaking maintenance activities
- Quantitatively evaluate risks using a risk matrix (involve maintenance team, Subject Matter Experts (SMEs), and Health, Safety, Security and Environment (HSSE) team in risk assessment process and hold Risk Assessment Workshops 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 and implement improvements following experience.

7.0 ATTACHMENTS

1. Attachment 1: EOM-ZM0-TP-000024 - Skill Level Matrix Mechanical Systems – Schools and Universities
2. Attachment 2: EOM-ZM0-TP-000025 - Equipment Criticality Matrix Mechanical Systems – Schools and Universities
3. Attachment 3: EOM-ZM0-TP-000026 -Task Instruction Sheet Mechanical Systems – Schools and Universities

Attachment 1: EOM-ZM0-TP-000024 - Skill Level Requirements Matrix Mechanical Systems – Schools and Universities

NOTE:

This matrix is for guidance only and should be developed further by the Entity to meet site-specific system-level and competency-level requirements.

In-House Skill:

Level 1 – Manufacturer Trained and/or Engineer
Level 2 – Certified Discipline Trained
Level 3 – Competency Assessed Operative
Level 4 – Assessed Helper

Specialist Skill:

Level 1 Specialist – Life Safety Licensed Company and Operatives
Level 2 Specialist – Manufacturer/Manufacturer Trained and Certified

Type of Maintenance Task	Service Provision by:		Required Competency Level
Mechanical Systems	**In-house**	**Specialist Supplier**	**In-House Skill Level 1 – 4, or Specialist Skill Level 1 – 2.**
Water Treatment Systems/Plants	☑	☑	
Life Safety Systems		☑	
Plumbing Systems	☑		
HVAC Systems	☑		
Generators/ Fuel Systems	☑	☑	
Medical Gas Systems		☑	
Chillers Systems	☑	☑	
Water Treatment System	**In-house**	**Specialist Supplier**	
Chilled Water Treatment	☑	☑	
Cooling Tower/ Condenser Water Treatment (Open Loop Building)	☑	☑	
DCP Cooling Tower (Community)	☑	☑	
CSSD RO Plant Treatment	☑	☑	
Dialysis RO Systems (Potable RO)	☑	☑	
Hydrotherapy Pool System	☑	☑	
Steam Boiler System (Laundry)	☑	☑	
Potable/Domestic Water System	☑	☑	
Filtration Systems (UV Systems)	☑	☑	
Neutralization System/Plant	☑	☑	
Gray Water Systems	☑	☑	
Sewage Treatment Plant	☑	☑	

Attachment 2: EOM-ZM0-TP-000025-Equipment Inclusion Criticality Matrix for Mechanical Systems in Schools and Universities

NOTE:

1. This matrix is for guidance only and should be developed further by the Entity to meet site-specific system-level and competency-level requirements.
2. Assigning criticality of assets, and standards compliance remains the responsibility of each Entity.

Description			System Equipment Category					Type of PM included in plan					Compliant to	Frequency
ME Systems	Sub-System	Equipment	Life safety	Critical	Essential	Utility	Non-Essential	Compliance	Standard	Regulatory	Manufacturer	Best Practice	Technical Standard	Site Specific FQ
Water	Chilled water	Automatic dosing systems	X	X					X		X	X		
	Cooling tower	Automatic controllers	X	X					X		X	X		
	DCP cooling tower	Sensors	X	X					X		X	X		
	CSSD RO	Multimedia filters	X	X				X	X		X	X		
	Dialysis RO	Control panels	X	X					X			X		
	Hydrotherapy pool	Test kits	X	X					X	X		X		
	Steam boiler	Carbon filters	X	X					X	X		X		
	Potable/domestic water	Filter housing	X	X				X	X	X	X	X		
	Filtration system	Water softeners	X	X				X	X	X	X	X		
	Neutralization system	Membranes	X	X				X	X	X	X	X		
	Gray water system	Pressure vessels	X	X	X	X	X		X	X	X	X		
	Sewage treatment Plant	Air blowers	X	X	X	X	X		X	X	X	X		
Plumbing	Potable cold water supply	Hot and cold mixture	X	X	X	X	X		X	X		X		
	Hot water supply	Valves	X					X	X	X	X	X		
	Drainage venting	Water meters	X					X	X	X	X	X		
	Water heater	Isolation valves	X	X				X	X	X	X	X		
	All types of pumps	Butterfly valves	X	X	X	X	X		X	X		X		
Life safety S/M	FM200	Hose reals	X	X	X	X	X		X	X	X	X		
	Fire Alarm	Fire pumps	X	X	X	X	X		X	X		X		
	Fire extinguishers	Fans and dampers	X	X	X	X	X		X	X	X	X		
	Sprinklers	Exist signage	X	X	X	X	X		X	X	X	X		
	Emergency lighting system	Manual call panel	X	X	X	X	X		X	X	X	X		
HVAC System	Central heating and cooling	Direct Expansion (DX)	X					X	X	X	X	X		
	Air distribution system	Variable-refrigerant Flow	X					X	X	X	X	X		
	DX units	Variable Air Volume (VAV)	X					X	X	X	X	X		
	Split units	Constant Air Volume	X	X	X	X	X		X	X		X		
		Roof Top Units	X	X	X	X	X		X	X		X		
		Air Handling Units	X	X	X	X	X		X	X		X		
		Fan Coil Units	X	X	X	X	X		X	X	X	X		
		Hybrid Heat Pump	X					X	X	X	X	X		
		Local Exhaust Ventilation	X					X	X	X	X	X		
Generators	Generator control unit	Diesel Tank	X					X	X	X		X		
	Internal combustion engine	Filters: air and fuel	X	X	X	X	X		X	X	X	X		
	Starter motor	Control panel	X	X	X	X	X		X	X		X		
	Alternator	controllers	X	X	X	X	X		X	X		X		
Medical Gas	Electrical System	Vacuum Pumps	X	X	X	X	X		X	X	X	X		
	Automatic Transfer Switch	Gas and Vacuum Shutoff	X					X	X	X	X	X		
	Emergency System	Pressure gauges	X					X	X	X	X	X		
	Life Safety Systems	Gas cylinders	X		X			X	X	X		X		
	Critical System	Pressure and Vacuum	X		X									
	Vacuum Systems	Oil indicators	X		X					X				
	Central Supply System	Pressure indicators	X		X					X				
	Electrical Power and Control	Moisture indicators	X				X			X		X		

	Medical Air Quality Monitoring	Circuit breakers	X				X			X		X		
	Surgical Vacuum Supply	Control Panels	X				X			X		X		
	Medical Air Compressor		X		X		X		X	X	X	X		
	Communication systems		X		X				X	X	X	X		
	Life safety systems		X		X			X	X	X	X	X		
	Dental Gas and Vacuum S/M		X		X			X	X	X	X	X		
	Incident Command System		X		X			X	X	X	X			
Chillers Systems	Cooling towers	Automatic dosing systems	X		X			X	X		X			
	compressor	Pumps	X		X	X		X	X		X			
	Evaporators	Pressurization unit	X		X	X		X	X			X		
	Condensers	Control panels	X		X	X		X	X			X		
	Refrigerants	Control valves	X		X	X		X		X		X		
	Heat recovery systems	Bypass valves	X							X		X		
	Control Systems		X							X		X		
	Hydronic distribution systems		X							X		X		

Attachment 3: EOM-ZM0-TP-000026-Task Instruction Frequency Sheet for Mechanical Systems in Schools and Universities

An example task instruction sheet for boiler systems is featured below. The Entity should use it as a basis by which to develop its own site-specific task instruction sheets for mechanical systems.

Skill Types

ME – Mechanical Engineer
EE – Electrical Engineer
IC – Instrumentation and Control Engineer
CE – Civil Engineer

Boiler Systems			
Item	**FQ**	**Action**	**Skill Types**
Water gauge test	Daily	NA	ME
Water level left & right hand gauge		Manual blow down	ME
Water Level Control		Test low water level cut-out and lock-out.	ME
Feed pump start/stop or modulation		Check operation	ME
Pressure readings		Record the pressure gauge reading	ME
PH and TDS water Test		Carry out TDS water quality test, record the result and make Adjustments where necessary	ME
Blow Down		Record quantity of water blown down.	ME
Feed water and condensate check		Check the feed tank level is adequate and there are no contaminants. Check that the chemical dose metering device is functioning and there are adequate chemical stocks in the tanks. Check that the in-house routine sample results are within their given parameters provided by the water treatment specialist and take remedial action when necessary. Check the temperature is above the required level for the treatment doses specified for oxygen scavenging.	ME
Flame failure	Weekly	Test flame failure lock-out. This may not be present on non-self-monitoring boilers	ME
Failure to ignite.		Test failure to ignite lock out	ME
Water level 1st.		Test by lowering water level to 1st low water level, by evaporation and controlled blowdown, and check burner locks out and the alarm is sounded	ME
Water level 2nd.		Test by lowering water level to 2nd low water level, by evaporation and controlled blowdown, and check burner locks out and the alarm is sounded	ME
Isolation from electricity supplies	Monthly	Switch and lock off. Remove fuses from both supplies.	ME
Water treatment		Ask if the system has been drained since last visit and if it was retreated with inhibitor.	ME
Water checks		Leakage checks	ME
Fan cooling air duct		Remove button front casing clean duct through casing, remove the rear end fan motor which is exposed when the casing is removed.	ME