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HVAC Maintenance Plan for Schools & Universities

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1.0 PURPOSE

Successful maintenance planning of Heating, Ventilating, and Air Conditioning (HVAC) systems relies on conducting maintenance at the right time to the right level such that the performance may be optimized, and equipment life may be maximized.

The purpose of this document is to provide guidance in developing and improving maintenance plans for HVAC systems within the schools and universities. These are minimum requirements for maintenance, inspection, and repair of the systems which the Entity shall modify specific to its needs. Furthermore, this document seeks to improve and enhance the Entity's overall understanding of HVAC systems maintenance, and convey best practice.

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, focusing on planned activities and the reduction of costly and disruptive reactive maintenance. The Entity, Facilities Management Company (FMC), and/or their specialist service providers shall take steps to enhance the current practice of developing a maintenance plan for efficient building operations.

The guidance contained herein covers key elements of maintenance planning for HVAC systems within schools and universities including, but not limited to:

- Maintenance task management
- Optimizing system efficiency
- Quality assurance
- Health and safety of stakeholders and the environment

HVAC systems are classified as Plant, Machinery, or Equipment (PME) that serve the aim of controlling the thermal environment, largely through simple adjustments to air temperatures. The method by which air temperature is adjusted and the effect that it has on overall comfort control, will depend on the form of air conditioning employed and its ability to provide a uniform thermal environment.

For the purpose of this document, 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, but not limited to:

- Lecture theaters
- Classrooms
- Kitchen facilities
- Physical education equipment
- Swimming pools
- Staff rooms
- Shared common areas and atriums
- Receptions areas
- Washrooms

HVAC systems either feature as a part of these areas or are servicing these areas from a centralized location (e.g., rooftop, plant room, or basement level).

The content contained herein is aimed at Facilities Management (FM) personnel and shall benefit the Entity's operations in several ways, for example:

- Increased equipment life
- Reduced system downtime
- Better visibility of plant condition through effective trending, recording, and reporting
- Reduced overall maintenance cost associated with increased system efficiency and reliability

3.0 DEFINITIONS

Term	Definition
Atmosphere	A gaseous envelope surrounding the earth (outside conditions)
Concealed Exterior	Concealed from view, protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures
Concealed Interior	Concealed from view and protected from physical contact by building occupants
Conditioned	Spaces directly provided with heating and cooling
Exposed Exterior	Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions
Exposed Interior	Exposed to view indoors (not concealed)
Finished Space	Space other than mechanical rooms, electrical rooms, furred spaces, pipe chases, unheated spaces immediately below roof, space above ceilings, unexcavated spaces, crawl spaces, tunnels, and interstitial spaces
Indoors	Located inside the exterior walls and roof of the building
Outdoors	Located outside the exterior walls and roof of the building
Abbreviations	
ACH	Air Change per Hour
ACOP	Approved Code of Practice
AE	Authorizing Engineer
AE (V)	Authorized Engineer (Ventilation)
AHJ	Authority Having Jurisdiction
AHRI	Air-Conditioning Heating and Refrigeration Institute
AHU	Air Handling Units
ANSI	American National Standards Institute
AP	Authorized Person
AP (V)	Authorized Person (Ventilation)
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
BESA	Building Engineering Services Association
BIM	Building Information Modelling
BMS	Building Management System
BOM	Bill of Materials
CAV	Constant Air Volume
CE	Civil Engineer
CIBSE	Chartered Institution of Building Services Engineers
CM	Corrective Maintenance
CMMS	Computer Maintenance Management System
COSHH	Control of Substances Hazardous to Health
COTS	Commercial off-the-Shelf
CP	Competent Person
CP (V)	Competent Person (Ventilation)
CRAC	Computer Room Air-Conditioning Unit
CRAH	Computer Room Air Handling Unit
DX	Direct Expansion
EE	Electrical Engineer
EMP	Emergency Management Plan
FCU	Fan Coil Unit

Term	Definition
FM	Facilities Management
FMC	Facilities Management Company
HEPA Filter	High Efficiency Particulate Air Filter
HSE	Health and Safety Executive
HSSE	Health, Safety, Security, and Environment
HTM	Health Technical Memorandum
HVAC	Heating, Ventilating, and Air-Conditioning
IBC	International Building Code
IC	Instrumentation and Control Engineer
ID	Identity
IEC	International Electric Code
IMC	International Mechanical Code
ISO	International Organization of Standardization
JHA	Job Hazard Analysis
KPI	Key Performance Indicators
LEV	Local Exhaust Ventilation
LOTO	Lock Out, Tag Out
LPHW	Low Pressure Hot Water
ME	Mechanical Engineer
NFPA	National Fire Protection Association
NMA & FM	National Manual of Assets and Facilities Management
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
P&ID	Process and Instrument Design
PdM	Predictive Maintenance
PME	Plant, Machinery and Equipment
PMT	Post Maintenance Testing
PPE	Personal Protective Equipment
PM	Preventative Maintenance
PTAC	Packaged Terminal Air-Conditioning unit
PTW	Permit to Work
QA	Quality Assurance
QC	Quality Control
RA	Risk Assessments
RAMS	Risk Assessments and Method Statements
RCA	Root Cause Analysis
RH	Relative Humidity
RTF	Run to Failure
RTU	Roof Top Units
SBC	Saudi Building Code
SLA	Service Level Agreement
SMC	Saudi Mechanical Code
SOP	Standard Operating Procedure
ULPA Filter	Ultra-Low Particulate Air Filter
VAV	Variable Air Volume
VFD	Variable Frequency Drive
VRF	Variable-Refrigerant Flow

Table 1: Definitions

4.0 REFERENCES

- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) – HVAC Applications
- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) – HVAC Systems and Equipment
- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE 15) – Safety Standard for Mechanical Refrigeration
- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE 62) – Ventilation for Acceptable Indoor Air Quality
- Building Engineering Services Association (BESA SFG 20) – Maintenance Tasks Schedules
- Building Engineering Services Association (BESA TR19) – Duct and Kitchen Extract Cleaning
- Chartered Institution of Building Services Engineers (CIBSE) Guide M
- HSE Approved Code of Practice (ACOPs) – L8 & HSG274
- International Organization of Standardization (ISO 90001: 2015) – Document Management System
- Expro Projects White Book – Building Management System and Mechanical System Integration Guide
- Expro Projects White Book – Mechanical Design Guidelines
- Expro Projects White Book, Volume 10 – HSSE Introduction
- National Fire Protection Association (NFPA 70) – National Electrical Code
- National Fire Protection Association (NFPA 72) – National Fire Alarm and Signaling code
- National Fire Protection Association (NFPA 90A) – Standard for Installation of Air Conditioning and Ventilation Systems
- National Fire Protection Association (NFPA 92) – Standard for Smoke Control Systems
- National Fire Protection Association (NFPA 96) – Standard for Ventilation Control and Fire Protection of Commercial Cooking
- National Fire Protection Association (NFPA 101) – Life Safety Code
- National Manual of Assets and Facilities Management, Volume 5 Chapter 2.6 – Seasonal Planning
- National Manual of Assets and Facilities Management, Volume 5, Chapter 5 – Building Management System (BMS)
- National Manual of Assets and Facilities Management, Volume 6 Chapter 3 – Descriptions and Definitions – EOM-ZM0-PR-000002
- National Manual of Assets and Facilities Management, Volume 6 Chapter 3 – Preventive Maintenance Program Procedure
- National Manual of Assets and Facilities Management, Volume 6 Chapter 3 – Types of Maintenance
- National Manual of Assets and Facilities Management, Volume 6 Chapter 3 – EOM-ZM0-PR-000003
- National Manual of Assets and Facilities Management, Volume 6 Chapter 4 – Maintenance Plan Writers Guide
- National Manual of Assets and Facilities Management, Volume 6 Chapter 27 – PMT Procedure
- National Manual of Assets and Facilities Management, Volume 7 – Work Control
- National Manual of Assets and Facilities Management, Volume 7 Chapter 2 – Requesting, Prioritizing, Scheduling and Planning Work
- National Manual of Assets and Facilities Management, Volume 12 – Risk Management
- National Manual of Assets and Facilities Management, Volume 10 – HSSE
- National Manual of Assets and Facilities Management, Volume 11 – Quality
- Saudi Building Code (SBC 201) Building Code - General
- Saudi Building Code (SBC 501) Mechanical Requirements
- Saudi Building Code (SBC 801) – Fire Protection Requirements

Note: Based upon the requirements on international best practices and standards. These shall be from Saudi Building code (SBC), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Health Technical Memorandum (HTM), National Fire Protection Association (NFPA), American National Standards Institute (ANSI). These 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 shall be appointed by management to perform maintenance tasks on HVAC systems. Key personnel are described in the following table:

Role	Description
Mechanical Safety Group	The role of this group is to discuss current issues, solutions, and forthcoming potential problems (e.g., with new projects or dealing with new legislation), and to assist in avoiding project clashes, outages, and taking formulating mitigating actions
The Responsible Person (Director of Facilities)	The Responsible Person is employed directly by the Entity, and is the "Duty Holder" of the engineering systems and the staff who operate those systems. This person is overall responsible and accountable for the design, installation, Operation and Maintenance (O&M), and control of HVAC systems The Responsible Person has a legal responsibility to ensure that the Entity has complied with the relevant legal regulations pertaining to those engineering systems and the staff involved. The Responsible Person shall also ensure that the systems are kept up to date with the latest relevant legal regulations. This person shall not be the Authorizing Engineer (AE)
Facilities Management Company (FMC)	The FMC is an appointed client representative who in collaboration with the client controls the maintenance engineering departments, and is responsible and accountable for the Authorized Person(s) (AP) and Competent Person(s) (CP) as well as the site engineering systems, maintenance, and ensuring that control of those systems is in line with the client Standard Operating Procedure (SOP) for the maintenance activities
The Authorizing Engineer (AE (V)) (independent)	AE (V) is appointed by the Responsible Person (normally under the recommendation of the client) to take responsibility for the effective management of the safety guidance. The AE (V) shall possess the necessary degree of independence from local management to take action where necessary and alert the Chief Executive (in the event where the local management do not take action to avoid harm)
Authorized Person (AP (V))	An individual who has been appointed by the Authorizing Engineer (AE) (or by an authorizing body within the Entity). AP (V) shall be trained, competent, skilled, experienced, responsible, and has the necessary site knowledge to operate and maintain the system in a controlled and safe manner. The AP (V) is responsible for work or testing carried out on the system
Competent Person (CP (V))	An individual with the necessary training, and who has been appointed by an AP or by an authorizing body within the Entity, after conformation of competence, knowledge, skill, and experience. The CP (V) can execute the required actions within a Permit To Work (PTW) and/or other directional documents as may be assigned to him

Table 2: Roles and Responsibilities

All personnel involved with maintenance of HVAC 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 describes the process which maps above responsibilities to the action of planning and implementing Planned Maintenance.

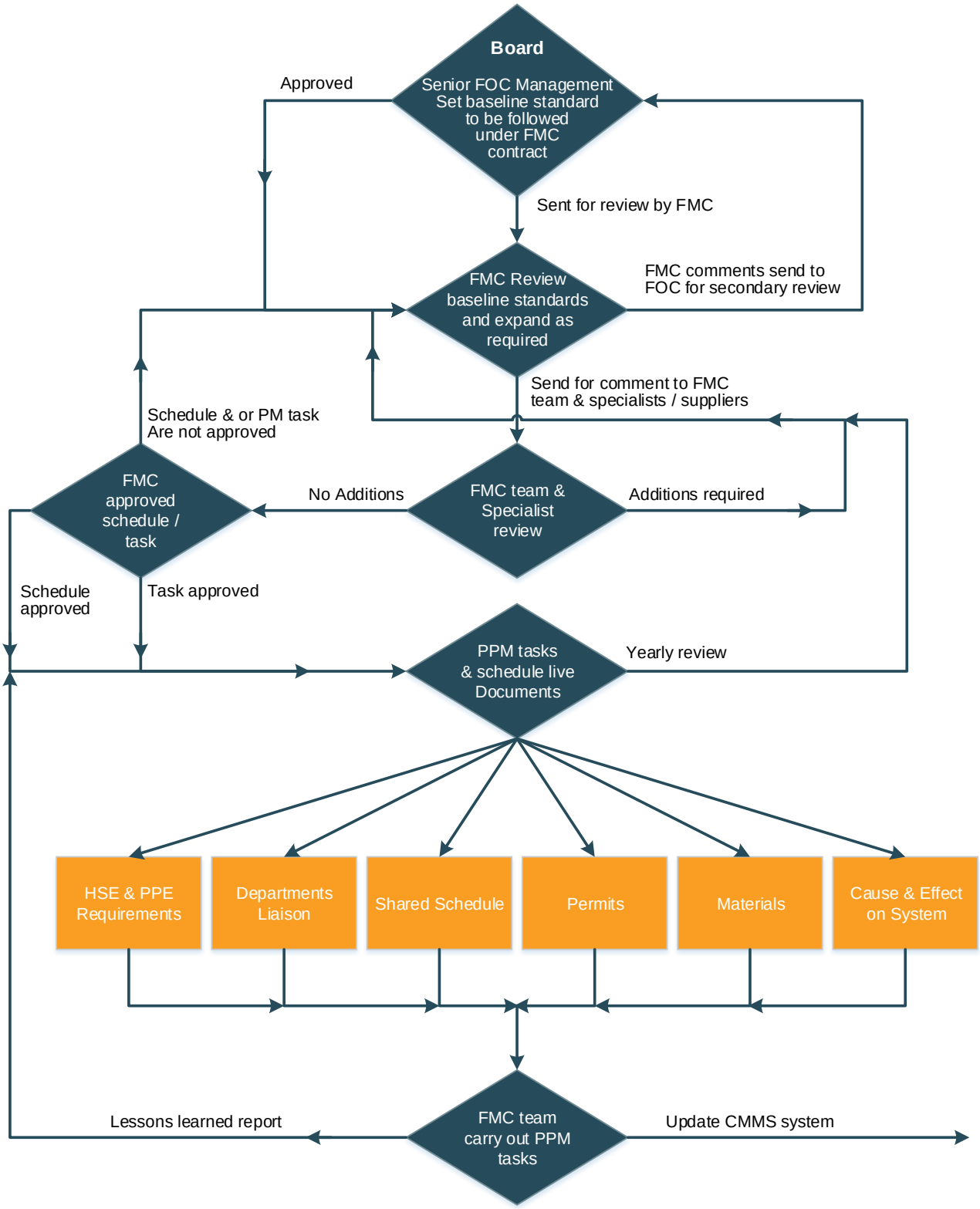

Figure 1: Roles and Responsibilities for PPM Scheduling and Implementation

5.1 Maintenance Management – HVAC Systems

Maintenance management plans involve the following:

- Health and safety (refer to NMA & FM, Volume 10 – Health, Safety, Security, and Environment)
- Maintenance plan standard requirements (refer NMA & FM, Volume 6, Chapter 4 – Maintenance Plan Writers Guide)

- Maintenance strategies, (refer to NMA & FM, Volume 6 Chapter 3 – Types of Maintenance)
- Quality (refer to NMA & FM, Volume 11 – Quality)
- Risk management (refer to NMA & FM, Volume 12 – Risk Management)
- Work management center (refer to NMA & FM, Volume 7 – Work Control)

These elements shall address the criticality of asset and an inventory of material issues e.g., long lead items, specialty items, spares, critical spares, Commercial off-the-Shelf (COTS) parts.

5.2 Mechanical Safety Group (MSG)

The aim of MSG is to introduce a structured approach for the management of mechanical services specific PME in compliance with current standards and guidelines. While not a direct requirement of the educational facility, it is deemed as best practice to adapt the example mentioned below to suit the Entity's goals and objectives.

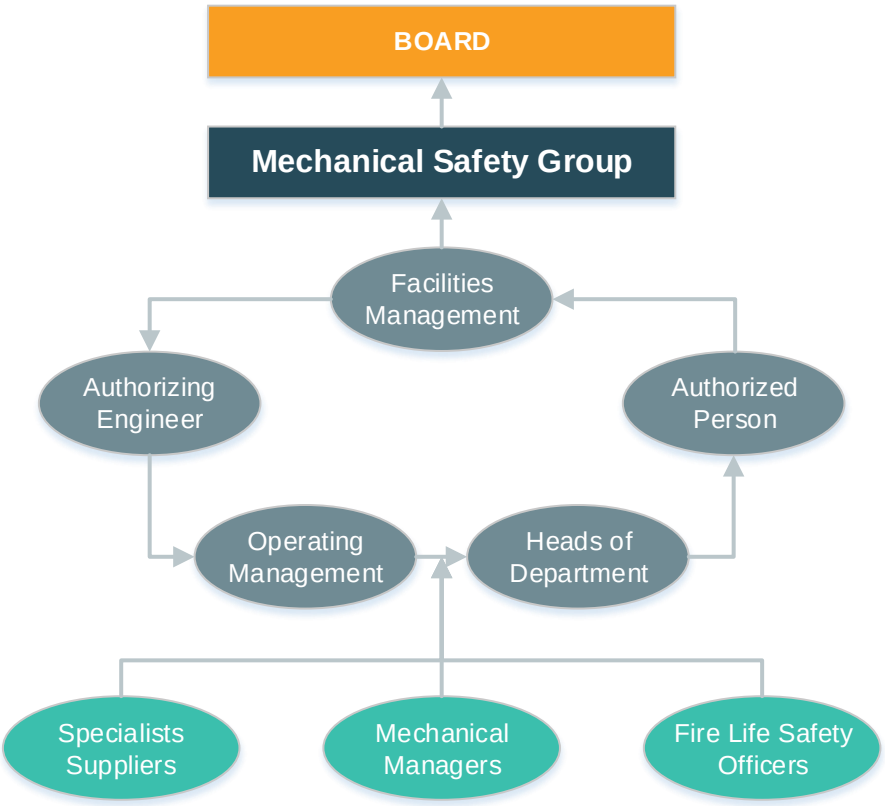

Figure 2: Mechanical Safety Group Organizational Structure

The reason for highlighting the organizational structure is to encompass those facilities, which may have a healthcare training, laboratory, or research element to their prospectus.

The primary purpose of the MSG is to guide stakeholders within the organization to implement a robust and measurable process for the safety and protection of those engaged in activities and the personnel (e.g., staff, students, visitors) that may come into contact. For example, it must ensure:

- Health and safety of employees in the conduct of their work
- Health and safety of those coming into contact or may be affected by activities
- Legal and statutory requirements of the organization
- Adherence to local and organizational requirements/standards
- Safe and effective maintenance using best practice and approved spare parts
- Communication to stakeholders and users
- Training and development of service staff

6.0 PROCESS

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

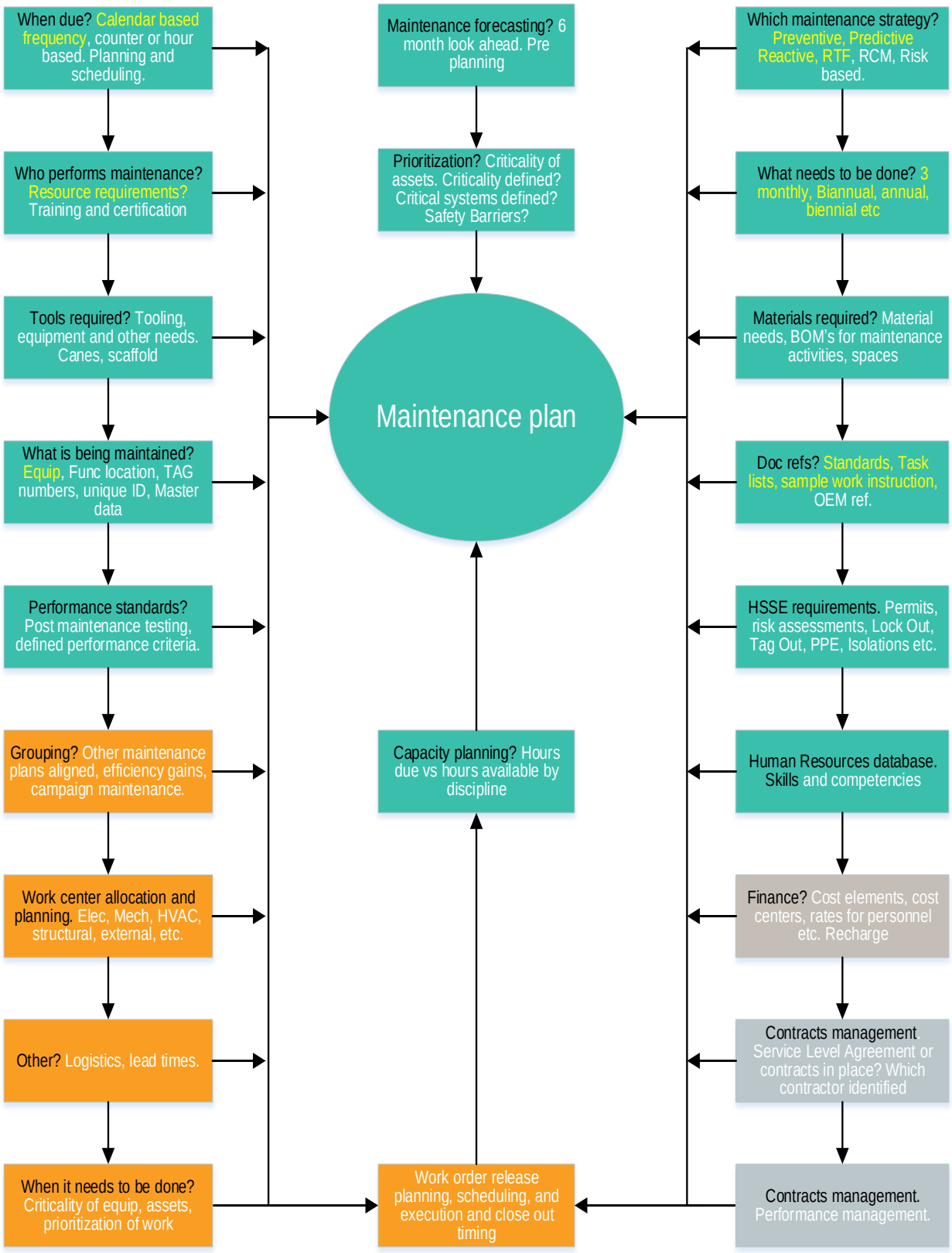

Figure 3: Maintenance Planning Components

6.1 Introduction to HVAC Systems

A central heating system provides thermal comfort to the whole interior of a building (or portion of a building) from one point to multiple rooms. When combined with a cooling system in order to control the building climate, the whole system may be considered as HVAC.

HVAC in schools and universities is used for quality air-conditioned supply to areas e.g., lecture theaters, classrooms, kitchen facilities, physical education areas. Air quality within a building is influenced by external and internal factors and the ability to maintain satisfactory air quality depends on:

- Identifying the factors that affect air quality in a specific application
- Controlling or eliminating detrimental factors and promoting beneficial ones

HVAC systems due to their dynamic nature, can significantly impact energy efficiency and operating costs for the schools and universities which require intensive energy use e.g., the use of HVAC in unoccupied areas, or outside peak working hours. Since the plant is normally controlled through local or building wide Building Management Systems (BMS), therefore, scrutiny of schedules shall be undertaken to prevent prolonged use of HVAC for reducing maintenance and utility costs.

The performance of a HVAC system will directly affect the facility's operating potential. Therefore, users of HVAC plant and equipment need to be aware of the system fundamentals in order to participate in the safe O&M of the systems. They shall be familiar with its arrangement and be able to start, stop, and isolate it in the event of an emergency. Service providers shall also be aware of current maintenance techniques in order to increase equipment efficiency and reliability, in relation to improving the HVAC utilization in existing and new buildings with the added benefits of, but not limited to the following:

- Increased equipment life to meet with the design life cycle
- Reduced downtime of plant and services through effective and targeted maintenance
- Utilization of best in class maintenance services
- Visibility of plant condition through effective reporting
- Increased performance and reduced utility costs

HVAC in schools and universities mostly comprise of a main HVAC system and associated sub-systems with equipment. Examples of HVAC systems typically found within such facilities include the following:

- Direct Expansion (DX)
- Variable-Refrigerant Flow (VRF)
- Variable Air volume (VAV)
- Computer Room Air-Conditioning (CRAC)
- Constant Air Volume (CAV)
- Roof Top Units (RTU)
- Air Handling Units (AHU)
- Fan Coil Units (FCU)
- Hybrid Heat Pump
- Chilled Beams
- Local Exhaust Ventilation (LEV)

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 HVAC systems within each facility:

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

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

6.2.1 Planned Maintenance

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

Task instruction sheets shall be prepared by each Entity as part of the planned maintenance regime to enable maintenance of HVAC systems describing the activity to take place at the prescribed frequency, a sample is contained within **Attachment 3**. Further examples can be obtained from the references highlighted above (e.g., SFG20 – Maintenance Task Schedules).

A Preventive 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 the ability to set threshold values against system parameters and execute trend analysis. HVAC systems maintenance plans captured within CMMS shall:

- Feature a prioritized list of tasks and associated frequencies
- Enable decision making which supports optimized system performance, maximizes equipment life, and offers energy and cost-saving opportunities
- Provide a list of critical/scheduled maintenance for assets

HVAC systems maintenance plans captured within CMMS shall also:

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

6.3.1 Record Keeping

HVAC systems design and performance information are 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, testing reports) associated with each system. In addition, this may be from third party specialists maintaining plant and equipment.

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 be stored in a centralized location with document numbering and control in line with ISO 90001: 2015 – Document Management System.

6.4 Maintenance Planning and Scheduling

The aim of maintenance planning for HVAC systems is to set out the activities that shall be undertaken, how the activities shall be performed, and how long each task shall take to complete.

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 and competencies necessary

- Assets to be maintained
- Maintenance activities to be executed and their associated type code (e.g. CM, PM, PdM)

Maintenance schedules shall be based upon several inputs including, but not limited to:

- Cross-department recommendations
- O&M team individual experience
- Equipment history
- Original Equipment Manufacturer (OEM) recommendations

Maintenance planners shall collaborate with internal and external stakeholders (as applicable) to achieve an optimized maintenance schedule.

Frequency of maintenance is a critical aspect of maintenance planning for HVAC systems. Frequency of maintenance shall range, for example from daily checks, up to major overhauls on a five year basis.

During maintenance planning tasks, a cause and effect matrix shall be prepared to comprehend the full impact of maintenance on operations within the school and university building. This exercise may be captured within the Risk Management described within **Section 6.10**.

Further guidance is provided within NMA & FM, Volume 7 Chapter 2 – Requesting, Prioritizing, Scheduling and Planning Work - EOM-ZW0-PR-000001.

6.5 Special Maintenance Planning

Annual inspection and verification are required for facilities with life science applications. Any specialized ventilation plant installed in university laboratories dealing with research, development or testing, whether involving drugs, animals, or genetically modified organisms, may be subject to a particular legislation with regard to their operation.

All ventilation systems shall be subject to at least a simple visual inspection annually. The purpose of the inspection is to establish that the:

- System is still required
- AHU conforms to the minimum standard
- Fire containment has not been breached
- General condition of the system is adequate for purpose
- System overall is operating in a satisfactory manner
- System is operating in compliance with statutory/regulatory restrictions, if applied

6.5.1 Critical Ventilation Systems

All critical ventilation systems shall be inspected quarterly and verified at least annually. In some circumstances, the verification may need to be carried out more frequently.

The purpose of the annual verification will be to ensure that the system achieves minimum standards specific to the application, is operating to an acceptable performance level, and remains fit for purpose.

Ventilation systems that serve the following are considered critical:

- Laboratory areas used for training or otherwise, including rooms used as chemistry facilities, requiring fume cabinets and dedicated ventilation systems.
- Category 3 or 4 laboratory or room (e.g. veterinary facilities used for instruction purposes)
- Any system classified as the LEV system under the Control of Substances Hazardous to Health (COSHH) Regulations
- Areas that require constant cooling and air-conditioned atmospheres (e.g., data halls, rooms containing critical IT equipment)

The loss of service from such a system would seriously degrade the ability of the premises to deliver optimal services.

6.5.2 Commercial Catering Exhaust Ventilation

Maintenance considerations shall be taken for the catering extract systems and their associated ductwork, especially in commercial kitchens which use appliances that produce greasy by products and smoke while cooking. All ductwork must be inspected at regular intervals to see if they require cleaning and analyze that the accumulation of grease and dirt in the system does not exceed acceptable standards.

The main concern is with kitchen canopy extract plenums, which if not properly cleaned and maintained correctly can poses a serious health and fire risk. Additionally, the accumulation of greases and debris in these systems can attract vermin and insects to the area. A comprehensive maintenance regime shall be in line with the international standards mentioned below:

- Building Engineering Services Association (BESA TR19) – Duct and Kitchen Extract Cleaning Systems
- National Fire Protection Association (NFPA 96) – Standard for Ventilation Control and Fire Protection of Commercial Cooking

6.5.3 Basic Requirements of Validation

- The plant must not contain any material or substance that could support the growth of microorganisms
- The plant must not contain any material or substance that could cause or support combustion
- Access to items that require routine service, such as filters, fog coils, and chiller batteries, shall be via hinged doors, with hold back facilities to prevent entrapment
- Electrical and mechanical services shall not restrict or impede access to those parts of the AHU that require inspection
- Viewing ports and internal illumination shall be fitted in order to inspect filters and drainage trays
- Internal illumination shall be provided by fittings to at least IP55 rating. Fittings shall be positioned so that they provide both illumination for inspection and task lighting
- Have a means of isolating services through dedicated electrical, mechanical means. Able to attach a padlock or appropriate locking device

6.5.3.1 Filtration

Filters must be securely housed and sealed in well-fitting frames that minimize air bypass. Air bypass can significantly reduce filter efficiency; the higher the filter grade, the greater the effect. Mounting frames shall be designed so that the air flow pushes the filter into its housing to help minimize air bypass.

High Efficiency Filters – High Efficiency Particulate Air (HEPA) and Ultra-Low Particulate Air (ULPA)

HEPA/ULPA filters are sometimes used in extract systems for the containment of hazardous substances organisms. They may be fitted with pre-filters to extend their service life. Where fitted, HEPA or ULPA filters shall be of the replaceable panel type with leak proof seals. Their installation shall permit the validation of the filter and its housing.

6.6 Quality Control and Quality Assurance (QA/QC)

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

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

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

QA shall be determined using several techniques and data analysis, including:

- Findings deduced from CMMS data trending
- Checklists designed for each maintenance activity
- 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 an AP

For further information, refer to ISO 9001 – Quality Management System

6.7 Spare Parts

Spare parts are components featuring an asset tag which are used to replace damaged, expired, or failed parts of HVAC systems. However, consumables are those which are not assigned an asset tag but are required for a HVAC system to operate or as part of a PM (e.g., filters, lubrication grease, drive belts).

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

- Maintenance strategy
- Spare parts list
- Running arrangements
- Risk Assessments (RA)

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 Identity (ID) and location indicator

The BOM shall become part of the CMMS to enable centralized storage and retrieval of asset data for HVAC systems. However, in case of unavailability of CMMS, a soft copy of the BOM shall be available with 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. Generally, this is an additional module of the CMMS system which can assist with the procurement and timely ordering of consumables required prior to a scheduled PM activity. 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 manufacturer 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 backup arrangements
- Alternate material selection options
- Technical specifications

Parts with high failure rates shall be highlighted through maintenance activities and further analysis shall be performed to identify root cause analysis of component failure.

6.8 Maintenance Testing

The Entity's asset management strategy, performance requirements, organizational maturity, and funding are the factors that dictate the Entity's approach to maintenance testing.

Post Maintenance Testing (PMT) shall be performed, as required, following execution of maintenance activities.

For further information, refer to NMA & FM, Volume 6 Chapter 27 – PMT Procedure (EOM-ZM0-PR-000008).

6.9 Health and Safety

Maintenance of HVAC systems holds inherent hazards due to proximity of energized equipment and moving parts. Maintenance activities which pose significant risk to people and to HVAC 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 malfunction. Given that the mechanical systems drive HVAC within all school and universities, scheduled maintenance during summer months, for instance, requires activities to be executed such that downtime is minimized. CM executed during the same period shall 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, and then work to reduce risk to people, systems, and the environment.

Maintenance activities on HVAC equipment shall only be undertaken by personnel who are trained in the risks associated with the activity and are fully knowledgeable about the systems being worked upon, for their safety and those that are affected by their actions.

6.10 Risk Management

The facilities maintenance team shall complete a comprehensive set of Risk Assessments and Method Statements (RAMS) covering each HVAC system within 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 be included within all RAMS and shall sign onto JHA as required.

The below elements shall be considered when carrying out a RA for HVAC systems maintenance:

- Identify hazards associated with each maintenance activity, for example loss of critical systems (e.g. HVAC, water), impact on operation of the facilities, and equipment failure
- Establish maintenance personnel, service providers, and building users who are at risk as a result of the maintenance activity
- Evaluate quantitative risks using a risk matrix. Involve maintenance team, subject matter experts, and HSSE team in RA process and hold a RA workshop as necessary
- Take action by deciding on mitigation measures needed, required investment, responsibilities, and timeline
- Review the risk evaluation following implementation of mitigation measure
- Record findings

7.0 ATTACHMENTS

1. Attachment 1 – EOM-ZMO-TP-000108 Skill Level Requirements Matrix HVAC Systems – Schools & Universities
2. Attachment 2 – EOM-ZMO-TP-000109 Preventive Maintenance (PM) Inclusion Check Matrix – Schools & Universities
3. Attachment 3 – EOM-ZMO-TP-000110 Plan/Activity Frequency – Task Instruction Sheet for HVAC Systems in Schools & Universities

Attachment 1: EOM-ZM0-TP-000108 Skill Level Requirements Matrix HVAC Systems – Schools & Universities

NOTE:

- This matrix is a guide representation only and should not be replicated as a true illustration of the HVAC system competency level requirements
- This matrix guide is not a final and comprehensive table and requires further development in line with the facilities' HVAC system assets

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 3 Specialist – Manufacturer/Manufacturer Trained and Certified

Type of Maintenance Task	Service Provision by:		Required Competency Level
HVAC Systems	In-house	Specialist Supplier	Level 1/2 in-house and Level 1 specialist
Central Heating and Cooling Systems	☑	☑	
Air Distribution Systems	☑	☑	
In-Room Terminal Systems	☑		
Applied Heat Pump and Heat Recovery Systems		☑	
Forced Air Heating and DX Cooling Systems	☑	☑	
Steam Systems (humidification)	☑	☑	
Hydronic Heating and Cooling Systems		☑	
Variable-Refrigerant Flow Systems	☑	☑	
Dust Collection Systems	☑	☑	
Condenser Water Systems	☑	☑	
Specialist Systems		☑	
Emergency Life Safety Systems		☑	
DX and Split units	☑		
Chilled Water Systems	☑	☑	
Chillers	☑	☑	

Attachment 2: EOM-ZM0-TP-000109 Preventive Maintenance (PM) Inclusion Check Matrix – Schools & Universities

NOTE:

- This matrix is a guide representation only and should not be replicated as a true illustration of the designated system categories or inclusion elements such as compliance, standard, regulatory, manufacturer, and best practice
- This matrix is not a final and comprehensive table and requires further development in line with the facilities HVAC system assets

Description			System Equipment Category					Type of PPM included in Plan					Compliant to
ME Systems	Sub-System	Equipment	Life Safety	Critical	Essential	Utility	Non-Essential	Compliance	Standard	Regulatory	Manufacturer	Best Practice	NFPA/HTM
HVAC System	Central Heating and Cooling	Direct Expansion (DX)			X			X	X	X	X	X	
	Air Distribution System	Variable-Refrigerant Flow (VRF)			X			X	X	X	X	X	
X	DX Units	Variable Air Volume (VAV)			X			X	X	X	X	X	
X	Split Units Cassettes	Constant Air Volume (CAV)		X	X				X	X		X	
X		Roof Top Units		X	X				X	X		X	
X		Air Handling Units		X	X				X	X		X	
X		Fan Coil Units		X	X				X	X	X	X	
X		Hybrid Heat Pump						X	X	X	X	X	
		Local Exhaust Ventilation (LEV)	X	X				X	X	X	X	X	
Chiller Plant	Cooling Towers	Automatic Dosing Systems			X			X	X		X		
Air Cooled	Compressor	Pumps			X			X	X		X		
Water Cooled	Evaporators	Pressurization Unit			X			X	X			X	
	Condensers	Control Panels			X			X	X			X	
	Refrigerants	Control Valves			X			X		X		X	
	Heat Recovery Systems	Bypass Valves			X					X		X	
	Hydronic DIS systems				x					X		X	
	Heat Exchangers					X							
Water Treatment	Chilled Water	Automatic Dosing Systems		X					X		X	X	
	Cooling Tower	Automatic Controllers		X					X		X	X	
	Steam Boiler	Carbon Filters		X					X	X		X	

Description			System Equipment Category					Type of PPM included in Plan					Compliant to
ME Systems	Sub-System	Equipment	Life Safety	Critical	Essential	Utility	Non-Essential	Compliance	Standard	Regulatory	Manufacturer	Best Practice	NFPA/HTM
	Sewage Treatment Plant	Air Blowers				X			X	X	X	X	
	MTHW Water Supply	Valves		X				X	X	X	X	X	
	Water Heater	Isolation Valves			X			X	X	X	X	X	
	All types of Pumps	Butterfly Valves				X	X		X	X		X	
Life safety S/M	FM200	Smoke Dampers	X	X				X	X	X	X	X	
	Fire Alarm	Fire Pumps	X	X				X	X	X		X	
		Pressure Extract Fans	X	X				X	X	X	X	X	

Attachment 3: EOM-ZM0-TP-000110 – Plan/Activity Frequency – Task Instruction Sheet for HVAC Systems in Schools & Universities

An example Task Instruction Sheet for HVAC Systems is featured below. The Entity should use it as a basis by which to develop its own site-specific Task Instruction Sheets for HVAC Systems.

Skill Types

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

HVAC System

HVAC Systems Terminal Unit FCU			
Item	**FQ**	**Action**	**Skill Level**
Status	6M	Switch off and isolate	ME
Condensate Drain Connection and Pump		Check connection is clear. Ensure condensate lift pump is operational and able to discharge condensate to the drainage pipework	
Permanent Filters		Clean and refit, ensuring proper location	
Disposable Type Filters		Replace, ensuring proper location	
Test Unit		Restore power supply and run unit. Check airflow is normal at correct speed setting	
Casing		Cleaning	
Ductwork Flexible Couplings (if fitted)	12M	Check condition. Repair/refix any ductwork to the spigots as necessary	
Grilles and Diffusers		Clean using vacuum or alternatively, remove, and clean	
Strainers		Inspect and clean strainers as necessary	
Chilled Water/LPHW control Valves	6M	Check functioning	
Thermostats	12M	Check operation by moving set point. Restore to original setting	
HVAC System - Active Chilled Beams			
Active Chilled Beams	12M	The frequency of cleaning will be driven by the environment in which the beams are installed and the filter level in the AHU and this should be reviewed on a site-by-site basis	ME
Heating and Cooling Coil		Vacuum all dirt clear to ensure air has a free path through the exchanger for maximum performance. If the fins are damaged, comb back into shape	
Air Connection Spigot		Check the air connection spigot is secure	
Unit Diffuser		Clean the unit with a cloth wetted with detergent diluted with water	
Control Valve		Check the operation of both the cooling and heating (as applicable) control valves. Take note of any signs of leaking and correct and/or report as appropriate	
Hoses		Check condition and report any signs of rusting or leakage	
HVAC System - Passive Chilled Beams			
Active Chilled Beams	12M	The frequency of cleaning will be driven by the environment in which the beams are installed. This should be reviewed on a site by site basis	ME
Item		**Action**	

HVAC Systems Terminal Unit FCU			
Heating and Cooling coil		Vacuum all dirt clear to ensure air has a free path through the exchanger for maximum performance. If the fins are damaged, comb back into shape	
Unit Diffuser Panel		Clean the unit with a cloth wetted with detergent diluted with water	
Control Valve		Check the operation of both the cooling and heating control valves, as applicable. Take note of any signs of leaking and correct and/or report as appropriate	
Hoses		Check condition and report any signs of rusting or leakage	