Best Practices for Operation and Maintenance Service of

HEATING, VENTILATION AND AIR CONDITIONING INSTALLATIONS

機電工程署
EMSD

Disclaimer

The Electrical and Mechanical Services Department of the Government of the Hong Kong Special Administrative Region, China ("the EMSD") publishes this booklet for the purpose of collecting, sharing and outlining the general, good and best practices for operation and maintenance service of heating, ventilation and air-conditioning installations ("the Booklet") based on the best knowledge exchange with trade practitioners.

This Booklet serves as good reference at the time of publication, and shall be reviewed and updated with trade practitioners on need basis, in particular on exchanging and updating new practical innovative and technology initiatives applied in operation and maintenance activities.

Users of relevant trade stakeholders such as building owners, building occupants, facility management professionals, maintenance agents and relevant trade operators are free to consider and adopt the subject practices when satisfying their own operational needs and reference. The legal provisions referred to in this Booklet shall be construed in accordance with the relevant ordinances of the Government of the Hong Kong Special Administrative Region. Users should not only rely on the information given in this Booklet and could consult independent and relevant professional personnel whenever there are doubts about the application of the relevant ordinance or guidelines stated on the Booklet on individual circumstances.

Whilst every effort has been made to ensure and upkeep the accuracy of the Booklet at the time of publication, the EMSD shall not be responsible for any liability howsoever caused to any person by the use of or reliance on this Booklet.

Acknowledgements

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Working Group on Compilation of Booklet

- **Architectural Services Department, the Government of the Hong Kong Special Administrative Region, China**
- **Building Services Operation and Maintenance Executives Society**
- **City University of Hong Kong (Division of Building Science and Technology)**
- **Hong Kong Housing Society**
- **Housing Department, the Government of the Hong Kong Special Administrative Region, China**
- **Mott MacDonald Hong Kong Limited**
- **The American Society of Heating, Refrigeration and Air Conditioning Engineer (Hong Kong Chapter)**
- **The Association of Consulting Engineers of Hong Kong**
- **The Chartered Institution of Building Services Engineers (Hong Kong Region)**
- **The Hong Kong Air Conditioning and Refrigeration Association**
- **The Hong Kong Association of Property Management Companies Limited**
- **The Hong Kong Federation of Electrical and Mechanical Contractors Limited**
- **The Hong Kong Institution of Engineers (Building Services Division)**
- **The Hong Kong Institute of Facility Management**
- **The Hong Kong Polytechnic University (Department of Building Environment and Energy Engineering and Department of Mechanical Engineering)**
- **The Real Estate Developers Association of Hong Kong**

Benchmarking Organisations

- **Henderson Land Development Company Limited**
- **Housing Department, the Government of the Hong Kong Special Administrative Region, China**
- **Hong Kong Jockey Club**
- **Hong Kong Science and Technology Parks Corporation**
- **Hong Kong University of Science and Technology**
- **Link Asset Management Limited, Link REIT**
- **Mass Transit Railway Corporation Limited**
- **New World Development Company Limited**
- **Savills (Hong Kong) Limited**
- **Sun Hung Kai Properties Limited**
- **Swire Properties Limited**

Preface

The EMSD endeavours to collaborate with the trade practitioners for adopting best practice and innovative technologies to improve the management of E&M assets, thereby enhancing the resilience and intelligence in buildings.

This Booklet recommends a basic framework for 15 key attributes important to users such as facility management professionals and relevant stakeholders involved in the design, construction, operation, maintenance, alteration, addition and replacement of heating, ventilation and air conditioning (HVAC) installations in buildings. Under each key attribute, it outlines the general, good and best practices for operation and maintenance service of HVAC installations based on the best knowledge exchange with trade stakeholders, regardless of size, complexity or location.

With the dedicated collaboration and commitment with our trade practitioners, it is intended to develop the guiding practices that are professional, reliable, up-to-date and widely applicable for the asset management of most of the relevant electrical and mechanical assets in Hong Kong.

TERMS, DEFINITIONS AND ABBREVIATIONS

AC Contractor	The Nominated Sub-contractor or the Specialist Sub-contractor employed by the Building Contractor or the contractor directly employed by the Employer as appropriate for the execution of the Installations in accordance with the Contract.
Installations	The work or services for the heat, ventilation and air conditioning (HVAC) Installations forming parts of the Works to be installed, constructed, completed, maintained and/or supplied.
Particular Specification	The specifications drawn up specifically for the Installations of a particular project.
ANSI	American National Standards Institute
ArchSD	Architectural Services Department, the Government of the Hong Kong Special Administrative Region, China
ASTM	American Society for Testing and Materials
BS	British Standards, including British Standard Specifications and British Standard Codes of Practice, published by the British Standards Institution
BS EN	European Standard adopted as British Standard
EMSD	Electrical and Mechanical Services Department, the Government of the Hong Kong Special Administrative Region, China
EPD	Environmental Protection Department, the Government of the Hong Kong Special Administrative Region, China
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
OFCA	Office of the Communications Authority of the Government of the Hong Kong Special Administrative Region
WSD	Water Supplies Department, the Government of the Hong Kong Special Administrative Region, China

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1 Introduction

1.1 About This Best Practice Booklet

This Booklet is intended to outline the guiding principles on general, good and best practice to be considered during the design, construction, operation, maintenance, alteration, addition and replacement for the heat, ventilation and air conditioning (HVAC) installations in buildings to upraise the efficiency of asset management.
It is designed for those users who are currently engaged in asset management of these installations in existing buildings or those who plan for new design and fitting-out works with these installations in new buildings. This Booklet should be read in conjunction with applicable ordinances and regulations in Hong Kong.

1.2 Target Audience

Target audiences of this Booklet are primarily for trade stakeholders including building owners, building occupants, facility management professionals, maintenance agent or relevant trade operators.

While in daily operations, the safety, system reliability, operational efficiency and sustainability of the assets rely on the daily operation and maintenance practices. In this regard, some information and recommendations to the interest of the trade stakeholders are outline in this Booklet as reference.

1.3 How to Use This Best Practice Booklet

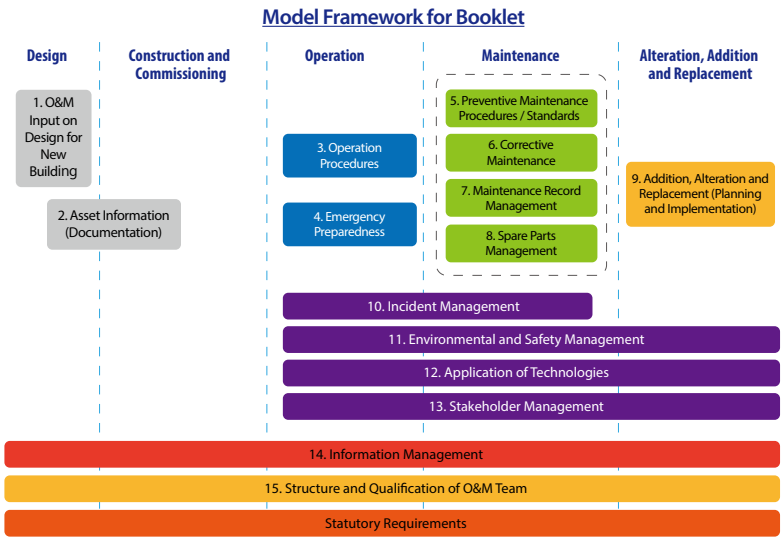
This Booklet mainly covers 15 key attributes in the following stages in new and existing buildings:

- **Design, Construction and Commissioning,**
- **Operation and Maintenance and**
- **Alteration, Addition and Replacement.**

The 15 key attributes are the key main considerations for achieving good or best performance in asset management of the HVAC Installations in buildings. Three levels of guiding principles, namely general, good and best practice, with associated examples of trade practices have been defined in each key attribute as reference. An additional chapter on "Innovative and Technology Initiatives" has also been included about the trend of technologies likely to be adopted to upraise the operation and maintenance service.

Level	Category	Description
Level 1	General Practice	Involving general operating practices in fulfilling statutory requirements and aligning common practice in the trade industry
Level 2	Good Practice	Involving good operating practices with higher standard on enhancing either asset safety, system reliability, operational efficiency or sustainability
Level 3	Best Practice	Involving best operating practices with highest standard on asset management with use of innovative technologies or relevant life-cycle considerations

The figure provides an illustrative map for the 15 key attributes in different sections of the booklet.



A summary of the contents in this booklet is as follows:

Section 1: Introduction to this Best Practice Booklet

Describes the important drivers for a building to perform efficiently and safely. This section explains what this Booklet is about, identifies key stakeholders, and directs the reader to specific sections.

Section 2: Operation and Maintenance Best Practice Attributes

Describes the 15 key attributes for implementing good performance operation and maintenance of HVAC Systems in buildings. It defines three levels of practices namely, general, good and best practice, for each.

The 15 key attributes are:

(i) O&M Input on Design for New Building – It is important for Design Engineers to consider accessibility and maintainability right from the planning and design of a facility, through its life cycle.

(ii) Asset Information (Documentation) – Good documentation is essential for facilitating good operation and maintenance. This section describes the key documents that are required for the efficient operation and maintenance of HVAC Systems.

(iii) Operation Procedures - All activities associated with the routine, day to day use, support, and maintenance of a building or physical asset; inclusive of normal/routine maintenance. O&M procedures at the system level do not replace manufacturers' documentation for specific pieces of equipment, but rather supplement those publications and guide their use.

(iv) Emergency Preparedness – Being prepared for emergencies is important, and emergency management allow stakeholders to anticipate the types of potential hazards that could occur, and to think of ways to reduce the impact.

(v) Preventive Maintenance Procedures / Standards - Preventive Maintenance consists of a series of time-based maintenance requirements that provide a basis for planning, scheduling, and executing scheduled (planned versus corrective) maintenance. It is of a planned nature (versus the unplanned nature of Corrective Maintenance (CM)).

(vi) Corrective Maintenance – This is an essential maintenance task performed to correct failures, breakdowns, malfunctions, anomalies or damages detected during inspections, or through monitoring, alarming, or reporting or any other source. The actions taken will aim to restore plant and equipment back into regular and required operation mode.

(vii) Maintenance Record Management – This is a key part requiring efficient storage and management. Proper maintenance records minimise the number of expensive repairs, increase safeness in operation and enhance the visibility of equipment health.

(viii) Spare Parts Management – Managing spare parts in an optimal way is an inherent and substantial part of O&M aimed at ensuring that spare parts are available in a timely manner for corrective maintenance in order to minimise the downtime of a system or equipment.

(ix) Addition, Alteration and Replacement (Planning and Implementation) - This includes the analysis, procurement, management on additional, alteration as well as disposal and replacement of assets to meet the organisation's long term aims and objectives.

(x) Incident Management – This is the essential process to restore normal service operation as quickly as possible and limit the potential disruption caused by an incident.

(xi) Environmental and Safety Management - The Building Owner has the ultimate legal and moral responsibility to ensure the health and safety of people in and around the building and for the protection of the environment around it.

(xii) Application of Technologies - Integration and adaptation of new technologies with innovative methods to optimise system performance as well as operational effectiveness.

(xiii) Stakeholder Management – This is a critical component to the successful delivery of any service. It allows the correlation of stakeholders with potential known triggers, such as disruptions to their normal patterns and update on work progress, etc. It also estimates the impact that these reactions may have on your project or strategies and identifies whether targeted communication, mitigation or an alternative solution is required.

(xiv) Information Management – This concerns a cycle of organisational activity involving the acquisition of information from one or more sources, and the custodianship and distribution of that information to those who need it.

(xv) Structure and Qualification of O&M Team - It is of critical importance that all O&M teams have a proper structure and their personnel have the relevant qualifications to perform the works in a safe, responsible and accountable manner.

Section 3: Innovative & Technology Initiatives

Describes the latest technology development in the use of innovative and technology initiatives adopted for O&M services for HVAC Installations.

Section 4: Industrial Standards and Requirements

Describes the summary of relevant statutory requirements involved in the O&M services for HVAC Installations.

Section 5: Useful Forms – Samples

Describes the commonly used forms / checklists adopted in O&M services for HVAC Installations.

1.4 Stakeholder Responsibilities

Trade stakeholders should be aware of their roles, responsibilities and commitments to drive for implementation of the good and best practice, whenever applicable, for the betterment of their routine asset management.

It is essential that all involved stakeholders shall work collaboratively as a team. While those involved for improving the current practices, they shall commit to facilitate and provide sharing on the necessary training, practical experience, knowhow and awareness of modern technology and the skills of optimising performance in their organisations.

1.4.1 Building Owner

The Building Owner has the ultimate responsibility for operating and maintaining the base / central building services installations in adherence with all applicable legal requirements.

The Building Owner should motivate and empower all Stakeholders to deliver efficiencies through O&M practices. The policies and strategies set by the Building Owner should drive the process for setting up the implementation of maintenance contracts and efficiency measures.

1.4.2 Building Occupant (Tenant)

Tenants hold the responsibility to ensure that the operation of the equipment is efficient, human behavioural patterns do not affect the efficiency of the HVAC Systems, and that work carried out during tenancy fit-outs does not affect the performance of base building services installations.

Tenants should adhere to the lease conditions when available, including Green Leases and Tenancy Fit-Out Guidelines, that express mutual expectations between Building Owners and Tenants with regards to operation, maintenance and performance requirements of buildings.

1.4.3 Facilities Manager

The Facilities Manager (FM) is responsible for the building management. The FM should implement the maintenance and environmental policies and strategies set by the Building Owner in accordance with the allocated resources. The FM must take on the role of the champion who leads the process for implementing changes that deliver better practices for the O&M of the building.

It is important for the FM to develop a maintenance regime that is geared towards delivering good outcomes in partnership with Maintenance Service Providers, who would benefit from the enhanced system efficiency. Forming good relationships and ensuring effective channels of communication including good documentation, is an important aspect to the process.

2 Key Model Framework

2.1 O&M Input on Design for New Building

Design for maintainability emphasises the importance of timely integration of design and construction knowledge with O&M experiences into the project design in order to optimise building life.

Accessibility and maintainability should be considered, and incorporated in to the building system design, ensuring the ease, accuracy, safety, and economy of maintenance tasks within that system. Maintainability refers to the effectiveness and efficiency of maintenance activities. New working practices encouraged, such as Building Information Modelling for Asset Management (BIM-AM), require the involvement of asset owners and FMs to understand the information they require on handover. FMs should be involved during design stage and ensure the information handed over by the contractor fits their specific needs.

★☆☆ Level 1

GENERAL PRACTICE

2.1.1

- Develop design according to various codes of practice and guidance documents on operation management and maintenance of HVAC systems;
- Seek and integrate design and testing and commissioning advice from maintenance team on maintenance accessibility and maintainability aspects of HVAC installations;
- Seek and integrate testing and commissioning advice from maintenance team;

- Test and commission the system to the satisfactory of the building owners, designers, operation and maintenance personnel (in house or outsourced), FM Manager;
- Provide training to operation and maintenance personnel (in house or outsourced) before putting the system in operation.

Level 2

GOOD PRACTICE

2.1.2

- Identify key design, commissioning and maintenance requirements for referral by designers, installers, operators and management;
- Collaboration of O&M team and project design team at various design stages of project to provide input a system design with the best operability and maintainability of installed systems; Project Team to walkthrough the O&M provisions incorporated in the design for the O&M team review;
- Establish design checking matrix covering accessibility and maintainability for incorporation by design consultants;
- Obtain maintenance requirements from potential major equipment suppliers for review by designers, operation and maintenance team.

Level 3

BEST PRACTICE

2.1.3

- Develop design with considerations of requirement in the life cycle of HVAC systems from commissioning, operation and maintenance through mid-life refurbishment to decommissioning or total replacement;
- Adapt design to incorporate facilities (e.g. isolation facilities for equipment replacement or sectional piping/cabling replacement, redundancies, interconnections, changeover and by-pass facilities) to maximise system resilience at contingency and minimise impact to users during maintenance activities;
- Establish in-house design guidelines for accessibility and maintainability aspects with regular review and update;

- Adopt Construction Design and Management (CDM) guidance to improve health and safety aspects on building construction and maintenance;
- Collect views from O&M team on the operability and maintainability of various building services systems to provide support to improve/refine the system performance before end of defect liability period.

2.2 Asset Information (Documentation)

Asset Information should be compiled, covering all major items of HVAC systems in a format that is useful to the FM and Maintenance Service Provider. The information should be placed in readily accessible locations, and updated regularly with:

- Any repairs, upgrades, refurbishments, maintenance or decommissioning work.
- Updates to assessment information (relating to performance or risk).
- Changes in the wider environment (including regulations, responsibilities or ownership).

★☆☆ Level 1

GENERAL PRACTICE

2.2.1

- Maintain proper upkeeping of certificates, license, as built drawings, final approved statutory design submissions, O&M Manual and other documentations as per statutory Requirements;
- Assign designations for each equipment for easy reference;
- Possess design documentation (e.g. design criteria, room datasheet, design calculations etc.).

Level 2

GOOD PRACTICE

2.2.2

- Possess up to date as-built drawings, testing and commissioning (T&C) reports, O&M instructions/manuals, and equipment lists showing brand name, model, rating, year of installation, etc., backup software, recommended spare part lists, tool lists and suppliers' contact, etc.;
- Maintain efficient asset information and filing system to administer and update all possessed asset information is available;
- Designate person(s) responsible to regularly update asset information and / or asset register.

Level 3

BEST PRACTICE

2.2.3

- Possess design documentation (e.g. design criteria, room datasheet, design calculations etc.);
- Digitise of all asset information with standardised file naming system in a reliable database server for easy retrieval;
- Implement computer-based Asset Management (AM) systems for asset records and version control, with corresponding workflow for data retrieval and as built updates, to ensure date validity throughout life cycle of assets;
- Maintain a computer database for monitoring of statutory documents with reminder functions for expiry and renewal, and ensure statutory compliance;
- Provide an interface for computerised asset information models such as BIM to enable essential asset information to be retrieved from asset information database easily whenever necessary.

2.3 Operation Procedures

Operational efficiency refers to the life-cycle, cost-effective mix of preventive, predictive, and reliability-centred maintenance technologies, coupled with equipment calibration, tracking, and computerised maintenance management capabilities all targeting reliability, safety, occupant comfort, and system efficiency.

★☆☆ Level 1

GENERAL PRACTICE

2.3.1

- Provide guidelines on requirements of manning level and qualification of O&M direct staff and / or contractor staff in discharging routine O&M services;
- Provide basic operation procedures of HVAC systems / equipment (e.g. plant switching instructions);
- Provide guidelines on requirements of maintenance frequency and procedures, performance target on fault attendance and rectification, inspection, testing and certification works;
- Provide general safety-related guidelines as well as induction training, risk assessment procedures and permit-to-work systems for routine O&M services;
- Provide guidelines on requirements of tools and equipment such as platform ladders, trestles, hand-held communication tools, calibrated measurement & testing equipment, materials or parts necessary for execution of O&M services and transportation tools and equipment;
- Provide basic guidelines including emergency plan and contact list for property management personnel.

Level 2

GOOD PRACTICE

2.3.2

- Maintain standardised checklists for inspection, testing and recording operation parameters of HVAC installations and equipment;
- Provide guidelines on requirements of uniform with badges and identity cards for O&M direct staff and contractor staff;
- Conduct awareness briefings and/or refresher training on "Do's and Don'ts" for property management personnel for using HVAC equipment under emergency situations;
- Upkeep essential operation information for review;
- Adopt system optimisation for improvement on energy performance and monitoring.

Level 3

BEST PRACTICE

2.3.3

- Establish hierarchy of policies, standards, procedures, instruction manuals and guidelines on O&M practices with appropriate approvals from competent and responsible personnel;
- Adopt risk-based approach to regularly review all associated guidelines and procedures by competent responsible personnel;
- Implement computerised maintenance management system (CMMS) with workflow and document control complying with ISO9000 standards;
- Adopt BIM-enabled workflow to suit routine operation works;
- Integrate HVAC-related sensor information via central building management system for ease of routine monitoring;
- Review the need for retro-commissioning with the view to implement if it proves beneficial.

2.4 Emergency Preparedness

Building Emergency Preparedness is an effort to connect the emergency planning and response with the building users. The goal is to train personnel in basic emergency response actions who know the building and occupants and can act as a resource and liaison to the stakeholders and building users.

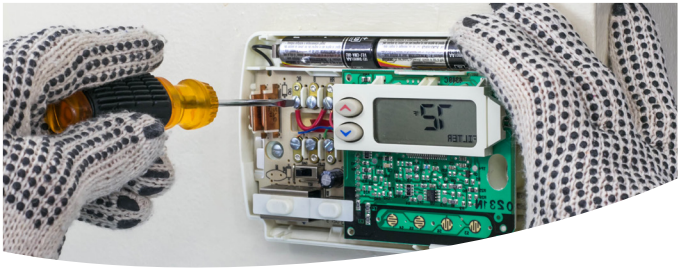
An emergency action plan should identify all the potential hazards associated with the HVAC Systems, with a personnel responsibility matrix for allocating appropriate resources. The written plan should become an action document, updated according to an appropriate timeframe to ensure accurate information, such as contact information, is provided.

★☆☆ Level 1

GENERAL PRACTICE

2.4.1

- Maintain an up-to-date emergency contact list including utility companies, registered specialist contractors, etc., on site;
- Ensure availability of up-to-date communication flow between the client (both administrative and operation), maintenance team and contractors.

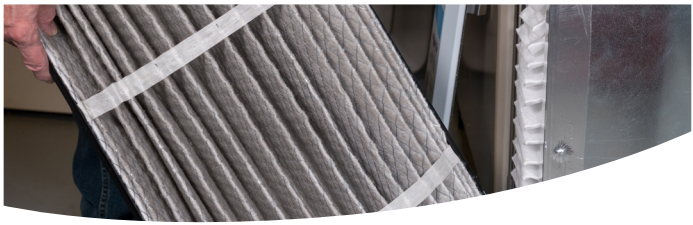


Level 2

GOOD PRACTICE

2.4.2

- Maintain an Emergency (Contingency) Plan / procedures/kit / drills;
- Include specific requirements in maintenance contracts for emergency situations such as response time;
- Provide sufficient materials and / or critical spare parts available on-site for quick fix to resume operation;
- Conduct training of operation and maintenance and property management personnel when system is upgraded,
- Provide opportunities for internal sharing of lessons learnt from incidents,
- Ensure availability of mobile air conditioning units / mobile chillers / ventilation fans.



Level 3

BEST PRACTICE

2.4.3

- Conduct annual reviews on emergency plan and drills;
- Digitise all reference documents including drawings for easy retrieval;
- Conduct regular training of operation and maintenance and property management personnel for emergency drills;
- Ensure availability of mobile chillers / ventilation fans.

2.5 Preventive Maintenance Procedures / Standards

The goal of Preventive Maintenance is to prevent equipment failure caused by fatigue, neglect, or normal wear, through replacing worn components before actual failure.

Maintenance activities include partial or complete overhauls at specified periods, and include oil changes, lubrication, minor adjustments, and so on. Typical procedures recommend that personnel record equipment deterioration upon any inspection to facilitate the replace or repair worn parts before any system failure. It is necessary to undertake preventive maintenance of installations and equipment to maintain efficient working order of the building's HVAC systems and their components. The HVAC systems require periodic inspection, testing and maintenance throughout their life cycle in addition to the need for overhauling, or replacement, at a certain age or interval, or due to specific issues or causes. These must be outlined specifically in a Preventive Maintenance Program.

The Preventive Maintenance Program must include the methodology and record for all actions that are necessary to maintain the efficient working order of the HVAC systems. The required maintenance procedures will be unique to each property and the installations and equipment within these facilities.

★☆☆ Level 1

GENERAL PRACTICE

2.5.1

- Conduct Preventive Maintenance in accordance with statutory requirements;
- Ensure O&M personnel induction training on safety, statutory requirements and performance target and work manner.

Level 2

GOOD PRACTICE

2.5.2

- Conduct Preventive Maintenance and overhauls with clear maintenance schedule, instructions and procedures;
- Provide notification to stakeholders for testing / shut down of major plant and equipment;
- Conduct periodic maintenance and testing, servicing, checking, calibration, overhauls, and certification; and annual inspection testing, witness regular test, and certification:
  - i) Half-yearly: override control system for ventilation / air conditioning control system;
  - ii) Annually: witness annual testing and issue of F.S. Certificate for ventilation and air conditioning control system.

Level 3

BEST PRACTICE

2.5.3

- Adopt Condition based / reliability based maintenance where appropriate;
- Conduct a regular review of all procedures / standards;
- Conduct a regular update of relevant procedures / standards against the latest statutory requirements and latest international standards, maintenance records and fault history by a working group comprising competent personnel;
- Adopt a web-based / mobile application-based Performance Monitoring System for maintenance that is contracted out.

2.6 Corrective Maintenance

The goal of every maintenance team is to be fast and effective, especially when it comes to unexpected breakdowns of critical plant and equipment, aiming to achieve:

i) Reduced duration of both planned and unplanned downtimes;
ii) Reduced cost of running a reactive maintenance strategy;
iii) Reduced overall cost of your maintenance operations.

Level 1

GENERAL PRACTICE

2.6.1

- Provide O&M personnel induction training for safety, statutory requirements, performance target and work manner.

Level 2

GOOD PRACTICE

2.6.2

- Establish a reporting mechanism for fault calls to responsible parties including the Owner, Owner's representatives, building management, end-users and maintenance team, with recordable means;
- Conduct corrective maintenance work during non-operating hours to minimise interruption and provide provision of temporary measures whenever possible;

- Maintain efficient and prompt response to breakdowns, emergency call-outs or complaints for installation / equipment failure and / or unsatisfactory services. For all situations, the Maintenance team should provide staff on site within different defined time periods;
- Establish Key Performance Indicator (KPI) on Corrective Maintenance for continuous improvement on performance.

★★★ Level 3

BEST PRACTICE

2.6.3

- Establish an Emergency Call Centre (ECC) to process work flow;
- Provide 24-hour ECC operations throughout the year, even in adverse weather conditions;
- Designate personnel to attend emergency cases and execute all works necessary to resume services promptly;
- Enhance system resilience to avoid service interruption due to corrective maintenance work;
- Provide regular updates to stakeholders to highlight major O&M activities and service levels attained;
- Utilise an electronic platform or software application to ensure that users receive notifications on the progress of Corrective Maintenance and facilitates the provision of feedback on service levels.

2.7 Maintenance Record Management

Good maintenance records are essential for ensuring that a piece of equipment is performing in line with manufacturer warranties and help to determine an equipment's preventive maintenance schedule. It also assists service technicians with diagnosing repeat problems with a plant or equipment. Clear records can also provide assistance in legal proceedings, if ever necessary.

★☆☆ Level 1

GENERAL PRACTICE

2.7.1

- Maintain paper records of all maintenance related activities including testing and commissioning certificates, records of tests, as-built drawings, statutory approved submission document, statutory maintenance certificates and calibration records of equipment, etc.;
- Maintain a register to monitor due dates of all testing equipment calibration and renewal dates of all statutory maintenance certificates;
- Maintain list of stock of spare parts, equipment and other components that are necessary to maintain the safe and satisfactory working condition and operation order of major plant and equipment at all times;
- Maintain emergency call / fault attendance report;
- Maintain records of usage of refrigerants.

Level 2

GOOD PRACTICE

2.7.2

- Set up efficient computerised registers and filing system to administer all statutory certificates, records, drawings, O&M documents, fault history etc.;
- Assign designated person(s) responsible to review and update routine maintenance inspection schedule, emergency call / fault attendance reports, etc., on a monthly basis;
- Set up record systems able to automatically provide alerts for outstanding shut down notices and annual maintenance certificate renewal dates.

Level 3

BEST PRACTICE

2.7.3

- Digitise all documents and records with a standardised file naming system in a reliable database server for easy retrieval;
- Maintain and regularly update and review the record of maintenance service and fault history.

2.8 Spare Parts Management

Spare parts management refers to a systematic and structured way to store and extract spare parts efficiently for any maintenance activity. A good system should minimise downtime during service disruption and simplify equipment maintenance.

★☆☆ Level 1

GENERAL PRACTICE

2.8.1

- Maintain a spare parts list for plant and equipment and an updated contact list of spare parts suppliers.

★★☆ Level 2

GOOD PRACTICE

2.8.2

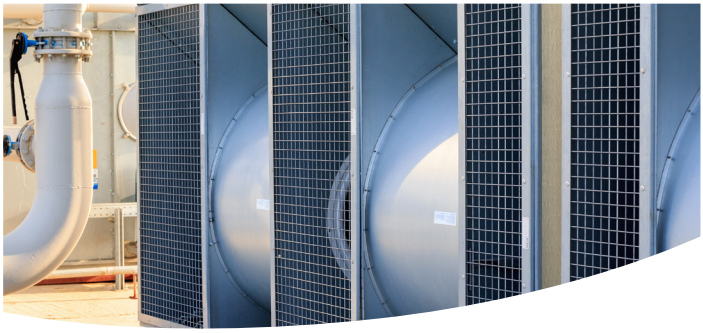
- Maintain sufficient spare parts including critical parts and equipment with long-lead items as well as the new equipment after their commissioning to minimise downtime of critical systems;
- Assign designated person(s) responsible for regular updates of any changes in spare parts inventory;
- Centralise and consolidate spare parts. Store spare parts in dedicated location for swift response to maintenance and repair works;
- Adopt security measures in locations where spare parts are kept;
- Monitor condition of spare parts to ensure their quality is maintained.

Level 3

BEST PRACTICE

2.8.3

- Derive the type, quantity of on-site spare parts from fault history, maintenance record, age and criticality;
- Utilise an inventory control system, such as barcodes and scanning functions to enhance the efficiency accuracy of stocktaking of spare parts;
- Review constantly the quality and quantity of spare parts in stock and restock when necessary;
- Identify long-lead items for early procurement;
- Identify discontinued items for sourcing of alternative parts or upgrade of the system.



2.9 Addition, Alteration and Replacement (Planning and Implementation)

This includes the analysis, procurement, and management on additions, alterations as well as disposal and replacement of HVAC Installations to meet the organisation's long term aims and objectives.

Level 1

GENERAL PRACTICE

2.9.1

- Conduct replacement of plant / equipment as corrective maintenance;
- Conduct alterations and additions works as per user requirements;
- Obtain confirmation from users before commencement of works and provide anticipated completion date for the works to users;
- Fulfil all the latest statutory requirements when conducting AA&R works;
- Provide all drawings and documents, including design calculations, equipment schedules & details, as-built drawings, testing and commissioning records, and O&M manuals of AA&R works, for record within a reasonable period;
- Prepare all necessary statutory submissions and obtain approval, if required.

Level 2

GOOD PRACTICE

2.9.2

- Establish detailed method statements and risk assessments for replacement and implementation plans to minimise impact on user operation;
- Risk based approach to plan and schedule replacement works in accordance with equipment age, fault frequency, criticality and spare parts availability as well as any specific law and safety requirements, etc. (i.e. Replacement Priority Planning);
- Develop an equipment and spare parts database, with all equipment schedules and ages for easy tracking;

- Review the routine maintenance report regularly to monitor the condition and performance of systems and conduct AA&R works when necessary;
- Develop a seamless action plan and contingency plan with users for equipment replacement works.
- Develop standard T&C records and O&M manuals for all AA&R works for equipment.

Level 3

BEST PRACTICE

2.9.3

- Acquire feedback from users regularly to keep track of actual performance of different systems according to their location and their fault frequency, so as to develop a more user orientated replacement plan;
- Conduct a holistic review on system performance and design for equipment replacement planning and where possible, introduce latest technology, i.e. energy dashboard, energy optimisation software, etc., that can enhance overall system reliability and energy efficiency;
- Digitalise all as-fitted drawings, T&C records, O&M Manual, catalogues of materials and associated statutory submissions for proper recording;
- Develop a database to record the expiry dates of certificates of materials. Those with upcoming expiration dates Bring up notices would be generated, once the date of statutory certificates coming to expire;
- Register all AA&R works conducted for various systems properly for easy tracking;
- Consider life-cycle cost of systems in the planning and design stage of replacement works.

2.10 Incident Management

Incident management refers to the "the combination of facilities, equipment, personnel, procedures and communications operating within a common organisational structure, designed to aid in the management of resources during incidents". When a service is disrupted or fails to deliver the promised performance during service hours, it is essential to restore the service to normal operation as quickly as possible. In addition, any condition that has the potential to result in a breach or degradation of service ought to trigger a response that prevents the actual disruption from occurring. These are the objectives of incident management.

★☆☆ Level 1

GENERAL PRACTICE

2.10.1

- Conduct incident investigation, review condition of similar systems and equipment to avoid recurrence;
- Keep proper records of incident investigation, downtime of system, rectification works and loss / damage to properties, etc.;
- Report workplace accidents and dangerous occurrences to Labour Department as per the statutory requirements.

Level 2

GOOD PRACTICE

2.10.2

- Establish an incident management plan to define alert levels, investigation procedures, reporting mechanism and requirements of investigator;
- Maintain updated emergency contact and escalation list, call appropriate level of management staff according to pre-defined incident levels when an incident occurs;
- Specify requirements for emergency situations, such as time for arrival for fault calls and emergency fault calls, etc.;
- Conduct regular training and emergency drills to strengthen staff's local knowledge to prepare for real incidents;
- Conduct necessary alteration, addition and improvement to enhance system reliability.

Level 3

BEST PRACTICE

2.10.3

- Conduct timely reviews of incident management plan, emergency contact and escalation list, training and drill documents;
- Share incident information with all O&M personnel within the same organisation / trade, and document all outcomes;
- Set up remote monitoring system, if applicable, for early fault detection and reporting;
- Set up working group to steer incident management, maintain good communication with all stakeholders for improving system's performance and reliability;
- Conduct review and lessons learnt from incidents for staff sharing, and take precautionary actions to eliminate future problems, and potential problems in other venues;
- Establish emergency task-force teams for incident response;
- Recommend critical parts and equipment with long delivery lead times to minimise downtime of critical systems.

2.11 Environmental and Safety Management

Environmental and Safety Management ensures that operations are safe for all building users and visitors. Building Owners are obliged to implement all reasonable precautions to protect the environment, and maximise the building's lifecycle efficiencies.

Level 1

GENERAL PRACTICE

2.11.1

- Fulfil all statutory requirements on environmental and safety management.

  Under the Factories and Industrial Undertakings (Safety Management) Regulation (Cap. 59), proprietors or contractors of certain industrial undertakings are required to develop, implement and maintain, in respect of their undertakings, an environmental and safety management system which contains a number of key process elements.

Level 2

GOOD PRACTICE

2.11.2

- Establish and implement Environmental Management Systems (e.g. ISO14001) and Safety Management Systems (e.g. OHSAS18001 or ISO45001);
- Optimise / minimise the use of materials and resources (e.g. electricity, fuel, hazardous chemicals, etc.) wherever appropriate, to be both energy and resource efficient;
- Avoid the use of environmentally unfriendly materials or equipment (e.g. refrigerants with high global warming potential (GWP) and ozone depletion potential (ODP));
- Minimise the production of all kinds of waste, and properly dispose of refrigerants and lubricating oil, etc., through registered recycler where applicable;
- Consider future health and safety issues that could occur while maintaining the building (Guidance on Construction Design and Management) during design phase;

- Conduct job hazard analysis and risk assessment on hazardous activities and take appropriate risk control measures to protect personnel;
- Provide training to equip staff with knowledge to work safely and without risk to health;
- Conduct chemical drills, such as refrigerant leakage, etc., to ensure staff are equipped to handle the occurrence of accidents.
- Establish and implement safety rules for safe working;
- Supervise personnel to ensure that safety rules are observed, and personal protective equipment is used and maintained properly;
- Report and investigate accidents and incidents to identify causes and to develop prompt arrangements to prevent recurrence;
- Identify potential equipment failure leading to refrigerant leakage and take appropriate action to fix the problem in advance.

Level 3

BEST PRACTICE

2.11.3

- Identify improvement opportunities on environmental (especially energy efficiency) and safety aspects;
- Reuse or recycle materials / construction waste as appropriate, e.g. adopt recycled components or equipment for maintenance works;
- Provide incentives to contractors similar to Development Bureau's "pay for safety and environment scheme" in government works contracts;
- Establish green purchasing plan and incentive scheme to use more green and efficient products whenever possible.

2.12 Application of Technologies

Technology and tools used to lower the cost of implementing and managing O&M best management practices.

Level 1

GENERAL PRACTICE

2.12.1

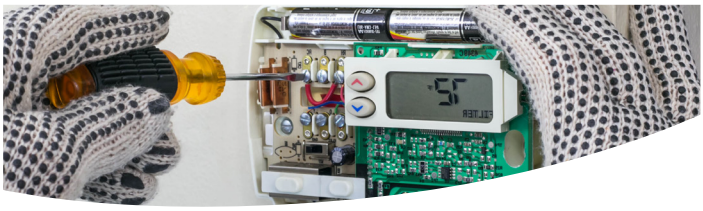
- Adopt minimum market available technologies as required by statutory requirements (e.g. BEC);
- Check and ensure that relevant statutory requirements are fulfilled when adopting new technological solutions.

Level 2

GOOD PRACTICE

2.12.2

- Calibrate tools and equipment as per the advice from the supplier / manufacturer;
- Get aware of the latest technologies available in the market;
- Introduce the latest available technologies that can enhance overall system reliability and energy efficiency for major replacement works or new installation works as appropriate (e.g. after payback calculation study);
- Review the existing maintenance approach and study the possible improvement in quality, cost and time if new technologies are implemented.



Level 3

BEST PRACTICE

2.12.3

- Actively review the plant and system specific problems and performance targets and explore technological solutions, e.g. by involving the supplier / manufacturer to provide tailor made solutions;
- Share the problem solving experience in applying new technologies with others;
- Conduct research and development of innovation and technology applications for continual improvement of O&M works.

2.13 Stakeholder Management

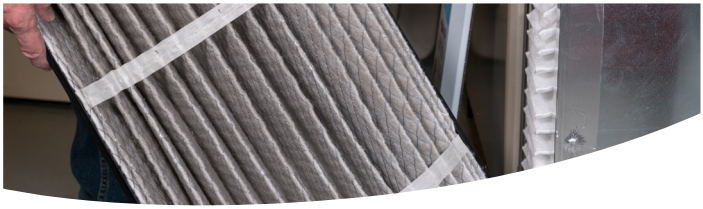
Stakeholder management is a set of techniques that harnesses the positive influences and minimises the effect of the negative influences. It involves systematic identification, analysis, planning and implementation of actions designed to engage with stakeholders. Stakeholders are individuals or groups with an interest in the building or facility operation because they are involved in the work or affected by the outcomes. Most buildings or facilities and portfolios will have a variety of stakeholders with different, and sometimes competing, interests. These individuals and groups can have significant influence over the eventual success or failure of the work.

★☆☆ Level 1

GENERAL PRACTICE

2.13.1

- Notification of Stakeholders on Service Interruption
  - Notify stakeholders (e.g. property management company, incorporated owners, building occupants and tenants) on the works schedule of maintenance activities and installation works which involve service interruption;
  - Implement an emergency plan to minimise service suspension.



Level 2

GOOD PRACTICE

2.13.2

- **Notification of stakeholders on scheduling maintenance activities involving service**
  - Agree with stakeholders the works schedule well in advance of works commencement;
  - Coordinate with stakeholders on service needs to improve O&M arrangements;
  - Establish a structured information sharing channel with stakeholders;
  - Maintain a log book at each installation and keep it at an agreed location for future reference by stakeholders.

Level 3

BEST PRACTICE

2.13.3

- **Engagement of stakeholders on O&M activities scheduling for addition, alterations and replacement works**
  - Engage stakeholders in scheduling of O&M activities as well as AA&R works as appropriate;
  - Keep stakeholders informed of the progress of all O&M activities and AA&R works, and performance of electrical installation;
  - Form a taskforce or establish a communication mechanism with stakeholders to regularly review the needs and measures to improve O&M practices, system reliability and performance.

2.14 Information Management

During the life of the system, the O&M phase is the longest and most expensive and the information system provides the most value to the organisation in this phase.

Level 1

GENERAL PRACTICE

2.14.1

- **Proper record of certificates and documentations as per statutory requirements by relevant parties**
  - Keep proper records of certificates and documentations (e.g. Form WR1/WR2 and relevant testing records) as per statutory requirements;
  - Ensure easy access to the updated list of REWs and RECs by making reference to EMSD's website;
  - Keep proper records of design documents, as-fitted drawings, O&M manuals and T&C results, if any;
  - Keep proper records of maintenance activities.

Level 2

GOOD PRACTICE

2.14.2

- **Sharing of maintenance information among different stakeholders**
  - Keep proper and updated as-fitted schematic diagrams at site;
  - Share O&M information among different stakeholders;
  - Set up an electronic database system for information storage;
  - Digitise maintenance related information such as design documents, as-fitted drawings, O&M manuals, T&C results and O&M records;
  - Arrange designated person(s) for regular updating of O&M information of various systems/equipment.

Level 3

BEST PRACTICE

2.14.3

- **Common platform for storage and dissemination of O&M information with a view to enhancing the transparency**
  - Set up a common electronic platform for storage and dissemination of O&M information with a view to enhancing transparency and version control;
  - Set up a common electronic platform for online sharing of O&M related information among different stakeholders;
  - Enhance data security of digitised information, e.g. by assigning different levels of access rights to different user groups;
  - Carry out periodic audit/review on the stored records.

2.15 Structure and Qualification of O&M Team

Structure is the people, positions, procedures, processes, culture, technology and related elements that comprise the organisation. It defines how all the pieces, parts and processes work together. This structure must be totally integrated with the strategy defined for the organisation to achieve its mission and goals. Structure supports strategy. If an organisation changes its strategy, it must change its structure to support the new strategy. When it doesn't, the structure acts like a bungee cord and pulls the organisation back to its old strategy.

★☆☆ Level 1

GENERAL PRACTICE

2.15.1

- Provide on-call maintenance team / contractors.
- Ensure electrical work is led by registered electrical contractors and registered electrical workers of the appropriate grade.

Level 2

GOOD PRACTICE

2.15.2

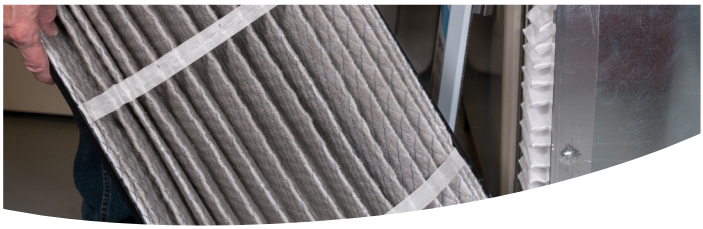
- Set up an O&M team with supervisors and maintenance personnel with proper qualifications and training;
- Arrange designated personnel to oversee and review system/team performance, maintenance activities and practices;
- Require Electrical Engineer / Building Services Engineer / Contract Manager to be professionally qualified with The Hong Kong Institution of Engineers (HKIE) of an appropriate discipline such as Electrical or Building Services / The Institution of Engineering and Technology (IET) / The Chartered Institution of Building Services Engineers (CIBSE).

Level 3

BEST PRACTICE

2.15.3

- Set up a resident O&M team on shift duty to oversee O&M activities round the clock;
- Continually enhance the knowledge and skills of the O&M team, for example, by adopting Continuing Professional Development ("CPD") mechanism;
- Set up a dedicated emergency service team for emergency repair;
- Provide training for maintenance team on use of BIM
- Set up Centralised / Regional Command Centre(s) for O&M activities.



3 Innovative & Technology Initiatives

The operation and maintenance of buildings have already been facing several critical challenges, including the aging workforce, aging assets and climate change. The new generation of smart technologies such as artificial intelligence, asset management Internet of Things, building management system, building information system or even specialised drone-enabled automation applications would have brought further challenges to us with safety and well-being of occupants and visitors inside buildings elevated to a completely new level. Building O&M practitioners shall endeavour to adopt innovations, technologies and best practice/guidelines to improve the management of E&M assets, thereby enhancing the resilience and intelligence of government buildings.

Below are 5 technology trends that may have impact on facilities management industry.

3.1 Technology Trend 1: CAFM Software

In the current dynamic market, computer aided facility management (CAFM) software is highly important for facilities manager in the workplace. Tasked with many responsibilities, facilities manager require complete day-to-day functionality by integrating technology, processes, and people. With the help of CAFM software, facilities manager can better execute daily operational responsibilities from monitoring and managing customer service requests to preventive maintenance and operational facility services.

3.2 Technology Trend 2: Building Information Modelling (BIM)

Although not a new technology, Building Information Modelling (BIM)-Asset Management (BIM-AM) is a tool used by contractors and architects to develop and scale virtual models of building projects. Giving building owners and operators a complete visual model of the facility prior to construction, it provides valuable insights into project delivery timelines and budgets.

When integrated with existing work order programs or facility maintenance software, BIM delivers on improved floor plans, asset information and financial estimates. As the technology continues to evolve, the importance of BIM in facilities management will continue to grow.

3.3 Technology Trend 3: Internet of Things (IoT)

The Internet of Things (IoT) refers to the network of internet accessible devices utilised by organisations. Relying on tools such as sensors, thermostats and actuators to evaluate data and reduce the amount of energy used for tasks, IoT systems effectively reduce energy bills and provide insightful data to improve efficiency within all facilities.
With various sensors generating data, facilities management organisations are able to identify issues and potential problems faster and easier.

3.4 Technology Trend 4: Drones

Drones are unmanned aerial vehicles (UAVs) that have the ability to improve efficiency in facilities management. Some of these opportunities include safety in inspections, and the automation of delivery services. Still in its infancy, there is no disputing that sending a drone equipped with a high-resolution camera is a quicker and safer way to evaluate a building's exterior than sending a member of the team.

3.5 Technology Trend 5: Artificial Intelligence (AI)

Artificial intelligence (AI) is the broader concept of machines being able to carry out tasks in a smart manner. AI also refers to machines imitating and bettering human performance. More adaptive than traditional systems, AI holds an array of capabilities for enhanced performance in the facilities management industry.
A part of AI, machine learning is a current application that provides machines access to data and allows them to draw insights on their own. With machine learning, facilities management organisations can better predict how much time an asset, such as a building, has before its performance degrades or fails. From online chatbots in customer service to finding patterns in historical data through the use of algorithms, AI will expand and benefit all departments within an facilities management organisation.

3.6 Technology Initiatives

Based on the above technology trends, the technology initiatives in respect of the 15 key attributes are summarised below for reference

O&M Aspect	Initiatives	Reference
O&M Input on Design for New Building	a) Simulate best practice O&M activities using BIM or other simulation software to understand operability and maintainability before construction.	• BIM for Facility Managers issued by International Facility Management Association (IFMA) • BIM-AM Standards and Guidelines issued by EMSD • Housing Authority BIM Standards and Guidelines
Asset Information (Documentation)	a) Adopt computerised asset information model such as BIM to maintain all asset information under an efficient asset management system; b) Inspect, digitise and upkeep latest record and logbook for HVAC equipment on a regular basis; c) Implement mobile solutions for asset management record retrieval and updating of records, e.g. O&M manual, fault history etc.; d) Adopt Radio Frequency Identification (RFID) or QR codes for asset management.	• BIM for Facility Managers issued by International Facility Management Association (IFMA) • BIM-AM Standards and Guidelines issued by EMSD • CIC BIM Standards

O&M Aspect	Initiatives	Reference
Operation Procedures	a) Adopt cloud-based technology to store information of HVAC Installations and equipment to be accessed by property management personnel when needed; b) Implement IoT-enabled self-diagnosis function for the healthiness of major HVAC equipment; c) Incorporate online condition monitoring and mobile technologies on HVAC systems to improve maintenance and reduce downtime.	
Emergency Preparedness	Nil	
Preventive Maintenance Procedure / Standards	a) Conduct predictive maintenance based on data analysis of fault history and equipment condition.	
Corrective Maintenance	Nil	

O&M Aspect	Initiatives	Reference
Maintenance Record Management	a) Adopt computerised monitoring system to maintain detailed maintenance information with capability for prompt alerts, review and further analysis. The system at least contains the following information for weekly updates by designated person(s): • Maintenance contractor's organisation chart and contact list • Monthly fault call and emergency repair reports • Daily fault call progress report • Details of corrective maintenance • Equipment breakdown report • KPI report • Working programme for maintenance, annual inspections and tests, overhaul, drills, safety inspections and any other scheduled works • Preventive maintenance schedule • Details of preventive maintenance completed • Spare parts list • Registers of tools, equipment, materials, spare parts and instruments as well as calibration certificates of instruments • Record of plants and equipment details • Overhaul reports • Record of statutory submission • Any other useful information (e.g. site photos)	

O&M Aspect	Initiatives	Reference
Spare Parts Management	a) Utilise an automatic inventory control system using Artificial Intelligence (AI) to manage spare parts inventory by prediction of spare parts requirements, and for advance and on-time spare parts procurement.	
Incident Management	a) Consider advance management tools to help optimise system performance, e.g., BIM – asset registers, equipment life-cycle track, system configuration, critical device status, maintenance history, installation visualisation, etc.; b) Adopt IoT technologies to allow quicker and instant reporting and maintenance data collection for future improvement.	
Addition, Alteration and Replacement (Planning and Implementation)	a) Adopt advance management tools such as integrated facility management tools to allow a quick search of all equipment information and records, to enhance effectiveness of overall planning.	
Environmental and Safety Management	a) Adopt recycled components or equipment for the maintenance / repair / replacement works; b) Use environmentally friendly materials for maintenance / repair/ replacement works; c) Emphasise adoption of more safety measures, tools and equipment for the maintenance / repair/ replacement works.	
Application of Technologies	a) Adopt application of AL, big data analysis, IoT, etc.; b) Enable knowledge transfer from research to industry to Interface Science / Technology.	

O&M Aspect	Initiatives	Reference
Stakeholder Management	a) Establish a smart system to automatically notify stakeholders on upcoming schedules and progress of all O&M activities, addition, alteration and replacement works.	
Information Management	a) Establish an integrated Building Management System (iBMS); b) Create a centralised database for automatic replacement planning for equipment; c) Establish an online real time server for storing maintenance related information through mobile devices; d) Provide online access of all information by maintenance party during preventive maintenance works.	
Structure and Qualification of O&M Team	Nil	

4. Industry Standards and Requirements

4.1 Guidance Notes and Codes of Practice

The readers may refer to the prevailing statutory requirements, websites of the Controlling Authorities and following documents for further information on the relevant specific requirements:-

- Building Information Modeling for Asset Management (BIM-AM) Standards and Guidelines (latest edition), Electrical & Mechanical Services Department, HKSAR, China;
- Code of Practice for Energy Efficiency of Building Services Installation (latest edition), Electrical & Mechanical Services Department, HKSAR, China;
- Codes of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment (latest edition), Fire Services Department, HKSAR, China;
- Code of Practice for Fire Safety in Buildings (latest edition), Buildings Department, HKSAR, China;
- Code of Practice for the Electricity (Wiring) Regulations (latest edition), Electrical & Mechanical Services Department, HKSAR, China;
- Code of Practice for Water-cooled Air Conditioning Systems, Electrical & Mechanical Services Department, HKSAR, China;
- Code of Practice for Prevention of Legionnaires' Disease, Prevention of Legionnaires' Disease Committee, HKSAR, China;
- Construction Design and Management (Health & Safety Design Management) Guidance Notes (latest edition), Development Bureau, HKSAR, China;
- Construction (Design and Management) Regulations, United Kingdom;
- Hospital Engineering Design Standard Checklist for Water-cooled Air Conditioning System (latest edition), Hospital Authority, Hong Kong, China;
- Fresh Water Cooling Towers Scheme (latest edition), Electrical & Mechanical Services Department, HKSAR, China;
- General Specification for Electrical Installation in Government Buildings (latest edition), Architectural Services Department, HKSAR, China;
- General Specification for Electrical Installation for Hong Kong Housing Authority (latest edition), Hong Kong Housing Authority, HKSAR, China;
- Good Operation and Maintenance Practice of Fresh Water Cooling Towers for Air Conditioning Systems (latest edition), Electrical & Mechanical Services Department,

HKSAR, China;

- Guidance Notes on Safety at Work for Maintenance of Low Voltage Electrical Switchgears (latest edition), Labour Department, HKSAR, China;
- Guidelines on Energy Efficiency of Air Conditioning Installations (latest edition), Electrical & Mechanical Services Department, HKSAR, China;
- Guidelines for Excavation Works near the District Cooling System at Kai Tak Development, Electrical & Mechanical Services Department, HKSAR, China;
- Guideline on Prevention and Control of Nosocomial Legionnaires' disease (latest edition), Hospital Authority, Hong Kong, China;
- Technical Guidelines for Connection to District Cooling System (latest edition), Electrical & Mechanical Services Department, HKSAR, China;
- Testing and Commissioning Procedure for Air-Conditioning, Refrigeration, Ventilation and Central Monitoring & Control System in Government Buildings (latest edition), Architectural Services Department, HKSAR, China; and
- Testing and Commissioning Procedure for electrical Installation in Government Buildings (latest edition), Architectural Services Department, HKSAR, China.

4.2 International Starndards

The readers may refer to the prevailing international standards as accepted by the Controlling Authorities or the approval standards for existing buildings:

- ANSI/NETA ATS-2017 – 'Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems';
- Construction (Design and Management) Regulations, United Kingdom;
- BS 7671: Requirements for Electrical Installations, IET Wiring Regulations, Eighteenth Edition, 2018 ;
- BS 6423: 2014 Code of practice for maintenance of low-voltage switchgear and control gear;
- BS 6626: 2010 Maintenance of electrical switchgear and controlgear for voltages above 1 kV and up to and including 36 kV – Code of Practice;
- BS 7698-12: 1998 / ISO 8528-12: 1997 Reciprocating internal combustion engine driven alternating current generating sets. Part12: Emergency power supply to safety services;
- BS 7430: 2011+A1:2015 Code of practice for protective earthing of electrical installations;
- BSRIA: AG13/2000 Toolkit for building operation audits 2000 Edition;

- BSRIA: Specification: FMS 8/2003 Specification for the procurement of building services operation and maintenance 2003 Edition;
- CIBSE Commissioning Codes;
- CIBSE Guide to ownership, operation and maintenance of building services;
- CIBSE Guide M Maintenance Engineering & Management, 2014;
- CIBSE TM31 : Building log books toolkit.
- NFPA 70B: Recommended Practice for Electrical Equipment Maintenance 2019 Edition;
- NHS Estates Concorde: Guide to building, engineering and grounds maintenance contracts for the NHS estate (archive) 1996 Edition.
- Health Technical Memorandum (HTM) 06-01 – 'Electrical services supply and distribution' (for hospitals) particularly Section 17 on maintenance and operational management;
- HVCA SFG 20: Standard Maintenance Specification for Mechanical Services in Buildings. 3rd edition 2004 Edition;
- IEC 60300-3-11-2009 – 'Dependability Management - Application Guide - Reliability Centred Maintenance';
- IEC 60364 Low-voltage Electrical Installations;
- SAE standard JA1011 – 'Evaluation Criteria for Reliability-Centered Maintenance (RCM) Processes'.

5. Useful Forms/ Check List/ Table - Samples

5.1 Recommended Minimum Monitoring Frequency for Different Water Quality Parameters for Cooling Tower System

Parameters	Minimum Monitoring Frequency for Cooling Water
Conductivity	Monthly
Total dissolved solids	Monthly
Suspended solids	Monthly
Calcium hardness	Monthly
pH	Monthly
Total alkalinity	Quarterly
Oxidising biocide	Monthly
Inhibitor level	Monthly
Temperature	Monthly
Chloride as mg/L Cl	Quarterly
Sulphate as mg/L SO4	Quarterly
Total iron as mg/L Fe	Quarterly
Residual Cl/ Oxidation Reduction Potential (ORP)	Monthly
5-day Biochemical oxygen demand (BOD5)	Monthly
Chemical Oxygen Demand (COD)	Monthly
Heterotrophic colony count	Monthly
Legionella	Quarterly*

*Remarks: Cooling tower systems installed at medical and health care premises should be monitored ex-ceptionally closely. Water sampling for cooling tower systems installed in these locations should be carried out at least once a month for both legionella test and HCC. Moreover, if legionella or HCC is found to be greater than the specified requirement under routine sampling, more fre-quent water sampling is required to form part of the system operation programme.

Parameters	Minimum Monitoring Frequency for Bleed-off Water
Colour	Quarterly
Turbidity	Quarterly
Threshold Odour No.	Quarterly
Ammoniacal Nitrogen	Quarterly
Suspended Solids	Quarterly
Dissolved Oxygen	Quarterly
5-day Biochemical Oxygen Demand	Quarterly
Synthetic Detergents	Quarterly
E. Coli/ 100mL	Quarterly

Note: The above checklists are for reference only. The owners of the cooling towner systems should develop their own water quality monitoring schedules to suit their systems.

5.2 Recommended Routine Inspection Checklist for Cooling Tower System

	Procedures	Inspection Frequency
1.	Check condenser water pumps	Weekly
2.	Check cooling water quality	Monthly
3.	Check internal surfaces of cooling towers/evaporative condenser for scale, rust, sludge and biofilm accumulation	Monthly
4.	Check cooling water for clarity, odour, surface debris and temperature.	Weekly
5.	Check strainers	Weekly
6.	Check drains	Weekly
7.	Check float valves	Weekly
8.	Check water treatment dosing equipment and conductivity sensors	Weekly
9.	Check water treatment chemicals for adequacy and safety	Weekly
10.	Check condition/cleanliness of fill pack/tubes	Monthly
11.	Check condition/cleanliness of drift eliminators	Monthly
12.	Check condition/cleanliness of distribution troughs/spray headers and nozzles	Monthly
13.	Check fans, drives and gearbox	Weekly
14.	Check water level of basin	Weekly
15.	Check bleed-off valve	Weekly
16.	Check for system leakage and overflow from cooling towers	Monthly
17.	Check air inlets and fan screens	Weekly

Note: The above checklists are for reference only. The owners of the cooling tower systems should develop their own inspection checklists to suit their systems.

5.3 Recommended Routine and Preventive Maintenance Checklist for Cooling Tower System

	Checklists	Maintenance Frequency
1.	Tighten all fasteners	Every 6 months
2.	Clean strainers	Monthly
3.	Clean water basin and all internal surfaces of cooling towers	Every 6 months
4.	Adjust and lubricate pumps and pump motors	Quarterly
5.	Adjust and lubricate fans and fan motors	Quarterly
6.	Remove drift eliminators and fills for cleaning	Every 6 months
7.	Adjust and lubricate valves	Quarterly
8.	Clean water distribution pipework, including nozzles	Quarterly
9.	Remove end cap in each header tor cleaning	Every 6 months

Note: The above checklists are for reference only. The owners of the cooling tower systems should develop their own routine and preventive maintenance checklists for their systems.

5.4 Recommended List of Personal Protective Equipment

Job	Potential Hazzard	Respirator and Clothing
Testing and commissioning	Aerosol	Half face piece, capable of filtering smaller than 5µm particulates, ordinary work clothing
Inspection	Aerosol	Half face piece, capable of filtering smaller than 5µm particulates, ordinary work clothing
Water Sampling	Aerosol	Half face piece, capable of filtering smaller than 5µm particulates, ordinary work clothing
High pressure spraying	Aerosol	Respirator as above, waterproof overalls, gloves, boots, goggles or face shield
Chemical treatment with sodium hypo-chlorite solution in ventilated space	Spray mist and very low concentration chlorine	Half face piece, acid gas and particulate respirator, goggles or face shield, overalls, gloves, and boots
As above, in confined space	Unknown chlorine concentration, high mist, possible lack of oxygen	To comply with the requirement under the Factories and Industrial undertakings (Confined Spaces) Regulation

5.5 Sample Operation and Maintenance Records for Cooling Tower System

A. System Description

Record	Details
Building Name & Building Address	
Cooling tower type	
Number of cooling towers in system	
Heat rejection capacities of the cooling towers	
Building owner's name/contact details*	
Owner of cooling towers' name and contact details*	
O&M contractor of cooling towers' name and details*	
Water treatment services provider's name and contact details*	
Water sampling/laboratory contractor's name and contact details*	

* To include company name, contact person's business and after office hours telephone numbers

B. Weekly Monthly Records for the month ( ) of year ( )

	Procedures	Date of Action				
		Week 1	Week 2	Week 3	Week 4	Monthly
1.	Check cleanliness, organic fouling and physical debris					
2.	Inspect for slime and algal growth					
3.	Inspect for deterioration of materials, damage to components, blockages and corrosion					
4.	Inspect for correct operation of fans, motors and pumps					
5.	Inspect water leaks from seams					
6.	Inspect misshaped exterior or collapsed internal supports					
7.	Inspect supporting framework					
8.	Inspect fill and drift eliminator					
9.	Check condition and operation of ball value					
10.	Check fan thermostat (if equipped)					
11.	Check sprays and distribution deck					
12.	Check bleed-off rate					

C. Quarterly/6-monthly/Yearly Records for the year ( )

	Procedures	Date of Action			
		Quarter 1	Quarter 2	Quarter 3	Quarter 4
1.	Lubricate fan and pump bearings/ gearbox				
2.	Drain basin and clean distribution deck, fill and drift eliminator				
3.	Check security of all bolts and fittings				
4.	Clean fan blades				
5.	Clean all components as required				

D. Monthly Water Sample Bacterial Test Records for the year ( )

Bacteria Test		Testing Laboratory	Data of Test	Test Results (cfu/mL)	Action
Heterotrophic colony count	Month 1				
	Month 2				
	Month 3				
	Month 4				
	Month 5				
	Month 6				
	Month 7				
	Month 8				
	Month 9				
	Month 10				
	Month 11				
	Month 12				
Total legionella count	Month 1				
	Month 2				
	Month 3				
	Month 4				
	Month 5				
	Month 6				
	Month 7				
	Month 8				
	Month 9				
	Month 10				
	Month 11				
	Month 12				

Note: The above formats are for reference only. The owners of the cooling towner systems should develop their own formats for their systems.

5.6 Sample Independent Audit Report for Cooling Tower System

Cooling Towner EMSD Registration No.	PS- _____No._____to_____
Auditing Period	_____ (month/ year) to _____ (month/ year)

A. System Description

Record	Details
Building Name & Building Address	
Cooling tower type	
Number of cooling towers in system	
Heat rejection capacities of the cooling towers	
Building owner's name/contact details	
Owner of cooling towers' name and contact details	
Designer of cooling towers' name and contact details	
O&M contractor of cooling towers' name and contact details	
Water treatment services provider's name and contact details	

*To include company name, contact person's business and after office hours telephone numbers

B. Documents Checking

Documents	Records available		Recommendation
	Yes	No	
Operation & maintenance manual			
Testing & commissioning records			
System schematic and layout drawings			
Routine inspection records			
Routine maintenance records			
Routine cleaning and disinfection records			
Monthly heterotrophic colony count (HCC) results			
Monthly/Quarterly* total legionella count results			
Routine water quality monitoring records (if available)			

*Delete as appropriate

C. Visual Inspection

Items	Acceptable		Recommendation
	Yes	No	
General cleanliness of cooling tower system			
Integrity of components including ladders, rails and platforms			
Operation condition of cooling towers and pumps			
Operation condition of water treatment equipment			
Cleanliness of plant area			
Drift loss control			

D. Risk Identification

	Assessment of Cooling Tower System	Recommendation/ remedial action required
System alteration	Any system addition, alteration and improvement work carried out in the previous year? ☐ Yes ☐ No	
	If yes, has operation and maintenance programme been reviewed? ☐ Yes ☐ No	
External environment	Is there any newly occupied building regarded as high risk designation located in vicinity to the system? ☐ Yes ☐ No	
	If yes, has operation and maintenance programme been reviewed? ☐ Yes ☐ No	
	Is there any construction site found nearby? ☐ Yes ☐ No	
	If yes, has operation and maintenance programme been reviewed? ☐ Yes ☐ No	
	Is the separation between the cooling towers and the nearest opening(s) maintained to meet the separation requirements as stipulated in Section 4.1 of Code of Practice Part 1? ☐ Yes ☐ No (please specify in details)	
System performance	Has fouling of cooling towers system occurred in the previous year? ☐ Yes ☐ No	
	If yes, has appropriate rectify work been carried out? ☐ Yes ☐ No	

	Assessment of Cooling Tower System	Recommendation/ remedial action required
Water treatment programme performance	Has HCC results exceeded 100 000 cfu/mL during the previous year? ☐ Yes ☐ No	
	If yes, has appropriate rectified work, including cleaning and disinfection and water treatment programme review been carried out? ☐ Yes ☐ No	
	Has total legionella count results exceeded 10 cfu/mL during the previous year? ☐ Yes ☐ No	
	If yes, has appropriate rectified work, including cleaning and disinfection and water treatment programme review been carried out? ☐ Yes ☐ No	
Compliance of Code of Practice for Fresh Water Cooling Towers	Is the system complied with the Code of Practice? ☐ Yes ☐ No	
Potential risk identified during walk-through inspection		

E. Progress of remedial works

	Assessment of Cooling Tower System	Recommendation/ remedial action required
Remedial works	Are all the remedial works as recommended in the previous year being carried out? ☐ Yes ☐ No ☐ N/A	

F. Other recommendation

_____
_____
_____
_____
_____
_____

G. Personal declaration

Part I: To be completed by Auditor*

*I, _____ (Full name of Auditor), Registered Professional Engineer (*Building Services / Mechanical Discipline), RPE Registration No: _____, have carried out annual independent audit for the above cooling tower system in according to section 4.3 of the Code of Practice for Fresh Water Cooling Towers, Part 2. And I am not involved in any O&M activities of this cooling tower systems.

OR

*I, _____ (Full name of Auditor), holder of_____ (Qualification of Auditor), issued by _____ (Institute issue the Qualification), have carried out annual independent audit for the above cooling tower system in according to Section 4.3 of the Code of Practice for Fresh Water Cooling Towers, Part 2. And I am not involved in any O&M activities of this cooling tower systems.

(* delete as appropriate)

Signed by the Auditor: _____

Full name of Auditor: _____

Registration no.: _____

Date: _____

#Remarks: The Auditor should have relevant operation and maintenance experience on cooling tower systems and possess either one of the following qualifications.

a) Registered Professional Engineer in Building Services or Mechanical discipline, or
b) Higher Certificate or above in building services engineering or mechanical engineering or air-conditioning system, plus at least five years of operation and maintenance experience on cooling tower systems.

Part II: To be completed by the owner of cooling tower system

I am the owner of this cooling tower system. I acknowledge that I have read this annual audit report and understand the latest conditions of this cooling tower system.

Signed by the Owner of cooling tower(s): _____

Full name of Owner of cooling tower(s): _____

Date: _____