Best Practices for Operation and Maintenance Service of ELECTRICAL 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 electrical 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 Electrical Contractors' Association Limited**
- **Hong Kong Housing Society**
- **Housing Department, the Government of the Hong Kong Special Administrative Region, China**
- **Mott MacDonald Hong Kong Limited**
- **The Association of Consulting Engineers of Hong Kong**
- **The Chartered Institution of Building Services Engineers (Hong Kong Region)**
- **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 and Electrical Division)**
- **The Hong Kong Institute of Facility Management**
- **The Hong Kong Polytechnic University (Department of Building Environment and Energy Engineering and Department of Electrical Engineering)**
- **The Institution of Engineering and Technology (Hong Kong Office)**
- **The Real Estate Developers Association of Hong Kong**
- **The University of Hong Kong (Department of Electrical and Electronic Engineering)**

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**
- **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 practices 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 electrical installations in buildings. Under each key attribute, it outlines the general, good and best practices for operation and maintenance service of electrical 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

Installations	The work or services for the Electrical Installations forming parts of the Works to be installed, constructed, completed, maintained and/or supplied.
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
CoP	Code of Practice for the Electricity (Wiring) Regulations
EMSD	Electrical and Mechanical Services Department, the Government of the Hong Kong Special Administrative Region, China
IEC	International Electrotechnical Commission
ISO	International Organisation for Standardization
REC	Registered Electrical Contractor
REW	Registered Electrical Worker

Table of Contents

1 Introduction

1.1 About This Best Practice Booklet

This Booklet is intended to outline the guiding principles on general, good and best practices to be considered during the design, construction, operation, maintenance, alteration, addition and replacement for the electrical 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

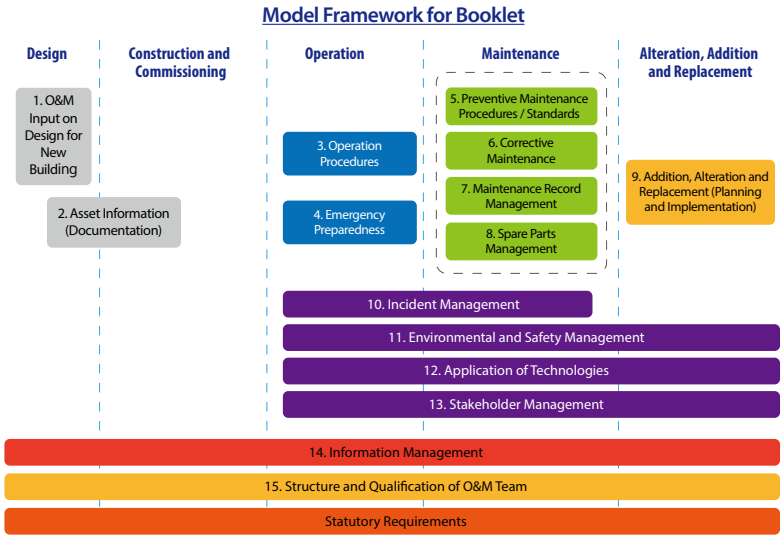
This Booklet mainly covers 15 key attributes in the following stages in new and existing buildings:

- **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 electrical Installations in buildings. Three levels of guiding principles, namely general, good and best practices, 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 Electrical Installations in buildings. It defines three levels of practices namely, basic/general, good and best practices for each.

The 15 key attributes are:

(i) O&M Input on Design for New Building – It is important for Design Engineers to consider operability, 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 good operation and maintenance. This section describes the key documents that are required for the efficient operation and maintenance of Electrical Installations.

(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 emergency is important, and emergency management allows stakeholders to anticipate the types of potential hazards that could occur, and to think of ways to reduce the impact.

(v) Preventative Maintenance Procedures / Standards – Preventive Maintenance (PM) consists of a series of time-based maintenance requirements that provide a basis for planning, scheduling, and executing scheduled 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 identify 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 Electrical Installations.

Section 4: Industry Standards and Requirements

Describes the summary of relevant industry standards and requirements for O&M services for Electrical Installations.

Section 5: Useful Forms – Samples

Describes the commonly used forms / checklists adopted in O&M services for Electrical 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 practices, 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 Occupants (Tenants)

Tenants hold the responsibility to ensure that the operation of the equipment is efficient, human behavioural patterns do not affect the efficiency of Electrical Installations, and that work carried out during tenancy fit-out 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's O&M. The FM should implement the maintenance and environmental policies and strategies set by the Building Owner in accordance with the allocated resources. The FM should 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 experience into the project design in order to optimise building life.

Maintainability should be considered, and incorporated into 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

- Design according to relevant codes of practice, guidance documents and international standards on operational management and maintenance of electrical systems. Electrical equipment must be installed to be capable of being maintained, inspected and tested with due regard to safety;
- Collect design advice from O&M team on operability, maintenance accessibility and maintainability aspects of electrical installations;
- Provide adequate working space for access, operation and maintenance of electrical installations. Minimum clearance space as stipulated in Code of Practice for the Electricity (Wiring) Regulations (CoP) should be provided for all switchgears. For protective devices and testing terminals for earthing conductor, they should be located at places readily accessible for inspection, testing and maintenance;

- Provide suitable lighting in switchrooms/substations for access, operation and maintenance; Suitable ventilation is also essential to prevent development of high ambient air temperatures around the electrical equipment.

Level 2

GOOD PRACTICE

2.1.2

- Project team identifies key design, commissioning and maintenance requirements for referral by designers, installers, operators and management;
- O&M team joins project design team at early design stage of project to provide input on system design ensuring best operability and maintainability of installed systems;
- Establish design checking matrix covering operability, accessibility and maintainability for incorporation by design consultants, including design consultants of electrical systems, consultants for other M&E systems;
- Determine the arrangement for electricity supply with power companies in early design stage. Special attention should be drawn to maximum demand and the estimated load profile, maximum instantaneous load, supply voltage, security and reliability of power supply, statutory requirements, energy efficiency and power quality, renewable energy equipment, location of transformer rooms and switchrooms, etc.;
- Adopt additional standby power supply, e.g. standby generator, plug-in unit for prompt connection with mobile generators, etc., for critical systems;
- Provide separate access to the power company's equipment room;
- Determine power distribution strategies based on importance of corresponding electrical system and its associated risk of electrical failure;
- Install data collection and monitoring system for new building for online real-time monitoring. Data captured can be used for further analysis of energy usage and electrical health condition of the electrical system; Separate metering should be provided for each individual user group;
- Allow for future expansion and addition of equipment in sizing of transformer, switchgear and switchboard.

Level 3

BEST PRACTICE

2.1.3

- Design the new building with considerations of life cycle cost of electrical installations, which includes initial project cost, utilities cost, service cost, maintenance cost, replacement cost, etc., and use them to facilitate planning, design, and construction;
- Liaise with the power company on alternative power supply arrangement depending on the level of reliability required for specific premises.
- Adopt the most cost effective electricity tariff scheme of power companies according to the maximum power demand, general load pattern of the system and on-grid arrangement of renewable energy installations;
- Design alternative renewable energy systems (e.g., solar photovoltaics, solar thermal, fuel cells, etc.) to optimise power supply system with consideration of load shedding especially in peak load period;
- Maximise electrical system resilience by providing redundancies, interconnections, changeovers and bypass arrangement to minimise impact to users during maintenance activities or power suspension incidents;
- Establish in-house design guidelines for operability, accessibility and maintainability aspects with regular review and update;
- Uplift health and safety performance in the whole project life cycle of building construction and maintenance by early hazards identification and mitigation since early design stage according to Construction Design and Management (CDM) Guidance Notes;
- Adopt Building Information Modelling (BIM) in construction for design visualisation to improve building quality by optimising planning and design, improving coordination, and reducing construction waste and enhancing workers' safety. BIM can also help to visualise O&M requirements in early design stage.

2.2 Asset Information (Documentation)

Asset Information should be compiled, covering all major items of Electrical Installations 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

- Properly keep certificates (e.g. Form WR1/WR2), as-fitted drawings and other documentations as per statutory requirements.

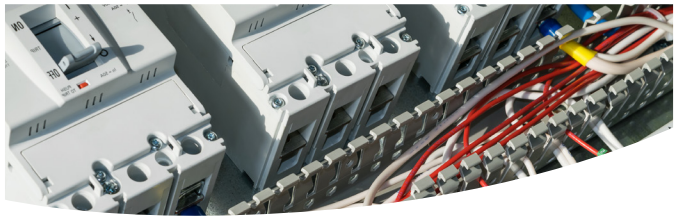
Level 2

GOOD PRACTICE

2.2.2

- Retain up-to-date as-fitted drawings, testing and commissioning (T&C) reports, O&M instructions/manuals, and equipment lists showing brand name, model, rating, year of installation, recommended spare part lists, tool lists and suppliers' contacts, etc.;

- Establish asset management (AM) information and filing system to administer and update all possessed asset information. Asset management information includes at least the asset inventory, asset risk registers, drawings, contracts, policies, procedures, work instructions, asset operating criteria, asset performance and condition data, asset management records resulted from asset management activities, etc.;
- Adopt systematic documentation to properly retain all information. Example of key systems relevant to asset management includes:-
    i) Fault call job card and report for maintaining information such as date and time of receiving and rectifying the fault, information of faulty equipment, cause of the fault, affected service areas, information of responsible staff and stakeholders, etc.;
    ii) Log-book for recording contractor's / frontline staff's maintenance activities; and
    iii) Records (e.g. fault summary) for measuring the contractor's performance against performance targets, etc.
- Ensure all records are prepared and maintained such that they are legible, readily identifiable, retrievable and traceable to the activity or service involved;
- Designate authorised person(s) to regularly update any changes in asset information and / or asset register; Implement appropriate control measures to ensure that only the correct versions of records are available to users.

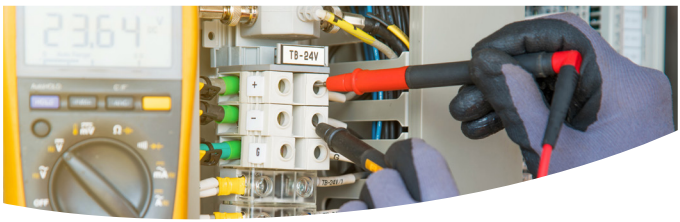


Level 3

BEST PRACTICE

2.2.3

- Properly keep all design documentation (e.g. design criteria, room datasheet, design calculations, etc.);
- Digitise all asset information with standardised file naming system in a reliable database server for easy retrieval;
- Implement computer based asset management systems for asset record and version control, with corresponding workflow for data retrieval and as-built updates, to ensure data validity throughout life cycle of assets;
- Streamline interface for computerised asset information model such as BIM or Computerised Maintenance Management System to enable essential asset information to be retrieved from asset information database easily whenever necessary;
- Adopt BIM-AM system following the BIM-AM Standards and Guidelines issued by EMSD to ensure smooth handover of as-built asset information from construction stage to O&M stage.



2.3 Operation Procedures

Operational efficiency refers to the lifecycle, 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

- **Maintain and update the following documents in daily operation**
  - i) Details of O&M team such as the organisation structure as well as name, contact information, qualifications and responsibilities of each team member;
  - ii) Basic operation procedures of electrical systems / equipment (e.g. switching / isolation instructions);
  - iii) General safety-related guidelines and training materials;
  - iv) Lists of tools and equipment, materials or parts necessary for daily operation;
  - v) Emergency plan;
  - vi) Contact list of power company, registered electrical contractors, spare parts suppliers, resident staff, etc.;
- **Implement general access control**
  - i) Prevent unauthorised entry into sub-stations or switchrooms;
  - ii) Display suitable warning notices for sub-stations, switchrooms, distribution boards and high voltage (H.V.) installations;
  - iii) Keep every H.V. enclosure locked, except where manned;
  - iv) Keep the access door key for entering the H.V. enclosures under the control of a responsible person and keep a duplicate key in a lockable key cabinet located in the general office or plant manager room of each plant or depot;

- **Take safety precautions when performing isolation and switching work**

  i) Use suitable and adequate personal protective equipment and proper tools in carrying out operation;

  ii) Implement permit-to-work system, in which an official form is signed and issued by a responsible person to a person having the permission of the responsible person in charge of work to be carried out on any earthed electrical equipment for the purpose of making known to such person exactly what electrical equipment is dead, isolated from all live conductors, has been discharged and connected to earth (if necessary), and on which it is safe to work.

Level 2

GOOD PRACTICE

2.3.2

- **Maintain the following documents in daily operation:**

  i) Standardised checklists for inspection and testing of electrical installations and equipment;

  ii) Detailed electricity safety guidelines on electrical work with content including but not limited to duties, definitions, procedures in appointment of Responsible Person and Person in Charge, safety rules, examination of tools and protective equipment, compliance audit, etc. A copy of the guidelines and Labour Department's "electric shock" poster should be displayed in switchrooms, workshops, plant rooms and control rooms;

  iii) Logs of the operation status of the electrical installation such as voltage, current, power consumption (kWh), temperature of switchboard, fault history, etc.;;

  iv) Guidelines on requirements of uniform with badges and identity cards for O&M direct staff and contractor staff;

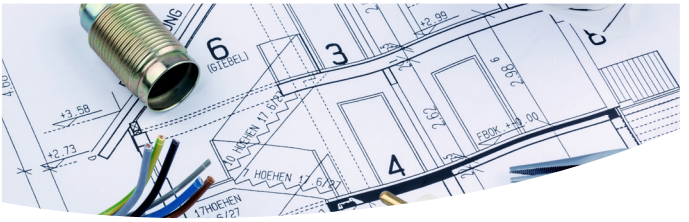
- Provide induction training and/or periodic awareness training on electrical safety to O&M team;
- Adopt system optimisation for improvement on energy performance and monitoring.

Level 3

BEST PRACTICE

2.3.3

- Implement quality assurance system such as ISO 9000 to achieve continual improvement in daily operation;
- Establish hierarchy of policies, standards, procedures and guidelines on O&M practices with appropriate approvals from competent and responsible personnel;
- Adopt appropriate occupational safety practices to reduce human error in carrying out electrical work;
- Set up remote monitoring system for early fault detection and reporting;
- Adopt risk-based approach to regularly review all associated guidelines and procedures by competent responsible personnel.



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 Electrical Installations, 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 updated contact information is provided.

Level 1

GENERAL PRACTICE

2.4.1

- Up-to-date emergency contact list including power company, registered electrical contractors, resident staff, etc. is available;
- Up-to-date communication flow between client / user (both administrative and operation), O&M team and contractors is available;
- A schematic wiring diagram showing the main distribution system should be displayed near the main switch with rating 100A or above;
- A duplicate key for each high voltage switchroom/substation should be available, for emergency purposes, in a key box at a designated location;
- At least one exit of a switchroom/substation should open outwards and this emergency exit should be identified clearly;
- Emergency generator and lighting shall be maintained in efficient working order at all times and shall be inspected by a registered fire service installation contractor at least once in every 12 months;
- The emergency generator should be run once per month under load conditions for a period of not less than 30 minutes according to maintenance checklist or O&M Manual. During this running period all

operating conditions should be checked. Following this running period functional tests should be carried out on all automatic and manual starting devices and safety controls. Fuel tanks shall be refilled to full after testing;

- Where electrical equipment in the switchroom/substation is required to be operated in case of mains power failure, adequate emergency electric lighting independent of the mains supply and capable of operation for a minimum period of 30 minutes should be provided.

GOOD PRACTICE

2.4.2

- All associated documents such as up-to-date floor plan to show the location of all distribution boards are available in an agreed location, such as security room and/or property management office;
- Up-to-date schematic wiring diagram showing the distribution system should be displayed near each distribution board;
- Emergency (contingency) plan / procedures and recovery plan are available. The plans should be established by the responsible parties to formulate the appropriate action items to handle the power supply failure due to any cable fault or switchgear fault, such as load shredding procedures, emergency power supply requirement list, etc.;
- Specific requirements in maintenance contracts for emergency situations such as response time are available;
- Regularly review the spare parts level and ensure that sufficient materials and / or critical spare parts are available on site for quick fix to resume operation;
- Training of property management personnel on emergency preparedness and whenever the system is upgraded;
- A power failure simulation test circuit provided at the emergency generator control panel should be considered to ease O&M staff in performing emergency generator changeover test where the city main is still in healthy condition;
- Proper maintenance and service should be provided to the generator and the associated engineering sub-systems including under-voltage detection, starting battery, fuel supply, cooling, automatic transfer switch, etc., to ensure the smooth start-up, transfer of power and continuous running of the standby generator;

- In addition to routine tests which help identify defective components of emergency generator, emergency generator should be replaced based on its service life. According to CIBSE Guide M (2014 edition), life expectancy of emergency generator is 25 years;
- If the designed spare capacity of the emergency generator is used up due to additional load connected to the essential supply, upgrading of the emergency generator should be planned;
- Maintain escalation procedures for critical incident reporting and decision making.

BEST PRACTICE

2.4.3

- Annual review on emergency / recovery plan and conduct drills;
- Availability of mobile generators with adequate power capacity and cables of adequate length for emergency use;
- Digitise reference documents including schematic wiring diagrams for easy retrieval.

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. Planned Maintenance and Condition Based 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 replacement or repair of worn parts before any system failure.

The Preventive Maintenance Program must include the methodology and record for all actions that are necessary to maintain the optimal functioning of the Electrical Installations. The required maintenance procedures will be unique to each property and the systems within these facilities.

Level 1

GENERAL PRACTICE

2.5.1

- Carry out inspection and testing in accordance with statutory requirements, i.e. Periodic Inspection, Testing and Certification (PITC) in accordance with the Electricity (Wiring) Regulations under the Electricity Ordinance (Cap. 406) and the CoP:-

  i) Fixed electrical installations with an approved loading at places of public entertainment, premises for the manufacturing or storing of dangerous goods and high voltage fixed installations are required to be inspected, tested and certified at least once every year;

  ii) Fixed electrical installations in factories and industrial undertakings with an approved loading exceeding 200 amperes, single or three phase at nominal low voltage are required to be inspected, tested and certified at least once every five years;

  iii) Fixed electrical installations in premises other than those mentioned above with an approved loading exceeding 100 amperes single or three phase at nominal low voltage are required to be inspected, tested and certified at least once every five years;

  iv) Low voltage fixed electrical installation located in hotel or guest house, hospital or maternity home, school, premises of the institutions listed in section 2 of the Education Ordinance (Cap. 279) and child care centre should be inspected, tested and certified at least once every five years;

- Electrical work (i.e. work in relation to the installation, commissioning, inspection, testing, maintenance, modification or repair of a low voltage or high voltage fixed electrical installation and includes the supervision and certification of that work and the certification of design of that installation) shall be carried out by a Registered Electrical Contractor (REC), or Registered Electrical Workers (REWs) of the appropriate grade employed by the owner of the electrical installation on a full time basis at a regular wage;
- Use calibrated testing equipment for all testing and commissioning;
- In order to ensure personal safety of the electrical workers and avoid affecting building power supply in case of electrical accident, the power company's electricity supply should be cut off in carrying out PITC work on main switchboard that is connected to power company's transformer;
- Prior to commencement of maintenance and overhaul work, all safety precautions complying with statutory requirements and safety regulations should be taken. All workers shall be fully aware and abide by the safety regulations at the site;
- To ensure the electrical work is carried out in a safe environment, the upstream switch of circuit breaker shall be switched off and isolated, and an appropriate warning notice should be securely displayed before the electrical work is carried out. The switch or circuit breaker should also be locked off if locking mechanism is equipped. The circuit/equipment to be worked on should be checked to ensure that it is dead ;
- Before entering into any working area where CO2/FM200 gas extinguishing system is installed, the system must be switched from auto to manual mode first for the whole working period. The auto mode shall be restored immediately after the persons engaged on the work have withdrawn from the protected enclosure;
- After completion of the testing, inspection and overhaul of switchboards, the Periodic Test Certificate (Form WR2) should be completed, signed by REWs and RECs and submitted to EMSD for endorsement together with associated wiring schematic and test reports. After that, the certificate should be properly retained for future inspection by EMSD.

GOOD PRACTICE

2.5.2

- Establish preventive maintenance plan of the electrical installations and their associated accessories/equipment generally according to the respective manufacturer's instruction;
- Carry out regular inspection and scheduled preventive maintenance (quarterly, half yearly and annual maintenance works, etc.) to ensure that the plant and equipment, including switchroom, switchgear and switchboard assemblies, switch, circuit breaker, automatic transfer switch, undervoltage relay, protection relay, heater, thermostat and thermal cut-out, earthing system, power analyzer, digital multi-meter and meter, current transformer, power factor correct device, surge arrestor, cable, busway, battery and battery charger, fuse, cable termination and terminal block, etc., are operating at the optimum and most efficient conditions, with the operating parameters running as designed. Here are some examples of regular inspection:-
  - i) Condition survey including visual inspection and functional testing to record the condition of the LV/HV switchgears in accordance with the CoP;
  - ii) Infrared inspection (thermographic scanning) to ascertain whether abnormal hot spots exist at the switchboard surface, switchgears, cables, busway and other components;
  - iii) Built-in protection test kits, if available, to examine the operation conditions of the OC/EF protection of the LV/HV switchgears;
  - iv) Ductor test to ensure that the contacts and joints for switchgears, cables, busbars, system earth as well as contacts and joints for cable and busbars are maintained in good conditions;
- Use suitable personal protective equipment so as to eliminate any possible/potential electric shock during electrical inspection and measurement;
- Isolation for the equipment under inspection or maintenance should be carried out by an appropriate authorised person; and permit-to-work document should also be issued before commencement of work;
- Keep sufficient numbers of spare parts as suggested by the manufacturer. Regularly check the availability of materials and spare parts to ensure sufficient parts for carry out scheduled maintenance and overhauling works;

- Prepare standardised form and checklist for inspection, testing and maintenance of electrical installations (See CoP Appendix 13 for sample test results form and checklist). All maintenance records should be taken and certified by the appropriate officer. The completed form and checklist should be kept properly;
- Check and record operation parameters, such as running current and voltage, and observe any abnormal noise or vibration of the electrical equipment, etc. before and after overhaul in accordance with relevant BS/IEC standards;
- Carry out performance test after maintenance and overhaul works; Prepare and record test report including date of measurement, location of equipment, equipment description, all the test results, records of any parts renewed and replaced, adjustments made, clearances measured, defects detected and modification made to the equipment; All test records should be properly entered in the course of testing and all parties should sign the report immediately after the test;
- The building owners, Incorporated Owners and property management companies should contact the power company to check for the opportunities of carrying out the PITC, maintenance and overhaul work, which would cause power suspension, at the same time with the power company's scheduled equipment maintenance work so as to avoid repeated power suspensions and hence minimise the disturbance to the building users;
- Notify stakeholders in advance for testing / shut down of major plant and equipment; All stakeholders (including REC, building owners, Incorporated Owners and property management companies) should closely collaborate to work out the power suspension arrangement and temporary measures that meet the building operational needs with the aim to minimising disturbance to the building users resulting from the maintenance and overhaul work; For example, they may arrange to suspend and resume the power supply by zones, provide temporary power supply during maintenance or overhaul works, devise a contingency plan to handle emergency situations, etc.; In addition to routine tests which help identify defective components, HV/LV switchboard should be replaced based on its service life. According to CIBSE Guide M (2014 edition), life expectancy of LV switchgear is 20 years and HV switchgears is 30 years;
- The upgrading/replacement of LV/HV switchgears should comply with the CoP and General Specification for Electrical Installation.

BEST PRACTICE

2.5.3

- Carry out electrical healthy check according to the requirements stipulated in the ANSI/NETA ATS-2017, including:

  i) Coordination Studies down to three levels of sub-main distribution boards and the related out-going circuits;

  ii) Load-Flow Studies for all branches and nodes in the switchboard;

  iii) Harmonic-Analysis Studies for all branches and nodes in the switchboard;

- Adopt Reliability Centred Maintenance (RCM) to determine the most suitable maintenance strategy, such as Condition Based Maintenance (CBM), Risk Based Maintenance (RBM), etc., for each specific plant and equipment in the premises as stipulated in Society of Automotive Engineers (SAE) / IEC standards.

  i) CBM optimises the interval between maintenance and minimises system downtime by monitoring the actual condition of the plant and equipment to decide what and how frequent maintenance needs to be carried out;

     1. Install high-ended power analyzing meters and software for collection of necessary data which allows maintenance personnel to perform maintenance at the exact moment it is needed, prior to failure;

     2. Adopt Power Quality and Energy Management System (PQEMS) for online real-time monitoring of power quality and energy usage. Data captured can be used for further analysis of energy usage and electrical health condition of the electrical system;

     3. Example of parameters to be measured and analysed for CBM: Breaker capacity, power factor, total harmonic current, alarm trend, harmonic distortion in current level, unbalance phase current, high neutral current, current trend, energy consumption, etc.;

  ii) RBM prioritises maintenance resources according to corresponding risk of causing a failure of each plant and equipment. Through a thorough risk assessment (5 x 5 risk matrix), the likelihood and consequence of failure of each plant and equipment will be determined and hence the frequency and scope of maintenance activities can be continuously optimised;

- Regularly review all procedures / standards;
- Regularly update relevant procedures / standards against the latest statutory requirements and latest international standards, maintenance records and fault history by competent responsible personnel;
- Adopt web-based / mobile Apps performance monitoring system for contracted-out maintenance.

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 maintenance operations.

Level 1

GENERAL PRACTICE

2.6.1

- Electrical work (i.e. work in relation to the installation, commissioning, inspection, testing, maintenance, modification or repair of a low voltage or high voltage fixed electrical installation and includes the supervision and certification of that work and the certification of design of that installation) shall be carried out by a Registered Electrical Contractor (REC), or Registered Electrical Workers (REWs) of the appropriate grade employed by the owner of the electrical installation on a full time basis at a regular wage;
- 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 relevant stakeholders including the Owner, Owner's representatives, building management, end-users and maintenance team by the means of verbally or in written form at any time;
- Maintain efficient and prompt response to breakdown, emergency call-out or complaint for timely attendance of installation / equipment failure and / or unsatisfactory services. For all situations, the maintenance team should have staff / contractor on site within different defined time periods;

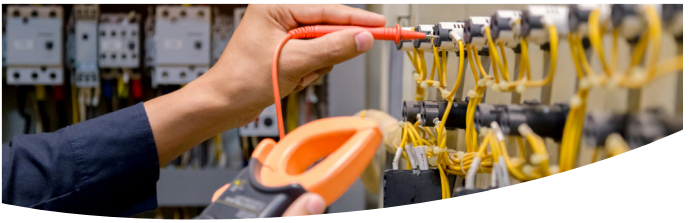
- Prepare sufficient tools, equipment (including personal protective equipment) and instruments, with sufficient and convenient means of transportation for the safe, efficient and satisfactory completion of the repair works, especially for non-resident fault call teams for unattended venues;
- Corrective maintenance work conducted in non-operating hours to minimise interruption as far as practicable;
- Establish Key Performance Indicator on corrective maintenance for continual improvement on performance.

Level 3 BEST PRACTICE

2.6.3

- Establish a round-the-clock (including public holidays and under bad weather conditions) fault call centre with hotlines, allowing stakeholders to report system faults;
- Develop an automatic control and remote monitoring system to provide relevant information on faults, including pre-alarms, fault indications, fault details, affected areas, etc.;
- Notify designated personnel for fault handling through auto-notification from fault call centre to mobile devices by phone calls/ SMS;
- Determine appropriate performance targets regarding various nature of faults and handle the fault in accordance with the performance targets, for example, setting different fault response time and fault rectification time for urgent faults and non-urgent faults, as well as for attended venues and unattended venues;
- Form an all-time standby fault attendance team, including suitable manpower strength, appropriate and sufficient tools, readily available transportation, to response the faults immediately after receiving fault reporting;
- Prepare daily fault call summary;

- Prepare fault report with fault description, root cause of fault, action taken, follow-up actions, short-term and long-term measures for record and fault analysis;
- Develop a system/equipment database for the ease of record finding, fault analysis, reliability monitoring, etc.



2.7 Maintenance Record Management

Good management of maintenance records is essential for ensuring that a piece of equipment is performing in line with the design specification and intent, and can help to determine its preventive maintenance schedule. It also assists service technicians with diagnosing repeated 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

- Make reference to O&M manuals and follow the manufacturer's recommended maintenance requirements;
- Maintain paper records of all maintenance related activities including latest single line diagram, records of tests, testing and commissioning certificates, as-fitted drawings, statutory approved submission document, statutory certificates (e.g. Form WR2 – Periodic Test Certificate), calibration records of equipment, etc.;
- Maintain a register to monitor the due date of all testing equipment's calibration and renewal date of all statutory maintenance certificates;
- Maintain a list of stocks of spare parts, equipment and other components which are necessary to maintain the safe and satisfactory working condition and operation order of major plant and equipment at all times;
- Maintain log book and reports of emergency call / fault attendance.

GOOD PRACTICE

2.7.2

- Set up an efficient computerised register and filing system to administer all statutory certificates, records, drawings, O&M documents, etc.;
- Set up an efficient computerised system for logging of equipment maintenance records and fault history for easy retrieval by premises owner or maintenance personnel for review on equipment condition and assisting in fault diagnosis;
- Assign designated person(s) responsible for reviewing and updating monthly routine maintenance inspection schedule, emergency call / fault attendance reports, etc.;
- Set up a record system able to automatically remind/alert all outstanding/ to be outstanding maintenance and statutory certificates renewal.

BEST PRACTICE

2.7.3

- Digitise documents and records with standardised file naming system in a reliable database server for easy retrieval;
- Maintain and regularly update and review records of maintenance service and fault history;
- Adopt a proper file keeping system to keep track of maintenance records for effective retrieval and analysis;
- Establish a computer database for monitoring of statutory documents with functions to automatically remind expiry and renewal and ensure statutory compliance.

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 part 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 / long-time delivery parts for minimising downtime of critical system when maintenance and repair is required;
- Monitor the conditions of spare parts to ensure their quality is maintained;
- Specify and monitor shelf-life of spare parts and replenish as required, to ensure quality and reliability of parts at use;
- Assign designated person(s) responsible for regularly updating on the spare parts inventory;
- Store spare parts at dedicated location with designated retrieval workflow and contact list for swift response to maintenance and faults;
- Adopt security measures in locations where parts are kept.

BEST PRACTICE

2.8.3

- Derive the type, quantity of on-site spare parts from fault history, maintenance records, age and criticality;
- Adopt a proper inventory control system to keep track of spare parts level and monitor usage with alerts to place orders;
- Review regularly with manufacturer or supplier on the obsolescence of spare parts and availability of substitutes;
- Conduct review on the dormant stock items to reduce the level of dormant stock and minimise the risk that the items become obsolete with the passage of time and advance in technology.

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 electrical Installations to meet the organisational long-term objectives.

GENERAL PRACTICE

2.9.1

- Employ REC to carry the addition, alteration and replacement (AA&R) works;
- Conduct alterations and additions works as per users' requirements;
- Obtain confirmation from users before works and provide anticipated works programme for stakeholders' reference;
- Fulfill all the latest statutory requirements when conducting AA&R works including but not be limited to the CoP and the Code of Practice for Energy Efficiency of Building Services Installation (also known as the "Building Energy Code" or "BEC");
- When the electrical work is completed, the electrical installation must be inspected and tested by a REW before the installation is energised;
- Provide all applicable documents and drawings, including but not be limited to design calculations, equipment schedules, as-fitted drawings, testing and commissioning records, work completion certificate (Form WR1) and O&M manuals of AA&R works for records;
- Prepare all necessary statutory submissions as applicable.

Level 2

GOOD PRACTICE

2.9.2

- Identify, plan and implement the replacement works in condition-based approach by considering the system performance, equipment age, fault frequency and spare parts availability as well as any specific law and safety requirements, etc.;
- Engage a REC to carry out a feasibility study before carrying out any addition to or alteration of an electrical installation. The owners should consider the future electricity demand to decide whether it is necessary to apply to the power company for increasing the approved loading of the installation;
- Establish detailed method statements and risk assessments for AA&R works;
- Update/develop equipment and spare parts database, with all equipment schedules and their ages for easy tracking on equipment data;
- Review maintenance reports regularly to monitor the condition and performance of systems and conduct AA&R works when necessary;
- Develop action plan and contingency plan with users with seamlessness approach for equipment replacement works.

Level 3

BEST PRACTICE

2.9.3

- Acquire feedbacks from users regularly to keep track of the systems for developing a user-orientated replacement plan;
- Derive a replacement planning mechanism with rolling plan to plan for the replacement works in coming years. The mechanism shall incorporate considerations from equipment age, physical condition, capacity meeting current loadings, failure rate, statutory and safety, maintenance cost, operation and/or energy performance, spare parts availability, design standards, etc.;
- Conduct a holistic review on system performance when planning and design the system replacement with the introduction of latest technologies to enhance overall system performance;
- Develop standard T&C records and O&M manuals for all AA&R works for equipment;
- Digitise all as-fitted drawings, T&C records, O&M manuals and associated statutory submissions for proper records;
- Register all the AA&R works conducted for the systems properly for easy tracking.

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

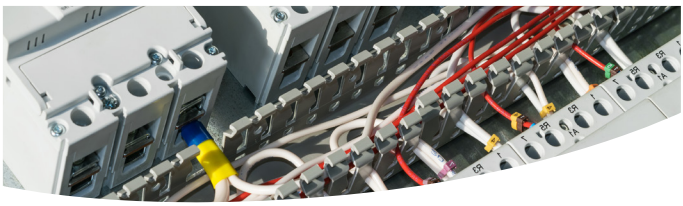
- Conduct incident investigation and make safe or isolate the affected parts of the electrical installation as soon as possible;
- Carry out corrective maintenance by REC/REW in accordance with statutory requirements;
- Ensure that work completion certificate (Form WR1) is certified by REC/REW;
- Keep proper records of incident investigation, downtime of system, rectification works, loss of property, recommendations for improvement, etc.;
- Report workplace accidents and dangerous occurrences to Labour Department as per the statutory requirements;
- Submit incident report prepared by REW when required by EMSD.

Level 2

GOOD PRACTICE

2.10.2

- Establish an incident management plan to define alert levels, investigation procedures, reporting mechanism, standard incident report form and requirements of investigator;
- Maintain updated emergency contact lists of appropriate levels of responsible officers of management staff and related stakeholders according to the pre-defined incident levels;
- Specify requirements for emergency situations, such as time for attendance of fault calls and emergency calls, etc.;
- Review the conditions of similar systems and equipment to avoid recurrence of the incident;
- Conduct necessary AA&R works to enhance the system reliability;
- Conduct regular emergency drills to strengthen staff's knowledge to prepare for incident break-out.

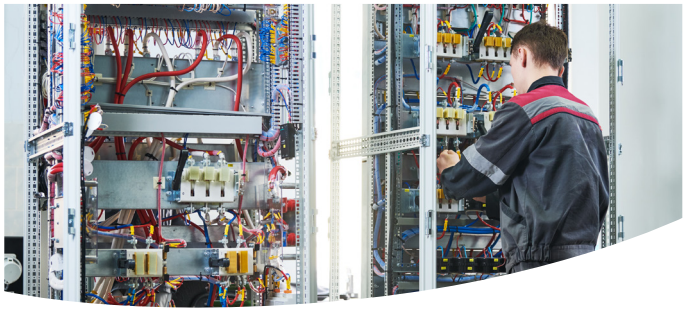


Level 3

BEST PRACTICE

2.10.3

- Regularly review 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;
- Set up a working group or dedicated team to steer incident management, maintain good communication with all stakeholders for improving system performance and reliability;
- Conduct review and share lessons learnt from incidents to all related parties and take precautionary actions to eliminate potential problems in other venues;
- Establish emergency task-force teams for incidents 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 life cycle efficiencies.

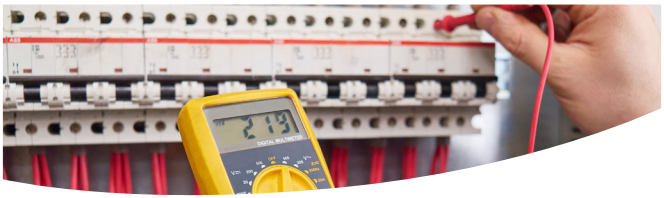
Level 1

GENERAL PRACTICE

2.11.1

- Fulfill 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.



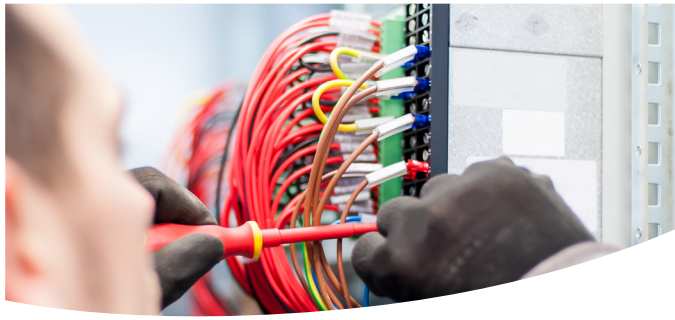
Level 2

GOOD PRACTICE

2.11.2

- Establish and maintain Environmental Management System (e.g. ISO 14001) and Safety Management System (e.g. OHSAS 18001 or ISO 45001);
- Optimise / minimise the use of materials, resources and energy (e.g. electricity, fuel, chemicals, etc.) wherever appropriate, to be both energy and resource efficient;
- Avoid the use of environmentally unfriendly materials or equipment and replace aging equipment with more environmentally friendly/safe and energy efficient alternatives;
- Utilise and rehabilitate existing useful components of the aging equipment subject to be replaced;

- Minimise the production of all kinds of waste where applicable;
- During design stage, consider health, environmental, energy efficiency and safety issues to facilitate the building to operate in a sustainable manner throughout its life cycle;
- 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;
- Establish and implement safety and environmental-friendly rules to provide instructions for different working conditions;
- Supervise personnel to ensure that safety and environmental-friendly rules are observed, and personal protective equipment are used and maintained properly;
- Investigate accidents and incidents including near miss cases to find out root causes and recommend suitable measures to prevent recurrence.



★★★ 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

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

Level 1 GENERAL PRACTICE

2.12.2

- 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

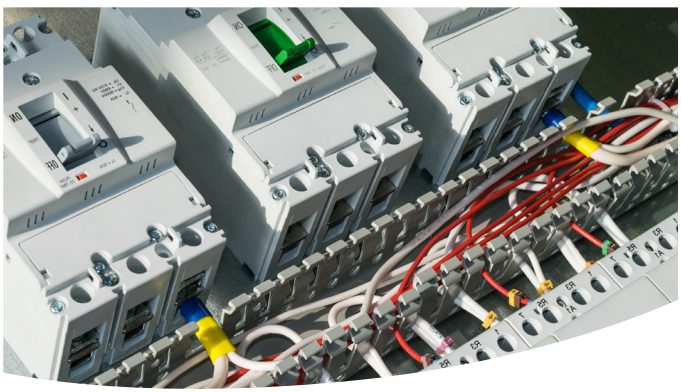
- Calibrate tools and equipment as per the advice from the supplier / manufacturer;
- Get aware of the latest technologies available in the market;
- Introduce the latest available technologies that can enhance overall system reliability and energy efficiency for major replacement works or new installation 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 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.

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 the organisation comprises. 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

- **Ensure electrical work is led by at least one REW of the appropriate grade:**

  i) Grade A electrical work is electrical work on that part of a low voltage fixed electrical installation that has a maximum demand not exceeding 400 A, single or three phase;

  ii) Grade B electrical work is electrical work on that part of a low voltage fixed electrical installation that has a maximum demand not exceeding 2500 A, single or three phase;

  iii) Grade C electrical work is electrical work on a low voltage fixed electrical installation of any capacity;

  iv) Grade H electrical work is electrical work on a high voltage electrical installation;

  v) Grade R electrical work may include electrical work on a neon sign installation, an air-conditioning installation, a generating facility installation, and any other type of electrical work, or work on any type of electrical installation or premises, specified in the certificate of registration;

- Ensure maintenance team / contractor available for on-call services.

Level 2

GOOD PRACTICE

2.15.2

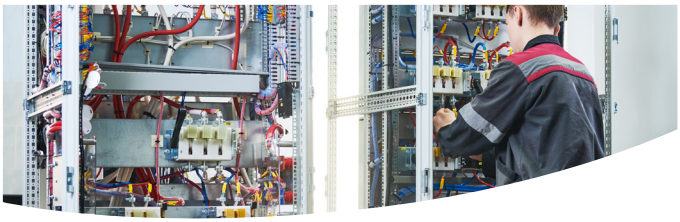
- Set up an O&M team with supervisors and maintenance personnel with proper qualifications and training;
- Arrange designated personnel to oversee and review system/team performance, maintenance activities and practices;
- Require Electrical Engineer / Building Services Engineer / Contract Manager to 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 practices/guidelines to improve the management of E&M assets, thereby enhancing the resilience and intelligence of government buildings.

Below are 3 emerging technology trends that may have impact on facilities management industry.

3.1 Technology Trend 1: Building Information Modeling for Asset Management (BIM-AM)

Although not a new technology, Building Information Modeling-Asset Management (BIM-AM) (BIM) 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. BIM software can help to simulate best O&M activities to testify operability and maintainability before construction.

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.

In recent years, EMSD has issued the BIM for Asset Management (BIM-AM) Standards and Guidelines for assets that need maintenance services. As far as the electrical trade is concerned, LV Switchboard, Emergency Generator, Lighting and Electrical Distribution are included. This standard provides the BIM modelling standard, coding standard and the information requirement for different types of Electrical & Mechanical (E&M) systems from construction stage to handover for building operation.

During design and construction stage, BIM is used as design visualisation and coordination tools. Meanwhile, asset information should be gradually built up in the BIM model so that by the end of the construction stage, the BIM model becomes an Asset Information Model (AIM) for handover to asset management.

3.2 Technology Trend 2: Integrated Building Management System (iBMS)

Integrated Building Management System (iBMS) is a master control system that integrates the electrical, mechanical, air-conditioning and building services (EMABS) systems into a single application for easy monitoring. Through iBMS, real-time operational parameters or asset operation data can continuously be collected from digitised equipment/installations such as electrical, lighting, emergency generator, air-conditioning, lift & escalator, fire services and general electronic installations. iBMS offers an automatic fault/alarm reporting system with the pre-alarm function that enables maintenance staff to take early action to prevent potential failure. It features Building Energy Management System (BEMS) applications utilising both historical and real-time asset operation data such as energy consumption, control set points, sequence control, operation schedule, environmental conditions, etc. for identifying energy management opportunities so as to formulate control strategies and control settings to optimise the energy performance. There are also insight applications exploring the available data, such as hours of operation, cycles for a specific asset, operation conditions, fault/alarm statistics and trending, failure frequency, time to failure, etc. to monitor and analyse asset health; to identify correlations and regression among the data for unveiling of equipment degradation; and to compare drivers and risk factors so as to flag up actionable insight to detect anomalies and to augment O&M effectiveness.

For electrical installations, an iBMS application typically includes the following elements:

a) Power Quality and Energy Management System (PQEMS) – Equipped with Power Quality Monitoring (PQM) and Energy Management System (EMS) connected with digital power analyzers via a common network protocol for data collection;

b) Digital Power Analyzer – Installed for every piece of equipment (such as those with electrical power rating 50 kW or above) and every floor or area (such as those with sub-main distribution exceeding 100A (3-phase 380V)) for measuring power quality and logging the energy consumption of each designated equipment or zone;

c) Power Factor Correction Device – For power factor improvement;

d) Active Harmonic Filter – For minimising Total Harmonic Distortion (THD);

e) Mobile Technology – For supporting instantaneous display and analysis of power quality and energy consumption data/information in mobile devices, as well as providing alarm notifications of abnormal power quality and energy consumption to support timely proactive maintenance and energy management.

iBMS can help to achieve certain performance targets in respect of power quality and energy management, for example, to achieve minimum 0.95 Total Power Factor (TPF), less than 4% THD for incomers at or above 2000A, and maximum current unbalance of not exceeding 10% for circuits at or above 400A.

3.3 Technology Trend 3: Predictive Maintenance using Artificial Intelligence (AI), Internet of Things (IoT) and Big Data

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 FM 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, FM 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 FM organisation.

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 occupancy within all facilities.

With various sensors generating data, FM organisations are able to identify issues and potential problems faster and easier.

Big data refers to data analytics involving large amounts of data available from different sources or systems, such as condition monitoring systems in the FM industry. Traditionally these datasets are stored and analysed independently. With the advent of IoT and other technological advancement, the discrete datasets can now be stored and analysed together for a more complete picture of asset health or for predictive analytics.

Predictive maintenance is generally conducted based on data analysis on fault history and equipment condition. Implementation of iBMS or similar platform for digitised asset management, together with the application of AI, IoT and big data, can strengthen predictive maintenance of the assets. It can predict possible equipment failure and hence facilitating overhaul/replacement/repair before the predicted failure. As a result, advantages like better asset availability (less downtime), improved system reliability, shortened maintenance time and reduced maintenance costs can be achieved.

3.4 Technology initiatives

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

O&M Aspect	Feasible Initiatives	Reference
O&M Input on Design for New Building	a) Design and construct electrical installations with BIM; b) Simulate best operation and maintenance activities using BIM or other simulation software to testify operability and maintainability of electrical installations 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-AM to maintain all electrical asset information under an efficient AM system; b) Inspect, digitise and upkeep latest record and logbook for electrical installations and equipment on regular basis; c) Implement mobile solution for AM record retrieval and updating, e.g. O&M manual, fault history, etc.; d) Adopt Radio Frequency Identification (RFID) or QR code for AM.	• BIM for Facility Managers issued by IFMA • BIM-AM Standards and Guidelines issued by EMSD • Construction Industry Council BIM Standards

O&M Aspect	Feasible Initiatives	Reference
Operation Procedures	a) Simulate operation procedures with BIM; b) Adopt cloud-based technology to store information of electrical installations and equipment to be accessed by O&M personnel when needed; c) Implement IoT-enabled self-diagnosis function for the healthiness of major electrical equipment; d) Incorporate on-line condition monitoring and mobile technologies on electrical systems to improve maintenance and reduce downtime.	
Emergency Preparedness	a) Identify affected areas by the electrical incidents using BIM to facilitate effective execution of the emergency plan.	
Preventive Maintenance Procedure / Standards	a) Adopt new technology and innovative system for conducting of electrical healthy check; b) Adopt IoT, AI and Big data for carrying predictive maintenance to eliminate electrical breakdown.	
Corrective Maintenance	a) Adopt creative method and methodology for improvement of fault report, fault attendance and progress reporting.	
Maintenance Record Management	a) Adopt computerised monitoring system to maintain detailed digitised maintenance information with capability for prompt alert, review and further analysis by AI, big data analytic, etc.	
Spare Parts Management	a) Utilise an automatic inventory control system to manage spare parts inventory by prediction of spare parts requirement using AI for advance and on-time spare parts procurement.	

O&M Aspect	Feasible Initiatives	Reference
Incident Management	a) Consider advanced 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 collect maintenance data for future improvement.	
Addition, Alteration and Replacement (Planning and Implementation)	a) Design and construct electrical installations with BIM; b) Adopt advanced management tools such as integrated FM tools to allow quick search of all equipment information and records, to enhance effectiveness of overall planning.	
Environmental and Safety Management	a) Adopt online platform for paperless contract execution; b) Adopt creative method and methodology for enhancing safety during the maintenance work of the electrical system.	
Application of Technologies	a) Apply new technology to improve the system reliability; b) Adopt I&T initiatives for enhancing the efficiency and effectiveness in the delivery of services; c) Enable knowledge transfer from research to industry to interface science / technology.	

O&M Aspect	Feasible Initiatives	Reference
Stakeholder Management	a) Establish a smart system to automatically notify stakeholders on the coming schedules and progress of all O&M activities, addition, alteration and replacement works.	
Information Management	a) Establish an iBMS; b) Create centralised database for automatic replacement planning for equipment; c) Establish an online real time server for storing maintenance related information through mobile device; d) Provide online access of all information by maintenance party during preventive maintenance works.	
Structure and Qualification of O&M Team	a) Provide training to O&M personnel so as to keep abreast with the technology advancements.	

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:-

- Electricity Ordinance (Cap. 406);
- 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;
- Construction Design and Management (Health & Safety Design Management) Guidance Notes (latest edition), Development Bureau, HKSAR, China;
- Construction (Design and Management) Regulations, United Kingdom;
- 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, HSAR, China;
- Guidance Notes on Safety at Work for Maintenance of Low Voltage Electrical Switchgears (latest edition), Labour Department, HKSAR, China; and
- Testing and Commissioning Procedure for electrical Installation in Government Buildings (latest edition), Architectural Services Department, HKSAR, China.

4.2 International Standards

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
- CIBSE Guide M Maintenance Engineering & Management, 2014
- NFPA 70B: Recommended Practice for Electrical Equipment Maintenance 2019 Edition
- Health Technical Memorandum (HTM) 06-01 – 'Electrical services supply and distribution' (for hospitals) particularly Section 17 on maintenance and operational management
- 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'

5.1 Schedule of Teat Results for Electrical Wiring (Sample)

Distribution Board Location & No.: _____

Testing Instrument: _____

Circuit Description	Protective Device		Wining Conductor		Test Result								
					Continuity		Insulation Resistance		Polarity	Earth Loop Impedance (Zs)	Functional Test		Remarks
	Type	Rating (A)	Live (mm^2)	cpc (mm^2)	Protective conductor (Ω)	Ring fina circuit (Ω)	L-L (MΩ)	L-E (MΩ)		(Ω)	RCD (ms)	Other	
												Tested By:	
												Date:	

Declaration: The above information is true to the best of my knowledge and belief. I understand that I may be liable to criminal prosecution if I knowingly provide false information.

Note: This sample test record form may be download from EMSD's homepage at www.emsd.gov.hk (path: Protecting Public Safety ▶ Electricity ▶ Pubications).

L represents live conductors, including phase conductors and neutral conductors.

Checklists for Inspection and Testing of Electrical Installations

(Note: For the use of the following five checklists, please refer to Code 22)

Checklist No. 1—Items For New LV Installation or Items For Periodic Testing of LV Installations

Installation Address: _____

		Tested by/Date (N/A if not applicable)
(a) Switchboards, Circuit Breakers and Main Switches		
(i)	No visible damage to impair safety.	_____
(ii)	Safe access provided.	_____
(iii)	Every circuit breaker, main switch and fuse holder(s) provided with up-to-date, legible and durable rating labels giving their ratings.	_____
(iv)	Every circuit breaker and main switch provided with a legible and durable identification label.	_____
(v)	An up-to-date schematic diagram displayed to show the main distribution system.	_____
(vi)	Link of adequate size installed in neutral circuit.	_____
(vii)	All accessible live parts screened with insulating plate or earthed metal.	_____

		Tested by/Date (N/A if not applicable)
(viii)	The overload and fault current protection characteristics of all circuit breakers verified with secondary injection test instruments where appropriate.	_____
(ix)	Lowest insulation resistance being ___Mohms (not less than 1 Mohm) measured between phases/neutral/ earth.	_____
(x)	All exposed conductive parts effectively earthed with a maximum earth fault loop impedance being ____ohms.	_____
(The following item(s) under this section shall be included for low voltage installations which was connected to supply after 1st Jun 1992)		
(xi)	An up-to-date notice of periodic inspection and testing provided at point of supply (i.e. a switchboard, a circuit breaker or a distribution board) of the installation in compliance with Code 17D.	_____

	Tested by/Date (N/A if not applicable)
(b) Substations	
(The following item(s) under this section shall be included for low voltage installations which was connected to supply after 1st Jun 1992)	
(i) A warning notice 'DANGER SUBSTATION, UNAUTHORISED ENTRY PROHIBITED' and '危險——電力分站，未經授權不得內進' provided at every entrance of substations in compliance with Code 17A(1).	_____
(ii) Suitable locking facilities provided for HV substations in compliance with Code 4F(1)(c).	_____
(iii) Suitable lighting provided in compliance with Code 4F(3)(a).	_____
(iv) Suitable ventilation provided in compliance with Code 4F(3)(a).	_____
(v) Entrance/exit free of obstruction in compliance with Code 4F(2)(c).	_____
(c) Switchrooms	
(The following item(s) under this section shall be included for low voltage installations which was connected to supply after 1st Jun 1992)	
(i) A warning notice 'DANGER —— SUBSTATION, UNAUTHORISED ENTRY PROHIBITED' and '危險——有電，未經授權不得內進' provided at every entrance of switchrooms in compliance with Code 17A(2).	_____

		Tested by/Date (N/A if not applicable)
(ii)	Suitable locking facilities provided for HV Switchrooms in compliance with Code 4F(1)(c).	_____
(iii)	Suitable lighting provided in compliance with Code 4F(3)(a).	_____
(iv)	Suitable ventilation provided in compliance with Code 4F(3)(a).	_____
(v)	Entrance/exit free of obstruction in compliance with Code 4F(2)(c).	_____

(d) Busbar Trunking System including Rising Mains

(i)	No visible damage to impair safety.	_____
(ii)	Phase identification marked on both ends of main cable/ conductor, and at terminations.	_____
(iii)	All joints of metal conduit or trunking to be mechanically sound, electrically continuous and protected against corrosion.	_____
(iv)	All accessible live parts screened with an insulating plate or earthed metal.	_____
(v)	Lowest insulation resistance being _____Mohms (not less than 1 Mohm) measured between phases/neutral/ earth.	_____
(vi)	All metal conduit or trunking effectively earthed with a maximum earth fault loop impedance being _____ohms.	_____

Tested by/Date
(N/A if not applicable)

(e) Meter Board/Box

(i) No visible damage to impair safety. _____

(ii) Safe access provided. _____

(iii) All exposed metal parts effectively earthed with a maximum earth fault loop impedance being _____ohms. _____

(f) Overhead Lines

(i) No visible damage to impair safety. _____

(ii) A minimum height of ____metres from ground (not less than 5.8 metres for lines acrossing any place accessible to vehicular traffic, 5.2 metres in other places or not less than the tallest height restriction of _____metres). _____

(iii) Lowest insulation resistance being _____ Mohms (not less than 1 Mohm) measured between phases/ neutral/earth. _____

(iv) All metal work associated with every steel pole effectively earthed. _____

(g) Main Cables

(i) No visible damage to impair safety. _____

(ii) Cables protected against mechanical damage. _____

		Tested by/Date (N/A if not applicable)
(iii)	Correct phase identification provided at both ends of the cable.	_____
(iv)	Lowest insulation resistance being _____Mohms (not less than 1 Mohm) measured between cores and cores to earth.	_____
(v)	All exposed metal parts including the cable armour effectively earthed with a maximum earth fault loop impedance being _____ohms.	_____

(h) Distribution Board

(i)	No visible damage to impair safety.	_____
(ii)	No fuse installed in the neutral circuit.	_____
(iii)	All live parts screened with an insulating plate or earthed metal.	_____
(iv)	Phase identification provided on the distribution board.	_____
(v)	Insulation resistance of not less than 1 Mohm measured between phases/ neutral/ earth.	_____
(vi)	All exposed metal parts effectively earthed.	_____

		Tested by/Date (N/A if not applicable)
(The following item(s) under this section shall be included for low voltage installations which was connected to supply after 1st Jun 1992)		
(vii)	A warning notice 'DANGER' and '危險' provided on the front panel of every distribution board in compliance with Code 17A(3).	
(viii)	A notice of periodic testing provided at or near the main distribution board incorporating a residual current device (RCD) in compliance with Code 17E.	
(i) Final Circuits		
(i)	No visible damage to impair safety.	
(ii)	All non-armoured cables susceptible to damage protected with steel conduit/trunking. Bushing and rubber grommet, where necessary, provided.	
(iii)	Conductor sized to suit the rating of the fuse/MCB protecting the circuit.	
(iv)	No cable joint in final circuit.	
(v)	All joints of metal conduits or trunking to be mechanically sound, electrically continuous and protected against corrosion.	
(vi)	For temporary installation, cables lying on the ground or attached to scaffoldings secured on suitable supports.	

		Tested by/Date (N/A if not applicable)
(vii)	Insulation resistance of not less than 1 Mohm measured between phases/ neutral/earth.	_____
(viii)	All metal conduits, trunking, switch boxes and exposed metal parts effectively earthed.	_____
(ix)	Residual current devices function properly.	_____
(x)	Earth fault loop impedance and polarities of every outlet checked.	_____

(j) Motors

(i)	No visible damage to impair safety.	_____
(ii)	Insulation resistance of not less than 1 Mohm measured between phases/ neutral/earth.	_____
(iii)	All exposed conductive parts effectively earthed.	_____

(k) Earthing

(i)	No visible damage to impair safety.	_____
(ii)	All exposed conductive parts of the wiring installation connected to the earthing terminal with appropriate protective conductor.	_____
(iii)	Bonding/earthing connection to water pipe/ gas pipe/duct effectively connected.	_____

		Tested by/Date (N/A if not applicable)
(The following item(s) under this section shall be included for low voltage installations which was connected to supply after 1st Jan 1985)		
(iv)	A warning notice 'SAFETY *EARTH/ ELECTRICAL CONNECT DO NOT REMOVE' and ' 安全接地終端 —— 切勿移去 ' provided at all main earthing terminal and main bonding connections.	
(v)	Main equipotential bonding conductors effectively connected to main water pipes, main gas pipes, other services pipes/ducting and exposed metallic parts of structural framework.	
(vi)	Supplementary equipotential bonding effectively provided between exposed conductive parts and extraneous conductive parts.	
(vii)	Exposed conductive parts of fixed equipment installed outside equipotential zone effectively earthed for the required disconnection.	
(viii)	Exposed conductive parts of fixed equipment installed within equipotential zone effectively earthed for the required disconnection.	
(ix)	Effectiveness of the main equipotential bonding connection to the main earthing terminal.	

		Tested by/Date (N/A if not applicable)
(x)	Effectiveness of the main equipotential bonding connection to the lighting protection system.	_____
(l) Motors		
(i)	No visible damage to impair safety.	_____
(ii)	Insulation resistance of not less than 1 Mohm measured between phases/ neutral/earth.	_____
(iii)	All exposed conductive parts effectively earthed.	_____
(m) Neon Sign		
(i)	No visible damage to impair safety.	_____
(ii)	The fireman's switch clearly labelled.	_____
(iii)	All high voltage equipment enclosed in an earthed metal box fitted with a 'DANGER' and ' 危 險 ' warning notice.	_____
(iv)	All live parts screened with an insulation plate or earthed metal.	_____
(v)	High voltage cables securely supported with glass or glazed porcelain.	_____
(vi)	Insulation resistance of the LV circuit being ____Mohms (not less than 1 Mohm) between phases/ neutral/earth.	_____

		Tested by/Date (N/A if not applicable)
(vii)	All exposed metalwork permanently and effectively bonded and earthed with a maximum earth fault loop impedance of _____ohms measured at LV side.	_____

*Delete whichever is inapplicable

Remarks: REC and REW are required to ensure their responsible fixed electrical installation is able to comply with the relevant requirements of this Code of Practice, rather than the items as listed in the checklists only.

Checklist No.2 - Additional Items for New LV Installation

Installation Address: _____

		Tested by/Date (N/A if not applicable)
(a)	**Switchboards, Circuit Breakers and Main Switches**	
(i)	Safe access and adequate clearance space provided in compliance with Code 4E.	_____
(ii)	Number of source of supply:_____ and the rating of each of them:_____	_____
(iii)	Maximum loading approved by the electricity supplier:_____	_____
(iv)	Suitable interlock scheme provided to prevent parallel operation of two or more sources of supply and 4-pole incoming and interconnecting circuit breakers provided for supply to be taken from more than one source and is interconnected in compliance with Code 6B(1)(c).	_____
(v)	Electrically and mechanically interlocked 4-pole changeover device(s) where standby generator set(s) is installed in compliance with Code 8A(1)(d).	_____
(vi)	The breaking capacity of the main switch is _____ kA and all circuit breakers/inter-connection devices are able to withstand the prospective fault current in compliance with Code 9C.	_____

		Tested by/Date (N/A if not applicable)
(vii)	Protective relays have been correctly set and overcurrent protective devices suitably set for all circuits in compliance with Code 21A(i).	
(viii)	Protective type C.T. are used for protective relays.	
(ix)	A means of isolation provided for every circuit in compliance with Code 8A(1)(c)(i).	
(x)	Operation of circuit breakers and main switches checked in compliance with Code 21B(9).	
(xi)	Control, indication and alarm functions checked in compliance with Code 21B(2)(viii).	
(xii)	No undersized conductor used between the main busbar and fuse/ MCB's in compliance with Code 13A(3).	
(xiii)	Fuses/MCB's matching the lowest rated conductor in the circuit in compliance with Code 9B.	
(xiv)	Suitable cable terminations provided in compliance with Code 25D.	
(xv)	Cable conductors of correct phases connected in compliance with Code 21A(b).	
(xvi)	Single-pole devices for protection or switching connected in phase conductors only in compliance with Code 10B.	

		Tested by/Date (N/A if not applicable)
(b)	**Busbar Trunking System including Rising Mains**	
(i)	The current rating of the rising mains is _____ amperes.	_____
(ii)	The rising mains, lateral mains and meter boards positioned at places accessible from public area.	_____
(iii)	Fire barriers provided where the busbar trunking system passes through floor slabs or walls designated as fire barriers in compliance with Code 14A(3).	_____
(iv)	Cables passing through smoke lobby protected by enclosures of adequate fire rating.	_____
(v)	Non-sheathed cables protected by conduit, trunking or ducting in compliance with Code 15.	_____
(vi)	Busbar trunking systems, cables and ductings adequately supported in compliance with Code 14A(2).	_____
(vii)	Armoured cables properly terminated to metal casing or trunking by proper cable glands in compliance with Code 25D(7).	_____
(viii)	Suitable cable lugs used for terminating cables in compliance with Code 4, Code 13C and Code 25D.	_____

		Tested by/Date (N/A if not applicable)
(ix)	Precaution against corrosion taking on aluminium conductor joined to copper conductor in compliance with Code 25D(7)(d)(ii).	
(x)	Cutout fuses for tapping off supply fitted with insulated carriers in compliance with Code 26B(6)(e).	

(c) Overhead Lines

(i)	A steel carrier wire provided between poles to prevent strain on conducton in compliance with Code 16A and 16H.	
(ii)	Substantial steel poles used to suspend cables crossing vehicular passes in compliance with Code 26K(3)(b)(ii).	
(iii)	Overhead cables supported on suitable insulators in compliance with Code 16B.	
(iv)	Suitable stay wires installed on the terminal poles and on each pole at which the line changes its direction in compliance with Code 16G(1).	
(v)	Minimum clearance of overhead lines to ground, roads and obstacles maintained in compliance with Code 16E(2)(a), (b) and (c).	

		Tested by/Date (N/A if not applicable)
(d) Main Cables		
(i)	The cross-sectional area or each core of the main supply cable is _____mm^2. Number of cables in parallel, if connected is_____.	_____
(ii)	Armoured cables properly terminated to metal casing or trunking by proper cable glands in compliance with Code 25D(7).	_____
(iii)	Cables passing through smoke lobby protected by enclosures of adequate fire rating.	_____
(iv)	Non-sheathed cables protected by conduit, trunking or ducting in compliance with Code 15.	_____
(v)	Cables and ductings adequately supported in compliance with Code 14A(2).	_____
(vi)	Cables at distribution board or busbar terminated with cable lugs in compliance with Code 4, Code 13C and Code 25D.	_____
(vii)	Main cables connected up with correct polarity	_____
(e) Distribution Board		
(i)	Safe access and adequate clearance space provided in compliance with Code 4E.	_____

		Tested by/Date (N/A if not applicable)
(ii)	Distribution boards securely mounted on suitable supports in compliance with Code 14A(2).	
(iii)	A suitable switch provided to control each distribution board in compliance with Code 8A(1)(a).	
(iv)	Phase barriers for 3-phase distribution board provided in compliance with Code 21A(g).	
(v)	The breaking capacity of MCB is _____kA in compliance with Code 9.	
(vi)	Suitable tools for withdrawal of fuses at a fuse board provided, where necessary in compliance with Code 9E(d).	
(vii)	Circuits connected to MCB or fuse in accordance with the schematic diagram in compliance with Code 6A(b).	

(f) Final Circuits

(i)	All fuses and single pole switches connected to the phase conductors only with correct polarity.	
(ii)	Wiring for emergency lightings and fire services installation segregated from other wirings in compliance with Code 5B(1)(b).	
(iii)	Low voltage circuits segregated from extra low voltage circuits in compliance with Code 5B(1)(a).	

		Tested by/Date (N/A if not applicable)
(iv)	Cables of all phases and neutral of the circuit bunched and contained in the same conduit in compliance with Code 25A(1)(f).	
(v)	Exposed insulated non-sheathed cables protected in compliance with Code 15.	
(vi)	Wiring inside false ceiling protected by conduit/trunking or metallic sheath in compliance with Code 25C(1)(f).	
(vii)	Socket outlets installed below 1.5m from floor being shuttered type complying to the prescribed requirements.	
(viii)	No socket outlet installed close to water tap, gas tap or cooker so as to avoid danger in compliance with Code 25E(d).	
(ix)	Floor socket outlets protected with suitable cover in compliance with Code 25E(b).	
(x)	No 2-pin sockets installed. All socket outlets connected with protective conductors and live conductors terminated at correct terminals.	
(xi)	Radial final circuits using 5A/15A socket outlets in compliance with Code 6D.	
(xii)	Final circuits using 13A socket outlets in compliance with Code 6E.	

		Tested by/Date (N/A if not applicable)
(xiii)	Final circuits using industrial socket outlets in compliance with Code 6F or 6G or 6H.	
(xiv)	Circuit protective conductor is formed by the enclosure and a separate protective conductor between the earthing terminal of socket outlet and its associated metal box provided in compliance with Code11D(3).	
(xv)	Circuit protective conductor is not formed by the enclosure and a separate protective conductor to the earthing terminal of socket outlet provided in compliance with Code 11D(3).	
(xvi)	Residual current device of 30 mA rated residual operating current provided for all socket outlets in compliance with Code 11B(b)(i).	
(xvii)	Means of isolation provided for every fixed appliance in compliance with Code 8A(1)(c).	
(xviii)	All chokes, starters and capacitors of discharge lamps enclosed in earthed metal box(es) and suitably ventilated in compliance with Code 26H(4)(c).	
(xix)	Phase conductors connected to the centre contact of the Edison-type screw lamp holders in compliance with Code 21B(6)(ii).	

		Tested by/Date (N/A if not applicable)
(xx)	No switches other than a switch fed from a safety source or operated by an insulation cord or rod or a push-button type of switch having an insulated button of a large surface area provided in bathrooms in compliance with Code 26A(3)(d).	_____
(xxi)	Shaver supply unit complying with IEC 61558-2-5 or equivalent in compliance with Code 26A(3)(e).	_____
(xxii)	Socket outlet in bathroom installed beyond Zone 2 (i.e. 0.6m away from shower basin or bathtub) protected by an RCD with a residual operating current not exceeding 30mA or protected by an isolating transformer to IEC 61558 in compliance with Code 26A(3)(j).	_____
(xxiii)	No fixed luminaire nor fixed heater having unguarded heating elements installed within reach of a person using the bath or shower in compliance with Code 26A(3)(h).	_____
(xxiv)	All circuits supplying electrical equipment with exposed conductive parts within 2.25m height above finished floor level in bathroom protected by RCD having a rated residual operating current not exceeding 30mA in compliance with Code 26A(3)(a).	_____
(xxv)	Appliances exposed to weather being splashproof type in compliance with Code 15A.	_____

		Tested by/Date (N/A if not applicable)
(xxvi)	Luminaires, switches, sockets and plugs, cable couplers installed outdoor, being splashproof type in compliance with Code 15A.	
(xxvii)	General/site lighting readily accessible to the public supplied from a safety source in compliance with Code 26K(3).	
(xxviii)	General/site lighting not readily accessible to the public and not supplied from a safety source, protected by RCD having a rated residual operating current not exceeding 30 mA.	
(g) Motors		
(i)	A local switch provided to control every motor in compliance with Code 8A(4)(a).	
(ii)	Means provided to prevent unexpected restarting of motors where such restarting might cause danger in compliance with Code 8A(4)(c).	
(iii)	Flexible conduits terminated with suitable brass bushes in compliance with Code 25A(2)(b)(i).	
(iv)	Separate supply to motor heaters having its terminals screened, with warning notice provided.	

Tested by/Date
(N/A if not applicable)

(h) Earthing

(i)	Rod electrode(s) having a minimum diameter 12.5mm copper or 16mm galvanised or stainless steel used in compliance with Code 12C(2)(a) and (b).	_____
(ii)	Copper tape electrode having a cross-section of not less than 25mm x 3mm in compliance with Code 12C(3)(a).	_____
(iii)	Copper plate electrode not less than 3mm in thickness and having a maximum dimension of 1 200mm x 1 200mm in compliance with Code 12C(4).	_____
(iv)	No gas/water pipe used as earth electrodes in compliance with Code 12C(1)(b).	_____
(v)	A test link provided at the main earthing terminal.	_____
(vi)	Minimum size of protective conductor used in compliance with Table 11(1).	_____
(vii)	Protective conductor up to and including 6mm^2 with green and yellow insulation sheath used throughout its length.	_____

		Tested by/Date (N/A if not applicable)
(viii)	Bonding conductors of _____mm^2 (not less than 150mm^2 copper equivalent) used for connection to the earthing terminal of the electricity supplier's transformer(s) in compliance with Code 11G(b).	
(ix)	Bonding conductors of _____mm^2 (not less than 150mm^2 copper equivalent) used for connection to the exposed conductive parts of the electricity supplier's underground cable(s) in compliance with Code 11G(b).	
(x)	Copper links provided at joints of metallic trunking which forms part of a protective conductor in compliance with Code 14A.	
(xi)	Separate protective conductors provided for all flexible conduits in compliance with Code 11D(3)(b).	

(i) Lightning Protection

(i)	Air termination network/down conductor/earth termination network having good continuity in compliance with relevant standard listed under Code 26I.	
(ii)	Joints and connections are mechanically and electrically sound in compliance with relevant standard listed under Code 26I.	

		Tested by/Date (N/A if not applicable)
(iii)	Connection link to the main earthing terminal provided in compliance with relevant standard listed under Code 26I.	
(iv)	Test joint provided in compliance with relevant standard listed under Code 26I.	
(v)	Rod electrode(s) having a minimum diameter 12.5mm copper or 16mm galvanised or stainless steel used in compliance with Code 12C(2)(a) and (b).	
(vi)	Copper tape electrode having a cross-section of not less than 25mm x 3mm in compliance with Code 12C(3)(a).	
(vii)	Copper plate electrode not less than 3mm in thickness and having a maximum dimension of 1 200mm x 1 200mm in compliance with Code 12C(4).	
(viii)	No gas/water pipe used as earth electrodes in compliance with Code 12C(1)(b).	
(ix)	Measured earth termination network resistance to earth not more than 10 Ohm when the connection to main earthing terminal disconnected in compliance with relevant standard listed under Code 26I.	

		Tested by/Date (N/A if not applicable)
(x)	No evidence of corrosion likely to lead deterioration of the lightning protection system.	
(j)	**High Voltage Discharge Lighting (Neon Signs)**	
(i)	_____ ampere control switch fitted with a removable handle or locking facilities in compliance with Code 26H(2)(b).	
(ii)	Fireman's switch provided with the 'OFF' position at the top in compliance with Code 8B(4)(g)(ii).	
(iii)	High voltage cables exceeding 1 metre in length for connection between lamps and transformers, being metal sheathed or armoured.	
(iv)	Bare or lightly insulated conductors for high voltage connection protected with glass tubing.	
(k)	**Warning Notices and Labels**	
(i)	Warning notices for substations and switchrooms provided in compliance with Code 17.	
(ii)	Warning notices for earthing and main bonding connections provided in compliance with Code 17.	
(iii)	All switchgears, distribution boards and electrical equipment properly labelled in compliance with Code 4D(1).	

Tested by/Date

(N/A if not applicable)

(l) Installation Having Both New and Old Cable Colours

(i) Warning notice provided in compliance with Code 17 and Appendix 18. _____

(ii) Proper labels provided near the cable termination interface to identify new colour cables/conductors for 1-phase circuits in compliance with Appendix 18. _____

(iii) Proper labels provided near the cable termination interface to identify both the new and old colour cables / conductors for 3-phase circuits in compliance with Appendix 18. _____

(iv) Conductors are properly identified in compliance with Code 13D(2). _____

Remarks: REC and REW are required to ensure their responsible fixed electrical installation is able to comply with the relevant requirements of this Code of Practice, rather than the items as listed in the checklists only.

Checklist No.3 - Item for Renewable Energy Power System (REPS) Installations

Installation Address: _____

		Tested by/Date (N/A if not applicable)
(a) Power Generating Equipment		
(i)	The solar PV panels are certified by the recognised national/international organisations or relevant testing and certification authorities complying with relevant safety standards such as IEC 61215, BS EN 61215, IEC 61730, UL 1703 or equivalent.	_____
(ii)	Other renewable energy power generating equipment (e.g. wind turbine) complies with relevant international design/safety standards.	_____
(b) Inverter		
(i)	Anti-islanding function incorporated (with tripping time as required by the Electricity Supplier).	_____
(ii)	Synchronisation check function incorporated (to ensure that connection of the inverter to the distribution system will only take place when the inverter output and the distribution system are operating in synchronism).	_____

		Tested by/Date (N/A if not applicable)
(iii)	Automatic isolation function incorporated (to isolate the REPS from the distribution system automatically when fault occurs in the REPS).	
(iv)	Voltage and frequency regulator incorporated.	
(v)	Under / Over-frequency / voltage protection function incorporated (to disconnect the inverter from the distribution system when the frequency and/or voltage of the Grid falls out of normal range).	
(vi)	Auto-reconnection function incorporated (to reconnect the inverter back to the distribution system when the frequency and/or voltage of the Grid resumes to normal operational range for a pre-defined period of time (with such time period to be agreed with the Electricity Supplier)).	
(vii)	Inverter are certified by the recognised national/international organisations or relevant testing and certification authorities complying with relevant safety standards such as IEC 62109, BS EN 62109, UL 1741 or equivalent.	

(c) Lightning Protection

(i)	Proper lightning protection systems provided for the outdoor equipment.	

		Tested by/Date (N/A if not applicable)
(d) Outdoor Installation		
(i)	Equipment installed outdoor being selected and erected in compliance with Code 15 of CoP.	
(e) REPS Circuit		
(i)	DC protection devices provided for the circuits between renewable energy power generating equipment and inverter in compliance with Code 9 of CoP.	
(ii)	Inverter incorporated with isolation transformer or separated isolation transformer in compliance with IEC 61558 or equivalent provided.	
(iii)	Pre- & post-meter lockable switches (DP / 4P) provided for isolating all sources of supply from the Grid and REPS to Renewable Energy Meter.	
(iv)	The earth fault loop impedance of the circuit in compliance with Code 11 of CoP.	
(v)	Operation of isolators, circuit breakers and switches checked in compliance with Code 21B(9) of CoP.	
(vi)	The RCD/RCBO trip time checked in compliance with Code 21B(9) of CoP (if applicable).	

	Tested by/Date (N/A if not applicable)
(f) Earthing	
Appropriate protective conductors effectively connected.	_____
(g) Notice and Labels	
(i) Notice displayed at the facility showing the name and registration number of the REC employed for maintaining the generating facility in continuous safe work order checked in compliance with Code 17 of CoP.	_____
(ii) Dual power supply warning labels displayed at all electrical equipment with dual power supply sources checked in compliance with Code 17 of CoP.	_____
(iii) DC warning labels displayed at DC switchgear checked in compliance with Code 17 of CoP.	_____

Remarks: REC and REW are required to ensure their responsible fixed electrical installation is able to comply with the relevant requirements of Code of Practice for the Electricity (Wring) Regulations (CoP), rather than the items as listed in the checklists only.

Checklist No.4 - Reserved for Future Uses

Checklist No.5 - Item for HV Installation

(Note: For LV Installation/Equipment, please refer to other checklists in this appendix)

Installation Address: _____

		Tested by/Date (N/A if not applicable)
(a) Switchboard, Circuit Breakers		
(i)	No visible damage to impair safety in compliance with Code 21A.	_____
(ii)	Safe access and adequate clearance space provided in compliance with Code 4E.	_____
(iii)	Work done properly recorded in log book in compliance with Code 4H(2)(d).	_____
(iv)	Every circuit breaker provided with a legible and durable identification label in compliance with Code 4D(1).	_____
(v)	An up-to-date schematic diagram displayed in compliance with Code 6A(b).	_____
(vi)	All accessible live parts screened with insulating plate or earthed metal in compliance with Code 4C(2)(b).	_____
(vii)	All exposed conductive parts effectively earthed in compliance with Code 11D.	_____
(viii)	Earthing system effectively connected in compliance with Code 12.	_____

		Tested by/Date (N/A if not applicable)
(ix)	Warning notice displayed at main bonding connections in compliance with Code 17B.	
(x)	All protective devices are functioned properly and correctly set in compliance with Code 21B(9).	
(xi)	Padlock facilities for shutters provided in compliance with Code 21C(c).	
(xii)	Maintenance test carried out according to relevant recognised standards and manufacturers' recommendation, where appropriate, with test reports (insulation resistance test, pressure test, ductor test, oil dielectric strength test etc.) in compliance with Code 21D(2).	

(b) Main Cables

(i)	No visible damage to impair safety in compliance with Code 21A.	
(ii)	Cables protected against mechanical damage and suitably supported in compliance with Code 25C.	
(iii)	All exposed metal parts including the armour effectively earthed in compliance with Code 11D.	
(iv)	Maintenance test carried out according to relevant recognised standards and manufacturers' recommendation, where appropriate, with test reports (insulation resistance test, pressure test etc.) in compliance with Code 21D(2).	

		Tested by/Date (N/A if not applicable)
(c) Transformers/Motors		
(i)	No visible damage to impair safety in compliance with Code 21A.	
(ii)	All accessible live parts screened with insulating plate or earthed metal in compliance with Code 4C(2)(b).	
(iii)	Proper ventilation provided to avoid excessive temperature rise in compliance with Code 4F(3).	
(iv)	Maintenance test carried out according to relevant recognised standards and manufacturers' recommendation, where appropriate, with test reports (insulation resistance test, pressure test, oil dielectric strength test etc.) in compliance with Code 21D(2).	
(d) Earth		
(i)	A warning notice 'SAFETY EARTH CONNECTION—DO NOT REMOVE' and ' 安全接地終端——切勿移去 ' provided at all main earthing terminal and main bonding connections in compliance with Code 17B.	
(ii)	Earthing conductors of adequate size.	
(e) DC Battery System		
(i)	Condition of battery system.	
(ii)	Voltage of each battery cell measured.	

	Tested by/Date (N/A if not applicable)
(f) Operation and Testing Tools and Equipment	
(i) Proper operation tools and equipment provided for switching and isolation use.	
(ii) Suitable self-test high voltage tester provided for verifying equipment dead.	

Remarks: REC and REW are required to ensure their responsible fixed electrical installation is able to comply with the relevant requirements of this Code of Practice, rather than the items as listed in the checklists only.