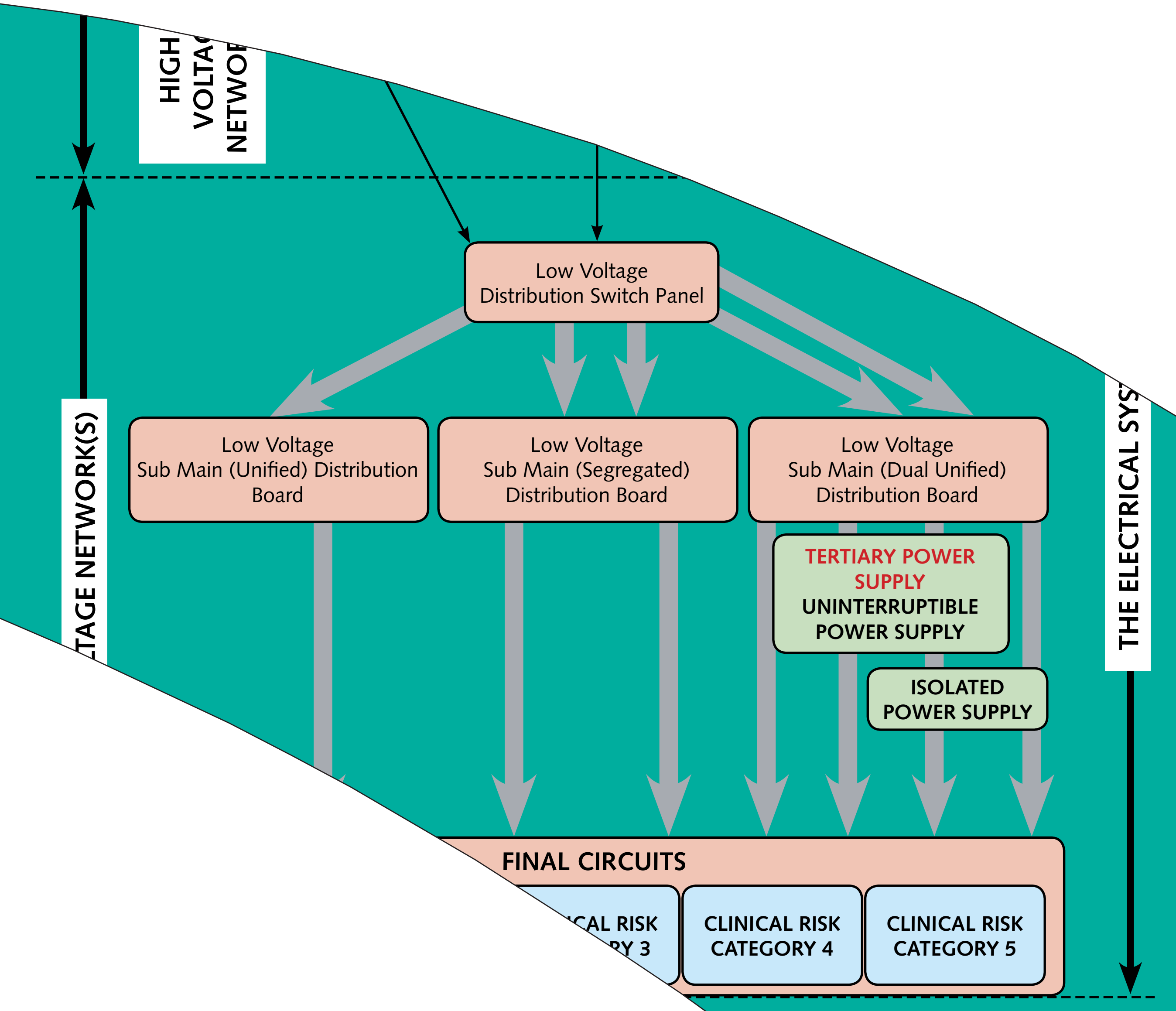
Department of Health

Electrical services
Health Technical Memorandum 06-01: Electrical services supply and distribution

Part B: Operational management



Electrical services – Health Technical Memorandum 06-01 Electrical services supply and distribution: Part B – Operational management

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Electrical services
Health Technical Memorandum 06-01: Electrical services supply and distribution

Part B: Operational management

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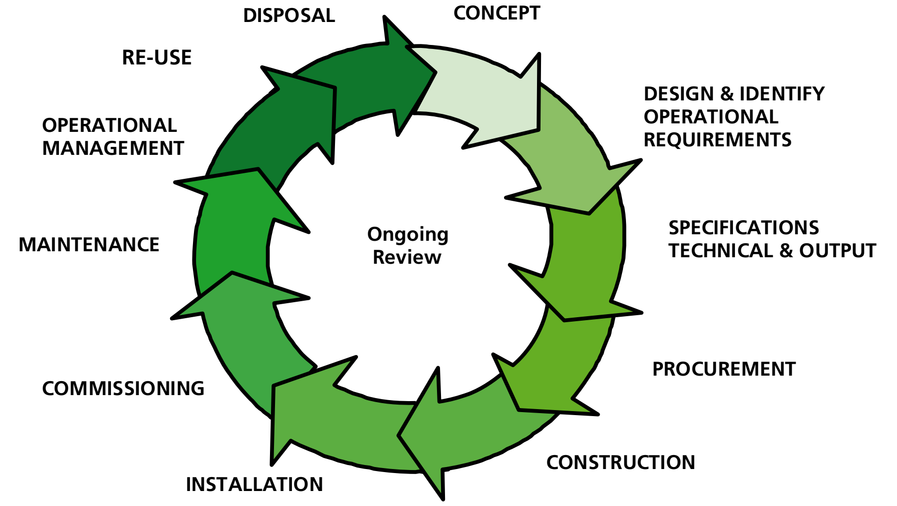
Preface

About Health Technical Memoranda

Engineering Health Technical Memoranda (Health Technical Memoranda) give comprehensive advice and guidance on the design, installation and operation of specialised building and engineering technology used in the delivery of healthcare.

The focus of Health Technical Memorandum guidance remains on healthcare-specific elements of standards, policies and up-to-date established best practice. They are applicable to new and existing sites, and are for use at various stages during the whole building lifecycle:

Figure 1 Healthcare building life-cycle



Healthcare providers have a duty of care to ensure that appropriate engineering governance arrangements are in place and are managed effectively. The Engineering Health Technical Memorandum series provides best practice engineering standards and policy to enable management of this duty of care.

It is not the intention within this suite of documents to unnecessarily repeat international or European standards, industry standards or UK Government legislation. Where appropriate, these will be referenced.

Healthcare-specific technical engineering guidance is a vital tool in the safe and efficient operation of healthcare facilities. Health Technical Memorandum guidance is the main source of specific healthcare-related guidance for estates and facilities professionals.

The core suite of nine subject areas provides access to guidance which:

- is more streamlined and accessible;
- encapsulates the latest standards and best practice in healthcare engineering;
- provides a structured reference for healthcare engineering.

Structure of the Health Technical Memorandum suite

The series of engineering-specific guidance contains a suite of nine core subjects:

Health Technical Memorandum 00
Policies and principles (applicable to all Health Technical Memoranda in this series)

Health Technical Memorandum 01
Decontamination

Health Technical Memorandum 02
Medical gases

Health Technical Memorandum 03
Heating and ventilation systems

Health Technical Memorandum 04
Water systems

Health Technical Memorandum 05
Fire safety

Health Technical Memorandum 06
Electrical services

Health Technical Memorandum 07
Environment and sustainability

Health Technical Memorandum 08
Specialist services

Some subject areas may be further developed into topics shown as -01, -02 etc and further referenced into Parts A, B etc.

Example: Health Technical Memorandum 06-02 Part A will represent:

Electrical Services – Electrical safety guidance for low voltage systems

In a similar way Health Technical Memorandum 07-02 will simply represent:

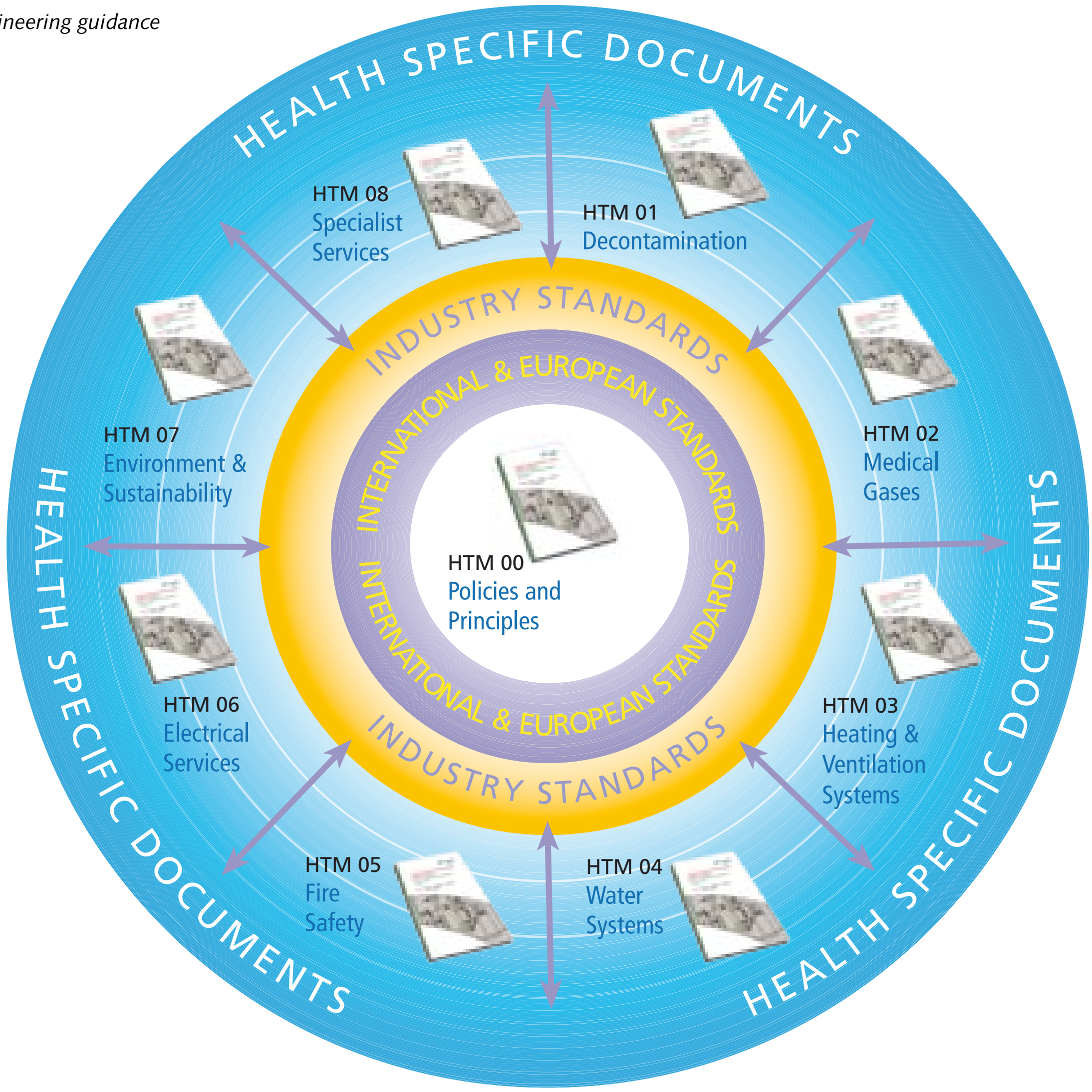
Environment and Sustainability – EnCO$_2$de.

All Health Technical Memoranda are supported by the initial document Health Technical Memorandum 00 which embraces the management and operational policies from previous documents and explores risk management issues.

Some variation in style and structure is reflected by the topic and approach of the different review working groups.

DH Estates and Facilities Division wishes to acknowledge the contribution made by professional bodies, engineering consultants, healthcare specialists and NHS staff who have contributed to the review.

Figure 2 Engineering guidance



Executive summary

Health Technical Memorandum 06-01 – 'Electrical services supply and distribution' replaces Health Technical Memorandum 2007 – 'Electrical services supply and distribution' and Health Technical Memorandum 2011 'Emergency electrical services', and absorbs Health Technical Memorandum 2014 'Abatement of electrical interference'.

This part (Part B) provides guidance for all works on the fixed wiring and integral electrical equipment used for electrical services within healthcare premises. Specifically, it considers the operational management and maintenance requirements for hard-wired electrical systems and fixed power plant.

The document is suitable for use with all forms of electrical maintenance work ranging from testing of plant, such as generators, to the periodic testing and inspection of the electrical network(s) and final circuits.

Acknowledgements

The refresh of Health Technical Memorandum 2007, Health Technical Memorandum 2011, and Health Technical Memorandum 2014 into the new Health Technical Memorandum 06-01 was finalised during 2005. The list of working group members and main contributions to the new Health Technical Memorandum 06-01 is provided below.

Main working group

Owen Cusack	Northumbria Healthcare NHS Trust
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Isolated Power Supplies	**John Murray**	Bender UK
Electromagnetic Compatibility	**Alwyn Finney**	ERA Technology

Contents

1 Scope of Health Technical Memorandum 06-01

1.1 Health Technical Memorandum 06-01 – 'Electrical services supply and distribution' replaces Health Technical Memorandum 2007 – 'Electrical services supply and distribution' and Health Technical Memorandum 2011 – 'Emergency electrical services', and absorbs Health Technical Memorandum 2014 – 'Abatement of electrical interference'.

1.2 This part (Part B) provides guidance for all works on the fixed wiring and integral electrical equipment used for electrical services within a healthcare premises. The document is suitable for use with all forms of electrical maintenance work ranging from testing of plant, such as generators, to the periodic testing and inspection of the electrical network(s) and final circuits.

1.3 It describes the maintenance requirements rather than the actual maintenance. The document follows, as far as practical, the format of Part A.

1.4 The provision of electrical services in healthcare premises is a management responsibility at both new and existing sites. This guidance is equally applicable to premises that offer healthcare services under the Registered Homes Act 1984.

1.5 The document provides healthcare premises managers with guidance on the European and British Standards for Electrical Safety, such as the IEE Regulations BS 7671, the Building Regulations, and the Electricity at Work Regulations. Healthcare premises managers may be able to fulfil their duty of care in relation to the Health and Safety at Work etc Act by adopting the recommendations of this document.

1.6 Health Technical Memorandum 06-01 Part B is written in a similar format to Health Technical Memorandum 06-01 Part A; therefore the maintenance tasks for each part of the fixed wiring are organised in the same way.

1.7 This Health Technical Memorandum recommends that designers and stakeholders review this part of Health Technical Memorandum 06-01 during the design process such that they may be more aware of the maintenance activities required.

Abbreviations

AC: alternating current

BMS: building management system

BS: British Standard(s)

CIBSE: Chartered Institute of Building Services

CHP: combined heat and power

CO_2: carbon dioxide

CPC: circuit protective conductor

CT: current transformer

DB: distribution board

DC: direct current

Designer: a person (or organisation) with the responsibility to provide electrical design support such that the electrical services are technically correct, safe and fit for purpose. The designer need not be a direct employee of the healthcare premises or NHS trust.

DNO: distribution network operator

DVM: digital voltmeter

EMC: electromagnetic compatibility

EMI: electromagnetic interference

ERB: earth reference bar

ESD: electrostatic discharge

HV: high voltage

HVAC: heating, ventilation and air-conditioning

IEE: Institute of Electrical Engineering

IEC: International Electrotechnical Commission

IMD: insulation monitoring device

IV: intravenous

IPS: isolated power supplies

ISO: International Standards Organisation

ISS: intake substation

LPS: lightning protection system

LV: low voltage

MCB: miniature circuit breaker

MCC: motor control centre

MCCB: moulded case circuit breaker

MD: maximum demand

MEIGaN: Medical Electrical and Installation Guidance Notes

MET: main earth terminal

NHS: National Health Service

OCB: oil circuit breaker

Operational and estates manager: a manager responsible for the operational safety of the electrical services at the healthcare premises. The operational and estates manager need not be a direct employee of the NHS trust.

PE: physical earth

PEC: protective earth conductor

PEI: primary electrical infrastructure

PELV: protective extra low voltage

PES: public electrical supply

PET: protective earth terminal

PF: power factor

PFC: power factor correction

PSCC: prospective short-circuit current

PV: photovoltaic cell

RCBO: residual current breaker with overcurrent

RCD: residual current device

SCADA: supervisory control and data acquisition

SELV: safety extra low voltage

SF_6: sulphur hexafluoride

SI: Système Internationale

SP & N: single phase and neutral

Stakeholder: a person (or organisation) with vested interests (not necessary pecuniary) for the electrical services quality and provisions at a healthcare premises. The stakeholder will normally be an employee of the healthcare premises or NHS trust.

UPS: uninterruptible power supply

2 Definitions

2.1 The aim of this document is to assist stakeholders and managers of healthcare premises to develop the concept of "electrical operational procedures" and "electrical maintenance requirements".

2.2 Healthcare facility managers should appoint managers with a duty to comply with the requirements of the Electricity at Work Act.

2.3 All forms of electrical operation procedures and maintenance tasks should adhere to the recommendations given in Health Technical Memorandum 06-02 – 'Electrical safety guidance for low voltage systems' and Health Technical Memorandum 06-03 – 'Electrical safety guidance for high voltage systems'. Designers and stakeholders should read this document when designing electrical network(s).

2.4 To avoid repetition, the following definitions will apply to all parts of the electrical fixed wiring system within healthcare premises. The various chapters correspond to the respective sections of the maintenance of the fixed wiring system.

Non-intrusive visual inspection

2.5 The non-intrusive visual-inspection maintenance tasks will include the regular visual inspection of the electrical plant and/or distribution service. Visual inspection should not require the removal of any housing or the isolation (disconnection) of the plant or services. In general, maintenance of this type will ensure that there has been no obvious damage since the last maintenance visit. The skill level for maintenance tasks of this type will be at a minimum related to the respective electrical plant or part of the electrical distribution system.

2.6 Non-intrusive visual-inspection maintenance tasks should be frequent ("frequency" in this document is given in terms of time between successive tasks).

2.7 Maintenance programmes for non-intrusive visual-inspection maintenance tasks may include the issue of a "limitation of access" document (see paragraph 2.30). However, there should not be a need to raise any other "permit to work/permit to test" document (see paragraph 2.29; see also Health Technical Memorandum 06-02 – 'Electrical safety guidance for low voltage systems').

Non-intrusive functional tests

2.8 The non-intrusive functional-test maintenance tasks will include the routine operational checks of the electrical plant and/or distribution service. The routine operational checks should not require the removal of any housing, but may require the momentary isolation (disconnection) of the plant or services. Non-intrusive functional tests ensure that the plant and safety devices operate in the required way. The skill level for non-intrusive functional-test maintenance tasks will be minimal related to the respective electrical plant or part of the electrical distribution system.

2.9 Maintenance tasks of non-intrusive functional tests should be of occasional frequency.

2.10 Maintenance programmes for non-intrusive functional-test maintenance tasks may include the issue of a limitation-of-access document. Depending on the actual tasks, the issue of a permit-to-work/sanction-for-test document may be a more appropriate document. Where the non-intrusive functional tests require the short-term isolation (disconnection) of a service (with no resilient connection), a "permission for disconnection/interruption of electrical services" should be issued (see Health Technical Memorandum 06-02 – 'Electrical safety guidance for low voltage systems').

Consumable services

2.11 Consumable-service maintenance tasks will include the servicing of the electrical plant and/or distribution service required to ensure that such items and systems operate in the most efficient way. The service checks may require the removal of housing and the isolation (disconnection) of the plant or services. The skills required to affect the consumable service of electrical plant will require formal training related to the respective electrical plant or part of the electrical distribution system.

2.12 Consumable-service maintenance tasks should be of occasional frequency.

2.13 Maintenance programmes for consumable services might require the issue of a permit-to-work/permit-to-test document. Where the consumable services require the short-term isolation (disconnection) of a service (with no resilient connection), a permission for disconnection/interruption of electrical services should be issued (see Health Technical Memorandum 06-02 – 'Electrical safety guidance for low voltage systems').

Full services

2.14 Full-service maintenance tasks will include the servicing of the electrical plant and/or distribution service required to ensure that the electrical plant and/or electrical distribution system may operate in the most efficient and safe way. The service checks may require the removal of housing and the isolation (disconnection) of plant or services. The skills required to affect full service will require detailed formal training related to the respective electrical plant or part of the electrical distribution system.

2.15 Full-service maintenance tasks should be of occasional frequency.

2.16 Maintenance programmes for full services might require the issue of a permit-to-work/sanction-for-test document. Where the full servicing requires the short-term isolation (disconnection) of a service (with no resilient connection), a permission for disconnection/interruption of electrical services should be issued (see Health Technical Memorandum 06-02 – 'Electrical safety guidance for low voltage systems').

Planned preventative maintenance

2.17 Set maintenance frequencies should be identified for each part of the electrical distribution and plant; they should be used to implement routine maintenance regimes. The typical ranges are:

- daily;
- weekly;
- monthly;
- six-weekly;
- six-monthly; and
- annually.

Maintenance tasks of least frequency will include all tasks that are more frequent. For example, the six-monthly maintenance tasks will include the six-monthly maintenance tasks, the six-weekly maintenance tasks and the weekly maintenance tasks for the same equipment or system. The maintenance tasks might be grouped as non-intrusive visual inspection, non-intrusive functional tests, consumable services and full services, as described above.

2.18 Planned preventative maintenance programmes should be designed to minimise the opportunity for failure of electrical plant and/or electrical distribution systems.

Condition-based maintenance

2.19 Condition-based maintenance requires the monitoring of the electrical plant, equipment and electrical distribution system. Maintenance records should be maintained so that comparisons can be made of the collected information and any historical data of the generic family of electrical plant and distribution system. Where the measured values fall to a preset tolerance value, corrective maintenance tasks should be initiated (see paragraph 2.25). Where the measured value continues to fall (due to the non-completion of the task), operational and estates managers should ensure more urgent attention to maintenance requirements.

2.20 Condition-based maintenance regimes should include predetermined tolerance values, designed to minimise the opportunity for failure of electrical plant and/or electrical distribution systems.

Failure maintenance

2.21 Failure maintenance is not a structured maintenance regime. Electrical plant and electrical distribution systems may continue to operate until a fault or failure causes their isolation. This maintenance strategy may be appropriate for items such as lamp-replacement maintenance where there is more than one fitting in the room. However, lamp maintenance strategies are outside the scope of this document.

2.22 This form of maintenance has no place within the fixed wiring system and electrical plant of a healthcare facility, and therefore is not covered any further in this Health Technical Memorandum.

2.23 Operational and estates managers should ensure that there are adequate measures in place for an appropriate response to such failures to meet the operational requirements of the facility. This entails establishing a fault category to aid the management of response.

2.24 Categories suggested may include immediate, urgent, same-day, next-day and general response. The initial response to a failure should not exceed 48 hours. The categories could relate to the clinical risk categories 1–5 identified in Health Technical Memorandum 06-01 Part A. The level of spare parts held should be adequate to avoid system downtimes exceeding one week. Improvements in the resilience of the electrical infrastructure may offset the level of spares held.

Corrective maintenance

2.25 Corrective maintenance of the fixed wiring systems and electrical plant includes any additional maintenance activities identified by any of the above service visits.

Frequent maintenance

2.26 Frequent maintenance will include any non-intrusive visual inspection or non-intrusive functional tests and, consequently, will require immediate or permanent access. The frequency of the maintenance will depend on the electrical plant and/or part of the electrical infrastructure. However, the frequency is likely to range between daily and six-weekly intervals.

Occasional maintenance

2.27 Occasional maintenance will include any consumable-service maintenance, and consequently access for maintenance should be readily achievable. Access may be by the opening of an unobstructed switchroom door or switchpanel door, but should not require the need to dismantle any building fabric or engineering services. The frequency of the maintenance service will depend on the electrical plant and/or part of the electrical infrastructure. However, the frequency is likely to range between six-weekly and yearly intervals.

Infrequent maintenance

2.28 Infrequent maintenance will include any full-service maintenance or plant replacement and, consequently, access for maintenance should be readily achievable. Access may be by the opening of an unobstructed switchroom door or switchpanel door, but should not require the need to dismantle any building fabric or engineering services. However, where the infrequent maintenance is for the replacement of plant or distribution cables etc, consideration may be given to the dismantling of specific soft-constructed building-fabric sections. The frequency of any infrequent maintenance is likely to range between six-monthly and yearly, or possibly greater, intervals.

Permit-to-work and limitation-of-access

2.29 The fixed wiring and electrical plant within a healthcare premises must prevent the risk of injury and/or danger. The only acceptable way of achieving this high standard will be the adoption of a permit-to-work system.

2.30 In addition, the control of access to specified areas must be regulated by a limitation-of-access system. These two standard procedures are procedures recognised by the Department of Health. The procedures are included in Health Technical Memorandum 06-02 – 'Electrical safety guidance for low voltage systems'.

Service/test/record documentation

2.31 Estate management staff should maintain countersigned records of all maintenance tasks and servicing activities on any part of the fixed wiring or plant.

2.32 In some cases, the service record may form part of an insurance inspection or similar mandatory requirement. Examples might include the standard electrical test sheets referred to in Appendix 2 of Health Technical Memorandum 06-01 Part A.

2.33 Maintenance software applications or similar database applications should record any maintenance test information. Where any part of the maintenance regime includes a computerised planned maintenance system, the software may include facilities to generate maintenance test record sheets.

2.34 The essential part of any maintenance record-keeping is to list out all the activities required at any particular service inspection visit and indicate the tasks that were successfully completed.

2.35 The service records should be kept either in a service logbook relating to the maintained item, or in the building logbook (see Appendix 2 of Health Technical Memorandum 06-01 Part A).

3 Understanding risk and ownership

3.1 This chapter deals with the assessment of risk and the need to ensure that the operational-management and maintenance regimes of the primary electrical infrastructure (PEI) adequately protect the end-user and, in particular, patients, from electrical faults and failures. The healthcare organisation's management should set up a multidisciplinary team to evaluate the risk and maintenance requirements. This multidisciplinary team should include designers, stakeholders, clinicians and end-users. Suitably qualified staff should be designated to identify and advise on manufacturers' technical specifications and the legal requirements of the Health and Safety at Work etc Act 1974.

3.2 Health Technical Memorandum 06-01 Part A identifies clinical and business continuity risks according to the type of healthcare therapy and associated plant and services. It also identifies appropriate electrical distribution strategies based on resilience that minimises the effect of electrical failures. The operational and maintenance strategies should complement the guidance given in Health Technical Memorandum 06-01 in order to maintain a minimal risk to end-users and, in particular, patients, from electrical failures.

Note

Figure 6 in Health Technical Memorandum 06-01 Part A shows the five clinical risk categories, Figure 7 shows the four non-clinical and business-continuity risk categories. Part A provides details for various electrical infrastructure and distribution strategies based on the type of healthcare premises and associated clinical, non-clinical and business-continuity risk. The strategies provided may vary according to the degree of resilience from a unified system, segregated system to a dual-unified fully resilient infrastructure.

4 Operational and maintenance strategy

4.1 This Health Technical Memorandum considers electrical operational management and maintenance requirements for the hard-wired electrical systems and fixed power plant at voltages up to and including high voltage (11 kV). When considering the operational and maintenance strategy for the electrical network(s) within the healthcare premises, it is essential to take a holistic approach.

4.2 The electrical system may include HV as well as LV distribution networks depending on the size of the healthcare premises. The operation and maintenance of the electrical systems should prevent the risk of injury and/or danger.

4.3 There are essentially two strategies for the operational management and maintenance of electrical services at a healthcare facility:

- planned maintenance, and
- condition-based maintenance.

These strategies are defined in Chapter 2. The maintenance regime should minimise the opportunity for failure of the electrical services. The electrical service may fail due to a supply failure, an electrical fault, accidental damage of electrical accessories or unauthorised interference with the electrical systems. Health Technical Memorandum 06-01 Part A provides the management guidance for these issues. Health Technical Memorandum 06-02 – 'Electrical safety guidance for low voltage systems' provides details on how to ensure that electrical systems are operated in a safe manner and, hence, minimise the opportunity for failure. Guidance on organising maintenance activities on the fixed electrical wiring or electrical plant is summarised in Tables 1–3 of Health Technical Memorandum 06-02.

4.4 The electrical plant and electrical distribution infrastructure might degrade to a point of failure unless suitable maintenance regimes exist. Maintenance strategies should be evaluated with the distribution strategy and clinical risks.

Planned preventative maintenance

4.5 See paragraphs 2.17–2.18 for a definition of planned preventative maintenance.

4.6 Effective planned preventative maintenance regimes should minimise the opportunity for the electrical plant and or distribution systems to degrade into a faulty status. Therefore, operational and estates managers may wish to consider planned preventative maintenance where the electrical infrastructure does not have a high resilience.

Condition-based maintenance

4.7 See paragraphs 2.19–2.20 for a definition of condition-based maintenance.

4.8 Effective condition-based maintenance regimes should minimise the maintenance workload by only initiating maintenance when it is actually required. However, the electrical service might fail or degrade at an unexpected rate and hence cause an interruption to the electrical supply at the final circuit point of connection. Condition-based maintenance programmes are most appropriate where the electrical infrastructure has high resilience.

Coordinated maintenance and business hours

4.9 Where maintenance tasks require electrical plant and/or part of the electrical services to be isolated and there are no duplicated provisions, a degree of inconvenience to patients and or end-users might be inevitable.

4.10 Where the electrical infrastructure does not have an appropriate degree of resilience, maintenance tasks should be arranged outside normal business hours. Where the electrical infrastructure has a degree of resilience, there are more opportunities to implement maintenance regimes without the inconvenience to patient services or services to staff and visitors.

Operational and maintenance policy

4.11 Detailed planning and organisation of the maintenance regimes will be required where the operation of electrical equipment and the continued electrical supply are vital to the continued function of the healthcare facility's risk category areas (see Health Technical Memorandum 06-01 Part A and Chapter 3 of this document). Designers of electrical systems should be made aware of the maintenance requirements and provide suitable redundancy. An operational and maintenance policy should be adopted, based on a suitable programme from the above maintenance strategies. The operational and maintenance policy should be reviewed and updated every five years or as significant changes take place.

Spares and tools

4.12 Estates departments should consider the range of spares and tools needed, and should consult with manufacturers for their recommendations of spare parts for the fixed wiring and electrical plant. The range of spares held should reflect the particular clinical risk and business continuity risk of the healthcare facility (see Health Technical Memorandum 06-01 Part A). Where the electrical infrastructure does not provide a high level of resilience (that is, a single unified distribution), a greater range and volume of spares might be considered.

4.13 Operational and estates managers should ensure that designers and installers standardise on a limited range of electrical plant types such that the overall volume of spares may be kept as small as practicable.

5 Switchgear and protection

5.1 All inspections and tests involving switching devices must be performed in a manner that does not cause injury or danger to the maintenance operator and/or end-users.

5.2 All switchgear and protection maintenance tasks should be arranged as planned preventative maintenance. For maintenance planning purposes, it is important to demonstrate and confirm that the original commissioning tests are repeatable, and at the same time examine the switching device for indication of wear in contacts and slackness in moving and rolling linkages.

5.3 The manufacturers' operational and maintenance switchgear and protection manuals should be adopted as far as is reasonably practical. The guidance here is only intended to supplement the manufacturers' data or provide a guide where a broader understanding is required.

Non-intrusive visual inspection

High-voltage switchgear and protection

5.4 Maintenance tasks should include non-intrusive visual inspection of any HV switchgear and protection systems as an occasional maintenance with frequency not exceeding six-monthly intervals.

5.5 The non-intrusive visual inspection should include the checks for leakage of coolants, lubricants, the status of all instrumentation, and general tidiness of the switchroom. The non-intrusive visual inspection should include a visual check that no devices have tripped and/or no fault passage indicators are in the alarm condition.

5.6 A limitation-of-access document should be raised for any non-intrusive visual inspection of the HV switchgear and protection systems.

5.7 Thermal imaging equipment is a useful supplementary method for understanding the condition of HV switchgear and protection systems.

5.8 Non-intrusive visual inspection may be achieved with the use of infrared photography, which will show any local high-resistant hot spots, without opening the switchgear etc.

5.9 A limitation-of-access document should be raised for any non-intrusive visual-inspection maintenance of the HV switchgear and protection system.

Transformers

5.10 Maintenance tasks should include non-intrusive visual inspection of any transformer as occasional maintenance with frequency not exceeding yearly intervals. The inspection should include checks for coolant and lubricant leakages, and general tidiness of the transformer enclosure. The inspection should also include a visual check of the cable-termination gland boxes, the cleaning of the transformer room/enclosure, and verification that any ventilation system is clear and tidy.

5.11 HV cable boxes should be inspected for indication of any deterioration in the terminations and bushings. Checks for any signs of oil or liquid penetration from the tank, or ingress from the environment, should be made.

5.12 LV cable boxes should be inspected for loosening of any multi-lug terminations. Checks for any signs of overheating or external ingress of tank oil or water should be made.

5.13 Cleaning of external insulators, the painting of the transformer tank and cooling fins, and checking the accuracy of temperature gauges and alarms should be undertaken.

5.14 The accuracy of sealed tank pressure gauges and pressure relief diaphragm, where fitted, should be checked to manufacturers' instructions.

5.15 A limitation-of-access document should be raised for any non-intrusive visual inspection of transformers.

Low-voltage switchgear and protection

5.16 Maintenance tasks should include non-intrusive visual inspection of any LV switchgear and protection as frequent maintenance with frequency not exceeding six-monthly intervals.

5.17 The inspection should include checks for coolant and lubricant leakages, the status of all instrumentation, and general tidiness of the switchroom.

5.18 A limitation-of-access document should be raised for any non-intrusive visual inspection of transformers.

Full services

High-voltage switchgear and protection

5.19 Planned maintenance should include a full examination of the breaker main and arc contacts and, for vacuum interrupter or SF_6, the chambers and indications. The setting and movement of all circuit-breaker actuating linkages using the "slow close" lever should be measured where the manufacturer gives guidance.

5.20 Secondary injection tests to verify the integrity of protection should be carried out at regular intervals. The frequency of this test is dependent on the number of breaker operations and the environment. A maximum time limit should be decided on, beyond which the breaker protection should be comprehensively inspected and tested. This should be annually or, in special circumstances, more frequent. The frequency should not be arbitrarily decided on the basis of human resources. Plant history, wider experience of other similar installations, and the manufacturer's guidance on protection should be the criteria.

5.21 When circuit breakers have been out of service for an extended period, the protection/alarms should be proof-checked, with the breaker in the isolated position, before returning to service. This may be done by special test-injection push-buttons or by manual operation of the relay or contacts. This will demonstrate the function of the trip circuit connections to the circuit-breaker mechanism.

5.22 Trip-circuit-faulty supervision alarm checks should be made frequently at the circuit breaker or switchboard push-button if provided.

5.23 When applying a circuit earth through an oil circuit breaker (OCB), the circuit-breaker close operation should be initiated from the remote-control station where possible.

5.24 Vacuum circuit breakers are generally expected to give long periods of maintenance-free operation. The vacuum interrupter can be expected to give between 10,000 and 50,000 operating cycles. The longevity of the interrupter will depend on the individual contact wear. A pointer mounted on the interrupter's frame will indicate an approximate maximum distance (mm) as advised by the manufacturer. The vacuum space in an interrupter may fail for a number of reasons (such as a leak, a hole, evaporation of gases from internal metal components or release of gas from high vapour pressure contaminants).

5.25 Transient overvoltage arrestor protection should be fitted at the terminations of HV inductive equipment that are switched by vacuum-interrupter circuit breakers.

5.26 SF_6 circuit breakers are expected to give long periods of maintenance-free operation. The SF_6 contactor chamber can be expected to give an operational life equivalent to the vacuum circuit breaker. The pressure of the chamber may be lost due to leaks. This can be monitored by a pressure-sensing and lockout alarm or gauge as required. The circuit breaker can operate, in emergency, in an SF_6 atmospheric gas pressure.

5.27 The general maintenance of an OCB involves protection relay testing, examination of operating linkages and terminations of control circuits, and operation of cubicle busbar shutters and sliding/plug-in contacts, similar to other circuit breakers.

5.28 Where OCBs are subject to regular routine operational switching, periodic examination samples of the tank oil quality should be tested to ensure that the quality standard of insulation is equal to BS 148:1998.

5.29 Any circuit breaker operation due to system fault should be determined immediately after the incident. The main contacts of the OCB should be examined and replaced if damaged, and the tank's oil tested and replaced if necessary. All residues of the contaminated oil should be removed by wet suction methods.

5.30 To protect the switchroom floor, a temporary absorbent covering should cover the working area. Maintenance staff should be provided with suitable protective clothing and footwear and be restricted from wearing their working footwear outside the area.

5.31 Thermal-imaging equipment is a useful method for understanding the condition of HV switchgear and protection systems.

5.32 A permit-to-work document should be raised for any full-service maintenance of the HV switchgear and protection systems.

5.33 Depending on the type of HV distribution strategy (see Health Technical Memorandum 06-01 Part A), a "permission for disconnection/interruption of electrical services" document should be raised for any full-service maintenance of the HV switchgear and protection systems.

Transformers

5.34 The routine operational procedures for transformers are limited to HV and LV circuit operations.

5.35 It is important to place transformers into the correct load centre of the site to provide the minimum voltage drop in the distribution cables.

5.36 Off-load tap change selection, when required, to adjust LV level. Off-load tap changing is achieved by moving the positions of the HV winding three-phase links to different stud positions for the voltage ratio as indicated.

5.37 Taking routine oil samples from conservator-type transformers, the inspection of tanks for oil leaks, the regular recording of temperature and tank vapour pressure indications, oil levels and dryer crystal appearance should all be undertaken.

5.38 Routine insulation resistance (IR) checks of HV and LV windings would usually include the LV and HV cables. The values of IR should be kept on record as an indicator of any changes in the integrity of the insulation. IR values of both cold and hot windings should be recorded.

5.39 Measurements of the continuity of the earth protective conductor should be taken.

5.40 Thermal-imaging equipment may provide a convenient method to understand the condition of the transformers.

5.41 A permit-to-work document should be raised for any full-service maintenance of any transformer.

5.42 Depending on the type of HV distribution strategy, a "permission for disconnection/interruption of electrical services" document should be raised for the full-service maintenance of any transformer.

Low-voltage switchgear and protection

5.43 The routine maintenance programme should include tests on the protection relays, auxiliary relays, timer relays, coils, terminations and linkages forming the open/close mechanism and busbar shutter mechanisms and sliding/plug contacts.

5.44 The main contacts and auxiliary contacts mounted on the mechanism should be routinely inspected for misalignment, contact wear, burning and spring tension. Arc chutes should be kept clear of debris, and metal plates cleared or replaced as necessary.

5.45 Contactors operate at higher current ratings than motor starters. It is not required to interrupt fault capacity currents. The range of operation of contactors is within the overload range of the electrical equipment installed in the system circuit.

5.46 The following tasks should be carried out:

a. the basic inspections will be similar to those of the motor starter. It is not expected that a test facility will be available on the isolator. The contactor may be withdrawn from its cubicle or have more cubicle space for inspection;

b. care must be exercised to isolate the contactor mechanism from the switching cubicle's incoming and outgoing circuits;

c. the main, arcing and control circuit contacts linked to the contactor should be periodically inspected for alignment, erosion and burning;

d. indication, alarm and control lamps should be regularly checked by a lamp test, operating push-button or by replacement.

5.47 The following maintenance checks should be carried out:

a. maintenance checks and tests should be based on the commissioning document's functional and protection tests;

b. main contacts, arcing contacts and auxiliary contacts should be replaced where wear or erosion is significant and contact alignment reset;

c. main contactor and relay coils should be checked for pull-in and dropout voltages, and latching contactors for trip operation by reduction of the initiating control voltage;

d. operating time sequence of timing relays should be checked;

e. terminal block connections should be checked for tightness, and conductor crimps inspected for breakage or looseness;

f. all fuse links should be examined for signs of overheating at the contacts, and current ratings confirmed;

g. the operation of motor starters should be checked at regular intervals in addition to the planned maintenance routines, especially where repetitive stop/start operations are made.

5.48 The following tasks should be carried out:

a. small direct online starters equipped with basic stop/start controls will result in the operation of the electric motor when the controls are tested. Electric motors should be prevented from starting by operating an isolating switch or disconnecting link box at or near the motor;

b. in motor control cubicles, the arrangement of starter controls is often simplified for off-load tests. The starter main on/off isolator has a third "test" position, where the power supply is isolated but the control and alarm supplies remain on. The starter-door-closed interlock will also be released and the starter cubicle door may then be opened. Control tests can be carried out at the starter local control start/stop and reset push-buttons depending on the selection of the "remote/local/auto" control selection switch as follows:

   (i) confirm the operation of the stop, running and reset push-buttons for overload trip/reset and control indication lamps and alarms in the three modes of control;

   (ii) confirm the operation of emergency stop push-button;

   (iii) operate and reset the thermal overload at the starter overload trip relay button;

   (iv) close alignment of the three-phase main contacts, arcing contacts and any auxiliary contacts, using a moving-coil analogue meter, measured at the control terminal blocks.

5.49 Fuse-switches and isolators should be inspected annually as follows:

a. the open and close action from the operating lever should be smooth and the spring recoil rapid;

b. the operation of the spring recoil should be effective in opening or closing before the lever arc movement has passed the half travel point;

c. the cubicle door should not be able to open until the switch is in the open position;

d. the bolts and set-screws should be tight in the mechanism and the insulation should be free of defect or damage;

e. moving blade surfaces and fixed contacts should be free of metal erosion or burning;

f. the isolator or fuse-switch moving contacts should make and break simultaneously with the fixed contacts when closing and opening.

5.50 Fuse links should be inspected annually as follows:

a. the rating and rupturing capacity of all fuse links should be clearly shown on a circuit list stored in, or labelled onto, the door of the distribution board (DB) or enclosure.

b. any work on exposed fuse-holder contacts should only be done with the incomer supply isolated.

5.51 Fuse-holders should be inspected annually as follows:

a. the fuse-holder should be identified by the circuit list and contain the correctly-rated fuse link;

b. the shroud on the fuse-holder main contact should be removed and the exposed spring contacts checked for firm compression, and they should be free from signs of overheating;

c. conductor terminations should be checked for tightness;

d. any dirt or dust should be removed and the DB or enclosure checked and sealed against ingress;

e. both sets of spring contacts should be cleaned and lubricated.

5.52 Miniature circuit breakers (MCBs) should be inspected annually as follows:

a. the MCB should be identified by the circuit list and be of the correct type and current rating. The rating should be clearly shown on a circuit list stored in, or labelled onto, the door of the DB or enclosure;

b. MCBs should be operated several times to determine the freedom of the operating mechanism;

c. the MCB terminals should be examined for overheating, and the conductor terminal screws checked for tightness;

d. any doubts as to the suitability or effectiveness of an MCB should lead to its replacement;

e. any dirt or dust should be removed, and the box or enclosure checked and sealed against ingress.

5.53 Thermal-imaging equipment is a useful method for understanding the condition of LV switchgear and protection systems.

5.54 A permit-to-work document should be raised for any full-service maintenance of the LV switchgear and protection system.

5.55 Depending on the type of HV distribution strategy (see Health Technical Memorandum 06-01 Part A), a "permission for disconnection/interruption of electrical services" document should be raised for any full-service maintenance of the HV switchgear and protection systems (see Health Technical Memorandum 06-03 – 'Electrical safety guidance for high voltage systems').

Service/test/record documentation

5.56 Records for any part of the switchgear and protection systems should include the following minimum set of details:

- manufacturer;
- date of installation;
- service contract details (as appropriate);
- rating/type.

High-voltage switchgear and protection

5.57 All testing of any part of the HV switchgear and protection systems should be recorded on a test form similar to that used in the validation process (see Appendix 2 in Health Technical Memorandum 06-01 Part A).

5.58 By maintaining good records, estate managers should be in a position to detect whether any maintenance may be deferred, based on the condition and past test records of the equipment. However, it is recommended that no more than three consecutive routine tests be deferred.

Low-voltage switchgear and protection

5.59 All testing of any part of the LV switchgear and protection systems should be recorded on a test form similar to that used in the validation process (see Appendix 2 in Health Technical Memorandum 06-01 Part A).

5.60 By maintaining good records, estate managers should be in a position to detect whether any maintenance may be deferred, based on the condition and past test records of the equipment. However, it is recommended that no more than three consecutive routine tests be deferred.

6 Secondary power sources

6.1 This chapter considers the operational and maintenance requirements of the secondary power sources. It describes the electrical requirements for standby generators and CHP as being identical. The electrical requirements of other secondary power sources (SPS) such as photovoltaic cells (PV) and wind turbines are outside the scope of this Health Technical Memorandum; in these cases, manufacturers' recommendations should be followed. However, the principle of the electrical test and maintenance requirements of these alternative power sources may be considered as being similar to that for a generator.

Routine online testing

Test to prove the essential electrical systems

6.2 All standby generator plant should be tested online with the building load every month. The duration of the online test should be at least one hour, but preferably two hours. The method of initiating the start of such test will depend on the electrical distribution strategy of the healthcare premises (see Health Technical Memorandum 06-01 Part A). A long-term paralleling of the generator and DNO connection (in accordance with the Energy Networks Association's 'Engineering requirements G59') will minimise the inconvenience to the healthcare premises staff. Without such arrangements, testing of generators with the building load will require a short-term isolation of the electrical supply, which may not be acceptable. In these cases, tests should be conducted with a load bank that has reactive and resistive components to test the generator. (Purely resistive load banks may damage the cylinder or cylinder liners due to the high carbon build-up.)

6.3 Where the essential standby plant consists of more than one generator connected to the same part of the distribution (and long-term parallel arrangements exist), it may not be necessary to test all sets at the same time. The generator(s) on test should operate at greater than 70% full load, by adjusting the load-sharing controls of the generator and mains. Allowing the generator to operate as the lead electrical unit and the DNO connection to act as the supplementary supply will achieve this. Where there is more than one generator connected to the same part of the healthcare site's distribution, there are advantages in starting the second set after about one hour of running the first. Synchronise the second set with the running set, before connecting to the load and then stopping the first generator after a further 15 minutes.

6.4 Note that a generator should run on offline after a test for a period of five minutes to allow the generator cooling system to stabilise.

6.5 The use of a permit-to-work document for any test of the secondary power source may be required.

Test to prove the generator engine condition

6.6 Maintenance programmes should include a longer test run to establish the generator engine mechanical performance. A test to prove the generator engine condition should be carried out annually. The period of the test should be not less than three hours and ideally four hours.

6.7 During the test to prove the generator engine condition, the opportunity should be taken to conduct various tests on the generator safety chain. The overspeed governor should be operated to prove its action. This test will depend on the type of overspeed governor – electrical or hydraulic. Over-temperatures should be simulated to test their alarm function and action. The fuel rack should be forced off to test the auto-shutdown of the set. These tests should not be carried out if there is only one generator running (in island or parallel mode).

6.8 The generator should be allowed to run on offline after a test for a period of ten minutes to allow the generator cooling system to naturally cool the set down.

6.9 The use of a permit-to-work document for any test to prove the generator engine condition of the secondary power source may be required.

Blackout test

6.10 Maintenance tests for standby generators should include a test of any automated switchgear used to transfer power supplies from the primary supply and secondary supply. Where the standby plant does not provide the recommended 100% coverage, the standby plant should include test runs in island mode. These tests will assist staff to understand the limitations of the electrical standby systems and, therefore, exercise their contingency plans.

Generators and public electrical supply in parallel

6.11 Where the distribution strategy exists and arrangements with the DNO are in place to allow the standby generators to operate in parallel with the PES, the frequency of the test to prove the essential electrical systems can be reduced. Operations with the standby generator and PES in parallel should be considered in order to offset the maximum demand and hence reduce energy cost. Where these strategies exist, the parallel operation can supplement the routine requirement to test the essential standby plant to six-monthly frequencies.

Non-intrusive visual inspection

6.12 Maintenance tasks should include weekly non-intrusive visual inspections of any primary and secondary power source systems. The non-intrusive visual inspection should include checks for coolant and lubricant leakage, the status of all instrumentation, and general tidiness of the generator house. The non-intrusive visual inspection test may include the sweeping out of the generator room.

6.13 A limitation-of-access document (see Health Technical Memorandum 06-02 – 'Electrical safety guidance for low voltage systems') should be raised for any non-intrusive visual inspection of the essential standby plant etc.

Non-intrusive functional test

6.14 Primary and secondary system maintenance programmes should include non-intrusive functional tests as an occasional maintenance with frequency not exceeding three-monthly intervals. These tests should include the measurement of battery unit cell voltage and charging current in accordance with the battery manufacturer's recommendations. (Where the batteries are open-vented, specific gravity of the electrolyte should be measured and recorded.) The pH of the coolant water should be between 8 and 10.5. A measurement of the coolant anti-freeze should indicate a 35% to 50% mixture, or as recommended by the engine manufacturer. If the coolant water anti-freeze is refilled, ethylene glycol base should be used. The coolant water should have a suitable corrosion inhibitor. The condition of any radiator guards and exhaust insulation should also be inspected. The generator should be isolated from all control systems and distribution connections while performing any non-intrusive functional tests.

6.15 A permit-to-work document (see Health Technical Memorandum 06-02 – 'Electrical safety guidance for low voltage systems') should be raised for any non-intrusive functional maintenance task of the secondary power sources.

Full services

6.16 Secondary power system maintenance programmes should include full services as an infrequent maintenance with frequency exceeding annual intervals but not greater than ten-yearly. The individual maintenance tasks should be based on the manufacturers' data sheets and recommendations. The full services maintenance task of any secondary power source should include the comprehensive overhaul of the alternator, stator and control systems (see Chapter 5 for more details).

6.17 The planned full mechanical servicing of the secondary power source should be undertaken at the same time as the electrical full services.

6.18 A permit-to-work document should be used for the full servicing of standby generator plant. The full service of standby generators will reduce the embedded essential power resilience. Distribution strategies with an N+1 resilient standby power system will negate such restrictions. Alternatively, additional mobile standby plant may be brought in for the duration of the full servicing.

Service/test/record documentation

6.19 A simple single-line diagram of the electrical infrastructure showing the interface of all primary and secondary power sources and their respective controls should be available at all times. The single-line diagram should include all earthing arrangements while the power is derived from the secondary power source.

6.20 Records should be kept of all hours that the standby plant is run, whether the purpose is for testing, parallel operation or an outage of the PES.

6.21 During any testing or parallel operation of the secondary power source, readings of the output phase-to-phase and phase-to-neutral voltage (V), current (A), frequency (Hz), true power (kW), apparent power (kVA) and power factor should be recorded. A computer software system for the automatic recording of the above parameters should be considered. Advantages include the automatic recording of data while the secondary power source is running due to an outage of the PES.

7 Electromagnetic compatibility

7.1 Maintenance of equipment during its operational lifetime is a requirement of UK regulations. Trade tests for apparatus should include provisions for detecting and rectifying EMC defects, in addition to more common functional and safety checks. Maintenance should typically include a combination of both visual inspection and electrical tests. Trade tests can be extensive; some of these are summarised below, but one essential requirement is that details of all work carried out, defect reports and remedial actions taken should be recorded.

Non-intrusive visual inspection

7.2 Cables should be routinely checked against segregation and separation requirements.

7.3 Cable terminations should be checked for damage, corrosion and irregularities. Where filter circuitry is used, such circuitry should be checked to ensure it has not been electrically bypassed during service etc, and transient protection circuitry should be checked for over-voltage or damage.

7.4 Enclosures should be routinely checked for corrosion and signs of damage. Clear guidance should be provided on the painting and treating of metallic surfaces, which are required to provide a high level of conductivity.

7.5 Enclosure doors that employ RF seals should be checked for uniform fit in the door frame. The RF seals may require cleaning and lubrication.

Non-intrusive functional test

7.6 Bonding straps between equipment etc should be routinely checked for damage and corrosion, and their DC resistance should be measured and compared with the required specification, typically 2 to 5 mΩ. If the bond connection has corrosion protection, this should be re-applied following disconnection.

7.7 Compliance should be achieved by checking the screwed and bolted connections during the active life of the installation. This verification should be performed either visually or by systematic tightening of each connection and by DC measurement across the joint.

Full services

7.8 Full servicing to eliminate any potential problems of electromagnetic compatibility should be considered as an infrequent maintenance with frequency not exceeding five-yearly intervals. The full servicing inspection may include a detailed survey by specialist companies to analyse the distribution circuitry for any stray radiated frequencies superimposed on the conductors.

7.9 A limitation-of-access document should be raised for any full services/surveys of the electrical distribution for electromagnetic problems.

7.10 It is good EMC practice that an audit of the installed systems, including cable segregation, earthing and bonding, is performed on a regular basis. The interval between audits will depend on the complexity of the healthcare premises. Audits should be performed every two years for complex units and every five years for non-complex units. An EMC audit should be incorporated with the scheduled audit of electrical systems. An audit checklist should be used. Specialist EMC advice should be obtained as to the content of the checklist and the training of the person carrying out the audit.

8 Earthing

Non-intrusive visual inspection

High-voltage earthing

8.1 HV earthing maintenance programmes should include non-intrusive visual inspection of any HV earthing systems as an occasional maintenance with frequency not exceeding yearly intervals. The non-intrusive visual inspection should include the bonding conductors between all HV equipment and, if appropriate, HV earth ground terminals owned by the healthcare premises.

8.2 A limitation-of-access document should be raised for any non-intrusive visual inspection maintenance of the HV earthing system.

Low-voltage earthing

8.3 LV earthing maintenance programmes should include non-intrusive visual inspection of any LV earthing systems as an occasional maintenance with frequency not exceeding six-monthly intervals. The non-intrusive visual inspection should include the main earthing terminal (MET), earth reference bars (ERBs), main earthing conductors and earth electrode connections.

8.4 A limitation-of-access document should be raised for any non-intrusive visual inspection maintenance of the LV earthing system.

Full services

High-voltage earthing

8.5 HV earthing maintenance programmes should include full servicing of any HV earthing systems as an infrequent maintenance with frequency not exceeding three-yearly intervals. The full services of any HV earthing should comply with the requirements of BS 7430 and include the bonding conductors between all HV equipment and, if appropriate, HV earth ground terminals owned by the healthcare premises. The actual interval between full services of the HV earthing system should be staggered such that the effects of the weather conditions (on soil resistivity) can be evaluated.

8.6 A permit-to-work/sanction-for-test document should be raised for any full-service maintenance of the HV earthing system.

Low-voltage earthing

8.7 LV earthing maintenance programmes should include full servicing of any LV earthing systems as an infrequent maintenance with frequency not exceeding two-yearly intervals. The full services of any LV earthing should comply with the requirements of BS 7671 and BS 7430 and include the MET, ERBs, main earthing conductors and earth electrode connections. The resistance of the earth loop should be as low as possible, and maintenance readings should be compared with the readings obtained at commissioning for the earth loop impedance and prospective short-circuit current (PSCC). A corrective maintenance strategy should be considered for any significant deterioration of the values.

8.8 The resistance of the earth electrode should be as low as possible and should not exceed 2 Ω, and subsequent maintenance readings should be compared with the readings obtained at commissioning for the earth loop impedance and PSCC. A corrective maintenance strategy should be considered for any significant deterioration of the values. The actual interval between full servicing of the LV earthing system should be staggered such that the effects of the weather conditions (on soil resistivity) can be evaluated.

8.9 A permit-to-work document should be raised for any full-service maintenance of the LV earthing system.

Service/test/record documentation

8.10 The records of the earthing systems should include a single-line block diagram showing the position of each earth electrode MET, ERB and protective earth terminal (PET) for each LV network, including isolated power supplies (IPSs). The single-line diagram should clearly identify any clean earths.

8.11 Records of the initial and subsequent soil resistivity readings and a record of the resistance readings of the earth electrodes should be maintained. The records should indicate where any low-resistive/high-conductive materials have been used to improve the soil resistivity surrounding the earth electrode.

Lightning protection

Non-intrusive visual inspection

8.12 The lightning protection system (LPS) should be visually inspected for any signs of damage without the need to expose any final earth electrodes. This will require a visual check of any exposed down-conductors, roof tapes and air finials. Where surge arrestors are included as part of the LPS, these should be visually inspected for their respective terminal connections.

8.13 Where non-intrusive visual inspection identifies damage to the LPS, consideration should be given to immediate repair or the delay of such corrective maintenance until the next full service. A quick measurement of the overall resistance to earth of the LPS may be used in this assessment.

8.14 The non-intrusive visual inspection maintenance frequency of the LPS may be considered as an occasional maintenance with frequency not exceeding six-monthly intervals.

Full services

8.15 The LPS should be annually tested for compliance with BS 6651and visually inspected for any signs of damage. Tests for effective continuity of each section of the LPS are required. Similarly, the resistance to earth of each individual electrode and the overall collective resistance to earth should be measured. The overall resistance to earth should not exceed 10 Ω. The test methods are described in BS 7430.

8.16 The soil resistivity around each LPS earth electrode should be re-measured where it is suspected that the ground conditions have changed by, for example, new building works.

8.17 The full-servicing maintenance frequency of the LPS may be considered as an infrequent maintenance task at not greater than 13-monthly intervals. The odd number of months will ensure that the soil-resistivity readings are taken at all times of the year through the life of the building.

Service/test/record documentation

8.18 LPS records should include a single-line block diagram showing the position of each earth electrode and air finial. Initial and subsequent soil-resistivity records and individual earth-electrode resistance records should be maintained. The records should indicate where any low-resistive/high-conductive materials have been used to improve the soil resistivity surrounding the earth electrode.

9 Containment

Non-intrusive visual inspection

9.1 Non-intrusive visual inspection containment maintenance should be considered as an infrequent maintenance with frequency not exceeding annual intervals. The non-intrusive visual inspection should include checks to ensure all covers and fixings of the containment system are in place and sound. Where appropriate, assessments should be made to determine whether the space factor of the containment has been exceeded.

9.2 Different maintenance frequencies may be considered for the various forms of containment system. For example, the non-intrusive visual inspection of a cable service-trench containment system might not justify the same maintenance frequency of, say, a trunking containment system used for final circuits.

9.3 A limitation-of-access document should be raised for any non-intrusive visual inspection maintenance of the containment system.

10 Busbars and cables

Non-intrusive visual inspection

10.1 Non-intrusive visual inspection of busbars and cables should be considered as an infrequent maintenance with frequency not exceeding annual intervals. The inspection should include checks to ensure that there is no obvious damage to the busbar and cable systems, including any cable termination glands/boxes. The damage may be due to the over-stressing of cables from a gradual power overload or a change in the local environmental conditions. The non-intrusive visual inspection maintenance should also verify that the required separation distance between services has not been compromised.

10.2 A limitation-of-access document should be raised for any non-intrusive visual inspection maintenance of the busbar and cable systems.

Full services

10.3 Full-service busbar and cable maintenance should be considered as an infrequent maintenance with frequency not exceeding ten-yearly intervals. The full services should include a pressure test to determine the conductor condition of each busbar and cable system. Such pressure tests should only be applied after carefully considering the applied test voltage and duration of any pressure test. In all cases, the manufacturer's advice should be obtained prior to conducting the test. Initial tests may be up to 125% of the normal operating voltage (V_0) for one minute. However, as the busbars and cables age, applied test voltages should be reduced to 80% of the previous test voltage. Any busbars and cables that are considered functional but operating at or near their design limit should not be exposed to any pressure test.

10.4 Any busbars and cables that show defects or failures from the pressure test should be considered for replacement. Where the test demonstrates that damage or faults are confined to a discrete section, only a section of the busbars or cables should be replaced. Where sections are replaced, the new section should be joined with approved connection units or jointing techniques. Cable joints should be limited to four joints per cable length before the replacement of the cable.

10.5 A permit-to-work document should be raised for any non-intrusive visual inspection maintenance of the busbar and cable systems.

11 Uninterruptible power supplies, inverters and batteries

Non-intrusive visual inspection

11.1 Non-intrusive visual inspection of uninterruptible power supplies (UPSs), inverters and batteries should be considered as a frequent maintenance task at intervals not exceeding monthly. The non-intrusive visual inspection should include a visual check that no alarms have been activated and that rooms are apparently at design condition.

11.2 Where the UPS, inverter or battery includes self-monitoring or data-logging facilities, the visual inspection should include a printout of these facilities. In such a way, a condition-based maintenance system can be initiated for full-service maintenance checks.

11.3 The cleaning of any ventilation grilles on the UPS should be carried out at the same time. In addition, the room's general environmental conditions should be noted.

Non-intrusive functional test

11.4 Non-intrusive functional tests of UPSs, inverters and batteries should be considered as an occasional frequency maintenance task at intervals not exceeding six-monthly.

11.5 Functional tests for UPSs, inverters and batteries should include a physical test of any connected automatic or visual alarms. Functional tests of UPSs should verify that the inverter input would change from the rectifier output to battery output within 0.5 s. Similarly, the static switch should operate within 0.5 s following any fault condition of the inverter unit.

Full services

11.6 The full service of UPSs, inverters and batteries should be considered as an occasional frequent maintenance task at intervals not exceeding six-monthly.

11.7 UPSs, inverters and batteries that can perform self-diagnostic tests at a preset frequency may be used to advantage. UPS systems above 80 kVA may have self-diagnostic test facilities for battery condition. The self-test replicates the above on a much more frequent basis and can alarm fault conditions. During such tests, any adverse battery condition will restore the UPS to the rectifier output.

11.8 Full-services tests should demonstrate that the batteries can hold their fully charged state while the UPS is on bypass. Secondly, the batteries and UPS should be tested online (with the mains disconnected). The battery discharge voltage and current should be monitored over a 10-minute period. Following this, the battery voltage and current-recharge conditions should be observed. Any adverse conditions should be corrected.

11.9 The test should verify the condition of the rectifier and inverter components, including the static switch and all bypass switches. All cable and component connections should be tightened as required. Verification of the inverter input and output waveforms should be made.

Service/test/record documentation

11.10 A simple single-line diagram of the UPS/inverter arrangement indicating how the units are connected into the electrical infrastructure should be maintained as part of the operational and maintenance manual and site logbook.

11.11 The site logbook should contain full details of the UPS, inverter and battery units. The details should include:

- battery autonomy;
- UPS rating (kVA);
- rectifier type (six or 12 pulse);
- mode of operation (single/double conversion, on/offline);
- single supply or dual supply;
- date of installation;
- manufacturer;
- service contract details.

11.12 Records should be kept of all alarms and outages of the UPS, and details from all tests and servicing. Operational and estates managers may wish to consider a standard form to record all test results from any UPS, inverter or battery within the healthcare premises.

12 Isolated power supplies

12.1 Isolated power supply (IPS) units should incorporate various self-diagnostic devices, which can assist in condition-based maintenance. Such devices include insulation-monitoring devices (IMDs).

Non-intrusive visual inspection

12.2 Non-intrusive visual inspections of isolated power supplies should be considered as a frequent maintenance task at intervals not exceeding monthly. The inspection should include a visual check that no alarms have been activated.

12.3 The cleaning of any ventilation grilles on the IPS should be carried out at the same time. In addition, the room's general environmental conditions should be noted.

Non-intrusive functional test

12.4 Non-intrusive functional testing of isolated power supplies should be considered as a frequent maintenance task at intervals not exceeding six-monthly.

12.5 The test should include audible and visual alarm tests. All alarm positions should be verified at the IPS unit, the nurses' station, and (if appropriate) any connected building management system (BMS).

12.6 IPSs that can perform self-diagnostic tests on a preset frequency should be used. For example, the IPS will include an IMD that will continuously monitor the circuit insulation resistance. The non-intrusive functional test should include a recording of the IMD readings.

12.7 Where the IPS is connected to the output of a UPS, the non-intrusive functional test should be conducted in conjunction with the UPS maintenance.

Full services

12.8 The full servicing of IPSs should be considered as occasional maintenance at intervals not exceeding annually.

12.9 The full servicing of IPSs should include an annual visual inspection of the settings on all protective devices associated with any part of the IPS electrical installation. Check that extraneous metalwork is bonded to the ERB and that all socket earth terminals are also bonded to the same earth reference point. Each earth path should have an impedance reading not greater than 0.1 Ω.

12.10 Check primary and secondary isolation transformer voltages.

12.11 Check transformer line-to-earth capacitive leakage current with a digital voltmeter (DVM) off load; the measured value should not exceed 0.5 mA.

12.12 The full servicing of IPSs that are connected to the output of a tertiary supply (such as a UPS) should include an annual test to verify that the supply changeover occurs within 0.5 s. Where the IPS is connected to a primary supply and secondary supply (generator), the annual test should verify that the supply changeover occurs within 15 s.

12.13 Apply a simulated 50 kΩ test-resistor earth fault on each socket circuit and confirm correct alarm indications. Check voltage levels in IPS areas between socket earth terminals and room earth reference terminals and extraneous metalwork are less than 20 mV (as far as practicable).

Service/test/record documentation

12.14 A simple single-line diagram of the IPS indicating how the units are connected in the electrical infrastructure should be maintained as part of the operational and maintenance manual and site logbook.

12.15 The site logbook should contain full details of the IPS. The details should include:

- number of transformers;
- number of outgoing circuits;
- circuit diagram indicating the location of each socket;
- IPS rating (kVA);
- date of installation;
- manufacturer;
- service contract details.

12.16 Records should be kept of all IPS alarms and outages, and details from all tests and servicing. A standard form should be used to record all test results from any IPS.

13 Harmonic filters

Non-intrusive visual inspection

13.1 Non-intrusive visual inspection maintenance programmes for harmonic filters should be considered as an infrequent maintenance at intervals not exceeding annually. The inspection should include the earth bonding conductors, cable terminations and fixing/mounting arrangements.

13.2 A limitation-of-access document should be raised for any non-intrusive visual inspection maintenance of harmonic filters.

Full services

13.3 Full-service maintenance programmes for harmonic filters should be considered as an infrequent maintenance at intervals between one and five years. The full services should include the earth bonding conductors, cable terminations and fixing/mounting arrangements, and physical measurements of the electrical distribution quality. The function of any full services of the harmonic filters should ensure continued compliance with the Energy Networks Association's 'Engineering Recommendations G54'.

13.4 A permit-to-work document should be raised for any full-service maintenance of harmonic filters.

14 Power-factor correction units

Non-intrusive visual inspection

14.1 Non-intrusive visual inspection maintenance programmes for power-factor correction (PFC) systems should be considered as an infrequent maintenance at intervals not exceeding one year. The non-intrusive visual inspection should include the earth bonding conductors, cable terminations and fixing/mounting arrangements.

14.2 A limitation-of-access document should be raised for any non-intrusive visual inspection maintenance of PFC systems.

Full services

14.3 Full-service maintenance programmes for PFC systems should be considered as an infrequent maintenance at intervals between one and five years. The full services should include the earth bonding conductors, cable terminations and fixing/mounting arrangements, and physical measurements of the electrical distribution quality. The function of any full services of the PFC systems should ensure the network-corrected power factor remains within the range 0.95 to 0.92. The PFC units should be turned off and the uncorrected power factor noted and compared with the power factor while the PFC units are active.

14.4 A permit-to-work document should be raised for any full services maintenance of PFC units.

15 Final circuits

15.1 Section 6 of the Health and Safety at Work etc Act states that it should be the duty of any person who designs or manufactures any part of an electrical system to ensure that adequate maintenance regimes are in place to prevent injury or danger. The maintenance regimes require routine inspection and testing.

15.2 IEE Guidance Note No 3 in BS 7671 provides guidance for the testing of the fixed wiring system. IEE's 'Electrical maintenance' booklet provides maintenance advice for the fixed wiring systems of a building.

15.3 Further guidance may be found in CIBSE Guide K – 'Electricity in buildings'.

Non-intrusive visual inspection

15.4 Non-intrusive visual inspection maintenance regimes of final circuits should be viewed as an occasional maintenance at intervals not exceeding six-monthly. The inspection should include the visual inspection of all electrical accessories for any apparent damage. In addition, non-intrusive visual inspection of the final circuits should include visual checks of final distribution and protective devices. The actual frequency of non-intrusive visual inspection of final circuits should be determined by the risk of injury or danger, and the environment of the installation. For example, in mental health accommodation the risk of accidental damage may be greater. Similarly, for final circuits in high-traffic circulation areas, accidental damage may be high. Non-intrusive visual inspection maintenance may be arranged as an integral part of other equipment maintenance activities, especially for healthcare premises with non-retained maintenance staff.

15.5 Damage to electrical accessories found during a non-intrusive visual inspection of final circuits should be considered as an urgent corrective maintenance task.

15.6 A limitation-of-access document should be raised for any non-intrusive visual inspection maintenance of final circuits.

Non-intrusive functional test

15.7 Non-intrusive functional test maintenance regimes of final circuits should be viewed as an infrequent maintenance task at annual intervals. The maintenance programme should include the operation of any automatic protective device trips and the manual operation of any isolator and/or switch disconnector. The actual frequency of non-intrusive functional tests should be evaluated by the risk of injury or danger and the environment of the installation. Non-intrusive functional tests of final circuits should be included as an integral part of other equipment maintenance activities, especially for healthcare premises with non-retained maintenance staff.

15.8 Faulty switchgear or protective devices found during the non-intrusive function maintenance of final circuits should be considered as an urgent corrective maintenance task.

15.9 A permit-to-work document should be raised for any non-intrusive visual inspection maintenance of final circuits. The non-intrusive functional tests of final circuits should be coordinated with the respective end-users where the necessity of isolating supplies may be required. Under such circumstances, the use of a "permission for disconnection/interruption of electrical services" document should be raised.

Full services and testing

15.10 The full service and testing of final circuits should be viewed as an infrequent, planned preventative maintenance at intervals between three and five years. Full services and testing should satisfy the requirements of BS 7671-7, Chapters 71 and 73. The actual frequency of full servicing and testing should be evaluated by the risk of injury or danger, and the environment of the installation.

15.11 Faults or non-compliances found during the full service and testing of final circuits should be attended to as an urgent corrective maintenance task.

15.12 A permit-to-work document should be raised for any full service and testing of final circuits. The full service and testing of final circuits should be coordinated with the respective end-users where the potential of isolating supplies may be required. Under such circumstances, a “permission for disconnection/interruption of electrical services” document should be raised.

15.13 The full service and testing of final circuits should be coordinated with other maintenance activities, since such work may require the closure of a ward or department.

Service/test/record documentation

15.14 Service/test/record documentation should satisfy the requirements of BS 7671-7, Chapter 74.

16 Portable appliance testing

16.1 Portable appliances include any item of electrical equipment that is designed to be hand-held while operating, but excludes any piece of medical equipment. Portable appliances include items such as personal computers, vacuum cleaners, floor polishers, hand tools and many more. Estates managers should make a comprehensive list of all electrical appliances that might be plugged into any part of the fixed wiring system.

16.2 Portable appliances will include items that are double-insulated as well as items which have an exposed conductive casing that is earthed.

16.3 A policy decision should be made regarding electrical equipment, including portable appliances, that are owned (and used) by patients or residential staff. The objective of any such policy should be for the safety of the fixed wiring system and any persons that might be exposed to the equipment and/or fixed wiring.

16.4 The healthcare organisation should adopt a policy that prohibits the use of personal electrical equipment until it has been tested (or other such safeguard). Equipment found faulty should be refused connection.

16.5 The equipment user should perform a visual inspection test each time the equipment is used.

Non-intrusive visual inspection

16.6 Non-intrusive visual inspection of portable appliances should be considered as frequent maintenance and performed as often as is practicable; it might vary according to the equipment. Where good records of routine testing are available, the records may be used to form a condition-based maintenance strategy.

16.7 Non-intrusive visual inspection testing of portable appliances will include the checking of the appliance lead/flex for any signs of damage or degradation, such as cuts, other damage or overheating. These tests can be carried out by the equipment user providing that he/she has been told how to conduct the inspection and he/she signs to confirm that the test has been regularly made.

16.8 Non-intrusive visual inspection testing of portable appliances also includes the checking of the equipment casing. These tests can be carried out by the equipment user providing that he/she has been told how to conduct the inspection, report defects, and he/she signs to confirm that the inspection has been made.

Non-intrusive functional test

16.9 Non-intrusive functional tests of portable appliances should be considered as infrequent maintenance and performed as required, but generally at intervals no greater than 18 months. This might vary according to the equipment. Where good records of routine testing are available, the records may be used to form a condition-based maintenance strategy.

16.10 Non-intrusive functional tests of portable appliances are performed using specialist test equipment that can automatically perform a range of tests suitable for the equipment. Tests will include operating current, insulation resistance of the appliance, correctly wired plugs and flexes.

16.11 The test equipment can store the results (electronically) and be suitable for downloading onto a computer. Test certificates for individual equipment or groups of equipment can then be produced. Suitable software packages may store long-term historic records, which might form the bases of any condition-based maintenance.

16.12 Non-intrusive functional tests of portable appliances should only be performed by suitably instructed staff who understand the significance of any test results and can determine what, if any, corrective action might be required.

Service/test/record documentation

16.13 Estates managers should compile a comprehensive asset register of all portable appliances within the healthcare facility, regardless of the owner of the equipment. The asset register should uniquely identify the equipment by serial number, the owner of the equipment, the test, and the test frequency that should be performed.

16.14 Where the portable appliance is owned by the healthcare organisation, an asset identification label should be fixed to the item for positive recognition.

16.15 All functional tests should be stored, ideally on a computer system. The test records should show the equipment name, owner and serial/asset number, the test performed (with results), and the date of the test. It is acceptable to produce a summary test certificate for grouped items within one location, provided full test details are available on the computer software.

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Note

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