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Portable Appliance Testing

A Practical Guide

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Seaward: making your life easier and more efficient

World-Leading Electrical Test Equipment from Seaward

At Seaward Group, we have over 70 years in the design and manufacture of innovative electrical safety test equipment. Today, our first-class range of products serves a wide variety of testing and precision measurement applications.

For the last 30 years we've moved our developments on. Our portable appliance testers are the benchmark for the portable appliance testing (PAT) market and are regarded as number one by the industry. Our PAT testing equipment has always been designed with the needs of our customers in mind. Safety in the workplace is of paramount importance and our testers provide the quick and effective key to electrical equipment preventative maintenance programmes. That's why each Seaward PAT tester is backed by a huge range of accessories, printers, asset management software and technical support. Peace of mind is guaranteed for our customers because they know that help and advice is only a phone call away.

Contents

2. Legislation

Although reference is made to legislation, this guide should not be considered to be legal advice. The reader should refer to the specific legislation and seek legal advice where necessary, which may vary from time to time.

Health and Safety at Work Act 1974 (HSW 1974) places a duty of care on both the employer and employee to ensure the safety of all persons using the work premises.

Management of Health and Safety at Work Regulations 1999 state that every employer shall make suitable assessment of the risks to health and safety of his employees to which they are exposed whilst at work and the risk to the health and safety of persons not in his employment arising of or in connection with the conduct by him of his undertaking.

The Management of Health and Safety at Work Regulations 1999 also state that:

a. Every employer shall make a suitable and sufficient assessment of the risks to the health and safety of his employees to which they are exposed whilst they are at work.
b. Where the employer employs five or more employees, he shall record the significant findings of the assessment.

Electricity at Work Regulations 1989 apply to every type of electrical equipment and state: "As may be necessary to prevent danger, all systems shall be maintained so as to prevent, so far as is reasonably practicable, such danger." (Regulation 4(2))

Provision and Use of Work Equipment Regulations 1998 places general duties on employers and lists minimum requirements for work equipment to deal with selected hazards whatever the industry.

The Regulations implement an EU Directive aimed at the protection of workers and the "general duties" will require the need to:

a. Make sure that equipment is suitable for the use for which it is provided.
b. Take into account the working conditions and hazards in the workplace.
c. Ensure equipment is used only for the operations for which, and under conditions for which, it is suitable.
d. Ensure that equipment is maintained in an efficient state, in efficient working order and in good repair.
e. Provide equipment that conforms to EU product safety directives
f. Plus certain other general duties and specific requirements etc.

Housing Act 2004 (England and Wales) introduced a new method for assessing risk in residential properties, called the Housing Health and Safety Rating System, to provide a safe and healthy environment for any potential occupiers or visitors. This includes portable electrical equipment and the condition of associated leads and plugs should be taken into account if they are provided as part of a rented dwelling. Portable appliance testing is one method of ensuring that electrical equipment is safe for continued use.

Housing (Scotland) Act 2006 defines the statutory requirements that have to be met by a private landlord and includes the electrical installation and electrical appliances. The landlord must ensure that the property meets the requirements at the start of the tenancy and at all times during the tenancy where the landlord is made aware of possible defects.

3. Who has responsibility?

Users of Electrical Equipment

Users of electrical equipment have a responsibility to ensure that equipment they use has no obvious visual damage or defects. The employer has a responsibility to provide and maintain a safe plant for every employee to use (HSW Act 1974 Sect 2(a)). This requirement is endorsed by the (EAWR 1989) Regs 4(1) and 4(2) with specific reference to electrical equipment. The (EAWR 1989) Reg 3(1) also places the same duties upon the self-employed.

Administrators

The IET Code of Practice gives advice to persons managing maintenance schemes. Administrators or managers of premises are required to understand and apply the legislation and assess the risks in respect of electrical equipment and appliances within their charge. Administrators have a legal responsibility to ensure that the electrical equipment in their charge is safe.

Test Operative

The person performing the inspections and tests on an item of equipment should be competent to carry out the inspections and tests, assess the results and the conditions in which the item is being used and state whether the item is safe for continued use. Training and experience will both be necessary.

4. Competence, Training and Experience

The User

Users may require training in identification of defects that can occur in electrical equipment. Users should be aware that:

a. Equipment that is faulty or suspected of being faulty should not be used.
b. Equipment that is faulty should be labelled and removed from service immediately.
c. The administrator or manager should be notified.

The Duty Holder

The duty holder, normally a manager or supervisor, is required to know their legal responsibilities as laid down in the Electricity at Work Regulations 1989 and have a legal responsibility to ensure that equipment in their charge is safe.

Duty holders may require training to allow them carry out risk assessments, maintain records of inspections, tests and repairs of equipment and manage the inspections and tests at appropriate intervals. Duty holders are required to interpret the recorded results and take appropriate actions or to provide relevant information and reports to a more senior person within the organisation. Competence to interpret records and results is achieved by appropriate training and experience.

The Test Operative

In the context of safety testing, the term “competence” refers to a person’s ability to perform the task without danger to themselves or others and to make a valid judgement based on the results, as to whether the unit

under test is safe to use and is likely to remain safe at least until the next scheduled test date.

It will be appreciated that the test person will require certain knowledge and information to enable such valid prospective judgements to be made. In addition the test person will require both the knowledge and the information necessary to make judgements regarding the testing process and its safety and the skill and ability to put such judgements into practice, this producing a safe system of work. Training and experience will both be necessary.

It is suggested that the following criteria are considered:

a. An adequate knowledge and practical experience of electricity and its hazards.
b. A clear understanding of precautions required to avoid danger.
c. The ability to recognise at all times whether it is safe for work to continue.
d. The ability to identify equipment and appliance types to determine the test procedures and frequency of inspection and testing.
e. Adequate understanding of the operating principles of both the test equipment and the unit under test.
f. The ability to create test records and take responsibility for the work.
g. Adequate knowledge of the required safety standards.
h. Adequate knowledge of possible hazards at a "strange" site.

The tester's skill and ability should encompass:

a. Adequate experience of relevant electrical work.
b. Adequate experience of appliance testing and the test equipment.
c. Adequate training where (b) cannot be otherwise satisfied.
d. Experience in the interpretation of results.
e. Practical "technical" experience of the type of equipment being tested.

Suitable sources of information may include:

a. Employer's safety manuals or instructions.
b. Equipment manufacturer's handbooks.
c. British Standards (see Appendix).
d. Health and Safety Executive (HSE) Guidance Notes (see Appendix).
e. IET Code of Practice for In-Service Inspection and Testing of Electrical Equipment.

Managers and Supervisors responsible for testing personnel should adjust their degree of supervision to take into account any inadequacy of the test person. The (EAWR 1989) Reg. 3 places a duty on the self employed to assess their own competence and subsequently to work within their limitations.

5. Types of Equipment

The IET Code of Practice applies to equipment supplied at voltages up to and including 1000V AC or 1500V DC between conductors or 600V AC or 900V DC. between conductors and earth including single, two and three-phase equipment supplied at 400V, 230V and 110V and at extra-low voltage including SELV (Separated Extra-Low Voltage). Several types of electrical equipment are defined in the IET Code of Practice.

Portable Equipment

An appliance of less than 18kg in mass that is intended to be moved whilst in operation or an appliance which can easily be moved whilst in operation or an appliance which can easily be moved from one place to another e.g. vacuum cleaner, toaster, food mixer, etc.

Hand Held Equipment or Appliances

This is portable equipment intended to be held in the hand during normal use e.g. drill, hair dryer.

The risk of damage which may cause the safety of hand held equipment to be compromised can be high. Also, the use of some hand held equipment carries a high risk due to the very nature of its use i.e. the user is in direct contact with the equipment.

Moveable Equipment (Transportable)

This equipment is either:

- 18kg or less in mass and not fixed, e.g electric fire or:
- Equipment with wheels, castors or other means to facilitate movement by the operator as required to perform its intended use e.g. air conditioning unit

Such equipment may be considered “transportable” rather than portable, but will still be connected to its supply where applicable by a flexible cable and plug. The risk of damage which may cause the safety of transportable equipment to be compromised can be high. Also, the use of some transportable equipment carries a high risk due to the very nature of its use (e.g. a high pressure steam/water cleaner) and in such circumstances transportable equipment can present a greater hazard than most portable equipment, therefore the requirement to periodically test must also apply to transportable equipment.

Stationary Equipment or Appliances

This equipment has a mass exceeding 18kg and is not provided with a carrying handle e.g. refrigerator, washing machine

Fixed Equipment/Appliances

This equipment or an appliance which is fastened to a support or otherwise secured in a specific location e.g. bathroom heater, towel rail. Fixed equipment can also be movable or portable equipment, when connected to the fixed installation via a fused connection unit (FCU), for security purposes. This practice is common in areas used by the general public, e.g. hotels, changing rooms etc. Equipment types connected in this way are numerous e.g. kettles, lamps, hair dryers etc

Appliances or Equipment for Building In

This equipment is intended to be installed in a prepared recess such as a cupboard e.g. a built-in cooker.

Information Technology Equipment

This equipment includes electrical business equipment such as computers, mains powered telecommunications equipment and other equipment for general business use e.g. printers, photocopiers, typewriters etc.

Extension Leads and RCD Extension Leads

Extension leads are used where an item of equipment requires connection to a mains supply but a convenient outlet is not available. An RCD extension lead is an extension lead that is fitted with a residual current device.

Multi-way Adaptors and RCD Adaptors

Multi-way adaptors are used where sufficient mains outlets are not available. RCD adaptors are used to provide protection for users of portable equipment, particularly when used outdoors.

6. Classes of Equipment Construction

Before an item of equipment can be tested the construction class must be determined in order to identify the appropriate tests. The equipment to be tested will normally be constructed in one of three basic classes, designated Class I, II or III. Constructional methods are summarised below, full details can be found in BS2754.

Class I equipment is constructed such that protection against electric shock does not rely on basic insulation alone. In addition to basic insulation around live internal parts, exposed conductive parts are connected to the protective conductor in the fixed wiring of the electrical installation. Class I equipment relies upon a connection to the protective conductor to prevent exposed conductive parts becoming live in the event of a failure in the basic insulation.

Class II equipment is constructed such that protection against electric shock does not rely on basic insulation alone. In addition to basic insulation around live internal parts, supplementary insulation is provided, there being no provision for connection of exposed conductive parts to the protective conductor. Such equipment is often described as "double insulated" and should carry the symbol ⧈.

Class III equipment is equipment in which protection against electric shock relies on a supply from a separated extra-low voltage source (SELV). In a SELV supply the voltage is less than 50V rms and no exposed conductive parts are connected to the protective conductor.

Note: Not all double insulated equipment bears the ⧈ mark, however, if the mark is applied the equipment must be double insulated. For the purposes of electrical safety testing, if a piece of equipment does not bear the ⧈ it should be treated as Class I.

7. The Inspection Process

User Check

User checks are performed before equipment is plugged in and switched on. The check involves a visual inspection of the mains plug, mains flex and the appliance for obvious signs of damage or degradation. An assessment should also be made of the suitability of the environment and the purpose for which the equipment is to be used. User checks are an important safety precaution as the user of the equipment is most familiar with its operation. User checks do not need to be recorded unless a problem is discovered, in which case the equipment should be labelled to show it is not to be used and removed from service as soon as possible. The administrator or manager should be notified.

Formal Visual Inspection

In practise, many equipment defects can be found during a formal visual inspection. Many potential hazards arise due to the way in which a piece of equipment is used or abused. For example, portable equipment may be prone to being dropped or a piece of movable equipment with a long,

trailing mains flex may be damaged as the equipment is moved around. Potential hazards such as enclosure damage, damage to the mains flex, signs of overheating, incorrectly fitted mains plugs, incorrect fuses etc. can be identified by a thorough visual examination.

A formal visual inspection carried out by a competent person will make the greatest contribution to minimising risk and eliminating potential safety hazards. Advice on the frequency of formal visual inspections is given in Table G (see page 19).

A formal visual inspection should include an inspection of the following:

1. **Manufacturer's instructions**
   a. The equipment should be installed and used in accordance with the manufacturer's instructions.
   b. The correct voltage, frequency and current requirements should be verified.
   c. Requirements for ventilation or heat dissipation should be met.

2. **Environment**
   a. Suitability of the equipment for the environment or purpose for which it is being used e.g. risk of mechanical damage, exposure to weather, temperature, fluids, corrosives, flammable materials.

3. **Switching of equipment**
   a. The inspector should determine whether there are suitable means of disconnecting the equipment from the mains supply under normal use, to carry out maintenance and in the event of an emergency (if applicable to the equipment).

4. **User feedback**
   a. Where possible the user of the equipment should be consulted as to whether there are any known problems or faults. The user may be aware of intermittent problems that may not be apparent during the inspection.

5. **The equipment enclosure/casing**
   a. Physical damage such as cracks or chemical corrosion. Particular attention should be paid to areas around switches, fuses, protective covers and mains couplers where damage may result in live parts becoming exposed.
   b. Signs of overheating.
   c. Signs of ingress of fluids or foreign bodies.

6. **Mains plugs**
   a. Correct fit in the mains outlet – not loose and can be removed without difficulty.
   b. Cracks or damage.
   c. Signs of overheating.
   d. Properly tightened off terminal screws.
   e. Correct wiring.
   f. Mains flex is properly secured by the cable grip.
   g. Correct fuse rating and type.

7. **Mains cables**
   a. Damage, cuts or fraying. Extension leads should be checked along the entire length.
   b. Joints or connections which are unsafe e.g. taped joints.
   c. Appropriate length.
   d. Correct rating for the equipment.

8. **RCD protected adaptors or extension leads**
   a. Correct operation of the RCD should be confirmed.

Operator accessible fuses on the outside of the equipment should be checked for correct type and rating. If the equipment manufacturer has specified a particular rating for the plug fuse, this should also be checked. If the manufacturer has not specified a fuse rating for the plug the maximum current carrying capacity is detailed in Table H (see page 22) related to the cross-sectional area of the cable conductors. Ensure that properly manufactured cartridge fuses are used and that fuses have not been replaced with a metal bar, wrapped in metallic foil or similar non-standard method.

Note: The requirements of a formal visual inspection will vary according to the equipment being inspected and the environment in which it is used. The 'prompts' built into Seaward Portable Appliance Testers are intended to provide guidance and should not be taken as a comprehensive list of items to be checked during a formal visual inspection.

8. Combined Inspection and Testing Procedure

Safety Considerations

Inspection and testing should only be carried out by a person who is competent to perform the inspection and testing and interpret the results obtained.

Preliminary Inspection

Before inspection and testing is carried out the test operative should obtain a copy of any previous test records if they are available. This will allow an assessment to be made of any degradation of the equipment under test.

Before attempting to carry out any electrical safety tests, the following preliminary inspection should be carried out:

a. Ensure that the equipment can be disconnected from the mains supply and other power sources. If permission is received, disconnect the equipment from the supply.
b. Disconnect the equipment from all other equipment, communication links and telecom lines.
c. Where the equipment under test has the provision to supply mains power to other accessories (for example a monitor powered from PC base station) the mains connection can remain in place during the tests.
d. Ensure that equipment is not in contact with extraneous metalwork such as parts of office furniture.
e. Thoroughly inspect the equipment under test for damage, as described in Formal Visual Inspection.

f. Inspect the mains plug as described in Formal Visual Inspection.
g. Inspect the mains cable as described in Formal Visual Inspection.
h. Assess the suitably of the equipment for the environment.
i. Where possible, consult the user as to whether there are any known problems with the equipment.

Note: Special care should be taken where equipment is powered from an uninterruptible power supply (UPS) or has internal battery backup.

In-Service Tests

The IET "Code of Practice for In-Service Inspection and Testing of Electrical Equipment" recommends a system of periodic inspection and testing, with up-to-date records, as a means of demonstrating compliance with the Electricity at Work Regulations 1989. Most companies and organisations that wish to comply with the requirements of the Electricity at Work Regulations 1989 will carry out in-service tests at intervals determined by risk assessment.

The order in which the tests are performed is important to the safety of the test operative. The testing sequence of Seaward portable appliance testers is designed to contribute towards a safe system of work. The sequence should always be:

1. Earth continuity test
2. Insulation resistance test
3. Protective conductor/touch current test or alternative/substitute leakage test
4. Functional check

An insulation test should always be carried out before attempting any tests which involve applying mains power to the equipment under test as it may detect a dangerous insulation failure.

The recommendations given by the IET Code of Practice for In-Service Testing of Electrical Equipment are as follows:

Class I Appliances

- Earth continuity test
- Insulation resistance test or protective conductor current test or alternative/substitute leakage
- Functional checks

Class II Appliances

- Insulation resistance test or touch current test or alternative/substitute leakage test
- Functional checks

Fixed Equipment or Appliances

Fixed equipment or appliances are more difficult to inspect and test due to their connection to the fixed wiring of an installation. This does not mean that only visual inspections are required for these types of

equipment and they should be subjected to a full combined inspection and test at intervals determined by risk assessment.

Testing fixed equipment or appliances must be carried out by a competent person, in accordance with the specific tests for particular class of equipment. The person carrying out the inspection and testing:

- must be competent to carry out safe isolation procedures,
- must be competent to carry out this more complex arrangement of work,
- must ensure safe systems of work are observed at all times,
- must ensure all inspections and tests, are relevant to the class of equipment.

Where the frequencies of any combined inspection and testing for permanently fixed equipment, determined by risk assessment, are similar to those for the fixed installation, inspection and testing can be undertaken during periodic inspection and testing of the fixed installation. Where equipment could be subjected to higher use or have a greater risk of damage, additional formal inspections may be required.

Appliance Cable Sets

A 3-core appliance cable should be tested as a Class I appliance and the following tests should be made:

- Earth continuity
- Insulation resistance
- Wiring polarity check

A 2-core appliance cable should be tested as a Class II appliance and the following tests should be made:

- Insulation resistance
- Wiring polarity check

Note: Seaward portable appliance testers are equipped with appliance cable tests that automatically perform all of the recommended tests, including wiring polarity.

Extension leads, multi-way adaptors and RCD adaptors

Extension leads and multi-way adaptors are tested as a Class I appliance and the following tests should be performed:

- Earth continuity
- Insulation resistance
- Wiring polarity check

When the extension lead or multi-way adaptor is fitted with an RCD, the RCD must have a rated residual operating current (the current at which the RCD is designed to operate) not exceeding 30mA.

The IET Code of Practice for In-Service Inspection and Testing of Electrical Equipment also recommends that the operation of the RCD should be checked using an RCD test instrument to determine that the trip time is within the limits specified in Table A below:

TABLE A

RCD Type	Maximum tripping time at rated current	Maximum tripping time at 5x rated current
Portable devices to BS 7071	RCD trip time ≤ 200ms	RCD trip time ≤ 40ms
BS EN 61008 **BS EN 61009**	RCD trip time ≤ 300ms	RCD trip time ≤ 40ms

Note: Many Seaward portable appliance testers are equipped with an RCD trip time test for testing the operation of RCDs in accordance with the recommendations of the IET Code of Practice for In-Service Testing of Electrical Equipment.

Testing After Repair

The IET Code of Practice recommends that equipment that has been repaired should be inspected and tested either in accordance with the manufacturer's production tests or in-service tests. The decision is based upon the type of equipment and the nature of the repair.

Class I Appliances

- Earth continuity test
- Insulation resistance test
- Dielectric strength test
- Protective conductor current test
- Functional checks

Class II Appliances

- Insulation resistance test
- Dielectric strength test
- Touch current test
- Functional checks

Testing after repair is performed to ensure that the repair has not compromised the electrical safety of the electrical equipment and this is reflected by the recommended electrical tests. For example, the earth continuity test will demonstrate that all protective earth connections have been replaced when the appliance is reassembled. Similarly, the dielectric strength test is a useful means of ensuring that all insulating materials has been correctly reassembled and that the insulation on live conductors has not been damaged during reassembly, for example, when wires are trapped or damaged by fixing screws.

Testing Hire Equipment

The IET Code of Practice does not cover inspection and testing of equipment or appliances that are used for commercial gain hire purposes. Equipment hire companies should refer to the Hire Association of Europe (HAE) and Event Hire Association (EHA) document, HAEEST2012: 'Guidance on Electrical Safety Testing in the Hire Industry', which gives guidance on in-service inspection and testing for hire equipment prior to its release to customers/clients.

The HAE/EHA Code of Practice recommends that combined inspection and testing should comprise of some or all of the following:

- Visual Inspection
- Earth continuity test
- Insulation resistance or protective conductor/touch current test
- Dielectric strength test
- Load (Run) Test
- Polarity check
- Functional checks

9. Electrical Tests

Earth Continuity

This test is performed on Class I equipment or mains cables and is used to verify the integrity of the connection between the protective conductor and all exposed metal parts intended to be connected to the protective conductor.

The IET Code of Practice for In-service Inspection and Testing of Electrical Equipment recommends either of the following:

A continuity measurement with a short circuit test current within the range 20mA to 200mA.

or

A continuity measurement with a test current not less than 1.5 times the rating of the fuse and no greater than 25A for a period of between 5 and 20 seconds.

Note: Some appliances, for example IT equipment, may have accessible metal parts which are connected to earth for functional or shielding purposes only. If the high current test option above is used, the test current will flow through sensitive components or wiring not intended to provide a protective earth connection. Inappropriate use of a high test current may damage the equipment under test. If in doubt, a low test current should be used.

When testing equipment with a mains cable, the continuity test is made between all accessible earthed metal parts of the equipment and the earth pin of the plug. When testing equipment without a mains cable, the continuity test is made between the earth pin of the mains input socket and all exposed metal parts. The resistance measurement should be observed while flexing the cable and an inspection of the flexible cable terminations at the equipment and the plug or flex outlet should be made. Variations in measured resistance should be investigated.

The measured resistance should not exceed the values given in Table B on the following page.

Note: Nominal values for resistance of the protective conductor of the supply cable are given in Table G (see page 22)

TABLE B

Appliances with a supply cable	(0.1 + R) ohm
Appliances without a supply cable	0.1 ohm
3 core appliance mains cables	(0.1 + R) ohm
Extension leads, multi-way adaptors and RCD adaptors	(0.1 + R) ohm

Note: R is the resistance of the protective conductor of the supply cable

Where possible, it is advisable to test equipment together with its supply cable. If the mains cable is not detachable, no practical alternative exists.

Care should be taken to ensure that test connections to the equipment under test make clean metal-to-metal contact otherwise contact resistance may introduce significant errors.

It is possible for Class I equipment to have conductive metal parts which are not accessible to the operator, accessible metal parts with protection against electric shock being provided by double or reinforced insulation or to have 'unearthed' metal parts which are in casual or fortuitous contact with earthed metal. In this case no earth continuity test is specified.

Insulation Resistance

Insulation resistance is measured by applying a test voltage of 500V DC and measuring the resistance.

When testing a Class I appliance the voltage is applied between both live conductors (phase and neutral) and the protective conductor (earth). When testing a Class II appliance, the test voltage is applied between both live conductors (phase and neutral) and a test probe. The test probe should be applied to any exposed metal parts or any suspect parts of the enclosure where conductive material may have accumulated. Multiple tests may be required.

Modern portable appliance testers produce a test voltage which is current limited. The voltage is not dangerous but could be uncomfortable. Appliances should not be touched during an insulation test.

This test may not be suitable for certain types of appliance. In the case of equipment fitted with mains filters, voltage limiting devices or surge

TABLE C Minimum Acceptable Insulation Resistance Values

Class of Construction	Minimum Insulation Resistance
Class I heating and cooking equipment With a rating ≥ to 3kW	0.3Mohm
All other Class I equipment	1.0Mohm
Class II equipment	2.0Mohm
Class III equipment	0.25Mohm

protection it may not be possible to obtain a satisfactory insulation resistance measurement with a 500V DC test voltage. IT equipment which does not comply with BS EN 60950 may be damaged by the 500V DC test voltage.

An alternative/substitute leakage, an insulation resistance test at a reduced test voltage such as 250V DC or a protective conductor/touch current measurement may be more appropriate.

This test should be performed with the equipment switch ON. Some electronic equipment may contain mains filter circuits connected between live/neutral and earth. Such devices could cause the insulation resistance to be less than specified. The manufacturer/supplier must be consulted in these cases as to the acceptable value of insulation resistance.

Insulation Resistance for Heating and Cooking Appliances

For equipment such as portable cookers the insulation resistance when cold can be very low. Switching on the appliance for a period of time drives out any absorbed moisture, enabling more realistic resistances to be obtained.

Alternative or Substitute Leakage Measurement

Alternative or substitute leakage is measured using a technique similar to that used when measuring insulation resistance. A test voltage is applied between both live conductors (phase and neutral) and the protective conductor (earth) during a Class I test, or, a test probe connected to the equipment enclosure during a Class II test. The resultant current is measured and then scaled to indicate the current that would flow at the nominal supply voltage.

The test voltage is 50Hz AC and normally in the range of 40V to 250V. The test voltage is current limited and so there is no hazard to the test operative. As the test voltage has the same nominal frequency as the mains supply the leakage paths are similar to those found when the equipment is in operation. Similarly, because the test voltage is not greater than the nominal supply voltage of the equipment under test measurements are not affected by transient suppressors, MOVs or other voltage limiting devices.

Portable appliance testers automatically make the necessary connection between the live and neutral conductors and apply the correct scale factor to the measured current. The equipment under test must be switched ON during the test.

Dielectric Strength Test

This test is also known as the “high voltage leakage test”, “high pot test” or “flash test” and is a ‘type approval test’ or ‘production test’.

Test voltages of 1500V AC and 3000V AC are available on selected Seaward testers that include this test.

The 1500V AC is applied at the mains plug of the appliance under test, between the protective earth conductor and the live/neutral conductors connected together. The 3000 V AC test is applied between the live/neutral conductors connected together at the mains plug and a high voltage test probe applied to the enclosure of the appliance under test. No other connection is necessary.

EN 60335 "Safety of household and similar electrical appliances" allows a high voltage leakage current of 0.75mA/kW with an overall maximum of 5mA. As Seaward testers are intended to test equipment with a maximum power consumption of approximately 3kVA the pass level defaults to 3mA. Equipment to BS2769 "Hand held electric motor operated tools" requires a 'flash' test voltage of 1.5kV and the maximum permitted leakage is 0.75mA. The test should be conducted with the unit under test switched ON.

Table D defines the test voltages for a range of appliances.

Warning: During flash testing, close proximity to the high level of charge present could cause damage to certain types of electronic equipment which incorporates semi-conductor devices. The advice of the equipment manufacturer should always be sought before testing when such conditions are suspected.

The IET Code of Practice does not recommend the use of the dielectric test as an in-service test but does state that it may be appropriate after a repair in accordance with the manufacturer's production or in-service tests, depending on the equipment and the nature of the repair.

The Hire Association Europe (HAE) and Event Hire Association (EHA) Guidance on Electrical Safety Testing in the Hire Industry includes recommendations and guidance on the use of dielectric strength testing.

Preload Check

Seaward portable appliance testers automatically perform a pre-check before tests which involves applying mains power to the equipment under test. This is included to protect the test person from potential hazards produced by a very low impedance or short circuit being present between

Table D Dielectric Strength Test Voltages

Standard	Basic Insulation	Supplementary Insulation	Reinforced Insulation
EN 60335 Safety of Household Electrical Appliances	1000V	2500V	2500V
EN 60065 Audio, Video and Similar Electronic Apparatus – Safety Requirements	1500V	2500V	2500V
EN 60950 Safety of Information Technology Equipment, Including Electrical Business Equipment	1500V	1500V	3000V

LIVE and NEUTRAL. The test should be conducted with the equipment switched ON.

Load Test

A load test is not a 'required' safety test, however it can provide useful information regarding the operation of the equipment under test. The portable appliance tester will apply the supply voltage to the equipment under test and measure the power consumption in kVA or load current in amperes.

The test is included since a higher power than expected from the specification may indicate reduced functional efficiency. A significant change from a previously recorded figure may provide an early warning of bearing failure in an electrical machine or shorted turns within a transformer, both conditions indicating the need for maintenance. Abnormally low power could be the indication of an open circuit, ruptured fuse or other form of fault.

Protective Conductor/Touch Current Measurement

The protective conductor/touch current is measured from live parts to protective earth for Class I equipment, or from live parts to accessible metal parts of the enclosure on Class II equipment under normal operating conditions. This test is an alternative to the insulation test where the insulation test is inappropriate. This test will provide evidence of possible deterioration of certain components under load and may indicate that the method of connection of the equipment to the supply is inappropriate.

Table E defines the limits for protective conductor or touch current.

Note: Should the equipment contain a mains interference suppression capacitor or filter, some residual leakage will be measured; this will not necessarily indicate a fault condition.

Warning: Special care should be taken during tests where the equipment under test is energised. Portable tools and rotating machines etc. should be rendered safe before the complete test sequence begins. All such machines should therefore be physically secure and have their cutting, grinding, drilling bits etc. removed where possible; where guards are provided they should be in place.

Table E Protective Conductor/Touch Current Limits

Class of Construction	Maximum Permissible Current
Portable or hand-held Class I equipment	0.75mA
Class I Heating appliances	0.75mA or 0.75mA per kW, whichever is greater, with a maximum of 5mA
Other Class I equipment	3.5mA
Class II equipment	0.25mA
Class III equipment	0.5mA

10. Frequency of inspection based on risk assessment

Guidance on the frequency of testing and/or inspection is provided in the IET Code of Practice and in HSE Guidance Notes such as 'Maintaining Portable Electrical Equipment in Low-risk Environments'. The duty holder should determine the appropriate interval between inspection and testing based on robust risk assessment.

Risk Assessment

Any risk based assessments are the responsibility of the duty holder however a duty holder may enlist the services of a competent person to assist in this process. Risk assessments should be reviewed regularly to ensure that any control measures are effective and that there are no changes which may alter the level of risk. If there are any significant changes, the risk assessment should be updated.

When assessing risk, the following factors should be considered:

1. The environment
2. The users
3. The equipment class of construction
4. The equipment type
5. The frequency of use
6. Type of installation methods
7. Previous records

Guidance on the initial frequency of suggested inspection and test periods is given in the IET Code of Practice for In-Service Inspection and Testing of Electrical Equipment, and can also be found in the HSE publications HSG107 Maintaining Portable Electrical Equipment and INDG236 Maintaining Portable Electric Equipment in Low-Risk Environments.

The table overleaf appears in the HSE Guidance Note HSG107 'Maintaining Portable Electrical Equipment' and provides suggested initial maintenance intervals.

Table F: Suggested Initial Maintenance Intervals

Maintaining portable electrical equipment HSG107 (3rd. edition) HSE 2013

Type of business		User checks	Formal visual inspection	Combined inspection and test
Equipment hire		N/A	Before issue/after return	Before issue
Battery operated equipment (less than 40 V)		No	No	No
Extra low voltage (less than 50 V ac), telephone equipment, low-voltage desk lights		No	No	No
Construction	110V equipment	Yes. weekly	Yes, monthly	Yes, before first use on site then 3-monthly
	230V equipment	Yes, daily/every shift	Yes, weekly	Yes, before first use on site then monthly
	Fixed RCDs	Yes, daily/every shift	Yes, weekly	Yes, before first use on site then 3-monthly (portable RCDs monthly)
	Equipment site offices	Yes, monthly	Yes, 6 monthly	Yes, before first use on site then yearly
Heavy industrial/high risk of equipment damage (not construction)		Yes, daily	Yes, weekly	Yes, 6-12 months
Light industrial		Yes	Yes, before initial use then 6-monthly	Yes, 6-12 months
Office information technology rarely moved, eg desktop computers, photocopiers, fax machines		No	Yes, 2-4 year	No if double insulated, otherwise up to 5 years
Double insulated ⧈ (Class II) equipment moved occasionally (not hand-held), eg fans, table lamps		No	2-4 years	No
Hand-held, double insulated ⧈ (Class II) equipment, eg some floor cleaners, some kitchen equipment		Yes	Yes, 6 months - 1 year	No
Earthed (Class I) equipment, eg electric kettles, some floor cleaners		Yes	Yes, 6 months - 1 year	Yes, 1-2 years
Cables, leads and plugs connected to Class I equipment, extension leads and battery charging equipment		Yes	Yes, 6 months - 4 years depending on type of equipment it is connected to	Yes, 1 - 5 years depending on the equipment it is connected to

Note: Cables, leads and plugs connected to Class II equipment should be maintained as part of that equipment. Cables leads and plugs not dedicated to an item of equipment should be maintained as individual items as appropriate. Over time, when you look at the results of user checks, formal visual inspections and portable appliance tests you will notice trends. These may tell you that you need to look at or test electrical equipment more or less often, depending on the number of problems being found. If electrical equipment is grouped together for testing at the same time, you should use the shortest testing interval in the group rather than the longest. Alternatively, it may be appropriate to group your electrical equipment by testing interval. The IET Code of Practice has a similar table but with the information presented in a slightly different manner. In some instances with more detail and specifics, however, the two sets of information are considered to be consistent with each other.

11. Record Keeping

Although there is no legal requirement to keep records of inspection and testing, the HSE Memorandum of Guidance on the Electricity at Work Regulations 1989 advises that records of maintenance including tests should be kept throughout the working life of the equipment.

In any proceedings for an offence consisting of a contravention of the EAWR 1989 Rep 4 (4).5 and 8 to 16 inclusive (i.e. those Regulations requiring "absolute" compliance); Regulation 29 states that it shall be a defence for any person to prove that they took all reasonable steps and exercised all due diligence to avoid the commission of that offence.

The most effective method for the duty holder to prove that he "exercised all due diligence" etc., is to produce proper records of the measures taken to prevent the accident. Hence full and accurate records made at the time of testing become essential, and the managed system designed to achieve this must be in place before the accident.

Step By Step Approach

A step-by-step approach would include the following:

a. Conduct a survey to identify all portable and transportable appliances which exist with the duty holder's control.
b. Each appliance should be marked with a unique identification code, cross referencing test results and inspection details.
c. A register of all equipment should then be created to include the following details:
    1. Identification number
    2. Location in which the equipment is kept
    3. A description of the appliance
    4. Serial number
    5. Periods between tests
    6. Any other details.

Due to the large number of appliances and the details that must be recorded a computer database is likely to be the most effective and efficient method of data collection and storage.

A comprehensive software package, such as Seaward's PATGuard, will enable the user to set up a detailed database of all items at any particular location easily.

By recording the information outlined in (c) above working documents can be produced which are a useful aid to proficiency and safety. For example a work schedule can be generated grouping products by test date, task sheets can be printed providing the person conducting the tests with a list of all items due for testing, together with their location, identification number etc.

Use of Advanced Portable Appliance Testers

Where advanced portable appliance testers are used, data can be transferred directly from the instrument to the database providing automatic creation or update of records.

In such situations reports of untested appliances and those which failed the tests can be produced and submitted to the duty holder for the appropriate action to be taken, this insures the investigation is thorough and avoids oversight.

Action on Completion of Tests

Any equipment found unsafe must immediately be removed from use, labelled with its fault and transferred to the repair facility and the appropriate person informed.

Although there is no requirement in the Electricity at Work Regulations 1989 to label equipment, the duty holder may find it useful to label equipment with the information shown below to indicate that it has been tested:

a. Unique identifier or asset ID
b. Current safety status e.g. PASS or FAIL
c. The date tested
d. The identity of the test person

Such information will enable the duty holder to manage this aspect of the overall safety of the area with his control. The IET Code of Practice 4th Edition recommends that the date for re-testing should not be marked on the label.

A convenient method of labelling equipment may incorporate a barcode. Seaward have a range of instruments which can be used with a barcode reader and collect appliance number and test codes without the need for manual data input. A full range of labels and data collection accessories are available from Seaward.

Data Transfer Between Test Instrument and PC

Advanced Seaward PAT Testers contain output ports which allow the tester to be connected to a PC running PATGuard software. Selected appliances from various locations can have their test data sent directly to the PAT (this is called upload) which after disconnection from the PC may then be taken to the location where the appliances are to be tested.

Simply by inputting the appliance number, the PAT will search the upload memory in an attempt to identify that particular appliance. If the appliance is identified the pre-determined sequence of tests will be suggested to the user. If this is accepted, the instrument will then automatically conduct the tests and record the results.

The advantage of this approach is that it helps avoid uncertainty as to which tests should be conducted on a particular appliance.

Table G Supply Lead Resistance

Nominal resistance of appliance supply cable protective conductors (cables to BS6500).

Nominal conductor c.s.a. mm^2	Nominal conductor Resistance At 20°C mΩ/metre	Length metres	Resistance at 20°C mΩ	Max current carrying capacity A	Max. diameter of individual wire in conductor mm	Approx. No of wires in conductor
0.75	26	1.0 1.5 2.0 2.5 3.0 4.0 5.0	26 39 52 65 78 104 130	6	0.21	24
1	19.5	1.0 1.5 2.0 2.5 3.0 4.0 5.0	19.5 29.3 39.0 48.8 58.5 78.0 97.5	10	0.21	32
1.25	15.6	1.0 1.5 2.0 2.5 3.0 4.0 5.0	15.6 23.4 31.2 39.0 46.8 62.4 78.0	13	0.21	24
1.5	13.3	1.0 1.5 2.0 2.5 3.0 4.0 5.0	13.3 20.0 26.6 33.3 39.9 53.2 66.5	15	0.26	30
2.5	8	1.0 1.5 2.0 2.5 3.0 4.0 5.0	8 12 16 20 24 32 40	20	0.26	50

The above table gives figures for the nominal resistance of the protective conductor per metre length and for various lengths of cable that may be fitted as supply leads to appliances. Once an earth bond test has been performed the approximate resistance of the protective conductor can be found and deducted from the test results to give a more realistic figure for the resistance of the earth bonding of the appliance.

Appendix

HSE Guidance Notes

HSG13 Electrical Testing

HSG107 Maintaining Portable Electrical Equipment

HSR18 Administrative guidance on the application of the EC 'Low Voltage Directive'

HSR25 Memorandum of guidance on the Electricity at Work Regulations 1989

PM29 Electrical hazards from steam/water pressure cleaners

PM32 The safe use of portable electrical apparatus

PM38 Selection and use of portable electric handlamps

GS27 Protection against electric shock

GS37 Flexible leads, plugs and sockets.

Codes of Practice

IET Code of Practice for In-service Inspection and Testing of Electrical Equipment 4th Edition	ISBN 978-1-84919-626-0
Hire Association of Europe (HAE) and Event Hire Association (EHA) document, 'Guidance on Electrical Safety Testing in the Hire Industry'	HAEEST2012

Legislation

The Health and Safety at Work etc. Act 1974	ISBN 0 10 5437743
The Electricity at Work Regulations 1989 (S.I.1989 No 635)	ISBN 0 11 096635X
The Plugs and Sockets etc. (Safety) Regulations 1987 (S.I.1987 No.603)	ISBN 0 11 076603

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