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PAT testing guide

(4th Edition)

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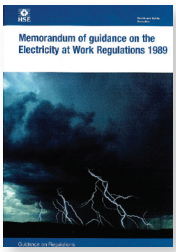
What is portable appliance testing?

Portable Appliance Testing is the visual examination and electrical testing of portable electrical equipment used in industrial, commercial or public access areas and locations (including rented property) to ensure they are safe to use, and cannot present an electrical hazard to the operator or anyone in their vicinity.

Why should electrical equipment and appliances be maintained?

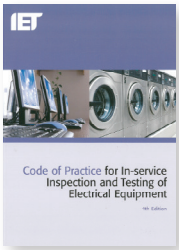
Testing portable appliances is a method of ensuring that employers and those with Public Liability Insurance comply with the mandatory requirements of the **Health and Safety at Work Act** and the **Electricity at Work Regulations**. Those documents themselves do not specifically dictate that Portable Appliance Testing must be carried out, but they do state that all electrical systems (which include appliances) must be maintained to prevent injury and danger.



Furthermore, **The Provision and Use of Work Equipment Regulations 1998 (PUWER 98),** made under the HSW 1974 act, states:
"the provision and maintenance of a working environment for his employees that is, so far as reasonably practicable, safe, without risks to health, and adequate as regards facilities and arrangements for their welfare at work".

Regulation 4(1) of PUWER 98 has a more direct meaning to portable appliances, it states:
"*Every employer shall ensure that work equipment is so constructed or adapted as to be suitable for the purpose for which it is used or provided."*

Therefore the liability is with the employer or owner of a place of work, or public place, to ensure that all electrical equipment accessible by employees or the public is maintained in a safe condition, and an acceptable method of ensuring this is by routine visual examination, electrical testing and documentation.



Detailed information on all the definitions and full requirements of Portable Appliance Testing can be found in the **Code of Practice for In-Service Inspection and Testing of Electrical Equipment (4th Edition) (ISBN 978-1-84919-626-0) (hereafter referred to as "the Code of Practice")** available from the Institution of Engineering and Technology (www.theiet.org). Where there is any doubt, the Code of Practice holds the definitive guidance.

Those environments where these regulations are applicable include any place where someone is employed, areas of public access, and rented accommodation of all kinds.

The Code of Practice for In-Service Inspection and Testing of Electrical Equipment identifies that regular visual examination and electrical testing of equipment is an essential part of any preventative maintenance programme. Records of maintenance, including test results, should be kept throughout the working life of the equipment to enable the condition of the electrical equipment to be regularly monitored.

What inspection and testing needs to be done?

The dangers of contact with live electrical parts need no explanation to an electrician. However, the environments in which the majority of portable appliances are used are not necessarily where

operators would be aware of the dangers or the implications of damage to equipment. The point of routine visual inspection and electrical testing is to identify potential hazards and actual dangers before they turn into an accident.

The hazards required to be identified include:

- Personal exposure to live conductors – *electrocution*
- High resistance faults causing excessive heat – *fire*
- Intermittent connection – *arcing causing heat and potential ignition*

These hazards will be identified by performing in-service visual examination and electrical testing by:

- Regular operator checks
- Visual examination
- Combined visual examination and electrical tests.

Who has responsibilities to ensure that equipment continues to be safe?

Various people have responsibilities for electrical equipment, these being:

Property owners, equipment owners, company owners, directors, and line managers etc.

The person undertaking the formal visual examination and electrical testing

Maintenance managers

Operators of the equipment – to ensure the equipment they use has no obvious faults or damage

The Duty Holder

The Duty Holder is usually, but not exclusively, a manager or supervisor. They must understand their responsibilities as defined in the "Electricity at Work Act 1989" and are responsible for ensuring the safe condition of the equipment for which they have jurisdiction.

The Duty Holder may wish to maintain adequate records for the inspection and testing of the electrical equipment as well as implement the necessary risk assessments to establish:

Suitable frequencies of inspection and testing

Repair of faulty equipment

Interpretation of the results

Where necessary, appropriate training may be required to competently fulfil these responsibilities.

Who can do the testing?

The Code of Practice states that inspection and testing can be carried out by any competent person. The "Competent Person" is defined within the Code of Practice (Code of Practice...2012 4th Edition; IEE; p25) as:

> *"A person possessing sufficient technical knowledge or experience to be capable of ensuring that injury is prevented".*
>
> *"Technical knowledge or experience may include: adequate knowledge of electricity; adequate experience of electrical work; adequate understanding of the system to be worked on and practical experience of that Class of system; understanding the hazards*

that may arise during the work and the precautions that need to be taken; or the ability to recognise at all times whether it is safe for work to continue."

Basically this explains that no formal qualifications are necessary to perform visual examination and electrical testing, but the operator must have the competencies above. These can be achieved by experience in working on electrical systems, or by any form of training including self-taught from technical publications.

As the person doing the testing, you must have an understanding of the types of electrical, mechanical and thermal damage of electrical equipment which may be encountered in any environment.

What types of electrical equipment need visual examination and electrical testing?

Everything portable or transportable, whether fitted with a plug for connection to a socket-outlet or connected directly to a fused spur. Such items can be identified as follows:

Multiway adaptors and RCD adaptors – Multiway adaptors are used to increase the number of connection points at any location within a property. The use of these adaptors should be avoided wherever possible, and a suitable judgement made during the visual examination as to how appropriate their use is in any specific application.

Extension leads and RCD protected extension leads – An extension lead is used where an item of equipment needs to be supplied but a convenient socket-outlet is not nearby. Preferably, the use of extension leads should also be avoided whenever possible. They can present physical hazards such as tripping that could be avoided if an installation has sockets in the appropriate place. An RCD extension lead is an extension lead that includes RCD protection either at the plug or near the sockets, for powering equipment used out-doors.

Hand-held equipment – These appliances require the operator to hold them in their hand(s) during normal operation (e.g. steam-irons, hair dryers, soldering irons and drills).

Portable appliances – These appliances are ones that can be easily moved while they are energised and have a mass of less than 18 kg. Equipment included in this category are items such as kettles and electric radiators.

IT equipment – This category covers Information Technology business equipment that is found in most commercial offices (e.g. mains-powered computers, telephones, printers, photocopiers, fax machines, laminators, shredders etc.).

Transportable equipment (sometimes called moveable) – This category covers equipment that is:

- Not fixed to the location and less than 18 kg, (e.g. a small television)
- Equipment with wheels or castors which is intended to be moved on an occasional basis (e.g. commercial kitchen or laundry equipment)

Static equipment – This equipment has a mass that exceeds 18 kg and is not provided with a carrying handle (e.g. large televisions, washing machines and refrigerators).

Fixed appliances – This equipment is securely fixed in one location. Typical appliances in this category are hot water boilers, hand dryers and some luminaries.

Built-in equipment – This equipment is intended to be built-in to a cupboard or similar where some electrical protection is provided by the location. Typically this equipment does not have an enclosure on all sides because that side is inaccessible when the equipment is in use (e.g. a built-in oven).

Construction of electrical equipment

The type of asset is classified depending on the way it is designed and made, these being Class I, Class II or Class III. The class of construction determines what electrical tests need to be carried out.

Class I equipment - Equipment that does not rely solely on insulating materials to protect against electric shock, but which includes the connection of exposed metal parts to the supply earth via the conductor in the supply cable, (sometimes referred to as CPC) in the fixed wiring of the installation. Class I items can be identified by the presence of an earth conductor in the supply cable. Some exposed metalwork may be bonded to earth, and some may be only in casual contact with earth. This casual contact may give an unexpectedly high bond-resistance when tested, and should not be confused with a poor connection which would fail.

Class II equipment – This equipment has extra layers of insulation to provide additional barriers between the operator and any hazardous voltages, and does not rely on just one layer of insulating material to protect against electric shock. There is no provision for connecting any exposed or internal conductive parts to the system earth.

Class II equipment can be identified by the Class II construction mark located in a prominent position on the asset. There is no earth conductor in the supply cable for Class II equipment

Class III equipment – This equipment provides protection by supplying the equipment from a separated extra-low voltage source (SELV), such as a safety isolating transformer. Typically this would include 12 V or 24 V lighting, 110 V shavers etc.

The Class III equipment can be identified by the Class III construction mark.

The safety isolating transformer should have the identification mark shown.

What checks and visual testing should be undertaken?

Visual examination is vital and always precedes electrical testing. It often reveals major defects that would not be revealed by testing alone. Categories of in-service visual examination and electrical testing are divided into three types:

- Operator checks (no records if equipment is ok)
- Formal visual examination (recorded)
- Combined visual examination and electrical testing (recorded)

How often should visual examination and electrical testing be undertaken?

The frequency of visual examinations and electrical tests are established by risk based assessment. No strict test schedules exist, although guidance is provided by the HSE documents HSG 107, and the IET suggested initial retest frequency table, a summary of which is provided below. A simple risk based assessment will identify the suitability of an asset for the application and environment in which it is being used and whether a change to the suggested retest frequency, or even removal

of the equipment altogether, is appropriate. Criteria that may influence the decision include the following:

Location of the equipment: Equipment installed on a construction site is more likely to suffer physical damage (and so degrade more quickly) than if installed in an office, and so will require frequent testing. Those types that are handheld and moved more than others can lead to rough handling, which often results in damage and early life failure. For example the continual flexing of a steam-iron cable will subject it to more risk of early failure than that of a microwave oven, however both are designed as Class I equipment.

The equipment type or class of construction: The safety of Class II equipment does not rely on the supply earth, but on its own construction. Therefore if Class II equipment is situated in a low risk environment such as an office, electrical testing (not visual examination for cable or casing damage) may be reduced in frequency. Class I equipment however relies on a low resistance path to the supply earthing system for safety protection. If the earth conductor within the power cable is damaged, the hazard rises, and will therefore require electrical testing on a more regular basis.

The skill of the user: If the equipment users are observant, aware and responsibly report faults/ damage as it occurs, hazards are more likely to be avoided and test frequency reduced.

The frequency of use: If the equipment is likely to receive constant unreported abuse, more frequent testing will be required.

How the equipment is installed: If the equipment is hard wired to a circuit and fixed to a wall (a hand dryer in a washroom) it is most likely going to be far less likely to suffer damage than a hand held hair dryer in the same location.

Availability of previous results Access to previous test results and the competency to interpret them allows the Duty holder to review the current test frequency and possibly make changes based on both the history and foreseeable use.

Whether the equipment is on hire Hire equipment of a duration exceeding one week should be considered for inclusion on a testing schedule. Discussion should be held with the hire company to identify a course of action.

All the factors used in the risk assessment should result in an informed decision as to the appropriate intervals for inspection and testing.

The following table is a guide to the initial testing frequency, but is only a guide and has no legal foundation. The risk assessment results should be used in conjunction with this table and/or the advice published by the HSE.

Product failure and reported issues should be carefully recorded and a review of the test and inspection frequency review as necessary.

This table provides guidance on initial frequencies of visual examination and electrical testing. However, this is only a guide and experience will lead the tester to determine correct frequencies.

Note: Equipment provided in hotel room is equipment used by the public. Equipment in hotels is considered to be equipment used by the hotel staff.
Hired equipment, in use for periods in excess of 1 week, should be included on an equipment register and a risk assessment carried out to determine the future frequency of inspections and testing, unless the equipment is covered by a suppliers lease and maintenance contract, providing the maintenance contract is robust and satisfactory.

It is the duty holders responsibility to determine re-test periods.
This table provides guidance on initial frequencies of visual examination and electrical testing. However, this is only a guide and experience will lead the tester to determine correct frequencies.
The duty holder should seek professional guidance if he/she is unsure on any aspect.

Guide to Frequency of testing	Location											
	Offices		Industrial		Construction		Hotels		Schools		Public access	
IT & Stationary Equipment	V	C	V	C	V	C	V	C	V	C	V	C
Class I	24 months	60 months	None	24 months	1 month	3 months	24 months	60 months	None	12 months	1 month	12 months
Class II	24 months	None	None	24 months	1 month	3 months	24 months	None	12 months	48 months	12 months	24 months
Moveable												
Class I	12 months	24 months	6 months	12 months	1 month	3 months	12 months	24 months	6 months	12 months	weekly	6 months
Class II	24 months	None	6 months	24 months	1 month	3 months	24 months	None	12 months	48 months	6 months	12 months
Portable												
Class I	12 months	24 months	6 months	12 months	1 month	3 months	12 months	24 months	6 months	12 months	weekly	6 months
Class II	24 months	None	6 months	12 months	1 month	3 months	24 months	None	12 months	48 months	6 months	12 months
Handheld												
Class I	12 months	24 months	6 months	12 months	1 month	3 months	12 months	24 months	6 months	12 months	weekly	6 months
Class II	12 months	None	6 months	12 months	1 month	3 months	12 months	None	12 months	48 months	6 months	12 months
Fixed												
Class I	24 months	48 months	12 months	24 months	1 month	3 months	24 months	48 months	12 months	36 months	12 months	36 months
Class II	24 months	None	12 months	48 months	1 month	3 months	24 months	None	12 months	48 months	12 months	36 months

Table 1 Guide to initial frequency of visual examination and electrical test

As previously stated table 1 is an initial guide. The frequency of visual examinations and electrical tests must be regularly reviewed. Particular attention must be paid to these initial inspections and electrical tests to determine whether the frequency or equipment type needs to be changed.

Key:

V - Formal Visual Inspection
C - Combined Visual Inspection and Electrical test
None - Not required

What are the procedures for in–service visual examination and electrical testing?

Operator Checks

All users of equipment must understand how important operator checks are. The Electricity at Work Regulations requires that employees' work safely with electrical equipment. Employers have a duty to give all employees adequate training to meet that need. Some equipment and environments may demand special needs but generally the following list is a typical checklist that operators should be using:

- Check the overall condition of the equipment for cracks/damage
- Check the supply cable, checking for cuts, abrasions, cracks, etc.
- Look for signs of overheating
- Check it has a valid label indicating it has been formally inspected and tested
- Check the item is suitable for the environment
- Check the plug and make sure the cable is securely gripped and there is no mechanical damage
- Also check the socket outlet to make sure there are no signs of damage or overheating
- Check that the appliance is working correctly and as expected.
- If the operator is not happy with any of the above then he/she must take the following action:
- Switch off and disconnect from the supply
- Clearly label to identify that it must not be used
- Report to the appropriate responsible person

Note: Once equipment has been reported faulty, the responsible person will have to make a judgment as to whether the equipment is suitable for both its use and the environment it is in. More frequent inspection and testing is not the solution to unsuitable equipment.

The formal visual inspection

This type of inspection should only be carried out by a competent person. The results of the formal visual examination should be documented on a suitable form such as can be found in Megger PowerSuite software.

There are a number of considerations when carrying out formal recorded visual examination of equipment:

The surroundings

The working environment plays a major part in the selection of appropriate equipment.

Selecting the wrong equipment for its surroundings can have a detrimental effect on its life. For example, special consideration should be given to equipment for use where it will be exposed to: the weather and natural hazards, extreme temperatures, high or low pressure, wet, dirty or corrosive conditions, solvents, mechanical or physical damage, flammable substances.

Good housekeeping

This covers several areas, but most of it is logical common sense. The following is a guide to what should be checked:

- Adequate space around the equipment for ventilation/cooling
- Easily accessible means of disconnection/isolation from the supply
- The equipment is operated with all protective covers located correctly and any interlocks operational
- There are no unprotected cable runs under carpets
- Minimum use of extension leads and multiway adaptors
- Cables are not located where they are likely to be damaged or create trip hazards
- Drinks, plants and work materials are not placed where they could spill into equipment.

Equipment suitability

If you consider the equipment that is being tested/inspected is unsuitable for either the environment or the purpose it is being used for, this fact should be recorded on the documentation and brought to the attention of the duty holder.

Disconnection/isolation of equipment

Operators must be able to easily isolate/disconnect equipment from the supply, i.e. in normal circumstances operators must be able to reach the plug/socket without difficulty. Isolation is simplest when the equipment is connected via a plug and socket. Not all equipment will be connected in this way and isolation may be achieved via a main switch or removal of a fuse. Caution must be exercised when inspecting equipment without the usual plug/socket arrangement.

When inspecting business, I.T. and telecommunications equipment, permission from the equipment operator should be gained before disconnecting from the supply. Failure to do this could result in serious loss of business data. It should also be noted that business equipment might need to be powered down in the correct manor before isolation. Equipment supplied by an uninterruptible power supply (UPS) must be isolated from its standby source before any electrical testing begins. This is best performed by the system owner if there is any doubt as to the correct procedure.

Equipment condition

Before beginning any equipment inspection, if possible operators should be asked if they are aware of any faults and whether the equipment is functioning as expected. The formal visual examination should involve similar checks to those undertaken by the operator. The following items need to be inspected:

The power cable

- Is it in good condition?
- Is it free from physical damage, wear and tear?
- Is it in a position where it could be damaged (by chair castors or desk-legs etc)?
- Is it a suitable length?
- Does it have adequate strain-relief and is the insulation sheath clamped sufficiently at the terminations?
- The cable-outlet or wall-socket

- Is it free from cracks or damage?
- Are there any signs of overheating?

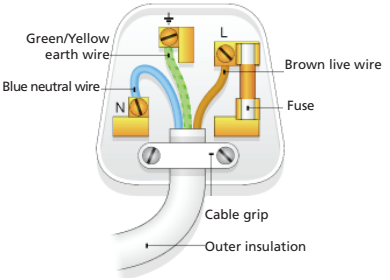
The asset

- Does it switch on and off correctly?
- Is it free from cracks and damage that could cause a hazard?
- Can it be used safely?
- Does it work?

The standard plug

The diagram shows the wiring of a standard 13 A plug.

Some of the following checks may not be possible if a non-rewirable (moulded-on) plug is used:



- Does the Class I power cable incorporate a continuous protective conductor (Earth)?
- Are there signs of overheating (this could be caused by a faulty or loose connection in the plug or the socket outlet)?
- Is the cable firmly fixed in its clamp? On a non-rewirable type the cable grip can be tested by firmly pulling and twisting the cable. No movement should be apparent
- Are the cable core terminations tight and the plug correctly wired?
- Is the fuse secure with no signs of overheating?
- The fuse should be BS 1362 approved. Also check the rating; it is usual that an appliance up to 700 W should have a 3A fuse (coloured red). Appliances larger than 700 W should have a 13 A fuse (coloured brown). Some IT equipment may have a 5 A fuse fitted however this is less common.

Environment and use

- Is the equipment suitable for the environment in which it is being used?
- Is the equipment being used for the correct purpose?
- Is the user is satisfied with the equipment?

Combined visual examination and electrical testing

Formal visual examinations will, if carried out correctly, reveal most (but not all) potentially dangerous faults. However, some internal deterioration of the cable, its terminals and the equipment itself can be expected after significant use. Additionally, equipment may be mis-used or abused to the extent that it may give rise to danger. Electrical testing, together with a thorough visual examination can detect faults such as loss of earth integrity, eg broken earth (CPC - circuit protective conductor) within a flexible cable, or deterioration of insulation integrity or contamination of internal and external surfaces. Failure of insulation could result in the operator receiving an electric shock with potentially fatal results.

Initial examination

This activity is a vital part of the testing process, and many faults are found at this stage. The nature of these faults is such that they will not always be found with electrical testing alone. The procedure for initial examination is as follows:

- Obtain permission from the responsible person and disconnect any business equipment communications leads. Do not test business equipment that is still connected to communications links as it may damage other remote equipment. Care should be taken when handling fibre optic links as they may be 'live' from remote equipment and cause retina damage. Fit dust caps to disconnected fibre links.
- Identify if the equipment can be powered down and isolated from the supply. If permission cannot be obtained then electrical tests cannot be performed. If it cannot be disconnected, perform as much visual examination as is possible without compromising your safety or the operation of the equipment. Record any defects and that the equipment has not been electrically tested, and label it as such.
- Thoroughly examine the asset for any signs of damage as during a visual examination, including the power cable, plug and wall-connection (socket or flex outlet)
- Judge the suitability of the appliance for the application and surroundings

Note: Standard new 13 A plugs (moulded-on or re-wirable) must conform to BS1363, which requires pins to be sleeved. This legislation only applies to new plugs, not old plugs already in use. However, it would be worth noting on the visual examination notes that the plug has un-sleeved pins.

Test procedures

Megger portable appliance testers are designed to test standard equipment that is supplied by plug and socket connection. This is done simply by unplugging the equipment and plugging it into a Megger portable appliance tester.

An insulation and continuity tester can test equipment that is permanently connected to a flex outlet with the test leads connected directly to the accessory terminals. However, to carry out this method the tester would need additional relevant competencies. An alternative method is to temporarily connect the asset to a 13 A plug and test conventionally using the portable appliance tester.

Electrical tests

Before any in-service electrical testing can be carried out, a preliminary inspection should have been performed. The electrical testing then consists of the following in this specific order:

- Earth continuity or bond tests
- Insulation resistance testing (if a 500 V insulation test is not appropriate, this can be replaced by a touch-current or alternative leakage-current test)
- Functional checks

Some test equipment is capable of performing tests that in certain circumstances could damage the appliance they are used on. Flash testing (also known as Hi-pot or dielectric strength testing) is one such test and is only normally carried out by manufacturers or when an appliance has had a deep overhaul.

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Earth bond test

Earth continuity tests only apply to Class I equipment. The purpose of the test is to ensure that the earth terminal has a low resistance connection to the conductive metal casing of the appliance by electrical bonding. This is because the appliance requires an effective connection to the system earth within the fixed installation of the premises to ensure safety.

There are two methods available and different circumstances will require each method:

- **Low current continuity test** A continuity measurement should be made using a short circuit test current of 20 to 200 mA between exposed conductive parts of the equipment and the earth pin of the plug (or earth-terminal of the supply). This is performed using the earth bond lead. The maximum value of resistance should be noted while flexing the asset supply cable and a visual examination of the power cable terminations at both ends should be made. Any fluctuation in the reading should be investigated to identify the cause. This low-current test is sometimes referred to as a 'Soft Test'
- **High current bond test** A continuity measurement using a test current of at least 1.5 times the fuse rating of the equipment to a maximum of 26 A (max 26 A) for between 5 to 20 seconds. The bond test should be connected between exposed earthed conductive parts of the equipment and the earth pin of the plug (or earth-terminal of the supply). This is done by connecting the earth bond lead to the exposed metalwork. The maximum value of resistance should be noted while flexing the asset supply cable and a visual examination of the power cable terminations at both ends should be made. Any fluctuation in the reading should be investigated to identify the cause.

Care should be taken when measuring earth bond on appliances where the design of construction includes exposed metalwork having a casual contact to earth. This metalwork is primarily protected by double or reinforced insulation, and the earth connection is only classed as 'fortuitous'. Under these circumstances, the resistance value is unlikely to be as low as truly bonded metalwork. A bond test performed on this unbonded metalwork may give unexpected or misleading results. Examples of this construction may include the sole-plate of a steam-iron or the metal chassis of a kettle. Additionally, a high-current bond test using up to 26 A may, in some circumstances, damage casual-contact components and a low-current test should be performed first to identify potential issues.

To pass the Earth Bond test, the measured value should not exceed:

For appliances without a supply cord	For appliances with a power cable (3 core); extension leads, multiway and RCD adaptors
0.1 Ω	(0.1 + R) Ω where R is the resistance of the protective conductor of the supply cable

Table 2 Earth bond limits

For manual verification, or if the resistance R of the protective conductor of the power cable cannot easily be measured, table 3 below provides nominal cable resistances per metre length for various types of

flexible cable. The supply cable should first be identified and the length measured. The resistance of the protective conductor can then be calculated by multiplying the nominal resistance by the length.

Nominal conductor CSA (mm^2)	Typical no. of strands in conductor	Maximum current carrying capacity (A)	Nominal conductor resistance (Ω/m)
0.5	16	3	0.039
0.75	24	6	0.026
1.0	32	10	0.0195
1.25	40	13	0.0156
1.5	30	15	0.0133
2.5	50	20	0.008
4	53	25	0.005

Table 3 - Nominal Conductor Resistance

Insulation test

Generally insulation testing is carried out by applying a known (500 V DC) test voltage and measuring the resistance. On sensitive equipment (IT for example) 500 V may cause damage, and so be unsuitable. Therefore it may be substituted by a low-voltage (250 V) insulation test; a touch current test; or an alternative leakage current test.

Appliances must not be touched during an insulation test, as if a fault exists, the exposed metalwork may rise to the test voltage, although this voltage in itself is not dangerous. The test method varies depending on whether the appliance is Class I or Class II. For an earthed (Class I) appliance the insulation test is carried out between the earth pin and the combined live and neutral pins of the plug. Megger PAT testers makes these connections for you. A Class II appliance is slightly different as there is no connection to the plug earth pin. This time a connection is made between the combined live and neutral pins and any metal parts or dirty and conductive areas of the casing, and may involve several tests. The connection method is the same as that used for the earth bond and continuity return, using the same lead.

Note: For both test methods it is essential that the appliance is switched on at its own power switch. If it is not then the electrical test is only being carried out as far as the switch. The minimum insulation readings that should be obtained are shown in Table 4.

Protective conductor and touch current measurement

This test is an alternative test to an insulation test and can be used where either an insulation test could damage the equipment it is applied to, or the results of the insulation test are suspect. **For this test, the asset is energised at its normal operating voltage,** and any current flowing to earth is measured. For Class I this is to the earth pin of the plug; and for Class II, this is to any accessible conductive surfaces using a remote probe. A low-voltage insulation test should be performed prior to any energised test such as the touch current test, to identify any potential danger from low insulation and shorted connections.

This test is only available on the more sophisticated portable appliance testers, such as manufactured by Megger.

The asset should be switched on throughout this test, so will be powered-up and operational during this period. It is essential therefore to ensure that the asset is safe to run during the test. For example, if testing a kettle, it should be part-filled with water so as not to damage the element during this test. It should also be noted that if testing a drill or another appliance with moving parts then a potential hazard may exist whilst the drill is energised, and machinery rotating.

The current is measured within five seconds after the application of the test voltage (usually the supply voltage); the values must not exceed those given in the Table 4 below.

Pass Values	Portable or handheld Class I	Class I heating equipment with with a rating ≥3 KW	All other Class I equipmemt	Class II equipment	Class III equipment
Insulation (min.)	1.0 MΩ	0.3 MΩ	1.0 MΩ	2.0 MΩ	250 KΩ
Touch Current (max.)	0.75 mA	0.75 mA or 0.75 mA per kW whichever is the greater with a maximum of 5 mA	3.5 mA	0.25 mA	0.5 mA

Table 4 Insulation and Touch current limits

Operational checks

When using the Megger portable appliance testers which powers up the equipment for you, a functional test is carried out during the load test. This test will determine a) if the asset functions correctly, and b) the VA rating of the appliance. This can be a good indicator of future problems and potential failures in an appliance. Problems like worn bearings on a drill would probably result in increased current drawn from the supply and therefore an increase in the VA reading.

Microwave ovens

Under visual examination, microwave ovens should not show any sign of damage, distortion or corrosion. Those that do should be withdrawn from service, labelled, and the client informed. Microwave ovens require specialist expertise to repair, and should be returned to an authorised repairer for service.

In addition to electrical testing, a functional check is essential to check that the door interlock interrupts the power supply satisfactorily.

High earth-return currents

Where leakage currents exceed 3.5 mA, BS 7671 (IEE wiring regulations) lays down specific requirements regarding connection and earthing arrangements. In the event that equipment is found to have leakage currents in excess of 3.5 mA reference should be made to BS 7671.

Care should be exercised when electrical testing equipment with suspected high leakage currents as substantial electric shocks can be received from exposed conductive parts and/or the earth terminal if the appliance is not adequately earthed. Whenever high leakage currents are present a warning label like the one below should be displayed adjacent to the primary power connections.

WARNING HIGH PROTECTIVE CONDUCTOR CURRENT
Earth connection essential before connecting the supply

Some equipment may be designed to work with relatively high leakage currents. Reference should be made to the Code of Practice for details of how to test and label this equipment.

Plug fuses

The fuse in the plug is fitted to protect the flex against damage and can allow the use of a reduced CSA flexible cable. In addition, in practice it also protects the appliance. In general, two fuse ratings are standard – 3 A (appliances up to 700 W) and 13 A (up to 3 kW). In addition, some manufacturers of IT equipment fit 5 A fuses as standard, and these should be replaced with fuses of the same rating.

Power cables and leads

Appliances with detachable power supply flexes (such as lawn-mowers) should be electrically tested with the cable plugged into the appliance as a complete assembly. The cable should then be labelled and tested again, separately from the appliance. A 3 core cable should be tested as a Class I appliance, with a visual examination and earth bond; polarity and insulation tests. A 2-core cable should be tested as a Class II appliance, with a visual examination and polarity and insulation tests.

The reason a detachable cable is examined and tested again separately from the asset, is that the cable could potentially be used to supply a different appliance.

A 2-core cable should not be fitted with a 3 pole connector except for the BS1363 plug.

For power supply cables protected by a BS 1363 plug and fuse, there is no limit to their length providing that the CSA is at least 0.5 mm^2 when using a 3 A fuse, or at least 1.25 mm^2 for a 13 A fuse.

Extension leads

If extension leads have a normal 3-pin socket outlet, it is essential that a protective conductor exists in the cable. Class II extension leads are dangerous and should not be used. The code of practice recommends maximum extension lead lengths, which should not exceed the following:

Conductor CSA	1.25 mm^2	1.5 mm^2	2.5 mm^2
Max Length	12 metres	15 metres	25 metres

Table 5 - Extension Lead Lengths

2.5 mm^2 extension leads are too large for standard 13 A plugs, although they may be used with BS EN 60309 industrial plugs. Extension leads exceeding the above lengths are acceptable; however they must be fitted with a 30 mA RCD manufactured to a suitable standard.

RCD and multiway adaptors

Multiway adaptors should not be necessary, and sufficient power sockets should be provided. However, where they are used because of a large quantity of low-power equipment (e.g. IT equipment), then you should decide what is reasonable in terms of safety of use etc and report as appropriate to the duty holder.

RCD adaptors are used to provide protection for persons using portable equipment, particularly for persons using equipment outdoors and should also be checked and electrically tested.

Faulty or damaged equipment

If you find damaged or faulty equipment then this should be labelled, and if unsafe removed from service, and brought to the attention of the duty holder. They need to make a judgment on whether the equipment is suitable for both the environment in which it is being used and the application to which it is being put. If they assess that it is unsuitable for either of these reasons it has to be replaced with more suitable equipment.

Missing equipment

Items of equipment on the test register that are not where they are expected to be should be brought to the attention of the duty holder.

Labelling

Any equipment that requires visual examination and electrical testing must be clearly labelled. The label must consist of a unique identifier for the equipment, the date it was tested and an indication of its state, optionally the re-test date can also be included. A failed asset does not need the dates on, just clear identification that it has failed.

Labels may either be filled in by hand or printed. Printed labels often consist of a bar code for the identifier, making them readable with a suitable barcode scanner. This can be a great time saver with a portable appliance tester that supports it such as the PAT400.

Labels should be manufactured so they can be applied to a mixture of surfaces. They should be durable and capable of lasting until the asset is re-tested.

Documentation

The Provision and Use of Work Equipment regulations 1998 contain no specific requirement to keep maintenance records. However, the Health and Safety Executive recommend a maintenance record for high risk equipment.

The Electricity at Work Regulations 1989 has no specific requirement for maintenance records either, but HSE's Memorandum of Guidance on these regulations advises that records are kept throughout the equipments working life. All this conflicting information makes it hard for the Manager to implement a scheme for their workplace. If it is mentioned in one of the main references then a good general rule is abide by it, so the recommendation is that full records are kept.

The following records should be established and maintained:

- A register of all equipment, including the required re-test period
- A record of formal and combined visual examinations and electrical tests
- A register of all faulty equipment
- A repair register

Suitable examples of these forms and registers are available in Megger PowerSuite software.

All of these records can be stored on paper or electronically, as long as reasonable precautions are taken with regards to the safeguarding of the data. Whichever method is chosen, previous test results must be available to the test operative.

As the company carrying out the testing, you should maintain the following paper or electronic records:

- Copy of the formal visual examination and combined visual examination and electrical test results
- Register of all equipment repaired, including the required re-test period.

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