Megger

Pocket guide to PAT testing

Forward

Following the publication of the Lofstedt report, back in November 2011, it was deemed necessary to look at the burden placed upon businesses due to a legislative over-compliance placed upon them – with a key issue being confusion over Portable Appliance Testing.

This drove the IET to introduce the 4th Edition of the Code of Practice for In-service Inspection and Testing of Electrical Equipment. This industry accepted code looked to clarify responsibility and give clear guidelines to companies who were looking to maintain compliance with the Electricity at Work regulations, 1989.

So what changed?

To begin with, the most significant change was the detailed requirement to carry out a risk based assessment of a portable appliance, to determine the type and frequency test. The code determined that this responsibility should fall to the "Duty Holder" For many however, having the technical understanding to be in a position to carry out such a risk assessment was beyond their area of expertise. To this end, Megger have produced a Risk Assessment App – available on the iOS, Android and Windows platforms.

In addition, the code clarified the need to record results, determined when a hired item should be included on your register and removed the need to have a re-test date on the test label. These are just a couple of items amongst many. Megger continually run local free to attend seminars where the changes are explained in far more detail – please see our Events page on the website. We also have available a booklet explaining these changes – available from your local Megger representative.

So with this pocket guide we have endeavoured to cover the details of the 4th Edition - rather than clarify the changes – in an easy-to-read manner. There is also an insight into the range of PAT Testers Megger produce, so if you have 1 to 100,000 items to test, we have a solution.

To download your copy of the Megger PAT toolbox App scan this QR code.

Pocket guide to PAT testing

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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.

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. The duty holder is normally drawn from these.**
- **The person undertaking the formal visual examination and electrical testing.**
- **Maintenance managers.**
- **Operators of the equipment – to monitor the equipment they use and ensure it 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.

The Duty Holder may wish to maintain adequate records of 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.**

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... 4th Edition 2012; p25) as: "A person possessing sufficient technical knowledge or experience to be capable of ensuring that injury is prevented".

And under section 9.5 Test operatives should have or be capable of:

- **Understanding appliance types and appropriate testing.**
- **Familiarity with test equipment used.**
- **Understanding of likely electrical, mechanical and thermal damage.**
- **Experience and technical knowledge to prevent risk to themselves or others and potential hazards arising during testing.**
- **Maintaining suitable records.**

What checks and visual examination and electrical 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 the visual examinations and electrical tests is established by risk assessment and experience. No strict test schedules exist, however a simple risk 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:

Location of the equipment

Equipment type and class of construction

Frequency of use

Competence of user

The installation method

Previous records

Whether the equipment is on hire

The frequency of visual examinations and electrical tests should 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.

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 or due to poor manufacturing. Additionally, equipment may be misused 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.**
- **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, 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 13A plugs (both moulded-on or re-wireable) must conform to BS1363, which requires live pins to be sleeved. This legislation only applies to new plugs. It should be noted on the visual examination notes if the plug has un-sleeved pins .

Earth continuity (or bond) test

Earth continuity is applicable to Class I equipment and extension leads. 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. There are two test methods available and the method used should depend on the circumstances.

- **Low current continuity test**
  A continuity measurement is made with the asset plugged in to the PAT tester and using a short circuit test current of between 20 and 200 mA. The test is made 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. Any fluctuation in the reading should be investigated. A visual examination of the power cable terminations at both ends should be made.
- **High current bond test**
  A continuity measurement is made with the asset plugged in to the PAT tester and using a test current of at least 1.5 times the fuse rating (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 of the PAT to the exposed metal work. The maximum value of resistance should be noted while flexing the asset supply cable. Any fluctuation in the reading should be investigated. A visual examination of the power cable terminations at both ends should be made.

Care should be taken when measuring earth bond on appliances where the construction includes exposed metalwork having a casual contact to earth. This metalwork is primarily protected by double or reinforced insulation. The earth connection is only classed as 'fortuitous'. So the resistance value is unlikely to be as low as truly bonded metalwork and a test performed on this un-bonded metalwork may give misleading results. Examples of this type of 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 damage casual-contact components and a low-current test should be performed first to identify potential problems.

To pass the Earth continuity test, the measured value should not exceed those shown in Table 2:

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 continuity limits

If the resistance R of the protective conductor cannot easily be measured, the table below provides nominal cable resistances per metre length for various types of flexible cable.

The cable should be identified and the length measured. The protective conductor resistance can be calculated using the app PAT toolbox or the table and a calculator. The Megger PAT400 testers have built-in compensation for resistance in long supply cables.

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 d.c.) test voltage and the resistance measured. 500 V may cause damage to sensitive equipment such as IT. Therefore it may be substituted by a low-voltage (250 V) insulation test; a touch current test; or an alternative leakage current test.

Appliances should not be touched during an insulation test, as if a fault exists, the exposed metalwork may rise to the test voltage.

The test method varies depending on whether the appliance is Class I or Class II.

For a Class I test the appliance is plugged in to the PAT tester and the insulation test is carried out between the earth pin and the combined live and neutral pins of the plug. The Megger PAT 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, dirty or conductive areas of the casing, and may involve several tests. The connection method is the same as that used for the earth bond test, using a test probe.

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. For equipment with an electrically operated switch, the insulation test can be substituted with a mains powered protective conductor or touch current measurement.

Protective conductor or touch current measurement

This test is an alternative to an insulation test and should be used when an insulation test could damage the asset, 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 the Megger PAT.

It is essential 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.

Protective conductor or touch current measurement using substitute leakage testing

This test is useful where it may be considered dangerous to run the asset during a protective conductor or touch current measurement. This test uses 40 V a.c., which will not operate the asset during the test. This test can be battery powered, removing the need for a mains supply during testing.

In all cases the current is measured within five seconds after the application of the test 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 a rating ≥ 3 KW	All other Class I equipment	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/Touch Current Limits

Operational checks

A functional test is carried out during the "load" test or during the mains powered protective conductor or touch current measurement. This test will determine

a) if the asset functions correctly

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

Microwave ovens should not show any sign of damage, distortion or corrosion. Those that do should be withdrawn from service. They require specialist expertise to repair or service. They require an addition functional test, to check that the door interlock interrupts the power supply satisfactorily.

High protective conductor currents

Some equipment may be designed to work with relatively high protective conductor (or leakage currents), exceeding 3.5 mA. BS 7671 (IEE wiring regulations) lays down specific requirements regarding connection and earthing arrangements. In this event reference should be made to the Code of Practice section 15.11 for details of how to test and label this equipment.

Plug fuses

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.

Appliance power cables and flexes

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 with a visual examination and earth bond; polarity and insulation tests. A 2-core cable should be tested with a visual examination and insulation tests. The cable is examined and tested again separately from the asset; this is because 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 flexes 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. However other considerations such as voltage drop may limit flex length.

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 lengths shown in Table 5.

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 BS7071.

RCD and multi-way adaptors

Multi-way adaptors should not be necessary; 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 or client. RCD adaptors are used to provide protection for persons using portable equipment, particularly for persons using equipment outdoors and should also be inspected and electrically tested.

Faulty, damaged and missing equipment

Faulty or damaged equipment should be labelled as such, removed from service if dangerous and brought to the attention of the duty holder or client. They need to judge whether the equipment is suitable for the application and whether to replace it or substitute it with more appropriate equipment.

Items not in the location described on the test register should be reported to the duty holder or client.

Labelling

There is no requirement to label any equipment that requires visual examination and electrical testing, but is useful to indicate the asset has been tested satisfactorily. The label should consist of a unique identifier for the equipment, and an indication of its state.

A failed asset should have clear identification that it has failed.

Labels should adhere to a mixture of surfaces to which they will be applied. They should be tough and able of last until the asset is re-tested. 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.

Printed labels should be of the "Thermal transfer" type, not "Direct thermal" which easily fade.

Documentation

The HSE's Memorandum of Guidance on these regulations advises that records are kept throughout the equipments working life.

The following records should be established and maintained:

- **A register of all equipment.**
- **A record of formal and combined visual examinations and electrical tests.**
- **A register of all faulty equipment.**
- **A repair register.**

Examples of suitable forms and registers are available in Megger software.

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.**