USB socket-outlets scrutinised

Electrical Safety First has for some time been working to raise awareness of concerns about the safety of substandard and/or unbranded plug-in chargers for mobile phones and the like.

We published an article in the spring 2010 issue of Switched On which showed serious safety defects in a number of such plug-in chargers that were tested for us by an independent laboratory.

Then, in the winter 2012 issue, we featured the European Union's move towards introducing a common (standard) charger for mobile phones. Amongst other things, the article raised concerns that, because most new phones would then be supplied without a dedicated charger, there was likely to be a significant increase in the number of counterfeit and/or substandard common chargers on the market, as unscrupulous suppliers sought to capitalise on the increased consumer demand.

Our attention has now turned to new types of product that are becoming increasingly popular — 13 A socket-outlets, extension leads and adaptors that incorporate USB power supplies.

Our concern is that such products could pose an electric shock or fire risk if the extra-low voltage parts of the USB power supply are not suitably segregated and electrically separated from the low voltage (230 V) parts of the accessory and/or, in the case of 13 A socket-outlets, of the fixed wiring.

As with all our previous safety screening exercises, we purchased a random sample of these types of product from a number of online retailers, for evaluation by an independent test laboratory.

The size of the problem

As shown in Table 1 (right), all nine samples failed to meet one or more safety requirements of the relevant product standard(s).

Product testing

USB socket-outlets are relatively new in concept, so are not yet covered by a single product standard. The test laboratory was therefore tasked with evaluating the product samples against the general safety provisions of the following standards:

- *BS 1363-2: 1995 + A4: 2012 13 A plugs, socket-outlets, adaptors and connection units. Specification for 13 A switched and unswitched socket-outlets*
- *BS 5733: 2010 + A1: 2014 General requirements for electrical accessories. Specification*
- *EN 61558-1: 2005 +A1: 2009 Safety of power transformers, power supplies, reactors and similar products. General requirements and tests*
- *EN 62684: 2010 Interoperability specifications of common external power supply (EPS) for use with data-enabled mobile telephones*

Summary of evaluation results

Markings and instructions (Clause 7 of *BS 1363-2* or Clause 8 of *BS 5733*)

Visual examination of the nine samples revealed that three of them lacked any brand name or trademark and that, where such marking was included, it was generally of a poor standard. Seven samples had no CE marking. The marking on the faceplate of Sample No 4 was so poor that it was easily erased if gently rubbed with a finger.

Four of the samples had no form of USB marking such as a symbol, lettering, and/or the maximum current rating (e.g. 1200 mA), to indicate what type(s) of device the USB sockets were intended to supply. Of those samples that were marked, one 13 A socket-outlet type had the marking on the back of the product, which would not be visible to users after installation.

Only three of the samples were supplied with adequate operational and safety instructions, and only three indicated that they were compatible with brands such as Apple and Blackberry. Whilst seemingly a minor point at first, one online retailer told us they had recently withdrawn one type of USB socket-outlet from sale following a number of complaints from Apple product owners alleging that their devices had been damaged while being charged through 'non-Apple approved USB ports'.

Construction (Clause 13 of *BS 1363-2* or *BS 5733*)

One of the samples of the 13 A socket-outlet type, shown in Fig 1, had a metallic part in close proximity to the printed circuit board (PCB), which was

Table 1. Evaluation Summary

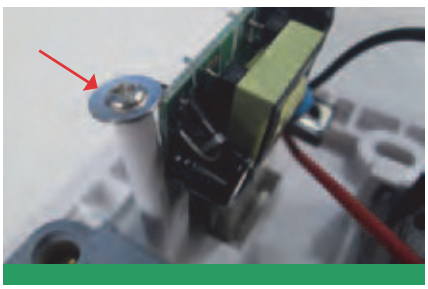
Safety Criteria	Sample number and evaluation results								
	1	2	3	4	5	6	7	8	9
									
Markings and warnings	F	F	F	F	F	IR	F	F	F
External construction	IR	P	IR	P	IR	P	F	P	P
Accessibility of live parts	P	P	P	P	P	P	F	P	P
Terminals and terminations	F	P	F	P	IR	P	F	IR	P
Internal wiring / separation	P	P	P	P	F	P	F	P	P
Screws, current-carrying parts and connections	F	IR	F	P	IR	IR	P	IR	P
Creepage & clearance distances through insulation	F	F	IR	F	F	F	F	F	P
Short circuit, overload and thermal protection	P	P	P	P	P	P	IR	P	P
Mechanical strength	P	P	P	P	P	P	F	P	P
Insulation resistance / leakage current	P	P	P	P	P	P	P	P	P
Electric strength	P	P	P	P	P	F	P	P	P
Provision for Earthing (where faceplate was metallic)	n/a	F	n/a	n/a	n/a	P	n/a	n/a	n/a
Output voltage and current under load	P	P	F	IR	P	P	F	P	P

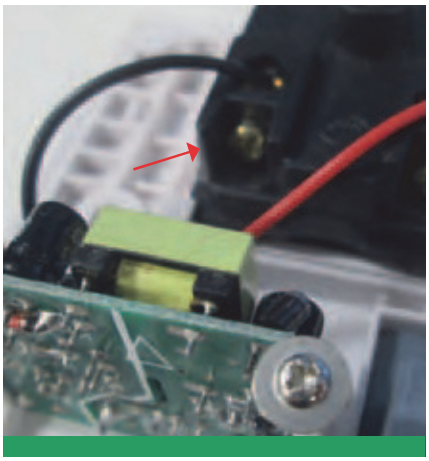
Key: **F** *Fail;* **P** *Pass;* **IR** *Improvement Recommended*

simply slotted into the plastic moulding of the accessory. There was no form of protection, such as an insulated physical barrier or cover, to separate the extra-low voltage components from low voltage parts and, potentially, the fixed wiring once installed. Whilst the limited evaluation process did not simulate installation conditions, it is reasonably foreseeable that such an arrangement could be compromised during installation, especially when the accessory is being pushed into the back box.

In the same sample, as also shown in Fig 1, one of the terminal screws for connecting the accessory to the fixed wiring was inaccessible when the PCB was in place.

Fig 1. *Typical examples of poor construction*





In another sample, the internal conductors used to power the PCB were soldered onto the live (line and neutral) socket contacts into which the live pins of 13 A plugs should fit.

However, as Fig 2 shows, the soldered connections prevented the test plug from being fully inserted, creating a potential source of overheating. Furthermore, should such a solder-only power connection fail, displacement of the wire could result in an earth fault, short-circuit, or mains voltage appearing at the USB charger output, creating a risk of electric shock and/or fire.

Fig 2. *Soldered connections in the accessory prevented the test plug being fully inserted*

Accessibility of live parts (Clause 9 of *BS 1363-2* or clause 8 of *BS 5733*)

To assess the accessibility of live parts, a standard 1.0 mm diameter test pin was applied with a force of 5 N perpendicular to the accessible external surface(s) of each of the samples.

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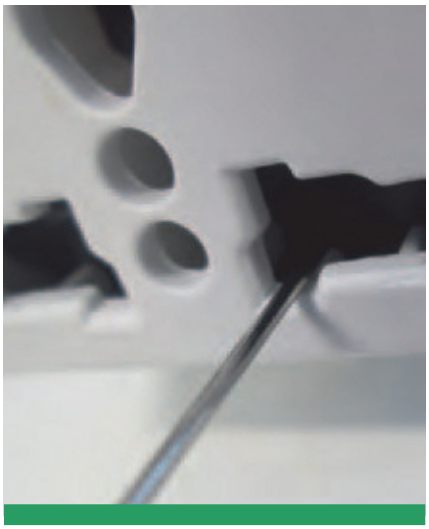
One sample, No. 7, failed this test due to poorly fitting shutters over the apertures to the live contacts in the socket-outlet, as shown in Fig 3. In fact, as shown in Table 1, this particular sample performed worse of all, failing 8 of the 12 test criteria.

Fig 3. *Access to live parts*



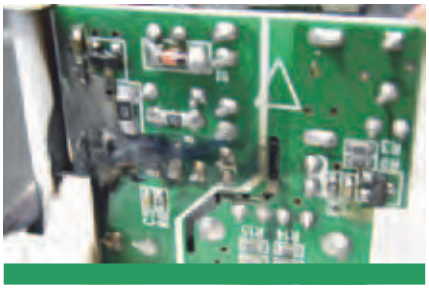
Output voltage and current under load (Clause 5 of *BS EN 62684*)

Each of the nine samples had an operating open-circuit voltage at the USB terminals within the maximum permitted range of 4.75 V d.c. to 5.25 V d.c. However, whilst all but one of the samples complied with maximum permitted output current requirement of 1500 mA, about half of them either over- or under-delivered on their stated current outputs. The sample that failed to comply with the maximum output current requirement had a stated output current of 2100 mA, but delivered a steady-state current of 2600 mA when tested under load.

During the output testing, the laboratory adjusted the load on each sample to maximise voltage and current output. Temperatures were then recorded at several key points on the samples every two hours for a period of around eight hours.

Two samples failed this testing. Sample No. 3 failed quietly, simply providing no output at the end of the test period. In contrast, Sample No. 7 failed with dramatic results after approximately 1.5 hours which, as Fig 4 shows, damaged the PCB extensively. A surface mounted resistor ruptured and both USB socket wires were blown off.

Fig 4. *Visible damage to one PCB caused by load testing*

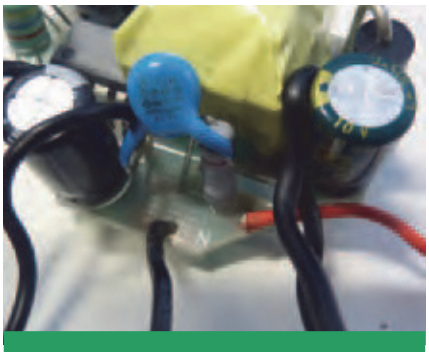


In terms of short-circuit protection, *BS EN 62684* permits a maximum output of 3 A under single fault conditions, a test which the majority of the samples passed. However, an output current of 4.1 A was recorded on one sample.

Electric strength (Clause 19 of *BS 5733* or clause 18 of *BS EN 61558-1*)

All but one of the samples passed the standard dielectric strength. The one that failed did so at just 800 V d.c. A burn test later revealed that arcing had occurred between the fusible resistor and the tail of a capacitor which, as can be seen in Fig 5, had been in direct contact with one another.

Fig. 5 *Point at which Sample No. 6 failed the electric strength test*



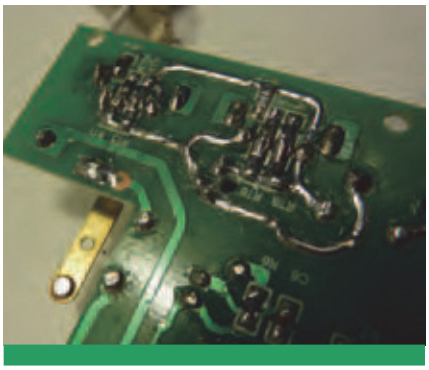
Creepage and clearance distances through insulation (Clause 26 of *BS EN 61558-1*)

As electronic circuits rely upon insulation and/or physical separation to prevent electric shock, excess heat and/or fire, the laboratory checked that the components, including the transformer and the conductive tracks of the PCB, complied with the safety requirements set out in the product standards. Regrettably, as indicated in Table 1, seven of the nine samples failed this test.

One significant failing was insufficient separation distances between the terminals of the primary and secondary windings of the transformers, even though most of them were constructed with three layers of insulation.

Another significant failing was seen on the PCB of Sample No. 2, where solder had been added to the tracks (see Fig 6). Presumably it was done to ensure they would withstand the flow of current, but this is not considered good practice and resulted in failure to meet the minimum separation distances.

Fig. 6 *Solder added to the tracks of the PCB in Sample No. 2*



Our conclusions:

As is clear from the results of our limited investigation, many safety risks and other unwanted effects can arise from use of the substandard accessories incorporating USB power supplies that are available at low cost online and elsewhere.

As with all our previous product safety investigations, we intend to share the findings of our research with the suppliers concerned to make them aware of the nature and extent of the electrical safety failures we have identified. Where appropriate, our findings will also be shared with Trading Standards to assist them with their market surveillance activities and enforcement duties.

We understand that the safety requirements for any socket-outlet that incorporates other components, such as USB power supplies, will in due course be included within the scope of *BS 1363* when the necessary standards development work is completed.

All our laboratory test reports are available to view in full in the 'Electrical professionals' section of our website: **www.electricalsafetyfirst.org.uk**