Time to lay down the law for portable appliance testing

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Note; No recommendations or advice within these notes may contravene or supersede any legislative requirements, neither locally nor nationally. Where legislation or local regulations require different procedures or tests those regulations will prevail in all circumstances.

Following many issues raised by ISCE members, where audio equipment and systems have been significantly damaged, badly re-connected or left misconfigured by general electrical testing companies, it is time we put a stop to this largescale dangerous testing of our systems by people lacking the competence and knowledge to correctly test complex audio systems for electrical safety.

It is recommended that such testing should be carried out by industry personnel who understand the nature of the items under test, and who MUST be competent, possessing the skill and knowledge to carry out the testing safely and correctly. Bearing this in mind, a general Portable Appliance Test "PAT" operative is not a competent person as required under their own test criteria. It is this lack of competence that often leads the "PAT" tester to continue testing systems they are not competent to test when they fail to understand the complex nature of the systems before them, often mistaking the components for simple domestic type appliances, whilst also attempting to maximise test revenues.

As competent specialists, we should take the lead on this problem by attaching "PAT" test prohibition notices to all our installed racks and consoles. We should use this opportunity to ensure that tests are carried out by persons intimate with the functioning and complexities of these systems, and who are able to identify potential danger and correctly pass or fail the systems where necessary. It is striking that, when the question was put to the ISCE mailing list, it seems that no member reading that list had experienced a reported "PAT" test fault from a third party "PAT" tester at any time, yet many of us do have a few horror stories of what we find out there.

The following recommendations are a basic starting point towards a sensible audio industry electrical testing code of practice and hopefully will help us bring the proper safe and correct testing of our systems back into the hands of us specialist engineers.

Competence

The first requirement for safe testing above all others is the competence of the person performing the test.

At a time where many electrical test devices are as close to fool proof as possible to operate and the abilities of the average test operative are often low, it is probably the most important aspect of correct testing of complex systems that the person testing should be able to fully understand the nature of the task they are performing and what it is they are testing. As 99% of electrical testing operatives are not knowledgeable in professional sound, or AV systems they should be restricted

from performing any test without adequate supervision, especially where they may mis-identify equipment, or not be fully aware of the nature of all system operation and connections.

By definition, an incompetent person is not of adequate competence to determine their own competence. For this reason, competent persons should take the responsibility for determining the minimum competence of person able to embark upon electrical testing of audio systems. In all cases regarding audio equipment, this task should be carried out by an experienced person in the field, covering the nature of the equipment. In all new installations, this should be the original installer. It is recommended that this determination be performed by the clear and prominent display of a notice upon the equipment declaring testing operative restriction to audio industry personnel, or specialists.

Ideally, an operator should be able to demonstrate this competence by showing either membership of a recognised industry body, learned institution, or through the ability to show industry experience or training. Competence should include the ability to identify and recognise without fail, the function, connection, operation, and purpose of every item of equipment under test as well as adequate competence in the task of electrical testing. The competent person MUST be able to demonstrate correct full function testing of the system.

Electrical Safety Risk Assessment

The original installer, or in the case of previously installed equipment the first competent tester, should determine by means of experienced assessment the necessary test periodicity for various parts of the system. Such assessments should be based upon the likelihood of physical damage, physical wear, physical or electrical degradation of connections, harsh environments, and amount of user interaction. Users should be categorised into high risk non-specialist persons, and low risk persons, such as maintenance staff or specialist engineering staff. Electrical Safety testing frequency should be clearly displayed on, or inside the equipment enclosure.

Many items which are enclosed, protected, and not part of any user interface would normally, if well installed in a correct environment, not degrade or be damaged to any degree over the lifespan of the equipment. The majority of electrical cables and connections would receive no user contact, nor be exposed to physical damage. It would be more than adequate for these items to be inspected no more than once every 5 years, from the point of the first installation electrical safety test.

Items installed in user areas should be tested based on the frequency and nature of use. For example a DJ style music playback console installed in a fixed position in a church hall that is used for half an hour a month by the vicar is not likely to be at as much risk as the same console brought out daily to an outdoor bar used by freelance DJs who are permitted to drink in the vicinity of the equipment. Common sense would dictate that the first example would be adequately served by 3 to 5 year testing, while the second example would be better served by 6 to 12 month testing. Additionally, quality and suitability of equipment and distribution components may have a bearing on expected longevity, components running close to their maximum capacity may well need more frequent monitoring.

Only a competent system designer or installer with adequate experience in the industry is capable of correctly specifying test intervals based on actual risk. Similarly, a competent field tester is able to

recommend any alteration to test intervals based on any changes of circumstance or wear they may see when performing tests.

System Definition

All items interconnected to form a system which processes audio, or in many cases, audio, video and effects lighting, constitute a single integrated item of equipment known as The Sound System, The Sound and Lighting System, or The AV system. Where these systems share audio, video, data or other similar cabling, they are electrically interconnected (often by means of cable screens or drain wires) so must be treated as single integrated systems.

It is worth remembering that parts of the same system may not even be in the same building. In the example of conference centres and football stadia, the systems often spread from building to building yet remain electrically interconnected.

Electrical Testing

The purpose of electrical testing is to ensure that the users and their customers are kept safe from any risks associated with the use of electricity. These risks are principally electric shock where a person comes into contact with the mains current, fire where arcing of current between conductors causes a source of ignition (*or where a conductor or connection is subject to excessive load so causes thermal failure of the insulation)*, and equipment failure through loss of electrical current when the system is performing a critical task. Any electrical test should cover the safety of all these areas thoroughly without fail whilst ensuring minimum risk is encountered between testing.

Equipment Classification

Under portable appliance testing standards there are two classes of equipment under test. Firstly the default standard item which is general electrical plant and machinery, usually solely consisting of a plug, a cable, a switch and a motor or light. Then there are other electrical items more complex and sensitive, which would be damaged by high current, high voltage testing. This equipment was initially deemed to be computerised equipment and as such the test for this equipment was designated an IT test. This test is actually incorrectly named as the majority of electronic equipment. This is basically anything that includes semiconductors (or other very low voltage components), and is equally as fragile with regard to excessive voltage and current. For this reason everything we use in the audio installation business with the exception of passive power distribution units MUST be designated IT equipment if any “PAT” test device is used for the purpose of testing. This means that no item except a passive power distribution unit may be subject to a high voltage insulation “flash” test or high current earth bond test.

Protective Bonding

Where potentially conductive surfaces such as metal are exposed to the person, they should at all times be bonded to earth as required in electrical regulations or adequately isolated as required under Class 2 equipment standards. This bonding should be carried out under current electrical regulations at the time of installation, thus each item of individual electrically supplied equipment must be connected to earth through its own power cable if it is not an item of class 2 equipment.

Signal cable screens and rack bolts are NOT acceptable forms of safety bonding. Enclosures, conduits and other non-electrical metal items should be independently bonded to earth as stated within national or local codes and this bond should be tested. Periodic testing must ensure that the integrity of the safety electrical bond is good, and that all bonding conductors are well connected. Good conductivity must be proven on each device without the use of high current testing which may damage internal filtering or similar audio circuits. Some modern test equipment will allow for this function to be effectively carried out at very low currents which is acceptable, however the presence of multiple earth paths will often prevent effective testing. Where multiple earth paths are present through signal cables it is recommended to temporarily disconnect all signal cables that may supply additional grounding in order to perform an effective safety electrical conductor test. It is not recommended to strip whole systems out of racks to individual components on the bench in order to test as this is problematic in itself and will not increase system safety to any significant extent.

It is worth noting that many unscrupulous installers will lift the supply earth to the equipment chassis of various components to try to remove induced interference currents that cause a hum due to bad system design. This is not only contrary to electrical regulations, but it is potentially dangerous as fault currents may travel through signal screens to user held equipment. Any equipment found to be in this condition MUST fail testing and be re-cabled. Whatever form of testing the operative sees fit to use, MUST effectively demonstrate a robust safety electrical connection to each piece of equipment that requires one.

Insulation integrity

To detect any insulation breakdown and potential arcing, all cables and applicable appliances should be tested for leakage between conductors. In audio systems any significant leakage may be the cause of serious degradation of the audio signal. Often the system will become unusable long before it will become electrically dangerous such is the sensitivity to reference ground interference. As no item of equipment may be flash tested only a high resistance test to chassis can be performed. Due to the sensitive nature of all audio equipment to reference ground currents, it is likely that this test will never yield results on an item that is not already deemed to be malfunctioning or tripping RCD devices. It should be noted that in un-monitored situations, such as induction loop systems, we may well see an electrical safety test picking up serious operational problems that may otherwise have gone unnoticed. The testing operative should decide the most appropriate method of testing (if required) for the equipment before them. It should be remembered that various forms of interference filters inside equipment will conduct certain frequencies between line and earth and may cause measurement error issues with certain methods. In many cases flash testing of the power distribution components and leads will be adequate.

Enclosures and racks that are not both fully sealed against human contact AND are seen to carry high voltage warning labels, may not have any form of exposed current carrying electrical terminals or connection blocks inside. This includes open DIN rail power terminals or the exposed rear panels of some sequential power-switching units. This is especially so

when it may be expected for an engineer or operator to be required to fault-find inside the rack or enclosure in poor access or lighting conditions. Any unit not designated a 240V or 415V internal hazard AND secured from human contact by means of key or tool, which has exposed electrical terminals inside, MUST fail an electrical safety test.

Cables and distribution

Where power leads and passive power distribution systems are used, they should be subject to standard electrical testing. All BS1362 fuses should be correctly rated for cable and connector ratings **only**. Leads and distribution strips should be tested for high current continuity, and may also be high voltage flash tested. All items should be visually inspected for suitability and damage.

It should be taken into consideration that originally installed items may have been substituted by others, equipment may have been upgraded, and items may have been removed from the system since original installation. Therefore, it should always be checked that the current capacity of supply cables, distribution strips, and supply breakers is adequate. Each individual outlet should be tested as poor contacts can develop when corrosion or heat affects the spring properties of some types of lower quality socket contacts. With cheaper items many BS1363 distribution strip sockets can become warm and thermally damaged well within their rated current capacity. It is important that all such outlets are fully tested periodically and where poor quality components are used, it may be wise to shorten the test interval or replace them with a more suitable more robust item. Plugs and sockets with any kind of visual sign of thermal stress should be visually failed regardless of the results of electrical testing.

Distribution systems with active or remote control should be tested carefully in accordance with their design and layout taking care to avoid any testing that may stress control circuits and items such as programmable logic controllers or solid state relays.

Supply

Correct and safe operation of any complex and sensitive equipment, such as an audio system, is reliant upon a good clean electrical supply and as low resistance as possible earth path. It is pointless ensuring protective earth bonding within the system if the supply earth is poor or missing.

In large commercial installations, the electrical supply systems often suffer far more modification and physical interference than fixed installed audio systems. It is imperative that when testing larger installations the electrical supply integrity is verified as part of the system testing.

A system cannot be signed off as safe if there is no protective earth supplying the system as a whole. Where different parts of interconnected systems are fed from different sources it is essential to have as similar as possible source impedance on the grounding path and

insignificant potential difference between grounds. Significant variations in these parameters will cause a possible potential difference between equipment and allow current to flow through signal cable screens and audio reference ground paths causing signal degradation. It is most important in large installations to note any significant differences, and ensure low supply earth loop impedance. In large systems with mainly electro-magnetic amplifier power supplies, it is also imperative to ensure that the supply lines have low L-N source loop impedance to prevent voltage drop and neutral shift with amplifier transient current demand. This often involves over sizing cables and using motor rated circuit breakers. System electrical testing in such circumstances should involve powering up all items simultaneously as though recovering from a power failure (this is often best done using a main switch). No circuit protective devices should be tripped by the turn on surge if correctly specified.

It is highly recommended that any electrical safety inspection of large scale systems includes documenting and non-intrusive verifying of the system electrical supply at the system rack and console connection points in addition to any other test on these lines carried out by others. Values, which are cause for concern, should be discussed with the site electrical contractor and should, if out of usual range, constitute a fail.

In smaller installations where only a few BS1363 connections are used it is important to inspect these for damage, and ensure that rack or console supply leads are not routed as to be subject to damage or cause trip or fall hazards. It is strongly advised that systems should not be fed from extension reels. Partially coiled extension reels carrying any significant current should cause a test to fail.

Hardware

All enclosures, consoles, and equipment should be visually inspected for electrical safety. Inspection should look for open holes exposing live parts, missing covers, severe cracks, open panels, doors that should be locked, missing warning notices, and any bypassed interlock protection cut-off switches. All equipment should be well ventilated and well clear of flammable materials, all enclosure fans should be clean and fully working without any binding or rattling. Special attention must be paid to the use of skeleton racks, which have no sides and expose all internals. These racks may be far more prone to interference if located in anywhere other than a dedicated locked room, it is recommended that test frequency be increased or sides be fitted in this case.

Operation

All equipment should be inspected for correct operation and functioning upon completion of the testing. Testing should include a full load test, which should be to maximum safe system output. It should be verified that no circuit protection device should activate here. The tester should ensure that all devices are powered from the intended source circuit and that no device has been wrongly reconnected in the process of testing. Sequential switching and zoned or timed power control should be verified to work as intended. Every input and output device should be verified as correctly working before the test is finally signed off.

Documentation

Upon completion, the customer should be issued with a certificate detailing the tests carried out, the results of the tests, and the duration to the next due test. The customer may well require these documents to produce for licensing, insurance and fire inspection purposes.