

# TEMPORARY POWER DISTRIBUTION SYSTEMS AND ELECTRICAL SUPPLIES FOR ENTERTAINMENT RELATED PURPOSES

By Mark Coles

The IET's technical helpline is frequently asked questions relating to the requirements for temporary electrical supplies and power distribution systems to many differing types of installation. This article looks at temporary electrical installations for use within the entertainment industry, the responsibilities associated with the installation in addition to the technical requirements that should be met.

## Events

Temporary electrical supplies are required for many different types of events. For example, television and film sets, theatre productions and concerts, both indoor and outdoor, have power requirements ranging from a few kilowatts to many megawatts. Due to the nature of the work, tight schedules, inclement weather, ever-changing plans, etc., the installation will need to be quickly assembled and quickly disassembled, particularly with a touring production.

## Overview

When a performance takes place in a small venue, an example of this could be a band in local pub, the electrical equipment will be supplied from local, strategically-positioned, socket-outlets. It is quite likely that extension leads will be used to provide more socket-outlets in places where required.

The method of electrical distribution in a large concert venue follows the same principle; socket-outlets will be provided to cover certain areas, distribution units and extension leads will then be used to distribute power to the point of utilisation.

In effect, beyond the fixed electrical installation, the temporary element is purely a kit-of-parts assembled to suit the situation or event.

## The Law

The law requires that electrical installations are maintained and kept in a safe condition. The fact that an electrical installation is of a temporary nature does not permit a lower standard of installation work; the standards of installation and maintenance need to be higher as the operating conditions are more onerous.

The Electricity at Work Regulations 1989, places duties on employers, designers and installers to insure all systems are safe.

## Competency

It must be noted that temporary electrical installations, particularly in the entertainment industry, may appear simple but, in reality, can be extremely complex and sophisticated. Certain types of connectors,

cables and equipment are designed and manufactured purely for use within the entertainment industry and will not be used on any other type of installation. It is therefore a requirement that all persons working on the installation are competent for the work they undertake and, where required, will be adequately supervised.

### Enforcement

Most places of entertainment will need a licence from the local authority. The law does not say what must be contained in the licence; there will usually be requirements for fire precautions and the licence can include conditions relating to electrical safety.

Commonly a venue will request, from incoming contractors, documentation which demonstrates that the electrical distribution equipment and appliances, they plan to install, have been recently tested and inspected for electrical safety.

### The requirements of BS 7671

There is no section of BS 7671 that specifically applies to temporary electrical installations for use within the entertainment industry, however, BS 7671 applies generally to exhibitions, fairs and other installations in temporary buildings, as stated in Regulation 110-01-01 (viii).

The IEE publication Guidance Note 7 – *Special Locations*, includes guidance based on IEC Publication 60364-7-711 and the draft CENELEC proposals prHD 384.4.7.711 S1:2002.

The particular risks associated with temporary installations are those of electric shock and fire. These arise from:

- the temporary nature of the installation
  - lack of permanent structures
  - severe mechanical stresses
  - access to the general public
- Particular attention should be paid to:
- suitability of the equipment for the environment
  - earthing and bonding requirements
  - connection to the supply

- use of accessories of the appropriate Degree of Protection (IP code) to suit the particular external influences

### Establishing responsibility

When a temporary electrical supply or temporary power distribution system is required, a person, or persons, should be appointed to undertake the responsibility for the design, provision, assembly, co-ordination and control of the installation. This is necessary to ensure that all works are co-ordinated through a single point, particularly on larger sites or installations.

The designer should establish a detailed outline of the temporary installation to meet the client's requirements as a base for their design. Discussions should also take place between the user and the person responsible for the installation. The following points should be addressed:

- System design
- Installation work
- Testing and certification
- Operation
- Safe removal of equipment

### Electrical supplies

Due to the practical difficulties of bonding all accessible extraneous-conductive-parts, a TN-C-S (PME) system is not appropriate for temporary outdoor installations. A TN-S system would be acceptable if such a supply was available from the distributor; if not, a TT system should be adopted.

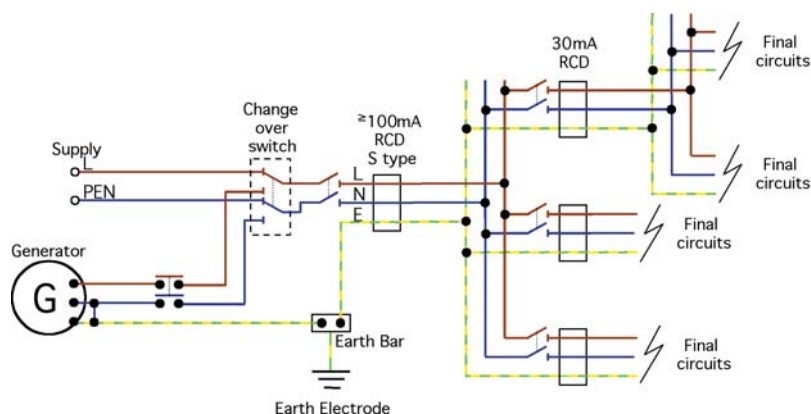


Fig 1: Exhibition/show distribution with standby generator

### Generators

Installations incorporating generator sets should comply with Section 551 of BS 7671. Where a generator is used to supply the temporary installation using a TN or TT system, it must be ensured that the installation is earthed, preferably by separate earth electrodes. For TN systems all exposed-conductive-parts such as stage structures or lighting grids should be earthed back to the generator. The neutral conductor and/or star point of the generator should be connected to the exposed-conductive-parts of the generator and reference earthed.

Regulation 21 from Part VI of the Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR), has requirements for switched alternative sources of energy (see figure 1) as follows:

*Where a person operates a source of energy as a switched alternative to a distributor's network, he shall ensure that that source of energy cannot operate in parallel with that network and where the source of energy is part of a low voltage consumer's installation, that installation shall comply with British Standard Requirements.*

The requirements for parallel operation are much more onerous. Often generators may be synchronized and connected together to provide either load sharing (to prevent the loss

Installation	Final circuit	Multi-circuit	Intake
Theatre	BS 546	TCMCC, QTBMCC	BS EN 60309-2
Television	BS EN 60309-2	TCMCC, QTBMCC	BS EN 60309-2
Film	BS EN 60309-2	TCMCC, QTBMCC	BS EN 60309-2
Pop music	BS 54 BS EN 60309-2	TCMCC, QTBMCC	Single pole connectors BS EN 60309-2
Technical and domestic services	BS 1363BS EN 60309-2	Not applicable	Not applicable

Key: TCMCC: threaded cylindrical multi-pin coupling connector; QTBMCC: quarter turn bayonet multi-pin connector

Fig 2: Table showing the preferred power distribution connectors

of power halting a show) or to provide more power. In such situations, only equipment designed for such purposes shall be used, further, cabling connecting two generating sets should be sized to take the maximum load expected if one set were to fail.

For further information, consult BS 7430, *Code of practice on earthing*.

### Earth fault loop impedance

On temporary distribution installations, special consideration should be made to earth fault loop impedance on final circuits. The use of extension leads in series can cause the earth fault loop impedance to become unexpectedly high resulting in a rise in disconnection time to a value outside the protection limits. The use of residual current devices rated at 30 mA is recommended.

The IEE publication *Code of Practice for In-service Inspection and Testing of Electrical Equipment* recommends that the length of an extension lead should be checked to ensure that the performance of the equipment is not affected by voltage drop.

### Residual Current Devices

The functional operation of RCDs should be verified by using the test button when setting up the temporary installation and thereafter at regular intervals, e.g. before each performance or use of the system.

It is good design practice to ensure that lighting does not share the same distribution circuit as the audio

equipment which also requires reliable RCD protection. This also helps to prevent mains-borne interference from affecting the audio system. RCDs protecting audio equipment should not be bypassed or disabled.

If a performer or other person is required to handle any piece of energized portable mains-powered class I electrical equipment, it should be protected by an RCD rated at 30 mA or less.

### Testing, inspection & certification

#### The fixed installation

In compliance with Chapter 73 of BS 7671, Periodic Inspection and Testing, the fixed installation will be tested and inspected at regular intervals to determine whether the installation is in a satisfactory condition for continued service.

A periodic inspection report will be made available by the venue to contractors who may be working on behalf of the production.

#### Portable equipment

The *Code of Practice for In-service Inspection and Testing of Electrical Equipment* recommends that all electrical equipment is inspected and tested at regular intervals. The frequency of inspection and testing will be established and frequently evaluated by the competent person responsible for the equipment.

Where practicable, cables and connectors should be assembled off-site and tested and certified as safe

and satisfactory before delivery to site. Installers and users are encouraged to inspect all cables and couplers prior to energising.

### Cables

Temporary power distribution cables should be of the multicore type for distribution circuits less than 125A. Single core cables are used for distribution circuits above 125A.

Cables for use indoor should be PVC or rubber sheathed in accordance with, BS 6500 or equivalent, with a minimum voltage designation of 300 V/500 V (ordinary duty flexible as a minimum, as defined in BS 7540).

Cables for use outdoor should be rubber insulated and sheathed in accordance with BS 6007 (commonly known as HO7RN-F which is widely used), BS 6500 or equivalent, with a minimum voltage designation of 450 V/750 V (heavy duty flexible as a minimum, as defined in BS 7540). Armoured cables or cables protected against mechanical damage should be used wherever there is a risk of mechanical damage, however, the use of steel wire armour protection is usually not necessary. Flexible cords should not be laid in areas accessible to the public unless they are protected against mechanical damage.

### Distribution circuits

Cables intended to supply temporary structures should be protected at their origin by residual current devices whose rated residual operating current does not exceed 300 mA. These devices should provide a delay by using a device in accordance with IEC 60947-2, or be of the S-type in accordance with IEC 61008-1 or IEC 61009-1 to enable discrimination with RCDs protecting final circuits.

All circuits for socket-outlets rated up to 32 A and all final circuits other than for emergency lighting should be protected by an RCD with a rated residual operating current not exceeding 30 mA.

Control and protective switchgear



**Fig 3: 400A Single pole mains connector Power lock in-line socket**



**Fig 4: 400A Single pole mains connector Power lock plug**

should be placed in closed cabinets which can only be opened by the use of a key or a tool, except for those parts designed and intended to be operated by ordinary persons.

### Plugs, socket-outlets and cable couplers

All temporary power connections on site should be made using approved plugs, sockets and cable couplers. Plugs, sockets and couplers should conform to British, or international standards, appropriate for the current and voltage and site conditions. Figure 2, is reproduced from BS 7909 and shows the preferred type of connector for the application.

Connectors not approved to another specific type standard should conform to BS EN 60309-1, or the salient requirements thereof. Plugs, sockets and connectors conforming to BS EN 60309-1 should be used in accordance with the recognised voltage colour code and mandatory keyway positions. Pin connections should conform to international, national or industry standards.

To prevent accidental interconnection of non-compatible circuits, alternative non-interchangeable connectors should be used, such as those shown in figures 3 and 4. Such single pole connectors should provide protection conforming to at least IP 44 when connected in normal use.

### Equipment

Electrical apparatus and wiring can be subject to severe abuse and should be designed to withstand the conditions expected. It is essential that correct circuit protection, earthing

arrangements and frequent inspection and testing are ensured.

Distribution equipment should have the following features:

- safety in use;
- flexibility in application for repeated use, i.e. to allow easy substitution of components for specific duties as required from site to site;
- suitability for transport, storage and handling;
- robustness in construction to resist damage;
- suitability for use in the intended environment.

All switchgear, distribution equipment, etc., not reserved for exclusive interior use, should be of a type approved for outdoor use or protected by suitable covers if used outdoors. Socket-outlets, plugs and cable couplers not reserved for exclusive indoor use should be of the splash-proof type or protected by suitable covers. Equipment should conform at least to the IP categories given in figure 6. ■

### Further reading and information

- BS 7909: 1998 Code of practice for Design and installation of temporary distribution systems delivering a.c. electrical supplies for lighting, technical services and other entertainment related purposes
- IEC 60364-7-711 Requirements for special installations or locations – Exhibitions, shows and stands
- HD 384.7.711 S1 2003 Requirements for special installations or locations – Exhibitions, shows and stands
- Guidance Note 7 – Special Locations, IEE Publication
- Code of Practice for In-service Inspection and Testing of Electrical Equipment, IEE Publication
- BS 7430: 1998 Code of practice for earthing
- PLASA - Professional Lighting and Sound Association <http://www.plasa.org/>



**Fig 5: A distribution unit consisting of:  
Incoming: 400A Power lock with link through  
Outgoing: 3 x 63A, 3Ø, to BS EN 60309-2  
3 x 16A, 1Ø, to BS EN 60309-2  
3 x 13A, 1Ø, to BS 1363**

Place of use	IP category
Indoor	IP 2X
Outdoor (protected)	IP 22
Outdoor (exposed)	IP 44

**Fig 6: Minimum IP protection  
(With all covers in place)**

- Electricity Safety, Quality and Continuity Regulations 2002
  - HSE Guidance Notes: Electrical Safety for Entertainers; further HSE guidance material:
1. Guidance Note PM 19, Use of lasers for display purposes HMSO, ISBN 0 11 883370 7
  2. Health and Safety at Work etc Act 1974 HMSO, ISBN 010 543774 3
  3. Electricity at Work Regulations 1989, SI 1989 No 635 HMSO, ISBN 0 11 096635 X
  4. Memorandum of guidance on the Electricity at Work Regulations 1989, HS(R)25, HMSO ISBN 011 883963 2
  5. The Event Safety Guide - A guide to health, safety and welfare at music and similar events 1999 - First published as 'Guide to health, safety and welfare at pop concerts and similar events', 1993 ISBN: 0717624536

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