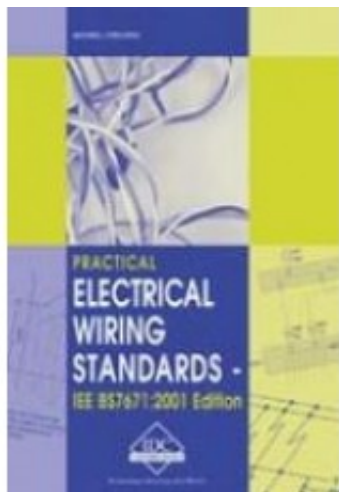


## WR-E - Practical Electrical Wiring Standards - IEE BS7671 - 2008 Edition+A12011 Edition



**Price: \$65.95**

**Ex Tax: \$59.95**

### **Short Description**

Internationally there is steady progress towards alignment of the electrical wiring standards for low voltage installations. This is reflected in the IEC standard 60364, the European Harmonisation Document HD 60364 and the UK "IET Wiring Regulations" 17th edition, now also known as British Standard BS7671:2008+A1:2011, all of which share a common format.

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Internationally there is steady progress towards alignment of the electrical wiring standards for low voltage installations. This is reflected in the IEC standard 60364, the European Harmonisation Document HD 60364 and the UK "IET Wiring Regulations" 17th edition, now also known as British Standard BS7671:2008+A1:2011, all of which share a common format.

This manual gives the reader up to date information on the current edition of BS7671:2008+A1:2011, requirements for electrical installations, in depth coverage of all aspects of the regulations and their application with many practical examples and sample design calculations. The manual also provides a summary of some of the basic principles necessary for a good understanding of electrical installation technology. Note: This manual is NOT the standard itself, it is a guide to the implementation of the standard.

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## **First Chapter**

### **An Overview - Practical Electrical Wiring Standards - IEE BS7671 : 2008+A1:2001 Edition**

#### **1 Overview**

*This chapter provides overview on the contents of the book and provides introductory information on the necessity, layout and scope of the manual.*

#### **Learning objectives**

- To familiarize the readers with the contents of the book and explain its necessity.
- To familiarize the readers with the objectives, scope and exclusions of the regulations.
- To familiarize the readers with the fundamental principles and organization of the regulations.

#### **1.1 Introduction**

The objective of this book is to familiarize readers with the BS 7671: 2008 - Amendment 1 (formerly known as the IEE Wiring Regulations) (Seventeenth edition) now published as the British standard BS7671:2008, which covers the requirements for electrical installations of nominal voltages up to and including 1000 V AC or 1500 V DC. It contains stipulations covering issues of safety, selection and installation of electrical equipment including those in special locations. The topics contained in the standard are of interest and relevance to all practitioners of electrical technology whether they are designers of electrical installations, erection engineers or personnel responsible for operation and maintenance of the installations.

In order to appreciate the requirements and stipulations contained in the standard better, it is necessary to have a clear understanding of the fundamental principles that the standard aims to address. In preparing this book an attempt has been made to give the reader an insight into the relevance of the stipulations of the

standard by first touching upon the basics of the relevant aspects of electrical theory and then go on to the requirements contained in the standard.

## **1.2 An overview of the contents of this book**

After this overview we will start with the evolution and growth of electrical power distribution systems. We will touch upon the reasoning behind the adoption of 3 phase AC as the worldwide standard in electrical power generation, transmission and distribution.

We will cover the basics of neutral earthing of electrical systems at the source and the need for protective earthing of electrical installations to ensure safe operation of electrical systems. The need for establishing earth continuity and equipotential bonding of all building services will be explained. The incidence of voltage surges in electrical systems due to atmospheric factors and switching of equipment and the need for lightning protection systems in building and surge protective devices for equipment will be discussed briefly. We will also go through in detail the types of electrical distribution configurations depending on the type of earthing adopted.

We will discuss the hazards of electricity, primarily electric shocks in detail. This topic is of importance since safety is the essence of the BS 7671:2008 – Amendment 1. The topic of electrical conductors and cables will be taken up as these components form the backbone of any electrical distribution system.

The control of electrical power and the need for proper isolation of electrical systems for safety will be touched upon. This again is a topic which the IET standard discusses in detail being an issue related to safety of personnel operating not only the electrical systems but also those involved in the operation and maintenance of the mechanical equipment powered by the distribution system.

Of the BS 7671:2008 – Amendment 1 (referred to in this book as the Rules), we will cover the scope of the standard as well as the exclusions as a part of this overview. The Rules are broad based and cover every conceivable condition of electrical installations some of which are not usually encountered in general domestic or industrial installations. It would be impossible to cover all such stipulations in this book. We will therefore focus our discussions on the most common types of installations and study the recommendations of the Rules as applicable for such installations.

We will discuss the need for systematic assessment of system requirements

while planning an installation. We will cover the stipulations of the standard in respect of electrical hazards, the various protective measures recommended and how they are to be applied in different situations. This is the central issue of the wiring rules being related to human safety. We will review the recommendations of the standards in regard to selection and installation of equipment including those in special locations. The subject of initial verification of any installation for conformity with the regulations, the periodic inspection and certification requirements will also receive due mention.

### **1.3 Why is such a standard necessary?**

A standard for equipment, appliance, device or an installation is necessary for the following reasons:

- To ensure proper interfacing between equipment and systems designed/ manufactured/installed by different agencies.
- To ensure manufacturing/installation quality and the application of a reasonable standard of safety, commensurate with available technology and experience.

We will illustrate these concepts further.

#### **1.3.1 Ease of interfacing**

Imagine for a moment, that there are no standards for electrical appliances. The result would be that each product manufacturer might choose a different voltage rating for his product. This means that we would have electrical heaters, ovens, toasters, etc. that cannot work on a common electrical system. Your power supply company might have a distribution voltage that is unsuitable for any or all of your gadgets. This obviously is not a helpful situation.

Thus a standard has to be established and its adherence made mandatory within a national or geographical entity so that generation, transmission, distribution and utilization of electrical energy are done at stipulated voltages and frequency which will vary only within bands specified for each parameter.

Such a standard enables the designer of an appliance to select a suitable voltage and frequency at which the appliance can function and also the variations of these parameters which have to be taken care of in the design for the operational range of the appliance. It also allows the designer to select appropriate conductors and configuration of power supply connectors forming part of the appliance.

In turn, this enables you to buy an off-the shelf appliance and connect it to the electrical outlet at home and use it without worrying too much about the suitability of the appliance for the electric supply provided by the power company. Anyone who has travelled with a device made in one country and tried to use in another where different standards prevail would certainly appreciate the convenience which uniform standards provide us with.

Also the use of standards reduces the number of variant appliance designs a manufacturer has to plan and manufacture; an issue which will have adverse cost implications to the manufacturer and hence to the buyer. Low cost mass production is thus a direct result of standards.

### **1.3.2 Ensuring quality**

Equipment and installations have to deliver functionalities for which they are designed without any undue hazards to the users or the environment for their entire design life under varying operating conditions. The provisions of a standard therefore define the parameters for functionality, safety and maintainability. They also contain stipulations that lay down the tests that the device has to withstand to either prove a design (by what are called Type tests conducted on prototypes or selected samples) or ensure that the output and quality parameters are met (by Routine Tests done on each piece manufactured). Thus when you buy an appliance or equipment that is declared as conforming to a particular standard, you have an assurance that it will perform under conditions defined by the standard, is safe to use and will deliver the output or functionalities which the manufacturer furnishes in accordance with the standard.

An installation standard has a similar objective too. When an installation is carried out in accordance with a standard, it has to follow the methodologies stipulated in the standard using recommended accessories which, in turn will ensure that the installation achieves the intended quality minima, is safe for personnel and environment, and will have adequate provisions for maintainability. An installation standard also usually lays down the procedures for initial inspection and testing for certifying that the installation is fit to be put in service and the periodicity and detail of subsequent inspections and testing to ensure that it is fit to remain in service till the next scheduled inspection.

### **1.4 Objective of the Rules**

The objective of the Rules is to provide the rules for the design and erection of electrical installations covered under its scope to ensure safety and proper functioning of the installation.

When use of a new material or invention in an installation results in deviation from one or more stipulations of the regulations, it should be ensured the degree of safety is not compromised by such use. The fact of such use shall also be recorded on the electrical installation certificate.

## **1.5 Scope of the Rules**

The requirements of BS 7671 :2008 – Amendment 1 are applicable to the following installations:

- Industrial, commercial, residential, agricultural/horticultural premises
- Prefabricated buildings and caravans
- Temporary installations such as those encountered in construction sites, exhibitions, fairs, etc.
- Highway power supplies and outdoor lighting installations
- Marinas, mobile units, photovoltaic systems, low voltage generating sets, highway equipment and street furniture.
- Medical locations
- Operating and maintenance gangways

The rules cover the requirements for:

- Circuits supplied at nominal voltage up to and including 1000 V AC or 1500 V DC.
- Circuits of over 1000 V AC when derived from an installation of less than 1000 V AC, such as high voltage discharge lighting systems, electrostatic precipitators, etc.
- Wiring and cabling systems not forming part of an appliance or equipment's internal wiring and not covered under the standard for the appliance
- All consumer installations external to the building
- All fixed and External wiring requirements for communication and information technology systems for power signalling and control
- Additions and alterations to an existing installation

The rules may have to be supplemented by the requirements of other British Standards that may be applicable for an equipment or installation (e.g. neon signs, emergency lighting, installations in environment containing explosive gases or conductive dust) or by the specified requirements of the agency ordering the installation.

**Note:**

Various definitions contained in Part 2 of the Rules have been reproduced in this book at the appropriate chapters in the manner shown below.

**Definition: Supplier**

A person who supplies electrical energy, and, where electric lines and apparatus used for that purpose are owned otherwise than by that person, shall include the owner of those electric lines and apparatus.

**Definition: Supplier's Works**

Electric lines, supports and apparatus of, or under the control of, a supplier used for the purposes of the supply, and cognate expressions can be construed accordingly.

**1.6 Exclusions**

The following are some of the installations to which the BS 7671 :2008 – Amendment 1 are NOT applicable.

- ‘Suppliers Works’ as defined by the Electricity Safety Quality and Continuity Regulations:2001
- Railway traction, rolling stock and signalling systems
- Motor vehicles and equipment on board ships, off shore installations and aircraft
- Mines and Quarry equipment covered by other statutory regulations
- Lightning protection installations on buildings
- Radio interference suppression equipment if not affecting the safety of electrical installation.
- Installations already covered by BS 5655/BS EN 81-1 and electrical equipment of machines covered by BS EN 60204.
- Electric fences covered by BS EN 60335

The standard does NOT cover the requirements for design/manufacture of electrical equipment but limits itself to their selection and application in electrical installations.

BS 7671:2008 – Amendment 1 are non-statutory in nature. In some cases, the requirements of the Rules will be supplemented by other codes of practice approved under Statutory Legislation such as Section 16 of Health and Safety at Work etc 1974 Act and Electricity at Work Regulations 1989 (described briefly in the following paragraphs).

For premises on which a Licensing or Statutory authority exercises control, the requirements of such authorities should be complied in the design and execution of the installation.

## 1.7 The Health and Safety at Work etc. Act 1974

The Health and Safety at Work etc. Act covers all work activity and places duties on employers, the self-employed and employees. The Act is very general in its requirements and is an umbrella act under which about 40 sets of Regulations have been made including:

- Electricity at Work Regulations
- The Asbestos Regulations
- The Noise at Work Regulations
- The Control of Substances Hazardous to Health

**Contravention of these Regulations is a criminal offence** and persons can be prosecuted personally, not just their employers. Employees are duty bound to co-operate with their employers in helping them fulfil their duties under the legislation.

## 1.8 Electricity at Work Regulations 1989

Electricity at Work Regulations 1989 covers every aspect of the design, construction, maintenance, and use of electricity, whatever the voltage. They include all workers, from electricians and engineers to teachers, typists, doctors, etc. Some important regulations are:

- **R 3** Employers and employees have to comply with the regulations in so far as matters are within their control.
- **R 4** Covers the construction, maintenance, and use of systems and the suitability of any protective equipment used.
- **R 13** Precautions for work on equipment made dead.
- Adequate precautions shall be taken to prevent electrical equipment, which has been made dead in order to prevent danger while work is carried out on or near that equipment, from becoming electrically charged during that work if danger may thereby arise.
- **R 14** Work on or near live conductors. No person shall be engaged in any work activity on or so near any exposed) live conductor that danger may arise unless –

- It is unreasonable in all the circumstances for it to be dead; and



- It is reasonable in all the circumstances for him to be at work on or near it while it is live; and

- Suitable precautions are taken to prevent injury.

- **R 16** Persons to be competent to prevent danger and injury

The Electricity at Work Regulations guidance states that competence can be made up of the following:

- Adequate knowledge of electricity.

- Adequate experience of electrical work..

- Adequate understanding of the system to be worked on and practical experience of that class system.

- Understanding of the hazards which may arise during the work and the precautions which need to be taken..

- Ability to recognize at all times whether it is safe for work to continue.

## **1.9 Fundamental principles of the Rules**

The fundamental principles contained in Chapter 13 of the Rules are essentially an outline of the issues it addresses. These will be individually covered in this manual in the coming chapters and therefore not being given in detail here. The issues are:

- Ensuring safety during normal and fault conditions, protections against thermal effects, over current, fault current and over voltage.
- Aspects that need to be considered in the design such as characteristics of available supply, nature of demand, emergency supplies for safety services, environmental considerations, conductors to be used, type of wiring, protective equipment, emergency control, isolation and switching, accessibility for operation, etc.
- Selection of electrical equipment in order to suit the voltage, current capacity and frequency of the supply system.
- Erection of equipment using good workmanship and proper materials, use of conductors with proper sizing and rating, proper jointing and connections at terminal points, installations in a manner not to cause

temperatures in excess of the design temperatures and verification and testing of equipment periodically to avoid degradation.

## **1.10 Organization of the Rules**

The Rules are organized into the following parts:

Part 1 covers the object, scope and fundamental principles, which we have briefly touched upon in the preceding paragraphs.

Part 2 contains definitions of the terms used in the Rules.

Part 3 sets out the assessment of general characteristics of an installation. The general purpose for which the installation is to be used, the maximum demand in amperes which it will draw from the supply, the earthing arrangement, the nature of power supply source/s and their parameters, ascertaining their suitability to the installation under consideration, special requirements for installations used for safety services or standby services, need for change over arrangements to a redundant source or considerations for parallel operation of sources etc. will be the prime characteristics that will receive due attention.

Part 4 deals with the issue of protection for safety. This part covers basic protection i.e. protection against normal conditions and protection against fault conditions. It deals with thermal effects during normal operation, protection against over currents, over voltage, under voltage etc. The need for proper isolation and switching of installations and their role in safe operation of the installation are also covered.

Part 5 covers the rules for selection and erection of wiring systems, switchgear, earthing arrangements, other equipments (such as low voltage generating sets, rotating machines, transformers, luminaires), safety services (such as emergency lighting, fire protection applications), etc.

Part 6 deals with inspection and testing of installations. This includes the requirements for initial verification and testing after an installation is completed as well as after additions and alterations to an existing installation. Requirements for periodic inspection are also stipulated. Sample formats for the issue of Electrical Installation Certificates for different types of inspection carried out as per this part are also included in Appendix 6

Part 7 contains the details of special installations where safety issues are of vital importance. This includes installations in baths, showers, swimming pools,

saunas, construction sites, caravans and caravan parks, marinas, exhibitions, shows and stands, solar photovoltaic power systems, mobile units, temporary electrical installations, medical locations, operating and maintenance gangways floor and ceiling heating systems, and so on. In all these cases the environment with high humidity, presence of water, high temperature with particular requirements occur and special steps need to be taken to ensure that the installation will remain safe and in good order over an extended period of time.

The arrangement of BS 7671 may be better understood by considering the plan illustrated in Figure 1.1.

**Part 1: Scope, Object and Fundamental Principles**

<b>Part 3:</b>	<b>Part 4:</b>	<b>Part 5:</b>	<b>Part 6:</b>	<b>Part 7:</b>
Assessment of General Characteristics	Protection for Safety	Selection and Erection of Equipment	Inspection and Testing	Special installations or locations
<b>Part 2: Definitions</b>				

**Figure 1.1**

*Organization of the Rules*

Part 1 gives the overriding requirements and is therefore placed at the top.

Part 2 gives the underlying Definitions, and is therefore placed underneath.

Note that where Special Installations or Locations as described in Part 7 are involved the general requirements are supplemented or modified. At each stage

the designer must therefore check for that involvement.

## **1.11 Appendices**

The Rules also contain the following fifteen appendices. The Appendices do not form part of the Rules, but provide “need to know” information.

- Appendix 1 British Standards to which reference made
- Appendix 2 Statutory regulations and associated memoranda
- Appendix 3 Time/current characteristics of over current protective devices
- Appendix 4 Current-carrying capacity and voltage drop for cables and flexible cords
- Appendix 5 Classification of external influences
- Appendix 6 Electrical Installation Certificate and Periodic Inspection Report forms
- Appendix 7 Harmonized cable core colour
- Appendix 8 Current-carrying capacity and voltage drop for busbar trunking and powertrack systems
- Appendix 9 Definitions -multiple source, DC and other systems
- Appendix 10 Protection of conductors in parallel against overcurrent
- Appendix 11 Effect of harmonic currents on balanced three-phase systems
- Appendix 12 Voltage drop in consumers' installations
- Appendix 13 Methods for measuring the insulation resistance/impedance of floors and walls to Earth or to the protective conductor system
- Appendix 14 Measurement of earth fault loop impedance: consideration of the increase of the resistance of conductors with increase of temperature
- Appendix 15 Ring and radial final circuit arrangements

## **1.12 Guidance notes to the Rules**

The IET has published a series of seven Guidance Notes to aid users of the Rules.

1. Selection and erection of Equipment
2. Isolation and Switching
3. Inspection and Testing
4. Protection against Fire
5. Protection against Electric Shock

6. Protection against Over current
7. Special Locations

Guidance Notes 1 and 3 are of most interest to installers and inspectors. The NICEIC requires its contractors to possess these

There is also an “On-Site Guide” for small installations which enables simple designs to be done with minimal calculations.

These are non statutory and are targeted mostly at designers of installations.

### **1.13 Harmonization with European Standards**

#### **Definition: Harmonized Standard**

A Standard which has been drawn up by common agreement between national standards bodies notified to the European Commission by all member states, details published in the Official Journal and published by each member state under national procedures.

To comply with European Union directives, and thereby assist free trade without technical barriers, member states are required to harmonize their technical standards. To do this, committees are formed, drawn from the standards committees of the different states. The European Mechanical Engineering standards body is CEN and the Electrical Engineering standards body is CENELEC. The first step is a Harmonization Document (HD), which is a standard containing most of the general requirements of each state in a common format. There is provision for each state to have its own variations on this. The next stage is to produce a Euro Norm; this is a standard agreed by all member states, the details being published in the Official Journal which then must be published in every member country with any conflicting national standard being withdrawn. A BS EN is a British Standard based completely on an EN. This will be identical in every respect with other European normalized standards. A Many European electrical standards are based on international standards as produced by IEC the International Electro-technical Commission. If a CENELEC standard is based on an IEC standard it takes the number as part of its own: e.g. IEC 439 was adopted by CENELEC and became EN 60439. Our BS 5486 became BS EN 60439.

The Wiring Rules since the 15th Edition has been based on IEC 60364. The 17<sup>th</sup> edition saw the adoption of the IEC numbering system, in which the component parts of a Regulation number are separated by a decimal point, as an aid to implementing changes to the requirements given in the International (IEC)

and European (Cenelec) base documents.

A number of the requirements contained in BS 7671:2008 – Amendment 1 are particular to the United Kingdom. To show where this is the case, a ‘100’ component has been introduced to the numbering system. For example, *Regulation 522.2.100*.

## **1.14 Summary**

We had an overview of the contents of this book in this chapter. We discussed the need and relevance of standards for engineering products and installations. We also covered the objectives and scope of the BS 7671:2008 – Amendment 1. We had a look at the fundamental principles of the Rules and the organization of the Rules. The movement towards harmonization of the rules with European Electrical standards was also brought out.

This book is not intended to replace BS 7671:2008 – Amendment 1 as a work of reference but is merely an introduction to it. In case further information is required it is recommended that the participants study the standards as well as other references such as the Guidance notes issued by IET. A lot of published literature is available on these topics by industry bodies and reputed manufacturers of electrical equipment as well as on the Internet and can be referred for assistance in solving specific problems one may come across.