

8th
EDITION



ADVANCED ELECTRICAL INSTALLATION WORK

LEVEL 3

City & Guilds 2365 Diploma in Electrical Installations
(Buildings and Structures)

Trevor Linsley

UPDATED TO THE 17TH EDITION OF THE
IET REGULATIONS 3RD AMENDMENT 2015



Advanced Electrical Installation Work

Updated in line with the 3rd Amendment of the 17th Edition IET Wiring Regulations, this new edition covers the City and Guilds 2365-03 course. Written in an accessible style with a chapter dedicated to each unit of the syllabus, this book helps you to master each topic before moving on to the next. End-of-chapter revision questions enable learners to check their understanding and consolidate key concepts learned in each chapter. With a companion website containing videos, animations, worksheets and lesson plans, this resource will be invaluable to both students and lecturers alike.

The 8th edition contains:

- Full-colour diagrams and photographs to explain difficult concepts
- Clear definitions of technical terms to make the book a quick and easy reference
- Extensive online material to help both students and lecturers.

The companion website material is available at www.routledge.com/cw/linsley.

Trevor Linsley was formerly a senior lecturer at Blackpool and the Fylde College and Head of the NVQ Assessment Centre. Over the last 20 years his books have helped thousands of students pass their electrical qualifications.

To Joyce, Samantha and Victoria



Advanced Electrical Installation Work

8th Edition

Trevor Linsley

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Preface

The 8th Edition of *Advanced Electrical Installation Work* has been completely rewritten in six chapters to closely match the six units of the City and Guilds 2365-03 qualification. The technical content has been revised and updated to the requirements of the new 17th edition of the IET Wiring Regulations (incorporating Amendment 3: 2015) and BS 7671. Improved page design with new illustrations gives greater clarity to each topic.

This book of electrical installation theory and practice will be of value to the electrical trainee working towards:

- The City and Guilds 2365 Level 3 Diploma in Electrical Installations (Buildings and Structures);
- the EAL Diploma in Electrotechnical Services;
- The City and Guilds 2399 series of Environmental Technologies Qualification;
- The SCOTVEC and BTEC Electrical Utilization Units at Levels II and III.

Advanced Electrical Installation Work provides a sound basic knowledge of electrical theory and practice which other trades in the construction industry will find of value, particularly those involved in multi-skilled activities.

The book incorporates the requirements of the latest regulations, particularly:

- 17th Edition IET Wiring Regulations (Incorporating Amendment 3: 2015);
- British Standards BS 7671: 2008 (Incorporating Amendment 3: 2015);
- Part P of the Building Regulations, Electrical Safety in Dwellings 2006;
- Hazardous Waste Regulations 2005;
- Work at Height Regulations 2005.

Trevor Linsley
2015

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- Martindale-electric.co.uk for technical information and photographs;
- Tenby electrical products for photographs;
- Legrand photographs visit legrand.co.uk for more information.

I would like to thank the many college lecturers who responded to the questionnaire from Taylor & Francis the publishers regarding the proposed new edition of this book. Their recommendations have been taken into account in producing this improved 8th Edition.

I would also like to thank the editorial and production staff at Taylor & Francis the publishers for their enthusiasm and support. They were able to publish this 8th Edition within the very short time-scale created by the publication of the new 3rd Amendment to the 17th Edition of the IET Wiring Regulations.

A special thank you must also go to my colleague John Gallagher, an electrical installation lecturer at Blackpool and The Fylde College, for writing the new section on preparing for the online assessment examination.

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Health and safety in building services engineering



Unit 201/501 of the City and Guilds 2365-03 syllabus

Learning outcomes – when you have completed this chapter you should:

- know about health and safety legislation;
- know how to handle hazardous situations;
- know the electrical safety requirements when working in the building services industry;
- know the safety requirements when working with heat-producing equipment;
- know the safety requirements when using access equipment;
- know the safety requirements when working in confined spaces and excavations;
- be able to apply safe working practices to manual handling and using access equipment.





This chapter has free associated content, including animations and instructional videos, to support your learning.

When you see the logo, visit the companion website for more on this topic www.routledge.com/cw/linsley

The 8th Edition of *Advanced Electrical Installation Work* covers the topics in the City and Guilds Level 3 Diploma in Electrical Installations (Buildings and Structures).

The six chapters of this book closely match the learning outcomes in the six units of the City and Guilds Level 3 Diploma.

The first unit in both the Level 2 Diploma and the Level 3 Diploma covers the essential health and safety learning outcomes described in unit 201 of the City and Guilds syllabus. Therefore, Chapter 1 of this book covers unit 201 of the City and Guilds qualification.

However, if this is the beginning of your second year studying for the Diploma in Electrical Installation Work (Buildings and Structures), you may have already received a credit for unit 201. If you believe that you have already received a credit for unit 201, you **may not** be required to study the topics in Chapter 1 of this book and can go straight on to the other five chapters. You should check **your own position** with your trainer or assessor.

The City and Guilds unit 201 is covered in Chapter 1 of this book for those students who have not yet received a credit for unit 201.

Important note!

You may have already studied the material in this chapter – check with your trainer or assessor before going any further.

Safety regulations and laws

At the beginning of the nineteenth century children formed a large part of the working population of Great Britain. They started work early in their lives and they worked long hours for unscrupulous employers or masters.

The Health and Morals of Apprentices Act of 1802 was introduced by Robert Peel in an attempt at reducing apprentice working hours to 12 hours per day and improving the conditions of their employment. The Factories Act of 1833 restricted the working week for children aged 13–18 years to 69 hours in any working week.

With the introduction of the Factories Act of 1833, the first four full-time Factory Inspectors were appointed. They were allowed to employ a small number of assistants and were given the responsibility of inspecting factories throughout England, Scotland, Ireland and Wales. This small, overworked band of men were the forerunners of the modern HSE Inspectorate, enforcing the safety laws passed by Parliament. As the years progressed, new Acts of Parliament increased the powers of the Inspectorate and the growing strength of the trade unions meant that employers were increasingly being pressed to improve health, safety and welfare at work.

The most important recent piece of health and safety law was passed by Parliament in 1974 called the Health and Safety at Work Act. This Act gave added powers to the Inspectorate and is the basis of all modern statutory health and safety laws. This law not only increased the employer's liability for safety measures, but also put the responsibility for safety on employees too.

Health, safety and welfare legislation has increased the awareness of everyone to the risks involved in the workplace. All statutes within the Acts of Parliament must be obeyed and, therefore, we all need an understanding of the laws as they apply to the electrical industry.

Statutory laws

Acts of Parliament are made up of Statutes. **Statutory Regulations** have been passed by Parliament and have, therefore, become laws. Non-compliance with the laws of this land may lead to prosecution by the Courts and possible imprisonment for offenders.

We shall now look at some of the Statutory Regulations as they apply to the electrical industry.

The Health and Safety at Work Act 1974

Many governments have passed laws aimed at improving safety at work, but the most important recent legislation has been the Health and Safety at Work Act 1974. The purpose of the Act is to provide the legal framework for stimulating and encouraging high standards of health and safety at work; the Act puts the responsibility for safety at work on both workers and managers.

The employer has a duty to care for the health and safety of employees (Section 2 of the Act). To do this he or she must ensure that:

- the working conditions and standard of hygiene are appropriate;
- the plant, tools and equipment are properly maintained;
- the necessary safety equipment – such as personal protective equipment (PPE), dust and fume extractors and machine guards – is available and properly used;
- the workers are trained to use equipment and plant safely.

Employees have a duty to care for their own health and safety and that of others who may be affected by their actions (Section 7 of the Act). To do this they must:

- take reasonable care to avoid injury to themselves or others as a result of their work activity;
- cooperate with their employer, helping him or her to comply with the requirements of the Act;
- not interfere with or misuse anything provided to protect their health and safety.

Failure to comply with the Health and Safety at Work Act is a criminal offence and any infringement of the law can result in heavy fines, a prison sentence or both.

Enforcement of health and safety regulations

Laws and rules must be enforced if they are to be effective. The system of control under the Health and Safety at Work Act comes from the Health and Safety Executive (HSE) which is charged with enforcing the law. The HSE is divided into a number of specialist inspectorates or sections which operate from local offices throughout the United Kingdom. From the local offices the inspectors visit individual places of work.



Figure 1.1 Both workers and managers are responsible for health and safety on site.

The HSE inspectors have been given wide-ranging powers to assist them in the enforcement of the law. They can:

- 1 Enter premises unannounced and carry out investigations, take measurements or photographs.
- 2 Take statements from individuals.
- 3 Check the records and documents required by legislation.
- 4 Give information and advice to an employee or employer about safety in the workplace.
- 5 Demand the dismantling or destruction of any equipment, material or substance likely to cause immediate serious injury.
- 6 Issue an improvement notice which will require an employer to put right, within a specified period of time, a minor infringement of the legislation.
- 7 Issue a prohibition notice which will require an employer to stop immediately any activity likely to result in serious injury, and which will be enforced until the situation is corrected.
- 8 Prosecute all persons who fail to comply with their safety duties, including employers, employees, designers, manufacturers, suppliers and the self-employed.

Safety documentation

Under the Health and Safety at Work Act, the employer is responsible for ensuring that adequate instruction and information is given to employees to make them safety conscious. Part 1, Section 3 of the Act instructs all employers to prepare a written health and safety policy statement and to bring this to the notice of all employees. Figure 1.2 shows a typical Health and Safety Policy Statement of the type which will be available within your company. Your employer must let you know who your safety representatives are, and the new Health and Safety poster shown in Fig. 1.3 has a blank section into which the names and contact information of your specific representatives can be added. This is a large laminated poster, 595 × 415 mm, suitable for wall or notice-board display.

All workplaces employing five or more people had to display the type of poster shown in Fig. 1.3 after 30 June 2000.

To promote adequate health and safety measures the employer must consult with the employees' safety representatives. In companies which employ more than 20 people this is normally undertaken by forming a safety committee which is made up of a safety officer and employee representatives, usually nominated by a trade union. The safety officer is usually employed full-time in that role. Small companies might employ a safety supervisor who will have other duties within the company, or alternatively they could join a 'safety group'. The safety group then shares the cost of employing a safety adviser or safety officer, who visits each company in rotation. An employee who identifies a dangerous situation should initially report to his site safety representative. The safety representative should then bring the dangerous situation to the notice of the safety committee for action which will remove the danger. This may mean changing company policy or procedures or making modifications to equipment. All actions of the safety committee should be documented and recorded as evidence that the company takes its health and safety policy seriously.

FLASH-BANG ELECTRICAL

Statement of Health and Safety at Work Policy in accordance with the Health and Safety at Work Act 1974

Company objective

The promotion of health and safety measures is a mutual objective for the Company and for its employees at all levels. It is the intention that all the Company's affairs will be conducted in a manner which will not cause risk to the health and safety of its members, employees or the general public. For this purpose it is the Company policy that the responsibility for health and safety at work will be divided between all the employees and the Company in the manner outlined below.

Company's responsibilities

The Company will, as a responsible employer, make every endeavour to meet its legal obligations under the Health and Safety at Work Act to ensure the health and safety of its employees and the general public. Particular attention will be paid to the provision of the following:

- 1 Plant equipment and systems of work that are safe.
- 2 Safe arrangements for the use, handling, storage and transport of articles, materials and substances.
- 3 Sufficient information, instruction, training and supervision to enable all employees to contribute positively to their own safety and health at work and to avoid hazards.
- 4 A safe place of work, and safe access to it.
- 5 A healthy working environment.
- 6 Adequate welfare services.

Note: Reference should be made to the appropriate safety etc. manuals.

Employees' responsibilities

Each employee is responsible for ensuring that the work which he/she undertakes is conducted in a manner which is safe to himself or herself, other members of the general public, and for obeying the advice and instructions on safety and health matters issued by his/her superior. If any employee considers that a hazard to health and safety exists it is his/her responsibility to report the matter to his/her supervisor or through his/her Union Representative or such other person as may be subsequently defined.

Management and supervisors' responsibilities

Management and supervisors at all levels are expected to set an example in safe behaviour and maintain a constant and continuing interest in employee safety, in particular by:

- 1 acquiring the knowledge of health and safety regulations and codes of practice necessary to ensure the safety of employees in the workplace,
- 2 acquainting employees with these regulations on codes of practice and giving guidance on safety matters,
- 3 ensuring that employees act on instructions and advice given.

General Managers are ultimately responsible to the Company for the rectification or reporting of any safety hazard which is brought to their attention.

Joint consultations

Joint consultation on health and safety matters is important. The Company will agree with its staff, or their representatives, adequate arrangements for joint consultation on measures for promoting safety and health at work, and make and maintain satisfactory arrangements for the participation of their employees in the development and supervision of such measures. Trade Union representatives will initially be regarded as undertaking the role of Safety Representatives envisaged in the Health and Safety at Work Act. These representatives share a responsibility with management to ensure the health and safety of their members and are responsible for drawing the attention of management to any shortcomings in the Company's health and safety arrangements. The Company will in so far as is reasonably practicable provide representatives with facilities and training in order that they may carry out this task.

Review

A review, addition or modification of this statement may be made at any time and may be supplemented as appropriate by further statements relating to the work of particular departments and in accordance with any new regulations or codes of practice.

This policy statement will be brought to the attention of all employees.

Figure 1.2 Typical Health and Safety Policy Statement.



Health and Safety Law

What you need to know

All workers have a right to work in places where risks to their health and safety are properly controlled. Health and safety is about stopping you getting hurt at work or ill through work. Your employer is responsible for health and safety, but you must help.






What employers must do for you

- 1 Decide what could harm you in your job and the precautions to stop it. This is part of risk assessment.
- 2 In a way you can understand, explain how risks will be controlled and tell you who is responsible for this.
- 3 Consult and work with you and your health and safety representatives in protecting everyone from harm in the workplace.
- 4 Free of charge, give you the health and safety training you need to do your job.
- 5 Free of charge, provide you with any equipment and protective clothing you need, and ensure it is properly looked after.

Your health and safety representatives:

Other health and safety contacts:

What you must do

- 1 Follow the training you have received when using any work items your employer has given you.
- 2 Take reasonable care of your own and other people's health and safety.
- 3 Co-operate with your employer on health and safety.
- 4 Tell someone (your employer, supervisor, or health and safety representative) if you think the work or inadequate precautions are putting anyone's health and safety at serious risk.

If there's a problem

- 1 If you are worried about health and safety in your workplace, talk to your employer, supervisor, or health and safety representative.
- 2 You can also look at our website for general information about health and safety at work.
- 3 If, after talking with your employer, you are still worried, phone our Infoline. We can put you in touch with the local enforcing authority for health and safety and the Employment Medical Advisory Service. You don't have to give your name.

HSE Infoline:
0845 345 0055

HSE website:
www.hse.gov.uk

Fire safety
You can get advice on fire safety from the Fire and Rescue Services or your workplace fire officer.

Employment rights
Find out more about your employment rights at:
www.direct.gov.uk



Health and Safety Executive

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Figure 1.3 Health and Safety law poster. Source: HSE © Crown copyright material is reproduced with the permission of the Controller of HMSO and Her Majesty's Stationery Office, Norwich.

The Electricity Safety, Quality and Continuity Regulations 2002 (formerly Electricity Supply Regulations 1989)

The Electricity Safety, Quality and Continuity Regulations 2002 are issued by the Department of Trade and Industry. They are statutory regulations which are enforceable by the laws of the land. They are designed to ensure a proper and safe supply of electrical energy up to the consumer's terminals.

These regulations impose requirements upon the regional electricity companies regarding the installation and use of electric lines and equipment. The regulations are administered by the Engineering Inspectorate of the Electricity Division of the Department of Energy and will not normally concern the electrical contractor, except that it is these regulations which lay down the earthing requirement of the electrical supply at the meter position.

The regional electricity companies must declare the supply voltage and maintain its value between prescribed limits or tolerances.

The government agreed on 1 January 1995 that the electricity supplies in the United Kingdom would be harmonized with those of the rest of Europe. Thus the voltages used previously in low-voltage supply systems of 415V and 240V have become 400V for three-phase supplies and 230V for single-phase supplies. The permitted tolerances to the nominal voltage have also been changed from $\pm 6\%$ to $+10\%$ and -6% . This gives a voltage range of 216–253V for a nominal voltage of 230V and 376–440V for a nominal supply voltage of 400V.

The next proposed change is for the tolerance levels to be adjusted to $\pm 10\%$ of the declared nominal voltage (IET Regulation, Appendix 2:14).

The frequency is maintained at an average value of 50 Hz over 24 hours so that electric clocks remain accurate.

Regulation 29 gives the area boards the power to refuse to connect a supply to an installation which in their opinion is not constructed, installed and protected to an appropriately high standard. This regulation would only be enforced if the installation did not meet the requirements of the IET Regulations for Electrical Installations.

The Electricity at Work Regulations 1989 (EWR)

This legislation came into force in 1990 and replaced earlier regulations such as the Electricity (Factories Act) Special Regulations 1944. The regulations are made under the Health and Safety at Work Act 1974, and enforced by the Health and Safety Executive. The purpose of the regulations is to ‘require precautions to be taken against the risk of death or personal injury from electricity in work activities’.

Section 4 of the EWR tells us that ‘all systems must be constructed so as to prevent danger ..., and be properly maintained. ... Every work activity shall be carried out in a manner which does not give rise to danger. ... In the case of work of an electrical nature, it is preferable that the conductors be made dead before work commences.’

The EWR do not tell us specifically how to carry out our work activities and ensure compliance, but if proceedings were brought against an individual for breaking the EWR, the only acceptable defence would be ‘to prove that all reasonable steps were taken and all diligence exercised to avoid the offence’ (Regulation 29).

An electrical contractor could reasonably be expected to have ‘exercised all diligence’ if the installation was wired according to the IET Wiring Regulations (see p. 13). However, electrical contractors must become more ‘legally aware’ following the conviction of an electrician for manslaughter at Maidstone Crown Court in 1989. The court accepted that an electrician had caused the death of another man as a result of his shoddy work in wiring up a central heating system. He received a nine-month suspended prison sentence. This case has set an important legal precedent, and in future any tradesman or professional who causes death through negligence or poor workmanship risks prosecution and possible imprisonment.

Duty of care

The Health and Safety at Work Act and the Electricity at Work Regulations make numerous references to employer and employees having a ‘**duty of care**’ for the health and safety of others in the work environment. In this context the Electricity at Work Regulations refer to a person as a ‘**duty holder**’. This phrase recognizes

the level of responsibility which electricians are expected to take on as a part of their job in order to control electrical safety in the work environment.

Everyone has a duty of care, but not everyone is a duty holder. The regulations recognize the amount of control that an individual might exercise over the whole electrical installation. The person who exercises 'control over the whole systems, equipment and conductors' and is the electrical company's representative on-site is the *duty holder*. He might be a supervisor or manager, but he will have a duty of care on behalf of his employer for the electrical, health, safety and environmental issues on that site.

Duties referred to in the regulations may have the qualifying terms '**reasonably practicable**' or '**absolute**'. If the requirement of the regulation is absolute, then that regulation must be met regardless of cost or any other consideration. If the regulation is to be met 'so far as is reasonably practicable', then risks, cost, time, trouble and difficulty can be considered.

Often there is a cost-effective way to reduce a particular risk and prevent an accident from occurring. For example, placing a fireguard in front of the fire at home when there are young children in the family is a reasonably practicable way of reducing the risk of a child being burned.

If a regulation is not qualified with 'so far as is reasonably practicable', then it must be assumed that the regulation is absolute. In the context of the Electricity at Work Regulations, where the risk is very often death by electrocution, the level of duty to prevent danger more often approaches that of an absolute duty of care.

Safety first



Duty holder

This person has the responsibility to control electrical safety in the work environment.

The Management of Health and Safety at Work Regulations 1999

The Health and Safety at Work Act 1974 places responsibilities on employers to have robust health and safety systems and procedures in the workplace. Directors and managers of any company who employ more than five employees can be held personally responsible for failures to control health and safety.

The Management of Health and Safety at Work Regulations 1999 tell us that employers must systematically examine the workplace, the work activity and the management of safety in the establishment through a process of 'risk assessments'. A record of all significant risk assessment findings must be kept in a safe place and be available to an HSE Inspector if required. Information based on these findings must be communicated to relevant staff and, if changes in work behaviour patterns are recommended in the interests of safety, they must be put in place. The process of risk assessment is considered in detail later in this chapter.

Risks, which may require a formal assessment in the electrical industry, might be:

- working at heights;
- using electrical power tools;
- falling objects;
- working in confined places;
- electrocution and personal injury;
- working with 'live' equipment;
- using hire equipment;
- manual handling – pushing – pulling – lifting;

- site conditions – falling objects – dust – weather – water – accidents and injuries.

And any other risks which are particular to a specific type of workplace or work activity.

The Control of Substances Hazardous to Health Regulations 2002 (COSHH)

The original COSHH Regulations were published in 1988 and came into force in October 1989. They were re-enacted in 1994 with modifications and improvements, and the latest modifications and additions came into force in 2002.

The COSHH Regulations control people's exposure to hazardous substances in the workplace. Regulation 6 requires employers to assess the risks to health from working with hazardous substances, to train employees in techniques which will reduce the risk and provide personal protective equipment (PPE) so that employees will not endanger themselves or others through exposure to hazardous substances. Employees should also know what cleaning, storage and disposal procedures are required and what emergency procedures to follow. The necessary information must be available to anyone using hazardous substances as well as to visiting HSE Inspectors.

Hazardous substances include:

- 1 any substance which gives off fumes causing headaches or respiratory irritation;
- 2 man-made fibres which might cause skin or eye irritation (e.g. loft insulation);
- 3 acids causing skin burns and breathing irritation (e.g. car batteries, which contain dilute sulphuric acid);
- 4 solvents causing skin and respiratory irritation (strong solvents are used to cement together PVC conduit fittings and tube);
- 5 fumes and gases causing asphyxiation (burning PVC gives off toxic fumes);
- 6 cement and wood dust causing breathing problems and eye irritation;
- 7 exposure to asbestos – although the supply and use of the most hazardous asbestos material is now prohibited, huge amounts were installed between 1950 and 1980 in the construction industry and much of it is still in place today. In their latest amendments, the COSHH Regulations focus on giving advice and guidance to builders and contractors on the safe use and control of asbestos products. These can be found in Guidance Notes EH 71 or visit www.hse.gov.uk/hiddenkiller.

Where PPE is provided by an employer, employees have a duty to use it to safeguard themselves.

Provision and Use of Work Equipment Regulations 1998

These regulations tidy up a number of existing requirements already in place under other regulations such as the Health and Safety at Work Act 1974, the Factories Act 1961 and the Offices, Shops and Railway Premises Act 1963.

The Provision and Use of Work Equipment Regulations 1998 place a general duty on employers to ensure minimum requirements of plant and equipment.



Figure 1.4