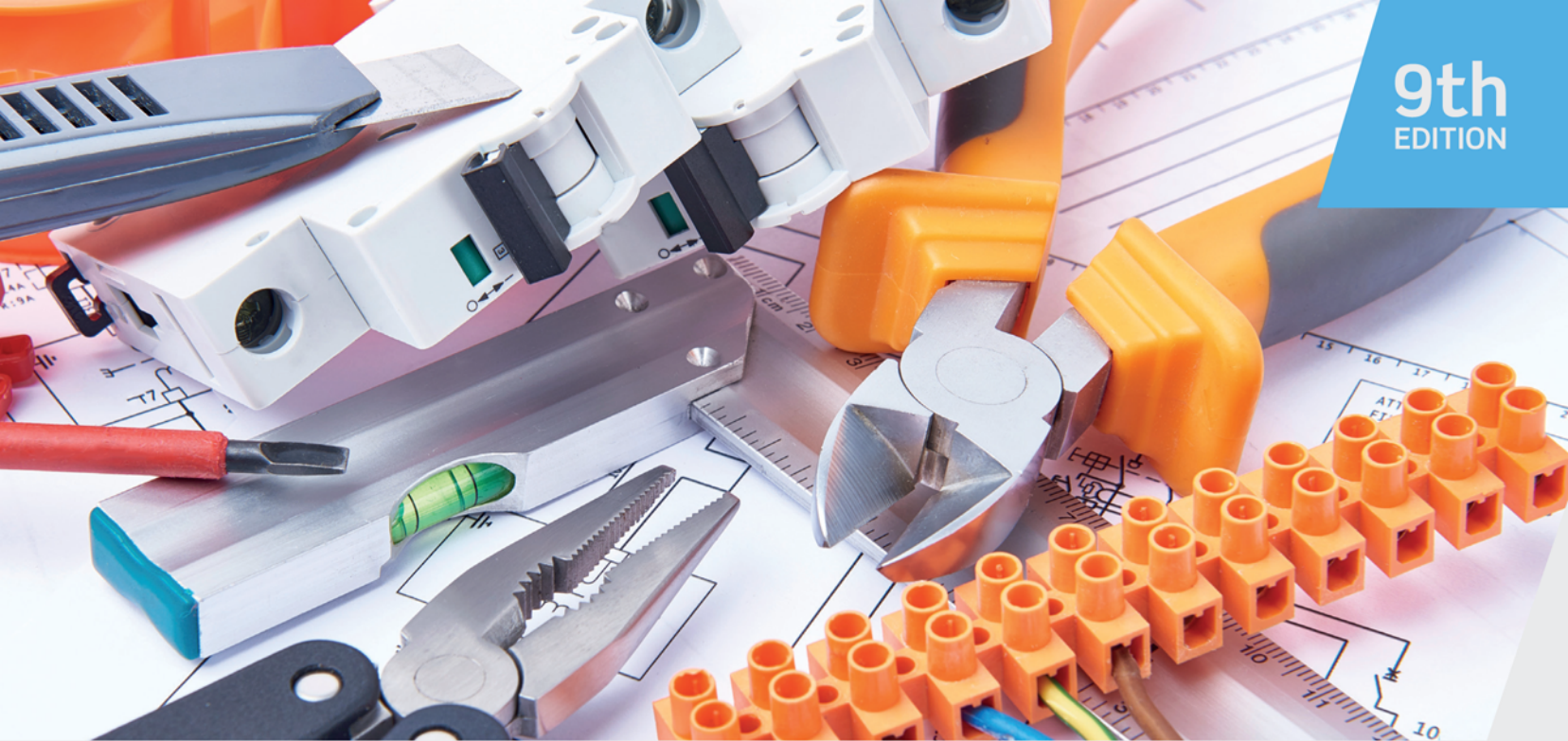


9th
EDITION



BASIC ELECTRICAL INSTALLATION WORK

LEVEL 2

City & Guilds 2365 Diploma in Electrical Installations

Trevor Linsley

UPDATED TO THE 18TH EDITION
OF THE IET REGULATIONS 2018



Basic Electrical Installation Work

Everything needed to pass the first part of the City & Guilds 2365 Diploma in Electrical Installations.

Basic Electrical Installation Work will be of value to students taking the first-year course of an electrical installation apprenticeship, as well as lecturers teaching it. The book provides answers to all of the 2365 syllabus learning outcomes, and one chapter is dedicated to each of the five units in the City & Guilds course.

This edition is brought up to date and in line with the 18th Edition of the IET Regulations:

- It can be used to support independent learning or a college based course of study
- Full-colour diagrams and photographs explain difficult concepts and clear definitions of technical terms make the book a quick and easy reference
- Extensive online material on the companion website www.routledge.com/cw/linsley helps both students and lecturers

Trevor Linsley was formerly Senior Lecturer in Electrical Engineering at Blackpool and the Fylde College of Technology. There he taught subjects at all levels from first year trainee to first year undergraduate courses; and was also head of the multidiscipline NVQ Assessment Centre and responsible for establishing and running the AM2 Electrical Skills Assessment Centre. He has had 26 books published and has also written many bespoke training packages for local SME electrical engineering companies in the North West of England.

To Joyce, Samantha and Victoria



Basic Electrical Installation Work

9th Edition

Trevor Linsley

Ninth edition published 2019
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

and by Routledge
711 Third Avenue, New York, NY 10017

Routledge is an imprint of the Taylor & Francis Group, an informa business

© 2019 Trevor Linsley

The right of Trevor Linsley to be identified as author of this work has been asserted by him in accordance with sections 77 and 78 of the Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this book may be reprinted or reproduced or utilised in any form or by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying and recording, or in any information storage or retrieval system, without permission in writing from the publishers.

Trademark notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

Eighth edition published by Routledge 2015

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data
Names: Linsley, Trevor, author.
Title: Basic electrical installation work / Trevor Linsley.
Description: 9th ed. | Abingdon, Oxon ; New York, NY : Routledge, 2019. | Includes bibliographical references and index. | Identifiers: LCCN 2018022529 (print) | LCCN 2018026647 (ebook) | ISBN 9780429883248 (Adobe PDF) | ISBN 9780429883231 (ePub) | ISBN 9780429883224 (Mobipocket) | ISBN 9781138603233 (hardback) | ISBN 9781138603219 (pbk.) | ISBN 9780429466977 (ebook)
Subjects: LCSH: Electric apparatus and appliances--Installation--Textbooks. | Electronics--Textbooks. | Electric wiring, Interior--Textbooks.
Classification: LCC TK452 (ebook) | LCC TK452 .L563 2019 (print) | DDC 621.319/24--dc23LC
record available at <https://lcn.loc.gov/2018022529>

ISBN: 978-1-138-60323-3 (hbk)
ISBN: 978-1-138-60321-9 (pbk)
ISBN: 978-0-429-46697-7 (ebk)

Typeset in 10/13pt Helvetica Neue by
Servis Filmsetting Ltd, Stockport, Cheshire

Visit the companion website: www.routledge.com/cw/linsley

Contents

Preface	vii
Acknowledgements	ix
Chapter 1 C&G unit 201/50.1: Health and safety in building services engineering	1
Chapter 2 C&G unit 202: Principles of electrical science	61
Chapter 3 C&G unit 203: Electrical installations technology and renewable energy systems	133
Chapter 4 C&G unit 204: Installation of wiring systems and enclosures	279
Chapter 5 C&G unit 210: Communicating with others in building services engineering	321
Answers to check your understanding questions	357
Preparing for assessment	359
Appendix A: Abbreviations, symbols and codes	361
Appendix B: Health and Safety Executive (HSE) publications and information	363
Appendix C: Environmental organizations	365
Glossary of terms	367
Index	377



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

Preface

The 9th Edition of *Basic Electrical Installation Work* has been rewritten in five chapters to closely match the five units of the City and Guilds Level 2 Diploma in Electrical Installations (Building and Structures) (2365–02).

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

- The City and Guilds 2365–02 Level 2 Diploma in Electrical Installations (Buildings, and Structures).
- The City and Guilds 2365 Level 3 Diploma in Electrical Installations (Building and Structures) (2365–03).
- The EAL Level 2 Diploma in Electrotechnical Services.
- The SCOTVEC and BTEC Electrical Utilisation Units at Levels I and II.
- Those taking Engineering and Modern Apprenticeship courses.

Basic 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-skilling activities.

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

- 18th Edition IET Wiring Regulations
- British Standards BS 7671: 2018
- Part P of the Building Regulations, Electricians Guide to the Building Regulations
- Hazardous Waste Regulations 2005
- Work at Height Regulations 2005.

Trevor Linsley
2018



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

Acknowledgements

I would like to acknowledge the assistance given by the following manufacturers and professional organizations in the preparation of this book:

- Crabtree Electrical Industries for technical information and data;
- Legrand photographs. Visit legrand.co.uk for more information;
- RS Components Limited for technical information and photographs;
- Stocksigns Limited for technical information and photographs;
- Wylex Electrical Components for technical information and photographs;
- Martindale-electric.co.uk for technical information and photographs;
- Tenby electrical products for photographs.

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 9th Edition.

I would also like to thank the editorial and production staff at Taylor & Francis the publishers for their enthusiasm and support, particularly my Editor, Tony Moore and his team. They were able to publish this 9th Edition within the very short time-scale created by the publication of the new 18th Edition of the IET Regulations.

A special thank you must also go to my colleagues Elliot Parkinson and John Gallagher, an electrical installation lecturer at Blackpool and The Fylde College, for writing the new section on preparing for assessment, and for providing all of the top tips used in the current edition.

Finally, I would like to thank Joyce, Samantha and Victoria for their support and encouragement.



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

Health and safety in building services engineering



Unit 201/501 of the City and Guilds 2365-02 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 for working with gases and heat-producing equipment;
- know the safety requirements when using access equipment;
- know the safety requirements for working safely 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

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.

Definition

Statutory Regulations have been passed by Parliament and have, therefore, become laws.

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.

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.

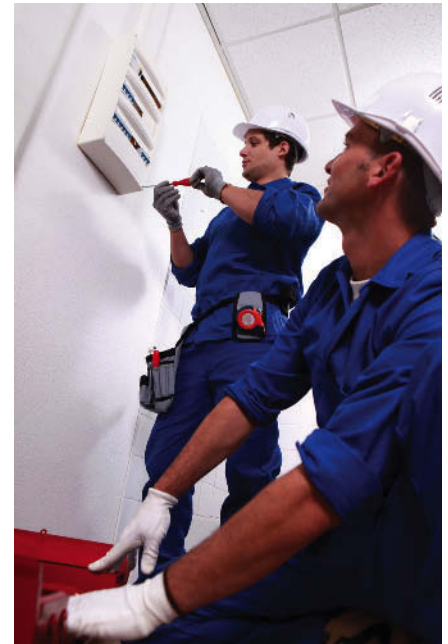


Figure 1.1 Both workers and managers are responsible for health and safety on site.

- 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.

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.

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.