SECOND EDITION

NEWNES INDUSTRIAL CONTROL WIRING GUIDE

BOB MERCER

ROUTLEDGE

ELECTRICAL ENGINEERING

NEWNES INDUSTRIAL CONTROL WIRING GUIDE

SECOND EDITION

BOB MERCER

A highly illustrated, step-by-step approach to control panel wiring

This manual provides a practical introduction to the standard methods and techniques of assembly and wiring of electrical and electromechanical control panels and equipment. Electricians and technicians will find this a useful reference work during training and a helpful memory aid at work.

This is a highly illustrated guide, designed for ready use. The contents are presented in pictures and checklists. Each page has a series of how-to instructions and illustrations, covering the subject in an easy to follow manner. Each step adds up to a comprehensive course in control panel wiring.

This new edition includes extra underlying theory to help the technician, plus application notes and limitations of use. Simple programmable logic controllers (PLCs) are covered, as well as new information about EMC/EMI regulations and their impact.

an **informa** business

ISBN 978-1-138-41340-5

9 781138 413405

ROUTLEDGE

Routledge

Taylor & Francis Group

www.routledge.com

NEWNES INDUSTRIAL CONTROL WIRING GUIDE SECOND EDITION

MERCER Routledge

Industrial Control Wiring Guide

Second edition

Bob Mercer

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2001 by Newnes

Published 2016 by Routledge
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN
711 Third Avenue, New York, NY10017

First issued in hardback 2017

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

First edition 1995
Second edition 2001

Copyright © 2001, Roffiey Park Institute. All rights reserved.

The right of Roffiey Park Institute to be identified as the authors of this work has been asserted in accordance with the Copyright, Designs and Patents Act 1988 ·

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means electronic, mechanical, photocopying, recording or otherwise without the prior written permission of the publisher

Notice
No responsibility is assumed by the publisher for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the material herein. Because of rapid advances in the medical sciences, in particular, independent verification of diagnoses and drug dosages should be made

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**
A catalog record for this book is available from the Library of Congress

ISBN 13: 978-1-138-41340-5 (hbk)
ISBN 13: 978-0-7506-3140-2 (pbk)

此为试读,需要完整PDF请访问: www.ertongbook.com

Industrial Control
Wiring Guide

BS EN60529 – IP Codes

First number Protection against solid objects	**Second number** Protection against liquids
0. No protection	0. No protection
1. Protected against solid objects over 50 mm, e.g. accidental touch by hands	1. Protected against vertically falling drops of water
2. Protected against solid objects over 12 mm, e.g. fingers	2. Protected against direct sprays of water up to 15° from the vertical
3. Protected against solid objects over 2.5 mm (tools + wires)	3. Protected against sprays 60° from the vertical
4. Protected against solid objects over 1 mm (tools + small wires)	4. Protected against water sprayed from all directions – limited ingress permitted
5. Protected against dust – limited ingress (no harmful deposit) permitted	5. Protected against low pressure jets of water from all directions
6. Totally protected against dust	6. Protected against strong jets of water, limited ingress permitted
	7. Protected against the effects of immersion between 15 cm and 1 m
	8. Protected against long periods of immersion under pressure

CONTENTS

BSEN 60529 – IP Codes vii

1. SAFETY 1
1.1. Personal safety 1
1.1.1. Accidents 1
1.1.2. Fire 2
1.1.3. Extinguishers for electrical fires 2
1.1.4. Electric shock 2
1.1.5. Working with electrical equipment 3
1.2. Building safe equipment 4
1.2.1. The Health and Safety at Work Act (HSAW) 4
1.2.2. Standards 4
1.2.3. The IEE Regulations (BS 7671) 6

2. DRAWINGS 7
2.1. Types of drawing 7
2.1.1. Circuit diagram 7
2.1.2. Wiring diagram 7
2.1.3. Wiring schedule 8
2.1.4. Block diagram 8
2.1.5. Parts list 8
2.2. Symbols 9
2.2.1. Conductors 9
2.2.2. Connectors and terminals 10
2.2.3. Inductors and transformers 10
2.2.4. Resistors 11
2.2.5. Capacitors 12
2.2.6. Fuses 12
2.2.7. Switch contacts 13
2.2.8. Switch types 14
2.2.9. Diodes and rectifiers 14
2.2.10. Miscellaneous symbols 15

3. WIRE TYPES AND PREPARATION 17
3.1. Insulation materials 17
3.2. Conductors 18
3.3. Wire specifications 18
3.4. Standard wire gauge 19
3.5. Coaxial and screened wire 19
3.5.1. Coaxial 19
3.5.2. Screened 19
3.6. Multiway cables 20
3.7. Insulation removal 21
3.7.1. Adjustable hand tool 21
3.7.2. Hand-held automatic 22
3.7.3. Non-adjustable 23
3.7.4. Cable strippers 24
3.7.5. Fault prevention 25

4. SOLDERING AND TERMINATION 26
4.1. Soldering equipment 26
4.1.1. The soldering iron 26
4.2. Solder 28
4.2.1. Using solder 28
4.3. Forming the wire 28
4.4. Soldering the joint 29
4.4.1. Checking solder joints 30
4.4.2. Soldering stranded wire 30
4.4.3. Checking your soldering iron 31
4.4.4. Safety aspects of soldering 32
4.5. Crimped joints 33
4.5.1. Crimp connectors 34
4.5.2. Crimping tools 35
4.5.3. Hand tools 36
4.5.4. Bootlace ferrules 37
4.5.5. Insulated eyelets and spades 39
4.5.6. Inspection 39
4.6. Screw clamp terminals 40
4.7. Terminating coaxial cable 41
4.7.1. Stripping 41
4.7.2. Making a 'pigtail' 41
4.7.3. Making an insulated pigtail 42
4.7.4. Fitting a BNC coaxial plug 43
4.7.5. Fitting a push-fit coaxial plug 45
4.7.6. Fitting a coaxial socket 46

5. CABLE FORMING 47
5.1. Cableforms 47
5.1.1. Wiring schedule 47
5.1.2. Template 47
5.1.3. Run-out sheet 48
5.1.4. Cableform binding 48
5.2. Continuous lacing 49
5.2.1. Start knots 49
5.2.2. Lock stitch 50
5.2.3. Double knot 51
5.2.4. Finish knot 52
5.3. Breakouts 52
5.3.1. Lacing breakouts 53
5.3.2. Lacing 'Y' breakouts 54
5.3.3. Lacing 'T' breakouts 55
5.4. Spot ties 56
5.4.1. Lacing cord 56
5.4.2. Cable ties 56
5.5. Laying the wires 56
5.6. Twisted pairs 58
5.7. Cable markers 60

6. CONNECTIONS AND ROUTING **62**
6.1. General 62
6.1. Conductor and cable runs 66
6.1. Conductors different circuits 67

7. HARDWARE **68**
7.1. Component mounting rails 68
7.2. Plastic trunking 69
7.3. Connector blocks 72
7.3.1. Clip-on terminals 72
7.4. Screw terminals 75
7.4.1. Barrier strips 75

8. COMPONENTS (ACTIVE) **76**
8.1. Contactors and relays 76
8.1.1. Electrical specification 77
8.1.2. Relay operating coil symbols 78
8.1.3. Relay contacts symbols 79
8.1.4. Physical details 80
8.1.5. Power control relays 82
8.1.6. Labelling 82
8.2. Contactors 83
8.2.1. Auxiliary contacts 84
8.2.2. Interlocks 84
8.2.3. Protective units 85
8.2.4. Labelling 86
8.2.5. DIN rail mounting 87
8.3. Transformers 88
8.3.1. Symbols 88
8.3.2. Physical details 90
8.3.3. Markings 91

9. COMPONENTS (PASSIVE) **92**
9.1. Fuses 92
9.1.1. Soldering recommendations 92
9.1.2. Symbols 93
9.1.3. Panel-mounted fuses and holders 93
9.1.4. Chassis-mounted fuse holders 94
9.1.5. Fuselinks 94
9.2. Resistors 96
9.2.1. Symbols 96
9.2.2. Fixed resistors 96
9.2.3. Variable resistors 97
9.2.4. Resistor colour codes 99
9.2.5. Resistor value markings 100
9.2.6. Temperature coefficient of resistance 101
9.2.7. Alphanumeric resistor code 101
9.2.8. Preferred values 102
9.2.9. Variable resistor markings 102
9.3. Capacitors 103
9.3.1. Symbols 103
9.3.2. Physical details 103
9.3.3. Polarity 105
9.3.4. Connections 105
9.3.5. Construction 106
9.3.6. Specification 106
9.3.7. Materials 106
9.3.8. Capacitance values 107

10. SWITCHES AND LAMPS **108**
10.1. Switches 108
10.1.1. Moulded one-piece 108
10.1.2. Modular 108
10.1.3. Switch actuators 109
10.1.4. Switch actions 109
10.1.5. Switch adaptors 110
10.1.6. Switch contacts 110
10.1.7. Rotary switch diagrams 111
10.2. Lamps 112

11. EARTHING AND SCREENING **114**
11.1. Earthing – the protective bonding circuit 114
11.1.1. Operational bonding 118
11.1.2. Cabinet earthing 119
11.1.3. Earth continuity conductor 119
11.2. Screen connections 120
11.3. System earth terminals 120

12. PLC WIRING **121**
12.1. Installation 122
12.2. Power supply wiring 123
12.3. Earthing 123
12.4. Wiring of inputs and outputs 124

Index **125**

此为试读,需要完整PDF请访问: www.ertongbook.com

1. SAFETY

1.1. Personal safety

Concern for your own safety as well as the safety of others should always be on your mind. Most safety procedures are common sense but, because some hazards are not obvious, there are regulations born out of experience which are designed to make the workplace safer.

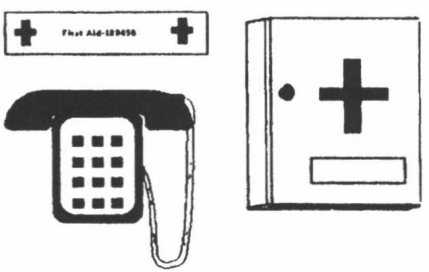
There are two aspects of safety which concern us in the assembly of electrical equipment and control panels.

The first concerns your own personal safety. In the words of the *Health and Safety Regulations*:

- the need to use safe working practices and safety equipment to avoid the risk of injury to yourself and to others in the course of your work.

While it is beyond the scope of this book to cover the detail of all the safety precautions and safe working practices which should be adopted, there are some general points which can be noted.

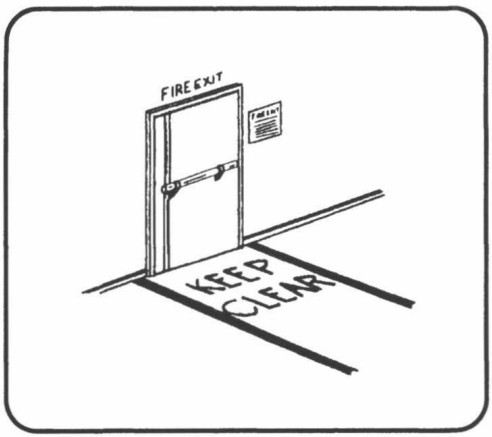
- Safety equipment, e.g. goggles, gloves, etc., should be provided and *must be used* where they are appropriate.
- The onus is on you to use the safety equipment provided by your company. Any damage to safety gear should be reported. Safe working practices are part of any job and you should always learn and adopt them as a natural way of working.
- Don't take shortcuts which compromise your safety, or that of anybody else.
- You should make yourself aware of the procedures used at your place of work to prevent accidents and to deal with common incidents.
- You should know how to isolate electric supplies and how to work safely on electrical circuits.



1.1.1. Accidents

- Know how to contact the correct person – *the designated first aider* – for help.
- Find out the location of the nearest first aid box.
- Know how to isolate electric supplies and how to release a person safely from contact with electricity.

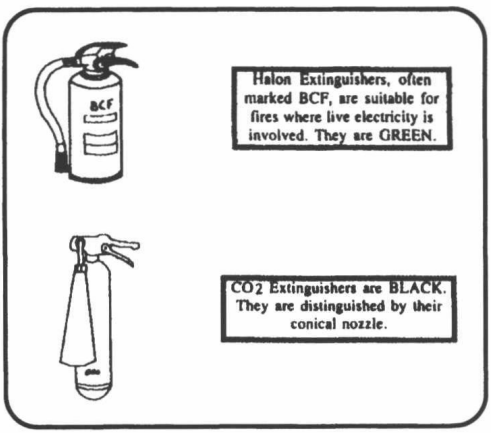
1. SAFETY



1.1.2. Fire

Before commencing work on electric plant, you should know:

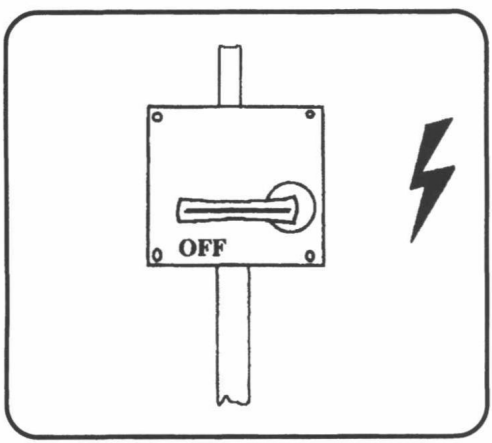
- Where is the nearest fire alarm activator, fire exit and fire extinguisher?
- Are the fire exits clear of equipment or rubbish?



1.1.3. Extinguishers for electrical fires

Be aware that *special extinguishers* are needed for fires which occur in *live electrical equipment* – do not use water-based extinguishers.

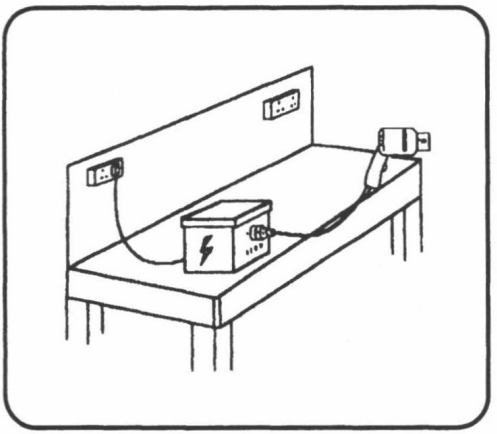
- RED extinguishers are water-based for wood/paper/cloth/plastic fires only.
- GREEN extinguishers are halon or BCF-based for general fires (not gases) including electrical fires.
- BLACK extinguishers are CO_2-based for flammable liquids and electrical fires.



1.1.4. Electric shock

Learn the basic first aid action drill.

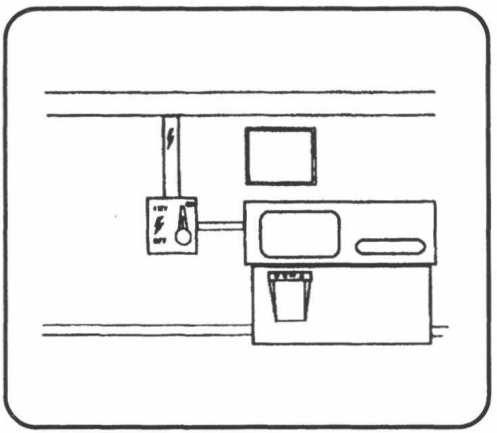
- *DO NOT TOUCH* the victim with your bare hands until the power is off or they have been pulled away from contact otherwise you will get a shock as well.
- Switch off the power and drag the victim off the live conductor.
- Alternatively if you cannot switch off then use something *non-conducting* to move the victim away from contact. Dry wood, plastic tubing (PVC conduit) even a dry piece of cloth folded several times will do.



1.1.5. Working with electrical equipment

Many of the tools we use are electrically powered, some by the mains, some by battery.

- Mains-driven portable tools should be connected to the supply through an isolating transformer.
- These are usually 110 V systems which reduce the effect of electric shock.



- Heavier, fixed machines are wired into the three-phase factory supply. This is 415 V and there are stringent safety regulations governing its installation and use.

Remember . . .

- Do not take liberties or chances with electricity.
- Don't interfere with electrical apparatus, i.e. use it as intended and don't remove any covers or panels.
- Don't use or tamper with electrical machinery and tools that do not concern you. Leave switches and buttons alone. If you want to know how something works then ask someone who is authorised to show you.
- Take care when using portable electric power tools since these cause the highest number of accidents in the workplace. Accident possibilities range from tripping over a carelessly laid power cord to getting swarf in your eye because you didn't wear eye protection.

1.2. Building safe equipment

The second aspect of safety concerns the requirement to:

- design, construct and use electrical equipment so that it is safe and does not give rise to danger even should a fault occur.

The designer of the equipment will have taken into account all these concerns in specifying the parts to be used, the wire types and colours, the type of enclosure and so on. Our part comes in ensuring that:

- no parts are to be substituted without an engineering change notice;
- manufacturers' instructions for any component must be followed.

Both of these aspects are statutory requirements laid down in law in a number of regulations.

1.2.1. The Health and Safety at Work Act (HSAW)

This is a wide-ranging Act of Parliament covering all aspects of safety at work. It has gradually replaced the Factories Act.

The HSAW allows for the introduction of regulations to control particular aspects of safety at work. These regulations, which must be complied with, are often produced because of European Directives, which in turn are designed to harmonise the safe working conditions for all members of the European Community.

Among the many regulations within the Act, some have a direct influence on the machinery control panels which we are interested in, for example:

- The Electricity at Work Regulations 1989.
- The Provision and Use of Work Equipment.
- The Supply of Machinery (Safety) Regulations.
- The Electrical Equipment (Safety) Regulations.

These affect other areas of safety besides those which concern us here and it is outside the scope of this book to go into any real detail on them. However, you may find it useful to consider how they affect the way we build these panels and the components we use in them.

1.2.2. Standards

A standard is a document specifying nationally or internationally agreed properties for manufactured goods and equipment.

Regulations and standards are two different things: regulations are the law and must be complied with; standards on the other hand are advisory. They are closely linked together.

Equipment sold in the EEC must be 'CE marked' to show that it complies with the regulations that are concerned with its safety. As part of this process the manufacturer must show how the risks and hazards that the equipment will present have been overcome or protected against. This information is placed in the Technical Document of the equipment so that it can be inspected should there be a query by the authorities regarding the equipment's safety or performance.

The best way to show compliance with a regulation is to use recognised standards in the design and construction of the product, thereby fulfilling the requirements of the regulation.

The British Standards Institute (BSI), as well as other European and international bodies, publish standards which give recommendations and guidance on – amongst other things – the selection and use of various electrical components and cables.

There are three types of standards that are important to us:

- British Standards (BS),
- European Harmonised Standards (EN or BS EN),
- International Standards (IEC).

These are of course mainly the concern of the designer but it is as well to be aware that they exist, as it may explain why one component is used instead of another and why only those components designated in the parts list must be used.

Standards of most importance to us are:

- BS EN 60204 – Safety of Machinery – Electrical Equipment of Machines,
- BS EN 60947 (IEC947) – Low Voltage Switchgear and Controlgear (7 Parts).

1. SAFETY

BS EN 60204 covers the way in which the electrical equipment should be constructed and includes everything from the selection of components, through the sizes, types and colour of the wiring, to the electrical tests that should be done on the finished equipment. Within BS EN 60204 there are references to other standards, including BS EN 60947, that will give more detail on individual parts or components.

BS EN 60947 and the international standard IEC 947 are in seven parts, giving the specification and other requirements of the individual components we will use in the equipment.

- Part 1: General Requirements. Defines the rules of a general nature to obtain uniformity in requirements and tests.

Each of the following parts deals mainly with the characteristics, conditions for operation, methods for testing and marking requirements of the various electrical components.

- Part 2: Circuit-breakers.
- Part 3: Switches, disconnectors, switch-disconnectors and fuse combination units.
- Part 4: Contactors and motor starters including short circuit and overload protection devices.
- Part 5: Control circuit devices and switching elements.
- Part 6: Multiple function equipment such as that used for automatic emergency power switching.
- Part 7: Ancillary equipment such as terminal blocks used to connect copper conductors.

Basically our control equipment panels should be built to conform to the requirements of BS EN 60204 using components manufactured to conform to the requirements of BS EN 60947 and other related component standards and approvals.

An approved component is one whose manufacture and performance has been checked and proven to meet the specifications set by the standards authority of an individual country. For example, a part approved in the UK would be 'BS approved'. These approvals may be important if the equipment is to be exported.

Some other standards authorities are:

- USA ANSI – approvals are made by the Underwriters Laboratory and marked UL.
- Canada, CSA.
- Denmark, DEMKO.
- Italy, CEI.
- Norway, NEMKO.
- Germany, DIN/VDE.
- France, NF/UTE.
- Europe, CENELEC.

Some other BSI documents

- PD 2754: Parts 1 and 2. Published document. Construction of electrical equipment for protection against electric shock. Part 1 deals with the classification of electrical and electronic equipment with regard to protection against electric shock, for example whether it is earthed, double insulated or uses a safe, low voltage supply. Part 2 is a more detailed guide to the requirements of the various classes as defined in Part 1.
- BS 7452: Specification for transformers of the type used in control panels. Equivalent to IEC 989: Control transformer specification.
- BS 3939: Graphical symbols. Provides comprehensive details of the symbols to be used in electrical, electronic and telecommunication diagrams. It is published in 12 parts and is broadly the same as EN 617 – Parts 2 to 12.
- BS EN 60073: Colours for indicator lamps, push buttons, etc. Provides a general set of rules for the use of certain colours, shapes, positioning requirements of indicators and actuators to increase the safety and operational efficiency of equipment. BS EN 60204 also provides guidelines specific to the electrical controls for machinery.
- BS EN 60529: Specification for classification of degrees of protection provided by electrical enclosures. Also known as 'IP Codes', it uses a

two or three digit number to define to what degree the enclosure is sealed to protect the contents against dust, moisture and similar damaging substances.

- BS 6231: Specification for PVC-insulated cable for switchgear and controlgear wiring. This deals with the requirements for the wires and cables used in the wiring of control panels up to 600 V/1000 V.

1.2.3. The IEE regulations (BS 7671)

The Institute of Electrical Engineers publishes its Regulations for Electrical Installations, which cover the design, selection and construction of electrical installations in buildings generally, and provide guidance for safety in the design and construction of electrical equipment. Although mainly concerned with electrical systems in buildings, the information is applicable to machine control panels because they will be connected to the building's electrical system. These are now published as BS 7671.

In addition there are:

- Guidance Notes from the Health and Safety Executive.
- Specifications and Regulations from the Department of Trade and Industry, BSI and the Institute of Electrical Engineers.

You may be interested to know that all the standards referred to here concern 'low voltage' equipment. Low voltages as defined by the IEE are those up to and including 1000 volts AC or 1500 volts DC.

此为试读,需要完整PDF请访问: www.ertongbook.com