BTEC Level 3

edexcel
advancing learning, changing lives

ENGINEERING LEVEL 3

BTEC National

Ernie Cooke | Robert Jones | Bill Mantovani
David Roberts | Bryan Weatherill
Series editor: Andy Boyce

A PEARSON COMPANY

Published by Pearson Education Limited, a company incorporated in England and Wales, having its registered office at Edinburgh Gate, Harlow, Essex, CM20 2JE. Registered company number: 872828

www.pearsonschoolsandfecolleges.co.uk

First published 2010

13 12 11 10

10 9 8 7 6 5 4 3 2 1

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

ISBN 978 1 84690 724 1

Development editing by Paul Stirner (DSM Partnership)
Designed by Wooden Ark
Original illustrations © Pearson Education Limited 2010
Illustrated by TechSet and Steve Moulds (DSM Partnership)
Cover design by Visual Philosophy, created by eMC
Cover images Corbis: Bill Varie/Surf
Picture research by Alison Prior and Pearson Education Limited
Index by Indexing Specialists (UK) Ltd
Printed and bound in the UK by Scotprint

Hotlinks

There are links to relevant websites in this book. In order to ensure that the links are up to date, that the links work, and that the sites are not inadvertently linked to sites that could be considered offensive, we have made the links available on the following website: www.pearsonhotlinks.co.uk. When you access the site, search for either the title BTEC Level 3 National Engineering or the ISBN 978 1 84690 724 1.

Disclaimer

This material has been published on behalf of Edexcel and offers high-quality support for the delivery of Edexcel qualifications. This does not mean that the material is essential to achieve any Edexcel qualification, nor does it mean that it is the only suitable material available to support any Edexcel qualification. Edexcel material will not be used verbatim in setting any Edexcel examination or assessment. Any resource lists produced by Edexcel shall include this and other appropriate resources.

The suggested activities in this book that involve practical work and exposure to hazards must be risk assessed and supervised by a qualified staff member.

Standards are current at the time of publication, unless otherwise indicated, but may be subject to change during the life of the book. Please check with the relevant standards organisations.

Copies of official specifications for all Edexcel qualifications may be found on the Edexcel website: www.edexcel.com

Contents

Credits

The publisher would like to thank Mark Shenton for his help and advice on this project.

Picture credits

The publisher would like to thank the following for their kind permission to reproduce their photographs:

(Key: b-bottom; c-centre; l-left; r-right; t-top)

Alamy Images: Alan King 249, Andres Rodriguez 3, Andrey Kekyalyaynen 65, Antony Nettle 69, Art Kowalsky 290, Creativeact-Education Services 105, David J Green 21, Dennis Hallinan 306, Dmitry Erokhin 71, Glenn Murray 263, Imagebroker 303, Jim Holden 11, Juice Images 35, Matthew Richardson 9, Nicola Asuni 123, Office 183, Photostock-Israel 374, Susan E Degginer 307, Trigger Image 241; **Andy Boyce**: 361; **Claudio Bacinello/Photographers Direct**: 72; **Corbis**: Construction Photography 4, Rachel Frank 39; **David Green/ Photographers Direct**: 212, 215; **David Roberts**: 292; **Getty Images**: Chris Ryan / OJO Images 63, Kalim Saliba 156, Reportage 291; **Graham Hare**: 359; **Health & Safety Executive**: 7; **iStockphoto**: Thomas Perkins 54, Paul Prescott 40; **Pearson Education Ltd**: David Sanderson 22tl, 22tr, 22l, 22r, 22bl, 22br, Gareth Boden 107; **Peter Garwood/Photographers Direct**: 368; **Press Association Images**: Larry McDougal / The Canadian Press 230; **Science & Society Picture Library**: 355; **Science Photo Library Ltd**: Andrew Brookes National Physical Laboratory 147, Andrew Lambert Photography 199, 201, 351, Lockheed Martin Corporation / NASA 138, Martyn Chillmaid 188, Maximilian Stock 294, Pasieka 209, Rosenfield Images 347, Sheila Terry 185, 298; **Shutterstock**: Andresr 237, Edyta Pawlowska 305, Jesper Skov 261, Ronen 345, StD 229, Stocklite 227, Hano Uzeirbegovic 44; **Thinkstock**: Brand X Pictures 301, Comstock 37, 265, 349, Creatas 67, Digital Vision 1, 145, Hemera 187, 287, iStockphoto 22cl, 22cr, 103, 225, Pixland 149; **Tomislav Stajduhar/Photographers Direct**: 354; **Warren McConnaughie/Photographers Direct**: Warren McConnaughie 27

Cover images: *Front*: **Corbis**: Bill Varie / Surf
Back: **Science Photo Library Ltd**: Andrew Brookes National Physical Laboratory

About the authors

Andy Boyce has 30 years of further education experience, teaching, assessing and managing engineering programmes from Level 2 to Level 5. His previous writing experience includes producing material for BTEC in a Box and Pearson Education's materials for the Engineering and Manufacturing Diplomas. He has also written downloadable tutor support material for Edexcel.

For a considerable number of years he has worked as an external verifier and is also a principal moderator. He has provided input to the transition of the engineering programmes from NQF to QCF and now provides training to centres to help them achieve the transition. He is a BTEC standards verifier.

Ernie Cooke has spent all of his working life in the engineering industry, starting with an apprenticeship in the structural steelwork and mining engineering industry. This was followed by employment as a craftsman in the agricultural machinery, commercial vehicle, industrial acoustics and industrial belt manufacture industries. He has taught in further education for 25 years, teaching in engineering disciplines at all levels.

Robert Jones started his career in engineering with a five-year apprenticeship with Frigidaire, during which he attended Hendon College of Technology. He went on to study for a Diploma in Engineering at Middlesex Polytechnic. After finishing his apprenticeship he worked for Frigidaire as a product engineer and later for AC Delco as an experimental engineer.

His teaching career started at Riversdale College of Technology, teaching a wide variety of engineering subjects. He joined the Kenya Polytechnic as a lecturer in mechanical engineering in 1979, later leaving to study for a Master of Science Degree in Mechanical Engineering at the University of Manchester. In 1985 he joined Mombasa Polytechnic as a lecturer, before returning to the to join North Devon College. He was until recently the BTEC programme co-ordinator for the National Engineering courses at the college.

Bill Mantovani has a long association with BTEC and delivering BTEC units but his involvement with electronics stretches back much further. He trained as an electronics engineer and was a founder member of the team that developed the electronic and digital telephone system in use today. Bill joined the team delivering BTEC courses at Wakefield College in the 1980s. He was course tutor at a number of levels, including Higher National, and eventually took on all responsibilities for a number of Higher National Diploma courses run jointly with Sheffield Hallam and Leeds Metropolitan universities. Bill is currently involved with BTEC First and National for Electrical and Electronic Engineering at Leeds City College and continues to write on his favourite subject of electronics and IT.

David Roberts is currently a course tutor for the BTEC Higher National Certificate and Diploma in Fabrication and Welding Engineering, which is taught on behalf of Teesside University at Hartlepool College of Further Education. His academic qualifications include a Batchelor's degree in Engineering along with a Higher National Certificate and Diploma in Fabrication and Welding. David specialises in teaching materials engineering and technology, theoretical and practical metallurgy, and welding metallurgy on both National and Higher National programmes. Prior to entering full-time education and lecturing, David worked as a time served engineering craftsman.

Bryan Weatherill began his career working in manufacturing engineering before completing teacher training at Garnett College and teaching at North Devon College. As an advanced practitioner and curriculum leader he was involved with the introduction of BTEC Engineering courses. As curriculum leader, he selected the teaching team and carried out the training requirements for the BTEC ethos, a new style of teaching and learning for staff and learners. He also created links with college feeder schools in their introduction of BTEC courses. He is a Registered Safety Practitioner and has specialised in the health and safety learning outcomes. He currently works in the UK and abroad as an educational, engineering and health and safety consultant.

About your BTEC Level 3 National in Engineering

Choosing to study for a BTEC Level 3 National Engineering qualification is a great decision to make for lots of reasons. This qualification will help you to build a foundation of knowledge in engineering, leading you into a whole range of professions or further study.

Your BTEC Level 3 National in Engineering is a vocational, or work-related, qualification. This doesn't mean that it will give you *all* the skills you need to do a job, but it does mean that you'll have the opportunity to gain specific knowledge, understanding and skills that are relevant to your future career.

What will you be doing?

The qualification is structured into **mandatory units** (ones that you must do) and **optional units** (ones that you can choose to do). How many units you do and which ones you cover will depend on the type of qualification you are working towards.

Qualifications	Credits from mandatory units	Credits from optional units	Total credits
Edexcel BTEC Level 3 Certificate	10	20	30
Edexcel BTEC Level 3 Subsidiary Diploma	20	40	60
Edexcel BTEC Level 3 Diploma	70	50	120
Edexcel BTEC Level 3 Extended Diploma	70	110	180

Other pathways available are:

- Electrical and Electronic Engineering
- Manufacturing Engineering
- Mechanical Engineering
- Operations and Maintenance Engineering.

For these pathways you will take the following:

Qualifications	Credits from mandatory units	Credits from optional units	Total credits
Edexcel BTEC Level 3 Diploma	60	60	120
Edexcel BTEC Level 3 Extended Diploma	60	120	180

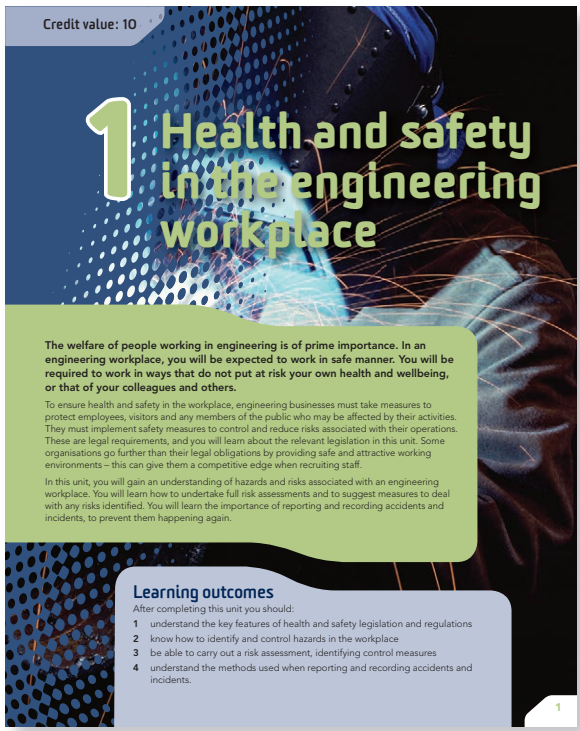
How to use this book

This book is designed to help you through your BTEC Level 3 National Engineering course.

This book contains many features that will help you use your skills and knowledge in work-related situations and assist you in getting the most from your course.

Introduction

These introductions give you a snapshot of what to expect from each unit – and what you should be aiming for by the time you finish it!


Credit value: 10

1 Health and safety in the engineering workplace

The welfare of people working in engineering is of prime importance. In an engineering workplace, you will be expected to work in safe manner. You will be required to work in ways that do not put at risk your own health and wellbeing, or that of your colleagues and others.

To ensure health and safety in the workplace, engineering businesses must take measures to protect employees, visitors and any members of the public who may be affected by their activities. They must implement safety measures to control and reduce risks associated with their operations. These are legal requirements, and you will learn about the relevant legislation in this unit. Some organisations go further than their legal obligations by providing safe and attractive working environments – this can give them a competitive edge when recruiting staff.

In this unit, you will gain an understanding of hazards and risks associated with an engineering workplace. You will learn how to undertake full risk assessments and to suggest measures to deal with any risks identified. You will learn the importance of reporting and recording accidents and incidents, to prevent them happening again.

Learning outcomes

After completing this unit you should:

1 understand the key features of health and safety legislation and regulations
2 know how to identify and control hazards in the workplace
3 be able to carry out a risk assessment, identifying control measures
4 understand the methods used when reporting and recording accidents and incidents.

1

Assessment and grading criteria

This table explains what you must do to achieve each of the assessment criteria for each unit. For each assessment criterion, shown by the grade button P1, there is an assessment activity.


BTEC BTEC's own resources

Assessment and grading criteria

This table shows you what you must do in order to achieve a pass, merit or distinction grade, and where you can find activities in this book to help you produce the required evidence.

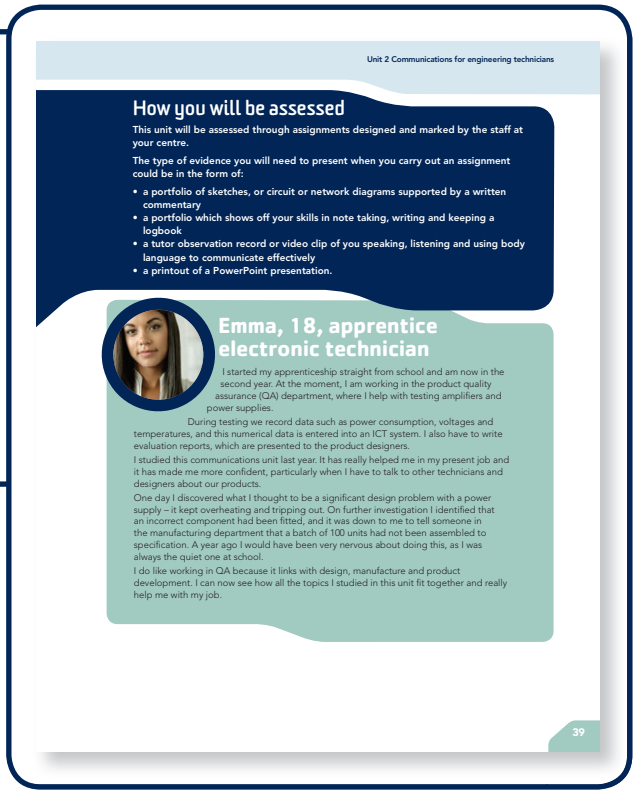
To achieve a pass grade the evidence must show that you are able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, you are able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, you are able to:
P1 prepare and maintain project records from initial concepts through to solutions that take account of changing situations **Assessment activities 3.1 page 74 and 3.6 page 102**	M1 maintain detailed, concurrent records throughout the project that clearly show the progress made and difficulties experienced **Assessment activities 3.1 page 74 and 3.6 page 102**	D1 independently manage the project development process, seeking guidance and support where necessary **Assessment activity 3.6 page 102**
P2 prepare a project specification **Assessment 3.2 page 85**	M2 use a wide range of techniques and selection criteria to justify the chosen option **Assessment activity 3.2 page 85**	D2 evaluate the whole project development process, making recommendations for improvements **Assessment activity 3.6 page 102**
P3 agree and prepare the procedures that will be followed when implementing the project **Assessment activity 3.2 page 85**	M3 evaluate the project solution and suggest improvements **Assessment activity 3.4 page 95**	
P4 use appropriate techniques to evaluate three potential solutions and select the best option for development **Assessment activity 3.2 page 85**	M4 present coherent and well-structured development records and final project report **Assessment activity 3.5 page 101**	
P5 outline the project solution and plan its implementation **Assessment activity 3.3 page 92**		
P6 monitor and record achievement over the lifecycle of the project **Assessment activities 3.3 page 92 and 3.6 page 102**		
P7 implement the plan and produce the project solution **Assessment activity 3.4 page 95**		
P8 check that the solution conforms to the project specification **Assessment activity 3.4 page 95**		
P9 prepare and deliver a presentation to a small group, outlining the project specification and proposed solution **Assessment activity 3.5 page 101**		
P10 present a written project report **Assessment activity 3.5 page 101**		

66

Assessment

Your tutor will set **assignments** throughout your course for you to complete. These may take the form of projects where you research, plan, prepare, make and evaluate a piece of work, sketchbooks, case studies and presentations. The important thing is that you evidence your skills and knowledge to date.

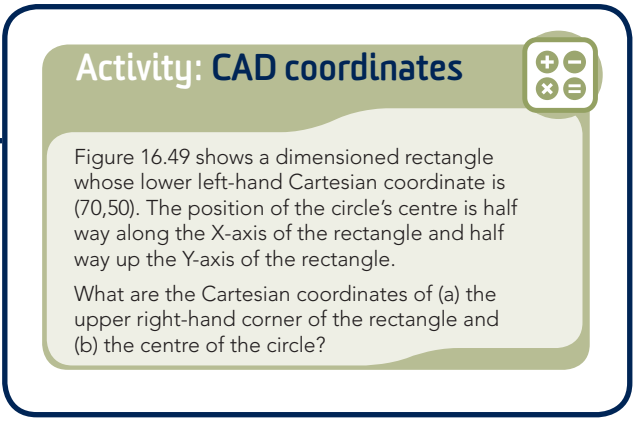
Stuck for ideas? Daunted by your first assignment? These learners have all been through it before…



Activities

There are different types of activities for you to do: **Assessment activities** are suggestions for tasks that you might do as part of your assignment and will help you develop your knowledge, skills and understanding. **Grading tips** clearly explain what you need to do in order to achieve a pass, merit or distinction grade.

There are also suggestions for **activities** that will give you a broader grasp of the industry, stretch your imagination and deepen your skills.



Personal, learning and thinking skills

Throughout your BTEC Level 3 National Engineering course, there are lots of opportunities to develop your personal, learning and thinking skills. Look out for these as you progress.

PLTS

When you were reaching the make-or-buy decision for the given product this should have involved discussion with other people. You may well have used a bit of persuasion to get your case across. In completing this assessment activity you will also show that you able to process and evaluate information when carrying out investigations.

Functional skills

It's important that you have good English, maths and ICT skills – you never know when you'll need them, and employers will be looking for evidence that you've got these skills too.

Functional skills

Carrying out costing calculations and techniques to inform make-or-buy decisions will develop your skills in mathematics (identify the situation or problem and the mathematical methods needed to tackle it).

Key terms

Technical words and phrases are easy to spot. You can also use the glossary at the back of the book.

Key terms

Nominal the stated size of some dimension. In reality, parts cannot be manufactured to a given nominal measurement, so they are produced within some specified tolerance.

WorkSpace

Case studies provide snapshots of real workplace issues, and show how the skills and knowledge you develop during your course can help you in your career.

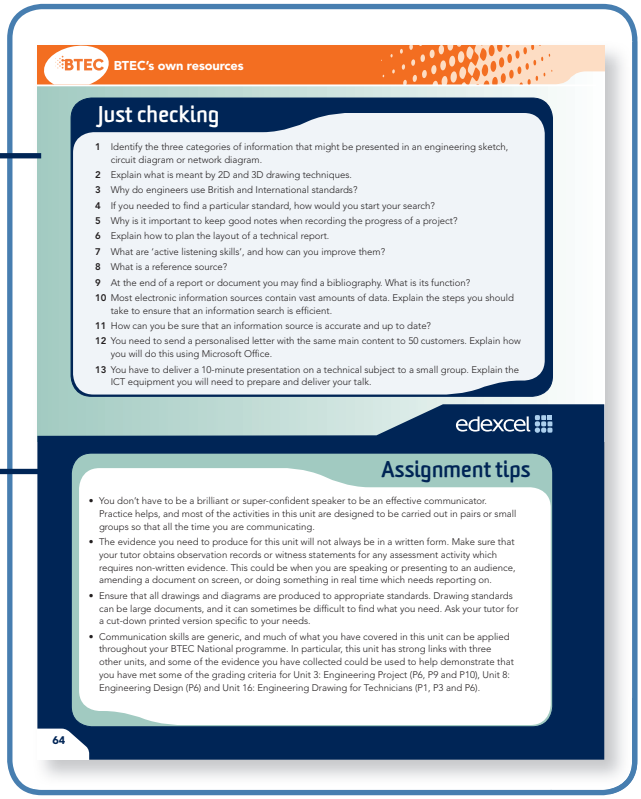
There are also mini-case studies throughout the book to help you focus on your own projects.

Just checking

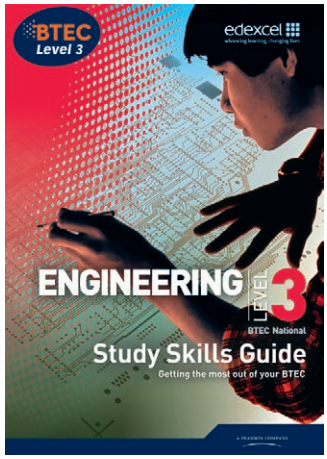
When you see this sort of activity, take stock! These quick activities and questions are there to check your knowledge. You can use them to see how much progress you've made or as a revision tool.

Edexcel's assignment tips

At the end of each chapter, you'll find hints and tips to help you get the best mark you can, such as the best websites to go to, checklists to help you remember processes and really useful facts and figures.



Have you read your **BTEC Level 3 National Engineering Study Skills Guide**? It's full of advice on study skills, putting your assignments together and making the most of being a BTEC Engineering learner.



Ask your tutor about extra materials to help you through your course. The **Teaching Resource Pack** which accompanies this book contains interesting videos, activities, presentations and information about the engineering sector.

Your book is just part of the exciting resources from Edexcel to help you succeed in your BTEC course.

Visit:

- www.edexcel.com/BTEC or
- www.pearsonfe.co.uk/BTEC2010

Credit value: 10

1 Health and safety in the engineering workplace

The welfare of people working in engineering is of prime importance. In an engineering workplace, you will be expected to work in safe manner. You will be required to work in ways that do not put at risk your own health and wellbeing, or that of your colleagues and others.

To ensure health and safety in the workplace, engineering businesses must take measures to protect employees, visitors and any members of the public who may be affected by their activities. They must implement safety measures to control and reduce risks associated with their operations. These are legal requirements, and you will learn about the relevant legislation in this unit. Some organisations go further than their legal obligations by providing safe and attractive working environments – this can give them a competitive edge when recruiting staff.

In this unit, you will gain an understanding of hazards and risks associated with an engineering workplace. You will learn how to undertake full risk assessments and to suggest measures to deal with any risks identified. You will learn the importance of reporting and recording accidents and incidents, to prevent them happening again.

Learning outcomes

After completing this unit you should:

1. understand the key features of health and safety legislation and regulations
2. know how to identify and control hazards in the workplace
3. be able to carry out a risk assessment, identifying control measures
4. understand the methods used when reporting and recording accidents and incidents.

Assessment and grading criteria

This table shows you what you must do in order to achieve a pass, merit or distinction grade, and where you can find activities in this book to help you produce the required evidence.

To achieve a **pass** grade the evidence must show that you are able to:	To achieve a **merit** grade the evidence must show that, in addition to the pass criteria, you are able to:	To achieve a **distinction** grade the evidence must show that, in addition to the pass and merit criteria, you are able to:
P1 explain the key features of relevant regulations on health and safety as applied to a working environment in two selected or given engineering organisations **Assessment activity 1.1 page 17**	**M1** explain the consequences of management not abiding by legislation and regulations and carrying out their roles and responsibilities in a given health and safety situation **Assessment activity 1.1 page 17**	**D1** justify the methods used to deal with hazards in accordance with workplace policies and legal requirements **Assessment activity 1.2 page 30**
P2 describe the roles and responsibilities under current health and safety legislation and regulations, of those involved **Assessment activity 1.1 page 17**	**M2** explain the importance of carrying out all parts of a risk assessment in a suitable manner **Assessment activity 1.2 page 30**	**D2** determine the cost of an accident in the workplace from given data **Assessment activity 1.3 page 34**
P3 describe the methods used to identify hazards in a working environment **Assessment activity 1.2 page 30**	**M3** explain how control measures are used to prevent accidents **Assessment activity 1.2 page 30**	
P4 describe how hazards which become risks can be controlled **Assessment activity 1.2 page 30**		
P5 carry out a risk assessment on a typical item/area of the working environment **Assessment activity 1.2 page 30**		
P6 suggest suitable control measures after a risk assessment has been carried out and state the reasons why they are suitable **Assessment activity 1.2 page 30**		
P7 explain the principles that underpin reporting and recording accidents and incidents **Assessment activity 1.3 page 34**		
P8 describe the procedures used to record and report accidents, dangerous occurrences or near misses **Assessment activity 1.3 page 34**		

How you will be assessed

This unit will be assessed through assignments that will be designed and marked by the tutors at your centre. Assignments are designed to allow you to show your understanding of the unit learning outcomes. These relate to what you should be able to do after completing this unit.

The type of evidence you will need to present when you carry out an assignment could be in the form of:

- **practical activities**
- **tutor observations of your practice in the workshop**
- **written reports.**

Tracy, 18-year-old engineering apprentice

This unit helped me to understand the responsibilities that are placed on people when they are at work. It was interesting to realise that everyone has responsibilities for health and safety.

I enjoyed learning about health and safety law. I learned about the hazards and the risks that arise in everyday work. It surprised me that even a computer or cleaning materials can be hazardous if they are not used correctly. I just took this for granted before. It was important to realise how everybody relies on other people to have the training and experience to do their jobs safely and correctly.

The practical tasks, such as carrying out a workplace inspection, helped me to identify common hazards. This helped me to conduct a risk assessment to show the risk factors. I also now understand why it is important to report and record all health and safety incidents – to prevent the same accidents happening time and again. All this will help me if I achieve my goal to progress into management.

1.1 Understand the key features of health and safety legislation and regulations

Start up

Why does 'health and safety' matter?

Think about the possible hazards in an engineering workshop. In this environment you could be:

- working with heavy tools
- operating machinery
- coming into contact with hazardous substances
- working alongside noisy machinery.

List ten hazards within a typical engineering workshop. Choose a workshop with which you are familiar. For each hazard, consider:

- its possible effects on you
- the training required by people in the workshop to minimise the risk it poses
- any psychological factors.

Discuss your findings in small groups. Compare the hazards you have identified and consider any common issues or problems that you uncovered.

How many hazards can you spot?

An engineering workplace can contain many hazards and pose risks to the health and wellbeing of anyone in the environment. Hazard and risk are key concepts in health and safety, and it is important that you understand these terms. A hazard is something that has the potential to cause harm to you or to someone else. For example, a substance such as acid is a hazard, as it will cause injury if it is handled by someone who is not wearing the correct personal protective equipment. A risk is the likelihood that harm will occur, and a measure of the severity of the harm that the hazard poses.

Safe working is about identifying hazards and minimising risks. There are three good reasons why safe working is important in an engineering workplace:

- cost – accidents can be expensive for employers
- morality – employers should look after their staff
- the law – there is a legal duty on everyone to work safely.

The cost of accidents at work can be very high. Employers can face the costs of accident investigation, machinery repairs and possibly lost production, and compensation payments to injured persons, legal costs and increased cost of insurance.

People's lives and wellbeing can be put at risk at work. Everybody has a moral obligation not to cause harm to others. It is not acceptable to subject people to unnecessary risk through poor health and safety systems. Training is essential – untrained workers are often not aware of the dangers in carrying out work or the risks their action can pose to others.

To reinforce these moral obligations, the law makes health and safety in the workplace a legal responsibility. Health and safety legislation places responsibilities on all persons involved in engineering activities. The legislation sets duties and roles for employers and employees.

Did you know?

You can get information about health and safety legislation on the internet. Put the words 'UK health and safety legislation' into a search engine. Make sure you only access sites that cover requirements under UK law, and always check that the information is up to date.

1.1.1 Key features of legislation and regulations

For this unit, you require an understanding of the roles and responsibilities of everyone involved in engineering. We will consider these later in the unit (see page 14), but let's start by looking at the relevant legislation and, in particular, statute law.

There have been laws on the statute books governing working conditions for over 200 years. The first, in 1802, was designed to prevent the exploitation of child workers in textile factories. Subsequently, Factories Acts were passed that extended the law to other industries and placed responsibilities on employers to maintain health and safety in the workplace. The main legal instrument for ensuring safe workplaces today is the Health and Safety at Work Act 1974.

The Health and Safety at Work Act 1974

The Health and Safety at Work Act (HASAWA) is a United Kingdom Act of Parliament. This means that it has progressed through the parliamentary system. Any person who does not comply with the act is breaking the law. Anyone suspected of breaking the law can be taken before the courts and, if found guilty, faces being fined or even sent to prison.

The Health and Safety at Work Act clearly outlines the health and safety responsibilities of everybody within an engineering business. Section 2 of HASAWA formalises the legal responsibilities of employers in respect of their employees. This means that if you are an employee of an engineering business, you are entitled to:

- safe machinery and systems of work – such as machine guards and safe procedures for operating machines so that you will not be injured
- a safe and healthy workplace – you should be provided with good welfare facilities, adequate lighting, appropriate temperatures and washing facilities at work
- a safe place of work – you will receive instruction on good housekeeping to ensure that all emergency exits are kept clear
- safe methods of storing, transporting, handling, using and disposing of substances and materials – all employees should be instructed in manual handling, the use of oils and greases, and disposing of waste, and this helps to ensure that you are not injured at work or suffer ill health
- competent and properly trained colleagues and supervisors – starting a new job in a strange environment is a challenge, but understanding the hazards that you can face is an even greater challenge, and supervisors and colleagues help you through these challenges.

Other obligations under the Health and Safety at Work Act include that employers should have a written health and safety policy as well as imposing specific responsibilities on employees. These are set out later in this unit (see section 1.1.2 on the roles and responsibilities of those involved, on page 14).

Employers also have more general legal responsibilities towards their employees.

Employment Act (EA) 2002

This legislation sets out an employer's duties and the rights of employees in respect of pay issues and general terms of employment such as Sunday working. The Employment Act also deals with maternity rights and the procedures that have to be followed for the termination of employment, and it offers some protection against unfair dismissal. Under this Act, employees have the right to be paid even if the employer has no work for them – to qualify, employees only have to have been in work for one month.

You need to know your rights when in employment. The Employment Act sets out:

- your right to belong to a trade union
- your right to be allowed reasonable paid time off work to look for another job if you are being made redundant
- your right to be paid for up to 26 weeks if you are unfortunate to be suspended from work on medical grounds
- your right to be given a minimum period of notice based on your length of service if you are being fired – however, if you have been with your employer for less than two years, this only entitles you to one week's notice of termination of employment.

Other employment rights are set out in law. The Employment Equality (Age) Regulations (EEAR) protect employees of any age from age discrimination, including contract workers and anyone in vocational training. All aspects of employment are protected from age discrimination, including recruitment, employment terms and conditions, promotion, transfer to other positions, dismissal and training. There is no statutory upper age limit on the right to receive redundancy payments or to make a claim against an employer for unfair dismissal.

This legislation – and other legislation designed to prevent discrimination at work – needs to be taken into account in a health and safety context. In general, employers cannot bar people from particular jobs because of their age or gender, but they may need to take additional health and safety measures for particular groups of employees. For example, special considerations have to be made for any activity that may adversely affect any female employee who is pregnant, such as activities that involve manual handling, the use of lead, or radiography.

Now let's return to specific health and safety legislation.

Regulatory Reform (Fire Safety) Order (RRFSO)

This order imposes a duty on employers to carry out fire risk assessments. The order also places duties on employees. If you work in an engineering business, you need to know what to do if there is a fire. Your duties in the event of a fire or other emergency are:

- to know the emergency routes and exits to a place of safety – you will be informed of these routes during the induction period when you first start work
- to turn your back on the fire and walk away, informing others in the vicinity
- to sound the alarm – this usually involves breaking the glass at a fire point at the point of exit from the building
- to make your way to the designated assembly point.

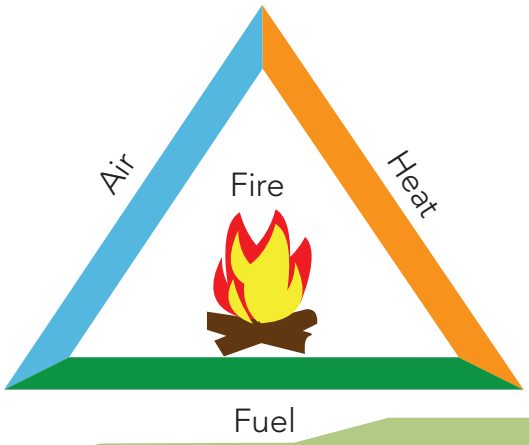
The Regulatory Reform (Fire Safety) Order (abbreviated RRFSO) requires workplaces to have fire detection and firefighting equipment. Detectors should be placed in each work area to check continuously for the presence of smoke or flames. The detectors are linked to an alarm system, which is activated when smoke or flames are detected. You will notice these detectors, usually fixed to the ceiling. They are white and sometimes display a small flashing red light.

Firefighting equipment includes extinguishers, fire hoses, fire blankets, sprinkler systems and inert gas systems. You can find these in various areas in a workplace, generally placed on emergency exit routes. Employees should not use this equipment unless trained to do so.

All detection and firefighting equipment must be maintained. You should be able to find evidence of maintenance on fire extinguishers. Ask permission to look closely at one or two extinguishers, and examine the label that keeps a record of the maintenance. When you are in an engineering workplace, check that you know the location of all firefighting equipment.

Companies must provide information about what to do in the event of a fire or other emergency to employees and to any visitors to their premises. Employees

can expect to receive training on their duties in an emergency situation. This training will start on their first day at work or during induction training.



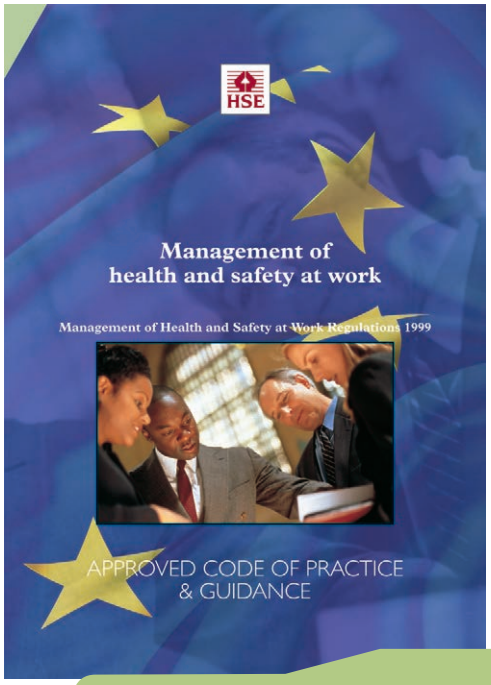
The fire triangle. You sometimes see a symbol like this displayed in workplaces. It is used as a short visual guide to preventing fires. Make sure you understand what the diagram means. If you are unsure, do some research on the internet by putting the term 'fire triangle' into a search engine.

Other health and safety legislation

There are many regulations that impose obligations on employers in respect of health and safety. Regulations are derived from European directives. The United Kingdom has been a member of the European Union since 1973 and, as it is a member state, European directives have to be implemented into UK law. This is to ensure harmonisation across all EU member states. Regulations are secondary to the Health and Safety at Work Act. However, regulations form part of UK legislation, so any person or company not complying with them is breaking the law. They can then be prosecuted under UK criminal law.

There is some guidance for employers to help them operate within the law. Approved Codes of Practice (ACOPs) provide a recognised interpretation of how an employer may comply with regulations. For example, Regulation 3 of the Management of Health and Safety at Work Regulations – the section that deals with risk assessments – can be difficult to understand due to the legal terminology. The approved codes of practice interpret the regulation in layman's terms. This makes the regulation more understandable and easier for employers to implement in the workplace. Employers must either meet the requirements set out in ACOPs, or show that they have complied with an equal or better standard.

The Health and Safety Executive (HSE) also issues guidance notes that give advice on how to comply with health and safety legislation. These have no legal standing. You will come across many HSE guidance notes in engineering. They contain more practical advice than that provided in ACOPs. For example, the HSE's guidance on the Manual Handling Regulations gives the recommended maximum weights that men and women respectively can safely hold and carry.



The approved code of practice for the Management of Health and Safety at Work Regulations. These can be obtained from the Health and Safety Executive (HSE).

The Management of Health and Safety at Work Regulations 1999

The Management of Health and Safety at Work Regulations (MHSW) apply to all workplaces, not just those carrying out engineering activities. These regulations state that the employer has the major responsibility for health and safety in the workplace, but further recognise that the employees also have responsibilities.

Regulation 3 requires that employers carry out 'suitable and sufficient' risk assessments for all activities. To

lessen the **risk**, precautions have to put into place so that employees are not injured. The aim of risk assessments is to identify **hazards** so that action can be taken to eliminate, reduce or control them, thereby helping to prevent accidents.

Regulation 4 requires that employers integrate health and safety into the management systems of the engineering companies. This ensures that employees are protected by precautionary measures that are properly planned and organised.

Provision and Use of Work Equipment Regulations (PUWER) 1998

Working in engineering involves the extensive use of machinery. The Provision and Use of Work Equipment Regulations define work equipment as any machinery, appliance, hand tool, powered tool or assembly of components.

Table 1.1: Types of work equipment

Type of equipment	Examples
Machinery	Photocopier, bench grinder, lathe, milling machine
Appliance	Car-lifting jack, microwave oven, air compressor
Hand tool	Hammer, screwdriver, spanner, chisel
Powered tool	Circular saw, industrial vacuum cleaner, electric drill
Assembly of components	Excavator, crane, concrete mixer, car assembly plant

To protect everybody who uses equipment at work, the regulations require employers to ensure that:

- all machinery is suitable and fit for purpose
- work equipment is maintained
- work equipment is inspected on a regular basis
- training and instruction is given to anyone who needs to use the equipment
- dangerous parts of work equipment are guarded as far as reasonably practicable
- controls on machinery are clearly marked
- machinery can be isolated from the electrical supply
- warning signs are fixed either on or close to machinery.

Key terms

Hazard something with the potential to cause harm, such as machinery being used by an untrained person.

Risk the combination of the likelihood that the hazard will cause damage or harm and the severity of the resulting injury.

This means businesses must select and purchase work equipment with care, paying attention to size, suitability for use and safety requirements. Engineers should check that the equipment is fit for purpose. This equipment must be properly maintained, ensuring that operatives do not hurt themselves and that machinery works efficiently.

All work equipment must be inspected on a regular basis. If you need to use a tool or carry out work on a machine, give it a check before you start work. So before you use a hammer, carry out a pre-use inspection. Check that the wooden shaft is not split and the striking face is not damaged. Before you use a grinding machine, check that the abrasive wheel is not cracked or broken and that the guards are in place. Before using any work equipment, you must also have received adequate training and instruction. It is wrong to ask someone to use work equipment without the appropriate training. If you are not sure how to use or operate any piece of work equipment, then ask someone who knows.

All machinery should have features to reduce the risk of injury. All dangerous parts of work equipment must be guarded if this is practicable. This ensures that when the machine is used correctly, it is safe. The controls on machinery should be clearly marked. The start control is green and recessed, so you have to push your finger in to switch the machine on. The stop control is red, mushroom shaped and stands proud for easy access. It must be possible to isolate any machinery from the electrical supply. Think of a kettle – it is usually switched off when not in use but not isolated. To isolate the kettle, the plug must be removed from the socket. This called an air gap.

Most machinery has warning signs fixed either on or close to the machine. It is important that you are familiar with these signs and understand what they mean. The signs can be referenced from the Health and Safety (Safety Signs and Signals) Regulations.

Supply of Machinery (Safety) (Amendment) Regulations 2005

You will find that engineering machinery, tools and other work equipment is marked or stamped with a CE mark. This mark denotes that the equipment meets European Union standards for safety. Known as harmonised standards, these are applied to a wide range of industrial equipment used in agriculture, engineering, construction, textiles and other industrial sectors.

A technical file has to be issued with the equipment. This is usually a comprehensive instruction manual, which includes:

- drawings of the machine and circuit diagrams
- technical specifications
- essential health and safety requirements
- methods to be adopted by the user to eliminate hazards when equipment is operated.

These ensure that when you operate work equipment, you are protected from all risks as far as possible.

CE

The standard CE mark shown on work equipment. This denotes that it meets EU safety standards.

Lifting Operations and Lifting Equipment Regulations (LOLER) 1998

Engineering organisations use cranes, hoists and lifting equipment for a wide range of lifting operations. You can see tower cranes being used on construction sites and forklift trucks being used in many workplaces. The Lifting Operations and Lifting Equipment Regulations (LOLER) are not industry specific and apply to most lifting operations. They place duties on employers and all persons using the equipment.

All persons operating lifting equipment must be authorised to do so. This means that they will have received appropriate training and instruction so that they can operate lifting equipment competently. This ensures safe operation, and reduces the risk for anyone working close to the lifting activity.

The lifting equipment must have the strength and stability for the planned lifting operation. Cranes, lifting accessories, forklift trucks and lorry-mounted lifting equipment are used for lifting goods, material and equipment (but not people). All these lifting devices are marked with a safe working load (SWL), and are fitted with overload protection. This sounds an alarm if the load is overweight, and the equipment should not work. All goods-lifting equipment must have a thorough examination by a competent engineer every year.

Lifts and hoists used for transporting persons are also covered by these regulations. Next time you are in a lift, look for a sign indicating the number of persons and the weight that can be carried. This is strictly controlled by an overload protection device. If the lift is overloaded, an alarm will ring and the lift will not move. Lifts are subject to a six-monthly thorough examination by a competent engineer, working on behalf of an insurance company.

When you get the opportunity, look closely at the structure of any lifting equipment and observe the size and strength of the various parts. Always ask permission first and do not approach if the equipment is being operated.

Manual Handling Operations Regulations (MHO) 1992

About a third of all reported injuries at work are the result of people using incorrect **manual handling** methods. Most engineering activities involve some form of manual handling. Working in engineering, you will be instructed and trained in the correct methods of manual handling. This is usually carried out in the first week as part of your **induction programme**.

Employers should ensure that their staff avoid manual handling any items in such a way that could cause them injury. If manual handling cannot be avoided, then a risk assessment must be carried out. This is in four parts, and involves considering:

- the task or activity that needs to be carried out
- the capacity of the individual doing the work
- the load to be moved
- the working environment.

A description of how to carry out a manual handling risk assessment is given later in this unit (see page 27).

Key terms

Manual handling the process of transporting or supporting a load (including lifting, putting down, pushing, pulling, carrying, or moving) by hand or by bodily force.

Induction programme introductory sessions and training that are provided to employees in the first few days of starting at a new place of work.

Control of Noise at Work Regulations 2005

Everybody working in an engineering environment will be exposed to noise. It is the responsibility of the employer to control noise to acceptable levels. The level of noise must be as low as reasonably practicable. Anyone subjected to excessive noise may suffer ill health, including temporary or permanent hearing loss, tinnitus, headaches or fatigue.

The Control of Noise at Work Regulations require employers to eliminate or reduce noise levels. For airborne noise, this can be achieved by installing sound absorbing shields, enclosures or coverings. If you can look under the bonnet of a car, notice the sound absorbing material immediately under the bonnet and against the bulkhead. This material looks like quilting and it is placed there to absorb the sound of the car engine. It is possible to use similar material to suppress the noise from machinery used in engineering.

Engineering organisations can take other steps to suppress noise. In particular, regular maintenance of work equipment and machinery helps to reduce noise. You would be surprised how a small amount of oil or grease applied to the right places can reduce noise.

When employees are exposed to excessive noise they should be allowed to recover in a quieter area. Any employee exposed to 80 dB – this noise level is known as the lower exposure action value – must be supplied with hearing protection. If you are likely to be exposed to this noise level, then your employer must provide you with the appropriate personal protection equipment (PPE). You must be trained in its use, storage, cleaning and replacement. At this noise level, it is your choice whether or not to wear the protective equipment. At noises levels of 85 dB and above – 85 dB is known as the upper exposure action value – employees *must* wear the supplied hearing protection. The work area must be designated a hearing protection zone and the correct signs should be displayed.

Did you know?

The ear senses sound as pressure waves travelling through the air. The ear has three parts: the outer ear, which channels pressure waves to the eardrum; the middle ear, in which eardrum vibrations are transmitted through three small bones to the cochlea; and the inner ear (the cochlea), which is filled with fluid and tiny hairs that respond to the sound and transmit signals via acoustic nerves to the brain.

Sound is measured in decibels (dB), a unit of sound pressure divided by intensity based on the threshold of hearing 0 dB. Table 1.2 shows some typical noise levels for different sound sources.

Table 1.2: Typical noise levels

Source	dB
Threshold of hearing	0
Library	> 30
Television at home	> 65–70
Engineering workshop	> 90
Activated smoke detector	> 100–105
Night club	> 105–115

Personal Protective Equipment at Work Regulations 1992

Personal protective equipment (PPE) must be supplied by an employer to protect workers. For example, if you are asked to sharpen a chisel on a grinding machine, then you must be provided with (and must wear) safety glasses or goggles to avoid eye injuries.

The choice of personal protective equipment is based on the type of hazard that the activity poses. It must be produced from appropriate material. For example, a welder wears a boiler suit made from flameproof material.

The equipment must fit the person it is supplied to, and it should be comfortable to wear. A welder must be issued with a flameproof boiler suit that is neither too small nor too large, and is made from breathable material. All PPE must be supplied free of charge and must be cleaned, repaired or replaced when not fit for use.

As an employee, you have the right under the regulations to have a say in the choice of the PPE and be trained in its correct use.

Can you identify the personal protection equipment being used in this photograph?

Electricity at Work Regulations (EAWR) 1989

Electricity is used to power machinery, lighting and work equipment in engineering. Electricity flows through circuits, which are easily controlled by switches and other electrical apparatus to ensure that machinery and lighting works efficiently and safely. However, electricity can create a hazard. Fires can be caused by sparking or arcing through faulty or overloaded electrical equipment.

Direct contact with electrical conductors can result in an electrical shock. This can cause injury, and severe shocks can be fatal. The victim can suffer electrical burns at point of contact with the electricity and point of exit, usually the hand or arm, through the body to the feet. It is therefore important to ensure that nobody touches a live bare wire.

Electricity cannot be seen or smelt, so it is vital to isolate any electrical equipment before working on it. Think of an electric kettle in a kitchen. Is it switched off or isolated? Switched off means that either the switch on the kettle is off or the switch is off at the socket on the wall. Isolated means that the plug is pulled out of the socket. In engineering terms, this is called an air gap. Electricity cannot flow through the air gap. Make sure that you know which is safer: switched off or isolated?

The Electricity at Work Regulations (EAWR) require employers to maintain all electrical systems and circuits. Inspections must be carried out regularly to look for hazards, broken sockets, loose connections, crushed cables and wires, etc. You are required to report any defects when you notice them. All circuits are required to be thoroughly inspected by a competent electrician every five years.

It is important to assess the strength and capability of circuits, as well as the insulation. Fuses are used as protection devices. Fuses or circuit breakers must be installed to withstand the effects of overloads or faults to earth. Fuses are often referred to as the weak link in a circuit. Carefully inspect the lead and plug of an electrical appliance. You will find that the plastic covering acts as the insulator, so that nobody can come into contact with the copper wires and connections inside. The copper wires inside cables and wires are highly conductive to electrical flow.

Confined Spaces Regulations (CSR) 1997

A confined space is any enclosed space where there is a specified risk of serious injury. Some enclosed spaces are easy to identify, such as deep excavations, storage tanks and poorly ventilated rooms. Other confined

spaces might be less obvious, such as silos, furnace combustion chambers and vats.

Risks from working in confined spaces arise from both hazards present in the confined space and those that may flow into the confined space, and they can include loss of consciousness due to asphyxiation.

Entry into confined spaces is hazardous. Work in confined spaces is strictly controlled by risk assessments, safe systems of work and **permits to work**. A permit to work details the work to be done and the safety precautions to be taken. It is only valid for a fixed period of time, usually eight hours.

Key terms

Permit to work a document issued to control entry into confined spaces. These are usually issued by a senior engineer for a single activity to a competent engineer, who carries out the work.

Fixtures and fittings items like electrical wiring, lighting, doors, ventilation systems, windows, carpets etc.

Emergency lighting illuminated green and white signs indicating emergency evacuation routes.

First aid treatment for preserving life and minimising consequence of injury or illness until medical help arrives and treatment for minor injuries that do not require professional medical attention.

Workplace (Health, Safety and Welfare) Regulations 1992

The Workplace (Health, Safety and Welfare) Regulations (WHSWR) are concerned with general safety and welfare in engineering workplaces. They ensure that you can enter and exit from any part of the workplace in a safe manner. The regulations also require that:

- all **fixtures and fittings** are maintained and kept clean
- the workplace atmosphere is healthy, receiving an adequate supply of fresh air
- temperatures are maintained at a minimum of 16°C for normal work and 13°C for energetic work
- lighting is the correct level for work being carried out, and there is **emergency lighting** for evacuations
- all work areas are kept clean (this is known as housekeeping)
- measures are taken to prevent falls from height, which are likely to cause injury to employees
- traffic management systems in work areas segregate vehicles and pedestrians
- welfare facilities are provided, including toilets and facilities to wash and dry hands
- fresh drinking water is provided when required.

Control of Substances Hazardous to Health (COSHH) Regulations 2002

COSHH regulations are designed to ensure the safe use and handling of hazardous chemicals in engineering. This reduces the likelihood of anyone suffering ill health or injury from coming into contact with any chemicals.

Some chemicals, such as petrol and oils, can be absorbed into the body through your skin and eyes. Others can enter your body through cuts and grazes. Chemicals can also enter your body by accidental or deliberate injection, such as from contaminated needles. Chemicals can also be swallowed. This can occur if you eat or drink while handling or using hazardous chemicals.

Airborne chemicals, such as gases, dusts and fumes, can be breathed in and enter your bloodstream through your lungs. There can also be microscopic particles in some environments, such as asbestos, which when breathed in can stay in the lungs and cause severe disease.

When using or working with chemicals:

- appreciate that some chemicals are more hazardous that others
- understand that some will harm faster than others
- always wash your hands before eating or drinking
- always use the correct type of personal protection equipment (PPE).

Did you know?

To investigate chemical hazards, information can be obtained from the internet and from the labels on chemical containers. You can also obtain information from the relevant material safety data sheets (MSDS) – these contain information on all the safety aspects related to a material, including the risk and safety phrases.

Health and Safety (First Aid) Regulations 1981

Employers have a legal requirement to provide **first aid** in the workplace. Every employer must provide adequate first-aid equipment. When you work in engineering, you must be aware of the location of first-aid boxes and know who are the first-aiders working in your area.

Anybody who works away from the main site must be supplied with a first-aid box. The law requires that first-aid boxes must be kept in delivery lorries and vans, and a travelling salesperson must have one in the car. First-aid boxes must be maintained. This means that the contents have to be topped up on a regular basis – you can check this as a list of contents is supplied with the box.

First-aiders must have a certificate of qualification, obtained by completing a four-day training course run by St John Ambulance or other recognised trainers. The certificate is valid for three years, after which first-aiders must attend a refresher course. First-aiders can give treatment and help until a injured person can receive professional medical help, but they are not allowed to give any form of medicine. You will find that many people are proud of achieving a first-aid qualification. First-aiders in the workplace are often recognised by the wearing of a badge, and they generally receive a small increase in pay for their first-aid duties.

Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995

All accidents, incidents (near misses) and dangerous occurrences in the workplace must be reported. The reporting procedure should be explained to new employees in their first few days at work.

An employer has a legal duty to report certain types of injuries, diseases, dangerous occurrences and gas releases. The reports are used by the Health and Safety Executive (HSE) to analyse health and safety trends and to compile statistics on the numbers of different types of accidents.

A responsible person, usually a manager, has to report serious accidents and incidents as soon as possible to the HSE, either by telephone or online. This same person has to complete RIDDOR form F2508, and send it to the HSE within 10 days.

An accident must be notified when a person dies or suffers a serious injury at work. Serious injuries include:

- the fracture of any bone, except a finger or toe
- amputation of any part of the body
- dislocation of a shoulder, hip, knee or spine
- permanent or temporary loss of sight
- loss of consciousness resulting from an electrical shock
- any injury requiring a stay in hospital of more than 24 hours
- acute illness or loss of consciousness due to inhalation, ingestion or absorption through the skin of any chemical
- any other injury leading to hypothermia or a heat-related illness.

If someone suffers an injury that causes them to remain off work for more than three days, then this is notifiable to the HSE.

Occupational diseases must also be notified. Diseases that are notifiable if contracted at work include:

- anthrax, which can be caught from animals
- hepatitis, caught from another person's body fluids
- legionellosis, caught from sprayed droplets of contaminated water
- leptospirosis, caught from contact with rat's urine
- tetanus, caught from contaminated soil or animals
- occupational dermatitis, caught from contact with cement dust, oils, waste materials.

Dangerous occurrences that must be notified include:

- the failure of any crane, lift, hoist or derrick
- the failure of a pressurised container, such as a tank on a compressor
- the turning over of a forklift truck.

Working Time Regulations 1998

People make mistakes when they are tired, and working excessive hours can pose safety risks. Under the Working Time Regulations all employees are entitled to regular rest breaks and days off. In most industries (there are exceptions for the armed forces, those who work at sea and some other occupations), no employee can be forced to work more than

48 hours a week on average. Anyone under 18 years of age, should not normally work more than eight hours a day or 40 hours a week.

Employees can choose to work longer hours. However, to comply with the law, there should be a written agreement between the employer and the employee stating that both parties agree to opt out of the provision setting a 48-hour limit on the working week. The Health and Safety Executive is responsible for enforcing the maximum weekly working time limit. It also monitors the provisions in regulations in respect of night work – work that takes place between 11pm and 6am.

Activity: Complying with the law

Ali is a production engineer in a small engineering company that makes racking for warehouses. This involves rolling, piercing and cutting steel to length and then spray painting the resulting steel strips. Ali has been asked to carry out an analysis of health and safety legislation and regulations to ensure that the company is complying with all relevant legislative requirements.

- How would you carry out the analysis?
- Which legislation and regulations would you expect to be applicable to Ali's company?

1.1.2 Roles and responsibilities

You should by now understand that everybody within an engineering business has some health and safety responsibilities. These are clearly outlined in the Health and Safety at Work Act 1974 and the various regulations that we have considered in this unit. More generally, we all have **common law** responsibilities to each other. The responsibility is based on a **duty of care** owed to other persons.

Employers

An employer owes you a duty of care while you are at work. If you have an accident and are injured at work, then you can seek **compensation** if you think your employer is a fault. A civil law case will decide if the accident was the result of **negligence** on the part of your employer. If proven on the **balance of probability**, you would be entitled to compensation. The level of compensation is an amount that should restore your quality of life to that you enjoyed before the accident.

You will find that all engineering organisations have a health and safety policy. This is a legal requirement. The policy should be in three parts.

- A statement of intent – one page that sets out the organisation's health and safety aims and objectives. It show the management's commitment to safe working, and should be signed and dated by the employer.
- Organisation – a description of how health and safety is organised by showing a structure of responsibility for all employees. This determines accountability and should indicate the lines of communication for health and safety issues. The allocation of responsibilities for health and safety should be given to competent employees. The whole system requires the co-operation of all employees through consultation.
- Arrangements – the nuts and bolts of the policy. This should include the procedures and systems for first aid, risk assessments, welfare requirements and consultation with employees, among others. These are legal requirements, as set out in the various regulations and the Health and Safety at Work Act.

Employees

All persons who work in engineering have roles and responsibilities for health and safety. As engineers progress through their careers, their level of responsibility generally increases. The Health and

Key terms

Common law based on the judgements made in past cases, called precedents.

Duty of care acting towards others in a manner that a reasonable person would adopt.

Compensation an amount of money paid to an injured person by an employer (or the employer's insurance company) in the event that the accident resulted from the employer's negligence.

Negligence tort, or wrong doing, of one person (or organisation) against another.

Balance of probability a less robust standard of proof than in criminal law, where cases must be proved beyond reasonable doubt.

Case study: Mustapha Mohammad

Mustapha, a 17-year-old apprentice engineer, suffered a horrific accident at work while operating a drilling machine. The little finger on his left hand was drawn into the rotating chuck, causing severe lacerations and a broken finger. As a consequence, Mustapha's finger had to be amputated close to his hand.

Mustapha had received no training on the machine – he was just told to go and drill the holes in a metal plate. He was not supervised while using the drilling machine, and an investigation revealed that the machine was running at too high a speed for the size of the drill bit in the chuck.

The engineering company was prosecuted for breaches of the Health and Safety at Work Act and Mustapha eventually received compensation for the loss of his finger.

1 Explain why Mustapha's company faced both criminal proceedings and a civil action in this case.

2 Describe the different levels of proof that are required in criminal and civil proceedings under UK law.

Safety at Work Act requires the involvement of employees and sets out the part that they have to play.

Section 7 of the act formalises these responsibilities. Employees must take reasonable care of their own health and safety and that of others who may be affected by their acts and omissions. This means, for example, that you must wear a hard hat when necessary, you must not obstruct a fire exit, or operate a machine unless authorised. You must cooperate with your employer (and your tutors at your centre when you are in the workshops) so that the organisation can comply with legal requirements. You should report any defects in machinery and attend training sessions when instructed.

These two responsibilities – to take reasonable care and to cooperate with an employer – are reinforced in the other regulations that we considered in the first section of this unit. In general, however, you should follow these rules whenever you are in an engineering environment.

- Be aware of your responsibilities under Section 7 of the Health and Safety at Work Act.
- Be aware of the hazards and the risks from any engineering activity in which you will be engaged.
- Be familiar with the risks assessments that have been made.
- Make sure you know about any relevant regulations. If you don't know which regulations apply to your area of work, then ask somebody who knows.
- Make sure that you know how to use any work equipment. This covers any hand tool to the most complex piece of machinery, from screwdrivers to automated assembly equipment.
- If an accident or incident occurs, report it.
- Ensure that you know the emergency evacuation routes.

The Health and Safety Executive

The Health and Safety Executive (HSE) is the enforcing authority for workplace safety under powers set out in the Health and Safety at Work Act. The HSE appoints inspectors to monitor health and safety in workplaces. These inspectors have wide-ranging powers to ensure that engineering companies comply with legislation. Their role is to ensure that employees and others are protected, to enforce the law and to advise on matters related to health and safety.

The inspectors' role is defined in the Health and Safety at Work Act. They have the power to enter any workplace at any reasonable time during normal opening hours. They can take a police officer with them if they are likely to be obstructed.

They can examine and investigate any part of an employer's premises or machinery. This can involve:

- directing that a part, or the whole, of a workplace be left undisturbed – this could mean shutting down that area of the site
- taking photographs, measurements and details of any piece of work equipment or part of the site
- taking samples of unsafe articles and substances for investigation
- testing, dismantling and examining any work equipment or substance
- interviewing and taking statements from any person.

Employers must give assistance where required. Inspectors have the ultimate power, and they can demand anything within reason.

The powers of HSE inspectors extend to enforcement. They can take a variety of actions depending on the seriousness of the issue. If the issue is relatively minor, they can give advice to employers either verbally or in writing. For example, they might advise employers on how to improve their risk assessment systems.

If there is a breach of health and safety law, inspectors can issue an improvement notice. An improvement notice might be issued if risk assessments have not been carried out in part of the workplace. Employers can appeal against improvement notices, and they can continue operating as before until an appeal is heard.

If in the opinion of the inspector there is, or there is the likelihood of, a risk of serious injury to an employee, an employer would be issued with a prohibition notice. The prohibition notice stops the activity as soon as it is issued. For example, if employees are being exposed to unacceptably high noise levels caused by poorly maintained machinery, then an employer would have to shut down the offending machinery on receipt of the prohibition notice.

Inspectors can also start prosecution against an employer following a accident to a employee.

Activity: Structuring a written health and safety policy

Karen works part time as a health and safety adviser to an agricultural engineering company. She has years of experience in the industry, and she has been employed because the company has been served with an improvement notice by an HSE inspector. The improvement notice has been issued because the company has not got a current health and safety policy. This is a breach of the Health and Safety at Work Act 1974. Karen's first job is to write a company health and safety policy.

If you had to produce a health and safety policy that would be compliant with the Health and Safety at Work Act, what three headings would you use to structure the document? How would you expand on the three headings?

Other individuals

The focus in this unit has been on the roles and responsibilities of employers and employees, and the enforcement role of the Health and Safety Executive. However, you should note that other people could be affected by engineering activities. These could include visitors to the site, such as a postal worker or salesperson, neighbours (anybody living or working close to the site) and contractors, workers from other organisations that come on to the site to carry out specific work, such as builders, painters and decorators, or caterers.

Health and safety legislation applies to these individuals just as much to as to the organisation's own employees. This means that the employer has a duty of care to all people who visit the site or who might be in the vicinity and affected by its operations. Similarly, anybody visiting the site must take reasonable care and must cooperate with any health and safety requirements.

Assessment activity 1.1

P1 P2 M1

BTEC

To complete this activity, you will need to write a report that covers the features of health and safety legislation as it applies to two workplaces. You will also report on the health and safety responsibilities of those working in each workplace and the management of health and safety in each organisation.

You can select the two separate working environments to write about in your report. An appropriate choice would be to choose one electrical and one mechanical engineering work area. This will allow you to show knowledge and understanding of the health and safety issues in different workplaces. For example, you might consider:

- your place of work (if you are in work, or on an apprenticeship or work placement)
- a training workshop
- a machine shop environment
- a maintenance workshop
- the health and safety issues facing electricians working on a site.

Get some advice from your tutor before making your final decision. Then begin the process of researching and writing your report. It should be in three sections.

P1 In the first section, explain the key features of the relevant legalisation and regulations applicable to each workplace.

P2 In the second section, describe the roles and responsibilities of the employees and others involved at each workplace.

M1 In the third section, explain the management of the health and safety system within one of your selected engineering workplaces.

Grading tips

P1 You should cover at least four appropriate regulations relevant to each chosen workplace. Try to select different regulations for each workplace, as this will enable you to cover a wider range.

P2 In this section of your report, try to relate the roles and responsibilities to the legislation and regulations that are applicable in each workplace.

M1 For this grade, you need to develop your work by looking at the management of health and safety in more depth. To do this, it is not enough to simply describe the various responsibilities; you need to explain the potential consequences of managers not complying with relevant legislation and of failing to meet their responsibilities.

PLTS

If you make extensive use of the internet to seek information on the current health and safety legislation that applies to your chosen workplaces you will be demonstrating skills in independent enquiry.

1.2 Know how to identify and control hazards in the workplace

In this section we will consider how to identify hazards in engineering environments. Hazards can be broken down into different types:

- mechanical (related to machinery), such as being entangled with moving parts, suffering abrasions on grinding wheels, being crushed between moving parts, and being cut by sharp blades
- electrical, such as contact with bare conductors owing to poor maintenance
- chemical, such as inhalation of exhaust fumes or contact with waste oils and greases
- thermal, such as contact with hot parts of machinery or excessive cold from the rapid use of LPG bottles
- noise, most machinery makes some noise
- vibration, machinery under operating conditions produces vibrations
- radiation, such as heat radiated from a welding operation
- ergonomics, such as injuries or disabilities caused by the poor selection, use and maintenance of work equipment.

We will start by considering how to assess some general hazards within the workplace.

1.2.1 Within the workplace

There are several methods of assessing hazards within an engineering environment. Perhaps the best way is to analyse a task, and then rank the hazards in order of severity. For simple tasks the hazards are easily identifiable, but for more complex tasks the hazards are not easy to determine.

Table 1.3 shows how this is done for two tasks. You will see that each task has the same basic objective, splitting a corroded nut, but the two tasks employ different methods and equipment. Observe how the hazards increase when undertaking the complex task.

The table shows the different types of hazards associated with each task. All these hazards have an associated risk. You will notice that the table also lists the possible outcomes of each hazard. When you carry out a risk assessment, you will have to analyse all hazards associated with an activity or an environment and assess their associated risks. Note that you need to consider more than the environment and the equipment that will be used; it is also important that you also take into account the *methods* of working.

Use of accident data

All reported workplace accidents and incidents should be investigated to determine their causes. If you can tackle the causes of health and safety incidents, then accident rates can be reduced. Accident investigations help managers learn any lessons to ensure that dangerous practices can be eliminated.

Accident data is used both to direct the need for risk assessments and to determine risk. Because risk is

Table 1.3: Task analysis

Task type	Equipment used	Hazards	Outcomes
Simple	Cold chisel to split nut	Hitting hand with hammer Flying steel particle into eye	Bruise on hand Loss of sight
Complex	Operating pneumatic jack hammer to split nut	Flying particle into eye	Loss of sight
		Noise	Temporary loss of hearing
		Vibration	Vibration white finger
		Compressed air	High pressure air into eye, and/or high pressure air into cut on hand – embolism – could cause death
		Manual handling of equipment	Strains and sprains, or long-term muscular injuries to back

Inspection of: *Mechanical workshop*	Date: *8/10/2010*		Carried out by: *AN Other*
Fire hazards	Acceptable? Yes	Acceptable? No	Comments
Fire extinguishers: Are these the correct type?	✓		*Correct types for fire hazards in area*
Fire extinguishers: Have they been Inspected?	✓		*Records show up-to-date maintenance*
Emergency exits: Are they correctly signed?	✓		*Right safe conditions signs*
Emergency exits: Are they unobstructed?		✓	*Remove obstructions and instruct staff to keep exits clear*
Emergency exits: Do they open?		✓	*One door is very tight to open – it seems to be sticking*

Figure 1.1: Part of a health and safety inspection checklist

a product of the probability that a hazard will cause damage or harm and the severity of the resulting injury, you can use past accident data to estimate these probabilities. For example, if there have been several reports of workers suffering crushed fingers in an engineering department, this would indicate that the probability of this type of accident is quite high and you would know from the reports the extent of the injuries. This data would also highlight the need for a new risk assessment to be carried out to lessen the risk of employees getting their fingers crushed.

Inspections

It is not sufficient to monitor accident data; engineering companies also need to be proactive in monitoring all aspects of health and safety. As well as conducting risk assessments (which we consider later in this unit, see page 24), inspections are carried out on a regular basis in all engineering organisations.

As an engineering employee, you are likely to be involved in these health and safety inspections. A standard form or checklist, which covers all aspects of health and safety in the workplace, is used for consistency. Your job will be to assess each aspect for compliance, tick yes for compliance or no if there is a problem or something lacking. There should be room on the form to add comments and suggestions for corrective action. Figure 1.1 shows part of a typical inspection checklist, covering two aspects of preventing fire hazards (namely the provision of fire extinguishers and emergency exits). The full inspection form would cover all parts of the workshop (and all relevant health and safety considerations) and would extend to at least two A4 sheets.

1.2.2 Working environments

Now let's look at some specific aspects of the engineering workplace in more detail. Particular situations, such as working in confined spaces and working with mechanical machinery, have the potential to cause harm and can pose hazards that become risks. In seeking to identify and control hazards in the workplace, it is useful to consider these situations individually as each poses specific risks.

Confined spaces

In assessing the risks from working in confined spaces, you need to consider both the hazards already present in the space and those that could flow or be introduced into the space.

One obvious concern is any gases that are present in the confined space – flammable gases could result in a fire or explosion. Dangerous gases could also be introduced into the space, such as fumes when carrying out welding in the confined space. Another hazard is the potential lack of drainage, as water from excessive rain or a broken water main may flow into the confined space and this could lead to a risk of drowning.

All confined spaces must have adequate ventilation. Without proper ventilation, workers could risk losing consciousness as a result of:

- an increase in body temperature – it becomes excessively hot to work and this can be exacerbated by the need to wear personal protective equipment (PPE)
- asphyxiation – gases, fumes and vapours can build up in the confined space and displace the oxygen.

Working at height

Falls from height are a common cause of fatalities and major injuries to employees. The main causes of falls can be attributed to:

- workers and employers not recognising the risk
- a failure to use correct access equipment
- a failure to adopt a safe system of work
- employees' lack of awareness of their own capabilities or that of their equipment.

There are several steps that can be taken to reduce the risks of working at height. First, everyone must understand that all work at height is hazardous. So, if possible, avoid having to work at height by the use of some other method of access.

If working at height is necessary, ensure that the correct type of equipment is used and that safe systems of work are followed.

A safe system of work is a step-by-step procedure to ensure that employees have the appropriate level of training, instruction and supervision, and that they use the correct working methods, access equipment and materials.

Electricity

Electricity is the energy source used to power most machinery, lighting and work equipment in an engineering environment. You will probably already know the basics of electricity: electrical current is the flow of electrons through a conductor and this flow results from electrical differences, known as pressure, measured in volts. In direct current (dc) the electrons flow in one direction, in alternating current (ac) the flow reverses direction 50 times per second. Most electrical systems used in engineering operate on alternating current.

Direct contact with an electrical conductor can result in an electric shock, which can be extremely harmful. The current flowing through the body interferes with muscles and the central nervous system, and can cause internal burns, convulsions, restrictions in the respiratory system and cardiac arrest. In addition, a person can suffer electrical burns – burning marks on the skin at the point of entry and exit – from the heating effect of the current burning body tissue. Electrocution from the mains supply (230 V ac) often results in a fatality.

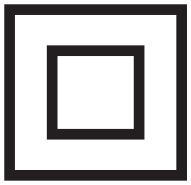
It is essential therefore to isolate any electrical equipment before working on it. This will ensure that you do not touch a bare wire that is live. Remember, electricity cannot be seen or smelt.

Although electrocution poses the greatest threat, electricity poses other hazards. Fires can be caused by sparking or arcing from faulty or overloaded electrical equipment. Circuit overloading, such as connecting too many appliances into one socket, can also cause overheating of conductors and sockets, which poses a fire hazard.

To control electrical hazards in engineering workplaces, it is necessary to:

- select suitable and adequate electrical equipment
- ensure that circuits are built using the correct materials and installed with good workmanship
- inspect, maintain and test systems regularly
- only use circuits up to designed current loading
- isolate any circuit before maintenance.

There are other steps that can be taken to improve safety. Equipment can come with double insulation. This offers additional protection in portable equipment by providing layers of insulation built around live electrical parts. Look carefully at electrical drills and saws for a double box sign. Equipment should show recognised standard marks for compliance to CE and double insulation requirements.



The symbol indicating that equipment comes with double insulation.