Work-Based Learning

Level 1
NVQ/SVQ CERTIFICATE

PERFORMING ENGINEERING OPERATIONS

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ALWAYS LEARNING

PEARSON

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Introduction

Welcome to the exciting and challenging world of engineering!

The world that we live in and the machines and systems that we depend on were all designed, built and maintained by engineers. The cars, ships, trains and aircraft that we travel in and the phones that we rely on are all examples of the work of engineers. Think what life would be like without these things!

Engineers drive key technological change. They are in the front line in moving the UK, and other European countries, from a society dependent on high carbon, low security energy to a mix of wind, wave, nuclear, solar and carbon capture energy sources. We urgently need this change to be made, making engineers all the more important in the modern world.

Engineering is a thriving sector of UK industry. It offers a very wide range of employment opportunities and is one area where there is no shortage of jobs. As an aspiring engineer you should be constantly questioning how and why things work the way they do and how they could be improved. We hope that this book will become a key part in this process.

About Performing Engineering Operations

Performing Engineering Operations (PEO) is an ideal first qualification in engineering that supports the delivery and assessment of the basic skills and knowledge required by a range of industries. PEO is available with qualifications at Levels 1 and 2 and leads to a variety of pathways in line with the specific requirements of industrial sectors. This includes aerospace, transportation, and general manufacturing.

PEO is part of a long-established and highly respected framework of National Vocational Qualifications (NVQ). Many young people enter employment each year having followed the NVQ route and employers recognise the value of these qualifications in providing them with a competent and effective workforce.

About this book

This book has been produced to help you build a sound knowledge and understanding of all aspects of the NVQ in Performing Engineering Operations. The topics in this book cover all the information you will need to attain the three core Level 1 units together with eight of the most popular optional units. Each chapter of the book relates to a particular unit and provides the information needed to form the required knowledge and understanding of that area. It can be used for any awarding organisation's qualification including Edexcel, EAL and City & Guilds.

The book has been written by a team of experienced authors and trainers who have many years of experience within the engineering sector. They aim to provide you with all the necessary information you need to support your studies and to ensure that the information is presented in a way that makes it both relevant and accessible.

About the authors

Terry Grimwood is a lecturer in electrical installation and technology at Oaklands College St Albans. He has taught PEO courses for many years and his Level 1 learner workbook earned him praise from both Ofsted and City & Guilds. Previously he worked for many years in the electrical industry, both for contracting companies and for BT. He is a published author of fiction, with three books and numerous short stories. His first novel *Bloody War* is available from Eibonvale Press.

Mike Tooley is a technical author and consultant. He was formerly Dean of the Faculty of Engineering and Vice Principle at Brooklands College in Surrey, where he was responsible for the delivery of learning to over 9000 further and higher education students. Originally trained as an electronic engineer, Mike is now the well-known author of several popular engineering and related text books, including widely adopted course texts for BTEC, A-Level, GCSE, Diploma and NVQ qualifications in Engineering.

Richard Tooley is a lecturer, Course leader and ILT Champion at Chichester College. He has taught engineering at all levels from Entry to Degree across a range of disciplines. Previous publications include resources to support BTEC Level 2 and 3 qualifications as well as articles in national engineering magazines. A keen innovator, his passion for engineering and education drives him to aim to create work that can truly inspire and enthuse today's young engineers.

Stephen Scanlon is a lecturer in Engineering at Chichester College and the Program Manager for the engineering apprentices there. He previously worked as a school teacher and in other further education establishments, teaching engineering since 1997, including NVQ, Technical Certificate, BTEC, GNVQ, Diploma, Foundation Degree and GCSE. He started his career as a production technician but has worked in prototype and small batch manufacture, machine tool repair and as a fabrication welder.

Stephen would like to thank his wife for her great support during this project.

Qualification mapping grid

This table maps the content of this book to some of the most popular awarding organisations.

Chapter	EAL	Edexcel	City & Guilds
1. Working safely in an engineering environment	QPEO1/001	L/600/5781	301 D/103/8765
2. Working efficiently and effectively in engineering	QPEO1/002	M/600/5899	302 H/103/8766
3. Using and communicating technical information	QPEO1/003	D/600/5901	303 K/103/8767
4. Wiring electrical equipment and circuits	QPEO1/020	K/600/5769	320 K/103/8784
5. Assembling electrical wiring support systems	QPEO1/021	T/600/5774	321 M/103/8785
6. Assembling and wiring electrical panels	QPEO1/022	J/600/5777	322 T/103/8786
7. Assembling electronic circuits	QPEO1/023	J/600/5780	323 A/103/8787
8. Making components using hand tools and fitting techniques	QPEO1/004	H/600/5902	304 M/103/8768
9. Using lathes for turning operations	QPEO1/007	L/600/5912	807 M/103/8771
10. Carrying out sheet metal cutting, forming and assembly activities	QPEO1/012	R/600/5930	312 L/103/8776
11. Using manual metal arc and manual oxy-fuel gas welding equipment	QPEO1/015 QPEO1/018	F/600/5938 T/600/5757	315 D/103/8779 318 D/103/8782

Features of this book

This book has been fully illustrated with artworks and photographs. These will help to give you more information about a concept or a procedure as well as helping you to follow a step-by-step technical skills procedure or identify a particular tool or material.

This book also contains a number of different features to help your learning and development.

Kitting up pages

These pages pick up the key health and safety areas you need to be aware of as you carry out the practical tasks the chapter contains. They also give information about the different tools you will use throughout the chapter and describe any important legislation or paperwork you will need to be familiar with.

Technical skills

Throughout the book you will find step-by-step procedures to help you practise the technical skills you need to complete to be successful in your studies (see example opposite).

Safety tips

These four features give you guidance for working safely with tools and equipment and in the workplace.

Keep It Safe

Green safety tips provide useful information about SAFE conditions in emergency situations and your personal safety.

Keep it safe

Red safety tips indicate a PROHIBITION (something you **must not** do).

Keep It Safe

Blue safety tips indicate a MANDATORY instruction (something that you **must** do).

Keep It Safe

Yellow safety tips indicate a WARNING (hazard or danger).

Key terms

These are new or difficult words. They are picked out in **bold** in the text and then defined in the margin.

Did You Know

This feature gives you interesting facts about the engineering sector.

Quick Tip

These provide small suggestions and pieces of advice for practical work, suggesting possible tips for best practice.

Hands On

These provide short activities or tasks to test your understanding of the subject.

Case Study

This feature provides examples of real-life working practice for you to read about and discuss.

Other features

QUICK CHECK

These are questions that appear throughout the chapter, relating to the recent content of that chapter to see how you are getting along.

CHECK YOUR KNOWLEDGE

This is a series of multiple choice questions at the end of each chapter, in the style of the end-of-unit tests used by some exam boards.

1 Working safely in an engineering environment

Being an engineer is a rewarding job and offers the chance to get involved in all sorts of exciting activities. However, you may be working with dangerous materials or tools and sometimes in a difficult working environment. You need to work safely, with thorough planning, carrying out the task correctly and clearing up afterwards. As an engineer, you must also know what to do in an emergency.

This chapter explores the essential working practices that will keep you and those around you safe. It also looks at the law and how it relates to your work.

In this chapter you will learn about:

- health and safety
- legislation and regulations
- risk assessment
- common hazards
- working safely
- personal protective equipment (PPE)
- warning signs
- manual handling
- fire
- emergency procedures
- first aid

Health and safety

Working in engineering might involve carrying out some dangerous tasks and working with hazardous tools and materials. Health and safety is all about being able to do your job safely. It is a legal requirement for you and your employer to follow the rules and regulations on health and safety, making sure that whatever you do in your job, you can do it as safely as possible. It is just as important that *you* understand what working safely involves. After all, the results of something going wrong could be very severe.

Key term

Legislation – a law passed by the Government that gives rules that must be followed

Legislation and regulations

There are lots of laws governing your work as an engineer. You don't need to know all the detail but you should be aware of the basic points of the main legislation.

Following the rules of health and safety is a legal requirement. If a company fails to follow these rules and regulations then those responsible could be prosecuted, fined or even imprisoned.

The Health and Safety Executive (HSE) is a government agency that designs, implements and monitors health and safety. A HSE inspector can visit a place of work at any time to check that all is well. They have the power to change the way things are done. If things are really bad they can completely close a company down if they feel that there is a severe threat to the health and safety of its staff. Inspectors would also be sent to a place of work to investigate the causes of a serious accident or if allegations have been made of unsafe practices.

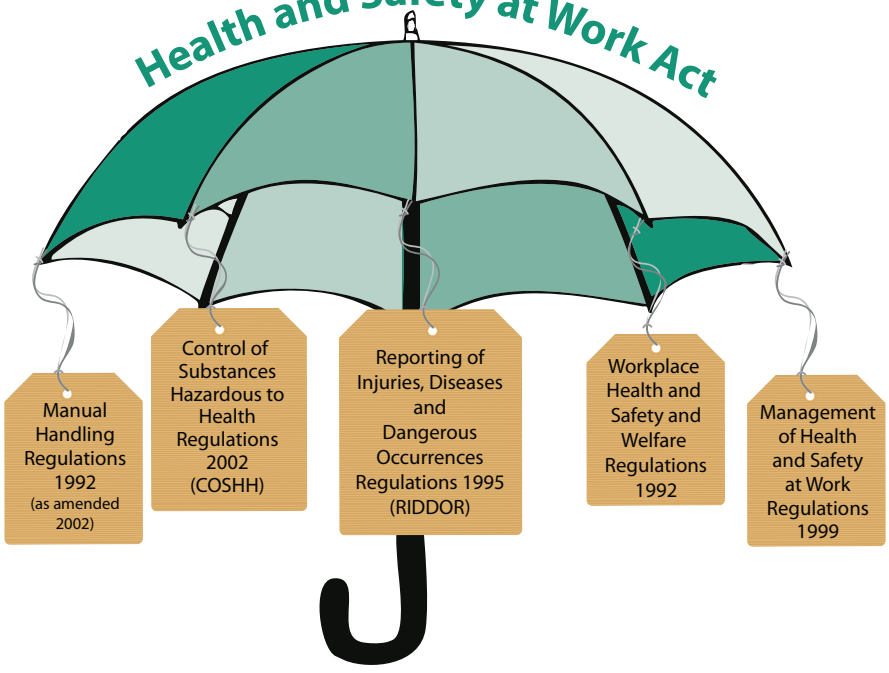


Figure 1.01 Regulations covered by HASAWA

The Health and Safety at Work Act (HASAWA) 1974

The Health and Safety at Work Act (HASAWA) 1974 is the main health and safety legislation in the UK and acts like an umbrella to cover all of the regulations that followed it.

HASAWA covers the main responsibilities of both employers and employees in terms of health and safety. A summary of these is shown in Table 1.01.

Section 2: Employers	Section 7: Employees
All employers have a duty:	As an employee you have a duty:
• of care for the welfare, health and safety of their employees where it is practicable for them to do so	• to take reasonable care at work for the health and safety of yourself and others who may be affected by what you do or do not do
• to provide and maintain safe equipment, tools and plant within the workplace	• not to intentionally or recklessly interfere with or misuse anything provided for your health and safety
• to ensure working conditions are safe and hygienic	• to bring to your employer's attention any situation you consider dangerous
• to provide proper personal protective equipment (PPE) and make sure it is used correctly	• to use any PPE provided correctly
• to make sure items and substances are used, handled, stored and transported safely	• to help your employer to meet their **statutory** obligations
• to provide any necessary information, instruction, training and supervision to ensure the health and safety of employees	• to co-operate with your employer on health and safety matters
• to make sure everyone can get in and out of the workplace safely	• to bring to your employer's attention any weakness in their welfare, health and safety arrangements
• to provide adequate facilities and arrangements for welfare at work	

Table 1.01 Summary of the health and safety duties of employers and employees

The Management of Health and Safety at Work Regulations 1999

Key term

Statutory – something that must be done by law

The Management of Health and Safety at Work Regulations 1999 detail some of the employer responsibilities in terms of health and safety. This includes carrying out risk assessments (see pages 7–8) to identify hazards and help prevent accidents. They state that emergency procedures and health and safety policies must be well designed, properly documented and taught to all staff who, in turn, must follow them.

The Workplace Health and Safety and Welfare Regulations 1992

The Workplace Health and Safety and Welfare Regulations 1992 cover the basic health and safety requirements of the working environment. For example, it says there should be a minimum working temperature of 16°C for desk work and 13°C for manual work (there are some exceptions such as freezer rooms or chilled processing environments). Employers must ensure the cleanliness of their facilities and provide toilets, drinking water, adequate ventilation, heating and lighting.

Figure 1.02 Facilities must be clean and well organised for employees

The Personal Protective Equipment (PPE) at Work Regulations 2002

The Personal Protective Equipment (PPE) at Work Regulations 2002 describe the responsibilities of employers to provide and maintain appropriate PPE for the activities it carries out. For more information on PPE, see pages 13–17.

The Manual Handling Operations Regulations 1992

The Manual Handling Operations Regulations 1992 cover the precautions and responsibilities of employers and employees when moving heavy loads. For more information on moving heavy loads safely, see pages 18–19.

The Provision and Use of Work Equipment Regulations 1998

The Provision and Use of Work Equipment Regulations 1998 describe how all equipment used in a workplace must be fit for purpose, used properly and maintained. It states that equipment should display the right safety signs correctly (e.g. to identify any potential hazards and PPE requirements), have guards in place to protect workers, and be inspected regularly.

Figure 1.03 Correct posture for working at a computer workstation

The Display Screen Equipment Regulations 1992

This covers the safe use of visual display units such as computer/laptop screens as well as those on portable equipment and machinery. When working at a computer for a long time you are entitled to regular breaks and your employer may be required to pay for eye tests. Sitting in a bad position at a computer workstation while using a keyboard and mouse for long periods of time without a break can cause repetitive strain injuries.

Hands On

Ask a friend to take a photo of you when you are working at a computer workstation. Print out the picture and evaluate how you sit compared with the posture in Figure 1.03. What could you do to improve things?

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

RIDDOR states that employers must keep a record of any accidents that occur as a result of their activities. It also states that any major accidents, diseases and dangerous occurrences must be reported to the Health and Safety Executive (HSE). This helps to see any potential trends developing as well as learning useful lessons from what has happened.

Major injuries	Notifiable diseases	Dangerous occurrences
• Fracture or dislocation of main body parts (other than fingers or toes) • Amputation • Eye damage including burns (chemical or hot metal) and any penetrating eye wound • Injury from electric shock causing unconsciousness • Any injury which causes unconsciousness, requiring CPR or hospital admittance for more than 24 hours • Unconsciousness caused by hazardous substance inhalation, ingestion or absorption through the skin • Illness caused by biological hazards, toxins or infected material • Injuries from any cause (however minor) that required the casualty to be away from work or incapable of fulfilling their full duties for a period of more than seven days	• Some types of poisoning • Work-related skin conditions such as dermatitis, skin cancer, chrome ulcer, and oil folliculitis/ acne • Lung conditions including occupational asthma, farmer's lung, pneumoconiosis, asbestosis and mesothelioma • Certain infections including leptospirosis, hepatitis, tuberculosis, anthrax, legionellosis and tetanus • Other medical conditions caused as a result of work including occupational cancer, certain musculoskeletal disorders, decompression illness and hand-arm vibration syndrome	• Collapse of lifting equipment • Explosion caused by damage to a pressurised vessel • Explosions or collapse that extend beyond the boundary of company premises • Accidents involving contact with overhead power lines • Failure of radioactive equipment, e.g. X-ray machines • Failure of breathing apparatus • Accidental release of biological agents • Accidents involving vehicles transporting hazardous materials • Incidents at a well or pipeline

Table 1.02 Incidents that must be reported directly to the HSE under RIDDOR

Any accidents or dangerous occurences, however small, should be recorded by an employer in an accident book. This says the time and date of the accident, what happened and who it happened to, what injuries were caused and who witnessed it. Those considered serious (shown in Table 1.02) would also need to be reported to the HSE.

Figure 1.04 A fume cupboard used to extract potentially harmful fumes and gases

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

Engineers often use substances that have the potential to cause harm to themselves or others. COSHH sets down rules covering the safe handling, storage, use and disposal of such substances. It states that correct PPE should be used when using hazardous substances (see pages 13–17) and that they are stored securely. Appropriate first aid and emergency equipment must also be available. Harmful waste products must be disposed of safely with consideration for the environment.

All materials must be clearly marked with their contents and the hazard that they present. A standard set of hazardous material symbols are shown in Figure 1.05.

European symbols

New international symbols

Figure 1.05 European and international hazardous substance labels

Keep It Safe

Always read the substance data sheet before working with any new hazardous materials.

Keep It Safe

Always check the regulations that relate to the kinds of activities that your job involves.

Other relevant legislation

There are many additional pieces of health and safety legislation that might apply to you, depending on the area of engineering that you are involved in. These include:

- Electricity at Work Regulations 1989
- Control of Noise at Work Regulations 1995
- Confined Spaces Regulations 1997
- Lifting Operations and Lifting Equipment Regulations 1998
- Supply of Machinery (Safety) Regulations 2005
- Work at Height Regulations 2005

Risk assessment

One of the key things that helps to ensure that whatever you do is done safely is a risk assessment. A risk assessment is carried out before an activity is started so that you can decide how safe it is and what you need to do to make it safer. Companies often have their own template for a risk assessment form but they generally all involve the following three basic steps:

1. **What are the hazards?** Look at any aspects of the activity that could potentially cause harm.
2. **What are the risks?** Once you know what the hazards are, you look at what these could cause to happen and how likely it is for this to happen.

   Who could potentially be harmed from aspects identified in points 1 and 2?
3. **What can we do to make it safer?** Decide what **control measures** you need to put in place to minimise the risks. This could be what PPE to wear, how to carry out the activity safely, what specialist equipment to use or what training is required before the task can be carried out.

A **risk factor** may also be calculated using the risk factor matrix. This takes into account how likely it is that something dangerous might happen and the seriousness of the injuries that may occur as a result.

Key terms

Hazard – anything that has the potential to cause harm to the engineers or anyone else around the activity area

Risk – what could happen as a result of the hazards identified

Control measure – action taken to try to reduce the risks involved in an activity

LIKELIHOOD	
1	Unlikely
2	Possible
3	Probable

Score: ____

×

SEVERITY	
1	Minor
2	Serious
3	Critical

Score: ____

=

RISK FACTOR	
1–3	Low risk
4–5	Medium risk
6–9	High risk

Risk factor: ____

Figure 1.06 Risk factor matrix

Hands On

Complete a risk assessment for an engineering activity that you are familiar with.

Risk Assessment

Details of assessor

Name:	Signature:	Date of assessment:
Gordon Jones	GFJones	3rd September 2012

Details of activity

Activity name:	Activity location:
Circuit board assembly line	Spark Electronics - Workshops A & B

Description of activity:
Assembly and hand soldering of consumer electronic products

Hazard identification

Hazards identified	Control measures in place to minimise
Fumes from solder flux could cause irritation and prolonged exposure is linked with occupation asthma. Aerosol flux cleaner is harmful if inhaled.	Permanent extraction system in place and inspected annually.
Electrical safety of portable equipment.	All equipment inspected before and after use. PAT testing carried out every six months. Broken or damaged equipment removed and logged.
Heat from soldering iron/solder could cause burns or start fire.	No flammable substances kept in vicinity. Soldering irons kept in stands when not in use. Equipment left to cool before storage. Lab coats worn to protect clothing and long hair tied back.
Trailing wires from equipment could cause trip hazard.	Dedicated bench-top power sockets used to minimise cable runs.
Sharp leads ejected during component trimming could cause eye damage if penetrating.	Safety spectacles worn by technicians.

Hazardous substances	Tools/equipment required	PPE required
Solder (containing flux) De-flux aerosol spray	Hand soldering equipment (soldering iron, side cutters, long-nosed pliers etc.)	Safety spectacles Lab coat Extraction system Anti-static wrist/leg strap

Risk factor assessment

Likelihood:	**Severity:**	**Risk Factor (Likelihood x severity):**
1 = unlikely to happen *2 = could possibly happen* *3 = likely to happen*	*1 = minor injury* *2 = serious injury* *3 = life critical injury*	*1–3 = Low risk* *4–5 = Medium risk* *6–9 = High risk*
Score: 1 – unlikely to happen	Score: 1 – minor injury	Result: 2 x 1 = 2 – low risk

Figure 1.07 Example risk assessment

Figure 1.08 Exposed belt drive on an antique combine harvester – this would never be allowed today!

Common hazards

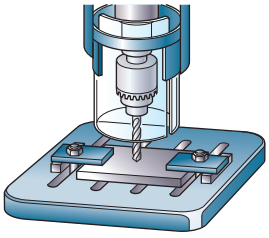
Hazards are everywhere in the engineering environment and when you carry out a risk assessment you will most likely notice lots of things that could cause you harm. Below are some common hazards in engineering:

Tools and equipment

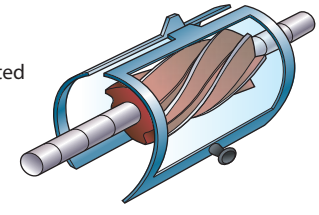
Even basic tools can be sharp or heavy with the potential to cause injury. Always handle and transport tools correctly. Never store tools in your pockets. Powered tools and machinery may present grab hazards that could catch clothing or hair and pull you in. Guards should be in place at all times to prevent this.

Figure 1.08 shows an exposed belt drive on an old piece of farming machinery. This would never be allowed today! It would be easy for a hand to get trapped in this machine.

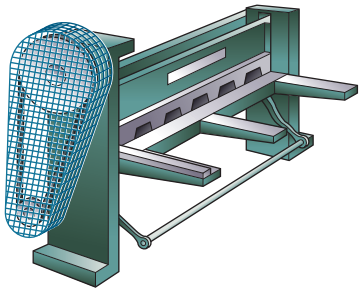
(a) Guard fitted to a pillar drill



(b) Guard fitted to a cutter



(c) Guard fitted to the drive belt of a power guillotine



(d) Guard fitted to the revolving bar of a lathe

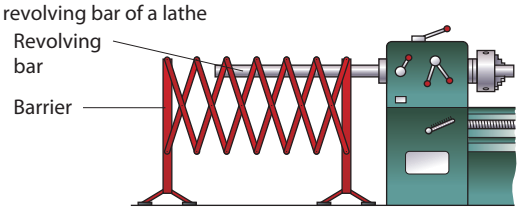


Figure 1.09 A range of guarding techniques

Key term

Portable Appliance Testing (PAT) – when equipment is checked for its electrical safety. This is often carried out by specialist PAT units that run a series of automated electrical tests on a piece of powered equipment. Tests must be carried out regularly and records kept

Keep It Safe

Always visually inspect any electrical equipment for signs of damage before you use it and report any damage.

Figure 1.10 A PAT unit

Electrical hazards

Electrical items have the potential to give lethal electric shocks. Equipment should be used according to the manufacturer's specifications, be maintained properly, with portable equipment **PAT tested** periodically. It is important to ensure that any test equipment used for PAT testing is also fully PAT tested.

Hazardous materials

Engineers often have to use potentially dangerous materials in their work. These might present a risk of poisoning, physical damage, fire or explosion. Therefore you should always carefully follow the manufacturer's guidelines (found on the material data sheet) and store them appropriately (see also COSHH, page 6)

Working at height

Injuries caused by someone falling or having objects dropped on them tend to be very serious so extra care should be taken when working at height. You may need extra training and need to use specialist equipment.

Figure 1.11 Working at height on a building scaffold

Working in confined spaces

Cramped, hot or very cold conditions can take their toll on engineers. The build-up of gases can lead to explosions or suffocation (due to the lack of oxygen). Water hazards might also be present, for example in a sewer system. You may need to use ventilation systems or breathing apparatus.

Figure 1.12 Engineers inspecting a fuel tank in a confined space

Hot work

Heat can have a big impact on the human body. You can easily become dehydrated or burn yourself if you don't take the necessary precautions. Make sure you are only in a hot environment for a safe, set period of time, take adequate breaks and drink regularly.

Figure 1.13 A foundry is a very hot and dangerous working environment

Trip hazards

Many work-related accidents are caused by a slip or trip. These can be avoided if you make sure you always run cables safely by securing them or using cable runners, and avoid running them across gangways. Clear any spillages immediately and cone off areas that are unsafe. It is very important to keep to and practise the top tips described in Figure 1.14 at all times.

Human error

We all make mistakes and knowingly or unknowingly do things incorrectly which could cause a hazard. The use of alcohol/drugs, stress and tiredness can affect our ability to work safely and make important decisions. Time pressure, laziness or ignorance might lead to 'cutting corners'. Failing to follow the correct procedures could be very dangerous.

Keep It Safe

Never work when you are under the influence of drugs or alcohol.

Hands On

Using the information covered so far as a guide, create a mind map of the types of hazards you might find in an engineering environment.

Figure 1.14 HSE trip poster

Working safely

All of the safety legislation looked at so far is really important for keeping you safe at work and everyone needs to play their part in following the rules. Below are some top tips on what to do and what not to do when working in engineering.

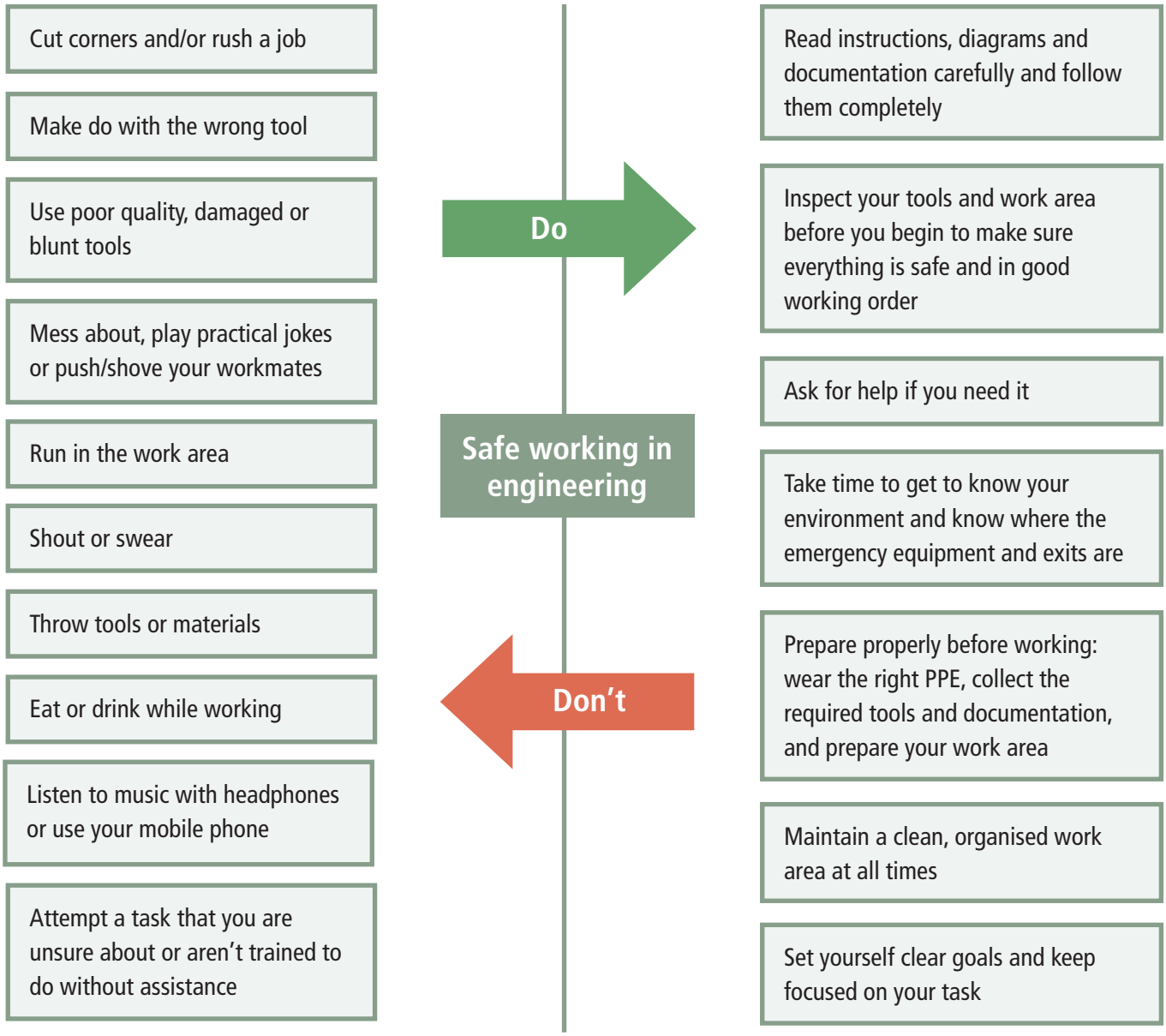


Figure 1.15 Dos and don'ts of working safely in an engineering environment

Hands On

Use a video camera to record how you/your workmates work. At the end of the session review the footage and discuss how good your working practices were. Make a list of what you did well and not so well. Make three suggestions on how you could improve in the future.