NEBOSH INTERNATIONAL DIPLOMA

UNIT IC: WORKPLACE AND WORK EQUIPMENT SAFETY - PART 2

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Course Structure

This textbook has been designed to provide the reader with the core knowledge needed to successfully complete the NEBOSH International Diploma in Occupational Health and Safety, as well as providing a useful overview of health and safety management. It follows the structure and content of the NEBOSH syllabus.

The NEBOSH International Diploma consists of four units of study. When you successfully complete any of the units you will receive a Unit Certificate, but to achieve a complete NEBOSH Diploma qualification you need to pass the three units within a five-year period. For more detailed information about how the syllabus is structured, visit the NEBOSH website (www.nebosh.org.uk).

Assessment

Unit IC is assessed by a two-part three-hour exam. Section A consists of six 10-mark compulsory questions, and Section B consists of five 20-mark questions, of which you must choose three.

NEBOSH set and mark this exam paper.

More Information

As you work your way through this book, always remember to relate your own experiences in the workplace to the topics you study. An appreciation of the practical application and significance of health and safety will help you understand the topics.

Keeping Yourself Up to Date

The field of health and safety is constantly evolving and, as such, it will be necessary for you to keep up to date with changing legislation and best practice.

RRC International publishes updates to all its course materials via a quarterly e-newsletter (issued in February, May, August and November), which alerts students to key changes in legislation, best practice and other information pertinent to current courses.

Please visit www.rrc.co.uk/news/newsletters.aspx to access these updates.

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Element IC6

Workplace Machinery

Learning Outcomes

Once you've read this element, you'll understand how to:

1. Outline the principles of safety integration and the considerations required in a general workplace machinery risk assessment.
2. Outline the principal generic mechanical and non-mechanical hazards of general workplace machinery.
3. Outline the main types of protective devices found on general workplace machinery.
4. Explain the principles of control associated with the maintenance of general workplace machinery.
5. Explain the key safety characteristics of general workplace machinery control systems.

Contents

Safety Integration and Machinery Risk Assessment

IN THIS SECTION...

- The **ILO Guarding of Machinery Convention C119, 1963** and the **ILO Guarding of Machinery Recommendation R118, 1963** set out proposals regarding the prohibition of the sale, hire and use of inadequately guarded machinery.
- **BS EN ISO 12100** provides machinery designers and manufacturers with an overall framework and guidance to enable them to produce machines that are safe for their intended use.
- **BS EN ISO 12100** establishes general principles for risk assessment, by which the knowledge and experience of the design, use, incidents, accidents and risks associated with machinery are brought together in order to assess the risks during relevant phases of the machine life-cycle.
- There are basic principles of safety for any machinery: machinery should be designed and constructed to be fit for purpose and to eliminate or reduce risks throughout the lifetime of the machinery including the phases of transport, assembly, dismantling, disabling and scrapping. When designing and constructing machinery and when drafting the instructions, use and foreseeable misuse should be considered. Machinery should be designed and constructed to take account of the constraints to which the operator is subject as a result of the necessary or foreseeable use of personal protective equipment. Machinery should be supplied with all the special equipment and accessories essential to enable it to be adjusted, maintained and used safely.
- Risk assessment enables the systematic identification and control of risks and is an integral part of the strategy for risk control. The factors to be considered when assessing risk include persons at risk, severity of possible injury, probability of injury, need for access, duration of exposure, reliability of safeguards, operating procedures and personnel.
- CE marking is a declaration by the manufacturer that the product meets all the appropriate provisions of the relevant legislation implementing certain European Directives.
- A manufacturer or distributor may not supply relevant machinery for use within the European Community **unless it is safe** and, in particular, it satisfies the **essential health and safety requirements (EHSRs)**, the **technical file** is compiled and made available, information required to operate it safely is provided, the appropriate **conformity assessment procedure** is followed, an EC **declaration of conformity** is drawn up, the **CE marking** is properly affixed to the machinery and **it is in fact safe.**

Definition of Machinery

Machinery can be defined as:

1. An assembly, fitted with or intended to be fitted with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application.
2. An assembly as referred to in point 1, missing only the components to connect it on site or to sources of energy and motion.
3. An assembly as referred to in points 1 or 2, ready to be installed and able to function as it stands only if mounted on a means of transport, or installed in a building or structure.

Machinery defined as any assembly with linked parts or components joined together

4. Assemblies of machinery as referred to in points 1, 2 or 3 or partly completed machinery, which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole.
5. An assembly of linked parts or components, at least one of which moves and which are joined together, intended for lifting loads and whose only power source is directly applied human effort.

ILO Guarding of Machinery Convention C119

The **ILO Guarding of Machinery Convention C119, 1963** and the **ILO Guarding of Machinery Recommendation R118, 1963** set out proposals regarding the prohibition of the sale, hire and use of inadequately guarded machinery. They:

- State that:
  - The manufacture, sale, hire, and transfer of specified types of machinery should be prohibited when this machinery comprises dangerous working parts (at the point of operation) which are without appropriate guards.
  - Where this prohibition cannot fully apply without preventing the use of the machinery, it should apply to the extent that the use of the machinery permits.
  - Machinery should be so guarded as to ensure that national regulations and standards of occupational safety and hygiene are not infringed.
  - The prohibition does not prevent the maintenance, lubrication, setting-up or adjustment of machinery (or parts of machinery) carried out in conformity with accepted standards of safety.
- Require that:
  - All working parts of machinery which may produce flying particles while in operation should be adequately guarded in such a manner as to ensure the safety of the operators.
  - All parts of machinery which are under dangerous electrical pressure should be protected in such a manner as to give complete protection to the workers.
  - Wherever possible, automatic safeguards should protect persons when machinery is being started, is in operation or is being stopped.
  - Machinery should be constructed to exclude (as far as possible) any other dangers to which a person working on the machines may be exposed, taking account of the nature of the materials or the type of danger.

Adequate guarding for machinery with moving parts

- Require that the employer should:
  - Take steps to bring national laws or regulations relating to the guarding of machinery to the notice of workers.
  - Instruct workers regarding the dangers arising and the precautions to be observed in the use of machinery.
  - Establish and maintain environmental conditions which do not endanger workers using machinery covered by the recommendation.
- State that no worker should:
  - Use any machinery without the guards provided being in position.
  - Be required to use any machinery without the guards provided being in position.
  - Make inoperative the guards provided on machinery.
  - Use machinery where the guards have been made inoperative.

BS EN ISO 12100

BS EN ISO 12100:2010 Safety of machinery - General principles for design - Risk assessment and risk reduction specifies:

- Basic terminology, principles and a methodology for achieving safety in the design of machinery.
- Principles of risk assessment and risk reduction to help designers in achieving this objective.

These principles are based on knowledge and experience of the design, use, incidents, accidents and risks associated with machinery. Procedures are described for:

- Identifying hazards and estimating and evaluating risks during relevant phases of the machine life-cycle.
- The elimination of hazards or sufficient risk reduction.

Guidance is given on the documentation and verification of the risk assessment and risk reduction process.

The standard details safeguarding and protective measures such as selecting and implementing guards and protective devices for the different uses, and at varying stages, of machine operation:

- Normal use.
- Machine-setting.
- Teaching.
- Process changeover.
- Fault-finding.
- Cleaning.
- Maintenance.

In theory, a designer may have designed a safe machine, but the true test of its safety is in its safe use.

Users need to be informed and instructed on how best to use the machinery; that is why signals and warnings, markings and instruction handbooks are produced and located so that they are easily understood and clearly visible.

The primary purpose of **BS EN ISO 12100** is to provide designers, manufacturers, etc. with an overall framework and guidance to enable them to produce machines that are safe for their intended use.

The standard also gives definitions for: reliability, maintainability, hazard, danger zone and intended use.

When defining the design of a machine a series of actions are given, which include the study of the machine itself, taking into account all phases of its life, including:

- Construction.
- Transport and commissioning, e.g. assembly, installation, adjustment.
- Use, including setting, teaching, programming or process changeover, operation, cleaning, fault-finding and maintenance.
- Decommissioning, dismantling and, as far as safety is concerned, disposal.
- The drafting of the instructions relating to all phases of the life of the machine mentioned above.

Definitions of Guarding

Of particular interest are the definitions of guarding (many of these types of guard will be covered in more detail later in this element):

- **Fixed Guard**

  Guard affixed in such a manner (e.g. by screws, nuts or welding) that it can only be opened or removed by the use of tools or destruction of the affixing means.

- **Movable Guard**

  Guard which can be opened without the use of tools.

- **Adjustable Guard**

  Fixed or movable guard which is adjustable as a whole or which incorporates adjustable part(s). The adjustment remains fixed during a particular operation.

- **Interlocked Guard**

  Guard associated with an interlocking device so that, together with the control system of the machine, the following functions are performed:

  – The hazardous machine functions 'covered' by the guard cannot operate until the guard is closed.

  – If the guard is opened while hazardous machine functions are operating, a stop command is given.

  – When the guard is closed, the hazardous machine functions covered by the guard can operate. The closure of the guard does not by itself start the hazardous machine functions.

- **Interlocking Guard with Guard Locking**

  Guard associated with an interlocking device and a guard locking device so that, together with the control system of the machine, the following functions are performed:

  – The hazardous machine functions covered by the guard cannot operate until the guard is closed and locked.

  – The guard remains closed and locked until the risk due to the hazardous machine functions covered by the guard has disappeared.

  – When the guard is closed and locked, the hazardous machine functions covered by the guard can operate. The closure and locking of the guard do not by themselves start the hazardous machine functions.

- **Control Guard**

  Guard associated with an interlocking device, with or without guard locking, so that the hazardous machine functions covered by the guard cannot operate until the guard is closed, and closing the guard initiates operation of the hazardous machine function(s).

- **Safety Device**

  Device (other than a guard) which eliminates or reduces risk, alone or associated with a guard.

- **Interlocking Device (Interlock)**

  Mechanical, electrical or other type of device, the purpose of which is to prevent the operation of machine functions under specified conditions (generally as long as a guard is not closed).

- **Enabling (Control) Device**

  Additional, manually operated device used in conjunction with a start control and which, when continuously actuated, allows a machine to function.

- **Hold-to-Run Control Device**

  Control device that initiates and maintains operation of machine elements only as long as the manual control (actuator) is actuated. The manual control returns automatically to the stop position when released.

- **Two-Hand Control Device**

  Control device that requires at least simultaneous actuation with both hands in order to trigger and to maintain hazardous machine functions, providing a protective measure only for the person who actuates it.

- **Trip Device**

  Device that causes a machine or machine elements to stop (or ensures an otherwise safe condition) when a person or a part of his body goes beyond a safe limit. Trip devices may be:

  – Mechanically actuated, e.g. trip wires, telescopic probes, pressure-sensitive devices, etc.

  – Non-mechanically actuated, e.g. photo-electric devices, devices using capacitive, ultrasonic, etc. means to achieve detection.

- **Mechanical Restraint Device**

  Device that introduces into a mechanism a mechanical obstacle (wedge, spindle, strut, scotch, etc.) which, by virtue of its own strength, can prevent any hazardous movement. This could include, for example, the fall of a ramp due to the failure of the normal retaining system.

- **Limiting Device**

  Device that prevents a machine or machine condition(s) from exceeding a designed limit, e.g. space limit, pressure limit or load moment limit.

- **Limited Movement Control Device**

  Control device, a single action of which, together with the control system of the machine, permits only a limited movement of travel of a machine element.

- **Deterring/Impeding Device**

  Any physical obstacle - e.g. low barrier, rail - which, without totally preventing access to a hazard zone, reduces the probability of access to this zone by offering an obstruction to free access.

Risk Reduction by Design

The standard also deals with risk reduction by design, including making machines inherently safe through:


Risk reduction factored in at design stage

- Avoiding sharp edges, corners and protruding parts.
- The shape and relative location of their mechanical component parts. For example, crushing and shearing hazards are avoided by increasing the minimum space between the moving parts so that the part of the body under consideration can enter the gap safely, or by reducing the gap so that no part of the body can enter it.
- The limitation of the actuating force to a sufficiently low value, so that the element does not generate a mechanical hazard.
- The limitation of the mass and/or velocity of the movable elements, and therefore their kinetic energy.
- The limitation by design of noise and vibration.
- Taking into account design codes, data about material properties and, in a more general way, all professional rules regarding machine design and construction, e.g. calculation rules.
- Using inherently safe technologies, processes, power supplies, e.g. on machines intended for use in explosive atmospheres.
- Applying the principle of the positive mechanical action of a component on another component.
- Observing ergonomic principles, including the correct location of controls.
- Applying safety principles when designing control systems.
- Safeguarding safety functions in re-programmable control systems.
- Principles relating to manual control.
- Preventing hazards from pneumatic and hydraulic equipment.
- Preventing electrical hazards.

Safeguarding

The standard gives information on safeguarding and includes the following requirements:

- Safeguards (guards, safety devices) shall be used to protect persons from hazards which cannot reasonably be avoided.
- The selection of guards and safety devices, as follows:
  - Where access to the danger zone is not required during normal operation of the machinery, safeguards should be selected from a fixed guard, an interlocking guard, a self-closing guard or a trip device.
  - Where access to the danger zone is required during normal operation of the machinery, safeguards should be selected from the following: interlocking guard, trip device, adjustable guard, self-closing guard, two-handed control device.
- Machines shall be designed so that the safeguards provided for the protection of the production operator might ensure also the safety of personnel in setting, teaching, etc. without hindering them in performing their task.

Requirements for the Design and Construction of Guards and Safety Devices

Requirements include:

- **General Requirements**

  Guards and protective devices shall:

  - Be designed to be suitable for their intended use, taking into account mechanical and other hazards involved.
  - Be compatible with the working environment of the machine and designed so that they cannot be easily defeated.
  - Provide the minimum possible interference with activities during operation and other phases of machine life, in order to reduce any incentive to defeat them.
  - Be of robust construction.
  - Not give rise to any additional hazard.
  - Not be easy to bypass or render non-operational.
  - Be located at an adequate distance from the danger zone.
  - Cause minimum obstruction to the view of the production process.
  - Enable essential work to be carried out on installation and/or replacement of tools and also for maintenance by allowing access only to the area where the work has to be done; if possible, without the guard or protective device having to be moved.

- **Requirements for Fixed Guards**

  Fixed guards shall be securely held in place either permanently (by welding, etc.), or by means of fasteners (screws, etc.), making removal and opening impossible without using tools.

  Note: a fixed guard can be hinged to assist its opening.

- **Requirements for Movable Guards**

  Movable guards against hazards generated by moving transmission parts shall (as far as possible) remain fixed to the machine generally by means of hinges. Movable guards against hazards generated by other moving parts shall be designed and associated with the machine control system so that:

  - Moving parts cannot start up while they are within the operator's reach and the operator cannot reach moving parts once they have started up.
  - They can be adjusted only by means of an intentional action, such as the use of a tool, key, etc.

- The absence or failure of one of their components prevents starting or stops the moving parts (this can be achieved by automatic monitoring).
- Protection against ejection hazards is ensured by appropriate means.

- Requirements for Adjustable Guards

  Adjustable guards may only be used where the hazard zone for operational reasons cannot be completely enclosed. They shall be:

  - Designed so that the adjustment remains fixed during a given operation.
  - Readily adjustable without the use of tools.

Adjustable guards where the hazard zone cannot be completely enclosed

- Control Guards

  Control guards may be used only if:

  - There is no possibility for an operator or a part of his body to stay in the danger zone, or between the danger zone and the guard while the guard is closed.
  - Opening the control guard or an interlocking guard is the only way to enter the danger zone.
  - The interlocking device associated with the control guard is of the highest possible reliability (as its failure may lead to an unintended/unexpected start-up).

- Hazards from Guards

  Care shall be taken to prevent hazards which might be generated by the guard construction (sharp edges or corners, materials, etc.) or the movements of the guard (shearing or crushing zones generated by power-driven guards and by heavy guards which are liable to fall).

Information for Use

This consists of communication links, such as texts, words, signs, signals, symbols or diagrams, used separately or in combination to convey information to the user.

Information for use shall clearly define the purpose for which the machine is intended and contain all directions required to ensure safe and correct use of the machine.

Visual signals, such as flashing lights, and audible signals such as sirens, may be used to warn of an impending hazardous event such as machine start-up or over-speed.

The instruction handbook or other information supplied to all personnel involved with the use, maintenance and supervision of work equipment must include details of:

- How the equipment should be used.
- Restrictions on its use.
- Foreseeable abnormal situations and what action to take in those situations.

Information is required relating to transport, handling and storage of the machine, commissioning of the machine, the use of the machine, maintenance, decommissioning, and dismantling. Also required is information for emergency situations.

Additional Precautions

These include:

- Each machine shall be fitted with one or more emergency stopping devices to enable actual or impending hazardous situations to be averted.

- Precautions for the escape and rescue of trapped persons.
- Maintainability factors should be taken into account, including:
  - Accessibility taking account of the environment, the dimensions of the human body, and working clothes and tools.
  - Ease of handling and human capabilities.
  - Limitations on the number of special tools and equipment.
- Provision for:
  - Isolation and energy dissipation.
  - Easy and safe handling of machines and their heavy component parts.
  - Stability of machines and their elements.

Remember that these standards are very comprehensive and these notes do not attempt to deal with all of the aspects covered by BS EN ISO 12100.

ISO/TR 14121

ISO/TR 14121-2:2012 gives practical guidance on conducting risk assessment for machinery in accordance with ISO 12100 and describes various methods and tools for each step in the process. It gives examples of different measures that can be used to reduce risk and is intended to be used for risk assessment on a wide variety of machinery in terms of complexity and potential for harm. Its intended users are those involved in the design, installation or modification of machinery (e.g. designers, technicians or safety specialists).

The standard:

- Gives guidance on the information required to allow risk assessments to be carried out.
- Describes procedures for identifying hazards and estimating and evaluating risk.
- Provides advice for decisions to be made on the safety of machinery and the type of documentation required to verify that the risk assessment has been carried out.

The standard is not intended to provide a detailed account of methods for analysing hazards and estimating risks, although a summary of some of these methods is given for information only.

It addresses the following issues:

- Hazard identification.
- Elements of risk – severity of harm and probability of occurrence of that harm.
- Factors to be considered when determining the elements of risk – including human factors.
- Risk evaluation – comparison of risks, documentation to be completed and kept.

The Principles of Safety Integration

The principles of safety integration can be found implemented in UK legislation, specifically the **Supply of Machinery (Safety) Regulations 2008 (SMSR)**.

The Regulations implement the **European Machinery Directive 2006/42/EC**, which aims to:

- Protect and promote the 'internal market' in machinery by establishing agreed standards.
- Provide the appropriate level of health and safety protection for those using, or coming into contact with, machinery.

To ensure that all machinery throughout the European Community is constructed to the same standards regarding safety, the **Machinery Directive** imposes compliance with the essential health and safety requirements. These are set out in Annex I to the Directive, reproduced as Part 1 of Schedule 2 of **SMSR**.

The **principles of safety integration** set out the following basic principles of safety for any machinery:

"(a) *Machinery must be designed and constructed so that it is fitted for its function, and can be operated, adjusted and maintained without putting persons at risk when these operations are carried out under the conditions foreseen but also taking into account any reasonably foreseeable misuse thereof.*

The aim of measures taken must be to eliminate any risk throughout the foreseeable lifetime of the machinery including the phases of transport, assembly, dismantling, disabling and scrapping.

(b) *In selecting the most appropriate methods, the responsible person must apply the following principles, in the order given:*

- *eliminate or reduce risks as far as possible (inherently safe machinery design and construction),*
- *take the necessary protective measures in relation to risks that cannot be eliminated,*
- *inform users of the residual risks due to any shortcomings of the protective measures adopted, indicate whether any particular training is required and specify any need to provide personal protective equipment.*

(c) *When designing and constructing machinery and when drafting the instructions, the responsible person should envisage not only the intended use of the machinery but also any reasonably foreseeable misuse thereof.*

The machinery should be designed and constructed in such a way as to prevent abnormal use if such use would engender a risk. Where appropriate, the instructions should draw the user's attention to ways – which experience has shown might occur – in which the machinery should not be used.

(d) *Machinery should be designed and constructed to take account of the constraints to which the operator is subject as a result of the necessary or foreseeable use of personal protective equipment.*

Machinery should be supplied with all the special equipment and accessories essential to enable it to be adjusted, maintained and used safely."

MORE... www.

The full text of the **Supply of Machinery (Safety) Regulations 2008** is available online at:

www.legislation.gov.uk/uksi/2008/1597/contents/made

Factors to be Considered when Assessing Risk

The use of risk assessment for the development of built-in safety features:

- Is a key principle for machinery safety.
- Means that risks can be identified and controlled systematically.
- Is an integral part of the strategy for risk control.

The first stage is to set the parameters in which the use of the equipment will take place. This is required as it will affect later decisions, e.g. the control measures for a risk will vary when equipment is used only infrequently when compared to equipment in continuous use. There are various factors to consider:

Person at risk from machinery use

- **Persons at Risk**

  Person-related factors to consider include:

  - Which people are at risk? Are they employees, such as operators/maintenance/cleaners? Contractors? Visitors? Passers-by?
  - How many are at risk?
  - When are they at risk? All the time? During different shifts? At certain parts of an operation or process?

- Probability of Injury

  If there is an occurrence, what are the chances of it causing an injury?

- Severity of Possible Injury

  What are the possible consequences? (Part of the risk-rating exercise.) Don't forget that machinery is invariably stronger than a person and likely to cause significant injury.

- Need for Access

  When is there going to be a need to go near the dangerous parts of the machinery? During normal operation? For breakdown/maintenance/adjustment/servicing purposes? For everyday cleaning?

- Duration of Exposure

  Consider the amount of time exposure is likely to last. This will tie in closely with the activity going on.

- Reliability of Safeguards

  Are the safeguards that are in place adequate to do the job? Are they well maintained and serviceable? Consider the hierarchy of guarding - does it reflect the measures that have been taken?

- Operating Procedures

  Are there procedures in place to ensure that all foreseeable risks have been addressed and safety measures introduced? Have warning notices and signs been put up to warn of the dangers of the machine?

- Personnel

  Have all personnel who are required, as part of their job, to come into contact with the machine had suitable training?

CE Marking

Purpose and Relevance of the CE Mark

Most new products placed on the European market must be CE-marked. This will include products which are "new" to Europe, such as second-hand products from outside Europe and which are put into service or placed on the market in Europe for the first time, as well as existing products which are so substantially modified as to be considered "new". However, some work equipment that is not powered or used to lift - such as hand tools, racking and ladders - does not currently come within the scope of any product safety Directive and so must not be CE-marked.

CE marking is the responsibility of the person who places the product on the market, or puts it into service, for the first time. In law this duty rests with the Responsible Person, which in most cases is either the manufacturer or the manufacturer's authorised (in writing) representative, but can also include those who import non-CE-marked products into Europe, any user in Europe who makes a product for their own use, and those who modify existing products already in use to such an extent that they must be considered "new" products.

DEFINITION

HIERARCHY OF GUARDING

The measures to be taken to prevent access to the dangerous parts of the machinery can be ranked in the following hierarchy:

- Fixed enclosed guards.
- Other guards or protection devices such as interlocked guards and pressure mats.
- Protection appliances such as jigs, holders and push-sticks, etc.
- The provision of information, instruction, training and supervision.

The purpose of the CE mark is to ensure that the Responsible Person who affixes the mark takes responsibility for the conformity of the product. CE marking is a visible sign that the product complies with all relevant product supply law, and its presence together with the Declaration of Conformity gives the product to which it is affixed presumption of conformity with relevant product safety Directives such as the **Physical Agents**, **Low Voltage** and **Machinery Directives**.

CE marking gives companies easier access into the European market to sell their products without adaptation or rechecking. The initials "CE" stand for *conformité européenne* (French for "European conformity") and are a declaration by the manufacturer that the product meets the requirements of the applicable European Directive(s).

Limitations of the CE Mark

The CE mark:

- Is not a mark or certification or approval issued by a third party.
- Is not for sales or marketing or promotion.
- Is not for components (although there are some exceptions, the vast majority of components do not need CE marking).

The CE mark is not a quality mark, nor a guarantee that the product meets all of the requirements of relevant EU product safety law.

Suppliers who install work equipment and users should make reasonable checks of any new products, looking for obvious defects, and should ensure that there are User Instructions. Any warning decals (pictograms) must be in English if the product is for the UK market. Where the instructions are not in English, the supplier must provide a translation into English and supply this together with the original instructions.

In most cases the Declaration of Conformity must be supplied to the end customer.

Selection and Integration

When work equipment is provided for use in European workplaces it should meet the health and safety requirements specified by the relevant EU Directives. So the employer must ensure that work equipment conforms with any essential requirements relating to its design and construction specified by Community Directives concerning the safety of products.

When an employer selects suitable work equipment, there is a heavy reliance on information and assurances provided by the manufacturer or supplier. Under the UK **SMSR** the manufacturer and/or supplier of machinery for use in the workplace is required to ensure that the machinery supplied is safe.

SMSR states that a manufacturer or distributor may not supply relevant machinery for use within the European Community **unless it is safe** and, in particular:

- It satisfies the **essential health and safety requirements**.
- The **technical file** is compiled and made available.
- Information required to operate it safely is provided, e.g. **operating instructions.**
- The appropriate **conformity assessment procedure** is followed (see later).
- An EC **Declaration of Conformity** is drawn up (see later).
- The CE marking is properly affixed to the machinery.
- **It is in fact safe** (that is to say, safe when properly installed, maintained and used for its intended purpose).

The requirements are similar but slightly different for "partly completed machinery" (i.e. parts of machines designed to be used with or incorporated into other machinery). Partly completed machinery must have a declaration of incorporation instead of a declaration of conformity.

The CE mark is marked on the machinery by the manufacturer in a **distinct, visible, legible** and **indelible** manner. It is supposed to be a readily identifiable logo that indicates that the machine satisfies the essential health and safety requirements. But, remember, it is (in most cases) simply an assessment by the manufacturer that the machine is safe. It therefore shouldn't be relied upon completely. Employers also need to satisfy themselves that the machine is safe before it is put into use.

The CE marking itself should conform to the following design:

Conformity Assessments

There are three different possibilities, all with different options (the Annexes referred to are those in Part 4 of Schedule 2 to **SMSR**):

1. Machinery that is listed in Annex IV (which poses special hazards, e.g. circular saws used for wood and meat), which is **manufactured fully in accordance with published harmonised standards** (**and fully covered by those standards**):

   Either

   a) Follow Annex VIII procedures:

      – draw up a **technical file**. The manufacturer ensures that there are internal checks carried out on the manufacturing process to make sure that manufactured machines comply with that technical file and also with the Directive.

   Or

   b) Follow Annex IX procedures:

      – submit a technical file to the approval body with an example of the machine for **EC-type examination** (see later). Internal manufacturing process checks must also be carried out as above.

   Or

   c) Follow Annex X procedures:

      – a full quality assurance programme, i.e. the manufacturer operates an "approved" quality system covering design, manufacture, final inspection and testing. A technical file must be produced too as part of the application for approval of the quality system.

2. Annex IV machinery **NOT manufactured fully in accordance with published harmonised standards or NOT fully covered by such standards**:

   Either

   a) Follow Annex IX procedures (as described above).

   Or

   b) Follow Annex X procedures (as described above).

3. Other machinery, i.e. most general machinery:

   The manufacturer follows Annex VIII conformity assessment procedures (as described above).

DEFINITIONS

HARMONISED STANDARDS

The Harmonised Standards are categorised into three general types:

- Type A Standards (Basic Safety Standards)

  These give basic concepts, principles for design and general aspects that can be applied to all machinery.

  The key standard is BS EN ISO 12100:2010 *Safety of machinery. General principles for design. Risk assessment and risk reduction*.

  ISO/ TR 14121-2:2012 *Safety of machinery – Risk assessment – Part 2: Practical guidance and examples of methods* gives practical guidance on conducting risk assessment for machinery in accordance with ISO 12100 and describes various methods and tools for each step in the process.

- Type B Standards (Generic Safety Standards)

  These deal with one safety aspect or one type of safeguard that can be used across a wide range of machinery. They are subdivided into:

  - Type B1 standards on particular safety aspects (safety distances, surface temperature, noise, etc.), e.g. BS EN ISO 13857:2008 is concerned with the minimum height and distance from the hazard.
  - Type B2 standards on safeguards (two-hand controls, interlocking devices, pressure-sensitive devices, guards, etc.).

- Type C Standards (Machine Safety Standards)

  These deal with detailed safety requirements for a particular machine or group of machines. For example, BS EN 692:2005 is concerned with mechanical presses.

Technical File

The technical file contains all the relevant material on which the manufacturer bases the decision to sign the CE declaration of conformity showing that the product conforms. The signature completes the declaration, allowing the CE marking to be affixed. Note that not all the information has to be kept together, but it **must** be made available within a reasonable time when requested.

The technical file for machinery will consist of (as described in Annex VII):

Compiling the technical file

- A general description of the machine.
- Drawings of the machine.
- Drawings of the control circuitry.
- Details of tests carried out to check conformity against essential health and safety requirements.
- List of applicable essential health and safety requirements.
- Description of methods adopted to eliminate hazards.
- The standards and other technical specifications used (indicate the essential health and safety requirements covered by these standards).
- Any technical reports/certificate giving the results of tests.
- A copy of the instructions for the machinery.
- Where appropriate, the declaration of incorporation for included partly completed machinery.
- Where appropriate, the EC declaration of conformity of machinery/products incorporated into the machine.

- A copy of the EC declaration of conformity.
- For series manufacture, the internal measures to be taken to ensure that production machinery is to the same standard (i.e. quality assurance and quality control).

The technical file for partly completed machinery is similar but slightly different in the details.

Declaration of Conformity

Drawing up an EC declaration of conformity is the procedure whereby the responsible person declares, regarding each item of relevant machinery which he or she supplies in the Community, that it complies with all the essential health and safety requirements applying to it.

An EC declaration of conformity (as described in Annex II) must:

- State the:
  - Business name and full address of the manufacturer and, where appropriate, their authorised representative.
  - Name and address of the person authorised to compile the technical file.
- Contain a description and identification of the machinery to which the declaration relates, including its:
  - Generic denomination (i.e. make).
  - Function.
  - Model.
  - Type.
  - Serial number.
  - Commercial name.
- Include a sentence expressly declaring that the machinery fulfils all relevant provisions of the Directive (and other directives, as appropriate).
- Where an EC type examination has been carried out (as per Annex IX), give the name, address and identification number of the approved body which carried it out and the number of the issued certificate.
- Where a full quality assurance has been approved (as per Annex X procedures), give the name, address and identification number of the approving body.
- Specify (as appropriate) the published harmonised standards used.
- Specify (as appropriate) any technical standards and specifications used.
- State the place and date of declaration.
- Contain the identity and signature of the person authorised to draw up the declaration on behalf of the responsible person.

The declaration of conformity is issued with the finished machine.

Declaration of Incorporation

Where the machinery is intended for incorporation into other machinery, the responsible person can draw up a declaration of incorporation. This declaration, without a 'CE' mark being applied, is applicable to partly completed machinery that:

- Is "almost machinery".
- Is intended for incorporation into other machinery.
- Cannot function independently.
- Is to be assembled with other machinery.

CE Marking and Other Marking

The **Machinery Directive**, Annex I, Essential Requirements 1.7.3, indicates that all machinery meeting the requirements must be marked with the following information in such a way that it is indelible:

- The "CE" marking (as described above).
- Name and address of the manufacturer.
- Designation of machinery.
- Designation of series or type.
- Serial number, if any.
- Year of construction (i.e. when it was actually completed).
- If designed for such, information regarding its use in an explosive atmosphere.
- Any safety-related information regarding the machinery in use (e.g. maximum speed of rotating parts).
- Mass of any part where it must be handled by lifting equipment during use.

The CE marking can only be applied when a declaration of conformity is supplied. It consists of a CE mark which must be visible, legible, indelible and distinct. The full specification of a CE mark is described in Annex III to the **Machinery Directive**. Note that where an Annex X conformity procedure has been followed (i.e. full quality assurance), the CE mark is followed by the identification number of the notified body.

MORE... www.

Two publications from the HSE:

INDG270 *Supplying new machinery: A short guide to the law and your responsibilities when supplying machinery for use at work* (www.hse.gov.uk/pubns/indg270.pdf) and

INDG271 *Buying new machinery: A short guide to the law and your responsibilities when buying new machinery for use at work* (www.hse.gov.uk/pubns/indg271.pdf)

give useful information on legal requirements and the responsibilities of manufacturers, suppliers and buyers of machinery.

1. Comply with all applicable essential health and safety requirements
2. Compile a technical file and make it available
3. Provide information on safe operation, e.g. instructions
4. Follow the relevant conformity assessment procedures
5. Produce an EC Declaration of Conformity
6. Affix 'CE' marking to the machine

Process to affix the CE mark

6.1 Safety Integration and Machinery Risk Assessment

TOPIC FOCUS

The UK's **Supply of Machinery (Safety) Regulations 2008** set out the following process to ensure that machinery is safe for supply and meets all relevant standards:

- The machine must:
  - Satisfy the essential health and safety requirements.
  - Be safe.
- The responsible person must have:
  - Carried out the appropriate conformity assessment procedure.
  - Issued a declaration of conformity.
  - Ensured that the machine complies with any relevant directives.
  - Fixed the CE mark in a distinct, visible, legible and indelible manner.
  - Prepared the technical file.

STUDY QUESTIONS

1. Outline the main requirements of the **ILO Guarding of Machinery Convention, C119**.
2. Under what circumstances can a CE mark be applied to a machine?
3. What information must be provided in the technical file?
4. What information is required to be marked on machinery meeting the requirements of CE marking?
5. Distinguish between Type A, B and C harmonised standards.
6. What is the preferred order for guarding?
7. Describe the principles of safety integration.
8. Outline the considerations required in a general workplace machinery risk assessment.

(Suggested Answers are at the end.)

Generic Hazards

IN THIS SECTION...

- Common machines that present hazards in general workplaces include: drills (radial arm, pedestal), circular saws, guillotines, disc sanders, abrasive wheels, lathes, automatic doors and gates, mechanical and hydraulic presses, portable power tools, CNC machines, robotics.
- Machinery hazards including mechanical and non-mechanical hazards.

Common Machinery Hazards

The following are factors that should be considered:

Common machinery hazard

- **Shape** of the moving part has a major effect. It will include the effect of having sharp edges, angular parts, etc. which may be a hazard even if not moving.
- **Relative motion** is concerned with the motion of one piece of the machine in relation to another. It is this form of motion which gives rise to crushing, shearing, etc.
- **Mass and stability** is concerned with the possibility of motion of the machine under the effect of gravity (i.e. will it fall down?).
- **Acceleration** is concerned with the increasing speed of motion of the machine. It is possible that the operator may guess at the travel time and take action accordingly, when in fact the machine is accelerating and less time is taken for it to travel, putting the operator in danger. This is analogous to crossing the road where cars are accelerating away from a stop position.
- **Inadequate mechanical strength** is concerned with the possible break-up or bursting of the machine. Abrasive wheels have poor mechanical strength, which is why they are designed to run at a specific speed which should not be exceeded.
- **Potential energy of elastic components** is concerned with the hazards from stored-up energy, e.g. springs or a bandsaw blade.

When considering the hazards we must look at:

- Aspects of operator-machine relationships during construction, installation, use and removal of the machine.
- The possible state of the machine, including breakdown situations as well as normal running.
- Foreseeable misuse.

The factors listed earlier in this section can be applied to typical machines, as shown in the table that follows.

Machine Hazards

Machine	Use	Mechanical Hazards	Non-Mechanical Hazards
Drills (radial arm, pedestal)	Boring holes in a number of different materials (metals, plastics, wood, etc.).	Main hazard is puncture or stabbing. Entanglement is also possible, due to rotation of the drill.	Noise, electricity and high temperature (due to the heat generated during the drilling process).
Circular saws	Cutting wood; use a very sharp circular blade rotating at high speed.	Main hazard is cutting. Drawing-in may also occur between the blade and table.	Electricity, noise and the production of hazardous substances (sawdust).
Guillotines	Cutting different materials (metal, paper, etc. (and, in the past, heads!)).	Main hazard is shearing.	Noise and electricity (electrically operated guillotines).
Disc sanders	Shape and finish articles by removing material by contact with an abrasive disc.	Hazards include: friction and abrasion from disc; entanglement and drawing-in from transmission machinery.	Electricity, heat, noise and hazardous substances given off as part of the process.
Abrasive wheels	Removing material; grinding using high-speed rotating wheel.	Hazards include: friction and abrasion, entanglement, drawing-in, and possible ejection of parts of the wheel should it break.	Electricity, heat, noise and hazardous substances (dust).
Lathes	Reducing, cutting and shaping metals and woods; make use of cutting tools and drills.	Entanglement and cutting.	Electricity, noise, high temperature of the workpiece and tools, and hazardous substances in the form of cooling and cutting fluids.
Automatic doors and gates	Power and/or remote operation of doors and gates.	Hazards include: crushing, shearing and impact.	Electricity.
Mechanical and hydraulic presses	Forming shapes in metals, plastics, etc. and pressing components to fit, e.g. bearings.	Crushing, and impact. If the press is hydraulically operated there is a high-pressure liquid hazard.	Electricity, noise and vibration.
Portable power tools	Include: drills, grinders, sawing, etc.; powered by electricity or compressed air.	Hazards depend on the use of the tool.	Electricity, noise, vibration and heat.
CNC machine	Computer numeric control systems provide a selection of features which can significantly improve the productivity of a machine (e.g. milling machines and lathes) and the quality of the work produced.	Entanglement with rotating parts, contact with sharp tools, shearing, crushing and ejection.	Electricity, noise, high temperature (due to the heat generated during the machining process).
Robotics	Take the place of humans in automated, repetitive tasks.	Hazards depend on which tasks the robot performs, e.g. drilling, cutting, paint spraying, high-pressure fluid hazards; impact, due to unexpected movements.	Electricity and others depending on the operation.

Types of Generic Machinery Hazards

Mechanical Hazards

BS EN ISO 12100 identifies the following mechanical hazards:

- Crushing.
- Shearing.
- Cutting (or severing).
- Entanglement.
- Drawing-in (or trapping).
- Impact.
- Stabbing, punctures and ejection.
- Friction and abrasion.
- High-pressure fluid injection.

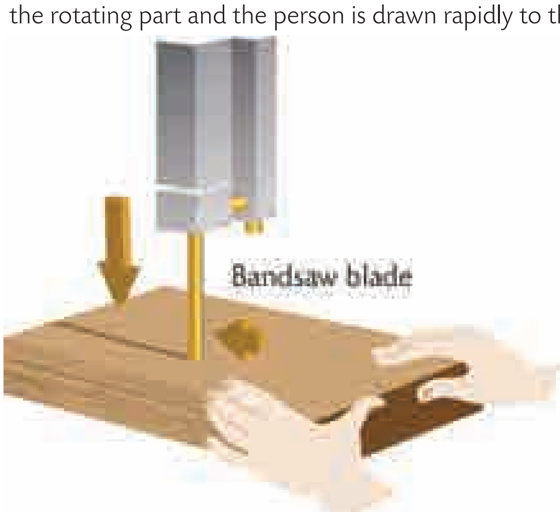
The hazards are illustrated below:

- **Crushing** is where the body or part of the body is caught between two moving parts of the machine or between moving and static objects such that they meet together.
- **Shearing** is where two parts of the machine are moving together to create a situation where one moves over the top of the other.

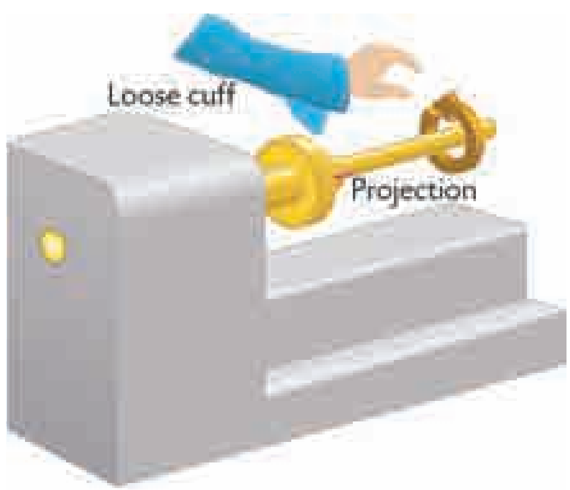
Crushing

Shearing

- **Cutting or severing** is where a sharp-edged part of the machinery comes in contact with the person. As implied, it is a similar effect to what happens when someone cuts themselves with a knife.
- **Entanglement** is associated with a single rotating part of a machine. Usually an item of clothing gets caught on the rotating part and the person is drawn rapidly to the machine.



Cutting or severing



Entanglement

- **Drawing-in or trapping** is where the body is caught between two moving parts and drawn into the machine. **In-running nips** occur at a point where a tangent meets a rotating member, i.e. belt/wheel, chair/sprocket, etc.

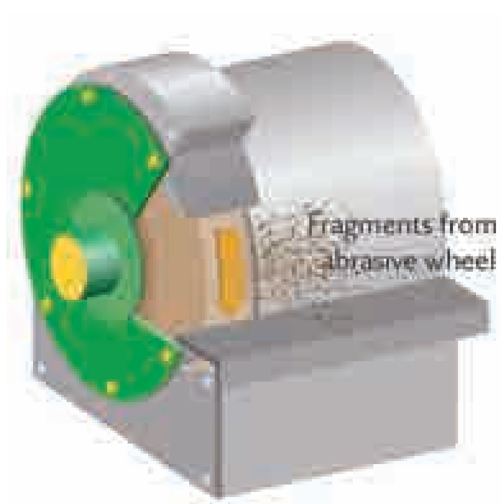
  Other examples of drawing-in and in-running nips can occur during use of gear wheels, mangles, dough mixers, screw conveyors, or even from materials in motion, e.g. swarf or clothes in a tumble dryer.

- **Impact** is where a powered part of the machine hits the person.

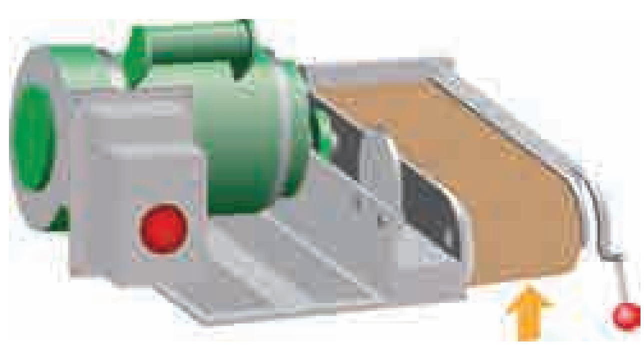
Rotating and tangential (rack and pinion)

Impact

- **Stabbing or puncture** is caused by some sharp part of the machine or process penetrating the person. The wound is normally small on the surface but deep into the body. Examples include ejected material such as flying swarf or broken tooling.
- **Friction or abrasion** is caused by coming into contact with a fast moving surface. The effect is a burn due to the generation of heat through the friction generated between the machine and the part of the body in contact. If the rotating or moving part has a rough texture, the effect will be to create an abrasion problem, similar to rubbing the hand hard against glass paper.
- **High-pressure fluid injection hazard** is associated with the use of hydraulic systems. The pressure to which the fluid is subjected in the system can be quite high. Following a sudden release, e.g. by a pipe or joint bursting, the fluid jet may have sufficient pressure to penetrate the skin and tissues of any person in the line of the spray. The problem is that it injects hydraulic fluid deep into the body where the circulatory system can distribute it widely.



Stabbing or puncture



Friction or abrasion

Non-Mechanical Hazards

BS EN ISO 12100 includes **hazards associated with use**, in addition to the mechanical hazards described earlier.

- Noise

  Noise is a hazard not only to the operator but also to those around. Its effects can lead to temporary or permanent hearing loss and tinnitus, and can impair working efficiency. It also causes communication problems by interfering with speech or audio warning signals.

- Vibration

  Vibration affects the body and, in extreme cases, produces vascular disorders, i.e. it interferes with blood flow. Its effect may be localised, as from holding hand tools, or full-body, such as from sitting in a poorly-designed driving position on vibrating machinery.

- Electricity

  Electrical hazards from machinery are covered later in this unit. It is sufficient to say here that electric shock is an ever-present danger.

- High/Low Temperature

  Thermal hazards arise from the extremes of either heat or cold. There are two ways in which they can affect the person:

  - As localised effects, e.g. burns from a cutting torch.
  - In general overall health, due to the extreme environment, e.g. in a furnace room or cold store.

- Radiation

  The various forms of radiation, e.g. heat, ultraviolet, infrared, etc., can create health hazards. An example of this could be the use of beta radiation to measure the thickness of paper manufactured on a production line.

- Hazardous Substances

  Materials used by the machine may give rise to hazards. This may be from contact with the substance(s), by fire or explosion, or by there being a biological hazard, e.g. yeasts used in brewing.

These hazards (except electricity) are covered in more detail in Unit IB of the International Diploma.

STUDY QUESTIONS

9. What are the mechanical hazards of an abrasive wheel?

10. What non-mechanical hazards would be associated with the operation of a lathe?

(Suggested Answers are at the end.)

Protective Devices

IN THIS SECTION...

The main types of safeguarding devices include:

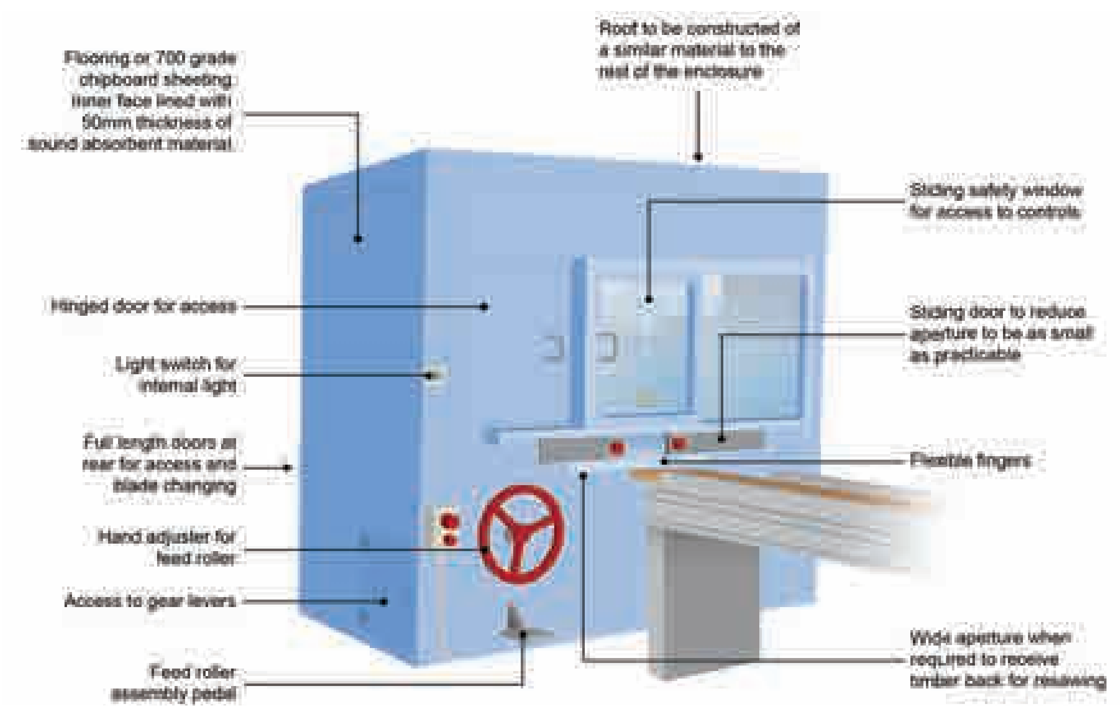
- Fixed enclosed guards.
- Fixed distance guards.
- Interlocked guards.
- Automatic guards.
- Trip devices.
- Adjustable/self-adjusting guards.
- Two-hand controls.
- Mechanical restraints.
- Jigs and push-sticks.

Main Types of Safeguarding Devices

This section will identify the characteristics, key features, limitations and typical applications of a range of guards.

Fixed Enclosed Guards

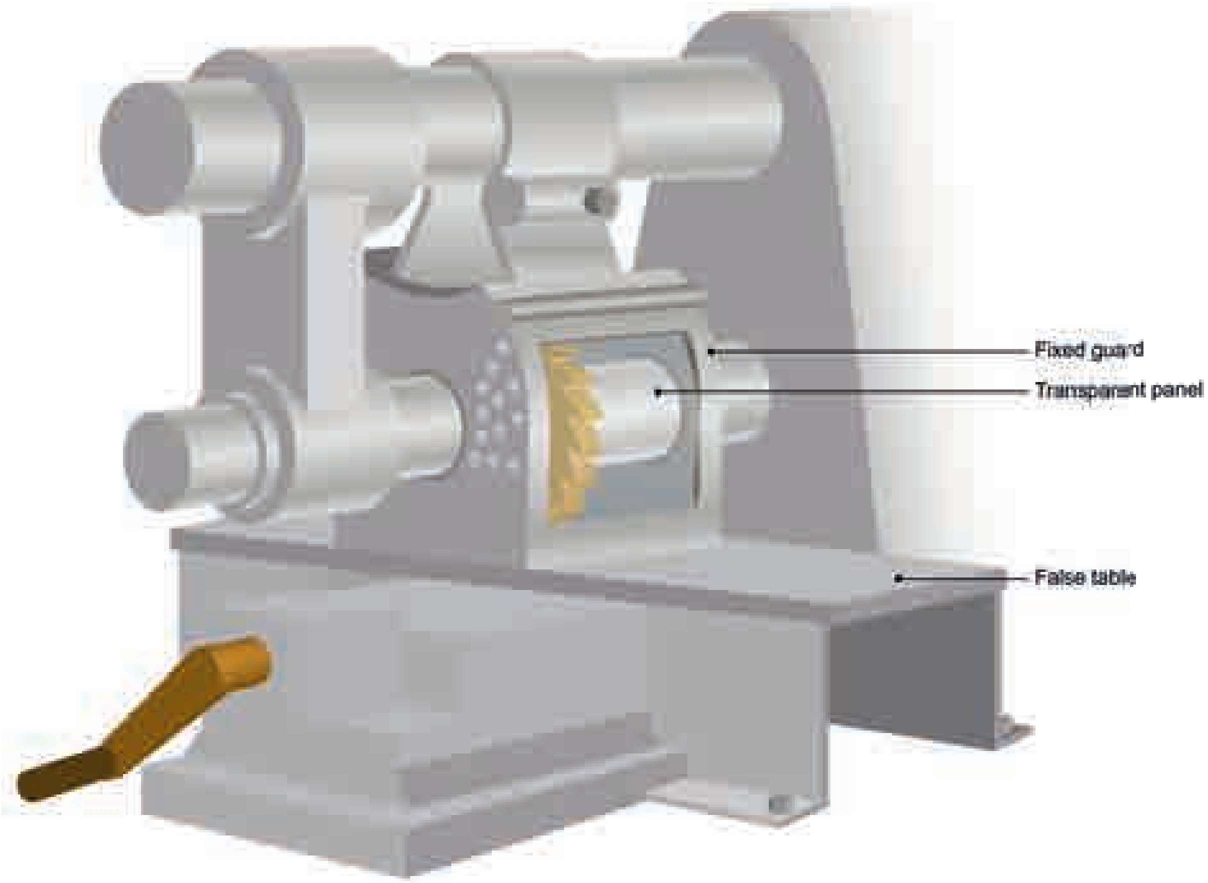
These are guards with no moving parts, and are designed to prevent access by enclosing the hazard. There may be access points where materials can be inserted and withdrawn, and hatches for maintenance or inspection.



Fixed enclosed guard

Fixed Distance Guards

This type of guard has no moving parts and is to keep the person away from the hazard. The false table shown in the diagram serves as a fixed distance guard.



Fixed distance guard

A fixed distance guard is a fixed guard that does not completely enclose a hazard, but which reduces access by virtue of its physical dimensions and its distance from the hazard.

Another type of distance guard which completely surrounds machinery is commonly called a perimeter-fence type guard. An example of this is the enclosure around a robotic area.

When it is necessary for work to be fed through the guard, openings should be sufficient only to allow the passage of material and should not create a trap between the material and the guard. If access to the dangerous parts cannot be prevented by the use of a fixed enclosing guard with a plain opening, then a tunnel guard of sufficient length should be provided.

Interlocked Guards

When an operator is required to enter a hazardous area of machinery and where fixed guards are not a practical option, interlocked guards are the next best protective device. An interlocked guard is defined as a guarding system which, when the hazard area is open, prevents the machinery from operating. Implicit in this definition are three important points which control the design and operation of an interlocked guard:

- It must prevent movement of the dangerous parts of the machine when the hazard area is open.
- It must not allow access to the hazardous area until the potential hazard has been made safe.
- It must not allow the machinery to operate until the guarding system is fully operational.

Other factors of importance are:

- If the interlocked system should fail, it should fail in such a way that the system remains safe.
- The interlocked system should be difficult to defeat.

The operation of an interlock may be electrical, mechanical, hydraulic or pneumatic. The choice is often dependent on the power medium (e.g. hydraulic) in use to operate the machine. In more complex machines, a combination of interlocks may be in place.

Electrical Interlocks

The electrical interlock is used to ensure that the power to operate the machine is not available until the guard is in place. The position of the guard is detected by means of electrical limit switches. The two main types are described below.

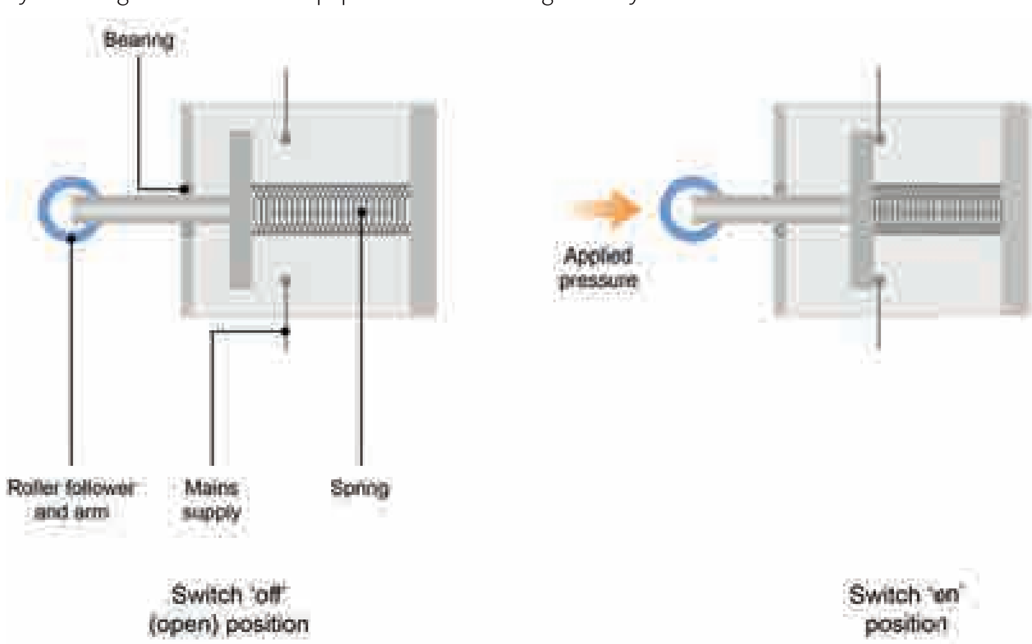
- Normally-Open Limit Switch

  The design of the switch is such that the spring will keep the contacts open until pressure is applied to the roller follower; see the "Normally-Open Electrical Limit Switch" diagram which follows. The diagram which follows that, entitled "Switch with a Guarding System", shows how a normally-open switch can be used in conjunction with an interlocked guarding system.

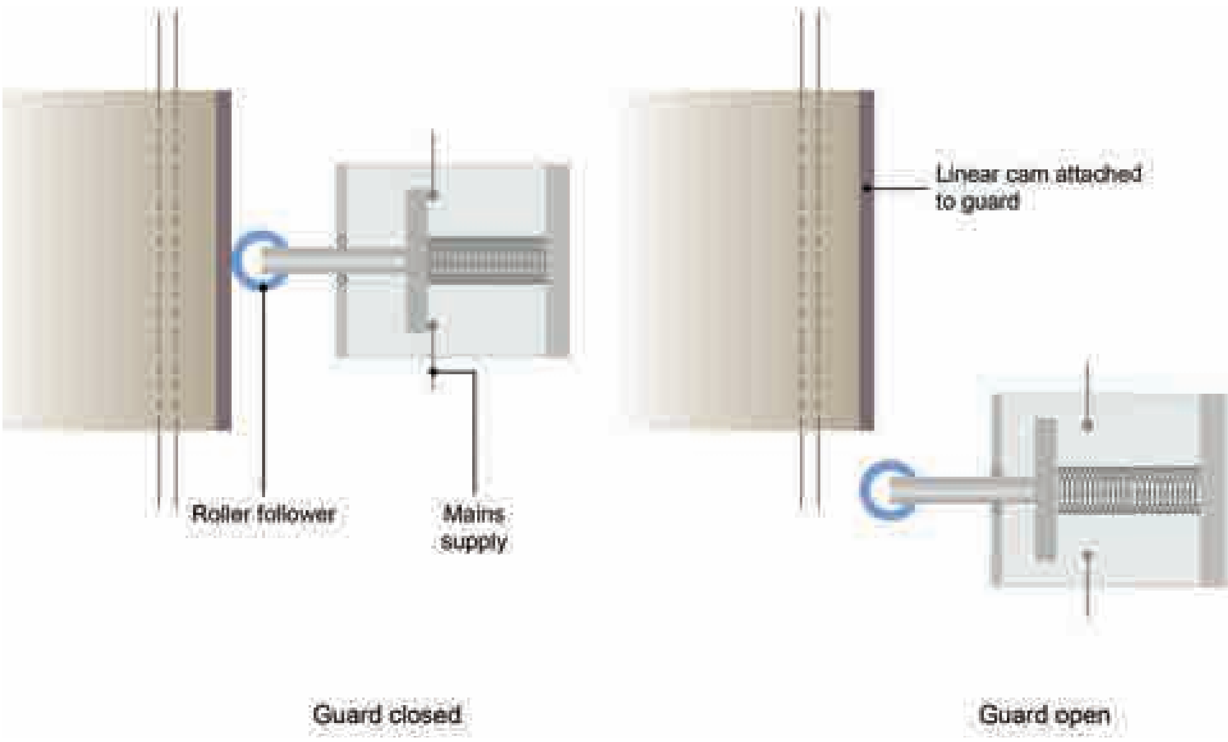
  There are three serious defects in the use of normally-open limit switches:

  – They are **easy to defeat** by simply holding down with the hand - or, more permanently, with some adhesive tape.
  – More seriously, if the spring should break, the switch would be left **on**, without any external pressure, and the guarding would **fail to danger**, leaving the operator vulnerable to an unexpected operation of the machine while the guard is open.
  – If the roller follower arm becomes bent or the bearing becomes still, the switch could become **jammed** in the on position, producing the same danger as above.

  Normally-open limit switches are frequently used by manufacturers as a method of controlling interlocked guards. With the defects mentioned above, they **do not satisfy basic safety criteria**. Employers would be well advised to see they are designed out of new equipment before taking delivery.



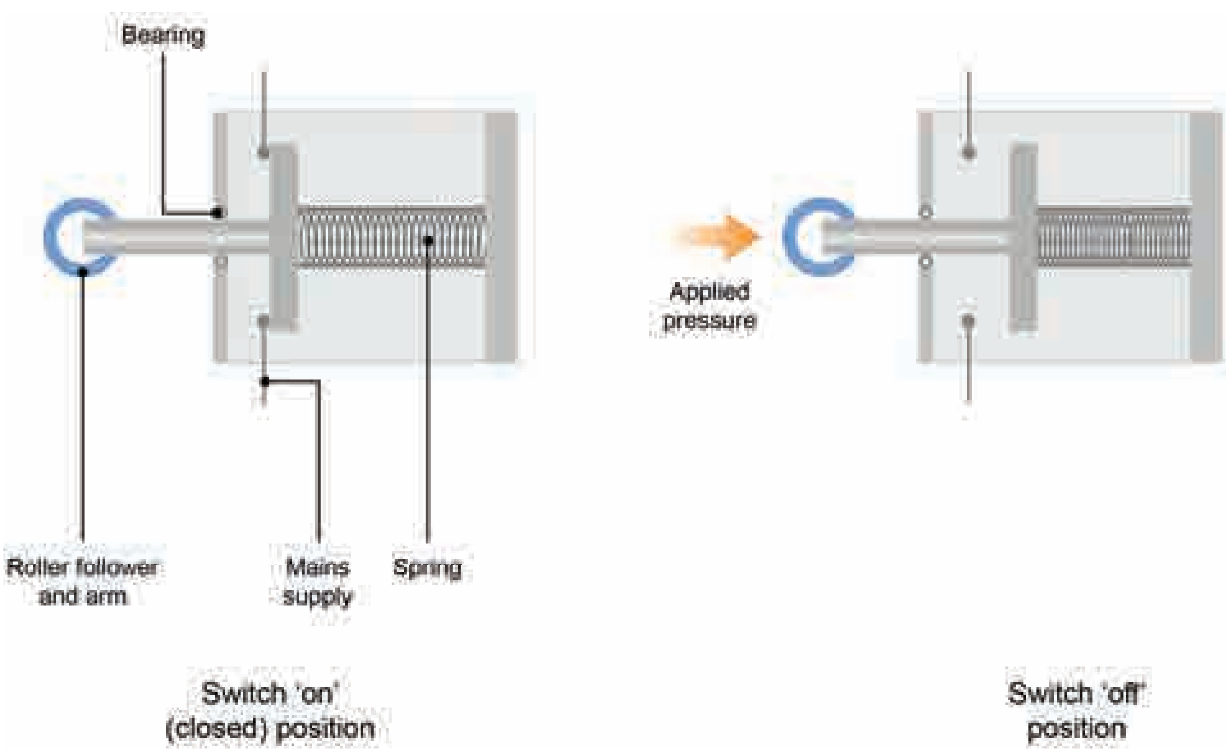
Normally-open electrical limit switch (negative mode)



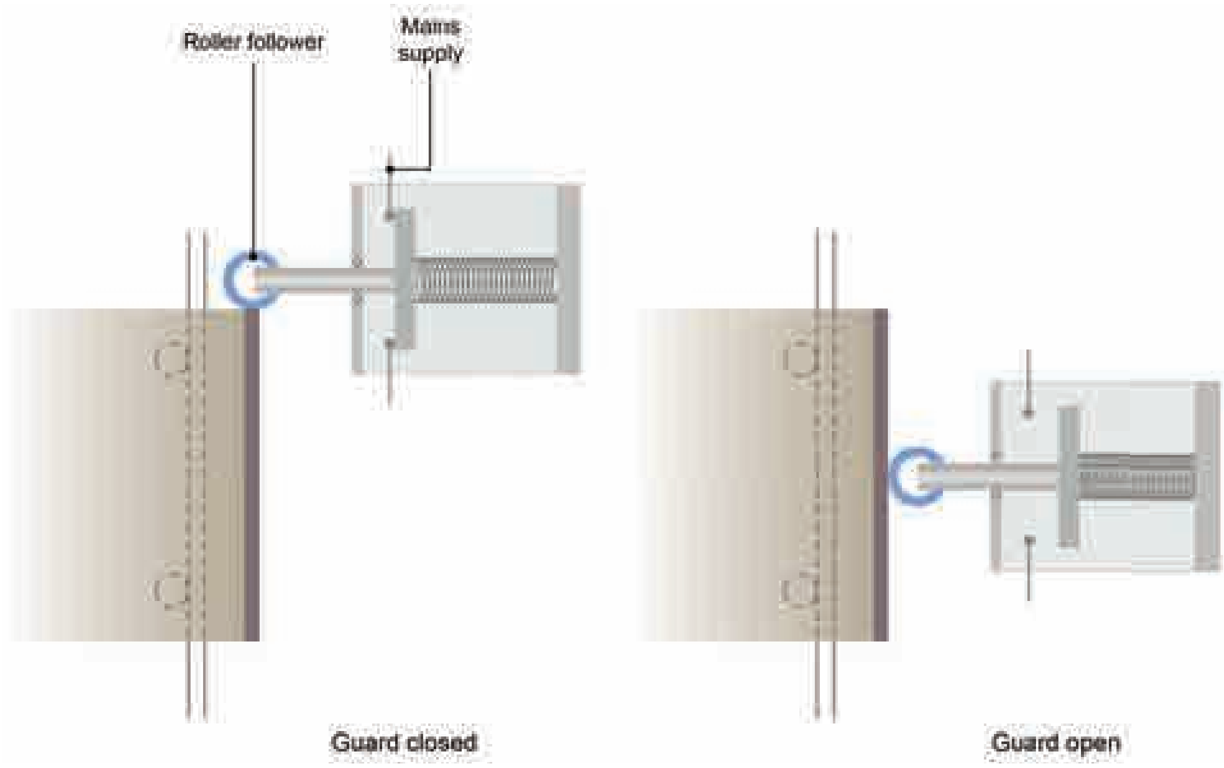
Switch with a guarding system

- **Normally-Closed Limit Switch**

  In this switch, the spring is designed to close the contacts when there is no pressure on the roller follower - see the diagram that follows. The diagram after that shows how the normally-closed switch can be used on an interlocked system.



Normally-closed electrical limit switch



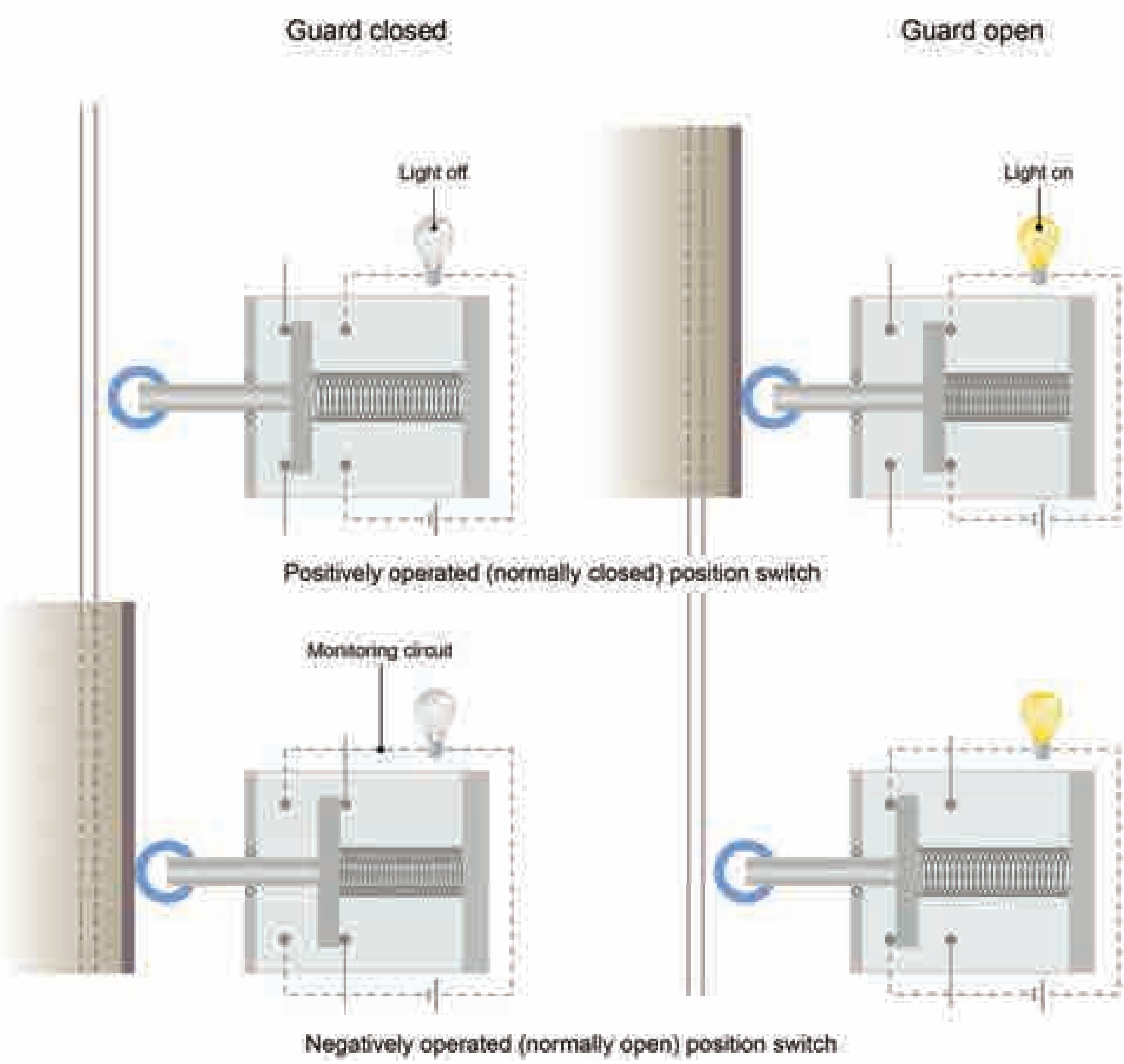
Normally-closed electrical limit switch on an interlocked system

The design of the normally-closed switch is safer than that of the normally-open switch, in that it is more difficult to defeat and, if the spring breaks, it will fail to safety. There are, however, defects in the system:

- Wear, misalignment, or overrun of the linear cam on the guard will result in a **fail-to-danger** condition.
- If the guard is removed, the switch will become activated, creating another **fail-to-danger** condition.

With its improved safety design, the normally-closed switch can be used to replace the normally-open type.

Where limit switches have to be used, they can provide a safer system if each type is used in series. The arrangement of this design is shown in the following diagram:



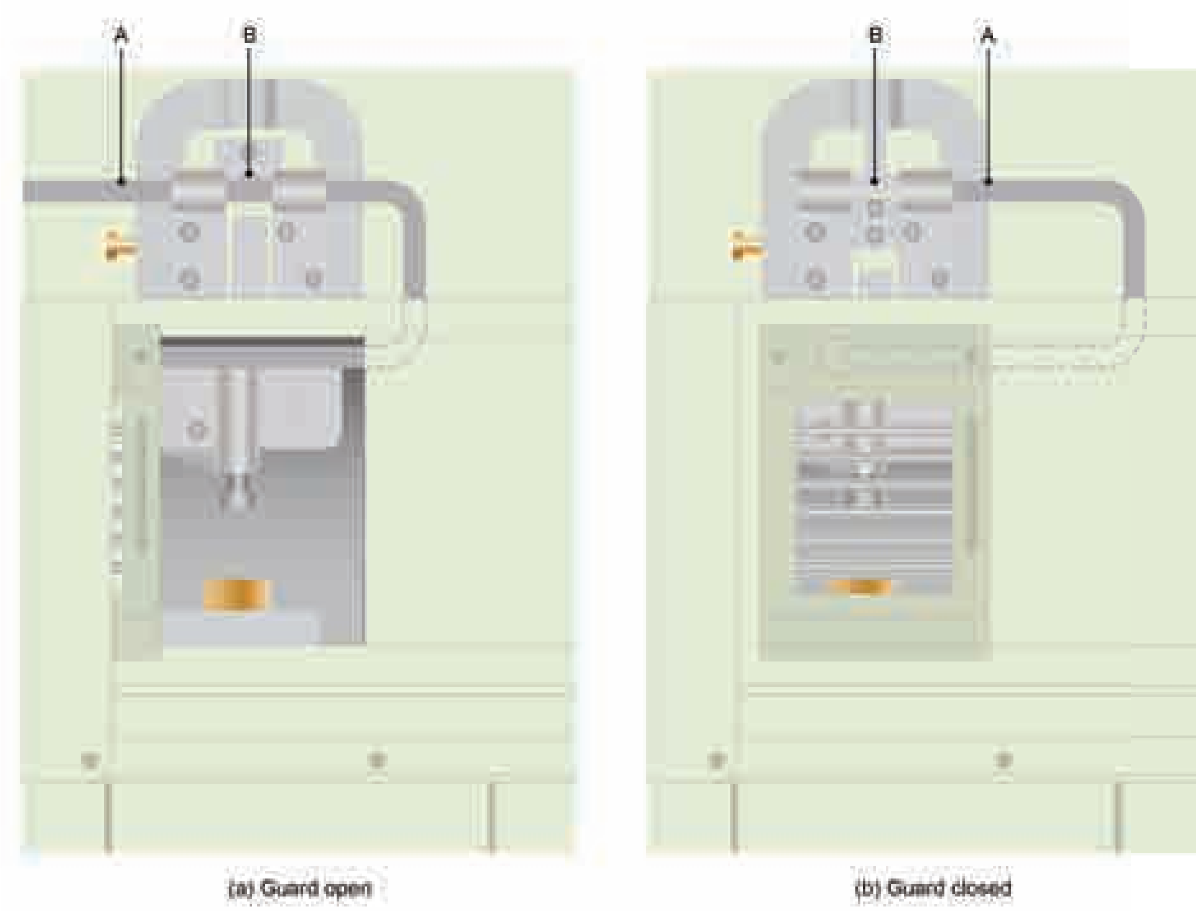
Design of a limit switch

Although the system is difficult to defeat, there is a possibility that one switch could fail in the on position, and the system would continue to operate until a fail-to-danger condition occurred. The possibility of failure and a hazard condition could be reduced by rigorous maintenance, especially if the switches are not monitored automatically. Monitoring of the switches incorporates warning lights for each switch, which light up when the switch is in the circuit position and the guard is open. Failure of a light would indicate the switch is not returning to open circuit (or, less seriously, the bulb has failed).

Mechanical Interlocks

The following diagram illustrates a simple mechanical interlocked system. When the guard is open, the press cannot operate, because the restraining arm A prevents movement of the block B. When the guard is closed, block B is freed and the press is allowed to operate.

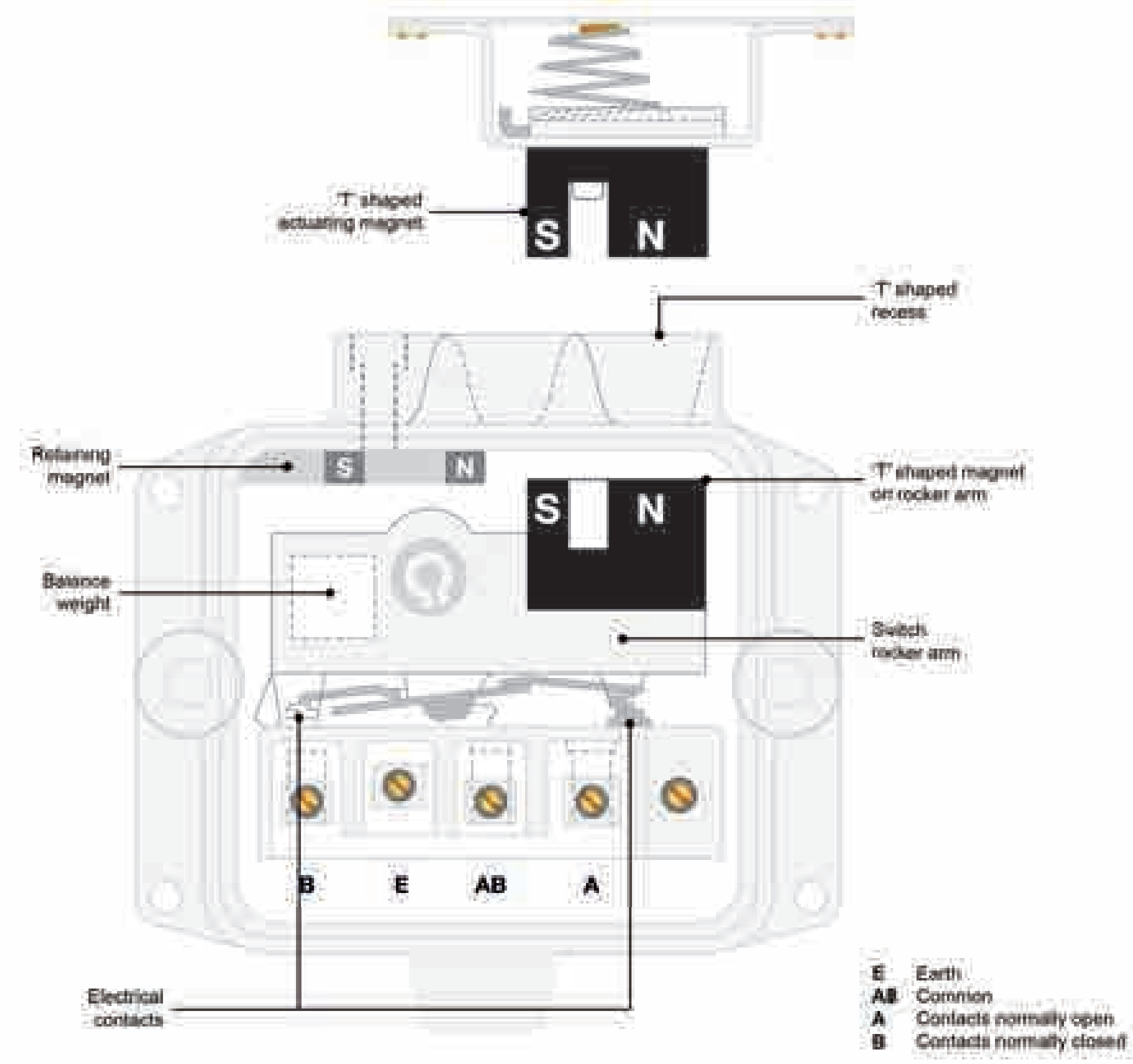
The design and positioning of the block B prevent the guard from opening while the machinery is in operation.



Simple mechanical interlocked system

Magnetic Switches

A common magnetic interlock uses magnetic forces to control and operate an electric switch. The next diagram illustrates this type of interlock.



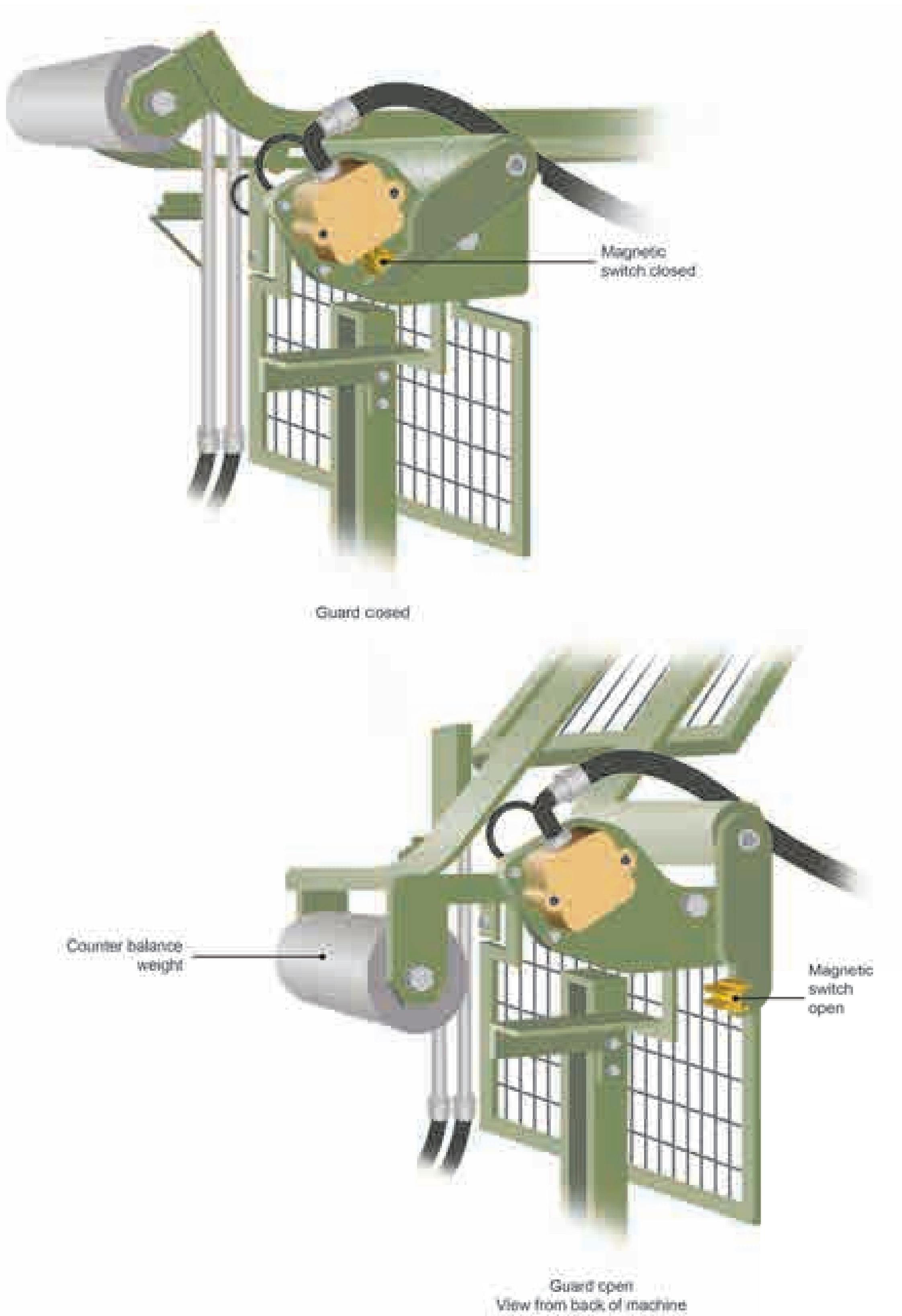
Magnetic safety switch

The electrical contacts in the unit are held **open** by the effects on them of the retaining magnet and the balance weight.

When the external T-shaped magnet system is brought into contact with the internal magnet, a repulsive magnetic force is generated, causing the magnet to move away. This action causes the contacts to close, and activates electric power.

This system is used on any machinery that has a lid or cover which is regularly being opened and closed. In general, the switch is robust and reliable, but there are two possible areas of weakness:

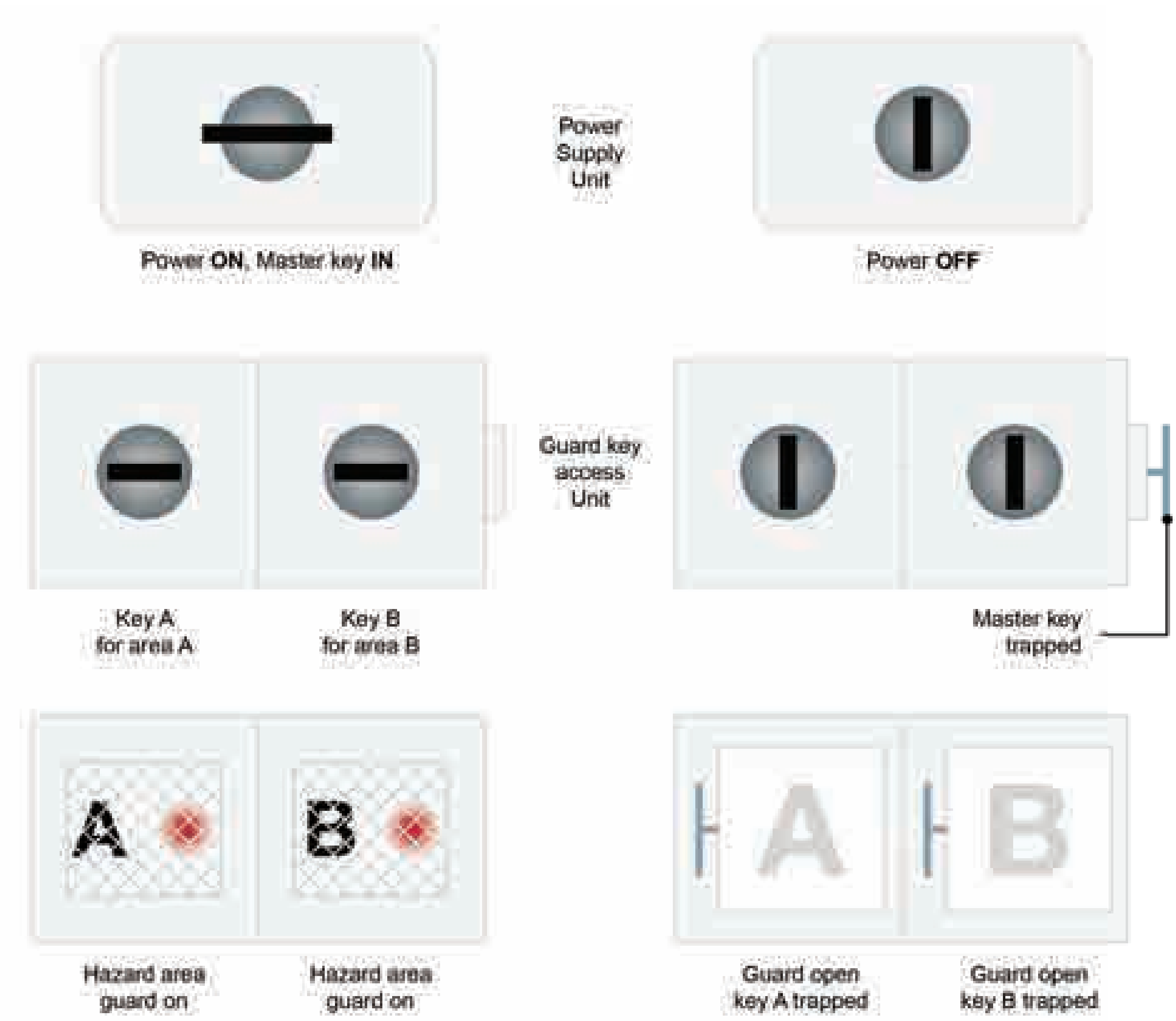
- Although the design of the magnetic fields produced by magnets is complex, they can, with difficulty, be defeated. The switch can therefore be opened with the magnet removed.
- There is a risk that the electrical contacts, under adverse conditions, could fuse together, so the switch would fail to danger. It is not possible to predict how likely the chances are of this failure occurring, but manufacturers of the units have recognised the possibility and their research has given them confidence to believe that such a fault could not occur.



Safety switch in operation

Trapped Key Systems

This type of interlock ensures that power to a machine is locked off if guards are open. Its operation is shown in the following diagram. A master key in the power-supply unit is turned to switch power off. This key may now be removed to operate the guard key access unit, which holds a number of keys necessary to open guards on the machine. When one or more guard keys are removed to unlock a guard, the master key is trapped in the access unit. Power remains locked off. When access to hazard areas is no longer required, guards are locked, and the keys are returned to the access unit. Not until all keys are securely in may the trapped master key be removed. It is then available to operate the power supply to the machine.

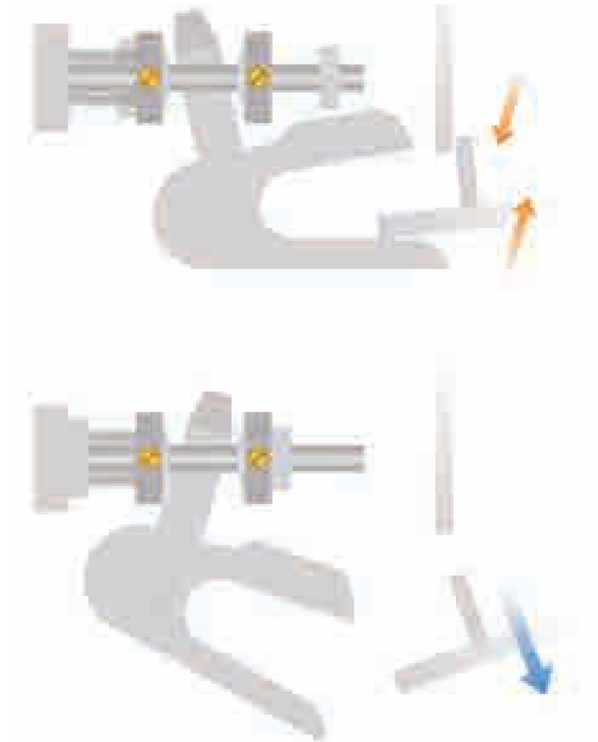


Interlock operation

Time-Delay Interlocks

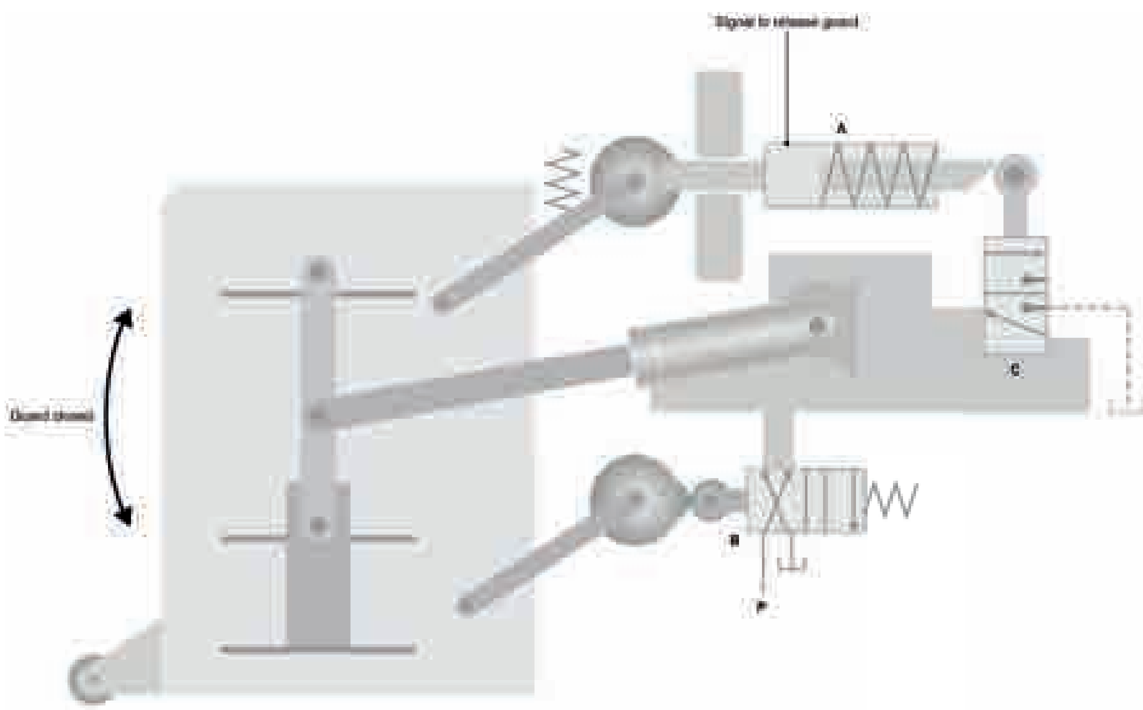
Routinely used in domestic washing machine doors, a time-delay interlock system incorporates a mechanical time-delay device which cuts in after power has been removed from the machine. They are fitted to machines where the system continues in motion after the power has been removed, e.g. centrifuges.

The next diagram illustrates a mechanical time-delay. To release the guard it is necessary to hand-wind the knurled knob. Note that the delay can be altered both by length and pitch of the threaded portion.



Time-delay interlock

A commonly used control guard for a pneumatic or hydraulic press is shown in the next diagram (in the **closed** position). Bolt **A** holds the guard closed and enables valve **C**. **B** is a back-up. When the work cycle is complete, **A** is withdrawn and **C** locked out. A delay can be built in using a pressure switch **P** linked to the primary hydraulic/ pneumatic circuit.



Control guard in closed position

Automatic Guards

Automatic guards may be defined as 'guards which **forcibly move** persons from the hazard area (sweep away) **before** the machinery operates'. In theory, the person should not be able to enter the hazard area while the automatic guard is operating.

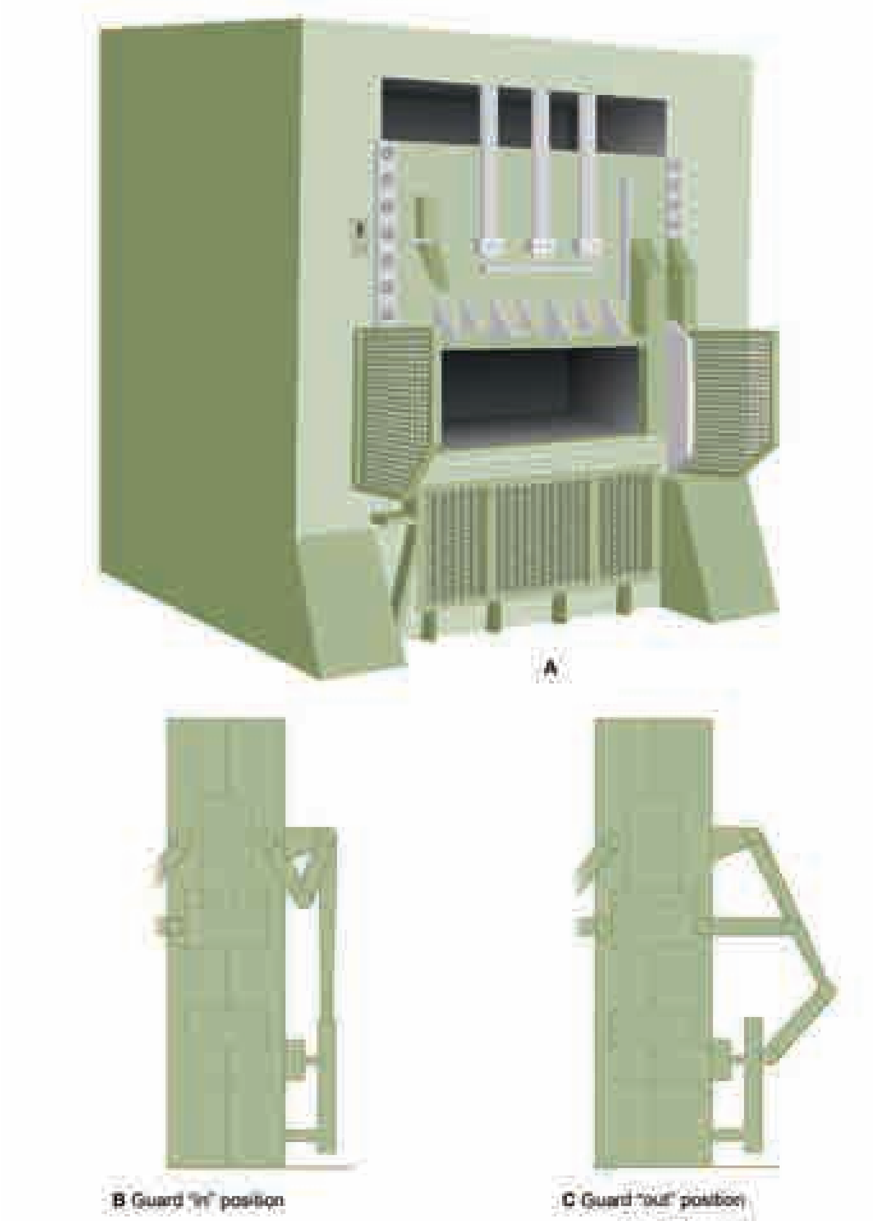
As the guarding system uses motion as an essential part of its protective mechanism, doubts as to the acceptability of such a system must be raised. Apart from the concept of motion being the fundamental cause of machinery hazards, there are practical considerations, such as:

- The speed at which the guard has to operate to overtake the hazard may be dangerous.
- Tall persons may fall or lean over the guard into the hazard area.

A typical arrangement for a power press is shown in the next diagram.

HINTS AND TIPS

You should note carefully the description of an automatic guard, as many candidates tend to confuse automatic guards and interlock guards in examinations.



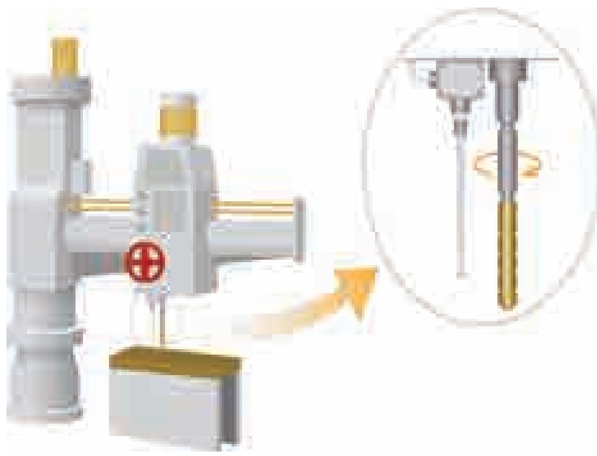
Automatic guard

Trip Devices

Safety trip controls provide a quick means for deactivating the machine in an emergency situation. A pressure-sensitive body bar, when depressed, will deactivate the machine. If the operator or anyone trips, loses balance, or is drawn toward the machine, applying pressure to the bar will stop the operation. The positioning of the bar, therefore, is critical. It must stop the machine before a part of the employee's body reaches the danger area.

Trip Bar for Radial or Pillar Drills

The next diagram illustrates a trip bar guard which can be fitted to pillar drills. A microswitch attached to the trip bar will, if slightly displaced, cut off AC supply and inject DC into the motor, so that it stops instantly.



Trip bar guard

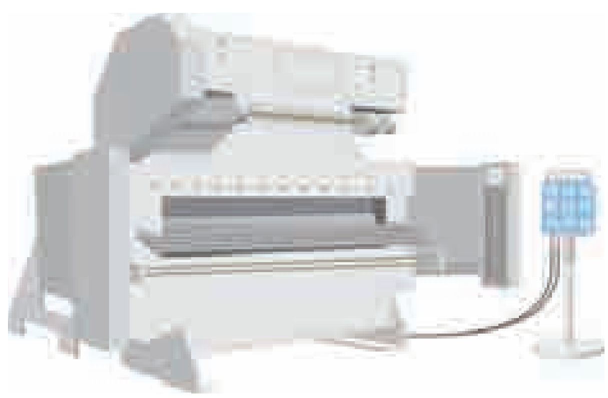
With this type of system employers should ensure:

- Maintenance of maximum sensitivity for the trip bar, i.e. so that the minimum of movement is required to activate the micro-switch.
- Monitoring of the micro-switch for contact wear.
- That the trip guard is not being used as an **operational** brake for the drill.

Photo-Electric Guards

Another form of trip device used for press brakes and hydraulic presses is the photo-electric guard.

The photo-electric (optical) presence-sensing device uses a system of light sources and controls which can interrupt the machine's operating cycle. If the light field is broken, the machine stops and will not cycle. This device must be used only on machines which can be stopped before the worker can reach the danger area. The design and placement of the guard depends on the time it takes to stop the mechanism and the speed at which the employee's hand can reach across the distance from the guard to the danger zone.

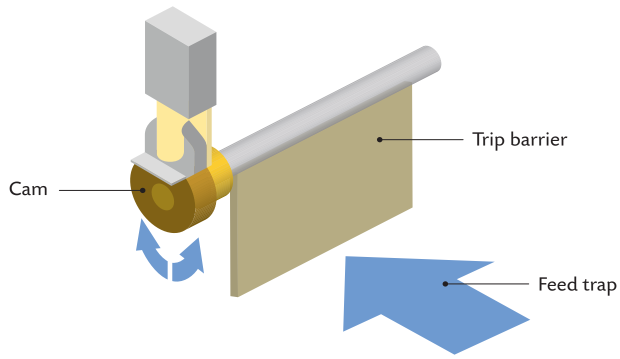


A photo-electric guard fitted to a press brake (Based on original source L22 Safe use of work equipment (4th ed.), HSE, 2014 (www.hse.gov.uk/pubns/books/l22.htm))

Cam-Activated Switches

A cam-activated switch usually works by the movement of a raised part of the switch arrangement, against a spring-loaded push rod. The push rod will normally have a roller at the end of it.

As the raised portion of the switch comes into contact with the roller, the push rod is depressed against the spring pressure. Depending on the operation of the switch, this will either make or break the contact, or open or close the valve. As the raised portion moves away from the roller, the spring reasserts itself.



Cam-activated switch

A typical example of the arrangement and operation of linear cam-activated switches is shown in the electrical limit switch diagrams which were seen earlier.

Safety Switchmats or Trip Mats

The concept of mat-pressure contact circuits has been applied in the development of safety mats, known as **safety switchmats**, or **trip mats**. Safety mats are pressure-sensitive safeguarding products that are designed to detect the presence of people on the sensing surfaces. These mats have two conductive hardened steel plates that are held apart by non-conductive compressible separators. Manufacturers often offer standard, configurable and custom mats, for different-shaped machines.

The mats are positioned round a machine at an appropriate distance from the hazard. Pneumatic or low-voltage electric contacts within the body of the mat are linked to the power circuit of the machine, in such a way that stepping on the mat shuts off the power.

The same principle of using contact pressure is found in devices known as **safety edges**. Narrow strips are fitted to sliding doors or machine parts which might close to trap a person. Circuits from the pressure strips halt the closing movement and, if desired, reverse it to avoid the trap.

Adjustable Guards

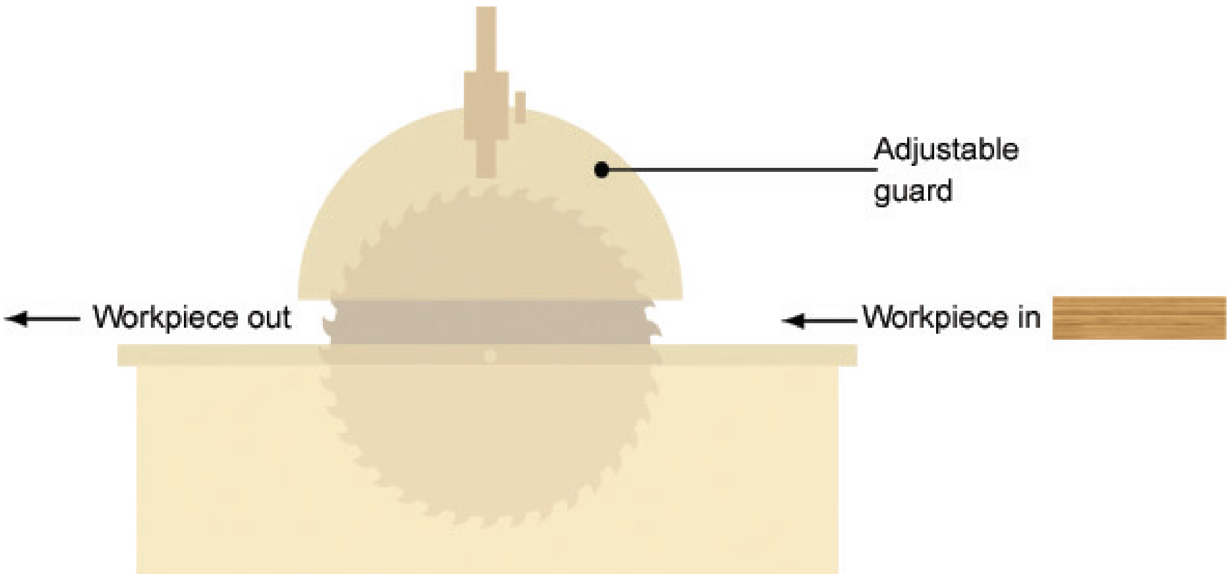
Where it is impracticable to prevent access to the dangerous parts because they are unavoidably exposed during use, e.g. the cutters on milling machines and the cutters of some woodworking machines, the use of an adjustable guard may be permissible in conjunction with other closely supervised conditions, e.g. a sound floor, good lighting and adequate training of the operator.

An adjustable guard provides an opening to the machinery through which material can be fed, the whole guard or part of it being capable of adjustment in order that the opening can be varied in height and width to suit the dimension of the work in hand. It is essential in such cases that the adjustment is carefully carried out by a suitably trained person. Regular maintenance of the fixing arrangements is necessary to ensure that the adjustable element of the guard remains firmly in place once positioned. The guard should be designed so that the adjustable parts cannot easily become detached and mislaid.

Adjustable guards are guarding systems which require manual adjustment to give protection. They are used on woodworking machinery, milling machines, lathes, drills and grinders. Many of the guards are designed so the workpiece can be observed during the machine operation. Windows of perspex, polycarbonate or armoured plate glass allow the operator a clear view. Some systems are made with a telescopic fencing or a slotted movable casting; both systems allow observation of the workpiece.

The following figures show adjustable guarding systems which are in common use.

- Circular Saws



Circular saw with adjustable guard

The cover is adjusted so that the height is large enough for the workpiece to be cut by the saw.

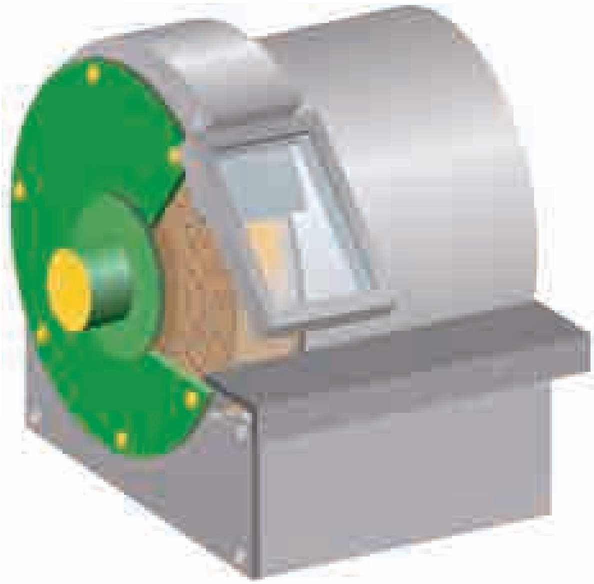
- Vertical Drills or Woodworking Moulder

The transparent cover, which allows a clear view of the drill or cutter, is adjusted and secured in position by the thumb screw.

Drilling machine chuck guard

- Abrasive Wheels

  A simpler version of an adjustable guard can be used on abrasive wheels.



Abrasive wheel guard

The use of adjustable guards is allowed in many situations by the enforcing authorities, but critical thought should be given before they are used as a guarding system. Their main weakness lies in the fact that they are controlled by the machine operator, and not by the person or organisation responsible by law for controlling the safety of the workplace. As a consequence there are two potentially serious risks:

- They can easily be defeated.
- They rely on operators being 100% vigilant in providing for their own safety – a condition which the guard should provide, not the operator.

Where adjustable guards are used, strict training and supervision of operators is of paramount importance.

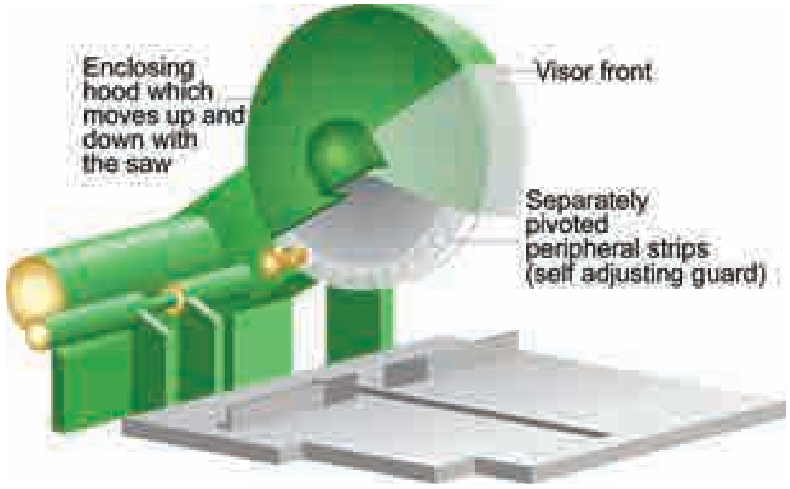
Self-Adjusting Guards

A self-adjusting guard is a fixed or movable guard which, either in whole or in part, adjusts itself to accommodate the passage of material, etc.

This type of protection is designed to prevent access to the dangerous part(s) until actuated by the movement of the workpiece, i.e. it is opened by the passage of the workpiece at the beginning of the operation and returns to the safe position on completion of the operation.

Consideration should be given to the use of feeding and take-off devices, jigs and fixtures when this type of guard is used.

The next diagram shows a typical arrangement. The guard rests on top of the work and closes fully when removed. Note that this kind of guarding can be difficult for the operator and is easy to defeat. However, it is sometimes the only practicable method.



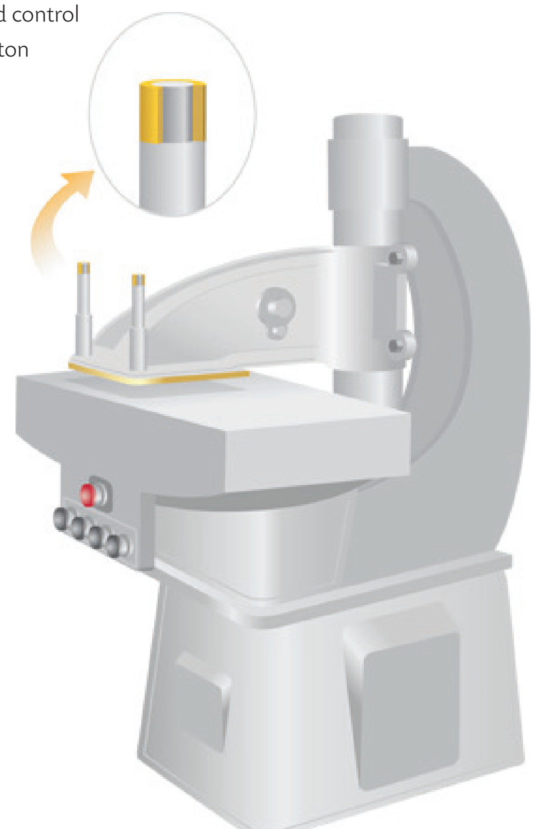
Typical arrangement of a self-adjusting guard

Two-Hand Controls

Where guarding is impracticable, as in the next illustration, two-hand control offers a means of protecting the hands of the machine operator. It may also be used as a hold-to-run control.

A two-hand control device requires both hands to operate the machinery controls, thus affording a measure of protection from danger to the machinery operator only. It should be designed as follows:

- The hand controls should be placed, separated and protected so as to prevent:
  - Spanning with one hand only.
  - Being operated with one hand and another part of the body.
  - Being readily bridged.
- It should not be possible to set the dangerous parts in motion unless the controls are operated within approximately 0.5 seconds of each other.
- Movement of the dangerous parts should be brought to a stop immediately; or, where appropriate, stopped and reversed if one or both controls are released while there is still danger from the movement of those parts.
- The hand controls should be situated at such a distance from the danger point that, on releasing the controls, it is not possible for the operator to reach the danger point before the motion of the dangerous parts has been stopped.



Two-hand control device

There are, unfortunately, difficulties with the use of two-handed controls:

- Experience has shown that most two-handed systems will eventually be defeated by the determined operator.
- During operation, the system protects the operator; third parties are always at risk.
- Often, frequent maintenance is required, as most systems require a complex mechanism in order to make them effective.

The use of two-handed control systems as a method of guarding machinery must be considered as having very limited practical value.

Mechanical Restraints

Mechanical restraints provide restraint to a dangerous part of machinery which has been set in motion due to the failure of the machinery control or other parts of the machinery, so as to prevent danger. It introduces into the moving mechanism a mechanical obstacle (e.g. wedge, spindle, strut, scotch) which, by virtue of its own strength, can prevent any hazardous movement. For example, the platen on a downstroke machine is held in place when the guards are open by the hydraulic system. If this failed, the platen could fall under gravity, giving rise to potential injury. A mechanical restraint would be used so that the downward movement was restricted and trapping could not take place.

Two key points about such a device are:

- It is used as a back-up against failure of some other part of the system.
- It is used in conjunction with other forms of guarding, rather than as a primary form of protection, and is linked to the operation of the primary guarding.

Jigs and Push-Sticks

These are designed to hold a workpiece in place when in the machine.

- **Jigs** remove the need for the person to be in the danger zone during operation. They are not, in themselves, a guard but can be considered as part of the safety measures when assessing the type of guard that is needed on any appropriate machine.
- A **push-stick** performs a similar function. A good example is feeding a length of wood into a circular saw. As the hands that are holding the wood approach the saw blade, a push-stick can be used to distance the operator's hand from the moving blade.

Machinery Guarding Guide

The following table provides a summary of the characteristics of different types of machinery guarding.

As machinery becomes more complex and production lines more automated, perhaps involving robots, the demands on the designer become greater and an overall systems approach is essential.

Machinery guarding

Type	Description	Strengths	Weaknesses	Means of Overriding
Fixed	Permanently in place after installation (e.g. welded, riveted). Normally require special tool to remove.	Presents the most desirable barrier between operator and hazard. No moving parts. Cannot be interfered with by operator. Virtually maintenance-free.	Machine will still operate with guard removed. Size of holes for material feed may limit operability.	Special tool for removal may be too widely available.
Interlock				
General	System where the guard is integrated with the control system.	Less dependent for their effectiveness on the control of human behaviour. Less easy to defeat. Do not represent the last line of defence as, e.g. a trip device does.	Design of the interlock critical; should be designed to fail to safety.	
Mechanical	Direct linkage between guard and power or linkage control.	Positive engagement required.	Wear on mechanical parts may prevent interlocking.	Difficult on well-designed systems.
Mechanical scotches	Used on certain types of presses to protect operator when reaching between platens.	Can be linked to guard operation so they are automatically positioned each time guard is opened.	Wear on mechanical parts may prevent interlocking.	
Electrical -General	Interlocks used generally in medium to low risk situations.			
Limit switch	Plunger switches operated either linearly or by cam. Positive make/break switch required.	Versatile, effective particularly if used in multiple.	Negative mode working less acceptable than positive. Subject to failure of components.	Difficult, particularly if in multiple.
Captive key	Comprises a key secured to the guard with combined switch and lock fitted to the machine. On rotation, guard mechanically locked, further rotation completes control circuit.	Control circuit inoperable until guard locked into place.		Difficult.
Trapped key (key exchange or key transfer)	Guard lock and switch are separate. Key cannot be removed until the guard is locked in place and then key used to activate control circuit.	Machine inoperable until guard locked and key used to activate control circuit.	Unsuitable for control interlocks except for specific guarding.	Spare key may be used to override system.

Machinery guarding (continued)

Type	Description	Strengths	Weaknesses	Means of Overriding
Magnetic switches	Magnet is attached to the guard which activates a reed switch to complete circuit when guard closed.	Detects position of guard.		Easily overridden by use of a magnet.
Time delay	Used when machine has big inertia and a long rundown time.	Prevents access when machine in motion after power switched off.	Slows process down.	
Automatic	Moves into position as part of machine cycle.	Pushes any part of person away from danger area.	Slows operation. Bad design may cause trapping hazard or impact injury.	Mechanical action can be overridden.
Others				
Trip devices (e.g. electro-magnetic beam, pressure mats or mechanical trips)	Causes machine to stop or become safe when person approaches.	Useful when approach by person required as part of job.	Trips may not be set to cover all means of access. Time delay in stopping machine may be greater than time from tripping guard to reaching machine.	Person can avoid devices as part of "I can beat this machine" syndrome.
Two-handed control	Two controls activated and released simultaneously.	Keeps operator's hands away from moving parts. Rapid manual movement of guard into place.	Protects only operator's hands, not other parts of body or other people.	Two people, each holding one handle.
Self-adjusting, manual adjusting	Guard which can be varied in size to suit situation.	Allows variable sized work-pieces.	Easily defeated.	Adjust out of range.

STUDY QUESTION

11. Outline the three main characteristics of an interlocked guard.

(Suggested Answer is at the end.)

Maintenance

IN THIS SECTION...

- Setting, cleaning and maintaining machinery are all activities outside the normal operation of the machine, which can expose persons involved to a greater degree of risk. There is a requirement for maintenance operations on machinery to be carried out without exposing the persons involved to risks to their health or safety. This can be achieved by employing:
  - Safe systems of work.
  - Permits-to-work.
  - Isolation.
  - Procedures for working at unguarded machinery.
- During repair, service or maintenance work it is often necessary to isolate machinery from potential uncontrolled energy sources.

Setting, Cleaning and Maintaining

Setting, cleaning and maintaining machinery are all activities outside the normal operation of the machine, which can expose persons involved to a greater degree of risk, but maintenance operations on machinery should be able to be carried out without exposing the persons involved to risks to their health or safety.


Personal protective equipment

Employers should ensure that:

- Work equipment is designed so that maintenance operations involving a risk to health or safety can be carried out while the work **equipment is shut down.**
- Maintenance operations can be **carried out without exposing the person carrying them out to a risk** to their health or safety.
- **Measures can be taken for the protection of any person** carrying out maintenance operations which involve a risk to their health or safety.

If equipment has to be running or working during a maintenance operation and this presents risks, measures should be taken to enable the operation of the equipment in a way that reduces the risk. These measures include further safeguards or functions designed into the equipment, such as limiting the power, speed or range of movement that is available to dangerous parts or providing protection during maintenance operations. Examples are:

- Providing temporary guards.
- Limited movement controls.
- Crawl speed operated by hold-to-run controls.

Other measures that can be taken to protect against any residual risk include wearing personal protective equipment and provision of instruction and supervision.

Access to danger zones should be minimised by locating maintenance, lubrication and setting points **outside** the danger zones. This includes access to such places, e.g. stairs and ladders with protection against falls as required.

It should be possible to carry out adjustment, maintenance, repair, cleaning and servicing operations with the machinery at a standstill. If this is not possible for technical reasons, then these activities must be able to be performed without risk.

Safe Systems of Work

Most of the comments so far in this element relate to the guarding of machinery in its **working state** (and to some examples of non-functioning state). However, machinery is not always working; tasks are required to set up and adjust the machine, for which the choice of guard becomes important. Likewise cleaning and maintaining the machinery is important to ensure that it is fit to function when required and to prolong its operational life. The basic premise starts with having in place a safe system of work which manages the risks. It may not be possible to introduce the same level of protection as when the machine is working, but remember that time of exposure should be taken into account.

It is emphasised that situations involving unguarded machinery under power in any phase of its life cycle should be avoided by appropriate design measures wherever technically feasible. Alternatives may include the use of completely different types of machine to achieve the same end product. When there is no alternative, the following general precautions should be observed by properly trained and supervised personnel:

- Safe access, with firm footholds (and handholds where necessary) should be provided. This should be free of obstruction and any material likely to cause slipping.
- Where the hazards include entanglement and drawing-in, loose clothing, neckties, gloves, rings and other jewellery, long hair (unless tied back and/or covered), fabric, first-aid dressings and bandages, and any other material likely to be caught up should be avoided. For any close approach, close-fitting overalls with close-fitting cuffs and no external pockets should be provided. It should be borne in mind that even when guarded against contact, entanglement hazards may be within reach of adjacent loose or stray material, etc. Material in the machine, e.g. material being processed, or by-products such as swarf, may also present an entanglement hazard.
- Where the hazards include impact or penetration due to flying objects, including small particles and dust, appropriate eye protection should be worn.
- Precautions against impact injuries due to kickback are necessary on certain types of cutting and abrasive machinery, particularly where workpieces are manipulated by hand. These include the following:
  - Provision of backstops on vertical spindle moulding work.
  - Ensuring circular saw blades are adjusted to protrude through the material being cut, and that riving knives are of the correct thickness.
  - Ensuring work rests are adjusted close to abrasive wheels or tool rests are correctly adjusted.
  - Ensuring that cutter speeds, or wheel speeds, are correct for the task in question: this includes ensuring that circular saw blades are of large enough diameter to have the correct tooth speed; machines should be labelled with the minimum blade diameter.
- Precautions against impact injuries due to bursting generally involve ensuring that relevant rotating equipment, and any abrasive wheels, etc., used with it are marked clearly with their maximum speeds.
- There are also practices relating to approach to mechanical hazards which are relevant to most of the types listed. These include the following:
  - Limiting closeness of approach, e.g. in work near overhead travelling cranes, or in taking off work from the rear of a saw table, and in avoiding presence in certain areas of a machine's traverse.
  - Provision and use of manual handling devices, e.g. tongs for forging work, push-sticks for circular saws and spindle moulders, or push blocks for planing machines.
  - Provision of jigs and holders for workpieces, e.g. for vertical spindle moulding, or for cutting irregular material on circular saws.
- Emergency stop controls should be readily accessible.

It is not always possible to eliminate hazards or to design completely adequate safeguards to protect people against every hazard, particularly during such phases of machine life as commissioning, setting, process changeover, programming, adjustment, cleaning and maintenance, where often direct access to the hazardous parts of the machine may be necessary.

There is also a number of types of machinery where, at present, it is recognised that complete safeguarding cannot be provided even for operational activities. For some of these types of machinery, safe working practices are specified, e.g. in statutory regulations. It should be emphasised that safety of machinery depends on a combination of hazard minimisation measures, safeguards and safe working practices. These should take account of activities during all phases of the machine's life.

Safe working practices should be taken into account at the design stage, since the provision of jigs, fixtures, fittings, controls and isolation arrangements will be frequently involved.

Permit-to-Work

Many systems, including those for working on equipment, may involve a number of factors that need to work together for the system to minimise the risk and therefore comply with legal requirements. Some of these factors may include:

- The working environment.
- Tools, plant and equipment, inspection and maintenance systems.
- Operator training.
- The enforcement of rules.
- Supervision.

Documentation will be required for all but the simple systems. Where a greater degree of control is required (because of the higher risks and therefore high potential loss), a formalised method is required to minimise the chance of error.

Effective control may be introduced by means of a written system known as a **permit-to-work system**. This sets out in writing all relevant checks and controls that need to be undertaken before work can commence. The following figure shows an example of a permit.

Machinery and Equipment

Certificate of Appointment

Part 1

REQUEST FOR CERTIFICATE OF APPOINTMENT to approach unfenced machinery for the purpose of observation which is found immediately necessary.

Signed: ______________________

(Supervisor)

I.D. No. _________ Dept:_________

Dated: ______________________

A Certificate of Appointment may only relate to one person.

The counterfoil must be handed to the authorised person and retained by him until the permit is returned with Part III completed.

Instructions can then be given to clear Part IV and resume normal operation.

Serial No: ______________________

Machinery and Equipment - Certificate of Appointment

Part II

Unfenced Machinery/Equipment

This certificate appoints Name: ______ Badge No: _______ Dept: ________

to approach Machine/Equipment _____ BT NO: ___ Loc: __ Dept _______

for observation purposes only of the process or part(s) as detailed herewith:

____

____

Note: ____

Part III

Signed: ________________ (Authorised Person) Date: _______________

Time: ______________________ am/pm

ONLY PERSONS AUTHORISED BY THE PLANT ENGINEER ARE PERMITTED TO ISSUE THIS CERTIFICATE OF APPOINTMENT

(To be completed by person appointed in Part II)

Part IV

I hereby declare that *(1) task designated is complete/incomplete.

*(2) all guards replaced or machine/equipment is left in a safe condition.

*(Delete whichever is not applicable)

Signed: ________________ (Appointed Person) Date:________________

Time: ______________________ am/pm

I hereby declare that this certificate is now cancelled.

Signed: ________________ (Authorised Person) Date: _______________

Time: ______________________ am/pm

THIS CERTIFICATE IS VALID ONLY FOR THE SHIFT IN WHICH IT IS ISSUED OR THE COMPLETION OF THE OBSERVATION (WHICHEVER IS EARLIER).

WHEN COMPLETED MAIL BOTH PARTS TO PLANT SAFETY ENGINEERING DEPARTMENT.

FORM NO:

Sample permit-to-work

(Printed on back of certificate)

PRECAUTIONS TO BE TAKEN FOR SAFE ENTRY INTO TRANSFER MACHINES FOR THE PURPOSE OF OBSERVATION

1. A close fitting, single piece overall suit in good repair shall be worn. It shall have no loose ends and no external pockets except a hip pocket. It shall be worn in such a way that it completely covers all loose ends of outer clothing.
2. No guard shall be removed from any part of machinery except when the observation cannot otherwise be carried out and it shall be replaced immediately the observations have been completed.
3. Appointed persons shall make proper use of any appliances provided for the safe carrying out of the observation.
4. Appointed persons shall make proper use of the secure foot-hold and hand-hold where provided as a precaution against slipping.
5. If a ladder is used it shall either be securely fixed, lashed or footed.
6. Another person, who has been instructed as to what to do in case of emergency, shall be immediately available within sight or hearing.
7. Where there is a foreseeable risk of eye injury from the machining process, the appropriate eye protection shall be worn.

SPECIAL NOTES:

- Only persons who have been appointed in writing overleaf, shall enter Transfer Machines specified for the purpose of observation.
- Only persons who have obtained the age of 18 shall be appointed.
- An appointed person must not perform any operation other than that specified in Part II of the certificate.
- The appointed person must have been instructed as to the requirements of the “Procedure for the Safe Entry into Transfer Machines” and be sufficiently trained for the work and be acquainted with the dangers from moving machinery.

Sample permit-to-work (continued)

A key point to note is that the person in charge signs to declare that all protection is in place before the certificate is issued and work can commence. This should (as much as possible) remove the human error element (and the possibility for mistakes) from the maintenance process. A weakness of the permit-to-work is that if not monitored, checked regularly and enforced, it can quickly fall into disuse, with obvious consequences.

Any check made on the permit-to-work system should ensure that all the relevant information (but only relevant information) is asked for. Non-relevant information has the effect of making the permit system appear to be only a paperbound exercise and of no practical value.

Isolation

Although safeguards are provided which prevent access during most phases of machine operation, they may not be effective at all times because of the need to gain access to hazardous areas, e.g. for setting-up purposes. Where interlocked guards are provided, many short-term activities such as adjustment or lubrication may be carried out safely by relying on the interlocks.

Isolation measures include locks, clasps, tags, closing and blanking devices, removal of mechanical linkages, blocks, slings, and removal from service.

Machinery isolation or lock-out is the isolation and safe removal of the energy source(s) from an item of machinery in such a way as to prevent the possibility of inadvertent energising of the machine. Each energy source should be isolated and locked-out at each isolation point along the energy source route, where practicable.

TOPIC FOCUS

It may be necessary to **isolate** machinery from potential uncontrolled **energy sources** during repair, service or maintenance work.

Energy sources may be in the following form:

- Electrical.
- Mechanical.
- Hydraulic.
- Pneumatic.
- Chemical.
- Thermal.
- Gravitational.
- Radiation.
- Stored or kinetic energy.

Isolation of energy sources is considered in more detail below.

Procedures for Working at Unguarded Machinery

Whether guards are in place or not, the hazards imposed by the equipment still exist. Where guards are **not** in place, these hazards should be managed to prevent them becoming a risk to the operator or others. Key to this is reducing the exposure and thus the risk.

Electrician places a lock-out tag on an electrical panel

The controls imposed are:

- That the use of the equipment is restricted to those persons given the task of using the equipment.
- That only those people designated can undertake the work. (Note that generally guarding is designed to protect everyone in the vicinity of the machinery from the danger and there is no restriction on persons approaching correctly guarded equipment. However, in this case, the designation of persons (preferably in writing) is the positive action required to minimise the risk.)
- That persons so designated are specifically trained and competent to deal with the particular risks involved.

Isolation of Energy Sources

It may be necessary to isolate machinery from potential uncontrolled energy sources during repair, service or maintenance work. The following subsections outline means for achieving this.

External Isolation and Energy Dissipation

Interlocks provide reliable and secure means of interrupting the power sources but, because of the nature of non-operational activities, the risk levels involved may frequently be higher, and therefore more reliable and more secure means of interruption may be called for. Interruption of the following may be involved:

- **Mechanical power transmission** – by:
  - Isolating clutches.
  - Removal of drive belts or chains, or shaft sections.

  Scotching may also be used.

DEFINITION

SCOTCH

Mechanical scotches are required on certain types of presses to protect the operator when reaching between the platens.

A **scotch** is a mechanical restraint device that can be inserted into the machine so as to prevent physical movement of dangerous parts. These scotches can be linked to the guard operation so they are automatically positioned each time the guard is opened.

It should only be possible to actuate it when the dangerous part (platen of down stroking press or injection moulding machine) has been fully retracted. Alternatively a progressive scotch will retain the platen at any position of its travel. Scotches can be used to retain a rise and fall guard in the raised position and should be used to prop the body of a tipper lorry when work is being carried out on the vehicle hydraulic system or transmission.

- **Electrical power** – by:
  - Isolating switches.
  - Removal of fuses.
  - Removal of plugs from sockets.

  Earthing may also be used.
- **Hydraulic or pneumatic power** – by:
  - Isolating valves.
  - Electrical isolation of hydraulic pumps.
  - Disconnection from pneumatic mains.

  Open venting to atmosphere may also be used.
- **Services** – by isolation of water, steam, gas or fuel supplies.
- **Process and material supplies** – by isolation of process lines and line blinding or blanking-off.

Provision for these facilities has to be made at the design stage.

Internal Isolation and Energy Dissipation

In each case, any residual energy storage or material in the machine or equipment may also have to be dealt with, as follows:

- **Mechanical power**: allow flywheels or high-speed rotating parts, e.g. centrifuge bowls, to run down and to minimise the potential energy of other parts.
- **Electrical power**: discharge of capacitors, or disconnection of stand-by batteries.
- **Hydraulic power**: discharge of accumulators, or relaxation of pressurised pipework.
- **Pneumatic power**: discharge of air pressure throughout the system (except where used for hold-up).
- **Services**: residual steam, gas or fuel may need to be vented, purged or drained.
- **Process and material supplies**: emptying, venting, purging, draining and/or cleaning may be required before entry.

Provision for these facilities has to be made at the design stage.

Checking for Absence of Hazards

After external and internal isolation and dissipation of hazards, a check should be made to ensure that no hazard remains. On occasion, this may involve special instruments or sensors, though this is more often the case with non-mechanical hazards.

Security of Safety Measures at the Control Station

Where controls are remote from the plant or machinery, the operator may be unable to see other people, such as maintenance personnel, who may be within the guarded area. In these circumstances, it is recommended that the relevant controls and facilities should be lockable, or such that they can only be operated by the use of keys or tools.

Multi-padlock hasps or a multiple key exchange arrangement should be provided where more than one person is at risk. Each person should apply an individual padlock or key to each relevant control.

STUDY QUESTIONS

12. If equipment has to be running or working during a maintenance operation and this presents risks, what measures can be taken to operate the equipment in a way that reduces the risk?

13. It may be necessary to isolate machinery from potential uncontrolled energy sources during repair, service or maintenance work.

    (a) Give examples of typical energy sources.

    (b) List possible isolation measures.

(Suggested Answers are at the end.)

Machinery Control System

IN THIS SECTION...

- **Control systems should** be safe, make allowance for the failures, faults and constraints to be expected in the planned circumstances of use, not create any increased risk to health or safety.

  Controls for starting or making a significant change in operating conditions should only operate by deliberate action.

- **Stop controls should** be provided to bring the work equipment to a safe condition in a safe manner, bring the work equipment to a complete stop where necessary for reasons of health and safety.
- **Emergency stop controls should** be provided unless this is not necessary due to the nature of the hazards, the time taken for the work equipment to come to a complete stop as a result of the action of a stop control and operate in priority to any stop control.
- **Controls should** be clearly visible and identifiable, by appropriate marking where necessary.

  The design of controls for plant and equipment can have a large impact on human performance. Designing tasks, equipment and workstations to suit the user can reduce human error, accidents and ill-health.

Safety Characteristics of Machinery Control Systems

The key requirements for machinery control systems are set out in **PUWER** in regulations 14 to 18 relating to:

- Controls for starting or making a significant change in operating conditions.
- Stop controls.
- Emergency stop controls.
- Position and marking of controls.
- Safety of control systems.

UK legislation contained in the **Provision and Use of Work Equipment Regulations (PUWER) 1998** sets out the following standards of good practice for each of these issues.

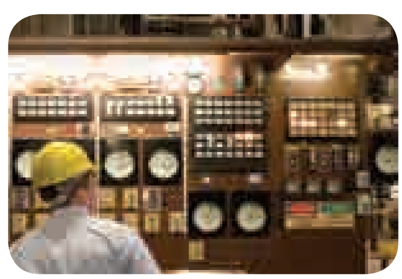
MORE... www.

BS EN ISO 13849-1:2008 provides guidance on design of control systems so as to achieve high levels of performance related to safety. Though aimed at new machinery, it may be used as guidance for existing work equipment.

Control Systems

Control systems should:

- Be safe.
- Make allowance for the failures, faults and constraints to be expected in the planned circumstances of use.
- Not create any increased risk to health or safety.
- Be designed so that any fault, damage or loss of power supply does not result in an increased risk to health or safety.
- Not impede the operation of any stop or emergency stop controls.



Control systems should not create any increased risk to health or safety

Consequently, failure of any part of the control system or its power supply should lead to a 'fail-safe' condition (more correctly referred to as 'minimised failure to danger') and not impede the operation of the 'stop' or 'emergency stop' controls. The measures required to mitigate against the effects of its failure will need to be balanced against the consequences of any failure, i.e. the greater the risk, the more resistant the control system should be to the effects of failure.

Controls for Starting or Making a Significant Change in Operating Conditions

Controls for starting or making a significant change in operating conditions should not operate except by deliberate action.

It should only be possible to start or restart the equipment by using appropriate controls. It should not be possible to restart the equipment simply by resetting a protection device (such as, for example, an interlock) or a person's withdrawal from an area covered by a sensing device – operation of the start control should also be required.

DEFINITIONS

CONTROL SYSTEM

'*A system or device which responds to input signals and generates an output signal which causes the equipment under control to operate in a particular manner*'.

The **input signals** may be:

- Made by an operator via a manual control.
- From the equipment itself, e.g. from automatic sensors or protection devices (photo-electric guards, guard interlock devices, speed limiters etc.).

Signals from the equipment may also include information (feedback) on the condition of the equipment and its response (position, whether it is running, speed, etc.).

STARTING

Starting work equipment includes re-starting after a stoppage for any reason.

SIGNIFICANT CHANGE IN OPERATING CONDITIONS

This includes changes to speed, pressure, temperature, power or other operating conditions of the work equipment where such conditions after the change result in risk to health and safety which is greater than or of a different nature from such risks before the change.

Any change in the operating conditions of the equipment should only be possible by the use of a control unless the change does not increase risks to health and safety. For example, certain multifunctional machines are used in the metalworking industry for punching or shearing metal using different tools located on different parts of the machines. Safety in the use of these machines is achieved by means of a combination of safe systems of work and physical safeguards which match the characteristics of the workpiece. It is essential that the function of the machine (e.g. punching or shearing) is changed by a conscious, positive action by the operator and that unused parts of the machine cannot start up unintentionally.

Start controls should not operate except by deliberate action

The start control can be separate, combined with controls for operating conditions, or more than one of each type of control can be provided. The controls can be combined with stop controls but not with an emergency stop control. 'Hold-to-run' devices are examples of combined stop and start controls. These should be designed so that the stop function has priority following the release of the control.

The controls provided should be designed and positioned so as to prevent, so far as possible, inadvertent or accidental operation. Buttons or levers, for example, should have an appropriate shrouding or locking facility. It should not be possible for the control to 'operate itself', e.g. due to the effects of gravity, vibration or failure of a spring mechanism. Starting that is initiated from a keyboard or other multifunction device should require some form of confirmation in addition to the start command. Furthermore, the results of the actuation should be displayed.

Stop Controls

Stop controls should:

- Be provided to bring the work equipment to a safe condition in a safe manner.
- Bring the work equipment to a complete stop where necessary for reasons of health and safety.
- Switch off all sources of energy after stopping the functioning of the work equipment if necessary for reasons of health and safety.
- Operate in priority to any control which starts or changes the operating conditions of the work equipment.

It is not always desirable to bring all items of work equipment immediately to a complete stop if this could result in other risks. Stopping the mixing mechanism of a reactor during certain chemical reactions could lead to a dangerous exothermic reaction, for example, which is why the requirement is to 'bring the work equipment to a safe condition in a safe manner'.

The stop control does not have to be instantaneous in its action and can bring the equipment to rest in sequence or at the end of an operating cycle if this is required for safety. This may be necessary in some processes, for example to prevent the unsafe build-up of heat or pressure or to allow a controlled run-down of large rotating parts with high inertia.

Stop sign

Parts of equipment which do not present a risk, such as suitably guarded cooling fans, do not need to be positively stopped but all accessible dangerous parts must be rendered stationary when the equipment is stopped.

Where internally stored energy could lead to risk, it should be cut off by the action of the stop control. For example, horizontal plastic injection moulding machines may store hydraulic energy in internal hydraulic reservoirs which, under certain fault conditions, may cause unexpected movements which could cause injury. In this case, the stop control should effectively isolate or dissipate the stored energy so as to ensure safety.

The stop control should take priority over any operating or start control. Where possible, it should not require anything other than a short manual action to activate it, even though the stop and disconnection sequence it initiates may take some time to complete.

Emergency Stop Controls

Emergency stop controls should:

- Be provided unless this is not necessary due to the:
  - Nature of the hazards.
  - Time taken for the work equipment to come to a complete stop as a result of the action of a stop control.
- Operate in priority to any stop control.

Emergency stop control with mushroom-headed button

An emergency stop control should be provided where the other safeguards in place are not adequate to prevent risk when an irregular event occurs. However, an emergency stop control should not be considered as a substitute for safeguarding.

Where it is appropriate to have one (based on the risk assessment), an emergency stop should be provided at every control point and at other appropriate locations around the equipment so that action can be taken quickly. Although it is desirable that emergency stops rapidly bring work equipment to a halt, this should not create any additional hazards.

As emergency stops are a response to a potentially dangerous situation, they should not be used as functional stops during normal operation.

Emergency stop controls should be easily reached and actuated. Common types are mushroom-headed buttons, bars, levers, kick-plates, or pressure-sensitive cables.

Position and Visibility of Controls

Controls should:

- Be clearly visible and identifiable, by appropriate marking where necessary.
- Not be in a position where any person operating the control is exposed to a risk to their health or safety.
- Be positioned so that the operator is able to ensure that no person is in a place where they would be exposed to any risk to their health or safety as a result of the operation of that control.

If this is not reasonably practicable, then in order to ensure that no person is exposed to risk as a result of the work equipment starting, it may be necessary to provide:

- Systems of work.
- Audible, visible or other suitable warning.
- Sufficient time and suitable means to avoid a risk to health or safety as a result of the starting or stopping of work equipment.

It should be possible to identify easily what each control does and on which equipment it takes effect. Both the controls and their markings should be clearly visible. As well as having legible wording or symbols, factors such as the colour, shape and position of controls are important; a combination of these can often be used to reduce ambiguity. Some controls may need to be distinguishable by touch, e.g. inching buttons on printing machines. Few controls will be adequately identifiable without marking of some sort.

Controls used in the normal running of the equipment should normally not be placed where anybody using them might be exposed to risk. However, controls used for setting-up and fault-finding procedures may have to be positioned where people are at some risk. For example, when setting-up robots it is necessary to operate the robot in close proximity to it using a hand-held device (a robot-teaching pendant). In such cases particular precautions should be employed to ensure safety; examples include:

- Hold-to-run controls.
- Enabling controls.
- Emergency stop controls.

Further precautions include the selection of reduced or limited capability of the work equipment during such operations to reduce the risk.

Controls should be positioned so that operators of equipment are able to see that no one is at risk from anything they set going. To be able to do this, operators need to have a view of any part of the equipment that may put anyone at risk. A direct view is best, but supplementing by mirrors or more sophisticated visual or sensing facilities may be necessary.

Where there is a risk other than from dangerous parts of machinery (e.g. noise, radiation), people at some distance from the work equipment may be affected. In such circumstances, it may not always be reasonably practicable for operators to have sight of all parts of the work equipment, so it may be necessary to employ systems of work or warning devices. Warning devices only provide limited protection and additional measures may be required if the risks are high. For example, it would not be acceptable to rely on audible or visible alarms where the risk is of an imminent, potentially fatal dose of ionising radiation, but they may be adequate where the risk is from noisy plant.

If the nature of the installation is such that it is not reasonably practicable for the operator at the control position to ensure that no one is at risk, then a system of work must be devised and used to achieve that aim. This should implement procedures to eliminate or reduce the probability of any workers being at risk as a result of starting-up. An example is the use of systems using signallers; these are often used to assist crane drivers, or tractor drivers setting a manned harvester in motion.


Location of controls needs to be considered

If warnings are used they should be given sufficiently in advance of the equipment actually starting, to give those at risk time to get clear or take suitable actions to prevent risks. This may take the form of a device by means of which the person at risk can prevent start-up or warn the operator of their presence.

Ergonomic Principles in Relation to Controls

The design of controls for plant and equipment can have a large impact on human performance. Designing tasks, equipment and workstations to suit the user can reduce human error, accidents and ill-health. Effective use of ergonomics will make work safer, healthier and more productive.

Key principles in design include:

- Equipment should be designed in accordance with ergonomics standards such as BS EN 614-1:2006+A1:2009.
- Users should be involved in the design process. This should include different types of users, such as operatives, maintenance and systems support personnel.
- Consideration should be given to:
  - Operator characteristics, including body size, strength and mental capability.
  - All foreseeable operating conditions, including upsets and emergencies.
  - The interface between the end user and the system.

STUDY QUESTIONS

14. Outline the principal requirements for control systems.

15. Outline the principal requirements for stop control systems.

16. Designing tasks, equipment and workstations to suit the user can reduce human error, accidents and ill-health. Outline the ergonomic design principles which can achieve these aims.

(Suggested Answers are at the end.)

Summary

Safety Integration and Machinery Risk Assessment

In particular, we have:

- Defined machinery.
- Considered the principles of safety integration (as set out in the UK's **Supply of Machinery (Safety) Regulations 2008**) which state that:
  - Machinery must be designed and constructed to be fit for purpose and to eliminate or reduce risks.
  - The principles must be applied in order to eliminate or reduce risks, take protective measures where risk cannot be eliminated and inform users of any residual risks.
  - Foreseeable misuse must be considered when designing and constructing machinery and when drafting instructions.
  - Operator constraints due to use of personal protective equipment must be considered.
  - Machinery must be supplied with all the essentials to enable it to be adjusted, maintained and used safely.
- Examined the factors to be considered when assessing the risks from machinery, which include persons at risk, severity of possible injury, probability of injury, need for access, duration of exposure, reliability of safeguards, operating procedures and personnel.
- Highlighted the purpose, relevance and limitation of the CE mark and its relevance in selecting and integrating work equipment in the workplace.
- Examined the conformity assessment procedures to demonstrate that machinery complies with essential health and safety requirements and can display the CE mark, including the use of harmonised standards and preparation of the technical file.

Generic Hazards

We have:

- Examined the following machines that present hazards in general workplaces: drills (radial arm, pedestal), circular saws, guillotines, disc sanders, abrasive wheels, lathes, automatic doors and gates, mechanical and hydraulic presses, portable power tools, CNC machines and robotics.
- Examined the following generic machinery hazards:
  - **Mechanical hazards**, which include crushing, shearing, cutting/severing, entanglement, drawing-in/trapping, impact, stabbing/puncture/ejection, friction/abrasion and high-pressure fluid injection.
  - **Non-mechanical hazards**, which include noise, vibration, electricity, high/low temperature, radiation and hazardous substances.

Protective Devices

We have:

- Examined the main types of safeguarding devices:
  - Fixed enclosed guards.
  - Fixed distance guards.
  - Interlocked guards.
  - Automatic guards.
  - Trip devices.
  - Adjustable/self-adjusting guards.
  - Two-hand controls.
  - Mechanical restraints.
  - Jigs and push-sticks.
- Identified the characteristics, key features, limitations and typical applications of each device above.

Maintenance

We have:

- Considered how machinery can be set, cleaned and maintained without exposing the persons involved to risks to their health or safety by employing safe systems of work, permits-to-work and isolation procedures.
- Noted that during repair, service or maintenance work it is often necessary to isolate machinery from potential uncontrolled energy sources.

Machinery Control Systems

We have:

- Considered the key safety characteristics of machinery control systems, which should be safe, make allowance for possible failures, not create any increased risk and be designed so that any fault does not result in an increased risk.
- Noted that controls for starting or making a significant change in operating conditions should only operate by deliberate action and that stop controls should be readily accessible and lead to a safe condition.
- Noted that emergency stop controls should generally be provided, be readily accessible and operate in priority to any stop control.
- Highlighted that controls generally should be clearly visible and identifiable, and not be in a position where any person operating the control is exposed to risk.

Exam Skills

QUESTION

A plastics injection-moulding machine is supplied to your workplace.

Outline the moulding machine's features that you would have expected to have been addressed in order to demonstrate that the machine is safe. **(20)**

Approaching the Question

This answer will need to show a logical progression of ideas, because there are no signposts in the question to tell you where the marks are coming from. All it tells us is that we need to outline the features of the machine that affect how "safe" it is. You need to devise your own structure for this question and a good starting point is reference to "essential health and safety requirements" as standards of best practice to ensure that machinery is safe. If you are familiar with the framework that specifies essential health and safety requirements you can use this as a checklist and apply it to the specific machine referred to in the question - a plastics injection-moulding machine.

Suggested Answer Outline

The examiner here would be expecting you to detail the following features that should have been addressed to demonstrate the safety of the plastics injection-moulding machine with regard to foreseeable use under the heading of **general features**, and those dealing with **controls**, protection against **mechanical hazards**, protection against **other hazards**, **maintenance** and **indicators**.

General issues:

- Addressing the ergonomic use of the machine and anthropometry.
- Safeguarding the user from the materials used in the construction of the machine or products created during its use (coolants).
- Lighting – ensure it is adequate (dazzle or stroboscopic effects).
- Ensuring sharp edges have been removed.
- Provide machine with eyebolts.

Controls and control systems should be designed so they are safe and reliable:

- Suitable for the rigours of normal use.
- Take account of errors in logic.
- Ensure that control devices are clearly visible, signed, logical and robust.
- Starting requires a deliberate positive action.
- A stop device is fitted which shuts off power to the actuators.
- Emergency stop - brings the machine to a halt quickly, without creating additional risk.
- Failure of the power supply and/or control circuit does not allow the machine to start unexpectedly and the protection devices remain effective.
- Any interactive software fitted is user-friendly.

Mechanical hazards which should have been addressed:

- Stability of the machine.
- Ensure against the risk of break-up during operation.
- Eliminate the risks caused by falling or ejected objects.

- Ensure the variations in speeds and risks from moving parts are designed to avoid hazards or provided with protective devices.
- Ensure the correct choice/characteristics of guards and protective devices, whether fixed, movable or adjustable, are suitable.
- Look at any other issues arising from use (working at heights).

Protection against **other hazards** would need consideration of:

- Electrical risks.
- Fire and explosion.
- Extremes of temperature.
- Noise and vibration.
- Emission of dust and/or gases.

Maintenance issues:

- Remote adjustment and lubrication, automatic cleaning, isolation, and means of access.

Indicators:

- Provision of unambiguous, easily understood information and warning devices.
- Provision of instructions on the installation, use and maintenance of the machine and its marking, in particular the CE mark, its serial number and details of the manufacturer.

Example of How the Question Could be Answered

The machine features that you would expect to have been addressed to demonstrate that the machine is safe would be as follows:

- *Documentation – The machine would need to have documentation supplied with it to cover the safe installation (addressing stability of), operation and maintenance of the machine. This would include all details of control systems and lubrication and coolants used.*
- *The machine must be CE-marked and have a signed Declaration of Conformity, with the standards to which it has been made to detailed.*
- *The machine itself would need to be designed to allow safe operation, which should address the ergonomic issues of operation, so should be adjustable from the point of view of height and reach to components and guards need to be suitable to address the issues of reaching through, under, over or around them. The guards themselves should be suitable for materials and environment used, prevent access to danger zones and be fixed or interlocked to prevent access to the danger zone.*
- *The machine controls need to be designed to ensure safe operation (can't be started by mistake) and to be easy and safe to stop under normal and emergency situations, so they need to be clearly sited and marked on the machine. The controls should be easy to operate, and not restart the machine if the power fails and then comes back on, as well as indicating the condition of operation clearly.*
- *The machine would need a local, lockable isolator, which should be signed to allow safe maintenance to take place on the machine.*
- *Other issues that need to be addressed by the safe design of the machine would include:*
  - *Noise – this should be reduced to as low as practicable and any significant issues of noise communicated to the user.*
  - *Vibration – as per noise.*
  - *Suitable lighting will be required for safe operation and maintenance of the machine and to ensure it doesn't dazzle the user or introduce a stroboscopic effect to users.*
  - *Other material hazards from materials used should be addressed.*

- *Electrical – ensure a suitable fused supply is provided, cables are of the appropriate types/colours/sizes, terminations are shrouded to prevent inadvertent contact and access to control panels is restricted by lockable access.*
- *Hot or cold surfaces are suitably guarded or indicated to prevent contact with them.*

Reasons for Poor Marks Achieved by Exam Candidates

An exam candidate would achieve **poor marks** for an answer which:

- Demonstrated a lack of understanding of what was required.
- Focused simply on the safe use of the machine rather than design features.

Element IC7

Mobile, Lifting, Access and Work at Height Equipment

Learning Outcomes

Once you've read this element, you'll understand how to:

1. Outline the main hazards and control measures associated with mobile work equipment.
2. Outline the main hazards and control measures associated with lifting equipment.
3. Outline the main hazards and control measures associated with access equipment and equipment for working at height.

Contents

Mobile Work Equipment: Hazards and Control Measures

IN THIS SECTION...

- Mobile work equipment is any work equipment which carries out work while it is travelling or which travels between different locations where it is used to carry out work.
- It can be self-propelled, towed, attached, pedestrian-controlled or remotely-controlled.
- A common type of mobile work equipment is the lift truck. Types of lift trucks include counterbalance, reach, rough terrain, telescopic materials handlers, side-loading trucks and pedestrian-controlled trucks.
- Lift-truck hazards are associated with the truck, operator and operation.
- To ensure the safety of mobile work equipment the following issues need to be addressed: roll-over, overturning, suitability for carrying passengers, unauthorised start-up, safe operating station/platform, excessive speed, failure to stop, contact with wheels and tracks, falls of objects, moving parts/drive shafts/power take-offs, overheating.
- The hazards associated with the refuelling or charging of mobile work equipment may be electrical in connection with battery charging, fire and explosion from LPG, and exhaust fumes and hot surfaces from diesel engines.
- Lateral and longitudinal instability of mobile work equipment and loss of control of vehicles are major problems in their safe use.
- The key control measures for the use of mobile work equipment are set out in the **Provision and Use of Work Equipment Regulations 1998** Approved Code of Practice and Guidance but also include the need for safe layout of areas where mobile equipment is used and the protection of pedestrians.
- Where lift trucks are used as working platforms, specific safeguards concerning the design, construction and attachment of the platform are necessary.
- The **Provision and Use of Work Equipment Regulations 1998** Approved Code of Practice and Guidance specifies a range of control measures for the use of mobile work equipment which includes roll-over protection, falling objects protection, speed control systems, guards and barriers and restraining systems, means of fire-fighting, vision aids.
- Training of lift-truck operators should include basic training, specific job training and familiarisation training.

Mobile Work Equipment: Hazards

Applications of Different Types of Mobile Work Equipment

Mobile work equipment is considered to be any work equipment which carries out work while it is travelling or which travels between different locations where it is used to carry out work. Such equipment would normally be moved on wheels, tracks, rollers or skids. Mobile work equipment may be:

- ### Self-Propelled

  Self-propelled mobile work equipment is work equipment which is propelled by its own motor or mechanism. The motor or mechanism may be powered by energy generated on the mobile work equipment itself, e.g. by an internal combustion engine, or through connection to a remote power source, such as an electric cable, electric induction or hydraulic line.

Mobile work equipment on tracks

- **Towed**

  Towed mobile work equipment includes work equipment such as towed machines and trailers which are primarily self-supporting on, for example, their own wheels. They may:

  – Have moving parts which are powered by the vehicle (e.g. a power harrow).
  – Have an integral power source (e.g. a powered crop sprayer).
  – Have no moving parts and function as a result of the movement of the mobile work equipment (e.g. a plough or trailer).

- **Attached**

  Attachments are work equipment which may be mounted on self-propelled mobile work equipment to alter its characteristics. For example, a load rotator fitted to a forklift truck will alter its load-handling capabilities and may alter its safety characteristics, such as stability. Attachments are not considered to be mobile work equipment in their own right, but if they can affect the safety of the self-propelled mobile work equipment when they are attached, they are considered to be part of the self-propelled work equipment. Attachments may be non-powered, powered by an independent power source or powered by the self-propelled work equipment to which they are attached.

- **Pedestrian-Controlled**

  Pedestrian-controlled mobile work equipment is operated by a person on foot, using controls which are physically connected to the equipment. Examples include pallet trucks and sack barrows, as shown in the picture opposite.

Pedestrian-controlled lifting equipment

- **Remotely-Controlled**

  Remote-controlled mobile work equipment is operated by controls which are not physically connected to it, e.g. by radio control.

Types of Lift Truck

The transport of materials is an essential feature of many workplace operations and the lift truck provides industry with a versatile materials-handling vehicle. In addition to the traditional use of trucks to lift, move and re-stack palletised loads, trucks may be fitted with a variety of attachments including drum-handling equipment, bale clamps, working platforms, skips, fork extensions and lighting appliances, all of which increase the versatility of the vehicle.

The following are the most commonly used types of lift truck:

Counterbalance LPG-powered lift truck

- **Counterbalance**

  The mass of a counterbalance lift truck acts as a counterweight so that the load can be lifted and moved without the truck tipping. However, the truck can be tipped over if:

  – It is overloaded.
  – The load is incorrectly placed on the forks.
  – It is travelling across an incline or an uneven surface.

  Instability is increased if the truck travels with the forks raised rather than lowered.

- **Reach**

  When the forks are extended, the reach truck behaves in a similar manner to the counterbalance truck. It is less likely to tip over when the forks are in, as the load is within the wheelbase of the truck, which increases stability. When the load is elevated and the mast tilted back, there is a significant risk of overturning. This risk increases if the load is high and the truck is operating on an uneven surface.

- **Rough-Terrain**

  These trucks are designed to operate on uneven surfaces such as those encountered on construction sites. However, care is needed on rough ground as bouncing can cause loss of control. The trucks should not be used for lifting to high levels unless the ground is reasonably level and consolidated and the truck is clear of excavations and walls. Unless specially designed, they should not be used for stacking on inclines.

- **Telescopic Materials Handlers**

  These trucks operate up to a height of 12 metres. They work in narrow aisles, but can also move outside the aisles. They must operate on high grades of flooring because of the lift height. Some have the operator at ground level, others have a rising cab. They can access the stack on either side of the aisle by using a mast which turns to the left or right (multi-directional).

- **Side-Loading Trucks**

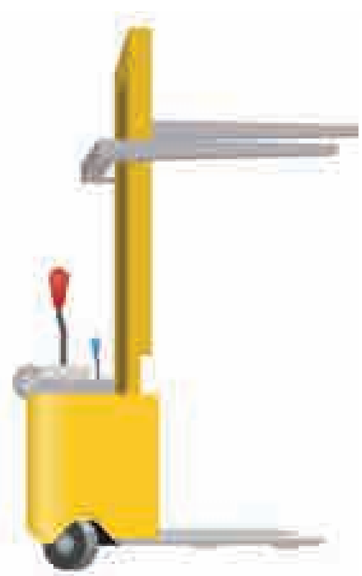
  This is a form of forklift truck commonly found in timber yards. It is a type of reach truck used to carry long lengths of timber.

- **Pedestrian-Controlled Trucks**

  These are operated by a pedestrian via a control handle. Operators should always face the direction of travel and not walk backwards nor directly in front of the control handle, which should act as a 'dead man's handle' on release by the pedestrian in the event of an emergency.

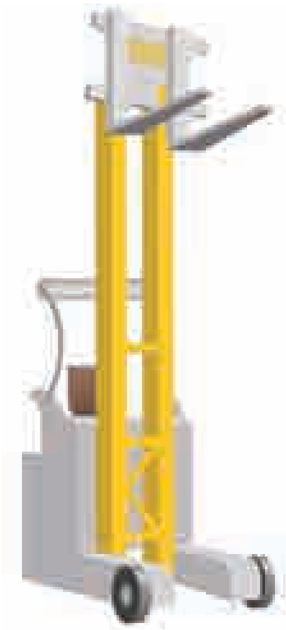
The following figures show examples of some of these types of lift trucks:

Four-directional truck



Pedestrian pallet stacker

Pedestrian counterbalanced truck


Reach truck


Side-loading truck

Types of lift truck

Agricultural Tractors

Agricultural tractors are used for pulling machinery or trailers for activities such as ploughing, tilling, discing, harrowing, planting, and similar tasks.

Works Vehicles

Works vehicles include any vehicles that are used in a work setting, such as forklift trucks, compact dumpers, tractors or mobile cranes. They can also include cars, vans and large goods vehicles when these are operating off the public highway.

Hazards Associated with Mobile Work Equipment

There is a range of general hazards associated with mobile work equipment but it is useful to start with a common workplace example, the lift truck, which provides some specific examples of workplace concerns.


Works vehicle

Lift-truck hazards are associated with the:

- Truck

  For electrically-operated trucks, there is the danger of production of hydrogen gas while charging the batteries, as well as the manual handling implications of changing them. For gas (LPG) operated lift trucks, there is a fire and explosion risk, particularly during the changing of cylinders. Hazards arise from poor maintenance of brakes, steering, tyres, lights, etc. and emission of substances while being used, i.e. exhaust gases.

- Operator

  Driving with a raised load or too fast and cornering at speed can cause the vehicle to overturn or lose its load.

- **Operation**

  Lift trucks are often used in areas where there is a possibility of pedestrian movement. Impact with people as well as with structures such as walls and racking is a constant hazard. Overloading of lift trucks can lead to loss of control in steering and braking, and unevenly or improperly loaded lift trucks can become unstable. Driving over unsuitable ground can cause the load to shift or fall off.

Mobile work equipment, in general, presents the following range of hazards:

- **Roll-Over**

  Under certain conditions there may be a risk of roll-over of mobile work equipment while it is travelling, e.g. a moving dumper truck on a construction site or an agricultural tractor manoeuvring on a slope. This can involve roll-over onto its side or end (i.e. through 90 degrees) or turning over completely (i.e. through 180 degrees or more). The risk will depend on the:

  – Nature of the mobile work equipment and any attachments or accessories fitted to it.
  – Effects of any work being carried out on or by the mobile work equipment.
  – Conditions in which it is used.

  Other factors include:

  – Uneven surfaces.
  – Variable or slippery ground conditions.
  – Excessive gradients.
  – Inappropriate speeds.
  – Incorrect tyre pressures.
  – Sudden changes in direction.
  – Inertia transmitted to the mobile work equipment by attachments used with it.

  Measures that can be taken to stabilise mobile work equipment and reduce the risk of roll-over include:

  – Fitting appropriate counterbalance weights.
  – Increasing its track width by fitting additional or wider wheels.
  – Locking moveable parts which could otherwise create instability by moving around when the mobile work equipment is travelling.

- **Overturning**

  The vertical mast of a forklift truck (FLT) will prevent an FLT overturning by more than 90 degrees, provided it has sufficient strength and dimensions for this purpose. It will also protect seated operators from being crushed between the FLT and the ground in the event of roll-over. However, if risk assessment shows that an FLT with a seated ride-on operator can rollover in use and there is a risk of the operator leaving the operating position and being crushed between the FLT and the ground, a restraining system, such as a seat belt, will be required. To be effective, the restraining system should prevent operators or others carried from falling out or being trapped by the FLT or its protective structure in the event of roll-over.

TOPIC FOCUS

The factors affecting the likelihood of an agricultural tractor overturning are:

- Gradient.
- Direction of travel.
- Uneven or soft ground.
- Stability of attachments.
- Wheel width.
- Tyre pressure or condition.
- Speed on cornering.
- Seizure of power take-off shaft.

- **Suitability for Carrying Passengers**

Mobile work equipment can present a hazard to persons being carried and therefore should be designed to prevent people falling from it and to allow them to stabilise themselves while it is travelling. Operator positions with seats or work platforms will usually provide a secure place that drivers and other people can travel on.

Seats provide security for:

– Drivers who need to be seated when operating mobile work equipment (e.g. the seat on a site dumper).
– People who need to be seated while being transported by the mobile work equipment (e.g. bench seats in mine locomotive man-riding carriages).
– People who are involved in on-board work activities which are best carried out in a seated position.

Properly designed and constructed cabs, operators' stations and work platforms can prevent people from falling from mobile work equipment when it is travelling. They should be provided with suitable side, front and rear barriers or guard rails, and may be fully enclosed or open to the environment.

Under exceptional circumstances, mobile work equipment not specifically designed for this purpose will be used to carry people, e.g. trailers used to carry farm workers during harvest time. Under these circumstances, the mobile work equipment must have features to prevent people falling from it and to allow them to stabilise themselves while it is travelling, e.g. sides of appropriate height, secure hand-holds and means to safely mount and dismount.

- **Unauthorised Start-Up**

Mobile work equipment can be prone to operation by unauthorised or untrained persons. This can be prevented by ensuring that the starter key or device is issued or made accessible only to authorised people. This means that access to starter keys and starting devices, such as removable dumper starting handles, should be controlled.

The use of keypads with operators allocated unique pin numbers has greatly reduced the number of incidences of this type.

Keys should be controlled

- **Safe Operating Station/Platform**

When mobile work equipment is used as a safe operating station or platform (integrated and non-integrated platforms), it is designed to provide a safe work platform for temporary work at height. In relation to the fall protection hierarchy, it is considered to be work equipment that can prevent a fall.

It is essential that the working platform is compatible with the truck on which it is used. Before any combination is used for the first time, the truck supplier must be consulted. It is particularly important to ensure that:

– The truck/working platform combination has adequate stability under all circumstances in which it is intended to be used.
– The platform can be securely attached to the truck.
– People on the platform cannot reach hazardous moving parts or controls on the truck.

In addition:

– The truck/working platform combination should only be used on firm, well-maintained and level surfaces.
– Gradients and uneven or inconsistent ground conditions can affect truck stability.

- **Excessive Speed**

If mobile work equipment suddenly speeds up, sudden movements could put the people being carried at risk. If speed is not controlled, mobile work equipment may become unstable, particularly on cornering or on gradients across which it needs to travel.

If work needs to be carried out during the journey, then speeds should be adjusted or limited as necessary. When carrying people, mobile work equipment should be driven within safe speed limits to minimise any risk to persons being carried.

- Failure to Stop

  Operators who are not properly in control of mobile work equipment may fail to, or not be able to, stop at junctions and crossings, putting other road users at risk.

- Contact with Wheels or Tracks and Falling Objects

  Operators and other workers travelling on mobile work equipment may be at risk from:

  – The wheels or tracks of the equipment.
  – Falling out of the equipment.
  – Unexpected movement while it is in motion or stopping.

  There may also be risks associated with the environment and the place in which the mobile work equipment is used, such as falling objects, low roofs and the surfaces on which the equipment operates.

- Moving Parts/Drive Shafts/Power Take-Offs

  The power output of mobile work equipment may be sufficient to cause damage to the connected work equipment which could lead to risk, e.g. seizure of the drive shaft could cause the ejection of parts.

  Control measures should be taken, such as:

  – Slip clutches on the power input connection of the connected work equipment to protect it from damage.
  – Guards to protect people from ejection risks in the event of equipment break-up.

- Overheating

  Overheating or fire due to friction from bearings running hot, electric motors burning out, thermostats failing, or cooling system failures are all risks that might arise during the use of mobile work equipment. Therefore, as we will note later, fire-fighting appliances such as appropriate extinguishers and fire blankets should be provided on the equipment.

DEFINITION

DRIVE SHAFT

A device that conveys the power from the mobile work equipment to any work equipment connected to it. In agriculture, these devices are known as power take-off shafts.

SEIZURE

Refers to stalling of the drive shaft as a result of the operating mechanism of any accessory or anything connected to it becoming incapable of movement due to poor maintenance, a blockage or some other reason.

Lateral and Longitudinal Instability and Loss of Control of Vehicles

Instability is one of the major problems involved in the safe use of vehicles. There are three main ways in which a vehicle may become unstable:

- **Longitudinal instability** is where a vehicle tips over the front or the back. An example is when a tractor's front wheels lift due to the weight applied by an attached trailer.
- **Lateral instability** is where a vehicle tips over onto its side. An example is when a lorry is blown over in a high wind or a loaded forklift tips while driving across a slope.
- **Loss of control** occurs when the wheels lose grip on a road surface. Examples include skidding on an icy road. Note that loss of control does not require the vehicle to overturn.

Longitudinal Instability

The figure shows the loading on a forklift truck. The weight of the truck is W and is effective through a point on the forklift called the "centre of gravity" (CG). It is at a distance y from the front wheels, so the effective force applied by the weight of the forklift anti-clockwise around the front wheels is Wy. The load also produces a force around the front wheels, but this time a clockwise one of *L.x*. The anti-clockwise force keeps the rear wheels on the ground and the clockwise force tries to lift the rear wheels. So for the forklift to remain stable, *W.y* must exceed *L.x*. When the load increases, i.e. when *L* increases, then the clockwise force increases. If this becomes greater than *W.y* then the forklift will turn clockwise, the rear wheels will lift and the forklift will overturn forwards until such time as it is stopped by the load falling off or the front coming into contact with the ground (one of the reasons for keeping the forks low).

When travelling down an incline, the weight of the forklift *W* and the weight of the load *L* will remain vertical (pulled towards the centre of the earth), as shown in the figure that follows.

Loading of a forklift truck

Travelling down an incline

In this case the distance from the front wheel to the centre of gravity y^1 is slightly reduced, reducing the force which will produce stability. The distance x^1 has increased, due to the slope. The load is shown elevated to demonstrate the effect of raising the load (consider its distance with the load at the bottom). The overturning clockwise force is therefore increased and the stabilising moment is decreased. So a forklift may be stable when moving a load on the level, but the effect of the slope is to cause the forklift to overturn.

Lateral Instability

The effect of the raised load when moving across a slope is shown in the following figure. In this case, overturning will occur when the load, acting outside of the lower wheel as shown, creates a moment greater than that created by the weight of the forklift.

Travelling across a slope

A similar effect to that of a slope may be created in the workplace if the ground over which the forklift is moving is uneven or potholed. This causes the front wheel to 'dip', giving the effect of a slope. (Note that the forklift is the most critical of vehicles, as the small solid wheels at the front have no suspension to help alleviate the problem.)

Not all vehicle movements are either straight up or down or straight across a slope. Consideration must be given to the problems when moving at some angle to a slope. One of the most common forms of transport across slopes is a tractor in agricultural use. (Tractors have small wheels at the front and large wheels at the rear, with the centre of gravity acting closer to the rear wheels.)

Loss of Control

Forces acting downwards are the weight of the vehicle and the weight of any load carried. This increases the resistance of the vehicle to skidding as it increases the force on the road-wheel interface, effectively increasing friction, which acts to keep the vehicle from moving outwards.

Forces acting outward include any horizontal loading, such as pressure against the vehicle from wind and the centrifugal effect when going round a corner. (This has the effect of 'pushing' the vehicle outwards.) Also to be taken into account is the forward motion of the vehicle, and conversely the braking effect, in the direction of travel.

For control to be lost, there must be an imbalance of forces at the road-wheel interface. If the forces are balanced positively, i.e. if the frictional forces are greater than those forces acting on the vehicle, then no loss of control will occur. When the forces become negative, friction will not hold the vehicle and there is a loss of control.

The balance can change quickly. For example, when a tyre comes into contact with oil on the road, the friction reduces as the oil acts as a lubricant. This loss of friction causes the forces to change balance and the vehicle skids; this is a loss of control situation.

Refuelling and Charging of Mobile Work Equipment: Hazards

For **electrically**-operated mobile work equipment there is the risk of production of hazardous hydrogen gas while charging the batteries, as well as the manual handling implications of the weight of the batteries when changing them.

For **gas** (LPG) operated mobile work equipment, there is a fire and explosion risk, particularly during the changing of cylinders.

For **diesel**-operated mobile work equipment there is the risk of inhalation of exhaust gases, particularly carbon monoxide, which can accumulate inside closed and inadequately ventilated structures. Hot surfaces on the diesel engine can also constitute a source of ignition if operated in flammable atmospheres.

Mobile Work Equipment: Control Measures

The key control measures for the use of mobile work equipment are considered later in this section.

As well as these issues which relate to the equipment itself, we need to consider the safe layout of areas where mobile equipment is used and also the protection of pedestrians.

Control measures include:

- Use of one-way systems.
- Installing signs and signals.
- Clearly designating pedestrian routes.
- Routes of adequate width.
- Setting up barriers, pedestrian crossings and 'give way' markings.
- Placing mirrors in low-visibility locations.
- Ensuring adequate, glare-free lighting in pedestrian areas.
- Enforcing speed limits.
- Banning mobile phones and personal stereos for pedestrians to avoid unnecessary distractions.
- Using lifting plans where mobile work equipment is used as part of a lifting operation, e.g. forklift truck with a lifting hook attachment used to move machinery or pressure vessels.

Using Lift Trucks to Move People

Certain lift trucks, such as counterbalance and reach trucks, are sometimes used to lift people on a working platform which itself is incapable of movement independent of the truck. The platforms are used to provide temporary places of work. Some platforms are used to transfer materials or people from one level to another. Other platforms, known as jib or boom type working platforms, are mounted either on the forks or on the carriage on which the forks traverse. They have jibs which can be independently moved, extended telescopically or rotated.

Forklift truck with non-integrated working platform

Based on: PM28 Working platforms (non-integrated) on forklift trucks, HSE, 2013 (www.hse.gov.uk/pubns/pm28.pdf)

The use of a lift truck as a working platform can provide a safer means of access to heights than, for example, a ladder. However, if a truck is to be used as a working platform for approximately 25% of its working life, it is recommended that a specifically designed mobile platform or similar is used in preference, where this is practicable.

Where lift trucks are used as working platforms, the following safeguards are necessary:

- The platform should be made of suitable material, soundly constructed, of adequate strength and properly maintained. It should be securely attached to the lift truck.
- The weight of the platform plus its load must not exceed one-half the capacity of the truck. The platform should be marked with means of identification and the maximum allowable load.
- The dimensions of the platform should be as small as possible but still compatible with the number of people it is designed to carry. No more than two passengers should be carried.
- Platform edges should be guarded by a top rail which is 900-1,100mm from the platform floor and by toeboards which are at least 100mm deep. An intermediate rail should be fixed midway between the top rail and toeboards. Total enclosure of the gap to the top rail may be achieved by wire mesh.
- Any gateway in the enclosure should automatically return to the closed and fastened position.
- The floor of the platform should be even and non-slip.
- All trapping, crushing or shearing points must be guarded. Where overhead hazards (such as roof trusses) exist, protection is necessary to prevent potential crushing injuries to passengers.
- The platform should be painted a conspicuous colour and display a notice, visible to the truck driver, which states that the parking brake should be on and the transmission in neutral before the platform is elevated.
- Before a truck is used for the first time as a working platform, the manufacturer or supplier should be requested to confirm whether the truck is suitable for such use.
- It is preferable that the raising and lowering of the platform is controlled by the person on the platform. The controls should be of the 'dead man's handle' type. Emergency control may be appropriate at ground level.

During use, the following precautions are necessary:

- Warning cones or signs should be located around the truck.
- People should not lean out of the truck.
- All people involved in the operation must be trained.
- Trucks should only be used on firm, level surfaces.
- Where controls are at ground level, the driver must stay in attendance for the duration of the operation.

Other Attachments Used on Lift Trucks

A variety of types of material-handling attachments are available for lift trucks. Some examples are given below:

- **Sideshifter** - allows the operator to move the forks and backrest laterally. This allows easier placement of a load without having to reposition the truck.
- **Rotator** - allows the forks to be rotated.
- **Fork positioner** – allows the forks to move together or apart.
- **Roll and barrel clamp attachment** - squeezes the item to be moved and is used for handling barrels, kegs, or paper rolls.
- **Pole attachments** - used instead of forks to lift carpet rolls.
- **Drum handler attachment** - a spring-loaded jaw that grips the top lip edge of a drum for transport.
- **Man basket** - a lift platform that slides onto the forks for hoisting workers.

Clamp attachment on a lift truck

Importance of Operator Protection, etc.

There are a range of control measures for specific risks associated with the use of mobile work equipment, including:

- Roll-Over Protective Structure (ROPS)

  The masts of most vertical-masted lift trucks, provided they have sufficient strength and dimensions, will generally prevent the truck from doing more than tipping over onto its side. However, where there is a risk of a truck rolling over and crushing the operator, a ROPS should be fitted to minimise the risk to operators should roll-over occur. Telescopic materials handlers are capable of rolling over 180° or more, and will need a ROPS to protect operators if used in circumstances where there is a risk of roll-over.

- Falling Objects Protection

  If people carried on mobile work equipment are at risk of injury from objects falling on them while it is in use, a falling object protective structure (FOPS) should be provided. This may be achieved by a suitably strong safety cab or protective cage which provides adequate protection in the working environment in which the mobile equipment is used.

- Speed Control Systems (Stopping and Emergency Braking)

  All self-propelled mobile work equipment should have brakes to enable it to:

  - Slow down.
  - Stop in a safe distance.
  - Park safely.
  - Be operated safely on the gradients on which it will be used.

  Where there are significant risks associated with failure of the main braking device, a secondary braking system is required. The secondary braking system may operate automatically through spring applied brakes or through a dual circuit system on the service brakes. It may also be operated through the parking brake system or other controls which are easily accessible to the driver.

- **Guards and Barriers**

  If there is a risk of contact with the wheels or tracks of mobile equipment when it is travelling, there should be means to separate persons from those wheels or tracks. This can be achieved by either positioning cabs, operator stations or work platforms to prevent the wheels and tracks being reached, or providing suitable barriers, such as guard rails or fenders.

- **Restraining Systems**

  If there is a risk of persons being injured through contact with mobile work equipment or being flung from it if it comes to a sudden stop or moves unexpectedly, there may be a need for a restraining system. This depends on the risks to workers operating and riding on the mobile work equipment and the practicability of fitting and using such restraints. Restraining systems can be full-body seat belts, lap belts or purpose-designed restraining systems. The need for protection against risks of rolling over and overturning may also need to be taken into account.

- **Means of Fire-Fighting**

  In the event of fire in self-propelled work equipment or any load handled by it, it might not be easy for operators to escape. In those circumstances, fire-fighting appliances such as appropriate extinguishers and fire blankets should be carried on the equipment. For self-propelled work equipment that is used on the public highways carrying a dangerous load, it may be necessary to carry suitable fire extinguishers.

- **Vision Aids**

  When mobile work equipment is about to move, or while it is travelling or manoeuvring, the driver's direct field of vision may be inadequate to ensure safety. Under those circumstances, visibility aids should be provided so that operators can see anyone who may be at risk when any control is operated. If direct vision is impaired, then mirrors, or more sophisticated visual or sensing facilities such as closed-circuit television (CCTV), may be necessary.

  Examples of devices which can aid the driver's vision include:

  – Plane, angled and curved mirrors.
  – Fresnel lenses (used as magnifiers when a thin, light lens is needed).
  – Radar.
  – CCTV systems.

  The risk assessment for the mobile work equipment should aid selection of these devices by considering the best way to improve driver visibility.

MORE... www.

Further information and guidance on lift trucks can be obtained from the following UK HSE publications:

INDG457 *Use lift trucks safely: Advice for operators*, which covers operating, people, loads and slopes and is available at:

www.hse.gov.uk/pubns/indg457.pdf.

L117 *Rider-operated lift trucks: Operator training and safe use: Approved Code of Practice and guidance*, which includes information on UK legal requirements, operator training, lift-truck features, safe use, how to protect pedestrians and guidance on maintenance and thorough examination and is available at:

www.hse.gov.uk/pubns/priced/l117.pdf.

INDG462 *Lift-truck training: Advice for employers*, which explains who should be trained, who to consult, training content, authorisation and assessment, refresher and conversion training, record keeping and how to choose an instructor and is available at:

www.hse.gov.uk/pubns/indg462.pdf.

Requirements for Training Lift-Truck Operators

Operator training should include three stages:

- **Basic Training**

  This includes the basic skills and knowledge required for safe operation of the type of lift truck and attachments which the driver will use. This should be training off-the-job.

- **Specific Job Training**

  This should cover knowledge of the workplace, any special requirements of the work to be undertaken and the use of specific attachments. Again, it should be training off-the-job and is often combined or integrated with basic training. The training should include:

  – Controls of the lift truck to be used.
  – Routine inspections of the truck, which should be carried out by the operator.
  – Use of the truck in various locations such as gangways, loading bays, slopes, rough terrain.
  – Problems of working in poor weather.
  – Site rules such as one-way systems, speed limits, work near overhead lines, excavations.
  – Work to be undertaken such as loading particular vehicles and using working platforms on forks.

- **Familiarisation Training**

  This is training on-the-job where the driver operates the truck using the skills learnt, under close supervision and under normal working conditions.

STUDY QUESTIONS

1. Identify the three main headings under which forklift-truck hazards are placed. Give two examples for each.
2. Explain what is meant by 'lateral instability'.
3. List five factors that may affect forklift truck stability.
4. What precautions should be taken when a lift truck is being used as a working platform?

(Suggested Answers are at the end.)

Lifting Equipment: Hazards and Control Measures

IN THIS SECTION...

- The main types of lifting equipment are mobile cranes, tower cranes, overhead cranes and hoists.
- The hazards associated with lifting operations involve the equipment itself, the type of crane, and also the operation of the crane.
- The main hazards associated with lifts and hoists are falls from a height; being struck by the platform or other moving parts of the hoist; being hit by materials falling from the platform and being struck by landing levels, parts of any enclosure or other projections while riding on the platform.
- The control measures for the use of cranes involve selection, siting and stability.
- The control measures for the use of hoists and lifts include site demarcation, enclosure gates, capacity control and arrestor systems.
- Lifting accessories or lifting tackle forms an important element of any lift and, as a consequence, deserves similar attention to that of the crane or hoist.
- There may be requirements for inspection and statutory examination of lifting equipment.

Applications and Types of Lifting Equipment

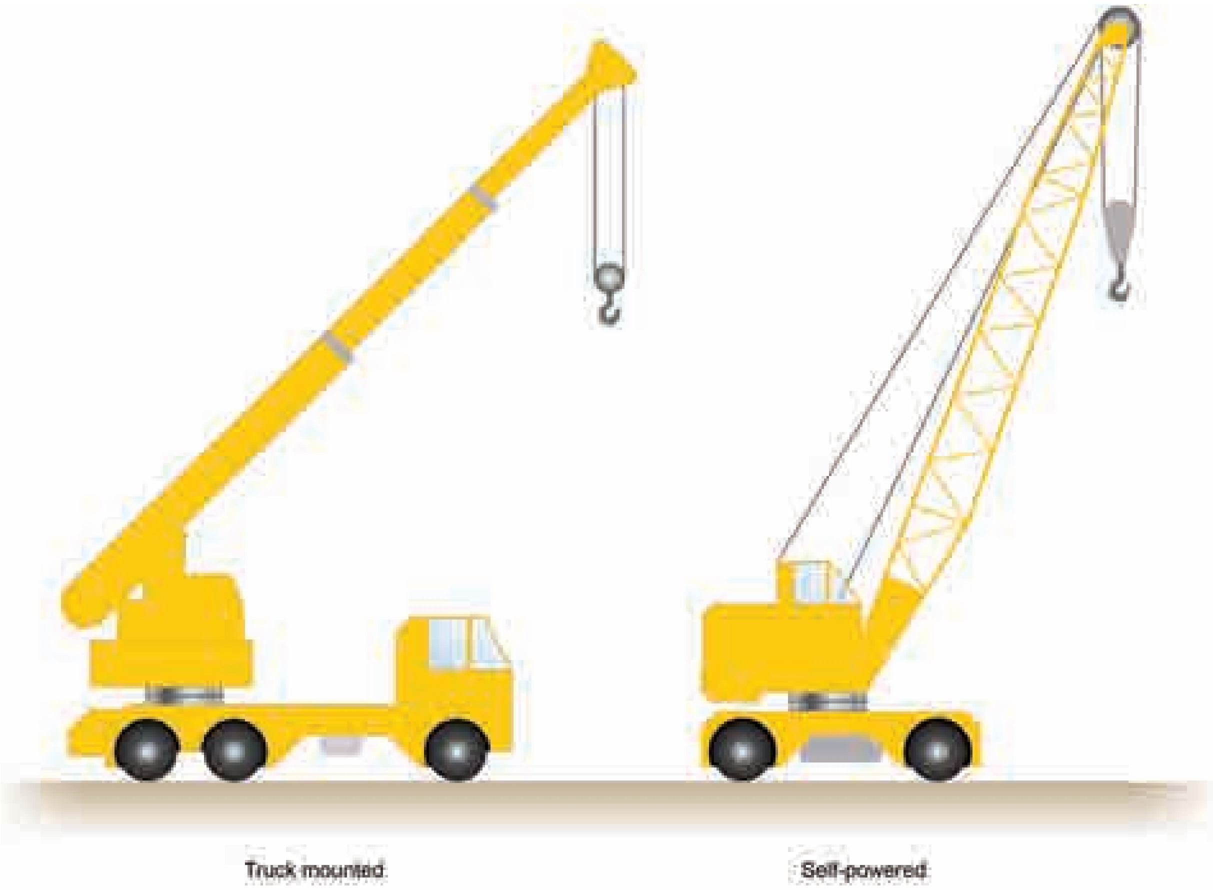
Mobile Cranes

These are the most common (see figure that follows). The smaller ones are rough-terrain wheeled cranes with a telescopic jib. They are very mobile and suitable for small lifts, making them useful around a construction site. It is the ease of movement which produces situations where control of the lifts fails, so they need more supervision than the larger cranes.

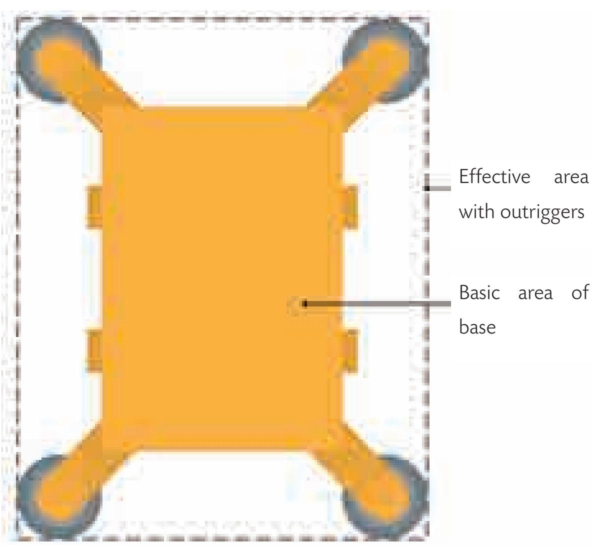

Mobile crane

The bigger road mobile cranes have a large chassis and either a lattice or a telescopic jib. They are normally available from a hire company, who will provide the design and/or the checking of the lift. They are normally used for a single large lift, as the erection and dismantling time is often far longer than the lift time itself.

Road mobiles normally have outriggers fitted. They extend from the chassis of the crane and are used to support the weight of both the crane and the load, lifting the running wheels clear of the ground. When using the outriggers, it is important to realise that while their use can increase the capacity of the crane, they also increase its size. The outriggers must be on firm foundations such as solid timber packing, steel plates or even specially cast concrete pads.



Mobile road or rubber-wheeled cranes



Outriggers

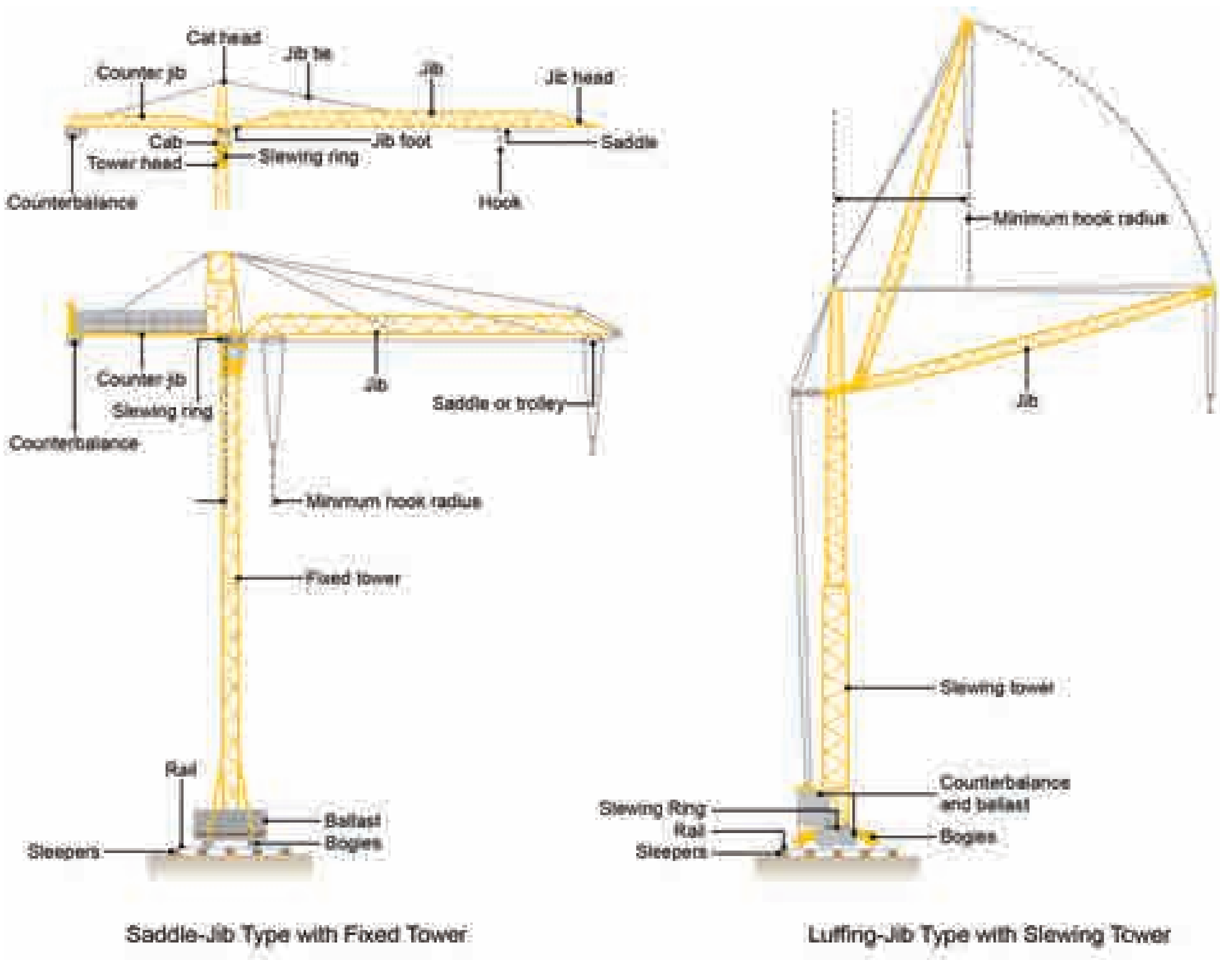
Tower Cranes

These consist of a tall, slender lattice mast with a jib unit at the top. They are used on long-duration work where large areas of access are required to be covered with the loads. Various types are available for special situations. They are normally fixed to one location but can be mounted on rails.

A conventional tower crane is usually transported in pieces and assembled (and dismantled) on site with the assistance of another crane, so is sometimes referred to as an 'assisted-erected crane'. Normally, these cranes are erected outside the building to be worked on. However, sometimes they are erected centrally inside the building (e.g. lift shaft) and their height increased without the addition of sections to the tower by 'climbing' from floor to floor as the building increases in height (hence the term 'climbing tower crane').

Tower cranes are also used for purposes other than construction, e.g. they may be installed permanently at storage yards and docks, or temporarily erected for bungee jumping.

Self-erecting tower cranes are complete units that are brought to site and then unfolded.



Tower cranes

Overhead Cranes

These are a version of gantry cranes generally used within buildings, although they can be found in outside situations. (Gantry cranes consist of a framework of two vertical supports connected with a horizontal beam or lattice along which a trolley moves. The bases of the uprights have wheels fitted that run on railway tracks, allowing the gantry to move backwards and forwards.) The verticals of the frame are omitted, the rails being attached to the structural steel framework of the building or on columns outside at a high level. Overhead cranes are common in engineering works and plants where lifting access for conventional cranes is difficult due to the layout (e.g. in power stations, to lift out turbines for maintenance). Capacity can be very high (200 tonnes is not unusual) and they are usually designed for a specific location.

Hoists

A basic hoist comprises a motor which operates either a wire rope, wrapped around a drum, or a chain raised by a pulley. They are used for the movement of loads vertically in a static location. Examples of hoists include gin wheels and construction site platform hoists.

Cantilever hoist

Hazards Associated with Cranes and Lifting Operations

The hazards associated with lifting operations involve both the equipment itself, the type of crane, and also the operation of the crane.

The main hazards associated with **mobile cranes** are:

- Working on uneven ground.
- Hitting overhead obstructions.
- Working without the stabilisers deployed.
- Driving with a suspended load.
- Impact with buildings and other structures.
- Overloading.

Hazards associated with the use of **tower cranes** include:

- Collapse of the tower due to incorrect construction.
- High wind conditions.
- Collapse or bending of the jib due to overloading or fatigue.
- Impaired operator vision of the load.
- Swinging or unstable loads.
- Operating outside the safe working radius.

Hazards associated with **overhead cranes** include:

- Movement of loads in the vicinity of other workers.
- Restricted vision of the load and travel.

Hazards Associated with Using Hoists and Lifts

Hoists include gin wheels and construction-site platform hoists.

Lifts include passenger and goods lifts and vehicle inspection lifts (as used in a garage).

A lift or hoist is a lifting device which has a platform or cage and where the direction of movement is restricted by a guide or guides. In practice, a lift will have some form of cage around the platform, while a hoist is open.

The styles and types vary according to the work and the work environment. The simplest form of hoists are the cantilever type used on construction sites (as shown in an earlier figure).

The drive systems utilised are:

- **Rope and friction**: used for goods only with a limited reach. As rough-terrain forklift trucks can be used as an alternative, these systems are becoming less common.
- **Rope and geared drive**: a more sophisticated machine.
- **Rack and pinion drive**: the drive turns a small cog where the teeth engage with similar teeth on the pinion. This system is extensively used, particularly on passenger-carrying hoists and lifts, as the locking of the cog acts as an effective brake. It is capable of carrying considerable weights and may be used on very high lifts.

The main hazards associated with lifts and hoists are:

- Falls from a height – from a landing level such as a scaffold platform, from the platform of the hoist or lift, or with the platform because of a failure in the operation (either as a result of operator error or mechanical failure).
- Being struck by the platform or other moving parts of the hoist.
- Being hit by materials falling from the platform.
- Being struck by landing levels, parts of any enclosure or other projections while riding on the platform.

Lifting Equipment Control Measures

Control Measures when Using Cranes

A lifting operation

Selection

Firstly, a crane must be selected which is suitable for the job. Cranes come in a variety of types, sizes and capacities. The selection of the appropriate type of crane will depend on the following factors:

- Weight and dimensions of loads.
- Heights of lifts and distances/areas of movement of loads.
- Number and frequency of lifts.
- Length of time the crane will be required.

- Site ground conditions.
- Space available for crane access, erection, operation and dismantling.
- Other special operational requirements (e.g. adjacent operations).

The capacity of a crane is its maximum lift in perfect conditions. Built into the capacity is a factor of safety which a competent person may increase (reducing the maximum load capacity) if circumstances are less than perfect.

Tower cranes offer the following advantages and disadvantages:

- **Advantages:**
  - Small base with relatively large working area.
  - Stable, as considerable care is taken to install.
  - Good visibility of the load and work area.
- **Disadvantages:**
  - Instability in high winds.
  - Workers may not always be aware of a load overhead.


Tower crane

Mobile cranes offer the following advantages and disadvantages:

- **Advantages:**
  - Suited to short-term contracts.
  - Lower transport costs.
  - Quicker set-up.
- **Disadvantages:**
  - Instability due to less certainty of ground make-up.
  - Greater potential for striking structures due to poor reach over building roof edges.
  - Contact with overhead power lines.

Siting

After ensuring that the right crane for the job has been selected - that is, it is able to lift the heaviest load at the required radius with capacity to spare - the crane should be sited in a place, so that:

- The driver has a good, clear view all around.
- It is well away from excavations and overhead power lines.
- It is on level ground which can take its full weight and its load (timber packings may be needed).
- There are no voids such as drains or basements which could collapse suddenly.

Stability

Stability is the ability of the equipment to remain fixed in its normal position for use.

Cranes can become unstable for several reasons, including operator error, movement of the load, uneven or sloping ground, wind or any combination of these. Therefore, basic questions that need asking are:

- Is the crane on a level base?
- Are the safe working loads and corresponding radii known and considered before any lifting begins?
- If the crane has a capacity of more than one tonne, does it have an automatic safe load indicator that is maintained and inspected weekly?
- Are all operators trained and competent?
- Has the banksman/slinger been trained to give signals and to attach loads correctly?

- Do the operator and banksman find out the weight and centre of gravity of the load before trying to lift it?
- Are the results of any examinations and inspections recorded?
- Does the crane have a current test certificate?

Control Measures when Using Hoists and Lifts

It may be necessary for a competent person to carry out a statutory examination of hoists and lifts every 6-12 months and record the results. Where faults are found on the equipment, the competent person should have the equipment taken out of use immediately, have the repairs carried out and re-examined before letting the equipment back into use.

- Site Demarcation

  Hoists with no cage arrangement make it possible for material to fall from them. It is important to consider this when locating the hoist and appropriate arrangements should be made to minimise the risk, e.g. demarcation of the site around the hoist or the construction, and some form of retention (such as netting) around the hoist area.

- Enclosure Gates

  To prevent people getting underneath a hoist and becoming trapped, substantial enclosure gates must be fitted at each landing. The enclosure gates must also be interlocked to the hoist platform so they cannot be opened when the platform is not there, thus preventing falls of people and material down the hoist route. The interlocking must also prevent the platform from moving until the enclosure gates are correctly closed. The construction of the enclosure must prevent any trapping of people or goods on the hoist.

- Capacity

  Hoists and lifts are designed for a maximum capacity, which should be marked on the unit. In passenger lifts, this is normally given in terms of the maximum number of people. In other locations, the maximum load is given in kilograms or tonnes, which requires an assessment of the weight of materials being carried (particularly on construction sites, where materials can have considerable weight for little volume).

- Arrestor Systems

  For hoists and lifts used for carrying people, additional safety arrangements are required to prevent the cage or platform over-running. This is normally in the form of an additional **friction brake** which locks onto the guide. It is important to ensure that it is effectively maintained and functioning. To prevent free-fall, measures such as **multiple ropes** should be fitted.

  Although not a legal requirement, good practice is not to carry goods and people in the lift at the same time.

Legal Requirements

National laws may establish requirements for hoists and lifts; in the UK these are set out in the **Provision and Use of Work Equipment Regulations** and also the **Lifting Operations and Lifting Equipment Regulations**, which establish the following good practice:

- Enclosure is required to prevent any person being struck by the hoist and to prevent people falling down hoistways.
- It should be fitted with a device:
  - To hold the platform in the event of failure of the cable.
  - To prevent over-run at the highest point.
- Where the operator does not have a clear view throughout the distance of travel, some form of signalling arrangement is required to enable stopping the platform in the correct position.

MORE... www.

The UK HSE Approved Code of Practice and Guidance to the **Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)** - L113 *Safe Use of Lifting Equipment* - is available at:

www.hse.gov.uk/pubns/priced/l113.pdf

- When a winch is used to provide the operation, the winch should be fitted with a brake which is applied when the lever is not in the operating position.
- Safe working load is to be marked and displayed in a prominent position, either as a weight or, in passenger-carrying hoists, as the maximum number of persons.
- Hoists should be examined at least every six months and the results recorded.
- Hoists should be loaded in such a manner that no goods can fall off.

Hoists and lifts are important pieces of equipment commonly encountered by the safety practitioner and the effective maintenance, inspection and control of misuse of such equipment is essential.

Integrity of Lifting Equipment (Ropes, Wires, Chains and Lifting Tackle)

Lifting accessories or lifting tackle forms an important element of any lift and, as a consequence, deserves similar attention to that of the crane or hoist. Lifting tackle includes chains, wires and fibre ropes, as well as the hooks, shackles, etc. that are used to connect the components. It also encompasses aids which are used to grip specific loads, such as nets, drum hooks or lifting beams (see the following figure).

Lifting equipment

In most cases, with the exception of fibre ropes or slings, such equipment should be clearly marked with the Safe Working Load (SWL) and all should be subject to regular examination for corrosion, stretching or deformity, broken or protruding wires and weld defects. Care must be taken in the use of lifting equipment to avoid damage or misuse and it should be stored in appropriate conditions to avoid deterioration.

Types of Lifting Equipment and their Limitations

Ropes, wires, chains and lifting tackle used on mechanical lifting equipment provide the link between the apparatus carrying out the lifting and the loads being moved or supported. Ropes, wires and chains require no explanation, but the term "lifting tackle" covers equipment such as chain and rope slings, rings, hooks, shackles and swivels, i.e. connecting units.

The types of lifting tackle in use include:

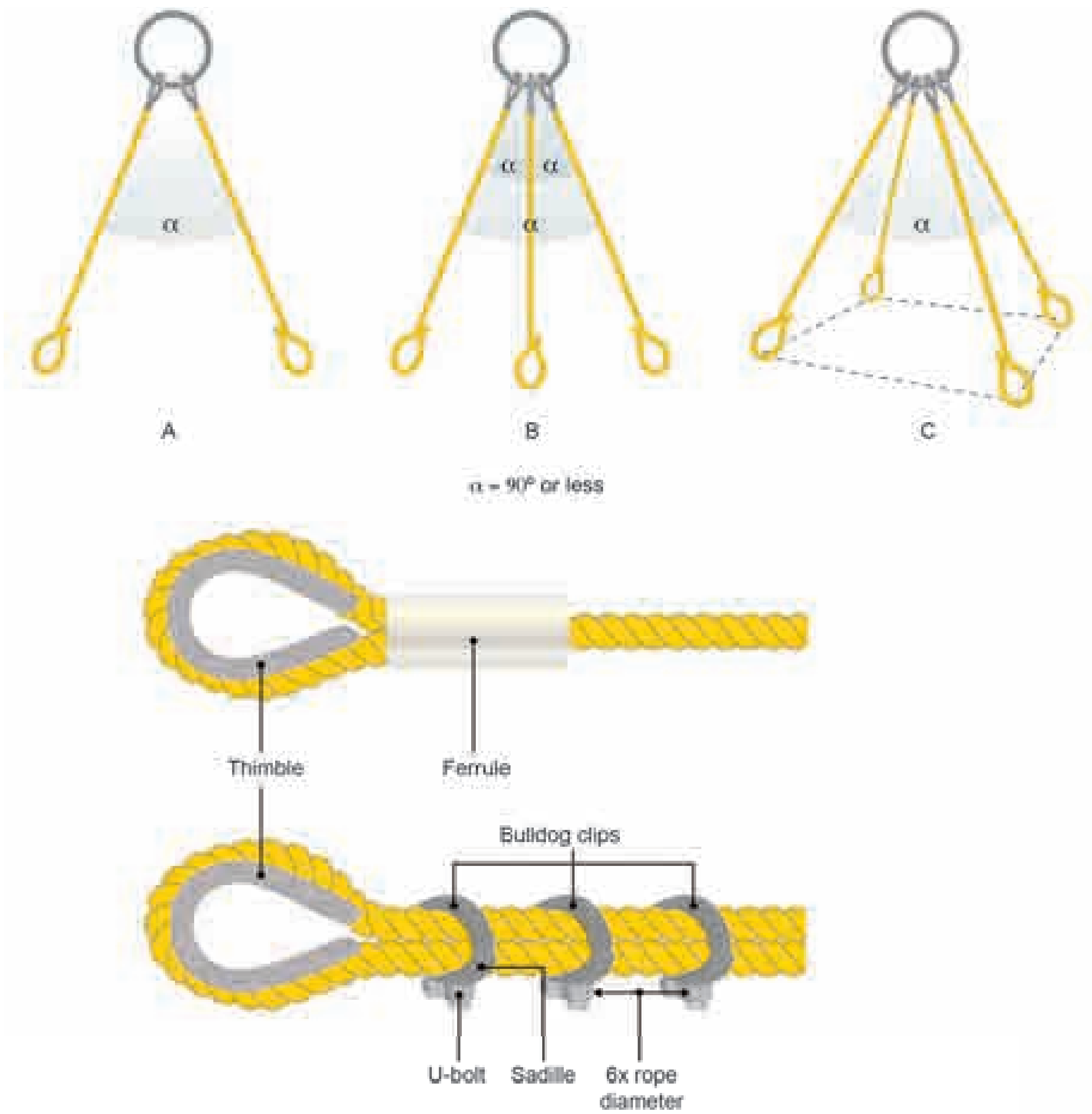
- Chains

  These, together with other types of slings, strops, etc., give a strong, flexible link between the load and the crane. They are usually used in conjunction with shackles (see later in this section). Chains of varying sizes and makes are widely used for lifting purposes. Wrought iron chains are still found in industry although their manufacture has virtually ceased. They provide a good system for carrying heavy loads and have considerable resistance to damage by corrosive atmospheres. They suffer a serious disadvantage in that they become work-hardened in use.

Work hardening is a process which causes changes in the crystal structure of wrought iron, making it brittle and therefore susceptible to brittle fracture. All wrought iron chains must undergo periodic annealing (i.e. subjecting to heat treatment, which enables the wrought iron to revert to its 'safer' crystal structure). Wrought iron chains may be identified by the scarf weld at the end of each link.

- Two-, Three- or Four-Legged Slings

Normally made of steel wire rope, slings usually have a large ring at one end to fit onto the hook, while at the other end there are eyes which allow the use of shackles (see the following figures).



Two-, three- and four-legged slings

A good guide to the safe condition of a wire rope is the number of broken wires which are visible. In a length of rope ten diameters long (for a 2cm diameter rope a length of 20cm would be required for inspection) there should be no more than 5% of the total number of wires broken.

- **Fibre Ropes**

  The term "fibre rope" is a general expression which covers natural or man-made fibre ropes. It is now possible to select a suitable rope from the different strengths and properties of the material available to suit most purposes. As there is no official test certificate for ropes, it is very important that ropes are obtained from a reliable source where adequate quality control during production, and testing of the final product, is carried out, and where reliance can be placed on the manufacturer's new rope test certificate. It is therefore important to have a visual inspection regime in place.

- **Endless Slings**

  A common type of lifting tackle, this is often made of webbing material or nylon, and is a continuous loop. It is passed under the load and simply slipped onto the hook (often in tandem). Care must be taken when using this type of sling that it does not pass over any sharp edges and, if necessary, padding should be used to protect the sling.

- **Webbing Straps (or Strops)**

  These are manufactured with a loop at each end to allow shackles to pass through them.

- **Shackles**

  These come in a variety of types and sizes, some common examples being 'D' shackles (because of their shape) and bow shackles. They are passed through the eye of the sling or strop and are connected to the load by means of a pin, often threaded.

- **Eye Bolts**

  These are threaded bolts which have an eye formed at the other end. They are used:

  – Where there are dedicated lifting points on the load which have been drilled and threaded.
  – In conjunction with shackles.

- **Lifting Beams**

  Very often these are specially designed to carry out specific lifts. They are steel and have arms or shackles that attach to lifting points on the load.

There are a number of other types of lifting tackle but they all work along the same principle - acting as a suitable connection between the load and the crane.

Factors Influencing Choice of Lifting Equipment

The choice of which lifting equipment to use will depend on:

- The weight of the load.
- The shape of the load.
- Whether there are any lifting points.

The main requirements relating to ropes, wires, chains and lifting tackle include the following:

- They should be well constructed, of suitable material and strength, and free from any defects.
- The **Safe Working Load (SWL)** should be **displayed** or marked on it; only marked items may be used in a lifting operation.
- The SWL should not be exceeded.
- Before being taken into service, all items should be **tested and thoroughly examined** by a competent person, and at regular intervals during service.
- **Certificates** should be issued for all items except ropes.
- **Registers should be kept**, giving details of equipment in use.

Competence of Workers

In addition to any legal requirements asking for competence, organisations such as the Construction Industry Training Board (CITB) in the UK offer courses for lifting operations supervisors, operators (various classes of cranes), banksmen and slingers. It is a general requirement in the construction industry that only competent persons who hold the relevant certification can perform the relevant task.

Maintenance, Inspection and Statutory Examination of Cranes and Lifting Equipment

There is a series of ISO standards that relate to the safe use of cranes:

- **ISO 7752-1:2010** - general principles relating to controls which are used in positioning loads.
- **ISO 7752-2:2011** - basic arrangements and requirements for mobile cranes.
- **ISO 7752-3:2013** - particular requirements for controls for tower cranes.
- **ISO 7752-4:1989** - operations for jib cranes.
- **ISO 7752-5:1985** - requirements for overhead travelling cranes and portal bridge cranes.

Characteristics of steel wire ropes and wire rope slings are also considered in **ISO 2408:2004** *Steel Wire Ropes for General Purposes – Minimum Requirements* and **ISO 7531:1987** *Wire Rope Slings for General Purposes - Characteristics and Specifications* respectively.

Best practice requires that lifting equipment being used is:

- Fit for purpose.
- Properly maintained in accordance with the manufacturer's instructions.
- Regularly inspected for faults.
- Subjected to thorough examination.
- Capable of lifting the load and of a type that will enable the task to be completed.

Circumstances Requiring Thorough Examination

The four situations in which thorough examination may be required are:

- When lifting equipment is first supplied, i.e. used for the first time by that employer.
- When certain equipment is installed, e.g. a tower crane.
- Periodically during the lifetime of equipment.
- Following exceptional circumstances.

Scope of Thorough Examination and Inspection

Devices fitted to cranes, which cut out hoisting, derricking or trolleying motions, e.g. when the SWL is exceeded, should be regarded as part of the lifting equipment and be included in the thorough examination.

This applies also to any radius/load indicator fitted.

The thorough examination of a forklift truck should include:

- Chains.
- Forks.
- Hoist mechanism (mast and cylinders, and any associated fork attachments).

Other items may be included in the thorough examination as a result of risk assessment by the competent person or the equipment owner.

Competent Person

The thorough examination should be carried out by a competent person.

Testing

Test certificates should be prepared at the discretion of the competent person carrying out the thorough examination.

Proof testing can cause damage to machinery and therefore the decision to test is one that may need to be made by the competent person.

Thorough Examination Regime

Best practice may require the following thorough examinations:

- Initial examination before installation.
- Thorough examination after installation but before use (generally limited to equipment which requires a considerable degree of assembly at the location before it is ready for use (tower cranes, overhead travelling cranes)).

Periodic Thorough Examination

Good practice requires a six-monthly period between thorough examinations for all lifting accessories and lifting equipment used for lifting persons.

Inspections

Inspections should normally be carried out by an in-house competent person and include visual and functional checks (e.g. that the alarm operates correctly on a crane overload device). They may be weekly or less frequent (monthly, quarterly) and will normally be carried out on machinery, e.g. a crane, rather than accessories.

Detachable chains and slings, etc. should receive a pre-use check by the operator, rather than periodic inspections.

The person carrying out the inspection should be:

- Competent to do so.
- Able to detect and appreciate the significance of defects and draw attention to them.

STUDY QUESTIONS

5. When establishing a safe system of work for crane operations, what factors need to be addressed to ensure crane stability?
6. Identify the main hazards associated with the use of tower cranes.
7. Identify the lifting equipment that needs to be inspected and examined.
8. How often must lifts and hoists have a thorough examination?
9. Describe the measures to be taken to prevent people becoming trapped underneath a hoist.

(Suggested Answers are at the end.)

Access and Work at Height Equipment: Hazards and Control Measures

IN THIS SECTION...

- The term Mobile Elevating Work Platform (MEWP) is generally used to describe the most commonly used access/work at height equipment.
- The basic types of MEWP are scissor lift, telescopic boom or jib, and articulating and telescopic boom.

  All of these may be either towable units, vehicle-mounted, self-propelled or pedestrian-controlled.
- The hazards associated with MEWPs arise from lack of mechanical strength of the carrier, lack of loading control and control devices, movements of the carrier, persons falling from the carrier, objects falling on the carrier and exceeding the SWL or number of persons permitted to be carried.
- Control measures for the use of access and work at height equipment involve space and strength corresponding to the maximum number of persons and maximum working load, fitting of a suspension or supporting system, control by persons in the carrier, emergency stop devices, hold-to-run controls, preventing tilting if there is a risk of the occupants falling, trapdoors that open in a direction that eliminates any risk of falling, protective roof if there is a risk of falling objects endangering persons and marking of the maximum number of persons and maximum working load.

Applications and Types of Access and Work at Height Equipment

The term Mobile Elevating Work Platform (MEWP) is generally used to describe the most commonly used access/work at height equipment and covers pedestrian-controlled, self-propelled and power-operated mobile elevating work and access platforms.

The MEWP is designed to provide a temporary working platform which can be easily moved from one location to another. It is particularly suitable for short-duration tasks, where the use of a ladder would be unsafe and the erection of a scaffolding platform would be time-consuming or impracticable in relation to the job to be done. Some units have specialised applications and the MEWP is becoming widely used in more complex forms.

DEFINITION

MOBILE ELEVATING WORK PLATFORM (MEWP)

This is a mobile machine that is intended to move persons to working positions where they are carrying out work from the work platform with the intention that persons are getting on and off the work platform at one defined access position and which consists (as a minimum) of a work platform with controls, an extending structure and a chassis.

Types and Applications

The basic types of MEWP are:

- Scissor Lift

  This is a vertical lift only (as shown in the following illustration). It may be fitted with outriggers, depending on the size and height to which it extends.

- Telescopic Boom

  This gives vertical height and outreach (as shown in the following figure). The platform may also be manoeuvrable.

Scissor lift MEWP

Telescopic boom MEWP

- Articulating and Telescopic Boom

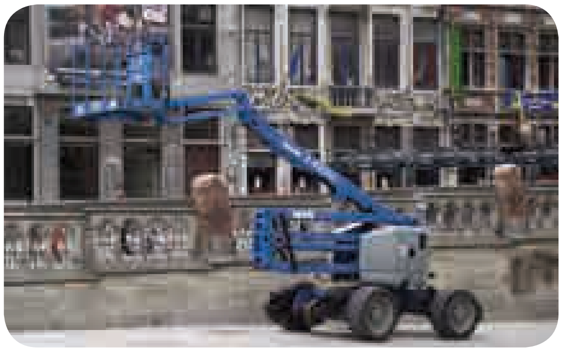
  This is usually vehicle-mounted (as shown in the following figure). It gives a wide range of reach and height, with platform mobility, and is nearly always equipped with outriggers. There are specialised types giving, for instance, access to the underside of bridges from above.

  Some units have four-wheel drive and the ability to 'travel while elevated'. Rough-terrain MEWPs have been specially developed for construction site work (as shown in the following illustration).

Articulated and telescopic boom MEWP

A **loader** is a type of **tractor** (usually wheeled, sometimes on tracks) that has a front-mounted **bucket** connected to the end of two arms to scoop up loose material from the ground, such as dirt, sand or gravel, and move it from one place to another.

Tractor with bucket



Rough-terrain MEWP

Mobile work platforms can also include mobile platform steps, which have a large working platform accessed by steps fitted with wheels to enable easy location.

Hazards of Use

The principal types of incidents involving MEWPs are as follows:

- MEWPs collapsing.
- MEWPs overturning.
- People being thrown from the carrier (basket or cage).
- The carrier being trapped against fixed structures.
- The vehicle may collide with pedestrians, overhead cables or nearby vehicles.

These incidents arise from the following primary causes:

- Equipment failure – failure of hydraulic hoses or mechanical strength of the structure.
- Ground conditions – underground cavities or poor positioning.
- Outriggers (not used or faulty).
- Trapping against a fixed structure.
- MEWP being struck by a vehicle.
- Load/unload of MEWP under power.
- Exceeding the SWL or the number of persons of a carrier.
- The carrier being struck by a load.

The risk of falling from a MEWP is from sudden movements caused by:

- An impact.
- Ground movement.
- Failure of a stability-critical part.
- Overreaching.

In broad terms, these hazards arise from lack of mechanical strength of the carrier, lack of control to prevent overloading or exceeding the SWL, and hazards to persons on or in the carrier, such as movements of the carrier, persons falling from the carrier or objects falling on the carrier.

TOPIC FOCUS

The **general hazards associated with the use of MEWPs** include:

- Falls from height of persons and materials.
- Instability of vehicles.
- Striking by vehicles.
- Trapping.
- Mechanical failure.
- Overhead lines and obstructions.
- Wind and wind chill.
- Collisions of persons.
- Overloading.

Control Measures for Use of Access and Work at Height Equipment

- **Space and Strength Corresponding to the Maximum Number of Persons and Maximum Working Load**

  If MEWPs are to be used directly to install materials, it is essential to know the weight and dimensions of those materials and to properly consider any manual handling and load-distribution issues. Boom type MEWPs generally have smaller baskets and lower lift capacities than scissor type MEWPs and their platforms can 'bounce' at height due to the boom structure flexing. This usually makes them unsuitable to use for installing long or heavy materials, or bulky materials that may obstruct the function controls.

- **Fitted with a Suspension or Supporting System**

  MEWP platform movement or boom flex should be minimised when the MEWP and its lifting structure are stationary. The MEWP lifting structure should be sufficiently stiff to avoid excessive platform movements due to boom flexing that could cause trapping accidents while work is being carried out.

Controlling a MEWP

- **Control Systems**

  The MEWP control system should allow control of movements by the persons in the carrier and incorporate emergency stop devices. Hold-to-run controls can link to and nullify the lift/lower controls until the controls in the platform are actuated by a person or persons in the platform. This means that the height of the platform or vehicle movement can only be adjusted by the vehicle operator when the platform controls are held by an operator in the platform. Hold-to-run devices will stop hazardous movements when the controls are released.

- **Preventing Tilting if there is a Risk of the Occupants Falling**

  MEWPs can be fitted with a tilt/trip 'lock' to prevent accidental tilting of the platform.

- **Trapdoors Open in a Direction that Eliminates Any Risk of Falling**

  Trapdoors in work platforms should be securely fastened to the work platform so that no inadvertent opening is possible either downwards or to slide sideways.

- **Protective Roof**

  If there is a risk of falling objects which might endanger persons occupying the carrier then it should be fitted with a protective roof.

- **Marked with Maximum Number of Persons and Maximum Working Load**

  The SWL specified by the manufacturer must not be exceeded. The maximum number of persons permitted on the platform may also be given, but if it is not, 80-85kg of the SWL should be allowed for each person.

  Care must be taken not to exceed the SWL with tools and equipment when work is being carried out from the platform. This can also be caused by:

  – Allowing an accumulation of plaster, cement, blasting grit or other loose material.
  – The lowering of fans, motors or other equipment from a high level onto the platform prior to removing them for repair or maintenance.
  – Any form of shock loading.

  It is usual for a single SWL to be specified for all conditions of height or reach.

General Precautions for the Use of MEWPs

MEWPs must not be used:

- As jacks, props, ties or supports.
- Primarily for the transfer of goods or materials.
- As cranes or lifting appliances.

Such uses are either outside the designed use and safe working limits of the machine or would bring it under other statutory provisions, such as those applicable to cranes and hoists.

Platforms must not be tied to buildings or other structures to gain additional support. Operation of the controls in such circumstances could cause an accident or create another major hazard.

MEWPs must not be used as cranes

Training of Operators

The main duties of operators are:

- To operate the machine safely and without risks to themselves or anyone else.
- To operate the machine in compliance with the manufacturer's instructions and recommendations and ensure that it remains safe and stable.
- Not to abuse, ignore or override any safety device or equipment.

No one should be allowed to operate a MEWP without proper and adequate training. Operators should be trained specifically for the type of machine in use; a person competent to operate a scissor lift would require separate and specific training for an articulated boom unit.

Both knowledge and skill should be tested during training to ensure that the operative has achieved a satisfactory standard of competence.

Three main stages of training can be identified, which apply to all types of unit:

- Basic understanding of the operating principles, and the knowledge necessary for the day-to-day operation of the platform.
- Task-specific training and practice on the type of machine concerned, if possible under all foreseeable operating conditions.
- Properly supervised on-site familiarisation, to gain experience and confidence.

It is important to ensure that operatives fully understand the functions of limit switches and interlocks, and the serious dangers which can be caused by defeating or overriding them.

Other points:

- Operatives should be permitted to use only the type of unit they have been trained and authorised to use.
- After training, an in-company licence should be issued, and adequate records kept of initial and any further training.
- The safety element of the training must include safety awareness and recognition of hazards.

Persons nominated or applying for training as operators should meet the following general requirements:

- Full physical mobility.
- Sufficient agility to climb into and out of the platform.
- A good head for heights and not subject to vertigo or acrophobia (fear of heights).
- Good hearing, in case warning signals are given.
- The correct colour vision for colour-coded controls.

- The ability to judge space and distance accurately.
- Good eye-to-hand co-ordination and sufficient dexterity to operate the controls.
- Good eyesight, with glasses if necessary - the ability to read a car number plate at 25 metres is usually satisfactory.
- A stable disposition.

Fainting or dizziness may render people unsuitable as operatives. Advice can be obtained from the relevant authorities (for example, in the UK, the Employment Medical Advisory Service (EMAS) of the Health and Safety Executive).

Siting and Stability

MEWPs are often fitted with outriggers or stabilisers and these must always be deployed and used as recommended by the manufacturer. Attempting to operate the unit too close to a building or obstruction can make it impossible to extend the outriggers fully, and therefore unsafe to use. Before deploying stabilisers or outriggers, check that the:

- Machine is either level or can be levelled up.
- Ground is firm and will support loading with the use of adequate packing if necessary.
- Machine is not over or adjacent to a cellar, basement, sewer, drain, manhole, old trench, uncompacted backfill or anything else which might collapse under load.

Travelling with the platform occupied or boom extended should only be undertaken when this mode of operation is within the machine's specified capabilities. Travel must never take place with outriggers or stabilisers extended, unless the machine is designed to function in this way.

Before travelling, a check should be made to ensure:

- No ramps, trenches, holes or other ground obstructions lie in the path of travel.
- No overhead electrical cables, building projections or other overhead hazards will be encountered.
- Adequate warning has been given to persons on the ground.
- A signaller or other responsible person is employed if necessary.
- Nothing has been left unsecured and liable to fall off the vehicle.
- No trailing hoses, cables, wires on the unit or other snagging hazards are in the path of travel.

Travelling up and down inclines and traversing slopes should only be undertaken within the limits laid down by the manufacturer.

Specially designed units, designated as rough-terrain, can operate (usually without any stabilisers or outriggers) on construction sites and other sites where ground conditions may not permit a standard-type vehicle to be used.

Overhead Power Cables

When working near overhead power cables, there is the risk of electric shock from contact or electric arcing due to close approach to any overhead cables. Either could be fatal.

Always maintain a safe distance. The absolute minimum distance, measured from the furthest point of outreach to the ground level barrier or point directly beneath the outmost conductor, must be at least six metres (when there is not work or passage under the lines) although most electrical utilities recommend eight metres.

High winds can cause cables to sway and significantly reduce this distance.

MORE... www.

The UK HSE guidance, GS6 *Avoiding danger from overhead power lines*, is available at:

www.hse.gov.uk/pubns/gs6.pdf

The HSE General Information Sheet No. 6, *The selection, management and use of mobile elevating work platforms* (GEIS6), provides information on what to consider before selecting a MEWP and the risks that need to be assessed and managed while the MEWP is in use.

GEIS6 is available at:

www.hse.gov.uk/pubns/geis6.pdf

No part of any machine should be closer than 15 metres to any overhead line on a steel tower (nine metres if on a wooden pole) unless by arrangement with the electrical utility.

Falls of Persons or Materials

- Ensure that safety harnesses are worn at all times.
- Do not allow any loose materials to accumulate on the platform.
- If there is any danger of tools being dropped from the operator or the platform, pedestrian access beneath the platform should be prevented.

Entrapment

- All moving parts and mechanisms should be properly and securely guarded.
- All operators should be made aware of the hazards and procedures for avoiding entrapment between the platform and any fixed obstruction.

Overturning

- Check for the hazard of soft or collapsing ground.
- Beware of overloading, especially if the platform is being used at maximum outreach to remove fans, motors, etc. Always observe the SWL.
- Be careful when operating on a slope with the unit not properly levelled out on the stabilisers or outriggers. Always check that the unit is stable before operating.
- Be careful when travelling with the platform raised on unsuitable ground conditions.
- Unless the unit is specifically designed to travel while the outriggers or stabilisers are deployed, never attempt to travel.
- Be careful not to collide with any obstruction or other vehicle.

STUDY QUESTIONS

10. Identify the advantages of using a MEWP over a scaffold or ladder.

11. Identify the checks that should be made before travelling with a MEWP.

12. Outline the principal types of incidents involving MEWPs.

(Suggested Answers are at the end.)

Summary

Mobile Work Equipment: Hazards and Control Measures

We have:

- Considered the applications of the different types of mobile work equipment and, in particular, lift trucks, agricultural tractors and works vehicles.
- Highlighted the following hazards associated with mobile work equipment:
  - Roll-over.
  - Overturning.
  - Suitability for carrying passengers.
  - Unauthorised start-up.
  - Safe operating station/platform.
  - Excessive speed.
  - Failure to stop.
  - Contact with wheels and tracks.
  - Falls of objects.
  - Moving parts/drive shafts/power take-offs.
  - Overheating.
- Examined the hazards associated with the refuelling or charging of mobile work equipment arising from electrical power, LPG or diesel.
- Explained the control measures to be used in the use of mobile work equipment, including safe layout of areas where mobile equipment is used, the protection of pedestrians and using lifting plans.
- Identified the conditions and equipment necessary to use lift trucks to move people and also the other types of attachments used on lift trucks.
- Outlined the control measures required for the use of mobile work equipment, which include:
  - Roll-over protection.
  - Falling objects protection.
  - Speed control systems.
  - Guards and barriers and restraining systems.
  - Means of fire-fighting.
  - Vision aids.
- Examined the requirements for training lift-truck operators.

Lifting Equipment: Hazards and Control Measures

We have:

- Identified the main types of lifting equipment as mobile cranes, tower cranes, overhead cranes and hoists.
- Examined the hazards associated with cranes and lifting operations, hoists and lifts.
- Explained the control measures for the use of cranes, hoists and lifts, including:
  - Integrity of lifting equipment.
  - Competence of workers.

- Maintenance.
- Inspection and thorough examinations.

Access and Work at Height Equipment: Hazards and Control Measures

We have:

- Considered the applications and different types of access and work at height equipment – or Mobile Elevating Work Platforms (MEWPs) – including self-propelled, trailer and truck-mounted hydraulic lifts, booms, scissor lifts, loaders and mobile work platforms.
- Identified the hazards associated with MEWPs arising from:
  - Lack of mechanical strength of the carrier.
  - Lack of loading control and control devices.
  - Movements of the carrier.
  - Persons falling from the carrier.
  - Objects falling on the carrier.
  - Exceeding the safe working load or number of persons permitted to be carried.
- Explained the control measures for the use of access and work at height equipment, which involve:
  - Space and strength corresponding to the maximum number of persons and maximum working load.
  - Fitting of a suspension or supporting system.
  - Control by persons in the carrier.
  - Emergency stop devices.
  - Hold-to-run controls.
  - Preventing tilting if there is a risk of the occupants falling.
  - Trapdoors that open in a direction that eliminates any risk of falling.
  - Protective roof if there is a risk of falling objects endangering persons.
  - Marking of the maximum number of persons and maximum working load.

Exam Skills

QUESTION

(a) **Outline** the factors that may cause an agricultural tractor to overturn. **(6)**

(b) **Outline** the measures that may be necessary to minimise the risk of a tractor overturning. **(4)**

Approaching the Question

This is a straightforward question, where you can use your knowledge and experience of vehicle stability to identify common-sense issues such as speeding and gradients to answer the first part of the question. In the second part, you need to work through the factors identified in part (a) to establish the control measures required for part (b).

Suggested Answer Outline

For part (a) you need to identify a range of factors affecting the possibility of overturning such as:

- The slope of any gradients.
- The direction of travel on gradients.
- Uneven or soft ground causing the tractor to tilt.
- Excessive speed on cornering.
- The wheelbase of the vehicle with narrow track width making the vehicle more unstable.
- Poor condition of tyres.
- Uneven tyre pressures.
- The effects of trailers on stability.
- The level of competence of the driver.

In part (b) these factors can be addressed by:

- Restricting the use of tractors on steep gradients.
- Restricting their speed.
- Increasing the width of the wheel track.
- Fitting counterbalance weights to improve stability.
- Introducing a regular maintenance system and pre-use inspection, particularly of the tyres.
- Providing training for drivers.

Example of How the Question Could be Answered

(a) One of the ways that a tractor could overturn is by travelling too fast round a corner or travelling across a steep slope. If the tractor sinks into soft ground or is working on uneven ground it could topple over. If the tractor had uneven tyre pressures or a narrow wheelbase that would also make it more unstable. Towing trailers can increase the load on the back of the tractor or possibly exert a turning effect on the tractor which could also increase the risk of it overturning. Finally, an untrained or incompetent driver would be more likely to operate the tractor in a way that might increase the risk of it overturning.

(b) To minimise the risk of overturning, the use of tractors on steep slopes should be restricted.

There should also be speed restrictions on the vehicle. The tractor itself could be selected to have a wider wheelbase and counterbalance weights could be fitted to improve stability. A regular maintenance system and pre-use inspection should identify tyre problems and training for drivers would increase their awareness of the factors that could lead to an overturning incident.

Reasons for Poor Marks Achieved by Exam Candidates

An exam candidate would achieve **poor marks** for an answer which:

- Simply provided lists rather than some degree of explanation in an outline.
- Suggested impractical measures such as not driving on soil or in wet conditions.

Element IC8

Electrical Safety

Learning Outcomes

Once you've read this element, you'll understand how to:

1. Outline the basic concepts of electricity.
2. Outline the hazards of electricity and static electricity.
3. Outline the issues relevant to the installation, use, inspection and maintenance of electrical systems.
4. Outline the main principles for safe working in the vicinity of high voltage systems.
5. Outline the main hazards, risks and controls associated with the use of portable electrical equipment.

Contents

Basic Concepts of Electricity

IN THIS SECTION...

- High voltage is defined as being in excess of 1,000V AC or 1,500V DC.
- Ohm's law relates potential difference (volts), current (amps) and resistance (ohms).
- An electrical circuit consists of a source of electric current, conductors and equipment powered by the current.
- By connecting all exposed metal parts to earth, any fault current is provided with a path to earth so that the exposed metal parts cannot become live.
- A current which flows in one direction only is known as **direct current (DC)**. If the direction of flow alters at regular intervals, it is an **alternating current (AC)**.

Differences between Low and High Voltage

- **High voltage**: this is defined in national and international standards as being in excess of 1,000V AC or 1,500V DC. However, historically, certain precautions have been applied in the UK to systems energised at more than 650V AC. To maintain the same degree of safety, HSG85 *Electricity at Work: Safe Working Practices* uses the term 'high voltage' where the voltage exceeds 650V AC.
- **Low voltage:** this is defined in national and international standards as any voltage in the range 50–1,000 V AC or 120–1,500 V DC and any voltage below 50 V is classified as extra low voltage.

Explanation of Terms

To understand how electricity is utilised, it is important that the various terms are explained.

Potential Difference (or Voltage)

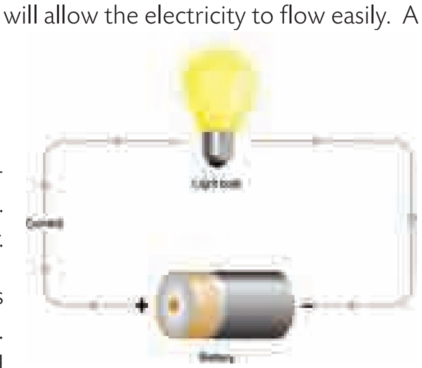
For electricity to flow, there needs to be a source. This can be a battery or the socket in a living room or workplace. This provides the **voltage** (unit - volts, symbol - V) which will push the electricity. The higher the voltage, the harder it will push.

Whatever the source of electricity, there are a minimum of two terminals - one from which the electricity flows and the other to which it returns. On a battery they are the positive and negative terminals; in the wall socket they are the live and neutral connections (the two at the bottom in UK sockets, for example). In certain electrical arrangements, there may be more than two terminals, e.g. three-phase systems (see later).

To enable electricity to flow, there needs to be a complete circuit between the two terminals through which it can travel. This is normally made by using wires known as conductors. A good conductor will allow the electricity to flow easily. A typical good conductor is copper and most electrical circuits use copper wire.

Current

The flow of electricity through the conductors is known as the **current** (unit - ampere, symbol - A). The faster the current flows, the more power is generated. Current flow can be increased by using more voltage to push it through quicker.



Current flow in a circuit

If a circuit were made consisting of just the source of electricity and conductors connected between the two terminals then a lot of damage would be caused. There would be nothing to slow down the flow and it would continue to speed up until something gave - the battery exploding or a fuse blowing. This is known as a **short circuit**.

Resistance and Impedance

To prevent a short circuit and to make the circuit useful, it is necessary to introduce something to slow the current flow. This is known as a **resistance** (unit - ohm, symbol - Ω). Typical resistances used in everyday life include light bulbs, power tools, hi-fi systems. In fact, everything that relies on electrical power is a resistance. (When related to an alternating current circuit, such as the mains, it is referred to as the **impedance**, which takes into account the resistance offered by many miles of cable that the current has to travel through.)

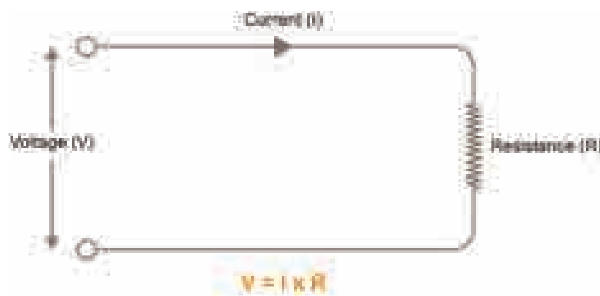
Ohm's Law

The simple electrical circuit which follows demonstrates how, using Ohm's Law, the terms described above are interrelated.

So for any two values the third can be calculated:

So for any two values the third can be calculated:

I = V/R or R = V/I



Simple electrical circuit

As the volts force the amps through the ohms in the circuit, energy is being used in one form or another and the voltage drops in value until at the neutral end of the transformer, at the substation, it is zero.

The power in an electrical circuit is expressed in **watts** (symbol - W), as the product of the voltage and current. For example, if the current taken by an electric heater is 5 amps when plugged into a 230-volt supply, then its power load will be 230 × 5 = 1,150 watts.

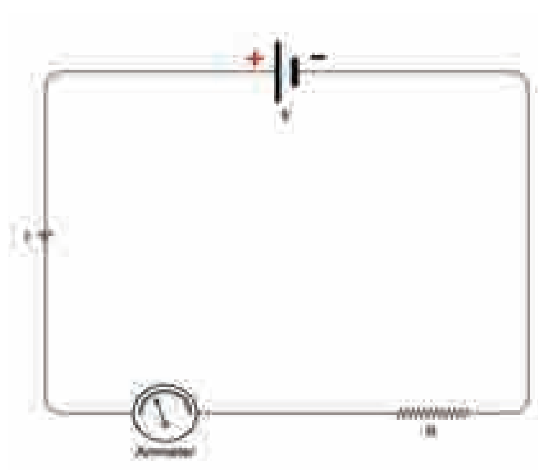
These equations can be used to calculate the current which flows in any circuit, given the resistance or power connected to a known voltage. The equations are used to determine fuse ratings for particular loads and the current flowing through a person who may inadvertently touch a live supply.

Basic Electrical Circuitry

An electrical circuit consists of a number of components - a source of electric current, conductors and equipment powered by the current.

The current is supplied from a **source** (e.g. a generator or battery) and applied to electric equipment (known as the **load**) such as a motor, a fire or a refrigerator, via connecting cables (the **conductors**).

The conductor which supplies the current is the **phase conductor**, or live or **line conductor**. Once the voltage is applied, an electric current will flow. At the point of use, e.g. an electric fire, the electric flow is converted back to energy in the form of heat. The current returns to the source via the neutral or **return conductor**. A simplified circuit is illustrated in the following figure:



Simplified circuit

An electric current will flow along a conductor if there is a difference in electrical pressure between its two ends. The difference in electrical pressure between two points is called the **potential difference** and is measured in volts. Potential differences can be created by a magnetic field, such as in a generator, or by a chemical reaction, such as in a battery. In the UK public electricity supply, the neutral conductor is usually at a potential of zero volts, while the phase (live) conductor has a potential of 230 volts. The zero point on the voltage scale is the potential of the mass of earth, which is considered to be at a potential of zero volts.

If a circuit is linked by a conductor, deliberately or accidentally, to an area of lower electrical potential, the current will flow to the lower potential instead of round the circuit. This is a **short circuit**. A short circuit current may be very large as a short circuiting link may reduce the resistance to the flow causing a greater current. The short circuit current which would result if a particular point in a circuit was connected directly to earth is called the **fault level** at that point. The current which would flow is called the **fault current** and the new circuit created by the short circuit is called the **earth fault loop**.

Earthing Principles

The earth conductor in a circuit, sometimes called the **protective conductor**, is linked to the general mass of earth, which is at **zero potential**. By connecting all exposed metal parts which should not normally carry a current to earth, any fault current is provided with a path to earth so that the exposed metal parts cannot become live.

Difference between Direct and Alternating Currents

A current which flows in one direction only is known as **Direct Current (DC)**. A battery gives a direct current. If the direction of flow alters at regular intervals, it is an **Alternating Current (AC)**. In the UK, the public electricity supply is established at 230 volts AC. Shock injury from DC is generally a lot less severe than from AC. The flow of AC is cyclic. For instance, a 230-volt public supply peaks at around 320 volts. This cyclic variation is not suited to some installations, such as driving electric motors. To overcome this problem a three-phase system is used, i.e. three electricity supplies are fed to the motor, each of which is out of phase with the others but which, in combination, produce a steady current. The additional hazards with three-phase systems are that three live conductors are present and that an electric shock at 415 volts can result between the live conductors.

STUDY QUESTION

1. What would be the power rating (watts) for a 230-volt electric fire that had a resistance of 23 ohms?

(Suggested Answer is at the end.)

Hazards of Electricity and Static Electricity

IN THIS SECTION...

- An electric shock results in a convulsive response by the nervous system to the passage of electricity through part of the body causing pain, burns, muscular contraction, respiratory failure, heart fibrillation and cardiac arrest.
- The factors influencing the severity of the effects of electric shock on the body include voltage, frequency, duration, impedance/resistance, current path, and whether the shock is direct or indirect.
- Common causes of fires include overloading of conductors, overheating, ignition of flammable vapour, ignition of combustible material and breakdown of insulation.
- Arcing can occur when the potential in a conductor is great enough to cross the air gap or insulation which separates the two conductors generating very large amounts of energy and ultraviolet radiation.
- Static generation is affected by the speed of separation of materials, the size of the contact area and the degree of conductivity.
- Control measures for static electricity include earthing, increasing conductivity, ionisation and, in relation to flammable atmospheres, ventilation, inerting and training of workers.

Effects of Electric Shock on the Body


Low voltage mat reduce the risk of electric shock

An electric shock results in a convulsive response by the nervous system to the passage of electricity through part of the body. No voltage can be considered safe in all circumstances, although low voltages may reduce the risk. We must always assume that the electricity supply of 230 volts is potentially fatal. Shock accidents usually occur when a person makes a contact with a live conductor when in simultaneous contact with an earthed object; e.g. a person touching a live terminal in a fuse-box while standing on a concrete floor. The reason for this is that most electrical supply systems are deliberately connected to earth at some point and, by touching one live terminal, the person automatically completes a circuit through his or her body and feet back to the supply system, through the earth. Such accidents also occur, although more infrequently, when contact is made with two live conductors. Once an electric current has passed the barrier of the skin, which has a relatively high resistance, the body itself offers little resistance and the current may take one of numerous paths through it.

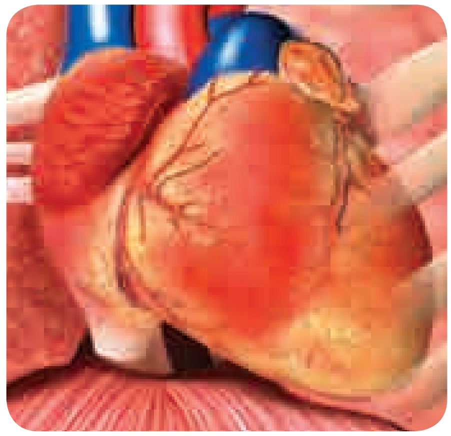
In order to function, the body needs a certain amount of electricity. The muscles are controlled by a small current in the order of 4 microamps acting on the central nervous system. In order for us to grasp an object, a signal is sent down to the nervous system which causes an increase of current in the muscles. An increase to about 4 milliamps (4/1000ths of an amp) causes the muscles to contract. The firmness of the grasping of the hand, for instance, will depend on the strength of the contraction of the muscles which is in turn dependent on the amount of current caused to flow through them.

When releasing the grasp, the extra current is first switched off. The hand is, at the time, still in the grasping position but is now relaxed. A similar signal is then sent down the nervous system to cause a current increase in the release muscles. The release current then causes these muscles to contract and so open out the hand.

It is important to appreciate that the release muscles are not as strong as the grasping muscles.

So, when a hand-to-hand electric shock is received, the muscles in the arms react to this electric current in a similar way to that in which they react to the current generated in the body. If this current is in excess of about 10 milliamps, the contracting muscles overcome the release muscles and involuntary grasping takes place that will continue while the electric current is flowing. Because the current swamps the effect of the ordinary control current the hand will, if holding the 'live' source, be unable to let go. The value of current that causes this effect is termed the 'let-go' value. The current may have a number of effects on the body, any of which may prove fatal:

- **Pain** arising from the sensation of electricity passing through the body and also from the associated burns.
- **Muscular contractions** which may cause the person to grip and be unable to release from the current source.
- **Respiratory failure** caused by current passing through the chest and the resulting spasm preventing respiratory movement and causing asphyxia.
- **Fibrillation of the heart** which is a vibration of the heart muscle which disrupts the normal rhythm of the heart and stops effective blood circulation.
- **Cardiac arrest** caused by current passing through the chest and heart and the resulting spasm stopping any movement of the heart muscle.
- **Internal burns** caused by the heating effect of current passing through the body which damages tissue and muscles.


Electric shock can cause fibrillation of the heart

Secondary Effects of Electric Shock

Electric shock may also initiate secondary causes of injury. The involuntary muscular reaction may throw the arm back so violently that the muscles become over-strained or ligaments are torn. More often, however, the shock startles the victim and causes momentary loss of control and balance, resulting in falls. If working from a ladder, the fall can result in more serious injuries than the electric shock.

Factors Influencing Severity of Effects of Electric Shock on the Body

Factors which mainly influence the likely effect of shock current are its voltage, frequency and duration and any impedance in the current path. The effects of electric shock are most acute at about the UK public electricity supply frequency of 50 hertz.

Voltage

The current driven through the body is proportional to the voltage and therefore the higher the voltage, the greater the amount of current passing through the body.

Frequency

The current passing through the body can be either direct or alternating current; the effect is proportional to both the magnitude and the frequency. The maximum current is usually considered to be just below the threshold for ventricular fibrillation.

Impedance/Resistance

The human body can be considered as two parallel resistance paths. Externally, the outer skin has a relatively high resistance, while internally the bloodstream and body tissues offer a relatively low resistance.

Average, dry skin has a resistance of between 1500 – 2000 ohms hand-to-foot, but the resistance drops considerably when the hands are wet. So once a person is holding an electrical source, the situation can only become worse. The person will immediately feel fear and will perspire. The perspiration reduces skin resistance so the current increases, which in turn leads to a firmer grasp of the source of electricity. Heating caused by the passage of electricity is proportional to the square of the current, so an increase in the current will cause an increase in the heating at the skin and the skin will burn. The skin will then be destroyed at the point of contact, leading to a further reduction in the resistance and a further increase of current.

Current Path

In order for an electric shock to occur, the body must form part of an electrical circuit. There must be a point of entry and a point of departure for the electrical current. Current paths through the heart are the most dangerous and the most likely to cause electrocution. Examples of such pathways would be a shock from: arm to arm, chest to arm, arm to chest, head to leg or arm to leg.

Duration

Very low levels of electric current below the perception level can be sustained almost indefinitely. However, a maximum current of, for example, 100 milliamps can only be endured for about one second. In between these two extremes, the let-go value could cause death by asphyxiation if sustained for more than a few minutes.

It is not possible to make definite statements to cover all situations, voltages, currents and people. There are many variables which will affect the seriousness of an electric shock to a particular person. For example, the electrical resistance of the skin, which would be low in the case of a child with a soft moist hand, would be high in the case of an adult manual worker with hard dry hands. The actual path of the current through the body is relevant; so is the general state of health of the person.

To help illustrate these points, the effects of a shock current passing through the body from hand-held electrodes are shown below:

Current in Milliamps	Effects
0.5-2	Threshold of perception.
2-10	Painful sensation.
10-25	Inability to let go, danger of asphyxiation.
25-80	Loss of consciousness from heart or respiratory failure.
Over 80	Burns at point of contact, death from ventricular fibrillation.

Direct and Indirect Shock

- **Direct shock** occurs on contact with an uninsulated electrical conductor which is normally expected to be live, such as an electrical cable or contact.
- **Indirect shock** occurs on contact with a metal part which is normally dead but due to a fault becomes live, such as a metal case of an electrical appliance.

BS 7671:2008 *Requirements for Electrical Installations* (a standard of best practice, which is covered in more detail later in this element) no longer uses the terms 'direct contact' and 'indirect contact'. They are replaced with:

- 'Basic protection' - protection against touching live parts.
- 'Fault protection' - protection against receiving a shock from conductive parts that have become live due to a breakdown of insulation or damage to equipment.

Common Causes of Fires

Fires of electrical origin can be caused in several ways:

- Leakage of current due to poor or inadequate electrical insulation, e.g. damaged insulation on flexible cables.
- Overheating of electrical equipment and cables due to overloading of conductors, e.g. flexible cable wound onto cable drums can overheat due to the lower thermal rating of cable which is wound; a safe current/time limit should be specified by the manufacturer.
- Overheating of flammable materials too close to electrical equipment, which is otherwise operating normally, e.g. waste paper next to electrical equipment which may have hot surfaces while in operation. This can cause combustion.
- Ignition of flammable vapour by electrical equipment which is not operating normally, e.g. arcing or sparking electrical equipment located in/adjacent to a paint spray booth may ignite flammable paint vapours produced during the spraying operation.
- Mechanical damage, e.g. the use of adaptors into which a number of plugs are connected, can lead to mechanical damage to the socket contacts, causing arcing between them and the plug pins, which can result in fire.

All of the above can ignite flammable materials if the temperature attained by the fault is sufficiently high.

Electric Arcs

Arcing can occur when the potential in a conductor is great enough to create a conductive path between that conductor and another which is at a lower potential. The resulting arc will be capable of crossing the air gap or insulation which separates the two conductors. Very large amounts of energy can be created in a short time, possibly less than one second.

Arcing generates ultraviolet radiation which can burn the skin and the retina of the eye. Additional burns may result from radiated heat and from molten/hot metal fragments. Severe, sometimes fatal, injuries and burns or serious fires may result from an arcing incident.

Static Electricity

Circumstances Giving Rise to the Generation of Static Electricity

Static electricity describes the effects produced by electric charges at rest, e.g. induction and friction.

- **Induction** is the creation of a charge due to the presence of an electric field, e.g. the charging of a person operating an electrostatic paint gun.
- **Friction** is the rapid separation of materials which are in contact with each other, e.g. the flow of liquids in a pipeline.

The static is actually produced by a build-up of electrons on poor conductors of electricity. The creation of static is affected by the:

- Speed of separation of materials.
- Size of the contact area.
- Degree of conductivity.

Greater charges are created by fast separation, large contact area and insulators. Two good conductors will create small charges which dissipate rapidly. Insulators such as plastic, paper and synthetic fabric can create charges of thousands of volts relatively quickly, which may be retained for long periods of time.

Hazards and Controls for Static Electricity

The main hazard of static electricity is the **discharge of very high voltages to earth which can ignite flammable atmospheres**. Liquids, solids and gases can build an electrostatic charge, either positive or negative, which will discharge into anything of opposite polarity on contact. If high voltages are involved, flashover, sufficient to ignite a flammable atmosphere (dust or gas) may occur. Electrostatically-charged liquids are a particular problem. A liquid may carry a charge some distance (such as into a fuel storage tank) which creates an explosion hazard away from the point of generation.


Discharge of high voltage to earth

Discharge of static through a person is rapid and likely to cause some discomfort, but unlikely to cause burns or a fatality, although it may cause a secondary accident such as a fall from height. Static can be a great inconvenience to industry, e.g. it can lead to product spoiling due to the attraction of dirt and dust, and paper products can stick together causing production problems. Particular plant and processes where static may be generated by solids include conveyor belts, chutes, paper manufacture, and mixing solids and loading them into drums. Static can also be produced when organic liquids, e.g. petroleum fuels, solvents or reagents, are put into motion. This can occur in pipelines during pumping, on vessels during filling or in mixing tanks. Small quantities of water in organic solvents can increase static build-up. Motion increases static charge, e.g. top loading, high pumping rates and high stirring/agitation rates produce high static charges in liquids and surrounding equipment.

The main method of discharging static in processes and plant is to earth it safely via special conducting systems, enabling the charge to leak away before dangerous voltages can develop and cause a spark discharge. The precautions used to prevent the build-up of electrostatic charges are:

- **Earthing**: with conducting materials, the provision of a conductive path is the best method of preventing the build-up of charge, e.g. to prevent ignition in large silos where dust clouds are present, and in large tanks containing flammable liquids, the spaces can be divided up by earthed partitions, wires or rods which prevent the build-up of charges in the contents. Earthing is also used on a smaller scale with mobile containers, such as those on non-conducting rubber tyres, which can acquire static charges. The charge can be dissipated by means of an earthing lead. An example is a small, mobile fuel tank, which should have its charge dissipated before the contents are handled. The charge is dissipated by an earthing lead, which is connected to the tank and earthed in a position remote from the flammable material.

  The sequence of earthing connections is particularly important, i.e. the earth connection is made before fluid transfer takes place and removed after the transfer is complete. Premature removal of the earth connection could produce a hazardous spark. All earth connections must be in good condition and securely fixed in position to remain effective.

- **Increasing conductivity**: in the case of insulators, the conductivity of the material can be increased in order to minimise the build-up of static charge. This can be achieved by modifications to the material, e.g. flammable liquid fuels treated with additives to reduce resistance, plastic treated with a surfactant chemical, and rubber or plastic conveyor belts containing carbon black. Where the use of additives is not practicable, the creation of a humid atmosphere will provide a leakage path to earth, as in the case of coating machines. The method would not be suitable for all materials, e.g. water-repellent substances.
- **Ionisation**: a conductive path can be created by ionising the air at the surface of the material, the objective being to prevent the build-up of static charge.

DEFINITION

EARTHING

Connection of the exposed conductive parts of an installation to the main earthing terminal of that installation.

An example of earthing is where the metallic outer case of an appliance is connected by the circuit protective conductor to the means of earthing, providing a safe path for fault or high leakage/high protective conductor currents.

Equipotential bonding: electrical connection maintaining exposed conductive parts and other conductive parts at substantially the same potential.

There are two types of equipotential bonding conductor:

- Main protective bonding conductor:
  used to connect conductive parts such as a metallic water pipe to the main earthing terminal.
- Supplementary bonding conductors:
  used to supplement fault protection by maintaining exposed conductive parts and other conductive parts at substantially the same potential; such as the connection of all exposed conductive parts and conductive parts that can be touched by employees in a food-processing facility.

- **Ventilation** can be used to weaken and disperse a flammable atmosphere so that it is below its lower explosive limit. Although this method does not tackle the electrostatic charge directly, it will prevent ignition of the atmosphere by a spark.
- **Inert atmosphere**: nitrogen and carbon dioxide are commonly used to create an inert atmosphere which will prevent explosions. Used in the case of oil tankers when the cargo spaces are rendered inert for the process of tank washing.
- **Training** of those working in hazardous areas. Where a flammable atmosphere and static charge may be present, persons may require particular training if ignition of the atmosphere is to be avoided. Ignitions can be caused by operators creating sparks, e.g. an operator standing on an insulating floor in insulating footwear who becomes charged is likely to create a spark if contact with an earthed object is made. On a less dramatic scale, you may experience a similar effect when pushing a trolley or pushchair with rubber wheels on a synthetic carpet in a shop. If contact with metal racking or a lift control panel is made, a static discharge can often be felt. In a hazardous environment, where such a spark may be sufficient to ignite a flammable atmosphere, operator training is vital.

STUDY QUESTIONS

2. List the factors that will determine the severity of an electric shock.
3. Explain how electrical equipment usage may cause an explosion.
4. What is the main hazard associated with static electricity?
5. What is the main method of discharging static electricity?
6. When using an earthing lead, what factors must be borne in mind?

(Suggested Answers are at the end.)

The Installation, Use and Inspection of Electrical Systems

IN THIS SECTION...

- The following factors are important in ensuring that electrical systems are planned, designed and installed in a way that prevents danger:
  - Strength and capability of electrical equipment.
  - Insulation, protection and placing of conductors.
  - Reducing the risk of shock.
  - Excess current protection.
  - Cutting off supply and isolation.
  - Working space, access and lighting.
- Control measures for electrical equipment and systems must consider the selection and suitability of equipment, protective systems such as fuses, reduced voltage systems, isolation, residual current devices, double insulation and earth free zones, the inspection and maintenance strategy including user checks, formal visual inspections, combined inspection and tests, records of maintenance and tests, frequency of inspection and testing, competent persons.
- A widely used standard of best practice for electrical installations is the British Standard BS 7671:2008 *Requirements for Electrical Installations*, also known as the **Institution of Engineering and Technology Wiring Regulations**.
- A preventive maintenance programme which includes the regular inspection of equipment is essential if electrical safety is to be ensured and records of maintenance, tests and repairs should be retained for the life of the equipment.
- There are limited circumstances where live working is deemed to be acceptable. They centre around the question of 'reasonableness' and, wherever possible, work on live equipment should be carried out from a distance by using specially designed insulated tools.
- When work is to be carried out on or near equipment which has been made dead, precautions must be taken to prevent the equipment from becoming electrically charged during the work.
- Written procedures such as permits-to-work are often needed for electrical work. They enhance safety by setting down the agreed safe working procedure in writing.
- When people are engaged in high-risk work activities such as working with electricity, they need to be competent. This requires possession of recognised qualifications and experience in the type of work being undertaken.

Important Aspects of Electrical Systems

Strength and Capability of Electrical Equipment

Electrical equipment should not be brought into use where its strength and capability may be exceeded in a way that may give rise to danger. This is to ensure that equipment is not subject to electrical stresses with which it would be unable to cope. The strength referred to relates to electrical strength, as in the case of equipment being able to withstand the effects of the electrical current which may be expected to flow in the system.

Strength and capability of a component may be exceeded

Equipment should be able to withstand normal, overload and fault currents. It should be used within the manufacturer's rating and in accordance with any instructions supplied with the equipment. The conditions a piece of equipment will withstand can be ascertained from electrical specifications and tests undertaken by manufacturers and accredited testing organisations based on international and national standards.

Insulation must also be suitable for the operation of the equipment. The current rating of the insulation should not be exceeded as it could result in the breakdown of the insulation and the exposure of live conductors.

Insulation, Protection and Placing of Conductors

Conductors in a system which may give rise to danger should be **suitably covered** with insulating material and protected as necessary or placed in a **safe position** to prevent danger. Placing conductors in a safe position includes locating them overhead, underground, behind barriers or in a secure enclosure. Insulation is the most frequently used method of preventing contact with a current-carrying conductor. When in good condition, it does provide effective protection against the risk of injury by contact with live conductors.

In some cases uninsulated conductors are unavoidable, such as railway electrification lines and down-shop conductors for overhead cranes in factories. Additional precautions are necessary in these circumstances and include keeping people away from conductors by erecting barriers or secure enclosures which place the conductors out of normal reach, developing safe systems of work, erecting warning notices and specialised training.

Cables which trail along the ground in an area where there is movement of personnel and/or vehicles, e.g. a construction site or a maintenance department, will be at risk unless steps are taken to protect them. Electric cables connected to portable tools are an example of equipment prone to this kind of damage.

Some chemicals, including solvents, oil and petrol, can damage insulation. Petrol and oil are more likely to come into contact with electrical equipment in garages than in most other situations. Rubber and plastics are degraded by contact with them. If the cable insulation is attacked and destroyed so that the conductors it protects are exposed, there is the danger of electrocution, as well as other related hazards.

Care must be taken in the selection and positioning of cables in such hostile environments to minimise these dangers. If electrical equipment must be used in damp or wet environments, every care must be taken to ensure that all connectors and plugs are waterproof.

Reducing the Risk of Shock

The risk of electric shock can be reduced by:

- Reducing the likelihood of a shock occurring by good design (e.g. double insulation), training, safe systems of work (including access, lighting, working space), maintenance, etc.
- Reducing the consequence should a shock take place by residual current devices, excess current protection, etc.

Excess Current Protection

Electrical systems require protection to cope with faults and overloads which could give rise to danger. Protection is usually in the form of fuses or circuit breakers or other means which interrupt the current or reduce it to a safe value. Excess current may result from:

- The inability of the equipment to support the load which is put on it, e.g. mechanical overloading of an electric motor.
- Short circuits between conductors where a large current flows between the two conductors.

Fuse in a plug (Adapted from original source HSG107 Maintaining portable and transportable electrical equipment (2nd ed.), HSE, 2004)

Factors to consider when selecting excess current protection include:

- The type of circuits/equipment to be protected.
- The possible fault levels.
- The environment.
- Whether the system is earthed or not.

The protective device selected must:

- Operate only when potentially damaging currents flow.
- Respond quickly enough to prevent danger.
- Operate without giving rise to further hazards such as igniting a flammable atmosphere.

There are many protection devices to cope with faults and overload which could give rise to danger. Protection devices disconnect the current flow when excess current is detected. The following types are commonly used:

- **Fuses**

  Fuses are designed to melt at a temperature which is related to the excess current against which protection is required. So, for example, a 5 amp fuse will melt if the current flow exceeds 5 amps, thus protecting the circuit from excess current. Fuses will protect the circuit but do not operate quickly enough to protect humans.

- **Circuit Breakers**

  These trip out when excess current is detected by either temperature increase or increased magnetic field, again protecting the circuit. Unlike the fuse, circuit breakers can be reset, quickly restoring the electricity supply, but need regular testing to ensure that they continue to work correctly.

- **Residual Current Devices**

  These devices continually measure the current flowing in the live and neutral lines and trip the circuit if there is any difference caused by short circuit to earth. They usually trip within 30 milliseconds if a fault current of 30 mA is detected. Consequently, human contact with a live conductor resulting in electrical current flow to earth will be detected fast enough to prevent sufficient current flow for long enough to prevent fatal shock. As with circuit breakers, these devices require regular testing to ensure that they continue to work correctly.

Cutting Off Supply and Isolation

Suitable means should be available to cut off the supply of electrical energy to equipment and to isolate the equipment. There is a major difference between 'switching off' and 'isolating'.

- **Switching off** refers to depriving the equipment of electric power.
- **Isolation** refers to depriving the equipment of electric power from any source, with the additional step being taken of ensuring that it cannot be inadvertently re-energised.

Electrical isolation

The means of cutting off the supply must be capable of operation in normal, abnormal and fault conditions, suitably located (accessible) and clearly labelled.

Isolation should establish an effective barrier between the equipment and the supply and ensure that no unauthorised person is able to remove the barrier. Isolation should:

- Establish an air gap between the contacts in the switch or some other barrier which would prevent the flow of current under all conditions of use.

- Include a padlock or lock which will prevent the removal of the barrier by unauthorised persons.
- Be accessible, easy to operate and clearly labelled. The means of isolation should only be common to several different pieces of electrical equipment if it is appropriate to energise and de-energise these as a group.

Working Space, Access and Lighting

Adequate working space, access and lighting should be provided at all electrical equipment where work is being carried out on or near the equipment in circumstances that may give rise to danger.

The requirement is not restricted to locations where conductors are exposed, but applies to any work in circumstances that may give rise to danger. In particular, it is important that adequate space is provided to allow persons to pull away from conductors and to pass each other without risk. Natural light should be provided where possible. Where artificial light is necessary, it is preferable that it is a permanent and correctly designed installation, although some locations may require the use of torches and headlamps. Whatever form of lighting is provided, it must be adequate to prevent injury.

Control Measures

Selection and Suitability of Equipment

The selection of suitable work equipment for particular tasks and processes makes it possible to reduce or eliminate many risks to the health and safety of people in the workplace. This applies both to the normal use of the equipment as well as to other operations, such as maintenance.

When evaluating the suitability of the construction of electrical systems, several factors should be considered:

- The manufacturer's recommendations.
- The likely load and fault conditions.
- The probable use of the system(s).
- The need for suitable electrical protection devices, such as overload protection.
- The environmental conditions that may affect the mechanical strength and protection required.

Protective Systems

Fuses

- A **fuse** forms a weak link in a circuit by overheating and melting by design if the current exceeds the safe limit.
- A **circuit breaker** is a mechanical device in the form of a switch which automatically opens if the circuit is overloaded.

Both protective devices should be chosen so that their rating is above the operating current required by the equipment but less than the current rating of the cable in the circuit.

Reduced Voltage Systems

These are also known as low voltage systems. Where environmental conditions are harsh, such as on construction sites or in areas which are wet, the use of reduced or low voltages is advisable to reduce shock effect. For hand-held portable tools and the smaller transportable units, the 110-volt centre-tapped (CTE) system is recommended. The system relies on the mid-point of the reduced voltage (i.e. 110 volts or less) transformer to be earthed. The maximum shock voltage to earth is half the supply voltage, i.e. 55 volts in the event of direct contact. As most shocks occur between a live part and earth, this is a major step in the reduction of the shock effect. The full 110-volt supply is available to power the equipment.

Lower voltage systems, which are called "safety extra low voltage" or SELV, are those in which the voltage does not exceed 50 volts AC between conductors in a circuit which is isolated from the supply mains and from earth, by means such as a safety isolating transformer. These systems represent even less of a hazard and should be used in other environments such as vehicle washing areas and in the vicinity of swimming pools. They are also recommended for hand lamps, soldering irons and other small hand tools where the risk of shock is high.

Isolation

This was discussed earlier in this element.

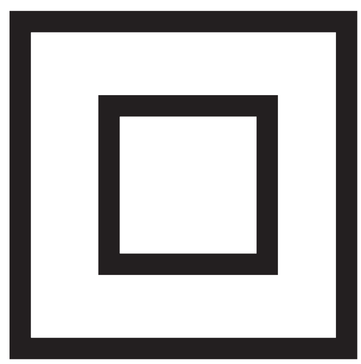
The protective measures discussed so far will reduce the risk of electric shock and go a long way towards protecting against the other hazards discussed earlier. However, there are other measures which must be considered for these hazards and merit separate discussion below.

Residual Current Devices

Sensitive earth-leakage protective devices provide another means of circuit interruption in the event of an earth fault and are also intended to provide indirect shock protection. These devices are current-operated, and interrupt the supply in the event of a small leak of current to earth by means of automatic circuit breakers. The sensitivity of the device to the amount of unsafe current can be adjusted so that any shocks experienced are not lethal. The devices are commonly known as **Residual Current Devices** (RCDs) or sensitive current-operated **Earth Leakage Circuit Breakers** (ELCBs). They determine when a current flows to earth by comparing the currents flowing in the phase (live) and neutral (return) conductors. They are sensitive enough to detect a leakage current which is too small to operate a fuse but which may be large enough to start a fire. Such a current would be detected by the device which trips the supply circuit breaker. The type of RCD usually used on part of a distribution system will function on an earth leakage current of 30 milliamps (mA) and trip the circuit in not more than 30 milliseconds (ms). Every RCD has a test button, which should be regularly checked to ensure correct operation. It is important to note that ELCBs only operate when a fault to earth occurs. They do not provide overload protection.

Double Insulation

If equipment has a metal enclosure, precautions must be taken to prevent the metalwork from becoming live. This can be achieved by 'double-insulation' in which the live parts of the equipment are covered by two layers of insulating material.



Symbol of double insulation

Each layer is capable of adequately insulating the live parts alone, but together they ensure that the occurrence of insulation failure and its associated danger is extremely improbable. This method is also suitable for portable equipment which often suffers particularly rough use, but regular maintenance is essential as the insulation only remains effective while it is intact. In addition to maintenance, the insulation must be soundly constructed and the equipment properly used.

Plugs fitted to double-insulated appliances should **not** have an earth conductor in the flex.

Earth-Free Zones

Earth-free zones are environments which ensure that if the conductors become charged, no danger arises. This is achieved by eliminating all conductors at earth potential, which removes the path to earth for any fault current and also any dangerous potentials to earth. There is no risk of electric shock, burn, fire or explosion in an earth-free environment. This method of protection is used only in very specialised circumstances, such as in test areas, and is costly to construct.

DEFINITION

DOUBLE INSULATION

Instead of earthing, appliances can be made with double insulation.

Double insulation protects the user of the appliance from an electrical shock by preventing any possibility of the external casing becoming live, thus eliminating the need for an earth connection.

First insulation: insulating electrical cable from the internal component of the appliance.

Second insulation: insulating internal metal part which could become live from the external casing.

Inspection and Maintenance Strategy

Maintenance is a general term which in practice can include visual inspection, testing, repair and replacement. Maintenance will determine whether equipment is fully serviceable or remedial action is necessary. Routine inspection and appropriate testing, where necessary, are normally part of any overall strategy for ensuring that work equipment is maintained in a safe condition.

Cost-effective maintenance of equipment can be achieved by a combination of actions applied at three levels:

- Checks by the user.
- Visual inspections by a person appointed to do so.
- Combined inspection and tests by a competent person or by a contractor.

This should be followed up by management monitoring the effectiveness of the system, and action should be taken where faults are found, particularly where detected fault levels or types of faults are found repeatedly.

User Checks

The person using the electrical equipment should be encouraged to look critically at it and, after a minimum amount of basic training, visually check for signs that the equipment is not in sound condition, for example:

- There is damage (apart from light scuffing) to the cable sheath.
- The plug is damaged; for example, the casing is cracked or the pins are bent.
- There are inadequate joints, including taped joints in the cable.
- The outer sheath of the cable is not effectively secured where it enters the plug or the equipment; obvious evidence would be if the coloured insulation of the internal cable cores were showing.
- The equipment has been subjected to conditions for which it is not suitable, e.g. it is wet or excessively contaminated.
- There is damage to the external casing of the equipment or there are some loose parts or screws.

MORE... www.

Guidance in the UK HSE's HSG107 *Maintaining portable electrical equipment* is available at:

www.hse.gov.uk/pubns/priced/hsg107.pdf

These checks also apply to extension leads and associated plugs and sockets. Checks should be undertaken by the user before and during use. Any faults should be reported to management and the equipment taken out of use immediately. Management should take effective steps to ensure that the equipment is not used again until repaired by a person competent to carry out the task (e.g. the defective equipment could be labelled as 'faulty' and its associated plug removed).

Formal Visual Inspections

The most important component of a maintenance regime is usually the formal visual inspection carried out routinely by a competent person. Most potentially dangerous faults can be picked up by such inspections. To control the risks and to monitor the user checks, a competent person should carry out regular inspections which include visual checks similar to those discussed above but undertaken in a more formal and systematic manner.

Additional checks could include removing the plug cover and checking that a fuse is being used (e.g. it is a fuse, not a piece of wire, a nail, etc.), the cord grip is effective, the cable terminations are secure and correct, including an earth where appropriate, and there is no sign of internal damage, overheating or ingress of liquid or foreign matter. The formal visual inspection should not include taking the equipment apart. This should be confined, where necessary, to the combined inspection and testing discussed later.

The competent person can normally be a member of staff who has sufficient information and knowledge, following appropriate training on what to look for and what is acceptable, and who has been given the task of carrying out the inspection. To avoid danger, competent persons should know when the limit of their knowledge and experience has been reached (this is one of the definitions of a competent person). Simple written guidance relating to the visual inspection can be produced, summarising what to look for, procedures to follow when faults are found and when unauthorised equipment is found in use. It can aid whoever is carrying out the formal visual inspection, as well as users.

The inspections should be carried out at regular intervals. The period between inspections can vary considerably depending on the type of equipment, the conditions of use and the environment. For example, equipment used on a construction site or in a heavy steel fabrication workshop will need much more frequent inspection than equipment such as floor cleaners in an office. In all cases, however, the period between inspections should be reviewed in the light of experience. Faulty equipment should be taken out of service and not used again until properly repaired.


Inspection by a competent person

In order to take remedial action, management can use the pattern of faults to show that:

- The right equipment is being selected for the job.
- Further protection may be necessary in a harsh environment.
- The equipment is being misused.

Combined Inspection and Tests

The checks and inspections outlined above will, if carried out properly, reveal most (but not all) potentially dangerous faults. However, some deterioration of the cable, its terminals and the equipment itself can be expected after significant use. Additionally, equipment may be misused or abused to the extent that it may give rise to danger. Testing, together with a thorough visual inspection, can detect faults such as:

- Loss of earth integrity, e.g. broken earth-wire within a flexible cable.
- Deterioration of insulation integrity.
- Contamination of internal and external surfaces.

Failure of insulation could result in the user receiving an electric shock, with potentially fatal results. Periodic inspection and testing are the only reliable ways of detecting such faults, and should be carried out to back up the inspection regime. Occasions when testing is likely to be justified are:

- Whenever there is reason to suppose the equipment may be defective and this cannot be confirmed by visual inspection.

- After any repair, modification or similar work.
- At periods appropriate to the equipment, the manner and frequency of use, and the environment.

The inspection carried out in conjunction with the testing should usually include checks for:

- Correct fusing.
- Effective termination of cables and cores.
- Suitability of the equipment for its environment.

Combined inspection and testing should be carried out by someone with a higher level of competence than that required for inspection alone, because the results of the tests may call for interpretation and appropriate electrical knowledge will be essential. However, this can often be carried out by a competent employee.


Test equipment for portable electrical equipment
Source: HSG107 Maintaining portable and transportable electrical equipment (2nd ed.), HSE, 2004

Persons testing portable electrical equipment (see later in this element) should be fully trained. It is the employer's duty to ensure that such persons are competent for the work they undertake. Basically, there are two levels of competency:

- The first is where a person not skilled in electrical work routinely uses a simple 'pass/fail' type of portable appliance tester (PAT), where no interpretation of readings is necessary. The person would, of course, have to know how to use the PAT correctly. Providing the appropriate test procedures are rigorously followed and acceptance criteria are clearly defined, the routine can be straightforward.
- The second is where a person with certain electrical skills uses a more sophisticated instrument, which gives actual readings that require interpretation. Such a person must be competent through technical knowledge or experience related to the type of work.

Records of Maintenance and Tests

A suitable log is useful as a management tool for monitoring and reviewing the effectiveness of the maintenance scheme and indeed to demonstrate that a scheme exists. It can also be used as an inventory of portable electrical equipment and a check on the use of unauthorised equipment (e.g. domestic kettles or electric heaters brought to work by employees).

The log can include faults found during inspection and may give a useful indication of the types of equipment or environment which are subject to a higher than average level of wear or damage. This will help monitor whether suitable equipment has been selected. Entries in a test log can also highlight any adverse trends in test readings that may affect the safety of the equipment, which will enable remedial action to be taken. Care should be taken in interpreting trends where a subsequent test may be carried out with a different instrument from that used for an earlier test, since differences in the results may be due to differences in the test instruments rather than indicating deterioration in the equipment being tested.

Records do not necessarily have to be on a paper system since test instruments are available which store the data electronically for downloading directly onto a computer database. It is useful to label equipment to indicate that it has been tested satisfactorily (i.e. has been passed as safe) and when the date for the next test is due. Otherwise, individual items may be missed on consecutive occasions.

Frequency of Inspection and Testing

Deciding on the frequency of maintenance is a matter of judgment for those responsible for the equipment, and should be based on an assessment of risk. Factors to consider when making the assessment include:

- Type of equipment and whether or not it is hand-held.

- Manufacturer's recommendations.
- Initial integrity and soundness of the equipment.
- Age of the equipment.
- Working environment in which the equipment is used (e.g. wet or dusty) or likelihood of mechanical damage.
- Frequency of use and the duty cycle of the equipment.
- Foreseeable abuse of the equipment.
- Effects of any modifications or repairs to the equipment.
- Analysis of previous records of maintenance, including both formal inspection and combined inspection and testing.

Competent Persons

The inspection and maintenance of electrical appliances and systems should be carried out by a competent person. (Competent persons are covered in more detail later in this element.)

Sources of Best Practice

A widely used standard of best practice for electrical installations is the **Institution of Engineering and Technology Wiring Regulations** (17th edition), otherwise known as British Standard **BS 7671:2008** *Requirements for Electrical Installations*.

The Regulations set safety standards for designers, installers, erectors and testers of permanent and temporary electrical installations and aim to protect people from the hazards of electric shock, burns, fires and mechanical movement of electrically-powered machinery.

The Regulations include specifications for:

- Installation requirements and characteristics.
- Installation control and protection:
  - Switching.
  - Isolation.
  - Electric shock protection.
  - High temperature protection.
  - Over-current protection.
  - Protection from faults.
  - Short circuit and overload protection.
- Cables, conduits and trunking:
  - Cable choice.
  - Cable supports.
  - Cable bends.
  - Cable joints.
  - Cable terminations.
- Earthing:
  - Earthing principles.
  - Earthing systems.
  - Earth fault loop impedance.
  - Protective conductors.
  - Earth electrodes.
  - Protective multiple earthing.
  - Residual current devices.
- Circuits:
  - Basic requirements.
  - Socket outlet circuits.
  - Industrial circuits.
  - Circuit segregation.

- Special installations:
  - Bath tubs.
  - Shower basins.
  - Swimming pools.
  - Saunas.
  - Construction sites.
  - Agriculture.
  - Caravans.
  - Highway power.
  - Heating appliances.
  - Underground wiring.
  - Overhead wiring.
  - Outdoor installations.
  - Reduced-voltage systems.
- Inspection and testing:
  - Inspection.
  - Testing sequence.
  - Insulation testing.
- Test instruments.

Importance of Schemes of Maintenance, Schedules, Plans and Records

A preventive maintenance programme which includes the regular inspection of equipment is essential if electrical safety is to be ensured. The aim of such a system should be to test and repair equipment before it breaks down and develops a fault which could lead to danger. The frequency of inspection will depend on the manufacturer's recommendations, the users' experience, the nature of the equipment, the working environment and the work to be undertaken. Regular inspections should be followed, where necessary, by testing and repair or replacement of equipment. Records of maintenance, tests and repairs should be retained for the life of the equipment, because this allows the efficiency of maintenance policies to be monitored by duty holders and it enables them, and the enforcing authorities, to assess whether the requirement for maintenance is being met.

Safe Systems of Work and Criteria of Acceptability for Live Working

The circumstances permitting live working centre around the question of 'reasonableness', i.e. whether it is:

- Unreasonable in all the circumstances for the live part to be dead.
- Reasonable in all the circumstances for the person to be at work on or near the live part while it is live.

Considerations that might justify live working include:

- The impracticability of carrying out the work with the equipment dead, e.g. where it may be necessary for testing purposes for the supply to remain on.
- The creation of other hazards by making the equipment dead, such as to users of the system, or in connection with continuous operation of process plant.
- The need to comply with any statutory requirements.
- The level of risk and the effectiveness of the precautions adopted judged against the economic need to work live.

Examples of work on or near live conductors include maintenance of electrified railway track, cable jointing in the electricity supply industry and fault testing. Wherever possible, work on live equipment should be carried out from a distance, e.g. by using specially designed insulated tools. In addition, those whose presence is not necessary to the work being carried out should be excluded from the vicinity.

To prevent injury, the following precautions should be taken:

- Only properly trained and competent persons should undertake the work.

- Adequate information should be provided to all those carrying out the work, e.g. information on the type of conductors, the associated system and the foreseeable risks.
- Suitable tools, equipment and protective clothing should be provided and used, e.g. test instruments with insulated probes and fused leads, insulated gloves, helmets and goggles, insulated screens, mats and stands.
- The person carrying out the work should be accompanied by a person capable of reducing the risk of injury by being skilled in recognising danger and administering help in an emergency.
- Regular, routine testing on live uninsulated conductors should be restricted to designated areas where measures are taken to ensure the work can be done in safety, e.g. in a non-conducting environment.
- Entry to the work area should be restricted to essential personnel only.

Safe Systems of Work on Installations Made Dead

When work is to be carried out on or near equipment which has been made dead, precautions should be taken to prevent the equipment from becoming electrically charged during the work. Ineffective means of ensuring that equipment is made and remains dead result in many accidents every year. The precautions which should be taken include:

- Cutting off the supply to the equipment.
- Isolating the equipment, preferably using a means of locking off the isolator to prevent accidental or inadvertent re-energising of the system.

If these means are not available, it is acceptable to remove fuses and links, provided they are kept safe and properly controlled by a responsible person. Where work is to be done on or near isolated conductors, the conductors should be proved dead before the work commences, and where a test instrument is used, it should itself be proved. The following sequence of work is recommended:

- Plan the job.
- Disconnect equipment.
- Isolate it securely.
- Prove the test instrument.
- Prove that the equipment is dead.
- Re-prove the test instrument.
- Earth the equipment.
- Post notices.
- Consider the need for additional precautions.
- Ensure an understanding of the job.

Disconnection of equipment

Use of Permits-to-Work

Written procedures such as permits-to-work may be appropriate, as they enhance safety by setting down the agreed safe working procedure in writing. They also ensure that the work is planned before it commences. The permit should contain only relevant and accurate information on, for example:

- Details of the work.
- Location.
- Necessary precautions.
- Identity of supervisor.
- Location of points of isolation.
- Location of precautionary notices.

Where the system isolation is undertaken by someone other than the person intended to carry out the work, it is often useful for a permit-to-work procedure to be adopted. This confirms the system isolation and provides other relevant information. The completion and issue of such a document therefore acts as a reminder that the necessary precautions to achieve electrical safety have been implemented, as well as providing a means of recording plant held out of service. A permit-to-work is essential for very complex systems and for any work on high-voltage systems (operating at voltages above 1,000V).

Where such a system of work is rigorously followed, an accident is unlikely to occur. Many accidents do, however, happen when work is attempted on what is intended to be a de-energised system but, due to some oversight, is still live. Invariably these arise due to a failure to follow strictly all the above-mentioned requirements for a safe system of work. There is a need for management to formulate a clear policy concerning work on electrical systems for which they have responsibility.

A permit can only be issued by a person who is competent at knowing what dangers can arise, what work has to be done and what is required to make the work area safe, and knows the competence of the person who will carry out the work. He or she will also know whether that person needs to be accompanied in the interests of safety.

The permit-to-work, as seen in the next figure, should be clearly written to avoid confusion and should contain the following information:

- The identity of the person supervising the work, to whom the permit is issued.
- Sufficient detail to accurately identify the equipment made dead and its location; a diagram will usually ensure that these points are precisely described.
- The location of the points of isolation.
- The location of temporary earth connections.
- The location of warning notices and safety locks.
- A detailed description of the work to be carried out.
- An account of other hazards which might be encountered, together with any detail necessary to identify them.
- Further precautions to be taken during the course of the work.

> **MORE...** www.
>
> Guidance on issues to consider when devising safe working practices for people who carry out work on or near electrical equipment can be found in the HSE publication, HSG85 *Electricity at work: Safe working practices*, available at:
>
> www.hse.gov.uk/pubns/books/hsg85.htm

Once the permit has been accepted and signed by the work supervisor, he takes full responsibility for his own safety and the safety of those under his control. He should retain the document until the work is completed.

Upon completion, the supervisor must ensure that all the workforce is withdrawn, together with their tools and equipment, and instructed not to return. Any temporary earth connections must also be removed.

The equipment should not be re-energised until the permit is returned to the person who issued it for cancellation. If it is necessary to alter the work schedule, the existing permit must be cancelled and a new one issued.

PERMIT-TO-WORK

Serial No. ______________________________

1 ISSUE: To ____ in charge of the work.

I hereby declare that the following electrical apparatus is dead, isolated from all live conductors and is connected to earth:

____

____

TREAT ALL OTHER APPARATUS AS LIVE.

The apparatus is efficiently connected to EARTH at the following points:

____

____

The points of isolation are:

____

CAUTION NOTICES have been posted at the following points:

____

____

SAFETY LOCKS have been fitted at the following points:

____

____

The following work is to be carried out:

____

____

____

(*Diagram of equipment/work*)

Signed______________________ Time__________ Date______________

(Continued)

Permit-to-work

2 RECEIPT I accept responsibility for carrying out the work on the apparatus detailed on this Permit-to-Work and no attempt will be made by me or by persons under my charge to work on any other apparatus.

Signed___________________Time___________________Date_______________________________

Note: After signing the receipt, this Permit-to-Work should be retained by the person in charge at the place where the work is being carried out, until work is complete and the Clearance Section is signed.

3 CLEARANCE

The work for which this Permit-to-Work was issued is now suspended*/completed* and all persons under my charge have been withdrawn and warned that it is no longer safe to work on the apparatus detailed on this Permit-to-Work.

The work is complete*/incomplete*.

All gear and tools have*/have not* been removed.

Additional earths have*/have not* been removed.

*Delete words not applicable and where appropriate state:

ABNORMALITIES ARE AT:

____

____

____

ADDITIONAL EARTHS ARE AT:

____

____

____

Signed___________________Time___________________Date_______________________________

4 CANCELLATION

This Permit-to-Work is cancelled.

Signed___________________Time___________________Date_______________________________

Permit-to-work (Continued)

Competent Persons

When people are engaged in work activities where technical knowledge or experience is necessary to prevent danger or injury, they must possess either of these skills or be under appropriate supervision. The scope of technical knowledge or experience may include:

- Adequate knowledge of electricity.
- Adequate experience of electrical work.
- Adequate understanding of the system to be worked on and practical experience of that class of system.
- Understanding of the hazards that may arise during the work and the precautions which must be taken.
- The ability to recognise at all times whether it is safe to continue working.

TOPIC FOCUS

Diagnostic testing and fault-finding on live systems require safety measures to be in place and the following conditions to be met:

- That it is unreasonable for the system to be made dead.
- That it is reasonable to work on the system while it is live.
- That suitable precautions are taken such as:
  - Test points should not allow access to fingers or tools other than test probes.
  - Test probes should be insulated and fused.
  - The test meter must be checked prior to use.
  - The area should be cordoned off by the use of barriers to prevent unauthorised access.
  - Depending on the circumstances, insulating mats and/or gloves may be required.
  - All live working should be subject to a permit-to-work system.

The engineer involved in the work should:

- Be technically competent.
- Be closely supervised by someone who is competent.
- Possess recognised qualifications and have experience in the type of work being undertaken.

Conductors should be protected so that:

- All incoming and outgoing supplies are suitably insulated and shrouded.

Additional shrouding may be required.

Earthing should be in place so that the:

- Cabinet is connected to the main earth.
- Cabinet door is earth-bonded to the cabinet.

There should also be:

- Sufficient working space.
- Suitable access.
- Adequate lighting.

STUDY QUESTIONS

7. Identify the factors to be considered when evaluating the suitability of electrical equipment.
8. What are the main purposes of the **IET Wiring Regulations** (BS 7671) and to what installations do they apply?
9. How long should electrical system maintenance, test and repair records be kept, and why?
10. When working on electrical systems, what factors should be considered when justifying work on live equipment?
11. What factors need to be considered when deciding a person's suitability to work on electrical systems?
12. Under what circumstances is a permit-to-work essential when working on electrical systems?

(Suggested Answers are at the end.)

Safe Working in the Vicinity of High Voltage Systems

IN THIS SECTION...

- High-voltage systems are those in excess of 1,000V.
- It must be ensured that all staff engaged in any work on high-voltage systems are competent to prevent danger.
- Work on high-voltage systems should be subject to a permit-to-work system.
- Underground cables are particularly hazardous because they are concealed, frequently close to the surface, sometimes occur in unexpected locations, and are often poorly protected. A safe system of work incorporating cable location and careful excavation should be used.
- Overhead lines, which are not normally insulated, can become accessible to those working on roofs, scaffolding or elevated platforms and precautions must be taken to avoid contact or near-contact with them.
- Live working can be carried out on overhead cables in order to replace insulators, repair conductors, install plant or work generally within the live zone, but there should be justification for the work and assurance that it can be carried out using acceptable live working methods.

Common High-Voltage Systems and Prevention of Danger

High-voltage systems mean different things to different people. Those who work in the power industry, for example, may refer to voltages above 11,000 volts as being high-voltage. For our purposes, however, high-voltage systems are often taken to be those in excess of 1,000V. Contact with overhead electric lines can be lethal whether they are carrying a voltage as high as 400,000V or as low as 230V. Overhead lines usually consist of bare (uninsulated) conductors (sometimes called cables) supported via insulators by wooden poles or metal towers. Work with or near overhead lines has led to many fatal and serious accidents. Direct contact with overhead cables is not necessary to cause harm since very high voltages can jump significant air gaps depending on the atmospheric conditions.

Overhead electricity lines

Competent and Authorised Persons' Role Related to System Modifications

It must be ensured that all staff engaged in any work on high-voltage systems are competent to prevent danger. In assessing competence, individual knowledge, training and experience in the particular class of work should be considered. Where deficiencies are identified, staff should be trained to ensure their competence for that class of work. As an alternative, specialist organisations such as electricity supply companies, consultants or contractors should be used. The more complex the system, the higher the level of competence that is required.

In the case of distribution systems, most electricity supply companies organise special high-voltage consumers' courses which provide legal, technical and practical guidance on distribution operating practice. The companies only permit 'authorised persons' to perform switching operations and to issue safety documents for work on their high-voltage distribution systems. Such people must have adequate knowledge and experience before they are appointed in writing.

Safe Systems of Work and Permit-to-Work Procedures

With high-voltage systems exceeding 1000 volts, obviously the degree of competence necessary to prevent danger and injury will be considerably higher than that needed for work at lower voltages.

Work on high-voltage systems should be subject to a permit-to-work (PTW), which enhances safety by setting down the agreed safe working procedure in writing. The correct use of a PTW procedure should ensure that the defined and limited section of the system to be worked on has been made and will remain safe until the PTW has been cancelled once the work is complete. A PTW should only be used on systems made dead. (Although working live on high-voltage systems may not be prohibited by law, such work is infrequent.)

The PTW should set out the precautions which must be taken, together with details of the nature and location of the work. The person compiling the permit must be technically competent with regard to the class of system involved, and capable of planning the work and ensuring the precautions detailed in the document are taken. It must also be ensured that the person in charge of the work has a clear understanding of the work schedule and all the necessary safety rules. The same safety rules apply as to work on lower-voltage systems, i.e. isolation, testing for dead and earthing.

The PTW should be accepted and signed by the supervisor of the work, who then takes full responsibility for the safety of those under his control. Once signed, a PTW should never be modified.

The recommended **safe working procedure** is as follows:

- Plan work.
- Disconnect equipment.
- Isolate it.
- Prove test instrument.
- Test system is dead.
- Re-prove test instrument.
- Attach temporary earth leads if necessary.
- Post warning notices.
- Take any other necessary precautions.

On completion of the work, the supervisor should sign the permit to indicate that all workers have withdrawn and been instructed not to return and that all tools, temporary earth connections and other equipment have been removed from the work area. The permit should then be returned to the person who issued it for cancellation before the system is re-energised.

As failure of the PTW could have severe consequences, the information which it contains should be accurate. It is also advisable to set up a monitoring system to ensure that no deviations from the established procedure occur. The monitoring should be undertaken by a person independent of those who issue and receive the permit.

Access to High-Voltage Areas

Access to high-voltage areas should be restricted to only authorised persons, who have been issued with authorisation in writing. The importance of isolating systems before gaining access for maintenance must be stressed. The physical barriers provided to keep high-voltage systems and people apart are more substantial than those provided for lower-voltage systems. In addition to secure fencing and locked access, as in the case of outdoor switchyards or indoor substations, interlocking may also be appropriate.

Additional Precautions

- Portable electrical tools and inspection lamps should operate at voltages no greater than 110V. Other tools should be all-insulated.
- With high-voltage systems, it is particularly important that adequate working space is provided to prevent danger. Best practice requires that in the case of uninsulated conductors in most high-pressure systems, a clear height of not less than 2.4m (8ft) and a clear width of not less than 1.1m (3ft 6in) should be maintained. Adequate lighting, either fixed, portable or both, is necessary to ensure safe access and working.
- Suitable working and protective equipment/clothing should be issued and used.
- Accompanied by a second person aware of the hazards and capable of rendering assistance where necessary. This is particularly important during testing procedures where test voltages are high. Suitable fire-extinguishing equipment should be available nearby.

Safe Working Near Overhead Power Lines and Underground Cables

Underground and overhead power lines exist at various voltages from 230V to 400,000V and are the cause of many accidents every year. The majority of underground cable accidents result in burns and a few fatalities; most overhead line accidents result in electrocutions.

As the precautions necessary vary considerably, underground cables and overhead lines will be considered separately.

Underground Cables

Underground cables are particularly hazardous because they:

- Are concealed, frequently close to the surface.
- Sometimes occur in unexpected locations.
- Are often poorly protected.

Damage to cables usually occurs during excavation work and is caused by the crushing or penetrating effects of hand or machine tools such as pneumatic drills and mechanical excavators. A tool may penetrate the sheath of a cable and the cable insulation or crush the cable and cause contact between the conductors or between the sheathing and one of the conductors. Damage to live cables often results in arcing currents with associated explosive effects, fire and flames, which usually cause severe (potentially fatal) burns to the hands, face and torso. Direct electric shock is rare.

Underground cables

As underground cables are widespread, if excavation work is to be undertaken it should be assumed that cables are present and live until it is proved otherwise. A safe system of work incorporating the following precautions should be used:

- Cable location plans.
- Cable location devices.
- Safe digging practices.
- Trained personnel.

Use of Cable Location Plans

Before work commences, cable plans or other information should be sought in an attempt to locate the position of all cables in the area in which the excavation is to take place. Where available, the information should be obtained from the owners of the cables, such as the local electricity company, the local authority and private land owners. Plans are frequently inaccurate for a number of reasons, such as repositioning of the cable without the knowledge of the owner, regrading of ground which alters the depth of the cable, removal of the reference points originally used to locate the position of the cable, and snaking of cables in trenches. Above-ground installations such as street lighting, illuminated signs, substations and evidence of backfilled trenches which may house underground cables can also be used.

Most plans will give useful information on the location, number and configuration of cables and will help in the use of cable detectors. However, they cannot be relied upon to give precise information.

Cable Locating Devices

The location of cables shown on plans should be checked as accurately as possible using a cable locating device. Where no plans have been obtained, the use of the cable detector is additionally important. As cables are located with the device, their routes should be marked on the surface of the ground with waterproof crayon, chalk, paint or wooden pegs as appropriate.

Various cable locating devices are available, the main categories being:

- **Hum detector:** detects the magnetic field radiated by live cables which have a current flowing through them. The disadvantage is that cables with little or no current flowing will not be detected.
- **Radio frequency detector**: receives the low-frequency radio signals which may be picked up and re-emitted by cables. A disadvantage is that objects other than cables may re-radiate the signal and be detected. Results may also vary depending on the locality and length of the cable.
- **Transmitter-receiver detector**: a signal is induced into a cable by a transmitter, which is connected either to the cable or placed close to it. The receiver detects the signal, thereby locating the route of the cable. These devices require more skill to operate and also rely on knowledge of some part of the cable in order that a connection point for the transmitter may be identified.
- **Metal detector**: this will locate flat metal covers and joint boxes but may not detect round cables. However, it can be useful in the location of possible points of connection for transmitters as above.

The main disadvantage of cable detectors is that they may be unable to distinguish between a number of cables in close proximity and may register them as one cable. If two cables are located one above the other, the upper one may be located but not the lower one. It cannot be assumed that all cables have been successfully identified and therefore use of cable locating devices cannot be relied on in isolation.

Locating devices should only be used by trained operators, within the manufacturer's guidelines, and should be maintained in good working order.

Safe Digging Practice

Once the location of cables has been ascertained using plans and detectors, the routes should be confirmed by digging trial holes, which should expose the cables. Hand tools should be used and particular care should be taken above or close to the route of the cable. It is preferable that excavations should be alongside rather than above the cable and that final exposure should be by horizontal digging, which is easier to control. Incorrectly used hand tools cause many accidents every year. Accidents may be minimised by the use of spades and shovels rather than other tools such as picks, avoiding spiking or throwing tools into the ground, or by using compressed air tools (such as air-knives) which can expose cables safely. **Hand-held power tools and mechanical excavators are a major source of danger** and should not be used too close to underground cables.

Certain precautions should be taken once cables have been exposed. In particular, cables:

- With spans of more than 1m should be supported.
- Should not be used as hand or footholds.
- Should not be moved unless absolutely necessary.
- Should be reinstated with advice from the owner.

If cable locations are altered during the work, the cable owner should be notified before backfilling of trenches in order that location plans may be amended.

Trained Personnel

All personnel who are involved in excavation work where underground cables may be present should be adequately trained in the dangers and the precautions which should be taken. Training should include details of how the hazards occur, types of cables, depths of laying cables, use of plans and location devices, and action to be taken in the event of cable damage.

If a cable is damaged, all work in the vicinity of the damage should stop. Temporary barriers and warning notices should be erected to keep people away from the danger and the cable owner should be requested to repair, or otherwise make safe, the damage before work is allowed to resume.

Overhead Lines

Although out of reach under normal circumstances, overhead lines, which are not normally insulated, can `become accessible to those working on roofs, scaffolding or elevated platforms. People operating vehicles such as cranes and excavators or handling equipment such as scaffold poles, metal ladders or pipes can also be at risk due to contact with, or flashover from, overhead cables. Approximately a third of accidents involving overhead lines are fatal.

Planning the Work

Precautions must be taken to avoid contact or near-contact with overhead lines. At the planning stage of any work in an area where overhead lines could be a hazard, the owner/operator of the lines should be requested to divert the lines or make them dead. If neither option is possible, other precautions that guarantee safe clearance distances from the lines must be taken.

In situations where the owner/operator has not been consulted for advice, no part of a vehicle, plant or equipment should approach or work in a position where it is liable to be within:

- 15 metres of lines suspended from steel towers.
- 9 metres of lines suspended from wooden poles.

The owner should be consulted as soon as possible in order that specific precautions may be adopted.

Precautions with Work Near Overhead Lines

Danger can virtually be eliminated if the following precautions and procedures of work are followed in liaison with the owners/operators of the lines. We shall discuss the precautions necessary for three broad categories of work:

- No work or passage of plant beneath lines.
- Passage of plant beneath lines.
- Work carried out beneath lines.

No Work or Passage of Plant Beneath Lines

On whatever side of the lines the work is to be carried out, ground-level barriers should be erected to prevent close approach to the lines. If there is danger to people carrying metal poles or other conducting objects, the barriers should exclude both people and plant. Barriers should consist of:

- Stout post and rail fence.
- Tension wire fence, earthed at each end, with flags on the wire.
- Large steel drums fitted with ballast.
- Earth bank, at least one metre high, marked by posts.
- Timber baulks to act as wheel stops.

Passage of plant beneath lines (Based on original source HSG144 The safe use of vehicles on construction sites (2nd ed.), HSE, 2009 (http://www.hse.gov.uk/pubns/priced/hsg144.pdf))

Barriers should be as distinctive as possible and should be positioned parallel to, and **at least 6m** from, the lines. However, if mobile plant such as cranes could encroach within this space, the distance between the barriers and the lines should be extended to 6m plus at least the jib length of the crane. If site conditions will not permit the extra clearance allowance, additional warning of the 6m distance should be given. This should be in the form of bunting or flags which are suspended above the barrier and at a distance of 3.6m above the ground (see figure).

To discourage people entering the area, the space between the lines and the barriers should not be used for storage.

Passage of Plant Beneath Lines

Where plant will pass beneath lines, the width of the passageway should be restricted to no more than 10m and preferably be at right angles to the lines. In addition, the number of passageways should be kept to a minimum.

The routes of passageways should be defined by fencing with goalposts erected at each end to act as gateways in the barriers which run parallel to the lines. Goalposts should be constructed of non-conducting material, e.g. timber or plastic pipe (see figure).

Near each set of goalposts, warning signs should be erected giving cross-bar clearance height and instructions to drivers to lower jibs to below that height. Safe clearance distances between the ground and the cables should not be reduced by uneven surfaces. Surfaces should be levelled, firmed and well maintained.

In situations where single-track passageways are impracticable, it may be impossible to restrict the passageway to a width which may be spanned by a rigid cross-bar. Tensioned steel or plastic ropes may be used. Such ropes must be located at least 12m from the outer conductor of the overhead lines. The increased distance is essential to ensure that, if ropes become caught up in and stretched by mobile plant, a safe distance from the lines will still be maintained. In the case of tensioned steel ropes, earthing at each end is necessary.

Where night work is to be carried out, warning barriers and the location of barriers should be illuminated.

Work Carried Out Beneath Lines

As described above, barriers, goalposts and warning notices must be erected. These precautions will not prevent danger from upward movement of plant and structures and those working on them. The following additional precautions will be necessary:

- Safe clearance distance should be obtained from the line owner/operator.
- Plant, equipment or hand tools which could extend beyond the safe clearance distance should not be used. Plant such as cranes should be modified by the use of physical restraints which prevent extension into the danger area.
- Work should be under the direct supervision of a responsible person who ensures that the safety precautions are observed.

- Where there is increased risk due to work in close proximity to the lines, e.g. in the case of a structure being erected under the lines, a horizontal barrier of insulating material should be erected to form a roof over the work area. Alternatively, an earthed steel net may be used.

In all situations where safe clearance distances are necessary, it should be ensured that they are not reduced by the dumping/tipping of waste material, landscaping operations or the creation of unplanned storage areas.

High-Voltage Glove Working and Live Line Overhead Working

Providing that it is justified, live working carried out on overhead cables may be necessary in order to replace insulators, repair conductors, install plant or work generally within the live zone.

Live line working can involve:

- **High-voltage glove working**, which involves hands-on operations using the protection of tested and approved gloves with over-gauntlets. The gloves often extend all the way to the shoulder to protect the worker's arms. Additional protection can be provided by a rubberised apron. To reduce the length of exposed conductor, insulating blankets and hoses can be draped over the equipment not being worked on. An additional layer of protection can be provided by the use of insulated tools such as pliers. Linemen often work from an insulated platform or non-conducting ladder; however, the primary protection is deemed to come from the gloves.
- **Long stick operations**, sometimes referred to as live-line tapping, which allow disconnection of high-voltage plant and automated plant. Attachments can be added to the long sticks to enable them to be used to work in close proximity to the live high-voltage line.
- **Short stick working**, sometimes referred to as hot stick, which incorporates written and approved procedures for installing, maintaining and disconnecting equipment.

STUDY QUESTIONS

13. Describe how damage to underground cables usually occurs, and the common effects of the damage.
14. What is the main disadvantage in the use of cable detectors?
15. Identify three types of operation or tasks where workers are at risk from overhead power lines.
16. When planning work near overhead power lines, what request should be made of the owner/operator of the lines?

(Suggested Answers are at the end.)

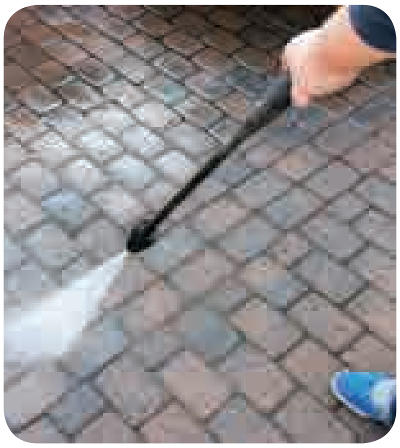
Portable Electrical Equipment

IN THIS SECTION...

- Nearly a quarter of all reportable electrical accidents involve portable equipment. Conditions and practices likely to lead to accidents include unsuitable equipment, inadequate maintenance and use of defective apparatus.
- Portable generators and arc welding present particular electrical risks.
- Control measures for portable electrical equipment include earthing, all-insulated casings, double insulation, reduced voltages and RCDs, as well as portable appliance inspection and testing.
- Aspects of supply to portable electrical equipment require consideration, e.g. height of cables, methods of interrupting electrical supply, etc.

Conditions and Practices Likely to Lead to Accidents

Nearly a quarter of all reportable electrical accidents involve portable equipment. The majority of these accidents result in electric shock; others result in fires, often caused by faulty leads to appliances.



A quarter of all reportable electrical accidents involve portable equipment

Failure to maintain equipment is a major cause of such accidents. The likelihood of accidents occurring and their severity will vary, depending on:

- The type of electrical equipment.
- The way in which it is used.
- The environment in which it is used.

A high-risk situation arises, for example, where a pressure water cleaner is used outside, powered by an electrical supply, with the cable trailing on the ground where it can be damaged by vehicles and other equipment and where water is present. Damage to the cable or other parts is likely to result in the operator or others receiving an electric shock. The equipment was not designed for use in these conditions.

Similar risks result when other types of electrical equipment, such as drills and portable grinders, are used in a harsh and sometimes wet environment, such as at a construction site where there is a high probability of mechanical damage. Lower risks result from floor cleaners or kettles, which are generally used in less hazardous environments, e.g. offices and hotels, but can be subject to intensive use and wear. This can eventually lead to faults which can also result in shock, burns or a fire.

Other conditions which may lead to accidents include:

- Incorrectly made connections.
- Damaged or missing insulation, exposing live conductors.
- Insulation failure, resulting in leakage currents and live metalwork.
- Servicing equipment without disconnecting the supply.
- Misuse of equipment.
- 'Unauthorised' equipment brought into the work environment by employees, e.g. electric heaters, kettles, coffee percolators, electric fans.

Hazards of Portable Electric Tools

As we have seen, portable electric tools and equipment account for a large proportion of the electrical accidents which occur each year. Most of these accidents are electric shock incidents, but many result in burns from arcing or fire. Accidents are typically caused by:

- **Use of unsuitable equipment**, e.g. flexible cable being dragged through areas where oils, greases or solvents are present. In this case, a cable should be selected which has a sheath resistant to those chemicals.
- **Use of defective equipment**, e.g. badly made joints in flexible cables, which can expose bare live conductors. Operators should be instructed:
  - Never to make their own repairs.
  - Never to use defective equipment.
  - To withdraw such equipment from use and not reuse it until it has been repaired and **checked by a competent person**.
- **Misuse of equipment**, e.g. attempting to service equipment without disconnecting it from the electricity supply, rather than withdrawing it from service for inspection by a competent person.
- **Inadequate maintenance**, e.g. no system of regular inspection and, if necessary, testing and repair of equipment. Regular inspections of portable equipment are particularly important because of the hard use that such equipment often suffers.

The hazards associated with hand-held tools are particularly significant as the hand is likely to be gripping the tool when in operation, making it more difficult or impossible for the operator to let go in the event of a fault.

Electrical Risks from Important Portable Appliances

There are two particularly important appliances we need to consider:

Portable generator

- **Portable generators** - a means of providing an alternative when mains supply is not available. To protect against electrical hazards:
  - Keep the generator dry and do not use in rain or wet conditions.
  - Plug appliances directly into the generator or use a heavy duty, outdoor-rated extension cord that is rated (in watts or amps) at least equal to the sum of the connected appliance loads.
  - Do not try to power building wiring by plugging the generator into a wall outlet, since this will bypass some of the built-in circuit protection devices.
- **Welders** - arc welding is a type of welding that uses a power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. Metal Inert Gas (MIG) and Tungsten Inert Gas (TIG) welding uses a shielding gas to protect the weld. When the welding circuit is connected, the following guidelines should be adopted:
  - The connection between the power source and the workpiece should be as direct as practicable.
  - Insulated cables and connection devices of adequate current-carrying capacity should be used.
  - Extraneous conductive parts should not be used as part of the welding return circuit unless they are part of the workpiece itself.
  - The current return clamp should be as near to the welding arc as possible.

  When attaching the welding current and current return cables, it is essential that an efficient contact is achieved between the connection device and the workpiece to prevent overheating and arcing. For example, current and return clamps must be securely attached to 'bright' metal, i.e. any rust or primer coatings should be locally removed.

Control Measures

Reducing the Risk of Electric Shock with Portable Equipment

As electric shock incidents often involve portable equipment, methods of reducing this risk must be considered when selecting equipment. In the event of a fault in the equipment, electric shock can be minimised by:

- Earthing all exposed metal parts.
- Using all-insulated casings.
- Using double insulation.
- Using reduced voltages.
- Providing sensitive earth-leakage protection to limit the duration of shock.

A combination of measures may be used to provide greater protection.

The type of environment in which the equipment will be used should be considered. The key point is whether the equipment is protected against environmental conditions. Enclosed ventilated equipment is only suitable for use in clean, dry conditions. In conditions where the ingress of solids or liquids is likely to be a problem, equipment of an appropriate standard should be selected and used. Further protection will be needed in special environments (such as where explosive mixtures are present, as discussed previously in this course).

Portable Appliance Inspection and Testing

To prevent accidents, routine inspection and maintenance of portable equipment is essential. All pieces of equipment should be **identified by a serial number** and **recorded in a register** which specifies when each item should be recalled for inspection. A nominated person should be appointed to ensure that recall and inspection do take place. The equipment should be marked to indicate to the user when the inspection is due. The frequency of inspection should be determined by the:

- Type of equipment and its use.
- Manufacturer's recommendations.
- Experience of the user.

The inspection and any subsequent tests and repairs should be carried out by a competent person experienced in this type of work. A record of inspection should be made and kept for the life of the equipment.

In addition to regular inspections, operators should be instructed never to use damaged or defective equipment. They should check equipment visually before use and withdraw any defective items from service until repaired. The use of 'unauthorised' equipment in the workplace should be discouraged.

Badly damaged plug and cable
Source: HSG107 Maintaining portable and transportable electrical equipment (2nd ed.), HSE, 2004

Equipment should be inspected for:

- Damage, e.g. cuts, abrasion (apart from light scuffing) to the cable covering.
- Damage to the plug, e.g. the casing is cracked or the pins are bent.
- Non-standard joints, including taped joints in the cable.
- The outer covering (sheath) of the cable not being gripped where it enters the plug or the equipment. Look to see if the coloured insulation of the internal wires is showing.
- Use in conditions where it is not suitable, e.g. a wet or dusty workplace.
- Damage to the outer cover of the equipment or obvious loose parts or screws.
- Overheating (burn marks or staining).

In addition, inspection could include **removal of the plug cover** and checking that:

- A fuse is being used (i.e. it is a proper fuse, not a piece of wire, a nail, etc.).
- The cord grip is holding the outer part (sheath) of the cable tightly.
- The wires, including the earth where fitted, are attached to the correct terminals.
- No bare wire is visible other than at the terminals.
- The terminal screws are tight.
- There is no sign of internal damage, overheating or entry of liquid, dust or dirt.

This does **not** apply to moulded plugs where only the fuse can be checked.

All these checks also apply to extension leads and their plugs.

A strategy to effectively maintain portable and transportable electrical equipment should include the following elements:

- Have a system of maintenance for portable (and transportable) equipment.
- Identify the portable electrical equipment that needs to be maintained and obtain information on where it is to be used and how.
- Decide what to do about ‘unauthorised equipment’ brought in by employees.
- Provide straightforward training and information to help employees carry out user checks.
- Set up a formal visual inspection system.
- Consider brief written guidance relating to the visual inspection, what to look for and procedures to follow when faults are found.
- Decide on the appropriate frequency for formal visual inspections.
- Find a competent person to test equipment that:
  - Is suspected of being defective.
  - Is due for a combined inspection/test.
- Review records of test results.
- Monitor all arrangements and ensure that follow-up action is carried out.

TOPIC FOCUS

Things to check during **routine visual inspection of a portable appliance**:

- Body of plug is intact and secure.
- Outer sheath of flex covers inner cores into body of plug.
- Plug cable clamp appears to be tight.
- Flex appears fully insulated, with no splits or severe kinks/pinches.
- Body of appliance is intact.
- Outer sheath of flex covers inner cores into body of appliance.
- Appliance cable clamp appears to be tight.
- No obvious scorch marks to plug or appliance body.
- Plug and appliance are not excessively soiled.
- Plug and appliance are not wet.

Aspects of Supply

Height of Cables

Some portable equipment (e.g. floor-polishers, hedge-trimmers, saws and soldering irons) is capable of causing damage to the sheath, or even to the insulation, of its own flexible cable. The cable should be raised and secured in such a way that it does not come into contact with parts that are moving or hot and located in a position that is out of danger. The users of such equipment should always be on the alert to avoid such damage. If damage does occur, they should stop using the equipment and report it.

Methods of Interrupting Electrical Supply

A Residual Current Device (RCD) can reduce the likelihood of an electrical injury but a shock can still cause very serious or fatal injuries, so an RCD should only be used as a secondary means of reducing the risk of people being injured by electricity. RCDs are not designed to prevent the ignition of an explosive atmosphere and should not be used for this purpose.

The best place for an RCD is built into the main switchboard, as this means that the electrical supply is permanently protected. If this is not possible, an electrical socket outlet incorporating an RCD, or a plug-in RCD adaptor, can also provide additional safety.

If an electrical socket outlet incorporating an RCD, or a plug-in RCD adaptor is used it should be tested, by the user, prior to use by operating the Test button. Faulty RCDs should not be used. They should be removed from use, quarantined and labelled as faulty.

If lighting circuits are protected by the same RCD that also protects other equipment, a fault that causes the RCD to trip will also result in the loss of lighting that could give rise to a number of risks (such as trips and falls or the dangers from moving machinery). A risk assessment should be carried out to identify the effect of fitting an RCD to electrical circuits.

STUDY QUESTIONS

17. What is the main cause of accidents involving portable electrical equipment?

18. (a) Outline the factors that affect the likelihood of accidents with portable electrical equipment.

    (b) What other conditions may lead to accidents?

19. How might the risk of electric shock from portable electrical equipment be reduced?

(Suggested Answers are at the end.)

Summary

Basic Concepts of Electricity

In particular, we have:

- Explained low and high voltage, basic terms (voltage, current and resistance/impedance), Ohm's law, basic electrical circuitry, the principles of earthing, and the difference between direct and alternating currents.

Hazards of Electricity and Static Electricity

We have:

- Identified the effects of electric shock on the body, which include pain, burns, muscular contraction, respiratory failure, heart fibrillation, and cardiac arrest, as well as the secondary effects of electric shock.
- Noted the factors that influence the severity of the effects of electric shock on the body.
- Examined the common causes of fires, which include overloading of conductors, overheating, ignition of flammable vapour, ignition of combustible material and breakdown of insulation.
- Explained that arcing can occur when the potential in a conductor is great enough to cross the air gap or insulation which separates the two conductors.
- Identified the circumstances giving rise to the generation of static electricity and the required controls, which include earthing, increasing conductivity, ionisation and, in relation to flammable atmospheres, ventilation, inerting and training of workers.

The Installation, Use and Inspection of Electrical Systems

We have:

- Explained the importance of:
  - Strength and capability of electrical equipment.
  - Insulation, protection and placing of conductors.
  - Reducing the risk of shock.
  - Excess current protection.
  - Cutting off supply and isolation.
  - Working space, access and lighting.
- Identified the control measures for electrical equipment and systems, which include:
  - Selection and suitability of equipment.
  - Protective systems such as fuses, reduced voltage systems, isolation, residual current devices, double insulation and earth-free zones.
- Explained the components of an inspection and maintenance strategy, which include checks, inspections and tests, with appropriate record-keeping.
- Noted that the British Standard BS 7671 *Requirements for Electrical Installations* (also known as the **IET Wiring Regulations**) is a widely used standard of best practice for electrical installations.
- Explained the importance of schemes of maintenance, schedules, plans and records.
- Described the safe systems of work on installations made dead and the safe systems of work and criteria of acceptability for live working.
- Explained the use of permits-to-work and the meaning of the term 'competent person'.

Safe Working in the Vicinity of High-Voltage Systems

We have:

- Noted that:
  - High-voltage systems are those in excess of 1,000V.
  - All staff engaged in any work on high-voltage systems should be competent to prevent danger.
  - Work on high-voltage systems should be subject to a permit-to-work system.
- Explained that underground cables are particularly hazardous because they are concealed, frequently close to the surface, sometimes occur in unexpected locations, and are often poorly protected and a safe system of work incorporating cable location and careful excavation should be used.
- Examined how overhead lines, which are not normally insulated, can become accessible to those working on roofs, scaffolding or elevated platforms and precautions must be taken to avoid contact or near-contact with them.
- Identified that live working can be carried out on overhead cables in order to replace insulators, repair conductors, install plant or work generally within the live zone, provided that there is justification for the work and assurance that it can be carried out using acceptable live working methods.

Portable Electrical Equipment

We have:

- Examined the conditions and practices likely to lead to accidents, including unsuitable equipment, inadequate maintenance and use of defective apparatus.
- Described the electrical risks from portable generators and arc welding.
- Noted the control measures for portable electrical equipment which include earthing, all-insulated casings, double insulation, reduced voltages and RCDs as well as portable appliance inspection and testing.
- Examined aspects of supply for portable electrical equipment, in particular the vulnerability of cables and methods of interrupting the supply.

Exam Skills

QUESTION

Direct contact with live parts of an electrical supply within a workplace can result in serious injury or death.

Outline a range of control measures that may prevent or limit the effect of such contact. **(10)**

Approaching the Question

As emphasised previously, the first stage in preparing to answer this question is to read it very carefully to ensure that you extract as much information as possible about what is required. The question is very broad and is concerned with the risk of contact with live conductors, but note that it asks us to "Outline a range of control measures that may prevent or limit the effect of such contact", so we can immediately see a structure to the answer.

We first need to consider methods to prevent contact with live conductors such as isolating the supply, locking it off and working dead. Complete insulation, barriers and enclosures, and positioning out of reach are also methods to prevent contact. But also, despite these measures, if contact does occur then we need to include means to limit the effects. Such controls would include RCDs, fuses and circuit breakers, insulating mats and tools or procedures such as permits-to-work.

Suggested Answer Outline

The examiner would be expecting you to identify control measures such as:

- **Prevent contact:**
  - Safe working - isolate and lock-off the supply to enable 'dead' working.
  - Insulation - prevent contact with live parts by the complete insulation of live parts such as cables, bus bars and connections.
  - Barriers or enclosures - by placing barriers across the usual direction of access or enclosures to prevent contact from any direction.
  - Out of reach - where unintentional contact might occur through the use of ladders or long metal tubes, live parts of the supply should be positioned completely out of reach.
- **Reduce the effects of contact:**
  - Residual Current Devices (RCDs) - limit the extent of shock by the use of RCDs.
  - Circuit protection - use of fuses or circuit breakers to protect against possible over-current.
  - Procedures - permits-to-work and safe systems of work.
  - Insulated tools, to the correct voltage.
  - Physical measures - insulated mats.
  - Fused test equipment, with shrouded probes.

Possible Answer by Exam Candidate

The control measures that could be implemented to prevent or limit the effects of direct contact with live parts of an electrical supply would include the following:

- *Prevent contact by isolation of supply, by locking-off and proving the supply is dead before work is allowed to progress.*
- *Insulation of live parts to prevent contact.*
- *Set up physical barriers to prevent contact.*
- *Interlock panels to prevent access to live parts.*
- *Protect circuits by provision of earth trips.*
- *Fusing circuits with correct sized fuse to ensure quick operation if contact occurs.*
- *Set up procedures for working on electrical circuits/systems to ensure work is conducted safely.*
- *Use of suitable test equipment, that is insulated, fused and shrouded.*
- *Provide insulated tools and equipment.*
- *Insulated matting where risk of shock is increased.*
- *Restrict use of conduction materials.*

Reasons for Poor Marks Achieved by Exam Candidates

An exam candidate would achieve poor marks for an answer which:

- Failed to consider a wide enough range of controls for both prevention of contact and limitation of effect.
- Concentrated solely on controls for portable electrical equipment and ignored the wider issues of dead and live working.

Element IC9

Construction and Works of a Temporary Nature - Hazards and Controls

Learning Outcomes

Once you've read this element, you'll understand how to:

1. Outline the scope and nature of construction activities.
2. Outline the principal duties and specific responsibilities for the effective management of health and safety on construction sites.
3. Explain the appropriate site control measures that should be adopted to protect employees and others during construction work.
4. Outline the hazards and control measures associated with working at height from fixed work or temporary platforms.
5. Explain the hazards and control measures associated with demolition work.
6. Explain the hazards and control measures associated with excavation work.

Contents

The Scope and Nature of Construction Activities

IN THIS SECTION...

- Terms used for different **types of construction work** include: building works, renovation, alteration, maintenance of existing premises (occupied or unoccupied); civil engineering; works of engineering construction and demolition.
- Construction work involves a variety of **different activities**, each with their own particular hazards, such as site clearance; demolition; dismantling; excavation; loading, unloading and storage of materials; site movements; fabrication; decoration; cleaning; installation; removal and maintenance of services; and landscaping.
- The nature of construction work is such that it has its own range of **particular issues** that can affect the risks to safety and health of those persons involved such as: the **transitory nature** of workers; the temporary nature of construction activities and the constantly changing workplace; fire arrangements; time pressures from clients; weather conditions; levels of numeracy and literacy of workers; and local or foreign language workers.

Types of Work

In general terms, construction work includes the:

- Construction, alteration, conversion, fitting out, commissioning, renovation, repair, upkeep, redecoration or other maintenance (including cleaning which involves the use of water or an abrasive at high pressure or the use of corrosive or toxic substances), de-commissioning, demolition or dismantling of a structure.
- Preparation for an intended structure, including site clearance, exploration, investigation (but not site survey) and excavation, and the clearance or preparation of the site or structure for use or occupation at its conclusion.
- Assembly on site of prefabricated elements to form a structure or the disassembly on site of prefabricated elements which, immediately before such disassembly, formed a structure.
- Removal of a structure or of any product or waste resulting from demolition or dismantling of a structure or from disassembly of prefabricated elements which immediately before such disassembly formed such a structure.
- Installation, commissioning, maintenance, repair or removal of mechanical, electrical, gas, compressed air, hydraulic, telecommunications, computer or similar services which are normally fixed within or to a structure.

DEFINITIONS

Terms used for **different types of construction work** include:

- **Building works** – the erection or extension of a building.
- **Renovation** – the process of improving a structure.
- **Alteration** – change or modification to a structure.
- **Maintenance of existing premises** (occupied or unoccupied) – keeping the premises in working order and preventing deterioration.
- **Civil engineering** – design, construction and maintenance of works such as bridges, roads, canals, dams and buildings.
- **Works of engineering construction** – the construction, structural alteration, repair, maintenance or demolition of a dock, harbour, inland navigation works, tunnel, bridge, viaduct, water-works, reservoir, pipeline, aqueduct, sewer, sewage works or gasholder.
- **Demolition** – dismantling or pulling down of a building or structure.

Range of Activities

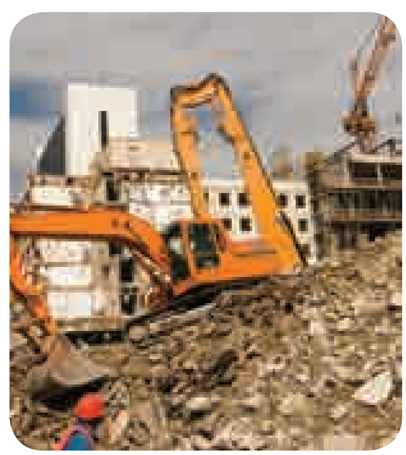
Construction work involves a variety of different activities as summarised below, each with their own particular hazards, which we will discuss in more detail later in this element:

Construction work involves a variety of different activities

- Site clearance – removing of buildings, facilities or unwanted materials from the construction site, including waste.
- Demolition – pulling down a building by mechanical methods such as pusher arm, deliberate collapse, demolition ball and also explosives.
- Dismantling – following the reverse order of construction techniques by gradually dismantling a building using hand tools.
- Excavation – the removal of earth by digging below ground level, usually to allow the construction of a foundation or basement.
- Loading, unloading and storage of materials – to ensure the continuous supply and availability of building and related materials.
- Site movements – of the wide range of vehicles and mobile plant used during construction work.
- Fabrication – of sub-structures on site, which then need to be incorporated into the final construction, including steel erecting.
- Decoration – of both interior and exterior surfaces of new and existing buildings.
- Cleaning – of both interior and exterior surfaces of buildings and other structures. Exterior cleaning may involve high-pressure water, abrasives or chemicals.
- Installation – of services or equipment required by the building or structure.
- Removal and maintenance of services - such as electricity, water or gas.
- Landscaping – to improve the general environment of the final construction by incorporating plants, fences or other material objects or changing the terrain shape and elevation.

Particular Construction Issues

The nature of construction work is such that it has its own range of particular issues that can affect the risks to safety and health of those persons involved:



Site clearance

- Transitory nature of workers – the construction industry relies on contractors hiring the workforce on a project basis. Consequently, work may be short-term and workers may be employed by a number of successive employers; therefore it can be difficult to ensure a consistent approach in protecting the continually changing workforce.
- Temporary nature of construction activities and the constantly changing workplace – as the construction project progresses, each stage may involve new activities and consequently new hazards. This means that risk assessments and safe systems of work need to be continually updated to reflect the changing work activities.
- Fire arrangements - lack of fire arrangements causes many serious fires on construction sites and buildings undergoing refurbishment every year and many of these could be avoided by planning and controlling work activities. Any outbreak of fire will be costly in damage and delay and can also be a hazard to people on the site and in surrounding properties. Fire can be a particular hazard in refurbishment work where there is often a lot of dry timber and flammable materials such as adhesives, insulating materials and soft furnishings present. Sites with high fire loading or a history of vandalism and arson may need additional measures such as lighting, out-of-hours security or CCTV.

- Time pressures from clients – the need to complete new projects within the shortest possible timeframe can encourage 'cutting corners' on safe working procedures and possibly compromise health and safety standards.
- Weather conditions – most construction work involves working outdoors and therefore weather conditions such as rain, wind, extremes of temperature and even exposure to the sun introduce additional risks to health and safety.
- Levels of numeracy and literacy of workers – poor levels of literacy and numeracy in a workforce where a high level of education is not a requirement for recruitment can reduce the degree of understanding of essential health and safety information or instructions.
- Local or foreign language workers – information, instruction and training, which are fundamental in ensuring that work is carried out in a safe manner, must be presented in a language that is understood by all of the workforce. Essential health and safety information should be presented in languages that are fully comprehended by all workers.

STUDY QUESTIONS

1. Describe the different types of work that might be included in the general term 'construction'.
2. How might the temporary nature of construction activities affect standards of health and safety?

(Suggested Answers are at the end.)

The Management of Health and Safety on Construction Sites

IN THIS SECTION...

- The **ILO Code of Practice - Safety and Health in Construction** details standards for construction site work activities and specifies the responsibilities of clients, designers, co-ordinators, principal contractors and other contractors. It also stresses the need for co-operation and co-ordination.
- The construction phase plan provides the health and safety focus for the construction phase of the project. It should identify the risks to health and safety that arise from the work and the measures necessary to deal with them.
- The health and safety file is a record of information for the client/end-user which informs those who might be responsible for the structure in the future of the risks that have to be managed during maintenance, repair or renovation.
- Site layout should provide for safe access and egress and protection of the public.
- Method statements and permits-to-work are documented systems specifying control measures, precautions and procedures.

Roles and Responsibilities

The **ILO Code of Practice - Safety and Health in Construction** details standards for construction site work activities and specifies the responsibilities of employers, employees, designers, architects, engineers and clients. It also stresses the need for co-operation and co-ordination.

Management of construction projects

The responsibilities of certain parties within the safety management framework for construction work are indicated below.

Clients

- Allocate adequate time and resources.
- Consider appointing a co-ordinator for the project.
- Should ensure that competent people are appointed.
- Provide information to other parties on the following:
  - Issues affecting the site.
  - Construction work.
  - Proposed use of the structure.
  - Time available for planning and preparation.
  - Any relevant information from an existing building health and safety file.
- Should ensure that construction does not start until the construction phase plan is prepared.

Designers/Engineers/Architects

- Avoid, when preparing a construction design, foreseeable risks to the health and safety of anyone who may:
  - Carry out construction work.
  - Be affected by it.

  - Be involved in maintenance or cleaning work.
  - Use a structure that has been designed as a workplace.
- Eliminate hazards/reduce remaining risks and provide information about any aspect of the design, construction or maintenance of the structure to fully assist other parties in complying with their duties.

Co-ordinators

- Ensure co-operation and co-ordination of the health and safety aspects of the design and planning process.
- Advise the client on the adequacy of the risk control arrangements put in place by other parties.
- Provide assistance and advice on the appointment of competent contractors and designers.
- Facilitate good communication and co-operation between members of the project team.
- Ensure that the health and safety file is prepared, liaise with the principal contractor concerning its contents and ensure that it is handed over to the client at the end of the construction phase.

Principal Contractors

- Take account of health and safety issues when submitting the tender.
- Prepare and review the construction phase plan that identifies the risks to health and safety arising from the work and the measures to address them.
- Co-ordinate the activities of all contractors to ensure that each complies with the construction phase plan. To this end, the principal contractor may give information, instructions, etc.
- Liaise with other contractors and the co-ordinator on the content of the health and safety file.

Other Contractors

- Plan, manage and monitor their own work so that risks to health and safety are minimised.
- Take reasonable steps to ensure that work is carried out in accordance with the construction phase plan.
- Provide information for the health and safety file.
- Tell the principal contractor about any injuries or incidents.
- Provide information for the construction phase plan on risk assessments and control measures.
- Comply with site rules and emergency procedures.

Planning, Co-ordination and Notification

One of the main factors responsible for the high accident rate in the construction industry is the complexity of the construction process and the need to carefully plan and co-ordinate the activities of the key players: the client, designer, project co-ordinator, principal contractor and subcontractor.

Key issues to consider include:

- Emphasising the need for effective communication, co-ordination and co-operation between the different parties involved in a project.
- Requiring duty holders to establish the competence of appointees, and also to ensure their own competence before accepting any appointment.
- Simplifying the ways in which the competence of relevant parties is assessed by duty holders before selection.
- Requiring the principal contractor, and other contractors, to be informed of how much time is available for planning and preparation before work begins.
- Requiring the client to take reasonable steps to ensure that the health and safety arrangements made by other duty holders are sufficient.
- Requiring designers to aim to eliminate hazards and reduce remaining risks.

9.2 The Management of Health and Safety on Construction Sites

There is therefore a need to impose an effective safety management framework on construction work. The **ILO Recommendation R175, Safety and Health in Construction, 1988** and the **ILO Convention C167, Safety and Health in Construction, 1988** set out requirements that include the need to co-ordinate and manage construction activities, as well as particular standards for safe working procedures.

The requirements for notification of intended construction work vary according to local legislation. One example of arrangements and criteria for notification exists in the UK **Construction (Design and Management) Regulations 2015**. These Regulations impose a safety management framework on construction work and assign specific duties to the various participants in a construction project. The client is such a participant and one of their specific duties is to notify the enforcing authority for the Regulations of any project that is expected to last longer than 30 working days and have more than 20 workers working on the project at any one time, or exceed 500 person-days.

> **MORE...** www.
>
> ILO Convention C167 and Recommendation R175 are available from the ILO website at:
>
> www.ilo.org/global/standards/lang--en/index.htm
>
> Guidance on the UK **Construction (Design and Management) Regulations 2015** can be found at:
>
> www.hse.gov.uk/pubns/books/l153.htm

Note that the criteria for notification are based on the duration and manpower of the project.

Construction Phase Plan

This provides the health and safety focus for the construction phase of the project and should identify the risks to health and safety that arise from the work and the measures necessary to deal with them. It should include:

- Arrangements for ensuring the health and safety of all who may be involved in the construction work. This should include:
  - A description of standards to be achieved and project rules.
  - Risk assessments.
  - Method statements.
  - Details of other control measures.
  - Common arrangements.
  - Emergency procedures.
- Arrangements for managing health and safety during the construction work and for monitoring compliance with legal requirements. This should include:
  - Organisation and responsibilities.
  - Communication routes.
  - Arrangements for information and training.
  - How compliance with the plan and legal requirements will be monitored.
- Information about welfare arrangements.

Health and Safety File

This is a record of information for the client/end-user which informs those who might be responsible for the structure in the future of the risks that have to be managed during maintenance, repair or renovation. The principal contractor needs to ensure that the health and safety file is prepared as the project progresses and given to the client when the project is complete. The client should make the file available to those who will work on any future design, building, maintenance or demolition of the structure. The file should include:

- Drawings.
- Construction method details.

- Equipment and maintenance facilities.
- Maintenance procedures and requirements for the structure.
- Operation and maintenance manuals.
- Details of utilities, services, emergency and fire-fighting systems.

Relevance of Site Layout

Access and Egress

There should be safe access onto and around the site for both people and vehicles, with safe segregation of people and vehicles/plant, especially:

- At site entrances.
- In vehicle loading/unloading areas.
- In parking and manoeuvring places.
- Where drivers' vision may be obstructed.

Protection of the Public

Whenever possible, the site should be fenced off and suitably signed to protect people (especially children) from site dangers and to protect the site from vandalism and theft. For some jobs the site may be shared, in which case the nature of the site boundary will have to be agreed, along with the system of access.

Use of Method Statements and Permits-to-Work

Method statements are an effective and practical management tool. They:

- Draw together the information compiled about various hazards and the ways in which they are to be controlled for any particular job.
- Should include all the control measures which will apply.
- Provide information to others working on the site who may be affected.
- Will help the principal contractor to develop the construction phase plan.

Permit-to-work systems are formalised, documented systems. They:

- Rely on suitably competent authorised persons to check a variety of situations depending on the job to be carried out.
- Indicate the precautions and procedures to be followed.
- May be required for:
  - Excavations.
  - Height work.
  - Work involving electricity.
  - Confined space entry.
  - Use of lifting equipment.

STUDY QUESTIONS

3. Identify the main responsibilities of: the client, the co-ordinator and the principal contractor.
4. Identify what should be included in the construction phase plan.

(Suggested Answers are at the end.)

Protecting Employees and Others During Construction Work

IN THIS SECTION...

- Site security consists of traditional physical and electrical measures as well as management and procedural measures.
- Arrangements for protecting employees and others include site rules, co-operation, and shared facilities (first-aid and welfare facilities).
- The Principal Contractor is responsible for ensuring that site inductions are in place and carried out for all workers and visitors to the site.

Site Security

The purpose of site security is to protect both the assets (plant, equipment, chemicals) on site and members of the public on and off site not familiar with construction activities. Site security consists of:

- Traditional physical and electrical measures such as:
  - Perimeter fencing.
  - Security guards on the premises.
  - Locked gates.
  - Means of securing plant and chemicals.
  - Roadside and security lighting.
  - Safe viewing points.
- Management and procedural measures such as:
  - Visitor registration and sign-in procedures.
  - Escorting persons while on site.
  - Education – especially of children.

Site security

Perimeter Fencing

All construction sites should use security fencing such as "Heras" fencing or hoarding (usually wooden boards) and apply safety signs to warn of the dangers on site. A common sight is of the Safety Board with the Mandatory signs for boots, hats and high-visibility vests, accompanied by the words "No Boots, No Hat – No Job!".

- Fencing should:
  - Be at least two metres high and well maintained.
  - Not be easy to climb.
  - Be robust and able to withstand bad weather and extreme environmental conditions.
- Access should be through gates which can be secured when the site is not in use.
- It is good practice to have a security guard at the gate to ensure that only authorised persons enter the site.

Protecting the Public

As well as perimeter fencing options, the following can be used to protect the public:

- Pedestrian tunnels and walkways with lighting.
- False ceilings and crash decks.
- Sheeting on scaffolding.
- Wrapping protrusions (bolts, couplings, etc.).
- Barriers and signs around excavations.
- Viewing points in safe areas and vision panels in solid hoardings.

Precautions for special risk groups, such as disabled persons, should be considered.

Safe Control of Children

Complete perimeter fencing is not always possible, especially on housing sites under development with access often required for prospective buyers and agents. All site staff need to be aware of this problem, particularly in the evenings, at weekends and during school holidays.

Visiting local schools, producing pictures and videos and arranging meetings and talks with parents and their children to make them aware of the hazards and risks on the site can help to promote site safety awareness and reduce accidents with children.

TOPIC FOCUS

In addition to secure fencing of sites, education and publicity, **precautions that can reduce site risks involving children** include:

- Removing all ladders from scaffolding, buildings and work platforms to a secure area.
- Providing secure and adequate supports around all excavations.
- Immobilising plant such as dumper trucks, excavators and other site vehicles.
- Isolating all electrical equipment not required for night safety and ensuring the integrity of emergency electrical supplies to the site.
- Reducing the height of stacked materials.
- Covering any holes that cannot be filled in.
- Blocking off debris chutes by fitting lids or covers to prevent them being used as slides.
- Locking away all chemicals, gas cylinders, tools and equipment in safe and secure storage facilities.
- Providing secure storage tanks for petrol, diesel and fuel oil.

Means of Securing Plant and Materials

All construction plant is expensive and must be looked after and protected, so safe areas are needed to secure such items. Some materials used are very expensive and may also be hazardous in some way, so a secure area will keep them safe and keep people away from the hazards associated with them, particularly children. Gas cylinders and storage tanks should be in a safe area. Both temporary and permanent security compounds can be used.

Environmental Dangers

Construction sites create dust, which becomes mud when wet. It is difficult to prevent dust going off the site – it is carried by the wind and on vehicles – but efforts can be made, such as:

- Wheel washes, to keep mud on site.
- Road sweeping, to stop dust off-site becoming a mud problem.

Arrangements for Protecting Employees and Others

Site Rules

These are usually enforced by the Principal Contractor. They are used in all on-site safety training and displayed at all times in prominent places. Site rules apply to all persons who may come onto the site, not just construction workers.

TOPIC FOCUS

The Principal Contractor will put in place **rules** covering:

- Site access – means of access and authorisations for certain areas.
- Operation of any permits-to-work.
- Personal protective equipment (PPE) requirements.
- Fire precautions and prevention.
- The nature and accessibility of welfare facilities.
- Site alarms and emergency response.
- First-aid and accident reporting.
- Site transport precautions – speed limits, driver rules, parking, reversing, loading and unloading, and deliveries to site.

The type and depth of the rules will depend on the nature and size of the site and the work carried out.

Co-operation and Consultation

Both are vital to ensure that safety covers not only those involved in the construction work, but also persons sharing the site, e.g. occupants of factories, shops, etc. being worked on, or nearby premises. Separate access and egress for occupants and no-go areas for the construction teams may be necessary.

Shared Facilities

- On a dedicated construction site, one set of facilities (welfare - toilets, washrooms, rest and eating areas; first-aid, etc.) is usually provided and shared by all contractors and participants in the work.
- On a site having occupants, there may be facilities already there that can be shared, e.g. toilets, first-aid, etc. These arrangements will be put in place following consultation with the occupiers.

Protection of Other Employees and Visitors

Where occupants of premises being worked on cannot be evacuated for the duration of the work, precautions must be taken to protect them. Methods of separation and segregation from plant and mobile equipment may be required. Occupants must be given adequate health and safety information about what is going on around them. On all sites, visitors need particular protection, as they will not be aware of the site layout and the hazards presented by the work in progress.

Working in Occupied Premises

Some construction work may take place in occupied premises. This may be in a commercial enterprise, such as an office block or a factory, or in a public environment such as a school, a hospital, or a shopping centre.

Safety rules need to be applied to ensure the health and safety of the construction workers, the employees of the client and members of the public. These rules must take into account existing rules that are in place governing the activities of the occupants.

Extra precautions may be required such as:

- Isolating areas of work from occupants.
- Arranging work outside 'normal' hours (e.g. at night or weekends).
- Appointing wardens to regularly inspect all occupied areas to ensure safety.
- Carrying out more frequent cleaning and waste removal.
- Safety briefs for occupants to make them aware of the hazards, understand the safety signs, etc.

In all cases, liaison must be ensured and a forum available for questions, comments and complaints to be made by the occupants.

Arrangements for Site Inductions

The Principal Contractor is responsible for ensuring that site inductions are in place and carried out for all workers and visitors to the site.

All inductions should be recorded and include:

- Details of site arrangements (e.g. signing-in procedures, car parking, use of PPE).
- Conditions of work.
- Emergency procedures, including accident reporting, fire precautions, medical welfare where appropriate, locations and purpose of all safety and fire equipment.
- Special hazards and permit-to-work requirements.
- Exclusion and no-go areas.
- Use of mobile telephones, etc.

In most cases, site induction will not contain any in-depth health and safety training about specific tasks or hazards, such as work at height or use of plant and equipment. Contractors usually deal with this in a regular series of toolbox talks.

STUDY QUESTIONS

5. Outline the site security measures that may be used on a construction site.
6. Explain what site rules should cover.
7. Outline the precautions necessary to prevent accidents to children on a construction site.

(Suggested Answers are at the end.)

Working at Height from Fixed or Temporary Platforms

IN THIS SECTION...

- Hazards associated with working at height include: falls from roofs, falls through roofs, bad storage of materials, insufficient guarding or edge protection, unsatisfactory access or egress and incorrect method of getting equipment or tools from ground level to the working platform.
- Precautions are required for the safe use of temporary (immobile) access equipment, which includes: ladders, trestles, simple independent scaffolds and tower scaffolds.
- Erecting and dismantling scaffolds and falsework is a high-risk activity; therefore scaffolders must follow safety systems during such work and precautions must also be in place to prevent scaffold collapse during use.
- The risk of falling materials should be minimised by keeping the work area clear of loose materials, the use of brick-guards and toeboards, the use of waste chutes, the erection of fan guards.
- To ensure safety during roof work, precautions are needed for work on fragile roofs and appropriate edge protection should be provided for flat and sloping roofs.
- A lot of maintenance work involves reaching parts of plant and structures that may not be readily accessible during normal work operations and therefore temporary access equipment such as cradles, boatswains' chairs, rope access and positioning systems may be required.
- The application of the hierarchy of control measures for working at height includes provision of personal and collective fall-arrest devices such as safety nets, airbags, belts and harnesses.

Hazards Associated with Working at Height

One of the major hazards in construction is that a great proportion of work is carried out at height. The danger of falls of people and materials affects not only those working at height, but also (sometimes to a greater degree) those underneath. Falls are the largest cause of accidental death in the construction industry. Accidents involving falls could be prevented if:

- the job is planned properly;
- safe systems of work are adhered to;
- the right equipment is used; and
- any specific precautions are taken.

Roof work accounts for almost a fifth of all construction deaths and these are mainly due to falls from or through roofs. Falls through fragile materials, such as roof lights and asbestos cement roofing sheets, account for more of these deaths than any other single cause.

Working at height

Other dangers include:

- Bad storage of materials.
- Insufficient guarding or edge protection.
- Unsatisfactory access or egress.
- Incorrect method of getting equipment or tools from ground level to the working platform.

Any company which has persons working at height should, at the very least, provide a method statement outlining the nature of the operations and precautions to be taken.

Safe Use of Temporary (Immobile) Access Equipment

It is a general duty of the employer to provide and maintain safe access and egress, in addition to a safe place of work.

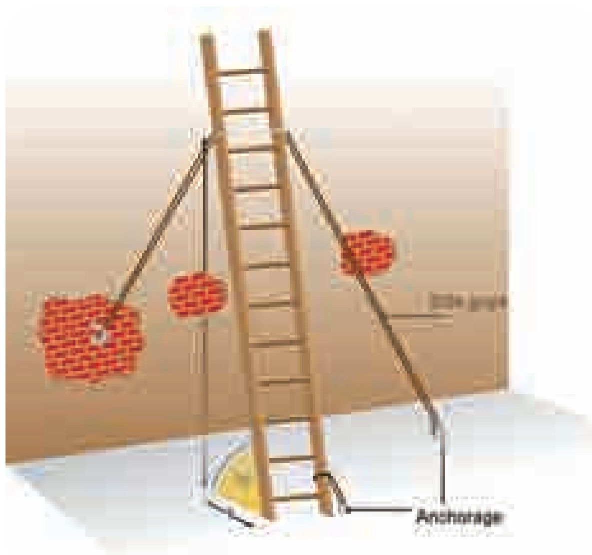
Safe access to either the working platform or roof requires careful planning. Typical methods include the use of:

- Scaffolding.
- Fixed or mobile tower scaffolds.
- Ladders.

The 'place of work' could be the top of a ladder, a working platform from any of the above scaffolds, or a roof. In addition to the physical safeguards (e.g. toeboards, guardrails, brick-guards, safety nets, etc.), personal protective equipment (such as harnesses, belts or fall-arrest mechanisms) must be provided.

Ladders

Ladders are so widely used that their dangers are often completely overlooked. They are frequently used in unsuitable locations where they form inappropriate working places, and they are often incorrectly used and poorly maintained.



Ladder secured by guy ropes

The following precautions should be taken when using portable ladders:

- Ladders should be erected on a firm, level base.
- They should be supported by the stiles (uprights) only.
- The top of the ladder should rest on a firm, solid surface. (If the surface is unsuitable, e.g. plastic guttering, a ladder stay may be used.)
- The ladder slope should be about 75° to the horizontal, i.e. 1m out to every 4m of height (**the 1:4 rule**).
- Ladders should be secured at the top where possible, or secured near the base by means of guy ropes (see next figure). Securing is necessary to prevent slipping.
- If it is not possible to secure the ladder to prevent slipping, someone must hold the ladder at the base while in use, but you should note that this is only effective with short ladders.
- Only one person should be on a ladder at any given time.
- Metal ladders should not be used where any electrical hazard exists, e.g. overhead electricity cables. (The same applies to timber ladders with metal stile reinforcement or when it is raining or when the ladder is still wet.)
- Timber ladders should be stored correctly to prevent warping and rungs loosening.


Ladder access to a working platform

- Painting timber ladders is not permitted because it obscures defects; coatings of clear varnish or preservative are allowed.

Ladders must extend at least 1.05m above any landing place or beyond the highest rung from which a person may work. This is to afford adequate hand-holds. If the ladder cannot provide a hand-hold, an alternative must be found.

From the stepping-off point, suitable (i.e. unobstructed and safe) access to the working place must be provided.

Landing places must be provided at least every 9m along the length of the ladder and must be guarded with toeboards and guardrails.

All ladders should be examined frequently and the following should be checked for:

- Mechanical damage to metal ladders.
- Splits, cracks, warping or bruising to timber ladders.
- Movement or wear and tear to rungs.
- Missing rungs.
- Tightness of wedges and tie rods.
- Split or damaged feet.
- Wear to ropes and pulleys on extension ladders.
- Brackets or latching hooks that are not soundly fixed and operational.

Trestles

Trestle scaffolds must be properly constructed using materials which are suitable for the purpose and free from defects. They must not be used if a person can fall more than 4.5m from the structure, or if more than one tier is resting on folding supports.

They must not be erected on a scaffold platform unless there is sufficient space for people and materials to pass easily. The trestle supports must be braced and fixed to the platform.

Scaffolds

Simple Independent Scaffolds

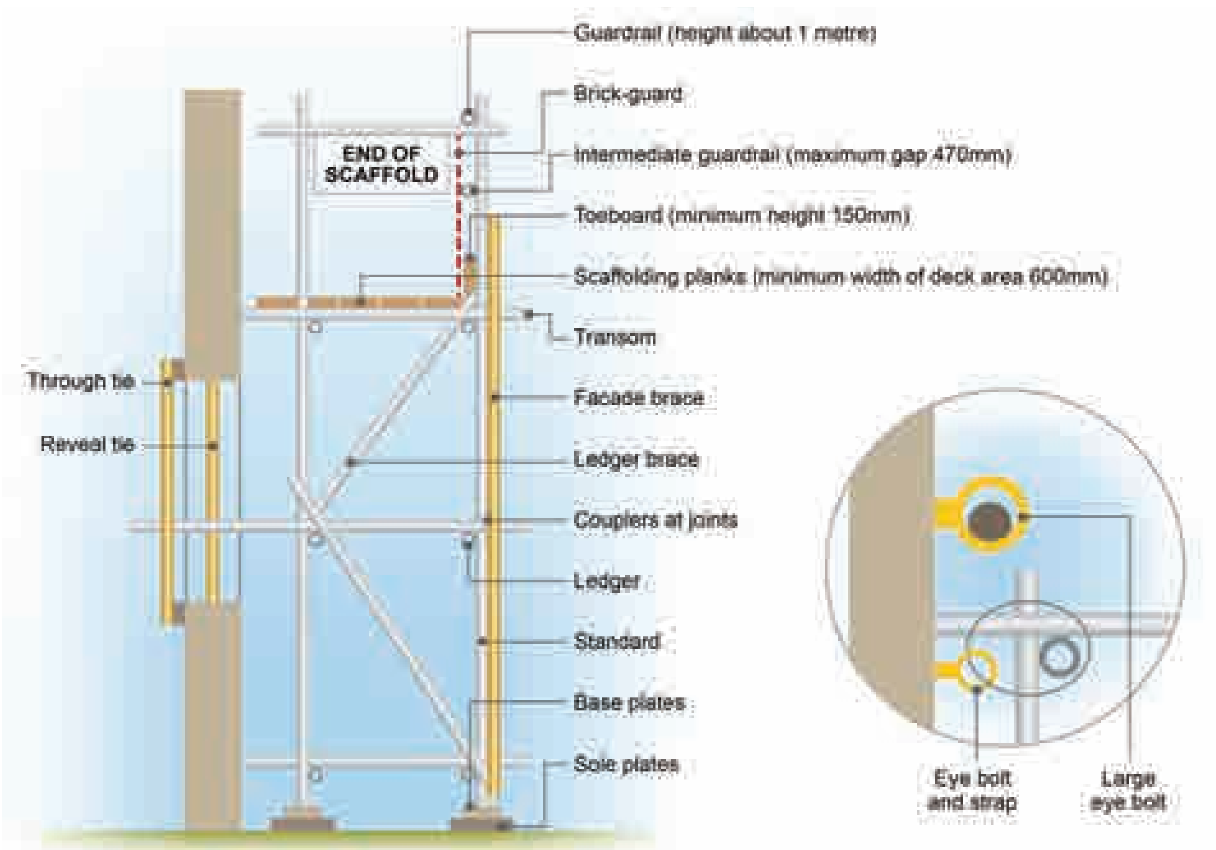
Terminology:

- **Standard** - a vertical tube used as a support for transferring a load to the ground or to a base plate.
- **Ledger** - a horizontal tube tying a scaffold structure longitudinally; it may also be used as a support for transoms or putlogs.
- **Transom** - a tube spanning across ledgers to tie a scaffold transversely; it may also be used to support a working platform.
- Brace - a tube fixed diagonally across a scaffold to prevent lateral movement and to improve stability of the structure.
- **Raker** - an inclined load-bearing tube attached to a scaffold, which may bear on the ground or on an adjacent structure.
- **Tie** - a tube used to connect a scaffold structure to a reveal tie, through tie, box tie or rigid anchorage (sometimes called a bolt tie or anchor tie). Its purpose is to ensure complete stability of the structure.
- **Coupler** - a scaffold fitting which, by a friction grip applied to the external surface of two tubes, holds them together. There are around six types in common use (you can often see heaps of them lying on the pavement in urban streets).
- **Base plate** - a flat square steel plate with a locating pin that must be inserted into the bottom of a standard to provide a bearing surface for load distribution.

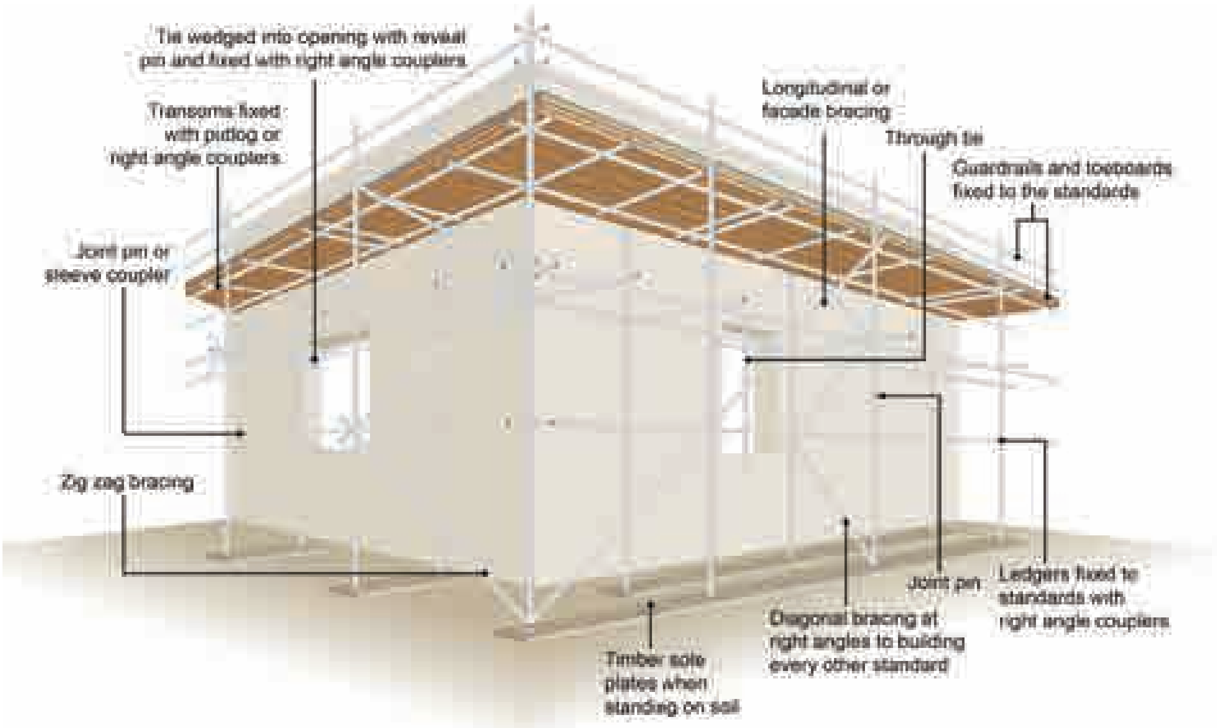
- **Sole plate** - a strong timber plank wider than a base plate and long enough to be positioned under at least two base plates. They provide extra load distribution capacity for the scaffold base. They must be used where the load-bearing conditions of the ground are poor, but it is good safety practice to use them for all scaffolding structures, irrespective of ground conditions. If the standard is resting on concrete or pavement, a 'plastic' sole plate can be used which fits under individual base plates.

An independent tied scaffold is designed to carry its **own mass** and the **full load** of **all materials** and **workers** used on the scaffold. The total load is supported by the ground on which the scaffold has been erected. The scaffold is not totally independent and must be tied to the building where it is sited, to give the stability that prevents any possible movement of the scaffolding away from or towards the building.

As the total mass of the structure when in use is supported by the ground, it is very important that the ground structure is suitable to cope with the load. The use of base plates and sole plates becomes a **vital** safety consideration in **spreading** the load. The following figures illustrate a typical independent tied scaffold:



Independent tied scaffold with a reveal tie



Independent tied scaffold

Independent tied scaffolds are also classified into three main types:

- **Light-duty -** where only one platform is used at any one time. These are used for painting and stone cleaning.
- **General-purpose -** where up to four working platforms can be used. These are used for general maintenance with loaded materials.
- **Heavy-duty -** which provides two heavy-duty working platforms and two other platforms for light duty and access. These are used for heavy masonry work or where large building blocks are used.

The basic requirements for working platforms on scaffolding are guardrails, toeboards and wind protection for boards. The platform must be fully boarded but the width varies with the type of work being undertaken. Platform widths can vary from three to seven boards:

- Three boards are used for footing, i.e. for people to work without materials deposited or as a gangway.
- Four boards for footing and storing materials.
- Five boards for general work.
- Six boards for masons and their materials.
- Seven boards for masons using trestles.

Where materials are deposited, a clearway of 0.43m is required; where passage of materials is needed, a clearway of 0.64m must be maintained.

TOPIC FOCUS

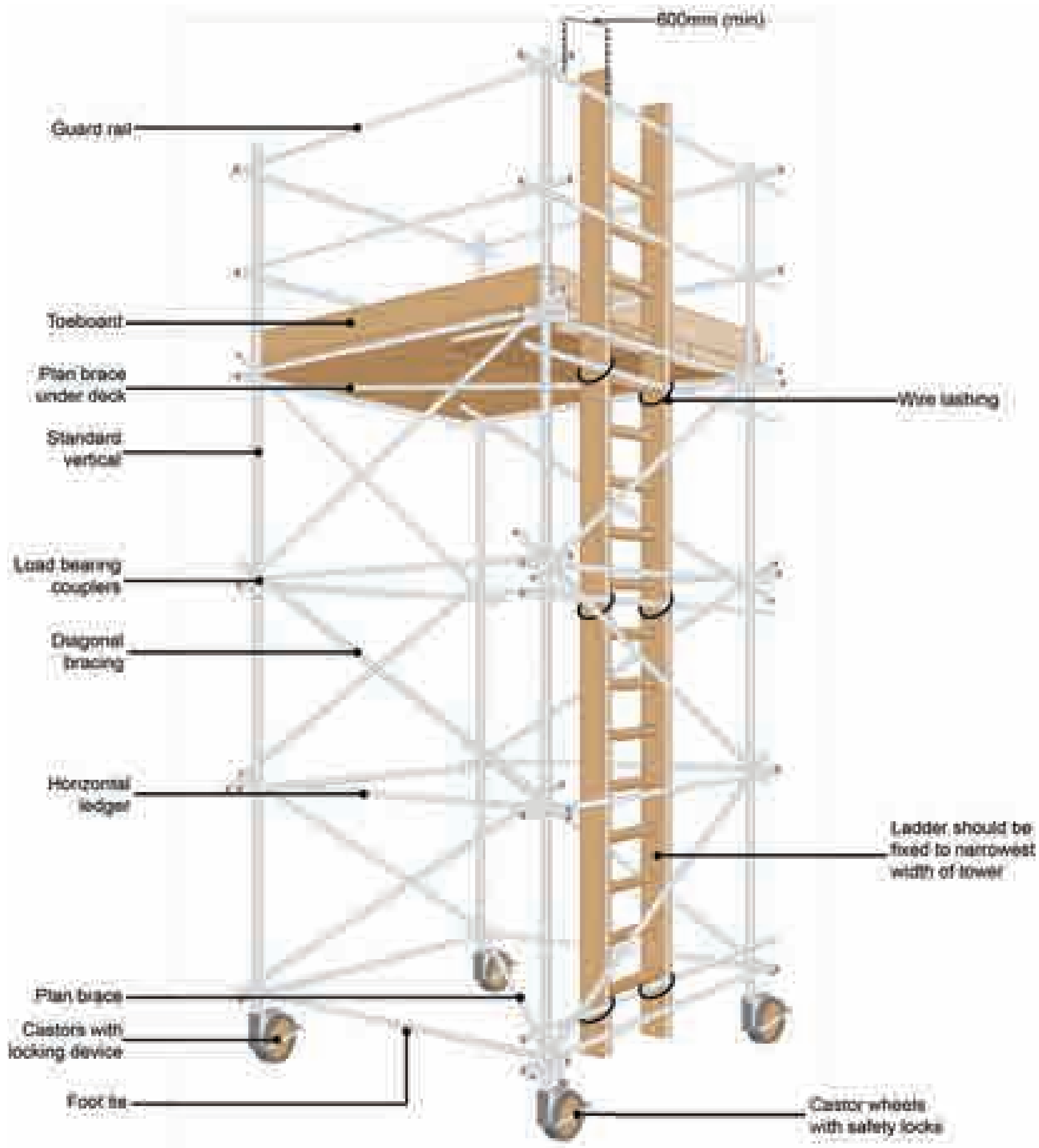
The **technical and procedural measures required to ensure the initial and continued stability** of an independent tied scaffold to be erected against a multi-storey building include:

- **Technical issues** - relating to the design and structure of the scaffold:
  - Designed to a recognised standard.
  - Withstand expected loads.
  - Suitable for use.
  - Sound materials.
  - Adequately braced.
  - Outriggers if necessary.
  - Base plates supported - sole plates, firm ground.
  - Tied into the building.
  - Traffic protection - markings, lighting.
- **Procedural issues** - concerned with erection, inspection and use:
  - Erected by competent persons.
  - Inspected by a competent person:
    - After erection.
    - After an interval of 7 days.
    - After alteration, damage or inclement weather.
  - Used at the correct level of duty.
  - Inspection and supervision:
    - Daily checks.
    - Defect reporting.

Tower Scaffolds

Mobile (tower) scaffolds are **light-duty** scaffolds only and their use should be restricted to inspection, painting and simple maintenance jobs. They have one working platform accessible by a ladder, which must be fitted internally. Mobile scaffolds can be constructed using normal scaffold tubes, but are more often proprietary structures. The structure is mounted on four wheels so the unit can be moved about with relative ease.

The height of a mobile scaffold is generally limited to 12m, except for special purposes. For **internal** use, the height should not exceed **three and a half times** the **shortest** base dimension. When used **externally,** the factor is **reduced** to **three**. When used above 9.8m, some form of guy rope, ballast or anchoring device must be used to give added stability. **Outriggers** are used to spread the base dimensions and increase stability.



Mobile access tower scaffold

The working platform should conform to the standards set out for other scaffolds, e.g. toeboards and guardrails. The recommended maximum distributed load is 145 kg/m^2. When in use, the following factors are considered essential:

- The scaffold must be set up on level ground.
- The wheels should be turned outwards to increase the effective area of the base and must be locked to prevent motion.
- The scaffold must only be moved by pushing or pulling at the base.
- The scaffold must not be moved while workers and materials are on the platform.

Erection, Use and Dismantling of Scaffolds and Falsework

Erecting and dismantling scaffolds and falsework (large, semi-permanent structures used on big construction projects) remains a high-risk activity, not only to those carrying out the work, but also to other workers and the general public. When scaffolding operations are in progress, the public must be excluded from both the area of work and a sufficient area around it.

Scaffolders must follow safe systems of work to prevent people falling. In particular:

- When lifting or lowering materials, scaffolders must be clipped on or working within a handling platform that is fully boarded, with double guardrails and toeboards.
- A minimum three-board working platform, together with a single guardrail, should be provided as erection or dismantling works progress.
- Safety harnesses are to be worn by scaffolders at all times.
- At least one bay of a scaffold should remain boarded out as work progresses and this should be used for ladder access for the full height of the scaffold.
- Safe ladder access for scaffolds should be incorporated as early as possible into the erection process.

To prevent scaffold collapse during use:

- The anchors specified to tie a scaffold to a structure should be suitable for the base material and installed correctly.
- Scaffold anchors or ties should be installed as erection work progresses. Conversely, they should not be removed too early during dismantling operations.
- More ties should be provided on a sheeted or netted scaffold to ensure its stability.
- Ensure scaffolds are not overloaded with equipment, especially tubes and fittings, during erection or dismantling operations.

Effective training of scaffolders is an essential factor in preventing accidents on site, along with monitoring the scaffolding contractor:

- Check the training levels of scaffolders and those who will supervise them on site.
- Monitor scaffolders on site to ensure they follow proper safety standards.

Hazards Associated with Falling Materials and Appropriate Precautions

It goes without saying that if something falls from a great height and meets something on the way, some form of damage will usually occur. The risk of falling materials should be minimised by keeping the work area clear of loose materials. The use of brick-guards, toeboards, etc. will prevent items from rolling over the edge. If waste material has to be disposed of from heights, then the use of 'waste chutes' must be considered, which eliminates any throwing of materials.

When working near the public, it may be necessary to erect fan guards or covered walkways, both of which should have a 'sandwich' of either plywood, metal, or heavy-duty plastic sheeting between double battens, to prevent dust or small items getting through. Small items of equipment or tools should be raised by hauling them up in either a bucket or bag, to reduce the risk of dropping them while ascending or descending the structure.

Safe Methods for Roof Work

Accident statistics show that a considerable number of workers fall from roofs and through roofs during construction and maintenance work. Nearly all roof-work fatalities could be prevented by the provision and correct use of readily available equipment.

Roof work includes construction of roofs and any subsequent major overhaul. It also includes maintenance work, such as replacing tiles, gutter cleaning, chimney repairs and repointing. Maintenance work is often undertaken in a hurry, e.g. storm damage repairs, and by people with little or no experience of roof work or working at height. Adequate planning, instruction, training and supervision are essential, as well as the provision of equipment such as roof ladders and edge protection.

Note that roofs are not a normal working area and must be included in a **risk assessment** for maintenance and a safe system of work (including a lone working scheme).

It has been shown that the majority of accidents involving falls from roofs occur mainly during small, routine jobs. The reasons given for this situation are that care and forethought for small jobs tend to be overlooked and accidents commonly result from not having sufficient equipment to work safely. This is basically the same reason given for many scaffolding accidents. The lesson to be learnt here is that it is vital for all roofing work to be planned down to the last detail before the work has begun; it is too late to make amends after the accident has occurred.

There is general agreement that to give minimum safety cover when roofing work is undertaken there should be:

- Two persons involved in the work.
- One ladder for access to eave level.
- One ladder for use on the roof slope.
- One safety rope long enough to extend right over the roof.
- Lashing, sandbags and a sturdy fixture to secure the ladders. If the ladder cannot be securely lashed to the building at the top, then there should be side guys and suitable anchorages, as we saw earlier.

Precautions during Work on Fragile Roofs

Any roofing structure which is **not** specifically designed to carry loads or does not have the strength to carry loads other than those produced by the weather (e.g. wind and snow) **must** be considered a fragile roof. Cement, asbestos, glass, reinforced plastics and light-tongued and grooved wood covered with roofing felt are all examples of materials which have collapsed under the weight of a worker. The resulting falls have caused severe injuries and even fatalities.

Fragile roof work

The accepted safe method of working on fragile roofs, including low-pitch or flat roofs, is by the use of **roof ladders and crawling boards**. They are able to distribute the load of the worker over a wide area and so enable the roof structure to sustain the load safely. Roof ladders also provide a good foot- and hand-hold for the worker. When a worker has to move over a roof, then **two** ladders should be used so that one can be moved while the other provides support. Falls have occurred as a worker has moved off a ladder in order to move it.

When walkways are constructed on fragile roofs, they must have a guardrail and warning signs, or alternatively the roof section alongside the walkway must have a protective covering.

All fragile roofs, except those made of glass, should have a large warning notice displayed on them. Remember that with a multinational workforce, a sign worded in one language does not provide sufficient warning. It must be backed by verbal warnings given to the people who have to work on a fragile roof.

MORE... www.

The UK HSE has produced an Information Sheet, *Fragile Roofs – Safe Working Practices* (GEIS5) which explains which surfaces present a particular risk and provides examples of safe systems of work for typical jobs on fragile roofs. The Information Sheet is available at: www.hse.gov.uk/pubns/geis5.pdf

TOPIC FOCUS

Maintenance on Fragile Roofs

The **characteristics** of the fragile material that may contribute to the risk of falls through the roof include:

- Age and condition of the material.
- Type of material, such as asbestos or fibre board.
- Thickness of the material.
- Span between roof supports.
- Condition of fixing.
- Whether the surface is slippery underfoot.

The **measures to be taken to reduce the risk** to those involved in the roofwork and those who might be affected by it include:

- A risk assessment that considers:
  - Access to the roof.
  - The need to transport tools and equipment.
  - The number of people working on the roof.
  - The general state of the roof.
  - Where fragile material exists.
- Development of a method statement to detail the safe system of work, covering:
  - The method of safe means of access, such as scaffolds, mobile work equipment and crawling boards.
  - Edge protection for persons and falling materials – equipped with guardrails, intermediate rails and toeboards.
  - Protection of falls through fragile materials using covers and supports.
  - Demarcation of areas where there are fragile materials – with barriers and signage, restriction of work there, and provision of safety nets under such areas.
  - Appropriate tools and equipment, including the means of carrying them.
  - Provision of safety harnesses with adequate fixing points and other necessary PPE, including hard hats and boots.
  - Arrangements to ensure that personnel are competent and aware of the risks of the job and the necessary precautions.
  - Emergency arrangements, including first aid.
  - Signs and barriers, to protect other persons such as occupants of the building and members of the public.
  - Monitoring and supervision of the safe system of work.

Precautions during Work on Flat Roofs

When the roof is considered flat (less than 10° pitch), then the guarding system used must conform to the requirements for any working platform above 2m from the ground (i.e. having guardrails and toeboards).

When it is not possible to construct physical barriers around flat or sloping roofs, safety harnesses must be used. The standard of safety provided by the harness or belt must satisfy an accepted specification, e.g. a British Standard specification.

Precautions during Work on Sloping Roofs

These are roofs with a pitch greater than 10°.

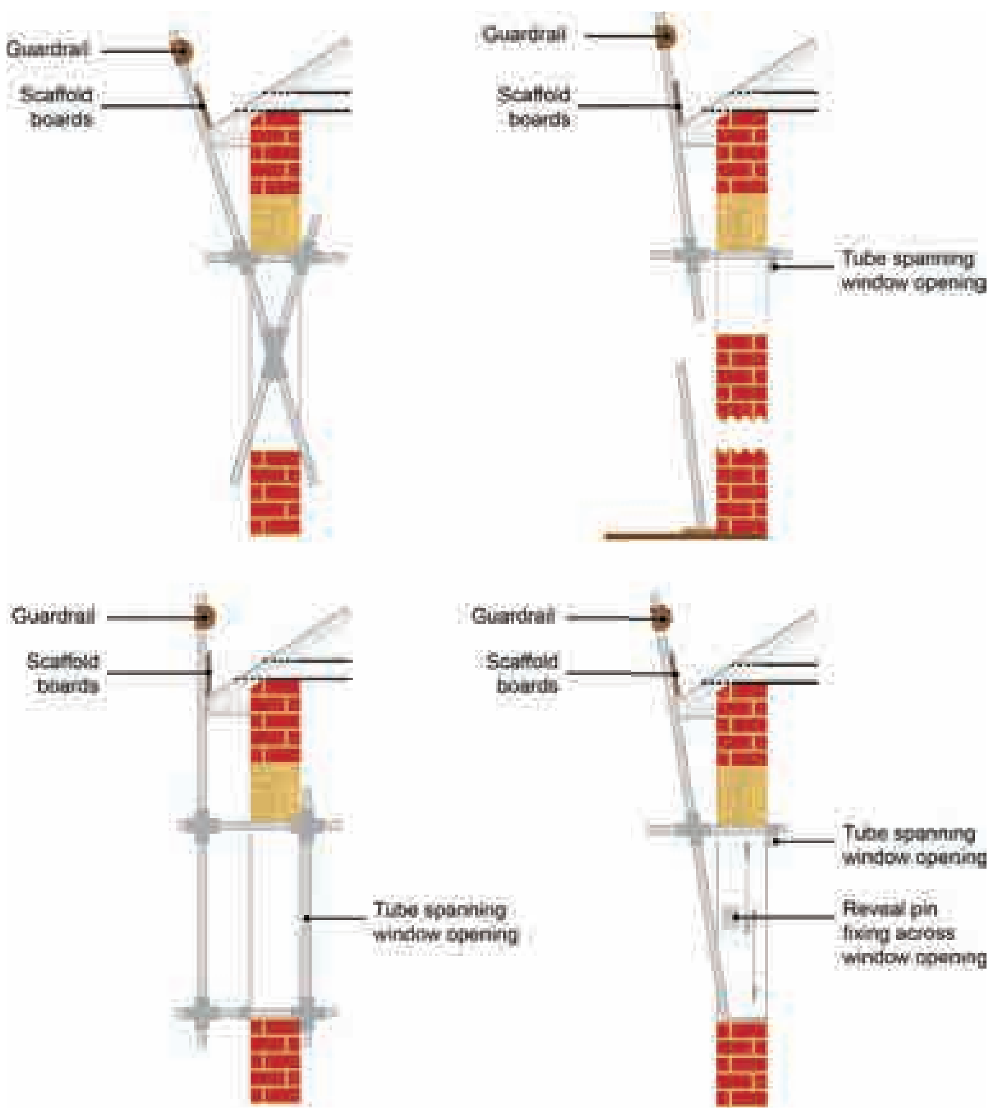
Falls from the edges of sloping roofs generally cause serious injury even when the eaves are low, as on a bungalow. If the person has slipped down the roof from the ridge, considerable acceleration can be generated, which tends to project the person from the eaves, adding to the force of impact with the ground and hence also adding to the seriousness of the injuries sustained.

To prevent people falling from sloping roofs, three basic safety systems have been devised.

Roof Edge Barriers

Roof edge barriers can be constructed using scaffolding tubes and boards. In essence, a guardrail is set up around the eaves which will catch any person who has the misfortune to fall down the roof.

The following figure shows methods which have been suggested for constructing the barriers, depending on the facilities available to secure the structure to the building. When the barrier has been erected, the scaffold boards (or close fencing) must extend to at least 400mm above the roof surface, and the upper guardrail to at least 950mm above the roof surface. The distance between the lower guardrail and the close fencing must not be greater than 470mm.



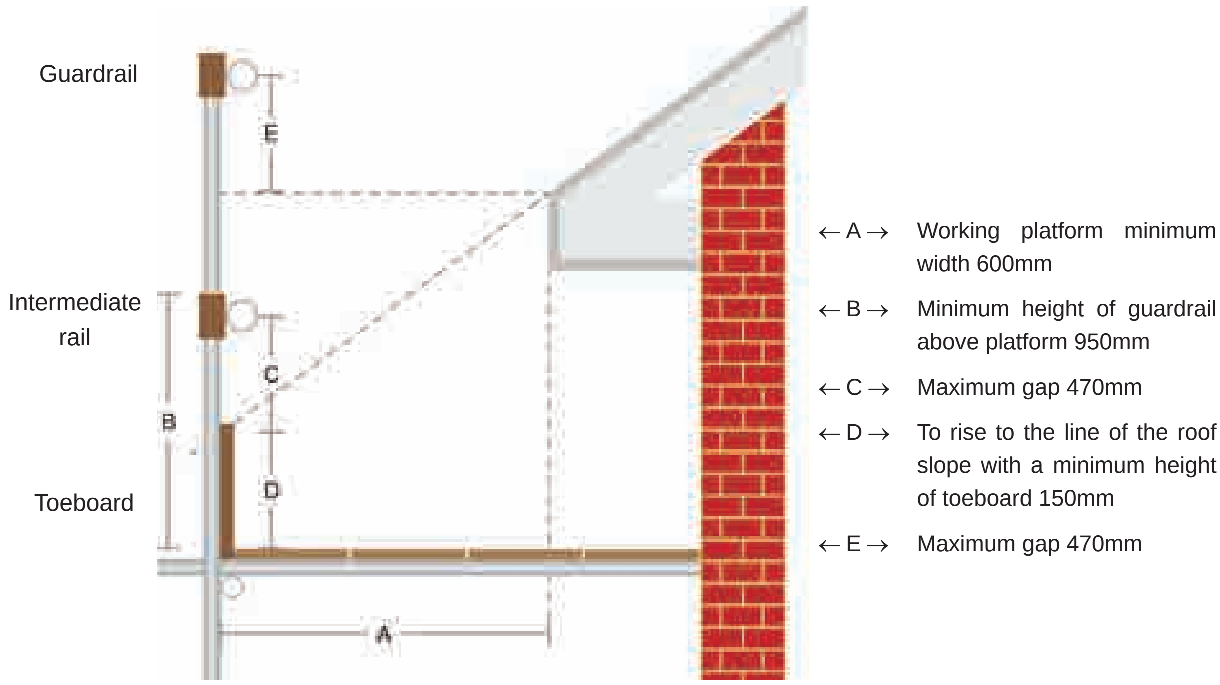
Alternative methods for constructing roof edge barriers

Special Working Platforms

Special working platforms can be erected just below the eaves of the roof, as illustrated in the next figure.

If a normal scaffold platform has been erected, then by modifying the guardrail, protection can be given to allow people to work safely on the roof.

These safety structures are required when work is being carried out on a roof, or if the roof is being used as a means of access to or egress from a workplace.



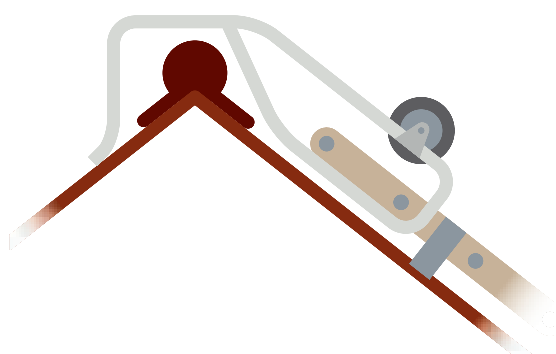
Special working platform with modified guardrails

Roof Ladders

Roof ladders must be suitable for the type of roof on which they will be used.

The roof ladder **must not** be supported by the ridge as ridge cappings and half round tiles are not designed to carry loads. The head board or anchorage should be so constructed that it fits over the ridge and bears on the opposite slope.

Too often, little attention is given to securing the ladder so that it does not slip or tip over; consequently, accidents occur.



A properly anchored roof ladder on a sloping roof

Wind Strengths

We must also take into account problems associated with fluctuations in the strength of the wind. At ground level, the rate of air flow is often reduced by the protection given by buildings, compared with its effect at roof level where a worker is exposed to its full force. Footholds at heights are generally not as good as at ground level and balance becomes a more obvious problem, so the carrying of large items of material, e.g. a roofing sheet or lengths of wide timber, will exaggerate the problem by acting as a 'sail' in the wind. Accidents have occurred when workers have been blown off a roof while handling large items of materials.

Means of Temporary Access

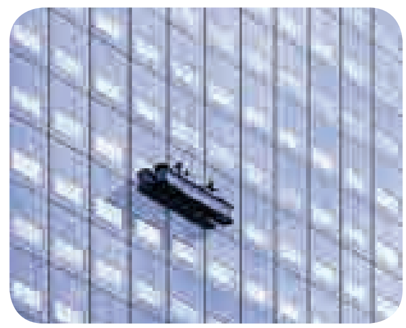
A lot of maintenance work involves reaching parts of plant and structures that may not be readily accessible during normal work operations.

This section looks at the types of access equipment available, the associated problems and precautions to be taken while using the equipment.

Cradles

Use

Suspended access systems (cradles) are most frequently used where it is impracticable or uneconomic to provide scaffolding, and where maintenance work, such as cleaning or light repairs, is necessary on tall buildings or structures.


Suspended access system

More complex systems consist of working platforms which are hoisted from ground level upwards, as the construction of the structure advances.

During the installation and prior to the use of suspended access systems, the advice of a competent person should be sought. Only people trained in the use and control of the system should be permitted to work from the system and, at all times during use, it should be under the charge of a competent person.

Types

Three main types of suspended access supported by fibre or wire ropes and raised and lowered by power or manual operation are in use:

- Hinged suspended platforms.
- Independent suspended platforms.
- Manually-operated cradles.

Each type is suspended from outriggers, tracks or similar means which are secured to the building or structure.

Safety Features

- Hinged Suspended Platform

  This system, also known as an **articulated system**, consists of a number of working platforms hinged together to form a continuous platform.

  The whole platform can be raised or lowered as a unit, or in sections, to give working platforms at various levels. The maximum slope of a platform suspended at an angle must not exceed 15°.

  The platforms are attached by wire ropes to outriggers (metal joists, timber poles, or scaffold tube framework), which in turn are secured to the building with bolts if the system is permanent.

  In the case of temporary systems, counterweights are used to hold down the inboard (i.e. building side) end of the outrigger. Counterweights must be firmly attached to the outrigger, marked with their weight and give a resisting moment of not less than three times the overturning moment.

  Only wire ropes which are individually identified and have suitable terminations should be used. Winches must be strong enough for the work; they must also be tested, thoroughly examined and inspected.

All climbing winches should have fall-arrest devices which hold the load on winch failure.

Working platforms should be not less than 700mm wide when used for people and materials. They should be close-boarded and securely fixed to the equipment framework. The Safe Working Load (SWL) for each section must be prominently displayed on the platform, in addition to the maximum number of people permitted per section.

- Independent Suspended Platform

  This system consists of one working platform which can be raised or lowered, or moved horizontally on a traversing track. Suitable outriggers are rolled sections, similar girders or stiffened steel scaffold poles. The methods of securing outriggers to the building are the same as for hinged systems.

  Where used, traversing track should be an alloy or steel beam, with end stops fixed at each end of the track to prevent the platform running off the end of the track. Winches with fall-arrest devices must be to the same standard as those outlined above.

- Manually-Operated Cradle

  Two types of manually-operated cradle are in common use:

  – Suspended on blocks by natural or synthetic fibre ropes.
  – Suspended on wire ropes with hand-operated lifting appliances mounted on the cradle.

  Cradles may be able to be raised or lowered (i.e. fixed) or raised, lowered and moved horizontally (i.e. travelling).

  Suitable outriggers are timber poles (particularly fir), stiffened steel scaffolding tubes or rolled sections. One outrigger per suspension point is necessary, as above.

  End stops must be provided on traversing track to prevent the cradle running off.

  Where the cradle is:

  – 3.2m long or less, natural or synthetic fibre ropes and pulley blocks can be used for suspending the cradle.
  – Longer than 3.2m, wire ropes attached to lifting appliances on the cradle itself must be used.

  Lifting appliances should have the SWL prominently displayed. Equipment should be manufactured, selected, installed, tested and dismantled so that it is suitable for its intended purpose. The equipment should be designed so that the omission or failure of any individual joint or fixing component does not lead to structural collapse.

Rope Access

Use

Rope access is used for inspections and for some short-term construction work. This technique should only be used where access from a working platform is not practical.

Risk Assessment

A risk assessment must be carried out prior to the use of rope access. In addition, rope access must only be used within a defined system of work. When the system of work is drawn up, account must be taken of general risks from rope-access operations. Attention should also be paid to the particular risks that are present, and can be foreseen, for that specific job. The safe system should specify:

- Rescue arrangements.
- Selection of correct equipment.
- Selection of people with the necessary level of competence.
- Arrangements for control and communication.

Types of Rope Access

- Working in Suspension (Descent and Ascent)

  This type of rope access covers most situations, such as building exteriors. It may fall into the following categories:

  – **Straightforward** - the rope follows a simple, straight path from the anchor point to the ground. Workers can use relatively simple techniques for descent and ascent, as well as rescue.
  – **With deviation** - the rope is pulled a small distance away from the vertical during descent. This is slightly more hazardous than the previous example, and requires slightly more advanced technique.
  – **With 're-belays'** - intermediate anchor points are required between the top and bottom of the descent. A single descent to the ground is not possible, and a major improvement in technique over previous examples is needed. The hazards will increase further if using this method to perform a rescue.

- Without Clear Egress at Bottom

  This method is potentially hazardous. It will therefore require a significant further increase in technique, including competence in long ascents and special rescue methods.

  In any of these cases, the situation may be complicated by other factors, such as:

  – Difficulty in reaching the point of descent.
  – Lack of convenient anchorages.
  – Presence of sharp edges.
  – Complex structure.
  – Busy worksite.
  – Proximity of roads or other public thoroughfares.
  – Other objective dangers.

- Aid Climbing and Traversing

  This type of rope access is used in situations where a special method, making use of special techniques, is needed. The work situation in which a worker carries out the task may be particularly hazardous due, for example, to conditions such as:

  – Heat (e.g. in glass atria).
  – Possibility of falling.
  – Difficulty of rescue.

  A risk assessment must be carried out, and appropriate access, rescue plans and equipment must be provided. Only qualified and trained workers should make use of this method.

Safety Features

The use of rope access can be made less hazardous by following certain safety features:

- A competent person must supervise the erection of all equipment, which must be pre-checked prior to use.
- A competent, trained person only must make use of rope access.
- A single suspension point should not be used. Both the main and safety ropes should be attached to separate suspension points, where possible, to increase the safety of the descent.
- Equipment must be checked before use and maintained to a high standard during use.
- Tools should be attached to the operator by means of ropes or chains to prevent the risk of objects being dropped.
- Where a risk of dropped tools exists, the area below should be fenced off or protected in some way, e.g. with covered walkways.

Work Positioning Systems

Use

Work positioning systems are intended for use by workers who are required to work at height on poles or other structures in a supported position, thereby enabling them to have both hands free for working. Work positioning systems are often used in circumstances where access is required through exposed or multi-storey steel structures. For example, net riggers and painters may use straps to move along girder structures in an under-slung method of work positioning. Alternatively, workers may be required to climb telecommunications towers in order to work in an upright position on overhead lines.

Work positioning is sometimes confused with work restraint systems, which are a type of fall protection.

Types

Work positioning systems usually consist of a waist restraint and a lanyard. A waist restraint is not intended to arrest a fall.

Positioning lanyards are generally constructed of a stretch-resistant material (e.g. stiffened polyester webbing) in 3-6 foot lengths, to help a person with positioning only. For example, they will prevent someone from getting too close to an edge or hazard.

Safety Features

As with all lifting equipment, work positioning systems should be fitted with suitable devices to minimise the risk of the worker falling freely. For example, tree workers (arborists) must ensure that they do not climb above anchor points when using work positioning techniques.

In order to prevent the failure of a work positioning belt, pre-use checks must be carried out prior to work commencing. In addition, regular detailed inspections must also be carried out. Cuts to the fabric or ingress of dirt and UV light can cause damage to the webbing fibres, which can lead to loss of strength.

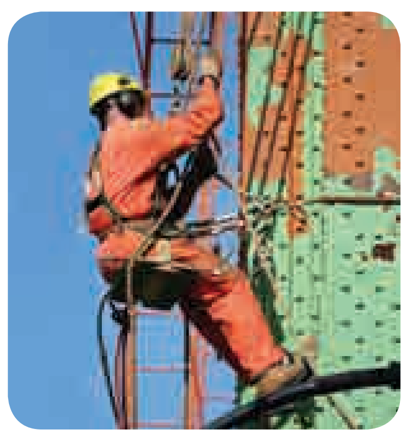
Waist restraints should be restricted to situations where, in conjunction with a lanyard, they prevent the wearer putting themselves in a position where a fall is possible.

Boatswains' Chairs

Use

Boatswains' chairs should not be used instead of suspended scaffolds unless the work itself is of such comparatively short duration, or in such a position, that the use of a suspended scaffold is impossible.

A person in a boatswain's chair is extremely vulnerable. He or she is suspended high above the ground. If anything goes wrong, the chances are that he or she is beyond help. Any incident is likely to be serious, if not fatal.


Boatswain's chair

Types

A boatswain's chair is a suspended chair for one person.

Safety Features

- Should be rigged with a pair of single-sheave pulley blocks. Outriggers or other selected forms of support should be strong enough and be securely held in position by being either bolted down or securely weighted at the tail end to prevent overturning.

- On the chair itself, means must be provided to prevent the occupant from falling out; where possible, a safety strap should be provided.
- The fall rope should always be maintained under or around the cleat provided, to act as a brake.
- All fittings used should be designed so that, when they are assembled, no part can become accidentally detached.
- All ropes and chains should be:
  - Thoroughly examined before use for any sign of chafing or other wear.
  - Securely attached to the anchorage and to the chair, with a swivel connection at the suspension point to prevent spinning.

Use of Personal and Collective Fall-Arrest Devices

Practical examples of the application of the **hierarchy of control measures** for working at height (see Element IC1) include:

- Mitigate by using collective work equipment to minimise the distance and consequences of a fall:
  - Nets and soft landing systems, such as airbags positioned close under work equipment to minimise distance from work surface.
- Mitigate by using personal work equipment to minimise the distance and consequences of a fall:
  - A personal fall-arrest system with the anchorage point sited above the head.
  - Rope access.
  - A work positioning system.
  - A personal fall-arrest system with anchorage level at sternum/dorsal attachment point.
  - A personal fall-arrest system with an anchorage point sited at the feet.

Consequently:

- Collective fall-arrest systems protect a number of persons and include safety nets and airbags.
- Personal fall-protection systems only protect individuals and include belts and harnesses.

Safety Nets

When combined with complete perimeter edge protection, these are the most effective means of securing the fall hazard; they also offer protection to those who work or pass below.

Safety nets:

- Are collective; they secure all persons who go onto the roof.
- Are passive; no action is required to experience protection.
- Should be installed as close as possible to the working platform.
- Should extend the required 'catching width' ahead of any leading edge.
- Can have a debris mesh overlay placed on them to catch small tools and material fragments; this allows work to continue below the leading edge of the roof, which can be a great advantage on critical programmes and in re-roofing applications.
- Should comply with appropriate standards and be erected according to the current standards and codes of practice.
- Require regular inspection and maintenance, as their performance deteriorates over time.

The use of nets is most effective to:

- Prevent injury due to falls from leading edges in new roof building.
- Guard roof lights and fragile materials during cleaning, etc.
- Prevent injury due to falls during roof truss erection.

Airbags

Airbags are designed to reduce the number of injuries and deaths resulting from a fall from height. They:

- Are filled with a type of 'memory' foam that enables them to retain their original shape. At the same time, the airbags provide a more yielding surface on which to fall.
- Can be used in the construction industry to reduce the working height for construction workers to less than 2m. They are particularly useful where it would be extremely difficult or impossible to provide secure fencing to protect workers. Instead, the height is reduced and the bags themselves will protect the workers should a fall occur.
- Should be positioned correctly before work begins; it is important to ensure that this is the case. Bags should be clipped together to ensure that they will not separate should anyone fall onto the junction between two bags.
- Should be checked when re-positioned or after a fall has occurred to ensure that they have not been damaged.
- Should be used as a last resort and not relied on as the one and only control measure.

Belts

Some aspects of steel erection may permit the use of belts, as may maintenance work of short duration and window cleaning.

Although workers are often tempted to wear belts rather than harnesses, harnesses give a falling person a far greater chance of avoiding serious injury.

Even after a fall of one or two metres, tremendous force is exerted on a body which is suddenly restrained by a safety rope or wire. However, the problem can be largely overcome by the use of a harness, which spreads the load more widely, or by using shock absorbing lanyards or fall-arrest blocks.

Harnesses

The provision of a safe place of work and system of work to prevent falls should always be the first consideration. However, safety harnesses can provide vital protection in some circumstances.

Worker using fall-arrest equipment - note the full body harness with lanyard attached at the back

Remember, a harness will not prevent a fall - it can only minimise the risk of injury if there is a fall. The person who falls may be injured by the shock load to the body when the line goes tight, or when they strike or rebound against parts of the structure during the fall. A shock absorber fitted to the harness lanyard can reduce the risk of shock loads. In any case, allow for a free-fall distance of no more than 2m.

Attach the harness lanyard above the wearer where possible. Additional free movement can be provided by using running lines or inertia reels. Any attachment point must be capable of withstanding the shock load in the event of a fall - expert advice may be needed.

Employers should consider how they will recover anyone who does fall and make sure everyone knows how to check, wear, adjust and attach their harness before use.

STUDY QUESTIONS

8. List five precautions to be taken when using portable ladders.
9. Explain, giving an example, when a cradle might be used to gain access for maintenance.
10. Describe where the use of nets is most effective.
11. When using a harness, where should the harness lanyard be attached to a secure anchor point?

(Suggested Answers are at the end.)

Demolition Work

IN THIS SECTION...

- The main techniques in demolition of buildings include demolition by hand, pusher arm method, deliberate collapse method, use of demolition ball and mechanical means.
- Associated hazards and control measures involve falling materials associated with premature collapse of buildings or with the materials of construction, and the need for careful planning to address structural surveys and surveys for hazardous substances, provision of working places and means of access/egress, use of method statements and permits-to-work, security of site boundaries and protection of the public.

Main Techniques Used in Demolition of Buildings

The table that follows gives guidance on methods of demolition for various structures.

BS 6187:2011 Code of Practice for Full and Partial Demolition

Type of Structure	Type of Construction	Method of Demolition			
		Detached Building		Attached Building	
		Isolated Site	Confined Site	Isolated Site	Confined Site
Small and medium two-storey buildings	Load-bearing walls	ABCDM	ABDM	ABDM	ADM
Large buildings three storeys and over	Load-bearing walls	ABDM	ABDM	ABDM	AD
	Load-bearing walls with wrought iron and cast iron members	ABDM	AM	AM	AM
Framed structures	Structural steel	ACM	AM	AM	AM
	In situ reinforced concrete	ADM	ADM	ADM	AM
	Pre-cast reinforced concrete	ADM	ADM	ADM	AM
	Pre-stressed reinforced concrete	ADM	ADM	ADM	AM
	Composite (structural steel and reinforced concrete)	ADM	ADM	ADM	AM
	Timber	ABCDM	ABDM	ABDM	ABDM
Independent cantilevers (canopies, balconies and staircases)		ADM	ADM	ADM	ADM
Bridges		ABCDM	ABCDM	AM	AM
Masonry arches		ACDM	ACDM	ACDM	ACDM
Chimneys	Brick or masonry	ACD	A	ACD	A
	Steel	AC	A	A	A
	In situ and pre-cast reinforced concrete	AD	A	AD	A
	Reinforced plastics	AC	A	A	A
Spires		ACD	A	A	A
Pylons and masts		AC	A		

Key to letters in table:

A Hand demolition
B Mechanical demolition by pusher arm
C Mechanical demolition by deliberate collapse
D Mechanical demolition by demolition ball
M Demolition by other mechanical means
(excluding wire-pulling)

(Methods may be combined, and explosives may be used where appropriate.)

Demolition by Hand

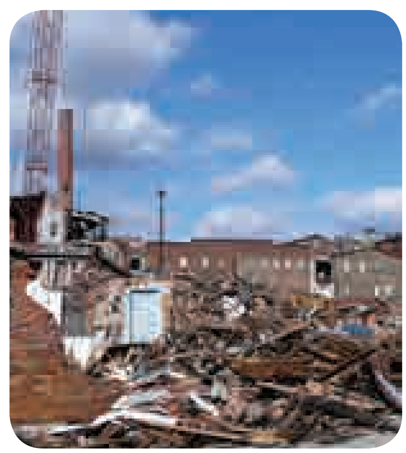
This process tends to follow the reverse order of construction technique; the building is gradually dismantled using hand tools and the loose material lowered to the ground by cranes or conveyed down a gravity chute to a skip or pile. Material should be dropped directly only when **no other way** is possible, and this must be carried out under a strict safe system of work scheme, which must include a lookout person to see that the ground area is cleared and no one enters the danger zone.

As structures are usually gutted before demolition takes place in order to salvage reusable construction material, e.g. floorboards, operatives may have to work in areas where there is a high risk of falls occurring. Care must be taken to see there is always a safe means of access to and egress from the work area (see later in this section). Debris build-up at high levels and against the walls of a structure must also be carefully controlled.

Use of Demolition Ball

Use of a demolition ball suspended from a crane, or an excavator converted to a crane, is a common technique in demolition, and requires considerable skill on the part of the operator to use it in a safe manner. The demolition ball consists of a large steel pear-shaped ball suspended from the jib of an appliance. It is used in three main ways:

- By raising it to a height and then allowing it to fall vertically onto a structure.
- By swinging it forward into a structure in line with the jib of an appliance.
- By swinging it sideways by slewing the jib of an appliance.



Demolition in progress

Precautions in the use of demolition balls can be summarised as follows:

- The manufacturer's advice should be sought as to the permissible weight of the ball and the type of operations which may be carried out without risk.
- Drag lines must be attached to the ball to control its operation. They prevent overswing and act as an anti-spin system.
- Operators must be well-trained and supervised, and must operate the demolition ball only when the appliance is stationary and on flat ground.
- The ball should not be directly joined to a wire rope on the appliance. A length of chain should be interposed which is capable of withstanding the rough treatment sustained by the ball and its immediate connecting section.
- The cab of the appliance should be protected by extra guarding structures able to withstand possible impact by flying debris. The windows should be shatterproof.
- A lookout must always be posted when ball demolition is being carried out and no unauthorised persons should be allowed in the working area.

- Because of the type of operations carried out, all equipment should be subjected to regular and rigorous maintenance checks. Connectors, ropes and chains should be checked at least twice during a working day when in constant use.
- Tall buildings should be reduced to about 30m before ball demolition is carried out.

Pusher Arm Method

In this method, an excavator is fitted with an extended arm which has a steel pad on its end. The pusher arm operates by pushing into the structure being demolished. As the material is being pushed in, this technique enables considerable control of the falling debris and therefore reduces demolition risk. One limitation is that the pusher arm has limited reach and the temptation to gain height by moving the appliance onto debris must be prevented by vigilant supervision.

Operating a pusher arm appliance is a very skilled job and the driver should be well trained. Operation of the appliance should conform to the manufacturer's instructions. The cab of the appliance should be made of steel with a cover of heavy gauge steel bars; shatterproof windows must be used.

Deliberate Collapse Method

This is an economical method of demolition which relies on removing key structural members so the remaining structure collapses under its own weight. There are inherent hazards with this method:

- The structure may collapse to a greater extent than expected.
- The planned collapse may only partially take place and a very insecure and hazardous structure will remain.
- Considerable amounts of debris may be projected over a wider area than expected, with the possibility of hitting unprotected persons.
- The collapsed structure may leave a difficult and dangerous pile of debris to be removed.

Another method of creating a deliberate collapse is by attaching a wire to the structure and pulling away the main supports using a heavy tracked vehicle or a winch to provide the motive power. Apart from the problems noted above, other problems arising are:

- Overstressing of the wire rope.
- Breaking of the wire rope and the resulting whiplash.
- Overturning of the winch or tracked vehicle.
- Inadequate power to complete the operation once it has begun.

Where deliberate collapses are engineered, it is recommended that no one should be nearer to the building than twice the height of its highest part.

Mechanical Means

In theory, the safe way to demolish a structure is to reverse the order used for its construction. However, the process may be overridden by controlled collapses or mechanical destruction, which give a very quick and economical way to reduce a structure to a removable pile of rubbish. When utilising mechanical demolition, the driver is protected from falling materials by a cage.

Mechanical means of demolition

Typical Hazards

Falling Materials

This can be due to the intentional throwing down of materials or an unexpected collapse of part of the structure.

Premature Collapse of Buildings

The main causes of accidents are premature collapse of buildings and structures; and falls from working places or access routes. A common feature of many of these incidents is a failure to plan the operation at an early stage. Lack of planning often leads to workers devising their own means of access and methods of work, both of which are inherently dangerous.

Whenever possible, methods of work should be used which make it unnecessary for people to work at heights. Where this is impracticable, methods such as deliberate controlled collapse, which reduces work at height, should be used.

Materials of Construction

The materials of construction and the method of construction will have a considerable bearing on the method chosen and the sequence of work.

Control Measures

Planning

The client should prepare pre-construction information and provide information relating to the health and safety file to the co-ordinator. Details should include:

- A general description of the work.
- Details of timings within the project.
- Information required by potential principal contractors to demonstrate competence or adequacy of resources.
- Details of risks, as far as can be established at that stage.
- Information for preparing a health and safety plan for the 'construction phase' of the work.

If the owner cannot provide details and building drawings, or if a surveyor's report associated with any change of ownership is not available, an experienced structural engineer or surveyor should be employed to obtain this information. In premises such as factories, hospitals and other buildings where chemicals may have been stored or used, the hazards associated with such substances, including radioactive materials, should be known to the owner, but if the site has lain idle or changed hands since, the services of a competent analyst may be required. The previous use of the building may have produced hazards requiring the person undertaking any survey to take precautions for their own health and safety.

Structural Surveys and Surveys for Hazardous Substances

It is essential to understand how a building is put together. It is important to determine the **structural condition**, as deterioration may impose restrictions on the demolition method. There may be seriously weakened structural members or connections due to corrosive atmospheres or arising from the process used on the premises, or the structure may be dilapidated through exposure to the elements or vandalism.

The building may also contain hazardous substances such as:

- Asbestos.
- Lead.
- Residual flammable materials.
- Pathogens (disease-causing micro-organisms) which may lie dormant in the structure.

It is therefore necessary to survey the site for the presence of such materials before demolition begins; otherwise workers may be exposed to airborne hazardous substances.

Provision of Working Places and Means of Access/Egress

The very nature of demolition work creates serious difficulties in maintaining a safe means of access and egress for workers; it is therefore necessary to keep the problem under review and update safety systems as conditions change. One of the basic means of maintaining safe access is by maintaining housekeeping at a high standard. Where scaffolding is used, platforms and gangways must be kept free from debris and tripping hazards. The security of scaffolds is important and continued surveillance is required to see that when the structure is demolished sufficient ties are maintained with the building.

Where there is a possibility of falling debris injuring workers or pedestrians, protective fans must be constructed. It is important to remember that fans are not designed to carry heavy loads and regular inspection must be made to see that debris which has inadvertently fallen is cleared away.

Securing of ladders is another problem area. As the structure is lowered and ladders are removed to lower levels, or moved to different positions, the temptation to put them in position and go back to work without making them secure is ever-present.

Some operations require the demolition worker to occupy precarious positions where it is not possible to provide an adequate safety structure. Here it becomes crucial that safety harnesses are used and attached to a secure part of the structure. Where floors have been removed, some boards should be left so that a skeleton floor structure remains to allow work to proceed in relative safety.

Use of Method Statements and Permits-to-Work

The proposed demolition should be recorded in a method statement, which should also include **drawings or sketches** clearly showing:

- The sequence of operations.
- Details of the machinery and equipment to be used, including personal protective equipment.
- The activity of the labour force.

Where possible, operations in which there is a need for a **permit-to-work system** should be identified.

Security of Site Boundaries

A considerable amount of demolition is carried out by undermining a structure and causing collapse of material. The amount of material will vary, but irrespective of the quantities involved, one general principle which emerges is the **need to isolate** the demolition area so that potential hazards may be confined. This precaution will also help to exclude from the site persons not directly involved in the work.

The methods used will vary depending on the nature of the demolition. Ideally some form of high fencing or board about 2.5m high should be erected around the site where the public could be at risk. In areas restricted from the public, rope and spigot barriers decked overall with plastic strips are satisfactory. Warning notices must be set up around the barriers being used.

Where space is limited, scaffolding will have to be erected around the site, and protective screens and fans constructed to reduce the possibility of debris falling onto pedestrians. Broken glass from windows can be a hazard to workers, but if window panes can be removed without indiscriminate breakage, this hazard can be reduced. Window and door frames should be left in a structure until the last possible moment, as they can be used to advantage by providing structural support for a building while demolition is taking place.

Protection of the Public

Demolition is frequently carried out near highways or areas to which the public have access. Because of the public's unfamiliarity with the dangers, their curiosity about the work and the number of people that can be at risk, high standards of site protection, safe systems of work and effective supervision of the work are needed.

At all sites where it is reasonably practicable, a **fence** should be erected enclosing all the demolition operations. The fence should **not be less than 2m high** and should not be capable of being easily climbed. Access gates should be secured outside working hours. Danger notices should be displayed.

At some sites it may not be reasonably practicable to erect a perimeter fence. In such cases, excavations should be fenced, vehicles and plant should be effectively immobilised and electricity and gas supplies should be isolated or enclosed in locked compounds. Outside working hours, ladders which provide access from the ground to the first landing place should be removed and stored in a secure area.

It may be a necessary precaution to provide debris fans and facade netting to prevent people being accidentally struck by falling objects. Where debris fans are provided, they should not be used as a means of access by the labour force or allowed to become loaded with debris.

STUDY QUESTIONS

12. Outline the following demolition methods:

    (a) Demolition by hand.

    (b) Mechanical demolition by demolition ball.

    (c) Mechanical demolition by deliberate collapse.

13. What are the typical hazards associated with demolition?

(Suggested Answers are at the end.)

Excavations

IN THIS SECTION...

- Excavations can cause fatal accidents due to:
  - Collapse.
  - Work in confined spaces.
  - Persons, objects and vehicles falling into the excavation.
  - Groundwater.
- Contact with buried services such as underground electricity, gas and water is a serious risk associated with excavation work.
- During excavation work, temporary shoring systems provide safety for workers in a trench.
- To prevent contact with buried services, plans should be consulted and cable locating devices used. Precautions include safe digging practices and trenchless methods.
- Excavators are heavy construction plant used to dig trenches, holes or foundations. Most accidents occur by striking persons with the vehicle or the bucket, or trapping persons between the excavator and fixed structures.
- The **ILO Code of Practice - Safety and Health in Construction** (Section 9.2) details standards for inspection and examination of excavations.

Hazards and Controls Associated with Excavation Work

Excavations can cause fatal accidents due to:

- Collapse.
- Work in confined spaces.
- Objects (persons, building materials, dumper trucks) falling into the excavation.
- Groundwater.
- Buried services.

The air in a deep trench (a confined space) can be contaminated by toxic gases (such as CO_2, CO, H_2S, petrol vapour, LPG) and the oxygen level may drop. Such a space requires a permit-to-work system.

Excavations can cause fatal accidents

Collapse

Excavations are particularly related to the construction of foundations, drainage work and site regrading. The main hazard associated with excavation work is ground collapse; no soil can be relied upon to support its own weight for any length of time, a factor which becomes increasingly important as additional loads are applied, such as those from plant and materials.

Even a minor collapse of ground can cause serious injury (1m^3 of earth weighs approximately 1.3 tonnes).

If an excavation cannot be battered (sloped back) to a safe angle, the sides will require support to prevent the possibility of collapse. When a fall occurs, the worker will most likely be knocked over and the weight of the soil on the body will be sufficient to cause a serious crushing injury (or be fatal), even if the arms, head and shoulders are not covered.

9.6 Excavations

There is a widespread belief among those who investigate excavation accidents that they are caused by a general lack of knowledge about the structure of soils among those involved in digging operations. Many excavation collapses occur during the first day of the dig; some are delayed for several hours, while others can occur within minutes. The time factor often depends on the type of soil involved and the soil structure. Equivalent soils may not exhibit the same hazardous nature if their structures differ.

Preventing Collapse

Excavation collapses may be prevented if:

- Workers are trained in the safe installation of basic systems of safety.
- Basic safety equipment is provided on site, and used.
- Adequate and competent supervision is provided to ensure that correct safety precautions are observed, and assessments are made of changes in conditions which might necessitate changes in levels of safety.

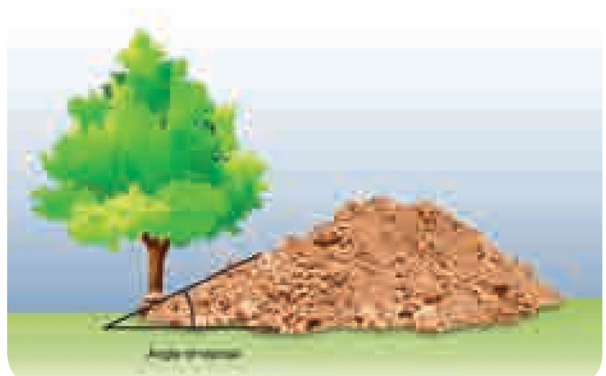
Basic Excavation Support Systems

The main function of excavation supports is to prevent falls of material into the excavation and to allow work to proceed safely and without interruption. The type of support structure will vary in design depending on the soil conditions and the type of excavation, e.g. trenches or pits.

Battered Sides

This technique will allow almost any excavation to be carried out safely **without** the need for a support system. The technique relies on the property of particulate materials to form a stable sloping pile when allowed to form naturally into heaps. The sloping surfaces of the heap form an angle with the horizontal called the **angle of repose**. Each material has its own particular angle of repose, which will differ with the moisture content.

The way to demonstrate the variations of the angle of repose between materials is by taking a quantity of material and pouring it into a pile on a flat surface.


The angle of repose

If an excavation is carried out and the side sloped back to the angle of repose, then the soil will support itself without the need for extra support. It is important that the angle of repose of the soil being excavated is known, especially if the soil has several strata, and also that the battered sides are kept at this angle during the digging operation. The technique has one drawback, in that it requires considerable space in which to construct an excavation, but it should be remembered that accidents in correctly battered excavations are very rare. Note that predictability is limited to uniform soils of known water content.

Double Sided Support

In this system, the soil on each side of the excavation is supported by a structure which is held in position by forces transmitted through waling and struts from opposite faces. Provided the support system is strong enough, an equilibrium is set up which keeps the structure secure.

The technique is widely used not only in trenches with two faces, but in pits or shafts with four faces. It has the disadvantage that the struts tend to impede the working space. As the structure relies heavily on secure strutting, it is very important that they are securely fixed to prevent 'accidental' removal (deliberate or otherwise).

Access

The use of access ladders which are badly sited (both on the floor level of the excavation and in respect of the overhang available to get onto the ladder at ground level) can lead to people slipping or falling off.

A safe means of access and egress must be provided for all excavations. Ladders provide the main method for access and egress and care should be taken to see they are in good condition. They must be suitably secured to prevent undue movement and extend above the excavation to give the necessary height required for a safe hand-hold. To allow for adequate means of escape in an emergency, it is considered that one ladder every 15m is an average to work to, but **more** may be required depending on the number of workers and the potential risk, e.g. where there might be a possibility of flooding from a rising water table.

Handrails must be provided around every accessible part where a person is liable to fall. Gangways across excavations should have guardrails and toeboards.

As most excavations requiring support are not completed during a day's work, consideration has to be given to lighting, either for the purpose of warning of the potential hazards or for illuminating working areas.

- Battery-operated or paraffin units are often satisfactory for warning lights.
- For workplace illumination, high-powered electric lights or those which operate from liquid petroleum gas (LPG) will be needed.

Falls of Persons, Objects and Vehicles

Unprotected edges to the excavation allow people, materials or vehicles to fall in, often through not noticing the hole.

Where a person may fall into an excavation, the edge must be protected by barriers or the excavation securely covered.

It is important when plant is being used that adequate stops or wheel chocks are put in place to prevent vehicles from running into the excavation. Badly constructed ramps used for vehicular access to the excavation can cause vehicles to topple over into the site.

Safe control of material being dug from an excavation is generally covered by checking that any stock piles are set well back from the edge of the excavation. This will cover two possible problems:

- Materials falling back into the excavation.
- The weight of excavated material undermining the edges of the excavation.

Use of Transport

Materials stored or machinery/vehicles working or parked too close to the edge of the excavation can make them liable to fall in if there is any collapse of the ground around the edge. (The vibration caused by machinery may contribute to such a collapse.)

Flooding

Flooding may occur as a result of:

- Weather conditions (rain or melting snow).
- Digging into and beyond the natural water table of the land.
- Disruption to the natural drainage flows within the ground.
- Changes in the level of the water table (as a result of rainfall).

This is unlikely to present a significant risk to people working in the excavation except where a watercourse is breached and there is a massive surge of water into a confined space such as a trench.

The flooding of excavations by water is a common accident situation and may occur **naturally** or as a result of an **unexpected** encounter with a large water pipe or drain.

Dealing with a burst pipe is generally fairly straightforward, after a suitable valve has been located and closed. Dealing with the problem of natural water may not be so easy.

Buried Services

The term 'buried services' means all underground electricity, gas, water (including piped sewage), and telecommunications systems.

Types and Consequences of Damage

- Electrical Cables

  Every year many workers digging on building sites and roadworks have narrow escapes when they accidentally hit live buried electricity cables; others are not so lucky and suffer burns, which may prove fatal.

  Injuries resulting from damage to live electricity cables are usually caused by the explosive effects of arcing current and by associated fire or flames which may follow when the sheath of a cable and the conductor insulation are penetrated by a sharp object such as the point of a tool.

  When a cable is crushed severely enough to cause internal contact between the conductors, this causes severe and potentially fatal burns to the hands, face and body. Direct electric shock is rare but not impossible.

  Buried electrical cables were covered in more detail earlier (see Element IC8).

- Gas Pipes

  Damage to gas pipes can cause leaks, which may lead to fires or explosions. There are two types:

  - Damage which causes an immediate leak - a risk to people carrying out work and to others in the vicinity.
  - Damage which causes a leak at a later date. This damage may occur at the time the work is carried out, e.g. damage to a pipe wrapping may eventually lead to corrosion; or subsequently, e.g. reinstatement may leave a pipe inadequately supported or subjected to unequal forces.

A shallow excavation revealing a collection of buried services

- Water Pipes and Sewers

  Damage to water pipes is less likely to cause injury but a jet of water from a high-pressure main could injure a person or damage adjacent services.

  A leak of water from an underground pipe could wash away subsoil and reduce the support for adjacent services, highways and structures. Further dangers include the risk of flooding the trench or low-lying areas such as nearby basements.

  Some sewage is pumped at pressure. The main danger from damage to a sewer is the possibility of contamination.

- Telecommunication Cables

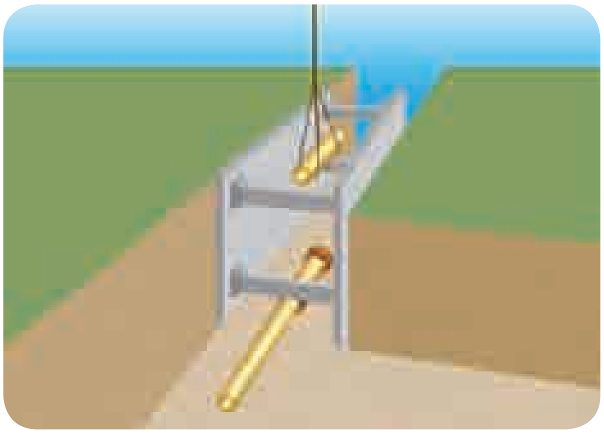
  Although damage to telecommunication cables can be very expensive, there is not usually a risk of personal injury.

Temporary Shoring

During excavation, temporary shoring systems provide safety for workers in a trench. Shoring is designed to prevent collapse, whereas shielding is only designed to protect workers when collapses occur.

Shields or Drag Boxes

These devices are provided mainly as protection for workers in the excavation rather than for excavation support. Side sheets are kept apart by struts which span the width of the device, thus producing a rigid box. As work advances, the box is pulled forward by the excavation machine to the next work location.



Rigid strut-type drag box

Steel Sheet Piles

Steel sheet piles are used for permanent and temporary works structures. The section of the pile interlocks and produces a continuous wall with a succession of closely fitting joints. Pile sections are designed to be as light as possible without compromising strength and durability. The design of the interlocks provides a watertight joint.

Shoring the sides of an excavation by 'close sheeting'

Methods of Checking for Buried Services

We have already examined the detailed requirements for safe working near underground cables. The methods of checking for buried services and the precautions to be observed are summarised below:

- Consulting Plans
  - Contact the owner of the cables and obtain plans (where they are available) showing the approximate line and depth of known cables.
  - Water, gas and telecommunications companies should be able to provide plans of their respective buried services.

- Cable Locating Devices
  - Trace the position of cables as accurately as possible with a cable locating device in conjunction with any available cable plans.
  - Operators of detection devices must be fully conversant with the instruments and must be trained in their use.
  - Detection devices should be regularly checked and maintained in good working order.
- Safe Digging Practices
  - Underground cables can often be found just below the surface and therefore even the shallowest excavation may be a source of danger.
  - Once the approximate position has been determined, expose buried cables by using hand tools with care using spades and shovels rather than forks or picks.
  - Keep a careful watch for evidence of cables during digging work and repeat checks with a cable locator.
  - Where practicable, do not use power tools within 0.5m of the indicated line of a cable, and never over the line of the cable.
  - If necessary, dig carefully by hand under the surface to locate the cable.
  - If you have to break away or disturb concrete in which cables are embedded, the cables should be made dead or an alternative safe method of excavation agreed with the electricity company or other owner of the cable before work starts.
  - If you are in any doubt about whether an exposed service is a live or dead cable, a water pipe or other service, **treat it as a live cable**.
  - Continuous supervision must be exercised as a hole or trench proceeds. Cable locators should be used frequently to confirm the lie of a cable.
  - Any cables exposed must be suitably protected to prevent damage. Where a cable exposed for more than 1m crosses a trench, it must be adequately supported to prevent sag damage.
  - Precautions should be taken to prevent access to exposed cables by children or unauthorised people.
  - Care must be taken when backfilling to ensure that cables are not damaged. Concrete backfill should not be used within 300m of a gas pipe. All protection devices for cables must be replaced before backfilling.
  - Cast iron water pipes look very like cast iron gas pipes. If you uncover a cast iron pipe, treat it as a gas pipe.
  - Do not work bare-chested. Experience suggests that normal work clothing (except man-made fibres such as nylon) can provide some protection from flash burns and reduce the degree of injury in the event of damage to a cable.

Using a cable locator
Source: HSG47 Avoiding danger from underground services, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg47.pdf)

Trenchless Methods

Trenchless methods are increasingly being used for laying and renovating buried pipes and cables where there is a need to avoid surface disruption. These involve use of tunnelling machines (moles).

Plans, locators and trial excavations should be used to locate existing services in the same way as for traditional excavation methods.

As a general guide, the minimum clearance between adjacent services should be either one and a half times the diameter of the pipe being laid or 150mm, whichever is the greater.

Moles are prone to deflection from their original course and if there are existing services in the vicinity, a mole-tracking device should be used.

Training

Anyone who works near underground services should be properly trained in safe procedures. Information issued to employees can usually supplement this training and act as a reminder of the main points. The training should cover the following key areas:

- Advice to site personnel when working near underground services.
- Actions to be taken:
  - Before starting work.
  - When you start work.
  - If you suspect a gas leak.

A record of all training should be kept.

Use of 360° Excavators

Excavators are heavy construction plant used to dig trenches, holes or foundations. The excavating bucket is attached to a hydraulic arm mounted on a rotating platform, along with the operator's cab, on tracks or wheels.

Excavator

Most accidents occur when the excavator is:

- **Moving** – and strikes a pedestrian, particularly while reversing.
- **Slewing** – trapping a person between the excavator and a fixed structure or vehicle.
- **Working** – when the moving bucket or other attachment strikes a pedestrian or when the bucket inadvertently falls from the excavator.

The main precautions needed to control excavator hazards are:

- **Exclusion**: people should be kept away from areas of excavator operation by the provision of suitable barriers. Most excavator-related deaths involve a person working in the vicinity of the excavator rather than the driver.
- **Clearance**: when slewing in a confined area, the selection of plant with minimal tail swing is preferred. Clearance of over 0.5m needs to be maintained between any part of the machine and the nearest obstruction.
- **Visibility**: excavators should be equipped with adequate visibility aids to ensure drivers can see areas where people may be at risk from the operation of the machine.
- **Signaller**: a signaller should be provided in a safe position to direct excavator operation and any pedestrian movements.
- **Bucket attachment**: quick hitches can be used to secure buckets to the excavator arm but need to be managed carefully. A number of deaths have occurred in recent years when the bucket has fallen from the machine.
- **Training and competence**: drivers, signallers and pedestrians on site should be trained and competent regarding the excavator hazards and precautions.
- **Inspection and maintenance**: a programme of daily visual checks, regular inspections and servicing schedules should be established in accordance with the manufacturer's instructions and the risks associated with each vehicle.

Inspections and Examinations of Excavations

The **ILO Code of Practice - Safety and Health in Construction** (Section 9.2) details standards for inspection and examination of excavations:

- An excavation should be thoroughly examined by a competent person.
- The working part of an excavation should be inspected once a day (or, if greater than two metres, before each shift).

The following list details the major points that should be checked:

- An adequate supply of suitable quality support material, which has been inspected and passed by a competent person, should be available in order to carry out excavations safely.
- Adequate provision should be made before working commences and during the work to secure the stability and security of any part of a structure.
- Support work involving erection, alteration or dismantling should be done only by, or under the direction of, a competent person.
- No person should work in an excavation before it has been competently examined.
- Materials, plant or equipment should not be sited near the edges of excavations in a manner likely to endanger persons working in the excavation. When material or equipment is being placed into an excavation, it should be done in a safe manner.

DEFINITION

QUICK HITCH

A quick hitch on an excavator is a latching device that enables attachments to be connected to the dipper arm of the plant and interchanged quickly. An excavator operator may change the bucket on his excavator up to 30 times a day in order to maximise the machine productivity.

Approximately 13% of all accidents investigated on excavators are attributed to the bucket detaching from a quick hitch and injuring a ground worker. These are mostly fatal and major injuries. However, there may be many more dangerous occurrences when a bucket detaches unintentionally from the hitch, but no injury results because no one is underneath at the time. This means that quick hitch failures are relatively common, although injuries are less so.

STUDY QUESTIONS

14. Identify the common hazards associated with excavation work.
15. What precautions must be taken to prevent people falling into an excavation?
16. Explain what is meant by 'angle of repose'.
17. When must the working part of an excavation be inspected?

(Suggested Answers are at the end.)

Summary

The Scope and Nature of Construction Activities

We have:

- Identified the different types of construction work, the range of construction activities and the particular issues that can affect the risks to safety and health of those persons involved.

The Management of Health and Safety on Construction Sites

We have:

- Outlined the respective roles and responsibilities of clients, designers/engineers/architects, co-ordinator, principal contractors and contractors.
- Noted the need for planning, co-ordination and notification.
- Described the content of the construction phase plan and the health and safety file.
- Noted the relevance of site layout, including access and egress and protection of the public.
- Considered the use of method statements and permits-to-work.

Protecting Employees and Others During Construction Work

We have:

- Set out the elements of site security, including perimeter fencing, signs, safe viewing points, means of securing plant/chemicals and means of controlling dangers such as mud on public highways.
- Explained the arrangements for protecting employees and others, including site rules, co-operation, and shared facilities (first-aid and welfare facilities).
- Noted that the Principal Contractor is responsible for ensuring that site inductions are in place and carried out for all workers and visitors to the site.

Working at Height from Fixed or Temporary Platforms

We have:

- Explained the hazards associated with working at height, which include:
  - Falls from roofs.
  - Falls through roofs.
  - Bad storage of materials.
  - Insufficient guarding or edge protection.
  - Unsatisfactory access or egress.
  - Incorrect method of getting equipment or tools from ground level to the working platform.
- Noted the precautions required for the safe use of temporary (immobile) access equipment, which includes:
  - Ladders.
  - Trestles.
  - Simple independent scaffolds.
  - Tower scaffolds.

- Explained that erecting and dismantling scaffolds and falsework is a high-risk activity and therefore scaffolders must follow safety systems during such work and precautions must also be in place to prevent scaffold collapse during use.
- Explained how the risk of falling materials should be minimised by:
  - Keeping the work area clear of loose materials.
  - The use of brick-guards and toeboards.
  - The use of waste chutes.
  - The erection of fan guards.
- Noted that to ensure safety during roof work, precautions are needed for work on fragile roofs and appropriate edge protection should be provided for flat and sloping roofs.
- Explained temporary access equipment such as cradles, boatswains' chairs, rope access and work positioning systems, and their safety features.
- Examined the use, application, selection and precautions in use of personal and collective fall-arrest devices such as safety nets, airbags, belts and harnesses.

Demolition Work

We have:

- Explained the main techniques used in demolition of buildings and also the associated hazards and safe working practices with particular reference to:
  - Falling materials associated with premature collapse of buildings or with the materials of construction.
  - The need for careful planning to address structural surveys and surveys for hazardous substances, provision of working places and means of access/egress, use of method statements and permits-to-work, security of site boundaries and protection of the public.

Excavations

We have:

- Examined how excavations can cause fatal accidents due to:
  - Collapse.
  - Work in confined spaces.
  - Persons, objects and vehicles falling into the excavation.
  - Groundwater.
  - Buried services.
  - Contaminated air.
- Explained that contact with buried services such as underground electricity, gas and water is a serious risk associated with excavation work and that to prevent contact with buried services plans should be consulted, cable locating devices used, as well as precautions such as safe digging practices and trenchless methods.
- Explained that excavators are heavy construction plant used to dig trenches and that most accidents occur by striking persons with the vehicle or the bucket, or trapping persons between the excavator and fixed structures.
- Noted that the **ILO Code of Practice - Safety and Health in Construction** details standards for inspection and examination of excavations.

Exam Skills

QUESTION

An independent tied scaffold to a new ten-storey office block has collapsed into a busy street.

(a) **Outline** the factors that may have affected the stability of the scaffold. **(8)**

(b) **Outline** the main principles of scaffold design, erection and use to ensure the stability of such a scaffold. **(12)**

Suggested Answer Outline

In this question you are asked for a lot of information – the question calls for an "outline" so it is likely that the examiner would be looking for 8 pieces of information in part (a) and 12 in part (b). You aren't therefore required to give a great deal of depth – so detailed knowledge of scaffolding design and construction isn't needed, just a good appreciation of causes of collapse and safe construction.

(a) In this section examiners would be looking for you to provide an outline covering points such as:

- Problems with the initial design.
- Problems with the installation.
- Inadequate foundations or damage caused by, e.g. erosion.
- Use of incorrect fittings, such as non-load-bearing couplings.
- Use of damaged scaffold, e.g. bent standards, corroded couplings.
- Inadequate number of ties, or ties installed incorrectly.
- Damage to the scaffold caused by collision with or alteration of the structure.
- Overloading with materials or wastes.
- Adverse weather such as high winds affecting stability, especially if sheeting is installed which can act as a sail.

(b) In this section you could structure your answer around the three areas signposted in the question, namely the design, erection and use of the scaffold. You could use the answers given in part (a) in this section if appropriate.

Main principles of design:

- Designed by a competent person.
- Designed to an appropriate standard.
- Designed to withstand the loads and operating conditions to be experienced.
- Constructed of sound equipment.

Main principles of erection:

- Installed by competent persons.
- Good foundations, with standards on base plates and sole plates.
- Ensuring that joints in the standards are staggered.
- Installing longitudinal and diagonal bracing and ledger bracing installed at alternate pairs of standards.
- Installation of adequate number and type of ties.
- Ensuring that if ties are removed, temporary ties are used.
- Ensuring vehicles can't strike the scaffold.

Green World Group

Main principles of use:

- Used only to the load specified in initial design.
- Not modified by unauthorised persons.
- Not overloaded.
- Inspected at least every seven days and after any alterations, damage or bad weather.

Example of How the Question Could be Answered

(a) Scaffold stability can be affected by a great number of factors, including the following:

- *Poor design at the outset, e.g. not designed to take the loading required during the construction.*
- *Poor installation not following the intended design, such that the scaffold was inadequately constructed.*
- *Poor foundations, e.g. the base being installed on soft or uneven ground.*
- *Overloading of the scaffold, e.g. the storage of too many bricks at height, resulting in a load in excess of the design specification.*
- *Inadequate number of ties installed or ties not installed correctly, resulting in the scaffold 'peeling' away from the building.*
- *Inadequate bracing resulting in lateral instability (swaying).*
- *Standards which are damaged or bent.*
- *Striking of the scaffold by a vehicle due to vehicle movements too close to the structure.*
- *Inadequate bracing to take into account the effect of high winds and adverse weather, exacerbated by sheeting and netting which may be installed.*

(b) The main principles of scaffold design include:

- *Ensuring that the scaffold is designed for the specific purpose for which it is to be used, taking into account the location and requirements of the building.*
- *Ensuring that the scaffold is designed in accordance with the relevant standards.*
- *Designing the ties to ensure that the scaffold will be secured to the building throughout.*
- *Ensuring that the designer was competent.*

The main principles of scaffold erection include:

- *Ensuring that the installers are competent, e.g. members of a trade body.*
- *Using only suitable materials for the site and scaffold, which are in good condition and not damaged or bent.*
- *Placing the footings on firm level ground, on base plates and sole plates to avoid subsidence.*
- *Ensuring the standards are straight.*
- *Bracing the scaffold to prevent longitudinal and lateral movement.*
- *Using appropriate ties, e.g. drilled in ties, box ties and reveal ties.*

When the scaffold is in use, stability should be ensured by:

- *Carrying out regular statutory inspections to ensure it remains safe.*
- *Not overloading the structure.*
- *Ensuring that vehicles are kept away from the scaffold to avoid collisions.*

Reasons for Poor Marks Achieved by Exam Candidates

An exam candidate would achieve **poor marks** for part (a) by focusing on the aspects of a scaffold which wouldn't affect stability, such as guardrails and toeboards.

For part (b) **poor marks** would be awarded if parts of a scaffold were listed without explanation as to why they were important for stability; or if the candidate failed to identify the need to consider the design and use of the scaffold, or the need for competent persons.

Element IC10

Workplace Transport and Managing Work-Related Road Risk

Learning Outcomes

Once you've read this element, you'll understand how to:

1. Outline the factors to be considered in a workplace transport risk assessment and the controls available for managing workplace transport risk.
2. Outline the role and purpose of a work-related road risk policy and the key components of a work-related road traffic safety management system.

Contents

Workplace Transport Risk Assessment and Risk Controls

IN THIS SECTION...

- A number of factors need to be considered in a workplace transport risk assessment, including factors associated with shared workplaces.
- Information needs to be provided to all employees and visitors to site relating to workplace transport issues.
- The UK HSE guidance document, HSG136 *A Guide to Workplace Transport Safety*, gives guidance on controlling the risks from workplace transport under the headings:
  - Safe site (design and activity).
  - Safe vehicle.
  - Safe driver.

Factors to be Considered in a Workplace Transport Risk Assessment

Every year, there are accidents involving transport in the workplace, some of which result in people being killed.

People are knocked down, run over or crushed against fixed parts by vehicles (e.g. HGVs, lift trucks and tractors), plant and trailers. People also fall from vehicles – whether getting on or off, working at height or when sheeting, loading or unloading.

Employers are often required by law to assess risks to anyone who might be affected by their work activity and take appropriate preventive and protective steps to control those risks.

This requirement applies to all activities, including those involving transport on site. The risk assessment must be "suitable and sufficient" and must:

- examine all the hazards evident;
- take into account everybody who might be harmed (including visiting drivers and contractors);
- evaluate the likelihood and consequences of the risks; and
- put controls in place to either eliminate the risk or reduce it to a tolerable level.

A suitable and sufficient risk assessment is required for transport on site

It is good practice to record the details of the risk assessment and it should also be regularly reviewed - particularly if there is an accident or a significant change to the use of the site.

Risk assessors should keep in mind that, generally speaking, there are four main kinds of accidents that involve workplace transport:

- People being struck by or run over by moving vehicles.
- People being struck by something falling from a vehicle.
- People falling from vehicles.
- Vehicles overturning.

Factors to Consider

The factors to be considered in a workplace transport risk assessment (depending on the complexity of the site) might be:

- The activities that take place on the site such as deliveries, loading or collecting materials.
- The actions of the drivers and others who are near to vehicles (whether working or as pedestrians).
- The numbers of vehicles and people moving around the site and where they are likely to interact or come into conflict.
- The features of the site (such as how routes are laid out and whether they are in good condition).
- The design of the traffic system and flow around the site – is it one-way or a dead end and do drivers have to reverse to park or exit the site?
- The training and competency requirements for drivers working on the site.
- Maintenance standards and requirements for vehicles on site.
- Environmental effects that might be important such as:
  - Will drivers be dazzled by strong sunlight at times of the year when the sun is low in the sky?
  - Is there bad visibility in the loading area when deliveries are made at night?
  - Could people working high up on the outside of vehicles be affected by strong gusts of wind?
  - Is the site in an area affected by heavy rain, mist, snow, ice or frost?

Example of appropriate traffic controls in a workplace

In a shared workplace, risk assessors will have to take time to look at the work activities involving other organisations that might impact on their employees and take into account how their organisation's vehicles impact on the safety and health of employees from other organisations on the site. This will involve observing:

- where vehicles are going;
- what the drivers are doing;
- how they are doing it; and
- why they are doing it.

Assessors may not always be able to find out the training levels of drivers from other organisations and this factor should also be considered in the process when evaluating risks.

Reasons for Providing Information to all Employees and Visitors

The International Labour Organisation's **Occupational Safety and Health Convention, 1981 (No. 155)** sets a standard for employers to look after the health, safety and welfare of their employees and to provide them with information about the hazards and risks on their site, including workplace transport safety:

"Article 16

1. *Employers shall be required to ensure that, so far as is reasonably practicable, the workplaces, machinery, equipment and processes under their control are safe and without risk to health."*

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The site owner should ensure that workers, contractors, visitors and members of the public are not put at risk while on site as a result of the work carried out on the premises. As part of this duty of care, these people should be provided with information relating to hazards and risks on the site and this includes workplace transport issues. A comprehensive set of site rules handed out and explained at induction, together with notices warning of hazards on site ("Deep excavation", etc.) and good supervision, will normally satisfy this requirement.

Site Rules

It is important that all drivers using a site are aware of all the rules that apply such as one-way systems, speed limits, parking, etc. Visiting drivers may need to be given both general and specific instruction about the management systems operating on site.

TOPIC FOCUS

Rules to Control the Use of Vehicles

There are a number of general rules applying to all situations in order to prevent unauthorised use or misuse of vehicles, and to ensure that, when unattended or parked, they do not create hazards.

- When a vehicle is not in use, the keys should be kept in a secure place. At the end of the work period, the engine should be switched off and the brakes applied. On battery-operated vehicles, the battery should be disconnected.
- All vehicles should always be parked in a safe place and not obstruct emergency exits, other vehicle routes, fire-fighting equipment or electricity control panels.
- Vehicles should not be left unattended on a gradient. If a vehicle has to be left or parked on a gradient in an emergency, even for a short period of time, it should be left in neutral with the parking brake applied and wheels chocked to prevent unexpected movement.
- Horns should be sounded at every potential danger point, such as before entering doorways and at blind corners, although the use of a horn does not give the driver right of way.

Controlling Risks from Workplace Transport

The UK HSE's HSG136 *A Guide to Workplace Transport Safety* provides advice for employers on what they need to do to comply with the law and reduce risk. The document includes advice on general legal duties and information on health and safety management for managers, supervisors, employees and their safety representatives, as well as contractors, vehicle operators and other organisations concerned with workplace transport safety. There is also more specific advice on controlling risks associated with workplace transport under three main headings:

- safe site (design and activity);
- safe vehicle; and
- safe driver.

Safe Site

Management of Vehicle Movements

The way in which vehicles move around a site should be carefully controlled and be appropriate for the types of vehicle operating on the site. This needs to be carefully thought out and can have wider implications – for example, the circulation of vehicles collecting rubbish from skips and bins, and their need to park during operations, may affect the siting of the rubbish containers or require special access routes to them.

- **Movement Systems**

  As far as possible, the need for vehicles to reverse should be eliminated, since this is one of the biggest causes of accidents. One-way systems are one means of achieving this and many sites operate such systems. Specially designated turning areas may also be used. Other systems to address the risk to pedestrians from reversing vehicles include:

  – The use of a banksman.
  – Limiting reversing to hours when there is little or no pedestrian traffic.
  – Avoidance of blind spots or fitting CCTV/mirrors.

  Traffic lights may be employed to control movements at heavily used junctions or at blind exits, e.g. around doors.

- **Speed Limits**

  Speed limits should be set and enforced on all parts of the site. They should take into account:

  – Environmental hazards.
  – Presence of pedestrians.
  – Conditions of the road surface.
  – Types of vehicle.
  – Operations they are involved in.

  Particular restrictions may apply in certain parts of the site, especially where pedestrians are close, such as in loading/unloading bays.

  As enforcement is often difficult, speed retarders accompanied by prominent warning notices may be used to prevent vehicles being driven at excessive speeds. These are not appropriate, however, if they might create other hazards, such as dislodging loads.

- **Vehicle Parking**

  Sufficient and suitable parking areas should be provided for all vehicles using the site – including employees' and visitors' private vehicles. If vehicles are left in unplanned areas, the safe operation of the site may be jeopardised, e.g. by obscuring sight lines.

- **Signs and Markings**

  Surface markings and road signs play an important part in regulating vehicle movements, for example:

  – White lines on the road surface may be used to divide two-way roads into lanes, indicate priorities at junctions and delineate the boundaries of parking spaces and loading bays.
  – Hazards should be clearly marked by diagonal yellow lines on a black background – e.g. to identify temporary or permanent obstructions, low bridges and speed bumps.
  – Warning and prohibition signs should be clearly visible to the drivers of all types of vehicles operating on a particular route and should give adequate warning of approaching hazards or requirements.
  – Directional signs should clearly indicate any required movements such as one-way systems – and facilitate drivers finding their destination.

Vehicle Collisions

A common type of accident arising from workplace transport operations is that of collisions with:

- **Other vehicles** – where traffic routes and operational areas are congested and vehicles cannot be prevented from operating in close proximity.
- **Pedestrians** – where effective segregation of vehicles and pedestrians has not been implemented.
- **Fixed objects** – where roadways, loading and storage areas have not been designed with adequate space, protection or signage to prevent such collisions.

Congested sites increase the risk of collision

Environmental Considerations

- Visibility

  Adequate lighting is essential for safe and efficient operations, as well as for security purposes. Outside areas which may have natural daylight will require artificial lighting when it is dark and during weather conditions which restrict visibility. Increased levels of lighting may be necessary in certain circumstances – for example:

  - At junctions of traffic routes.
  - Where traffic routes are close to buildings or plant.
  - In pedestrian areas.
  - At places where there is regular movement of vehicles and other mobile plant.

  Lighting columns close to the edges of routes can cause difficulties and if they cannot be set back, overhead or wall-mounted lights should be used.

  The sight lines of traffic routes must be carefully considered to ensure that drivers can see ahead and around them, and so that others can see them. Hazards such as sharp bends or blind corners should be eliminated where possible by, for example, lowering or removing walls and stacks at corners and junctions. Where this is not possible, warning signs, hazard markings, mirrors and transparent doors can reduce the risk.

  Parked vehicles should not be allowed to cause obstruction to sight lines. This can be a problem where vehicles are stopped for checking on leaving premises. Laybys should be provided wherever appropriate.

- Ventilation

  Indoors, ventilation needs to be considered wherever petrol- or diesel-powered vehicles are to operate, or where battery-powered trucks are placed on charge.

- Gradients and Changes of Level

  Excessive gradients – those in excess of one in ten – should be avoided where possible. This may be difficult in certain areas, and any steep ramps should always be clearly marked. Strict rules about driving on steep slopes are required.

  The camber of traffic routes should be such as is necessary to allow for adequate drainage, but not be any steeper due to the risk of overturning. Wherever possible, traffic should not be allowed to travel across slopes.

- Surface Conditions

  All routes should be even, constructed of suitable materials for the vehicles using them and well drained. Maintenance of roads is particularly important – for example:

  - Potholes should not be allowed to develop.
  - Loose materials should be cleared regularly.
  - Snow clearing and gritting may be necessary.
  - Any temporary obstructions (including goods, etc. fallen from vehicles) should be cleared as soon as possible.

  Raised kerbs should be kept to a minimum where collision with them may cause overturning, e.g. where forklift trucks operate.

Surface conditions must be considered

Traffic Route Design

- Suitability and Sufficiency of Traffic Routes

  Workplaces must be organised so that pedestrians and vehicles can circulate safely and traffic routes must be suitable for the people and/or vehicles using them. Where vehicles and pedestrians share a traffic route, they must be safely separated.

  Traffic routes should be constructed so that the driving surface is suitable for the purpose for which it is used and similar to that required for public highways.

TOPIC FOCUS

General principles for safe traffic routes include:

- Being wide enough for the safe movement of the largest vehicle permitted to use them (including visiting vehicles).
- Taking vehicle height into account:
  - The height of a vehicle may vary, e.g. when the body of a tipper vehicle is raised.
  - Potentially dangerous obstructions, such as overhead electric cables, or pipes containing hazardous chemicals, need to be protected.
- Being planned to give the safest routes between calling places, avoiding:
  - Unprotected fuel or chemical tanks or pipelines.
  - Unprotected road edges.
  - Unfenced edges of elevated weighbridges, loading bays or excavations.
  - Anything that is likely to collapse or be left in a dangerous state if hit by a vehicle.
- Being constructed of suitable material for the:
  - Location.
  - Type of traffic.
  - Size of the route.
  - Ground or foundation.
- Having firm and even surfaces, and being properly drained.
- Avoiding steep slopes, sharp or blind bends.
- Maintenance to provide a good grip for vehicles and people.

Temporary workplaces such as construction sites, forestry operations or farms often have routes for vehicles and pedestrians that change as work progresses, or 'unprepared' routes such as unsurfaced roads or open ground.

These routes should comply with the same basic safety standards applying to 'prepared' routes. They should:

- Be suitable for their purpose.
- Have firm and even surfaces.
- Be properly drained.
- Be free from steep slopes.

Safety banks may be needed on some routes to prevent vehicles running over open edges, or to indicate a safe route.

An 'unprepared' route for vehicle operation

Temporary roadways increase the risk of accidents. Precautions should include:

- Driver competence.
- Information and instructions to drivers.
- Safe systems of work and traffic management.
- Supervision of drivers, vehicle activities, and other employees.
- More frequent preventative checks to ensure that vehicles do not develop faults while working on unprepared roadways.

- **Segregating of Pedestrians and Vehicles**

Wherever possible, pedestrians should be physically segregated from vehicle traffic routes. Measures to ensure this include:

- Barriers to separate pedestrians from vehicle traffic routes or, where this is impractical, the use of clear surface markings to delineate the separate routes. These are particularly required outside exits from buildings where there is a risk of pedestrians walking directly onto a road.
- Designated points for pedestrians to use when crossing vehicle routes. These should be clearly marked and controlled by traffic lights if necessary. Where traffic is particularly heavy, bridges or subways may be necessary.
- Where vehicles pass through doorways, or under narrow bridges or through tunnels which have insufficient width to allow vehicles and pedestrians to be separated by a raised or railed-off footpath, separate access for pedestrians should be considered.

Segregating vehicles and pedestrians

- **Measures to be Taken when Segregation is Not Practicable**

There are many situations where pedestrians and vehicles cannot be separated for operational reasons. In such situations, the following measures should be taken:

- Pedestrians may be required to wear high-visibility jackets.
- Vehicles should be fitted with warning lights and alarms to indicate movement, particularly on reversing.
- Structural and environmental conditions should be altered to enhance safety, with particular attention to visibility (through lighting and mirrors).

Protective Measures for People and Structures

Appropriate means of warning people of hazards relating to vehicle operations, and of protecting them, the buildings, plant and equipment in the workplace, must be provided.

- Barriers

  Physical protection of vulnerable plant and equipment such as storage tanks, pipework and storage racking may be necessary. Such plant should be located away from roads, but where this is not possible, suitably constructed barriers should be provided for protection.

  Columns, pillars and walls may need to be padded to limit damage in the event of vehicles colliding with them.

  Barriers may also be used to prevent pedestrians entering vehicle traffic routes and to separate vehicles within traffic routes.

- Marking Signs, Markings and Signals

  Attention should be given to the need to provide information to pedestrians about vehicle movements and other aspects of vehicle operations, as well as to inform drivers about the hazards, rules and directions applying to traffic routes.

  Dangerous locations – where there is a risk of collision with vehicles, such as the edges of loading platforms, the edges of inspection pits, projecting surfaces or objects, etc. – should be identified and, where it is impractical to safeguard them by other means, must be clearly marked using yellow and black angled stripes.

- Warnings of Vehicle Approach and Reversing

  Lights and sirens may be used to warn people, and other drivers, of the approach of vehicles at blind corners and junctions (e.g. at doors) and on reversing.

Traffic Route Activity

- Reversing

  "Many deaths and serious injuries involving vehicles at work happen during reversing, with poor visibility being the main cause. There are several measures that can help to reduce the risk of reversing accidents, but removing the need for reversing is the most effective.

  Adopting a one-way system is one of the best ways to reduce reversing operations... If a one-way system is not possible, consider:

  - *establishing drive-through loading and unloading zones, and parking areas with entrances and exits on either side;*
  - *providing turning areas to allow vehicles to turn and drive forwards for most of the time ...*

  If reversing cannot be avoided:

  - *establish and clearly mark dedicated 'reversing areas' using longitudinal guides or white lines that are clearly signposted for both drivers and pedestrians;*
  - *design or modify existing reversing areas, e.g. by making them larger, to improve visibility for both drivers and pedestrians;*
  - *exclude non-essential personnel from areas where vehicles are reversing;*
  - *fit fixed mirrors or other visibility aids in the workplace to improve visibility around vehicles;*
  - *consider installing reversing aids on vehicles, such as CCTV and reversing sensors;*
  - *use a trained banksman (signaller), but only when all other options have been exhausted."*

  (Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

- **Signalling**

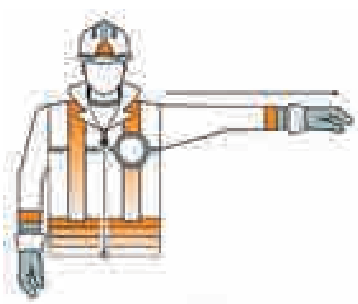
  Where vehicles are required to reverse, or to operate in confined spaces such as loading bays, the use of a banksman to direct vehicle movements may be required. There are standard hand and directional signals used for this, including those shown in the following diagrams:

Danger (emergency stop)

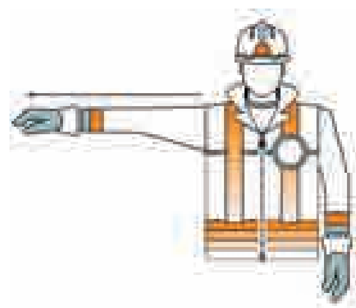
Indicating horizontal distance

Move forwards

Move backwards



Move to the (signalman's) left



Move to the (signalman's) right

Standard hand and directional signals for banksman

- **Parking Areas**

  Wherever possible, safe and suitable parking areas should be provided, with parking for work-related vehicles separate from that for private cars, motorcycles and bicycles. Clearly signposted and enforced parking areas may be necessary if there is an increased risk of injury from uncontrolled parking.

  Drivers leaving parked vehicles should not have to cross potentially hazardous work areas or traffic routes and physical precautions such as bollards and barriers can help prevent vehicles from crossing into pedestrian walkways.

"Parking areas should:

- *be clearly signposted;*
- *not impede traffic routes;*
- *ensure pedestrians and vehicles are kept apart;*
- *allow drivers and pedestrians to see clearly;*
- *be firm, level and well drained;*
- *be well lit, if possible;*
- *be as close as possible to where people need to go when they leave their vehicles."*

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

Pedestrian walkway in a car park

Employers should consider providing drive-through parking areas for larger vehicles, to eliminate the need for reversing. If this is not possible, then enforcing a reverse parking policy with the parking bays at an angle will reduce the number of vehicles having to reverse into the flow of traffic.

- Safe Parking

"Vehicles should be parked on firm and level ground, preferably in a dedicated parking area. No vehicle should be left unattended unless the parking brakes have been firmly applied, the engine has been switched off, the starter key has been removed, and any mounted equipment has been lowered to the ground or secured. Remember the following:

- *brakes ON;*
- *engine OFF;*
- *key OUT;*
- *equipment SAFE."*

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

Vehicle keys should be removed and securely stored when vehicles are parked overnight or for long periods.

- Coupling

Many large goods vehicles (LGVs) are articulated lorries which comprise a towing truck and a trailer which carries the freight. The advantage of this flexible arrangement is that trucks can transport a wide range of different trailers, but this requires coupling and uncoupling the truck and trailer which can involve risks. Accidents and dangerous situations can occur when drivers of LGVs fail to follow safe coupling and parking procedures. Unsafe practices often lead to vehicle runaway or trailer roll-away situations. They can result in serious or fatal injury to the driver or others, and costly damage to both vehicles and property.

Coupling and uncoupling can have serious risks if not carried out safely.

Problems can arise from:

- Poor lighting.
- Vehicle movement due to inadequate application of brakes or sloping surfaces.
- Incorrect coupling putting the vehicle at risk when moving off.

DEFINITION

COUPLING AND UNCOUPLING

Coupling and uncoupling is simply transport industry terminology for connecting (coupling) and disconnecting (uncoupling) a truck to/from a trailer. It introduces hazards not present for 'solid' trucks which don't require this type of connection.

Loading, Unloading and Securing Loads

"Loading and unloading are among the most hazardous transport activities in the workplace. People can be hit by objects falling from vehicles, struck by lift trucks, or fall from vehicles."

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

Many accidents occur during loading and unloading of vehicles

Many accidents occur during these operations due to:

- Loading
  - Vehicles loaded beyond rated capacities or the legal limits of gross weight.
  - The floor of the vehicle not being strong enough for the load.
  - Load not evenly distributed.
  - Load not secured or arranged to prevent movement in transit.
  - Tail and side boards left open.
  - Overhangs not marked or kept to a minimum.
- Unloading
  - Load not checked for stability before ropes or tarpaulins are removed.
  - Load not stable and evenly distributed during unloading.
- Securing
  - Need to gain access to the tops of vehicles with resultant risk of falls from elevated areas.

In addition, none of these operations should take place near overhead electric lines and particular care is required if the raised body of a vehicle may foul an overhead line.

- Visiting Drivers

  "Visiting drivers should report to the site operator for any relevant instructions, such as the workplace layout, which route to follow, and where to park, load and unload. They may not have visited the site before and may not be fluent in English so consider, for example, providing a plan of the workplace at the entrance with clear and concise instructions in several languages, possibly including pictures.

  It is important for site operators to co-operate with the employers of visiting drivers, to co-ordinate the measures required to help them both meet their health and safety responsibilities."

Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

Example of a sign for visiting drivers (Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

- Loading and Unloading Areas

  "When deliveries and collections are made, loading and unloading areas should:

  - *be in designated places, clear of passing traffic, pedestrians and other people who are not involved in loading or unloading;*
  - *be clear of overhead power cables or pipework so there is no chance of fouling them, or of electricity jumping to 'earth' (arcing) through machinery, the load or people;*

– *be on firm, level ground, free from potholes and debris;*
– *have a safe area for drivers to wait that allows them to rest between driving shifts, especially if they may be waiting for several hours, with easy and safe access to toilet, washing and refreshment facilities and shelter in case of bad weather."*

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (hwww.hse.gov.uk/pubns/priced/hsg136.pdf))

- Loading Bays

"Loading bays are dedicated areas where goods can be transferred from vehicles to a building, such as a distribution centre, and vice versa. They should have at least one exit point from the lower level. Wide loading bays should have at least two exit points, one at each end. Alternatively, a refuge should be provided which can be used to avoid being struck or crushed by a vehicle."

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

- Preventing Vehicles from Moving

"Vehicles should be prevented from moving while they are being loaded or unloaded. This can reduce:

– *'drive-away' incidents, when the driver of a vehicle being loaded drives off from the loading bay unexpectedly. These can have serious consequences, especially if lift trucks are involved;*
– *'creep' incidents, when gaps are created between the loading bay and the vehicle, caused by equipment such as lift trucks moving between the loading bay and the vehicle.*

There are a number of ways to prevent vehicles from moving during loading and unloading at loading bays including:

– *vehicle or trailer restraints, such as wheel chocks;*
– *traffic lights, barriers or other 'stop'-type signals;*
– *various systems for controlling access to vehicle keys or the cab;*
– *safe systems of work to make sure the driver knows when it is safe to leave;*
– *fitting four-wheel braking systems or other effective methods to make sure vehicles cannot move;*
– *alarm systems that go off if the driver tries to leave the vehicle cab without applying the handbrake."*

"Anyone responsible for loading should be given clear instructions and training on how to distribute loads safely on the vehicle so it is safe to drive."

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

MORE... www.

The Institution of Occupational Safety and Health (IOSH) and the Freight Transport Association (FTA) joint publication, *Loading dock safety guide*, has more information and is available at:

www.fta.co.uk/export/sites/fta/_galleries/downloads/loading_of_vehicles/12160_Loading_dock_safety.pdf.

Overturning of Vehicles

"Nearly a fifth of all workplace transport deaths are caused by vehicles overturning. Lift trucks, tractors, compact dumpers, tipper lorries, forestry and all-terrain vehicles, multi-deck vehicles and cranes are all more likely to overturn."

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

There are two main ways in which a vehicle may overturn:

- Onto its side – lateral instability – such as when a high-sided lorry is blown over in high wind or when a loaded forklift truck tips over while driving across a slope.
- Onto its front or back – longitudinal instability – such as when a tractor's front wheels lift due to the weight applied by an attached trailer, or when a forklift truck is moving up or down a slope.


Lateral instability

Such instability is a major problem in the safe use of high vehicles, particularly those with lifting mechanisms. The risk is increased by:

- Speed of travel.
- Steepness of the slope.
- Height the load is raised to and the stability of the load.
- Increased tyre pressure.
- Any external longitudinal pressure, such as wind or colliding objects.
- Presence and size of any bumps or holes in the surface.

A similar effect to that of a slope may be caused by uneven ground. Where a vehicle goes over a pothole, the front wheels will dip, giving the effect of a slope. Forklift trucks are the most critical of vehicles here as they have small wheels which will exaggerate the effect and no suspension to keep the body steady.

Dumper trucks on construction sites are notorious for overturning, even though they are designed with a wide wheelbase and low centre of gravity. Causes include ground conditions and excavations, overloading, speeding and hitting obstructions, tyre pressure and inadequate maintenance to deal promptly with defects. They should be fitted with roll-over protection, and seat belts.

Controls to Prevent Overturning

Site operators should examine ways of making overturns less likely by:

- Planning suitable routes and avoiding slopes that are too steep, uneven or slippery surfaces, kerbs or sharp turns.
- Maintaining traffic routes.
- Erecting barriers, walls, banks and signs to help drivers avoid unsuitable terrain or hazards such as pits or trenches.
- Considering speed restrictions and enforcing them where appropriate.
- Loading evenly according to the loading capacity of the vehicle.
- Using vehicles suitable for the task.
- Transporting loads on lift trucks with loads carried as close to the ground as practicable.
- Ensuring vehicles are well maintained.
- Only allowing properly trained operators to drive vehicles.
- Keeping surfaces well-repaired, free of obstructions (such as cables) and clear of debris.

Work at Height on Vehicles

"Falls from vehicles are very common and account for around a third of all workplace transport injuries, many while loading and unloading. They are often caused by:

- *slipping while walking on loads;*
- *tripping on ropes or torn sheets, causing overbalancing;*

- *wearing inappropriate footwear;*
- *poor working surfaces made worse by bad weather;*
- *poor means of access onto and off the vehicle;*
- *a lack of awareness and training."*

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

Site operators must take suitable and effective measures to prevent anyone from falling a distance that is likely to result in injury - this includes getting on and off a vehicle trailer or climbing into and out of a vehicle cab.

The hierarchy of controls for working at height includes:

- Avoid work at height where it is reasonably practicable to do so.
- Where work at height cannot be avoided, prevent falls using either an existing place of work that is already safe or the right type of equipment.
- Minimise the distance and consequences of a fall by using the right type of equipment where the risk cannot be eliminated.
- Do as much as you can from the ground, e.g. by using gauges and controls that are accessible from the ground.

If work at height on a vehicle cannot be avoided, collective control measures should always take priority over personal control measures. Collective measures protect everyone who is at risk (i.e. more than one person at any one time), e.g. using gantries or platforms fitted with guardrails, and they usually require no action by the user to work effectively.

Walking on Vehicles

If workers have to stand on a load or on a vehicle, there is a risk of a fall. Site operators should always make sure there are suitable measures in place to prevent this happening. Workers should be informed not to walk or lean backwards, especially near the back or open sides of a vehicle (e.g. during sheeting) and never stand on a load once it is attached to lifting equipment (e.g. a crane or a lift truck).

Sheeting and Netting

There is a number of reasons why a load may need to be covered and sheeting or netting is a good way of doing this. Some materials may need to be kept hot while being transported, such as bitumen or asphalt. Other loads need to be kept dry, such as quicklime or some other powders. Depending on national legislation, there may also be legal duties to cover some types of load to protect the environment, prevent materials being blown off, or to keep them safe.

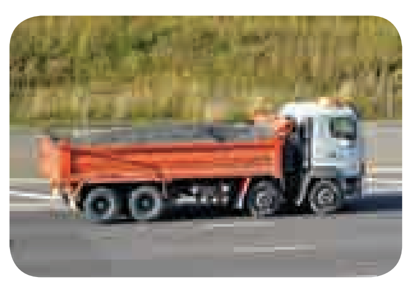
However, attaching or removing sheets or nets can be dangerous, especially when it is carried out by hand since it may involve working at height on the top of the vehicle.

Vehicle operators should consider automated sheeting systems that require little or no intervention from the driver and do not put them at risk of working at height.

DEFINITION

SHEETING

A protective covering applied over the top of materials to protect them (and the people and environment around them) during transit.



Front-to-rear sheeting system

Safe Vehicle

Site operators should ensure that any workplace transport used on site and any vehicles which might be used on public roads comply with national legislation and are suitable for the purpose.

In Europe, most non-road mobile work equipment must meet the requirements of the EU **Machinery Directive (2006/42/EC)**, which has specific requirements relating to the design and construction of all machinery.

Seat Restraints and Driver Protection

Most workplace vehicles manufactured recently will already be provided with the measures required by the law. However, employers should still ensure that people only use vehicles with features to reduce risks (so far as reasonably practicable) such as safe and comfortable seats, restraints and roll-over protection.

Drivers must be adequately protected in their driving position. The main means of achieving this is the use of seat belts, secured doors and protective cages (both for roll-over and to provide protection from falling objects) and cabins with shatter-proof glass. Vehicles at particular risk of overturning, such as cranes, forklift trucks and tractors, need extra protection. Drivers must ensure that they use all such measures at all times.

Roll-Over Protective Structure (ROPS)

Safe access to and from vehicles is also important. Every year, many accidents happen when drivers and operators fall getting into or out of their cabs. Well designed, positioned and maintained handrails and footholds are one way of preventing such falls.

Drivers may also need personal protective equipment in respect of any environments they enter, e.g. dust masks and ear protection.

Special measures to prevent vehicles overturning or running away may also be provided. These include safety stops to prevent vehicle movements on slopes and extendable legs to provide stability when operating.

A particular hazard with vehicles which have raised or tipping bodies, or extending parts, is that the body or extended part may descend and trap any person working underneath. No work should be carried out beneath a raised body unless it is suitably propped, and warning notices to this effect should be displayed. It is preferable that body props are incorporated into the vehicle itself. A tipping lorry should never be driven unless the body is locked in the lowered position.

MORE... www.

Guidance on the **Machinery Directive** can be found in the UK HSE's leaflet, *Buying new machinery* (INDG271), available at:

www.hse.gov.uk/pubns/indg271.pdf

Vehicle Visibility and Reversing Aids

"It is important that drivers are able to see clearly around their vehicle, so they can see hazards and avoid them. Vehicles should also be clearly visible to pedestrians and other vehicles in the workplace, so consider fitting, for example, additional lights, reflectors and flashing (or rotating) beacons (as well as horns for drivers to warn others that they are approaching).

Some types of vehicle (such as straddle carriers, large shovel loaders and some large quarry vehicles) often have poor visibility from the cab. Visibility can be poor to the side or front of a vehicle as well as behind, and loads on vehicles can severely limit visibility from the driving position. Consider fitting extra mirrors, reversing alarms or sensors, and CCTV where visibility is reduced. Lift trucks and compact dumper vehicles in particular have reduced forward visibility when they are transporting bulky loads."

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

Closed-Circuit Television (CCTV)

"CCTV can cover most blind spots and may be appropriate for some vehicles where the driver cannot see clearly behind or around the vehicle. Colour systems can provide a clearer image where there is little contrast, for example outside on an overcast day. However, black-and-white systems normally provide a better image in lower light or darkness, and usually come with infrared systems, which can be more effective than standard cameras. Multiple-camera systems are being developed to provide a 360-degree view on a single monitor.

Monitors should have adjustable contrast, brightness and reverse image selection and may need a hood to shield them from glare. CCTV reversing cameras fitted in a high position in the rear of the vehicle provide a better angle for the driver to judge distance and a greater field of vision. This will also keep the camera clear of dust and spray and out of the reach of thieves or vandals.

Vehicle CCTV

CCTV systems have the following limitations:

- *they require drivers to check them regularly and react to any obstructions;*
- *camera lenses need to be cleaned regularly to be effective and may be affected by bright sunlight or reflections from wet surfaces;*
- *it can be difficult for drivers to judge heights and distances on CCTV monitors;*
- *the area covered by the camera may not cover all blind spots;*
- *drivers may become complacent about checking behind them and rely too much on the CCTV;*
- *operators of CCTV need to be trained to use the equipment properly."*

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

Reversing Sensors and Alarms

"Sensing systems are increasingly being fitted to road-going vehicles as parking aids. Some workplace vehicles use laser, radar or ultrasonic sensors to slow down or stop vehicles when they sense an object or person while reversing (e.g. some lift trucks, construction and quarrying vehicles). Some systems also give an audible or visual warning to alert the driver. Sensing systems may not be as effective where they would be set off very often, although some now incorporate features to prevent unwanted alarms. It is important that they are tested regularly.

If reversing alarms are fitted, they should be kept in good working order and be loud and distinct enough so they can be heard. Sometimes they may be drowned out by other noise, or may be so common on a busy site that pedestrians do not take any notice. It can also be hard to tell exactly where an alarm is coming from."

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

Maintenance and Repair

Employers (site operators) should ensure that work equipment is maintained in a safe condition.

Site operators should carry out inspections of vehicles and associated equipment to ensure this happens, including daily driver checks before using the vehicle and regular preventive (planned) maintenance inspections based on time or mileage. Owners of work equipment should always follow the manufacturer's guidelines on regular maintenance.

"Employers should give drivers a list of daily checks to be signed off before vehicles are driven. Drivers will need instruction or training in how to carry out these checks and should be monitored to ensure they are carrying them out properly. There should be a simple system for reporting any problems and deciding if the vehicle is safe to use or if it needs to be taken out of use while waiting to be repaired."

(Source: HSG136 A Guide to Workplace Transport Safety, HSE, 2014 (www.hse.gov.uk/pubns/priced/hsg136.pdf))

MORE...

www.

HSG136 *A guide to workplace transport safety* includes specific advice on controlling risks associated with workplace transport and is available at:

www.hse.gov.uk/pubns/priced/hsg136.pdf

Vehicles should be maintained so they remain mechanically sound. Planned inspections are an important part of maintenance. Preventive maintenance is also needed to help avoid failures during use. This should be thorough, regular and frequent enough to meet the manufacturer's guidance.

Key areas of concern in ensuring the safe operation of vehicles include:

- Braking systems – in respect of emergency brakes, general ability to slow down and parking without fear of movement.
- Steering mechanisms – to ensure full control over vehicle movement.
- Tyres – to ensure that grip is maintained at all times and the risk of blow-outs is minimised.
- Tyre pressure.
- Exhaust systems – to reduce fumes and other emissions.

As with all maintenance work, vehicle maintenance work involves a range of hazards and accidents in motor vehicle repair can involve:

- Slips, trips and falls.
- Lifting and handling.
- Crushing incidents involving the movement or collapse of vehicles under repair.
- Petrol-related work causing serious burns and fires.

There is also potential for work-related ill-health:

- Many of the substances used require careful storage, handling and control.
- Isocyanate-containing paints are a cause of occupational asthma.
- A number of substances in use can cause disabling dermatitis.
- The use of power tools can cause vibration white finger.

Safe Driver

Selection and Training of Drivers

Many of the control strategies are dependent for their effectiveness on the driver operating in accordance with the rules and applying the necessary measures at all times. It is of the utmost importance, therefore, that there are systems and procedures in place to ensure driver competence. These should cover the initial appointment and training of drivers, and developing and maintaining their skills.

- **Driver Selection**

  Of prime importance is the careful selection of potential drivers. The first consideration is age. Drivers should be at least 17, except where a minimum age is specified in legislation – in the case of agriculture and horticulture, operators should be over the minimum school-leaving age.

Other factors to be taken into consideration are that operators should be reliable, able to do the job in a responsible manner, and have a reasonable level of physical and mental fitness and intelligence. These parameters do not automatically exclude disabled people, but in such cases, it is advisable to seek medical advice to assess their suitability. The use of selection tests can avoid wasteful attempts to train unsuitable trainees.


Systems must be in place to ensure driver competence

- Training

  Operator training should include both general and specific requirements:

  - General basic training – the basic skills and knowledge required for safe operation of the type of vehicle and any attachments which the driver will be required to use.
  - Specific job training – covering knowledge of the workplace, any special requirements of the work to be undertaken and the use of attachments in specific situations. This will include detailed controls of the vehicle to be used, routine inspections which should be carried out by the operator, use of the vehicle in various locations and in different weather conditions, site rules, loading and unloading procedures and transporting loads. Many accidents happen with dumper trucks on construction sites if they are used by untrained drivers.

  Refresher training is also beneficial for all drivers, but is specifically required when drivers need to operate different vehicles or if there is a change of work.

Management Systems for Assuring Driver Competence including Local Codes of Practice

There are schemes to accredit training to prescribed standards which ensure safe transport operations. Certificates of completion of accredited training programmes, in particular vehicles and vehicle operations, may be a requirement of employment.

Employers should hold records of all training undertaken by drivers, including that certified by recognised bodies. The record should indicate the types of vehicle which a driver may operate and any special conditions which might apply, such as area limitations and expiry dates.

Where an operator possesses previous experience and/or training, the evidence should be examined before they undertake any driving tasks. It is necessary to assess whether the previous experience and training are suitable and sufficient to enable the driver to operate safely the particular types of vehicles and attachments used in the specific work environment. Previous training certificates should be examined and, where they are not available, the operator should undergo an assessment while actually driving the vehicle concerned.

Specific arrangements for ensuring the understanding of, and skills involved in, operating in the particular conditions of a site may also be necessary, e.g. in relation to permit-to-work systems.

Loss of Control

TOPIC FOCUS

Many workplace transport accidents arise from **loss of control** caused by:

- **Mechanical failure** – for example, the braking or steering mechanisms, causing the driver to be unable to apply key controls.
- **Environmental conditions** – particularly as they affect the road, such as snow and ice, but also as they may affect visibility, such as sunlight suddenly blinding a driver.

(Continued)

TOPIC FOCUS

Driver error is often a key factor in vehicle accidents and this can vary from simple mistakes to acts of gross irresponsibility, such as driving too fast – particularly cornering at excessive speed, and sudden braking. The influence of alcohol or drugs can be another or compounding factor. Many such errors occur during reversing procedures and manoeuvring. Driver error may compound or cause the following hazards:

- **Overturning** – tipping over onto the vehicle's side or onto its front or back.
- **Collisions** - with other vehicles, pedestrians or fixed objects.

STUDY QUESTIONS

2. Outline the four main kinds of accidents involving workplace transport that risk assessors should keep in mind when completing workplace transport risk assessments.
3. Outline the factors that might be taken into account in a workplace transport risk assessment.
4. In a shared workplace, risk assessors will have to take time to observe the work activities involving other organisations that might impact on their employees and take into account how their organisation's vehicles impact on the safety and health of employees from other organisations on the site.

   Identify which areas risk assessors might be observing.
5. Employers are required to ensure that workers, contractors, visitors and members of the public are not put at risk while on site as a result of the work carried out on the premises.

   Outline the information that might be provided to workers, contractors and visitors as part of the employer's duty of care in this respect.
6. Explain the rules to control the use of vehicles on site.
7. The HSE has produced guidance on workplace transport in the form of HSG136 *A Guide to Workplace Transport Safety*, which provides advice for employers on what they need to do to comply with the law and reduce risk.

   Give the three main headings as set out in the guidance document which provide more specific advice on controlling risks associated with workplace transport.
8. Outline the way in which vehicle operations and movements around a site may be managed.

(Suggested Answers are at the end.)

Work-Related Road Risk Policy and Components of a Work-Related Road Traffic Safety Management System (RTSMS)

IN THIS SECTION...

- The role and purpose of a work-related road risk policy is to manage road risk at an appropriate level and reduce or eliminate the risk of employee road accidents and the organisation being prosecuted for a management failure, or suffering a large civil claim for compensation.
- In establishing the policy, the management team should ensure that the policy is appropriate to the organisation.
- There are both moral and business-benefit reasons for the introduction of a road traffic safety (RTS) management system.
- The management system specified in ISO 39001:2012 is designed to help an organisation focus on its RTS objectives and targets, and guides the planning of RTS activities.
- Possible key elements of an RTS management system include planning, support, document information, operation, performance evaluation and improvement.
- There are both benefits and limitations in using ISO 39001:2012.

WHO Global Status Report on Road Safety

The *Global Status Report on Road Safety 2015* from the World Health Organisation, which reflects information from 180 countries, suggests that worldwide the total number of road traffic deaths has reached a plateau of 1.25 million per year, the highest fatality rates from road traffic incidents being in low-income countries.

Target for road safety to halve the number of deaths from road traffic crashes

In recent years, 17 countries have aligned at least one of their laws with best practice on speed, drink-driving, seat-belts, motorcycle helmets or child restraints.

Progress has been made towards improving road safety legislation and making vehicles safer, but the report shows that the pace of change has not been fast enough. The newly adopted 2030 Agenda for Sustainable Development has set the ambitious target for road safety of halving the global number of deaths and injuries from road traffic crashes by 2020 and urgent action is needed to achieve this.

Statistics in the UK indicate that the total value of prevention of reported road accidents in a year is estimated to be approximately £15.6 billion. Allowing for accidents not reported to the police, this total could increase to around £34.8 billion.

The consequences of accidents to the self-employed and small businesses are likely to be proportionately greater than for larger businesses with more resources.

The benefits of managing work-related road safety can be considerable, no matter what the size of the organisation.

- As work-related road traffic accidents (RTAs) are a significant cause of preventable death and injury, people should be protected from the hazards.

- Employers should ensure they produce and effectively communicate a policy for the management of work-related road safety with their staff.
- This policy should be signed by top management such as the Chief Executive Officer (CEO) or the Managing Director and cover suitable and properly maintained vehicles; driver suitability, fitness and training; and realistic timescales for journeys, to prevent stress or pressure to take risks.
- The policy should be communicated to all employees who drive as part of their role in the organisation and regularly reviewed.
- Journeys should be properly planned to avoid undue fatigue and plans reassessed if weather conditions deteriorate.
- Employers need to control the risks from 'driver distraction' and include this in their policy, e.g. prohibit activities like phone-use and eating while driving.
- Managers should consider alternatives to driving, e.g. train travel or video- and tele-conferencing.
- In addition to RTAs, employees should also be encouraged to inform employers of any serious near-misses on the road, so that lessons can be shared.

TOPIC FOCUS

The UK HSE's INDG382 *Driving at Work* estimates that more than a quarter of all road traffic incidents involve somebody who is at work at the time. Because driving is a common activity that people also participate in outside of work, it is easy to underestimate the serious potential of work-related road traffic accidents.

Work-Related Road Risk Policy

Role and Purpose of the Policy

The **role** of the Management of Road Risk Policy is to manage road risk at an appropriate level.

The **purpose** of the policy is to reduce or eliminate the risk of employee road accidents and the organisation being prosecuted for a management failure, or suffering a large civil claim for compensation. This involves:

- Carrying out an appropriate risk assessment for the management of road risk.
- Having in place written arrangements to deal with any material risks identified.
- Having a clear audit trail to follow up.
- Carrying out regular reviews and further risk assessments at reasonable intervals.

Typical Content of the Policy

A member of the Board of Directors should be appointed to be the Board champion of occupational road risk, to demonstrate the importance of this area to the organisation. In establishing the policy, the management team should ensure that the policy is appropriate to the organisation and includes:

- A clear written policy statement about who is entitled to use company-controlled vehicles.
- A clear written policy about the need for employees to submit mileage returns to identify high-risk cases.
- A clear statement requiring all employees to observe all normal road rules as set out in national legislation.

Specific issues which should be mentioned might include:

- Policy on use of mobile (cell) phones (including hands-free kits).
- Policy on alcoholic drink and drugs.

- Policy on maximum driving time behind the wheel:
  - at any one stretch; and
  - overall within any one working day.
- A process to ensure that anyone driving on employers' business is properly licensed for the types of vehicles to be used (cars or vans of different weights, towed trailers, minibuses, etc.).
- Confirmation of a company insurance policy for employees' own cars.
- A process to ensure that all vehicles are serviced at least in line with manufacturers' recommendations.
- Facilities to provide employees with information and training where necessary and supervision to be safe on the road.
- Summary of the risk assessment documentation and a timetable for all future steps in the process.
- Targets set to improve road safety on a continuous-improvement basis, with the process being benchmarked against other fleets.

Reasons for the Introduction of a Road Traffic Safety (RTS) Management System

Pain and Suffering – the Moral Reason

Although the number of people killed on the road network worldwide has reached a plateau, fatal accidents still account for too many deaths each year – and inevitably some of these cases involve fleet vehicles in the course of their normal everyday activities. In the UK, for example, employee deaths as a result of using the roads on employers' business outnumber all other causes of at-work death. Road Traffic Safety Management Systems should be in place to ensure employees do not become part of those statistics.


RTSMS' should be in place to manage risk

Business Benefits - ISO 39001:2012

There is good evidence to show that the use of generic management systems – such as BS OHSAS 18001 *Occupational Health and Safety Management Systems* – can bring business benefits. These include:

- Potentially lower insurance premiums.
- A robust framework for identifying risks and putting measures in place to mitigate them.
- Helping organisations to target their resources in the most cost-effective way.

In addition, experience from around the world shows that large reductions in death and serious injury can be achieved by fleet operators adopting a holistic 'Safe System' approach to managing RTS.

This 'Safe System' approach is set out in ISO 39001 and involves organisations placing a clear and unequivocal focus on RTS results and taking evidence-based actions for the interim and long term, supported by appropriate management resources.

The management system specified in ISO 39001 is designed to help an organisation focus on its RTS objectives and targets, and guides the planning of RTS activities. Annex A provides some key guidance on the implementation of the standard, while Annex B describes categories of RTS results, the Safe System approach and a framework for good practice RTS management, and shows how they can be aligned with ISO 39001.

For fleet transport operators, ISO 39001 helps direct attention to addressing common, system-wide, fatal and serious injury risk factors that they can influence and includes addressing areas such as:

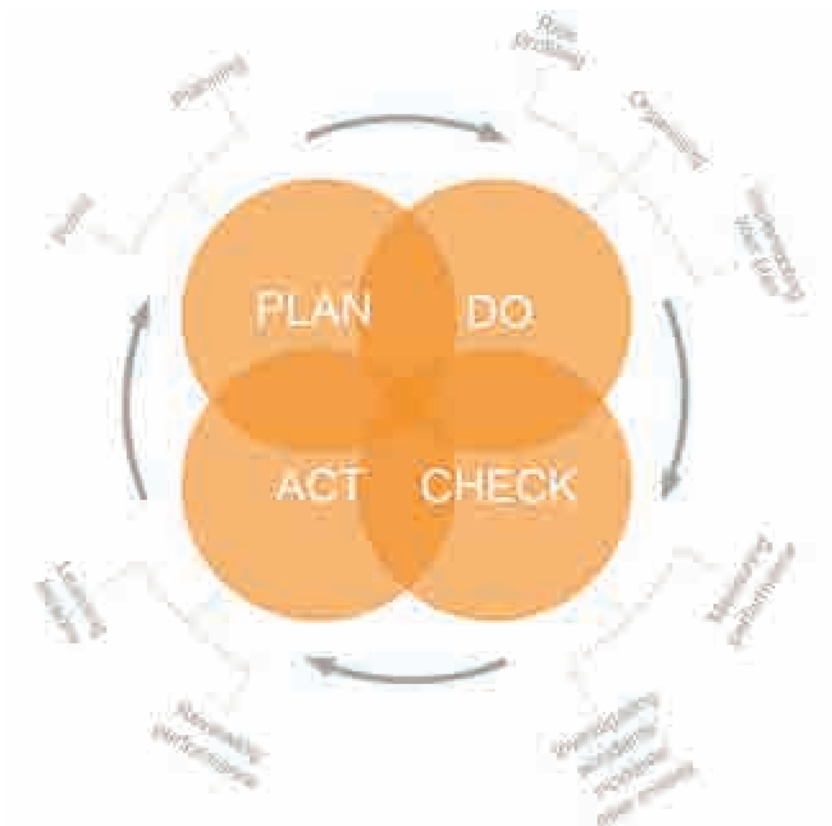
- Safe speeds.
- Driver impairment by alcohol, drugs or fatigue.

- Use of appropriate safety equipment, such as seat-belts.
- Safe journey planning.

The standard also emphasises the need to ensure that all employees who drive as part of their work comply with relevant rules on safe road use, so that key risks are either eliminated or adequately managed. The standard is based on a process approach (Plan-Do-Check-Act) to encouraging continuous improvement, similar to other ISO standards such as ISO 9001:2015 *Quality Management Systems*.

By adopting the structured, holistic approach set out in ISO 39001, organisations should be able to improve their RTS results beyond simple compliance with laws while suffering fewer road injuries and fatalities.

Following the Plan – Do – Check – Act guidance set out in Annex A of the standard, the organisation should first of all establish its role and how it impacts on the road traffic system.



Work-related road safety should be integrated into the existing arrangements for managing health and safety at work
(Diagram based on the approach in HSG65 Managing for Health and Safety (3rd ed.), HSE, 2013 (www.hse.gov.uk/pubns/priced/hsg65.pdf))

The standard describes how the RTS examines the interactions between four components, i.e. roads; vehicles on those roads; use of the roads and vehicles; and emergency response, trauma care and rehabilitation. Each of these components is controlled and influenced by many organisations which ultimately affect the RTS.

The organisation's impact on RTS depends on the nature of the organisation's activities, products and services and the location where and the conditions under which it functions, as well as the effectiveness of its RTS management system.

Examples of activities within organisations, public and private, large and small, that can involve RTS are listed below. Most RTS performance factors are relevant to all organisations, although their significance varies across organisations.

- Employees' use of the road traffic system to and from work, or on duty, in public or private vehicles as a passenger or driver, and while walking or cycling.

- Goods and passenger transport in the road traffic system carried out by the organisation, or contracted to other organisations.
- Activities that generate traffic to and from locations controlled or influenced by the organisation such as supermarkets, schools, and locations with many visitors.
- Service delivery and products for the road traffic system, such as transport service, management, planning, design, construction and maintaining infrastructure, vehicles and related products, emergency medical response, trauma care, rehabilitation, enforcement and legislative activities.

Even though some organisations only have a small number of processes linked to RTS issues, these can be very important in reducing deaths and serious injuries. It is, therefore, important to identify transport needs and the level of risk exposure for motorised and non-motorised users. Specific external issues can be recognised by the occurrence of road traffic crashes or complaints from third parties. Internal issues can be recognised by the occurrence of near-misses or deviations from documented procedures.

Possible Key Elements/Components of a Road Traffic Safety (RTS) Management System

Planning

Actions to Address Risks and Opportunities

Acting on the risks and opportunities identified by a risk assessment for the management of road risk will:

- Reduce death and serious injury in road traffic crashes.
- Reduce the costs to the organisation.
- Increase the time and resources available for productive activity.
- Increase confidence in the organisation from customers and other stakeholders.

Examples of risks and opportunities identified might be:

- A high percentage of older drivers.
- A mix of motorised and non-motorised users.
- High traffic volumes on major routes.
- Strict demand for on-time delivery from customers.
- Road safety activity in different regions.
- The level of compliance activity with key safety rules.
- The quality of the road infrastructure, vehicle fleet, and emergency medical system.

Risk Assessment

Risk assessments for work-related driving should follow the same principles as risk assessments for any other work activity (HSE's '5 steps' approach):

Step 1 - Identify the hazards.

Look for hazards that may result in harm when driving on public roads. The main areas to consider are the driver, the vehicle and the journey.

Step 2 - Decide who might be harmed.

In almost all cases this will be the driver, but it might also include passengers, other road users and/or pedestrians and possible groups who may be particularly at risk, such as young or newly qualified drivers and those driving long distances.

Step 3 - Evaluate the risk and decide whether existing precautions are adequate or more should be done.

A first consideration is always elimination of the need to drive but if this is not an option then other possible controls need to be evaluated, such as revision of delivery schedules, improved maintenance schedules or better protection in the event of an incident for drivers and passengers.

Step 4 - Record your findings.

The recorded findings should show that a proper check was made on work-related road safety, those who might be affected were consulted, and the obvious hazards relating to the driver, the vehicle and the journey were considered.

Step 5 - Review your assessment and revise it if necessary.

The assessment needs to be monitored and reviewed to ensure that the risks to those who drive, and others, are suitably controlled. For this to be effective there needs to be a system for gathering, recording and analysing information about road incidents, together with details of driver and vehicle history. There will also be the need to review the assessment to take account of changing circumstances such as the introduction of new routes, new equipment or a change in vehicle specification.

HSE '5 Steps' Approach

Evaluating the Risks and Adequacy of Controls

The three principal hazard areas associated with work-related driving are the driver, the vehicle and the journey. Related to each of these are a number of factors to consider in order to decide whether existing precautions are adequate or more should be done. The control measures that might need to be considered to reduce work-related driving risks are examined below.

The Driver

- Competency

  Drivers must be competent and capable of doing their work in a way that is safe for them and other people.

  Issues to consider include:

  – Previous experience.
  – Current driving licence.
  – Skill and expertise required for the circumstances of the particular job.
  – Awareness of company policy on work-related road safety.

- Fitness and Health

  Drivers should be sufficiently fit and healthy to drive safely and not put themselves or others at risk. Consequently:

  – Drivers of heavy lorries, for which there are legal requirements for medical examination, should have the appropriate medical certificate.
  – At-work drivers, who are most at risk, may also benefit from regular medicals.
  – Staff who drive at work should be reminded of the eyesight requirements set out in national legislation.
  – Staff should not drive, or undertake other duties, while taking a course of medicine that might impair their judgment.

- Training

  Drivers must be properly trained, which includes:

  – Induction training.
  – Additional training to carry out their duties safely such as:
  – Routine safety checks.
  – Use of safety equipment.
  – Safety following the breakdown of the vehicle.
  – Dangers of fatigue and what they should do if they start to feel sleepy.

The Vehicle

- Suitability

  Vehicles should be fit for the purpose for which they are used.

  Consequently:

  – When purchasing new or replacement vehicles it may be necessary to formally investigate which vehicles are best for driving and public health and safety.
  – If a vehicle fleet is not suitable for the type of work, consideration should be given to supplementing or replacing it with leased or hired vehicles.
  – Privately owned vehicles should not be used for work purposes unless they are insured for business use and have a valid MOT certificate when necessary.

Vehicles should be fit for the purpose for which they are used

- Condition

  Vehicles should be maintained in a safe and fit condition by:

  – Having adequate maintenance arrangements in place.
  – Ensuring that maintenance and repairs are carried out to an acceptable standard.
  – Carrying out planned/preventative maintenance in accordance with manufacturers' recommendations.
  – Drivers carrying out basic safety checks.
  – Ensuring that vehicles do not exceed maximum load weight and that goods and equipment are properly secured.

- Safety Equipment

  Should be:

  – Properly fitted and maintained.
  – Appropriate and in good working order.

- Safety-Critical Information

  Drivers should have access to information that will help them to reduce risks, such as:

  – Recommended tyre pressures.
  – How to adjust headlamp beam to compensate for load weight.
  – How to adjust head restraints.
  – The action drivers should take where they consider their vehicle is unsafe and whom they should contact.

- Ergonomic Considerations

  A driver's health, and possibly safety, should not be put at risk from inappropriate seating position or driving posture. Consequently:

  – Ergonomic considerations should be taken into account before purchasing or leasing new vehicles.

  – Drivers should be provided with guidance on good posture and how to adjust their seat correctly.

TOPIC FOCUS

Condition of Vehicles

Issues to check regarding the condition of vehicles and whether they are being maintained in a safe and fit condition include:

- Are there adequate maintenance arrangements in place?
- Are maintenance and repairs carried out to an acceptable standard?
- Is planned/preventive maintenance carried out in accordance with manufacturers' recommendations?
- Do drivers know how to carry out basic safety checks?
- How is it ensured that vehicles do not exceed maximum load weight?
- Can goods and equipment which are to be carried in a vehicle, such as loose tools and sample products, be properly secured?
- Are windscreen wipers inspected regularly and replaced as necessary?

The Journey

- Routes

  Routes should be planned carefully and consideration given to using safer routes which are more appropriate for the type of vehicle.

- Scheduling

  Work schedules should be feasible and take into account:

  – The risk of driver fatigue.

  – Periods of peak traffic flow.

  – The limitations of new trainee drivers.

- Time

  Sufficient time should be allowed to complete journeys safely and therefore:

  – Journey times should take account of:

  – Road types.

  – Road condition.

  – Rest breaks.

  – Drivers should not be put under pressure and encouraged to take unnecessary risks because of agreed arrival times.

  – Drivers should be able to make an overnight stay, rather than having to complete a long road journey at the end of the working day.

  – Drivers should not be put at risk from fatigue caused by driving excessive distances without appropriate breaks.

- Weather Conditions

  Consideration should be given to the possibility of adverse weather conditions, such as fog, snow or high winds, when planning journeys and journey times and:

  - Routes rescheduled if this is a possibility.
  - Vehicles properly selected and equipped to operate in poor weather conditions.
  - Drivers instructed in the action they should take to reduce risk.

Checking Drivers' Licences and Documentation

We established earlier that drivers must be competent and capable of doing their work in a way that is safe for them and other people.

The following checks on licences and documentation may be necessary to establish:

- If the employee has relevant previous experience.
- If the job requires anything more than a current driving licence, valid for the type of vehicle to be driven.
- The validity of the driving licence - it should be checked on recruitment and periodically thereafter.
- The validity of any LGV/PSV (large goods vehicle/ public service vehicle) driving entitlements - these should be checked as part of the recruitment procedure and periodically thereafter. (Such entitlements may not have been restored after a period of disqualification.)

Driver Training

Drivers must be properly trained and in addition to the general issues considered above, it may also be necessary to confirm that:

Systems must be in place to ensure driver competence

- Driver training gives priority to those at highest risk such as:
  - Those with high annual mileage.
  - Those with poor accident records.
  - Young drivers.
- Drivers are aware of important safety information such as:
  - How to use anti-lock brakes (ABS) properly.
  - How to ensure safe load distribution when undertaking multi-drop operations.
  - The height of their vehicle both laden and empty (there are estimated to be around three to six major bridge strikes in the UK every day).
- A handbook has been provided for drivers, giving advice and information on road safety.
- Money has been budgeted for training to allow periodic assessment, including the requirement for refresher training.

Vehicle Checks

We established earlier that vehicles should be:

- Fit for the purpose for which they are used.
- Maintained in a safe and fit condition.

Regular checks should also be carried out on the condition of the vehicles and any safety equipment carried.

Journey Planning

The nature of driving at work is such that the journey itself is a major contributor to the risk of accident or injury to those involved. Consequently, journey planning is an important control measure and should:

- Take account of appropriate routes.
- Incorporate realistic work schedules.
- Not put drivers at risk from fatigue.
- Take sufficient account of adverse weather conditions.

Identification of Performance Factors

One of the major aspects of complying with the standard is for an organisation to identify RTS performance factors. These are broken down into three elements:

- Risk Exposure Factors

  Such as:

  - Distance travelled.
  - Road traffic volume.
  - Choice of road systems (whether motorways or 'B' class roads are available or used).

- Final Safety Outcome Factors

  - The number of deaths and serious injuries.

- Intermediate Safety Outcome Factors

  These are related to the safe planning, design and use of the road network and its products and services (including the conditions for entry and exit of those products, services, etc.), and the recovery and rehabilitation of road traffic crash victims, and might include:

  - The use of appropriate roads, taking into account the vehicle type and cargo.
  - The use of personal safety equipment such as seat-belts or motorcycle helmets.
  - Safe speed limits.
  - Weather conditions.
  - Fitness of the drivers.
  - Journey planning.
  - Use of road-worthy vehicles.
  - Making sure employees are licensed to drive the vehicle.
  - Removal of unfit drivers and vehicles.
  - Post-crash response, which would include recovery and rehabilitation.

Setting Objectives

As with all of these generic standards, there is much emphasis placed on setting objectives ('What gets measured gets done').

For an organisation to achieve accreditation to the standard, it must establish RTS objectives at all levels and these should be consistent with the RTS policy. Targets and objectives should:

- Be measurable (if practicable).
- Take into account any applicable requirements.
- Be monitored and communicated to the workforce and all interested stakeholders, including clients, contractors and customers.

Periodic reviews of the objectives should mean they are updated when and as appropriate. All of the documentation regarding the targets and objectives should be retained for future reference.

Support

- Co-ordination

  Too often, targets and objectives set by organisations fall short because of lack of support from other levels or functions. For an organisation to realise the full potential benefits from the introduction of an RTS, there should be internal and external consultation and co-ordination of its activities designed to achieve the established RTS objectives and targets.

- Allocation of Resources

  The organisation should allocate adequate resources to ensure it is able to establish and implement the provisions of the standard. These resources could include having a competent workforce, with any specialised skills required, as well as organisational, technological and financial resources.

- Competence

  The organisation should carry out a comprehensive Training and Competence Needs Analysis (TNA) to establish the necessary competence (education, training and experience) required to work within the RTS.

  Any shortfalls highlighted by the TNA should be addressed by further training, refresher training or hiring in of contract drivers who do have the necessary competence.

- Awareness

  All employees should be made aware of the policy and their contribution to the effectiveness of their part in the RTSMS. Employees should also be left in no doubt as to the implications of non-compliance with the policy.

Document Information

At every stage of the process the organisation should be documenting each activity so that policies, procedures and information are available for audit and if required by insurance companies or enforcing agencies.

A robust document control procedure should be in place that:

- Ensures both controlled and uncontrolled documents can be traced.
- Is adequately protected from loss of confidentiality, improper use or loss of integrity.

Operation

The organisation should have rigorous operational planning and control over all aspects of the RTSMS, including keeping documented evidence so that it has confidence that the processes have been carried out as planned. Processes for the management of change should be in place to ensure that planned changes occur as scheduled and any consequences of unintended changes are mitigated. Outsourced processes should be included.

The organisation should have an emergency preparedness and response plan in place to deal with fatalities and serious injuries among its staff caused by road traffic accidents or incidents. The plan should be:

- Periodically reviewed and revised if required.
- Tested at regular intervals and any lessons learned incorporated.

Performance Evaluation

From the outset, if the organisation decides to seek accreditation to the standard, it will be expected to monitor, measure, analyse and evaluate all aspects of the process and evidence of this will be required by the accreditation company auditors.

Information from road traffic accident investigations – including analysis of the immediate, root and underlying causes, with evidence of corrective and preventive actions which should have been carried out in a timely manner – will also be required.

Evidence of internal audits and management reviews will also be required, together with improvement plans to deal with any corrective actions arising from non-conformance reports, thus demonstrating continual improvement.

Benefits and Limitations of an RTSMS

Benefits

Benefits that might come from developing a Road Traffic Safety Management System could be:

- Reduction of road traffic accidents (RTAs).
- Reduction of staff absence from injuries and trauma arising from an RTA.
- Reduction in motor transport repair bills.
- Reduction in motor insurance premiums.
- Improvement in Corporate Social Responsibility credentials.
- Advantages at competitive tender.
- Advantage when promoting the business.
- Reduced risk of litigation for negligence.

Limitations

ISO 39001 is applicable to any organisation, regardless of type, size and product or service provided, that wishes to:

- improve RTS performance;
- establish, implement, maintain and improve an RTS management system;
- assure itself of conformity with its stated RTS policy; and
- demonstrate conformity with the standard.

However, the standard is intended to address Road Traffic Safety (RTS) management and is not intended to specify the technical and quality requirements of transportation products and services such as roads, traffic signs, vehicles, cargo and passenger transportation services or rescue and emergency services.

Accreditation to the standard does not imply uniformity in the structure of RTS management systems or of documentation.

The standard is not intended to exclude road users from their obligations to comply with road traffic laws and behave responsibly.

Although it can support the organisation in its efforts to encourage road users to comply with the law, it has to be remembered that all requirements of the standard are generic.

STUDY QUESTIONS

8. Outline the role and purpose of a work-related road risk policy.
9. Give the typical content of a management of road risk policy.
10. Outline the business benefits of using ISO 39001:2012.
11. Explain the limitations of using ISO 39001:2012.

(Suggested Answers are at the end.)

Summary

Workplace Transport Risk Assessment and Risk Controls

We have:

- Examined the factors to be considered in a workplace transport risk assessment (including those factors associated with shared workplaces).
- Outlined the reasons for providing information to all employees and visitors to site relating to workplace transport issues.
- Examined how to control risks from workplace transport with reference to the HSE document, HSG136 *A Guide to Workplace Transport Safety*, under the headings of:
  - Safe site (design and activity).
  - Safe vehicle.
  - Safe driver.

Work-Related Road Risk Policy and Components of a Work-Related Road Traffic Safety Management System (RTSMS)

We have:

- Examined work-related road risk policy in relation to:
  - The role and purpose of the policy.
  - How it should be established and signed by 'top management'.
  - The typical content, including the policy being appropriate to the organisation.
  - Communication of the policy to all relevant employees.
  - Ensuring the policy is recorded (written down) and regularly reviewed.
- Outlined the reasons for the introduction of a road traffic safety management system and the key elements and components with reference to ISO 39001:2012 *Road Traffic Safety (RTS) Management Systems*, such as:
  - Planning:
    - Actions to address risks and opportunities.
    - Identification of performance factors.
    - Setting objectives.
  - Support:
    - Allocation of resources.
    - Use of competent drivers.
    - Making employees aware of the policy and their contribution to its effectiveness and that of the RTSMS.
    - The implications of individual non-compliance.
  - Documentary information:
    - Ensuring the relevant policies, procedures and information are documented.
    - Controlling documented information.
  - Operation:
    - Operational planning and control.
    - Emergency preparedness and response.

  - Performance evaluation:
    - Monitoring, measurement, analysis and evaluation of the RTSMS.
    - Accident investigation.
    - Internal audit.
    - Management review.
  - Improvement:
    - Non-conformity and corrective action.
    - Continual improvement.
- Examined the benefits and limitations of an RTSMS.

Exam Skills

QUESTION

Outline the main features that would need to be considered when planning the design of a warehouse and its associated traffic routes to minimise risks associated with the movement of vehicles. **(10)**

Suggested Answer Outline

The examiner would want you to outline the **design** features that should be considered in order to minimise risks associated with the movement of vehicles in a warehouse. These could include:

- Providing traffic routes which have a smooth and stable surface.
- Segregating vehicles/pedestrians (separate access/egress with vision panels in the access doors).
- Providing sufficient width/headroom for the types of vehicle on site.
- Eliminating sharp bends/blind corners and steep gradients.
- Siting of mirrors/aids in those areas with poor/limited visibility.
- Looking at setting up a one-way system to minimise the need for reversing.
- Setting up passing places for vehicles where necessary.
- Introducing speed limits and the provision of speed retarders.
- Providing crossing places for pedestrians.
- Designating parking spaces for vehicles to avoid congestion.
- Providing protection for racking/vulnerable items.
- Using wheel stops/dock locks at loading bays and in areas where tipping is necessary.
- Providing adequate ventilation to clear diesel exhaust gases from the building.
- Providing adequate lighting, avoiding driving from dark areas to bright light (glare), e.g. at the exit to a building. Equally ensuring inside the building is not so dark as to affect vision on entering.

Example of How the Question Could be Answered

The main design features of a warehouse and associated traffic routes that need to be implemented to reduce the risks associated with internal transport would include the following:

- *Working with staff and drivers on setting up designated traffic routes, pedestrian crossings.*
- *Looking at layout of the workplace to ensure it has good visibility, good surface, avoids blind spots and slopes.*
- *The layout should look at provision of a one-way system to avoid reversing of vehicles where possible.*
- *Lighting is another issue which needs addressing as the vehicles could be used in the dark months in the winter or indoors with poor visibility, so adequate light and maintenance of that light needs to be ensured, as well as looking at the wattage and light coverage to ensure dark spots are avoided. It would also be necessary to ensure that driving from dark to light environments is avoided, e.g. emerging from a dark building into bright sunlight, or into areas too brightly lit.*
- *Vehicles will need to be loaded and unloaded, so the issue of safe loading and unloading needs to be addressed to prevent drivers/staff falling off vehicles while loading/unloading.*
- *Provision of signage and establishing suitable and enforceable speed limits.*
- *Maintenance – surface needs to be selected so that it is easy to maintain and can be easily salted in the event of frost/snow.*
- *Set up driver competence assessment schemes and refresher training.*

Reasons for Poor Marks Achieved by Exam Candidates

An exam candidate would achieve **poor marks** for an answer which failed to identify appropriate design features.

Revision and Examination

The Last Hurdle

Once you have worked your way through the revision questions in this book, use the suggested answers on the following pages to find out where you went wrong (and what you got right), and as a resource to improve your knowledge and question-answering technique.

Your NEBOSH Examination

You will need to successfully complete a three-hour examination for each of Units IA, IB and IC, as well as completing Unit DNI, a workplace-based assignment, before you achieve the International Diploma.

Your examination will consist of one exam paper which consists of two parts:

- **Section A** has six short-answer questions worth 10-marks each. These questions are compulsory, and are designed to test your breadth of knowledge across the full range of elements in the syllabus.
- **Section B** has five long-answer questions worth 20-marks each. Only three questions need to be answered from this section which are designed to test your depth of knowledge across the full range of elements in the syllabus.

You are allowed three hours in which to complete the exam and are given ten minutes' reading time before the exam begins.

As a guide, you will need to achieve a minimum of 45% to pass the Unit IA, IB and IC exams, and 50% in the workplace-based assignment (Unit DNI). When you have passed each Unit, you will then be issued with a Unit Certificate, showing a pass grade.

Once you have been awarded a Unit Certificate for all four Units (Units IA, IB, IC and DNI), you will receive an overall grade as follows:

Pass	**185 to 239 marks**
Credit	**240 to 279 marks**
Distinction	**280 marks or more**

The overall mark is calculated by adding together your four Unit Percentage scores.

Remember that your overall grade includes Unit DNI, the workplace-based assignment. Although at this stage of your studies you are quite a way off being ready to attempt the assignment, be aware that you will need to apply what you have learnt throughout your Unit studies when you write your assignment.

Revision Tips

Using the RRC Course Material

You should read through all of your course material once before beginning your revision in earnest. This first read-through should be done slowly and carefully.

Having completed this first revision reading of the course materials, consider briefly reviewing all of it again to check that you understand all of the elements and the important principles that they contain. At this stage, you are not trying to memorise information, but simply checking your understanding of the concepts. Make sure that you resolve any outstanding queries with your tutor.

Remember that understanding the information and being able to remember and recall it are two different things. As you read the course material, you should understand it; in the exam, you have to be able to remember and recall it. To do this successfully, most people have to go back over the material repeatedly.

Re-read the course material and make notes that summarise important information from each element. You could use index cards and create a portable, quick and easy revision aid.

Using the Syllabus Guide

We recommend that you downlaod a copy of the *Guide to the NEBOSH International Diploma in Occupational Health and Safety*, which contains the syllabus for your course. If a topic is in the syllabus then it is possible that there will be an examination question on that topic.

Map your level of knowledge and recall against the syllabus guide. Look at the **Content** listed for each Unit element in the syllabus guide. Ask yourself the following question:

"If there is a question in the exam about that topic, could I answer it?"

You can even score your current level of knowledge for each topic in each element of the syllabus guide and then use your scores as an indication of your personal strengths and weaknesses. For example, if you scored yourself as 5 out of 5 for a specific topic in Element 1, then obviously you don't have much work to do on that subject as you approach the exam. But, if you scored yourself at 2 out of 5 for a topic in Element 3, then you have identified an area of weakness. Having identified your strengths and weaknesses in this way, you can use this information to decide on the topic areas that you need to concentrate on as you revise for the exam.

Another way of using the syllabus guide is as an active revision aid:

- Pick a topic at random from any of the International Diploma elements.
- Write down as many facts and ideas that you can recall that are relevant to that particular topic.
- Go back to your course material and see what you missed, and fill in the missing areas.

Your revision aim is to achieve a comprehensive understanding of the syllabus. Once you have this, you are in a position to say something on each of the topic areas and attempt any question set on the syllabus content.

Exam Hints

Success in the exam depends on averaging half marks, or more, for each question. Marks are awarded for setting down ideas that are **relevant to the question asked** and demonstrating that you understand what you are talking about. If you have studied your course material thoroughly then this should not be a problem.

One common mistake in answering questions is to go into too much detail on specific topics and fail to deal with the wider issues. If you only cover half the relevant issues, you can only achieve half the available marks. Try to give as wide an answer as you can, without stepping outside the subject matter of the question altogether. Make sure that you cover each issue in appropriate detail in order to demonstrate that you have the relevant knowledge. Giving relevant examples is a good way of doing this.

We mentioned earlier the value of using the syllabus to plan your revision. Another useful way of combining syllabus study with examination practice is to create your own exam questions by adding one of the words you might find at the beginning of an exam question (such as 'explain' or 'identify' or 'outline') in front of the syllabus topic areas. In this way, you can produce a whole range of questions similar to those used in the exam.

Before the Exam

You should:

- Know where the exam is to take place.
- Arrive in good time.
- Bring your examination entry voucher, which
  includes your candidate number, photographic proof of identity, pens, pencils, ruler, etc. (Remember, these must be in a clear plastic bag or wallet.)
- Bring water to drink and sweets to suck, if you want to.

During the Exam

- Read through the whole exam paper before starting work, if that will help settle your nerves. Start with the question of your choice.
- Manage your time. The exam is three hours long. You should attempt to answer all six questions from Section A and any three questions from Section B in the three hours.

  Check the clock regularly as you write your answers. You should always know exactly where you are, with regard to time.
- As you start each question, read the question carefully. Pay particular attention to the wording of the question to make sure you understand what the examiner is looking for. Note the verbs (command words), such as 'describe', 'explain', 'identify', or 'outline' that are used in the question. These indicate the amount of depth and detail required in your answer. As a general guide:
  - 'Explain' means to provide an understanding. To make an idea or relationship clear.
  - 'Describe' means' to give a detailed written account of the distinctive features of a subject. The account should be factual, without any attempt to explain.
  - 'Outline' means to indicate the principal features or different parts of.
  - 'Identify' means to give a reference to an item, which could be its name or title.
- Pay close attention to the number of marks available for each question, or part of a question – this usually indicates how many key pieces of information the examiner expects to see in your answer.
- Give examples wherever possible, based either on your own personal experience, or things you have read about. An example can be used to illustrate an idea and demonstrate that you understand what you are saying.
- If you start to run out of time, write your answers in bullet-point or checklist style, rather than failing to answer a question at all.
- Keep your handwriting under control; if the examiner cannot read what you have written, then he or she cannot mark it.
- You will not be penalised for poor grammar or spelling, as long as your answers are clear and can be understood. However, you may lose marks if the examiner cannot make sense of the sentence that you have written.

Unit IC - Part 2

Suggested Answers

No Peeking!

Once you have worked your way through the revision questions in this book, use the suggested answers on the following pages to find out where you went wrong (and what you got right), and as a resource to improve your knowledge and question-answering technique.

Element IC6: Workplace Machinery

Question 1

- The manufacture, sale, hire, and transfer of specified types of machinery should be prohibited when this machinery comprises dangerous working parts (at the point of operation) which are without appropriate guards.
- Where this prohibition cannot fully apply without preventing the use of the machinery it should apply to the extent that the use of the machinery permits.
- Machinery should be so guarded as to ensure that national regulations and standards of occupational safety and hygiene are not infringed.
- The prohibition doesn't prevent the maintenance, lubrication, setting-up or adjustment of machinery or parts thereof carried out in conformity with accepted standards of safety.
- All working parts of machinery which, while in operation, may produce flying particles should be adequately guarded in such a manner as to ensure the safety of the operators.
- All parts of machinery which are under dangerous electrical pressure should be protected in such a manner as to give complete protection to the workers.
- Wherever possible, automatic safeguards should protect persons when machinery is being started, is in operation or is being stopped.
- Machinery should be so constructed as to exclude (as far as possible) any other dangers to which a person working on the machines may be exposed, taking account of the nature of the materials or the type of danger.
- The employer should:
  - Take steps to bring national laws or regulations relating to the guarding of machinery to the notice of workers.
  - Instruct workers regarding the dangers arising and the precautions to be observed in the use of machinery.
  - Establish and maintain such environmental conditions as not to endanger workers employed on machinery covered by the recommendation.
- No worker should:
  - Use any machinery without the guards provided being in position.
  - Be required to use any machinery without the guards provided being in position.
  - Make inoperative the guards provided on machinery.
  - Use machinery where such guards have been made inoperative.

Question 2

The CE marking can only be applied when a declaration of conformity is supplied.

Question 3

The technical file will consist of:

- A general description of the machine.
- Drawings of the machine.
- Drawings of the control circuitry.
- Details of tests carried out to check conformity against essential health and safety requirements.
- List of applicable essential health and safety requirements.
- Description of methods adopted to eliminate hazards.
- The standards and other technical specifications used (indicate the essential health and safety requirements covered by these standards).
- Any technical reports/certificates giving the results of tests.

- A copy of the instructions for the machinery.
- Where appropriate, the declaration of incorporation for included partly completed machinery.
- Where appropriate, the EC declaration of conformity of machinery/products incorporated into the machine.
- A copy of the EC declaration of conformity.
- For series manufacture, the internal measures to be taken to ensure that production machinery is to the same standard (i.e. quality assurance and quality control).

Question 4

All machinery meeting the requirements must be marked with the following information in such a way that it is indelible:

- The "CE" marking.
- Name and address of the manufacturer.
- Designation of machinery.
- Designation of series or type.
- Serial number, if any.
- Year of construction (i.e. when it was actually completed).
- If designed for such, information regarding its use in an explosive atmosphere.
- Any safety-related information regarding the machinery in use (e.g. maximum speed of rotating parts).
- Mass of any part where it must be handled by lifting equipment during use.

Question 5

- Type A identifies basic concepts and principles that can be applied to all machinery.
- Type B are generic standards. B1 is concerned with a particular safety aspect, e.g. safety distances, and B2 applies to safeguards, e.g. two-handed controls.
- Type C standards give detailed requirements for a particular machine.

Question 6

The preferred order for guarding is to:

- Provide fixed guards that enclose every dangerous part or rotating stock bar.
- Provide other guards or protection devices.
- Provide jigs, holders, push-sticks or similar protection appliances used in conjunction with the machinery.
- Provide information, instruction, training and supervision.

Question 7

The principles of safety integration involve:

- Eliminating and reducing risks throughout the life cycle of the machinery (cradle to grave).
- Risks must be eliminated or reduced as far as possible.
- Instructions issued taking account of use and foreseeable misuse.
- Take account of operator constraints.
- Machinery must be supplied with essentials for operation and maintenance.

Question 8

The considerations required in a general workplace machinery risk assessment would be:

- Persons at risk.
- Severity of possible injury.
- Probability of injury.
- Need for access (to the danger zone).
- Duration of exposure.
- Reliability of safeguards.
- Operating procedures and competence of personnel.

Question 9

The mechanical hazards of an abrasive wheel include:

- Friction and abrasion.
- Entanglement.
- Drawing-in.
- Possible ejection of parts of the wheel should it break.

Question 10

- Electricity.
- Noise.
- High temperature of the workpiece and tools.
- Hazardous substances in the form of cooling and cutting fluids.

Question 11

The three main characteristics of an interlocked guard are that it must:

- Prevent motion of the dangerous parts of the machine when the hazard area is open.
- Not allow access to the hazardous area until the potential hazard has been made safe.
- Not allow the machinery to operate until the guarding system is fully operational.

Question 12

- Providing temporary guards.
- Limited movement controls.
- Crawl speed operated by hold-to-run controls.
- Personal protective equipment.
- Provision of instruction and supervision.

Question 13

(a) Energy sources may be in the following forms:

- Electrical.
- Mechanical.
- Hydraulic.
- Pneumatic.
- Chemical.
- Thermal.
- Gravitational.
- Radiation.
- Stored or kinetic energy.

(b) Isolation measures include:

- Locks.
- Clasps.
- Tags.
- Closing and blanking devices.
- Removal of mechanical linkages.
- Blocks.
- Slings.
- Removal from service.

Question 14

Control systems should:

- Make allowance for the failures, faults and constraints to be expected in the planned circumstances of use.
- Not create any increased risk to health or safety.
- Be designed so that any fault, damage or loss of power supply does not result in an increased risk to health or safety.
- Not impede the operation of any stop or emergency stop controls.

Question 15

Stop controls should:

- Be provided to bring the work equipment to a safe condition in a safe manner.
- Bring the work equipment to a complete stop where necessary for reasons of health and safety.
- Switch off all sources of energy after stopping the functioning of the work equipment if necessary for reasons of health and safety.
- Operate in priority to any control which starts or changes the operating conditions of the work equipment.

Question 16

Key principles in design include:

- Equipment should be designed in accordance with key ergonomics standards.
- Users should be involved in the design process. This should include different types of users, such as operatives, maintenance and systems support personnel.
- Consideration should be given to:
  - Operator characteristics, including body size, strength and mental capability.
  - All foreseeable operating conditions, including upsets and emergencies.
  - The interface between the end user and the system.

Element IC7: Mobile, Lifting, Access and Work at Height Equipment

Question 1

The three main headings are:

- Operators:
  - Unauthorised use by untrained personnel.
  - Driving too fast and cornering at speed can cause the vehicle to overturn or lose its load.
- The lift truck:
  - Emission of substances while being used, i.e. exhaust gases.
  - For electrically-operated trucks, there is the danger of production of hydrogen gas while charging the batteries as well as the manual handling implications of changing them.
- Operations:
  - Lift trucks are often used in areas where there is a possibility of pedestrian movement. Impact with people as well as with structures such as walls and racking is a constant hazard.
  - Overloading of lift trucks can lead to loss of control in steering and braking, and uneven or improperly loaded lift trucks can affect the stability.
  - Driving over unsuitable ground can cause the load to shift or fall off.

(Only two examples were required.)

Question 2

'Lateral instability' is where a vehicle will tip over onto its side. Examples are when a lorry is blown over in a high wind or a loaded forklift tips while driving across a slope.

Question 3

Factors which can affect the stability of a forklift truck are: load weight, height of load, speed, ground undulations and slopes.

Question 4

During use as a working platform, the following precautions are necessary:

- Warning cones or signs should be located around the truck.
- People should not lean out of the truck.
- All people involved in the operation must be trained.
- Trucks should only be used on firm, level surfaces.
- Where controls are at ground level, the driver must stay in attendance for the duration of the operation.

Question 5

Crane stability depends on setting up a system of work which minimises the risk of overturning or other failure. The safe system will include:

- Planning the lift.
- Selection of correct crane.
- Selection of correct lifting tackle.

- Selection and provision of trained and certificated staff.
- Ensuring test certificates, etc. are available and in order.
- Controls to prevent unplanned lifts or movements.

Question 6

Hazards associated with the use of tower cranes include:

- Collapse of the tower due to incorrect construction.
- High wind conditions.
- Collapse or bending of the jib due to overloading or fatigue.
- Impaired operator vision of the load.
- Swinging or unstable loads.
- Operating outside the safe working radius.

Question 7

Items of lifting equipment needing to be examined include cranes and lifting machines, as well as all the miscellaneous items of lifting equipment, such as lifting tackle, chains, ropes, rings, hooks and shackles.

Question 8

All hoists and lifts should have a thorough examination every six months by a competent person and the results should be recorded.

Question 9

To prevent people getting underneath a hoist and becoming trapped, substantial enclosure gates must be fitted at each landing. The enclosure gates must also be interlocked to the hoist platform so they cannot be opened when the platform is not there, thus preventing falls of people and material down the hoist route. The interlocking must also prevent the platform from moving until the enclosure gates are correctly closed. The construction of the enclosure must prevent any trapping of people or goods on the hoist.

Question 10

MEWPs can be easily moved from one location to another. They provide a safer working platform than a ladder. They avoid the need for time-consuming scaffold erection.

Question 11

The following checks should be made:

- The state of the ground on the path of travel.
- Overhead cables, projections or other overhead obstructions.
- Has warning been given to persons on the ground?
- If necessary, a signaller should be used.
- There should be no insecure load.
- There should be no trailing hoses or wires that may catch or snag.

Question 12

The principal types of incidents involving MEWPs are as follows:

- MEWPs collapsing.
- MEWPs overturning.
- People being thrown from the carrier (basket or cage).
- The carrier being trapped against fixed structures.
- The vehicle colliding with pedestrians, overhead cables or nearby vehicles.

Element IC8: Electrical Safety

Question 1

To calculate the power you need to take two steps.

- Firstly, you need to determine the current. Using Ohm's law, I (current) = V (voltage) divided by R (the resistance). Therefore, I = 230 divided by 23 = 10 amps.
- To calculate the power next, we use W = I × V = 10 × 230 = 2,300 watts (2.3kW).

Question 2

The severity and type of injury suffered in the case of an electric shock will depend on:

- Voltage.
- Frequency.
- Duration.
- Impedance/resistance.
- Current path.

Question 3

Explosions, which can cause burns and injuries from flying debris, can arise in two ways:

- Ignition of a flammable substance such as a gas, dust, liquid or vapour by an electric arc, spark or the heating effect of electric equipment which has a hot surface. There is no voltage limit which will allow the safe use of electricity in a potentially flammable environment without additional precautions being taken.
- The explosion of electrical equipment due to excessive currents or prolonged internal arcing faults. The overload of energy can cause rapid and violent rupture of the equipment.

Question 4

The main hazard of static electricity is the discharge of very high voltages to earth which can ignite flammable atmospheres.

Question 5

The main method of discharging static electricity in processes and plant is to earth it safely via special conducting systems, enabling the charge to leak away before dangerous voltages can develop and cause a spark discharge.

Question 6

The sequence of earthing connections is particularly important. The earth connection must be made before fluid transfer takes place and not removed until after the transfer is complete. Premature removal of the earth connection could produce a hazardous spark. All earth connections must be in good condition and securely fixed in position to remain effective.

Question 7

- Manufacturer's recommendations.
- Likely load and fault conditions.
- Probable use of the system(s).
- Need for suitable electrical protection devices, such as overload protection.
- Environmental conditions that may affect the mechanical strength and protection required.

Question 8

The **IET Wiring Regulations** (otherwise known as British Standard 7671:2008) set safety standards for designers, installers, erectors and testers of permanent and temporary electrical installations and aim to protect people from the hazards of electric shock, burns, fires and mechanical movement of electrically-powered machinery.

Question 9

Records of maintenance, tests and repairs should be retained for the life of the equipment, because this allows the efficiency of maintenance policies to be monitored by duty holders and it enables them, and the enforcing authorities, to assess whether the requirement for maintenance is being met.

Question 10

Considerations that might justify live working include the:

- Impracticability of carrying out the work with the equipment dead, e.g. where it may be necessary for testing purposes for the supply to remain on.
- Creation of other hazards by making the equipment dead, such as to users of the system or in connection with continuous operation of process plant.
- Need to comply with any statutory requirements.
- Level of risk and the effectiveness of the precautions adopted judged against the economic need to work live.

Question 11

The scope of the person's technical knowledge or experience, which may include:

- Adequate knowledge of electricity.
- Adequate experience of electrical work.
- Adequate understanding of the system to be worked on and practical experience of that class of system.
- Understanding of the hazards that may arise during the work and the precautions which must be taken.
- The ability to recognise at all times whether it is safe to continue working.

Question 12

A permit-to-work is essential for very complex systems and for any work on high-voltage systems (operating at voltages above 1,000V).

Question 13

Damage to underground cables usually occurs during excavation work and is caused by the crushing or penetrating effects of hand or machine tools, such as pneumatic drills and mechanical excavators. A tool may penetrate the sheath of a cable and the cable insulation or crush the cable and cause contact between the conductors or between the sheathing and one of the conductors. Damage to live cables often results in arcing currents with associated explosive effects, fire and flames that usually cause severe (potentially fatal) burns to the hands, face and torso.

Question 14

The main disadvantage of cable detectors is that they may be unable to distinguish between a number of cables in close proximity and may register them as one cable. If two cables are located one above the other, the upper one may be located but not the lower one. It cannot be assumed that all cables have been successfully identified and therefore use of cable locating devices cannot be relied on in isolation.

Question 15

Groups of workers at risk from overhead power lines include those:

- Working on roofs, scaffolding, or elevated platforms.
- Operating vehicles such as cranes and excavators.
- Handling equipment such as scaffold poles, metal ladders or pipes.

Question 16

At the planning stage of any work in an area where overhead lines could be a hazard, the owner/operator of the lines should be requested to divert the lines or make them dead.

Question 17

The main cause of accidents is failure to maintain the equipment in a serviceable condition.

Question 18

(a) The likelihood of accidents occurring and their severity will depend on the:

- Type of electrical equipment.
- Way in which it is used.
- Environment in which it is used.

(b) Other conditions which may lead to accidents include:

- Incorrectly made connections.
- Damaged or missing insulation, exposing live conductors.
- Insulation failure, resulting in leakage currents and live metalwork.
- Servicing equipment without disconnecting supply.
- Misuse of equipment.
- 'Unauthorised' equipment brought into the work environment by workers, e.g. electric heaters, kettles, coffee percolators, electric fans.

Question 19

In the event of a fault in the equipment, electric shock can be minimised by:

- Earthing all exposed metal parts.
- Using all-insulated casings.
- Using double insulation.
- Using reduced voltages.
- Providing sensitive earth-leakage protection to limit the duration of shock.

Element IC9: Construction and Works of a Temporary Nature - Hazards and Controls

Question 1

The following different types of work might be included in the general term "construction":

- Building works – the erection or extension of a building.
- Renovation – the process of improving a structure.
- Alteration – change or modification to a structure.
- Maintenance of existing premises (occupied or unoccupied) – keeping the premises in working order and preventing deterioration.
- Civil engineering – design, construction, and maintenance of works such as bridges, roads, canals, dams and buildings.
- Works of engineering construction – the construction, structural alteration, repair, maintenance or demolition of a dock, harbour, inland navigation works, tunnel, bridge, viaduct, water-works, reservoir, pipeline, aqueduct, sewer, sewage works or gasholder.
- Demolition – dismantling or pulling down of a building or structure.

Question 2

The temporary nature of construction activities can affect standards of health and safety because, as the construction project progresses, each stage may involve new activities and consequently new hazards. This means that risk assessments and safe systems of work need to be continually updated to reflect the changing work activities. In addition, the construction industry relies on contractors hiring the workforce on a project basis. Consequently, work may be short-term and workers may be employed by a number of successive employers. It can therefore be difficult to ensure a consistent approach in protecting the continually changing workforce.

Question 3

- The client should ensure that:
  - Only competent people are appointed.
  - Adequate resources are available.
  - Construction does not start until the construction phase plan is prepared.
- The co-ordinator:
  - Advises and co-ordinates the health and safety aspects of the planning and design stage.
  - Advises the client on the adequacy of the risk control arrangements put in place by other parties.
  - Provides assistance and advice on the appointment of competent contractors and designers.
  - Facilitates good communication and co-operation between members of the project team.
  - Prepares the health and safety file in liaison with the principal contractor.
- The principal contractor should:
  - Take account of health and safety issues when submitting the tender.
  - Prepare and review the construction phase plan.
  - Co-ordinate the activities of all contractors to ensure that each complies with the construction phase plan.
  - Liaise with other contractors and the co-ordinator on the content of the health and safety file.

Question 4

The plan should include: arrangements for ensuring the health and safety of all involved in the construction work; arrangements for managing health and safety during construction work and ensuring legal compliance; information about welfare arrangements.

Question 5

Site security consists of:

- Traditional physical and electronic measures.
- Management and procedural measures.

For example:

- Perimeter fencing.
- Locked gates.
- Temporary compound.
- Roadside lighting.
- Permanent compound.
- Security guards on the premises.
- Visitor registration and sign-in procedures.

Question 6

Site rules should cover areas such as:

- Site access.
- Permit-to-work systems.
- The wearing of PPE.
- Fire prevention rules.
- Welfare facilities.
- Alarms and emergency response.
- First-aid facilities.
- Accident reporting.
- Site transport precautions.

The actual rules will depend on the nature of the site and the type of industry where the construction work is being carried out.

Question 7

The precautions necessary to prevent accidents to children on a construction site would include a secure perimeter fence or hoarding which is appropriately signed, as well as:

- Removal of any access ladders to scaffolding, buildings and working platforms.
- Secure and adequate trench supports.
- Immobilising plant and equipment such as excavators, dumpers and vans.
- Isolating electrical equipment and ensuring the integrity of emergency supplies to the site.
- Reducing the height of any stacked materials.
- Filling or covering any holes or excavations.
- Blocking off debris chutes using lids or covers.

- Locking away any equipment, chemicals, flammable materials in safe and secure storage areas.
- Securing storage tanks for oil, petrol and diesel.

Question 8

- Should be erected on a firm, level base.
- Should be supported by the stiles (uprights) only.
- Top of the ladder should rest on firm, solid surface.
- Should slope about 75° to the horizontal.
- Should be secured at the top where possible.
- Only one person should be on the ladder at a time.
- Avoid using metal ladders where there is danger from overhead cables.
- Ladders should be stored correctly and painting wooden ladders should be avoided.

(Only five were required.)

Question 9

Cradles are used where it is impracticable or uneconomic to provide scaffolding. Examples might be cleaning or carrying out small repairs on tall buildings.

Question 10

The use of nets is most effective to:

- Prevent injury due to falls from leading edges in new roof building.
- Guard roof lights and fragile materials during cleaning, etc.
- Prevent injury due to falls during roof truss erection.

Question 11

Attach the harness to a secure anchor point, above the wearer, where possible. The following list includes structures and items that should **never** be used as anchorage points for a personal fall-protection system:Standard guardrails.

- Standard guardrails.
- Standard railings.
- Ladders/rungs.
- Scaffolding.
- Light fixtures.
- Conduit or plumbing.
- Ductwork or pipe vents.
- Wiring.
- Lanyards.
- Vents.
- Fans.
- Roof stacks.

Question 12

Demolition methods:

(a) Demolition by hand: this process follows the reverse order of construction technique. The building is gradually dismantled using hand tools and the loose material is usually lowered to the ground by cranes or conveyed down a gravity chute to a skip or pile. As structures are usually gutted before demolition takes place in order to salvage reusable construction material, e.g. floorboards, operatives may have to work in areas where there is a high risk of falls occurring. Care must be taken to see there is always a safe means of access to, and egress from, the work area. Debris build-up at high levels and against the walls of a structure must also be carefully controlled.

(b) Mechanical demolition by demolition ball: this involves a demolition ball suspended from a crane, or an excavator converted to a crane. It is a common technique in demolition, and requires considerable skill on the part of the operator to use it in a safe manner. The demolition ball consists of a large steel pear-shaped ball suspended from the jib of an appliance.

Various precautions must be in place to ensure that:

- The ball cannot overswing.
- It is only used in accordance with the manufacturer's instructions.
- It is used by a well-trained and supervised operative.

Other precautions involve making sure that the work area is clear of unauthorised persons, and that the cab is protected from flying debris. It is also important that all the plant and equipment is properly maintained.

Tall buildings should be reduced to about 30 metres before a ball demolition is carried out.

(c) Mechanical demolition by deliberate collapse: this is an economical method of demolition which relies on removing key structural members so the remaining structure collapses under its own weight.

Another method of creating a deliberate collapse is by attaching a wire to the structure and pulling away the main supports using a heavy tracked vehicle or a winch to provide the motive power.

Where deliberate collapses are engineered, it is recommended that no one should be nearer to the building than twice the height of its highest part.

Question 13

The following are typical hazards associated with demolition:

- Falling materials.
- Premature collapse of buildings.
- Materials of construction (e.g. asbestos).
- Presence of hazardous substances.
- Poor housekeeping.
- Poor means of access and egress for workers.
- Poor site security.

Question 14

The following common hazards are associated with excavation work:

- Collapse.
- Work in confined spaces.
- Objects falling into the excavation.
- Groundwater.
- Buried services.
- Impure air.

Question 15

The edge must be protected by barriers or the excavation securely covered when not in use.

Question 16

It is a property of particulate materials that they form a stable sloping pile when allowed to form naturally into heaps. The angle formed by the slope with the horizontal is the 'angle of repose'.

Question 17

Once a day or, if deeper than 2m, before each shift, or after any event that may have affected its strength or stability, or after a fall of rock or earth.

Element IC10: Workplace Transport and Managing Work-Related Road Risk

Question 1

Risk assessors should keep in mind that, generally speaking, there are four main kinds of accidents involving workplace transport:

- People being struck by, or run over by, moving vehicles.
- People being struck by something falling from a vehicle.
- People falling from vehicles.
- Vehicles overturning.

Question 2

The factors to be considered in a workplace transport risk assessment (depending on the complexity of the site) might be:

- The activities that take place on the site such as deliveries, loading or collecting materials.
- The actions of the drivers and others who are near to vehicles (whether working or as pedestrians).
- The numbers of vehicles and people moving around the site and where they are likely to interact or come into conflict.
- The features of the site (such as how routes are laid out and whether they are in good condition).
- The design of the traffic system and flow around the site – is it one-way or a dead-end and do drivers have to reverse to park or exit the site?
- The training and competency requirements for drivers working on the site.
- Maintenance standards and requirements for vehicles on site.
- Environmental effects that might be important such as:
  - Will drivers be dazzled by strong sunlight at times of the year when the sun is low in the sky?
  - Is there bad visibility in the loading area when deliveries are made at night?
  - Could people working high up on the outside of vehicles be affected by strong gusts of wind?
  - Is the site in an area affected by heavy rain, mist, snow, ice or frost?

Question 3

The areas risk assessors might be observing are:

- where vehicles are going;
- what the drivers are doing;
- how they are doing it; and
- why they are doing it.

Assessors may not always be able to find out the training levels of drivers from other organisations and this factor should also be considered in the process when evaluating risks.

Question 4

As part of this duty of care, these people should be provided with information relating to hazards and risks on the site and this includes workplace transport issues. A comprehensive set of site rules should be handed out and explained at induction. This, together with notices warning of hazards on site ("Deep excavation", etc.) and good supervision, will normally satisfy this requirement.

Question 5

There are a number of general rules applying to all situations in order to prevent unauthorised use or misuse of vehicles, and to ensure that, when unattended or parked, they do not create hazards.

- When a vehicle is not in use, the keys should be kept in a secure place. At the end of the work period, the engine should be switched off and the brakes applied. On battery-operated vehicles, the battery should be disconnected.
- All vehicles should always be parked in a safe place and not obstruct emergency exits, other vehicle routes, fire-fighting equipment or electricity control panels.
- Vehicles should not be left unattended on a gradient. If a vehicle has to be left or parked on a gradient in an emergency, even for a short period of time, it should be left in neutral with the parking brake applied and wheels chocked to prevent unexpected movement.
- Horns should be sounded at every potential danger point, such as before entering doorways and at blind corners, although the use of a horn does not give the driver right of way.

Question 6

The three main headings are:

- Safe site (design and activity).
- Safe vehicle.
- Safe driver.

Question 7

Management of vehicle operations and movements around a site encompasses the following measures:

- Movement systems:
  - The way in which vehicles move around a site should be carefully controlled and be appropriate for the types of vehicle operating on the site.
- Speed limits:
  - Speed limits should be set and enforced on all parts of the site.
- Vehicle parking:
  - Sufficient and suitable parking areas should be provided for all vehicles using the site – including employees' and visitors' private vehicles.
- Signs and markings:
  - Surface markings and road signs play an important part in regulating vehicle movements and should be clear, unambiguous and comply with the national road traffic legislation.

Question 8

The role of the Management of Road Risk Policy is to manage road risk at an appropriate level. The purpose of the policy is to reduce or eliminate the risk of employee road accidents and the organisation being prosecuted for a management failure, or suffering a large civil claim for compensation. This involves:

- Carrying out an appropriate risk assessment for the management of road risk.
- Having in place written arrangements to deal with any material risks identified.
- Having a clear audit trail to follow up.
- Carrying out regular reviews and further risk assessments at reasonable intervals.

Question 9

The typical content of a management of road risk policy should be:

- A clear written policy statement about who is entitled to use company-controlled vehicles.
- A clear written policy about the need for employees to submit mileage returns to identify high-risk cases.
- A clear statement requiring all employees to observe all normal road rules as set out in national legislation.

Specific issues which should be mentioned might include:

- Policy on use of mobile (cell) phones (including hands-free kits).
- Policy on alcoholic drink and drugs.
- Policy on maximum driving time behind the wheel:
  - at any one stretch; and
  - overall within any one working day.
- A process to ensure that anyone driving on employers' business is properly licensed for the types of vehicles to be used (cars or vans of different weights, towed trailers, minibuses, etc.).
- Confirmation of a company insurance policy for employees' own cars.
- A process to ensure that all vehicles are serviced at least in line with manufacturers' recommendations.
- Facilities to provide employees with information and training where necessary and supervision to be safe on the road.
- Summary of the risk assessment documentation and a timetable for all future steps in the process.
- Targets set to improve road safety on a continuous-improvement basis, with the process being benchmarked against other fleets.

A member of the Board of Directors should be appointed to be the Board champion of occupational road risk, to demonstrate the importance of this area to the organisation. In establishing the policy, the management team should ensure it is appropriate to the organisation.

Question 10

The business benefits of using ISO 39001:2012 might be:

- Potentially lower insurance premiums.
- Reduce the potential for prosecutions and compensation claims.
- Provide a robust framework for identifying risks and putting measures in place to mitigate them.
- Increase confidence in the organisation from customers and other stakeholders.
- Help organisations to target their resources in the most cost-effective way.
- Increase the time and resources available for productive activity.

For fleet transport operators, ISO 39001 helps direct attention to addressing common, system-wide, fatal and serious injury risk factors that they can influence and includes addressing areas such as:

- Safe speeds.
- Driver impairment by alcohol, drugs or fatigue.
- Use of appropriate safety equipment, such as seat-belts.
- Safe journey planning.

The standard also emphasises the need to ensure that all employees who drive as part of their work comply with relevant rules on safe road use so that key risks are either eliminated or adequately managed.

Question 11

The limitations of using ISO 39001:2012 could be:

- The standard is intended to address Road Traffic Safety (RTS) management and is not intended to specify the technical and quality requirements of transportation products and services such as roads, traffic signs, vehicles, cargo and passenger transportation services or rescue and emergency services.
- Accreditation to the standard does not imply uniformity in the structure of RTS management systems or of documentation.
- The standard is not intended to exclude road users from their obligations to comply with road traffic laws and behave responsibly.
- Although it can support the organisation in its efforts to encourage road users to comply with the law, it has to be remembered that all requirements of the standard are generic.
- At the introduction of the standard, a great deal of time and effort will be taken up by staff and management training, to the detriment of production and/or service.
- Owners and managers may not have an adequate understanding of the requirements of the standard and this will have to be countered with ongoing training, mentoring and auditing.
- Many smaller companies, who have less funding available, will struggle to meet the required commitments of the standard and may find it difficult to adopt the system.
- All ISO standards generate large volumes of documentary evidence and smaller firms in particular may not have the necessary manpower or resources to cope.
- All ISO registration processes require a long-term commitment from the management and the workforce which some organisations may find difficult to maintain.